Natural Resources Canada
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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE
INFORMATION PRODUCT 46e

Standards User's Guide for Geographic Information

GeoConnections
IDON Technologies Inc.

2016

Canada

Standards
User's Guide for
Geographic Information

Prepared by
IDON Technologies Inc.
under contract
NRCan 3000543726

21 January 2015

ACKNOWLEDGEMENTS

The author, Doug O'Brien, IDON Technologies Inc., would like to thank Jean Brodeur, from GeoConnections at Natural Resources Canada, who supervised the project.

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1. Introduction

The GeoConnections program, led by Natural Resources Canada, provides coordination and leadership for standardization for the interoperability of geospatial information, in support of the Canadian Geospatial Data Infrastructure (CGDI). The CGDI is built upon international standards developed through the formal international process of the International Organization for Standardization (ISO), and also through industrial standards development consortia such as the Open Geospatial Consortia (OGC) [11]. The GeoConnections program fosters interoperability and standardizes the way information is stored, accessed, and presented online through a suite of endorsed interoperable standards for both systems and data developed in national, international and industrial standards organizations.

Standards are complex and there are many different aspects. Some standards are focused whereas others are very general in nature. Also some standards relate to data, others to systems and services as well as to more general procedural topics. It can be confusing for anyone not familiar with the whole range of standardization in the field of geospatial information to understand the purpose of different standards and which ones apply in different situations.

This user's guide provides both background and practical knowledge of the relevant standards. Many detailed standards are of interest only to the technician or software programmer developing a specific aspect of the CGDI. This guide is aimed at the more general user or manager that needs to have a higher level understanding of the overall relevance of standards so that they can make decision on what and how to apply standards but they do not need to know the details of most standards. This is especially true of geospatial information standards since these standards bridge the two distinct disciplines of Earth Science and Information Technology.

In order to develop a guide that is focused on the manager, professional, or user, and not on the technician, three topic areas have been identified, in effect acting as case studies in standardization. These topic areas are representative:

- Establishment of a Geospatial Information Environment;
- Creation of a Data Product;
  - Feature oriented Vector data products;
  - Coverage based data products (including Imagery);
- Web service implementation.

These are practical areas that address the needs of professionals and managers in both the Earth Science and Information Technology fields.

1.1 Geospatial Information Environment Overview

A Geospatial Information Environment is an aggregate of all of the resources that provide a person access and understanding to geospatial information together with the information itself. Of primary importance is the organization of the data and the resources including feature catalogues, registers, schemas, etc., but it also includes the encodings used to disseminate geospatial information and the services through which users interact with applications utilizing the geospatial information.

The ISO approach to organizing geospatial data is to use a feature oriented methodology where the world is modelled as a set of features with geospatial and other attributes and where the relationships between these feature objects are established. This approach is now widely used throughout the Geospatial Information community. A number of standards pertain to the definition of features, the establishment of the geometric and temporal primitives that describes the spatial and temporal aspects of these features including the establishment of feature catalogues and concept dictionaries. The set of features with their associated definitions and associated spatial and other attributes is first described in a conceptual model which forms the basis for a product specification for that type of data. For example a simple road map may contain the feature types “road”, “highway”, “path” etc. The geometry type “curve” describes the shape and the location of the road map features. Attributes may describe the characteristics of the road. An attribute might indicate if a path is a "bicycle path", a "foot path" or a "combined pedestrian and bicycle path." A spatial reference system would relate the road map features to the Earth.

Metadata is the information about the geospatial information resources, e.g. when and by whom geospatial information was produced, the area it covers, and the quality of the data. Metadata is important for understanding the currency and relevance of the resources and is extremely important to drive services which allow one to find relevant geospatial information. An example is the Catalogue Service for the Web (CSW) by which users may search for available digital map information.

In order to receive data from a database or other online storage mechanism it is necessary for the data to be encoded into some data format. There are many data formats designed for an array of special purposes or are specific to a particular manufacturer’s systems and equipment, and a few formats that are very general in nature. One of the most flexible and widely used is the Geography Markup Language (GML) which is an XML based encoding. Many Web based geospatial services make use of GML.

Compatibility depends upon all parties having the same understanding of the meaning of any elements within the set of geospatial information. This is facilitated by the maintenance of managed lists of information elements, such as Concept Dictionaries that provide definitions for feature types or Metadata Dictionaries that provide definitions for metadata elements. Sets of definitions help define context so different users from varied backgrounds can understand the same information in context. Understanding of context can help in establishing Semantic Interoperability. For example, a “Road” feature type may mean something different to a transportation engineer who needs to consider road maintenance and other details, than the meaning understood by a traveller who simply wants to pass along the road.

Section 2 of this standards guide sets the foundation of a Geospatial Information Environment and the aspects needed to define information elements and service interfaces that operate within that environment and their relationships.

1.2 Data Product Overview

Data and the standards that describe it are important aspects of the CGDI. Framework data is one of the four key components of the CGDI. Many government departments are generators of geospatial information, from Topographical Maps, to Hydrographic Charts, Remote Sensing Imagery, Census and Election maps, etc. Industry also produces a lot of geospatial information, some of it commercially for sale, and other information to support their primary business; for example, mapping done by a mining company might be exclusively designed to support their mining activities. Interoperability between data produced by different sources is of great importance. That mining company may want to be able to ingest data from government sources so that it does not have to "start from scratch" in its mapping effort. Also governments (federal, provincial, municipal and native band councils) may be interested in some of the output from the mining company's activities.

The second subsection of the guide addresses the Creation of a Data Product. This includes an explanation of the purpose of a Product Specification and its major components. Product specifications are the central guiding specification used in developing a mapping data product, and they touch on many of the other supporting standards. The primary components of a product specification are:

- application schema, (how the data is organized);
- metadata (information about the data set);
- feature catalogue (the real world elements that are included in the data set).

In addition a Product Specification describes:

- conformance testing (to ensure compliance with the specification to ensure uniformity of the data);
- quality (a description of the quality measures of the data);
- encoding of the data (how it is formatted for data exchange); and optionally
- portrayal (how the data is intended to be visualized).

Some examples of focused Product Specifications are the standards for data products included in the GeoBase suite of available geospatial data or hydrographic charts upon which safety of navigation depends.

Section 3 of this guide illustrates what is included in a product specification and how the supporting standards relate.

Subsection 3.1 addresses a vector based data product, and describes how feature objects are represented spatially by point, curve and surface geometric primitives. Such a vector data product typically contains a number of different feature objects with associated attributes and metadata. Formats are an important part of data exchange for vector based data products. Typical data formats are XML, GML and KML, although other more specialized data formats are also used.

Subsection 3.2 addresses a coverage based data product. Coverage data describes how information covers an area. Imagery, elevation models and Triangular Irregular Networks (TIN) are good examples of types of coverages.

1.3 Web Service Overview

The classical printed paper map is being supplanted by electronic maps, many of which are viewable and/or downloadable through Web services. Standardization of geospatial online services has been led by the Open Geospatial Consortium (OGC) which has developed a number of consensus specifications that describe many aspects of data services and more specifically Web services. ISO work on services is primarily driven by the work in OGC.

Section 4 of this guide addresses the relevant aspects of Web services. More specifically, it deals with the following types of services:

- Data Discovery and the Catalogue Service;
- Web Mapping Service;
- Web Feature Service;
- Web Coverage Service;
- Web Processing Service.

One of the most basic services is the Catalogue Service that allows users to browse metadata and find data. This is the core service for many applications, and it is driven by the metadata. This is an area where both the data and service standards overlap. However, the data discovery use case is different than most of the other geospatial service situations in that a user needs to be able to find all data, based on all metadata standard versions.

2. Establishment of a Geospatial Information Environment

Geospatial information is typically generated in a context for a particular purpose, so it is important to know and document the distinguishing aspects of the context in order to understand the data. The contexts for different communities of interest (groups of users) also overlap so an understanding of data is highly dependent upon the user's point of view. Standards are needed to describe these contexts so that different groups of users with different backgrounds can develop mutual understandings. The approach is to work at the element and interface levels and define these well so that different communities of interest can agree on most aspects. Where there is disagreement, there can be a translation to allow meanings to be bridged between different contexts.

The ISO component view methodology for describing geospatial information and services is based on the feature oriented approach. In this approach, the meaning of each individual feature type is defined. The feature type meaning may be refined using modifying attributes; such as, the location of the feature, operations that may be applied to the feature and relationships of the feature to other features. These aspects are defined in an application schema. The definition for each feature and its bound attributes are described in a feature catalogue, and a feature concept dictionary may be used to collect these definitions so that they may be used consistently. These elements drive to the elaboration of a Geospatial Information Environment.

The term "information environment" is widely used but seldom defined. A definition is given by the military as "the aggregate of individuals, organizations, and systems that collect, process, disseminate, or act on information, also included is the information itself [13]" The Geospatial Information Environment includes all aspects related to spatial information including the structure of the data and all of the interfaces to the systems that disseminate or present the information. Components of a Geospatial Information Environment are:

- Data structure/schema (Application Schema);
- Data description/semantics (Feature Catalogue);
- Metadata;
- Data and metadata capture operations;
- Data (the data elements);
- Data management;
- Discovery;
- Access;
- Transformation.

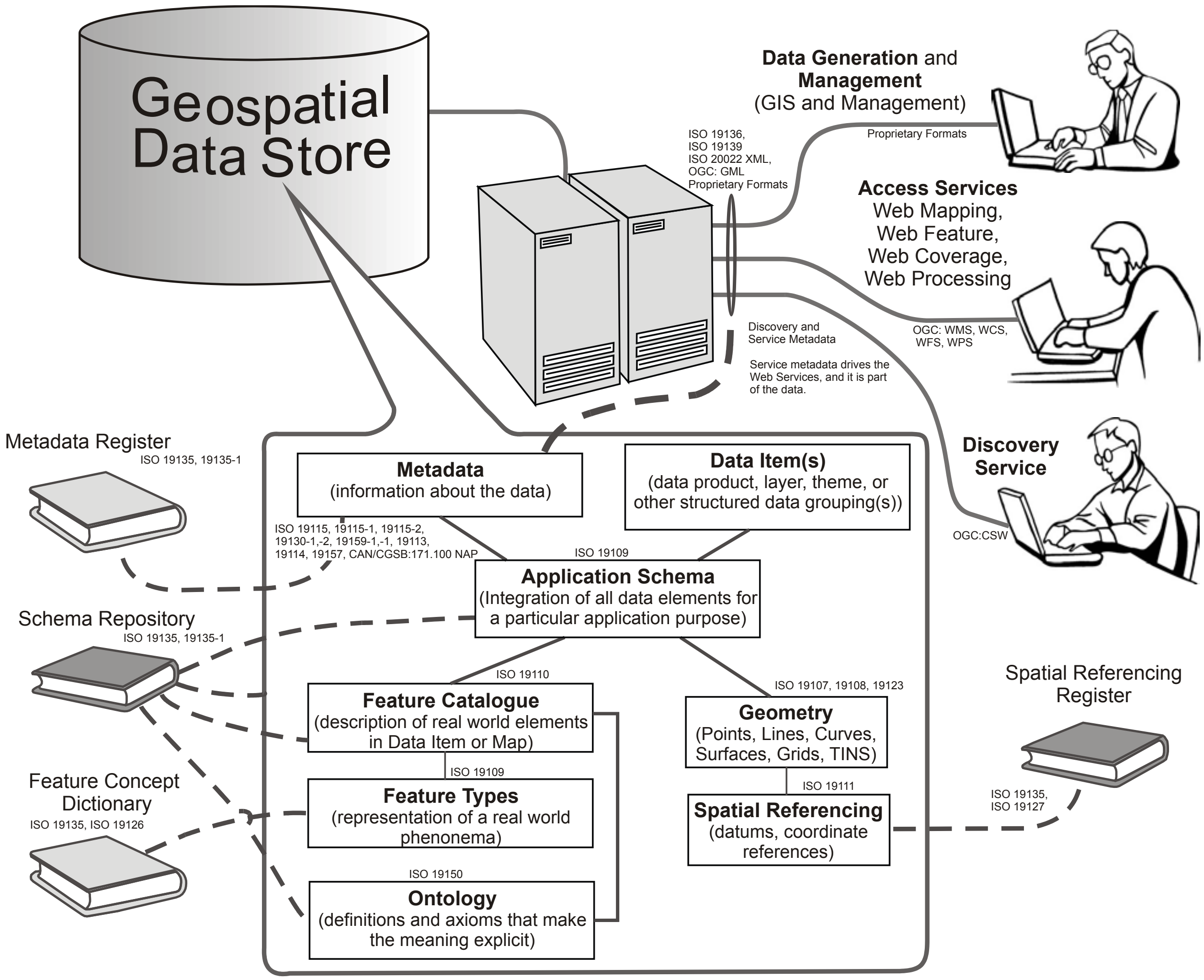


Figure 1. Geospatial Information Environment.

This is illustrated in Figure 1. Different users access the system through various information services. These include the Discovery Service (e.g., CSW) to find data, the Web Mapping and related access services to retrieve and process data, and the generation and management of data in a Geographic Information System (GIS) which may both retrieve and generate data. The data is composed of Geospatial Feature Objects that are assembled through a Feature Catalogue to address a particular world view. That is, a Feature Catalogue binds Features and Attributes to describe real world objects. The data may be organized in many different ways in the data store, as layers, thematic groups, or other structures. Metadata is data about the resources, such as production dates, quality, etc. The Application Schema integrates all of the components for a particular use. For example, certain features comprise a hydro network. Some of the same feature types may also exist in other Application Schemas such as a river in a road map, but the attributes would be different. With careful management, the same feature instance could exist in the data store in such a way so that if there were a change in the river the change could be reflected in both uses. Registers support the data structure by providing definitions for metadata elements, and feature concepts. The Spatial Referencing Register can list Geodetic Codes and Parameters, and the Schema Repository would make the various Application Schemas available. The data that flows out to users would be encoded. Some of the standards that apply across these interfaces and to these components are indicated in Figure 1.

There are a number of high level standards that support the development of a Geospatial Information Environment. They define the rules for Application Schemas, Feature Cataloguing Methodology, Feature Concept Dictionaries, and Geodetic Codes and Parameters as well as the elements of Metadata and the Spatial and Temporal Schemas. A user or manager only needs to understand that such rules exist. They should be more interested in the resulting application schema and the feature catalogue used for a particular type of data. The feature concept dictionary, when it is defined, establishes the vocabulary of feature and attributes types. The user may want to look-up the definition of a feature type in the dictionary to understand the data.

The data has common information components and the services define the interfaces that allow access to that data. This section addresses the following component of a Geospatial Information Environment: Feature Based Approach, Schemas, and Schema Repositories, Feature Catalogues and Concept Dictionaries, Metadata, Geospatial Data and Data Sharing, Registers and Semantic Interoperability.

2.1 Feature Based Approach and Application Schema

The feature based approach for geospatial information derives from the ISO/TC 211[8] General Feature Model as described in *ISO 19109 – Geographic Information, Rules for application schema* [17]. This standard guides the creation of the conceptual definition of geospatial information, also called the Application Schema. The purpose of an Application Schema is to structure the data for a particular application. It allows one to:

- Structure and develop a geospatial database;
- Implement a GIS for a specific domain;
- Derived an encoding schema (e.g., GML schema);
- Set the semantics of the data;
- Support analysis.

The General Feature Model is the ISO high level model that states that a feature has attributes, properties, constraints, and relationships with other features such as the generic association, aggregation association, and classification association (subtype of). Such a feature is described within an application schema.

Developers of geospatial information products and databases need to closely follow ISO 19109 to define, structure, and organized geospatial data coherently. On the other hand, users will benefit by becoming familiar with the uniform structure of the data source or product.

The most fundamental element of the General Feature Model is the Feature Type, which allows the description of features. The first step is to determine the feature types required to describe a particular domain of geospatial information. A particular use of geospatial information is analysed to determine which features are needed to represent the spatial information. For example a hydro map will need hydrology features such as rivers, waterbodies, and watershed area.

An application schema is built-up out of a set of features together with the properties of those features, including spatial attributes, temporal attributes and other attributes related to the type of feature. A signal tower may have specialized attributes identifying flash rate and pattern of the light on the tower.

The Application Schema is the core of a Geospatial Information Environment. It relates the feature types to the geometry and other attributes and identifies the associated information such as the metadata. The Application Schema is represented as a model. There are many different way of expressing that model.

An Application Schema can define a hierarchical tree of all Feature Types used in a data product including relationships between features.

A simple hierarchy which is part of an application schema is shown in Figure 2 for a Hydro Feature which has subtypes of a Watershed feature, a Waterbody feature, and a River feature. The River feature itself has a subtype of Water Linear Flow.

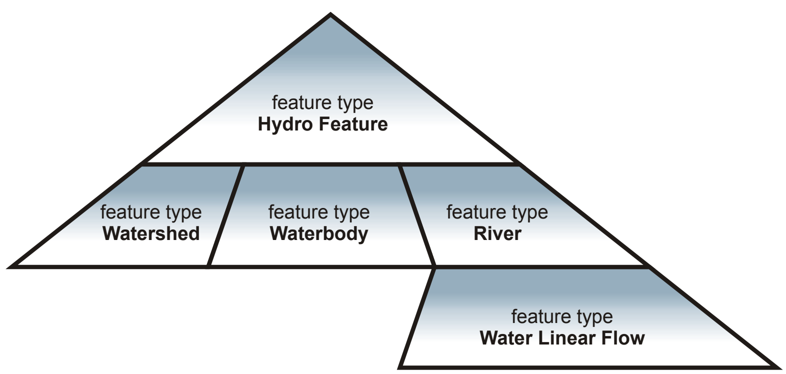


Figure 2. Example of a Hydrologic Feature Set.

An application schema is typically defined using the UML modelling language (See Annex A). Attributes give additional details to instances of each feature. The geometry of a feature is defined as a feature attribute.

Other relationships are also defined. The mechanism used throughout the ISO suite of geographic information standards is the Universal Modelling Language (ISO/IEC19505) [58]. This formal modelling language is intended for database developers and managers. A user needs to know that these rigorous models exist. Their content and their management are of high importance.

Figure 3 illustrates a bridge feature type. The bridge in this example is made of one Span and two Approach Roadways and includes Piers and Bridge Railings. In a generic bridge feature type the span is necessary since a bridge cannot exist without a span. The generic bridge feature type can have two or more approach roadways, and optionally may have piers and railings. The bridge also has a relationship with the river feature that it crosses over.

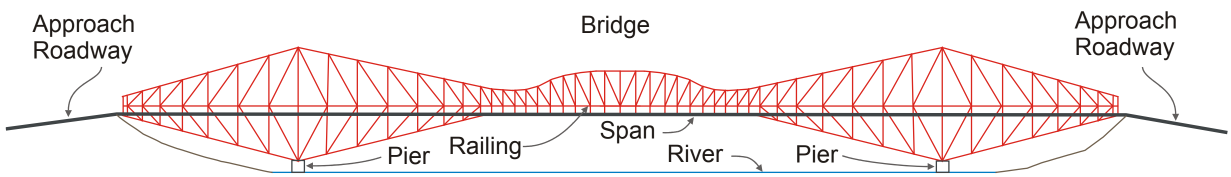


Figure 3. Example of a Bridge Feature.

The geometry and temporal aspects are defined for a feature type through the attributes associated with the feature. A feature type may have multiple attributes including multiple geometries. For example, a bridge may be described as an area with a boundary on a 1:5,000 scale map and be described only as a point on a 1:1,000,000 scale map. Features with complex shapes may have several curve geometries associated at different levels of generalization.

The Application Schema is the core of an information environment. It relates the feature types to the geometry and other attributes and identifies the associated information such as the metadata. The Application Schema is represented as a model. There are many different way of expressing that model.

Figure 4 shows a set of data from the GeoBase National Hydro Network. It shows drainage and 16 other feature types. A Feature Collection is a feature type that is used to group other features.

Once all of the features are assembled, other properties need to be assigned.

Geospatial data needs to be located on the Earth. Spatial information is of two types: a set of spatial primitives and referencing of a position in relation to the Earth.

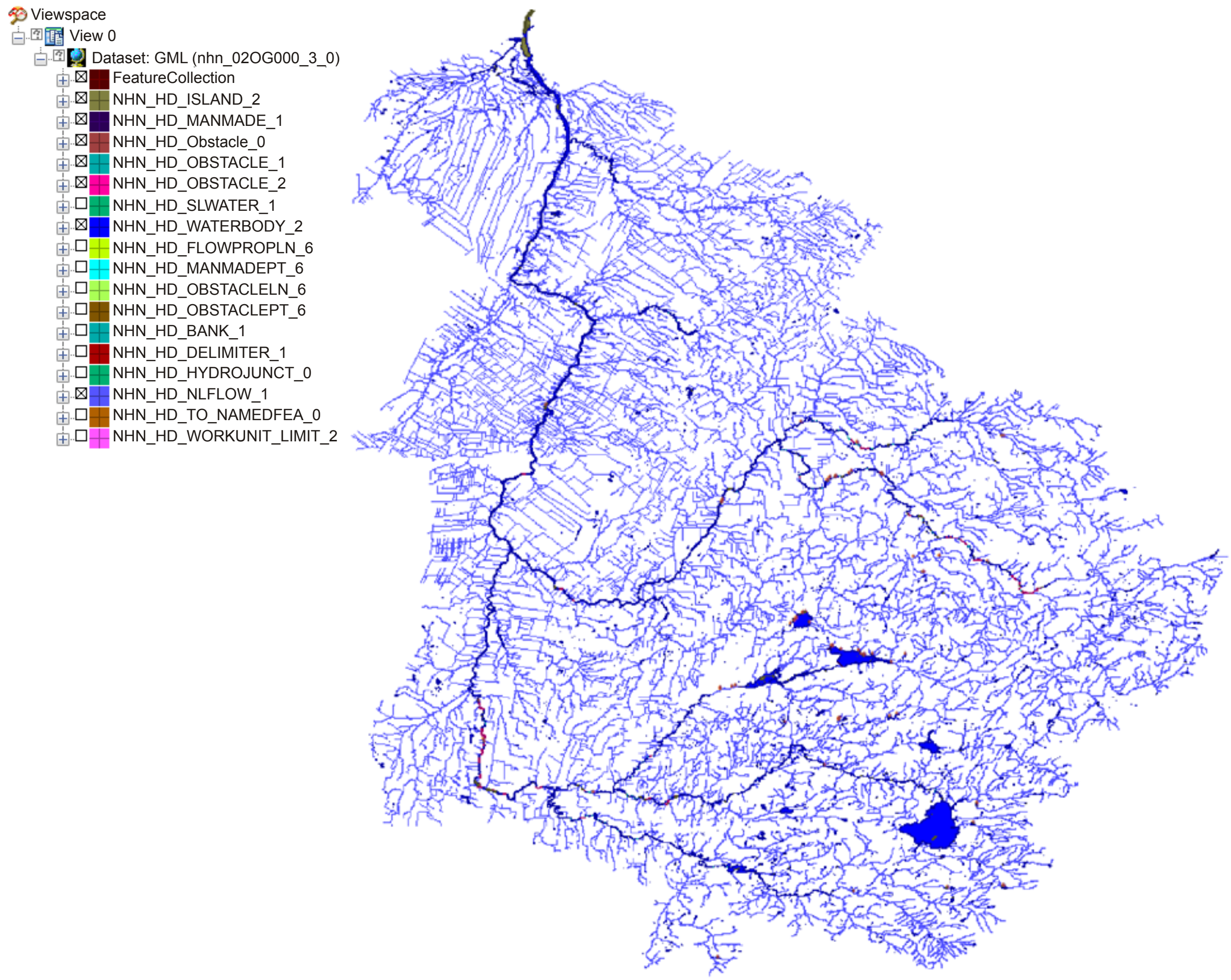


Figure 4. Example from the GeoBase Hydro Network.

A set of spatial primitives is defined in *ISO 19107 Geographic information –Spatial Schema* [16]. From it, a set of spatial primitives are selected. The spatial primitives in a two dimensional space are basically a point, a curve (curved line segments), and a surface (area). Special types of lines may be used in some situations. The available set of geometric primitives defined in the ISO 19107 standard is very rich. A group of implementation subsets have been defined in the *ISO 19136 Geographic information – Geography Markup Language (GML)* [35] [67]; an encoding standard. The user or manager should know and understand the set of geometric primitives that are available for the definition of geometric attributes for features.

The other important part of the spatial information is the referencing of a position in relation to the Earth. A Coordinate Reference System (CRS) is the mechanism that allows it. The standard *ISO 19111 Geographic information – Spatial referencing by coordinates* [19] provides a standard approach to fully describe a coordinate reference system. Users need to be able to identify which of the spatial referencing systems, that have already been standardized and registered in a well-defined register, is used. Typically these would be the North American Datum NAD83, or its predecessor NAD27 or the World Geodetic System 1984 WGS84, or one of the many other localized reference systems. A code identifying the system would be part of metadata. A standardized register holds the geodetic codes and parameters defined in accordance with ISO 19111. There are a number of registers of geodetic codes and parameters. One is being established by ISO which will be the definitive list referenced in Canada. Another register which is well used has been defined by the International Association of Oil and Gas Producers (formally the European Petroleum Survey Group (EPSG) [5]). This is not an authoritative list but it assigns codes that are broadly used in many geospatial services to identify reference systems.

A feature catalogue is usually developed, as a companion resource, to document all the elements defined in an application schema. Feature catalogue is presented in Section 2.2.

2.2 Feature Catalogues and Concept Dictionaries

Feature Catalogue

A feature catalogue is a documentation mechanism that supports the description of an application schema. It is also based on the General Feature Model introduced earlier and described in the standard ISO 19109. It is intended for data producers to describe and end users to understand the significance of the feature types, their attributes and their relationships. A feature catalogue is one of the support mechanisms for semantic interoperability.

ISO has standardized the content and structure of a for feature catalogue in *ISO 19110 Geographic information – Methodology for feature cataloguing* [18].

