Spatial Data Infrastructure (SDI) Manual for the Americas

CP-IDEA

PERMANENT COMMITTEE FOR GEOSPATIAL DATA INFRASTRUCTURE OF THE AMERICAS

PERMANENT COMMITTEE FOR GEOSPATIAL DATA INFRASTRUCTURE OF THE AMERICAS (PC-IDEA)
2009 – 2013

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Permanent Committee for Geospatial Data Infrastructure of the Americas
(PC-IDEA)

Spatial Data Infrastructure (SDI) Manual for the Americas

Rio de Janeiro
2013

ACKNOWLEDGEMENTS

GeoConnections (www.GeoConnections.NRCan.gc.ca), Natural Resources Canada, led the research and development of the SDI Manual for the Americas to address the needs of the United Nations Permanent Committee for Spatial Data Infrastructure of the Americas member nations. The Manual is part of Canada's contribution to the 2009 – 2013 work plan of PC-IDEA. The SDI Manual for the Americas was completed thanks to the contributions of the individuals who provided expertise, content, direction, comments and critiques.

In 2011, PC-IDEA conducted a survey that found that there is a lack of documentation and dissemination of best practices in the region and that PC-IDEA must promote this activity and find efficient mechanisms for disseminating best practices. Solutions to the language barriers also need to be provided. The study also concluded that nations needed guidelines for monitoring social and economic impacts and benefits of SDI initiatives. The Manual incorporates and references existing guides, best practices and case studies and highlights examples from PC-IDEA member nations and elsewhere and new content was also developed where required.

GeoConnections would like to particularly acknowledge the contributions made by Hickling Arthurs and Low Corporation - Ed Kennedy, Tatiana Delgado and Betty Anne Benes for providing research, writing and editing of the Manual, as well as Garfield Giff and Joep Crompvoets for the special chapter to support monitoring and measuring the impacts of SDI. The staff at GeoConnections who provided management, input and direction for the project were Paula McLeod, Rhian Evans, Simon Riopel and Jean Brodeur, in addition Mélodie Bujold, Adam Balogh, Jenna Findlay and Kyra St. Pierre provided assistance in compiling the Manual.

GeoConnections; Hickling Arthurs Low Corporation; Giff, G. , 2013

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1. Introduction to the Manual

The purpose of this chapter is to introduce the reader to the contents of the *Spatial Data Infrastructure (SDI) Manual for the Americas* and to provide an overview of basic spatial data infrastructure (SDI) concepts. It provides the context for the document, including the sponsorship, process and rationale for this SDI Manual for the Americas.

1.1 Background

1.1.1 Project Sponsors – PC-IDEA

The Manual has been developed from the decisions and work of the Working Group on Planning (GTplan) of the Permanent Committee on Geospatial Data Infrastructure for the Americas (PC-IDEA). PC-IDEA was established based on resolutions of the 6th United Nations Regional Cartographic Conference for the Americas (UNRCC-A) in 1997, and operates under its guidance (PC-IDEA, 2012). The primary goal of PC-IDEA is to maximize the economic, social and environmental benefits of using spatial information, by exchanging knowledge, experiences and technologies of different countries, based on a common development model that allows for the establishment of an SDI in the Americas region. Further goals of PC-IDEA include:

- The establishment and development of National SDIs in each of the member countries;
- The exchange of spatial information among all members of the community of the Americas (respecting each country's autonomy, but acting in accordance with the overarching laws and policies); and
- The encouragement of cooperation, research and exchange of experiences in the areas of knowledge related to the field of geomatics.

Following a meeting of the PC-IDEA Executive Board in New York in May 2010, GTplan was created in response to the recommendations of the 9th UNRCC-A. Canada co-chairs the working group with Chile and membership includes representatives from Mexico, Cuba, Brazil, Guatemala, Colombia, Canada and Chile. In 2011, GTplan conducted a survey of all PC-IDEA member countries focused on five key areas: innovation in national cartography institutes, state of qualifications, evaluation of national SDI development, state of standards and specifications, and best practices for the implementation of spatial data infrastructures. The survey results identified further needs for manuals and best practices regarding SDI implementation and assessment, and GTplan decided to proceed with the development of this manual.

1.1.2 Development Process

The Manual was created by Ed Kennedy of Hickling Arthurs Low Corporation (HAL), a management consulting firm based in Ottawa, Canada, under contract to the GeoConnections Division of Natural Resources Canada, which represents Canada on PC-IDEA and GTplan. Dr. Garfield Giff and Dr. Joep Crompvoets contributed the contents of Chapter 10 of the Manual. The creation process was based upon thorough research, analysis and synthesis of information from documents and literature relating to SDI policies, standards, technologies, framework data, collaboration, leadership and governance. It incorporates the results of the GTplan survey of PC-IDEA countries and international good practices gleaned from the document and literature research. The draft structure of the Manual was circulated to PC-IDEA members for their review and the final content has benefited from the feedback received from those reviewers. The Manual will be formally submitted to PC-IDEA member countries for consideration during its 2013 meeting, to be held along with the X UNRCC-A, in New York.

1.1.3 Why Another SDI Manual?

It is important to note that there are already a number of SDI guidance documents, including *The SDI Cookbook* (GSDI, 2009), *Spatial Data Infrastructure Cookbook v1.1* (New Zealand Geospatial Office, 2011), and *SDI Africa: An Implementation Guide* (UN-ECA, GSDI, EIS-Africa, ITC, 2004). While these guidelines are very valuable resources, GTplan decided that a manual covering a broader range of SDI planning and implementation considerations was required to meet the needs of PC-IDEA member countries. In addition, unlike other guides, this manual is available in four languages (English, Spanish, Portuguese and French). It highlights examples within the Americas and is adapted to the needs of the member countries.

As a consequence, this manual has been designed to provide guidance in several areas not covered by previous SDI manuals, including user-needs assessments, SDI governance, policy processes, and the impact of SDIs and benefits measuring and monitoring. It is hoped that the discussion of these challenges, and the best practices to deal with them, will also be of interest to the SDI community outside of the Americas.

1.1.4 Objectives

The objectives of the Manual are threefold:

- To provide guidance on planning for and implementing SDIs in PC-IDEA member countries;
- To share international and Americas good practices in SDI implementation; and
- To allow PC-IDEA members to learn from each other's experiences.

1.2 The SDI Concept

1.2.1 A Brief History

While it is difficult to pinpoint the origins of the SDI concept, it appears that the term "National Spatial Data Infrastructure" may have first been described by a Canadian, Dr. John McLaughlin, in 1991 (McLaughlin, 1991). However, the term appeared several times without definition in the US National Research Council Mapping Science Committee's 1990 report, *Spatial Data Needs: The Future of the National Mapping Program* (Mapping Sciences Committee, 1990). Other early references to the SDI concept were made by Rhind, (1992), Mapping Sciences Committee, (1993), Tosta, (1994), Commission of the European Communities, (1995), Brand, (1995), and, in a comprehensive paper on building an SDI, by Mclaughlin, Coleman, & Nichols, (1997).

The first formal adoption of the SDI concept at the national level occurred in the United States in 1994, with the issuance of *Executive Order 12906*, establishing the National Spatial Data Infrastructure (NSDI) (Robinson, 2008). In 2002, the NSDI was incorporated into one of the most important policy documents for the coordination of geographic information in the United States, the *Office of Management and Budget (OMB) Circular A-16*. While not called an SDI at the time, it may be argued that the Netherlands had an even earlier start, with implementation of its National Geographic Information Infrastructure (NGII) beginning in 1992 (now the National Georegistry).

Other early adopters of the SDI model at the national level included Australia (Australian Spatial Data Infrastructure, initiated in 1998), Canada (Canadian Geospatial Data Infrastructure, initiated in 1999) (Hall, 2002), and Germany (Geodaten-Infrastruktur Deutschland – GDI-DE, initiated in 2001). While there was some earlier movement towards the SDI model in other European countries (e.g., Sweden, Denmark and the United Kingdom), the first comprehensive efforts began in most countries with the adoption of the INSPIRE Directive in May 2007, which created a mandatory requirement for the implementation of national SDIs by all European Union (EU) Member States (European Commission, 2007).

1.2.2 SDI Definition and Components

SDI Definition and Key Capabilities

The most commonly used definition of the term spatial data infrastructure is as follows: "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data" (GSDI, 2009). A number of jurisdictions have extended this definition to include base or framework data and standards, as illustrated in Figure 1.1, which identifies the components and underlying principles of the Canadian Geospatial Data Infrastructure. An SDI consists of more than a single spatial data set or database; it hosts spatial data and attributes and provides sufficient documentation (metadata) and a means to discover, visualize, evaluate and access the data.

The key capabilities of an SDI can be described as follows (GeoConnections, 2005):

- Enable online access to a wide range of spatial information and services
- Enable integration of geographically distributed spatial information
- Enable collaboration by multilateral information exchange and synchronization
- Allow autonomous organizations to develop interdependent relationships in a distributed environment
- Facilitate the definition and sharing of spatial semantics

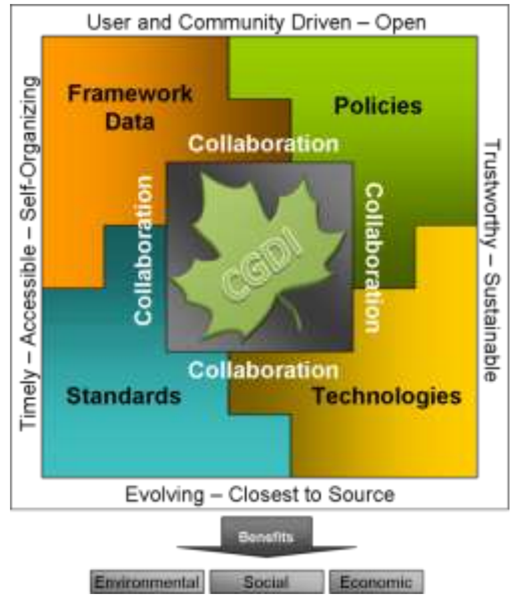


Figure 1.1: CGDI Components and Guiding Principles

Interoperability

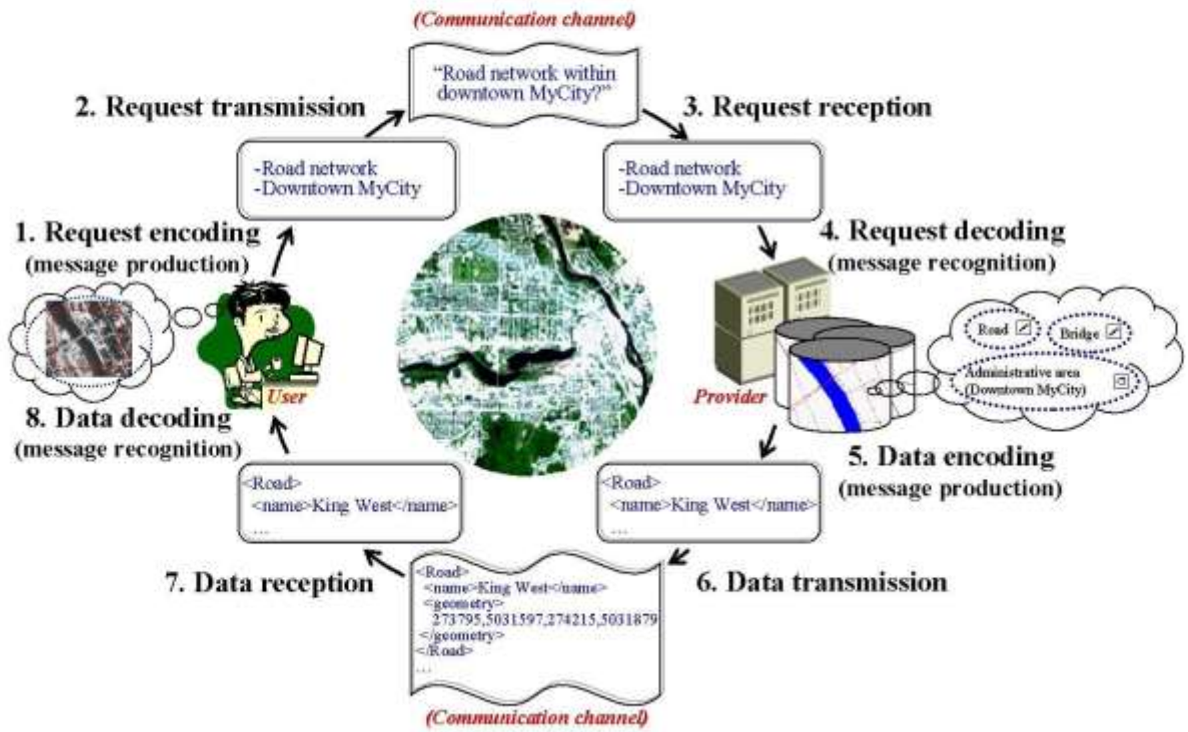
The common ingredient in fulfilling these fundamental SDI capabilities is interoperability. Interoperability facilitates information sharing and allows users to find information, services and applications when needed, independent of physical location. It allows users to understand and employ the discovered information and tools, regardless of platform (local or remote). Through interoperability, users can also evolve a processing environment without being constrained to a single vendor's offerings.

To achieve interoperability between systems and system components, an SDI must include the following (GeoConnections, 2005):

- *Network Protocol Interoperability* – Allows basic communications between components;
- *Standard Interface Specifications* – Allow client applications to execute procedures on remote systems;
- *Data Transport Interoperability* – Allows for sharing of data and services through transparent access, regardless of any proprietary data storage formats; and
- *Semantic Interoperability* – Means that applications can interpret data consistently in the same manner in order to provide the intended representation of the data.

Interoperability adheres to the human communication process, as illustrated in Figure 1.2, where agents (e.g., human beings, systems, etc.) interact together at the system, syntactic, schematic, and semantic levels to share information. Each agent has its own conceptual representation of reality and uses it to encode (steps 1 and 5) and decode (steps 4 and 8) messages (e.g., queries and responses about geographic information), which are transmitted (steps 2 and 6) to or received (steps 3 and 7) from another agent through the communication channel. Interoperability happens only when both agents engaged in a communication have the same understanding about the message (Brodeur & Badard, 2008).

Figure 1.2: Illustration of Framework for Interoperability



Source: Brodeur & Badard, 2008

SDI Components

The primary components of an SDI can be briefly described as follows:

- *Institutional Arrangements* – The mechanisms created to enable key stakeholders to collaborate and engage actively in the planning and implementation of the SDI. These can take the form of legislation, regulations, policies or written agreements, or be developed through more informal negotiation.
- *Framework Data* – The set of continuous and fully integrated spatial data that provides context and reference information for a jurisdiction. Framework data (sometimes called base mapping data) are expected to be widely used and generally applicable, either underpinning or enabling spatial applications by helping to integrate other types of spatial data (sometimes called thematic data).
- *Policies* – The strategic- or operational-level instruments that help facilitate the development or use of an SDI. Strategic policies address high-level issues and set directions for organizations (e.g., enforcing compliance with certain standards and procedures). Operational policies address topics related to the lifecycle of spatial data and help facilitate access to and use of spatial information (e.g., guidelines and manuals dealing with data collection, management, dissemination and use).
- *Standards* – Spatial standards are technical documents that detail interfaces or encodings, which have been developed to address specific interoperability challenges. The more

standardized the structure and content of information, the more effectively it can be accessed, exchanged and used by both humans and electronic devices. SDI-implementing organizations typically adopt international standards developed collaboratively by the International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC).

- *Technologies* – The technological architecture of an SDI is composed of a network of physical servers that provide Web services, and data via these services, in such a way that an application can be developed that makes use of these services. The Internet is the "highway" through which data and services are accessed, and applications use data from Web services so that users can produce and analyze spatial information to make informed decisions.

1.3 How to Use the Manual

This manual is intended for anyone interested in learning about the details of planning and implementing an SDI initiative. The primary audience for the Manual is those people responsible for the planning and implementation of spatial data infrastructure initiatives. This audience comprises such individuals as SDI managers, geographic information system (GIS) professionals, data analysts, business analysts, enterprise architects, information and solution architects and other stakeholders who are directly involved with the SDI initiative. While such people are most likely employed by the SDI lead organization, they may also be working with other stakeholders that are key providers of spatial data and Web services through the infrastructure.

The Manual may also be of interest to users of spatial information. Among the potential benefits of an SDI are significant workflow improvements and positive changes to organizational structure and business plans, so managers of programs that use spatial information are also likely to benefit from this guidance. The material describing data stewardship and custodianship responsibilities, and how organizations can generally gain from SDI participation, will for instance resonate with those concerned with business outcomes. Some of the material may also be useful in procurement and can be readily included in tender documents. In addition, decision-makers involved in seeking political support for SDI initiatives will find some of the contents of particular value (e.g., SDI Economics, Institutional Arrangements, Governance and Strategic Framework).

As noted in Section 1.1.2, extensive use has been made of existing reference material, including other SDI manuals, in the preparation of the Manual. If readers are interested in additional details in any of these areas, they are encouraged to consult the References appendix. Readers are guided through the steps involved in planning, implementing and encouraging the adoption of an SDI, as well as measuring and monitoring its performance, generally in the order in which the topics need to be dealt with. The Manual includes an extensive glossary of terms and acronyms, with hyperlinks in the text to the relevant part of the Glossary of Terms appendix, providing readers with a quick and easy way to ensure they fully understand a potentially unfamiliar term.

First and foremost, this guidance document is intended to fulfill the needs of PC-IDEA members and should be adapted to their individual circumstances. As a consequence, existing good practices in the Americas have been highlighted to the extent possible, and it is expected that the Manual will be a living document, upgraded and improved over time with the addition of more material from PC-IDEA member countries as they proceed further with SDI planning and implementation. To help ensure the widest possible exposure and use, the *Spatial Data Infrastructure (SDI) Manual for the Americas* is being distributed freely under a Geogratis license.

1.4 Manual Overview

This manual is structured in 11 chapters, including this introductory chapter, plus several appendices.

Chapter 2 provides guidance on the identification of the users of the SDI and of the stakeholders who are the key supporters of the SDI initiative. It goes on to describe the processes for identifying user needs and highlights some experiences in this regard in different countries in the Americas.

The purpose of Chapter 3 is to describe different aspects of the economics of spatial data infrastructure initiatives. It includes different requirements for and approaches to SDI financing, and some of the more common methodologies that are being used to justify expenditures on SDI initiatives.

Chapter 4 covers the fundamentals of SDI development. The different kinds of institutional arrangements for the creation of SDIs are briefly described, along with governance and organizational models for their implementation. The basics of strategic frameworks related to SDI initiatives are discussed, including alignment of the project with political priorities and strategic and implementation planning.

The purpose of Chapter 5 is to familiarize the reader with basic framework data concepts, including the definition of framework data layers or themes, different approaches for the creation and maintenance of the data, and framework data models.

Chapter 6 highlights the importance of standards as one of the key pillars of SDI. It introduces the concepts of semantics, syntax, services, profiles and cultural and linguistic adaptability. The standards development and maintenance processes are described along with monitoring of standards implementation by SDI stakeholders.

The purpose of Chapter 7 is to describe the role that policies play in supporting SDI development and implementation. The importance of linking SDI initiatives to the policy priorities in the jurisdiction is highlighted and the policy identification and development processes explained. A number of contemporary policy topics relevant to SDI are discussed and examples of policies to address those topics are provided, with an emphasis on operational policies.

Chapter 8 provides an overview of the technological considerations associated with the development and implementation of an SDI. Included are a discussion of SDI architecture models, a description of data discovery, visualization and access services and options, and a brief review of other tools.

Chapter 9 introduces two final topics related to the development and implementation of successful SDIs ─ Outreach and Awareness and Capacity Building, and Case Studies ─ and provides some guidance on their application.

The primary purpose of Chapter 10 is to highlight for the reader the importance of measuring and monitoring the benefits of the SDI initiative. Following an introduction to the concept of measuring and monitoring SDIs, additional topics covered include measuring and monitoring methodologies, lessons learned from several existing measuring and monitoring programs, and the way forward for the Americas.

Chapter 11 draws several conclusions from the material presented throughout the Manual.

Finally, there are three appendices attached to this manual – References, the Glossary of Terms, and the Template for Documenting Good Practices.

2. SDI Users and their Needs

This chapter provides guidance on the identification of the users of the SDI and the stakeholders who are the key supporters of the SDI initiative. It goes on to describe the processes for identifying user needs and highlights some experiences in this regard in different countries in the Americas.

2.1 Identifying Users

The dramatic growth in the awareness and use of spatial information has resulted in a significant expansion in the user community. As the use of spatial information has become more commonplace, the demand for easier access to and integration of different types of data from a multitude of sources has increased. Spatial data infrastructure initiatives are responding to this demand. SDI users can be grouped into the following broad categories: suppliers, developers, marketers, enablers/facilitators, and end users (GeoConnections, 2007a).

- *Suppliers* – Provide spatial data and Web services to the SDI. They are at the core of the SDI, providing the building blocks necessary to develop spatial applications. For example, a federal government department may supply soil information to the SDI through an SDI-endorsed standard such as a Web Map Service (WMS).
- *Developers* – Create Web-based applications that allow users to interact with the SDI. For example, a company may develop an application that uses the WMS to visualize soil information.
- *Marketers* – Sell or otherwise promote spatial applications to end users. For example, marketers may sell or promote an application that allows users to analyze soil information.
- *Enablers/Facilitators* – Typically government agencies and programs that facilitate the use of spatial information by a larger group. For example, a federal government agency that manages spatial information may produce a Web-based application that enables users to access the most current information on soil types across Canada.
- *End users* – Use spatial data in decision-making or in business operations and rely on applications to produce usable outputs. For example, end users for an SDI-based soil application could include farmers, gardeners, researchers, scientists, municipal government officials, and staff responsible for preparing soil reports.

Suppliers are key stakeholders in the development and implementation of an SDI ─ they supply the “goods” that users of the “information highway” need for their spatial applications. Their primary use of the SDI is to access and employ the standards, policies and tools that provide guidance on how they can connect with and use the infrastructure to provide access to their data assets. As key stakeholders in the success of the SDI initiative, data providers are also often heavily involved in SDI governance and may be key contributors to the development of standards, policies and tools.

Spatial data users in the other categories (i.e., developers, marketers, enablers/facilitators and end users) cover a broad spectrum of public and private sector organizations and the public at large. Of particular importance in gaining senior official and political support for SDI initiation and long-term sustainability are those user communities that are most directly linked to government priorities. Such key user organizations typically have high profile programs in which the effective application of spatial information to decision support and operations can have important positive impacts for the country and its citizens.

Such users within organizations (we will call them "professional users") are typically looking for spatial information that complies with accepted standards, that they can quickly access (whether via direct download from the provider's server or via Web services) and that they can integrate with their data or other data accessed via the SDI. This may involve relatively sophisticated spatial applications that serve a specific organizational need. In addition to the conventional high volume spatial data user sectors like natural resources, defence, environment, infrastructure and land administration, spatial information is seeing increasing use in sectors such as health, education, retail services, and safety and security.

Users in the general public (we will call them "non-professional users") typically use the SDI to access spatial data for such purposes as locating a particular service or business, planning a trip or vacation, or facilitating a recreational activity. Professional users have a higher need for authoritative spatial information than non-professional users and consequently make greater use of the SDI (which is generally focused on making such data discoverable and accessible) than do non-professional users. The needs of non-professional users can often be met by commercial spatial information providers ─ the so-called Mass Market Geomatics providers such as Google, MapQuest and Microsoft, Apple.

2.2 Identifying User Needs

2.2.1 User-Needs Assessment Methodologies

User-needs assessment (UNA) involves discovering and assessing the needs of users in order to meet those needs. User needs influence several aspects of SDI initiatives; they drive the development of SDI technology, the content of decision support applications and systems, and often the setting of standards within thematic data areas. For example, as national framework data providers continue to maintain and expand their data sets, a key part of this process is consulting data users to determine what data enhancements are required, and the themes for new framework data layers. Understanding and meeting user needs is important in developing effective decision support applications and systems that will be widely used, as well as in creating coherent and accepted SDI technology and content.

> **Good Practice**
>
> *The* **GeoConnections** *report,* Understanding Users' Needs and User-centered Design, *provides comprehensive guidance on conducting a user-needs assessment (UNA) and using user-centered design (UCD) for systems and applications development (GeoConnections, 2007a). Appendices provide information on additional literature on these subjects and sample survey research questions.*

A UNA can help SDI organizations set priorities and make decisions about data, applications or systems, or the allocation of resources. Since determining who or what constitutes a "specified user" and "specified needs" is a key challenge, the following *strategic* questions must be answered (GeoConnections, 2007a):

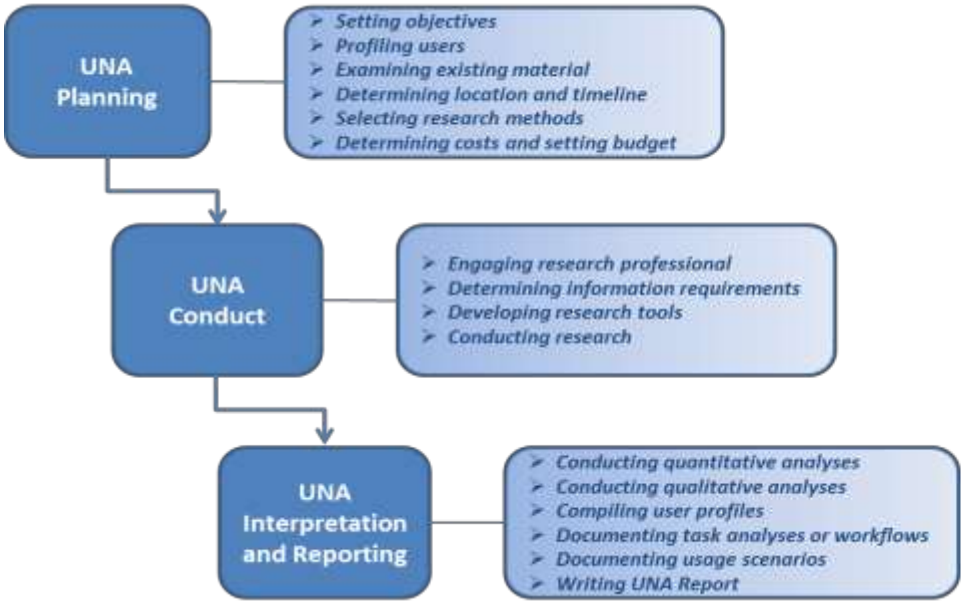
- Do the project team's assumptions and hypotheses about the target audience for the SDI hold true?
- Do members of the target audience see any value in the SDI?
- If so, are the drivers of value what the SDI sponsors had assumed?

In order to answer these strategic questions, the SDI project team can employ a UNA to answer the following:

- Who is your audience?
- Is it best to segment them by:
  - Profession/type of work (e.g., activists, researchers, farmers, doctors, etc.)?
  - Sector (natural resources, infrastructure, health, land administration, etc.)?
  - Geography (e.g., rural versus urban, by province)?
  - Attitude (e.g., "trusts technology, mistrusts government" or "trusts government, mistrusts technology")?
  - Level of comfort using technology?
  - A combination of the above?
- Which segment is dominant in terms of:
  - Numbers/segment size?
  - Similarities with SDI project objectives?
- Do they:
  - Prefer downloading malleable data?
  - Primarily prefer processed information in flat formats?
- Will they most likely access the SDI from:
  - An office with high-speed Internet connectivity?
  - A mobile wireless device with limited display capability?
  - A dial-up connection with low bandwidth and slow connections?

The user-needs assessment process is typically carried out in three phases: (i) planning the assessment; (ii) conducting the assessment; and (iii) interpreting and reporting the assessment results. This process is illustrated in Figure 2.1. It is often helpful to establish a steering committee to oversee the UNA and to provide external, objective feedback throughout the process.

Figure 2.1: Steps in the User-Needs Assessment Process



UNA Planning

The planning process involves the following steps:

- *Setting objectives* – Identifying the priority areas for assessment and establishing the project plan (purpose and goals of the UNA, including specific tasks that will be carried out).
- *Profiling users* – Identifying the main SDI users (see segmenting alternatives above) and developing a list of people to be contacted for the research.
- *Examining existing material* – Compiling existing user feedback, which could include comments on existing websites, studies, correspondence, policies and other documents, as well as practices, and providing it to the research professional, who may then do a more in-depth review.
- *Determining location and timeline* – Identifying where the UNA will take place (i.e., city, province, region or in multiple locations across the jurisdiction), and estimating the duration of the UNA.
- *Selecting research methods* – Deciding on the research methods, should take into consideration the type of questions to be asked and the type of information required. Interviews and focus groups/workshops are best used to understand attitudes and feelings (i.e., qualitative research, where data are obtained from a relatively small group of respondents and not analyzed with statistical techniques). Questionnaires and surveys are appropriate for answering specific questions (i.e., quantitative research, where a sample size is chosen that is large enough to allow the generalization of results across an entire population and the data are analyzed using statistical methods, including statistical tests of significance).
- *Determining costs and setting the budget* – The cost of a UNA will depend on such factors as the assessment complexity, sample size and distribution, available resources, and professional research contracting costs. User consultation typically costs no more than about 10% of the total project budget.

UNA Conduct

Once the planning of the UNA is complete, the research tools can be developed and the research conducted, often by research professionals to help ensure impartiality. However, it is important for SDI project proponents to stay involved and provide input into the UNA process, since the research professional will not necessarily have the subject matter expertise to deal with questions from interviewees. While conducting a user-needs assessment, it is useful to remember that requirements are gathered that may still be general in nature, so when the SDI is being developed, a user-centered design (UCD) process should be applied.

To provide a firm foundation for the subsequent UCD process, the research instruments (surveys, interview guides, etc.) must be carefully constructed. The kinds of information to be collected include:

- The business rationale (i.e., the business requirements that must be met);
- The data content (its format and sources) and/or services that must be provided;
- The requirements for key functionality or data properties;
- The technology requirements to support user needs (e.g., the portal or primary user interface of the SDI);
- The policies needed to resolve user issues;
- The standards required to facilitate interoperability of systems, applications and data sets;
- The specific intended user group(s);
- The user characteristics that may impact use (e.g., skills, knowledge, job characteristics, etc.); and
- The key activities or tasks performed by users (e.g., in the form of a workflow diagram demonstrating the order of tasks or activities in completing a process or a hierarchical task analysis demonstrating the relationship between higher order tasks and sub-tasks).

> **Good Practice**
>
> *A user-needs assessment conducted for the proposed* **Marine Geospatial Data Infrastructure (MGDI)** *initiative helped to determine marine and freshwater user requirements by means of several workshops held in various regions in Canada (Geospatial Projects Integration Office, 2001). Challenges to the success of MGDI that were identified included obtaining satisfactory solutions to many of the user needs, developing viable partnership models for prototype projects and developing a level of confidence in the user community to sustain MGDI during its formative years.*

UNA Interpretation and Reporting

The final step in the UNA process is the interpretation or analysis of the research results and development of a user-needs assessment report. A variety of statistical techniques can be used to interpret the quantitative research results and present them in tabular and graphical form, with the objective being to identify the priority needs that are common to the majority of users. The primary objective of the qualitative research interpretation is to identify a broader context for, and develop a deeper understanding of, the priority user needs.

The interpreted results of the UNA are synthesized into a UNA report that will provide input into the UCD process. To be most useful, this report must clearly articulate the key issues that designers will need to consider. Ideally the report contents will include, or lend themselves to be easily turned into, user profiles, task analyses or workflows, and usage scenarios. The UNA report serves as the primary reference to develop an SDI project and indicates the users' view to the developers. It should portray a clear picture of what the end users expect once the project is completed, and provide developers with a basis for estimating the resources required to build the overall solution.

2.2.2 User-Needs Assessment Experiences

Research and analysis of existing documentation on identifying user needs in various countries has provided some useful examples of good practices in this area. For example, the 3rd Strategy of the **Colombian** Spatial Data Infrastructure (ICDE) is to address the weakness identified regarding geographic information production and management (CONPES, 2009). This is aimed at ensuring that its acquisition or production should correspond to a National Strategic Plan (ICDE, 2012) derived from the main *common* users' needs, instead of the specific needs of each entity.

With the objective of identifying key business requirements of organizations that use spatial information in one of four thematic areas ─ public health, public safety and security, environment/sustainable development, and matters of importance to Aboriginal Peoples ─ the ***Canadian*** *Survey of Geographic Information Decision-Makers* (ENVIRONICS, 2006) was undertaken. The study revealed that many decision-makers in the four thematic areas were aware of the GeoConnections program prior to being involved in the survey, and there was a wide range of areas where they saw the Canadian Geospatial Data Infrastructure (CGDI) being applicable to their organization. However, there was an ongoing need to promote the CGDI to organizations in these areas, as well as the need for continuing education efforts among decision-makers. Key findings were documented on the following:

- Organizational use of spatial information
- Kinds and importance of spatial information
- Sources of spatial information
- Formats of spatial information
- Sharing of spatial information
- Barriers to access and use of spatial information
- Online spatial information and tools

The **Canadian** *Aboriginal Community Land and Resource Management: Geospatial Data Needs Assessment and Data Identification and Analysis* helped to establish a better understanding of the spatial data needs of Aboriginal groups across Canada and the issues surrounding how these data are being used. The *Data Identification and Analysis Report* (Volume 2) (Makivik Corporation, 2008) documents and summarizes the spatial data used in 10 Aboriginal land use planning projects. Data sources and their custodians, data availability and data sets that were missing at the time of the planning were investigated. In addition, data needs were organized by theme and by statistical summaries on the frequency of their use.

2.2.3 Changing User Needs

It is important to recognize that user-needs assessment is an ongoing process. At the outset of an SDI initiative, many users will have been accustomed to working in a "stovepipe environment," where they employ a closed system and database that has little reliance on outside sources of data or services. When data is required that is not already in their system, they may have been in the habit of procuring it themselves rather than searching for existing external sources. If they did identify suitable external data sets, they may have had disappointing experiences in trying to integrate that data into their database. Such a context may bias potential participants in a proposed SDI initiative against its use and result in only limited (or in extreme cases, misleading) expressions of user needs. Even if stakeholders have a positive view of the initiative, it is not uncommon for their limited knowledge of the SDI model and its potential to result in a constrained set of user needs being identified.

As the SDI evolves and begins to mature, users' attitudes and understanding of the potential of the model change. Based on early experience with open standards and specifications, increased interoperability and the value of Web services versus data downloading, users typically expand their use of the SDI and have an expanded set of requirements (e.g., new framework data layers, new core functionality, updated Web standards and specifications, etc.). That is why ongoing SDI measuring and monitoring (see Chapter 10) is critical to its long-term success and sustainability. If the SDI users recognize that their changing needs are being understood and addressed, the use of the infrastructure and the user base will continue to grow.

2.3 Chapter Highlights

In summary, the key user identification and needs fundamentals the reader should take away from this chapter are as follows:

- SDI users can be grouped into the following broad categories: suppliers, developers, marketers, enablers/facilitators and end users.
- The needs of professional users and non-professional users are quite different, and these differing needs must be taken into consideration in SDI planning and design.
- Structured user-needs assessment methodologies are the most effective means of fully understanding user requirements, and these are discussed in some detail.
- It must be recognized that user-needs assessment is an ongoing process, and that users' perspectives on the value of the SDI initiative will change with exposure to the infrastructure.

3. SDI Economics

The purpose of this chapter is to describe different aspects of the economics of spatial data infrastructure initiatives. It includes requirements for, and approaches to, SDI financing, and a review of methodologies to justify expenditures on SDI initiatives.

3.1 SDI Financing

3.1.1 Alternate Funding Models

In planning their SDI initiatives, organizations must decide upon the financing model that best fits their circumstances. The choice of funding will depend upon a number of factors, including:

- The product access that the SDI facilitates (i.e., spatial information as public goods or as quasi-public goods);
- The level of the SDI (i.e., national, regional or local);
- The government structure influencing the SDI implementation (e.g., within a single organization or as a collaborative effort involving multiple organizations); and
- The implementation environment (e.g., open data policies, budget austerity, etc.).

Table 3.1 identifies a range of possible SDI financing models that fit different circumstances (Giff & Coleman, 2005).

Table 3.1: Selected Funding Models for SDI Implementation and Maintenance

Funding Model	Description
Government Funding	Funding of an SDI from the budgets of the different levels of government and also, in some cases, from the different government ministries within each level of government. These funds are derived from general taxation, or in some cases, from financing provided by international financial or aid institutions (e.g., World Bank, Inter-American Development Bank, United Nations). For example, the GeoConnections program for the development of the CGDI is funded as a special initiative from general taxation, as are the FGDC activities to develop the US NSDI and the development of the Colombian ICDE (see Section 3.1.2). An example of SDI development with support of international institutions is the Cuban national and local SDI programs, which have received funding support from the United Nations Development Program (UNDP) (Delgado-Fernández & Crompvoets, 2008). The Bahamas National GIS initiative received a major injection of funds under the IADB Land Use Policy and Administration Project (Blake, Lance, Sutherland, & Opadeyi, 2008). In addition, Belize, Colombia, Ecuador, Jamaica and Peru have all received funding support from the GSDI Small Grants Program (GSDI, 2012d).

Funding Model	Description
Public Sector Funding	Funding from quasi-government organizations (i.e., Crown corporations or statutory bodies). Although these organizations answer to government, they are self-sufficient and do not rely exclusively on taxes for their funding.
Special Taxation	Positive or negative imposition of taxes on the general public or on selected groups for the sole purpose of funding SDI implementation. In this model, positive taxation can be used as an incentive for investment in an SDI while negative taxation can be used to raise revenue for investment.
Partnerships	The collaboration among the different sectors of society aimed at implementing an SDI, which usually involves the pooling of resources (financial and non-financial) to efficiently implement the SDI. Under the umbrella of partnership, several sub-categories exist, each with its own unique characteristics, described below.
Government Partnerships	The arrangement among the different levels of government in pooling resources for the efficient implementation of an SDI. An example is the pooling of resources to acquire framework data, such as the Government of Canada National Master Standing Offer (NMSO) for GeoEye-1 and IKONOS imagery (PACGEO and GeoEye, 2012).
Public Sector Partnerships	The collaboration among various public sector bodies in implementing an SDI. Again the collaboration can be financial, non-financial or a combination of both.
Public-Private Partnerships	The collaboration among the different levels of governments, quasi-government (public sector) organizations and the private sector in implementing an SDI. An example of this type of arrangement is the partnership between the Government of Jamaica and Spatial Innovision/Space Imaging/GeoEye for the acquisition of a variety of satellite imagery, DEM and large scale mapping data for their NSDI (Delgado-Fernández & Crompvoets, 2008).
Matching Ratios	Involves two or more parties working together to fund SDI implementation. In this model one partner (e.g., federal, provincial or local governments, NGOs, companies, or community groups) would match (according to the specified ratio) the amount of funds invested in the SDI by the other partner(s).
Financial Instruments	The umbrella for all funding models available in the capital markets. These financial instruments are customized for their application in SDI implementation. Examples are described as sub-categories below.
User Fees	The different types of fees charged to the user for spatial information, the access to which is facilitated by the SDI. For example, Cayman has been reported to have used funding derived from the sale of products and services (Blake, Lance, Sutherland, & Opadeyi, 2008). In addition, Chile and Colombia recover part of their SDI operational costs through charges for data access and use (see Section 7.4.6).
Private Sector Funding	The models that are built solely on direct private sector investments into the development of an SDI.
Limited-Recourse Structures	The models that promote the different types of build, own, operate or transfer systems. In this category the private sector - depending on the specific model - will undertake the construction, financing, operating and maintenance of the infrastructure for a limited concession period.

It is important to recognize that the economic circumstances of emerging economies typically require the creation of a pool of funds that are combinations of the funding models described above and draw upon external resources as well. While there has been limited research on funding of SDIs in emerging nations and nations in transition, Figure 3.1 illustrates the available options (Giff & Coleman, 2002).

Figure 3.1: SDI Funding Pool for Emerging Nations and Nations in Transition

Source: Giff and Coleman, 2002

Financing the creation of national or regional SDI initiatives in emerging economies can be complex. In many of these countries the lack of local financial resources means that spatial information implementation is not financially sustainable and therefore depends primarily on donor funds (Giff and Coleman, 2002). Usually donor support for these projects is time-limited and the future of many of these systems may be uncertain beyond the end of international assistance. Coordination of donor funding for an SDI initiative is complicated because (i) each donor has its own objectives for the systems, (ii) there is often competition among the donors, and (iii) there may be a lack of local capacity to coordinate donor activities (GSDI, 2012a). A coordinated SDI-based approach could change the priorities for spatial information implementation, and the potential conflict of donor objectives may be avoided if donors are invited as partners to take part in the participative process defining the components of an SDI.

3.1.2 Examples of SDI Financing Initiatives

Financing the NSDI: National Spatial Data Infrastructure (Urban Logic, Inc., 2000) is a comprehensive account of the potential opportunities for aligning or leveraging resources, or investments for spatial data activities in support of the NSDI in the **United States**. An appendix to the report discusses a range of analogies (e.g., Securitizable Loan Analogy: Fannie Mae Mortgage; Community Infrastructure Analogies: Surface and Mass Transportation, and U.S. Electricity Power Exchanges; Community Development Analogy: Commerce's EDA Revolving

Loan Funds) and their lessons for potential funding of the NSDI. The report contains some 13 recommendations drawn from the research regarding the settings for the NSDI, the characteristics for success from the analogies, a GeoData Forum and a hearing before the House Government Management, Information and Technology Subcommittee.

The article *Financing SDIs: Lessons Learned from the PAMAP Experience* (Bacastow, Cary, & Alter, 2007) identifies lessons learned regarding the design of a sustainable, long-running SDI funding strategy in the State of Pennsylvania, **United States**, through the Pennsylvania Map (PAMAP) statewide SDI program. Key lessons learned include the following:

- *Return on investment* – Capturing the full public and private return to society from an SDI initiative requires a long-run funding strategy that keeps the infrastructure intact.
- *Budgeting* – There is a critical relationship between the nature and timing of the work to be accomplished to collect data and establish the SDI, and the length of the public budget cycle. One solution is to budget for SDI development on a multi-year basis.
- *Benefits determination* – Both the public and private long-run benefits of an SDI must be considered to gain a full picture of its societal importance and all the potential financing options.
- *Communication of benefits* – It is important to conceptualize and detail a rich, comprehensive, long-run view of the public and private benefits of SDIs and to work continuously to ensure public and political support for investment in this infrastructure.

Covering the period from 1999 to 2015, the **Canadian** Geospatial Data Infrastructure received $150 million in federal funding, which was more than matched by other Canadian geomatics community stakeholders (McLeod & Mitchell, 2012). Included in this total federal funding, for its Phase III (2010-2015), a renewed commitment for the GeoConnections program was announced in the 2010 federal budget, providing $11 million in funding over two years. On March 16, 2011, the Government of Canada announced further funding of $30 million from 2010 to 2015 for GeoConnections to ensure a federal leadership role in the long-term sustainability of the CGDI that continues to provide benefits to Canadians (GeoConnections, 2012).

Following the methodology of the National Planning Department, a budgetary project valued at US$350,000 was confirmed in order to support the development and consolidation of the **Colombian** Spatial Data Infrastructure (ICDE). This budget is complementary to the funding allocations of each institution that are targeted to spatial information production.

3.1.3 Financing Requirements

Regardless of the funding model chosen, significant financial resources are necessary to cover the costs of planning and implementing the SDI. While specific guidance on the level of funding required is not possible because of the widely varying circumstances under which SDIs are developed, the general categories of expenditure requirements can be briefly described.

SDI Organization

Responsibility for SDI planning, development and implementation is normally assigned to a lead organization, which may be an existing spatial information agency (e.g., national mapping organization, cadastre organization, etc.) or a new group created within such an agency or within a more central government organization (e.g., Government Services, Chief Information Officer Branch) (see Chapter 4 for further discussion of the SDI organization structure). The typical costs associated with the assignment of this responsibility include:

- The hiring of new staff or upgrading of existing staff's skills;
- Facilities expansion or upgrading (e.g., office space, furniture, computers);
- Expenses associated with stakeholder engagement activities (e.g., travel, living, meeting); and
- Consulting fees for engagement of specialized experts to assist with SDI planning, to conduct research and studies, etc.

