

Applying ISO/TC 211 Standards in the Development of Data Standards

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Introduction

ISO Technical Committee 211 (ISO/TC 211), Geographic information/Geomatics, aims to establish a structured set of standards for geographic information and to “provide a framework for the development of sector-specific applications using geographic data.” [1] Common use of the schemata (*schema*, singular) developed through ISO/TC 211 will promote data sharing at the international, regional, national, and local levels. Standards developed through ISO Technical Committee 211 are identified as the ISO 19100 series of geographic information standards, as the standards are assigned document numbers beginning with ISO 19101.

This paper will discuss three standards from the ISO 19100 series of geographic information standards that are instrumental in the development of data standards. These three standards are:

1. ISO 19109, Geographic information - Rules for application schema
2. ISO 19123, Geographic information - Schema for coverage geometry and functions
3. ISO 19115: 2003, Geographic information – Metadata

This paper will continue with a discussion of the application of ISO 19109, ISO 19123, and ISO 19115 in the development of data standards through the Geospatial One-Stop e-government initiative sponsored by the Office of Management and Budget of the U.S. Government.

ISO 19109, Geographic information - Rules for application schema

The purpose of ISO 19109, Geographic information - Rules for application schema, is not to define specific application schemata, but to define rules for their definition. This standard first

presents the General Feature Model (GFM) for definition of geographic features, and then discusses creation of an application schema in the Unified Modeling Language (UML).

Figure 1 presents an extract of the General Feature Model. The GFM defines feature types according to property types and recognizes three property types: attributes, operations (which describe behavior of a feature type), and feature association roles (which describe the roles a feature type may have with other feature types). Additional concepts are feature associations between the feature type and itself or other feature types; inheritance relationships (generalization and specialization) with other feature types; and constraints on the feature type.

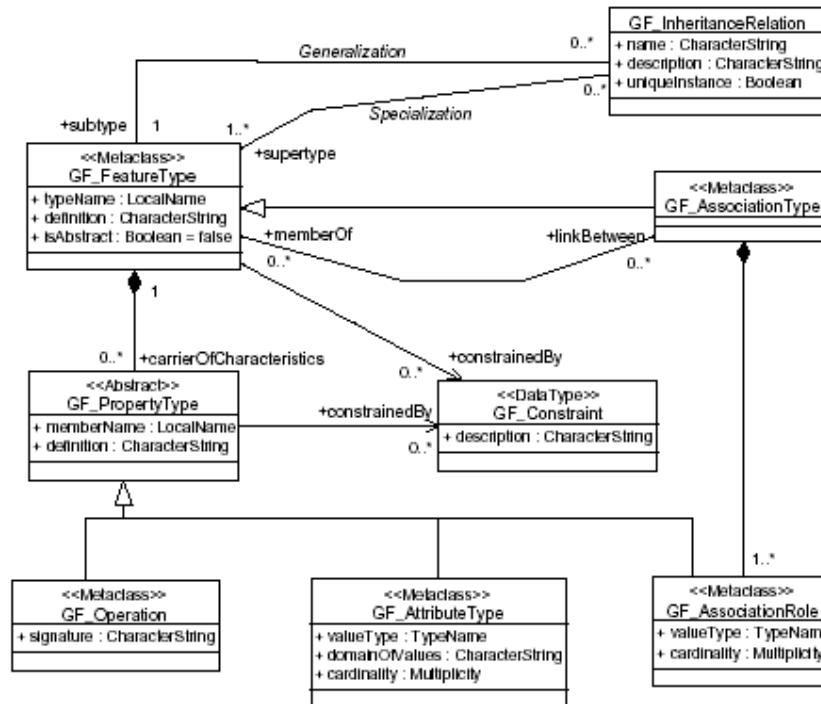


Figure 1 - Extract of General Feature Model

ISO 19109 identifies six attribute types. Value types for five of the attribute types are defined by other standards in the ISO 19100 series of geographic information standards. Table 1 shows these five attributes types and identifies the standard which provides the value type.

Attribute type	ISO standard providing value type
GF_SpatialAttributeType	ISO 19107:2003 Geographic information — Spatial schema
GF_TemporalAttributeType	ISO 19108:2002 Geographic information — Temporal schema
GF_QualityAttributeType	ISO 19115:2003 Geographic information — Metadata
GF_LocationAttributeType	ISO 19112:2003 Geographic information — Spatial referencing by geographic identifiers
GF_MetadataAttributeType	ISO 19115:2003 Geographic information — Metadata

Table 1 - Attribute types and ISO standard providing value type

The sixth attribute type, GF_ThematicAttributeType, represents attributes that carry any other descriptive characteristic of a feature. Value types and value domains for thematic attributes are normally defined by the user or by the application.

