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Civil servants learning programme

DISTANCE LEARNING OF GEOGRAPHIC INFORMATION INFRASTRUCTURE

Training Material

# STANDARDS, SPECIFICATIONS AND METADATA FOR GEOGRAPHIC INFORMATION

# GII-03

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Training material „Standards, specifications and metadata for Geographic information“ (GII-03)

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# 1 Introduction to Geo-Spatial Standards and Specifications

Geo-spatial standards can greatly benefit different members of society, such as businesses, customers, governments, trade officials, developing countries, consumers, as well as an citizen of the planet. This module introduces geo-spatial standards and specifications. The needs for spatial standards, required to build a Spatial Data infrastructure, are listed in this module. Major international, regional and local standardization organizations set forth geo-spatial standards that can be used in building a Lithuanian Geographic Information Infrastructure are outlined in this module. Information Technology standards and specifications that affect geo-spatial standardization processes are also discussed. Standard development processes for initial and derived (profiled) standards and specifications are examined in detail. Recommendations for developing national and sub-national standards are provided are summarized at the end of the module.

<u>Module Outline</u>

Topic 1: Definitions
Topic 2: Needs for SDI Standards
Topic 3: What Organizations Produce Geospatial Standards
Topic 4: Types of Standards Impacting Spatial Data Infrastructure
Topic 5: The Standards Development Process, Profiling
Topic 6: What Should Local Governments Do? What Should A Nation Do?
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## 1.1 Definitions

Before discussing geo-spatial standards and specifications, some general definitions are required, such as what is a “standard”, a “specification” and what is the difference between these two terms.

A **standard** is a documentation that is established by consensus and approved by an accredited standards body recognized by industrial, professional, trade, or governmental organizations nationally or internationally. Standards reflect agreements on products, production method, terminology, practices, services or operations. Compliance, however, is not mandatory. Standards are established to achieve an optimum degree of order and consistency in the production and reliability of a product or a service. Standards provide rules, guidelines, or characteristics for activities or their results for common and repeated use.

A **specification** is an essential *technical* documentation that *precisely* prescribes the requirements, design, behavior, or/and characteristics for systems, items, materials, procedures or/and services. A specification is intended primarily for supporting the procurement of a service.

A specification is a more industry-oriented documentation and ready-to-use in practical applications. A standard is a more abstract or conceptual description that can be practically applied but requires further detailed elaboration. A standard is open to some interpretation.

Often, a standard is set up and established by a recognized authority or standard-setting organization. The authority of a specification rests on its inherent technical excellence and on the breadth of its acceptance in the marketplace.

## 1.2 Need for SDI Standards

For the past thirty years, many organizations have applied computer and information technology to assist in cartography, surveying, photogrammetry, urban planning and other geo-information related application areas. At first, individual organizations implemented their own mapping computer-assisted systems to satisfy specific production needs. These systems were primarily geared for the production of hard copy maps. There was little data inter-exchange between mapping organizations and little need for geo-spatial standards.

Over time, manufacturers developed computer-assisted mapping systems in the form of mapping hardware workstations using GIS and mapping software packages. Equipment of different manufacturers was incompatible; software worked with proprietary data formats. There was no standardization.

Historically, geographic information has been handled in a variety of different data structures and architectures. Due to the nature of GIS, data sharing is extremely important in order to create a complete and correct solution to a geographic-based problem. The data incompatibilities problem was being solved temporarily by developing data conversion software utilities. However, this problem requires more comprehensive solutions, namely geo-spatial data transfer standardization. Initially geo-spatial standards addressed the problem of geographic information incompatibilities and proprietary spatial data transformation problems in order to create an open exchange of data worldwide.

Standards were then developed within organizations. If the organization was influential, it tried to convince others within its industrial sector to use the same standards. Some manufacturers' systems have been very successful and their proprietary data formats have become the de-facto data standards (e.g., DXF format of Autodesk, SHP format of ESRI). These manufacturers have even developed their own user communities.