Framework Data

The framework or base mapping data that provides a foundation for the integration of all kinds of other thematic data within the SDI may already exist and be of suitable quality (see Chapter 5 for more information about framework data). However, additional resources are often required to bring data contributed by different data stewards into a common standard or to upgrade its quality (i.e., accuracy, currency, etc.), and to add or improve metadata. Associated with this work may be the development of common data models (e.g., linear referencing system for features such as roads and water courses). These tasks may be accomplished with in-house resources or require the help of external contractors.

Standards

Spatial standards are needed to provide developers with consistent and interoperable patterns for creating, reproducing, updating and maintaining their spatial data and services (see Chapter 6 for details on the role of standards). Technical and data standards permit diverse data sources, services, applications and systems to interoperate with each other. SDI organizations need resources to identify and set national requirements for interoperability, and to plan, coordinate and support the development, and possibly fund the implementation, of those standards. Such work is very specialized and often requires hiring new staff or engaging outside experts.

While most countries are using international spatial standards (e.g., International Organization for Standardization (ISO), Open Geospatial Consortium (OGC)), effort is still required to have them formally adopted and implemented within the SDI community of data providers and users. In addition, standardized sets of descriptive spatial properties need to be developed within specific user communities (e.g., land use planning, public health, etc.) to permit sharing of community-specific spatial data that may include guidance on expected structures, definitions, repeatability, and conditionality of elements. Such development and subsequent adoption and implementation efforts also require financial resources.

Policies

Policy development work may be required at both the strategic and operational levels to facilitate the widespread use of the SDI as an operational spatial information environment (see Chapter 7 for a discussion of supportive SDI policies). Documentation of good practices in SDI policy development is becoming more prevalent and accessible to SDI implementation organizations, so policy development work may be possible with internal resources. However, external experts may also be required to conduct background research, consult with stakeholders, and adapt good international practices to the local context.

Technologies

One of the most significant SDI funding requirements is typically related to technologies (see Chapter 8 for details of SDI technology requirements). Technology-related costs can include:

- Development and deployment of the SDI Geoportal, providing single-window access to the data and services available through the infrastructure;
- Procurement of open standards-based software to facilitate access to data via Web services;
- Development or enhancement of significant national applications that leverage the data and services available via the SDI; and
- Support of the development of specialized SDI tools in the private sector, which can be employed by the user community.

Supporting and Monitoring SDI Adoption and Implementation

Finally, resources will be required for outreach, communication and training related to the adoption of the SDI by users and its implementation within their operational environment (see Chapter 10 for a discussion of SDI measuring and monitoring approaches). Typical expenditures include the development of online training aids, webcasts, seminars and workshops to educate prospective SDI users about the benefits of the infrastructure and how to use it. Resources may also be required to work more intensively with selected user communities to develop applications that employ the SDI to help solve major challenges or inform decision-making in high priority government policy areas.

It is also good practice to establish a measurement and monitoring program to help demonstrate the benefits and performance of the SDI initiative. While demanding modest resources, such a program requires dedicated effort to create a performance-based management framework, and to regularly collect and analyze data on how well the SDI is meeting its intended goals, objectives and outcomes.

3.2 Expenditure Justification

3.2.1 The Need

Organizations of all types are increasingly being asked to not only do more with less, but also to prove that their expenditures will have a reasonable return. Increased scrutiny of government spending, both from inside and outside government, has meant that organizations receiving public funds for an initiative must clearly achieve and demonstrate efficiency, effectiveness, and impact with their resources. Organizations planning the implementation of an SDI face the often considerable challenge of accessing the financial resources to develop and sustain the infrastructure. It is normal for funding providers (e.g., government ministers, private sector partners, etc.) to require justification for approving what are typically large expenditures.

Expenditure justification analysis is driven by the question "Is what we will get worth the cost?" The answer to this question is needed not only to justify the original investment, but also as a foundation from which to identify problems, make corrections, demonstrate success, and improve understanding of how outcomes can best be achieved in the ongoing use and maintenance of the initiative. This information is of interest to evaluators for ensuring government accountability, to program managers for ensuring that programs are properly administered, and to departments for planning and resource allocation. Ultimately, the value of an expenditure justification exercise lies as much in the discipline involved in analyzing relationships among outcomes, activities and stakeholders, as in the results themselves.

In the end, the justification of any expenditure comes down to weighing the costs against the benefits. Presumably, if the benefits exceed the costs, the expenditure can be economically justified. However, as will be discussed in the following sections, the determination of the costs and benefits of implementing an SDI can be a complicated and nuanced process that depends critically on the situation. Indeed, impact measurement in the public sector is not easy. Mintzberg has argued the following: "Many activities are in the public sector precisely because of measurement problems; if everything was so crystal clear and every benefit so easily attributable, those activities would have been in the private sector long ago" (Mintzberg, 1996). It is strongly advised that organizations attempting to provide expenditure justification of an SDI for the first time seek experienced assistance.

3.2.2 Approaches and Variations

There are numerous variations of expenditure justification analysis. Terms such as performance measurement, cost-benefit analysis, and cost-effectiveness analysis are common. All are concerned with comparing the benefits and costs of an initiative, although they may differ in terms of breadth and depth of scope. As examples, the following approaches represent three levels of increasing scope.

- **Return on Investment Analysis** – This approach is typically applied to private sector investments. The costs and benefits considered are strictly financial and can be expressed as cash flows over time. The point of view is restricted to that of the investing entity. Techniques include the calculation of the Net Present Value[1] and Internal Rate of Return[2] of revenue streams.
- **Economic Impact Analysis** – This approach is typically applied to public sector investments. As with return on investment analysis, the costs and benefits considered are strictly financial, although sometimes ways are found to convert non-financial impacts (e.g., time savings) into financial terms (e.g. using estimates of the value of time to an individual). However the point of view of this approach is expanded to include the entire economy. Techniques include the use of input-output economic models.
- **Socio-Economic Impact Analysis** – This approach expands economic impact analysis to include non-quantifiable social impacts in addition to the financial impacts. For example, issues such as environmental protection and national sovereignty, which cannot be reasonably converted to financial terms, are considered using non-financial metrics. These aspects rely primarily on descriptive analysis and illustrations. Where benefits and costs are quantified in similar measures, they can be compared directly. Where benefits and costs are in dissimilar measures, it will ultimately be up to the stakeholders to determine if the trade-offs are worthwhile.

> Social benefits and costs cannot, and should not, be reduced to a single monetary number. This is a contentious issue, as many policy makers are most comfortable with simple economic impact statements. However, purely economic measures can be fraught with difficulties when used for public sector decision analysis. First, dissimilar benefits and costs must be converted to a common denominator. For example, if safety is a benefit, what is the value of human life? Second, some benefits and costs cannot be quantified. For example, what is the value of national pride? Third, the nature of benefits and costs is hidden in the numbers. This hides the pros and cons of an initiative from stakeholders and therefore a simple numeric result is a poor tool for gaining support among different groups.

Regardless of which approach is used, the financial portion of the results are usually expressed as a benefit-cost ratio where the net present value of the benefits value is divided by the net present value of the costs value.

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[1] $NPV = \sum_{i=1}^{T} \frac{NB_i}{(1+d)^i}$

$NB: net\ benefit\ in\ period\ i$

$d: discount\ factor$

$i: time\ period$

$T: last\ period$

[2] $IRR = d, such\ that\ NPV(d) = 0$

There is no single correct approach to expenditure justification analysis. Many different techniques and disciplines need to be brought to bear, and the selection depends on the situation. In determining the appropriate approach, a number of things need to be considered, such as the diversity of interests of stakeholders, the prevalence of non-financial benefits and costs, the geographic and economic scope of the initiative, and the time scales for implementation and returns.

3.2.3 The Process

The process of expenditure justification can be thought of in terms of the following steps:

- Definition of the study
- Understanding of the context (i.e., objectives of the SDI initiative)
- Development of the analysis framework
- Choice of measures
- Design and conduct of data collection
- Analysis of the data
- Communication of results

The following points comment on some of the considerations at each step in the process:

- **Study Definition** – A number of factors should be considered when defining the study. What is the purpose of the study? Perhaps justification, advocacy or evaluation. What will be the timing of the study? Different approaches are required for prospective, compared to retrospective, studies. What is the appropriate scale and scope of the study? Consider the relevant stakeholders, industrial sectors, technologies, geographic extent, time period, and costs and benefits to include. Who is the audience? Consider reflecting the points of view of citizens, governments, industry and society.

- **Context Understanding** – It is important to understand the broader context for expenditure justification analysis: societal, economic, political, regional, industrial, environmental and other special interests.

- **Analysis Framework** – The development of an analysis framework formalizes the proposed relationship between a set of inputs and outputs. The degree of formality that is feasible depends on the situation. Logic models are descriptions of the relationships among inputs, outputs and impacts. Economic models are more rigorous in defining the mathematical relationships between inputs and impacts.

- **Measures** – Different measures are of interest to different stakeholders for different purposes. The choice of the appropriate measures should consider the study objectives, and the resulting number, cost, complexity and validity of possible measures. Impact measures can be economic (dollars) or non-economic (including environment, sovereignty and security, health, advancement of knowledge, quality of life and social well-being).

- **Data collection** – Decisions need to be made about the data collection sources, frequency, and methods. There will be trade-offs to be made among cost, timeliness and usefulness. To the extent feasible, data should be collected using multiple lines of enquiry that support and complement each other, such as national economic statistics, document reviews, interviews, surveys, case studies and workshops.

- **Analysis** – Economic justification analysis involves the following steps:

  - *Definition of the Base Case* – Ultimately, it is the incremental impact of the SDI that is of interest. This is the difference between what will happen as a result of the initiative and what would have happened in the absence of the initiative. Analysis of this difference requires a base case that defines how the future will unfold without intervention. The base case is probably not simply the current state of affairs, because the characteristics of any situation are not static. However, a starting point for the base case is the current situation.

  - *Definition of Options and Marginal Improvements* – Given the base case developed above, the next step is to define the options that will be analyzed. Options are defined in terms of changes in the salient characteristics of the SDI. A starting point for these definitions is often two options (limited implementation and optimum implementation).

  - *Estimation of Costs and Time Frames* – Two additional pieces of information are required in order to compare the base case with the options. First is the marginal cost of each option. Cost obviously covers monetary expenditures of all the parties involved, but also includes less tangible expenses such as contributions in kind and possible detrimental effects on some stakeholders. Second is the time frame for the initiative. Money has a time value, and benefits today are worth more than benefits tomorrow. Also, uncertainty increases with time, and confidence in estimates of benefits to be derived far in the future will be lower.

  - *Segmentation of Benefits* – SDIs typically provide a wide range of benefits. These benefits can be segmented into infrastructure, wealth creation and public good. Infrastructure is an investment in the future that will create wealth and public good impacts over time. Infrastructure includes physical structures, institutional systems, knowledge and qualified human resources. Wealth creation benefits include the following concepts:

    - Growth – Increased sales of products and services, domestically and internationally;
    - Productivity – Increased capacity, skills and competitiveness of national firms;
    - Employment – Increased or sustained high-skilled jobs and reduction in the brain drain; and

- Industrial development – Creation or maintenance of knowledge-based economy firms, partnerships, networking and technology transfer among clusters of firms, universities, government, and international partners, and increased business, management and technical capabilities.

Public good benefits include the following concepts:

- Social – Improved regional development, health and safety;
- Political – Improved national identity, unity, pride and sovereignty, improved international relations, international reputation and recognition of national capabilities, and international cooperation and peace;
- Environmental – Contributions to understanding of the earth, surveillance of pollution, and natural resource management; and
- Knowledge – Advancement of scientific knowledge, new technologies and processes, education, and S&T careers.

- *Segmentation of Stakeholders* – Further segmentation will be required to customize the framework according to the stakeholders:
  - *Segmentation of Users* – Some of the benefits from an SDI will accrue to the users of the SDI. The characteristics of each user segment are estimated in terms of number, size, requirements, barriers to participation, etc.
  - *Segmentation of Industry* – Some of the benefits from an SDI will also accrue to the spatial data industry. The characteristics of each industry segment are estimated in terms of number, size, involvement with the SDI, market barriers, etc.

- *Estimation of Marginal Benefits by User Segment and Industry Segment* – Through consultations with the providers and users of a program, and an understanding of their characteristics gained from the literature review, the benefits that will accrue to each into the future are estimated.

- *Estimation of Marginal National Benefits* – In addition to the benefits that will accrue to users and industry, there may be national benefits that cannot easily be assigned to an individual or organization. Examples include most of the public good benefits outlined above.

- **Communications** – Reports should be tailored to the needs of the stakeholder in terms of the information content, delivery timing, and delivery format. Stakeholders include the public, government, strategic management and SDI management.

3.2.4 Considerations

When conducting an expenditure justification, the following considerations should be kept in mind.

Incrementality

The impacts and effects to be considered are those which are directly due to the SDI. These impacts and effects are called incremental, which is defined as the difference between what will happen as a result of the SDI and what would have happened without the SDI. If nothing will change as a result of implementing the SDI, incrementality will be zero.

Attribution

A concept related to incrementality is that of attribution. Even if the SDI makes incremental differences in impacts, some fraction of the impacts may logically be attributable to other programs, funding sources, organizations or stimulants. Impacts and effects may be attributable to more than one initiative or event. Such incremental activities may give rise to impacts and effects that are not wholly (or fairly) attributable to the SDI. In these cases, if the other programs or activities are to be credited with some of the impacts, these impacts must be attributed to the various contributing programs in some way. To the extent that these other sources can be identified, they should share in the allocation of impacts and effects associated with the SDI implementation.

Time

Time frame plays an important role in the assessment of impacts. The major benefits attributable to the SDI will accrue to society long after its completion and over many years into the future. This causes difficulties for identifying and measuring impacts and attributing them to the originating activity. These difficulties involve:

- The uncertainty as to whether the SDI will be maintained
- The uncertainty as to whether the SDI will perform as expected
- The lack of knowledge of the unintended or unexpected effects of the SDI
- The uncertainty of the level of benefits and costs of the SDI implementation

Uncertainty

Any forecast about the future is inherently uncertain. Therefore, an important aspect of any analysis is the specification of the degree of confidence in the results. Too seldom is the level of confidence or the range of results specified in analyses. Possible approaches to uncertainty analysis include the following:

- *Sensitivity Analysis* – Ranges of values are examined for individual variables to assess the impact on the results;

- *Scenario Analysis* – Ranges of values are examined for sets of variables that correspond to possible futures to assess the impact on the results; and
- *Monte Carlo Analysis* – Probability distributions are assigned to variables to assess the probabilistic impact on the results.

The process to assess uncertainty involves:

- Identification of the key factors that are uncertain
- Quantification of this uncertainty using expert input
- A combination of these assessments of uncertainty within the analysis framework

3.2.5 The Role of Government

The preceding sections examined the process to determine if SDI expenditures can be justified economically. However, SDIs are typically implemented by governments, and there may be a need to justify their involvement. There are both economic theory and national interest reasons for government involvement in an SDI that can be put forth.

An SDI is a form of "public good" and is often associated with "external benefits." Because public goods and externalities are, in turn, often associated with "market failure," there will be a role for government in these markets. "National interest" arguments, which are not purely concerned with economics, often provide an additional stimulus for government involvement. These characteristics highlight why governments throughout the world have not left the creation of SDIs purely to the market.

A Public Good

It is important to distinguish between the economic concept of "a public good" and the policy concept of "in the public interest." In economic theory, a public good has the following characteristics:

- The marginal cost of providing an additional unit is zero
- Use by one individual does not reduce availability to others (non-rivalry)
- Individuals cannot be excluded from using the good or service (non-excludability)

An SDI has the above characteristics.

External Benefits

"Externalities" arise where

- Production of a good by one "agent" imposes costs on and/or delivers benefits to other producers or consumers; or
- Consumption by one individual imposes costs on and/or delivers benefits to other consumers or users.

In markets where "externalities" are present, an important feature is that output levels resulting from free market provision will not be optimal. SDIs have important "external" benefits associated with:

- Ensuring consistency in the collection of data (production externalities)
- Promoting efficiency of decision-making (consumption externalities)
- Providing users with access to the same data (network externalities)

Production Externalities

Inconsistency between different data sets or between data relating to different geographical areas can raise the costs of using data and limit the range of applications. Coordination between emergency services can, for example, be important when major accidents occur, and costs can be saved on infrastructure projects when all key users share the same underlying data set. Collecting data on a consistent basis can therefore help to raise the value of the individual data sets. In part, the problem is a practical one associated with the process of agreeing and publishing standards, and defining standards for data specification, especially given the development of historic data sets on different bases. Common standards are necessary, but not sufficient, for consistent data sets. If common standards are not agreed upon, there is a danger of fragmentation.

Consumption Externalities

The external benefits associated with promoting more informed decision-making and greater accountability of public bodies have long been appreciated. The argument is that, by providing citizens with information, debate and decisions will be better informed to the general benefit of society. Examples include:

- Planning inquiries where those making representations might be in a better position to make their case with access to information; and
- Controlling pollution where access to information allows pressure groups to be more effective in influencing government policy and in monitoring activities.

External benefits such as these are, of course, difficult to value or more generally to measure.

Network Externalities

Network externality has been defined as a change in the benefit, or surplus, that an agent derives from a good when the number of other agents consuming the same kind of good changes (Liebowitz & Margolis, 1997). As Facebook increased in popularity, for example, it became increasingly valuable since more people had greater use for it. This allows, in principle, the value received by consumers to be separated into two distinct parts. One component is the value generated by the product even if there are no other users. The second component is the additional value derived from being able to interact with other users of the product, and it is this latter value that is the essence of network effects.

The difference between a network effect and a network externality lies in whether the impact of an additional user on other users is somehow internalized. Since the effect is almost always assumed to be positive, the social value from another network user will always be greater than the private value. If network effects are not internalized, the equilibrium network size may be smaller than is efficient.

Market Failure

In markets with external benefits, under-provision and excessive prices often result because private providers take no account of the wider social benefits when setting prices, since no financial benefit will accrue to them. A range of policies can be used to address the market failures that result, including:

- Regulation of the markets
- Government provision of the product or service
- Use of subsidies (or taxes)
- Specific licensing obligations (e.g., on emission levels)

Public goods are often associated with market failures in a competitive economy. Problems arise from difficulties in making goods non-excludable (e.g., stopping illegal copying of intellectual property). In addition, users have no incentive to reveal their true marginal valuation of the good; they realize it is worth suppliers reducing their price to cover short-run marginal costs or dissemination costs once major investment in the public good has been made. These market failures would typically lead to under-provision of a public good in a free market. They begin to provide the economic justification for some form of government involvement in the market, either in terms of economic regulation or ownership of information providers.

There is an important distinction between private and public goods. Private goods are efficiently distributed by markets. Public goods generally become a public responsibility (e.g., for financing and regulation), but this does not necessarily imply public provision.

In the Public Interest

In the context of general debate on service provision by government, arguments are often framed in terms of the national interest. These arguments are usually linked closely to the economic arguments on public goods and externalities. Sometimes additional arguments, less concerned with economics, are also made for collection and provision of information by government. They include: protection of life and limb; promotion of democracy; protection of the rights of individuals; support for minority groups in a population; equity; the need to maintain confidentiality of data collected; and, a basic need to meet government functions. These national interest arguments can be very important in determining the overall policy stance of SDI providers.

3.2.6 An Example

The approach used in the 2007 study on the socio-economic impact of the spatial data infrastructure (SDI) of Catalonia (Craglia & Campagna, 2010) will be used to illustrate a good practice in cost and benefit valuation. The Catalonia study was based on the methodology developed by the e-Government Economic Programme (eGEP) in Europe (Codagnone, Boccardelli, & Leone, 2006). The costs estimated for this study were in two categories:

- *Technology* – Implementation set-up costs (including design, hardware, and software development), management costs and maintenance costs.
- *Processes* – Changes in organizational models, training, coordination, consultation and normative development and control.

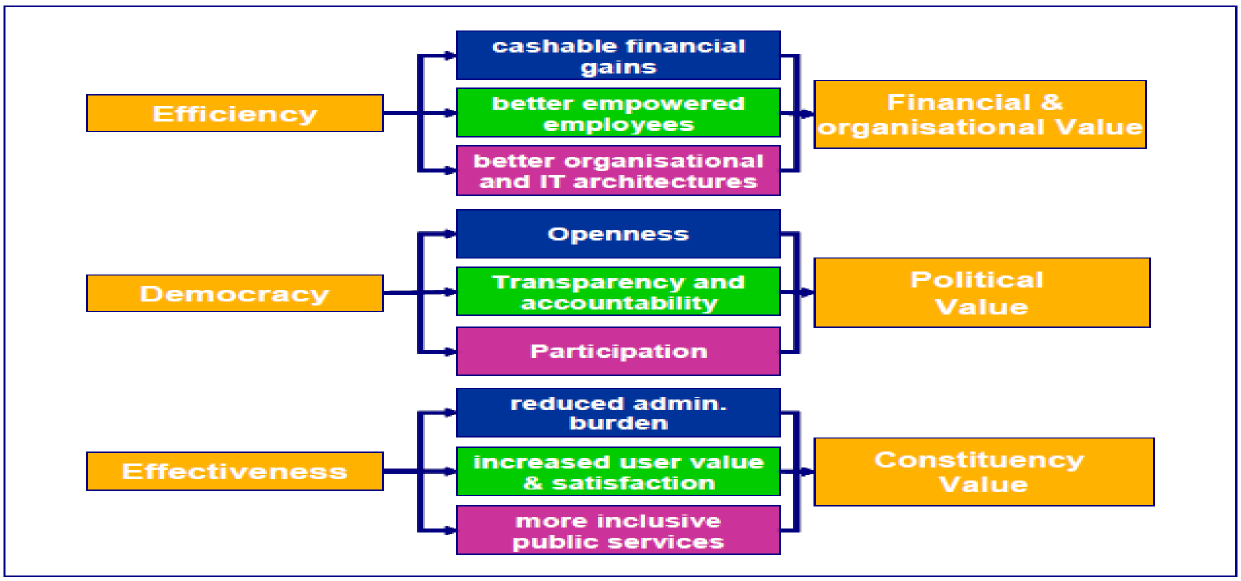


Figure 3.2: eGEP Measurement Framework Analytical Model

The eGEP Measurement Framework Model is built around the three value or benefit drivers of **efficiency**, **democracy** and **effectiveness**. It is designed to produce a multi-dimensional assessment of the public value potentially generated by e-Government initiatives, including both quantitative financial impacts, and more qualitative impacts, as illustrated in Figure 3.2. While the eGEP measurement framework identifies some 90 possible indicators to measure the impacts of e-Government based on a range of available data sources (e.g., official statistics, administrative records, user surveys and Web crawlers), the Catalonia study team narrowed the list down to 20 indicators that were relevant in the context of its SDI, shown in Table 3.2. The team also decided that it was necessary to collect the information needed through face-to-face interviews rather than surveys (because the concept of an SDI is still rather fuzzy in the mind of local government officials), or official statistics (which are poorly developed in the SDI field).

Table 3.2: Indicators Selected for the Catalonia Study

Efficiency

Impact	Indicator
Monetary gains	Savings in time (hours per month) Expected or predicted savings in consumables (qualitative)*
Better prepared personnel	More motivated employees with new training (qualitative)*
Improvements in the organization	Time saved in the redesigned processes (hours per month) New processes (e.g., cadastre maintenance, license teams) (list qualitative) Interoperable services (e.g., public service, permits) (list qualitative) Interdepartmental data sharing (list qualitative) Better planning of actions and decisions (list qualitative) GIS services accessible from municipal websites (list qualitative)

Effectiveness

Impact	Indicator
Benefits for users	Time saved by residents (hours per month) Time saved by companies (hours per month)
User satisfaction	Repeat users of services (qualitative)* Volume of data queries and downloads (number) User satisfaction (qualitative)
Extension of services	Use of new services by businesses (qualitative)* Use of new services by residents (qualitative)* Uses enabled exclusively by SDI (qualitative)

Democracy

Impact	Indicator
Openness and transparency	Interactive services and Web access (number) Available metadata records (number)
Participation	Complaints, queries, suggestions, errors, etc., transmitted electronically (number per month)*

NOTE: The indicators marked with an asterisk (*) were originally meant to be quantitative, but it became clear during the data collection that it was not possible to quantify them at the current state of development. Therefore they were assessed in qualitative terms.

3.3 Chapter Highlights

In summary, the key SDI economic considerations the reader should take away from this chapter are as follows:

- There is a wide range of possible funding models for SDI initiatives (e.g., government, public sector, private sector, special taxation, partnerships), and the choice will depend on several factors in the local environment.
- Financing will be required for all the key SDI components: organization, framework data, standards, policies, technologies, and for supporting and monitoring SDI adoption and implementation. These needs are discussed in the chapter.
- SDI financing must be well justified and three primary methodologies can be employed for such expenditure justification: return on investment analysis, economic impact analysis, and socio-economic impact analysis;
- The choice of expenditure justification method will depend on a number of factors, such as the diversity of interests of stakeholders, the prevalence of non-financial benefits and costs, the geographic and economic scope of the initiative and the time scales for implementation and returns.
- Several considerations must be kept in mind when conducting expenditure justifications, including the following:
    - *Incrementality* – Impacts and effects to be considered are those directly due to the SDI;
    - *Attribution* – Sharing of impacts and effects with affiliated programs, funding sources, organizations or stimulants;
    - *Time* – Difficulties in identifying and measuring impacts and attributing them to the originating activity due to uncertainties of SDI timeframe; and
    - *Uncertainty* – Importance of specifying the level of confidence in SDI benefits based on such techniques as sensitivity, scenario or Monte Carlo analyses.
- Finally, there may be a need to justify government involvement in an SDI initiative, and several economic theory and national interest reasons for that can be put forth, including public good, externalities, market failure and public interest arguments.

4. SDI Development Fundamentals

This chapter covers the fundamentals of SDI development. The different kinds of institutional arrangements for the creation of SDIs are briefly described, along with governance and organizational models for their implementation. The basics of strategic frameworks related to SDI initiatives are discussed, including alignment of the project with political priorities, and strategic and implementation planning.

4.1 Institutional Arrangements

Once the decision to proceed with an SDI initiative has been made, the institutional arrangements must be put in place to enable the infrastructure to develop and mature. Below are some key choices that will have to be made:

- What type of model will be used for SDI development (i.e., mandatory versus voluntary)?
- Who will lead the SDI development?
- Who are the key partners in the initiative and how will they be engaged?
- What are the sources of authoritative spatial data?

4.1.1 SDI Development Model

Mandatory Model

The *mandatory model* of SDI development is normally backed up by legislation, regulation or some other type of government decree or directive that requires spatial information providers to make their data sets discoverable and accessible via the infrastructure. This model exists in the European Union, where SDIs are being implemented in Member States as mandated by the INSPIRE Directive (Council of the European Union, 2007), and common Implementing Rules (IRs) are being adopted as Commission Regulations/Decisions in a number of specific areas (e.g., Metadata, Data Specifications, Network Services, Data and Service Sharing, and Monitoring and Reporting).

The mandatory SDI model is also prevalent throughout the Americas, as indicated by Table 4.1. This table summarizes the situation in several countries in the region by identifying and describing the SDI enforcement mechanisms that have been put in place.

Table 4.1: SDI Enforcement Mechanisms in the Americas

Country	SDI Name	Enforcement Mechanism	Description
Brazil	National Spatial Data Infrastructure (INDE)	Presidential Decree No. 6666 of November 27, 2008	INDE implementation is coordinated and supervised by the National Commission of Cartography (CONCAR) (Planalto, 2008). The decree also defines the role of the Brazilian Geography and Statistic Institute (IBGE) in the NSDI implementation, as the organization responsible for building and making available and operable the Brazilian Portal of Geospatial Data (named SIG Brazil portal), in accordance with the Action Plan for the NSDI implementation, as well as for enforcing the policies emanating from it (CONCAR, 2010).
Chile	National System of Coordination of Territorial Information (SNIT)	Supreme Decree No. 28 of March 10, 2006	SNIT is led by the Ministries Council of Territorial Information, presided by the Ministry of National Properties. An Executive Secretary accompanies the head of the SNIT, assisting the Minister and leading the Technical Committee of Inter-ministerial Coordination (Ministerio de Bienes Chile, 2006).
Mexico	Geographic and Environmental Information Subsystem of the National System of Statistical and Geographical Information	Article No. 26 of the Law of the National System of Statistical and Geographical Information	The Law regulates the National System of Statistical and Geographical Information, the roles of providers, as well as its organization and functioning by the National Institute of Geography and Statistics (INEGI) (INEGI, 2008). Planning, programming, production and diffusion of relevant information are conducted through the following instruments: ▪ The Strategic Program of the National System of Statistical and Geographical Information ▪ The National Program of Statistics and Geography ▪ The Annual Program of Statistics and Geography
United States	National Spatial Data Infrastructure (NSDI)	Executive Order 12906 of April 11, 1994	Established executive branch leadership with the Federal Geographic Data Committee (established in the Office of Management and Budget's *Circular No. A–16*) for development of the coordinated National Spatial Data Infrastructure, and called for development of a National Geospatial Data Clearinghouse, spatial data standards, a National Digital Geospatial Data Framework and partnerships for data acquisition.

Country	SDI Name	Enforcement Mechanism	Description
Uruguay	National Program of Cadastre and the Spatial Data Infrastructure	Presidential Resolution of June 16, 2006	Working Group "Pro-catastro" was created to generate the basis for the SDI.
		Law No. 18362, article 75, October 2008	Honorary Advisory Board of Geographic Information Systems (CAHSIG) was established in the Agency for Electronic Government and Information Society (AGESIC).
		Resolution 001/2009	AGESIC created the Working Group on Spatial Data Infrastructure (GTIDE) to articulate and deepen knowledge of georeferencing issues in Public Administration and to implement the Spatial Data Infrastructure of Uruguay, including the development of the GeoPortal (AGESIC, 2010).
Venezuela	Spatial Data Infrastructure of Venezuela (IDEVEN)	Decree on June 15, 2012	A new decree was passed on access and electronic exchange of data, and information and documents among organs and entities of the State, which establishes guidelines and principles for guaranteeing an interoperability standard (Gaceta Oficial Venezuela, 2012).

Voluntary Model

The alternative to SDI implementation under some type of enforcement mechanism is the *voluntary model*. This SDI model is less prevalent, but has been successfully used in some countries in the Americas. Perhaps most noteworthy is **Canada**, where use of the Canadian Geospatial Data Infrastructure (CGDI) is on a purely voluntary basis. In Canada's case, formal partnership arrangements were put in place to facilitate CGDI development. For example, the *Canadian Geomatics Accord* (Canadian Council on Geomatics, 2004) was signed in 2002 to signify the commitment of federal, provincial and territorial departments and Crown corporations to cooperate in geomatics initiatives of mutual interest, including the CGDI. The Accord was unanimously extended for a further five years in 2007.

The commitment to the voluntary partnership at the federal level in Canada has recently been renewed with the formation of the Federal Committee on Geomatics and Earth Observation (FCGEO), created to collectively enhance the responsiveness, efficiency and sustainability of the federal geomatics and earth observation infrastructure, and to provide proactive, whole-of-government leadership in establishing priorities for geomatics

Good Practice

The ***Canadian Geomatics Accord*** *is an example of a successful SDI partnership agreement between multiple levels of government and has been in force since 2002. Areas of cooperation under the Accord include:*

- *the establishment of a Canadian geospatial data infrastructure (CGDI)*
- *data and information production, integration, and sharing*
- *data distribution and licensing*
- *standards and specifications*
- *technical and policy research*
- *applications development*

and earth observations and their application in support of government priorities, decision-making, and Canada's competitive advantage (Natural Resources Canada, 2012). FCGEO succeeds the Inter-Agency Committee on Geomatics, which played a key role in the initiation of the Canadian SDI.

The *National GI Policy* of **Colombia** highlights an approach to coordinating SDI harmonization at all levels. SDIs at local, subnational and sectorial levels are coordinated by the Colombian Spatial Data Infrastructure (ICDE), and ICDE developments are coordinated with other regional and global SDI initiatives (CONPES, 2009).

4.1.2 Building Partnerships

Since no single organization can build an SDI, collaborative efforts are essential for the success of any SDI initiative, and particularly so with the SDI voluntary model. Cooperation and partnerships across different levels of the public sector and with the private sector are an important means at every stage of SDI development to collect, build, share, and maintain spatial data. In **Canada**, the GeoConnections program to build the CGDI had a strong initial focus: working across governments, and with the private sector, to advance the amount of information accessible through "clearinghouse" systems; developing data frameworks to ease data integration; fostering advanced technology and application development; and building supportive policies to speed industry growth. To this end, guiding partnership principles for the provincial and territorial government agencies involved in geomatics were agreed upon (see Good Practice text box).

Good Practice

CGDI Principles for Data Partnership:

1. *Data should be collected once, closest to the source and in the most efficient way possible.*
2. *Data should be as seamless as possible, with coordination across jurisdictions and boundaries when possible.*
3. *Data should be collected, processed and maintained according to international standards.*
4. *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 and distribute it to their stakeholders.*
5. *There should be an attempt to harmonize terms and conditions for use where practical.*
6. *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.*
7. *A group or agency within each province and within the federal government should be designated to promote and coordinate the development of a common geospatial data infrastructure, both within its jurisdiction and between jurisdictions.*
8. *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.*
9. *CGDI must consist of a set of coordinated and interrelated policies, practices and possibilities that build on the vision.*
10. *Agreements between agencies will normally be negotiated on a case-by-case bilateral or multilateral basis, according to these principles of partnership.*

4.1.3 Authoritative Data Sources

Successful SDI initiatives rely upon a solid foundation of authoritative framework data that is provided by qualified data providers (typically national mapping organizations, and in some cases supplemented by provincial or state mapping organizations). In some countries, the provision of authoritative spatial data has been formalized by the designation of data custodians and data stewards. For example, **New Zealand** has adopted this practice, with the appointment of a New Zealand Geospatial Steward (Sweeney, 2012). It identified the need to develop stewardship, custodianship and service principles and responsibilities for each fundamental (i.e., framework) spatial data set in its SDI strategy, the *New Zealand Geospatial Strategy* (Land Information New Zealand, 2007). It appears that this model has now been adopted, since the stewardship and custodianship model for the management of all data sets (whether fundamental or not) has been incorporated in their *SDI Cookbook v1.1* (New Zealand Geospatial Office, 2011).

Good Practice

The NZ SDI Cookbook *provides a very good outline of the responsibilities that can be assigned to* **data stewards** *and* **data custodians**. *Stewards can be organizations with statutory responsibilities for specific data sets or those that are assigned that role by a Chief Geospatial Steward.*

Responsibilities of data stewards can include:

- *data collection, maintenance and revision*
- *standards development*
- *quality control*
- *provision of access*
- *metadata*
- *security and privacy*

Responsibilities of data custodians can include:

- *collection of data under their custodianship to agreed specifications*
- *discrepancy tracking and resolution*
- *data quality assessment and reporting*
- *data accessibility assurance*

The *ISO 19115 Geographic information – Metadata* standard contains custodian designation requirements (National Oceanic and Atmospheric Administration, 2012). An identical requirement is incorporated into the implementation of the EU INSPIRE Directive. For example, the *Implementing Rule for Metadata* names a custodian as a responsible party role (European Commission, 2007).

4.2 Governance

Closely associated with the institutional arrangements necessary for SDI initiatives is the establishment of a governance structure. A typical SDI governance structure includes components similar to those identified in Table 4.2 (Natural Resources Canada, 2006) (United Nations, 2008) (FGDC, 2005a) (Canadian Council on Geomatics, 2008).

Table 4.2: SDI Governance Structure Components and Roles

Governance Component	Typical Roles
Board of Directors / Management Board	▪ Identification of strategic priorities for the SDI initiative ▪ Assessment of annual resource allocations and recommendations on additional funding, if required ▪ Direction on communications and outreach strategies ▪ Promotion of the implementation and active use of the SDI deliverables within key communities of practice ▪ Oversight of and review of reports on SDI implementation activities ▪ Direction on the SDI performance management framework ▪ Consideration of recommendations in independent evaluations of SDI performance
Policy Committee	▪ Identification of key strategic policy and operational policy needs ▪ Commission of research and studies to support policy development ▪ Oversight and review of reports on SDI policy development activities ▪ Promotion of the adoption and implementation of SDI policies by the stakeholder community
Standards Committee	▪ Evaluation of international spatial data standards for endorsement as standards for the SDI initiative ▪ Coordination of the maintenance of endorsed standards with the designated maintenance authorities ▪ Promotion, as appropriate, of the adoption of SDI standards as official national standards ▪ Consideration of requests from communities of practice for revision of existing standards or development of new standards ▪ Development of methods for supporting and working with standards groups in specific communities of practice ▪ Promotion of the adoption and implementation of endorsed standards by the stakeholder community
Framework Data Committee	▪ Identification and approval of framework data themes/layers ▪ Designation of the data custodians for all framework data themes/layers ▪ Development of a strategy for the creation of a standardized framework data set ▪ Review of progress on the development of the standardized framework data set, reporting on and recommending adjustments as necessary ▪ Promotion of the adoption and implementation of framework data in spatial information applications by the stakeholder community
Technology Committee	▪ Commissioning of research and studies to support SDI architecture definition ▪ Definition of overall SDI architecture and the technologies required for its implementation ▪ Review of progress on the development of the SDI architecture, reporting on and recommending adjustments as necessary
Special Interest Groups	▪ Collaboration in identifying and dealing with common issues in specific communities of practice (e.g., data integration issues, needs for common data models, standards) ▪ Recommendation of actions to SDI committees

For example, the governance model of the NSDI of **Brazil** is comprised of the Steering Council, the Management Council and a Technical Committee (CONCAR, 2010). CONCAR assures the functioning of both the Steering and Management Councils and the following technical sub-commissions:

- Sub-commission on National Defence Issues (SDN)
- Sub-commission on Spatial Data (SDE)
- Sub-commission on publicizing (communication) (SDI)
- Sub-commission on Legislation and Standards (SLN)
- Sub-commission on Planning and Monitoring (SPA)

Under the guidance and direct monitoring of CONCAR's technical sub-commissions, the Technical Committee, a specialized CONCAR committee, supervises, guides and monitors the operationalization of the Action Plan of the NSDI by means of working groups.

4.3 Organizational Structure

Leadership is required to ensure that the SDI initiative is successfully planned and implemented. It is common under both the mandatory and voluntary models of SDI implementation for an existing or newly formed organization to be given leadership responsibility. The responsibilities of such organizations can include:

- Managing the funds committed to the planning and development of the SDI;
- Developing and implementing the SDI performance management framework;
- Developing the SDI planning process (i.e., vision, mission, roadmap, and strategic plan);
- Leading and facilitating the development and deployment of the key SDI components — institutional arrangements, framework data, policies, standards and technologies;
- Promoting and facilitating the use of the SDI through communication, and outreach and training activities, and support of selected applications development; and
- Managing the SDI measuring and monitoring program.

Examples of lead SDI organizations in the Americas are indicated in Table 4.3.

Table 4.3: SDI Lead Organizations in the Americas

Country	SDI Lead Organization
Brazil	National Commission of Cartography (CONCAR)
Canada	GeoConnections Division, Mapping Information Branch, Natural Resources Canada
Chile	Ministry of National Properties
Colombia	Colombian Commission of Space (CCE)
Ecuador	National Geoinformatics Council (CONAGE)
Mexico	National Institute of Geography and Statistics (INEGI)
United States	Federal Geographic Data Committee (FGDC)

Country	SDI Lead Organization
Uruguay	Agency for Electronic Government and Information Society (AGESIC)
Venezuela	Geographic Institute of Venezuela Simon Bolivar

4.4 SDI Strategic Framework

The creation of an effective strategic framework is an important prerequisite to success in planning and implementing any spatial data infrastructure. Close alignment with the priorities of the government(s) that will provide the financial backing for the SDI initiative will help to ensure political support for the infrastructure's development and ongoing sustainability. Once those priorities are determined, the steps in creating the strategic framework include the development of a strategic plan or roadmap (i.e., vision, mission, goals, objectives and initiatives) and implementation plans (i.e., activities or tasks to achieve the objectives and a timetable for their completion) for the SDI initiative that aligns with those priorities.

4.4.1 Alignment with Government Priorities

Good Practice

*During the second phase of **Canada's** CGDI development, GeoConnections focused on support of four key Government of Canada priorities:*

- *Public Safety and Security*
- *Environment and Sustainable Development*
- *Public Health*
- *Matters of Importance to Aboriginal Peoples.*

This focus helped to secure five more years of funding support and resulted in the improved use of geospatial information for policy and decision-making in these important areas.

Government priorities change over time, depending on the aims of the political parties in power, and SDIs must exhibit the flexibility to adapt to those changes if they are to be sustainable. During the initial planning of SDI initiatives and the securing of political support for their funding, it is particularly crucial that those priorities be well understood. Such priorities can be ascertained from a number of sources, such as:

- Budget documents
- Departmental business plans
- Speeches by politicians and senior government officials
- Government press releases and media coverage
- Other print and online publications, websites, etc.

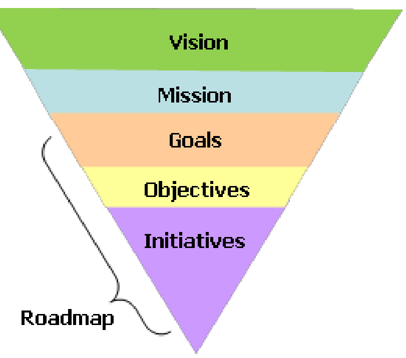
Good Practice

*The National GI Policy of **Colombia** highlights the coordination of GI generation with a National Strategic Plan, which is defined among users and producers within the ICDE framework (CONPES, 2009). The implementation of this policy can be illustrated with the response of ICDE to a national priority identified in the field of Emergency and Risk Management (ICDE, 2012).*

Once priorities are established, the key stakeholders must be identified and convinced of the role that the SDI can play in helping them to address those priorities. Examples of government priorities that can benefit from SDIs include open government, innovation, public safety and defense, emergency management, economic development, environment and sustainable resource development, public health, and infrastructure renewal. In the initial stages of SDI planning, it is critical to ensure that the stronger users of spatial information (typically natural resource, land management, engineering and public works and defense organizations) are engaged and supportive, and then to expand the engagement process to include less experienced spatial data user groups.

4.4.2 Strategic Plan or Roadmap

Figure 4.1: Key Strategic Plan or Roadmap Elements



As illustrated in Figure 4.1, the strategic planning process begins with the articulation of a *vision statement* for the SDI initiative. A good vision statement is a long-term view that describes the desired future for the SDI and is intended to inspire, motivate and align the activities of those people interested in seeing that future become a reality (GeoConnections, 2012b). The *mission statement* describes what the SDI initiative seeks to achieve in the long term and provides guidance to all stakeholders invested in working together to achieve the vision. The *strategic plan* or *roadmap* then goes on to define the path to the achievement of the vision as follows:

- *Goals* – High-level, qualitative statements that describe what needs to be accomplished in order to achieve the vision in broad terms;
- *Objectives* – Measurable steps that, taken together, lead to the achievement of goals; and
- *Initiatives* – Investments of time and money in projects that must be undertaken by specific stakeholders in order to achieve the objectives and ultimately realize the vision of the SDI.

4.4.3 Implementation Plans

> **Good Practice**
>
> **Ecuadorian CONAGE Mission** (CONAGE, 2007):
>
> *Formulating policies and standards for the usage of information generated by institutions who manage geospatial data, by integrating producers and users in an Ecuadorian Geospatial Data Infrastructure, as a support to economic, social and environmental activities contributing to the integral and sustainable development of the country.*

The implementation planning process is tactical in nature and is designed to provide all stakeholder organizations with detailed direction on how they can collectively support the realization of the SDI vision. Implementation plans establish *priorities* for action in individual organizations and describe in detail the *activities* that the organization plans to undertake to help achieve the SDI objectives. They also include *timetables* for the scheduling of the activities and *performance measures* against which the success of those activities in achieving the objectives will be assessed. Regular monitoring of the progress against plans provides evidence of performance and allows for realignment of resources and activities if necessary. For example, the *Strategic Plan 2007-2011 of the* ***Ecuadorian*** *Geospatial Data Infrastructure* (CONAGE, 2007) proposes the outcomes as performance measures, by year, as shown in Table 4.4.