ISO 19109 then discusses how to create an application schema in UML. It provides basic rules for representing instances defined by GFM constructs in UML: for example, an instance of feature type is represented as a CLASS in UML and an instance of attribute type is represented as an ATTRIBUTE in UML. Specialized rules are provided for integrating the application schema with schema provided by other standards in the ISO 19100 series of geographic information standards:

- ISO 19115: 2003, Geographic information — Metadata (including data quality reporting)
- ISO 19108:2002, Geographic information — Temporal schema
- ISO 19107:2003, Geographic information — Spatial schema.
- ISO 19107 defines both geometric and topological objects. In the definition of an application schema, ISO 19107 uses structures and definitions from ISO 19111:2003, Geographic information – Spatial Referencing by Coordinates, for geodetic and other coordinate reference systems.
- ISO/DIS 19110, Geographic information — Feature Cataloguing Methodology
- ISO 19112:2003, Geographic information — Spatial referencing by geographic identifiers

Chapter Two: Geospatial Data Development: Building data for multiple uses, of the SDI Cookbook, version 1.1 (2001), identifies ISO 19109 as a standard “that will greatly assist in the global specification of content models and feature models for framework and non-framework data.” [2] At the time of writing (December 2003), ISO 19109 has been submitted to the ISO Central Secretariat for publication as a Final Draft International Standard (FDIS). ISO 19109 is targeted for publication as an International Standard (IS) in May 2004.

ISO 19123, Geographic information - Schema for coverage geometry and functions

The term “coverage” has several definitions in geographic information applications.

The online glossary for the U.S. Fish and Wildlife Service's Interactive Map and Data Server (IMADS) [3] provides these definitions for coverage:

1. A digital version of a map forming the basic unit of vector data storage in ArcInfo. A coverage stores geographic features as primary features (such as arcs, nodes, polygons, and label points) and secondary features (such as tics, map extent, links, and annotation). Associated feature attribute tables describe and store attributes of the geographic features.
2. A set of thematically associated data considered as a unit. A coverage usually represents a single theme such as soils, streams, roads, or land use.

Coverage can also be taken to mean the extent of the earth's surface covered by a data resource such as a national map series or remote sensing data.

ISO 19123, however, defines coverage as a “feature that acts as a function to return values from its range for any direct position within its spatiotemporal domain.” A coverage is a feature that associates positions within a bounded space (its spatiotemporal domain) to feature attribute values (its range). Therefore, coverage is a subset of feature. More specifically, a coverage is a feature that has multiple values for each attribute type, where each direct position has a single value for each attribute type. Examples of data sets that can be represented as coverages include digital orthoimages (where the brightness value is the attribute type) and gridded elevation data sets (where height is the attribute type). Thematic classification maps such as soils maps (where soils classification is an attribute type associated with a direct position associated with an area) is another example of coverage.

Coverages are of two types: discrete or continuous. A discrete coverage has a spatiotemporal domain that consists of a finite collection of geometric objects and the direct positions contained in those geometric objects. Discrete coverages are classified by the type of geometric object in the spatial domain: point, grid point, curve, surface, or solid. The soils map would be an example of a discrete surface coverage. A gridded elevation data set is an example of a discrete grid point coverage. A continuous coverage has a spatiotemporal domain that consists of a set of direct positions in a coordinate space. ISO 19123 specifies schemas for five subclasses of continuous coverages: Thiessen polygon coverages, quadrilateral grid coverages, hexagonal grid coverages, Triangulated Irregular Network (TIN) coverages, and segmented curve coverages. The digital orthoimage is an example of a continuous coverage, more specifically, a quadrilateral grid coverage.

Figure 2 shows the various coverage geometry packages in ISO 19123.

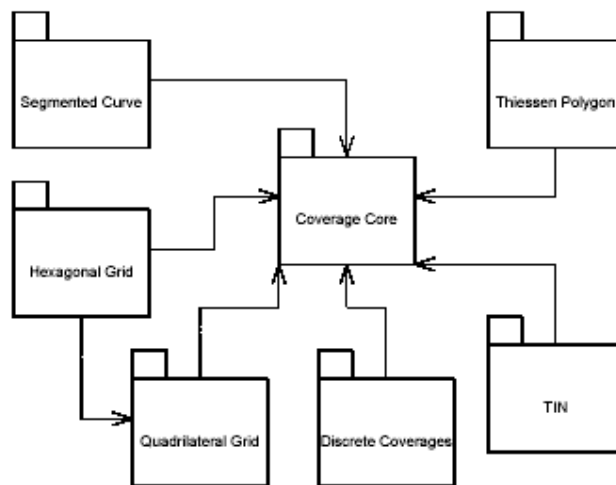


Figure 2 - Coverage geometry packages in ISO 19123

At the time of writing (December 2003), ISO 19123, Geographic information – schema for coverage geometry and functions, has been submitted to the ISO Central Secretariat for registration as a Draft International Standard (DIS). ISO 19123 is targeted for publication in May 2005.