Each feature type that may be used in the data is defined together with the attributes that apply to that feature. The user needs to know this in order to be able to understand the content and the data producer (of whatever discipline) needs to know this in order to establish collection criteria to gather the data to represent on a map. This is true for electronic maps as it has been in the past for paper maps. The legend on the paper map is effectively the feature catalogue for that map.

Figure 5 presents an extract from the National Vector Catalogue Profile (NVCP) developed by the Earth Sciences Sector of NRCan in compliance with ISO 19110. The extract is from the Feature Catalogue giving the definition of one feature type and the associated attributes from the example given in Figure 4. Every feature type has an identifier and a definition. Also associated with the feature are a set of attributes, each of which also has an identifier (name) and a definition. The attributes are bound to the feature. This means that the particular set of attributes that apply to this feature, and whether they are optional or mandatory. The feature with its bound attributes is the primary descriptor of a geographic object.

Abstract Class : Water Linear Flow

Code	Catalogue	Name - *(French name)*	Geometry
1100009	Earth Sciences Sector Integrated Data Model, MGT, Hydrographic Features	Water Linear Flow - *(Filamentaire d'écoulement)*	Area
Definition			
A feature that traces the movement of water in a one-dimension virtual water flow route.			

Attribute Section

Attribute	Attribute name	Attribute definition
FEATURE_ID	Feature Identifier	▸ Unique numeric identifier necessary for the operation of ESRI.
FLOW_DIRECTION	Flow Direction	▸ The water flow direction compared to the feature digitizing direction.
FLOW_QUALIFIER	Flow Qualifier	▸ The nature of the Water Linear Flow.
BDG_ID	GDB Identifier	▸ Unique internal feature identifier used in Spatial Reference Data Base (SRDB).
NAME_DATABASE	Geographical Name Database	▸ Name of the database from which the geographical name comes from.
LEVEL_PRIORITY	Level Priority	▸ Water Linear Flow route classification within the hydro network.
MD_ID	Metadata Identifier	▸ Identifier of the metadata describing a feature occurrence.
NAME1_ID	Name Identifier 1	▸ The geographical name identifier from the geographical name database.
NAME2_ID	Name Identifier 2	▸ The geographical name identifier from the geographical name database.
MD_NETWORK_QUALITY	Network Data Quality	▸ Quality of the network construction. By its nature, this attribute falls naturally under the metadata model defined by ISO 19115. Its duplication or presence at the entity level can only be explained by a desire for ease of access and convenience for the user, namely provide direct access to this information
PERMANENCY	Permanency	▸ Nature of the occurrence through time.
PURPOSE	Purpose	▸ The purpose or representation of the geometry
MD_TOPONYMIC_LINK_QUALITY	Toponymic Link Quality	▸ Quality of toponymic association. By its nature, this attribute falls naturally under the metadata model defined by ISO 19115. Its duplication or presence at the entity level can only be explained by a desire for ease of access and convenience for the user, namely provide direct access to this information
WATER_DEFINITION	Water Definition	▸ The nature of a body of water defined according to its water velocity, usage and configuration.
ZT_ID	Zone of Transaction Identifier	▸ Identifier of the transactional metadata polygon delimiting the area where the transaction occurs. The transaction refers to the work from which the feature occurrence comes from.

Figure 5. Example of One Feature Type from an On-line Feature Catalogue.

Feature Concept Dictionary

A feature concept dictionary is also a set of definitions, but it is at a more abstract level. The definitions in the concept dictionary are isolated and are separate from the feature types and from the attributes. In a feature concept dictionary, the attributes are not bound to the features. The

Feature Concept Dictionary can be compared to a language dictionary. The standard *ISO 19126 Geographic information – Feature concept dictionaries and registers* [27] describes the mechanism for establishing and managing feature concept dictionaries established as registers.

The purpose of the feature concept dictionary is to provide guidance to the developer of the feature catalogue so that common definitions can be used where possible in different feature catalogues. It provides consistency across different application areas. If the dictionary definition is too broad it can be narrowed in the feature catalogue. The feature concept dictionary and the feature catalogue complement each other. There is no need for a feature concept dictionary if one has a narrow environment. Only the feature catalogue is absolutely necessary.

Some organizations such as the International Hydrographic Organization (IHO) [7] and the Defence Geospatial Information Working Group (DGIWG) [3] have defined Feature Concept Dictionaries to support a range of different data products developed by these organizations. Most other organizations have a narrower scope and have only define Feature Catalogues.

Figure 6 – shows the feature definitions from the DGIWG Feature Data Dictionary [4].

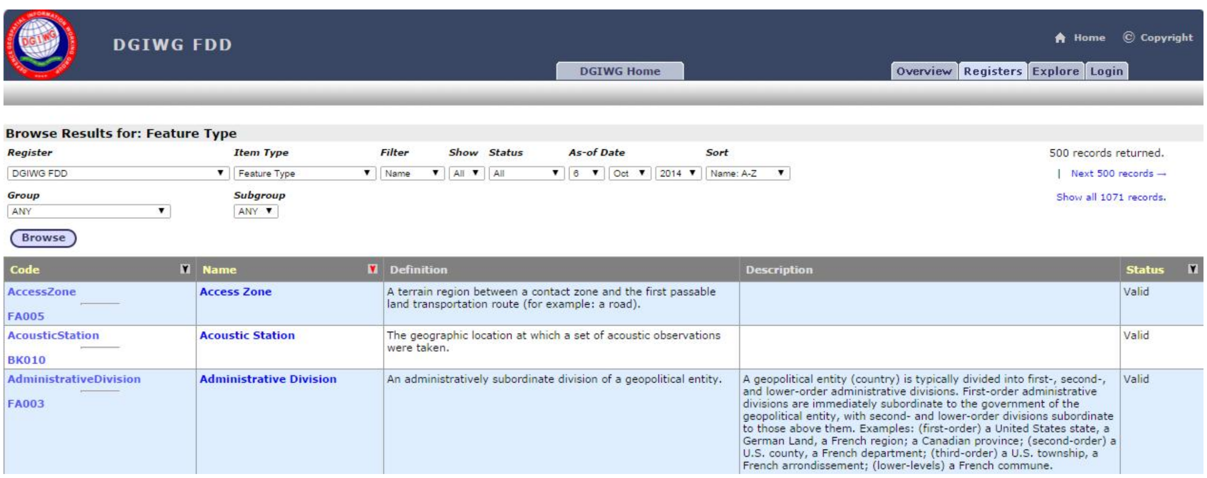


Figure 6. Extract from the DGIWG Feature Concept Dictionary.

ISO has standardized the structure of the feature concept dictionary in ISO19126. However, ISO 19110 for feature catalogue is the more important standard than ISO 19126. Users or managers need to understand that both resources exist, the distinction between them, and that they complement each other.

2.3 Schemas and Schema Repositories

As mentioned previously, every set of data needs to be well documented, or it cannot be understood by a user. The application schema documents the structure and content of a particular type of geospatial information designed to address a set of uses. A schema repository is a database or register used to store and manage a group of schemas including all versions of those schemas, and their associated element descriptions. It allows one to define multiple layers of information that can be used separately or together to describe many aspects of a geospatial reality.

A set of independent layers is illustrated in Figure 7. Each layer is a type of data and may have an independent feature catalogue, metadata and other elements. These layers can be aggregated into an overall Application Schema for a particular usage.

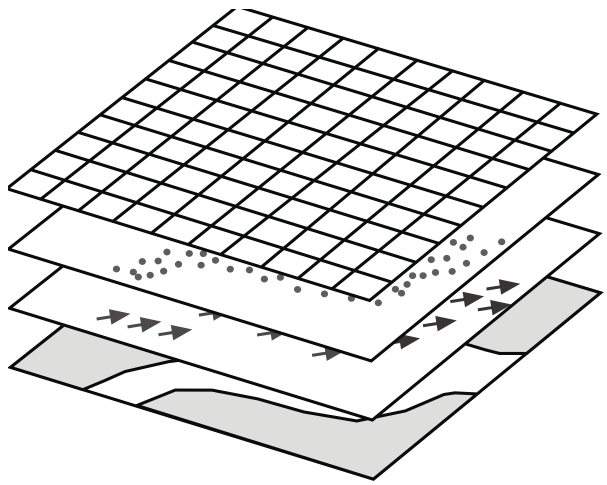


Figure 7. Example of a set of layers.

Systems that read, process, or display data need to understand the schemas, as do the Geographic Information Systems (GIS) that produce data. An end user needs access to information maintained in the schemas to understand the data received.

A practitioner such as a GIS professional, a surveyor, a biologist or any of the many other professionals that produce data in a map form, need to have access to the schemas to be able to produce consistent data products. A third type of user is the developer of the schema for a particular topic domain. This user does not want to start "from scratch" and develop a unique product specification; rather, the desire is to build upon and extend existing schemas and schema parts developed by others.

In order to share schemas, there needs to be some mechanism in place to make the schema information available to the various users. This involves the access to a schema repository. A schema repository needs to be a managed database (i.e. a Register), which contains multiple sets of:

1. application schema;
2. feature catalogue;
3. code lists of all of the attribute values permitted in the data set;
4. allowed metadata elements and the type(s) of encoding.

It may also include information to assist in the portrayal of the data, such as symbol sets and style sheets.

The Schema Repository in Figure 8 illustrates the possible contents of a schema repository. The mandatory parts are the references to the Application Schema, Feature Catalogue, Metadata, and Spatial Referencing System. Some method of encoding the data product, either for exchange or storage is also required.

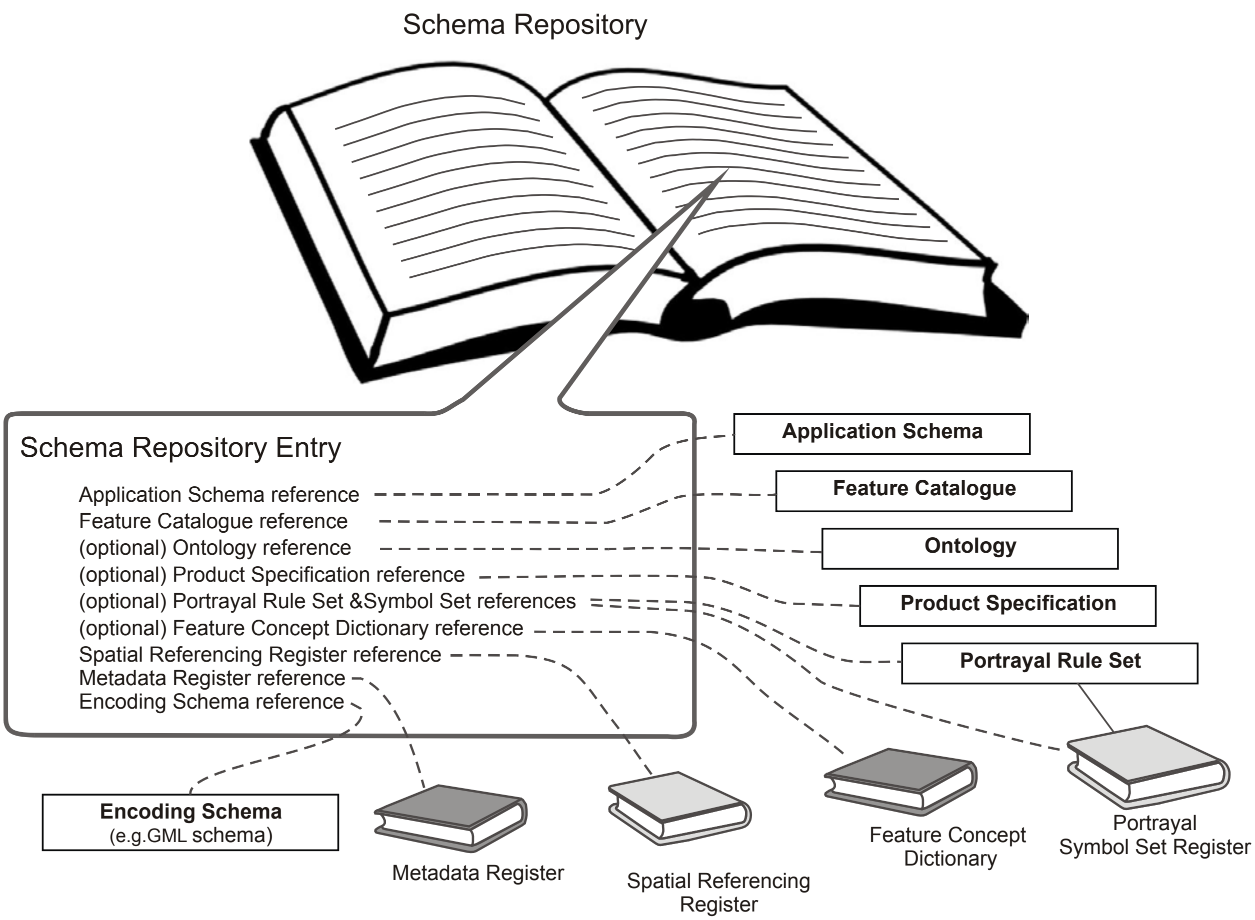


Figure 8. Contents of the Schema Repository.

2.4 Metadata

There are some standards that define common information elements that are of great importance across all uses of geospatial information. Metadata is one of these standards. Metadata is information about resources. One may have a detailed map or other set of geospatial information, but only with the metadata can one know where the map covers, how up to date it is, what quality it is and who produced it. In the era of paper maps the metadata was printed in the margins of the map and was often very limited although it was usually easily readable. With digital geospatial information, it is possible to provide more metadata although the amount of metadata varies significantly and without standardization is may not be consistent or easily readable.

The basic metadata standard *ISO 19115, Geographic information – Metadata* [22] and its revision *ISO 19115-1 Geographic information – Metadata – Part 1: Fundamentals* [23], sets the metadata elements required to describe geospatial data and service resources. A limited subset is mandatory. For a particular application schema, much more is required than the list of possible metadata elements defined in the ISO standards. A clear identification of which metadata elements and code lists that are used is a required part of an application schema.

Every data product needs to define the metadata that will be provided within the product specification written for that data product type. (see section 3). The amount of metadata that is required varies with the type of data. A hydrographic navigational chart is a legal document that establishes the rules for where a ship may navigate, and sufficient metadata is required so that the charted data can be defended in a court in the case of a ship's grounding; however, a tourism map may need little metadata other than the location and date.

Metadata has many different uses. It allows a user to discover, trust, exchange, use and manage data [1]. For example, some data products may have extensive detailed metadata described in a product specification that pertains to a particular version of a data product. A catalogue service for data discovery needs to be very flexible. It must be able to read and interpret all metadata, including that defined according to legacy standards and the most recent product specifications. Users expect to be able to search and discover all relevant data no matter how recent it is or whether it was defined according to previous versions of the standards. Metadata used in data discovery is less comprehensive, but must bridge versions.

[1] Adapted from D. Danko, Handbook of Geographic Information [2]

The metadata elements include but are not limited to:

- Identification Information (title, date, producer, …);
- Data Quality Information (the quality and level of processing of the data);
- Spatial Data Organization Information (vector, coverage, or other type of data);
- Spatial Reference Information (location of the data and spatial referencing system, …);
- Entity and Attribute Information (reference to feature catalogues, concept dictionaries, …);
- Distribution Information (media, distribution restrictions, …);
- Metadata Reference Information (version of the metadata standard, dates, …).

Although any information may be queried, it is the Identification Information which primarily drives the data discovery.

Figure 9 is an example of the Identification Information portion of the metadata associated with a data set from The National Hydro Network.

This is only the first part of the metadata associated with this dataset. A query to find this data through a Web Catalogue Service, such as through Catalogue Service for the Web (OGC CSW) [68], would allow a query on any of the metadata elements; however, the primary elements are the location, title, originator and data. A complete metadata description would also include information about the quality of the data including the lineage, the spatial organization (vector), the spatial referencing system (e.g. NAD83), a reference to the feature catalogue, the distributer, and information about the version of the metadata specification itself.

The ISO 19115 standard is just one of several important metadata standards. The standard has been revised in 2014 to be ISO 19115-1. There is also *ISO 19115-2, Geographic information – Metadata – Part 2: Extensions for imagery and gridded data* [24], which includes additional information about the properties of measuring equipment used to acquire the imagery data, and the type of processing of that data.

The metadata standards also need to be customized to address local or specialized needs. Canada and the U.S. have developed a joint profile of the ISO 19115 metadata standard as a bi-national standard: The *North American Profile of ISO 19115:2003 – Geographic Information –Metadata (NAP – Metadata)* [79]. This profile makes certain optional fields of ISO 19115 mandatory, supports multiple languages, and takes certain free text fields and makes them into Code Lists. There are two important aspects of the NAP - Metadata standard. One is that it makes a transition from the earlier Content Standard for Digital Geospatial Metadata (CSDGM) from the U.S. Federal Geographic Data Committee (FGDC) [84], which was an earlier but popular metadata standard, and also that the NAP – Metadata standard is supported by an on-line register identifying and defining all metadata elements and codelists. NAP – Metadata [2] has been established as a National

[2] On-line register available at: http://nap.geogratis.gc.ca/metadata/register/

standard as CAN/CGSB-171.100-2009 [79]. This standard has also been included into a Treasury Board of Canada Secretariat Standard (Standard on Geospatial Data) [85].

Citation:
Citation Information:
Originator:
Government of Canada; Natural Resources Canada; Earth Sciences Sector; Canada Centre for Mapping and Earth Observation
Publication Date: 2013-11-12
Title: 02OG000, Yamaska
Edition: 3.0
Geospatial Data Presentation Form:
vector digital data
Series Information:
Series Name:
National Hydro Network (NHN)
Issue Identification: 1.0-CL2_NC2
Publication Information:
Publication Place:
Sherbrooke, Quebec, Canada
Publisher:
Government of Canada; Natural Resources Canada; Earth Sciences Sector; Canada Centre for Mapping and Earth Observation
Online Linkage:
http://www.geobase.ca
Description:
Abstract:
The National Hydro Network (NHN) …
Purpose:
National Hydro Network, Canada, Level 1, Edition 1.0 " Standard in accordance with CCOG resolution F03-05 ….
Supplemental Information:
… This National Hydro Network (NHN) dataset contains Completeness Level 2 (CL2) data. ...
Time Period of Content:
Time Period Information:
Range of Dates/Times:
Beginning Date: 1999-11-01
Ending Date: 2013
Currentness Reference:
ground condition
Status:
Progress: Complete
Maintenance and Update Frequency:
Unknown
Spatial Domain:
Bounding Coordinates:
West Bounding Coordinate: -73.2
East Bounding Coordinate: -72.2
North Bounding Coordinate: 46.2
South Bounding Coordinate: 45
Keywords:
Theme:
Theme Keyword Thesaurus:
GCMD (Global Change Master Directory)…
Place:
Place Keyword:
Continent > North America > Canada > Quebec …
Access Constraints:
Open Government Licence - Canada (http://data.gc.ca/eng/open-government-licence-canada)
Use Constraints:
Open Government Licence - Canada (http://data.gc.ca/eng/open-government-licence-canada)

Figure 9. Example Identification Metadata.

With respect to imagery, *ISO 19130, Geographic information – Imagery sensor models for geopositioning* [30], and *ISO 19130-2, Geographic information – Imagery sensor models for geopositioning -- Part 2: SAR, InSAR, Lidar and sonar* [31], address Imagery sensor models for geopositioning for optical and for radar, laser and sonar and defines metadata elements for these sensors. The *ISO 19159, Geographic information – Calibration and validation of remote sensing imagery sensors* [46], series of standards also includes metadata elements related to the Calibration and Validation of remote sensing imagery sensors. For vector data the standards *ISO 19113, Geographic information – Quality principles* [20], *ISO 19114, Geographic information – Quality evaluation procedures* [21], and *ISO 19138, Geographic information – Data quality measures* [37], all initially described aspects of data quality that are expressed as metadata. These three quality standards have been revised, and reorganized into the *ISO 19157, Geographic information – Data Quality* [45].

The revision of the quality related standards illustrates an important aspect of metadata. Standards evolve over time. Any one particular data set is compliant with one set of standards, but some information services, especially the Catalogue Service will need to be able to read and interpret data described according to both the revised and the previous standards. Backward compatibility for services is very important. Legacy data exists and will continue to exist and even new data may be published according to product specifications established in alignment with previous versions of the standards. The guiding rule for ensuring backward compatibility is to ensure, where possible, that new systems are able to read and interpret data defined according to previous versions of the standards, and where it is not possible for systems to directly interpret legacy data, that the data be properly identified and a conversion translator be made available.

Figure 10 illustrates the planned [3] evolution of the ISO metadata standards and metadata encoding.

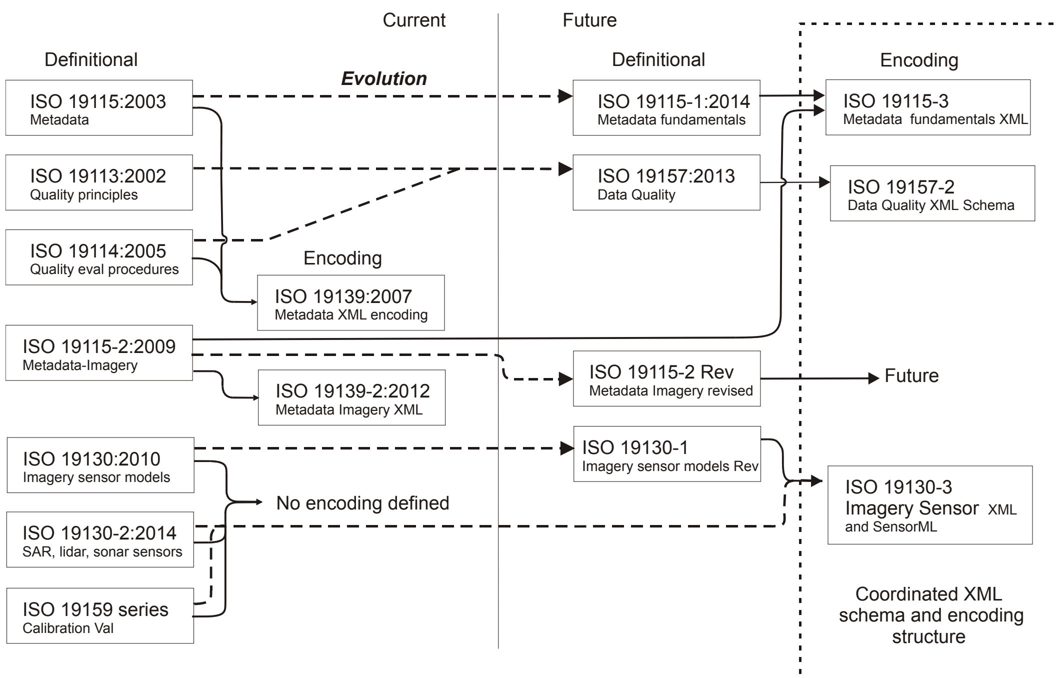


Figure 10. Metadata and Metadata Encoding Evolution.

To be used in a data product or service, metadata must be encoded. Some specialized data products may use unique encoding mechanisms. For example, Hydrographic charts make use of the ISO 8211 [50] Specification for a data descriptive file for information interchange.

[3] This diagram represents the status of the ISO/TC 211 plan as of its meeting November 2014

A common encoding mechanism is the WC3 Extensible Markup Language (XML) [4] [95]. XML is considered the "neutral" encoding for geographic information. An XML schema has been developed for the ISO 19115 (2003) and ISO 19115-2 metadata standards. This is *ISO 19139:2007, Geographic information – Metadata – XML schema implementation* [38], and *ISO 19139-2 Geographic information – Metadata – XML Schema Implementation – Part 2: Extensions for imagery and gridded data* [39]. The North American Profile of ISO 19115 (NAP - Metadata) is encoded using a profile of the ISO19139 XML schema. Of course as the metadata standards evolve these XML schemas also need to evolve.

In the revision of the metadata standards, ISO has been very careful to provide backward compatibility. New capabilities have been added but nothing has been deleted. However some metadata elements have been moved around and restructured. This especially affects the XML encoding because each of the restructured elements obtains a new XML tag. Software that reads metadata needs to keep track of all of the versions of tags including those defined in previous versions of the standards. Managers or users, that purchase software, use open source software, customized existing software, or develop their own application for metadata, need to ensure that the software can read all relevant XML metadata complying the metadata standards and properly interpret the tags.

2.5 Geospatial Data and Geospatial Data Sharing

Geospatial data describes the real world. A feature or object is a signifier (or sign) that refers to a real world phenomenon. This sign can exist in many forms and still carry the same semantic meaning. Geospatial data can exist in a database or other storage media or be encoded in many ways for data exchange or sharing. All of these different expressions comply with the same Application Schema. In addition the same data can be portrayed in many different equivalent ways. Not only are there standards describing the structure and other aspects of the data content, but there are also a number of encoding standards and portrayal mechanisms.

Figure 11 illustrates a river system that is described in a database using an Application Schema. There are a number of different feature types including a "river", and a "stream". When it is portrayed the attributes of some of the feature instances are presented as textual place names. These names are part of the data and it is the portrayal process that takes the attribute values and renders them either as symbols or texts after the data has been read by a user system and displayed on a screen.

[4] XML has been standardized by the World Wide Web Consortium (W3C) an international consortium that develops open standards for the Web. XML is a profile of ISO 8879 Information processing – Text and office systems – Standard Generalized Markup Language (SGML).

