White Paper
July 2011

Esri Technology for the Canadian Geospatial Data Infrastructure (CGDI)

Esri Canada CGDI Cookbook

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Trademarks

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1 Introduction

1.1 Purpose and Organization of this White paper

The development of the Canadian Geospatial Data Infrastructure (CGDI) has been ongoing for more than a decade. Although the CGDI continues to evolve, there are operational systems which use the infrastructure to perform day-to-day business activities. Given that a useable infrastructure is in place, this document outlines why organizations or individuals would want to use the CGDI, and what they need to know in order to exploit it.

Systems, software and people are what drive the CGDI. Esri Canada is the leading provider of GIS software and services in Canada, and has a broad client base that can benefit from leveraging the CGDI. This document describes how Esri Canada solutions may be used by Internet developers, GIS practitioners or Web users to effectively exploit the growing availability of data and services within the CGDI.

1.2 The Spatial Data Infrastructure concept

In the past, GIS implementations were independent systems. The only way to share spatial data between users was to download a geospatial file or copy the file to and from an exchange media. Since creating and maintaining spatial data then was an expensive activity, the concept of collecting data once and sharing it with others made remarkable sense. At the time however, this question still remained: what mechanisms could be used to allow data producers and users to exchange spatial data quickly and efficiently?

The solution was to implement a series of standards and specifications that allowed anyone connected to the Internet to share spatial data. This sharing paradigm is called the “publish, find and bind” model. In this model, a user ‘publishes’ (or makes available) their data. Another user ‘finds’ this data and if it is suitable, ‘binds’ it to their application. This concept describes a Spatial Data Infrastructure (SDI), which has been defined as the technology, policies, standards, human resources and related activities necessary to acquire, process, distribute, use, maintain and preserve spatial data.

An SDI facilitates “geospatial interoperability”, which refers to the capability of a system or a product to work with other systems or products without special effort on the part of the user. For example, interoperability is required when a television cable line is plugged into a cable box, which is then connected to a VCR that is plugged into a television set - all the components need to work together. Geospatial interoperability can be defined as the ability of software and hardware on different machines from different vendors to share geospatial data (most often over the Internet).

Implementing an SDI requires standards, coordination, resources and time. Therefore, clear benefits are needed to justify the requisite resources. In general, some benefits of an SDI are:

- Economic
  - Immediate access to authoritative data reduces data integration costs
  - Standard licensing reduces administrative costs
  - Online searches and metadata catalogues reduce data discovery costs
  - Access to current data removes the unknown cost of using obsolete data
- Technical
  - Reliable access to geospatial data encourages development of new uses and applications
  - Open standards reduce interoperability development costs
  - Simpler data interoperability allows innovative combinations of data

- Commercial
    - Access to the best available information improves decision-making
    - Data discovery and access reduces potential duplicate data collection
    - Internet accessibility increases market share and audience reach
    - Infrastructure development stimulates economic growth

On a global level, the SDI concept is usually implemented by the national or federal government in each country. In fact, there is a worldwide coordinating body for the implementation of national SDIs called the Global Spatial Data Infrastructure (GSDI) Association [Ref. 1]. There are currently over 120 countries developing SDIs within their jurisdictions.

2 CGDI—Initiative for a Canadian SDI

2.1 CGDI Vision, Mission and Guiding Principles

Like many other countries, Canada is actively developing the CGDI and is a member in good standing of the GSDI. At the national level, the CGDI development is being led by the GeoConnections Program of Natural Resources Canada (NRCan).

The federal government stimulated initial CGDI development by providing $60 million in special funding to GeoConnections from 1999 to 2005. A second round of $60 million in funding was approved for 2005 to 2010. In 2010, the government announced renewed funding of $11 million over the next two years for the program. In 2011, they announced that the program would be extended and would receive $30 million over the period of 2010 to 2015.

The Canadian Geomatics Accord [Ref. 2] is an agreement between the federal, provincial and territorial levels of government to cooperate in areas related to geomatics including the establishment of the CGDI.

The GeoConnections Vision [Ref. 3] for the CGDI is:

> *"To enable access to the authoritative and comprehensive sources of Canadian geospatial information to support decision-making"*

The GeoConnections Mission [Ref. 3] for the CGDI is:

- *Enable decision-making and policy development that address Canada's priority issues such as health, social, cultural, economic and natural resources*
- *Facilitate access to the leading sources of Canadian geospatial information*
- *Provide continued involvement and leadership in the development of geospatial standards and specifications*
- *Foster partnerships and sharing of geospatial information across all sectors, at all levels of government, and at the international level*
- *Support a broad and vibrant user community*
- *Ensure that infrastructure operations are ongoing and sustainable*

The GeoConnections guiding principles [Ref. 3] for the CGDI are:

- ***Open:** The CGDI will be based on open and interoperable standards and specifications for operations and information exchange.*
- ***Transparent:** The CGDI will allow users to access data and services seamlessly, despite any complexities of the underlying technology.*

- ***Cooperative:*** *The CGDI will facilitate the cooperation and collaboration of participating organizations from all sectors, levels of government and academia.*
- ***Evolving:*** *The network of organizations participating in the CGDI will continue to address new requirements and business applications for information and service delivery to their respective users.*
- ***Timely:*** *The CGDI will be based on technologies and services that support timely or real-time access to information.*
- ***Self-sustaining:*** *The CGDI will be sustained through the contributions of the participating organizations and broad user community, and through its relevance to these groups.*
- ***Self-organizing:*** *The CGDI will enable various levels of participating organizations to contribute geospatial information, metadata, services and applications.*
- ***User-driven:*** *The CGDI will emphasize the nurturing of and service to a broad user community. Users will drive the future development of the CGDI.*
- ***Closest to Source:*** *The CGDI will build upon its principle of self-organization by encouraging organizations that are closest to the source to provide data. This will increase quality and efficiency by eliminating duplication and overlap.*
- ***Secure:*** *The CGDI will be secure and protect data that is sensitive or proprietary.*

In order to guide the development of the CGDI, GeoConnections has produced the following publications:

- Vision: Better Knowledge for Better Decisions [Ref. 3]
- Roadmap: Achieving the Vision of the CGDI [Ref. 4]
- Architecture: Architecture Description Version 2.0 [Ref. 5]

2.2 CGDI Current Status

The ongoing development and coordination of the CGDI will continue to be led by the NRCan GeoConnections Program, as stated in the federal government's announcement of the full third tranche of funding for the CGDI [Ref. 6]: *"Initiated in 1999 and housed at Natural Resources Canada, GeoConnections leads the development of the Canadian Geospatial Data Infrastructure (CGDI), an online resource that enables disparate geospatial databases to be connected and used as one.*

Geomatics is one of today's fastest growing information technology sectors, helping Canadians deal with a variety of important challenges, including:

- *emergency preparedness, by making sure that police, fire departments, local 911 authorities and other critical care first-responders are able to respond more quickly by using accurate, up-to-date and standardized location data*
- *public safety, by enabling local health authorities and hospitals to track and project pandemics, such as H1N1*
- *more efficient oil, gas and mineral exploration, by integrating modern mapping data with geological information*
- *agricultural production, through better crop management based on a better understanding of geography, hydrology and geology and their integration with a knowledge of soils, rainfall patterns and sunshine."*

The status of the CGDI implementation is as follows:

Mandated Federal Standards

Metadata – In 2009, the federal Treasury Board of Canada Secretariat (TBS) mandated that all federal departments implement the ISO19115 Geographic Information - Metadata standard by 2014 [Ref. 7]. Because the North American Profile (NAP) is a subset of the ISO19115 standard, most

agencies are standardizing their metadata to the NAP standard; so by default, they will be ISO19115 compliant.

Web Services – Also in 2009, the TBS mandated that all federal departments implement the ISO 19128 Geographic information - Web Map Service (WMS) standard by 2014 [Ref. 7].

Endorsed CGDI standards

The CGDI endorses international standards for implementation and compatibility within the CGDI. According to the GeoConnections Web site, the following is a list of currently endorsed CGDI standards.