Good Practice

Colombian ICDE Vision 2022 (ICDE, 2011):

Be consolidated as the National Spatial Data Infrastructure leader in Latin America and the Caribbean, being recognized for its advances and successful experiences worldwide in actions aimed to own and implement geographic information management processes, highlighting its articulation with the strategies and policies of Earth Observation and public information access, characterized by its contribution to decision making, mainly regarding social well-being by means of the incorporation and application of concepts, technical and technological tools, and functional methodologies, guaranteeing an environment of interaction and harmonic coordination among its members, as well as the optimal use of Information and Communication Technologies associated with Geographic Information.

Good Practice

Mexico's Strategic Program of the National System of Statistical and Geographical Information (INEGI, 2010):

Mission: To provide the information of national interest to the society expediently, by means of the coordination among the actors of the System and the generalized adoption of national and international standards.

Vision 2034: The National System of Statistics and Geography has a solid prestige at national and international levels and provides universal access to relevant, appropriate and quality information.

Table 4.4: Ecuador's SDI Performance Measurements

Year	Outcome
2007	▪ Fostering a structured organization with programs in the short, medium and long term
2008	▪ Strengthening CONAGE with a supportive operating team, characterized by a teamwork approach and an excellent communication level ▪ Elaborating a diagnostic of institutional spatial information management at the national level ▪ Designing a relational database of institutional spatial information at the national level
2009-2010	▪ Establishing normative documents and national technical standards of spatial data management ▪ Establishing an organization with a public image and recognition at national and international levels ▪ Implanting a Clearinghouse into the framework of the EGDI
2011	▪ Working on the positioning of CONAGE as a recognized organization at the national and international level, with a consolidated legal framework, and taking direct action on the control of standards and norms of spatial information management

The implementation strategy of the NSDI in **Brazil** is proposed in the *NSDI Action Plan* (CONCAR, 2010), based on staggered goals according to priorities and well-defined objectives to be achieved over three implementation cycles:

- *Cycle I – December 2010*: Implementation of a minimal infrastructure of hardware, software, telecommunications and facilities of the Brazilian Directory of Geospatial Data (DBDG) and the GIS Portal Brazil, with search tools, exploration and access of data and spatial metadata implemented and working.
- *Cycle II – 2011 to 2014*: Consolidation of the DBDG in the federal government and its extension to other levels of government. This cycle also marks the strengthening of the institutional and people components, besides the development of norms and standards. The focus will be on both the data and services, which will be expanded according to the user demands.
- *Cycle III – 2015 to 2020*: The major goal of this cycle is to transform the NSDI into the main search engine for exploration and access to Brazil's spatial data and information. This will support public policy formulation by the government sector, in addition to supporting the society itself in decision-making related to its normal routines, including encouraging voluntary participation. At the end of Cycle III, it is expected that the NSDI will also be internationally recognized for its ability to contribute to transnational projects.

The Action Plan has an analytical structure elaborated in the following main categories, each one associated with a set of "products" or "lines of action" (CONCAR, 2010): Management, Norms and Standards, Data and Metadata, Technology, Capacity Building, and Communication (Dissemination).

4.5 Chapter Highlights

In summary, the key SDI fundamentals the reader should take away from this chapter are as follows:

- Whether the adoption and use of the SDI is mandatory or voluntary will have a significant impact on the institutional and other arrangements that are put in place for its development and implementation, with partnership development being particularly important for the voluntary model.
- Identifying authoritative data sources and assigning data stewardship and custodial responsibilities is an important cornerstone for a successful SDI initiative.
- An effective SDI governance structure is essential for guiding the planning, design, implementation and ongoing monitoring of the infrastructure, and typical governance components have been identified and described.
- The SDI strategic framework, which underpins the SDI development and implementation activities, is based upon a close alignment with overall political priorities in the jurisdiction and includes a formal strategic plan and implementation plans for all SDI components.

5. Framework Data

The purpose of this chapter is to familiarize the reader with basic framework data concepts, including the definition of framework data layers or themes, different approaches for the creation and maintenance of the data, and framework data models.

5.1 Introduction to Framework Data

Framework data (sometimes referred to as "base mapping," "fundamental," "core" or "reference" data) is the set of continuous and fully integrated spatial data that provide context and reference information in the SDI (GeoConnections, 2009a). There is a loose division between framework data and thematic data (i.e., data that has more narrow and specific applications), with framework data often being used as the foundation for the display of thematic data. Jurisdictions often have different interpretations of what constitutes the framework layers, and sometimes thematic layers become framework layers as user demand demonstrates that they are commonly required. Specifying any type of data as framework data is normally subject to its availability over large areas of the jurisdiction in which the SDI is being developed, and a consensus among major stakeholders on the importance of the data.

Why are framework data so important? Framework data function as important "anchors" for the development of integrated data sets for data collection, reporting and analytical processes. Framework data make an important contribution to the "interoperability" of systems on the Internet (see Section 1.2.2 for a discussion of interoperability). One reason that interoperability is important is that it significantly reduces the time required for data conversion, leaving more time for the important activities of analyzing and presenting information. Interoperability also allows organizations in different departments or jurisdictions to more easily share and exchange information or work on joint projects. Use of common framework data facilitates the breaking down of "information silos" that often inhibit the development of cross-organizational spatial information projects required to address increasingly complex horizontal policy issues.

The essential rationale for standardizing framework data layers is to improve their usability, and to make interoperability easier. Adoption of common standards for framework data improves the ability not only to integrate data for analysis, but also to reduce the potential for duplication in the creation and maintenance of the data within different organizations. The key framework data aspects can be expressed as GSDI, (2009):

- Specific layers of digital spatial data with content specifications
- Procedures, technology, and guidelines that provide for integration, sharing, and use of these data
- Institutional relationships and business practices that encourage the maintenance and use of the data

5.2 Defining Framework Data Layers

5.2.1 Framework Data Content Decisions

Framework data typically takes one of the following three principal forms (GeoConnections, Hickling Arthurs Low Corporation, 2009a):

- *Alignment layers* – Visible features such as road intersections on maps and imagery and control points required to adequately position spatial information, with the layers being critical to the reliability and use of all other layers;
- *Land feature/form layers* – Representations of well-defined and readily observable natural or man-made physical features that are not subject to interpretation, including many of the same features that are visible on topographic maps and Internet mapping applications like Google Maps, such as roads, rivers and major structures (may also be used to provide reference information for the conceptual layers); or
- *Conceptual layers* – Frameworks that society develops and uses to describe and administer the country, which are often interpreted from observations of physical, economic or social factors, and include features such as municipal boundaries, federal electoral districts and ecological areas.

A number of approaches can be taken to decide upon the layers or themes that will be included in the SDI's framework data. In many countries, the SDI initiative is led by the National Mapping Organization (NMO) that has historically had responsibility for the topographic mapping program. In those cases, the NMO may decide on the composition of framework data based on the respective country's experience in providing base mapping data, and the layers are composed of the digital base mapping data set or an associated subset. Or the NMO may seek consensus with the broader SDI stakeholder community on the layers to be included.

In other jurisdictions, the development of framework data may be a collaborative effort between the NMO and other major data providers (e.g., state/provincial and municipal mapping organizations), in which case consensus is reached between the partners on the data layers to be included. Data from other reliable data sources (e.g., utilities and private sector data suppliers) are also sometimes integrated into the framework data. This approach follows the principle of data being collected once, closest to source, and shared with many.

An important part of defining the framework data layers is deciding on the specifications to which these data will be created and maintained. This is an important decision, since it has a significant impact on the suitability of the framework data as a foundation for thematic data within the SDI, and on interoperability. The publication of these specifications helps to ensure the level of accuracy, quality, attribution, and documentation of the framework data and allows users to be comfortable that the data is authoritative.

5.2.2 Examples of Framework Data Layers in the Americas

Several countries in the Americas have published or reported their plans for development of framework data within their SDI initiatives. For example, the **Colombian** ICDE's reference layers include geodetic control, digital orthoimages, elevation, transport, hydrography, limits, cadastre and geographic names (ICDE, 2012).

The **Ecuadorian** *Official Register No. 378 of February 4, 2011* states a classification system to establish the order and hierarchy of geographic information, within the framework of the National Information System, by grouping data into three categories (Registro Oficial-Ecuador, 2011):

- Fundamental (core) data: geodetic system, limits, altimetry, bathymetry, remote sensing data, vial infrastructure, hydrographic networks, geographic names
- Basic data: geo-statistics, natural resources, cadastre and natural hazards
- Thematic or value-added data: highly specialized data

Article No. 26 of the Law of the National System of Statistical and Geographical Information (INEGI, 2008) established the Subsystem Geographical and Environmental Information, also called Spatial Data Infrastructure of **Mexico**. It will generate, as a minimum, the following group of data: geodetic reference frame; limits (coastal, international, state and municipal), altimetry (continental, insular and submarine); cadastral, topographic, natural resources and climate; and geographic names.

5.3 Creation and Maintenance Approaches

The process by which framework data is created and maintained depends on whether a centralized or decentralized model is established. In the former instance, one option is for the NMO to handle the entire process itself (i.e., use its own data assets to create the framework data). A second option is to integrate data that are provided by its framework data partners with its own data. In both cases, the NMO is the data steward and the data custodian, and provides access to the data through a centralized clearinghouse. This model has the advantages of strong central control over specifications and data quality, and elimination of the need for developing and administering a distributed data custodianship program. However, if this option is chosen, additional effort is required on the part of the NMO and its partners to transfer data. Since the partners' data is being integrated with the steward's data, different versions of data layers will exist, creating some duplication of effort and potential confusion for users.

In the decentralized model, it is normal for the framework data steward to be a single organization, but data custodianship responsibilities can be distributed to the organizations responsible for different data layers. Each custodian can separately create and maintain the data layers for which it is responsible, using the common data specifications and quality control procedures that have been agreed upon. Users can access the different layers of framework data directly from the respective custodians, via a decentralized clearinghouse. The advantages of this model include the greater effectiveness and efficiencies inherent in having organizations that are mandated to collect certain data as custodians of that data, and the reduction in data duplication or overlap. However, the steward is faced with the additional risk and complexity of managing the framework data under the partner organizations' control, and the need to ensure compatibility between the different framework data layers residing on external servers.

Good Practice

***GeoBase** is a joint initiative of Canadian federal, provincial and territorial government mapping agencies working together to increase efficiency in collecting and maintaining framework data and to reduce the duplication of effort among agencies.*

*The **GeoBase Principles, Policies, and Procedures** document (GeoBase Steering Committee, 2008) is a collection of GeoBase principles, policies and procedures, which are updated regularly, plus the decisions made by the Canadian Council on Geomatics (CCOG) related to the development and direction of GeoBase. The document describes the data themes that are currently available for GeoBase, together with proposed new themes and the process for adding new themes.*

Organizations responsible for framework data maintenance are exploring the potential of user-generated content as one means of keeping their information current. National and provincial or state mapping agencies in several public jurisdictions and some professional private data providers are using, or investigating the use of, volunteered geographic information or VGI (see Section 7.4.7 for further discussion of VGI) to help maintain their authoritative geospatial databases (GeoConnections, 2012b). For example, in Canada, the Centre for Topographic Information of Natural Resources Canada is assessing the potential of a collaborative mapping model (i.e., contributions from provincial and municipal mapping organizations, crowdsourcing from citizens, etc.) for data maintenance. Esri Canada's Community Maps Program sources geospatial information from a range of federal, provincial and local government mapping organizations (Esri Canada, 2011). International examples include the Notification for Editing Service developed by the Department of Sustainability and Environment, State of Victoria in Australia; the OpenStreetMap Collaborative Prototype (OSMCP) project at the U.S. Geological Survey (USGS); and swisstopo Revision Service at the Switzerland Federal Office of Topography. Success in the use of VGI will depend on the resolution of several important challenges, including quality control, security and legal implications.

5.4 Framework Data Models

As described in more detail in Section 6.1, data modeling defines data elements and their structures and the relationships between them. Conceptual data modeling involves the development of data product specifications, for which an international standard exists—*ISO 19131:2007 Geographic information – Data product specifications* (ISO, 2007). Such standards are particularly critical for framework data since it provides a foundation for the SDI, and the adoption of common data models helps to facilitate data interoperability. *ISO 19109:2005 Geographic information – Rules for application schema* (ISO, 2005) provides rules to ensure the conceptual data models are harmonized and contribute to interoperability. Thematic data product specifications are also important because they help to guide thematic data users to the proper data sets for their applications.

Framework data models and specifications have been developed in a number of jurisdictions in the Americas. For example, in **Colombia**, the ICDE's information production is being led by a Quality Management System generalized from the Instituto Geografico Augustin Codazzi (IGAC) experience, which is designed to obtain the Quality Certification of cartographic production. As part of this Quality Management System, the IGAC has designed, and shared with the rest of the ICDE's data producers, a Model of Geographic Information Management in order to integrate processes and components of the SDI. Technical guidelines for Geographic Information Management have been defined within the context of ICDE (CONPES, 2009).

Development of **Canada's** GeoBase framework data product has also included data modeling. The *Canadian National Hydro Network, Data Model – Edition 1.0 (NHNC1)* comprises specifications of a hydrographic data model oriented to a Linear Reference System (LRS) approach and expressed in Unified Modeling Language (UML) (GeoBase, 2004). The Data Model is described by means of five packages: Hydro Network, Hydrographic, Hydro Events, Hydrography and Metadata. The *Canadian National Road Network (NRN)* conceptual model (GeoBase, 2012) was elaborated in collaboration with interested data providers and adopted by the Canadian Council on Geomatics (CCOG). The standard *ISO 14825:2011 — Intelligent transport systems — Geographic Data Files (GDF) — overall data specification* served as a guide for the elaboration of the NRN conceptual model. The NRN vocabulary used (class names and attribute names) largely conforms to the *ISO 14825:2011*. The conceptual model is represented using UML notation.

An example of thematic data modeling is provided by the **Canadian** *Critical Infrastructure Information Identification Project Final Report* (GeoConnections, 2008a), which lists and assesses recommendations to achieve the National Infrastructure Data Model. The storage of critical infrastructure data in varying formats and in various locations makes it difficult to work with a single, consistent, easily referenced view of this infrastructure. This Project responded to the problem with the first iteration of a National Infrastructure Data Model (NIDM) to support emergency management planning. Initial development of the NIDM was achieved through six regional workshops where project stakeholders shared views on what data elements should be part of the NIDM model. They also sought to compile authoritative sources of infrastructure data and to determine how best to facilitate sharing among organizations. The NIDM is organized into 12 sections: 1 for each of 10 critical infrastructure sectors, 1 for common elements, and 1 for unclassifiable infrastructure types. Implementation of this model will establish management and technical guidelines for all stakeholders.

5.5 Chapter Highlights

In summary, the key framework data fundamentals the reader should take away from this chapter are as follows:

- As one of the SDI pillars, framework data has an important role to play in helping to ensure interoperability within the infrastructure. Key considerations include the following: the data layers that are selected; procedures, technology and guidelines that provide for data integration, sharing, and use; and institutional relationships and business practices that encourage data maintenance.
- The selection of framework data layers depends upon jurisdictional circumstances, but typically this is handled by the principal national mapping organization alone or in partnership with other key data producers, based on user needs assessments.
- Publication of framework data specifications helps to ensure the level of accuracy, quality, attribution and documentation of the framework data and allows users to be comfortable that the data is authoritative.
- Ongoing maintenance of framework data layers is an important consideration. The way this is managed depends upon circumstances in each jurisdiction and how custodianship responsibilities are assigned, with both centralized and decentralized models having advantages and disadvantages.
- Framework data stewards are exploring the potential of capitalizing on the volunteered geographic information movement to help keep their data current, but several important concerns must be addressed. Data models are an important means of facilitating interoperability.

6. Standards

This chapter highlights the importance of standards as one of the key pillars of SDI. It introduces the concepts of semantics, syntax, services, profiles, and cultural and linguistic adaptability. The standards development and maintenance processes are described along with monitoring of standards implementation by SDI stakeholders. A table summarizing the international spatial information standards mentioned in this manual is provided in Appendix C.

6.1 The Importance of Standards

Standards provide digital coding to locate and describe features on, above or below the earth's surface and facilitate the development, sharing and use of spatial data. Standards are technical documents that detail interfaces or encodings, which software developers use to build open interfaces and encodings into their products and services. Ideally, when the standards are implemented in products or online services by two different software engineers working independently, the resulting components "plug and play," that is, they work together without further debugging (GeoConnections, 2012c). The International Standard *ISO 19105:2000 Geographic Information – Conformance and Testing* provides a methodology for testing and criteria to be achieved to claim conformance of products and services to the family of ISO geographic information standards (ISO, 2000).

As noted in Chapter 1, an important purpose of an SDI is to permit interoperability between systems and system components, and the specification and adoption of a compatible suite of standards is a critical means of enabling interoperability. Standards are necessary for facilitating robust, open transfer of spatial data packages between platforms, especially in a varied network of computers that are managing a diverse range of spatial data stores and data types. Since standards are typically developed through a consultative process, they become adopted within the wider community. In response, the industry develops software programs to implement the standards in their offerings, providing options for users that want to be compatible with the SDI.

Standards related to SDI development and operation can be groups in three categories (GPC Group, 2012):

- *Data Content Standards* – For understanding the contents of different data themes by providing a data model of spatial features, attributes, relationships, and a data dictionary.
- *Data Management Standards* – For handling spatial data involving actions such as discovery of data through metadata, spatial referencing of data, collection of data from the field, submission of data by contractors to stakeholders, and tiling of image-based maps.
- *Data Portrayal Standards* – For visual portrayal of spatial data using cartographic feature symbology.

Spatial information standards that will be of most value to the SDI are those based on standards developed and maintained for the wider information technology industry by the International Organization for Standardization (ISO). By using these more widely applicable standards, the SDI will facilitate interoperability of spatial information systems with other IT systems.

6.1.1 Semantics

Conceptual Modeling

Data modeling is a process used to define and analyze data requirements needed to support the business processes within organizations. Data modeling defines not just data elements, but their structures and the relationships between them. Three different types of data models are produced while progressing from requirements to the actual database to be used for an information system (Simsion & Witt, 2005):

- *Conceptual data model* – Records data requirements initially as a set of technology-independent specifications about the data, used to discuss initial requirements with the business stakeholders;
- *Logical data model* – Documents structures of the data that can be implemented in databases (implementation of one conceptual data model may require multiple logical data models); and
- *Physical data model* – Organizes the data into tables, and accounts for access, performance and storage details.

A number of components or elements combine to facilitate data interoperability in the SDI. The structure of spatial data sets is specified by **application schema** standards**,** which provide a computer-readable data description defining the data structure, and achieve a correct understanding of the data by documenting the data content of the particular application field. Such schemas are expressed in a **conceptual schema language** standard based on a formal language such as Unified Modeling Language (UML) (ISO, 2009). A **feature concept dictionary or register** is used to manage names, definitions and descriptions of all spatial object types in application schemas. A **feature catalogue** standard defines the spatial object types specified in an application schema as well as the properties of these spatial object types. Application schemas, feature concept dictionaries and feature catalogues are published through a registry service for the following purposes (INSPIRE Drafting Team "Data Specifications", 2009):

- Styling of the application schema information into a human readable presentation
- Access by software and humans to the individual elements in the application schema

One of the challenges in interoperability and data integration is understanding what the data means. Definition of features can vary between organizations (e.g., one organization may define the boundaries of a highway by the edge of the pavement while another may use the surveyed boundary). By each organization providing a machine-readable description of its data (known as an **ontology**), these semantic differences are made explicit, and ontologies can be used to provide bridges between these different views of features. As the **semantic Web**[3] community develops techniques for ontology merging, and ontology to database mapping, it will become easier to semi-automatically integrate data from different providers. The most important requirement for a better and automatic interchange of data is to be able to define and describe the relations among data (i.e., resources) on the Web. The Resource Description Framework (RDF) is a standard model for data interchange on the Web that allows structured and semi-structured data to be mixed, exposed and shared across different applications (W3C, 2004a). *ISO/TS 19150-1:2012 Geographic information -- Ontology -- Part 1: Framework* defines a high level model of the components required to handle semantics in the ISO geographic information standards with the use of ontologies (ISO, 2012d).

Finally, **data product specification** standards can be used to describe the content and structure of data product specifications and provide help in their creation, so that they are easily understood and fit for their intended purpose. Data product specifications may be created and used by different parties and for different reasons (e.g., may be used for the process of collecting data as well as for products derived from existing data). They may be created by producers to specify their product or by users to state their requirements. While it is not necessary to specify production processes, specifications may include production and maintenance aspects if judged necessary to describe the data products (ISO, 2009). Specifications for framework data are particularly critical in the SDI context, and several national SDI initiatives have created such standards (e.g., *INSPIRE Data Specifications,*[4] *CGDI – GeoBase Data Product Specifications,*[5] and *FGDC Content Standards*[6]). Thematic data product specifications are also important for guiding a wide range of thematic data users to the proper data sets for their applications (e.g., Canada's National Infrastructure Data Model to support emergency management planning).

The international committee on geographic information standardization, ISO/TC 211, has developed the following international standards dealing with conceptual modeling (ISO, 2009):

- *ISO/TS 19103:2005 Geographic information – Conceptual schema language*
- *ISO 19109:2005 Geographic information – Rules for application schema*
- *ISO 19110:2005 Geographic information – Methodology for feature cataloguing*
- *ISO 19131:2007 Geographic information – Data product specifications*

Geometry

A number of other elements related to the geometry of the data also help to facilitate interoperability. **Spatial schema** standards define in detail the geometric and topological

[3] The Semantic Web is a collaborative effort led by W3C to provide a common framework for data to be shared and reused across application, enterprise, and community boundaries, and to be processed automatically by tools as well as manually, including revealing possible new relationships among pieces of data.
[4] See http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2.
[5] See http://www.geobase.ca/geobase/en/index.html.
[6] See http://www.fgdc.gov/standards/projects/FGDC-standards-projects/fgdc-endorsed-standards.

characteristics that are needed to describe geographic features spatially. Spatial characteristics of a feature encompass its geometry, its location with respect to a coordinate reference system, and its topological relationships with other features (Brodeur & Badard, 2008). Standards for conceptual schema can be developed for the description of **spatial referencing by coordinates** and the information required to change coordinates from one **coordinate reference system** to another. The schema can be extended to add time as a temporal coordinate reference system within a compound coordinate reference system (i.e., spatio-temporal referencing). A final standard closely associated with spatial schema is a register of **geodetic codes and parameters**, which contain coordinate reference system data (e.g., system scope, valid area and datum type) and coordinate transformation data (ISO, 2009).

Schema for coverage geometry standards define the relationship between the domain of a coverage (e.g., rasters, triangulated irregular networks, point coverages and polygon coverages) and an associated attribute range (ISO, 2009). A coverage domain consists of a collection of direct coordinate positions that may be defined in terms of up to three spatial dimensions (horizontal position and height) as well as a temporal dimension.

Temporal schema are useful for tracking the life cycle of spatial objects when they are updated individually, in which case version information is typically attached to the individual spatial object. This can be handled, for example, as attributes of the spatial object (e.g., using "start" and "end" date/time stamps and/or with a version count) or as temporal extent metadata attached to the spatial object. Such schema can also be used for spatiotemporal descriptions (e.g., the position of an airplane in movement) and to describe the temporal existence of an object (e.g., the Precambrian geologic period) instead of when it was captured or updated. It is important to note that different temporal information may be required by different applications using the data, such as the following (INSPIRE Drafting Team "Data Specifications," 2009):

- Transaction time (time when the object version was inserted in the database)
- Valid time (time when the object version became valid in the real world)
- Publication time (time when the object version was published)
- Verification time (time when the object version was or (for forecasts) will be verified to be correct

Data quality standards provide an important means of describing the quality of spatial data so that users can select the data set that best meets their application needs or requirements. The following data quality elements are typically used to describe how well a data set meets the criteria set forth in its product specification (ISO, 2009):

- *Completeness*: Presence and absence of features, their attributes and relationships
- *Logical consistency*: Degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical)
- *Positional accuracy*: Accuracy of the position of features;

- *Temporal accuracy*: Accuracy of the temporal attributes and temporal relationships of features
- *Thematic accuracy*: Accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships

ISO/TC 211 has developed the following international standards dealing with geometry (ISO, 2009):

- *ISO 19107:2003 Geographic information – Spatial schema*
- *ISO 19108:2002 Geographic information – Temporal schema*
- *ISO 19111:2007 Geographic information – Spatial referencing by coordinates*
- *ISO 19113:2002 Geographic information – Quality principles**
- *ISO 19114:2007 Geographic information – Quality evaluation procedures**
- *ISO 19123:2005 – Geographic information – Schema for coverage geometry and functions*
- *ISO/TS 19127:2005 Geographic information – Geodetic codes and parameters*
- *ISO/TS 19138:2006 Geographic information – Data quality measures**[7]

Metadata

Knowledge about geographic information is collected in terms of **metadata**. Metadata constitutes a description of captured or modeled data in databases or applications, and includes the following:

- Content (i.e., the features included)
- Structure (i.e., the representation of objects, topology, etc.)
- Semantics (i.e., the mapping between a representation and the reality represented)
- Lineage (e.g., source, collecting process)
- Quality (e.g., positional and content accuracy)
- Vintage
- Resolution
- Distribution format
- Persons or institutions responsible for the data

Good Practice

*The **Canadian Standard on Geospatial Data** (Treasury Board of Canada Secretariat, 2012) adopts measures that have been endorsed by the Canadian Geospatial Data Infrastructure. The standard requires managers and functional specialists responsible for creating or using geospatial data or systems that use geospatial data to:*

- *apply* ISO 19115 Geographic information – Metadata*;*
- *apply the* North American Profile of ISO 19115 Geographic information - Metadata (NAP – Metadata*; and*
- *apply all of the elements of* ISO 19128 Geographic information - Web map server interface*.*

If such standardized descriptions of spatial information are available and accessible, users can interpret the information and identify the suitability of the data for their specific application (i.e., fitness for use).

[7] ISO191132002, ISO19114:2003, and ISO 19138:2006 will be superseded by ISO19157, Geographic information - Data quality.

ISO/TC 211 has developed an international standard on geographic metadata, *ISO 19115:2003 Geographic information – Metadata* (ISO/TC 211, 2003), which formalizes the content and structure of geographic metadata and simplifies its use (Brodeur & Danko, 2007). As indicated in the text box above, a good practice is to develop a profile of the ISO standard, such as the *North American Profile of ISO 19115:2003 Geographic information – Metadata (NAP – Metadata)*, which Canada and the US jointly developed.

The *ISO 19115:2003 Geographic information — Metadata* standard defines metadata elements, provides a schema required for describing geographic information and services, and establishes a common set of metadata terminology, definitions and extension procedures (ISO, 2009). It provides information about the identification, extent, quality, spatial and temporal schema, spatial reference, and distribution of digital geographic data. The *ISO 19115:2003* standard defines:

- Mandatory and conditional metadata sections, metadata entities, and metadata elements;
- The minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- Optional metadata elements to allow for a more extensive standard description of geographic data, if required; and
- A method for extending metadata to fit specialized needs.

The *North American Profile (NAP) of the ISO 19115:2003 Geographic information – Metadata* extends standardization across national borders. It replaces the FGDC *Content Standard for Digital Geospatial Metadata*, which was widely adopted in the US and Canada, and provides the following features:

- Fewer mandatory elements and more optional elements;
- Extended elements and new elements to capture more specific information;
- A hierarchical structure that creates "packages" of metadata that can be reused and combined to form new metadata records;
- Support for the documentation of new spatial data topologies and technologies, including geodatabases, Web mapping applications, data models, data portals and ontologies; and
- Suggested good practices for populating metadata elements in a manner that enhances the quality and usefulness of the metadata.

6.1.2 Syntax

Encodings

Rules in encoding standards allow spatial information defined in an application schema to be coded into a system-independent data structure suitable for transport or storage. **Encoding rules** specify the types of data to be coded and the syntax, structure and coding schemes used in the resulting data structure, which may be stored on digital media or transferred using transfer protocols (ISO, 2009). Definition of an encoding rule requires that three important aspects be specified: the input data structure, the output data structure, and the conversion rules between input and output data structure elements.

The **Geography Markup Language (GML)** standard is an Extensible Markup Language (XML) encoding used for the transport and storage of geographic information modeled according to the ISO geographic information conceptual modeling framework, including both the spatial and non-spatial properties of spatial features. The GML standard defines the XML Schema syntax, mechanisms, and conventions that (ISO, 2009):

- "Provide an open, vendor-neutral framework for the description of geospatial application schemas for the transport and storage of geographic information in XML;
- Allow profiles that support proper subsets of GML framework descriptive capabilities;
- Support the description of geospatial application schemas for specialized domains and information communities;
- Enable the creation and maintenance of linked geographic application schemas and datasets;
- Support the storage and transport of application schemas and data sets; and
- Increase the ability of organizations to share geographic application schemas and the information they describe."

GML specifies XML encodings for the following conceptual classes defined in the ISO geographic information standards (ISO, 2009):

- *ISO/TS 19103 – Conceptual schema language* (units of measure, basic types)
- *ISO 19107 – Spatial schema* (spatial geometry and topology)
- *ISO 19108 – Temporal schema* (temporal geometry and topology, temporal reference systems)
- *ISO 19109 – Rules for application schemas* (features)
- *ISO 19111 – Spatial referencing by coordinates* (coordinate reference systems)
- *ISO 19123 – Schema for coverage geometry and functions* (coverages, grids)

The **Metadata – XML schema implementation** standard provides XML schemas that help to enhance interoperability by providing a common specification for describing, validating and exchanging metadata (ISO, 2009).

ISO/TC 211 has developed the following international standards dealing with encoding (ISO, 2009):

- *ISO 19118:2005 Geographic information — Encoding*
- *ISO 19136:2007 Geographic information — Geography Markup Language (GML)*
- *ISO/TS 19139:2007 Geographic information — Metadata — XML schema implementation*

Portrayal

Portrayal schema standards define schemas for describing the portrayal of geographic information in a form understandable by humans, and include the methodology for describing symbols and mapping of the schemas to application schemas (ISO, 2009). They provide general guidance to application developers on how to portray the feature instances of a data set. The portrayal mechanisms make it possible to have general rules valid for the whole data set, as well as rules valid for a specific value of a feature attribute only.

ISO/TC 211 has developed the *ISO 19117:2012 Geographic information – Portrayal* standard for spatial data portrayal, which defines a feature-centered, rule-based portrayal mechanism (ISO, 2009). The portrayal information is handled as portrayal specifications applied according to specific portrayal rules, making it possible to portray the same data set in different ways without altering the data set itself. The portrayal rules are stored in a portrayal catalogue, and the portrayal specifications are stored separately from the data set and referenced from the portrayal rules. Portrayal information may be specified either by sending a portrayal catalogue and portrayal specifications with the data set, or by referencing an existing portrayal catalogue and portrayal specifications from metadata. But the user has the option of applying a user-defined portrayal catalogue and portrayal specification.

6.1.3 Services

The goals of Web service interoperability are to provide seamless and automatic connections from one software application to another and the seamless flow of data between Web-based applications and services. Web services encapsulate linguistic resources and tools and combine them in a common service-oriented architecture. To be interoperable, these Web services must first agree on protocols defining the interaction between the services (e.g., WSDL/SOAP, REST, XML-RPC), and they must also use a shared and standardized data exchange format, which is preferably based on widely accepted formats already in use (e.g., UTF-8, XML) (CLARIN, 2010). The following sections describe the commonly used Web services in the spatial information domain.

Web Services

The World Wide Web Consortium (W3C) defines a Web service as "a software system designed to support interoperable machine-to-machine interaction over a network" (W3C, 2004b). W3C has developed a wide range of standards to help facilitate interoperability on the Web,[8] and organizations such as OGC and ISO (see Section 6.4.1 for detailed information on these organizations) develop spatial information Web services standards, such as those described below.

[8] See http://www.w3.org/TR/

Web Map Service

According to a standard that was originally developed and published by OGC in 1999 and subsequently adopted as an International Standard by ISO in 2005 (*ISO 19128:2005 Geographic information — Web map server interface*), a Web Map Service (WMS) is a standard protocol for serving georeferenced map images over the Internet that are generated dynamically by a map server using data from a database. The standard specifies operations to retrieve a description of the maps offered by a server, to retrieve a map, and to query a server about features displayed on a map. The International Standard is applicable to pictorial renderings of maps in a graphical format (e.g., PNG, GIF or JPEG); it is not applicable to the retrieval of actual feature data or coverage data values (OGC, 2006). A basic WMS classifies its geographic information holdings into "layers" and offers a finite number of predefined "styles" in which to display those layers. The WMS International Standard supports only named layers and styles, and does not include a mechanism for user-defined symbolization of feature data.[9]

The three operations defined for a WMS are as follows (ISO, 2009):

- *GetCapabilities* (mandatory) – To obtain service metadata. The response to a GetCapabilities request is an XML document containing service metadata formatted according to the XML Schema in E.1 of Annex E of the WMS Implementation Specification, which specifies the mandatory and optional content of the service metadata and how the content is formatted.
- *GetMap* (mandatory) – To return a map. The response to a GetMap request is a map of the spatially referenced information layer requested, in the desired style, and having the specified coordinate reference system, bounding box, size, format and transparency.
- *GetFeatureInfo* (optional) – To provide more information about features in the pictures of maps that were returned by previous Map requests. Typically, a user sees the response of a Map request and chooses a point (I,J) on that map for which to obtain more information and can specify the pixel that is being asked about, the layer(s) that should be investigated, and the format in which the information should be returned.

Web Feature Service

The OGC first published the *Web Feature Service Specification* in 2005 (OGC, 2005) and it was adopted by ISO as the *ISO 19142:2010 Geographic information – Web Feature Service* International Standard in 2010 (ISO, 2010a). The Web Feature Service (WFS) offers direct access to geographic information at the feature and feature property level. Web feature services allow clients to retrieve the data they are seeking, rather than retrieving a file that contains the data they are seeking and possibly much more.

[9] NOTE: The OGC Styled Layer Descriptor (SLD) specification defines a mechanism for user-defined symbolization of feature data. An SLD-enabled WMS retrieves feature data from a Web Feature Service and applies explicit styling information provided by the user in order to render a map.

The WFS specifies the following kinds of operations (OGC, 2005):

- *Discovery* – Allows the service to be interrogated to determine its capabilities and to retrieve the application schema that defines the feature types the service offers (i.e., GetCapabilities and DescribeFeatureType);
- *Query* – Allows features or values of feature properties to be retrieved from the underlying data store based on constraints, defined by the client, on feature properties (i.e., GetPropertyValue, GetFeature and GetFeatureWithLock);
- *Locking* – Allows exclusive access to features for the purpose of modifying or deleting them (i.e., GetFeatureWithLock and LockFeature);
- *Transaction* – Allows features to be created, changed, replaced and deleted from the underlying data store (i.e., Transaction); and
- *Stored query* – Allows clients to create, drop, list and describe query expressions that are stored by the server and can be repeatedly invoked using different parameter values (i.e., CreateStoredQuery, DropStoredQuery, ListStoredQueries and DescribeStoredQueries).

Catalogue Service for the Web

The *OpenGIS® Catalogue Services Specification* was published by OGC in 2007 (OGC, 2007a). Catalogue Services for the Web (CSW) provides a registry service to support the ability to publish and search metadata for data, services and related information objects. Catalogue services are required to support the discovery and binding to registered information resources within an information community. CSW specifies the interfaces between clients and catalogue services, through the presentation of abstract and implementation-specific models. For most registries, CSW will require the development of specific profiles before they can be used.

Web Coverage Service

The *OGC® WCS 2.0 Interface Standard – Core*, published in 2010, specifies how a Web Coverage Service (WCS) offers multi-dimensional coverage data for access over the Internet (OGC, 2010). Unlike the WMS (which portrays spatial data to return static maps, rendered as pictures by the server), the WCS provides available data together with their detailed descriptions, defines a rich syntax for requests against these data, and returns data with its original semantics (instead of pictures) that may be interpreted, extrapolated, and so on, and not just portrayed. Unlike the WFS (which returns discrete spatial features), the WCS returns coverages representing space-varying phenomena as grid values (e.g., as a GeoTIFF file) that relate a spatial-temporal domain to a range of properties (possibly multi-dimensional).

The WCS interface specifies the following operations:

- *GetCapabilities* – Similar to WMS, allows a client to request information about the server's capabilities and coverages offered;
- *DescribeCoverage* – Allows a client to request detailed metadata (full descriptions) of one or more selected coverages offered by a particular server; and

- *GetCoverage* – Allows a client to request a coverage comprised of selected range properties at a selected set of spatial-temporal locations, expedited in a well-known coverage encoding format.

Filter Encoding

The *OpenGIS Filter Encoding 2.0 Encoding Standard*, published by OGC in 2010 (OGC, 2010), was subsequently adopted by ISO in the same year (*ISO 19143:2010 Geographic information – Filter encoding*) (ISO, 2010b). This standard provides XML and KVP encoding for expressing projection, selection and sorting clauses (e.g., a subset of features might be identified to render them in a particular color or to convert them into a user-specified format), collectively called a query (or filter) expression. These common components are modular and can be used together or individually by a number of Web services. Filter encoding can handle both spatial and non-spatial aspects of a query and will restrict the records that are returned in response to the query.

ISO 19143:2010 defines XML encoding for the following predicates (ISO, 2010):

- A standard set of logical predicates: and, or and not;
- A standard set of comparison predicates: equal to, not equal to, less than, less than or equal to, greater than, greater than or equal to, like, is null and between;
- A standard set of spatial predicates: equal, disjoint, touches, within, overlaps, crosses, intersects, contains, within a specified distance, beyond a specified distance and BBOX;
- A standard set of temporal predicates: after, before, begins, begun by, contains, during, ends, equals, meets, met by, overlaps and overlapped by; and
- A predicate to test whether the identifier of an object matches a specified value.

Gazetteer Service

Approved in early 2012, the *OGC® Gazetteer Service – Application Profile of the Web Feature Service Best Practice* (OGC, 2012a) allows a client to search and retrieve elements of a georeferenced vocabulary of well-known place names. A gazetteer is an online “dictionary” of spatial words or terms, with or without applicable feature geometries. For example, a gazetteer system may be able to transform the name of a city into a polygon or a single point that represents that city, and may include the capability to do geocoding (i.e., convert a street address to a geographic location) (GeoConnections, 2012d). To ensure semantic interoperability, this profile defines the response schema elements according to the gazetteer data model defined in *ISO 19112 Geographic information — Spatial referencing by geographic identifiers*.

A gazetteer service has the following operations:

- *GetCapabilities* – Able to describe its capabilities (specifically, it must indicate which SI_LocationInstances are supported by the service and what operations are supported);
- *DescribeFeatureType* – Able, upon request, to describe the structure of the SI_LocationInstance it services;

- *GetFeature* – Able to retrieve feature instances, specify which feature properties to fetch, and constrain the query spatially and non-spatially; and
- *Transaction* – Able to service transaction requests composed of operations that modify features (i.e., create, update and delete operations on geographic features).

6.1.4 Examples of Standards Adoption in the Americas

Several countries in the Americas have been active in developing spatial information standards or adopting/endorsing international standards for use in their SDI initiatives. For example, the Standardization Technical Committee CTN 028, founded in **Colombia** in 1996 under the supervision of ICDE and supported by ICONTEC, the Colombian Institute of Technical Standards (ICONTEC, 2011), is responsible for adapting and adopting international geomatics standards to be implemented by geographic information producers and other ICDE stakeholders. Since 2007, CTN 028 has been working on the following standards:

- *DE054/08 Geographic metadata* – Second update (ISO 19115)
- *DE052/08 Quality basic concepts* – First update (ISO 19113)
- *DE053/08 Methodology for feature cataloguing* (ISO 19110)
- *DE055/08 Technical specifications of geographic products* (ISO 19131)
- *DE051/08 Quality evaluation – processes and measures* (ISO 19114, ISO 19138)

In order to sustain harmonious development of the **Ecuadorian** Geospatial Data Infrastructure, CONAGE has a specific working group dedicated to standardizing geographic Information, which is coordinated by SENPLADES (SENPLADES, 2012) and linked to the national standardization body INEN, a member of the ISO/TC 211. In its *Operative Plan for 2012*, CONAGE projects the following scope for the Standardization Working Group of the Ecuadorian Geo-Spatial Data Infrastructure (IEDG):

- Elaboration of technical specifications for both basic and thematic cartography
- Compilation of a glossary of terms for geographic information
- Translation and adoption of standards from the ISO 19100 family

The *Ecuadorian Metadata Profile* (PEM), published in the Official Register No. 288 of September 2010 by means of the approval of Resolution 003-CONAGE-2010 (Registro Oficial - Ecuador, 2010), is based on international metadata standards *ISO 19115:2003* and *ISO 19115:2009*.

The institutionalization of *the Electronic Government Interoperability Standards* (e-PING) in **Brazil**, by means of the *Normative Ordinance No. 05 of July 14^th^ of 2005* (GOV.BR, 2005), defines the means of version updating of the *e-PING Reference Document* (CEGE, 2012). The policies and standards of this e-PING document are mandatory for use by federal government organizations. In the 2012 version, the general policies of the e-PING's construction are described in the following categories:

- Preferential adoption of open standards
- Public software and/or free software
- Transparency
- Security
- Market support
- Technical, semantic and organizational dimensions of interoperability

The e-PING document governs the information exchange among crosscutting areas of the government, whose standardization is relevant for the interoperability of electronic government services, such as data and processes, accounting information and geographic information. Regarding the data relating to the geo-processing area, the e-PING defines a set of open standards that must be used. Those standards are based primarily on the definitions of the OGC (CONCAR, 2010). The Brazilian Directory of Geospatial Data (DBDG) must follow the e-PING norms and policies.

Under *Resolution No. 1 of November 30th of 2009* of the Secretary of Strategic Planning and Investments, the *Profile of Geospatial Metadata in Brazil* (MGB Profile) was approved as a national cartography standard, in compliance with the *Technical Standards of National Cartography* (D.O.U., 1984) supporting the construction of the NSDI (CONCAR, 2009). CONCAR, through the Structuring Committee of Geospatial Metadata (CEMG) and a specific working group (WG1-CEMG), created the MGB Profile based on the ISO 19115 standard (CONCAR, 2009). The MGB Profile includes most of the sections of metadata in ISO 19115, including the most relevant aspects of the documentation of geographic information (GI) produced in the country. The profile should be applied mainly to the metadata of Basic Cartography products, but the WG1-CEMG also specified a summarized version of the profile, based on Core Metadata for "Geographic Datasets" from ISO 19115, to be adopted by other GI producers.

The National Institute of Statistics and Geography of **Mexico** (INEGI), in accordance with its function of standardizing and coordinating the *National System of Statistical and Geographical Information*, has published the following technical standards linked to Mexico's Spatial Data Infrastructure (INEGI, 2011a):

- *Technical Standard for the National Geodetic System*
- *Technical Standard for the generation, capturing and integration of cadastral and register data with statistical and geographical purposes*
- *Technical Standard for geographical addresses*
- *Technical Standard on positional accuracy*

The National Standardization Institute (INN) of **Chile** has been incorporated as a Member P (participant) in the Technical Committee ISO/TC 211, responsible for the geographic information standards. This fact signifies the maturity reached by the standards framework of SNIT, which is developing a project to evaluate the adoption of 19 standards of the ISO 19100 family from ISO/TC 211 (SNIT, 2012).

The Committee on Geomatics of the Canadian General Standards Board (CGSB-CoG) is the Canadian mirror committee to ISO/TC 211 and is responsible for endorsing ISO standards for Canada, as well as developing national profiles (e.g., NAP-Metadata) and developing national standards. The Treasury Board Secretariat (TBS) *Standard on Geospatial Data* in **Canada** represents the institutionalization of two endorsed standards (19115 Metadata for geodata; 19128 Viewing geospatial data) as applicable for all of the Government of Canada's geospatial data holdings. This institutionalization process followed the steps below (McLeod & Mitchell, 2012a):

- An interdepartmental Working Group, led by Natural Resources Canada, was established in March 2006 to construct compliance and implementation plans that addressed the scope, phasing of implementation, cost estimates, etc., for both standards;
- Twenty-eight departments and agencies were formally consulted through a balloting process under the Treasury Board Chief Information Officer Standards Program;
- The organizations that responded overwhelmingly supported the Standard on Geospatial Data;
- All issues raised were successfully addressed by the Working Group; and
- The Treasury Board *Standard on Geospatial Data* was approved and became mandatory in June 2009.