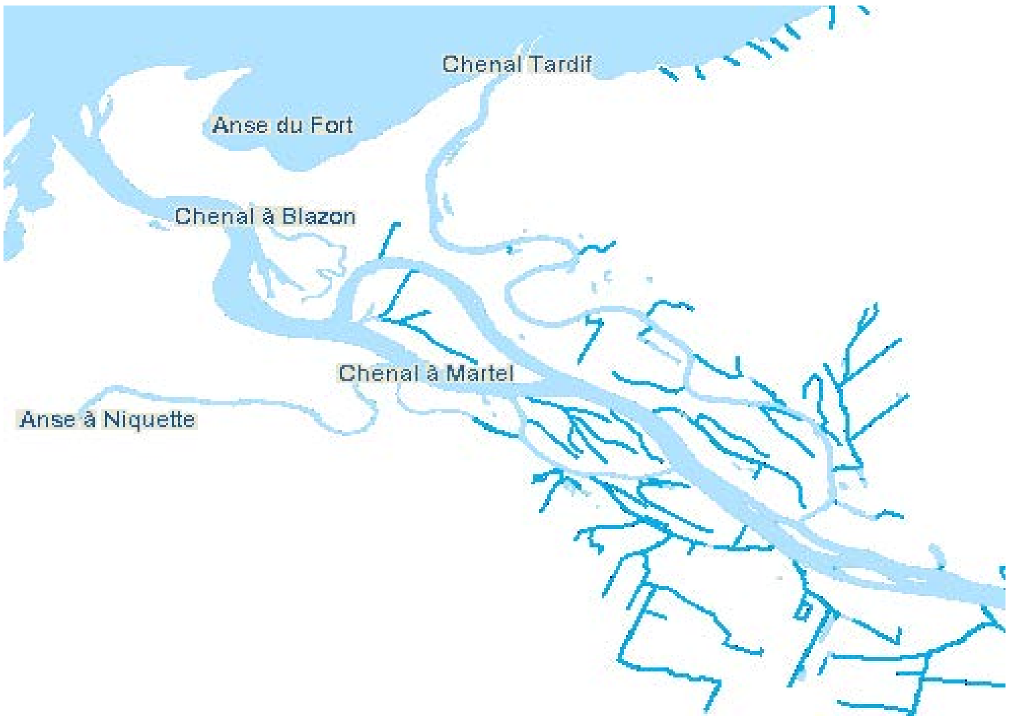


Figure 11. Example of a River Data Set.

The data set contains all of the elements identified previously. It includes a set of feature and metadata instances together with geometry primitives such as curves. It complies with an Application Schema and the features are instances of the Feature Types defined in the Feature Catalogue. The metadata elements in the data set are also instances of the metadata classes referenced by the Application Schema. This set of data is fully described by a Product Specification (section 3), that documents the Application Schema, Feature Catalogue, Metadata, Geometry primitives, Spatial Referencing and other aspects of this data product. Other data sets, such as other river maps, may also follow the same Product Specification.

In order to exchange, share or use data in a Web Service, it needs to be encoded. That is, the logical information structures described by the Application Schema need to be realized in physical bits and bytes. There are many different encoding formats defined; some highly specialized, and others more general and more commonly understood. Very compact binary encodings may be needed in some applications where bandwidth is limited, such as sending information via radio links to ships at sea. Other encodings are deliberately redundant so that they are self-defining. An archive system needs a self-defining format, since all the documentation of a data set, including the Product Specification, Application Schema, etc. must be included with the data set, since the unknown user sometime in the future may need to reconstruct the data from only what is recorded in the archive.

The most common encoding mechanisms are somewhere in between. They are somewhat inefficient in their encoding mechanism, and they require references to external schema. Most GIS companies have developed their own proprietary encoding formats which are dependent on the GIS system that produced the data. An example is the SHAPE [88] file format developed by ESRI Inc., or the TIGER format [94] developed by Intergraph Corp for the US Census. These are valid encoding formats and are widely used, but they may not be appropriate to send to a general end user if he or she does not have access to the specialized GIS software or a translator/reader for the software being used.

The most flexible encoding format is the eXtensible Markup Language XML. This is a standardized approach for encoding data as a text stream with tag delimiters. Data is delimited by the use of tags imbedded between angle brackets. For example, <tag>data<\tag>. The structure is hierarchical and tags may be nested, and the meaning of the tags is given by an XML schema. One predefined set of tags for describing geospatial information is called GML (Geography Markup Language). GML was developed and standardized by the OGC and then introduced in ISO as *ISO 19136, Geographic information – Geography Markup Language (GML)* [35] [67]. This is a foundation for all of the OGC Geospatial Web Services.

Figure 12 is an example of GML developed by the OGC. It describes a simple feature like a building with some attributes and LineString (curve) geometry. The “epsg:27354” attribute is a reference to a Spatial Referencing System maintained in a register [5].

```
<Feature   fid="142" featureType="school" >
  <Description>Balmoral Middle School</Description>
  <Property Name="NumFloors" type="Integer" value="3"/>
  <Property Name="NumStudents" type="Integer" value="987"/>
     <Polygon  name="extent" srsName="epsg:27354">
         <LineString  name="extent" srsName="epsg:27354">
            <posList>
             491888.999999459,5458045.99963358 491904.999999458,5458044.99963358
             491908.999999462,5458064.99963358 491924.999999461,5458064.99963358
             491925.999999462,5458079.99963359 491977.999999466,5458120.9996336
             491953.999999466,5458017.99963357 </posList>
         </LineString>
     </Polygon>
</Feature>
```

Figure 12. Example of a Feature described in GML.

GML defines the names of the tags. The feature type “school”, its attributes, the associated metadata etc. still needs to be described in an Application Schema. A GML Schema is an XML

[5] European Petroleum Survey Group EPSG register, http://www.epsg-registry.org/

schema that describes the tags together with the structural information from the Application Schema of the data set.

OGC maintains a schema repository for its “Adopted Technology” (Implementation Standard), such as OGC's GML, SensorML, or Web Mapping Service (WMS) and its “Best Practices Guidelines” [6]. These are broader range schemas, such as the schema for all that can be expressed in GML, or all that can be processed through the WMS.

Figure 13 shows a small portion of the “Common Element” schema from the European INSPIRE schema repository [7].

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns="http://inspire.ec.europa.eu/schemas/common/1.0">
(…)
    <xs:complexType name="responsibleOrganisation">
        <xs:sequence>
            <xs:element name="ResponsibleParty">
                <xs:complexType>
                    <xs:sequence>
                        <xs:element name="OrganisationName" type="notEmptyString"/>
                        <xs:element name="EmailAddress" type="emailType"/>
                    </xs:sequence>
                </xs:complexType>
            </xs:element>
            <xs:element name="ResponsiblePartyRole" type="responsiblePartyRole"/>
        </xs:sequence>
    </xs:complexType>
(…)
</xs:schema>
```

Figure 13. Part of a INSPIRE Schema for Metadata.

An application will use the schema information to read and understand the elements in the data set. In this example the parameters for the metadata element “responsibleOrganization” are defined. There will be many other element types and subtypes defined in the schema.

The schema for decoding data is necessarily broader than the schema for encoding data. When a data set is produced the choices are narrowed to explicitly those elements that the producer could generate in the data product.

For example, if a Hydrographic Field Sheet uses only point data to represent depth soundings, then the schema for that very specialized data product would contain only the Point and MultiPoint

[6] http://www.ogcnetwork.net/schemarepos
[7] Available at: http://inspire.ec.europa.eu/schemas/

geometric primitives. A schema for a system that reads all types of hydrographic source data would be able to read the field sheet data, but also other types of source data including source data that includes curve and surface geometry primitives.

2.6 Registers

Registers provide a technique for managing standardized geospatial information elements. A register is a recording mechanism of any kind of elements (items) to support a Geospatial Information Environment. The content of the register is an important resource for interoperability; for example, for semantic interoperability, multilingual information, evolution of standards. The content in a register remains for ever and there are linkages between new and deprecated items. This allows legacy data sets to refer to the same register retaining their linkages to items, even when the items are revised and superseded [9].

Many of the standards in the suite of ISO Geographic information standards define templates or rules for describing features, attributes, relations and metadata. The actual instances of the features, attributes and metadata are application dependent and are defined following the rules and templates. For example, a "road" may be described differently in a transportation logistics map than in a cadastral map. Registers may be used to hold the definitions of the features, attributes, metadata and other aspects so that they can be used common in similar applications.

ISO defines several standards for the management of registers for different purposes. The generic Information Technology standard for registers is *ISO 11179, Information technology – Metadata registries (MDR)* [52]. It combines a "concept" with an "object class" to establish a "data element concept". The geographic information standard for registers is ISO 19135 [8] [34]. This standard "specifies procedures to be followed in establishing, maintaining and publishing registers of unique, unambiguous and permanent identifiers, and meanings that are assigned to items of geographic information". This is both a procedural standard and a register content standard that includes the rules for managing the register.

As illustrated in Figure 14 a register contains two main entities, the Registered Item and the Item Class.

[8] The standard ISO 19135 is currently under revision but the scope of the revision has the stated goal of being backward compatible.

Item Class

Name =	...
Description =	...
...	...

describes

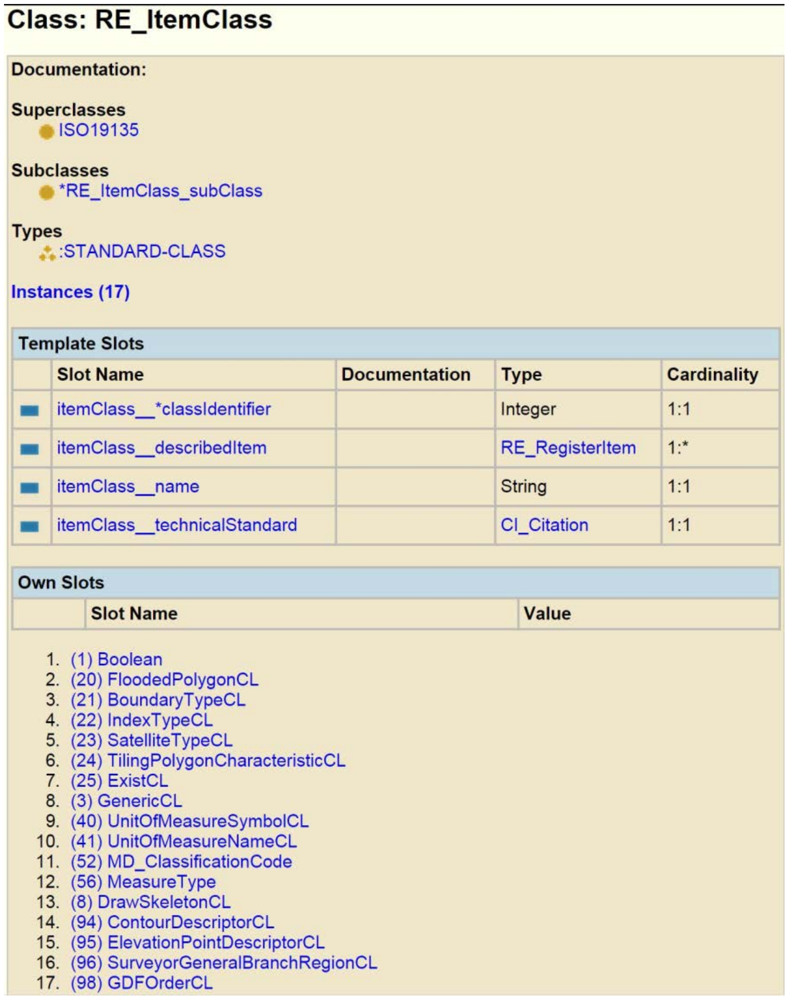
Registered Item

ID	Name	Description	Validity	Date Entered	Date Superceded
...					
74	phi	Polarization Perpendicular	Valid	25/05/2010	
75	circular	Polarization Left Circular	Superceded	25/05/2010	13/06/2013
76	theta	Polarization Parallel	Valid	25/05/2010	
...					

Figure 14. Example Register Structure.

The Registered Item is a list of items that contain the information. The Item Class describes what is in the Registered Item. Each entry has a validity state and a date of entry. If the item is superseded then the end date is also recorded. This means that legacy data can still reference previously registered items. Refer to the standard ISO 19135 for a detailed description of a register.

Figure 15 illustrates an extract from the Code List Register maintained by NRCan Earth Science Sector. Code lists describe the available choices that may be used to populate an attribute.



Class: RE_ItemClass

Documentation:

Superclasses
- ISO19135

Subclasses
- *RE_ItemClass_subClass

Types
- :STANDARD-CLASS

Instances (17)

Template Slots				
	Slot Name	Documentation	Type	Cardinality
	itemClass__*classIdentifier		Integer	1:1
	itemClass__describedItem		RE_RegisterItem	1:*
	itemClass__name		String	1:1
	itemClass__technicalStandard		CI_Citation	1:1

Own Slots		
	Slot Name	Value

1. (1) Boolean
2. (20) FloodedPolygonCL
3. (21) BoundaryTypeCL
4. (22) IndexTypeCL
5. (23) SatelliteTypeCL
6. (24) TilingPolygonCharacteristicCL
7. (25) ExistCL
8. (3) GenericCL
9. (40) UnitOfMeasureSymbolCL
10. (41) UnitOfMeasureNameCL
11. (52) MD_ClassificationCode
12. (56) MeasureType
13. (8) DrawSkeletonCL
14. (94) ContourDescriptorCL
15. (95) ElevationPointDescriptorCL
16. (96) SurveyorGeneralBranchRegionCL
17. (98) GDFOrderCL

Figure 15. Example of a Code List Register.

2.7 Semantic Interoperability

Semantics is the study of the meanings of words and phrases in a particular context [12]. It deals with the relations between signs (identifiers/names) and what they refer to, including the cognitive meaning of concepts. GeoSemantic interoperability aims to facilitate the communication of geospatial information between people, organizations and systems [1].

Semantic interoperability is very important for geospatial data because there are many different communities of users in different disciplines that may ascribe different meanings to the same geographic features. For example, a “tower” on a land map is a building feature. On a sea chart a “tower” has the special meaning of being a “landmark” because it may be used as a reference point for navigation. On an air chart a tower is a “vertical obstruction” that one needs to avoid. These three different communities of users have different understandings of the same real world feature.

An ontology is “an explicit specification of a conceptualisation [6].” The *ISO 19101-1, Geographic information – Reference model – Part 1: Fundamentals* [14], standard describes it as “Formal representation of phenomena of a universe of discourse with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships.” The use of ontologies allows for the development of processes to develop semantic interoperability so that different disciplines can understand the same data in their own contexts.

Interoperability of geospatial information requires that both the sender and receiver of the information understand the meaning of the information element encoded and communicated over a communications channel. If two persons are using their own vocabularies and therefore their own understandings of the information miscommunications may result. The feature type “Tower” may have different meanings in different communities. Two persons cannot communicate directly. The concepts understood by the sender must be converted into physical form (bits and bytes) and then reconstituted by the receiver into concepts understood in the receiver’s frame of reference. Because ontologies provide the definitions of concepts and relationships between them with respect to some context, reasoning and inference are possible [1]. A Geospatial Semantic Web can be built upon the emerging Web technologies for managing ontologies and semantic relationships such as the Ontology Language for the Web (OWL). This brings opportunities for interoperability beyond exchange of data allowing integration of data from multiple sources for use for many different purposes.

ISO has developed *ISO/TS 19150-1, Geographic information – Ontology – Part 1: Framework* [43] and is developing *ISO 19150-2, Geographic information – Ontology – Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)* [44], for developing geospatial ontologies. As the field of Geospatial information grows to touch a wider number of disciplines, semantic interoperability will become an ever increasingly important aspect of managing geospatial data. The standard ISO 19150-2 will provide the mechanism to translate an application schema into a Web Ontology to support interoperability of geographic information between disciplines. This provides access to the “Semantic Web”. Figure 16 provides a snippet of an ISO19150-2 compliant ontology corresponding to some of the feature types identified in Figure 2.

Figure 16 shows a snippet of a simple ontology description for the hydrologic feature set expressed in the Web Ontology Language (OWL). It defines 3 classes. A more detailed ontology is presented in Annex B with class and property definitions including multiplicities and associated property types.

```
<rdf:RDF xmlns="http://standardsUserGuideExamples.org/hydrologicFeatureSet#"
    xml:base="http://standardsUserGuideExamples.org/hydrologicFeatureSet"
    xmlns:example="hstandardsUserGuideExamples.org/hydrologicFeatureSet#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
```

```
   xmlns:skos="http://www.w3.org/2004/02/skos/core#"
   xmlns:dc="http://purl.org/dc/elements/1.1/"
   xmlns:iso19150-2="http://def.isotc211.org/iso19150-2/2012/base#"
   xmlns:gfm=http://def.isotc211.org/iso19109/2013/GeneralFeatureModel#>

  <owl:Ontology rdf:about="http://standardsUserGuideExamples.org/hydrologicFeatureSet">
    <rdfs:label>Hydrologic feature set ontology example</rdfs:label>
    <owl:versionInfo>ed-1</owl:versionInfo>
    <owl:versionIRI rdf:ressource="http://standardsUserGuideExamples.org/hydrologicFeatureSet"/>
    <owl:imports rdf:resource="http://def.isotc211.org/iso19150-2/2012/base"/>
    <owl:imports rdf:resource="http://def.isotc211.org/iso19109/2013/GeneralFeatureModel"/>
  </owl:Ontology>

<!-- example:HydroFeature -->
  <owl:Class rdf:about="&example;HydroFeature">
    <rdfs:label>Hydro Feature</rdfs:label>
    <rdfs:subClassOf rdf:resource="&gfm;AnyFeature"/>
  </owl:Class>

<!-- example:River -->
  <owl:Class rdf:about="&example;River">
    <rdfs:label>River</rdfs:label>
    <rdfs:subClassOf rdf:resource="&gfm;AnyFeature"/>
    <rdfs:subClassOf rdf:resource="&example;HydroFeature"/>
  </owl:Class>

<!-- example:FlowDirectionCL -->
  <owl:Class rdf:about="&example;FlowDirectionCL">
    <rdfs:label>FlowDirectionCL</rdfs:label>
  </owl:Class>

(…)

</rdf:RDF>
```

Figure 16. Example of an OWL Ontology Description.

3. Data Product

A Product Specification is a formal documentation of all of the aspects of a data set or data set series. It “details the data product for production, end-use and other purposes, and is a precise technical description of the data product in terms of the requirements [9]”. A data product specification allows for the production of consistent data to address a particular requirement. It contains an application schema, together with associated metadata, and a feature catalogue. It also contains any conformance tests, quality metadata, and encoding and portrayal information. It may also contain information about the data capture process (capture criteria), required data processing steps in the production of the data, and maintenance processes.

All data needs to be documented in order for a user to be able to interpret the geospatial data and for a data producer to be able to consistently produce that data. The classical approach to cartography has been to collect source data and process it to generate a specific map series. These map series, such as topographic maps in different scale bands, have been and still are very important to users who make use of them in their applications. These data products have always been produced in compliance with rigid production specifications.

With the introduction of digital geospatial data collected into massive data stores, the use of product specifications has become even more important.

The set of GeoBase layers, as illustrated in Figure 17 [10], is a good example of an integrated set of data products each supported by a product specification.

For a data set (view) generated as a result of queries into a geospatial data store aggregating data from different sources the product specifications associated with each of the contributing elements of source data provide the context that indicate whether it is appropriate to combine certain data elements.

The structure of a Product Specification is standardized in *ISO 19131, Geographic information – Data product specifications* [32]. This standard specifies requirements for the specification of geographic data products, based upon the concepts of other ISO Geographic Information Standards.

[9] From ISO 19131,Data Product Specification [32]
[10] From Geobase < http://www.geobase.ca/geobase/en/data/>

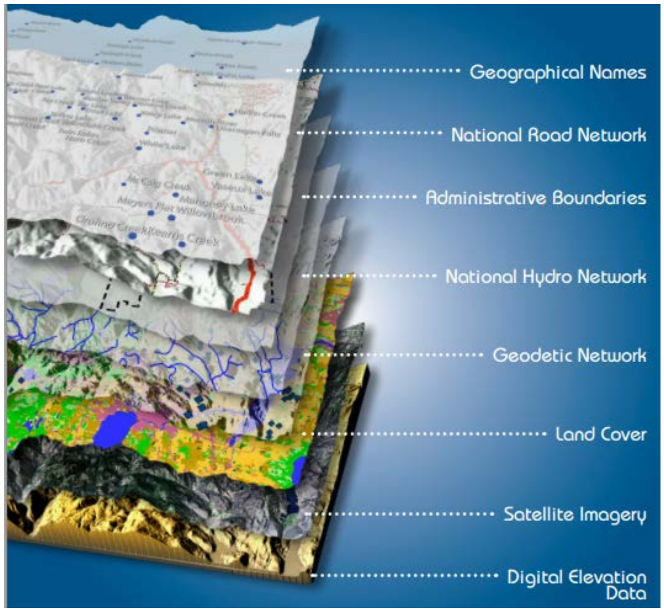


Figure 17. GeoBase Layers.

Users and managers need to know that a standardized Product Specification provides consistency in geospatial data sets and data set series. ISO 19131 establishes how this must be documented. By utilizing the information from the Product Specification, a user is able to look-up the metadata and quality metadata definitions, understand the geometric elements, and know what type of encoding is used so that the appropriate software tool can be chosen to see and interpret the data via an interface. For example, if the data is encoded in GML then a service that supports GML will be needed to read the data.

Product specifications and associated schemas are needed for all data products. This is even more evident for data products that are more broadly distributed than others. Some data products are of high importance and wide interest. Standardized products, such as those distributed by GeoBase need to have associated publicly available schemas available in an open schema repository. Four product specifications of data products available from GeoBase have been established as national standards. These are:

- CAN/CGSB-171.101-2010 Canadian Geographical Names, Level 1 (CGIS – CGN1) [80];
- CAN/CGSB-171.102-2010 National Road Network 2.0 (CGIS - NRN2) [81];
- CAN/CGSB-171.103-2010 Canadian Digital Elevation Data, Level 1 (CGIS - CDED1) [82];
- CAN/CGSB-171.104-2010 Landsat 7 Orthorectified Imagery over Canada (CGIS - ORI) [83].

All Product Specifications for publically available data need to be made openly available. This can be done through the use of a Product Specification register. The Product Specification register builds upon the Schema Repository, Metadata Register(s), Feature Concept Dictionary(ies), and Spatial Referencing System register(s) which are the components of the Geospatial Information Environment. All organizations or government agencies (of any level of government) should be able to register their product specifications in the Product Specification register.

A Product Specification Register is illustrated in Figure 18. The Product Specification Register contains entries of interest in Canada from multiple sources, including government, commercial and academic sources. It makes reference to the Schema Repository and to registers of geospatial component information as required.

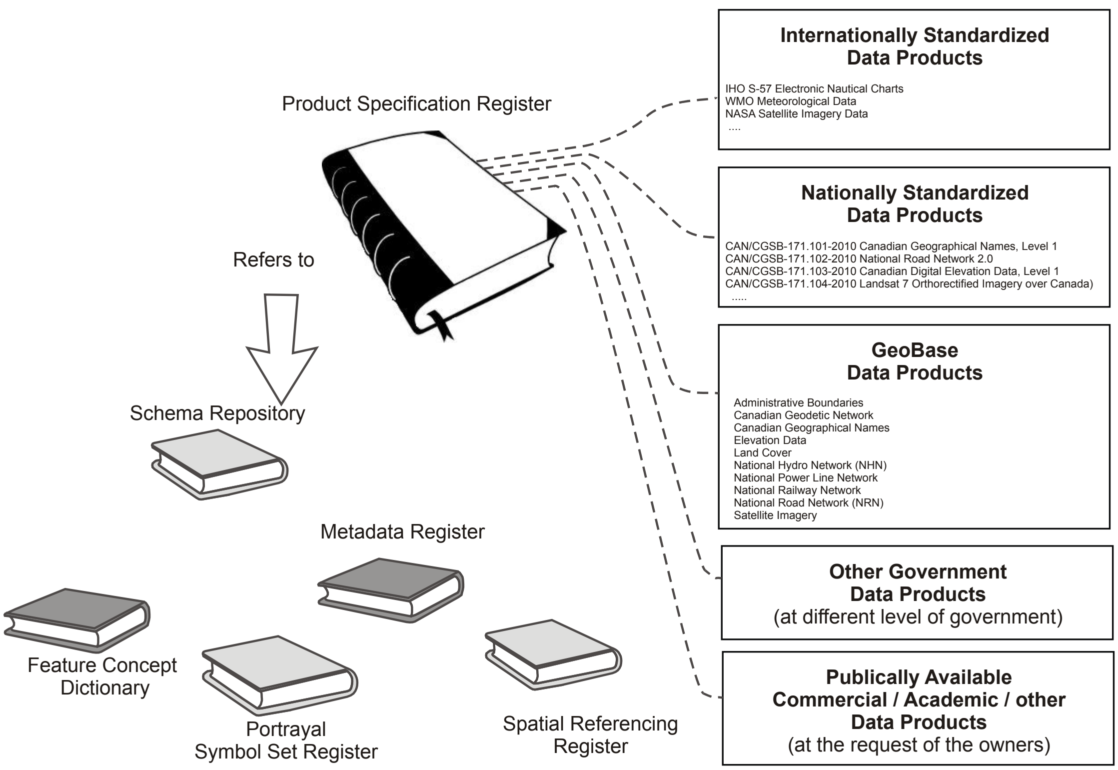


Figure 18. Product Specification Register.

A template for a Product Specification is provided in Annex C.

A product specification describes only one data product. The Geospatial Information Environment illustrated in Figure 1 includes many different types of data specified in accordance to multiple product specifications.

3.1 Vector Based Data Products

There are many types of geospatial data ranging from lists of place names or statistics linked to location (a Gazetteer) to three dimensional simulation of a physical environment often called Simulation and Modelling (or Environmental Representation), to conventional maps. All of these types of data use geometry to provide position to feature instances. The term vector based data derives from the use of vector geometry to provide location or boundaries to features.

The feature based approach was introduced in Section 2.1. Vector based data products make extensive use of this approach.

3.1.1 Geometry

A fundamental characteristic of geospatial data is its spatial aspect. Features may be described by one or more spatial attributes. The set of available spatial representations are defined in the standard *ISO 19107, Geographic information – Spatial schema*. Spatial attributes may be represented either by geometric objects or topological objects. A geometric object describes the location of the feature in relation with the earth, whereas the topological object describes a feature's spatial relationship with other features.

An example of a vector map is shown in Figure 19. This represents a few blocks in downtown Montreal. The roads are represented as lines (curves) and there is one point feature symbolized as a square symbol with the letter M representing a metro station. The curves are intended to represent the true shape and relative position of the roads, and the point feature represents the relative position of the metro station.

Figure 20 illustrates a topological map of the Montreal metro system. This is an entirely topological map. The absolute shape of the map does not matter. What is represented is the connectivity between metro stations. The metro lines are represented as topological edges joined at nodes.

Figure 19. Example Vector Map[11].

Figure 20. Example Topological Map [12].

[11] Derived from a digitization of the Google Map satellite view of Montreal <maps.google.ca>.
[12] Adapted from Montreal Metro map <http://www.stm.info/en/info/networks/metro>. Some routes on the generated map were deliberately straightened to emphasise the topological nature of the map.

Some maps include both geometric and topological primitives with nodes corresponding to points, edges corresponding to curves, and faces corresponding to surfaces.

Topological constraints can be used to ensure that curves do not inadvertently cross, and that there are no slivers or gaps in the data.

The spatial objects available are given in the following table [13]:

Geometric objects			Topological objects	
Geometric primitives	**Geometric complexes**	**Geometric aggregates**	**Topological primitives**	**Topological complexes**
GM_Point GM_Curve GM_Surface GM_Solid	GM_CompositePoint GM_CompositeCurve GM_CompositeSurface GM_CompositeSolid GM_Complex	GM_Aggregate GM_MultiPoint GM_MultiCurve GM_MultiSurface GM_MultiSolid GM_MultiPrimitive	TP_Node TP_Edge TP_Face TP_Solid TP_DirectedNode TP_DirectedEdge TP_DirectedFace TP_DirectedSolid	TP_Complex
NOTE The table lists only the highest level classes of spatial objects. Subtypes of these may also be used.				

Table 1. Geometric Objects as defined in ISO 19109.

The standard *ISO 19137, Geographic information – Core profile of the spatial schema* [36], defines a minimum set of the spatial primitives. This minimum set is common to many implementations. In addition, the standard *ISO 19125-1, Geographic information – Simple feature access – Part 1: Common architecture* [26] [63], defines a set of spatial primitives that are used in spatial queries. The encoding standard *ISO 19136, Geographic information – Geography Markup Language (GML)* [35] [67], also organizes the spatial primitives into several subsets for the purposes of encoding. Managers and users need to be aware of the available set of geometric primitives and the structure of the geometry and topology used to describe vector data, and also the potential limitations imposed on which spatial primitives are available by different systems and by encoding standards.

[13] Table from ISO 19109:2005 Geographic Information - Rules for application schema [17]

3.1.2 Metadata

Metadata may be represented in a data product as information related to the entire data set or as information related to specific features or groups of features. The application schema for a data product defines the metadata elements used in that data product. This metadata contains all of the mandatory elements defined in the ISO 19115 metadata standard. It may also contain the optional or conditional elements from the ISO 19115 metadata standard or any of the related standards that provide metadata elements. Establishing which metadata is used is one of the more important roles of the product specification.

Metadata may also be used as attributes to features or groups of features. This allows detailed information to be applied at the feature level. Describing which feature attributes are bound to particular features is the role of the Application Schema. The Product Specification needs to reference the Application Schema associated with the data product as well as identify the version of the metadata standard or standards being used as the source for the metadata.

In addition unique metadata elements may be defined as part of the application schema for a particular data product. This allows the producer the open ended freedom to include all relevant information. When unique metadata is defined it needs to be fully documented in the application schema.

Users and managers should understand that the product specification is the documentation for one type of data within a Geospatial Information Environment. The product specification includes or references all of the constituent parts of the data.

3.1.3 Encoding XML, GML and KML

Encoding and data formats are an important part of data exchange and interoperability. Over the years there have been many different defined formats, so many in fact that they have an important impact on interoperability. In addition manufacturer based GIS system formats, such as ESRI Shape files [88], are themselves just another format. There exist many formats, some which are very efficient compact binary formats, and others that are self-data descriptive which are among others, relevant for archival purposes.

XML [14] is a markup language style format. It is actually just a text string that is easily processed by a computer, with tags imbedded in angle brackets “<” and “>”. XML based data is used everywhere on the internet because it is easy to process. GML is a namespace for XML that includes a number of tags defined to support the encoding of geospatial information. XML and GML are verbose, but they can almost universally be stored and transferred on and between computer systems, and there are many tools available to generate and decode these widely used

[14] eXtensible Markup Language standardized by the World Wide Web Consortium (W3C) [95]

formats. ISO/TC 211 calls XML the neutral default format. XML schemas have been defined by ISO for certain types of data such as geospatial data, metadata, register, etc. Compression techniques can be used to reduce the data volume of large GML data files. GML compresses well.

KML [15] is an XML encoding for visualization of geographic information, including annotation on maps and images and the control of the user's navigation in the data. It is used in Google Maps and in “mash-ups” based on Google maps.

Managers or users would possibly have heard of XML, GML, the XML metadata encodings, and KML. In general, it is important to recognize that they are all addressing different but specific purposes.

Figure 21 is an example of XML taken from metadata encoded using the ISO 19139 metadata XML encoding standard. It shows a keyword description expressed in English and French which has been delimited by a number of tags.