Discovering Geospatial Resources
- Geodata Discovery Service
- Metadata for Geodata

Viewing Geospatial Data
- Web Map Service (WMS)
- Web Map Context Document
- Styled Layer Descriptor (SLD)
- Tile Mapping Service (TMS)
- Keyhole Markup Language (KML)

Accessing Geospatial Data
- GeoRSS
- Geolinked Data Access Service (GDAS)
- Web Coverage Service (WCS)
- Web Feature Service (WFS)
- Filter Encoding
- Geographic Markup Language (GML)

Manipulating Geospatial Data
- Web Processing Service (WPS)

2.3 Business Case and Key Benefits

GeoWeb-enabling an organization requires a business case, but this is generally very easy to justify nowadays because the benefits of connecting to the CGDI are many and the cost is continually decreasing. For the most part, much of the necessary technology is now commercially available out of the box. Many organizations already have this technology, they just need to turn it on and modify it for their business process. The business benefits of implementing the CGDI include the following:

- **Improving efficiency –** Implementing the CGDI facilitates collecting data once and using it many times. In addition, it allows the common usage of tools and services.
- **Saving money and reducing costs –** Web-enabling certain functions can help cut costs related to data location, capture, workflows and problem solving.
- **Saving time -** When organizations become Web-enabled, they increase efficiency and productivity since tasks can be more easily accomplished via the Internet (or Intranet) due to data access and viewing becoming quick and simple.
- **Increasing quality –** The CGDI helps combine information from online sources that provide the most accurate, up-to-date data. Information that is the highest quality produces better products.

- **Increasing productivity -** The CGDI encourages productivity gains because disparate spatial data can be made available anytime, simply and efficiently over the Internet.
- **Improving communication and collaboration –** Sharing geospatial data with clients and stakeholders is made simple via the Web as even novice users can obtain results.
- **Generating revenue –** Although one of the goals of the CGDI is to provide free and unencumbered data and services, there is nothing to prevent an organization from charging a fee for CGDI data or services.
- **Supporting decision-making –** The CGDI allows users to easily access a multitude of spatial data and services. Clearly using additional data that was not previously available should assist in decision-making processes.
- **Improving information bases –** Due to the collaborative nature of the CGDI, feedback to the data supply organization about data errors will help them improve their datasets.
- **Managing resources –** The CGDI provides quick, efficient access and delivery of spatial data and services, helping organizations better manage their resources as some activities will require fewer resources once the function is Web-enabled.

3 Esri Canada CGDI approach

3.1 CGDI Implementation Strategies

The basic architecture of the CGDI is relatively simple. As depicted in the following diagram, spatial databases are 'published' to the CGDI common infrastructure either directly via a Web site or through a content portal. This is the server side of the infrastructure. The user applications can be thin clients such as a standard Web browser or a thick client such as ArcGIS or ArcGIS Explorer.

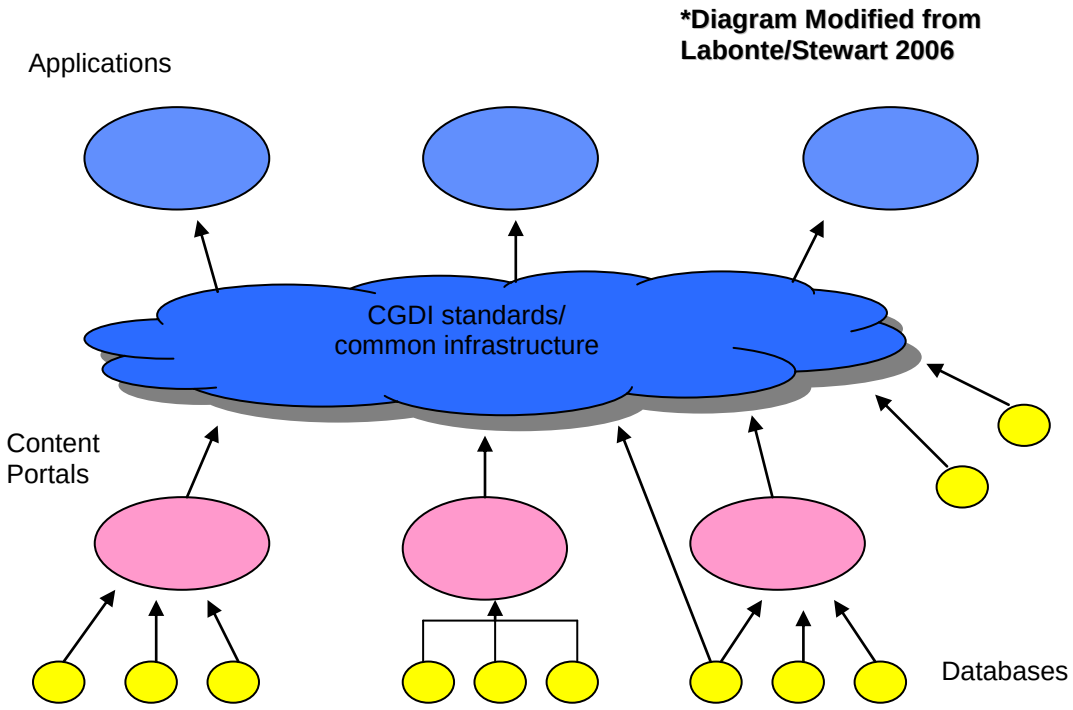


Figure 1 - CGDI Conceptual Architecture

3.2 Esri Approach

Because the CGDI is based on internationally accepted technical standards, Esri technology supports CGDI interoperability 'right out of the box'. The objective is to provide Canadian geomatics practitioners with a flexible, comprehensive and integrated software stack that supports users from the desktop to the large enterprise implementations. In addition, users who wish to interoperate with SDIs in other countries will find that Esri technology most likely supports this. Also, if Esri technology users in Canada wish to interoperate with other Esri users, performance and efficiency gains can often be obtained by using the generic core Esri technology stack.

3.3 The Esri Technical Solution

Esri Canada offers a complete solution for CGDI users by combining Esri's proven ArcGIS geographic information system and SDI platform technologies. Core capabilities that are available to CGDI users include: the capability to author geospatial data and metadata, serve network services (view, download and discovery services), and use geospatial services and data—all in a CGDI-compliant form.

4 Implementing the CGDI

4.1 Technology Overview

Esri has long focused its technology development on the creation of solutions that contribute to building and positioning the world's geospatial information resources for responsible and effective use. Over the past four decades, automated mapping, GIS and spatial data communication technologies developed by Esri have been implemented throughout the world, contributing significantly to the global grouping of electronically enabled geospatial information – in other words, the global SDI. Esri technology enables these existing databases of geospatial information and GIS capability to be made available on the Internet.

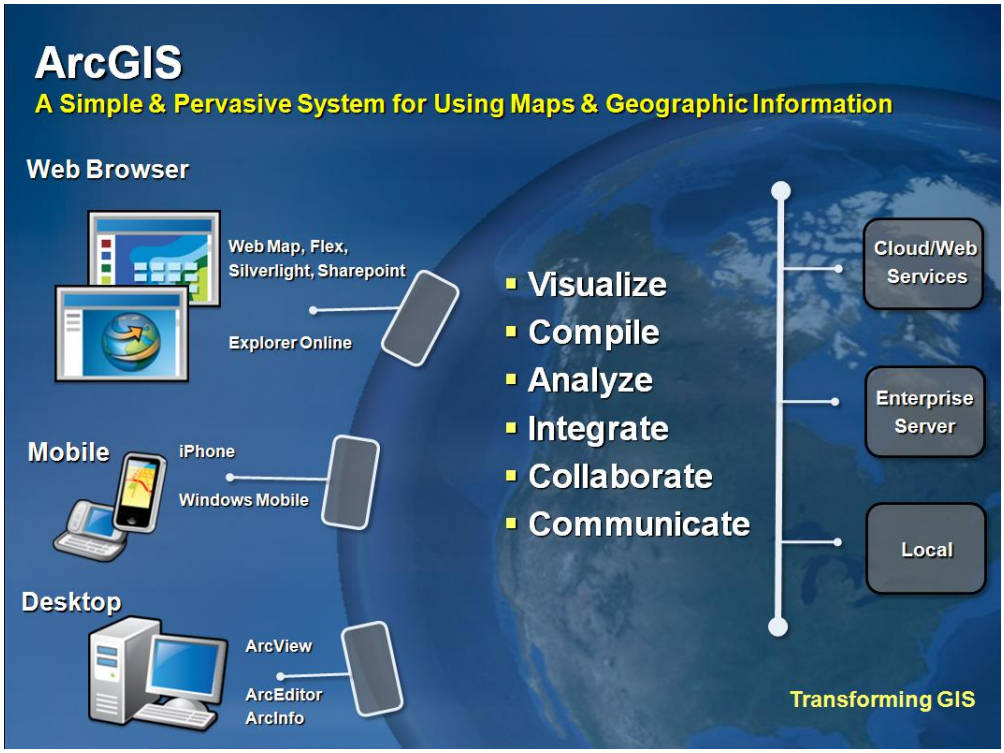


Figure 2 - ArcGIS Technical Architecture

The ArcGIS platform is a simple but effective way to enable the use of spatial information not only in Web browsers, but also on mobile devices and on desktop devices, as seen in Figure 2 - ArcGIS Technical Architecture. This spatial data can be enabled from local devices, from enterprise servers or from cloud services. ArcGIS provides not only the capability of supporting the CGDI, but also other modern devices and technology.