In the **United States,** the InterNational Committee for Information Technology Standards – L1 Geographic Information Systems (GIS) (INCITS-L1) is the national mirror committee in the US for ISO/TC 211. The *FGDC Policy on Recognition of Non-Federally Authored Geographic Information Standards and Specifications* (FGDC, 2005c) establishes a mechanism for Federal Geographic Data Committee (FGDC) recognition of non-federally authored standards or specifications. This policy defines a mechanism for the identification, selection, and coordinated implementation of non-federally developed standards. It defines categories of spatial information-related standards and specifications, establishes two levels of FGDC recognition (endorsement and recommendation), describes the steps to be completed for endorsement or recommendation by the FGDC, and provides for exceptions to this process in special circumstances.

The FGDC *NSDI Standards in Software Acquisitions* (FGDC, 2005b) establishes the requirement for procured spatial software to be compliant with the National Spatial Data Infrastructure (NSDI) (i.e., able to interoperate using well-defined and commonly supported open standards). The document contains a table organized under three categories of spatial requirements: (i) Spatial Data Access and Visualization, (ii) Metadata or Catalog Access, and (iii) Spatial Reference Systems and Place Codes. These can be identified within the functional software acquisition requirements. The table includes the relevant NSDI service interoperability standards and is intended to help agencies acquire software that supports the relevant standard.

6.2 Profiles

A spatial information **profile** is a subset of one or several spatial information standards. The *ISO 19106:2004 Geographic information – Profiles* standard defines the purposes for which profiles are used as (ISO, 2004):

- "Identifying those base standards, together with appropriate classes, conforming subsets, options and parameters, which are necessary to accomplish identified functions for purposes such as interoperability;
- Providing a means to enhance the availability of consistent implementations of functionally defined groups of base standards, which are expected to be the major components of real application systems;
- Promoting uniformity in the development of conformance tests for systems that implement the functionality of profiles."

For example, for the *ISO 19110:2005 Feature Cataloguing Standard,* a profile would correspond to a subset of the elements that are required for cataloguing feature types. Some optional elements may be discarded if they are not required by a community.

Multiple catalogues can be developed using the *ISO 19106:2004* methodology, which will guarantee that the resulting feature definitions contain the same components and are catalogued in the same manner, but will not guarantee that the definitions of features and attributes within the catalogue are not conflicting. For example, each standards-setting organization or national body that develops a feature catalogue could define "roads," "rivers" or "administrative boundaries" differently. The catalogues will be consistent, but the definitions they contain will not.

6.3 Cultural and Linguistic Adaptability

In the Americas, there is a requirement to support cultural and linguistic adaptability in metadata standards, conceptual schema and feature catalogues and more specifically to support multiple languages. In the *NAP – Metadata*, English and French are supported, but multiple languages such as Spanish and languages of native communities can be easily integrated (Brodeur & Danko, 2007). This adaptability is made possible with *NAP – Metadata* through the description of free text metadata elements in languages other than the one identified for the Metadata Record Information. Items in the profile register (i.e., a set of files containing identifiers assigned to items with descriptions of the associated items) can also be described in multiple languages.

6.4 Standards Process

6.4.1 International Standards Development and Review

Spatial information standards are primarily developed and maintained by the ISO Technical Committee 211 (ISO/TC 211) and the OGC. From the outset in 1994 when both the ISO/TC 211 and the OGC were formed, the development and implementation of standards for spatial information were conceived as dependent on other information and communications technology (ICT) standards. These two groups collaborate closely under a cooperative agreement to define and maintain two types of standards in the field of spatial information management (New Zealand Geospatial Office, 2011):

- *Service invocation standards* – Define the interfaces that allow different systems to work together, or the expected behaviour of geoprocessing software systems; and
- *Information transactional standards* – Used to define the content of spatial information or its encoding for interchange between different processing systems.

International Organization for Standardization

The ISO Technical Committee 211 was formed to develop an integrated set of standards for spatial information. Its mandate and strategic directions can be viewed to encompass development, deployment and the underlying coordination and consensus process that integrates both these phases for successful standardization. Since spatial information has become a common consumer commodity in the electronic/Internet/wireless communities, the diverse requirements, costs and complexity of standardization has increased dramatically in the past decade. In recognition of the need for the strategic directions for spatial standardization to be responsive to these challenges, the standardization program for ISO/TC 211 is characterized by three generations (ISO, 2009):

Figure 6.1: ISO Standards Development Process

- *First generation* – Spatial data standards
- *Second generation* – Location-based services and imagery standards
- *Third generation* – Information communities and frameworks for domain-specific standards

Each International Standard developed by ISO technical committees goes through a uniform six-step process, illustrated in Figure 6.1 (ISO, 2012a). The steps in the process are as follows (ISO, 2012b):

- *Proposal stage* – Confirmation that a particular International Standard is needed. A new work item proposal is submitted for vote by the members of the relevant technical committee (TC) or sub-committee (SC) to determine the inclusion of the work item in the program of work. The proposal is accepted if a majority of the permanent or P-members of the TC/SC votes in favor and if at least five P-members commit to participate actively in the project. A project leader is then appointed.
- *Preparatory stage* – Creation of a working group of experts to prepare a working draft. Successive working drafts may be produced until the working group is satisfied that it has developed the best technical solution to the problem being addressed. The final draft is forwarded to the working group's parent committee (e.g., ISO/TC 211) for the consensus-building phase.
- *Committee stage* – Registration of first committee draft by the ISO Central Secretariat (CS) and distribution for comment and, if required, voting by the P-members of the TC/SC. Successive committee drafts may be considered until consensus is reached on the technical content. Once consensus is reached, the text is finalized for submission as a Draft International Standard (DIS).
- *Enquiry stage* – Circulation of the DIS to all ISO member bodies by the ISO CS for voting and comment within a period of five months. It is approved for submission as a Final Draft International Standard (FDIS) if two-thirds of the P-members of the TC/SC are in favour and not more than one-quarter of the total number of votes cast are negative. If not approved, the text is returned to the originating TC/SC for further study and a revised document will again be circulated for voting and comment as a DIS.
- *Approval stage* – Circulation of the FDIS to all ISO member bodies by the ISO CS for a final Yes/No vote within a period of two months. The text is approved as an International Standard if the same criteria used at the enquiry stage are met. If these approval criteria are not met, the standard is referred back to the originating TC/SC for reconsideration in light of the technical reasons submitted in support of the negative votes received.
- *Publication stage* – Forwarding of the final text to the ISO CS, which publishes the International Standard. Once an FDIS has been approved, only minor editorial changes, if and where necessary, are introduced into the final text.

If a document with a certain degree of maturity is available at the start of a standardization project (e.g., a standard developed by another organization like OGC), it is possible to use the so-called "fast-track procedure." Such a document can be submitted directly for approval as a Draft International Standard (DIS, stage 4) or, if the document has been developed by an international standardizing body recognized by the ISO Council, as a Final Draft International Standard (FDIS, stage 5).

Open Geospatial Consortium

The Open Geospatial Consortium, Inc. (OGC) was formed in 1994 to realize the vision developed by its predecessor, the OpenGIS Project: "diverse geoprocessing systems communicating directly over networks by means of a set of open interfaces based on the 'Open Geodata Interoperability Specification' (OGIS)" (OGC, 2012b). Since 1994, the OGC membership has grown to more than 470 government, academic and private sector organizations, including traditional GIS vendors, technology integrators, data providers and location services companies. Since the OGC Standards Program first approved an implementation standard in 1997, over 55 OGC standards have been developed to address the challenges that were identified at OGC's inception and to deal with many other challenges that have been identified since then, several of which have been adopted by ISO as International Standards.

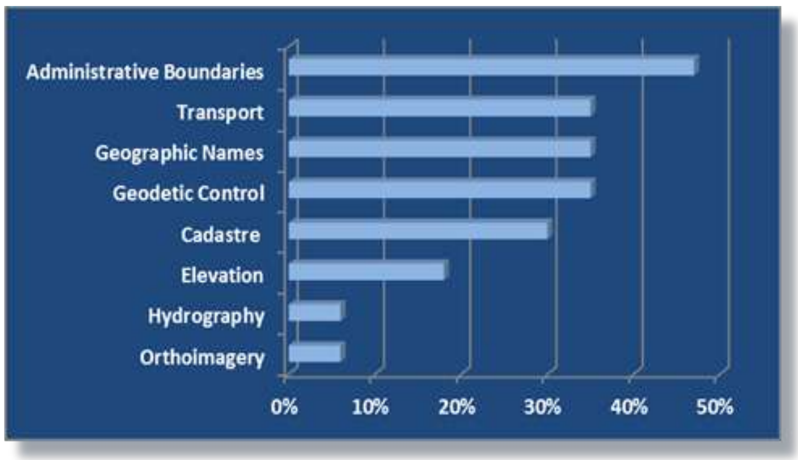
OGC has adopted a user-driven process, which encourages collaboration among and between OGC members, to define, develop, test, document, demonstrate, and implement open standards that solve spatial interoperability problems. The following steps are involved in the OGC standards development and implementation process (OGC, 2012c):

- *Interoperability problem identification* – OGC members identify specific interoperability problems and issues from industry, government and academia that span many topics, and then discuss and prioritize them.
- *Solution development* – Members work together to define requirements for a new interface standard or enhancements to an existing OGC standard. There are several formal OGC processes that can be used:
  - Request for Comment (RFC) – Individual members or teams of members work on their own and introduce candidate standards;
  - Interoperability Program (IP) – Members use a test bed or pilot initiative to rapidly prototype their ideas to come up with draft standards, implement technologies that use them, and/or validate the quality of their solutions in formal demonstrations; and
  - Standards Program (SP) – A theoretical and deliberate approach that relies on high-level discussion and document writing to open a work item focused on the interoperability problem within Working Groups that operate as part of OGC's Technical Committee. The results of the first two processes, RFC and IP, end up in the SP too, as that is where the consensus process is applied to all candidate standards.
- *Proposed standard evaluation and approval* – All OGC members and ultimately the general public have a chance to comment on it, provide input, and suggest changes. Members collaborate to ensure all comments are considered and integrated into a final product: a draft standard that can be put to a formal member vote. Once a standard is approved by the OGC membership, it is made publicly available without cost on the OGC website.
- *Standards implementation* – OGC's Marketing and Communications Program takes additional steps to help educate technology developers and those who use spatial products about the benefits of products that use OGC standards. The goal is to encourage developers to include the standards in their products and software buyers to select products that do so.

PC-IDEA

The Permanent Committee for the Spatial Data Infrastructure of the Americas (PC-IDEA) is actively engaged in considering spatial standards for the region. In 2011, a Standards and Technical Specifications Working Group (NET) was formed to establish a set of standards and technical specifications that are applicable to the region as a whole, beyond the national specifications (NET, 2012a). NET conducted an evaluation in 17 countries in the Americas on the use of "core or framework data" standards, and found the percentages illustrated in Figure 6.2.

Figure 6.2: Framework Standards Use in the Americas



NET has identified a group of proposed core standards for use in the Americas, including Geodetic Reference System, Boundaries, Relief/Digital Elevation Models, Geographical Names, Hydrography, Cadastre, Topography, Geospatial Data Model, Metadata and Interoperability. NET has also developed a proposal to form a permanent PC-IDEA Standards Working Group to guide the development of a set of standards and specifications that are applicable to the region. The objective would be to adopt the set of regional standards by mid-2013, working in cooperation with the ISO/TC 211-PAIGH[10] Working Group on International Standards formed in 2010 (NET, 2012b).

6.4.2 Standards Introduction and Adoption

The previous sections have demonstrated that considerable resources are being invested and thorough processes are being used to create spatial standards that can be effectively employed in developing SDI initiatives. The key challenge for SDI implementers is not how to develop spatial standards, but to decide upon the suite of standards to be used, and to introduce the standards and promote their adoption and use by stakeholders in the initiative.

[10] Pan-American Institute of Geography and History

Deciding on a Standards Suite

A primary consideration is the choice of a minimal group of compatible mature standards upon which the SDI will be based. As explained in *The SDI Cookbook*, interoperability problems can result from the selection and use of standards that are incompatible because of different versions affecting interdependencies. Below are some criteria that can be used in deciding the suite of standards to be employed (GSDI, 2009):

- *Evidence of implementation* – Ensure stability and evidence that a given standard is widely implemented and supported in both commercial and open source technology. The OGC website lists products that have implemented OGC standards. In addition, several OGC members have developed tools that search the Web looking for publicly available OGC Web Service-enabled servers.
- *Dependencies* – Identify implicit and explicit dependencies between standards. 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, since related standards may evolve on an independent schedule.
- *Stability and conformance* – Develop means of assessing or testing technical standards for conformance or compliance. An example of a compliance testing environment is the OGC Compliance & Interoperability Testing & Evaluation (CITE) capability for testing WMS and WFS compliance.[11] The CITE program provides a mechanism by which users and buyers of software that implements OGC standards can be certain that the software follows the mandatory implementation rules as specified in the standard.

Good Practice

GeoConnections established a **Technology Advisory Panel** *to help identify the following suite of international standards that are recognized and promoted for use through the CGDI* (GeoConnections, 2012e):

- *OpenGIS® Catalogue Service Implementation Specification*
- *North American Profile of ISO19115:2003 - Geographic Information – Metadata*
- *OpenGIS® Filter Encoding Standard (FES)*
- *Gazetteer Service – Application Profile of the Web Feature Service (WFS) Implementation Specification*
- *OpenGIS® Geography Markup Language (GML) Encoding Standard*
- *OpenGIS® City Geography Markup Language (CityGML) Encoding Standard*
- *OpenGIS® GML in JPEG 2000 for Geographic Imagery Encoding Standard*
- *GeoRSS Simple and GeoRSS-GML*
- *OGC® KML*
- *OpenGIS® Styled Layer Descriptor (SLD) Profile of the Web Map Service Implementation Specification*
- *OpenGIS® Symbology Encoding (SE) Implementation Specification*
- *OpenGIS® Georeferenced Table Joining Service Implementation Standard*
- *OGC® Web Coverage Service (WCS) Implementation Standard*
- *OGC® WCS 2.0 Interface Standard - Core and Protocol Extensions*
- *OpenGIS® Web Coverage Processing Service (WCPS) Language Interface Standard*
- *OpenGIS® Web Feature Service (WFS) Implementation Specification*
- *OpenGIS® Web Feature Service 2.0 Interface Standard*
- *OpenGIS® Web Map Context Implementation Specification*
- *OpenGIS® Web Map Service (WMS) Implementation Specification*
- *OpenGIS® Web Map Tile Service (WMTS) Implementation Standard*
- *OGC® Web Processing Service (WPS)*

[11] See http://www.opengeospatial.org/resources/?page=testing

- *Core or supplemental status* – Identify the spatial standards that appear to be common and required to implement SDIs, and those other standards that may be optional. The "core" standards should provide baseline functionality in an SDI, while supplemental standards identify optional, well-known capabilities.

Introduction and Promotion

Once a suite of standards for the SDI has been decided upon, a concerted effort is required to introduce them to, and promote their use within, the user community. This includes designing and developing a standards communication and outreach program, as well as a capacity building program (see Section 9.1 for a more detailed discussion of these topics).

Success in achieving spatial standards adoption will depend on a number of factors. A principal consideration is the enforcement model for standards adoption. In jurisdictions where SDI development and use is prescribed by legislation (i.e., acts, regulations, directives or formal policies), the adoption of standards is implicit. For example, in the European Union, the *INSPIRE Directive* lays down detailed technical provisions in *Implementing Rules* relating to a number of technical and policy areas (i.e., metadata, interoperability of spatial data sets and services, network services, data and service sharing and coordination, and measures for monitoring and reporting). While *Implementing Rules* are binding and do not make specific reference to standards, *Technical Guidance* documents accompanying the Rules, which are not legally binding, do reference ISO, OGC and other standards (OGC, 2012d).

In jurisdictions where the use of geospatial standards is not mandatory, SDI implementers must devise strategies to encourage stakeholders to voluntarily adopt the standards. For example, strong arguments can be made for the business value of adopting standards. Some of these arguments are as follows (Geonovum, 2009) (ASTM, 2001) (Booz Allen Hamilton, 2005):

- *Vendor independence* – Standards make it possible to avoid dependency on a single supplier. Solutions can work on different platforms and be cared for by more parties.
- *Transparency, accountability and manageability* – Standards help provide a clear account for compliance with legal provisions, for the completion of audits and for verification of information security.
- *Interoperability* – Software-independent links and open standards in the fields of application such as remote sensing, GIS, location-based services are available.
- *Digital sustainability* – Solutions can be maintained by parties other than the first vendor, providing room for further innovation.
- *Competitive advantage* – Organizations that participate in standardization and influence the content of a standard gain an edge over non-participating organizations in terms of insider knowledge.
- *Cost reduction* – Overall project costs are lower (cost reductions of more than 25% have been demonstrated) and transaction costs drop because of the greater availability and

usability of data (reductions in operations and maintenance costs of more than 30% have been demonstrated).

- *Strategic alliance formation* – Helping form a collection of harmonized technical rules or "coding" of knowledge can help organizations cooperate and create strategic alliances.
- *Meeting market demand* – Standards are needed to meet the demand for interoperability and connectivity between an increasingly wider array of electronic devices.

The GPC Group white paper, *Geospatial Standards*, contains a useful summary of the kinds of benefits derived from standards adoption, as shown in Table 6.1 (GPC Group, 2012).

Table 6.1: Geospatial Standards Benefits

Customer Benefits	Operational Benefits	Financial Benefits	Strategic Benefits	Social Benefits
▪ Improved customer interactions by stakeholder entities ▪ Improved customer responsiveness ▪ Better services to contractors, consultants, academia, and public	▪ Improved business productivity ▪ Improved workforce efficiency ▪ Improved control over data updates and new versions of datasets ▪ Improved data consistency ▪ Better integration and analysis of diverse sources of data, including demographic and business data ▪ Improved opportunities to collaboratively plan data collection to serve multiple uses ▪ Enhanced eServices ▪ Ability to easily add new technology	▪ Decreased cost of geospatial data ▪ Reduced data maintenance & operations costs ▪ Cost avoidance of duplicate data ▪ Reduced cost of data sharing ▪ Reduced time for data integration & interoperability ▪ Lowered risks and reduced cost of new applications development ▪ Stakeholders empowered to reduce risk, stimulate market activity and innovation, and future-proof applications ▪ Higher societal / institutional Return on Investments	▪ Improved customer understanding ▪ Improved market understanding ▪ Improved partner relationships ▪ Improved cross-jurisdictional decision-making ▪ Enhanced working relationships among stakeholders and across jurisdictions ▪ Improved data security ▪ Increased data integration and interoperability ▪ More ability to reuse data for new applications ▪ Improved rigor and transparency regarding data collection, processing,	▪ Improved data access ▪ Increased data sharing among stakeholder organizations ▪ Facilitate better use of data assets ▪ Higher quality of data ▪ Improved documentation of information resources ▪ Better understanding of the benefits of data sharing ▪ Improved communication across diverse information communities ▪ Increased access to relevant data in emergencies, disasters, and conflicts ▪ Increased institutional effectiveness ▪ Strengthened community building

Customer Benefits	Operational Benefits	Financial Benefits	Strategic Benefits	Social Benefits
	▪ Reduced system integration time		and update ▪ Reinforced commitment to standards ▪ Effective data sharing agreements ▪ Innovative new businesses, products, and services	▪ Increased geospatial awareness

While also important in jurisdictions with mandatory standards use, a particularly important strategy for encouraging voluntary adoption of standards is the development of effective communication, outreach and capacity-building processes and tools. Promotion and support of the use of standards can take a variety of forms. For example, a number of national SDI portals and websites contain detailed information on the standards that are endorsed/recommended for use (e.g., CGDI – *GeoSpatial Standards Index,*[12] FGDC – *FGDC Endorsed External Standards,*[13] NZ – *SDI Cookbook v1.1*[14]).

Capacity building initiatives to help new users learn about standards and how to implement them can take the form of online training modules (e.g., Land Information Ontario – *Metadata Resources and Training,*[15] and FGDC – *Introduction to NSDI Standards,*[16]) or knowledge-sharing forums. For example, the Dutch national SDI program has created a wiki site to share a broad spectrum of knowhow concerning spatial standards (Geonovum – Background initiative WIKI on geo-standards[17]). Tools to help users deal with standards are also important. The *Quick Guide for CGDI Service Compliance Testing and Performance Optimization* (GeoConnections, 2009b) identifies and describes resources available for OGC Web Services (OWS) testing, and presents best practices for optimizing OWS performance. The OWSs covered by the guide include WMS, Web WFS, z39.50 distributed server used as part of an OGC Catalogue Services for Web implementation (CSW), GeoRSS and KML-based services. The SNIT Executive Secretary in Chile is developing an SDI implementation guideline in order to deliver general guidance and recommendations on SDI standards implementation.

[12] See http://geoconnections.nrcan.gc.ca/1017
[13] See http://www.fgdc.gov/standards/fgdc-endorsed-external-standards/index_html
[14] See http://www.geospatial.govt.nz/sdi-cookbook-v1-1-home
[15] See http://www.mnr.gov.on.ca/en/Business/LIO/2ColumnSubPage/266883.html
[16] See http://www.fgdc.gov/training/nsdi-training-program/materials/NSDIStandards_Intro_20100604.pdf
[17] See http://geostandards.geonovum.nl/index.php/Main_Page

6.5 Maintenance of Standards

Once standards are developed and adopted, care must be taken to ensure their ongoing viability in relation to such factors as changing technology and user needs, and compatibility with the underlying IT standards. SDI managers have obligations to maintain contact with the stakeholder community (i) to identify the need for changes to existing standards or development of new standards to fill identified gaps, and (ii) to remain cognizant of evolving standards and promote and support the adoption of updated or new standards. In this environment of continuous change, maintaining compatibility between adopted standards can be challenging.

The main standards development bodies have processes in place to manage standards maintenance. For example, OGC uses the formal "Change Request" process, whereby online requests submitted for existing or proposed OpenGIS standards are reviewed by OGC staff and/or a Standards Working Group. They are then posted on the OGC Change Request Web page, where the status of the request is updated as it goes through the consideration and approval stages (OGC, 2012e). ISO/TC 211 has created the following working groups with responsibilities for standards maintenance work (ISO, 2012c):

- *Terminology Maintenance Group* – To review and update the ISO/TC 211 online terminology repository;
- *Harmonized Model Maintenance Group* – To ensure that the UML models of ISO/TC 211 projects and standards are harmonized;
- *XML Maintenance Group* – To ensure that the XML used in ISO/TC 211 projects is maintained and made accessible; and
- *Group for Ontology Maintenance* – To ensure that the ontologies used in ISO/TC 211 projects are maintained and made accessible.

6.6 Monitoring Standards Implementation

The task of monitoring the implementation of spatial standards is also related to the enforcement model for standards adoption. Where adoption of standards is mandatory, it is possible for jurisdictions to set up and administer formal monitoring and reporting processes. This is the case under the *INSPIRE Directive*, which contains clauses requiring EU Member States to report annually on a number of indicators for monitoring the implementation and use of their infrastructures for spatial information (e.g., a list of spatial data sets and services belonging to those infrastructures). In addition, a report must be prepared and submitted every three years covering information on coordinating structures, use of the infrastructure for spatial information, data sharing agreements, and costs and benefits of implementing the *INSPIRE Directive* (INSPIRE, 2012). Although there are no specific requirements to report on standards implementation, this can be inferred from the information on data access and Web services use.

Implementing monitoring standards is more challenging in a voluntary standards adoption situation. One means of doing so is to adopt a performance management framework, against which performance is measured on a regular basis (see Section 10.1.2 for a more detailed discussion of this mechanism). For example, such a framework has been created for the GeoConnections program and independent performance audits have been conducted to identify how well the CGDI development and deployment strategies have been executed (including those related to standards use) and whether the outputs and outcomes have been achieved (GeoConnections, 2009c). While this mechanism provides a less formal (and potentially less frequent) assessment of standards implementation, it is a workable solution for a voluntary adoption environment.

6.7 Chapter Highlights

In summary, the key standards fundamentals the reader should take away from this chapter are as follows:

- As another of the SDI pillars, standards play a critical role in helping to enable interoperability between systems and systems components.
- Standards can be classified in a number of ways, and in this chapter the classification is by semantics, syntax, services and profiles, with each type of standard being described in some detail. Specialized expertise is essential in dealing with standards development and adopting standards within the SDI environment.
- International standards development is a complex process involving multiple stakeholders and extended time frames to develop consensus and receive formal approval, with the International Organization for Standardization (ISO) and Open Geospatial Consortium (OGC) being the two main players.
- PC-IDEA is playing a proactive role in establishing a group of common standards for use in SDI development across the Americas.
- SDI developers and implementers must decide on the standards that are required in their specific SDI initiative, and the adoption of international standards is a recommended good practice.
- A compatible suite of standards is critical. Criteria that can be used in deciding the suite include evidence of implementation, dependencies between standards, stabilty and conformance, and core or supplemental status.
- Standards must be maintained and upgraded to adapt to changes in technology and user needs, and ISO and OGC have processes in place to handle this maintenance. Nonetheless, maintaining compatibility between standards can be challenging for SDI managers.
- Standards adoption is an important area to be covered in the SDI performance management framework.

7. Policies

The purpose of this chapter is to describe the role that policies play in supporting SDI development and implementation. The importance of linking SDI initiatives to the policy priorities in the jurisdiction is highlighted and the policy identification and development processes explained. A number of contemporary policy topics relevant to SDI are discussed and examples of policies to address those topics are provided, with an emphasis on operational policies.

7.1 Policy Environment

Successful spatial data infrastructure initiatives are closely linked to the overall policy environment in the jurisdiction in which they are implemented. SDI aligns particularly well with open government policy thrusts. There is strong emphasis on facilitating public access to data held by government to develop new and useful products and applications that leverage the value of the original data. A good example of this policy link is the UK Location Program established to create the UK Location Information Infrastructure, which is being driven in part by the UK Government's *Open Data Policy* (Boguslawski, 2010).

In the case of Europe's infrastructure for spatial information (INSPIRE), the primary alignment is with EU environmental policy. The objective is to make available the spatial information necessary to support national and community environmental policy, and policies that affect the environment (JRC, 2012). In addition, INSPIRE is addressing key concerns of another major EU policy thrust, the *Digital Agenda for Europe*. This Agenda addresses fragmented digital markets and lack of interoperability inhibiting the development of innovative cross-border and multilingual services.

Other examples of policies with which SDI initiatives can be aligned or that impact SDIs include the following: innovation and technology development, collaborative approaches to horizontal governance, improved citizen engagement, availability of data for a fee or free, reduction in regulatory and administrative burdens, and reduction in duplication and costs in government.

7.2 Defining Policies

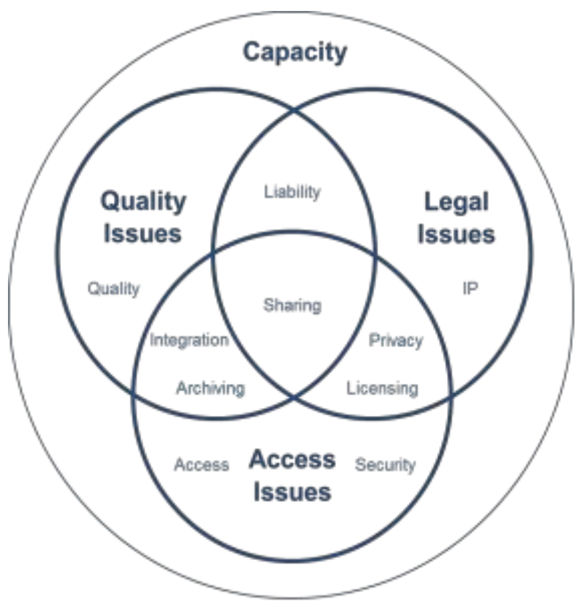
7.2.1 Policy Categories

As discussed in Section 1.2, policies are one of the primary components of an SDI. SDI policy instruments can be divided into two categories ─ strategic policies and operational policies.

Strategic policies help create a formal structure within which the SDI initiative is developed, and help to encourage stakeholder commitment to participate in the development of and to use the infrastructure. The signing of the *Canadian Geomatics Accord* by federal and provincial/territorial geomatics agencies signified a mutually agreed upon policy to cooperate in the development of the CGDI. In the absence of SDI laws or regulations, such policies can also provide a means of helping to ensure standards adoption and use. For example, the Treasury Board of Canada Secretariat (TBS) adopted a policy in 2009 to require all federal government managers and functional specialists responsible for creating or using spatial data or for systems that use spatial data to (TBS, 2009):

- Apply *ISO:19115 Geographic information – Metadata*
- Apply all of the elements of *ISO:19128 Geographic information – Web Map Server Interface*
- Apply the *North American Profile of ISO:19115 Geographic information – Metadata (NAP – Metadata)*

Operational policies are practical tools that help facilitate access to and use of the SDI, and address topics related to the collection, management, use, access and dissemination of spatial data. They include a broad range of guidelines, directives, procedures and manuals that apply to the day-to-day business of organizations in developing, operating and using an SDI. Operational policies are essential to solving data sharing barriers and enabling the effective and efficient interoperable exchange of location-based information, making issues such as data access, quality, ownership and integrity easier to manage. Figure 7.1 illustrates a range of possible operational policy considerations within the SDI development context (GeoConnections, HAL, 2011a). The issues identified have many commonalities and linkages. They can be grouped into three broad areas: Quality Issues, Legal Issues and Access Issues, and the figure shows generally where the issues fall in the intersections among these areas. Capacity is an additional concern.



Source: CGDI Operational Policies Needs Analysis

Figure 7.1: SDI Operational Policy Considerations

7.2.2 Policy Identification and Prioritization

The identification of policy requirements can be accomplished in a variety of ways. In some SDI initiatives, a Policy Committee or other mechanism is created to identify and ensure the creation of policies to meet stakeholder requirements. Below are some examples of such policy mechanisms:

- The **FGDC Steering Committee** has endorsed several policies and guidelines to promote data sharing, ensure appropriate access to spatial data and protect personal privacy in spatial databases (e.g., *Policy Statements for Federal Geographic Data Sharing*, *FGDC Policy on Access to Public Information and the Protection of Personal Information Privacy in Federal Geospatial Databases*, and *FGDC Policy on Recognition of Non-Federally Authored Standards*) (FGDC, 2006).
- During GeoConnections Phases I and II, the **GeoConnections Policy Advisory Node** took action in a number of key policy areas of concern to CGDI stakeholders (e.g., Data Policy (KPMG Consulting, 2001), Archiving, Management and Preservation of Geospatial Data (Brown & Welch, 2006), and Data Licensing (GeoConnections, 2008b)).
- To help with the technical implementation of the EU's SDI, **INSPIRE Working Groups** have developed a number of guidelines that fall under the operational policy category (e.g., Implementation of Discovery Services, Implementation of View Services, and Coordinate Transformation Services) (INSPIRE, 2010, 2011).

Secondly, as noted in Section 2.2, policies to address user issues may be identified during user needs assessment exercises. In this instance, the data collection instruments are designed to capture key challenges and problems with which spatial data users are faced, along with ideas for the types of policies that could be developed to address them. A third approach is to use a formal environmental scan process to identify trends and drivers of future change (e.g., economic, political, technological) that may impact the SDI initiative. This approach can lead to the proactive development of operational policy instruments that help SDI stakeholders to become aware of potential consequences of these changes for their operations and to plan mitigation measures.

Prioritization of policy development normally involves stakeholder consultations followed by a formal decision-making process by SDI management. A number of factors can affect the priority with which policy issues are addressed, including the following:

- *Scope* – The number of parties that need to be involved in developing and implementing the policy (e.g., one department versus multiple levels of government);
- *Impact* – The policy consequences in terms of how it affects existing systems, business processes and human and financial resources;
- *Importance* – The scope of demand for the policy and the extent to which the issues are critical; and

- *Complexity* – How challenging it will be to develop and implement the policy (e.g., technical, legal and administrative complexity).

A rational consideration of all of these factors may lead, for example, to priority being given to a less important policy because of its more limited impact and complexity. In other cases, although the scope may include a large group of stakeholders, the issue may be of such great importance that SDI management decides to devote the time and resources to that policy issue.

7.3 Policy Development Initiatives in the Americas

The National Policies of Geospatial Information in **Ecuador** are developed in accordance with the principles of relevancy, opportunity, quality, publicity and accessibility, transparency, interoperability, interdependency and decentralization (Registro Oficial-Ecuador, 2010). Their strategic guidelines focus on the following:

- *Generation and updating of geoinformation* – Determining roles of producers, owners and custodians in compliance with the principles of the National Policies of Geospatial Information, the standards approved and under harmonization with the National Information System, led by the Secretaría Nacional de Planificación y Desarrollo (SENPLADES);
- *Use of geoinformation* – Recognizing the intellectual property of producers and the massive use of the official geoinformation under free or commercial licenses according to specific cases;
- *Diffusion of geoinformation* – Guaranteeing the completeness, accuracy and accessibility of public information; and
- *Delivery, exchange and commercialization of spatial information* – Determining roles and the mandatory release of spatial information as a state good and under established standards.

With a view to regulating processes of production, acquisition, documentation, access and use of statewide geographic information, the National Council of Economic and Social Policy of the Republic of **Colombia** (CONPES) approved Document No. 3585, *Consolidation of the National Policy of Geographic Information and the Colombian Spatial Data Infrastructure – ICDE* (CONPES, 2009). This policy establishes the mandatory use among state entities of the official GI, produced by responsible institutions according to their functional missions. In addition, it specifies the need for special agreements for generating new geographic information, which will be negotiated between the counterparts when the required information is not available. The policy also regulates the use of the Reference System MAGNA-SIRGAS, as has been adopted by Colombia. The National GI Policy of Colombia embraces the following issues:

- Use of the official core GI
- Coordination of GI generation
- Production and custodianship of GI
- GI standardization and documentation

- Consolidation of the National Image Bank
- Use of mechanisms designed for GI access
- Promotion of effective use of resources for GI production
- Ownership of GI property
- Guarantee of intellectual property, security and quality of GI
- Harmonization of SDIs at all levels
- Promotion of a culture for GI use

According to *Article 4 of the Supreme Decree No. 28* issued in **Chile** in 2006 (Ministerio de Bienes Chile, 2006), the National System of Coordination of Territorial Information (SNIT) is responsible for advising the Territorial Information Policy Management. The following policy guidelines are used:

- Permanent communication on the new territorial information with public characteristics produced and managed by public providers;
- Publication of the characteristics (metadata) of the territorial information produced and managed by public institutions;
- Compliance with the standards established by the SNIT, in coordination with the Chilean Space Agency and other pertinent Chilean standardization bodies;
- Information exchange free of charge among public institutions (excluding public institutions approved for selling) when this information is built through fiscal budgets; and
- Guarantee of the knowledge by citizens about the available public territorial information and the conditions of its access.

Policy terms and conditions for the use of geographical data from the Spatial Data Infrastructure of **Uruguay** (IDE-Uruguay) are defined by the Agency for Electronic Government and Information Society (AGESIC, 2011) regarding the following issues:

- *Information source* – Covers public institutions within the context of IDE-Uruguay;
- *Use of data*: Public, open and free use is possible, but all types of commercialization are forbidden;
- *Quality of information* – Due to the variety of data sources, no responsibility is assumed for possible consequences derived from their use;
- *Treatment of information* – Diffusion associated with information contained in the geographic data set (i.e., metadata) should include the appropriate reference to AGESIC, the conditions of use, date and version, as well as the notification of modifications made by users;
- *Responsibility of user* – The user will be responsible for the use of geographic data and the products obtained from them;
- *Updating* – Updating processes can take place on the geographic data without previous notification to users;
- *Refusal of access* – The refusal of access is possible if in the public interest, or if required by any statute; and

- *Safeguarding* – Any direct or indirect use of geographic data to generate or provide services, applications and publications to users must be subject to the acceptance of these terms and conditions.

In **Canada**, a complete CGDI is designed to include not only strategic policies, but also a comprehensive suite of spatial operational policies, fully supported and available for adoption and implementation by CGDI's national stakeholders. The topics involved with these operational resources include the following:

- Liability
- Data Quality
- Privacy
- Confidentiality, Sensitive Information and Security
- Intellectual Property and Licensing
- Archiving and Preservation
- Data Sharing and Integration
- Cloud Computing
- Volunteered Geographic Information (VGI)

7.4 Policy Issues

The following sections provide a brief discussion of the issues that have engendered development of some of the most common policies, and examples of good policy development practice.

7.4.1 Data Production

Since framework data is one of the pillars of most SDI development projects, its production and ongoing maintenance have typically assumed prominence. In circumstances where the responsibility for framework data lies entirely with one organization (e.g., the National Mapping Organization (NMO)), policy instruments are not usually required. On the other hand, when such responsibility lies with a number of data custodians, policies may be required to ensure that the data is created and revised by all in accordance with common specifications and rules. Such is the case with the GeoBase framework data product, which is the joint responsibility of **Canada**'s NMO, Natural Resources Canada, and its provincial/territorial counterparts. Two instruments were created as GeoBase data production policies:

- *Canadian Geomatics Accord* – The aforementioned strategic policy that establishes high-level commitment to GeoBase production and ongoing maintenance; and
- *GeoBase Principles, Policies and Procedures* – The operational policy document that reflects the decisions made by the Canadian Council on Geomatics (CCOG) related to the development and direction of GeoBase (Mepham, 2008).

A similar type of distributed data production and maintenance environment exists in **Australia**'s State of Victoria, where responsibilities for specific data layers or themes have been assigned under the Victorian Spatial Information Framework to multiple data custodians. The *Spatial Information Custodianship Guidelines* policy document provides an overview of the Framework's spatial information management principles and a detailed practical guide to the implementation of custodianship by data custodians (Victorian Spatial Council, 2009).

7.4.2 Data Sharing and Integration

Spatial data infrastructure initiatives to facilitate data sharing and integration are in keeping with the broader open data movement, in which common goals are as follows: removing restrictions on use and dissemination, disseminating works at minimal or no cost, and improving public use and access in the public interest. Spatial data sharing is the transfer of location-based information between two or more organizations. Data sharing can take many forms, from sharing metadata to sharing individual data layers, to sharing complete databases. Data integration can be described as the process of matching different data sets geometrically and topologically and of establishing the correspondence of attributes to create a new product that is richer in content than in the original sources (Mohammadi, Rajabifard, & Williamson, 2009).

Data Sharing Principles

The full and open exchange of spatial data is grounded within a context established by important principles of data sharing, such as the following (GeoConnections, Hickling Arthurs Low Corporation, 2012a):

- *Simplicity* – Data sharing arrangements should be simple to understand and designed to minimize compliance costs. The application of consistent approaches (such as using common data sharing templates) will contribute to simplification of data sharing arrangements.
- *Non-exclusivity* – Data sharing arrangements should be structured so that parties are not excluded due to their lack of detailed knowledge of the spatial domain, lack of familiarity with the data and associated technology, or inability to pay.
- *Fairness* – Data sharing should be undertaken on terms that are fair to all parties, with terms in agreements recognizing the benefits of the sharing arrangement to both the provider and user of the information, including benefits to third parties.
- *Non-discrimination* – Terms should be extended fairly to all parties for similar uses of the data so that, for comparable data uses, some users do not receive benefits that are not available to others.
- *Acknowledgment and attribution* – In all cases, the users of the shared data should acknowledge and attribute the source(s) of the data integrated within their products. Such transparency is particularly critical if the recipient of the shared data is charging for the derived data products, in which case prospective buyers are in a better position to judge the appropriateness of the product fees.

- *Transparency* – Organizations should demonstrate that they are committed to the full and open exchange of spatial data by proactively communicating their data sharing policies and making the terms of data sharing as accessible to potential users as possible.
- *Promptness* – Users should be provided with access to the shared data in the shortest time possible, and no longer than is absolutely necessary to exercise effective quality control. Use of simplified, standard terms will facilitate the process.

Data Sharing Challenges

While the success of SDI is built upon the principle of data sharing, organizations often encounter barriers and challenges even though they want to share their data and integrate others' data with their own (GeoConnections, Hickling Arthurs Low Corporation, 2011b). For example, **cultural and institutional norms** within communities and organizations may influence individuals' willingness to share their data assets. This is particularly true within Aboriginal communities, where there is considerable sensitivity around sharing indigenous traditional knowledge with external communities or researchers. This barrier also exists in the health care and finance sectors, where there are concerns about the potential linkage of such information with geography giving rise to privacy infringement. In other instances, organizations may be particularly risk-averse, have had bad experiences with depending on other organizations' data, or be concerned about exposing data of a substandard quality to a broader user base.

Another potential barrier may be **legislative requirements** of the jurisdiction (i.e., nation, province, state, municipality, etc.) that prevent data sharing or release to the public (e.g., intellectual property rights, protection of personal or confidential information, and state secrets or national security). While in most cases it may be legally permissible for a government body to share spatial data sets, organizations need to ensure compliance with any legislation that may apply to a specific type of data. The **policy environment** within which individuals work can also create obstacles to spatial data sharing. In some cases, explicit policies discourage data sharing because of concerns about the inability to prevent data misuse or liability claims, uncertainty about the accuracy or fit for use of data, revenue generation requirements, and so forth. In other instances, lack of policy can be an inhibitor. When organizational members are uncertain about the data policy and fearful of making a mistake, unsure of the intellectual property implications, or do not have access to the tools to facilitate effective data sharing, they often err on the side of data protection and withholding.

Data sharing and integration efforts can also face a myriad of **technical challenges**. For example, a GeoConnections study to examine good practices in spatial information integration, based on case studies in four communities of practice, identified the following common challenges (GeoConnections, Hickling Arthurs Low Corporation, 2008c):

- *Standards* – Inconsistency in data standards between organizations wishing to share or exchange data, or a complete absence of such standards;

- *Web services* – Incomplete or poorly functioning implementation of Web services standards in commercial software products; and
- *Security* – Concerns around the ability to cost-effectively prevent unauthorized users from accessing private or confidential information.

Other common technical barriers to data sharing and exchange are as follows: lack of semantic interoperability, as a result of semantic differences between data sets that have different feature definitions; differing quality specifications; differences in datum, projections and coordinate systems; multiple raster and vector formats; and different data models (Mohammadi, Rajabifard, & Williamson, 2009).

Data Sharing Arrangements

Spatial data sharing and exchange arrangements can cover a broad spectrum but fall generally into the following categories:

- *Data sharing from one provider to many users* – The most common, and typical for government mapping agencies whose mandate is to disseminate their data to the broadest possible audience, usually at no or minimum cost and with no or limited restrictions on reuse;
- *Data sharing from one provider to one user* – Typically used within a project context, often includes specific conditions on use of the data provided, and may include payment for the data provided;
- *Data exchange between two providers* – Confers mutual benefits on the data providers, where each generally receives updates made by the receiving party to the data provided, and may include financial compensation to the contributing party; and
- *Data exchange between multiple providers* – Can be in the form of a data cooperative or exchange, in which all parties provide data and have access to the data contributed by the other parties, or a cooperatively created and maintained data set or product.

These arrangements can be formalized by using the following types of instruments (GeoConnections, Hickliing Arthurs Low Corporation, 2011b):

- *Non-contractual* – Typified by the use of a more general type of non-binding **data sharing agreement** to cover the sharing or exchange of data between organizations where there is normally no exchange of funds, with the agreement clearly stating the terms and conditions (can also be referred to as a Memorandum of Agreement or Understanding, or Letter of Agreement or Understanding);[18] and
- *Contractual* – Typified by a binding contractual **licensing agreement** (see Section 7.4.6) or a **service level agreement** between a service provider and customer, with the agreement

[18] The research demonstrates that the terms “Data Sharing Agreement,” “Memorandum of Understanding,” “Memorandum of Agreement,” “Letter of Understanding” and “Letter of Agreement” are often used interchangeably. While the format may vary (e.g., letters tend to be shorter and use less formal, legalistic language), the intentions are common–to establish a written understanding of the terms under which data are to be shared or exchanged between the signatories.

establishing a common understanding about services, priorities, responsibilities, guarantees and warranties, and detailing the nature, quality, and scope of the service to be provided, usually in measurable terms (e.g., associated with provision of data access through Web services).