Many organizations, over the years, have invested significant sums of money, time and effort into implementing third-party spatial tools and customizing them to meet their needs. However, there are any number of examples over the past couple of decades where that investment has had to be thrown away and re-implemented using another product. Some examples are

- A vendor ceases to be financially viable and closes shop.
- A vendor is taken over by another entity to remove competition or purchase market share; it is trendy to have one of those in the portfolio.
- A vendor retires a product range to focus on a new technology but does not worry about providing an upgrade path.

Many organizations have been bitten by these scenarios.

In response to this predicament, there have been a number of efforts to develop public domain standards in different nations and for different application areas. Some of these have been successful within their area of influence. In some cases, the success of narrowly focused standards hinders broader standardization. Over a decade ago, international standards organizations and consortiums that represented different nations took the task of standardizations in the geo-information domain into their own hands.

International standards give organizations a way to abstract their business functionality in such a way that they will be able to swap in and out of vendors or use open source components. If done right, they can avoid situations of re-implementing spatial components into their businesses.

Geospatial standards are becoming increasingly important now, especially when international, regional, and national bodies are trying to build or/and harmonize their Spatial Data Infrastructures (**SDI**). The geo-information industry continues to expand through the application and manipulation of geospatial data and services. A Spatial Data Infrastructure provides a basis for the discovery, evaluation, and application of geospatial data and services by users and providers. All levels of government, commercial and non-profit sectors, and academia can benefit from SDI.

Spatial Data Infrastructure encompasses the technology, policies, standards, and institutional arrangements necessary to acquire, process, store, distribute, and improve the utilization of geospatial data - data from many different sources and for potential use by a wide group of users.

- The National SDI is composed of:
    - Data Access Policies
    - Clearinghouse
    - Metadata
    - Data Protection
    - Geospatial data
    - Partnerships
    - Leadership
    - Standards
    - Communication Network (e.g. a Portal)

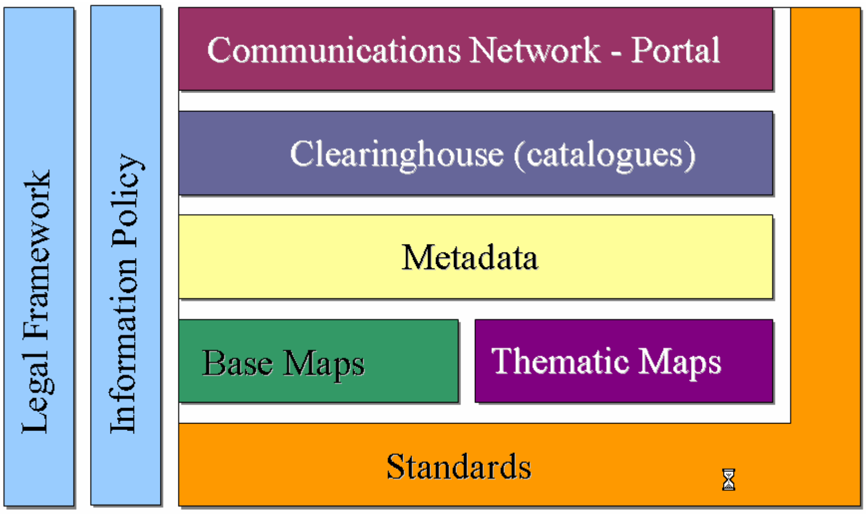



**Figure: The components of a national SDI**

Standards are one of the key components of SDI. The ability of the parts of the SDI to interoperate is dependent upon standards. Standards provide a language and rules for collaboration among participants. Without standards, this interaction is impossible. Standardization contributes to a more stable infrastructure. A minimum set of standard practices, protocols and specifications are needed to support an environment that facilitates access to geographically-related information.