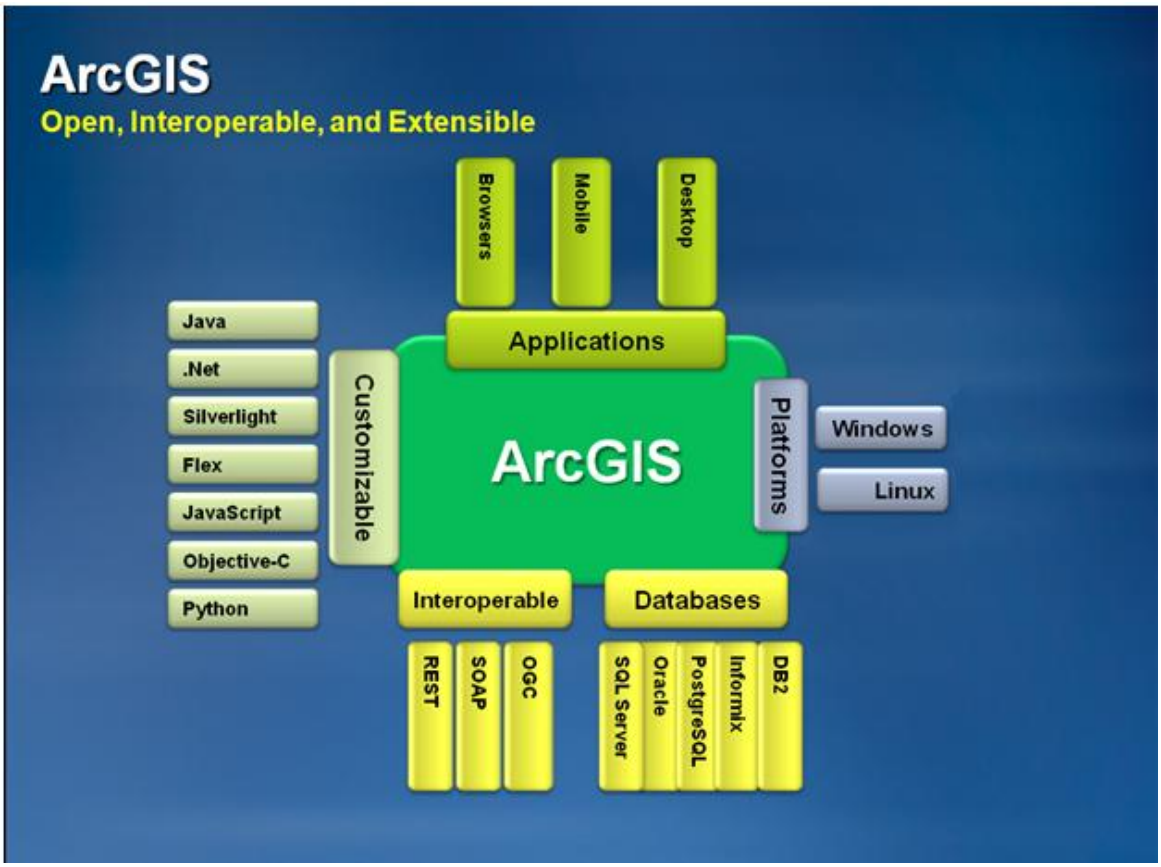


Figure 3 – ArcGIS is an Open, Interoperable and Extensible System

The Esri ArcGIS family of GIS solutions provides a fully integrated and interoperable platform for SDI development and operation (see Figure 3 – ArcGIS is an Open, Interoperable and Extensible System). It supports numerous platforms, including major industry hardware and operating systems such as Windows and Linux. Various database APIs are supported, as well as application linkages for desktop, mobile and browser applications. Interoperable capabilities through internationally recognized standards such as REST, SOAP and OGC services are available. Finally, extensive customization capabilities are available for developers to meet client requirements.

This new generation of ArcGIS SDI technologies enables spatial data producers to create and serve their data to the World Wide Web (or local intranet networks) and enables spatial data users to capture that information for use in their local enterprise GIS environment or GIS desktop environment. In short, ArcGIS provides the technological foundation and interoperability paradigm (see Figure 4 - Geospatial data interoperability paradigm) for fully functional SDI information-sharing communities - including the CGDI.

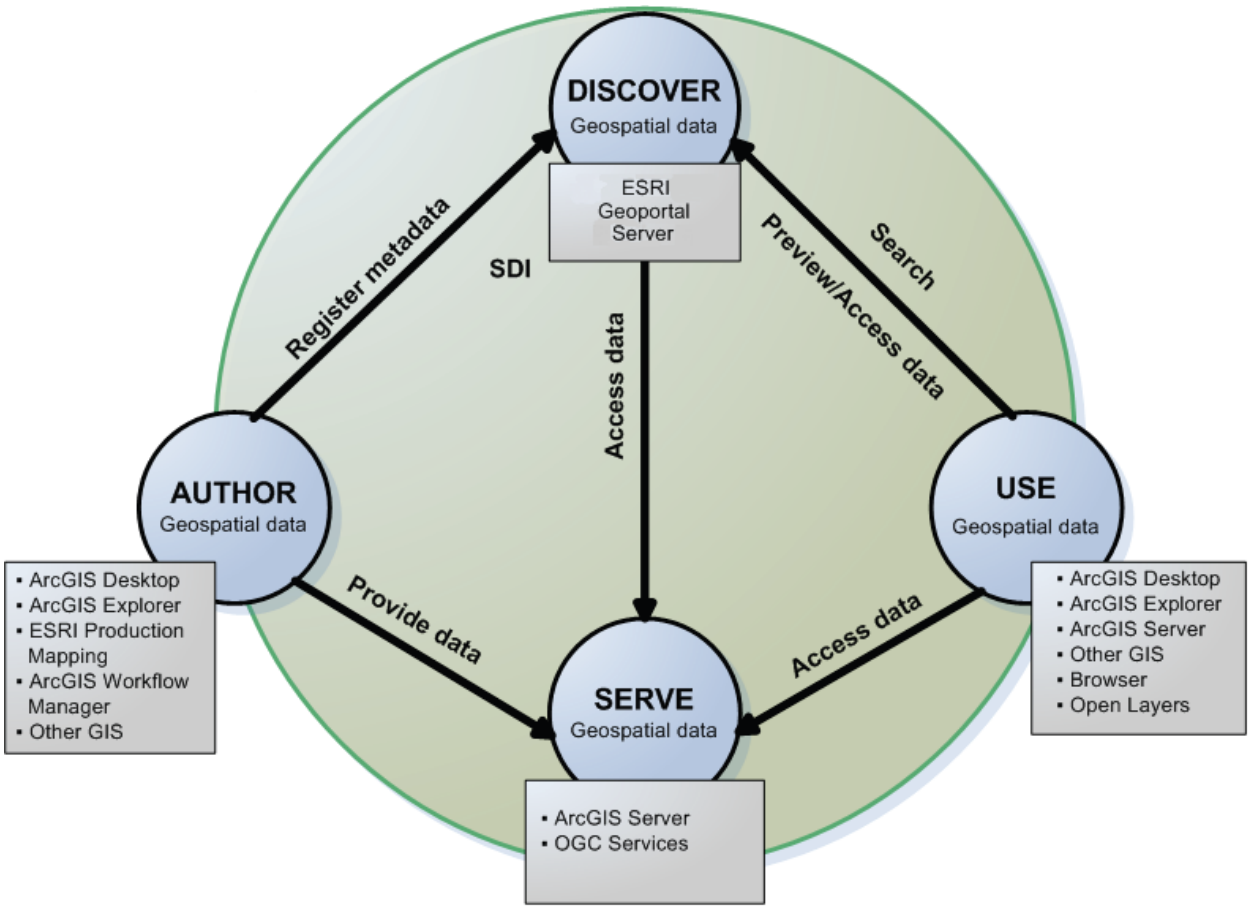


Figure 4 - Geospatial data interoperability paradigm

4.1.1 Hardware

The type of equipment and systems necessary for implementing a CGDI solution depends on the system usage requirements. Clearly, the architecture of a single-user system would be quite different from an enterprise portal solution supporting hundreds of users. Sometimes, system usage requirements are not initially known, so system scalability is also often a requirement. CGDI solutions within distributed computing environments require selection of a computer platform size, client-server architecture and network infrastructure.