National Data Sharing and Integration Policy Initiatives

Data sharing and integration is a widespread concern, and a number of jurisdictions are taking action to eliminate barriers. For example, the **European Union** report *Good practice in data and service sharing* (European Commission, 2010) provides examples of existing good practices on data sharing for three scenarios: for Member States with the Community institutions and bodies, between Member States, and between public authorities within a Member State. Practices across Europe and in several other countries were examined and the report covers the following topics considered particularly critical to a successful data and service sharing arrangement:

- Coordination (of data and service sharing)
- Framework agreements
- Transparency (on the data)
- Licences
- Charging mechanisms
- Public access
- Emergency use
- Third party data

Practices were examined against the following criteria that were considered critical for successful data sharing:

- A clearly defined and well-communicated policy for coordination
- Measures for efficient communication between stakeholders
- Clear and transparent information to existing and potential new stakeholders
- Measures for effective sharing across levels of government
- Practical support provided
- Administrative and technical infrastructures provided

The **Canadian** *Good Practices in Regional-Scale Information Integration Final Report* (GeoConnections, Hickling Arthurs Low Corporation, 2008c) presents analysis from detailed case studies of four GeoConnections-sponsored projects to identify good practices for organizations seeking to share geospatial data. It also highlights success factors for the further deployment of the CGDI and makes recommendations on how to accelerate the delivery of trusted applications and data to end users through collaborative frameworks.

The **Australian** *Data Access and Management Protocol* (ANZLIC – the Spatial Information Council, 2003) was developed to "support a cooperative and consistent Australia-wide approach to data access and management." This guideline describes access, ownership, custodianship, archiving and updating arrangements for data collected, developed for and used in partnership projects. It intended to ensure consistency with protocols, standards and guidelines for the development of an Australian Spatial Data Infrastructure. The Protocol references the agreed upon principles for data management in Australia and identifies two categories of access to data:

- *Community access* – Allows use by other parties and the public if the copyright interests of the owner(s) are protected, at no charge for data viewing and downloading over the Internet; and
- *Restricted access* – Confidentiality and use provisions apply and data are available to the parties only by agreement of the data owner(s) under conditions outlined in a license agreement.

The Protocol also includes provisions on data archiving, metadata, data maintenance and updates, and standard conditions in project data funding contracts and agreements, as well as the *Model Licence Agreement for the Supply of Data Categorised as 'Community Access'.*

The overall purpose of the **United States** *Policy Statements for Federal Geographic Data Sharing* (FGDC, 1992) is to facilitate full and open access to federal geographic data by federal users and the general public. They were prepared to be consistent with the goals of the Federal Geographic Data Committee, *Office of Management and Budget Circular A-16*, the *Data Management for Global Change Research Policy Statements*, and the proposed revision of *Office and Management and Budget Circular A-130*. The Policy Statements stress the following: importance of the entire information management life cycle; the use of international standards; maximizing the usefulness of the data while minimizing the cost to government and the public; and setting use charges for data products at a level no higher than the cost of dissemination.

In **Brazil**, as provided by article 3 of *Decree No. 6666/08* (Planalto, 2008), the sharing and dissemination of geospatial data and metadata is obligatory for all agencies and entities of the federal Executive Power and is voluntary for agencies and entities of the state, county and municipal executive authorities. An exception to this obligation is information the secrecy of which is vital to the society and State security, in accordance with article 5, subsection XXXIII, of the *Constitution* and *Law no. 11.111 of May 5th, 2005*. The geospatial data available in the Brazilian Directory of Geospatial Data (DBDG) from the federal, state, county and municipal bodies and entities are accessible through the SIG Brazil, freely and without tax, to properly identified users.

7.4.3 Privacy

Concerns have arisen in a number of jurisdictions that the increasing utilization of spatial data is impinging on individual privacy, which typically has legislated protection under privacy and personal information protection laws. The key issue is the potential for the combination of disparate streams of personal information with (seemingly) non-identifying spatial information to result in the development of very detailed profiles of individual behavior (GeoConnections, Canada Privacy Services, 2010). There are three potential areas of concern:

- *Spatial privacy* – The invasion of a person's privacy through the use of spatial imaging (e.g., satellite, airborne or street-level images);
- *Location tracking* – Location-based information about individuals enabling the tracking of their movements either in real time or over a specific time period (e.g., GPS coordinates, property ownership/title records); and
- *Re-identification of persons* – The emerging challenges presented by the possible combining of publicly available and privately held data layers or types with geographic coordinates.

The **Australian** *Spatial Information Privacy Best Practice Guideline* (ANZLIC - The Spatial Information Council, 2004) has the following aims:

- *To ensure each government agency is confident that any personal information shared with another will continue to be protected to the same or a higher standard;*
- *To encourage good privacy practices throughout the spatial information industry; and*
- *To build community trust in our commitment to protect privacy*.

Good Practice

The **Geospatial Privacy Awareness and Risk Management Guide for Federal Agencies** *was developed by GeoConnections with the following objectives in mind (GeoConnections, Canada Privacy Services Incorporated, 2010):*

- *Define key terms that are of relevance to the issue of privacy in a geospatial context;*
- *Provide a brief background concerning the development of geospatial information;*
- *Assess the privacy impacts of geospatial information;*
- *Examine the legal and policy environments within which dealings with geospatial data by federal government institutions take place;*
- *Explore the meaning of "personal information" at law and assess whether the point(s) at which geospatial information becomes personal information can be accurately identified;*
- *Furnish guidelines for identifying and mitigating privacy-related risks and issues arising from the collection, use, retention, disclosure and disposition of personally identifiable geospatial information; and*
- *Communicate the results of the inventory of a sample of geospatial data sets held by federal government institutions, which revealed insights relating to the collection and dissemination of geospatial personal information.*

The target audience for these privacy guidelines was public sector agencies that are custodians of or that collect, maintain or distribute information with a spatial content. For the purposes of the Guideline, personal spatial information was defined as "information combined with, linked to or contained within any spatial object or location. Examples include a person's name linked with their address, or the linking of a mobile phone owner's name, mobile phone number, and the geographical 'cell' within which the phone is being used."

The **United States** *FGDC Policy on Access to Public Information and the Protection of Personal Information Privacy in Federal Geospatial Databases* (FGDC, 1998) endorses public access to information and appropriate protections for the privacy and confidentiality of personal information in federal spatial databases. The policy applies to all federal spatial databases from which personal information is retrieved. Such databases may be considered systems of records subject to the Privacy Act of 1974. The policy specifies the actions that federal spatial agencies should take to ensure compliance with the Privacy Act.

De-identification Practices (Electronic Health Information Laboratory, 2012) is part of the **Canadian** Electronic Health Information Laboratory, which is a knowledge base that compiles articles, recommendations and tutorials for handling privacy and confidentiality concerns, especially as they apply to public health. This online resource is a "Frequently Asked Questions" style collection of articles describing data risks and challenges in the public health sector, as well as tools and actions that can be used to manage these issues, including data "anonymization."

7.4.4 Confidential / Sensitive Information and Security

Good Practice

Good practices to deal with the factors that influence **data confidentiality or sensitivity** *include the following (GeoConnections, AMEC, 2010):*

- *Review organizational data sets on a periodic basis to determine whether the context has changed over time;*
- *Ensure a full understanding of the implications and, in many cases contradictions, of the regulatory environment;*
- *Be aware of how adjacent jurisdictions view the sensitivity of the same information;*
- *Ensure understanding of any confidentiality associated with the data whether it is explicitly stated in an agreement or implicit in the economic implications of the information;*
- *Establish clear definitions of roles and responsibilities so that personal views can be eliminated from the assessment process; and*
- *Apply standards and processes by which spatial data can be consistently assessed as to its sensitivity.*

Similar to privacy concerns, the protection of confidential business or sensitive[19] information and the related security risks are potential inhibitors to the use of SDI. Here are some factors that influence the confidentiality or sensitivity of data (GeoConnections, AMEC, 2010):

- *Context* – Influenced by time and recent events, the context in which data sensitivity or confidentiality is determined depends on circumstances. For example, heightened awareness of the vulnerability of critical infrastructure, partly as a result of the 9/11 disaster, resulted in restricted access to many types of data in the US that were not previously considered sensitive.
- *Regulatory Environment* – In addition to the legislation related to privacy and personal information protection mentioned in the previous section, organizations may be bound by other acts, regulations or policies. Examples include legislative measures dealing with species at risk or endangered species, clean water, wetlands and other critical habitat, and archeological sites.
- *Jurisdictions* – The interpretation of data sensitivity varies between jurisdictions. For example, the abundance of a species can vary quite drastically over its range, with the result that a species that is abundant in one jurisdiction may be endangered in a neighboring jurisdiction. Researchers could consequently find themselves with very detailed species location data in one area and very generalized information in another.

[19] The term "confidential business or sensitive" refers to geospatial data that may be considered restricted for purposes of dissemination (e.g., because it could provide the user with a business advantage, or threaten national security, endanger threatened species or expose culturally sensitive sites) and therefore require some form of safeguarding.

- *Competition* – An issue of significance to the private sector is the release of information provided by private sector bodies to government that could put them at a competitive disadvantage. Examples of such information include address information, land base mapping and associated orthophotography, forest inventories and mineral exploration areas.
- *Roles and responsibilities* – The views of the individuals involved will always influence sensitivity assessments. Personal biases such as reluctance to share for fear of data misuse, or premature data release that infringes on research publication rights can give rise to claims of data "sensitivity." Clear roles and responsibilities for data sensitivity assessment are critical.
- *Risk management* – Potential negative impacts of releasing the data could include inappropriate use of the data, unauthorized release of data, and infringement on privacy. The resulting risks to the organization are legal or disciplinary fallout from violation of the organization's regulatory governance, and loss of organizational or database credibility.

The **Canadian** *Best Practices on Sharing Sensitive Environmental Geospatial Data Version 1.0, 2010* (GeoConnections, AMEC, 2010) seeks to educate data contributors, custodians, stewards and consumers about the issues and concepts associated with protecting, sharing and utilizing sensitive spatial data. It offers practical guidance to those interested in developing their own sensitive environmental spatial data sharing policies and protocols, particularly in the environment and sustainable development community. It will also help readers to recognize the potential impact on the credibility of organizations if sensitive data is mistreated.

The **Canadian** *Mapping for Preparedness: A Guide to Improved Emergency Management through Location-Based Solutions* (The Conference Board of Canada, 2009) report examines the use and potential of location-based information in emergency management practices. Further progress in enhancing emergency management with spatial infrastructure data faces two important challenges: a deficit in necessary awareness in the value of spatial data and a difficulty in gaining access to mostly privately held infrastructure data. To address these challenges, the report:

- Explains the role of location-based information in emergency management
- Helps Canadian organizations understand the value of sharing spatial data for the purpose of emergency management
- Presents approaches taken in other jurisdictions to foster information exchange
- Identifies and analyzes the barriers to public-private information sharing
- Identifies six strategies critical to achieving private sector engagement in the use of spatial information for emergency management

The **United States** *Guidelines for Providing Appropriate Access to Geospatial Data in Response to Security Concerns* (FGDC, 2005d) provide standard procedures to:

- Identify sensitive information content of spatial data that pose a risk to security
- Review decisions about sensitive information content during reassessments of safeguards on spatial data

The Guidelines provide a method for balancing security risks and the benefits of spatial data dissemination. In cases where safeguarding is justified, the Guidelines help organizations select appropriate risk-based safeguards that provide access to spatial data and still protect sensitive information content. Included is a procedure consisting of a sequence of decisions, which is illustrated in the form of a decision tree for providing appropriate access to spatial data in response to security concerns.

7.4.5 Intellectual Property

In the SDI context, protection of intellectual property (IP) rights is closely linked with licensing the right to use spatial data sets (see Section 7.4.6 for a fuller discussion of licensing). Intellectual property rights generally fall into three categories ─ copyright, trademark and patent ─ with only the first providing the means of protecting rights in spatial information[20] (GeoConnections, Hickling Arthurs Low Corporation, 2011c). Typically, copyright legislation will protect only “original works” (i.e., the work must not be copied and must be the result of an exercise of skill and judgment), and courts have found that, for example automated processes to harvest, sort or generate data may not meet the requirements of originality.[21] As a result, the copyright status of some spatial data compilations may be difficult to predict, and may only be fully known after a court decision.

The **Canadian** *IP Law Backgrounder* (GeoConnections, Hickling Arthurs Low Corporation, 2011c) outlines the three main areas of intellectual property: copyright, patent and trademark. Its purpose is to define each of these areas for stewards of spatial data and to focus on the relevance of each in protecting spatial data, information and products. The backgrounder first explains the difficulties in protecting confidential information under civil law, beginning with the assertion that spatial data is not inherently property. Protection of such data is difficult, if not impossible, when accessed by parties with no relationship to the data source and that are not bound by any contract. The paper also points to the trend of data compilers seeking to protect important information in the form of data compilations. The most commonly used form of protection is copyright law.

The Geospatial Digital Rights Management Reference Model document (OGC, 2007b) is a reference model for digital rights management (DRM) functionality for spatial resources published by the Open Geospatial Consortium (OGC). Its purpose is to give larger market access to spatial resources through a DRM mechanism that is easy to understand and similar to those already in use, and it defines:

- a conceptual model for digital rights management of spatial resources, providing a framework and reference for more detailed specification in this area;

[20] Copyright normally covers compilations of data such as databases, maps and charts, or georeferenced photographs and other documents and products, but not raw spatial data.
[21] *Telstra Corporation Limited v. Phone Directories Company Pty Ltd*., [2010] FCA 44, (see http://www.austlii.edu.au/au/cases/cth/FCA/2010/44.html).

- a metadata model for the expression of rights and associated information used in the enforcement and granting of those rights, such as owner metadata, available rights and issuer of those rights;
- requirements enforcement for rights management systems (these systems must implement only those restrictions necessary to enforce the rights defined, and must include measures sufficient to enforce those rights); and
- an implementation concept to facilitate the ubiquity of spatial resources in the general services market.

The **United Kingdom** *UK Location Data Sharing Operational Guidance Part 3 - Intellectual Property: Rights and Confidentialities in Data Publishing* (Department for Environment, Food and Rural Affairs, 2012) is the third part of the *UK Location Data Sharing Operational Guidance* published under the *UK Location Strategy*. The document provides a general overview of intellectual property rights and contractual rights. It highlights three examples of good practice to show how different organizations deal with particular issues.

In accordance with the *National Direction of Author Rights* of the Interior and Justice Ministry of **Colombia**, CONPES Document No. 3585 (CONPES, 2009) establishes the guarantee of moral rights of authors and patrimonial rights of GI producer entities. It also establishes GI quality and security as part of the functions of producer entities, conforming to ICDE policies.

7.4.6 Licensing

The formal sharing or dissemination of data under a contractual instrument is typified by the use of a **licensing agreement**, under which the owner of the data allows a licensee to use, make or sell copies of the original data. The agreement usually limits the scope or field of the licensee. It specifies whether the license is exclusive or non-exclusive, and whether the licensee will pay royalties or some other consideration in exchange. Licenses fall into four general categories, summarized in Table 7.1 (GeoConnections, Hickling Arthurs Low Corporation, 2012a).

Table 7.1: Types of Licensing Agreements

Name	Purpose	Conditions
Licensing Agreement A: No-Cost Data Access with No Restrictions	For sharing of data under licensing terms, where there are no restrictions on the use of the data and no fees are to be paid to the licensor	No conditions attached to the use of the data
Licensing Agreement B: Fee-Based Data Access with No Restrictions	For sharing of data under licensing terms, where there are no restrictions on the use of the data and fees are to be paid to the licensor	No conditions attached to the use of the data

Name	Purpose	Conditions
Licensing Agreement C: No-Cost Data Access with Restrictions	For sharing of data under licensing terms, where some restrictions on the use of the data apply and no fees are to be paid to the licensor	Typical conditions: • Intended use(s) stated • Disallowed use(s) stated
Licensing Agreement D: Fee-Based Data Access with Restrictions	For sharing of data under licensing terms, where some restrictions on the use of the data apply and fees are to be paid to the licensor	Typical conditions: • Intended use(s) stated • Disallowed use(s) stated

The **Canadian** *Dissemination of Government Geographic Data in Canada – Guide to Best Practices, Version 2* (GeoConnections, 2008) provides an integrated framework of recommendations for geographic data dissemination and the licensing models commonly used in Canada for geographic data. The Guide provides clear guidance to assist licensing practitioners in selecting the most appropriate model and licensing agreement for their purposes. The document also recommends approaches to fundamental concepts such as ownership of intellectual property, liability, duration and termination, and documentation as guided by data dissemination policy directives currently in force across federal departments and agencies. The GeoBase framework data in Canada is released under the GeoBase Unrestricted Use License Agreement,[22] an example of Licensing Agreement A in Table 7.

The **United Kingdom** *UK Location Data Sharing Operational Guidance Part 2 – Licensing and Charging* (Department for Environment, Food and Rural Affairs, 2011) guidance document deals mainly with data sharing between public authorities, and sets out how data sharing will operate in that area. Its purpose is to establish the *UK Government Licensing Framework (UKGLF)* as the basis for licensing the use of data sets published in UK Location, explain the policy and provide practical solutions for licensing, and describe the circumstances in which charges may be made under the INSPIRE Regulations. The *Open Government License (OGL)*[23] is the default license for location data where no further restrictions, conditions or charges are required, another example of Licensing Agreement A. License models within the UKGLF to meet UK Location needs are under development. In the meantime, the guideline provides good practice sample clauses that can be adapted to meet specific needs.

The Military Geographic Institute (IGM) of **Ecuador,** by means of *Resolution No. IGM-e-2011-04* dated April 4, 2011, established the release of 204 sheets of digital cartography at 1:50,000 scale, version 2.0 (SHP format), based on the *IGM Feature Catalogue Version 4.0* (Military Geographic Institute of Ecuador, 2011). Other data releases have also been done in JPG format

[22] See http://www.geobase.ca/geobase/en/licence.jsp

[23] The OGL is a licensing model that encourages the use and re-use of a broad range of public sector information, including location data, at no cost to the user or re-user.

(e.g., the Geographic Map of Ecuador at 1:500,000 scale and the City Map of Guayaquil at 1:6,000 scale) (IGM Ecuador, 2012). Free information is accessible and downloadable directly from the IGM GeoPortal under a "Free Access and Use of Geographic Information" License.[24] Since the acquired data cannot be redistributed or used for the production of value-added products, this is an example of Licensing Agreement C in Table 7.

The National Council of Economic and Social Policy of the Republic of **Colombia**, in its Document 5535 (CONPES, 2009), mandates the release of GI services containing public information, according to international and national standards. Recognizing that the Colombian State is the owner of GI produced or acquired by public entities, its use for institutional purposes is allowed at the costs associated with administration, maintenance, reproduction and distribution. Colombia's main spatial data provider, the Instituto Geográfico Agustín Codazzi (IGAC), has provided access to its basic information through Colombian Spatial Data Infrastructure (ICDE) since 2011. So far, the basic cartography at 1:100,000 and 1:500,000 scales are available, as well as national level thematic maps of soils, land cover and land use (1:100,000), and the Ecosystems Map (1:500,000).

The Military Geographical Institute of **Chile** is the provider of most of the SNIT's basic information. In accordance with its self-financed orientation, the Institute has implemented a business mechanism consisting of distribution of its 1:50,000 scale map among public institutions with a 10% royalty. The Ministry of Public Works made the first investment, purchasing the maps at this scale for the whole country at the original price.

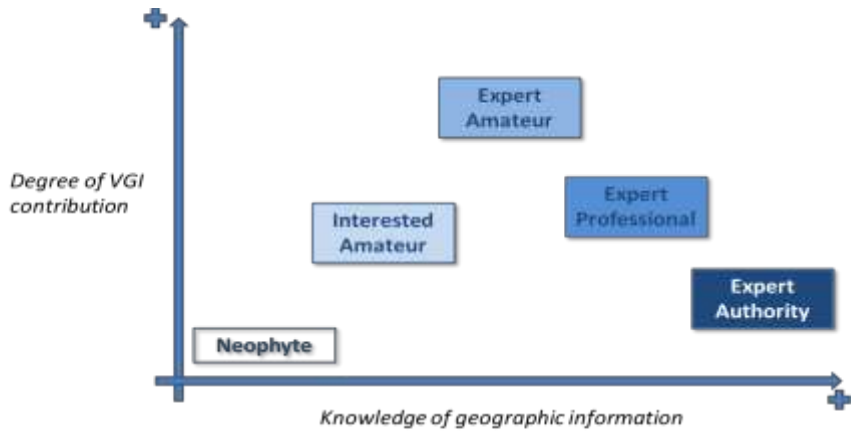
7.4.7 Volunteered Geographic Information

Volunteered geographic information (VGI) can be described as an application of user-generated content on the Internet in the spatial information domain. Using VGI to help create or maintain spatial data sets is a rapidly growing trend. While there has been a history of interested individuals offering geographic input and feedback to authoritative spatial data producers and communities of interest (e.g., environmentalists, land use planners), VGI involves the community, playing a much more organized and influential role. The term coined for such contributors, "producers" (Produsers.org, 2007) (Coleman, Georgiadou, & Labonte, 2009), signifies that VGI participants are typically users of online geographic information who want to improve the content by submitting notices of changes to, and errors in, the data.

The range of VGI contributors is fairly broad. The overlapping categories into which they can be subdivided, based on relative knowledge of geographic information, can be described as Neophyte, Interested Amateur, Expert Amateur, Expert Professional and Expert Authority (Coleman, Georgiadou, & Labonte, 2009). As illustrated in Figure 7.2, the patterns of contribution of VGI content to date have not necessarily been in relative alignment with levels of knowledge on the subject.

[24] See http://www.geoportaligm.gob.ec/portal/recursos-1/cartografia-gratis/licencia-de-uso-de-la-informacion-geografica

Figure 7.2: Spectrum of VGI Contributors



Source: Volunteered Geographic Information (VGI) Primer

Policy-related concerns associated with VGI use in an SDI context include the following (GeoConnections, Hickling Arthurs Low Corporation, 2012b):

- *Data Quality* – Typically, concerns include four quality aspects: positional and attribute accuracy, completeness of data, currency of data and credibility of data sources (Coleman et al., 2010). A number of methods are being employed to assess source credibility (e.g., independent confirmations of contributed data, algorithms and automated methods). Different approaches are required for quality control of VGI contributions.
- *Legal* – To avoid potential problems with **copyright**, contributors are normally required to guarantee that they have all necessary rights in the works that they contribute. They must also indemnify the host site for any law suits that may arise relating to the contributed materials. Where data is sourced from other data providers, conflicting terms in those organizations' data **licences** may need to be resolved. Recipients of VGI contributions also have an obligation to protect the **privacy** of their contributors. VGI user organizations could incur **liability** in several circumstances (e.g., unauthorized use of copyrighted data that is contributed by another data supplier, contravention of privacy legislation or regulations, or use of erroneous data contributed by someone with malicious or criminal intent).

> **Good Practice**
>
> **Procedural and cultural changes** *that may be necessary with VGI use (Coleman et al, (2009):*
>
> - *Acceptance of and respect for rules imposed by contributor communities (e.g., quick acceptance and use of contributions, crediting of source);*
> - *Toleration of contributor community's values taking precedence over traditional practices and policies (e.g., releasing some control to "the crowd" over decisions about whether or not to post a contribution);*
> - *Acceptance of data produced through VGI as a perpetually unfinished artefact (i.e., authoritative geo-information in a state of constant imperfection and fluidity);*
> - *Balancing the rights of individual contributors, the contributor community and the producer organization;*
> - *Shift of the planning and production focus from a "coverage-based" to a "feature-based" orientation;*
> - *Shift from production of data to filtering of data contributions; and*
> - *Evolution to a mix of professional quality controllers and networks of informed data consumers for quality control.*

- *Archiving and Preservation* – Organizations need to consider these potential future demands on their data in planning their VGI initiatives. For example, changes in mapped features over time may be of interest to researchers, or identification of the state of an organization's data sets at a particular point in time may also be required for legal purposes (e.g., Electronic Discovery (eDiscovery) processes).
- *Security* – Opening spatial applications to contributions through VGI can result in some unique security challenges (e.g., malicious attacks such as SQL[25] injection and cross-site scripting). Good data management practices such as user authentication procedures are essential.

The **Canadian** *Volunteered Geographic Information (VGI) Primer* (GeoConnections, Hickling Arthurs Low Corporation, 2012) introduces key issues in spatial operational policy that are imperative to the success of any venture into VGI. It provides readers with a better understanding of the emerging trend of VGI and areas of related operational policy, briefly described above. The consideration of all these issues is informed by good practices research and case studies of three examples of VGI in operational use.

Good Practice

Here are 10 characteristics of a **good digital preservation repository** (Center for Research Libraries, 2007)*:*

- *Commits to continuing maintenance of digital objects for identified community/communities;*
- *Demonstrates organizational fitness (including financing, staffing structure and processes) to fulfill its commitment;*
- *Acquires and maintains requisite contractual and legal rights and fulfills responsibilities;*
- *Has an effective and efficient policy framework;*
- *Acquires and ingests digital objects based on stated criteria that correspond to its commitments and capabilities;*
- *Maintains/ensures the integrity, authenticity and usability of digital objects it holds over time;*
- *Creates and maintains requisite metadata about actions taken on digital objects during preservation as well as about the relevant production, access support, and usage process contexts before preservation;*
- *Fulfills requisite dissemination requirements;*
- *Has a strategic program for preservation planning and action; and*
- *Has technical infrastructure adequate to continuing maintenance and security of its digital objects.*

A collaborative prototype of a VGI application was developed as part of the GeoPortal Vicosa Digital, in a municipality of Minas Gerais in **Brazil** (Silva Miranda, 2010). As part of this effort, a collaborative database was prepared and made available to users, with the aim of facilitating collaboration. The application allows contribution registration, management and integration. Reputation management mechanisms were also implemented. As a result, a municipal SDI has been expanded with collaborative contributions.

7.4.8 Data Archiving and Preservation

Long-term access to the wealth of data within SDIs will be compromised unless policies and procedures are created and implemented by spatial data custodians to ensure their preservation and continued availability. Research has shown that spatial data preservation policies currently in

[25] Structured Query Language

place are inconsistent, or even non-existent, and do not address the wide range of information management issues created by the digital environment (Brown & Welch, 2006) (GeoConnections, Hickling Arthurs Low Corporation, 2011d). In addition, there is very little guidance on how to go about spatial data archiving and preservation in a digital environment characterized by very rapid changes in data. Some of the key challenges and approaches for dealing with them are shown in Table 7.2 (GeoConnections, Hickling Arthurs Low Corporation, 2011d).

Table 7.2: Key Spatial Information Archiving and Preservation Challenges and Potential Solutions

Challenges	Potential Solutions
Identification of legislative requirements for archiving and preserving spatial data	Conduct a thorough review and analysis of all acts, regulations and policies that relate to spatial information, and to different parts of the information management life cycle, to determine the type and extent of data assets that may require archiving and preservation treatment.
Joint creation of data sets by organizations at different government levels that may have conflicting archiving and preservation requirements	Incorporate specific provisions for data archiving and preservation within agreements for the co-creation of digital spatial data sets, including processes to examine and resolve any associated intellectual property and copyright issues.
Determination of the appropriate frequency of dynamic digital data capture for archival purposes	Include the following in user needs assessments: the users' requirements for long-term access to data, and the applicable periods or intervals, for operational, scientific research or other purposes.
Decision-making on the best approach to spatial data preservation and archiving - centralized or distributed	Consult with data custodians to reach consensus on the preferred approach (i.e., archiving and preservation of data closest to source (distributed model) or consolidation in one archive (centralized model)). Depending on the approach chosen, consider creating either a centralized or distributed spatial data archive hub as an SDI service.
Lack of formal guidance and processes for spatial data archiving and preservation	Consult with the key stakeholders and experts in a collaborative effort to develop a spatial data archiving and preservation policy and guidelines, as part of an overarching spatial data records management policy based on a life cycle model.
Lack of comprehensive operational models for spatial data archiving and preservation	Develop an operational model for use by spatial information producers in integrating archiving and preservation into ongoing information management operational environments, based on detailed investigation of good practices.

National Archiving and Preservation Initiatives

Research for the preparation of this manual uncovered only very limited information on digital spatial information archiving and preservation initiatives. The **Canadian** *Final Report: Geospatial Data Archiving and Preservation* (GeoConnections, Hickling Arthurs Low Corporation, 2011d) provides analysis and recommendations for producers and managers of geospatial information who are challenged with the increasing complexity and pace of records generated. It also offers analysis and recommendations on the issue of archiving and preserving Canadian Geospatial Data Infrastructure (CGDI) data assets and solutions for perpetual access. The report primarily assesses the presence or lack of specific clauses on the creation of geospatial data sets in fulfilling the acts and regulations referenced. The documents reviewed illustrate the diverse types of data available, associated software and systems used to manage this data, and the methods used to ensure the data is authentic.

Document No. 3585 of the National Council of Economic and Social Policy of the Republic of **Colombia** (CONPES, 2009) sets out a policy of *Production and Custodianship of GI* aimed at defining the responsibility of public entities with functional competence for the production and custodianship of fundamental data. Public entities are required to identify and exploit the production opportunities, cooperation and common use of the GI data frame, with the objective of sharing costs and avoiding duplication by improving the inter-institutional exchange. According to the goals of CONPES Document 3585/2009 (CONPES, 2009), a methodology to preserve and conserve geographic information is under development, and will conform to UNESCO and IFLA guidelines and take into account the preservation methodologies of IGAC and IDEAM (CCE, 2009).

7.4.9 Cloud Computing

Cloud computing provides flexible, location-independent access to computation, software, data and storage resources that are quickly and seamlessly allocated or released in response to demand. For spatial data and software providers, cloud computing represents a potential new way of doing business by providing lower cost or free options for clients to access products and services online. The "cloud" is poised to become the accepted place for a broader range of relatively unsophisticated spatial data users to access and use this powerful technology. However, based on research conducted in 2011, there are several policy-related concerns associated with cloud use in an SDI context. These are summarized along with possible risk mitigation strategies in Table 7.3 (GeoConnections, Hickling Arthurs Low Corporation, 2012c).

In a survey of 1,200 decision-makers conducted by Trend Micro in May 2011, 43% of those using a cloud computing service reported a data security lapse or issue that year (Trend Micro, 2011).

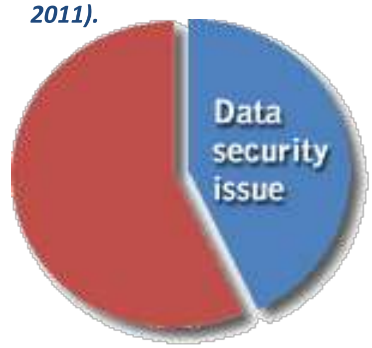


Table 7.3: Risks in the Cloud and Potential Mitigation Strategies

Risks	Mitigation Strategies
Security – The following security risks in the cloud have been reported: abuse and nefarious use of cloud computing by spammers, malicious code authors and other criminals; insecure application programming interfaces; shared technology vulnerabilities; data loss/leakage; and account, service and traffic hijacking.	▪ Opt for private clouds behind firewalls or on premises. ▪ Insist that data not be stored on public cloud servers located in jurisdictions where there are concerns about security breaches. ▪ Protect sensitive information by stripping off some attributes from the spatial data before sending them to the cloud. ▪ Implement security everywhere (e.g., encrypted transport into the cloud, secure coding and access control inside applications, and encryption at rest), rather than the normal perimeter approach to security. ▪ Ensure that all application programming interfaces (APIs) and data sources are checked with penetration tests[26] and thoroughly analyzed. ▪ Divide responsibilities between your administrators and the cloud provider's administrators so that no one organization has free access to all security layers. ▪ Develop a policy statement and training materials covering the types of information allowed on cloud computing services, and establish a process for conducting security reviews according to the policy.
Privacy and confidentiality – The following risks have been reported: variable terms of service and privacy policies; disclosure of information to a cloud provider; location of information in the cloud; laws obliging a cloud provider to examine user records; and intrusions into individuals' data, either accidentally or deliberately, for unauthorized purposes.	▪ Involve privacy staff in evaluating areas concern related to specific legislation, including information moving to the cloud, the proposed service delivery model, and the cloud provider's proposal before a contract award takes place.. ▪ Encrypt data prior to uploading it to the cloud. ▪ Employ hardware-based security initiatives, such as the Trusted Platform Module, that are designed to provide a remote user with the confidence that data submitted to a cloud computing provider is processed only according to an agreed policy. ▪ Beware of "ad hoc" cloud computing; have standardized rules in place so that employees know when and if they can use cloud computing and for what data.
Legal/liability – Risks include needing to accept contractual terms that favor the cloud provider in areas such as the following: safeguards against changes to the technical environment; warranties and indemnities for intellectual property rights; security, back up and disaster recovery obligations; and data protection and confidentiality provisions. In addition,	▪ Specify that the user owns the data and what happens to the data upon contract termination. ▪ Ensure that data is accessible and usable in case of interruption, litigation or bankruptcy, and agree in advance on data formats and retrieval costs. ▪ Request the right to audit performance levels under service level agreements. ▪ Clarify who bears the cost of data replication and indemnification for lost or deleted data.

[26] A method of evaluating the security of a computer system or network by simulating an attack from malicious outsiders who do not have an authorized means of accessing the organization's systems, and malicious insiders who have some level of authorized access (Wikipedia, 2012).

Risks	Mitigation Strategies
users need to ensure that they can fulfill their legal obligations to produce documents in case of litigation (e.g., proper preservation processes, responsive search methodologies and selection processes), which can be more complicated in a cloud computing environment.	▪ Ensure that appropriate data retention and destruction policies are agreed upon. ▪ Include specific clauses in contracts for mandatory data breach notification, and indemnification for inappropriate access, use, disclosure or transfer of personal information. ▪ Request the right to audit clauses and demand transparency of security and continuity of management programs. ▪ Request specific terms on how disputes are to be resolved and the details of the issue escalation process; **alternative dispute resolution** (ADR) is a good tool if multiple jurisdictions are involved.
Regulations – There is a risk that an organization may have limited cloud options due to the need to adhere to regulations around business continuity and disaster recovery, security standards (ISO 27001), logs and audit trails, and specific standards and governmental compliance requirements.	▪ Adopt a hybrid or community cloud solution to store different types of data in different cloud deployment options in order to ensure regulatory compliance.

There are at least two implications of the rapid growth in cloud adoption for SDI managers, especially when there are limited spatial knowledge management and processing skills in the organization(s) involved (GeoConnections, Hickling Arthurs Low Corporation, 2012b):

- *Demand for framework data* – Since many cloud clients will not have the technical skills or staff capacity to build, acquire and maintain their own base spatial data, they will rely on these data to be available as a service; and
- *Increased spatial functionality* – The need for thematic data (e.g., resource management, agriculture, environment, demographics, economics, education) and for additional spatial processing functionality will also grow.

If an SDI initiative is not well positioned to meet this demand with high quality and capacity Web services to deliver data and functionality, it risks being displaced by private entrepreneurs that move rapidly to fill the gap.

Good Practice

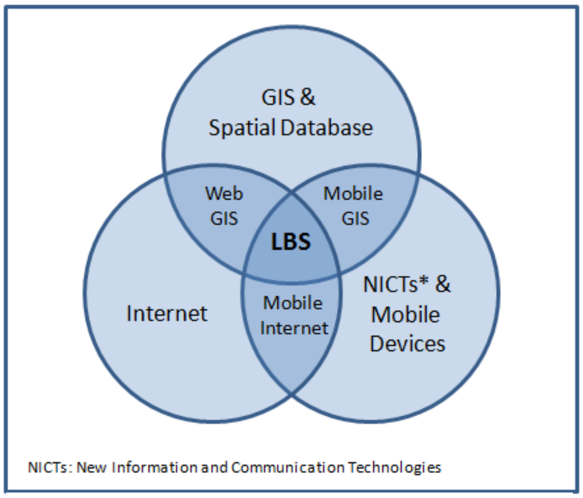
Use of a **Threat Risk Assessment (TRA)** *is an effective means of ensuring that the cloud computing risks are well understood. The TRA investigates such things as (GeoConnections, HAL, 2012b) the availability and continued operation of the cloud service, confidentiality and security of the key data, linkages with other external services/systems, and trust and cooperation of partners and users. In so doing, the TRA looks at the overall system and its deliverables, the clients, system components, application architecture, network architecture, user access control, security features of the hosting facility and the client facility, and the related IT standards and requirements in place.*

Based on this investigation, the TRA will then involve the following:

- *Sensitivity assessment – Note and evaluate each asset with respect to confidentiality, integrity and availability;*
- *Threat assessment – Identify and describe threats to the system and the potential impact on the confidentiality, integrity, and availability attributes of the information and assets;*
- *Vulnerability assessment – Examine the system for weaknesses or safeguard deficiencies; and*
- *Risk assessment – Quantify the degree to which a given risk is acceptable.*

7.4.10 Location-Based Services

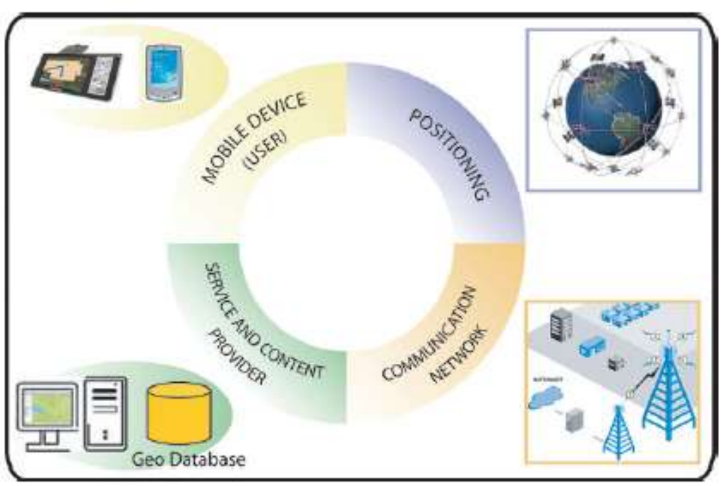
Location-based service (LBS) can be described as "information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device" (Virrantaus, Markkula, Garmash, & Terziyan, Developing GIS-Supported Location-Based Services, 2001). LBS can be viewed as the intersection of three technologies, as illustrated in Figure 7.3 (Brimiscombe, 2002). It is obvious that LBS is totally dependent on the improved geospatial information interoperability, accessibility and usability on the Internet that has occurred in the past five years.



Source: A.J. Brimicombe, 2002

Figure 7.3: LBS as an Intersection of Technologies

Although an LBS and a geographical information system (GIS) have similarities (e.g., handling of data with geographical reference and spatial analysis functions), the two geospatial information technologies have very different origins and users (Steiniger, Neun, & Edwardes, 2006). Whereas GIS was developed for professional users with extensive computing resources (first used in the mid-1960s), LBS was developed for non-professional user groups with restricted mobile computing devices (introduced in Japan in 2001). GIS has become the dominant technology in the geospatial sector, while LBS is an emerging technology in the mobile telecommunications sector. The basic LBS components are illustrated in Figure 7.4.



Source: Steiniger, Neun, & Edwardes, 2006

Figure 7.4: The Basic Components of LBS: User, Communication Network, Positioning, and Service and Content Provider

LBS Good Practices

The **Australian** *AMTA Guidelines: Location Service Providers. For the Use of Mobile Technology to Provide Passive Location-Based Services in Australia* (Australian Mobile Telecommunications Association, 2010) define the principles of good practice for providing LBS. The Guidelines are designed to provide advice to Location Service Providers (LSPs) about the consumer protection measures they should implement when offering location based services. They provide a framework to assist LSPs in appropriately assessing and managing the risk that the services they offer will be misused. They also provide additional guidance in implementing privacy protection in the use of passive LBS.

The **United Kingdom** *Industry Code of Practice for the Use of Mobile Phone Technology to Provide Passive Location Services in the UK* (Mobile Telecommunications Industry Working Group, 2006) focuses on "passive" location services and is designed to provide consumer (particularly child) protection measures that supplement the legal and regulatory requirements such as privacy and data protection legislation. It includes codes of practice for child location services, adult/friend location services, mobile games and similar services that are integrated with passive location services, and corporate location services.

The **United States** *CTIA – Best Practices and Guidelines for Location Based Services* (CTIA - The Wireless Association, 2010) are intended to promote and protect user privacy with a focus on the user whose location information is used or disclosed. Since there are many potential participants (i.e., LBS providers) who play a role in delivering LBS to users, a user perspective is adopted to clearly identify which entity in the LBS value chain must comply with the guidelines. The guidelines rely on two fundamental principles:

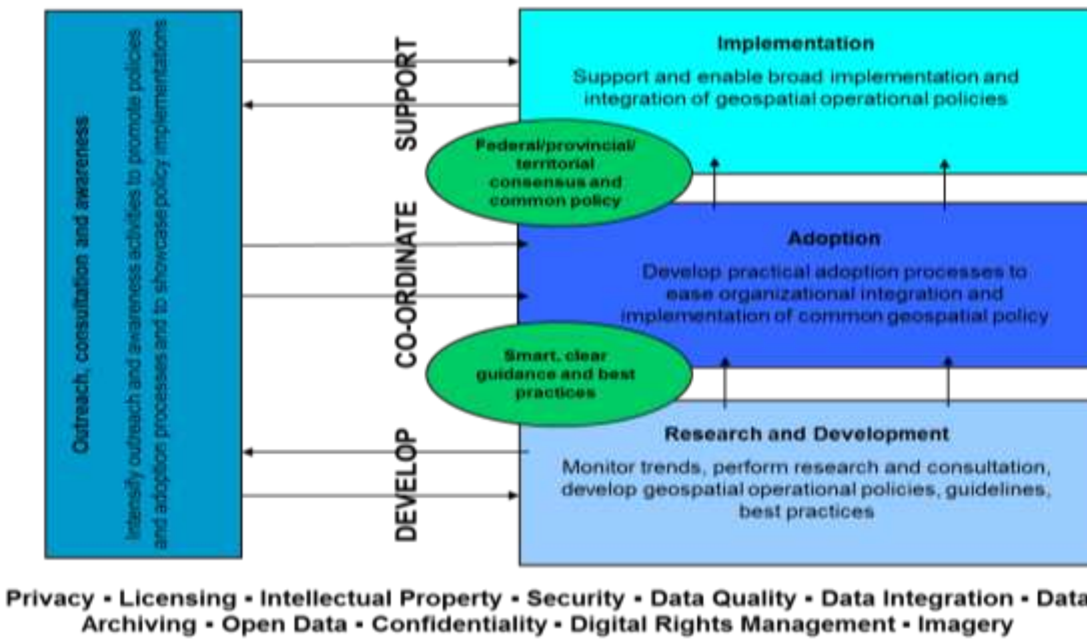
- LBS providers must ensure that users receive meaningful notice about how location information will be used, disclosed and protected; and
- LBS providers must ensure that users consent to the use or disclosure of location information, and users must have the right to revoke consent or terminate the LBS at any time.

7.5 Policy Process

7.5.1 Development

Since operational policies focus on practical issues, stakeholder engagement is essential in their formulation. A typical operational policy development process follows these steps (McLeod & Mitchell, 2012b):

- *Environmental Scan* – A comprehensive assessment of the environment within which the SDI will be developed is a primary means of uncovering the potential need for supportive policies. This should include an understanding of the overall policy environment in the jurisdiction and the role of operational policies in supporting various SDI dimensions, as well as identification of existing operational policies and classification of them according to the spatial data management life cycle. The assessment should also identify gaps or inconsistencies in existing policies.
- *Needs Analysis* – As discussed in Section 2.2, understanding user needs, including needs for operational policies, is critical to achieving success in SDI implementation. A variety of techniques can be used to engage stakeholders to identify those needs ─ surveys, workshops, forums or focus groups, and interviews, to name a few. In addition, the needs can be deduced as part of the scan of previous studies and reports, and industry and media literature. For example, the recent PC-IDEA survey of SDI organizations in the Americas is one useful resource for helping to understand operational policy needs.
- *Topics Identification and Prioritization* – Once the policy needs are understood, the specific operational policy topics can be selected and prioritized. In some cases, a topic may address more than one issue (e.g., IP rights are relevant to data sharing, licensing, and the use of VGI and cloud computing).
- *Stakeholder Involvement* – It is important to engage stakeholders not only to learn about their needs, but also to involve them in developing policies. Depending on the operational policy topic, the range of stakeholders may be very broad (e.g., decision-makers, data stewards and users within different levels of government, industry, academia, legal counsel, Chief Information Officers and Privacy Commissioners, and the policy community). Sometimes it is unclear which agency has the mandate to take the lead for the topic covered by the policy, so it is important to identify who owns the issue and what the respective roles of the key stakeholders will be.
- *Policy Creation* – For any policy development undertaking, it is important to develop a roadmap to guide the process, as is illustrated in Figure 7.5. A number of options exist for creating the policy, including adapting an existing policy instrument, developing the policy with an in-government team or cross-jurisdictional working group, or contracting out the policy development to a consultant or academic research organization.