ISO 19115 Geographic information – Metadata

ISO 19115 Geographic information – Metadata provides a schema for geographic information metadata. The ISO 19100 series of geographic information standards defines metadata as simply “data about data.” Metadata enables users to evaluate a geospatial data set for fitness for use in an application. A standardized metadata schema facilitates data discovery through a geospatial data clearinghouse.

The main package in ISO 19115 is Metadata entity set information. It is an aggregate of other packages:

- Identification information – basic information required to uniquely identify a resource or resources
- Constraint information – restrictions on the access and use of a resource or metadata
- Data quality information – scope, lineage (information about events or source data used in constructing the data), and data quality element information (Completeness, Logical Consistency, Positional Accuracy, Thematic Accuracy and Temporal Accuracy).
- Maintenance information - scope and frequency of updating data.
- Spatial representation information - information concerning the mechanisms (grid or vector) used to represent spatial information in a dataset.
- Reference system information - description of the spatial and temporal reference system(s)

- Content information – information about the feature catalogue used and/or information describing the content of a coverage dataset
- Portrayal catalogue information - information identifying the portrayal catalogue used.
- Distribution information - information about the distributor of and options for obtaining a resource.
- Metadata extension information - information about user specified metadata extensions.
- Application schema information - information about the application schema used to build a dataset.
- Extent information – metadata elements that describe the spatial and temporal extent of the referring entity.
- Citation and responsible party information - data types for citing a resource (dataset, feature, source, publication, etc.) and information about the party responsible for a resource.

Among these packages, only the Identification information package is mandatory. The other packages are optional; however, comprehensive documentation of geographic information is encouraged to protect the value of geospatial data assets. ISO 19115 identifies a minimum set of elements for basic documentation.

Among the metadata elements for basic documentation of geospatial are elements to document language and character sets used by metadata and the source data.

The codes in ISO 639-2, Codes for the representation of names of languages-- Part 2: alpha-3 code, are used to identify language [4]. In a press release dated 30 September 2003, ISO reaffirmed free-of-charge use of ISO 639 [5].

The default value for character set code is “utf8,” which represents the 8-bit variable size Universal Character Set (UCS) Transfer Format, or UTF-8. UTF-8 maps character codes in ISO/IEC 10646:2003, Information technology -- Universal Multiple-Octet Coded Character Set (UCS) [6] to unique byte sequences. Character codes and encoding forms such as UTF-8 are synchronized between ISO/IEC 10646 and the Unicode standard [7].

ISO 19115 was published as an International Standard (IS) in May 2003.

Application of standards developed by ISO Technical Committee 211 in Geospatial One-Stop

Geospatial One-Stop is one of 24 E-government initiatives of the U.S. Federal government identified through the President’s E-government strategy [8]. The Office of Management and Budget oversees the direction of all E-Government Initiatives. The Department of the Interior serves as the Managing Partner, and a Board of Directors comprising both Federal and non-Federal representatives provides guidance to the project. The Federal Geographic Data Committee (FGDC) supports Geospatial One- Stop project implementation.

The objectives of Geospatial One-Stop are to:

- Raise the visibility of the strategic value of geographic information and the National Spatial Data Infrastructure (NSDI).
- Accelerate implementation of the NSDI.
- Increase Federal agency accountability for the stewardship and sharing of geospatial resources.
- Make it easier, faster, and less expensive for all levels of government and the public to access geospatial information.

Geospatial One-Stop establishes a collaborative model for directing an intergovernmental initiative. It seeks to integrate numerous government activities across Federal agencies and from Federal, State, and local levels.