Esri has prepared documentation describing a system design strategy that promotes successful selection of GIS enterprise architecture solutions. Guidelines include appropriate rationale and logic to support a system that will satisfy the initial performance needs for most clients. Once the initial implementation is operational, the document shows how a system environment can be further adjusted or 'tweaked' to fit specific user needs. The System Design Strategies Wiki page has the latest documentation on systems design [Ref. 10].

4.1.2 Software and Applications

No computer-based system runs without software and applications. Within the CGDI, in order to get useful work done, the concept of a client/server model is used. The client/server model is a method to describe the working relationship between two computer programs. The 'client' program makes a service request to another program called the 'server' program, which performs the service request

and then sends a response back to the 'client' program. Within the CGDI, these service requests between the programs are communicated through a network, most often the Internet.

Across the Internet, the location of the client and the server is nearly irrelevant to the transaction. For example, within the CGDI, a user could request through a client program to display a topographic map of Northern Québec. The client program would determine that this data resides in a server system at NRCan in Sherbrooke, Québec. The client could then make a Web Service call to the Sherbrooke server which would create the map and return it to the client in a special format file. The client program would then display this map file for the user.

The CGDI architecture allows for many client-side programs including viewer clients, discovery clients, publish clients and edit clients. Server-side program types include portals, data servers and spatial processing servers.

From the Esri Canada perspective, client-side programs could include:

- Internet Explorer (or other Internet browsers)
- ArcGIS Explorer
- ArcGIS Explorer Online
- ArcGIS for Desktop
- ArcGIS for Server (when fusing other services for further distribution)

Server-side programs could include:

- ArcGIS for Server
- Esri Geoportal Server

4.1.3 Network Communications

The CGDI is concerned primarily about communicating over the Internet, which includes networking standards such as SOAP, REST, TCP/IP, UDDI, XML, HTTP and a host of other Internet standard protocols. This basic set of Internet standards is essential for the Internet to work and is thus essential for the CGDI. The CGDI developers, however, generally do not participate in the standardization of these Internet specifications. They simply use existing industry standards that are developed by the World Wide Web Consortium (W3C).

In addition to Internet communications, additional network standards are supported by Esri software. These include the following equipment: servers, desktops, laptops, Personal Digital Assistants (PDAs), smartphones, tablet PCs and other mobile devices. The Esri Commercial-off- the-Shelf (COTS) software is designed to support a variety of scalable networked hardware.

4.2 Data

Data is both the huge benefit of the CGDI and its weak point. Data means many things to many people. For example, data handling applications include:

- Data compilation and editing
- Data management and synchronization
- Data analysis and modeling
- Data discovery and formatting
- Data product creation

This section outlines data types, formats and data issues specific to spatial data.

4.2.1 Data Types and Formats

So what types of data can be used in the CGDI? The answer is lots of different types of data, including:

- Spatial data
- Cartographic data
- Multidimensional data
- Annotation data
- Cadastral data
- Topological data
- Framework data
- And many more….
- Metadata
- Vector data
- Terrain data
- Survey data
- CAD data
- GPS data
- Thematic data
- Attribute data
- Raster data
- Location data
- Address data
- 3D data
- Base data
- Geodetic data

Not only is there a multitude of types of data, there is also a multitude of different published formats that the CGDI data can be stored in. These formats include:

- Esri shape
- Esri Geodatabase
- JPEG 2000
- MapInfo MIF
- Well Known Binary
- ADRG
- GeoTiff
- And many more….
- Esri coverage
- AutoCAD DXF
- GML
- MapInfo TAB
- USGS DLG
- Intergraph DGN
- NetCDF
- Esri ASCII grid
- AutoCAD DWF
- Google Earth KML
- Oracle Spatial
- DTED
- SDTF
- S-57

In order for the CGDI to share data between clients and servers, both systems must support not only the same standard, but also the same version of the standard. Only a few exchange formats are supported by the CGDI standards in order to reduce complexity. The following table indicates some of the data formats supported by the interoperability software interfaces.

Interface specification	**Sample Data format support**
Web Map Service	JPEG, PNG, Tiff
Web Feature Service	GML
Web Coverage Service	NetCDF, GeoTiff

4.2.2 CGDI Data Themes

Each data theme (or data layer) contains information about one specific topic or subject such as roads, rivers, vegetation, land use or elevation. There are generally two classes of data themes: base data and thematic data. Base data layers are basic or framework data themes that are commonly used on most output products. These include roads, place names and rivers. Thematic (or operational) layers contain additional information that may be specific to certain maps. Examples of thematic layers include demographics, zoning, soil, geology or ecological areas. Imagery is an additional layer that is often used for presentation or visualization purposes. The concept of data themes is depicted in Figure 5 - CGDI Thematic Data Layers.

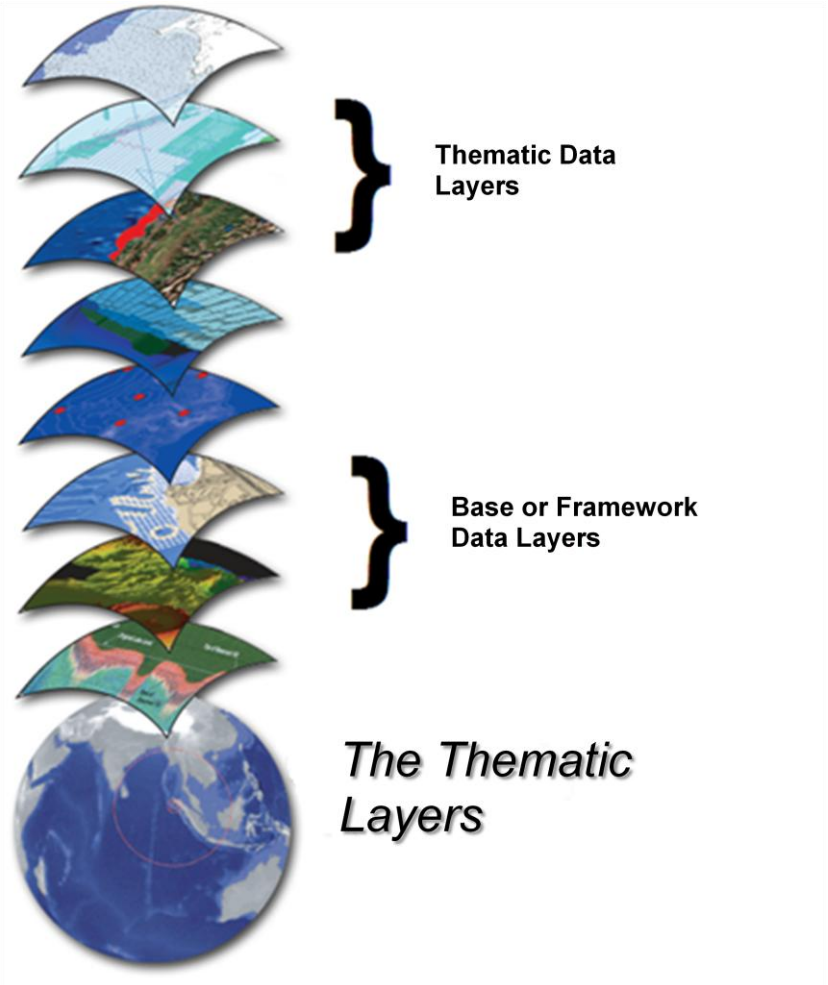


Figure 5 - CGDI Thematic Data Layers

There are a number of standards or specifications that define spatial data themes. These include the Geospatial Bluebook, the Federal Geographic Data Committee (FGDC), the Geospatial-One-Stop (GOS-2), The Digital Geographic Information Working Group (DGIWG) and the ISO 19115 standards. The following table compares the theme names for similar layers in each of the standards mentioned above.