```
<gmd:MD_Keywords>
  <gmd:keyword          xsi:type="gmd:PT_FreeText_PropertyType">
    <gco:CharacterString>Hydrography</gco:CharacterString>
    <gmd:PT_FreeText>
      <gmd:textGroup>
        <gmd:LocalisedCharacterString

  locale="#FR">Hydrographie</gmd:LocalisedCharacterString>
      </gmd:textGroup>
    </gmd:PT_FreeText>
  </gmd:keyword>
(…)
</gmd:MD_Keywords>
```

Figure 21. Example of a simple XML string.

The tags provide meaning so that the text string can be parsed. In Figure 21 the information elements in blue are the XML tags. These tags come from the namespace “gmd:” which has been defined in ISO 19139. The information in red are attributes of the tags such as “locale="#FR"” where the LocalizedCharacterString local attribute has the value “"#FR"” representing French. The information in black is the actual text “Hydrographie”.

[15] KML (Keyhole Markup Language) was developed by Google Inc. and standardized by OGC [71]

Figure 22 illustrates a set of vector based primitives Polygon, Point and LineString that make use of the GML name space "gml:" which is defined in *ISO 19136, Geographic information - Geography Markup Language (GML)* [67] [35]. Additional examples are available [16].

```
<gml:Polygon>
  <gml:outerBoundaryIs>
    <gml:LinearRing>
      <gml:posList>0,0 100,0 100,100 0,100 0,0</gml:posList>
    </gml:LinearRing>
  </gml:outerBoundaryIs>
</gml:Polygon>

<gml:Point>
  <gml:posList>100,200</gml:posList>
</gml:Point>

<gml:LineString>
  <gml:posList>100,200 150,300</gml:posList>
</gml:LineString>
```

Figure 22. Example of GML.

GML provides a standardized set of predefined tags for geospatial information. These have been standardize first in the OGC and then in ISO. The OGC and ISO standards are coordinated but develop in parallel, so managers and users need to be aware of which version of GML that is used in a particular application.

Figure 23 is an example of KML [17]. KML is designed to overlay already available background information or imagery displayed in a specialized browser such as Google Maps. It allows for customization of Google maps, such as placing the location of a hotel on a map. There are a few basic KML types, Placemark, Descriptive Text, Ground Overlays, Paths, and Polygons. Also one can apply styles to customize geometry, or icons (symbols).

KML is a XML representation of data used to display geospatial data in a specialized geospatial browser such as Google Earth and Google Maps. Initially KML was a Google Corporation proprietary format, but it has been standardized through the OGC.

[16] Additional examples are available at: http://www.gmlcentral.com/examples/
[17] Example from: https://developers.google.com/kml/documentation/kml_tut

Figure 23. Example of KML.