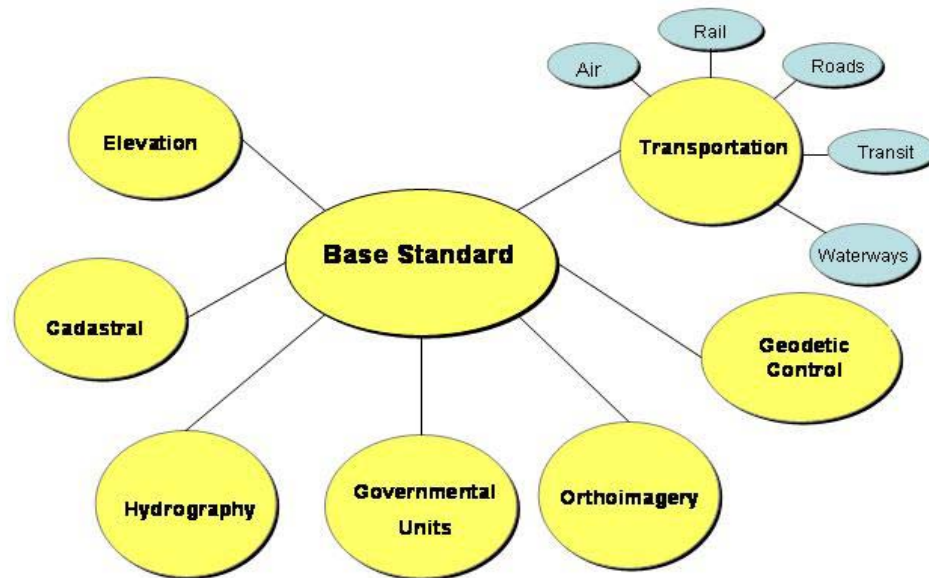
Geospatial One-Stop consists of five modules, each designed to advance the objectives of the initiative:

1. Develop standards for data themes used by many different GIS applications. These themes are known as NSDI Framework themes.
2. Inventory existing Framework data holdings and create metadata to enable data discovery through the NSDI Clearinghouse.
3. Create metadata for planned data acquisition and update of Framework data to enable data discovery through the NSDI Clearinghouse. The intent is to enable opportunities for partnerships.
4. Prototype and deploy enhanced data access and web mapping services for Federal Framework data.
5. Establish a (One-Stop) Federal Portal providing web services to extend the capabilities of the NSDI Clearinghouse Network.

The remainder of this paper will focus on the first module and, to a lesser extent, on the second module.

Seven data themes have been identified as NSDI Framework themes. The seven themes are Geodetic Control, Cadastral Data, Digital Orthoimagery, Elevation, Hydrography, Governmental Units Boundaries, and Transportation. Transportation has five subthemes: Airport facilities, Roads, Railroads, Waterways, and Transit. Figure 3 is a bubble diagram showing how the

NSDI Framework data themes fit into the standard being developed through Geospatial One-



Stop.

Figure 3 – Organization of NSDI Framework Themes in Geospatial One-Stop Standard

As standards in the ISO 19100 series of geographic information standards have reached a level of maturity in the ISO standards process, standards development teams applied these standards in the development of standards for NSDI Framework data themes.

Application of ISO 19109

The NSDI Framework themes for Geodetic Control, Cadastral data, Hydrography, Governmental Units Boundaries, and Transportation applied ISO 19109, Geographic information – Rules for applications schema, to define feature types and their attribute types and to create an application schema in UML. This section will use the Governmental Units Boundaries theme to show how ISO 19109 was used in the development of standardized data content.

Figure 4 shows the UML model for the Governmental Unit Boundaries data theme.