No.	Bluebook	FGDC/ANSI	GOS2	DGIWG/ DIGEST	ISO 19115
1.	Emergency Operations				
2.	Structures/Critical Infrastructure		Facilities and Structures		Structure(17)
3.	Governmental Units	Governmental Units (5)	Administrative and Political		Boundaries(03)
4.	Utilities		Utilities and Communication		Utilities, Communication(19)
5.	Addresses and Names				
6.	Transportation	Transportation (7)	Transportation Networks		Transportation(18)
7.	Cadastral	Cadastral (1)	Cadastral	Cadastral	Planning, Cadastre(15)
8.	Hydrography	Hydrography (6)	Inland Water Resources Oceans and Coasts	Hydrography	Inland Waters(12) Oceans(14)
9.	Environmental		Agriculture and Farming Biology and Ecology Environment and Conservation Geological and Geophysical		Farming(01) Biota(02) Environment(07) Geoscientific(08)
10.	Land Use/Land Cover				Imagery, Basemap, Earthcover(10)
11.	Basemap		Imagery and Basemaps		(Imagery, Basemap, Earthcover(10)*)
12.	Elevation	Elevation (3)	Elevation	Hypsography	Elevation(06)
13.	Imagery	Digital Orthoimagery (2)	(Imagery and Basemaps*)		(Imagery, Basemap, Earthcover(10)*)
14.	Geodetic Control	Geodetic Control (4)	Locations and Geodetic Networks	Demarcation	Location(13)
15.			Atmosphere and Climatic		Climatology, Meteorology, Atmosphere(04)
16.			Business and Economic		Economy(05)
17.			Cultural, Societal and Demographic	Culture	Society(16)
18.			Human Health and Disease		Health(09)
19.				Physiography	
20.				Vegetation	
21.				Aeronautical Information	
22.				Special Use	
23.				General	
24.					Intelligence, Military(11)

No standard or specification has been approved for the naming and contents of data themes within the CGDI; however, some work is being done to arrange layers into a logical taxonomy. Thus, users should be careful in selecting the appropriate layer for their needs.

4.3 Standards and Specifications

ISO Technical Committee (TC) 211 aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the earth. These standards specify methods, tools and services for data management, including: acquiring, processing, analyzing, accessing, presenting and transferring geographic data in digital form between different users, systems and locations. Once a standard achieves ISO published status (IS), then where applicable, Esri will in general implement the ISO standard in the ArcGIS software. The current suite of TC211 standards includes the following. For an updated list, see [Ref. 17].

Standard	Number	Status
Standard representation of latitude, longitude and altitude for geographic point locations 6709/Cor 1:2009	6709:2008	IS
Reference model (under revision)	19101:2002	IS
Reference model - Part 2: Imagery	19101-2:2008	TS
Conceptual schema language (under revision)	19103:2005	TS
Terminology	19104:2008	IS
Conformance and testing	19105:2000	IS
Profiles	19106:2004	IS
Spatial schema	19107:2003	IS
Temporal schema 19108/Cor 1:2006	19108:2002	IS
Rules for application schema	19109:2005	IS
Methodology for feature cataloguing 19110 Amd 1 under development	19110:2005	IS
Spatial referencing by coordinates	19111:2007	IS
Spatial referencing by coordinates - Part 2: Extension for parametric value	19111-2:2009	IS
Spatial referencing by geographic identifiers	19112:2003	IS
Quality principles (under revision as PT 19157)	19113:2002	IS
Quality evaluation procedures (under revision as PT 19157) 19114/Cor. 1	19114:2003	IS
Metadata (under revision) 19115/Cor. 1:2005	19115:2003	IS
Metadata - Part 2: Extensions for imagery and gridded data	19115-2:2009	IS
Positioning services	19116:2004	IS
Portrayal (under revision)	19117:2005	IS
Encoding (under revision)	19118:2005	IS
Services 19119/Amd. 1:2008	19119:2005	IS
Functional standards	19120:2001	IS
Imagery and gridded data	19121:2000	IS
Qualifications and Certification of personnel	19122:2004	IS
Schema for coverage geometry and functions	19123:2005	IS
Simple feature access - Part 1: Common architecture (under revision)	19125-1:2004	IS
Simple feature access - Part 2: SQL option (under revision)	19125-2:2004	IS
Profile - FACC Data Dictionary	19126:2009	IS
Geodetic codes and parameters	19127:2005	TS
Web Map server interface	19128:2005	IS
Imagery, gridded and coverage data framework	19129:2009	IS
Sensor and data models for imagery and gridded data	19130:2010	IS

Data product specifications	19131:2007	IS
Location based services - Reference model	19132:2007	IS
Location based services - Tracking and navigation	19133:2005	IS
Multimodal location based services for routing and navigation	19134:2007	IS
Procedures for registration of geographical information items	19135:2005	IS
Geography Markup Language	19136:2007	IS
Core profile of the spatial schema	19137:2007	IS
Data quality measures (under revision as PT 19157)	19138:2006	TS
Metadata - XML schema implementation	19139:2007	TS
Schema for moving features	19141:2008	IS
Web Feature Service	19142:2010	IS
Filter encoding	19143:2010	IS
Classification Systems – Part 1: Classification system structure	19144-1:2009	IS
Classification Systems – Part 2: Land Cover Meta Language (LCML)	19144-2	IS
Registry of representations of geographic point location	19145	IS
Cross-domain vocabulary	19146:2010	IS
Transfer nodes	19147	Stage 0
Linear referencing	19148	IS
Rights expression language for geographic information - GeoREL	19149	IS
Ontology	19150	RS
Logical location identification scheme	19151	TS
Land Administration Domain Model (LADM)	19152	TS
Geospatial Digital Rights Management Reference Model (GeoDRM RM)	19153	TS
Place Identifier (PI) Architecture	19155	TS
Observations and measurements	19156	TS
Data quality	19157	TS
Quality assurance of data supply	19158	TS
Calibration and validation of remote sensing imagery sensors and data	19159	TS
Addressing	19160	Stage 0

The CGDI standards are based primarily on specifications developed by the Open Geospatial Consortium (OGC), which are aligned with the ISO TC211 standards set. Due to the dynamic nature of the development of standards, it is best to consult the GeoConnections Web site for the most up-to-date list of CGDI standards.

4.4 People

People are critical to the implementation of the CGDI. They are needed to make decisions on the direction, management and use of CGDI-enabled systems. SDI or CGDI training is essential for people to gain the necessary knowledge and skills to make informed choices and implement the CGDI smoothly.

The GeoConnections Web site provides some online training material that can be used. Esri Canada also has a number of training courses ranging from project management to software development to application use. As well, there are a number of Esri User Conferences across Canada that allow GIS practitioners to share and learn about best practices and success stories.

Capacity building can also be performed through the use of books and specialized material such as this cookbook. These tools allow staff to learn at their own pace. In addition, Esri Canada has a range of consulting services that can be used by clients to assist in specific areas where there is a problem or where the nascent knowledge is insufficient in the implementing organization.

5 Esri SDI Technology

Esri Canada supplies, customizes and supports a host of technology and services in support of Canadian organizations interested in developing CGDI or SDI applications. This technology includes:

1. ArcGIS for Desktop
2. ArcGIS for Server
3. ArcGIS Image Server
4. Esri Geoportal Server
5. Esri ArcIMS
6. ArcGIS Explorer
7. ArcGIS APIs for JavaScript, Flex and Silverlight
8. ArcGIS for Mobile
9. ArcGIS Online, ArcGIS.com and Community Maps
10. ArcGIS for Smartphones

Each of these technologies will be briefly discussed in the remainder of this section.

5.1 ArcGIS for Desktop

ArcGIS for Desktop is the primary product used by GIS professionals to compile, use and manage geographic information. It includes comprehensive professional GIS applications that support a number of GIS tasks, including mapping, data compilation, analysis, geodatabase management and geographic information sharing.