```
<kml xmlns="http://www.opengis.net/kml/2.2">
    <Placemark>
        <name>Simple placemark</name>
        <description>Attached to the ground. Intelligently places itself
          at the height of the underlying terrain.
        </description>
      <Point>
        <coordinates>-122.0822035425683,37.42228990140251,0</coordinates>
      </Point>
    </Placemark>
</kml>
```

A manager or user needs to understand the flexibility of the XML based encodings used for geospatial information, and the difference between XML used for metadata and other spatial components, GML (a complete namespace for representing geospatial information) and KML (intended for overlays on services such as Google Maps).

3.2 Coverage Based Data Products

Most people are familiar with digital pictures on their smart phones or other digital camera. They have a sense that pixels are the little dots that make up an image and that the number of megapixels in an image determines how sharp the image is. To the majority of people imagery seems simple. However, beyond the initial apparent simplicity of conventional photography, geospatial imagery gets very complex. The complexity exists in two places. The first is the concept of coverages, and the second is the extensive metadata required to describe how imagery is collected, processed, rectified and related to the Earth and how imaging systems are calibrated and validated. Coverage geometry and the associated metadata is addressed in a number of ISO standards. The basic coverage geometry is addressed in *ISO 19123, Geographic information – Schema for coverage geometry and functions* [25]. The framework that links the coverage geometry and metadata is addressed in *ISO/TS 19129, Geographic information – Imagery, gridded and coverage data framework* [29]. The associated metadata is defined in several standards including: *ISO 19115, Geographic information – Metadata*; *ISO 19115-2, Geographic information – Metadata – Part 2: Extensions for imagery and gridded data* [24]; and the standards for sensors models and calibration and validation (which are discussed below).

An image is not just a set of Pixels (i.e. picture elements), but rather the underlying visual surface represented by the set of Pixels. An interpolation function can operate on this underlying surface to generate intermediate values between the pixels. One set of pixels can be converted to another of a different density or geometry. For example a satellite image can be orthorectified to adjust it to be spatially referenced to the Earth. For an oblique image, such as that from synthetic aperture radar, or side scan sonar, this can be a significant adjustment. An elevation model is also a type of coverage as is a choropleth map or a discrete map such as a map of postal codes.

A coverage is a feature that associates positions within a bounded space (its spatiotemporal domain) to feature attribute values (its range) [18]. There are two types of coverage: a discrete coverage and a continuous coverage. A discrete coverage is a step function where a set of zones that cover the bound area each have an attribute value. An example is a map of postal codes. Obviously one cannot interpolate between postal codes.

A classification system uses a discrete coverage. An example is the Land Cover Classification System described in ISO standard *19144-2, Geographic information – Classification systems – Part 2: Land Cover Meta Language (LCML)* [42]. The land cover classes established using the LCML form a legend (or Feature Catalogue) for the polygonal areas constituting the discrete coverage. Figure 24 illustrates an example of land cover from the UN Food and Agriculture Organization Africover project [19]. Each coloured area corresponds to a different "Legend item" (i.e. feature type from the Feature Catalogue).

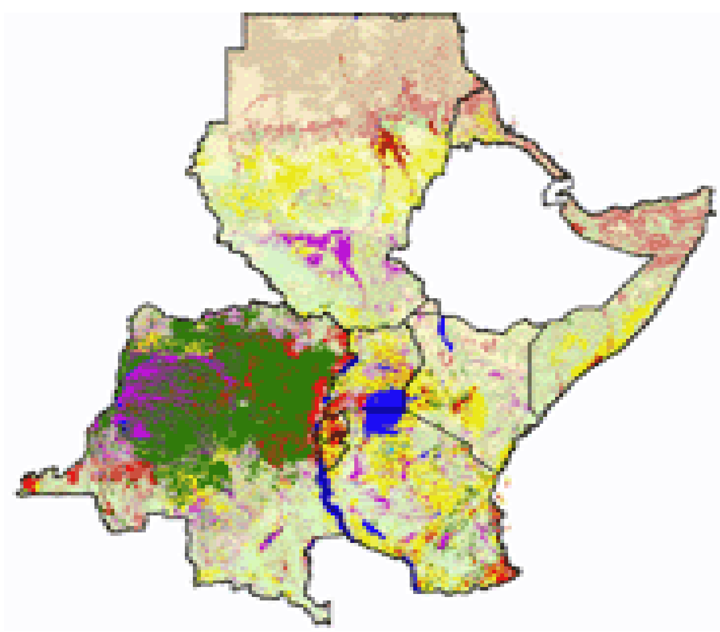


Figure 24. Classification Discrete Coverage.

[18] "Coverage" is defined in ISO 19123 Geographic information - Schema for coverage geometry and functions [25]
[19] From <http://www.glcn.org/activities/africover_en.jsp>

A continuous coverage allows a continuous variation between any points in the coverage domain. An example is a temperature map where values are samples at given locations. The actual temperature may vary across the coverage domain and the value at intermediate points may be determined mathematically by functions such as interpolation. An image is also a continuous coverage where the value of light intensity seen by a camera or other sensors may vary across the domain.

A set of standards describes coverage geometry including the organization of the set of values driving the coverage function (see 3.2.1). In many cases, a coverage is organized as a quadrilateral grid with a traversal rule relating the data values to the grid; for example, a row by column organization. Many other structures and organizations are also possible such as a Triangular Irregular Network (TIN).

The metadata that accompanies an image or other coverage is as important as the set of pixels (grid values) that defines the image (see 3.2.2). Several standards define the special imagery metadata including information about the imagery sensors and calibration and validation techniques.

There are a large number of speciality encodings that have been developed for imagery making interoperability of this type of data still an issue to address. Some of the standards endeavour to bridge this compatibility gap.

3.2.1 Coverage Geometry

The concept of coverages can easily be misunderstood. It does not seem natural to consider a picture to be a mathematical surface; however, that is what is needed if the image is to be processed and adjusted. Only the specialist needs to know how the mathematics works. What the user or manager needs to know is that there is complexity, and also sophisticated power in the concept of coverages. They also need to understand the various types of coverages, how they relate and what they are useful for. The types of coverages are described in the standard *ISO 19123 Geographic information – Schema for coverage geometry and functions*. How one or more coverages and associated metadata are assembled into an Imagery, Gridded or Coverage data set is described in *ISO 19129, Geographic information – Imagery, gridded and coverage data framework* [29].

The various types of coverages are described below with examples. The user or manager should understand that, although they appear to be very different, all of these coverage types operate on similar mathematical principles. The difference is on how the data values that drive the coverage function are organized.

One of the most familiar aspects of coverage is imagery. Figure 25 shows an optical satellite image taken by the Spot Image 4 satellite over a portion of southern Quebec [20]. Some cloud cover is visible.

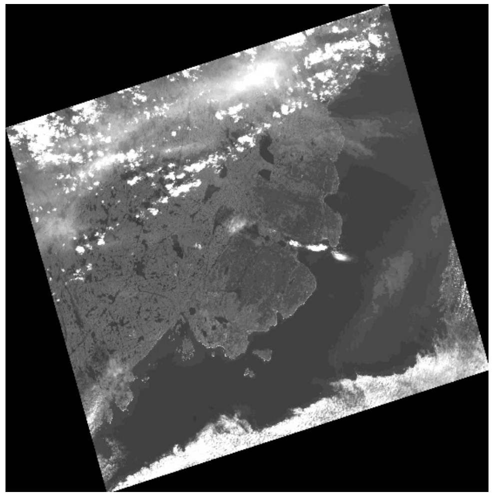


Figure 25. Oblique Distorsion on a Satellite Image.

This is an example of the extensive imagery available over Canada available from GeoBase [21].

Raw satellite imagery may be viewed but it is not directly usable until it is processed. It needs to be orthorectified and georeferenced. An orthorectified image is corrected so that the scale is uniform and the geometric distortions are removed [22] [23].

Figure 26 illustrates one type of geometric distortion that may occur when a satellite views the curved Earth surface at an oblique angle. More severe distortions may occur in images from other types of sensors such as multi-beam sonar and synthetic aperture radar.

If the image is considered as a mathematical surface (a coverage function) it may be adjusted until it is uniform. The image is not the set of pixels, since new uniformly spaced pixels result from the adjustment. An image is really a set of values in a value matrix that drives a coverage function.

[20] Image from <http://www.geobase.ca/geobase/en/find.do?produit=imr> image s4_05702_5132_20071002_m20_lcc00

[21] GeoBase, http://www.geobase.ca/geobase/en/data/imagery/imr/index.html

[22] A tutorial on the fundamentals of Remote Sensing is available from NRCan at: http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309.

[23] Geometric Distortion in imagery is explained at <http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9401>.

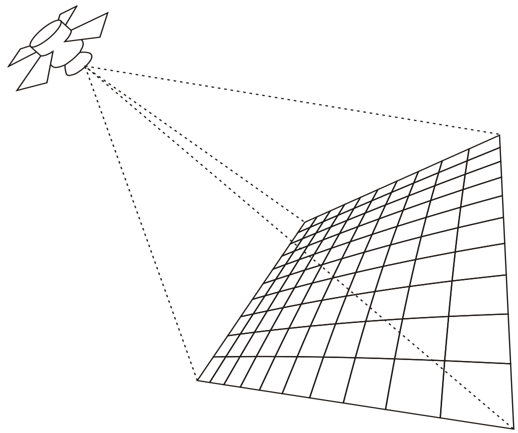


Figure 26. Oblique Distorsion on a Satellite Image.

A quadrilateral grid is the most common type of coverage where it is traversed by straight lines. The grid may be defined in terms of a coordinate reference system such as rows and columns.

Figure 27 shows a Linear Scan quadrilateral grid in Row then Column order.

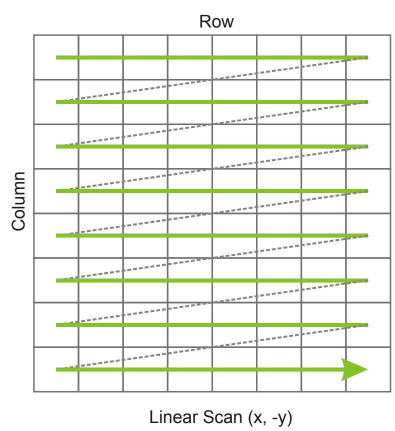


Figure 27. Linear Scan Quadrilateral Grid.

There are many other types of grid traversal methods. Figure 28 shows a Morton order traversal. This order is useful in that it supports non-uniform grid cells such as in a quad-tree. It may also be extended to 3 or more dimensions. Bit interleaving techniques for generating an index can be used to order the grid points in any grid, including grids that are irregular in shape or have grid cells of different sizes.

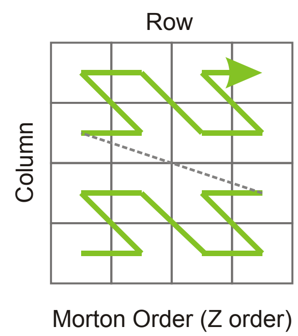


Figure 28. Morton Order Traversal.

Figure 29 is an example of a Quad Tree gridded image which is ordered by a Morton order traversal method. The quad tree method has the advantage of allowing high resolution for some portions of an image and the elimination of redundant data for areas with the same values. Some GIS systems operate on the quad tree principle.

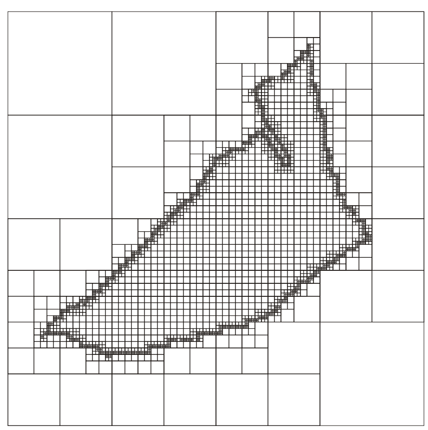


Figure 29. Quad Tree Gridded Image.

Grids do not need to be rectangular. A tessellation of a space into regular hexagons is a hexagonal grid.

There are also a number of other types of coverages that are familiar to a user. These include a Digital Elevation Model (DEM), measurements of the depth of the sea (hydrographic soundings) that form a point set coverage, vector field (representation of current in a river as vectors of intensity and orientation), Thiessen polygons, and the Triangular Irregular Network (TIN).

A grid of elevation values supporting a Digital Elevation Model (DEM) is illustrated in Figure 30. A DEM is an ordered array of ground elevations at regularly spaced intervals.

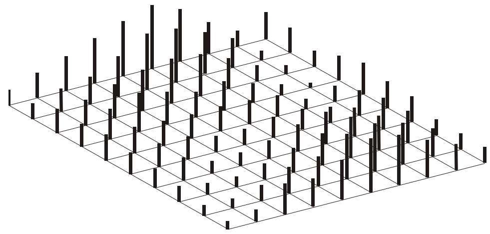


Figure 30. Digital Elevation Model Grid.

Figure 31 shows an example of a shaded relief map based on a DEM. This is an area of northern Quebec near Ungava bay.

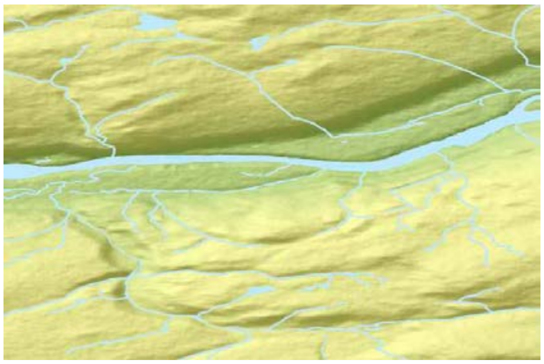


Figure 31. Shaded Relief Map based on a DEM.

GeoBase provides an extensive set of DEM data covering all of Canada [24].

Another way to represent an elevation surface is a TIN coverage. This is illustrated in Figure 32. A TIN is a coverage defined by irregularly distributed nodes with three-dimensional coordinates (x, y, and z) that are arranged in a network of non-overlapping triangles. TIN surfaces are often used for calculations since it is relatively easy to calculate intersections with the surface.

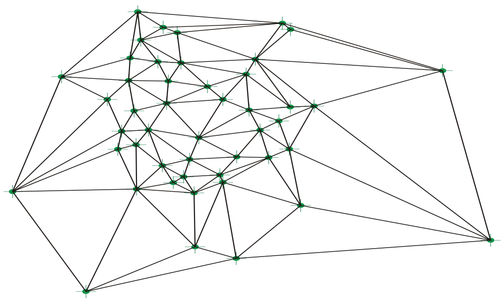


Figure 32. Example of a TIN Coverage.

[24] GeoBase, http://www.geobase.ca/geobase/en/find.do?produit=cded

A point set is another type of coverage. The point set is well used in ocean hydrography to represent depth soundings. Closely related is the Thiessen polygon coverage which divides an area into a set of polygon areas by forming the set of direct positions that are closer to that point than to any other point in the defining set.

Figure 33 represents a section of a hydrographic chart [25] showing a set of soundings that represent the depth as a point set coverage [26]. Chart standards are built upon the International Hydrographic Organization (IHO) S-100 [91] suite of standards which are built on the ISO geographic information standards, including the coverage geometry standards. The Electronic Nautical Chart product specification is S-101 [92]. The previous hydrographic charting standard was IHO S-57 [90].

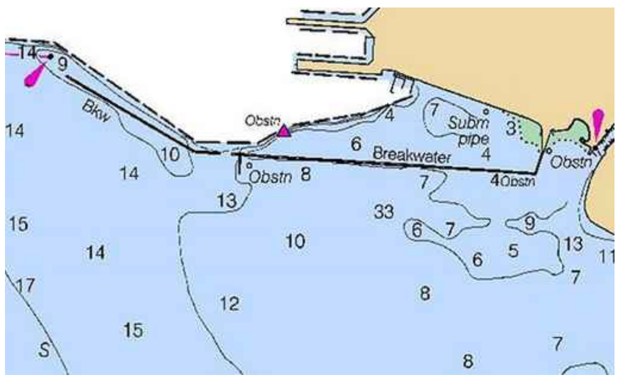


Figure 33. A Set of Soundings as a Point Set Coverage.

An example of a vector field coverage is shown in Figure 34. A vector field coverage is used for the representation of flows such as river currents or winds. This coverage type is used in the IHO standard S-111 Currents [93].

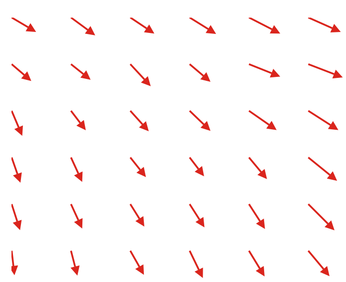


Figure 34. Vector Field Coverage.

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[25] Canadian charts are available from the Canadian Hydrographic Service at: http://www.charts.gc.ca/.

[26] This sample chart has no identification information so that it cannot be used for navigation (http://www.nauticalcharts.noaa.gov/)

Managers and users are guided to treat imagery, gridded and coverage data as structured data that can be analysed mathematically. Continuous coverage data can be treated as matrix values and interpolated or otherwise processed to form a new image or coverage, sometimes of higher clarity (by noise removal). Images can be merged and adjusted mathematically. Managers and users also need to understand that different software, services and encodings are used for different types of coverages, and that they are unique to the type of coverage.

There are a number of standards that address imagery, gridded and coverage data. The main ISO standards are *ISO 19129, Geographic information – Imagery, gridded and coverage data framework* [29], and *ISO 19123, Geographic information – Schema for coverage geometry and functions* [25]. OGC has an *Abstract standard Topic 7- Earth Imagery* [60] which is related to ISO standard *19101-2 ISO 19101-2, Reference Model - Geographic Information – Imagery* [15]. OGC also has developed *Abstract standard Topic 6 Schema for coverage geometry and functions* [66] which is parallels *ISO 19123 Coverage Geometry*. It is in the process of developing the standard GML Application Schema – Coverages (GMLCOV) which is a description of coverage elements using GML as the schema language. This is not a GML encoding standard but is an important structural schema standard. OGC also is developing a number of encoding standards based on these schema parts, such as for GeoTIFF [77], GMLJP2 (JPEG 2000) [72], and others. This is being aligned with the ISO work on encoding, especially the encoding for Remote Sense Satellite Imagery as described in *ISO 19163 Geographic information -- Content components and encoding rules for imagery and gridded data* [48].

3.2.2 Coverage Metadata

The metadata that accompanies an image or other coverage data is as important as the set of pixels (grid values) that define the image or other coverage data. The image or coverage depends upon the sensor, and there are many different types of sensors, both satellite and airborne, and also sonar for hydrography. Figure 25 illustrated a basic satellite image showing how it needs to be adjusted (orthorectified) to be referenced to the Earth (georeferenced). In addition to mathematical adjustment of the coverage, georeferencing requires that the position of the satellite or other sensor be precisely known, or there be a number of known reference control points on the ground.

Figure 35 shows one type of satellite imager as described in *ISO 19130, Geographic Information – Sensor and Data Model* [30]. The camera focal plane is situated on the satellite platform and the scanning operation consists of the oscillation of the scan mirror and the ground track of the satellite. To determine the position of the image one needs to know the satellite orbit, and the characteristics of the telescope, mirror and other parts of the instrument. *ISO 19159-1, Geographic information – Calibration and validation of remote sensing imagery sensors and data -- Part 1:*

Optical sensors [46], describes how to calibrate such an instrument. All of this produces specialized metadata that needs to accompany an image to allow it to be processed.

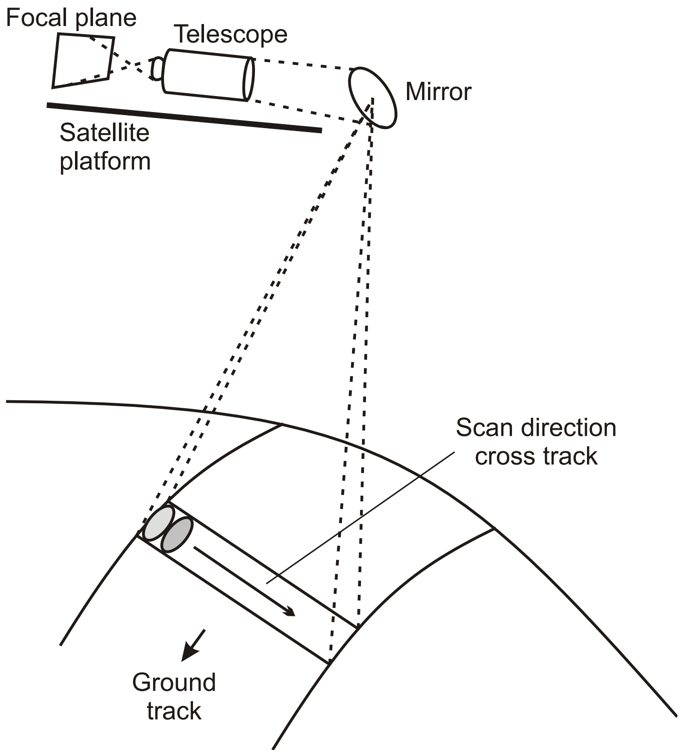

Figure 35. Line Scan Satellite Imager.

The basic metadata standard has been extended in *ISO 19115-2, Geographic information – Metadata - Part 2: Extensions for imagery and gridded data* [24] to address imagery and gridded data. Other types of coverage data are generally addressed by the basic metadata standard. In addition, there are two series of standards (ISO 19130-1, and 19130-2) [30] [31] that address sensor data models, and (ISO 19159-1 and ISO 19159-2) [46] [47] that address Calibration and Validation. The metadata elements defined in these standards need to be included in the Metadata Registry identified in Section 2.6.

Users and Managers need to understand that there are many auxiliary standards that define metadata for coverage data. The metadata that accompanies coverage data, and especially imagery data, can be very extensive and should not be overlooked for proper interpretation of the coverage data.

3.2.3 Coverage and Imagery Encoding

There are many imagery encoding standards. All have different purposes. Some include a large amount of metadata and some are very simple but are restricted to viewing one type of image. Since the types of coverage information is so varied, it is expected that there will be many different types of encodings. The user or manager needs to understand that the various imagery formats are fit to specific purposes and it is sometimes difficult for users of imagery to be able to convert data from one format to another. Sometimes in a conversion of data formats the all-important metadata is lost.

Imagery encoding formats range from the simplest imagery encoding formats to speciality formats for scientific data and special coverage types. All are modelled using the same coverage elements as defined in the standard ISO 19123. The principle of the separation of the "carrier" encoding from the "content" is described in the standard ISO 19129. This means that the information content may be defined rigorously in terms of a conceptual model (such as a UML model) independent of how it is encoded. Some of the encodings are capable of carrying the information content. Other encodings may result in the loss of information since they may not have the capability to carry all of the information, or may not support the particular coverage type. Most encodings address imagery structured as a quadrilateral grid.

The Technical Report *ISO/TR 19121 Geographic information – Imagery and gridded data* [49] studied the various encoding formats for types of Coverage data. The number of encoding standards has increased since the report was published in 2000. An augmented list is given in Table 2.

Users and Managers should use Table 2 to determine whether metadata will be lost in using different coverage encoding formats.

There is a need for diversity in the encoding of Imagery, Gridded and Coverage data because of the great diversity of coverage types and the different levels of data. Some raw satellite imagery data requires extensive metadata to allow for processing, whereas some finished imagery products need much less metadata. Still there is a need for a level of compatibility between all of these diverse standards.

ISO/TC211 is developing a standard ISO*/DTS 19163, Geographic information – Content components and encoding rules for imagery and gridded data* [48], which builds a common core model which can serve as a basis for data compatibility between these formats in the remote sensing imagery domain. Subsequent parts of the standard allow for the binding to the various encoding formats. In addition, ISO and OGC are coordinating their work to establish a method for common encoding bindings for all coverage types. Managers and users need to understand the level of complexity involved in Imagery, Gridded and Coverage data encoding and the fact that there are many diverse and somewhat incompatible standards. They also need to understand that there is potential information loss in converting between standards, such as the loss of some metadata, and of resolution loss cause by resampling an image to a different resolution.

Table 2. Imagery, Gridded and Coverage Data Encoding Formats.

Encoding Format	Type of data
ISO 12087-5, Information technology – Computer graphics and image processing – Image Processing and Interchange (IPI) – Functional specification – Part 5: Basic Imagery Interchange Format (BIIF) [54]	Quadrilateral gridded imagery data, with vector overlays, and many speciality extensions to support special data types. It includes **extensive geospatial metadata**.
ISO/IEC 11544, Information technology – Coded representation of picture and audio information – Progressive bi-level image compression (JBIG) [53]	Bi level quadrilateral gridded imagery data, **no geospatial metadata.**
ISO/IEC 10918, Digital compression and coding of continuous-tone still images (JPEG), and ISO/IEC 10918-5, Information technology – Digital compression and coding of continuous-tone still images: JPEG File Interchange Format (JFIF) [51]	Compressed continuous-tone quadrilateral gridded images, **no geospatial metadata.**
ISO/IEC 15444-1, Information technology – JPEG 2000 image coding system: Core coding system [57]	Lossless (bit-preserving) and lossy compression methods for coding bi-level, continuous-tone grey-scale, palletized colour, or continuous-tone colour quadrilateral gridded imagery data. A provision to add tagged metadata. **A tag for GML encoded metadata is defined**.
OGC 08-054r4, GML in JPEG 2000 (GML-JP2) Encoding Standard Part 1: Core [72]	JPEG 2000 data with the imbedded tag for GML used to allow the encoding of any GML data, **including geospatial metadata** within JPEG 2000 data stream. Note GML can be used the other way and externally reference JPEG 2000 data.
ISO/IEC 13249-5, Information technology – Database languages – SQL multimedia and application packages – Part 5: Still image [56]	Data types for simple still images and associated text comments as part of the SQL MM database query standard. It makes use of ISO/IEC 10918-4 JPEG image as a binary large object. **Geospatial metadata may exist in the database.**
ISO 12234-2, Electronic still-picture imaging – Removable memory – Part 2: TIFF/EP image data format [55]	Tag Image File Format/Electronic Photography, quadrilateral gridded imagery data with **no geospatial metadata.**
OGC 12-100r1, GML Application Schema - Coverages - GeoTIFF Coverage Encoding Profile, and the upcoming OGC GeoTIFF from GeoTIFF– Open Source standard [77],	TIFF encoding with defined Geo tags supporting **some Geo metadata**. DGIWG has a profile of GeoTIFF which maps metadata to GeoTIFF and OGC is developing a standard for GeoTIFF that aligns with the ISO coverage standards and DGIWG.
DGIWG (DIgital Geographic Exchange STandard) DIGEST [87] itself is now considered a legacy standard but NSIF, the imagery part, is well used	DIGEST (Annex D), known as the Image Interchange Format, is an encapsulation of the NATO Secondary Imagery Format (NSIF) NATO STANAG 4545 which is based on ISO 12087-5 NIIF. It includes **extensive geospatial metadata.**
IHO S-57 [90**Erreur ! Source du renvoi introuvable.**] and IHO S-100 [91] Imagery and Gridded data component.	Imagery and Gridded data for hydrography, such as undersea bathymetry, and vector fields for currents, based on ISO 19123 and ISO 19129. The encoding is the Hierarchical Data Format

Encoding Format	Type of data
	HDF. It includes **extensive geospatial metadata** for hydrography.
CEOS - Committee on Earth Observation Satellites family of formats for Earth Observation data. [86]	Metadata is encoded using the Z39.50:1995 Application Service Definition and Protocol Specification, and the data itself tends to be satellite dependant. It includes **extensive geospatial metadata.**
EOS-HDF Hierarchical Data Format HDF for Earth Observation Satellite data	The HDF encoding format is an open source format developed by the US National Center for Supercomputing Applications that is designed to store and organize large amounts of numerical data. The EOS profile is the NASA format for Earth Observation missions based on HDF. It includes **extensive geospatial and satellite platform metadata.**
OGC 10-090r3, NetCDF - Network Common Data Form Core Encoding Standard version 1.0 [76]. There are other NetCDF related standards and product specifications developed in OGC. Also NetCDF and HDF version 5 are converging.	The NetCDF format is an open format developed by the University Corporation for Atmospheric Research (UCAR) describing machine independent array oriented scientific data, including imagery and gridded data. It can carry **extensive metadata including geospatial metadata**. NetCDF is simpler (and more limited than HDF).

3.3 GeoBase Data Products

The availability of data is a large factor in defining standards. When data is openly available it becomes well used and implicitly becomes the template for standards.

GeoBase is part of the Canada Base Map (CBM) which provides a "Continuous base mapping coverage from national to local scales in a single, easy-to-use, cartographically designed, web mapping service"[27]. This collection of base maps has been created under the auspice of the Canadian Council of Geomatics with the support of Natural Resources Canada (NRCan), other Federal departments, as well as Provincial and Territorial mapping departments to provide locational context with an emphasis on transportation networks over which thematic information can be overlaid. The data sources for the CBM are shown in Table 3.

[27] http://geogratis.gc.ca/geogratis/CBM_CBC?lang=en

Table 3. CBM data sources.

Data Source	Data Scale	Minimum Scale	Maximum Scale
GeoBase		1:1,000	1:30,000
CanVec	1:50,000	1:1,000	1:115,000
NTDB	1:250,000	1:115,001	1:550,000
Atlas of Canada	1:1,000,000	1:550,001	1:2,750,000
Atlas of Canada	1:7,500,000	1:2,750,001	1:13,750,000
Atlas of Canada	1:15,000,000	1:13,750,001	1:200,000,000

GeoBase is a Canadian (federal, provincial and territorial) government initiative to provide access to a standardized set of quality and current geospatial data for all of Canada. It is managed by the Canadian Council on Geomatics (CCOG) which is a consultative body between the geospatial agencies of the federal-provincial-territorial governments.

GeoBase provides open access to data covering all of Canada. The underlying principles [28] are to provide:

- Quality geospatial data (current, accurate, consistent and maintained);
- Unique geospatial data (one data, collected once and maintained closest to the source);
- Data at no cost and with no restrictions for users.

GeoBase provides access through a Web Portal service to all users. The GeoBase holdings are organized into nine layers:

[28] http://www.geobase.ca/

Table 4. GeoBase Data Layers.

Administrative Boundaries	Aboriginal Lands, Canadian Geopolitical Boundaries, Federal Electoral Districts and Municipal Boundaries
Digital Elevation Data	an ordered array of ground elevations at regularly spaced intervals at scales of 1:50,000 and 1:250,000
Geodetic Network	horizontal and vertical geodetic control information for the Canadian Base Network, Primary Vertical Bench Marks, Federal 3-D Densification Network and Federal 2-D Densification Network
Geographical Names	a toponomy of Canada's geographical names and their attributes that have been approved by the Geographical Names Board of Canada GNBC
Land Cover	a discrete coverage of vectorized polygons classified from satellite imagery in accordance with a legend including agriculture and forest cover
National Road Network	an integrated road network including 1.1 million kilometres of road network data (Network, Street Names, Address Ranges) In addition a set of named populated places at various scales is provided.
National Hydro Network	an integrated network of Canada's inland surface waters including lakes, reservoirs, rivers, streams, canals, islands, obstacles and constructions with a linear drainage network (hydrography, flow network, boundaries of drainage areas, toponyms). In addition 1:1 M scale bathymetric data of the waters in and around Canada is provided.
National Railway Network	an integrated network of Canada's railways including ferry connection for network connectivity
Satellite Imagery	orthorectified and raw satellite imagery covering Canada from Landsat 7, SpotImage 4/5 and Radarsat-1, with control points

The GeoBase data is available in both official languages with textual elements in the language selected.

Each of the GeoBase data layers is defined together with a Product Specification and a Feature Catalogue, where applicable. Four of these product specifications have been standardized through the Canadian General Standards Board Committee on Geomatics as National Standards. (see Section 3 above).

Access to the data is through a GeoPortal that supports metadata based data discovery and downloading of the data. This portal is available at: http://geogratis.gc.ca/geogratis/search?lang=en.

The user and manager needs to know that this wealth of standardized freely available geospatial data is available for download and through a Web Service interface. The specifications for the data are also published on the GeoBase Website with each type of data. It provides reference data for government, business and personal use.

4. Development of a Web Service

The most common interface to geographic information is the classical printed paper map. Such maps are still useful, but they are rapidly becoming supplanted by electronic maps, many of which are now downloadable through web services. The area of Web Services brings together the Earth Science and Information Technology views of Geospatial Information.

Standardization in the management of data and the delivery of data through online services has been led by the Open Geospatial Consortium (OGC) which has developed a number of consensus specifications that describe many aspects of data services. ISO/TC 211 also has a working group addressing services, but that group is primarily driven by the work in OGC. The OGC standards evolve at the same speed as the technology, thus requiring constant monitoring to ensure that, for example, the Canadian Geospatial Data Infrastructure (CGDI) stays up to date.

This section of the guide addresses web services including how data can be accessed and processed online and what the issues involved. The services addressed are:

- Data Discovery and the Catalogue Service for the Web;
- Web Mapping Services;
- Web Feature Services;
- Web Coverage services; and
- Web Processing Service.

4.1 Overview of Web Services

Web services provide a number of functions. The different services allow users to find data, view it, and access it allowing for the downloading of files or the supply of data to other applications. An example of an application that makes use of web based information is a Location Based Service. Web services also allow data to be processed online.

The wide availability of geospatial data drives the implementation of Catalogue Services for their discovery by the way of geospatial metadata. A user query for data discovery through a Catalogue Service for the Web (CSW) [65] selects data based on metadata elements.

The Web Mapping Service (WMS) [61] allows a user to visualize data. In a Web Mapping Service the web map image needs to be adjusted in projection, scale and position to correctly overlay other map images. Any integration of the data occurs in the eye of the viewer.

A Web Feature Service [59] is different from a Web Mapping Service as it serves geospatial data as opposed of a map image. A Web Feature Service operates on feature oriented data. If data is to be selected from multiple sources and fused into a combined data set the feature catalogues from the various data sources need preferably to be in alignment. A feature object taken from one source must mean the same thing as a similar feature taken from a different source if the data is fused.

A Web Coverage Service [75] is also different from a Web Mapping Service as it serves geospatial data as opposed of a map. A Web Coverage service operates on imagery and other types of coverage data. The standards permit the support of many coverage types.

Location Based Services (LBS) [33] allow geospatial information to drive specific applications based on location. Location based services identify a location (often the location of a user derived from a GPS) and selects the closest features objects. For example if a user needed to know the location of the closest banking machine, then the application on their mobile device or smart phone that drew the location on a map would be a location based service. LBS have applications parcel and vehicle tracking and navigation, discovery of nearby objects or persons and in other social media based information services. In fact, most query services are now query based. If a user searches the Internet through a Web browser based search engine such as Google, Yahoo or Bing, the search engine will determine the user's approximate location from the internet address and tailor the query response to the location.

A number of standards exist for Web services. Some of the higher level architectural standards are available from ISO/TC 211 for both Geospatial Services and for Location Based Services. Some abstract standards as well as the practical implementation level service specification standards have been defined by the OGC.

4.2 Data Discovery and the Catalogue Service

One of the most basic services is the OGC Catalogue Service for the Web (CSW) that allows users to find data. This is the core service for a spatial data infrastructure and many applications, and it is driven by metadata. This is an area where both the data and service standards overlap. However, the data discovery use case is different than most of the other geospatial service situations in that a user needs to be able to find all data, including legacy data. This implies support of multiple versions of at least a subset of the metadata standard at the same time. As the metadata standards evolve, CSW based systems need support metadata from multiple metadata standards versions so that a query using either a former or a new metadata element will discover data that has been defined using either form of the metadata standard. The methodology for managing both new and former data in a Web service environment is a management issue. These standards are evolving, but the use of ontologies and semantic queries is becoming more important.

The CSW illustrated in Figure 36 is taken from the GeoConnections – Discovery Portal [29]. The figure shows the base page of the advanced search option of the discovery portal where the Topic

[29] http://geodiscover.cgdi.ca/web/guest/advanced-search

Category “Imagery and Basemaps” and the Resource Type “Raster/Matrix” have been selected. The graphical interface has allowed an area of southern Quebec to be selected between N:49° S:45° E:-71° W:-78°.

Figure 36. GeoConnections Discovery Portal.

This query resulted in multiple hits, so it needed to be refined. Running the query again with the keyword “GeoBase” resulted in just a few hits. This list is shown in Figure 37. It indicates that Orthoimagery is available from the SPOT Image 4 and 5 satellites. The legend indicates that data is Canadian data, with verified metadata, and is cost free.

Figure 37. Discovery Portal Query Results.

The user can select to view the associated metadata. A section of the metadata is shown in Figure 40.

The General information part of the metadata gives a file identifier for the XML file of the metadata together with the data stamp. The other metadata elements: Contact Information, Identification Information, Distribution Information, Data Quality Information, and Metadata Constraints, are also available.

By following the link a summary of the GeoBase Orthoimage data is available. Also the links lead to the GeoBase website and to a directory of files where the data may be downloaded. A step by step example on how to use the Discovery Portal is available at: http://geodiscover.cgdi.ca/web/guest/cbts.

Figure 38. Orthoimage Metadata.

There are a number of underlying standards that support the Discovery Portal. The relevant OGC standards [30] are:

- OGC Standard – OGC: 07-006r1 Catalogue Services Specification 2.0.2 - Corrigendum 2, 2007 [65];

[30] OGC standards are under active revision. The latest relevant CSW standards are listed at: <http://www.opengeospatial.org/standards/cat>.

- OGC Standard – OGC: 13-084r2 OGC I15 (ISO19115 Metadata) Extension Package of CS-W ebRIM Profile 1.01, 2014 [78];
- OGC Standard – OGC: 07-144r4 CSW-ebRIM Registry Service – Part 2: Basic extension package 1.0.1 - Corrigendum 1, 2007 [70];
- OGC Standard – OGC: 07-045 Catalogue Services Specification 2.0.2 - ISO Metadata Application Profile, 2007 [68].

These are service standards that hold metadata about available data sources in a register and allow a user to search the data based on matching the metadata elements.

Metadata drives the Data Discovery and the Catalogue Services for the Web. The user establishes a service connection including a request for the capabilities of the service and then sends a discovery query through the Catalogue Service interface. The system matches the query request with the metadata in the Metadata Repository, and possibly the metadata in other connected CSW systems. The metadata describes the data holdings in the Geospatial Data Store. This is illustrated in Figure 41.

The access of the data from the data store is done through other OGC Service Interfaces such as the Web Mapping Service.

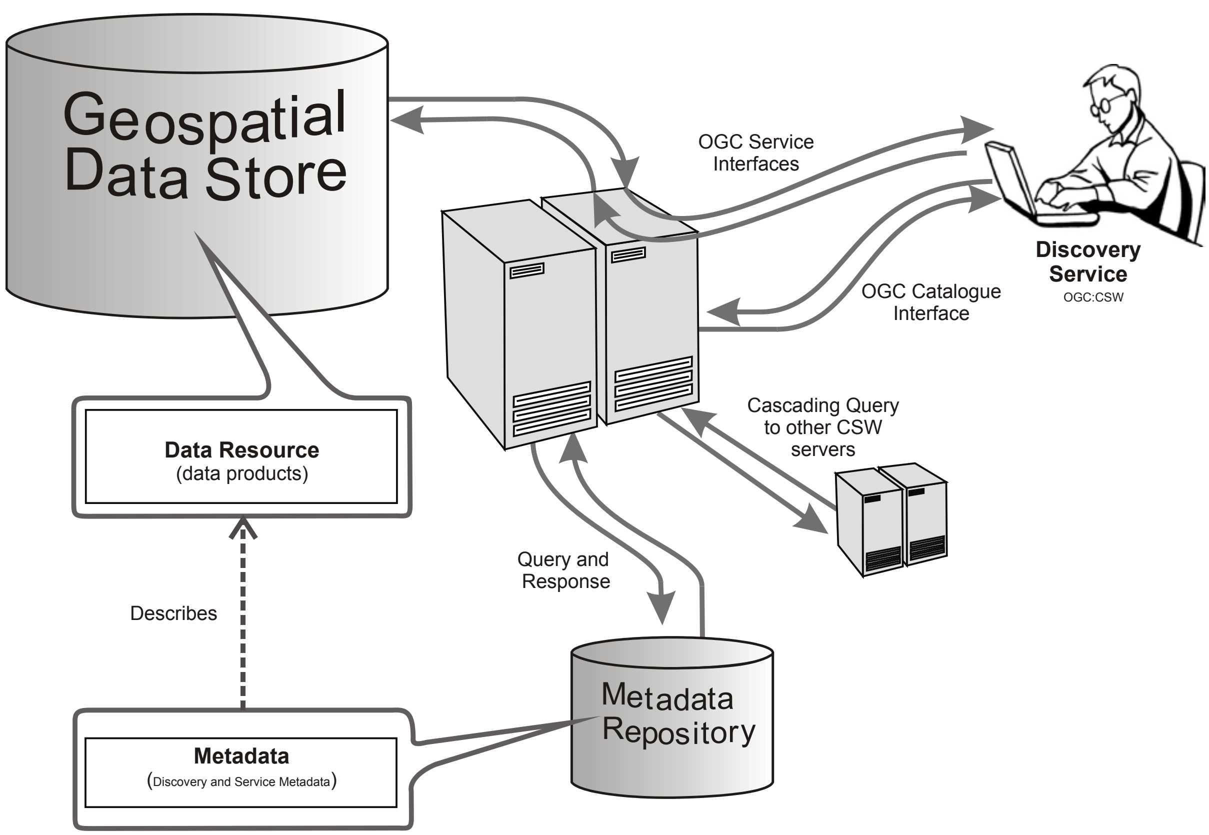

Figure 39. CSW Reference Architecture[31].

Figure 42 shows the protocol sequence defined in the CSW standard. It shows the flow of information across the link between the client and the service.

When a user accesses the Discovery Portal Web page shown in Figure 38, the initialization sequence is performed. When the user selects the "Search" button, the "searchRequest" command is sent. After obtaining a response that confirms that data is available, the system requests the records, and generates response page as shown in Figure 39.

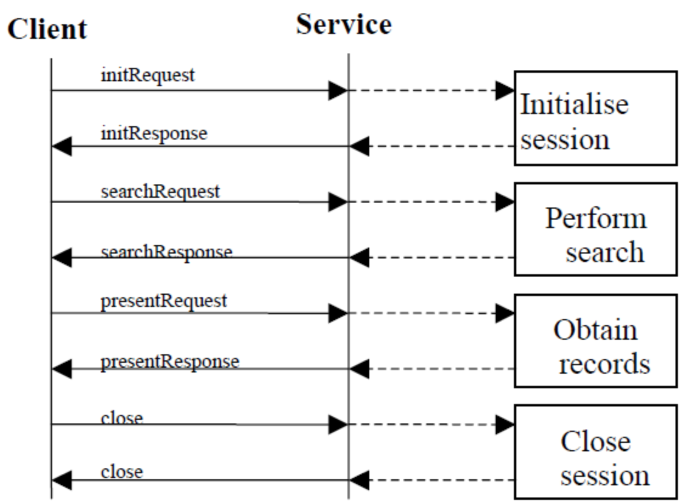

Figure 40. CSW Protocol Sequence.

Users and managers must understand that the discovery process operates on metadata and how important metadata is. Data without a good metadata description will be very hard to find. The query capability of the CSW service is very flexible allowing structured queries in accordance with the OGC Filter Specification [74].The description of the data in the metadata repository includes information about the data, but also Digital Rights information about whether the data is available freely or for sale. Critically the metadata repository must have permanent URLs for access to the data. Managers especially must understand that if they change the storage location of the data that they have responsibility, then the CSW systems may not be able to find it. Data managers have a responsibility to maintain the interface to their data.

The OGC CSW supports the use of one of several identified query languages to find and return results using content models (metadata schemas) and encodings. Its specification defines two types

[31] Derived from Figure 3 of OGC Standard OGC 07-006r1, Catalogue Services Specification [65]

of operations, Discovery and Publication. The Discovery operations are used to query a server and the Publication operations are used to manage the metadata in a catalogue.

The Discovery requests are:

- **GetCapabilities** - returns an XML document containing service metadata about the server.
- **DescribedRecord** - returns a schema of the information supported by the catalogue service supported by the server.
- **GetRecordById** - retrieves the default representation of catalogue metadata records using their identifier.
- **GetRecords** - queries the catalogue metadata records.
- **GetDomain** - requests a description of the value domain for a specified data element or request parameter.
- **GetRepositoryItem** - allows a client to retrieve the repository item corresponding to some extrinsic object.

The Publication requests are:

- **Harvest** – allows for the creating, modifying and deleting catalogue records in a server. This operation requires authentication so that only the appropriate catalogue managers can update the catalogue.
- **Transaction** – defines an interface for creating, modifying and deleting catalogue records in a server.

These operations may be communicated to the server using different HTTP protocols. The examples below use the Key Value Pair (KVP) method.

An example GetCapabilities request to the CGDI Discovery Portal is:

> http://geodiscover.cgdi.ca/wes/serviceManagerCSW/csw?
> request=getCapabilities&service=CSW&version=2.0.2

The result is an XML document describing the capabilities of the CSW service.

This would be followed by a DescribedRecord request to obtain the schema of the records:

> http://geodiscover.cgdi.ca/wes/serviceManagerCSW/csw
> ?request=DescribeRecord&service=CSW&version=2.0.2
> &outputFormat=application/xml
> &schemaLanguage=http://www.w3.org/XML/Schema&
> namespace=csw:http://www.opengis.net/cat/csw/2.0.2

The result is an XML Schema document (an XSD document) that describes the record schema.

This would be followed by either one or more GetRecordByID requests or a GetRecords request with filtering. The GetRecords is the principle request used to search catalogue content. A simplified example of a GetRecords request is shown below:

> http://geodiscover.cgdi.ca/wes/serviceManagerCSW/csw?request=GetRecords
> &service=CSW&version=2.0.2&constraint=...

The response message would be an XML file that would include the registry objects selected.

4.3 Web Mapping Service

Geographic information may be visualized through the Web Mapping Service (WMS). This service allows map images to be displayed through Web client software. The software may be either a service operating through a Web browser or it may be a dedicated software client that directly issues requests using the WMS standard interface. One of the most powerful aspects of the Web Mapping Service is its ability to request and overlay web map data from multiple sources. In order for this to occur the data must be adjusted to the same scale and projection, and the presentation must be adjusted so that the overlay data does not visually conflict with the background map.

The Web Mapping Service has been established through several OGC standards. In addition the OGC has worked with ISO/TC 211 to establish an international standard. The relevant standards [32] are:

- OGC Standard – OGC 06-121r9 Web Services Common Implementation Specification, 2010 [64];
- OGC Standard – OGC 06-042 Web Map Service Implementation Specification, 2006 [62];
- OGC Standard – OGC 05-055 Web Map Context Implementation Specification, 2005 [61];
- OGC Standard – OGC 07-057r7 Web Map Tile Service Implementation Standard, 2010 [69];
- ISO 19128 - Web Map server interface [28].

Figure 43 is an example of a Web Mapping Service interface as displayed to a user. In this case data is selected from the GeoBase data store. Several separate layers are overlaid. These are the

[32] OGC standards are under active revision. The latest relevant WMS standards are listed at: http://www.opengeospatial.org/standards/wms> and <http://www.opengeospatial.org/standards/common

Administrative Boundaries: Municipal Boundaries and Aboriginal Lands. In addition the layers "Landmass", Place Names" and "Hydrography" have been displayed.

The user is free to change the parameters of the map by adjusting the scale bar, panning to adjacent information, or selecting different overlays from within those available from GeoBase.

This is a GeoBase WMS interface intended to allow users to view the GeoBase data holdings. This interface does not support access to external data.

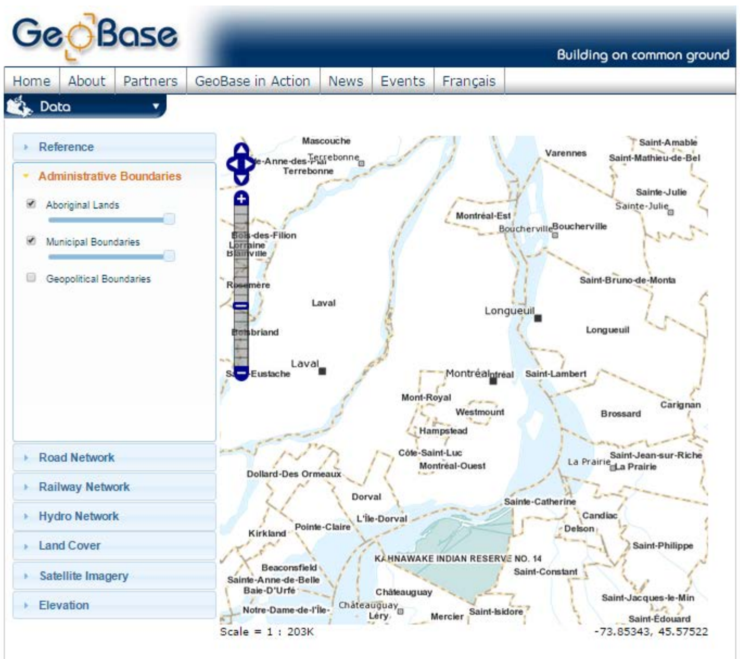

Figure 41. Example WMS map image[33].

The capability to copresent map images from multiple sources is an important aspect of the WMS service. GeoBase serves its data through a WMS protocol interface so that client software can access its data and possibly combine it with data from other sources. The GeoBase WMS interface is available at[34]:

- English: http://ows.geobase.ca/wms/geobase_en;
- French: http://ows.geobase.ca/wms/geobase_fr.

The NRCan Toporama WMS service provides access to the CanVec, National Topographic Data Base (NTDB) and Atlas of Canada data. The WMS interface is available at:

[33] This is an example that was taken from the GeoBase WMS at: http://www.geobase.ca/geobase/en/viewer.jsp which is not maintained anymore.
[34] The GeoBase WMS interface is not available anymore.

- • English: http://wms.ess-ws.nrcan.gc.ca/wms/toporama_en;
- • French: http://wms.ess-ws.nrcan.gc.ca/wms/toporama_fr.

The separate interfaces for English and French allow the textural elements such as labels and place names to be presented in the selected language.

Figure 44 shows a Web Mapping application over El Salvadore where data has been accessed from different servers. The background data is from the US Geological Survey Shaded Relief data set. On top of that is the "Mitch Base Map" from UNITEC as well as "Mitch Rivers" and "Mitch Lakes" also from UNITEC. In addition, international boundaries are from the DGIWG Digital Chart of the World (DCW) hosted on a USGS server.

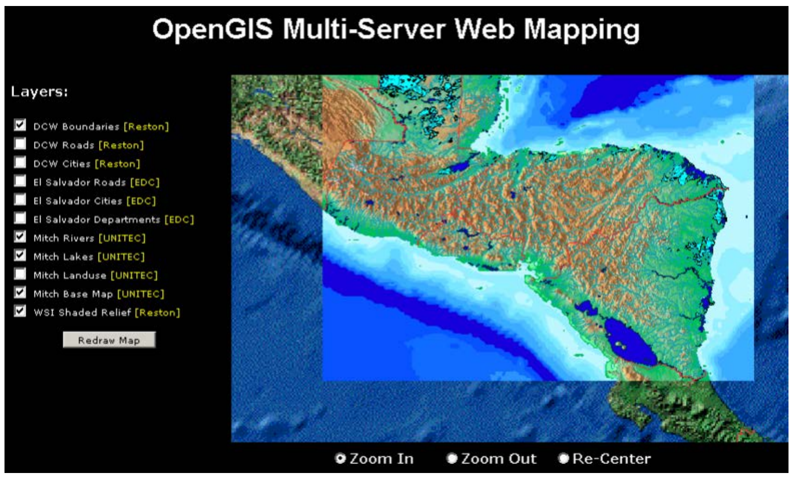

Figure 42. Multi Server Web Mapping [35].

As is clear from the example, the WMS data must be adjusted so that it aligns with the same scale and projection. For the portion of the screen where it is displayed the "Mitch Base Map" data completely covers the background "Shaded Relief" data set from the USGS. The other data sources, the rivers, lakes and boundaries have transparent backgrounds so that they do not obliterate the background.

Two configurations for a Web Mapping Service are illustrated in Figure 45. The first makes use of a Web Browser interface. In this configuration the Web access service client software is on a remote computer and the user communicates with it via a conventional Web Browser. The web access service client software on the remote computer accesses the Web service host computer(s) using the OGC web service protocols such as WMS.

[35] This example is from the US Federal Geospatial Data Committee at: http://www.fgdc.gov/training/nsdi-training-program/materials/GeoWebservices_Intro_20100604.pdf

The second configuration has the Web service client software on a local computer run by the user. Here the local computer accesses the web service host computer(s) using the OGC Web service protocols. In both configurations the client software, on the remote or local computers, may access multiple Geo Web servers to allow for the integration of data from multiple sources.

This architecture works in a similar manner for all of the OGC data access services WMS, WCS, WFS, and WPS [36]. In fact data retrieved via any of these services can be combined in the client system.

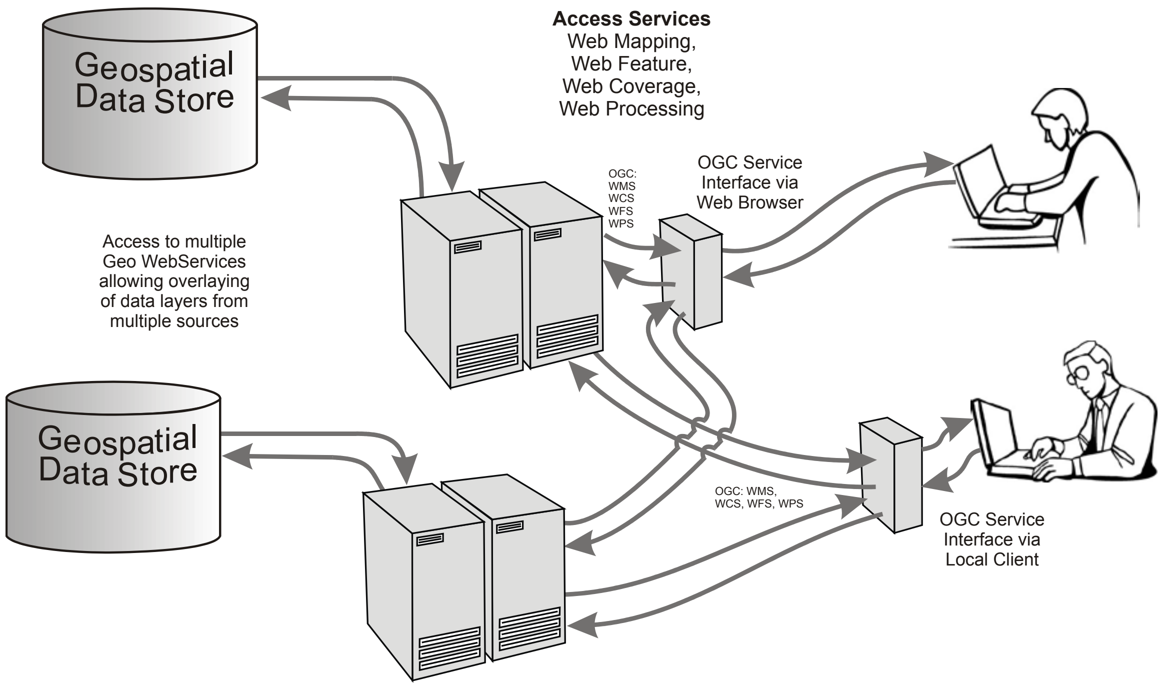

Figure 43. Example Multi-Server Web Service.

The WMS defines a number of requests that may flow from the WMS client software to the WMS host system. The two primary requests are:

- **GetCapabilities** - returns an XML document describing the WMS resource (such as map image format and WMS version compatibility) and the available layers (map bounding box, coordinate reference systems (CRS), location of the data (URI) and information about whether the background is transparent- to allow overlays). The server may optionally return a narrative description of a layer in the form of an abstract, and a keyword list that may be used to aid catalogue searches. It may also return a reference to a location where the metadata for the layer may be obtained.

[36] The WFS, WCS and WPS services are described in the sections 4.4, 4.5 and 4.6.

- **GetMap** - returns a map image. Parameters include: width and height of the map, coordinate reference system, rendering style, image format. A mandatory Styles parameter lists the style in which each layer is to be rendered. The host system may have to adjust the projection of the map so that it matches the Width and Height specified so that alignment between layers is possible.

The WMS system may optionally support the additional request type:

- **GetFeatureInfo** – for layers marked as 'queryable' returns data about a feature based on a coordinate on the map image.

The format used to encode the Get resource commands is the Hypertext Transfer Protocol (HTTP) as defined in the Internet Engineering Task Force standard (IETF RFC 2616) [89]. This is a constructed string using HTTP key/value pair encoding. For example a GetMap operation for a particular GeoBase data layer would look like:

```
http://ows.geobase.ca/wms/geobase_en?service=wms&request=GetMap&version=1.1.1
&srs=epsg:4269&bbox=-72,45.35,-71.85,45.5&width=800&height=600
&style=&format=image/png&layers=nhn:hydrography,nrn:roadnetwork,nrwn:track
```

This result from this GetMap request is shown in Figure 46. This is a map image of Sherbrooke Quebec in "png" format. A similar request to the NRCan Toporama WMS server produces a dataset that aligns but includes different layers of information.

The GetCapabilities for the GeoBase WMS service would request the capabilities of the GeoBase mapserver. This data would be returned as an XML document. Such a file is too long to include in this guide. Some examples of the capabilities that would be reported would be that the GeoBase map server is capable of returning data in the png, gif, jpeg, png 8-bit, and tiff formats.

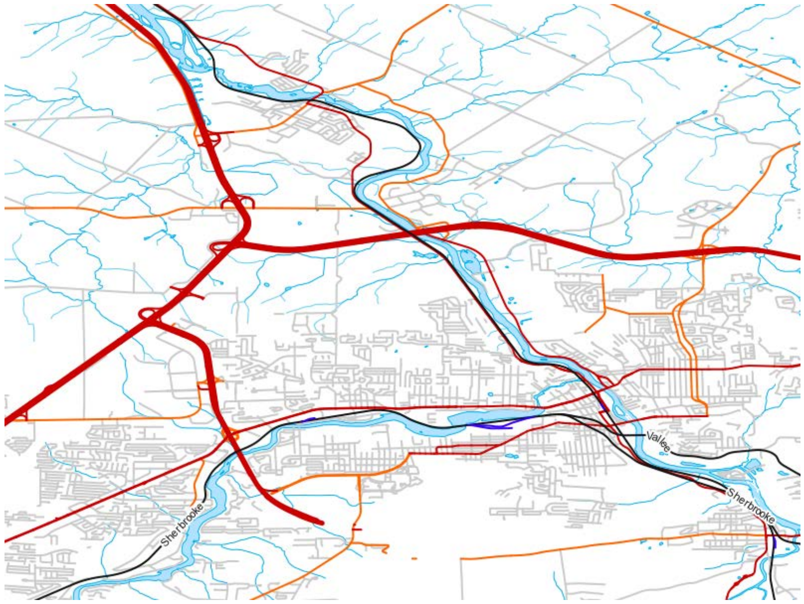

Figure 44. Example Data Returned from a GetMap Request[37].

The results of the GetCapability request would inform the client software, for example allowing it to request the data in the "&format=image/png" resulting in the image in Figure 46. The GetCapabilities query would look like:

http://ows.geobase.ca/wms/geobase_en?service=wms&request=GetCapabilities

The WMS service is complex and powerful. Users and managers should understand the capabilities and the general architecture so that they can make use of the service. Using an interface via a Web browser with the WMS client software on a remote computer is limited to the capabilities provided by the host of the client software. This is usually a viewer for the host's data offerings. This is useful for browsing data sources. Local computer WMS client software allows a user or developer to build a custom system to access many sources of WMS data.

Users and managers should be aware that there are many companies/organizations that supply WMS (and other Web Service) client software including several freeware and open source versions. The OGC lists 147 companies that provide WMS software compliant to the latest version of the specification [38], many of them Canadian. Most GIS systems are also capable of importing data via the WMS, WFS and WCS protocols.

[37] Example from: http://www.geobase.ca/geobase/en/wms/index.html (not maintained anymore)
[38] http://www.opengeospatial.org/resource/products/byspec/?specid=50

4.4 Web Feature Service

The Web Feature Service (WFS) [59] provides web access to the set of features that are used to define a data product. The WMS service allowed access to an image of a map that can be viewed and adjusted in scale and orientation. The WFS allows access to the underlying features. These features, complete with their attributes, can be displayed in a much more dynamic way where the portrayal can be adjusted dependent upon the value of an attribute. The features accessed through WFS can also be combined with other features from other sources to produce completely new maps. They may also be analysed; for example, the connectivity of the road features in a road network can be processed to determine the shortest route.

The basic architecture of a WFS service is the same as that for all of the OGC based Geospatial Web Services as shown in Figure 44.

A WFS provides different functionality [73] compare to a WMS, but it is also more complex. The additional functionality derives from the ability of the service to access individual feature types and instances. The data returned from the WFS server is encoded in the GML encoding standard and optionally in the KML encoding standard.

A Gazetteer Service is an application profile of a WFS. Figure 47 illustrates a WFS query on the Canadian Geographical Names Data Base (CGNDB). This is web form that requests information about the Single feature, the City of Sherbrooke in the province of Quebec.

The WFS provides a fine grain access to geospatial information. It allows users to be able to Get or Query selected feature types and instances. A second level of the service also allows a user to be able to Create, Modify or Delete features from multiple geospatial data servers for which they have been assigned access permission. Through this version of the service teams can cooperatively develop data sets; for example, weather spotters could report local temperature readings by creating an instance of a temperature reading feature at a specific geographic location and potentially modifying the attributes.

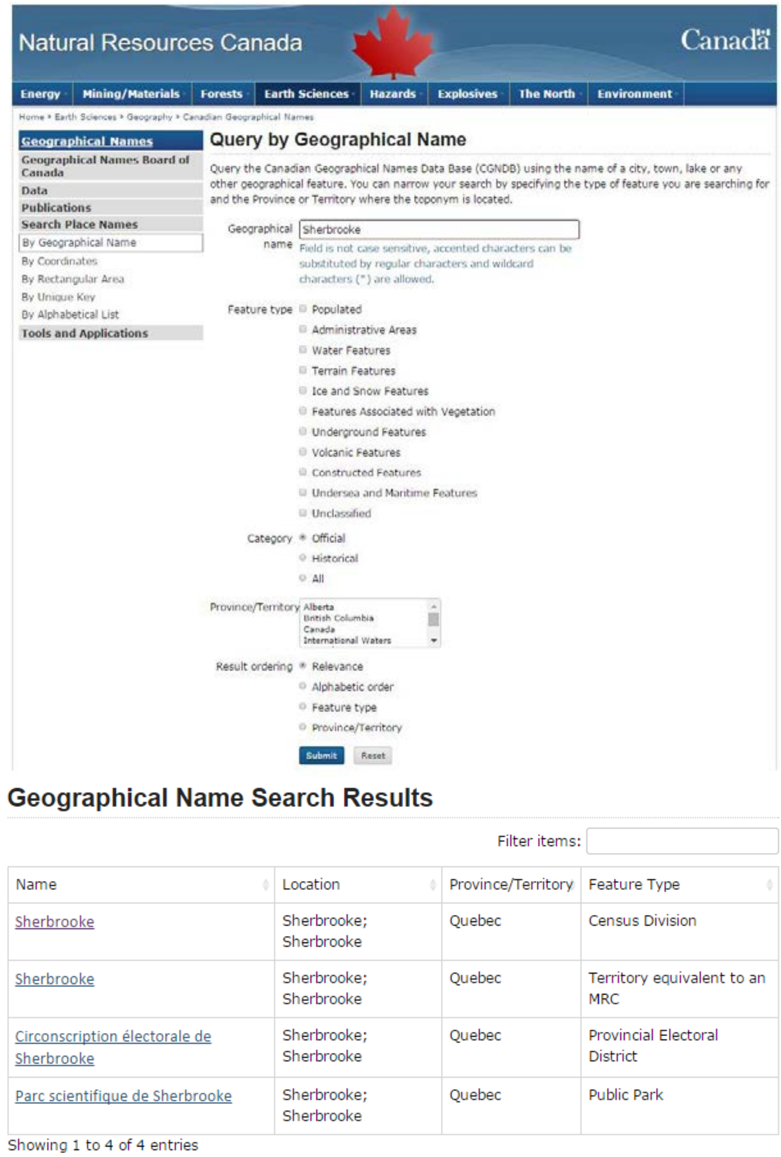

Figure 45. WFS Query on Geonames Gazeteer.

The interfaces for a Web Feature Service must be defined in XML and GML to be used to express the features across the interface [59]. The datastore used to store geospatial features is opaque to the user except through the functions provided by the WFS interface.

The WFS operations are:

- **GetCapabilities** – A WFS returns an XML document describing the capabilities of the WFS. This document will indicate which feature types the WFS can service and what operations are supported on each feature type.
- **DescribeFeatureType** – Request the schema entity of the data being served.

- **GetFeature** - A Web feature service must be able to service a request to retrieve feature instances. In addition, the client should be able to specify which feature properties to fetch and should be able to constrain the query spatially and non-spatially.
- **GetGmlObject** - A Web feature service may optionally be able to service a request to retrieve element instances by traversing XLinks (external or internal links to XML/GML documents) that refer to their XML IDs. In addition, the client software should be able to specify whether nested XLinks embedded in returned element data should also be retrieved. The GetGmlObject allows a service request to follow the links as used in GML documents.
- **Transaction** - A Web feature service may optionally be able to service transaction requests. A transaction request is composed of operations that modify features; that is create, update, and delete operations on geographic features.
- **LockFeature** - A Web feature service may optionally be able to process a lock request on one or more instances of a feature type for the duration of a transaction. This ensures that serializable transactions are supported.

Based on the operation descriptions above, three classes of Web Feature Services can be defined:

- **Basic WFS** - A **Basic WFS** would implement the **GetCapabilities**, **DescribeFeatureType** and **GetFeature** operations. This would be considered a READ-ONLY web feature service.
- **XLink WFS** - An **XLink WFS** would support all the operations of a basic web feature service and in addition it would implement the **GetGmlObject** operation for local and/or remote XLinks, and offer the option for the **GetGmlObject** operation to be performed during **GetFeature** operations.
- **Transaction WFS** - A transaction WFS would support all the operations of a basic Web Feature Service and in addition it would implement the **Transaction operation**. Optionally, a transaction WFS could implement the **GetGmlObject** and/or **LockFeature** operations.

The first step in a WFS dialogue is the issuance of a GetCapability request by the client software. The result would be the return of a capabilities document from the server system. Based on the results the server and the client software would go into a negotiation sequence.

> **Example negotiation**: Server understands versions 1, 2, 4, 5 and 8. Client understands versions 1, 3, 4, 6, and 7. Client requests version 7. Server responds with version 5. Client requests version 4. Server responds with version 4, which the client understands, and the negotiation ends successfully.

The GetCapabilities query for the GeoBase WFS for GeoNames CGNS would look like:

> http://cgns.nrcan.gc.ca/wfsu/cubeserv.cgi?service=wfs&datastore=cgns

&request=getCapabilities&version=1.1.0

Figure 48 shows a portion of the response from the GeoBase WFS for GeoNames CGNS.

The service supports the get feature capability for geographic name queries, for the single feature type CGNS-Codes.

The second step in a WFS dialogue is the issuance of a DescribeFeatureType query. The request would take the form:

http://cgns.nrcan.gc.ca/wfsu/cubeserv.cgi?service=wfs&datastore=cgns&request=describeFeatureType&typename=GEONAMES

This returns an XML/GML schema that allows the client software to understand the subsequent GML used in the session. It includes a list of attributes so that the client software can apply custom filters on the results.

The next step in the WFS dialogue is to request a feature. The following is an example which queries the CGNDB for names equal to "Sherbrooke".

http://cgns.nrcan.gc.ca/wfsu/cubeserv.cgi?service=wfs&datastore=cgns&request=getFeature&typename=GEONAMES&filter=<Filter><PropertyIsEqualTo><PropertyName>GEONAME</PropertyName><Literal>Sherbrooke</Literal></PropertyIsEqualTo></Filter>

The result of this query is shown in Figure 47.

This example illustrates only a very small part of the power of the basic read-only WFS for a single feature type and attribute query. The service can be used to extract multiple types of features allowing the client system to build custom map products. In addition the transaction service in the WFS allows the user to create, update, or delete features with proper permissions. Using the transaction service applications can be created that allows the distributed reporting of data, crowd sourcing geospatial information, distributed editing of information and many other custom applications.