Source: SDI Operational Policies Development SNIT Workshop

Figure 7.5: Example of an Operational Policy Development and Implementation Roadmap

7.5.2 Adoption

Once policies are developed, the focus shifts to ensuring or encouraging their adoption. If the SDI initiative is being developed as a mandatory model, this process is more straightforward. This is because policy adoption, similar to the adoption of standards and the use of the infrastructure and its data, will be required. Under the voluntary model, additional effort may be required to convince the SDI stakeholders that implementation of the policies in their organizations will be to their advantage and will help to achieve interoperability goals (Mcleod & Mitchell, 2012b). If possible, formal policy introduction, review and adoption processes should be employed. Policy adoption processes can also be included in new or evolving agreements or enabling administrative arrangements and use new and existing governance structures and stakeholder groups.

A communications program is an important means of building awareness of new operational policies and encouraging their adoption and implementation. Effective means of outreach to promote the benefits of operational policies as a means of improving interoperability include workshops and seminars, webinars, publication on websites and in industry media and newsletters, and sharing of case studies and best practices reports (see Section 9.1 for more on this topic).

7.5.3 Implementation

Once stakeholders are obligated to adopt policies (under the mandatory SDI model) or are convinced of the merits of doing so (under the voluntary model), policy implementation still requires considerable effort. Implementation of new policies often requires changes in work processes and software adjustments, and will normally involve skills upgrading as well. So change management is an important factor that SDI managers have to take into consideration. Continued outreach and awareness building is required and specific capacity-building efforts will support the success of policy implementation. Collaborative cost-shared projects that implement operational policies can be an effective means of encouraging policy implementation under a voluntary SDI model. Working with communities of practice to implement operational policies (e.g., framework data community support for the adoption of VGI operational policy guidance) is another useful way to ensure that policies are effectively implemented.

7.5.4 Monitoring Implementation

SDI managers will be required to monitor the usage by stakeholders of supportive policies that have been developed, to ensure that they are meeting their intended purposes and to identify any new gaps or inconsistencies that have arisen. Chapter 10 discusses in detail concepts and tools for measuring and monitoring SDIs, which apply to the monitoring of policy implementation as well.

For example, under the **European Union** *INSPIRE Directive*, the "state of play" of SDI initiatives is being monitored annually (i.e., EU Member States are required to submit reports describing, analyzing and assessing the status of their National SDIs). The following policy topics are among the 32 indicators reported on (Vandenbroucke, 2011):

- There is a policy framework for sharing GI between public institutions.
- There is a pricing framework for trading, using and/or commercializing GI.
- The geodetic reference system and projection systems are standardized, documented and interconvertible
- There is a documented data quality control procedure applied at the level of the SDI.
- The national language is the operational language of the SDI.
- The SDI initiative is devoting significant attention to "standardization issues."

In **Canada**, application of the Treasury Board Secretariat policy on geospatial data standards (to be fully implemented by federal departments and agencies by 2014) is being monitored on an annual basis. In 2011, for example, of the 16 organizations that reported standards-related activities:

- One department noted that it was compliant with the policy
- Three departments noted that they had projects underway towards compliance
- Nine departments were planning for compliance
- One department was evaluating the standard for relevance
- Four departments cited challenges to compliance

7.6 Chapter Highlights

In summary, the key SDI policy considerations the reader should take away from this chapter are as follows:

- The formal policy and legislative environment within which the SDI initiative is situated is an important consideration, and alignment with policy priorities is critical for SDI success.
- SDI policies can be classified as follows:
  - *Strategic* – High-level, formal policies that depend on the jurisdictional context; and
  - *Operational* – Practical tools to facilitate access to and use of the infrastructure and its data and services, which are common across jurisdictions.
- Policy identification can happen through a governance vehicle like a policy committee, user needs assessment or environmental scan, and prioritization of policy development must take into consideration factors such as scope, complexity, impact and importance.
- Research has identified the following prevalent themes for policy development: data production and sharing; privacy and confidential/sensitive data; intellectual property protection; data licensing; data archiving and preservation; adoption of volunteered geographic information and cloud computing; and location-based services Each of these areas has been briefly explored.
- It is important in policy development to follow a structured process. A typical operational policy development approach has been described, including the following steps: environmental scan, needs analysis, topics identification and prioritization, stakeholder involvement and policy creation.
- Policy adoption requires encouragement and support, especially under the voluntary SDI model, and effective outreach and awareness and capacity building initiatives are critical. Users also need support in their implementation efforts, and efforts focused on communities of practice and cost-shared collaborative projects are important means of providing such support.
- Policy adoption is an important area to be covered in the SDI performance management framework.

8. Technologies

This chapter provides an overview of the technological considerations in developing and implementing an SDI. Included are a discussion of SDI architecture models, a description of data discovery, visualization and access services and options, and a brief review of other tools.

8.1 Architecture Models

The premise that distributed networked access makes data more readily available is one of the key driving forces behind SDI initiatives. The SDI architecture is designed to facilitate such access and enable the implementation of systems to support service providers, data providers and application developers, using interoperable and reusable components. The *Reference Model for Open Distributed Processing (RM-ODP)*, a joint standard of the ISO and International Electrotechnical Commission (IEC) that defines views of a distributed system of systems, provides a solid architecture framework upon which SDIs can be built. In recognition that an architecture is complex and cannot be described in a single representation, the RM-ODP framework describes an architecture from a number of "viewpoints," as shown in Table 8.1 (GeoConnections, 2005).

Table 8.1: Reference Model for Open Distributed Processing

RM-ODP Viewpoint	Areas of concern
Enterprise viewpoint: Articulates a "business model" that should be understandable by all stakeholders; focuses on purpose, scope, operational objectives, policies, enterprise objects, etc.	▪ Purpose and scope ▪ Policies ▪ Responsibilities ▪ Business process along with use cases
Information viewpoint: Focuses on information content and system behaviour (i.e. data models, semantics, scheme)	▪ Information processing semantics ▪ System information
Computational viewpoint: Captures components, interfaces, interactions and constraints without regard to distribution	▪ Functional decomposition ▪ Interfaces ▪ Operations ▪ Binding rules
Engineering viewpoint: Describes infrastructure and mechanisms for components distribution, distribution transparency and constraints, and binding and interaction	▪ Infrastructure required to support distribution
Technology viewpoint: Defines implementation and deployment environment using technologies, standards and products of the day - best of breed	▪ Choice and suitability of technology to support system distribution

Source: GOS Implementation Architecture, Open Geospatial Consortium® document, 2003

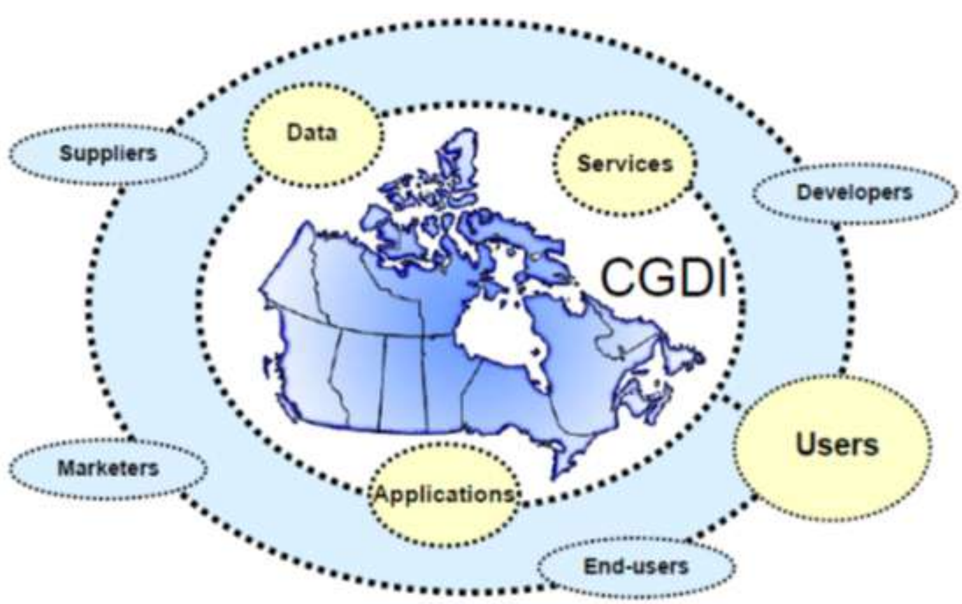
The following sections discuss the conceptual, operational, technical and systems perspectives of SDI architecture.

8.1.1 Conceptual Architecture

From a conceptual perspective, the SDI architecture consists of data and service providers and consumers who utilize applications to access spatial information. Figure 8.1 illustrates these four key elements and their relationship to an SDI example, the CGDI, and delineates the users into four distinct categories ─ suppliers, developers, marketers and end users:

- *Data* – Timely and secure access to accurate and up-to-date data is key to the SDI's success;
- *Services* – The SDI is based on open Web services that provide access to spatial data;
- *Applications* – Applications use data from Web services to provide users with the ability to produce and analyze spatial information to make informed decisions; and
- *Users* – Users are the consumers of spatial data, who fall into four categories:
    1. *Suppliers:* Providers of spatial data and Web services
    2. *Developers:* Creators of applications for other user groups to facilitate interaction with the SDI
    3. *Marketers:* Sellers/supporters of spatial applications for end users
    4. *End Users:* Consumers of spatial data
    5.

Figure 8.1: The CGDI Conceptual Architecture



Source: Canadian Geospatial Data Infrastructure Architecture Description, Version 2.0

8.1.2 Operational Architecture

From an operational perspective, the SDI architecture contains descriptions (often graphical) of the operational elements, assigned tasks and activities, and information flows required to support users. It defines the types of information exchanged, the frequency of exchange, which tasks and activities are supported by the information exchanges, and the nature of information exchanges in enough detail to identify specific interoperability requirements. Operational architecture views are generally independent of organization structures and systems technology.

8.1.3 Technical Architecture

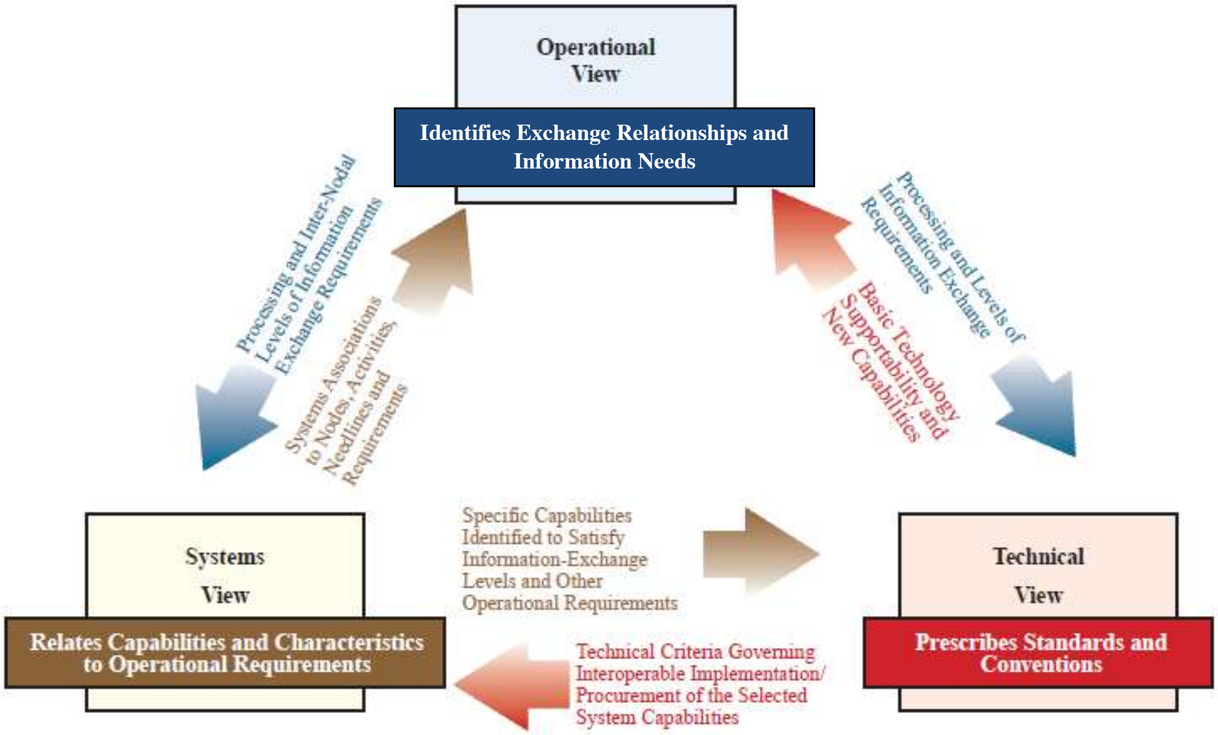
The technical view of the SDI architecture provides the technical systems implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed. The technical architecture view includes a collection of the technical standards, conventions, rules and criteria that govern system services, interfaces, and relationships for particular systems architecture views that relate to particular operational views. The standards and criteria should reflect multiple information system implementation paradigms. Technical architectures must accommodate new technology and the phasing out of old technology, as well as evolving standards.

8.1.4 Systems Architecture

The SDI systems architecture view shows how multiple systems link and interoperate, and may describe the internal construction and operations of particular systems within the architecture. For the individual systems, the systems architecture view includes the physical connection, location, and identification of key nodes, circuits, networks, platforms, and so forth, and specifies system and component performance parameters (e.g., mean time between failure, maintainability and availability). The systems architecture view associates physical resources and their performance attributes with the operational view and its requirements under the standards defined in the technical architecture. Systems architectures are based on and constrained by technical architectures, are technology-dependent, and show how multiple systems link and interoperate.

To be consistent and integrated, an architecture description must provide explicit linkages among its various views. Figure 8.2 illustrates some of the linkages that help to describe the interrelationships among the operational, technical and systems architecture views. “Interoperability” is a typical SDI architecture focus that demonstrates the criticality of developing these inter-view relationships (C4ISR AWG, 1997).

Figure 8.2: Fundamental Linkages Among the Operational, Technical and Systems Architecture Views



Source: C4ISR Architecture Framework Version 2.0

8.1.5 National Architecture Model Examples

The ***Canadian*** *Geospatial Data Infrastructure (CGDI) Architecture Description Version 2.0* (GeoConnections, 2005) is an update and revision of the original CGDI Architecture Description, and provides a high-level overview of the architecture of the CGDI. It describes the range of services that comprise the CGDI, and provides contextual and reference information for the more technical standards and specifications documents that detail the individual services and other specific architecture components. It also describes the underlying architecture that is common to all services.

The ***Brazilian*** *Directory of Geospatial Data* is based on a multi-layer architecture, detailed in Chapter 5 of the *Action Plan of the NSDI* (CONCAR, 2010). It subdivides the set of services in each layer: application, intermediary and servers. Other requirements are also shown, as well as their connection with the electronic government interoperability patterns established by the Federal Government e-PING standard.

8.2 SDI Architectural Components

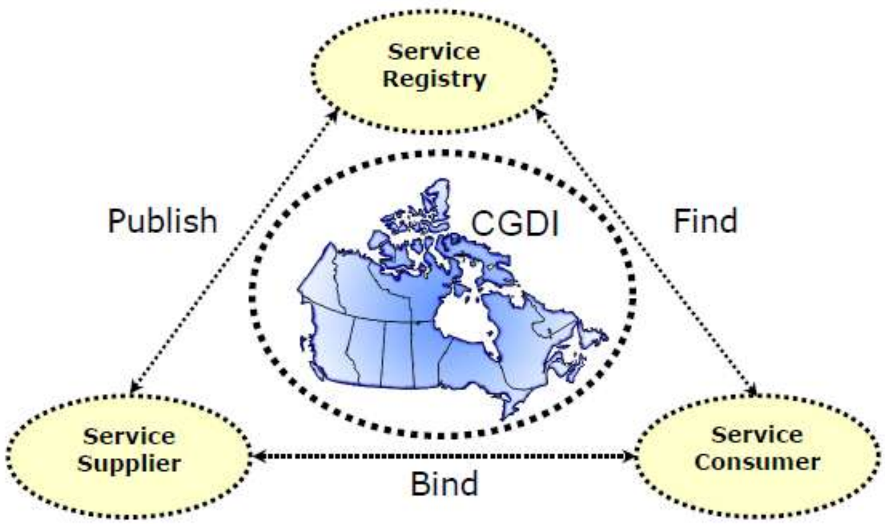
SDI architectures typically contain the components identified in Table 8.2 (GeoConnections, 2005).

Table 8.2: SDI Architectural Components and Their Functions

Components	Functions
Objects	Spatial objects describe real-world entities that are employed in client applications. The SDI makes the interfaces to the objects available to clients and providers with seamless views of the information. A representative list of fundamental geospatial objects includes: ▪ Geographic Features ▪ Geographic Coverages ▪ Geographic Measurements/Observations ▪ Spatial Reference Systems ▪ Geographic Projects ▪ Geographic Events ▪ Geographic Transformations ▪ Map Styles and Symbologies
Open Standards and Specifications	The endorsement and adoption of international or national standards ensures the SDI is interoperable for operational transactions and information exchange with other SDIs around the world. SDI managers typically adopt or endorse international standards to achieve the following benefits: ▪ Reduce development costs ▪ Minimize redundancy ▪ Hide the complexity of components ▪ Permit GIS practitioners and developers to benefit from "plug and play" components (See Chapter 6 for more information on standards.)
Registries	The service registry serves as the key link between supplier and consumer. Once a supplier has published metadata about its offering to the registry, a consumer can verify with the registry before connecting to the supplier. Furthermore, when changes to the supplier's offering occur, the registry can redirect the consumer to the new location, or present alternative services from similar suppliers. Visually this Web services "find-bind-publish" relationship can be depicted as shown in Figure 8.3.
Metadata	Metadata answers the who, what, where, when, why and how of every facet of the data or service available through the SDI. Using metadata, SDI users are able to: ▪ Determine what geospatial data is available ▪ Evaluate the suitability of the data for their use ▪ Access the data ▪ Transfer and process the data ▪ Accomplish these things in the order appropriate for them (See Section 6.1 for more information about metadata.)

Components	Functions
Security and Authentication	The need for security and authentication mechanisms increases with the need to share information in an open and interoperable fashion, particularly in those operations that create or update data. For access to services and data, a secure infrastructure will provide the following: ▪ *Protected access* – Interactions between components are private (prevents eavesdropping) and integrity is ensured (prevents tampering); ▪ *Verified access* – Communications are authenticated (to avoid impostors by confirming identity or role) and signed (to be non-deniable); and ▪ *Authorized access* – Access to services and data is controlled by the verified identity and/or role of the requesting user or client.

Figure 8.3: Registries Within a Web Service Architecture



Source: Canadian Geospatial Data Infrastructure Architecture Description Version 2.0

8.3 Data Discovery, Visualization and Access

A fully functioning SDI architecture provides users with the functionality to discover the type of data they are seeking, to visualize the data online to confirm that it will meet their needs and, if so, to access the data directly. As discussed in Section 6.1, international Web service standards and specifications have been developed to facilitate the incorporation of such functionality into the SDI initiative. The following sections discuss these three functions.

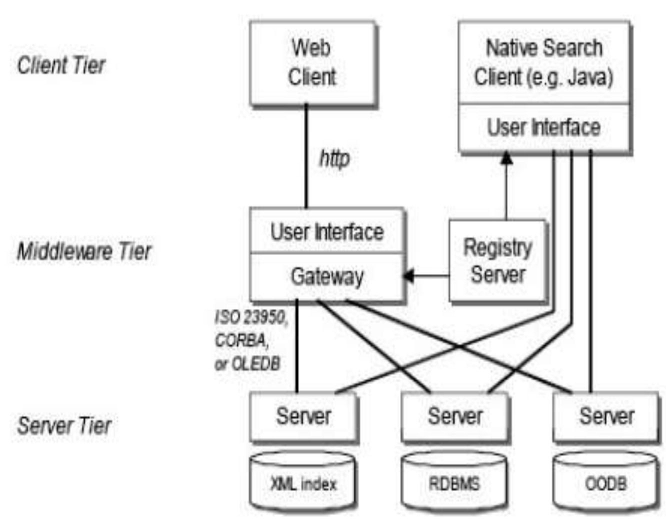
8.3.1 Discovery

The functionality to support data discovery is referred to variously as "catalogue services," "data directories" and "clearinghouses." Distributed catalogues are preferable to centralized indexes of metadata because synchronization between detailed metadata and such an index is extremely difficult and costly in a dynamic data environment, and because data custodians are the most capable of publishing and maintaining the metadata (GSDI, 2012b). A user interested in locating spatial information uses a search user interface and fills out a search form, specifying queries for data with certain properties. The search request is passed to a **catalogue gateway** that poses the query to one or more **catalogue services** registered in a **registry**. Each catalogue service manages a collection of **metadata or catalogue entries**. Within the metadata entries, there are instructions on how to access the **spatial data set** being described. The **metadata** plays three roles: 1) documenting the location of the information; 2) documenting the content and structures of the information; and 3) providing detailed information on its appropriate use.

A 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 illustrated in Figure 8.4. The client tier consists of a traditional Web browser, which uses conventional HyperText Transport Protocol (HTTP) communications, or a native search client application, which uses the ISO 23950 protocol directly against a set of servers.

The middle tier in the architecture includes a gateway between the World Wide Web and catalogue services, which provides parallel distributed searches of multiple catalogue servers from a single client Web session. A Directory of Servers or Registry can be searched as a special catalogue so that an intelligent one-pass search of eligible servers can be performed. This way the user does not have to select servers from a list, and all queries do not have to pass to all servers.

Figure 8.4: Implementation View of Distributed Catalogue Services



Source: The SDI Cookbook

At the bottom tier of the service architecture are the catalogue servers, which can be accessed using the GEO Profile of the ISO 23950 protocol or CORBA implementations. GEO includes spatial coordinates (latitude and longitude) and temporal fields in addition to free text (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.

A typical Use Case scenario for a discovery user is as follows (GSDI, 2012a):

1. The user uses client software to discover that a distributed catalogue search service exists (i.e., a catalogue gateway).
2. The 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 the user's requirements through the catalogue gateway. 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. Visualization of multiple results may also be available through the display of data set locations on a map, thematic groupings or temporal extent.
5. The user selects the relevant metadata entry by name or reference and selects the presentation content (e.g., brief, full) and the format (e.g., HTML, XML, Text) for further review.
6. The 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, or distribution information that lists alternate forms of access.

8.3.2 Visualization

Data visualization or viewing can be accomplished using simple Web mapping concepts and tools (i.e., part of a portrayal service to show spatial information online when the information originates from several discrete data servers that may be in different organizations). A Web Map Service (WMS) helps discover and visualize spatial information referenced from catalogue services. An SDI user accessing a catalogue service can discover data and WMSs and then request and display maps from different servers. A WMS can (GSDI, 2012c):

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

If a user chooses the same bounding box, spatial reference system and output size for queries from multiple map servers, the results can be superimposed. By standardizing the way in which maps are requested, WMS users 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 standards and specifications, which are discussed in Section 6.1.3.

An SDI manager can use a number of commercial off-the-shelf and open-source software packages that are compliant with the WMS standards and specifications. OGC publishes a list of products that are compliant with its standards, such as the WMS standard.[27] The OGC Compliance Testing Program provides a formal process for testing compliance of products that implement OGC® Standards. A product is compliant if a specific product implementation of a particular OGC® Standard complies with all mandatory elements as specified in the standard and these elements operate as described in the standard (OGC, 2012f).

8.3.3 Access

Data access involves the ordering, packaging and delivery, offline or online, of the specified data. The focus of geospatial data access has shifted from the supplier side (strong emphasis on technology and community-based standards and specifications) to the user side (a demand-driven operation). Consumers expect simple discovery and access to cheap (or free) data in simple standard formats that can be used in desktop applications or on mobile devices.

The overlap between information managed by subject-specific communities in possibly parallel infrastructures can compound problems of data discovery and access. For example, as individuals in communities such as the biodiversity or geosciences community attempt to leverage a combined spatial data infrastructure to support their own goals, they introduce new factors (e.g., new standards or conventions that they commonly require, new attribution requirements on the data not previously realized, or the need to provide common access to data not otherwise visible from a spatial data infrastructure) (OGC, 2012g).

Developing a supportive organizational, policy and technology environment is very important to the success of the SDI's data access component. Potential stakeholders will only become active participants if they see advantages for their organizations and if they do not feel threatened by the infrastructure. For example, the access component must provide multiple levels of buy-in, from basic advertising of products and services, to 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. Developing a sustainable business model for data access is critical to the long-term success of the entire infrastructure.

Implementations of data access services could include the following (OGC, 2012g):

- Offline services (e.g., packaging and physical delivery of data sets in either hardcopy or softcopy);
- Direct to data store services (e.g., delivery via ftp, specified via e-commerce order request);

[27] See http://www.opengeospatial.org/resource/products/compliant

- Brokered services (e.g., provide specification of data access request to secondary online or offline access service); and
- Online data service (e.g., request/response access protocol to data warehouse) supporting online operations such as drill down, aggregation and generalization.

Mature SDIs provide fully functional data access with online data services, so that users can request, access and integrate only the data they need (i.e., the geographic window, quality, and features required for their applications) from multiple sources over the Internet, without having to download the data. The Web mapping services described in Section 6.1.3 (i.e., WMS for georeferenced static map images, WFS for features and feature property level data, WCS for image data, and filter encoding for restricting the information returned according to projection, selection and sorting criteria) facilitate this access process.

8.3.4 The Role of Geoportals

SDI implementations typically use geoportals as a single window into the infrastructure that provides discovery, visualization and access functionality. Spatial information providers use geoportals to publish descriptions of their information, and spatial information consumers use them to search and access the information they need.

SDI geoportals have already been implemented across the Americas. For example, the **Colombian** Spatial Data Infrastructure (ICDE) Geospatial Portal provides access to a wide variety of map services that belong to some 10 different providers, headed by IGAC as the main GI producer (ICDE, 2012). Searches by maps, galleries, catalogue services, geographic Web services or applications that consume basic services from ICDE (e.g. viewers, GIS) are available. The basic cartography available in Colombia is also accessible by means of geo-services on the geoportal. IGAC provides basic cartography at the scales 1:100,000, 1:500,000 and 1:2,100,000, as well as cadastral maps, aerial photos and other thematic maps, among others.

The **Ecuadorian** Geospatial Data Infrastructure (IEDG) has an operational geoportal with access to WMS-type services for cartography from the Military Geographic Institute, as well as a gazetteer service. Also, a catalogue service to search and discover metadata and geospatial data allows public access to the main spatial resources from IEDG (IGM-Ecuador, 2012).

The National Institute of Geography and Statistics of **Mexico** (INEGI) enables discovery of the available maps and orthophotos. It also allows downloading free of charge of selected cartography, including Topographic Map 1:250,000, Vector Data 1:1,000,000 and Hydrographic Network 1:50,000 (INEGI, 2011b). The metadata and data discovery service implemented in the Geographic Portal of Mexico (INEGI, 2012) includes advanced searching criteria, which allows searching across several distributed national map servers and numerous international clearinghouse nodes.

Since its launch in 2008, the **Chilean** Geospatial Portal has allowed not only the discovery and visualization of available cartography of the SNIT's providers, but also includes some analytical tools capable of integrating data from different sources to obtain new powerful maps (SNIT, 2012). The GeoPortal developers enhance its functionalities according to user demands.

The basic geographic data of the **IDE-Uruguay** is provided by the Military Geographic Service (SGM), accessible and downloadable from its Geoportal (SGM Uruguay, 2012). Among its main functionalities, the SGM Geoportal allows discovery of data and metadata using the popular and ISO-compatible catalogue service GeoNetwork, or direct access to specific services in a list of the WMSs available. In addition, it has a generic viewer to visualize the information required.

The **Brazilian** Portal of geospatial data, SIG-Brazil, serves as the entry point to the Brazilian Directory of Geospatial Data (DBDG) (CONCAR, 2010), with the following possibilities for publication of metadata and geospatial data:

- From the institution's own servers that provide the metadata and geospatial data; and
- From servers managed directly by the Brazilian Geography and Statistic Institute (IBGE) and that host metadata and geospatial data from institutions that do not have the necessary infrastructure to meet the requirements of the e-PING and NSDI.

According to the Action Plan of the NSDI in Brazil, the functionalities of SIG-Brazil include searching and managing geospatial metadata, viewing maps, downloading data, and different capacities for searching and discovering geospatial data (CONCAR, 2010).

In conformance with OGC standards, the Military Geographic Institute of **Bolivia** provides services for WMS visualization, metadata discovery (Geonetwork) and downloading of the available cartography at 1:250,000 scale (IGM - Bolivia, 2012). Within the framework of the project "GeoBolivia" the Spatial Data Infrastructure of the Plurinational State of **Bolivia** (IDE-EPB) has arisen as an inter-institutional initiative aimed at fostering the use and access of digital geographic information by government agencies, the public sector and the society (GeoBolivia, 2011). This is geared to products and services from social networks such as *OpenStreetMap*[28] and *Geonames*.[29] More than 500 layers are accessible by WMS using *GeoServer*.[30] The GeoBolivia portal provides metadata searching using *Geonetwork*.[31]

The Spatial Data Infrastructure of **Venezuela** includes a geospatial portal built on the principles of *Decree 3390*, whereby the National Public Administration is required to use free software developed with open standards in its informatics services and projects (Gaceta Oficial - Venezuela, 2004). The geoportal is hosted on the website of the Geographic Institute "Simón Bolívar" and includes a viewer with the main national cartographic layers available. New nodes

[28] OpenStreetMap (OSM) is a collaborative project to create a free editable map of the world (http://www.openstreetmap.org/).
[29] GeoNames is a geographical database available and accessible through various Web services, under a Creative Commons attribution license (www.geonames.org).
[30] GeoServer is an open-source server written in Java that allows users to share and edit geospatial data, using open standards.
[31] The GeoNetwork opensource project is a free and open source cataloguing application for spatially referenced resources.

are being incorporated, including the National System of Territory Ordering and Management (SIGOT), a node to share hydrographic maps (SIGIA), as well as one with physical, economical and geographic data (DTZC) (Instituto Geográfico de Venezuela Simón Bolívar, 2012).

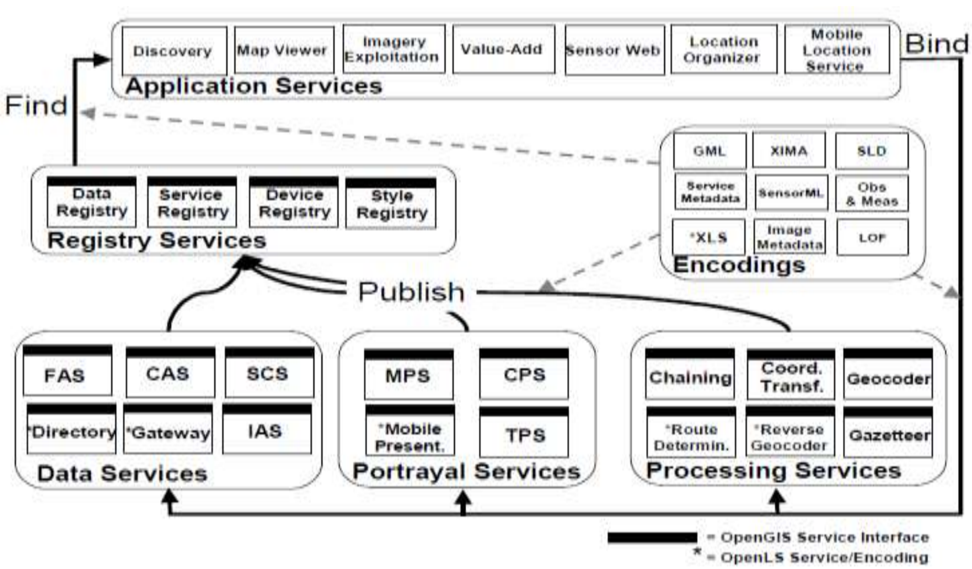
Canada's GeoConnections Discovery Portal is a metadata catalogue that enables spatial information users, developers and data suppliers to find, evaluate, access, visualize and publish Canadian spatial and geoscience data products and Web services (GeoConnections, 2012f). The portal provides three main ways to find data or services:

- *Quick Search* – Provides the capability to search by entering a term;
- *Search Catalogue* – Enables search refinement by selecting one or more search options for data based on resource type, location or category; and
- *Advanced Search* – Allows users to perform a search based on a geospatial area.

8.4 Tools

Spatial information technologies are evolving from the traditional model of stand-alone systems (in which spatial data is tightly coupled with the systems used to create them) to a distributed model based on independently provided, specialized, interoperable spatial services. Services can provide users with just the functionality and data they need, without the need to install, learn or pay for any unused functionalities. By using common service interfaces, applications and services can be added, modified or replaced without impacting other applications. This loosely coupled, standards-based approach to system development can produce very agile systems, which can be flexibly adapted to changing requirements and technologies.

Figure 8.5: Open Web Services (OWS) Service Framework



Source: OGC Reference Model

While data discovery, visualization and access services are fundamental to all SDIs, a broad range of other spatial services may also be developed, as briefly discussed in the following sections. Figure 8.5 illustrates the OGC Service Framework, which can be implemented in different ways, and primarily provides a basis for coordinated development of new and extended spatial services (OGC, 2003).

8.4.1 Application Services

Application services operate on user terminals (e.g., desktops, laptops, mobile devices) or servers to provide access to the various other services. Users employ them to access catalogue, 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.

8.4.2 Catalogue or Registry Services

Registry or catalogue services provide access to metadata on data, services and devices and are discussed in Section 8.3.1.

8.4.3 Data Services

In addition to the data access services discussed in Section 8.3.3 (i.e., Feature Access Services (FAS) or WFS, and Coverage Access Services (CAS) or WCS), geospatial data services could include Image Archival Service (IAS) to provide access to and management of large sets of digital images and related metadata and provide access to location-based data in the form of the following services:

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

8.4.4 Portrayal Services

Portrayal services provide visualization of geospatial information, as discussed in Section 8.3.2. Given one or more inputs, portrayal services produce rendered outputs (i.e., 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. Portrayal services can be sequenced into a “value chain” of services to perform specialized processing in support of information production workflows and decision-making. Below are some examples of such services:

- *Map Portrayal Services (MPS)* – Such as WMS described in Section 8.3.2
- *Coverage Portrayal Services (CPS)* – Such as OGC Coverage Portrayal Service
- *Mobile Presentation Services* – For presentation of spatial information on mobile devices

8.4.5 Processing Services

These services provide operations for processing or transforming data in a manner determined by user-specified parameters, and can be tightly or loosely coupled with other services such as the Data and Processing Services. Examples of processing services are as follows:

- *Coordinate Transformation Services* – To convert geospatial coordinates from one reference system to another;
- *Chaining Services* – To enable the combination or pipelining of results from different services in response to user requests (e.g., where a CPS fetches several image coverages from different WCS services, then assembles mosaics from them to portray the resulting composite image);
- *Geospatial Analysis Services* – To exploit information available in a Feature or Feature Collection to derive application-oriented quantitative results that are not available from the raw data itself;
- *Geocoder Services* – To find the geographical location of a given address; and
- *Gazetteer Services* – To provide access to geospatial data indexed by place name rather than by coordinate locations.

8.5 Chapter Highlights

In summary, the key technological considerations the reader should take away from this chapter are as follows:

- The SDI architecture is designed to facilitate distributed networked access to data, but such architecture is complex and can be considered from a variety of perspectives:
  - *Conceptual* – Architecture consists of data and service providers and consumers who utilize applications to access spatial information;
  - *Operational* – Architecture contains descriptions of the operational elements, assigned tasks and activities, and information flows required to support users;
  - *Technical* – Architecture provides the technical systems implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed; and
  - *Systems* – Architecture shows how multiple systems link and interoperate, and may describe the internal construction and operations of particular systems.

- The typical components found in most SDI architectures include spatial objects, open standards and specifications, registries of services, metadata, and security and authentication mechanisms.
- A fully functioning SDI architecture provides users with the functionality to discover the type of data they are seeking, to visualize the data online to confirm that it will meet their needs and, if so, to access the data directly.
- Data discovery is facilitated via catalogue services, and distributed catalogues are preferable to centralized indexes of metadata because synchronization between detailed metadata and such an index is extremely difficult and costly in a dynamic data environment, and because data custodians are the most capable of publishing and maintaining the metadata.
- By encouraging WMS implementation, SDI managers help users to quickly and easily integrate and visualize data from multiple sources. OGC publishes a list of products that are compliant with its standards.
- Developing a sustainable model for data access is critical to the long-term success of the entire infrastructure, and developing a supportive policy, technology and organizational environment is very important to the success of the SDI's data access component.
- SDI initiatives facilitate the evolution of spatial information technologies from the traditional model of stand-alone systems (in which spatial data is tightly coupled with the systems used to create them) to a distributed model based on independently provided, specialized, interoperable spatial services.
- To complement the basic SDI functionalities of data discovery, visualization and access, SDIs can provide a range of other tools of great value to users, such as application services, registry services, data services, portrayal services and processing services.

9. Projects and Activities

This chapter provides guidance on two final topics related to the development and implementation of successful SDIs ─ Outreach and Awareness and Capacity Building, and the use of Case Studies.

9.1 Outreach and Awareness and Capacity Building

As noted previously in several places (e.g., Sections 2.2 User Needs, 4.1.2 Authoritative Data Sources, 4.4 SDI Strategic Framework, 6.3.3 Standards Introduction and Adoption, 6.4 Maintenance of Standards, 7.2.2 Policy Identification and Prioritization, 7.5 Policy Process), stakeholder engagement through outreach and awareness and capacity building is essential to successfully plan, develop and implement an SDI initiative. From the initial identification of the individuals that will champion and lead the SDI initiative, through to the development of processes to help support the adoption and implementation of policies and standards, communications is key.

9.1.1 Outreach and Awareness Building

As has been discussed elsewhere, communications/outreach/awareness building can take a number of forms, including print and online publications, workshops, focus groups, webinars, open forums and face-to-face meetings with key individuals on critically important topics. Including stakeholders in working groups and committees to address specific issues or challenges is another way to ensure that they are actively engaged in SDI planning and implementation and helps to expand the outreach process.

A beneficial means of encouraging organizations to become partners in and users of the SDI is to support their participation in **pilot projects**. By providing assistance and guidance for them to test an application that takes advantage of the data and services available through the infrastructure, SDI managers can have greater success in adopting the SDI in the organizations' day-to-day operations. Pilot applications provide a relatively low risk means of "test driving" the SDI. If successful, they will be an important means of convincing organizations to use the infrastructure and become engaged in ensuring the SDI initiative is a success, through making their data discoverable and accessible, and possibly involving them in SDI governance. For example, in the **United States** under the FGDC Community Demonstration Projects initiative undertaken between 1998 and 2000, NSDI-based pilots were designed to demonstrate the value of spatial data and the NSDI to improve decision-making in communities.[32] In the initial phase of the GeoConnections program in **Canada**, funding was provided to communities under the Sustainable Communities Initiative to develop pilot applications built on the CGDI.[33]

9.1.2 Capacity Building

Capacity building is an important element of the SDI implementation strategy. Systems developers need to know how to interface with the infrastructure, and spatial data users need to understand and be comfortable with data discovery, visualization and access processes and any other spatial tools and applications that are provided by the SDI. Taking advantage of the potential of a fully operational SDI requires a paradigm shift from a closed GIS environment to an open Web services environment. Moreover, experienced spatial data users need to develop the awareness of the advantages of making this shift as well as develop the capacity to effectively employ the SDI.

SDI implementers can develop such capacity with online learning tools, webinars, seminars, workshops and courses, either through their own efforts or in cooperation with educational institutions. Efforts to have SDI capacity-building elements included in spatial information programs at colleges and universities will pay dividends by helping to ensure that future graduates will be equipped to become strong SDI users. Of course, one of the primary objectives of this manual is to contribute to capacity building within the spatial information community in the Americas. As was mentioned in Section 1.1.3, there are also several "cookbooks" that provide useful guidance to SDI planners and implementers. A number of other useful resources have been mentioned throughout this manual.

9.1.2.1 Examples of National Outreach and Awareness and Capacity Building Initiatives

A number of online tools have been developed for **Canada's** CGDI to help developers and users access and use the infrastructure and data.[34] *A Developers' Guide to the CGDI: Developing and publishing geographic information, data and associated services* (GeoConnections, 2007b) was created by the GeoConnections program to inform and educate the public about the abundance of information and resources that comprise the CGDI. It describes the makeup of the CGDI and how the reader can use it to increase the accessibility and visibility of an organization's data and services, as well as how to build an application with CGDI-endorsed standards and specifications. Useful summaries in the introductions to each section and chapter ensure that the document will help even inexperienced geomatics users understand the concepts in geomatics programs.

[32] See http://www.fgdc.gov/library/whitepapers-reports/sponsored-reports/cdp
[33] See http://geoconnections.nrcan.gc.ca/10
[34] See http://geoconnections.nrcan.gc.ca/18

Computer-Based Training (GeoConnections, 2012g) is an online training video that provides users with step-by-step instructions to rapidly learn and understand the power and interoperability of the GeoConnections Discovery Portal. The training video allows users to practice using the application before moving on to the actual application. The six modules focus on the following different areas of the application:

- *Module 1* – How to perform a catalogue search
- *Module 2* – How to perform an advanced search
- *Module 3* – Working with search results
- *Module 4* – How to create an account
- *Module 5* – How to publish content
- *Module 6* – How to use the resulting map

The accompanying *User's Guide* (GeoConnections, 2012h) provides more detailed guidance on the use of the Discovery Portal. The Guide include the following: creating a user account; the contents of the home page; catalogue and advanced searching; publishing resources and services and entering metadata; using the interactive map; and information on the Help feature. The *Catalogue API Guide* (GeoConnections, 2012i) provides developers with details of the GeoConnections Discovery Portal Catalogue API, with examples of how to use this network-accessible service. The guide begins with a description of Catalogue Service for the Web (CSW) and goes on to outline the methods that are available under the Catalogue API, including GetCapabilities, GetRecordByID, GetRecords, GetRepositoryItem, GetDomain, DescribeRecord, Group CSW Queries, API Wrapper, Portal Coding, Gazetteer API and Context Rendering.

The FGDC in the **United States** has developed a comprehensive online NSDI training program and regularly hosts training events.[35] For example, the *Guidelines to Encourage Cooperation in Development of the National Spatial Data Infrastructure* (FGDC, 1996) was created to establish policies and criteria for the Federal Geographic Data Committee (FGDC) and Cooperating Groups to cooperatively interact in activities and initiatives that further develop the National Spatial Data Infrastructure (NSDI). The guidelines foster the development of cooperative groups among federal, state, local, private and academic sectors and set out the roles that such groups can play. The publication also defines the role of the FGDC in supporting such groups and sets out the procedure for recognition of a Cooperating Group.

The workshop *Introduction to Framework Data: Concepts, Standards, and Applications* (Hamerlinck & Lanning, 2007) provided an introduction to framework data concepts, highlighting the framework component of the NSDI and the FGDC's Framework Data Standard. The workshop content included the following:

[35] See http://www.fgdc.gov/training

- *Framework Background* – Overview of Framework, NSDI Future Directions, FGDC Framework Themes and Framework Standards;
- *Why is Framework Important?* – Data Interoperability, Data Quality, Cost Savings, Agency Cooperation and Government Mandates;
- *How to Implement Framework* – Development Tools, White Papers, Educational Materials, Standards and User Buy-In;
- *Teaching Framework* – Approaches and Framework Base Standard; and
- Summary – Review of Key Points and Concepts.

As part of its *National Geographic Information Policy* (CONPES, 2009), **Colombia** promotes a culture for geographic information use in all public administration sectors and at all government levels. The ICDE defined a specific strategy to address the low capacity of institutional management identified previously. This strategy integrates activities to improve the institutional capacity to manage geographic information issues, by defining and implementing research, training, diffusion and project development frameworks at both institutional and sectoral levels. The IGAC, as the coordinator of ICDE, has developed the *Model of Knowledge Management* as well as the *Methodology of Research and Development*, which are integrated into its *Quality Management System*.