ArcGIS for Desktop is the platform that GIS professionals use to manage their GIS workflows and projects, and to build data, maps, models and applications. It's the starting point and the foundation for deploying GIS across organizations and on the Web.

As seen in Figure 6 – ArcGIS for Desktop Usability, many ArcGIS for Desktop users have a special role and responsibility to provide high-quality maps and geographic information to others in their organizations and on the Web. They do this by creating and sharing maps, layers, geodatabases, imagery and analytic models.

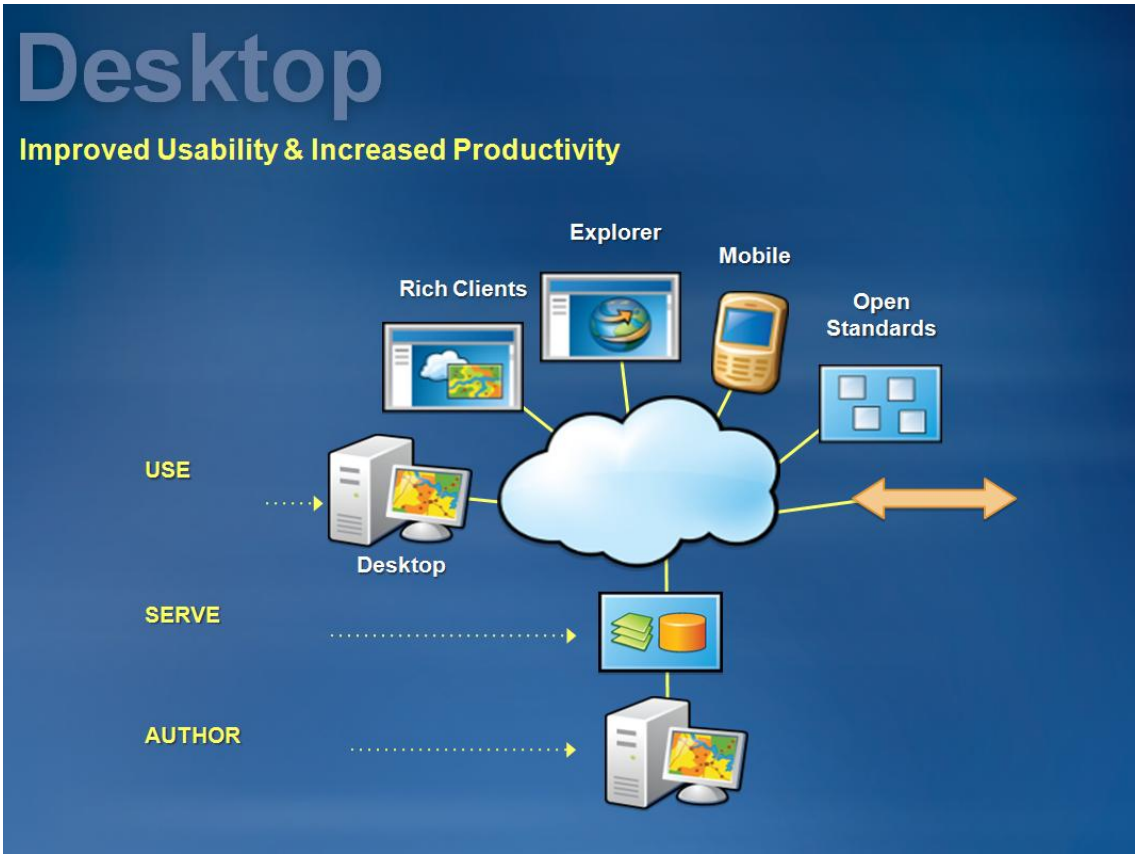


Figure 6 - ArcGIS for Desktop Usability

5.2 ArcGIS for Server

ArcGIS for Server is a server-based implementation of ArcGIS and is used to serve the maps, geodatabases, and other elements of geographic information that professional users create using ArcGIS for Desktop. The GIS services published using ArcGIS for Server follow widely adopted Web standards for access and use. ArcGIS for Server also provides enterprise geodatabase management and transactional support. Server is widely used in enterprise GIS implementations and for all kinds of Web GIS applications. ArcGIS for Server can run on Windows and Linux servers, both on premise and in cloud configurations.

ArcGIS for Server includes:

- A set of comprehensive GIS and map services and tasks
- Open, standards-based, Web service interfaces for accessing and using ArcGIS services
- An administrator's console for setting up and managing ArcGIS for Server installation
- Powerful enterprise geodatabase management in a number of DBMSs including: Oracle; SQL Server and SQL Server Express; DB2; Informix; and PostgreSQL

In addition to their use in ArcGIS for Desktop, these server capabilities can be accessed and used in Web applications and combined with content on the open Web such as GIS content from ArcGIS.com and consumer maps from Bing and Google.

5.3 ArcGIS Image Server

ArcGIS Image Server allows users to manage and process huge volumes of raster data and provide enterprise-wide access to an infinite number of image datasets within GIS, CAD, imaging and Web applications. Traditionally, image processing and distribution have been considered two separate stages in image exploitation. This separation causes data redundancy, explodes volumes of data and hinders efficient data management. With ArcGIS Image Server, these two stages can be combined, enabling the administrators of data to maintain only the primary imagery with multiple image products created instantly, on the fly, as required by users.

By improving on the traditional workflow for image management and distribution, ArcGIS Image Server can reduce costs and improve efficiency by:

- Simplifying the process of serving large volumes of image data
- Eliminating the need for data storage at different stages of processing
- Reducing the delay from image acquisition to dissemination
- Improving image quality by reducing subsampling
- Supporting many file formats
- Providing multiple representations of the same base data

5.4 Esri Geoportal Server

Esri Geoportal Server is a free open source product that enables discovery and use of geospatial resources including datasets, rasters and Web services. It helps organizations manage and publish metadata for their geospatial resources to let users discover and connect to those resources. The Geoportal Server supports standards-based clearinghouse and metadata discovery applications.

With Esri Geoportal Server, you can:

- Reduce time and redundancy of data production by connecting geospatial data and service producers with consumers
- Maintain data integrity by allowing organizations to easily share the authoritative version of data among its users
- Enable easy search and discovery of existing geospatial data and services by allowing users to create and manage descriptions of their geospatial resources and supporting easy-to-use, sophisticated, data discovery technologies

Esri Geoportal Server was released under the Apache 2.0 license, which allows developers to freely customize and redistribute the software.

5.5 Esri ArcIMS

Esri ArcIMS is a longstanding, but recently deprecated solution for delivering dynamic maps and GIS data and services via the Web. It provided a highly scalable framework for GIS Web publishing. ArcGIS 10.0 was the last planned release for ArcIMS. At ArcGIS 10.1, ArcIMS will no longer be shipped as part of ArcGIS. Users can continue to use existing versions of ArcIMS after this time; however, Esri will no longer provide new releases. Users who are currently using ArcIMS should develop a plan and migrate to the ArcGIS for Server or Web API technology.

5.6 ArcGIS Explorer

ArcGIS Explorer is a free, downloadable GIS viewer that gives users an easy way to explore, visualize and share GIS information on the Web. ArcGIS Explorer adds value to any GIS because it helps users deliver authoritative data to a broad audience via the Web.

With ArcGIS Explorer, users can:

- Access ready-to-use ArcGIS Online basemaps and layers
- Fuse local data with map services to create custom maps
- Add photos, reports, videos and other information to their maps
- Perform spatial analysis (e.g., visibility, modeling, proximity search)

ArcGIS Explorer Online is an online application that lets users explore and present maps within an efficient and well-structured environment. ArcGIS Explorer Online lets you open a map, add other content to it, navigate around it, ask questions the map can answer, and present and share the map with others, all on the Web. ArcGIS Explorer Online differs from ArcGIS Explorer in that users do not need to download an application to their system. ArcGIS Explorer Online simply requires the Silverlight 4 platform from Microsoft, and a browser which supports the Silverlight plug-in, for example, current versions of Microsoft Internet Explorer or Google Chrome on Microsoft Windows, or Safari on MacOS.