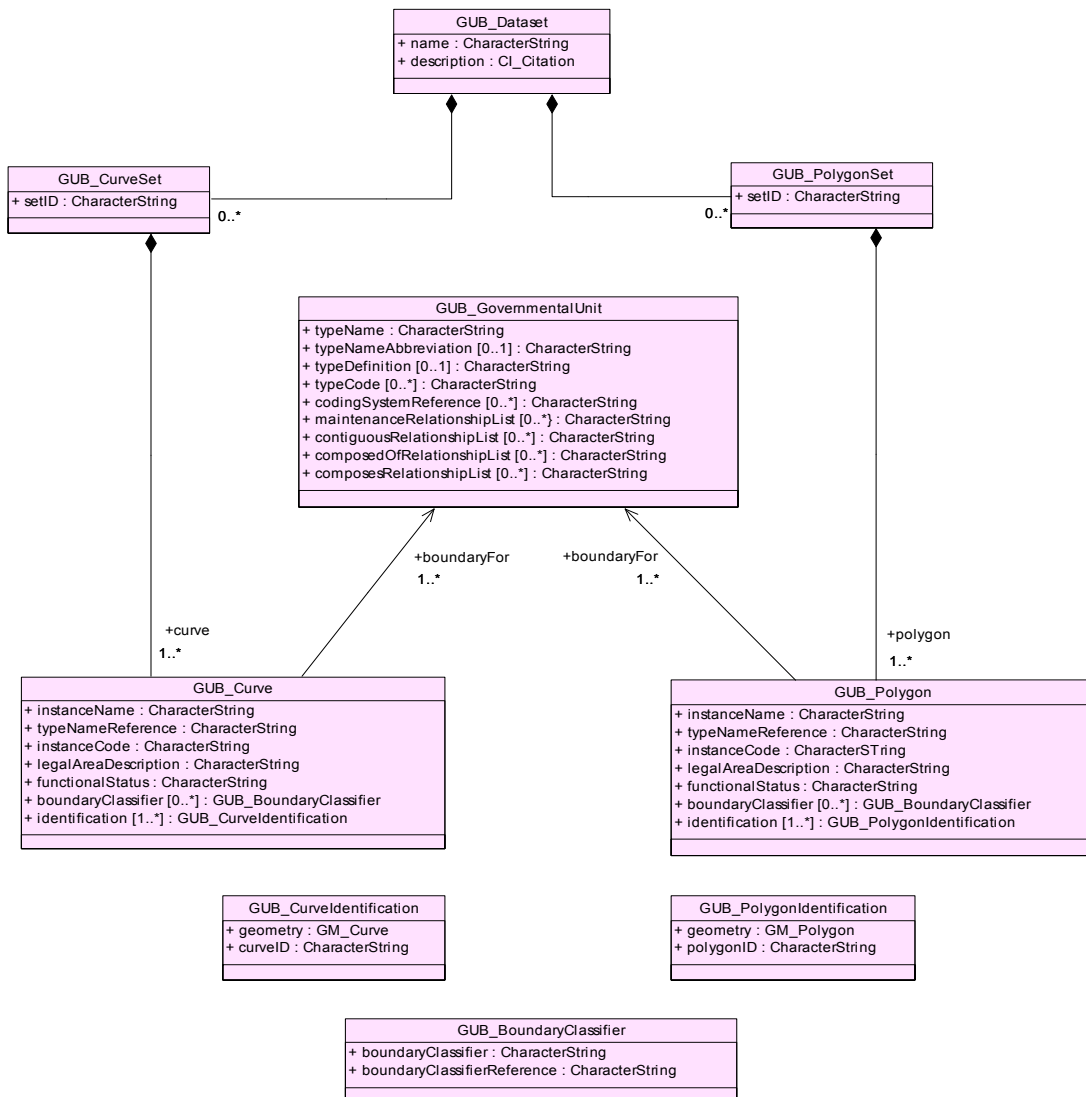


Figure 4 - UML Model for Governmental Unit Boundaries

Figure 4 illustrates the re-use of structures and definitions of other standards in the ISO 19100 series of geographic information standards. The attribute type description for the GUB_dataset entity uses CI_Citation from the citation and responsible party package in ISO 19115, Geographic information – Metadata, as a value type. The attribute type “geometry” in the GUB_CurveIdentification class inherits characteristics from GM_Curve class in ISO 19107, Geographic Information – Spatial Schema. Similarly, the attribute type geometry in the GUB_PolygonIdentification inherits characteristics from the GM_Polygon class in ISO 19107.

The standards being developed through Geospatial One-Stop contain documentation of all features, attributes, and relationships and their definitions. A data dictionary table is used to describe the characteristics of the UML model diagrams in terms of Name/role name, definition,

obligation/condition, maximum occurrence, data type, and domain. Table 2 shows documentation for the GUB_GovernmentalUnit entity.

B.1.1.1.1 GUB_GovernmentalUnit					
Name	Definition	Obligation	MO	Data Type	Domain
GUB_GovernmentalUnit	The GU being documented	M	1..*	Class	Lines 20-28
typeName	The designated name for the type of GU whose data are being described	M	1	CharacterString	Annex C, free text
typeNameAbbreviation	The abbreviated name for the type of GU whose data are being described	C/ if an abbreviation exists for GU Type Name	0..1	CharacterString	Free text
typeDefinition	Definition of the type of GU whose data are being described	C/ if the type definition is known	0..1	CharacterString	Annex C, free text
typeCode	The specific code which identifies the GU being described	C/ if a type code exists	0..*	CharacterString/ Integer	Free number
codingSystemReference	GU type code reference	M	1..*	CharacterString/ Integer	FIPS code, free text, free number
maintenanceRelationshipList	List of common areal information between one or more GUs or legal entities and geographic area features for the GU type being described	C/ if one or more maintenance relationships exist	0..*	CharacterString	Free text
contiguousRelationshipList	List of GUs or feature objects that share a common point or portion of a boundary	C/ if one or more contiguous relationships exist	0..*	CharacterString	Free text
composedOfRelationshipList	List of GU or feature object that contains subentities that are completely contained within and are the extent of the entity	C/ if one or more composed of relationships exist	0..*	CharacterString	Free text
composesRelationshipList	List of GU subentities that are completely contained within an entity	C/ if one or more composes relationships exist	0..*	CharacterString	Free text

Table 2 - Documentation for GUB_GovernmentalUnit entity

The name/role name is a label assigned to an entity or element. In Geospatial One-Stop, entity names shall begin with a three letter abbreviation that denotes the UML. "GUB" denotes the UML package for Governmental unit boundaries. Element names are unique within an entity by the combination of the entity and element names (example: GUB_GovernmentalUnit.typeName).