```
<?xml version="1.0" encoding="UTF-8"?>
<WFS_Capabilities xmlns="http://www.opengis.net/wfs"
xmlns:gml="http://www.opengis.net/gml" xmlns:ogc="http://www.opengis.net/ogc"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:ows="http://www.opengis.net/ows"
xmlns:cw="http://www.cubewerx.com/cw"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="1.1.0"
xsi:schemaLocation="http://www.opengis.net/wfs
http://cgns.nrcan.gc.ca/schemas/wfs/1.1.0/wfs.xsd http://www.opengis.net/ows
http://cgns.nrcan.gc.ca/schemas/ows/1.0.0/owsAll.xsd">
<ows:ServiceIdentification>   [17 lines]
```

```
  <ows:Title>
    Canadian Geographical Names Service Web Feature Service
  </ows:Title>
(…)
  <ows:OperationsMetadata>   [474 lines]
    <ows:Operation name="GetFeature">
      <ows:DCP>
      <ows:HTTP>
        <ows:Get
xlink:href="http://cgns.nrcan.gc.ca/wfsu/cubeserv.cgi?DATASTORE=cgns&"/>
        <ows:Post
xlink:href="http://cgns.nrcan.gc.ca/wfsu/cubeserv.cgi?DATASTORE=cgns"/>
      </ows:HTTP>
    </ows:DCP>
(…)
  <FeatureTypeList>   [18 lines]
  <SupportsGMLObjectTypeList>   [91 lines]
  <Filter_Capabilities xmlns="http://www.opengis.net/ogc">   [59 lines]
</WFS_Capabilities>
```

Figure 46. WFS Get Capabilities Sequence.

The Web Feature Service is more powerful than the Web Mapping Service; however, the WMS is more frequently implemented. Users and managers should understand that the WFS provides fine grain access to feature based data sets, and although the resultant image on a display screen may be similar to the output from a WMS, the WFS allows the user to adjust how the information is to be displayed based on the attributes of the features, allows the user to select which features are to be selected and allows custom applications including the creation and editing of data. The WFS provides access to the feature data. The user and manager should also be aware that the combination of data from different sources is permissible using the WFS, but that the feature sets need to be compatible. Selecting different types of data to be combined, such as restaurant locations combined with road map data from a different source is valid. Combining similar features from different sources could cause confusion if the definitions of the features are not the same. If two sources of road map data define a road differently it may not be appropriate to combine the data. A four lane highway is not equivalent to a path, but both are types of a generic road.

4.5 Web Coverage Service

The Web Coverage Service (WCS) [75] provides Web access to coverage data. The WCS allows users to query a geospatial server to select and download or display portions of coverage type information. The WMS service provides the user with static images of maps that can be visualized. This is different than the WCS service that returns that actual coverage value matrix data that is used to describe an image or other coverage type together with the associated metadata. Coverage data returned from the WCS service can be analysed or processed by the user. A coverage is a type of feature, so the WCS service is similar to the WFS service providing a rich syntax for the query and selection of elements of the information. The difference between the WCS and the WFS is that the coverage information type requires different kinds of interaction than do vector or textual geographic features. Range subsetting (clipping), scaling, Coordinate Reference System (CRS) adjustment, and interpolation are different functions in a coverage environment. The WCS complements the WFS service and a user can use both together to; for example, overlay feature oriented vector or textual data on a coverage image, or drape a vector oriented map over a 3 dimensional Digital Elevation Model.

The encoding of coverage data requires support for many different types of encoding formats. These formats have different purposes, some being highly efficient, some being easy to interpret, etc. These formats have been outlined in Table 2. The encoding model used in the WCS is called GMLCov (GML Coverage). Initially GML was limited to only the Quadrilateral Grid coverage. The GMLCov model currently permits most of the coverage geometries allowed in the standard ISO 19123 and it is evolving to address more. ISO is also developing an exchange model in ISO/DTS 19163, Geographic information – Content components and encoding rules for imagery and gridded data, which will align with GMLCov and which will bind to many different encoding formats. Currently WCS supports the GeoTIFF, NetCDF, JPEG200 and GMLJP2 (GML imbedded in JPEG200) formats. WCS also supports multi-part data in which part of the coverage data is encoded in one of the many imagery encoding formats, and additional information (mostly metadata) is encoded in GML.

WCS is also complemented by a Web Coverage Processing Service (WCPS). The WCPS defines a language for filtering and processing of multi-dimensional raster coverages, such as sensor, simulation, image, and statistics data. This is related to the Web Processing Service (see 4.6). It allows for the evaluation of a coverage function at a location and the filtering of the results. For example a WCPS service could be an edge analysis of an image.

Some aspects of WCS are still under development and there are as yet fewer WCS servers available than for services such as WMS and WFS.

Figure 49 shows a temperature map of the world obtained as the result of a WCS query. The image was encoded using the JPEG encoding format.

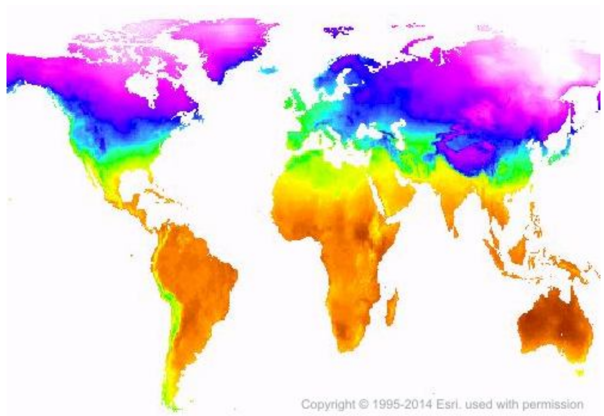

Figure 47. Result of WCS query for a Temperature Map.

The image was obtained using the WCS commands GetCapabilities, then Describe Coverage, then GetCoverage. These are the core commands in the WCS service, although there are many other commands available. The WCS core commands are outlined below.

- **GetCapabilities** – A WCS returns an XML/GML document of the service metadata describing the capabilities of the WCS indicating which coverage types and encodings the WCS can service and what operations are supported.
- **DescribeCoverage** - This request will return a full description of one or more coverages within the service in GML format.
- **GetCoverage** - This request will return a coverage in one of the supported encoding formats.

The WCS Core establishes basic spatial and temporal extraction functions. These are trimming of the coverage area (or volume) within a bounding box or slicing, performing a cut across the spatial extent of the coverage data set reducing the dimension of the resulting coverage. Both operations are dependent on the coverage type and may involve reorganizing the data using a different traversal method across the resultant value matrix.

Below are the requests to an ESRI ArcGIS WCS Server [39] to produce the image in Figure 49.

The request **GetCapabilities** was of the form:

http://sampleserver3.arcgisonline.com/ArcGIS/services/World/Temperature/ImageServer/WCSServer?SERVICE=WCS&VERSION=1.0.0&REQUEST=GETCAPABILITIES

[39] This example from ESRI Inc.is used with permission: http://resources.arcgis.com/en/help/main/10.1/index.html#//015400000603000000

The results of this command indicate that the WCS server "sampleserver3" hosts "a mosaic dataset that contains a collection of images which represent the average monthly temperature over the surface of the entire Earth from 1950 – 2009" and that the service supports the WCS core commands and uses the WGS84 CRS.

Based on the results of this command the user's client software then issued the **DescribeCoverage** request:

> http://sampleserver3.arcgisonline.com/ArcGIS/services/World/Temperature/ImageServer/WCSServer?SERVICE=WCS&VERSION=1.0.0&REQUEST=DescribeCoverage&COVERAGE=1

The results of this command describe that the coverage data was within a Latitude/Longitude envelope of -179.99 to 180 degrees and -55.5 to 83.5 degrees. It also described the coverage type as a rectified grid and traversal order with a defined range, using the EPSG 4326 CRS (WGS84 CRS). It indicates that nearest neighbour interpolation is supported. It also stated that it could respond with the data encoded in one of the formats (GeoTIFF, NITF, HDF, or PNG).

The user's client software then issued the **GetCoverage** request:

> http://sampleserver3.arcgisonline.com/ArcGIS/services/World/Temperature/ImageServer/WCSServer?SERVICE=WCS&VERSION=1.0.0&REQUEST=GetCoverage&COVERAGE=1&CRS=EPSG:4326&RESPONSE_CRS=EPSG:4326&BBOX=-158.203125,105.46875,158.203125,105.46875&WIDTH=500&HEIGHT=500&FORMAT=jpeg

Users and managers need to be aware of the utility of the Web Coverage Service, but also be aware that the service is at the forefront of development and that WCS implementations are not yet common. As the WCS technology develops, the WCS will integrate into the suite of geospatial Web services and allow users to freely mix coverage data with feature based data in composite maps. The WCS together with the emerging WCPS will also allow the online analysis of geospatial imagery, scientific and statistical data. Users and managers should also be aware that the issues of data format incompatibility, which now impede the integration of imagery, gridded and coverage data are actively being solved by standards working groups in both the OGC and ISO.

4.6 Web Processing Service

The Web Processing Service (WPS) allows a client to request the execution of a process as part of the geospatial Web services suite. A user may request the execution of an available process and indicate how the output of that process is to be handled, including submission of the data generated by a WPS request to be handled by a subsequent service such as a WMS service.

The WPS is very flexible. It can offer any type of geospatial processing service across a network. The type of processing is application dependant and depends upon the application server offering the service. WPS processes may be as simple as calculating distance between two points to running a complex weather model. The WPS provides the interface. Some of the processing services offered may themselves be standardized, or the processing services may be custom services offered only to operate on specific data.

Figure 50 shows the response to a request for Hydro Network data from the GeoBase Web Mapping Service (WMS). This is similar to the request shown in Figure 43. The resultant base map image shows the river drainage network flow pattern near Mont-Joli Quebec.

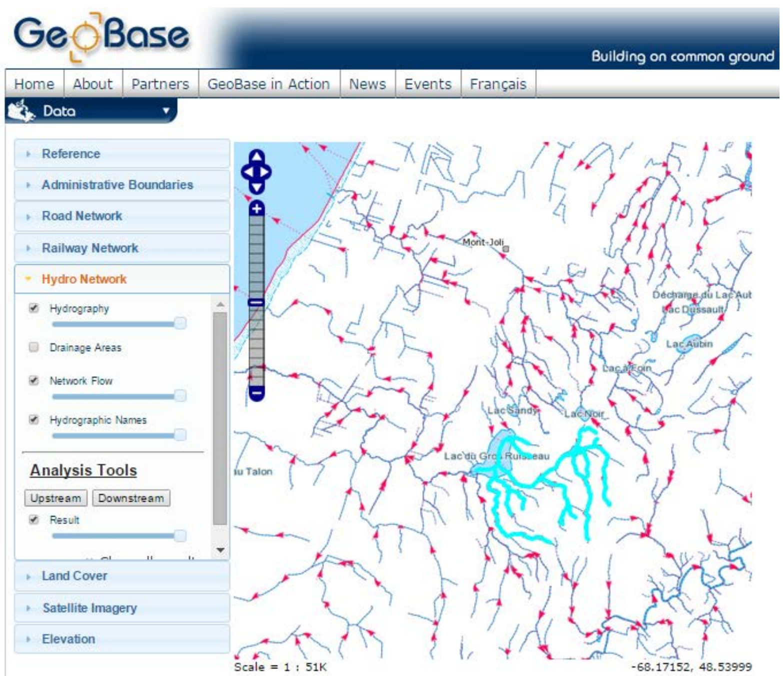

Figure 48. WPS Processing Hydro Flow Data.

On top of this base map was a request using the Web Processing Service to calculate from the hydrographic network flow data all of the waters that are upstream of Lac du Gros Ruisseau, which is a small lake near Mont-Joli.

The Web Processing Service (WPS) operates in a similar manner to the other geospatial Web services. The three defined operations are:

- **GetCapabilities** – A WPS returns an XML document describing the service metadata of the capabilities of the WPS. This can vary widely. Various servers can provide different analysis capabilities to operate on specific types of data. For example, the flow network analysis capability in the GeoBase WMS server allows the WPS service to operate only on the hydrographic network flow data. The GetCapabilities operation provides the names and general descriptions of each of the processes offered by a WPS.

- **DescribeProcess** - This request returns an XML document which provides a description of the process including its inputs, outputs and supported formats. Inputs can be Web accessible URLs that invoke other processes, such as a WFS service to provide data. Outputs can be an image that can be overlaid in a WMS service, or it can be data in a format that can be passed on to other processes. That is, WPS requests can be cascaded.
- **Execute** - This request will return the output of the process in one of the formats identified in the DescribeProcess request.

The initial step in operating a WPS session is to send the GetCapabilities request. This has the form:

> http://www.geobase.ca/geoserver/ows?request=GetCapabilities&version=1.0.0&service=wps

The result of this command is an XML file that indicates that the WPS server supports the requests GetCapabilities, DescribeProcess and Execute. It also supports sub processes "JTS:area", "JTS:boundary", "JTS:buffer", "JTS:centroid", … and many other support sub-processes including the specific processes "egp:NHNUpstreamEn" ,"egp:NHNDownstreamEn", "egp:NHNUpstreamFr" and "egp:NHNDownstreamFr". These latter four sub-processes calculate the network flow lines upstream and downstream of a point.

The results of this command are used by the client software to issue the **DescribeProcess** request:

> http://www.geobase.ca/geoserver/ows?request=DescribeProcess&version=1.0.0&service=wps

The result of this command is a XML XLink to the location of the schema describing the process. In this case the schema is located in the OGC schema repository.

The user's client software then issued the Execute request. This request includes the service type identifier e.g. WPS, operation name e.g. EXECUTE, identifier of process from the GetCapabilities response, reference to the data inputs for the process, identifier of the response form and the language to be used for textual data.

> http://www.geobase.ca/geoserver/ows?request=Execute&version=1.0.0&service=wps, (...)

Users and managers should understand that the Web Processing Service allows custom applications to be constructed that operate on geospatial data. The service is very flexible. This service has been defined for many years but it has not been integrated into many web services because it operates at the summit of a hierarchy of other web services, such as the WMS, WFS and WCS that need to be in place before one can implement a WPS. As the level of implementation of the other web services increases there will be more implementations of the WPS to provide integrated access to geospatial data.

5. Conclusion

This standards guide is intended to how standards are the basis of a spatial data infrastructure. Both the information content and the methods of accessing this information are governed by standards.

There are a number of different standards at different levels of abstraction that describe everything from the overall structure of geospatial information and the services that provide access to it. Some standards are very general and are of interest primarily to the high level planner or system architect. Other standards are very specific describing in detail which bits and bytes are to be communicated over particular interfaces. Some very important standards define resources, such as feature catalogues, and metadata and other registers which are used across an entire spatial data infrastructure to maintain compatibility.

The user or manager needs to be generally aware of the standards environment, but does not need to be acquainted with the particular details of many of the standards. Users, managers and developers of data products should be aware of the following:

- Geospatial data products are structured according to an application schema in a standardized manner. The schema for the data is the core for interpretation of production of the data.
- Geospatial data is feature oriented. The definitions of features are described in a Feature Catalogue and the definitions may come from a Feature Concept Dictionary. The attributes that may be applied to a feature are also defined in a Feature Catalogue.
- The geometric and temporal aspects describing a feature are defined by a spatial schema in a standardized manner.
- A standardized spatial referencing system relates positions to the earth.
- A product specification is the documentation for one type of data within a Geospatial Information Environment. The product specification includes or references all of the constituent parts of the data.
- Data needs to be encoded to be exchanged. There are many different encodings, such as XML, GML, KML and the many imagery encodings. All are all addressing different but specific purposes.
- Imagery, gridded and coverage data is structured data that can be analysed mathematically. A coverage is a type of geospatial feature.
- The various imagery formats are fit to specific purposes and it is sometimes difficult to convert data from one format to another.
- The user and manager needs to know that this wealth of standardized freely available geospatial data is available for download and through a Web Service interface.
- The Web services have standardized interfaces that work with the standardized data types. Standardized services exist for data discovery (Catalogue Service for the Web), Web Mapping service (viewing data), Web Feature Service (access to fine grain feature

oriented data), Web Coverage Service (access to imagery, gridded and other coverage data), and Web Processing Service (performing calculations on the web).

- Some services have multiple levels, such as the Web Feature Service that permits user input to implement applications such as crowd sourced data, or reporting of incidents.

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17 ISO 19109 – Geographic Information, Rules for application schema.

18 ISO 19110 Geographic information – Methodology for feature cataloguing.

19 ISO 19111 Geographic information – Spatial referencing by coordinates

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21 ISO 19114 Geographic information – Quality evaluation procedures

22 ISO 19115 Geographic information – Metadata

23 ISO 19115-1 Geographic information – Metadata – Part 1: Fundamentals

24 ISO 19115-2:2009 Geographic information – Metadata – Part 2: Extensions for imagery and gridded data

25 ISO 19123 Geographic information – Schema for coverage geometry and functions
26 ISO 19125-1 Simple feature access - Part 1: Common architecture
27 ISO 19126 Geographic information – Feature concept dictionaries and registers
28 ISO 19128 Geographic information - Web map server interface
29 ISO 19129 Geographic information – Imagery, gridded and coverage data framework
30 ISO 19130 Geographic information – Imagery sensor models for geopositioning
31 ISO 19130-2 Geographic information – Imagery sensor models for geopositioning -- Part 2: SAR, InSAR, Lidar and sonar
32 ISO 19131 Geographic information – Data Product Specification
33 ISO 19132 Geographic information - Location-based services -- Reference model
34 ISO 19135 Geographic information -- Procedures for item registration
35 ISO 19136 Geographic information – Geography Markup Language (GML)
36 ISO 19137 Geographic information – Core profile of the spatial schema
37 ISO 19138 Geographic information – Data quality measures
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40 ISO 19142 Geographic information - Web Feature Service
41 ISO 19143 Geographic information -- Filter encoding
42 ISO 19144-2 Geographic information -- Classification systems -- Part 2: Land Cover Meta Language (LCML)
43 ISO 19150-1 Geographic information – Ontology – Part 1: Framework
44 ISO 19150-2 Geographic information – Ontology – Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)
45 ISO 19157 Geographic information – Data Quality
46 ISO 19159-1 Geographic information – Calibration and validation of remote sensing imagery sensors and data -- Part 1: Optical sensors
47 ISO 19159-2 Geographic information – Calibration and validation of remote sensing imagery sensors -- Part 2: Lidar
48 ISO/DTS 19163, Geographic information – Content components and encoding rules for imagery and gridded data
49 ISO TR 19121 Geographic information – Imagery and gridded data

Other ISO Standards:

50 ISO/IEC 8211 Information technology -- Specification for a data descriptive file for information interchange
51 ISO/IEC 10918, Digital compression and coding of continuous-tone still images (JPEG), and ISO/IEC 10918-5, Information technology – Digital compression and coding of continuous-tone still images: JPEG File Interchange Format (JFIF)
52 ISO/IEC 11179-1:2004 Information technology -- Metadata registries (MDR) -- Part 1: Framework

53 ISO/IEC 11544, Information technology – Coded representation of picture and audio information – Progressive bi-level image compression (JBIG),
54 ISO/IEC 12087-5, Information technology – Computer graphics and image processing – Image Processing and Interchange (IPI) – Functional specification – Part 5: Basic Imagery Interchange Format (BIIF)
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56 ISO/IEC 13249-5, Information technology – Database languages – SQL multimedia and application packages – Part 5: Still image
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80 CAN/CGSB-171.101-2010 Canadian Geographical Names, Level 1 (CGIS – CGN1)
81 CAN/CGSB-171.102-2010 National Road Network 2.0 (CGIS - NRN2)
82 CAN/CGSB-171.103-2010 Canadian Digital Elevation Data, Level 1 (CGIS - CDED1)
83 CAN/CGSB-171.104-2010 Landsat 7 Orthorectified Imagery over Canada (CGIS - ORI)
84 Content Standard for Digital Geospatial Metadata (CSDGM) from the U.S. Federal Geographic Data Committee (FGDC)
85 Treasury Board of Canada Secretariat Standard (Standard on Geospatial Data) <https://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=16553&section=text>

Other Standards:

86 CEOS - Committee on Earth Observation Satellites family of formats for Earth Observation data < wgiss.ceos.org>
87 DIGEST (DIgital Geographic Exchange STandard), DGIWG Defence Geospatial Information Working Group, <www.DGIWG.org>
88 ESRI Shapefile Technical Description, ESRI Corporation, July 1998, <http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf>
89 IETF RFC 2616 Hypertext Transfer Protocol (HTTP) Internet Engineering Task Force standard
90 IHO S-57 IHO TRANSFER STANDARD for DIGITAL HYDROGRAPHIC DATA Edition 3.1 - November 2000, International Hydrographic Bureau (IHB), Monaco
91 IHO S-100 The Universal Hydrographic Data Model- January 2010, International Hydrographic Bureau (IHB), Monaco
92 IHO S-101 ENC Product Specification, International Hydrographic Bureau (IHB), Monaco
93 IHO S-111 Surface Current Product Specification, International Hydrographic Bureau (IHB), Monaco
94 TIGER (Topologically Integrated Geographic Encoding and Referencing) US Census Bureau <http://www.census.gov/geo/maps-data/data/tiger.html>

95 WC3 TR/2006/REC-xml11-20060816, Extensible Markup Language (XML) 1.1 (Second Edition), World Wide Web Consortium (W3C), 2006 < http://www.w3.org/TR/2006/REC-xml11-20060816/>

Annex A - Overview of UML

The Unified Modeling Language (UML) [58] is an ISO standardized object oriented modeling language developed by the Object Modeling Group (OMG) [10]. The UML Logical Model is a description of the objects and object classes that make up a system. It describes how classes of objects relate, what attributes are encapsulated. Services manipulate the state (behaviour) of the classes. UML is used extensively throughout the suite of ISO geospatial standards and by the OGC. ISO TC/211 maintains a harmonized model that incorporates all of the UML classes defined in all of its standards.

UML is a technical specification language aimed at the technical experts that develop systems and data. Users and managers will benefit from a general understanding of what UML is and how it is used in the standards. A general understanding of UML allows one to be able to read the standards and is beneficial even for a high level comprehension of the standards.

Classes may be collected into packages. Many standards contain one package for all of the classes in the standard; however, some standards such as metadata contain many packages related to different aspects addressed in the standard.

Classes may be collected into packages. Many standards contain one package for all of the classes in the standard; however, some standards such as the ISO 19115 metadata standard contain many packages related to different aspects addressed in the standard. Figure A1 shows four packages from the ISO 19115 Metadata standard where the “Metadata entity set information” package references the “Content information” and the “Distribution information” packages. These in turn reference the “Citation and responsible party information” package. All of the classes within a package must have unique names.

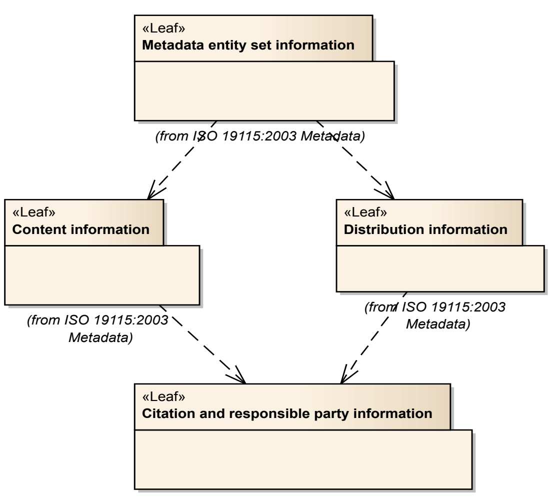

Figure A 1. Example packages.

Figure A2 illustrates the same hierarchical structure as was presented in Figure 2. It shows a “HydroFeature” class with three subclasses “Watershed”, Waterbody” and “River”. Each subclass is a subtype of the parent class and it inherits all of the characteristics and attributes from the parent class. That is, the class “Watershed” also supports the attributes “featureID” and “metadataReference” since they are inherited from the parent class.

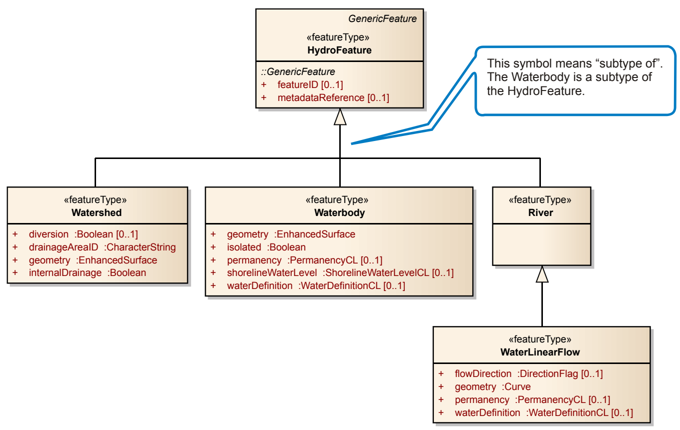

Figure A 2. Class Hierarchy with Subtyping.

The class “WaterLinearFlow is a subtype of “River” at the next level in the hierarchy. The numbers following the attributes show the multiplicity. [0..1] means 0 to 1 occurrences (indicating optional). The attributes take on value types such as “Boolean”, or values defined in another class such as the code list “WaterDefinitionCL”.

Objects may also be composed of parts. This is illustrated in Figure A3 which is the UML for the example in Figure 3. The diamond headed arrow indicates aggregation and the numbers indicate multiplicity.

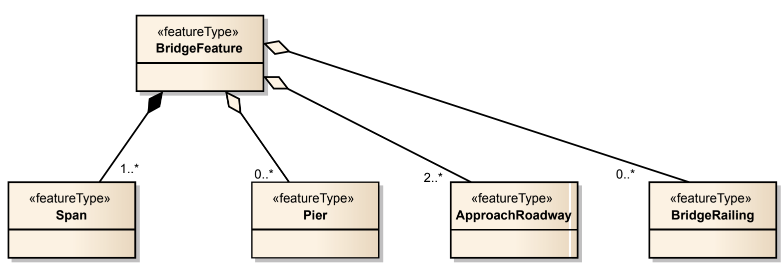

Figure A 3. Aggregation and Composition.

The bridge is made of at least one Span and two ApproachRoadway(s) and may include Piers and BridgeRailing(s). The span is a strong association (aggregation). A bridge cannot exist without a span. The numbers on the associations give the multiplicity. Attributes have been omitted for simplicity.

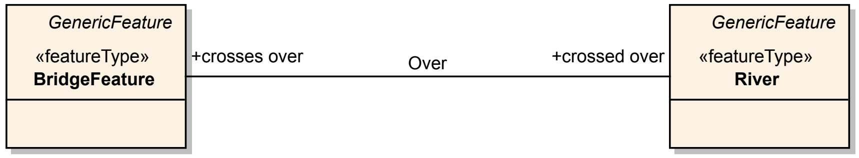

Figure A 4. Relationship between classes.

Figure A4 shows the relationship between the bridge feature and the river feature shown in Figure 3.

Other relationships between classes may also be expressed in UML. Methods may also be defined for classes to implement interfaces. UML is a large and expressive language; however, an understanding of some of its simple structures makes the reading of the geospatial standards easier.

Annex B - OWL Ontology Example

The Web Ontology Language (OWL) example in this annex represents the classes presented in Figure 2 and the Figure A2 in part. It defines 3 classes and 2 properties with multiplicities and their associated types so that the semantics of the objects may be understood.