The creation of SDI standards is driven by production and distribution cost efficiencies, potential market development, and control issues. The following concepts are behind these driving forces:

- *Portability* or "interchangeable parts" - this concept implies ability to use and move data, software, and custom applications among multiple computers and operating system environments without re-tooling or reformatting.
- *Interoperability* and *information access – these* concepts affect computers and networks, along with the users' ability to connect and retrieve information from multiple systems.
- *Maintainability* – this concept addresses the use of standards to promote long-term and efficient updating, upgrading, and the effective use of computer systems and databases and to facilitate information sharing.

The creation of standards is also driven by:

- Potential market development and control issues.
    - For example, standards can be used for quality control; they provide a technical base for safety.
- Technology transfer and the potential for efficiency improvement, due to the standard, for any user organization.
    - Standards and technology are closely linked and there is a global marketplace for geomatics technology.
    - For example, up-to-date standards can aid in transferring technology into user production systems.
- Political compromises, democratic mechanisms, and consensus of technical solutions.
    - Standards enable easier and fairer trade flows between countries.
    - In the case of standards used by political entities (e.g., countries), the use or avoidance of a standard may represent a political efficiency as well as an economic one.

In general, standards that affect SDI may be categorized as:

- 'Independent' (also referred to as 'consensus') or "*de jure*" standards:
    - A recognized body through a well-defined consensus setting, in which multiple interested parties have participated, formally approves independent standards.

- '*De facto*' standards:
    - De facto standards are those that become accepted because of their broad popularity and use but are not necessarily accompanied by any formal approval by an independent standards organization.
        - For example, the Keyhole Markup Language (KML) from Google; Open Database Connectivity (ODBC) developed by Microsoft Corporation; and DXF data exchange format of Autodesk.

## *1.3 What Organizations Develop Geospatial Standards?*

A range of organizations develops geospatial standards. These organizations can be categorized on a hieratical basis (international, regional, national, etc.), and by authority status (independent inter-governmental bodies, public consortia and associations, and professional organizations). The organizations that are developing geospatial standards can belong to one of the following bodies:

- International independent standards bodies
- Regional independent standards bodies
- International industrial consortia and trade associations
- National government organizations
- Sub-national government organizations
- Professional organizations

For the Lithuanian Geographic Information Infrastructure (**LGII**), and its users, there are three standardization systems what are most relevant: the International Organization for Standardization (**ISO**), the regional European Committee for Standardization (**CEN**), and Lithuanian national standardization bodies and organizations.

### 1.3.1 International Independent Standards Bodies

A number of international bodies develop international standards. Some of the existing international standards bodies include the International Organization for Standardization (**ISO**), the International Electrotechnical Committee (**IEC**), and the International Telegraphic Union (**ITU**). In the field of geo-information more topic-specific international standards development is done by the ISO.

The International Organization for Standardization is a worldwide federation of national standards bodies (http://www.iso.org/). ISO is a network of the national standards institutes representing 157 countries. One member per country is represented and the Central Secretariat is located in Geneva, Switzerland, where it coordinates the entire system. ISO is a non-governmental organization. Many of its member institutes are part of the governmental structure within their own country or have been mandated by their government to present the state. ISO acts as a bridging organization where consensus is attained on solutions that meet the requirements of business and society in general.

ISO is responsible for promoting the development of standards to facilitate the international exchange of goods and services. This formal standards body works on a consensus-building process when adopting and promoting formal standards. It includes representation from government agencies, professional organizations, and private companies. ISO, as an independent standards body, has open policies for membership (with rules for participation) and formal committee structures and procedures for standards development, review, and approval. Comments by individual nations are made through their respective national standards body.

ISO international standards provide a reference framework, or a common technological language, between suppliers and their customers, thereby, facilitating trade and the transfer of technology. ISO standards are voluntary. As a non-governmental organization, ISO has no legal authority to enforce the implementation of specific standards (http://www.iso.org/iso/en/aboutiso/introduction/index.html).

## Technical Committee 211 (ISO/TC 211)

In 1993, a **GIS Committee** was formed within the **ISO** to address a wide range of standards that affect GDI. This Committee, now called the *Geographic Information / Geomatics Committee* (**Technical Committee 211**), includes participants from most of the developed and developing nations.