The definition is the description of the entity or element.

Obligation indicates whether an entity or element shall always be documented (i.e. contains value(s)) or sometimes is documented. This descriptor may have the following values: M (mandatory), C (conditional), or O (optional).

Mandatory (M) indicates that the entity or element shall always be documented. Here, the entity GUB_GovernmentalUnit shall always be documented, and elements GUB_GovernmentalUnit.typeName and GUB_GovernmentalUnit.codingSystemReference within that entity shall always be documented.

Conditional (C) specifies a condition under which an entity or element is mandatory. If the answer to a condition is positive, then the entity or the element shall be mandatory. To facilitate understanding by users, the condition is stated in plain text (ex. " C/ if one or more maintenance relationships exist" for GUB_GovernmentalUnit.maintenanceRelationshipList)

Optional (O) indicates that an entity or element may be documented or may not be documented. Optional entities may have mandatory elements: if the optional entity is used, the mandatory elements within that entity shall be documented. If an optional entity is not used, the elements contained within that entity (including mandatory elements) are not be used. Table 2 contains no optional elements.

Maximum occurrence (abbreviated as "MO" in Table 2), also known as cardinality, specifies the maximum number of instances the entity or the element may have. Single occurrences are shown by "1"; repeating occurrences are represented by "N". Fixed number occurrences other than one are allowed, and will be represented by the corresponding number (i.e. "2", "3"...etc). "0" indicates an optional or conditional obligation: for example: GUB_GovernmentalUnit.maintenanceRelationshipList has zero or at least one occurrence, represented as 0..*, consistent with its conditional obligation.

Data type specifies a set of distinct values for representing the elements, for example, CharacterString. The data type attribute is also used to define entities, stereotypes, and associations.

For an entity, the domain indicates the line numbers for the entries covered by that entity.

For an element, the domain specifies the values allowed or the use of free text. "Free text" indicates that no restrictions are placed on the content of the field. Integer-based codes, such as Federal Information Processing Standards (FIPS) codes, shall be used to represent values for domains containing code lists.

Application of ISO 19123

Standards for the Elevation and Digital Orthoimagery themes applied ISO 19123, Geographic information - Schema for coverage geometry and functions. For these themes, an attribute type is common to all positions in the spatiotemporal domain. The standards development team for elevation data found ISO 19123 so complete in providing schemata for different representations of elevation data such as gridded elevation data and TINs that its leader was concerned about violating copyright because the projected standard would incorporate large portions of ISO 19123.

It should be pointed out that representations of geographic phenomena as discrete features or coverages are not mutually exclusive. A discrete feature or a coverage could represent the same phenomenon. For example, a geodetic control dataset could be represented as a point coverage. Similarly, ownership parcels in a cadastral data set could be represented as a polygon coverage.

Figure 5 shows top level classes from the working draft document for digital orthoimagery.