Some of the things you can do with ArcGIS Explorer Online include:

- Search for and open maps, and navigate within a map
- Find out more information about the things shown in the map
- Locate places, addresses, airports, intersections and other geographic entities
- Measure the length and area of things on a map
- Create a presentation to show to other people
- Share your map with other people

5.7 ArcGIS APIs for JavaScript, Flex and Silverlight

ArcGIS Web Mapping can also be performed through a collection of Application Programming Interfaces (APIs), which define the set of rules that the software can use to access Web services and resources. These APIs are an efficient way to utilize mapping, geocoding and geoprocessing services provided by ArcGIS for Server and ArcGIS Online.

Web Mapping APIs allow you to develop rich, interactive applications using JavaScript, Flex or Silverlight. You can embed your applications in Web pages or launch stand-alone Web applications from any Web page. These APIs allow users to:

- Add content to the map via online services
- Add their own tools and widgets
- Build stand-alone applications
- Add GeoRSS feeds and other Web content
- Connect to GIS servers

Development with the APIs is free and deployment is also free under certain conditions.

5.8 ArcGIS for Mobile

ArcGIS for Mobile helps organizations deliver GIS capabilities and data from centralized servers to a range of mobile devices. Users can use ArcGIS for Mobile to deploy intuitive and productive mobile GIS applications to increase the accuracy and improve the currency of GIS data across organizations. Easy-to-use ArcGIS for Mobile applications enable field staff who do not necessarily have any GIS experience to do:

- Mapping
- Spatial query
- Sketching

- GPS integration
- GIS editing

5.9 ArcGIS Online, ArcGIS.com and Community Maps

ArcGIS.com is a Web site for working with maps and other types of geographic information. In ArcGIS.com, users can create maps; find and use maps, applications, and tools; and share maps and applications with others. Users will also find useful basemaps, data, applications and tools that can be viewed and used, plus communities you can join.

ArcGIS Online is Esri's repository of maps, data, applications and tools. ArcGIS Online includes content from Esri, its partners and the GIS community at large. Anyone can share maps and data via ArcGIS Online. The ArcGIS.com Web site lets you access all the content in ArcGIS Online using a Web browser. ArcGIS.com is just one way to work with ArcGIS Online. If you are using an Esri product such as ArcGIS for Desktop (starting at version 10) or ArcGIS Explorer Desktop, you can view ArcGIS.com Web maps, download layer packages, and access ArcGIS Online using commands inside those applications.

The **Esri Canada Community Maps Program** provides a cost-effective and efficient framework for Canadian organizations to share their geographic information with the public. The program enables organizations across Canada to contribute their geographic information to be published as community maps on ArcGIS Online. The available maps are rendered with uniform cartography, cached and integrated into a World Topographic Map on ArcGIS Online.

5.10 ArcGIS for Smartphones

The ArcGIS Apps for Smartphones allows users to navigate maps, collect and report data, and perform GIS analysis. It is a part of the ArcGIS system and is a great way to:

- Discover content by browsing map galleries from ArcGIS Online, the Canadian Topo Map or leverage existing enterprise GIS services
- Display maps and capture information
- Develop a custom application or brand users own application specific requirements to business needs
- Extend GIS to a wider audience

The ArcGIS API for Smartphones enables developers to build applications that utilize the powerful mapping, geocoding, geoprocessing and custom capabilities provided by ArcGIS for Server. Developers also have the ability to embed ArcGIS maps and tasks into your line-of-business applications. ArcGIS for Smartphones allows developers to:

- Use and display services from ArcGIS Online and/or ArcGIS for Server
- Execute sophisticated geoprocessing tasks and display results
- Create applications that collect and update data

ArcGIS supports the following smartphone technology with downloadable APIs for users and developers:

- API for iOS (Apple iPhone, iPod Touch and iPad devices)
- API for Windows Phone
- API for Android

6 Case Studies—Esri Technology at Work in the CGDI

6.1 Overview

This section describes some of the more notable SDI implementations in Canada. They include one federal site, three provincial sites and a municipal site:

- Indian and Northern Affairs Canada (INAC) GeoViewer
- Service New Brunswick GeoNB Portal
- Government of Saskatchewan GeoSask Portal
- Alberta Tourism, Parks and Recreation Online Campground Reservation Service
- York Regional Government GeoViewer

6.2 Indian and Northern Affairs Canada (INAC) GeoViewer

INAC Geoviewer Home Page

Indian and Northern Affairs Canada (INAC) has developed a significant national site that is CGDI compatible. The site allows internal and external users to view and query INAC business data within a geographical context. It contains Aboriginal thematic data on First Nations, Canada Lands, Tribal Councils, Inuits and Metis.

INAC required a common approach to Aboriginal consultation and accommodation across the country. Rights vary depending on the treaty, the activities, the resources and the location in Canada where the project/activity is to take place. Consultation procedures and approaches must be sensitive to differences and provide adaptations in different geographical areas in the country. For reference purposes, INAC developed an Internet site that offers a map of Canada illustrating the geographic location of modern treaties (i.e. comprehensive land claim agreements).

The INAC site has been fully operational since 2008 and has an externally available viewer at http://geovisualiseur-geoviewer.ainc-inac.gc.ca/geoviewer/Default.aspx?LANGUAGE=en. The site is fully bilingual and supports the federal “common look and feel” policy. The site also provides

metadata for the data layers. This INAC site uses the full base topographic data from NRCan, which had not been used in this type of Web application before.

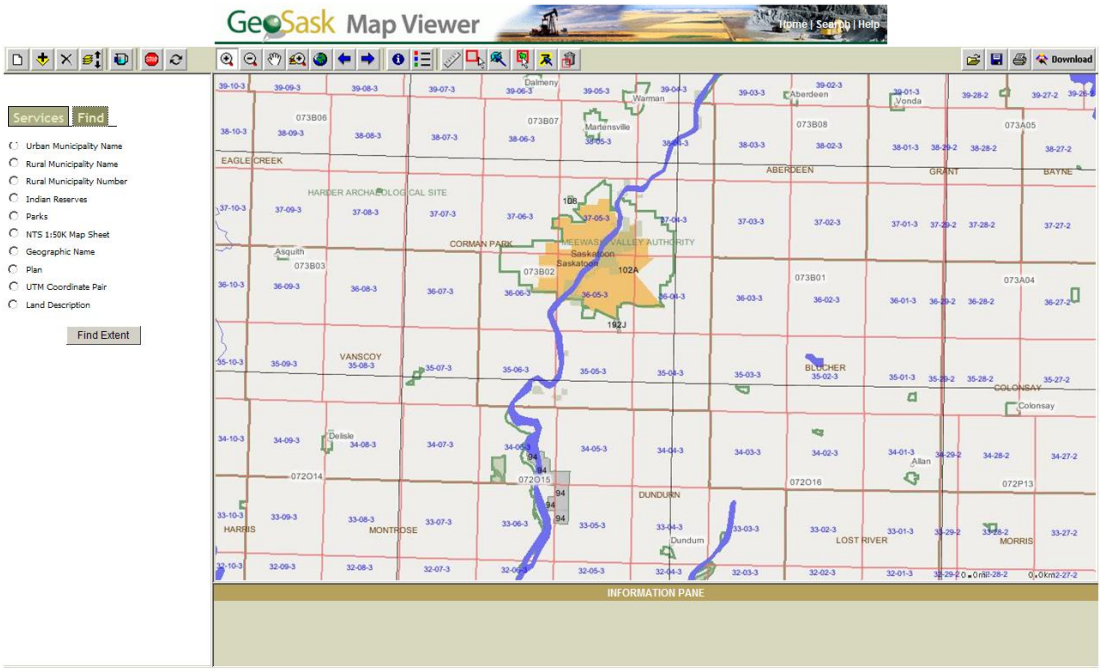
6.3 Service New Brunswick GeoNB Portal

GeoNB Flex Viewer Screen Capture

The Government of New Brunswick (GNB) had many rich geographic information datasets that were underutilized. To improve the use of GNB's geographic information, a portal was created that allowed New Brunswick map data to be viewable by the public. The site is operated by Service New Brunswick (SNB). It provides SNB with political visibility on their activities, as well as exposes GNB geographic data for further use and exploitation.