**Technical Committee 211** (ISO/TC 211) is dedicated to developing and deploying standards relating to geographic information / geomatics. It is also known as the **ISO 19100 series** (http://www.isotc211.org/). ISO/TC 211 tries to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with locations on the Earth.

ISO/TC 211 provides standards for:

- Geospatial data, including imagery and information;
- Geospatial data administration and information management; and
- Geospatial services, including location-based services.

Currently, there are 43 registered projects in the **ISO 19100 series** (19101–19143). Among them are 33 functional international standards and reports (on June 2007) and the others are under development and/or review. A few projects have been canceled and, therefore, some gaps exist in the numeration.

ISO/TC 211 geographic information standards may specify methods, tools, and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting, and transferring such data in digital/electronic format between different users, systems, and locations. The ISO TC211 family of standards defines rules and standardized schemata for the definition and description of geographic information and information management.

The Committee has established Working Groups to address standards that cover such topics as data transfer, metadata, data classification, data quality, and other related topics. ISO/TC 211 organizational structure, members, liaisons, and Working Groups are presented in http://www.isotc211.org/ under *Organization* link. Working Groups are finalizing a family of standards; this process involves the development of one or more committee drafts, a draft international standard, and finally the international standard.

The current stats for the ISO/TC 211 Geographic information/Geomatics Committee:

- Number of published ISO standards under the direct responsibility of the TC 211 Secretariat: 37
- Participating countries: 29
- Observer countries: 31

List of published ISO standards and/or guides of TC 211 could be found in http://www.isotc211.org/ under *About ISO/TC 211 > Published Standards and Reports*

It should be noted that the core ISO TC 211 standards are conceptual (*abstract*). The "first generation" GIS standards, being created within ISO/TC 211, are, for the most part, written at an **abstract specification** level. These standards provide a solid foundation for the development of technological *implementation specifications*. ISO standards could be considered necessary but they are not sufficient for building SDI or its parts. Implementation standards (technical specifications) are needed for information coding, software interfaces, data structure specifications, inter-exchange protocols, etc. Other organizations, such as The Open Geospatial Consortium (**OGC**), are carrying out the standards and specifications for implementation tasks. Many of the second generation of ISO TC 211 standards are based on more detailed OGC specifications. It could be noted that the second generation of ISO standards (for example, ISO/TS 19103:2005 -- Conceptual schema language) also can be considered as technical specifications (**TS**). Thus, core standards from the ISO 19100 series, including ISO 19107, ISO 19115 and ISO 19119, are also abstract specifications of OGC.

In this course, we will be discussing ISO/TC 211 standards. These can be divided into the following groups:

- Guidance category of geospatial standards (organizational and educational standards);
- Content and data category of geospatial standards;
- Services' and reports' categories of geospatial standards (access and technology standards);
- Metadata and quality categories of geospatial standards.

Guidance category of geospatial standards (organizational and educational standards) includes the following standards:

- ISO 19101:2002 Geographic information - Reference model
- ISO/TS 19104 Geographic information - Terminology
- ISO 19105:2000 Geographic information - Conformance and testing
- ISO 19106:2004 Geographic information - Profiles
- ISO/TR 19120:2001 Geographic information - Functional standards
- ISO/TR 19122:2004 Geographic information / Geomatics - Qualification and certification of personnel
- ISO 19135:2005 Geographic information - Procedures for item registration

Content and data categories of geospatial standards include the following standards:

- ISO/TS 19103:2005 Geographic information - Conceptual schema language
- ISO 19107:2003 Geographic information - Spatial schema
- ISO 19108:2002 Geographic information - Temporal schema
- ISO 19109:2005 Geographic information - Rules for application schema
- ISO 19111:2007 Geographic information - Spatial referencing by coordinates
- ISO 19112:2003 Geographic information - Spatial referencing by geographic identifiers
- ISO/TR 19121:2000 Geographic information - Imagery and gridded data
- ISO 19123:2005 Geographic information - Schema for coverage geometry and functions
- ISO/TS 19127:2005 Geographic information - Geodetic codes and parameters
- ISO 19131:2007 Geographic information - Data product specifications
- ISO 19137:2007 Geographic information - Core profile of the spatial schema