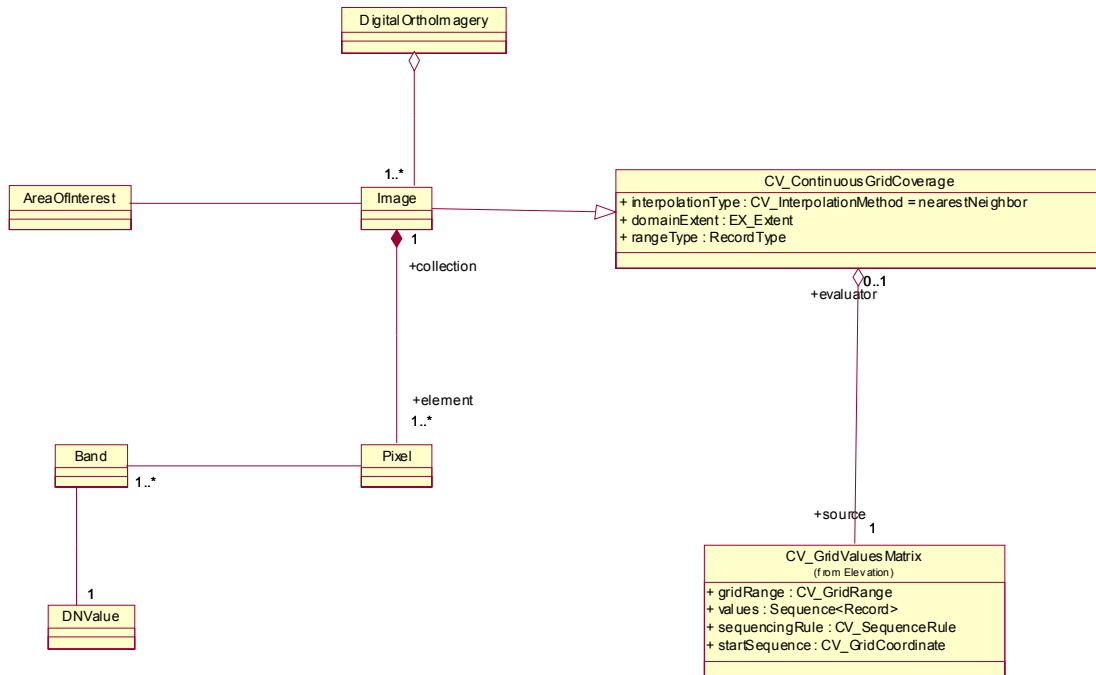


Figure 5 – Top Level Digital Orthoimagery Classes

The entity names in Figure 5 have not yet been revised to begin with a three letter abbreviation denoting the UML package for digital orthoimagery. Two entity names, **CV_ContinuousGridCoverage** and **CV_GridValuesMatrix**, suggest that the classes came directly from ISO 19123; however, there is no class named **CV_ContinuousGridCoverage** in ISO 19123, while the **CV_GridValuesMatrix** class in Figure 5 differs from the **CV_GridValuesMatrix** class in ISO 19123, as it contains an additional attribute type (**GridValuesMatrix.values**). Despite these problems, these two classes show how the digital orthoimagery theme took advantage of data types defined in the ISO 19100 series of geographic information standards: for example, **EX_Extent** was defined in ISO 19115. The **CV_SequenceRule** data type was defined in ISO 19123, and the **CV_GridRange** data type reuses the **CV_GridCoordinate** data type defined in ISO 19123.

Application of ISO 19115

ISO 19115, Geographic information – Metadata, is relevant to every NSDI Framework theme. In discussing the application of ISO 19115 to Geospatial One-Stop, this paper will focus on the core set of metadata elements identified in ISO 19115 for basic documentation of geospatial data.

Standards developed through Geospatial One-Stop will be compliant with ISO 19115. Metadata elements from ISO 19115 have been crosswalked with metadata elements from the FGDC Content Standard for Digital Geospatial Metadata version 2.0, FGDC-STD-001-1998 [9]. Generally, there is good agreement between ISO metadata elements and FGDC metadata

elements. Standards developed through Geospatial One-Stop will also be compliant with the FGDC Metadata standard.

Both ISO 19115 and the FGDC Metadata standard provide metadata elements for keywords. A keyword is a work or phrase that signifies the meaning or main ideas of a data set. Keywords are core elements for both ISO 19115 and the FGDC Metadata standard. They are often used as an index to the contents of a data set and facilitate data discovery through a geospatial data clearinghouse. A thesaurus of keywords was created for NSDI Framework data themes to fulfill the requirements of Module 2 of Geospatial One-Stop. The theme keyword values from the thesaurus are presented in Table 3.

NSDI Framework theme	Theme Keyword Value
Cadastral	FWCADASTRAL
Elevation	FWELEVATION
Geodetic Control	FWGEODETTICCONTROL
Governmental Units	FWGOVERNMENTALUNITS
Hydrography	FWHYDROGRAPHY
Orthoimagery	FWORTHOIMAGERY
Transportation	FWTRANSPORTATION
Air	FWAIR FWTRANSPORTATION
Rail	FWRAIL FWTRANSPORTATION
Roads	FWROADS FWTRANSPORTATION
Transit	FWTRANSIT FWTRANSPORTATION

Table 3 - Keyword values for NSDI Framework data themes

Below is an example of XML data encoding for NSDI Framework data themes. The tags <themekt></themekt> and <themekey></themekey> are short names for the Theme Keyword Thesaurus and Theme Keyword metadata elements from the FGDC Metadata standard.

```
<theme>
  <themekt>FGDC Framework Themes</themekt>
  <themekey>FWELEVATION</themekey>
  <themekey>FWORTHOIMAGERY</themekey>
</theme>
```

There are a few important differences between ISO 19115 and the FGDC Metadata standard. ISO 19115 provides a metadata element for data set topic category, which is a core metadata element. The FGDC Metadata standard does not have a metadata element for data set topic category. Geospatial One-Stop adopts the list of data set categories provided by ISO 19115 as the basis of data “channels” for the web portal being developed through Module 5.