The Centre of Research and Development in Geographic Information (CIAF), as part of the Geographical Institute Agustín Codazzi in **Colombia**, offers four advanced educational programs, under joint agreements with universities, targeted to specific user needs. Additionally, it provides short courses on demand in three categories: spatial data infrastructures, geographic information systems and remote sensing (IGAC, 2012). These courses and educational programs have not only reached the main stakeholders and users of ICDE at the national level, but have also left a footprint at the regional level in Latin America and the Caribbean.

The Executive Secretariat of the SNIT promotes and develops capacity building activities targeted to sectors and regions in **Chile**. The objectives of these training activities are mainly to enhance the technical knowledge of the tool Geonodo and the Geoportal, although other specific courses are also implemented on demand (e.g. Open Source Software).

With support from the *Canadian International Development Agency*, the *University of New Brunswick* and the *Instituto Brasileiro de Geografia e Estatística* assisted **Brazil** by transferring Canadian methodology and technologies in the areas of national spatial reference systems and techniques (IBGE-UNB, 2011). The principal outcome of this program was a new national geospatial framework, as a foundation for future progress in land reform, environmental management and natural resource development. This was achieved by enhancing the capacity of Brazilian institutions to develop, implement and maintain a national geodetic framework, while coordinating the impact of such a fundamental change on public and private communities. Training modules were tailored to the indigenous communities of *Guarani* in Rio de Janeiro and *Quilombola* in Pernambuco.

9.2 Case Studies and Good Practices

9.2.1 Case Studies

The documentation of case studies is an effective mechanism to help convey the underlying factors that led to the growth of spatial data infrastructures and success stories in SDI implementation. As a normal practice, case studies of SDI initiatives provide the following types of information:

- Background, context and rationale for the SDI initiative
- Brief details of the SDI implementation, including organizational and technical highlights
- Good practices
- Lessons learned (from which planners and implementers of other SDIs can benefit)

9.2.2 Good Practices

Good practices are often incorporated into case studies. They are actions, approaches and methods that are most successful or have proven most successful in the past in achieving or contributing to an objective, and that are shared with peers in order to contribute to collective learning. Identifying good practices involves judgment, which requires prior analysis using criteria such as those identified in Table 9.1 (WHO, 2009) (Julien, 2010). A good practice need not meet all of the identified criteria, since it can be anything that works to produce results without using inordinate resources, and that can be useful in providing lessons learned.

Table 9.1: Common Criteria for Selecting Good Practices

Criteria	Explanation
Effectiveness	The practice must work and achieve its expected results, corroborated by quantitative and/or qualitative measures.
Efficiency	The practice must produce results with a reasonable level of resources and time.
Relevance	The practice must address the priority issues or operational challenges in the domain in question.
Sustainability	The practice must be implementable over a long period of time without any massive injection of additional resources.
Replicability	The practice has the potential to be transferred (replicated or adapted) to other settings and to generate comparable success.
Innovation	The practice introduces new approaches and methods that have not been used before, or offers a creative application of existing approaches.

In the SDI context, it is important for early entrants to document good practices in planning, developing and implementing spatial data infrastructure so that those that follow can avoid costly mistakes. In addition, the sharing of good practices will contribute to the goal of creating a global spatial data infrastructure based on compatible and interoperable national and regional SDIs. To ensure readability and a clear presentation of what makes practices innovative, interesting, informative and indeed "good practices," a common format should be used. Appendix C is a sample template for collecting information and documenting good practices.

9.2.3 National and International Case Study Examples

The literature contains many examples of case studies of relevance to SDI initiatives that have been conducted by international and national SDI organizations. At the international level, the **Global Spatial Data Infrastructure (GSDI)** *SDI Cookbook* contains case studies of local, national, regional and global SDI implementations. A US case study involving crime management is highlighted as one of many examples of local communities benefiting from the investment in SDI. The Colombian experience in developing and harmonizing geographic information systems is examined as a national SDI implementation example. A case study from the Southern African Development Community's Regional Remote Sensing Unit is an example of how a focus on critical regional issues yields elements of infrastructure valuable for cooperating nations. Finally, the authors reviewed the major organizations, systems and processes that are operating to achieve one or more aspects of the Global Spatial Data Infrastructure as the global case study.

The **United States** report *Toward a Coordinated Spatial Data Infrastructure for the Nation* (Mapping Science Committee, National Research Council, 1993) contains an assessment and critique of the efforts to build the National Spatial Data Infrastructure in the US. This study addressed the question "What could be done better or more efficiently if the content, accuracy, organization and control of spatial data were different?" The MSC reviewed the spatial data activities of a number of federal agencies and identified several general issues and impediments that needed to be resolved to build a more robust NSDI, including:

- No agreed-upon national vision of the NSDI or apparatus to implement it
- Extensive overlap and duplication in spatial data collection
- No mechanisms to identify collected data, where it is stored, who controls access, and data content and coverage
- No specific measures and standards of data content, quality, currency, and performance of various components of the NSDI
- Major impediments to, and few incentives for, spatial data sharing among federal, state and local organizations

The study included an in-depth assessment of two broad areas of intense spatial data activity — urban fabric and wetlands — and provided a number of recommendations to address the issues identified.

The **Canadian** *Volunteered Geographic Information (VGI) Primer* is based in part on case studies of the following three operational examples of VGI use:

- For the Notification and Editing Service (NES) of the state government of Victoria, Australia, the VGI model was adopted to meet the growing demand for higher quality (particularly more current) geospatial data within existing resource constraints. Change request contributors submit notices of new features or changes to existing features, which are then channelled to the organizations responsible for those features (i.e., data custodians).
- OpenStreetMap (OSM) sees daily feature additions, modifications of inaccurate features, and deletions of stale or invalid data from its contributor base of over 530,000 registered users. Organizations have also donated complete data sets to OSM, some of which have been incorporated wholly into their database. While OSM does not use quality control experts to vet contributions, the quality of its data is refined over time through iterative corrections of submitted data by subsequent contributors.
- Contributions to Esri Canada's Community Maps Program are presently only allowed by geospatial data providers, but Esri Canada plans to allow the public to identify data errors and new features, and to transfer those notifications back to the authoritative data sources for action. As of December 2011, Natural Resources Canada and some 20 municipalities were participating in Community Maps and approximately 80 other organizations were considering becoming involved.

The **Canadian** *Primer on Policy Implications of Cloud Computing* is based in part on case studies of the following two operational examples of cloud computing use:

- Ordnance Survey Great Britain makes significant use of cloud computing as part of its online Web mapping services, which serve Ordnance Survey's mapping data directly into customer websites or enterprise systems. It chose to host these services on the public Amazon Web Services (AWS) platform and in 2011 initiated a consolidation project to use commodity hardware and virtualization to build a more efficient private cloud infrastructure within its data center.
- Ontario GeoPortal is a hosted data, software and infrastructure service of Infrastructure Ontario, a Crown corporation responsible for managing the province's real property assets. Ontario GeoPortal provides a geographic platform in the cloud to integrate, publish and visualize tabular business data and non-structured content, and make this information securely accessible to users through a mapping interface. In early 2012, the service supported over 1,600 users within the Ontario government and has 14 corporate applications supporting a variety of business requirements.

In the field of emergency and risk management, **Colombia's** ICDE has shown good practices in implementing its policies. To face the *La Niña* phenomenon in 2010−2011, IGAC, IDEAM[36] and DANE[37] combined their efforts to identify flooding zones using patrimonial images delivered voluntarily to IGAC. In a second stage (2011−2012), a project valued at nearly 9 million pesos is being undertaken, entitled *Monitoring of flooding zones by using geospatial information*, which is acquiring and processing satellite and radar images with national cover at scales 1:10,000 and

[36] IDEAM – Institute of Hydrology, Meteorology and Environmental Studies.
[37] DANE – National Department of Statistics

1:25,000, respectively. This practice is in line with a national priority to strengthen the institutions of the National System for Disaster Prevention and Attention (ICDE, 2012).

Under the representation of the Technical Advisory Committee of Geographical Information and the coordination of INEGI, the National Interactive Atlas of **Mexico** (INEGI, 2005) is the framework for the integration and discovery of the heritage of statistical and geographical information available in Mexico. It constitutes a practical expression of the Spatial Data Infrastructure, which embeds the catalogue and map services, providing easy functionalities for end users. These functionalities are as follows: generation of tailored thematic maps from distributed map servers; navigation on the maps; feature queries by attribute, consult metadata, among others. The Digital Map of Mexico 5.0 is a WMS application based on the Spatial Data Infrastructure of Mexico (INEGI, 2011c). It offers general searching by keyword, and specific searching including the selection of a layer.

Sectoral and sub-regional deployment of geospatial data infrastructures is a key outcome obtained by the SNIT in **Chile**, as is evidenced by the implementation of Regional Systems of Territorial Information in three regions, Los Rios (SNIT, 2012), “Bio Bio” (Sistema Regional de Información Territorial - Biobío, 2012) and Atacama (INE-Atacama, 2010), thanks to the use of the tool *Geonodo*. At the sectoral level, Territorial Information Management Units (UGIT) are being created to develop spatial data infrastructures at the ministerial level. One example is the UGIT of the Ministry of Public Works, established by *Resolution No. 211 of the Planning Direction* (Ministerio Obras Públicas Chile, 2012). This Territorial System of the Public Works Ministry is a strategic component of the Ministry Modernization Program and facilitates access to and integration of the spatial information at both the institutional and individual level.

9.3 Chapter Highlights

In summary, the key project and activity considerations the reader should take away from this chapter are as follows:

- As has been emphasized throughout this manual, stakeholder engagement through outreach and awareness and capacity building is essential for the successful planning, development and implementation of an SDI initiative.
- Including stakeholders in working groups and committees to address specific issues or challenges and using pilot projects to test an application that takes advantage of the data and services available through the infrastructure are two effective outreach and awareness building ideas.
- Capacity building can take a number of forms and the use of workshops, open forums, webinars, online learning tools and operational policy instruments are all good capacity development practices.
- Documenting successful SDI development and implementation experiences is a very effective way of contributing to outreach and awareness and capacity building efforts, and guidelines for developing case studies and documenting good practices are provided.

10. Measuring and Monitoring Impacts and Benefits

The primary purpose of this chapter is to highlight for the reader the importance of measuring and monitoring the benefits of an SDI initiative. Following an introduction to the concept of measuring and monitoring SDIs, additional topics covered include measuring and monitoring methodologies, lessons learned from several existing measuring and monitoring programs, and the way forward for the Americas.

10.1 The Concept of Measuring and Monitoring SDIs

In today's market-oriented society, managers of public sector programs are required to demonstrate the performance of these programs as well as the impact they are having on the society. Similarly, the demand for reporting on the performance and benefits of SDIs is a growing challenge in the SDI community. To demonstrate the benefits and performance of their programs, public sector managers have implemented performance-based management systems that facilitate systematic measuring and monitoring of the processes within these programs. A similar concept can be adopted by the SDI community to demonstrate that SDIs are achieving their objectives. However, it is a challenge to develop cost-effective, functional frameworks to measure and monitor the performance of this complex infrastructure (e.g., multiple components, multiple stakeholders, multi-dimensional).

Measuring and monitoring performance is vital to the successful management of an organization in that it provides key information on whether or not the organization is achieving its objectives in an efficient manner, producing the desired outputs, having effective outcomes, and on whether its impacts are having positive effects on the society. Measuring and monitoring also clearly identifies areas in an organization that are operating efficiently and effectively and those areas that require improvement to achieve the desired goals.

10.1.1 What SDI Practitioners Need to Know About Measuring and Monitoring Performance

The best information from a measuring and monitoring exercise is gained through systematic design and implementation (i.e., performance should be measured and monitored regularly based on a defined time interval). The regularity, however, will depend on the functions of the program and its budget. To ensure that performance is measured in a timely manner and performance information is used in the management process, public sector agencies around the world have implemented different versions of a *Performance-Based Management Framework*. Performance-based management (PBM) is a technique that facilitates the operation of an organization by constantly identifying, monitoring, analyzing and managing strengths and weaknesses (GSA, 2000). Performance-based Management is defined as follows (PBM SIG 2001):

> "…a systematic approach to performance improvement through an ongoing process of establishing strategic performance objectives; measuring performance; collecting, analyzing, reviewing, and reporting performance data; and using that data to drive performance improvement."

The PBM style is an iterative operation that involves at least six key processes capable of facilitating monitoring and measuring in a systematic manner (Environment Canada, 2000). The information gained from the processes is then used to constantly improve the quality of the program, as well as to justify continuous investment in the program (Figure 10.1). This type of management framework is important to SDI coordinators as it can be used to identify and demonstrate the benefits of the outcomes and impacts of an SDI, as well as effectively identify processes that require improvement.

Figure 10.1: Six Key Processes of the PBM Style (Giff and Crompvoets, 2008)

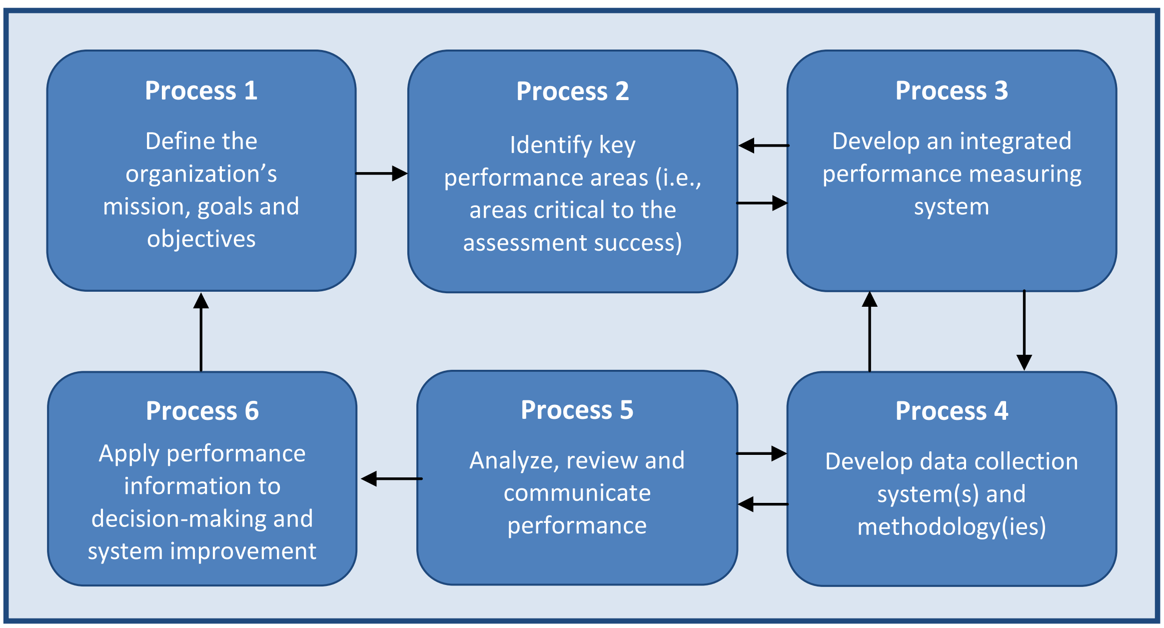


Figure 10.1 lists the six processes common in most PBM frameworks and illustrates the relationship among the processes in facilitating the measuring, monitoring and reporting of performance. The performance of a program is derived from the relationship among its *objectives*, *inputs*, *processes*, *outputs*, *outcomes*, and in some cases, the *impact*. Therefore, in order to accurately measure and monitor performance, it is imperative that objectives, inputs, processes, outputs and outcomes are clearly defined, as well as the relationship among them. Table 10.1 provides definitions of these terms within the context of an SDI. In addition, key indicators (or metrics) must be developed to be used as yardsticks for measuring performance.

These indicators — referred to as performance indicators or PIs — measure the degree to which the selected function of an organization is achieving the desired goals. Performance indicators can be quantitative or qualitative; however, their main function is to communicate performance.

Table 10.1: Definition of PBM Terms and Examples of Their Application to SDIs

Term	Definition	SDI Example
Objective	The intention of the program/SDI, i.e., the objective is what the program was designed, developed and implemented to achieve.	"To coordinate Canada's numerous databases of geographic information and make them accessible through a common window on the Internet." (From CGDI Phase I, see AC, 2001)
Input	The resources (e.g., information, knowledge, materials, labour and equipment) that goes into the system/processes to achieve the desired output. Inputs are usually quantitative in nature and are normally represented in monetary value.	Data sets, software, hardware, metadata, and human resources with different skills in implementing and maintaining an SDI.
Process	Represents all the activities carried out to transform the inputs into the desired outputs. It usually involves the interaction of material, equipment and labour.	Design and implementation of a clearinghouse (geoportal). Development of policies to support access to geo-information and services.
Output	The service or product produced by the process from specific input(s), i.e., the service or product created for the intended population. It should be noted that the output of one process can be the input for another process.	An online portal of geo-information and services used by decision-makers to enhance decision-making. Standards for information discovery, access, exchange, and security.
Outcome	The results of the interaction of the target population with the output, i.e., the benefits derived by the target population utilizing the output.	Users of the portal are achieving greater efficiency in accessing and using geo-information due to the services offered by the portal.
Impact	The long-term gains/benefits of the desired outcome. It is achieved through the long-term (5 years or more) interaction of an outcome with the wider society. Often viewed as a long-term outcome.	Users evolve their business processes and decision-making by sharing, developing and using common standards, tools and services offered by the SDI.

See the text box to the right for the summary of a paper by Giff and Crompvoets (2008). The authors discuss and present practical examples of the application of SMART performance indicators to SDI assessment. Table 10.2 and Figure 10.2 provide snapshots of SMART PIs used in SDI assessments. Additional information on the application of performance indicators to SDI assessment can also be seen in Giff (2008) and GeoConnections (2011).

Good Practice

In their paper entitled ***Performance Indicators a tool to Support Spatial Data Infrastructure Assessment,*** *Giff and Crompvoets, (2008) presented, discussed, and analyzed the application of performance indicators as a possible tool to assist in the measuring, monitoring, and reporting on the performance of an SDI. The paper discussed:*

- *the benefits of using Specific, Measurable, Attainable, Relevant and Timely (SMART) PIs in the assessment of SDIs;*
- *the role of the logic model in facilitating the design of SMART PIs to measure both efficiency and effectiveness;*
- *a framework to guide SDI coordinators in designing PIs for their initiatives, consisting of 11 iterative steps and data collection methods (see Figure 10.3);*
- *the practical application of the framework through the presentation of two case studies – the GeoConnections program and the City of Fredericton, New Brunswick, Canada GIS; and*
- *use of the framework, not only in capturing the variables contributing to the complexity of an SDI but also the methodologies, cost, personnel and intricacies involved in the collection of SDI performance information.*

In summary, it is recommended that programs be measured and monitored within a PBM framework. PBM frameworks offer three key sets of activities (i.e., processes 1−3 in Figure 10.1) that are vital to the measuring and monitoring of performance. These consist of 1) clearly defining the goals and objectives of the program; 2) identifying the inputs, processes, outputs, outcomes, impacts, and the relationships among these variables; and 3) developing performance indicators. Within a PBM framework, there are a number of management tools available to help develop and implement these three key processes. However, the main tool often used by managers to assist in identifying and defining the three processes and one that every SDI coordinator and practitioner should be familiar with is the *Logic Model*.

Table 10.2: Snapshot of GeoConnections Performance Indicators

OUTCOME	INDICATOR	DATA SOURCE AND METHOD
Canadian organizations are aware of issues, practices and standards related to geospatial information management, sharing and use.	Percentage of organizations aware	Program reports and studies, project files and reports Consultation – Analysis based on baseline data report in the 2005 User Needs Assessment and 2008/2009 Annual Report for GeoConnections
Canadian government organizations have the necessary tools and resources to incorporate geospatial data in the delivery of programs and activities, and policy making.	Increase in tools and resources available	Program outputs (see Performance Measure 1). Program Data Analysis – Project files and reports, CGDI performance progress report (2012, 2015). Interoperability demonstration pilot project reports; 2 case studies.

Figure 10.2: Snapshot of Application of Balanced Scorecard to the Swedish SDI

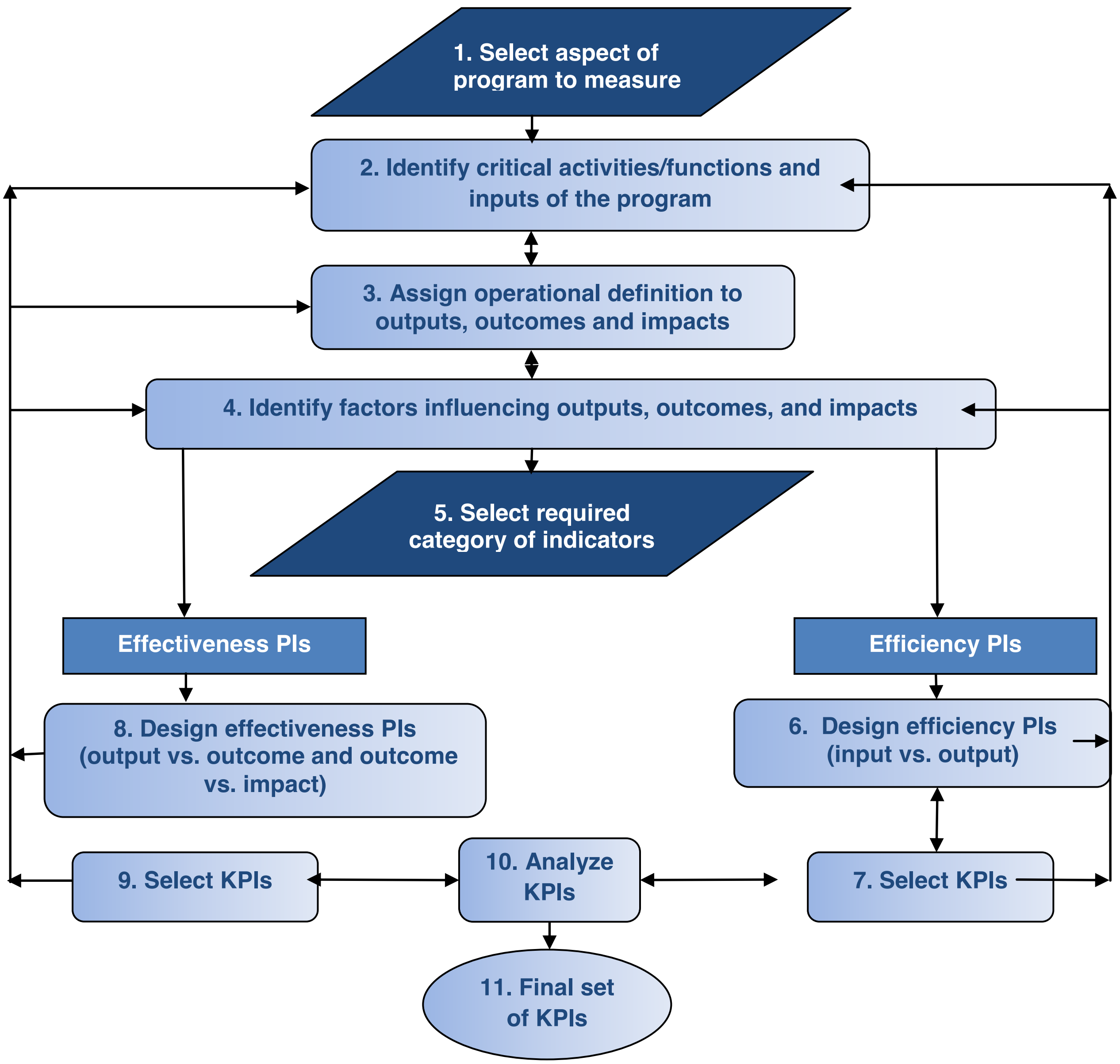
Perspective	2009	2010	Area of interest	2010	Critical success factor	2009	2010
Data and services	58.3	71.5	Data	58.1	Metadata for datasets is available	74.0	80.7
					Data covers planned area	99.0	99.0
					View services are available	25.0	35.9
					Download services are available	4.0	16.6
			Services	85.0	Metadata for services is available	66.0	85.0
User perspective	63.1	63.6	Data	62.3	Data covers the demand	55.0	57.0
					Data is accessible	61.0	60.0
					Data quality is sufficient	65.0	65.0
					Data structure is usable	65.0	67.0
			Services	65.0	The Geodata portal is user friendly	65.0	66.0
					View services are user friendly	64.0	65.0
					Download services are user friendly	65.0	64.0
Co-operation	15.0	38.3	Co-operation	35.5	All core stakeholders participate	0.0	69.6
					All municipalities participate	0.0	1.4
			Reference system	41.2	Sweref99 implemented by all core stakeholders	34.8	47.8
					Sweref99 implemented by all municipalities	57.6	72.1
					RH2000 implemented by all core stakeholders	17.4	30.4
					RH2000 implemented by all municipalities	10.0	14.5

10.1.2 The Logic Model

The Logic Model is a fundamental tool for measuring and monitoring performance. It assists managers in clearly and concisely identifying and illustrating the logical relationships between a program's objectives, inputs, processes, outputs, outcomes and impacts. In addition, the logic model is the foundation for developing SMART performance indicators. It is a widely accepted view that a well-designed logic model will result in the automatic emergence of a set of SMART performance indicators (Schacter, 2002).

A logic model is a visual schema that seeks to convey explicitly the assumed relationships (activities and interactions) among inputs, outputs, outcomes and impacts (Schmitz & Parsons, 1999). It conveys these relationships through boxes, connecting lines, arrows, feedback loops and other visual metaphors, as illustrated in Figure 10.3. In addition to visually expressing the presumed effects of a program, the logic model serves as a tool for providing a framework to support program planning, implementation and assessment.

Figure 10.3: Flow Diagram of Key Processes Involved in Designing SDI PIs



The logic model appears to be very applicable to the planning, reengineering, and recapitalization of an SDI, as well as the monitoring and measuring of its performance. See Giff and Crompvoets (2008) and Giff (2008) for examples of the practical application of the logic model to SDI. To demonstrate the logic model's application to SDI, Figure 10.4 provides a simplified example of how it is applied to develop inputs, processes, outputs, outcomes and impacts of an SDI component.

Figure 10.4: Application of the Logic Model to an SDI Component (Giff and Crompvoets, 2008)

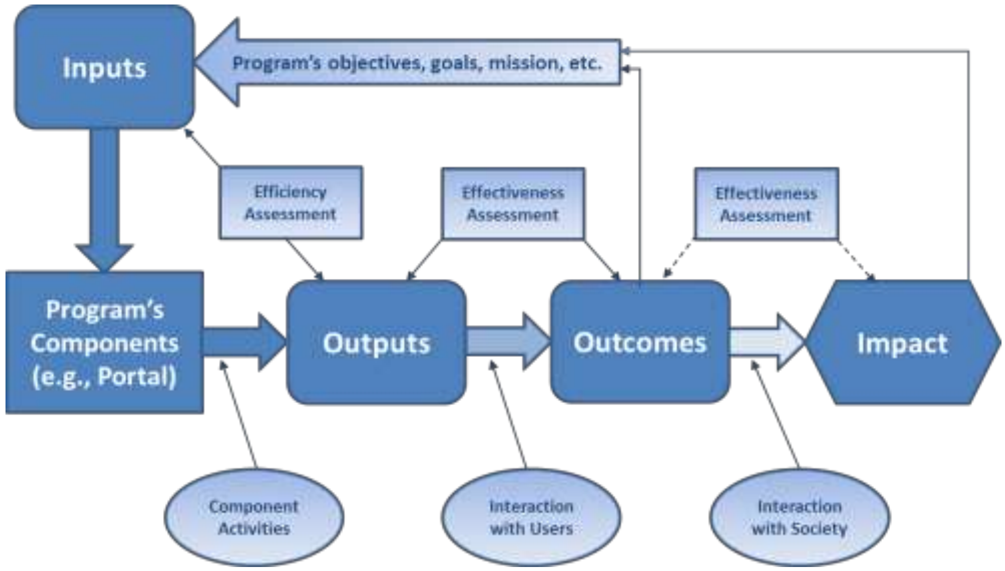
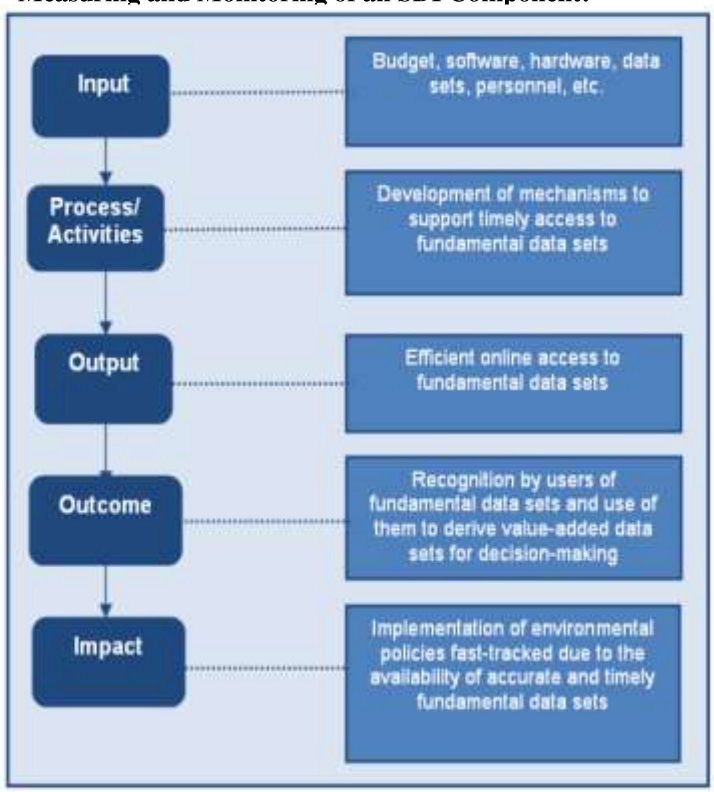


Figure 10.5 provides SDI examples of inputs, processes, outputs, outcomes and impacts developed with the aid of a logic model. This is the first phase of developing SDI performance elements using the logic model. The next phase involves designing SMART indicators and then selecting data collection methods that are practical and cost-effective (Giff and Crompvoets, 2008). The collection of performance information for SDIs can be challenging since an SDI's outcomes and impacts are qualitative in nature. In addition, the complex and multi-dimensional nature of an SDI will require multiple data collection methods, as well as a multi-step performance methodology to provide accurate performance information to satisfy the needs of the various stakeholders. Section 10.2 reviews the different methodologies used to measure and monitor the SDI performance.

Figure 10.5: The Application of the Logic Model to the Measuring and Monitoring of an SDI Component.



10.2 Methodologies Used to Measure and Monitor SDIs

Funders of SDI initiatives are demanding a clear indication and demonstration of the benefits of SDI implementation. This has led to increased awareness of the need for SDI assessment, as well as for actual measuring and monitoring of SDIs. This is evident from not only the growing number of SDIs evaluated but the growth in literature on SDI assessment and the development of new methodologies to assess SDIs. The most notable new methodology is the concept of a *Multi-View Framework* for the assessment of SDIs (see Crompvoets et al., 2008). The significance of this methodology is that it recognizes that SDIs are multi-dimensional and multi-sectoral with different perspectives. Therefore, not all SDIs can be evaluated with a single methodology. The multi-view framework proposes a number of methodologies for evaluating an SDI based on the SDI objectives, the purpose of the assessment, and the potential users of the performance information.

Current SDI assessment (measuring and monitoring) techniques can be classified into two distinctive categories: *Readiness* and *Performance Evaluation*. Within these two categories, different methodologies are employed to measure and monitor performance. The methodology selected is usually based on the skills of the personnel involved, ease of use, cost, the required performance information, and the time it takes to perform the evaluation. This section will review SDI measuring and monitoring methodologies by category (readiness and performance) and provide practical examples of their application.

10.2.1 SDI Readiness Assessment Methodologies

A readiness assessment is a fact-gathering exercise to determine the “as is” status of a program. It provides insight into whether or not the tools and personnel are in place to achieve the stated objectives (i.e., the program’s readiness to perform the activities necessary to achieve the set goals). In the case of an SDI, a readiness assessment provides information on whether or not the key components are in place to achieve the SDI objectives, as well as the level of completeness of their implementation. This partly explains why early SDI evaluations were mainly readiness assessments.

Clearinghouse Readiness

The most popular and documented readiness assessment is the Clearinghouse Readiness developed by Crompvoets and Bregt. It was established to measure the status of SDI clearinghouses across the world. The assessment was conducted systematically and periodically (i.e., April 2000, December 2000, April 2001, December 2001, April 2002, December 2002 and April 2005). See Crompvoets and Bregt (2007) for more details on SDI Clearinghouse Readiness assessments for the period 2000–2005. The Clearinghouse Readiness assessment included identifying key characteristics of a clearinghouse (12 in 2000) and conducting an online survey to determine the existence and status of each characteristic within the targeted clearinghouses (Crompvoets et al., 2004). Where additional information was required, the clearinghouse coordinator would be interviewed. The results were used to benchmark the development and evolution of the clearinghouses over time.

Clearinghouse Suitability Index

Crompvoets and Bregt evolved the Clearinghouse Readiness assessment into the Clearinghouse Suitability Index, with its first application in 2005 and the next in 2008. The Clearinghouse Suitability Index was used as the standard to determine the suitability of clearinghouses worldwide. In the Clearinghouse Suitability Index, 15 characteristics of a clearinghouse were identified and a weighted value between 0.00 and 1.00 was assigned to each characteristic, depending on their importance to the efficient functioning of the clearinghouse (Crompvoets and Bregt, 2008, Chapter 7). The Clearinghouse Suitability Index allowed clearinghouses to be ranked, and it facilitated the establishment of benchmarks to be used to identify positive or negative changes in the characteristics, as well as the clearinghouse itself.

The SDI Readiness Model

Another methodology employed to assess the readiness of SDIs across the world is the SDI Readiness Model developed by Delgado et al., and first applied to the assessment of the Cuban SDI (Delgado et al., 2005). Similar to the Clearinghouse Suitability Index, the SDI Readiness Model uses indices to determine the readiness of an SDI. The model evaluates and ranks the following five key characteristics of an SDI: organizational structure, information, human resources, financial resources, and technology. Indices for each characteristic, as well as the SDI, were defined using a fuzzy-based model, which was supported by Compensatory Logic (Delgado et al., 2008, chap. 6). The model was applied to 27 countries worldwide, including 17 from the Americas. Questionnaires directed to the SDI coordinators were used to capture information for the model, and the resulting information was used to benchmark SDI development.

INSPIRE State of Play

The most systematic and periodic readiness assessment performed on SDIs is the Infrastructure for Spatial Information in the European Community [INSPIRE] State of Play. The State of Play was first employed in 2002 to determine the status of SDIs in Europe and has been employed annually since then. The early State of Play assessments set out to measure whether 32 national SDIs in Europe had the five key components of an SDI (i.e., legal framework, geographic data, metadata, access services and standards). With the experience gained from each assessment, the INSPIRE monitoring team continuously updated the methodology of the State of Play assessment, and by 2006, the State of Play assessment framework had seven characteristics with 30 indicators to monitor the changes in the status of the SDIs over time (Vandenbroucke et al., 2008, Chapter 8). The State of Play assessment is constantly evolving to match INSPIRE's need for performance information on its stakeholders' SDIs. It is expected that future State of Play assessments will focus more on measuring and monitoring performance than readiness. Information on the latest State of Play (2011) can be found in (Vandenbroucke et al., 2011). Also, copies of all the State of Play reports and additional information on the methodology used can be obtained from the INSPIRE website at http://inspire.jrc.ec.europa.eu/.

The readiness assessment methodology is the most widely used methodology for measuring and monitoring SDIs. This is mainly because it is simple and cost-effective to implement and administer. The readiness assessment methodology is the most suited to the application of SDIs in their early implementation phase or to determine the status of an SDI in terms of its ability to achieve the predetermined targets. The main weakness of the readiness methodology, however, is that it does not provide sufficient information on 1) the level to which the defined targets are being achieved, and 2) the actual usage of the SDI or the usage of individual components. This can only be achieved through a performance assessment. The State of Play and the SDI Readiness Model are two readiness methodologies that can be useful to regional coordinating bodies in comparing the development of SDIs within their region. All the methodologies reviewed in this category demonstrated strengths and limitations in measuring and monitoring SDIs. These strengths and limitations are summarized in Table 10.3.

Table 10.3: Summary of the Pros and Cons of the SDI Readiness Assessment Methodologies

<table>
<tr><th>Readiness Assessment Methodology</th><th>Key Features for SDI Assessment</th><th>Drawbacks</th></tr>
<tr><td>Clearinghouse Readiness</td><td>1. Provides concise information on the implementation status of an SDI's clearinghouse components
2. Cost-effective to implement
3. Provides benchmark information for tracking clearinghouse implementation</td><td>1. The information collected is mainly associated with the clearinghouse
2. Performance information is not collected
3. The methodology does not fully support continuous measuring and monitoring
4. Results are very qualitative</td></tr>
<tr><td>Clearinghouse Suitability</td><td>1. A more scientific methodology for measuring the readiness of key clearinghouse components
2. Indices provide more precise information on implementation status
3. Standardized method for benchmarking the implementation of clearinghouse components
4. Features 1−2 of the Clearinghouse Readiness listed above</td><td>1. Drawbacks 1−3 listed above for the Clearinghouse Readiness also apply to the Clearinghouse Suitability
2. Quantification of the clearinghouse status can be time-consuming and costly</td></tr>
<tr><td>SDI Readiness Model</td><td>1. Provides quantitative information on the readiness of an SDI
2. Facilitates the identification of the implementation status of key components of an SDI
3. Facilitates the comparison of SDI implementation status (year to year or with other SDIs)</td><td>1. Drawbacks 2−3 listed above for the Clearinghouse Readiness also apply to the SDI Readiness Model
2. Requires skilled personnel to analyze the results
3. Can be costly to implement</td></tr>
</table>

Readiness Assessment Methodology	Key Features for SDI Assessment	Drawbacks
State of Play	1. Systematic and timely methodology 2. Comprehensive assessment of SDI components 3. Facilitates the comparison of SDI implementation status 4. Mix of qualitative and quantitative information collected 5. Some performance information collected	1. Results are too qualitative 2. Can be costly because of its comprehensiveness 3. Insufficient performance information

10.2.2 SDI Performance Assessment Methodologies

An SDI performance assessment goes beyond identifying whether or not key components or desired components have been implemented. It also seeks to determine if these selected components are performing (i.e., if the SDI is achieving its objectives). The knowledge of whether or not an SDI is achieving the desired outputs, outcomes and impact is usually gathered through performance indicators that are consistently measured and monitored.

The number of reported SDI performance assessments is steadily increasing, in part due to demand from the SDI funders for performance information, as well as an increase in the body of knowledge on measuring and monitoring SDI performance. While the majority of the performance assessments are being managed within a "PBM framework," it should be noted that many SDIs do not totally utilize the tools of the PBM framework. In most instances, only a single tool within the PBM framework is used to enhance the measuring and monitoring of performance. The PBM tools used by SDI coordinators to capture and report performance vary from SDI to SDI. The variation in the tools used is affected by such factors as the quality of the performance information required, the budget available to carry out assessment, the objectives of the SDI, the maturity of the SDI, the number of stakeholders, and the users of the performance information.

The GeoConnections Framework

One SDI program that uses a number of tools available within the PBM framework is the CGDI. The GeoConnections program — coordinator of the CGDI — employs PBM tools (e.g., organizational assessment, strategic planning, program planning, performance measurement, process standardization and the logic model) to efficiently and effectively measure and monitor the performance of both the program and the CGDI. For example, the logic model was successfully utilized to define the outputs, outcomes and impacts of the GeoConnections program. Once the outputs, outcomes and impacts were identified, the next application of the logic model was to develop key performance indicators (KPIs) to be used in measuring the levels to which outputs, outcomes and impacts were being achieved.

GeoMaturity Framework

The Abu Dhabi Spatial Data Infrastructure (AD-SDI) is another SDI that utilizes tools from a PBM framework. The AD-SDI coordinating team developed a multi-level framework called the GeoMaturity Framework for measuring and monitoring the performance of the AD-SDI. The GeoMaturity Framework utilizes tools for the PBM system to identify key components of the AD-SDI, to define the outputs and outcomes of each component, as well as to develop KPIs for the outputs and outcomes and indicators for its general objectives (i.e., impacts). A key feature of the GeoMaturity Framework is its capability to assess the readiness of the stakeholders, and users in general, to use the services offered by the AD-SDI.

Balanced Scorecard

The Swedish SDI is another SDI that uses tools from the PBM framework. The main tool is the Balanced Scorecard (BSC). Currently, the coordinators of the Swedish SDI use the BSC to measure and monitor progress in their SDI over time. However, it is expected that this tool will also be used in the near future to assist in planning improvements to the SDI. The BSC was used to measure and monitor the following three components of the Swedish SDI:

- Data and Services – The availability and access to spatial data via the SDI
- User Satisfaction – The level to which the user community is satisfied with the spatial data and services provided by the SDI
- Cooperation – The willingness of stakeholders to participate in the development and usage of the SDI

The objectives and targets for each component were clearly defined, performance indicators were developed to monitor progress over time, and questionnaires and Web services were used for data collection. Reporting on the measuring and monitoring of the Swedish SDI has been an annual exercise since 2010. For more information on how the BSC is used to measure and monitor the Swedish SDI, see Toomanian et al. (2011) and Geodata (2010).

Upon review of the methodologies in this category, all were found to have a number of features that make them very applicable to the measuring and monitoring of SDI performance. Table 10.4 provides a summary of the positive features of each methodology, as well as the features that limit their application to SDI performance measuring and monitoring.

Table 10.4: Summary of the Pros and Cons of the SDI Performance Assessment Methodologies

Performance Assessment Methodology	Key Features for SDI Assessment	Drawbacks
GeoConnections Framework	1. Systematic and timely assessment that employs PBM tools 2. Comprehensive with concise indicators to support continuous measuring and monitoring of performance 3. Facilitates clear definition of an SDI's objectives, inputs, outputs, outcomes, impacts and performance measures 4. Utilizes automated data collection techniques	1. Data collection methods can be costly 2. Requires knowledge on the logic models and the development of SMART performance indicators 3. Can be time-consuming and uses significant human resources
GeoMaturity	1. Assesses an SDI from the viewpoints of the different categories of stakeholders 2. Very user-centric assessment 3. Facilitates the collection and quantification of extensive and important qualitative information 4. 1−4 of the GeoConnections methodology are also applicable	1. Costly to develop and implement the frameworks 2. Current data collection methods are costly 3. Relies on the commitment of stakeholders
Balanced Scorecard	1. Multi-dimensional in nature (links cause and effects) 2. Uses PIs in the assessment process 3. Results are quantitative 4. Facilitates graphical presentation of results	1. Steep learning curve required 2. Very mathematical 3. Processing of information is time-consuming 4. Requires knowledge of the development of SMART performance indicators

10.2.3 The Multi-View Framework

Sections 10.2.1 and 10.2.2 reviewed methodologies for measuring and monitoring SDI performance with the categories of Readiness and Performance Evaluation. However, SDIs are complex and multi-disciplinary in nature. Therefore, no single methodology is capable of effectively collecting and reporting the performance information required by SDI coordinators, practitioners and stakeholders. In recognition of this concept, SDI practitioners and scholars met in Wageningen, The Netherlands in May 2007 to brainstorm methodologies that could comprehensively assess SDIs. The result of this three-day workshop was the birth of the *Multi-View Framework* for assessing SDIs.

The Multi-View Framework consists of nine SDI assessment methodologies from which an SDI coordinator can select the best methodology(ies) for assessing an SDI from the required viewpoint. The framework structure is flexible and allows for the addition of new methodologies. Therefore, once new methodologies to enhance SDI assessment are identified, they can be easily included in the framework to provide more precise assessments. The Multi-View Framework does have its drawbacks; the application of multiple frameworks will require personnel with knowledge of the different frames used, and combining frameworks to suit the assessment needs will be an iterative process. In addition, data collection methods associated with the Multi-View Framework can be costly.