The GeoNB site has both a public-facing component and an internal-facing component. The site was made operational in 2009 and is publicly available at http://geonb.snb.ca/geonb/. The public site is fully bilingual and has the following map layers: topographic, aerial, weather radar, civic addresses, land parcels, flood information and wetlands. A small set of measurement and analysis tools is also available. A video describing some of the features of the GeoNB site is available from YouTube at http://www.youtube.com/watch?v=SHvhx1WnE6I.

6.4 Government of Saskatchewan GeoSask Portal

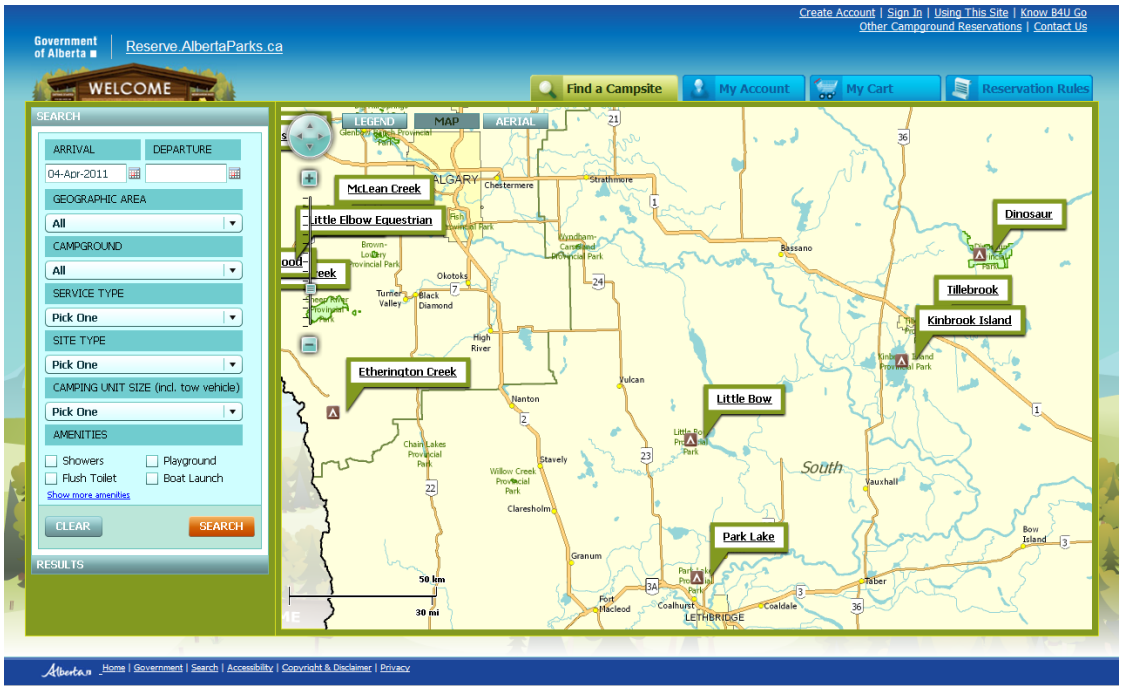


GeoSask Geoportal Site Screen Capture

GeoSask is a collaborative effort with the Government of Saskatchewan (GoS) to facilitate the publishing of Saskatchewan GIS information and maps. GeoSask is accessible to executive government, businesses and the public. It features free GIS data available from participating GoS ministries and agencies. GeoSask was built and is maintained by the provincial Crown corporation Information Services Corporation (ISC).

The GeoSask Portal provides standardized high-quality map information about the province. The portal uses the Esri Geoportal Toolkit (now known as the Esri Geoportal Server). The publicly available portion of the Web site was launched in 2007 and is available at http://www.geosask.ca/Portal/. Metadata searches and data downloads are featured in GeoSask.

6.5 Alberta Tourism, Parks and Recreation Online Campground Reservation Service



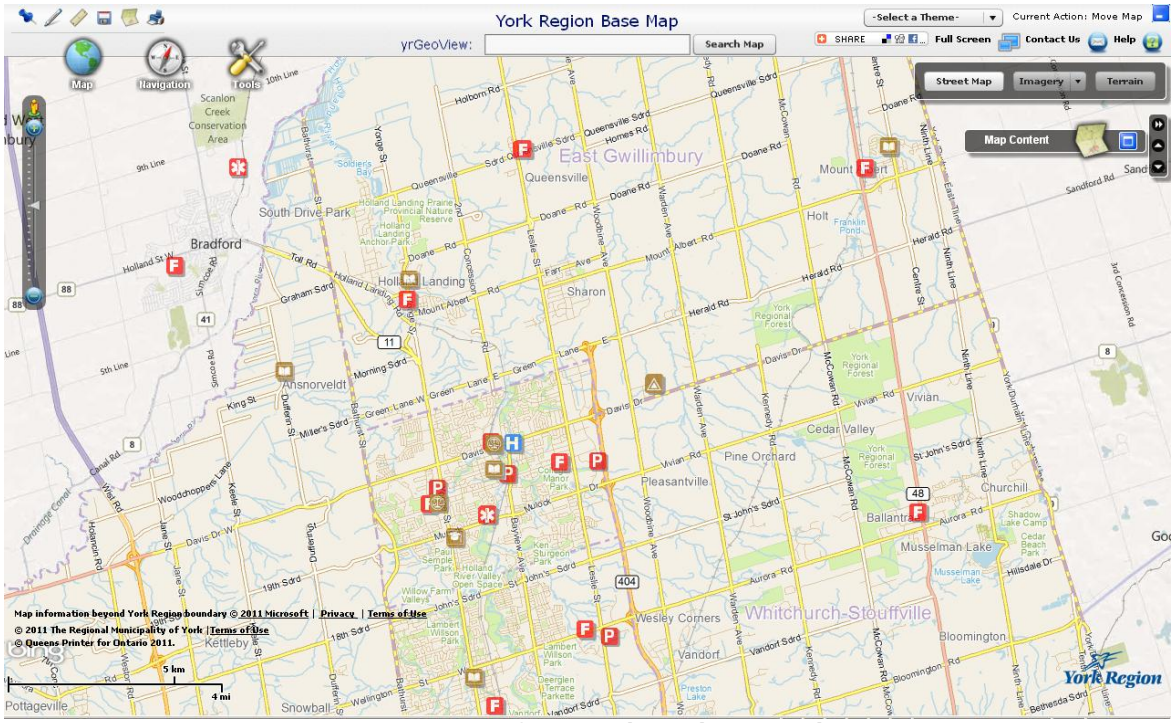
Screen Capture of Reserve Alberta Parks

Alberta Tourism, Parks and Recreation increased administrative efficiency and improved visitor satisfaction with their online campsite reservation service, which handles more than 4,000 campsites across 50 provincial campgrounds. The highly successful Web site helps make recreational opportunities in Alberta more accessible; replaces the inefficient phone and in-person reservation system; and allows users to view, explore and reserve campsites online.

The system manages and serves up large amounts of information about the campsites, including more than 12 million map, data and image files created for this application. The application's user interface needed to be intuitive for easy use by the general public, as well as provide integrated multimedia of campsites. The site allows users to search campsites by geography, features and amenities, and obtain panoramic views of the campground to help them choose the best site for their needs. The system is designed to accurately process up to 100,000 reservations per year.

In early 2009, the Web site was launched in time for the 2009 camping season. In 2010, the Alberta Tourism site project won an Esri Canada Award of Excellence. The site is available at Reserve.AlbertaParks.ca and uses ArcGIS for Server technology within an enterprise GIS environment.

6.6 York Regional Government GeoViewer



Screen Capture from York Region GeoView

The York Regional Government wanted everyone to be able to access information about the region via the Internet. In addition, they wanted to enable quality decision-making through geospatial information. Over the years, they deployed a number of informative Web sites that implemented standards, data models, creation and scheduled maintenance of data, quality control processes and documentation to ensure managed geospatial information was correct, current and complete.

The impressive, award-winning York Region Web site is operational and publicly available at http://maps.york.ca/yorkexplorer/default.jsp. The publicly available Flash-based YRGeoView was implemented in 2010 and is available at http://ww3.yorkmaps.ca/yrGeo/yrGeoView/RegionalBase/index.html.

Numerous geographic data layers are available on the York Region Web site, which are provided from internal or other sources. Partnerships are in place to source data and provide maintenance of orthophotography, parcel fabric, single line road network and address points.

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