```
<rdf:RDF xmlns="http://standardsUserGuideExamples.org/hydrologicFeatureSet#"
    xml:base="http://standardsUserGuideExamples.org/hydrologicFeatureSet"
    xmlns:example="hstandardsUserGuideExamples.org/hydrologicFeatureSet#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:skos="http://www.w3.org/2004/02/skos/core#"
    xmlns:dc="http://purl.org/dc/elements/1.1/"
    xmlns:iso19150-2="http://def.isotc211.org/iso19150-2/2012/base#"
    xmlns:gfm=http://def.isotc211.org/iso19109/2013/GeneralFeatureModel#>

  <owl:Ontology rdf:about="http://standardsUserGuideExamples.org/hydrologicFeatureSet">
    <rdfs:label>Hydrologic feature set ontology example</rdfs:label>
    <owl:versionInfo>ed-1</owl:versionInfo>
    <owl:versionIRI rdf:ressource="http://standardsUserGuideExamples.org/hydrologicFeatureSet"/>
    <owl:imports rdf:resource="http://def.isotc211.org/iso19150-2/2012/base"/>
    <owl:imports rdf:resource="http://def.isotc211.org/iso19109/2013/GeneralFeatureModel"/>
  </owl:Ontology>

<!-- example:HydroFeature -->
  <owl:Class rdf:about="&example;HydroFeature">
    <rdfs:label>Hydro Feature</rdfs:label>
    <rdfs:subClassOf rdf:resource="&gfm;AnyFeature"/>
  </owl:Class>

<!-- example:River -->
  <owl:Class rdf:about="&example;River">
    <rdfs:label>River</rdfs:label>
    <rdfs:subClassOf rdf:resource="&gfm;AnyFeature"/>
    <rdfs:subClassOf rdf:resource="&example;HydroFeature"/>
  </owl:Class>

<!-- example:FlowDirectionCL -->
  <owl:Class rdf:about="&example;FlowDirectionCL">
    <rdfs:label>FlowDirectionCL</rdfs:label>
  </owl:Class>

<!-- example:flowDirection -->
  <owl:ObjectProperty rdf:about="&example;flowDirection">
    <rdfs:label>Flow direction</rdfs:label>
```

```
        <rdfs:domain rdf:resource="&example;WaterLinearFlow"/>
        <rdfs:range rdf:resource="&example;FlowDirectionCL"/>
    </owl:ObjectProperty>

<!-- example:WaterLinearFlow -->
        wl:Class rdf:about="&example;WaterLinearFlow">
        <rdfs:label>WaterLinearFlow</rdfs:label>
        <rdfs:subClassOf rdf:resource="&gfm;AnyFeature"/>
        <rdfs:subClassOf rdf:resource="&example;HydroFeature"/>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&example;flowDirection"/>
                <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
            </owl:Restriction>
        </rdfs:subClassOf>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&example;flowDirection"/>
                <owl:allValuesFrom rdf:resource="&example;DirectionFlag"/>
            </owl:Restriction>
        </rdfs:subClassOf>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&example;geometry"/>
                <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
            </owl:Restriction>
        </rdfs:subClassOf>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&example;geometry"/>
                <owl:allValuesFrom rdf:resource="&example;Curve"/>
            </owl:Restriction>
        </rdfs:subClassOf>
    </owl:Class>

<!-- example:Curve -->
    <owl:Class rdf:about="&example;Curve">
        <rdfs:label>Curve</rdfs:label>
    </owl:Class>

<!-- example:geometry -->
    <owl:ObjectProperty rdf:about="&example;geometry">
        <rdfs:label>Geometry</rdfs:label>
        <rdfs:domain rdf:resource="&example;WaterLinearFlow"/>
        <rdfs:range rdf:resource="&example;Curve"/>
    </owl:ObjectProperty>

</rdf:RDF>
```

Annex C - Product Specification Template

Instructions for completing the template

The use of this template has the objective to ease the creation of a document in conformance to the ISO 19131: Geographic information - Data product specifications standard. This template is a subset of the options available in the ISO 19131 standard. It contains all the mandatory fields and a good part of optional fields. This subset should be suitable for the majority of the data product specifications. When the data product contains some particularities not covered in this template, please refer to the ISO 19131 standard to add or modify the specifications of the product.

Explanation on how to fill the template:

[Text]	Explanation text that guided in filling in the template. It must be removed in the final product specification.
<Text>	Text to be replaced by a real value (information about the data product)).
{text}	Descriptive text to keep and/or adjust if needed (remove braces {}).
Shaded section	Optional prescriptive section that may be completed if needed; otherwise, it must be removed.
(VD)	Text that applies only to vector data (point, line, and area). This label must be removed in the final document.
(CD)	Text that applies coverage type data (raster, samples, …). This label must be removed in the final document.
(GD)	Text that applies only to grid data (matrix of points). This label must be removed in the final document.
Mandatory section	All mandatory sections must be completed and included in the document. When the content of a mandatory section is not known an explanation must be included.

C 1 Overview

C 1.1 Title

[The title (name) used to promote the product.]

[Example:] <National Road Network>.

C 1.2 Reference date

[The creation date of the product specifications. (YYYY-MM-DD)]

[Example:] {Data product specifications creation date:} <2007-06-01>

C 1.3 Responsible party

[Location of the person or the organization (contact information) responsible for the product or its distribution must include: person or organization name, complete civil address, phone number, fax number, e-mail address, web site…]

[Example:]

<GeoBase

Natural Resources Canada, Geomatics Canada

Centre for Topographic Information

2144, King Street West, suite 010

Sherbrooke (Quebec), Canada, J1J 2E8

Telephone: 1-800-661-2638 (Canada and USA)

Fax: (819) 564-5698

E-mail: supportgeobase@NRCan.gc.ca

URL: http://www.geobase.ca>

C 1.4 Language

[The list of available languages into which the product specifications are written.]

{Languages in which the data product specifications are available according to ISO 639-2 standard:

eng – English

fra – French}

C 1.5 Terms and definitions

[Description of the terms used in the product specifications takes the following form:]

<Term 1>

<Definition 1>

<Term 2>

<Definition 2>

<…>

[This may take the form of a reference to a terminology repository.]

C 1.6 Abbreviations and acronyms

[Description of the abbreviations and acronyms used in the product specifications takes the following form:]

<Abbreviation/acronym 1> <Definition 1>

<Abbreviation/acronym 2> <Definition 2>

<…>

C 1.7 Informal description of the data product

[An informal description is intended to give a short introduction to the data product specification and allow a human reader a better understanding of the specification. The informal description of the data product shall contain general information about the data product, which may include the following aspects.]

<The content of the dataset.

The extent (both spatial and temporal) of the data.

The specific purpose for which the data shall be or has been collected.

The data sources and data production processes.

The maintenance of the data.>

C 2 Specification scope

[A “Data Product Specifications” document may contain more than one section “Specification Scope” but in most cases only one section is necessary and it covers the entire product specifications.]

[When more than one scope is used, sub-sections are repeated by incrementing the sections number.

Example:

2.1 Scope <Scope name 1>

2.1.1 Scope identification

…

2.2 Scope <Scope name 2>

2.2.1 Scope identification

…]

{This section describes the scope which makes reference to the information in the subsequent sections describing the product.}

<In these specifications, only one scope is used.>

[or] <In this multi-part product {x} scope statements are used>

C 2.1 Scope identification

[Scope identification is used to reference in other sections of the document.]

<Scope identifier. When there is more than one scope, the term “Global” is used. When there is more than one scope, the term “Global” is applied to the super scope.>

C 2.2 Level

[Name of the hierarchical level of the data specified by the scope (see: ISO 19115: MD_ScopeCode «codeList»]

{This scope makes reference to the following level according to the ISO 19115 standard:}

[Example:]

<006 – series, 005 – dataset, …>

C 2.3 Level name

[Name of the hierarchy level of the data specified by the scope.]

<Write the name level. Example: NRN, CanVec, NHN>

C 2.4 Level description

<Detailed description about the level of the data specified by this scope.>

C 2.5 Extent

{This section describes spatial and temporal extents of the scope.}

[If sections 2.5.2 or 2.5.3 or 2.5.4 are empty then section 2.5.1 becomes mandatory and must be filled.]

C 2.5.1Description

<Description of spatial and temporal extents covered by the data.>

C 2.5.2Vertical extent

[Explain particularities of vertical extent if necessary.]

[When this section is used then subsection Vertical datum is optional.]

C 2.5.2.1 Minimum value

<The lowest vertical extent (elevation) contained in the dataset.>

C 2.5.2.2 Maximum value

< The highest vertical extent (elevation) contained in the dataset.>

C 2.5.2.3 Unit of measure

<The units used for vertical extent information.>

C 2.5.2.4 Vertical datum

<The units used for vertical extent information.>

C 2.5.3 Horizontal extent

[Explain particularities of horizontal extent if necessary.]

C 2.5.3.1 West bound longitude

<Western-most longitude [-180..180] of the limit of the dataset extent.>

C 2.5.3.2 East bound longitude

<Eastern-most longitude [-180..180] of the limit of the dataset extent.>

C 2.5.3.3 South bound latitude

<Southern-most latitude [-90..90] of the limit of the dataset extent.>

C 2.5.3.4 North bound latitude

<Northern-most latitude [-90..90] of the limit of the dataset extent.>

C 2.5.4 Temporal extent

[Explain particularities of temporal extent if necessary.]

[Time period covered by the content of the dataset. If the temporal extent represents a fixed moment in time then sections “Beginning date” and “Ending date” are identical.]

C 2.5.4.1 Beginning date

<The beginning date according to format YYYY-MM-DD.>

C 2.5.4.2 Ending date

<The ending date according to format YYYY-MM-DD.>

C 2.6 Coverage

<The coverage to which the information applies.>

C 3 Data product identification

C 3.1 Title

<The title of the data product.>

C 3.2 Alternate title

<Short name or other name by which the data product is known.>

C 3.3 Abstract

< A brief summary of the data product (the what).>

C 3.4 Purpose

< Summary of the intentions with which the data product is developed (the why).>

C 3.5 Topic category

[The main themes of the data product (see ISO 19115: MD_TopicCategoryCode «CodeListEnumeration»).]

{Main topics for the product, as defined by the ISO 19115 standard:}

[Examples:]

<010 – imageryBaseMapsEarthCover

012 - inlandWaters>

C 3.6 Spatial representation type

[NOTE: This section is optional in the standard.]

[The form of the spatial representation (see: ISO 19115: MD_SpatialRepresentationTypeCode «CodeList»).]

<Choose one value among: 001 - vector, 002 - grid, 003 - textTable, 004 - tin, 005 - stereoModel, 006 - video.>

C 3.7 Spatial resolution

[NOTE: This section is optional in the standard.]

[The scale factor which provides a general understanding of the density of spatial data in the data product (ex.: 50 000). In the event of multiple scales, identify the denominators of the scales.]

{Spatial resolution denominators of the data:}

[Example:]

<10 000 - 50 000.>

C 3.8 Geographic description

C 3.8.1 Authority

[The name of the authority responsible to describe the code (3.8.2) of geographic region (see ISO 19115: CI_Citation).]

{International Organization for Standardization (ISO)}

C 3.8.1.1 Title

[The name of the person or organisation responsible.]

{Standard of the code of geographical regions:

ISO 3166-1:1997 Codes for the representation of names of countries and their subdivisions – Part 1: Country codes.}

C 3.8.1.2 Date

[The authority reference date according to ISO 19103 format.]

{Reference date of the ISO 3166-1 standard:

1997-10-01}

C 3.8.1.3 Date type code

[Event used for reference date according to ISO 19115: CI_DateTypeCode <<CodeList>>. Possible values: 001 - creation, 002 - publication, 003 - revision.]

{Type of date according to ISO 19115 standard:}

[Example:]

<002 – publication>

C 3.8.2 Code

<The code of the geographic region covered by the product. >

{Code of the geographical region covered by the product according to the ISO 3166-1 standard:}

[Example:]

<CA – Canada>

C 3.8.3 Extent type code

[Indication of whether the bounding polygon encompasses an area covered by the data or an area where data is not present.]

[Write: 0 - exclusion or 1 - inclusion.]

{Type of code of the delimitation polygon of the extent according to the ISO 19115 standard:}

<0 – exclusion or 1 – inclusion>

C 3.9 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the data product identification. This section refers to only one scope and is always pointing to the super scope "Global".]

{Global}

C 4 Data content and structure

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.

This section varies according to the type of data model to document: a feature based model or a coverage type model. For a feature base model section 4.2.2 Feature catalogue must be specified. Information about coverage type model must be filled in section 4.3.]

C 4.1 Description

<A narrative description of the data model and the information structure must be included.>

C 4.2 Feature information (VD)

C 4.2.1 Application schema

[An application schema provides the formal description of the data structure and content of the data product. It is a conceptual model described with a conceptual schema language such as UML. It shall include the representation of feature types, property types (including attribute types), operations, and association roles as well as association types inheritance relations and constraints. Attribute types cover descriptive, geometric, and temporal properties. Associations include spatial and temporal relationships such as topological relations as well as non-spatial relationships (e.g. building ownership) that occur between feature types.]

<Reference to a UML or other model describing the application schema>

C 4.2.2 Feature catalogue

[The product specifications must include a description for each entity of the product. The feature catalogue may be part of the data product specification or an external feature catalogue may be referenced by the data product specification. The feature catalogue must always follow ISO 19110: Geographic information - Methodology for feature cataloguing standards.

A feature catalogue contains the description of feature types, with their attributes and attributes values, association types between feature types, and feature operations. The description of all feature types in the application schema shall be included in the feature catalogue.]

<Reference to a feature catalogue describing the features used in the product.>

C 4.3 Coverage information (CD)

C 4.3.1 Description

<Technical description of the coverage.>

C 4.3.2 Coverage type

[Coverage type. It is preferable to choose one type of coverage identified in ISO 19123 Geographic information - Schema for coverage geometry and functions.]

<Possibles values for a continuous coverage: Continuous quadrilateral grid coverage, Thiessen polygon coverage, Hexagonal grid coverage, TIN coverage, Segmented curve coverage.

Possible values for a discrete coverage: Discrete point coverage, Discrete grid point coverage, Discrete curve coverage, Discrete surface coverage, Discrete solid coverage.>

C 4.3.3 Specification

[Additional information about the coverage according to section CV_Coverage of ISO 19123 Geographic information - Schema for coverage geometry and functions.]

C 4.3.3.1 Domain extent

[Domain extent (spatial and temporal) for the coverage. Refer to section 2.5 of this document for more details about the domain (corresponds to section EX_EXTENT of ISO 19115 standard).]

[Example:] <Canadian landmass tiled by NTS.>

C 4.3.3.2 Range type

[Data range type of values for the coverage. It consists of a list of attribute name and data type for the range values.]

[Example: For a scanned color map like CanMatrix product]

<Name: Radiometry>

<Value: Integer (0-255)>

C 4.3.3.3 Common point rule

[Rule indicating the method used when pointing at a position on a coverage where there is at least two geometric objects at that location. NOTE: The value of the pointing may vary due to the application used.]

<Possible values are identified in section CV_CommonPointRule <<CodeList>> of ISO 19123 standard: average, low, high, all, from or end.>

[NOTE: The value of the pointing may vary due to the application used.]

C 4.4 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the data content and information structure.]

[Example:] {Global}

C 5 Reference systems

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.

The data product specifications document shall include information that defines the coordinate reference system used in the data product.]

C 5.1 Spatial reference system

[The description of a spatial reference system can be done by referring to an external registry containing parameters of spatial reference system or by describing a reference system according to ISO 19111 Geographic information - Spatial referencing by coordinates if the reference is based on coordinates system or ISO 19112 Geographic information - Spatial referencing by geographic identifiers if the reference is based on a relation with another object, such as a country, an address, a postal code.]

[Describe the spatial reference system (datum, coordinates system, units (decimal degrees, meters…), number of decimals.]

[Example:]

<Spatial data expressed in latitude (φ) and longitude (λ) geographic coordinates in reference to the North American Datum 1983 Canadian Spatial reference System (NAD83CSRS). The longitude is stored as negative number to represent a position west of the prime meridian (0°). The coordinates measuring unit is the degree expressed as a 7-decimal real value.>

C 5.1.1 Authority

[NOTE: This section is optional in the standard.]

C 5.1.1.1 Title

[The name of the registry containing spatial reference system parameters.]

{Registry containing reference system parameters:}

[Example:] <EPSG Geodetic Parameter Dataset>

C 5.1.1.2 Date

[The reference date according to ISO 19103 format of the registry containing reference system parameters.]

{Reference date:}

[Example:] <2007-02-08>

C 5.1.1.3 Date type code

[Event used for reference date according to ISO 19115: CI_DateTypeCode <<CodeList>>. Possible values: 001 - creation, 002 - publication, 003 - revision.]

{Type of date according to ISO 19115 standard:}

[Example:] <002 – publication>

C 5.1.1.4 Responsible party

[Location of the person or the organization (contact information) responsible for the reference system registry; should at least include the name of the organization and the Web site.]

[Example:]

<OGP (International Organisation of Oil and Gas Producers)

URL : http://www.epsg.org>

C 5.1.2 Code

[Alphanumerical identifier of the reference system or CRSID (Coordinate Reference System Identifier) indicated in the reference systems registry.]

{Reference system identifier or CRSID (Coordinate Reference System Identifier):}

[Example:] <4140>

C 5.1.3 Code space

[NOTE: This section is optional in the standard.]

[Name or identifier of the person or organization responsible for the code space of the reference systems registry parameters.]

[Example:] <EPSG - European Petroleum Survey Group>

C 5.1.4 Version

[NOTE: This section is optional in the standard.]

[Version of the spatial reference systems registry parameters.]

[Example:] <6.12>

C 5.2 Linear reference system

[Identify the way LRS data is expressed in the product: percentage, distance, geographical coordinates, etc.

If spatial reference used during the creation of LRS data is different from the one identified for other spatial data of the product, then it must be indicated in this section.]

[Example:]

<Data provided in accordance to the LRS is expressed in percentage calculated to the spatial reference system X. Percentage values are expressed as real numbers ranging from 0 to 100.>

C 5.3 Temporal reference system

<This section is filled according to ISO 19108: Geographic information - Temporal schema and it applies only if the temporal reference system is not the Gregorian calendar.>

C 5.4 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the reference systems.]

[Example:] {Global}

C 6 Data quality

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.

All items and sub items describing the data quality must be documented according to ISO 19113: Geographic information - Quality principles, ISO 19114: Geographic information - Quality evaluation procedures and ISO 19115: Geographic information – Metadata or the new ISO 19157 Geographic information - Data Quality and ISO19115-1 Geographic information – Metadata Part 1: Fundamentals. If an item about the quality is not applicable then "Not applicable" or "Unknown" should be indicated. For sub items that does apply (commission, omission, logical consistency…), the level of quality expected and/or the methodology used to achieve the results and/or the results of all measures taken to verify the quality required must be indicated.]

C 6.1 Completeness (VD)

<Describe the overall context for the data completeness (presence and absence of features, their attributes and relationships).>

C 6.1.1Commission

[Excess data present in a dataset.]

<Describe: the methodology and/or the expected results and/or results obtained; or write "Not applicable" or "Unknown".>

C 6.1.2Omission

[Data absent from a dataset.]

<Describe the methodology and the results or write "Not applicable" or "Unknown".>

C 6.2 Logical consistency

[Degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical).]

C 6.2.1 Conceptual consistency

[Adherence to rules of the conceptual schema.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.2.2 Domain consistency

[Adherence of values to the value domains.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.2.3 Format consistency

[Degree to which data is stored in accordance with the physical structure of the dataset.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.2.4 Topological consistency

[Correctness of the explicitly encoded topological characteristics of a dataset.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.3 Positional accuracy

[Accuracy of the position of features.]

C 6.3.1 Absolute external positional accuracy (VD, GD)

[Closeness of reported coordinate values to values accepted as or being true.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.3.2 Relative internal positional accuracy (VD, GD)

[Closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.3.3 Gridded data positional accuracy (GD)

[Closeness of gridded data position values to values accepted as or being true.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.4 Temporal accuracy

[Accuracy of the temporal attributes and temporal relationships of features.]

C 6.4.1 Accuracy of a time measurement

[Correctness of the temporal references of an item (reporting of error in time measurement).]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.4.2 Temporal consistency

[Correctness of ordered events or sequences, if reported.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.4.3 Temporal validity

[Validity of data with respect to time.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.5 Thematic accuracy

[Accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships.]

C 6.5.1 Thematic classification correctness

[Comparison of the classes assigned to features or their attributes to a universe of discourse (e.g. ground truth or reference dataset).]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.5.2 Non quantitative attribute accuracy

[Accuracy of non-quantitative attributes.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.5.3 Quantitative attribute accuracy

[Accuracy of non-quantitative attributes.]

<Describe: the methodology and/or the expected results and/or results obtained; or write “Not applicable” or “Unknown”.>

C 6.6 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the data quality.]

[Example:] {Global}

C 7 Data capture

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.]

C 7.1 Description

[The data product specification may provide information on how the data has been captured or is to be captured.]

<When this section of the data product specification is included, it shall contain a data capture statement which shall be a general description of the sources and the processes to be used.>

C 7.2 Reference to the specification scope

[Provide specification scope (2.1) that corresponds to this description of the data capture.]

[Example:] {Global}

C 8 Data maintenance

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.]

C 8.1 Description

[The data product specification may provide information on how the data has been captured or is to be captured.]

<When this section of the data product specification is included, it shall contain a data capture statement that shall be a general description of the sources and the processes to be used. This must include the update frequency.>

C 8.2 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the data maintenance.]

[Example:] {Global}

C 9 Portrayal

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.]

[The data product specification may provide information on how the data held within the dataset is to be presented as graphic output as a plot or as an image.]

<When included, this shall take the form of a reference to a set of portrayal rules and a set of portrayal specifications. The portrayal catalogue shall be defined in accordance with ISO 19117: Geographic information – Portrayal.]

[NOTE: Only mandatory sub-sections of section CI_CITATION of ISO 19115 standard are indicated in this template.]

C 9.1 Title: <Name>

[Title of the document on data product portrayal specifications.]

[Example:]

<National Topographic System, Polychrome Map, Standards and Specifications, version 2.0, Centre for Topographic Information, Natural Resources Canada.>

<Replace <Name> by Polychrome map.>

C 9.2 Date

[Date of data product portrayal specifications according to format YYYY-MM-DD.]

{Date of data product portrayal specifications:}

[Example:] <2001-09>

C 9.3 Date type code

[Event used for reference date according to ISO 19115: CI_DateTypeCode <<CodeList>>. Possible values: 001 - creation, 002 - publication, 003 - revision.]

{Type of date according to ISO 19115 standard:}

[Example:] <002 – publication>

C 9.4 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the data portrayal.]

[Example:] {Global}

C 10 Data product delivery

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.

The data product specification shall identify any requirements for the data product delivery information. These shall include delivery format information and delivery medium information, where applicable. This section can be repeated, as often as, there is data formats and/or medias.

Sections 10.1 and 10.2 are repeated as many times as there are delivery formats and medium.]

C 10.1 Delivery format information <Format name>

C 10.1.1 Format name

[Name of the data format.]

<Choose: Shape, GML, DGN, DXF, GeoTIFF, …>

C 10.1.2 Version

<Version of the format.>

C 10.1.3 Specification

<Name of a subset, profile, or product specifications of the format.>

C 10.1.4 File structure

<Structure of delivery file.>

C 10.1.5 Language

[Language(s) used within the dataset in accordance with ISO 639-2.]

<Choose: eng-English; fra-Français; …>

{Languages used in the dataset according to ISO 639-2 standard:}

[Example:]

<eng–English

fra–French>

C 10.1.6 Character set

[The name of the characters set is mandatory if it is different from ISO 10646-1 list of characters set.]

[See ISO 19115: MD_CharacterSetCode «CodeList».]

C 10.2 Delivery medium information <Medium name>

C 10.2.1 Units of delivery

[Description of the units of delivery.]

[Examples:] <Tiles of the National Topographic System, Layers, Geographic areas, …>

C 10.2.2 Transfer size

<Estimated size of a unit in the specified format, expressed in Mbytes.>

C 10.2.3 Medium name

[Name of the data medium.]

<Choose: CD-ROM, DVD, File Transfer …>

C 10.2.4 Other delivery information

[Other information about the delivery.]

C 10.3 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the data product delivery.]

[Example:] {Global}

C 11 Additional information

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.

This section of the data product specification may include any other aspects of the data product not provided elsewhere in this specification.]

C 11.1 Description

<Write all additional information.>

C 11.2 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the additional information.]

[Example:] {Global}

C 12 Metadata

[This section can be repeated if the product has more than one scope. See the example on sub-sections number incrementing at section 2.

The core metadata elements as defined in ISO 19115 shall be included with the data product. Any additional metadata items require to be supplied shall be stated in the data product specifications. The format and encoding of the metadata shall be stated in the data product specifications.

A link to another document containing detailed metadata fields describing the product could be identified, if needed.]

<Write “Not applicable” if there is no supplemental metadata for the product.>

C 12.1 Reference to specification scope

[Provide specification scope (2.1) that corresponds to this description of the metadata. This section refers to only one scope and is always pointing to the super scope “Global”.]

{Global}