The multi-view assessment was applied to 10 countries in the Americas (i.e., Argentina, Brazil, Canada, Chile, Colombia, Cuba, Ecuador, Guyana, Mexico and Uruguay) as a case study to determine its functionality (Grus et al., 2008, chap 18). However, an actual application of the Multi-View Framework can be seen in the measuring and monitoring of the Netherlands' SDI. In 2008, the Dutch SDI established four goals that needed to be realized by 2011(VROM, 2008):

- The public and businesses will be able to retrieve and use all relevant geo-information about any location
- Businesses will be able to add economic value to all relevant government-provided geoinformation
- The government will use the information available for each location in its work processes and services
- The government, businesses, universities and knowledge institutes will collaborate closely on the continuing development and enhancement of the key facility

To determine the level to which the SDI was performing with respect to these four goals, the coordinators decided to measure and monitor the progress over time. Due to the nature of the goals, the Multi-View Framework was the most appropriate methodology to measure, monitor and report on the progress. Four methodologies from the Multi-View Framework were applied simultaneously to measure and monitor the SDI with respect to the four goals. The four methodologies were used to develop 12 indicators for measuring and monitoring progress towards the goals. For more information on the application of the Multi-View Framework to the measuring and monitoring of the Dutch SDI, see Grus et al. (2010) and Castelein and Manso Callejo (2010).

The Multi-View Framework is a very comprehensive tool for measuring and monitoring the performance of SDIs. It provides SDI coordinators and practitioners with the option to select the most appropriate assessment methodology(ies) to measure, monitor and report on performance. In addition, the simultaneous application of multiple measuring and monitoring methodologies facilitates more effective comparison and analysis of the results.

10.3 SDI Measuring and Monitoring for the Americas

Based on the 2012 PC-IDEA survey of SDIs in the Americas, the majority of the countries comprising the Americas do not have frameworks in place to measure and monitor the performance of their SDIs (PC-IDEA, 2012). However, it was noted that the awareness of the need for measuring and monitoring SDIs in the Americas has burgeoned. The consensus on the need for a chapter in this manual to help SDI practitioners develop evaluation methodologies for their SDIs highlights this point. The sharing of experiences and lessons learned from actual SDI measuring and monitoring can only serve to strengthen the body of knowledge on SDI assessment in the region. The aim of this section is to present and analyze selected case studies on measuring and monitoring SDIs. The analysis will focus on the lessons learned from these experiences that are applicable to SDI measuring and monitoring in the Americas. The experiences presented will focus mainly on SDIs using the performance assessment methodology, since this is the assessment of the future. An assessment of this nature usually provides both performance and readiness information.

10.3.1 Measuring and Monitoring SDI in Canada

Implementation of the Canadian SDI (CGDI) is carried out on a phase basis with each phase having different objectives, expected outputs, outcomes and impact. Measuring and monitoring of performance is a key component of each phase. The task of coordinating the CGDI, and thus measuring and monitoring its performance, is carried out by the GeoConnections Program, an initiative led by National Resources Canada. In Phase I (1999−2005), the measuring and monitoring activities focused mainly on the performance of the GeoConnections program (i.e., the level of efficiency and effectiveness in implementing the targeted CGDI components). However, to identify the program's efficiency and effectiveness, it was also necessary to determine the CGDI components that were implemented. Therefore, some assessment aspects of the GeoConnections program could be viewed as a readiness assessment of the CGDI. The assessment results were fed into the design of Phase II, and helped justify additional funds to support that phase.

The growing need for accountability saw Phase II (2005−2010) of the GeoConnections program being coordinated more within the "Results-based Management and Accountability Framework," which is the Canadian version of the PBM. This resulted in the development of a new framework to measure and monitor the performance of the GeoConnections program in 2007, which consisted of a logic model that was used to develop clearly defined outputs (22), outcomes (16) and impacts (4). The logic model was also used to develop performance indicators to inform the relevant authorities of the extent to which the GeoConnections program was achieving the desired outputs, outcomes and impacts. For more on the logic model and development of the indicators, see GeoConnections (2011e) and Giff and Crompvoets (2008).

The GeoConnections framework used three distinctive methodologies to capture quantitative and qualitative performance information. Information for quantitative indicators was captured through the regular activities of the CGDI and GeoConnections, while the qualitative information was captured through surveys and interviews (GeoConnections, 2011). It should also be noted that project tracking software implemented by GeoConnections was an important measuring and monitoring tool that provided significant performance information.

Good Practice

GeoConnections' measuring and monitoring experience illustrates the following:

- *Measuring and monitoring is simpler and more efficient when carried out within a PBM framework, which provides the tools and structure for systematic, efficient and effective measuring and monitoring of performance.*
- *The development of a measuring and monitoring framework is an iterative process.*
- *The framework must have flexibility to facilitate changes in the SDI.*
- *The objectives, inputs, outputs, outcomes, impacts and performance indicators should be clearly defined, and the logic model is an excellent tool for this activity.*
- *Implementation of tracking software can greatly reduce the data collection time and costs.*
- *Sampling (i.e., the use of case studies) can also reduce the cost of data collection.*
- *It is not economically viable to measure and monitor all SDI activities, so key activities will have to be selected for measuring and monitoring.*

For Phase III (2010–2015) of the program, the framework was refined to make it more SDI- and user-centric, with the assessment focus shifting to the actual measuring and monitoring of the performance of the CGDI. Under the revised framework, the CGDI activities were classified into five component areas: collaboration and leadership, availability and accessibility of policy resources, availability and accessibility of standards, availability and accessibility of technology, and availability and accessibility of framework data. For each component, outputs, outcomes and impacts were defined, resulting in 47 sub-levels. The CDGI's performance was rated through a qualitative scorecard using colors to depict performance levels. In this rating scheme, green means "fully meets the criteria," yellow means "partially meets the criteria," and red means "does not meet the criteria." In some instances the color coding scheme was supported by notes providing additional performance information. Surveys and interviews, selected case studies and tracking were used to obtain accurate and precise performance information.

10.3.2 Measuring and Monitoring the Abu Dhabi SDI

The Abu Dhabi SDI (AD-SDI) is coordinated by the Abu Dhabi Systems and Information Centre (ADSIC). In 2009, ADSIC decided to implement a comprehensive measuring and monitoring program that sought not only to measure the performance of the AD-SDI but also the extent to which stakeholders are using the services offered by the infrastructure. The latter aspect of the assessment was very important as it provided vital information for the reengineering of AD-SDI in terms of services to be offered and the format for maximum utilization.

The framework developed for measuring and monitoring the AD-SDI, as well as the impact the AD-SDI was having on the usage of geo-information for decision-making in Abu Dhabi, was called the GeoMaturity framework. In adhering to the PBM concept, the GeoMaturity framework utilized the logic model to help design clear and concise outputs, outcomes, impacts and performance indicators. Similar to the CGDI's framework, the GeoMaturity framework was also user-centric and sought to capture the actual usage of the SDI. The frameworks differ, however, in terms of the comprehensiveness and data collection methodologies.

Good Practice

The Abu Dhabi 2010–11 GeoMaturity assessment was a success and illustrates the following:

- *Assessing stakeholders' readiness and actual usage of the SDI provides vital information on the services and the format of the services required by users.*
- *Involvement of stakeholders in the assessment and reporting of performance strengthens their participation in the SDI.*
- *The simultaneous application of multiple frameworks allows for gaps in one framework to be covered by another.*
- *Having a comprehensive multi-level framework facilitates the capture of more detailed performance information, which can be used for both reengineering and recapitalization of the SDI.*
- *The costs of data collection by interviews can be reduced through an online self-assessment framework.*
- *Assessments can produce a lot of information and the analysis of this information can be very time-consuming.*

The GeoMaturity framework is a multi-level assessment framework consisting of four sub-levels ─ the AD-SDI, stakeholders, sectors, and citizens assessment frameworks (ADSIC, 2010). The stakeholders, sectors, and citizens frameworks were designed to assess the readiness of each group to use the AD-SDI services, as well as their actual usage of the AD-SDI. This characteristic highlights the user-centric nature of the GeoMaturity framework and its capability to collect performance information based on the interests of the various sectors participating in the development of the AD-SDI. The AD-SDI assessment framework defined the key components of the SDI, their expected output, outcomes and performance indicators to measure their levels of achievement (KU Leuven, 2011). Another key feature of the AD-SDI assessment framework was its flexibility. It facilitated the simultaneous use of both the SDI Readiness and State of Play methodologies in the assessment process. This feature facilitated the comparison of results and allowed ADSIC to benchmark the progress of the AD-SDI with other SDIs around the world. The GeoMaturity framework used a five-level ranking system to rate the components being assessed.

For the application of the GeoMaturity framework in 2010−2011, a documentation review, interviews and portal tracking software were used for extensive data collection, with stakeholder interviews being the main tool. For Abu Dhabi and areas of similar geographic extent, this methodology is applicable but may be too costly for SDIs serving larger geographic areas. A more cost-effective data collection method for these areas would be to replace some of the interviews with selected case studies, as demonstrated in the CGDI assessment. For more information on the application of the GeoMaturity framework to the AD-SDI assessment, see KU Leuven, (2011).

10.3.3 Measuring and Monitoring MetroGIS

MetroGIS is a regional SDI in the State of Minnesota that serves the metropolitan areas of Minneapolis and St. Paul. The coordinators of MetroGIS have been measuring and monitoring its performance annually since 2002, with early assessments focusing mainly on the readiness of the MetroGIS portal, DataFinder. Similar to other SDIs, the assessment evolved into the measuring and monitoring of the performance of all MetroGIS components (i.e., a more user-centric approach). In 2009, MetroGIS coordinators developed a new measuring and monitoring framework designed to measure progress towards the four outcomes of the SDI: ease of data discovery and access, data currency, internal efficiencies and level of cooperation, and decision-making and service delivery (KLD Consulting, 2009). Eleven performance indicators were developed to monitor progress towards achieving these outcomes (Johnson and Kline, 2009).

Good Practice

MetroGIS's years of measuring and monitoring experience illustrate that:

- *measuring and monitoring can be performed cost-effectively and efficiently;*
- *tools such as Web Trends software, testimonials, surveys and case studies can be used to reduce data collection costs;*
- *measuring everything is not always necessary, but it is important to measure critical components that demonstrate value to funders and stakeholders;*
- *a measuring and monitoring framework can be simple but still effective in collecting relevant performance information;*
- *systematic voluntary performance reporting by stakeholders and users (i.e., testimonials) can significantly reduce data collection costs; and*
- *annual reporting on the measuring and monitoring of performance provides a wealth of performance information for benchmarking.*

For MetroGIS, the measuring and monitoring activities of this new framework had to be cost-effective and place minimum demand on staff resources. MetroGIS coordinators designed and implemented a simple framework that continued to use Web Trends software and other tracking mechanisms supported by case studies and surveys for data collection. However, data obtained from the tracking software were enhanced and made more meaningful with explanation notes in the new framework. To reduce the cost of collecting qualitative performance information, the case studies were supported by testimonials. For more information on the evaluation of MetroGIS, see KLD Consulting (2009) and Johnson and Kline (2009).

10.3.4 Measuring and Monitoring the Colombian SDI

The coordinators of the Colombian Spatial Data Infrastructure (ICDE) have realized that the success of future generations of the ICDE will depend, in part, on their ability to understand, analyze and report on the performance of the ICDE (Amaya, 2011). With this in mind, the coordinators sought the help of the Instituto Geografico Augustin Codazzi (IGAC) through its Geospatial Technology Observatory project in developing a PBM methodology to measure and monitor the performance of the ICDE. IGAC worked with graduate student Carolina Morera Amaya to develop the framework. Although the framework is yet to be officially applied to the measuring and monitoring of the ICDE, the authors feel that there is knowledge to be gained from partial application of the framework, and hence its discussion in the chapter.

Good Practice

Although still in its early stages, the measuring and monitoring of the ICDE provides SDI funders, coordinators and practitioners with knowledge on:

- *Application of the COBIT methodology to SDI measuring and monitoring;*
- *Use of the BSC to support COBIT in SDI measuring and monitoring;*
- *Application of the data collection and analysis tools associated with BSC and COBIT to SDI measuring and monitoring; and*
- *Use of the multi-view framework to develop a customized framework capable of measuring and monitoring the various components of an SDI.*

Morera Amaya (2011) reported that a Multi-View Framework, similar to that proposed by Crompvoets et al., 2008, was developed for measuring and monitoring the ICDE. The ICDE framework added the methodologies of the Control Objectives for Information and Related Technology (COBIT)[38] and the BSC to better assess the IT component of the SDI. The framework was successfully applied to the assessment of the IT component of the ICDE as a test of its capabilities (Morera Amaya, 2011).

10.3.5 Benefits of Measuring and Monitoring Performance Identified from the Case Studies

Measuring and monitoring performance is an additional task with which SDI practitioners, coordinators, and stakeholders must cope, and it can be a time-consuming and costly task. Section 10.1.1 highlighted the theoretical benefits to be derived from measuring and monitoring performance, but are such benefits achievable in an SDI environment? The case studies clearly demonstrate that a number of these benefits were applicable to SDIs and are being utilized by the SDI community. Table 10.5 provides a summary of the practical benefits derived by selected SDI communities from measuring and monitoring performance.

Table 10.5: Summary of Actual Usage of Performance Information by SDI Communities

SDI Analyzed	Benefits of Performance Information
CGDI	1. Used to assist in securing funding for additional phases of the CGDI 2. Used to assist in the identification of new objectives of the CGDI 3. Used to identify stakeholders' and users' needs and expectations of the CGDI
AD-SDI	1. Used to identify the needs and expectations of the different categories of stakeholders and users 2. Used to identify areas of the AD-SDI that required more attention from the coordinators 3. Incorporated in cost-benefit analysis to justify expenditure on the AD-SDI 4. Used to modernize the geoportal to better reflect users' needs

[38] See http://www.isaca.org/ for more information on COBIT and its application to IT measuring and monitoring.

SDI Analyzed	Benefits of Performance Information
MetroGIS	1. Used to secure continuous funding for MetroGIS 2. Used for planning the modernization of the SDI, in particular the geoportal
Swedish SDI	1. Used to monitor progress of the SDI towards targets and objectives (year-to-year) 2. Framework being developed to use as an SDI planning tool
GIDEON (Netherlands)	1. Used to monitor implementation of the strategies and/or fulfilment of the strategy objectives
INSPIRE	1. Used to monitor and report on the implementation and use of the SDIs in EU Member States 2. Incorporated in the *INSPIRE State of Play* to justify the assessment and improve its results

In general, the most common use of performance information by SDI communities is to support the reengineering and recapitalization of SDIs. From Table 10.5 it can be seen that the majority of the SDIs studied were using performance information to support recapitalization and all were exploring the concept of using performance information for reengineering purposes.

10.4 The Way Forward: Ensure Self-Measuring and Monitoring of SDIs in the Americas

The way forward for SDI measuring and monitoring in the Americas is for funders, coordinators and practitioners to have measuring and monitoring entrenched in the coordination and management (i.e., governance) of SDIs. Achieving this task will be a huge challenge to the SDI community of the Americas as designing and implementing a measuring and monitoring framework is complex and resource intensive. This highlights the importance of defining what is to be measured and, since we cannot measure everything, prioritization is necessary.

Although this chapter identified a number of measuring and monitoring methodologies, it is important to note that there is no methodology "tool kit" that can be handed to an SDI coordinator to perform a measuring and monitoring exercise. Effective and efficient measuring and monitoring can only be achieved by SDI coordinators/practitioners analyzing the program and identifying clearly what is to be measured. A performance analysis helps to identify the objectives (i.e., what the SDI developers want to achieve), the processes necessary to achieve the objectives (i.e., inputs, activities, outputs and outcomes), the resources required and available for the assessment, and the areas to be assessed that will best demonstrate success. Once armed with this information, SDI coordinators can select and customize the most suitable (i.e., feasible and flexible) methodology to efficiently and effectively measure and monitor the desired performance. The most suitable approach may be a combination of the methodologies reviewed in this chapter or other methodologies yet to be applied to SDI measuring and monitoring.

It should be noted that, regardless of the methodology chosen, the tools for data collection should help make the activity efficient and cost-effective. The most cost-effective tools identified by the review of the case studies are automated tracking software, online surveys, testimonials and selected case studies.

In closing, readers should view this chapter as a living document. As more SDIs are measured and monitored, the community's knowledge and expertise on SDI measuring and monitoring will grow and the chapter will need to be updated. In addition, SDIs are changing in response to demand, as well as technology. Therefore, measuring and monitoring methodologies will have to change to keep abreast of future generations of SDIs.

10.5 Chapter Highlights

In summary, the key assessment fundamentals the reader should take away from this chapter are as follows:

- It is good practise for SDI measuring and monitoring to be carried out within a PBM framework, which ensures, for example, that systematic and periodic assessment is achieved.
- What is to be measured should be clearly identified, and smart performance indicators should be developed to support measuring and monitoring.
- The logic model is an effective tool for defining what is to be measured and the indicators to measure them.
- Select the methodology(ies) that will best capture and communicate the performance of the prioritized components to the users of the assessment.
- The capturing of the performance information should be cost-effective, timely and automated, whenever possible.
- The validity of the performance information is greater if the performance framework is implemented by an organization independent of its design (e.g., in the cases of the AD-SDI and GeoConnections).
- Finally, trade-offs are unavoidable in measuring and monitoring performance.

11. Conclusions

This manual is intended to fill a gap in guidance for government officials and other stakeholders in the Americas for their efforts to plan, develop and implement spatial data infrastructure initiatives. It has been structured to cover all of the topics that those considering SDI will encounter, generally in the order in which they will need to be considered.

Starting with basic SDI concepts, the reader is guided through the key infrastructure planning considerations of identifying users and their needs. The manual then covers financing and the justification of SDI expenditures, the SDI fundamentals of making institutional arrangements, governance and organization, and strategic frameworks. Next, the basic SDI components of framework data, standards, policies and technologies are discussed. The reader is then introduced to considerations for SDI implementation, such as outreach and awareness and capacity building, and the use of case studies and good practice documentation for the sharing of knowledge. The manual closes with a discussion of the role of measuring and monitoring in ensuring ongoing sustainability and adaptability of the infrastructure.

While the primary target audience for this guide is those people responsible for planning and implementing spatial data infrastructure initiatives in the Americas, it may also be of interest to SDI developers in other regions and to users of spatial information. Other stakeholders in SDI initiatives, including decision-makers taking forward proposals for political support and those involved with the details of data production, standards, technologies and policies, will also find value. The compilation of the information in the manual has benefited greatly from the efforts of many other authors and SDI managers who have taken the time to document their approaches, good practices and lessons learned. Such practices are instrumental in the continuing efforts of spatial information professionals to develop increasingly better SDIs to serve the needs of society.

This guide is one in a series of documents being developed by GeoConnections. It is intended to be a living document, and may be updated as the approaches and methods for developing SDIs evolve. Therefore, GeoConnections encourages the submission of any contributions, links or relevant guidelines, case studies, good practices, and so on, that the reader feels would help to improve this document (email: info@GeoConnections.NRCan.gc.ca).

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B. Glossary of Terms

Acronym	Term	Definition
	Anonymized Data	A data set that has been irreversibly severed from the identity of the data contributor to prevent any future re-identification (may also include preserving identifying information that could only be re-linked by a trusted party in certain situations).
	Application	The use of capabilities, including hardware, software and data, to manipulate and process data for user requirements. Applications are designed to perform a specific function directly for the user or, in some cases, for another application program. Related terms: Application Program, Application Software, End-User Software
API	Application Program Interface	The interface (calling conventions) by which an application program accesses operating systems and other services. An API provides a means of developing custom user interfaces.
	Application Schema	Defines content and structure of both geographic data and other related data, and operations for manipulating and processing data by an application.
	Applications Profile	The set of metadata properties, policies and guidelines defined for a particular metadata application or implementation.
	Architectural Framework	Identifies key interfaces and services, and provides a context for identifying and resolving policy, management and strategic technical issues. Related terms: Conceptual Architecture, Reference Architecture
	Archiving	Creating a collection of historical records (i.e., records that have been selected for permanent or long-term preservation on grounds of their enduring cultural, historical or evidentiary value).
	Attribution	Ascribing the production of the data to a specific data custodian.
CGDI	Canadian Geospatial Data Infrastructure	The CGDI helps Canadians gain new perspectives into social, economic and environmental issues, by providing an online network of resources that improves the sharing, use and integration of information tied to geographic locations in Canada. More specifically, the CGDI is the convergence of policies, standards, technologies, and framework data necessary to harmonize all of Canada's location-based information.

Acronym	Term	Definition
	Capacity Building	Development of individuals with various profiles and backgrounds - through training and education - to meet well-defined objectives, usually within the scope of a program or project. Related terms: Organizational Development, Institutional Strengthening, Improvement Management
	Case Studies	Analyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more methods.
	Catalogue	A single collection of metadata entries that are managed together.
	Catalogue Entry	A single metadata entry made accessible through a catalogue service or stored in a catalogue. Related terms: Metadata Entry
	Catalogue Gateway	A centralized service with a user interface that allows a user to query distributed catalogue services through their metadata descriptions.
	Catalogue Service	A service that responds to requests for metadata in a catalogue and that complies with certain browsing or search criteria.
	Clearinghouse	A distributed network of geospatial data producers, managers and users linked electronically. Incorporates the data discovery and distribution components of a spatial data infrastructure for a community.
	Cloud Computing	A model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
	Community	A group of individuals who collectively promote the collaboration of people and efforts, or exchange information, in pursuit of issues or topics of common interest, common goals or objectives, missions or business processes. Related terms: Community of Practice, Information Community
	Conceptual Schema Language	Formal language based on a conceptual formalism for the purpose of representing conceptual schemas or data models.
	Conformance	Fulfillment of specified requirements.

Acronym	Term	Definition
CSDGM	Content Standard for Digital Geospatial Metadata	The Content Standard for Digital Geospatial Metadata (CSDGM), Ver. 2 (FGDC-STD-001-1998) is the current US Federal Metadata standard. The objectives of the FGDC CSDGM are to provide a common set of terms and definitions for the documentation of digital geospatial data. The standard establishes the names of data elements and compound elements (groups of data elements) to be used for these purposes, the definitions of these compound elements and data elements, and information about the values that are to be provided for the data elements. According to Executive Order 12096, all federal agencies are ordered to use this standard to document geospatial data created as of January 1995. The standard is often referred to as the “FGDC Metadata Standard,” and has been implemented beyond the federal level with state and local governments. In coming years, it is expected that the CSDGM will be replaced by the North American Profile of *ISO 19115:2003, Geographic information – Metadata, Ver. 1.0.1*.
	Coordinate Reference System	A system that defines the coordinate space such that the coordinate values are unambiguous.
	Copyright	A temporary monopoly granted over a work. Copyright protects a number of different rights over a work, chief of which is the right to create copies. The creator (or "author") of a work retains rights to that work but can transfer some or all of the rights to others. Re-creating a significant portion of a copyrighted work without permission is illegal.
	Coverage	A collection of direct positions in a coordinate space that may be defined in terms of up to three spatial dimensions as well as a temporal dimension, which may represent a single feature or a set of features.
	Data	Distinct pieces of factual information, especially information organized for analysis or used to reason or make decisions. Data are usually formatted in a special way and presented in a variety of forms.
	Data Collection	Data that has one or several common elements and that has been assembled by these common elements to form a data set. Related terms: Product Collection
	Data Custodian	An organization responsible for the continued physical existence, collection, storage, maintenance, availability and dissemination of the data.

Acronym	Term	Definition
	Data Model	An abstraction of the real world that incorporates only those properties thought to be relevant to the application at hand. The data model would normally define specific groups of entities, their attributes, and the relationships between these entities. A data model is independent of a computer system and its associated data structures.
	Data Product Specification	A detailed description of a data set or data set series together with additional information that will enable it to be created, supplied to and used by another party.
	Data Steward	An organization with formally appointed accountability for the management and maintenance of a spatial data set, including the quality, integrity, availability and security of the data.
	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.
	Decision-maker(s)	An individual (or group of individuals) who uses a cognitive process to select a final option between several other scenarios. The final decision should result in an action.
	Decision Tree	A decision support tool that uses a tree-like graph or model of decisions to help choose an appropriate action, tool, etc.
	Developer	An individual who creates Web-based applications that allow users to interact with an SDI.
	Discovery Mechanism	An online service that allows users to find, evaluate and access resources (data, services and organizations). Brings together suppliers (those providing resources) and users (those using the resources). Related terms: Portal
	Donor	International financial institutions such as The World Bank and Inter-American Development Bank, and United Nations (UN) organizations such as the UN Development Programme and UN Environment Programme, which provide funding for projects and programs in developing countries / emerging economies. Also includes development organizations in developed countries such as the Canadian International Development Agency (CIDA).
	Encoding	A type of encoded data that represents characters as bytes, accomplished by converting each character (which includes letters, numbers, symbols and spaces) into a binary code.
	Encoding Rule	An identifiable collection of conversion rules that defines the encoding for a particular data structure and specifies the data types to be converted, as well as the syntax, structure and coding schemes used in the resulting data structure.

Acronym	Term	Definition
	Expert Amateur	Someone who may know a great deal about geographic information and who practices it passionately on occasion, but still does not rely on it for a living.
	Expert Authority	Someone who has widely studied and long practiced in the field of geographic information systems to the point where he or she is recognized as having an established record of providing high-quality products and services and well-informed opinions, and who stands to lose that reputation and perhaps his or her livelihood if that credibility is lost, even temporarily.
	Expert Professional	Someone who has studied and has extensive experience in the field of geographic information systems, and who relies on personal knowledge in this field for a living and may be sued if his or her products, opinions or recommendations are proven inadequate, incorrect or libellous.
	Feature	An abstraction of real world phenomena.
	Framework	Information architecture. In terms of software design, a reusable software template, or skeleton, from which key enabling and supporting services can be selected, configured and integrated with application code.
	Framework Data	Common base map data that provides spatial reference to physical features and other types of information that is linked to geography and provides a foundation for integrating other kinds of data. Related terms: Reference Data, Fundamental Data, Core Data
	Gazetteer	Directory of instances of a class or classes of features containing information regarding position.
	GeoConnections	A national partnership initiative among federal, provincial and territorial governments and the private and academic sectors that is developing the CGDI, to make Canada's geographic data, tools and services readily accessible on the Internet.
GIS	Geographic Information System	An information system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth’s surface. Both vector and raster GISs are available. Related terms: Geographic Information Service
	Geolinked Data	Data that is referenced to an identified set of geographic features without including the spatial description of those features. It is normally attribute data in tabular form (such as population counts) that refers to a known jurisdiction (such as provinces), where the elements (the provinces) are referred to by their unique identifier (such as the province name).

Acronym	Term	Definition
	Geomatics	The science and technology of gathering, analyzing, interpreting, distributing and using geospatial data. Geomatics encompasses a broad range of disciplines, including surveying, global positioning systems, mapping, remote sensing and cartography.
	Geomatics Sector	Includes federal, provincial/state and municipal departments, non-profit organizations, academic organizations (universities, colleges) as well as commercial organizations that supply and use data, services and resources of a geospatial nature. Related terms: Geomatics Industry, Geospatial Information Industry
	Geoportal	A type of Web portal used to find and access spatial information and associated geographic services (display, editing, analysis, etc.) via the Internet.
	Geoprocessing	Use of computers - specifically GIS operations - to acquire, analyze, store, display and distribute information about geographic features.
	Georeferencing	The process of assigning a geographic location to a piece of information.
	Geospatial Data	Data with implicit or explicit reference to a location relative to the Earth's surface. Related terms: Geodata, Geographic Data, Location-Based Data, Spatial Data, Geospatial Information, Geographic Information
	Geospatial Privacy	The right to control access to geospatial information about one's self.
GeoWeb	Geospatial Web	A term that implies the merging of geographical (location-based) information with abstract information on the Internet, creating an environment where one could search by location instead of keyword only.
GSDI	Global Spatial Data Infrastructure	A set of policies, standards, practices, technologies and relationships to facilitate the flow of geographic data and information at all levels across government, academic, and private sectors globally. It is the top level of a hierarchal structure, linking multiple levels of jurisdictions' (municipal, provincial/state, federal, regional) spatial data infrastructures.
	Good Practice	A technique or methodology that, through experience and research, has reliably proven to lead to a desired result.
	Imagery	Digital data of the Earth collected by a variety of types of sensors (e.g., optical, radar) mounted on satellite, airborne or ground-based platforms.

Acronym	Term	Definition
IP	Intellectual Property	Information that is useful and transferable, and in which someone has rights that give control over the information. Types of IP include invention, copyright, trade secrets, plant breeders' rights, integrated circuit topography, industrial design and trademark.
	Interested Amateur	Someone who has "discovered" an interest in geographic information, begun reading the background literature, consulted with other colleagues and experts about specific issues, is experimenting with its application, and is gaining experience in appreciating the subject.
	Interface	An established ordering of parameters (with specific names and data types) and instructions (with specific names and functions) that characterizes the behaviour of an entity and enables one software component to exchange data and instructions with another software component.
IRR	Internal Rate of Return	The discount rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment.
ISO	International Organization for Standardization	A worldwide federation of national standards bodies from more than 160 countries. The ISO's mission is to promote the development of standardization and related activities in the world to facilitate the international exchange of goods and services, and to develop cooperation in the spheres of intellectual, scientific, technological and economic activity. The ISO's work results in international agreements that are published as international standards.
	Interoperability	The ability of different types of computers, networks, operating systems and applications to work together effectively, without prior communication, in order to exchange information in a useful and meaningful manner. There are three aspects of interoperability: semantic, structural and syntactical.
LAMP	Latin American Metadata Profile	Proposed structure that defines a documentation of geographic information in Latin America, determining some necessary items to describe any type of geographic information, its representation and UML layout scheme.
	Layer	Basic unit of geographic information that may be requested as a map from a server.
	Legacy Data	Information stored in an old or obsolete format or computer system that is difficult to access or process.
	Legal Framework	A set of ideas, rules or beliefs from which a legal structure is developed and on which decisions are based.

Acronym	Term	Definition
	Level of State: International	A group of two or more nations.
	Level of State: Local	Administration of a particular city, town, county or district, with its own representatives in government. Examples: municipalities, local governments, Aboriginal communities
	Level of State: National	Governed by a national body. Includes the entire country (all of its sub-national and local regions). In some nations can be represented by a federal government.
	Level of State: Regional	A group of nations in a specific geographic area of the Earth. Example: The Americas.
	Level of State: Sub-national	Divisions of specific areas within a nation. Normally referred to as states, provinces or territories.
	Liability	A legally binding obligation, debt or responsibility owed, which may have legal ramifications if ignored.
	Licence	A legal agreement granting someone permission to use a resource for certain purposes or under certain conditions that would otherwise be disallowed or unlawful. A licence does not constitute a change in ownership of the copyright. Includes data licenses and software licenses.
	Licensing	Authorizing by the licensor the use of the licensed material by the licensee.
	Linked Data	Creates links to data residing in other databases on the Web that are universally available.
LBS	Location-Based Services	A wireless IP service that delivers and uses geographic information to serve a mobile user.
MMG	Mass Market Geomatics	The preparation and online publication of geospatial data and services by private sector organizations such as Google Earth, Microsoft Virtual Earth and MapQuest.
	Metadata	Information about data. Metadata describes how, when and by whom a particular set of data was collected, and how the data was formatted. Metadata is essential for understanding information stored in data warehouses.
	Metadata Entry	A set of metadata that pertains specifically to a spatial data set.
	Metadata Schema	A semantic and structural definition of the metadata used to describe recordkeeping entities. It describes the names of metadata elements, how they are structured and their meaning.
	NAP-Metadata	North American Profile of *ISO 19115:2003 – Geographic information – Metadata*.

Acronym	Term	Definition
	Neophyte	Someone with no formal background in geographic information, but who has the interest, time and willingness to offer an opinion on the subject.
NPV	Net Present Value	The difference between the present value of cash inflows and the present value of cash outflows. NPV compares the value of a dollar today to the value of that same dollar in the future, taking inflation and returns into account.
	Ontology	A formal representation of phenomena with an underlying vocabulary, including definitions and axioms, which makes the intended meaning explicit and describes phenomena and their interrelationships.
	Open Data	A philosophy and practice that makes data easily and freely available - without restrictions from copyright, patents or other mechanisms of control - by way of portals, metadata and search tools in order to enable reuse of the data in new and unforeseen ways. Open data relies on 1) a permissive licensing model that encourages reuse, 2) data discoverability, and 3) data accessibility.
OGC	Open Geospatial Consortium, Inc.	A non-profit organization founded to address the lack of interoperability among systems that process geospatial data. The OGC is an international industry consortium of companies, government agencies and universities participating in a consensus process to develop publicly available geographic interface specifications that support interoperable solutions to "geo-enable" the Web, wireless and location-based services and mainstream IT.
	Open License	Enables third parties to reuse data with minimal or no legal or policy constraints, but copyright is maintained.
	Open Source	The special licenses governing the use and sale of software to ensure that the software source code remains in the public domain (free to all), though companies are allowed to sell products that include some or all of the source code.
	Open Standards	An open standard is one that 1) is created in an open, international, participatory industry process; 2) is freely distributed and openly accessible; 3) does not discriminate against persons or groups; and 4) ensures that the specification and license are technology neutral (its use must not be predicated on any proprietary technology or style of interface). Related terms: Open Specification
	Operational Policies	A broad range of practical instruments such as guidelines, directives, procedures and manuals that address topics related to the life cycle of spatial data (i.e., collection, management, dissemination, use) and that help facilitate access to and use of spatial information.

Acronym	Term	Definition
PAIGH	Pan American Institute of Geography and History	An international, scientific and technical organization of American countries dedicated to the generation and transfer of expertise in the areas of cartography, geography, history and geophysics. The organization constantly communicates and updates researchers and scientific institutions of the Member States, all in a constant process of modernization.
	Preservation	Protecting a collection of historical records (i.e., records that have been selected for permanent or long-term preservation on grounds of their enduring cultural, historical or evidentiary value) from destruction, decay or degradation.
	Producer	An individual or institution that generates geographic information from data.
	Produser	An individual involved in the collaborative and continuous building and extending of existing content in pursuit of further improvement, working in a networked, participatory environment that enables all participants to be users as well as producers of information and knowledge.
	Profile	A 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, necessary for building a complete computer system, application or function.
	Protocol	A set of semantic and syntactic rules that determine the behavior of entities that interact.
	Quality	Degree to which a set of inherent characteristics fulfills requirements, normally identified by the users.
	Registry	A listing of the individual data sets, services or other things made available by an organization to users of an SDI. There are two kinds of registries: ▪ Type Registry: A listing of different types or classes of objects, such as services, components or events that are recognized by the SDI services or applications. ▪ Instance Registry: A listing of individual services, components, data sets or other things that comprise the SDI or are relevant to its users. Instance registries are used to identify, locate and describe individual instances. Related terms: Catalogue, Directory, Inventory
	Relational Database	Stores data in such a way that it can be added to, and used independently of, all other data stored in the database.
	Schema	Formal description of a model.

Acronym	Term	Definition
	Semantic Web	Enables queries across the Web, as if the entire Web were a single federated database. In addition, the concept of a Semantic Web refers to the understanding of a machine or computer to find links or similarities to the searched data in order to provide the most useful search results.
	Semantics	In the spatial data context, semantics deal with representations of the geographical world as interpreted by human users or communities of practitioners. Defines the meaning of geospatial functions (e.g., the meaning of the input data, the capability of this function, the meaning of the output data).
	Sensitive Data	Geospatial data that may be considered restricted for purposes of dissemination and therefore requires some form of safeguarding.
	Service	A collection of operations, accessible through an interface, which allows a user to evoke a behaviour of value to the user.
SOA	Service-Oriented Architecture	A set of principles and methodologies for designing and developing software in the form of interoperable services. SOA separates functions into distinct units or services, which developers make accessible over a network in order to allow users to combine and reuse them in the production of applications.
SDI	Spatial Data Infrastructure	The relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. It is provided for users and suppliers within all levels of government, the commercial sector, the non-profit sector, academia and citizens in general. Related terms: Geospatial Data Infrastructure
	Spatial Data Set	A specific packaging of spatial information provided by a data producer or software, also known as a feature collection, image or coverage.
	Spatial Schema	Conceptual schemas for describing and manipulating the spatial characteristics of geographic features.
	Specification	A document written by a consortium, vendor or user that specifies a technological area with a well-defined scope, primarily for use by developers as a guide to implementation. A specification is not necessarily a formal standard.
	Stakeholder	A stakeholder in a program is any person or institution that has a controlling influence, benefits in some way from the program, has an interest in its process or outcome, or has resources invested in the program.

Acronym	Term	Definition
	Standard	Established by consensus and approved by a recognized body. A standard provides, for the common and repeated use of rules, guidelines or characteristics for activities or their results and is aimed at achieving the optimum degree of order in a given context. It is produced in the form of a published document and should be based on the consolidated results of science, technology and experience. It is also designed to promote optimum community benefits. Related terms: Standardization
SDO	Standards Development Organization	Any international organization that develops standards for the whole community.
	Syntax	In the spatial data context, syntax defines how the meaning of geospatial functions is expressed.
	Temporal Schema	Conceptual schemas for describing the temporal characteristics of geographic information as they are abstracted from the real world.
	Thematic Data	Data sets that describe the characteristics of spatial features or provide information on specific topics or themes, such as forest types, water contamination, historical flood areas or disease patterns and trends.
	Topology	Spatial relationships between adjacent or neighboring features; properties that define relative relationships between spatial elements, such as adjacency, connectivity and containment.
	Traditional Knowledge	Sometimes also called indigenous knowledge or traditional environmental knowledge, traditional knowledge generally refers to the long-standing traditions and practices of certain indigenous communities. It encompasses the wisdom, knowledge and teachings of these communities, which in many cases has been orally passed from person to person for generations.
UML	Unified Modeling Language	A standardized general-purpose modeling language in the field of object-oriented software engineering that includes a set of graphic notation techniques to create visual models.
	User	Refers to an individual who uses data, a computer, program, application, network or related service.
UCD	User-Centered Design	Involves the input of users at various stages in the design of an application or system to ensure that it is easy to use and meets the needs of its users. UCD examines how an application is used, how people go about doing their work, how they want or need to work, how they think about their tasks, and how often they do particular tasks.

Acronym	Term	Definition
VGI	Volunteered Geographic Information	A term coined by Michael F. Goodchild, who defines it as “the widespread engagement of large numbers of private citizens, often with little in the way of formal qualifications, in the creation of geographic information…” (Goodchild M. F., 2007)
	Web 2.0	Participatory information sharing, interoperability, user-centered design, and collaboration on the World Wide Web.
WFS	Web Feature Service	An Internet-based service that allows clients to conduct data manipulation on geographic features, allowing for querying, retrieval and transactional (i.e., add, update or delete) operations. The WFS conforms to the OpenGIS Web Feature Server Interface specification.
WMS	Web Map Service	An Internet-based service that allows clients to display maps and/or images with a geographic component and whose raw spatial data files reside on one or more remote WMS servers. The WMS conforms to the OpenGIS Web Map Server Interface specification.
	Web Services	Self-contained, self-describing, modular applications that can be published, located and invoked across the Web. Web services perform functions that can be anything from simple requests to complicated business processes. Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service.
W3C	World Wide Web Consortium	An international community that develops open standards to ensure the long-term growth of the Web.
XML	Extensible Markup Language	A markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the XML 1.0 Specification produced by the W3C, and several other related specifications.

C. International Standards

The following table identifies the key international standards mentioned in this manual that apply to the spatial information domain.

Standards Organization	Type of Standard	Standard Name
Semantics		
ISO	Conceptual Modeling	*ISO/TS 19103:2005 Geographic information – Conceptual schema language*
ISO		*ISO 19109:2005 Geographic information – Rules for application schema*
ISO		*ISO 19110:2005 Geographic information – Methodology for feature cataloguing*
ISO		*ISO 19131:2007 Geographic information – Data product specifications*
ISO		*ISO/TS 19150-1:2012 Geographic information -- Ontology -- Part 1: Framework*
ISO	Geometry	*ISO 19107:2003 Geographic information – Spatial schema*
ISO		*ISO 19108:2002 Geographic information – Temporal schema*
ISO		*ISO 19111:2007 Geographic information – Spatial referencing by coordinates*
ISO		*ISO 19123:2005 Geographic information – Schema for coverage geometry and functions*
ISO		*ISO/TS 19127:2005 Geographic information – Geodetic codes and parameters*
ISO		*ISO/TS 19138:2006 Geographic information – Data quality measures*
ISO	Metadata	*ISO 19115:2003 Geographic information – Metadata*
		North American Profile of ISO 19115:2003 Geographic information – Metadata (NAP – Metadata)
Syntax		
ISO	Encodings	*ISO 19118:2005 Geographic information — Encoding*
ISO		*ISO 19136:2007 Geographic information — Geography Markup Language (GML)*
ISO		*ISO/TS 19139:2007 Geographic information — Metadata — XML schema implementation*
ISO	Portrayal	*ISO 19117:2012 Geographic information – Portrayal*

Standards Organization	Type of Standard	Standard Name
Services		
ISO	Web Map Service (WMS)	*ISO 19128:2005 Geographic information — Web map server interface*
ISO	Web Feature Service (WFS)	*ISO 19142:2010 Geographic information – Web Feature Service*
OGC	Catalogue Service for the Web (CSW)	*OpenGIS® Catalogue Services Specification*
OGC	Web Coverage Service (WCS)	*OGC® WCS 2.0 Interface Standard – Core*
ISO	Metadata Service	*ISO 19115:2003 Geographic information — Metadata*
ISO	Filter Encoding	*ISO 19143:2010 Geographic information – Filter encoding*
	Gazetteer Service	*OGC® Gazetteer Service – Application Profile of the Web Feature Service Best Practice (OGC, 2012a)* Utilize *ISO 19112:2003 Geographic information — Spatial referencing by geographic identifiers*
Profiles		
ISO	Profiles	*ISO 19106:2004 Geographic information – Profiles*
Compliance		
ISO	Conformance and Testing	*ISO 19105:2000 Geographic Information – Conformance and Testing*

D. Template for Documenting Good Practices

GOOD PRACTICE TITLE

- Concise and reflecting the practice being documented.

INTRODUCTION

- Who was the organization and in which setting did it operate?
- What was the problem or issue being addressed?
- Which SDI component was being affected?
- How was the problem or issue impacting on the component?
- What were the objectives being achieved?

IMPLEMENTATION OF THE PRACTICE

- What were the main activities carried out that use this practice?
- When and where were the activities carried out?
- Who were the key implementers and collaborators?
- What were the resource implications?

RESULTS OF THE PRACTICE – OUTPUTS AND OUTCOMES

- What were the concrete results achieved in terms of outputs and outcomes?
- Was an assessment of the practice carried out? If yes, what were the results?

LESSONS LEARNED

- What worked really well and what facilitated this?
- What did not work, and why not?

CONCLUSION

- How have the results benefited the SDI initiative?
- Why can that intervention be considered a "good practice"?
- What recommendations can be made for those intending to adopt the documented good practice or how it can help people working on the same issue(s)?

REFERENCES

- Provide a list of references (not more than six) that give additional information on the good practice for those who may be interested in how the results have benefited the SDI.

Working Group on Planning (GTplan)

Coordinator:
Álvaro Monett Hernández (Chile)

Vice Coordinator:
Paula McLeod (Canada)

Topics of work :

Strengthening, Education and Training – CAP
Responsabiles:
Iván Darío Gómez Gúzmaz y Dora Inés Rey Martinez (until January 2013) (Colombia)
Alberto Boada Rodriguez, Fredy Montealegre Martínez and Elena Posada (Colombia)

Technical Standards and Specifications – NET
Responsabile:
Carlos Guerrero Elemen y Luis Gerardo Esparza Rios (Mexico)

Best practices and guidelines for the development of SDI – PRA
Responsabile:
Paula McLeod (Canada)

Innovation in the National Cartography Agencies – INN
Responsabile:
Moema José de Carvalho Augusto (Brasil)

Inventory of relevant issues on SDI for the region – REL
Responsabile:
Oscar Leonel Figueroa Cabrera (until Feb2012) (Guatemala) y
Esteban Tohá González (until Feb2013) (Chile)

Assessment of the SDI development in the Americas – DES
Responsabile:
Tatiana Delgado (until Maio 2011) (Cuba) y *Paula McLeod* (Canada)

Implementation of technological means for discussion of geospatial data access and dissemination – TEC
Responsabile:
Esteban Tohá González (until Feb2013) *y Álvaro Monett Hernández* (Chile)

Cover:
Eduardo Sidney Cabral Rodrigues de Araujo (IBGE)

www.cp-idea.org