Services' and reports' categories of geospatial standards (access and technology standards) include the following published standards:

- ISO 19116:2004 Geographic information - Positioning services
- ISO 19117:2005 Geographic information - Portrayal
- ISO 19118:2005 Geographic information - Encoding
- ISO 19119:2005 Geographic information - Services
- ISO 19125-1:2004 Geographic information - Simple feature access - Part 1: Common architecture

- ISO 19125-2:2004 Geographic information - Simple feature access - Part 2: SQL option
- ISO 19128:2005 Geographic information - Web map server interface
- ISO 19133:2005 Geographic information - Location-based services - Tracking and navigation
- ISO 19134:2007 Geographic information - Location-based services - Multimodal routing and navigation

Services' and reports' categories of geospatial standards (access and technology standards) include the following under-development standards:

- 19136 - Geography Markup Language, 2007-04
- 19142 - Web Feature Service, 2009-02
- 19143 - Filter encoding, 2009-02

Metadata and quality categories of geospatial standards include the following standards:

- ISO 19110:2005 Geographic information -- Methodology for feature cataloguing
- ISO 19113:2002 Geographic information -- Quality principles
- ISO 19114:2003 Geographic information -- Quality evaluation procedures
- ISO 19115:2003 Geographic information -- Metadata
- ISO/TS 19138:2006 Geographic information -- Data quality measures
- ISO/TS 19139:2007 Geographic information -- Metadata -- XML schema implementation

ISO TC211 makes extensive use of formal modeling techniques. Many of the TC211 standards are general models. Subsets and instances of these models can be combined to address data sets, services, and operations on geographic data. The *modeling* language used by ISO TC211 is the Universal Modeling Language (**UML**). We will examine this language in the following modules.

ISO standards usually use the Extensible Markup Language (**XML**) for *encoding* of data records within information files (e.g. metadata files). XML is a set of rules for creating standard information formats using customized tags and sharing both the format and the data across applications. XML developed by the W3C. XML has become an industry standard for storing data and transferring it across the Internet. XML is a widely accepted encoding methodology with international software support. It is supported by a lot of software, both free and commercial. Support for XML in parsing and presentation solutions is widespread on the Web and is presumed in current draft standards of the ISO TC 211 and OpenGIS specifications.

Thus, ISO UML data models in .xmi format (defined by OMG, http://www.omg.org/) can be transformed to XML/Geography Markup Language (**GML**) schema documents (the Document Type Definition (**DTD**)) through software tools. Further, the XML/GML schema documents can be used to create, validate, and process geographic information with XML parsing and validation software. We will also use XML language in the following modules.

### 1.3.2 Regional Independent Standards Bodies

Europe is the initial interoperability resting ground to test international geo-spatial standardization strategies. The Infrastructure for Spatial Information in Europe (**INSPIRE**) initiative (www.ec-gis.org/inspire) was launched at the end of 2001 with the aim of making available relevant, harmonized, and quality geo-information for the purpose of formulation, implementation, monitoring, and evaluation of Community policy making. To achieve its aim, INSPIRE has been addressing a broad set of issues, including common reference data and metadata, architecture and *standards*, legal aspects and data policy, funding and implementation structures, and impact analysis. The objective is to arrive at an agreed European legal framework that, whilst focusing on the needs of environmental policy, will subsequently be extended to other areas of Community concerns such as agriculture, regional policy, and transport.

A pan-European body called the Comité européen de normalization (**CEN**) is the main regional European standardization body and operates through the European Commission. The European Committee for Standardization was founded in 1961 by the national standards bodies in the European Economic Community and EFTA countries (http://www.cen.eu/CENORM/aboutus/index.asp).