As noted earlier, ISO 19115 provides mandatory or conditional metadata elements for language and character sets, which are core metadata elements. However, the FGDC Metadata standard does not have metadata elements for language and character sets. It should be not surprising that the FGDC Metadata standard lacks elements for language and characters, as most government and business activities in the United States are conducted in English. However, specification of language and character sets is an issue in India, which has two national languages (English and Hindi) and fourteen official regional languages with various scripts. It will become an issue for the United States as development of a North American profile of ISO 19115 gets underway to include both Canada and Mexico.

Summary and Conclusions

This paper has provided an overview of three standards from the ISO 19100 series of geographic information standards developed by ISO Technical Committee 211, Geographic information/Geomatics. ISO 19109, Geographic information – Rules for applications schema, presents the General Feature Model (GFM) for definition of geographic features and provides rules for definition of an applications schema in UML. ISO 19123, Geographic information - Schema for coverage geometry and functions, provides a conceptual schema for coverages. Coverage is a feature that associates positions within a bounded space (its spatiotemporal domain) to feature attribute values (its range) where the attribute type is common to all geographic positions within the spatial domain. ISO 19115, Geographic information – Metadata, provides a schema comprising various packages for comprehensive documentation of geographic information. ISO 19109, ISO 19123, and ISO 19115 are instrumental in the development of standardized data content for different applications. These three standards rely on other standards, both within and external to the ISO 19100 series of geographic information standards.

This paper then provided an overview of the Geospatial One-Stop e-Government initiative to make access to geographic information easier, faster, and less expensive for all levels of government and the public. One of the project modules of Geospatial One-Stop is to develop standards for NSDI Framework data themes needed by many different geospatial applications. Standards development teams applied the ISO 19100 series of geographic information standards in the development of standards for NSDI Framework data themes. This paper used the Government Units Boundaries schema to demonstrate the application of ISO 19109 and used the Digital Orthoimagery schema to demonstrate the application of ISO 19123. These examples show how the data standards for NSDI Framework themes also used elements defined in other standards. Standards developed through Geospatial One-Stop will be compliant with ISO 19115 and the FDGC Content Standard for Digital Geospatial Metadata version 2.0, FGDC-STD-001-1998, and differences between the two standards will be accommodated.

Geospatial One-Stop represents the first time that the U.S. has applied the ISO 19100 series of geographic information standards in the development of data standards, at least at this large scale. This was because standards within the program of work of ISO Technical Committee 211 had reached a level of maturity in the ISO standards development process. Development of data standards using the ISO 19100 series of geographic information standards has been very complex, due to the learning curve in grasping and applying new and unfamiliar concepts. At the time of writing, the standards being developed through Geospatial One-Stop are still working drafts and subject to change. As these standards become firm and get approved as American National Standards, the UML information content will be transformed into specific encoding environments, such as Geography Markup Language (GML) and Extensible Markup Language (XML). Only then will the promise of data interoperability be fully realized.

References

- ISO Technical Committee 211, Geographic information/Geomatics, <http://www.isotc211.org/> [1]
- This web site provides links to purchase ISO 19115: 2003, Geographic information – Metadata and other published International Standards in the ISO 19100 series of geographic information standards. Draft standards are password-protected, and users should contact the ISO member body in their country to obtain copies of the draft standards.
- Developing Spatial Data Infrastructures - SDI Cookbook, version 1.1 (15 May 2001), <http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf> [2]
- U.S. Fish and Wildlife Service Interactive Map and Data Server Glossary, <http://www.fws.gov/data/IMADS/glossary.htm> [3]
- ISO 639-2, Codes for the representation of names of languages-- Part 2: alpha-3 code, <http://www.loc.gov/standards/iso639-2/> [4]
- ISO reaffirms free-of-charge use of its country, currency and language codes, <http://www.iso.org/iso/en/commcentre/pressreleases/2003/Ref871.html> [5]
- ISO/IEC 10646: International Organization for Standardization. Information Technology - Universal Multiple-Octet Coded Character Set (UCS) [Geneva]: 2003. (ISO/IEC 10646:2003) [6]
- The Unicode standard, <http://www.unicode.org/standard/standard.html> [7]
- Geospatial One-Stop, <http://www.geo-one-stop.gov> [8]
- This web site contains information about the Geospatial One-Stop e-government initiative, drafts of the standards being developed through Geospatial One-Stop, and guidance for Module 2.
- Content standard for digital geospatial metadata, Version 2.0 (revised June 1998), FGDC-STD-001-1998, <http://www.fgdc.gov/metadata/constan.html> [9]