In 1992 the Comité Européen de Normalisation created technical committee number **287** with responsibility for geographic information standards. **CEN/TC (Technical Committee) 287** *Geographic Information* is responsible for development and publishing of geographic information standards.

In the area of the Geographic Information, CEN works closely with the International Organization for Standardization (ISO). CEN standards are mandatory in Europe. A family of European Pre-standards has now been adopted. There are 23 published standards of CEN/TC 287 (http://www.cen.eu/CENORM/BusinessDomains/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Standards.asp?param=6268&title=CEN%2FTC+287) and 8 standards under development (work started, drafts issued). Most of the CEN/TC 287 standards are based on respective standards of the ISO/TC 211 19100 series.

INSPIRE uses CEN/TC 287, ISO/TC 211 and Open Geospatial Consortium standards and specifications.

The member of another large mapping organization that is EuroGeographics (represents 49 National Mapping and Catastral Agencies from 42 countries across Europe, http://www.eurogeographics.org) are working to deliver the European Spatial Data Infrastructure (ESDI). EuroGeographics is providing the foundation of the ESDI by product specifications (especially in the field of metadata and mapping) that will be recognized as standard by the industry and will support the geographic information overall interoperability.

### 1.3.3 Industrial Consortia and Trade Associations

One of most active industrial consortium involved in geo-spatial standard development and promotion is the Open Geospatial Consortium (**OGC**), formerly the Open GIS Consortium. OGC is an international industry consortium of 344 companies, government agencies, and universities participating in a consensus process to develop publicly available interface specifications (http://www.opengeospatial.org). These support interoperable solutions that "geo-enable" the internet, wireless, and location-based services, as well as mainstream Information Technology. The products of OGC are OpenGIS® Specifications that often relate to technology implementations, including definition of open interfaces.

OGC has concentrated its efforts in the following areas:

- The encoding of information in software systems (data format standards and data transfer standards);
- The naming of features and feature relationships (data dictionaries);
- Schemas for descriptions of data sets (metadata).

OpenGIS® Specifications (standards) are technical documents that include:

- The *Implementation* Specifications that are written for a technical audience and detail the interface structure between software components.
  - Software developers may use these documents to build support for the interfaces or encodings into their products and services.
- The *Abstract* specifications provide the conceptual foundation for most OGC specification development activities.
  - Developed by the OGC Technical Committee (TC)
  - Provide a reference model for the development of OpenGIS *Implementation* Specifications.
- The OpenGIS® *Reference Model* (ORM) provides a framework for the ongoing work of the OGC.
  - Describes the OGC Standards Baseline (SB) focusing on the relationships between the OpenGIS Specification documents.

The ORM carries out the same function that ISO 19101:2002 Geographic information

  - - Reference model standard.

OGC develops specifications through a Request for Proposal bid process. The consortia members prepared an Abstract Specification. Based on this specification, the consortium then issues a Request for Proposal to *its members*. The response to these requests provides a basis for consolidating the positions of several bidders. After usually two rounds of bids, the result is an Implementation Specification that can be implemented by members of the consortium. The steps on how OGC's approach the development of specifications can be summarized as:

- Stage 1: OGC formalizes its specifications through consensus, in which committees composed of OGC members develop, review, and release OpenGIS Specifications.
- Stage 2: OGC then develops strategic business opportunities, by identifying user communities and markets in need of open spatial interfaces and involving those communities in the development and adoption of OpenGIS Specifications.
- Stage 3: OGC also develops strategic standards partnerships, in order to harmonize its geoprocessing standards with other international IT standards.
- Stage 4: Finally, this approach increases users' awareness and acceptance of OpenGIS Specifications through its marketing and public relations programs.

There are currently 19 documents for the Implementation Specifications on the OGS web site http://www.opengeospatial.org/standards and about 20 Abstract Specifications (http://www.opengeospatial.org/standards/as). Documentation of the OpenGIS® *Reference Model* (ORM) can be found on http://portal.opengeospatial.org/files/?artifact_id=3836 Additional documents can also be found on the OGS web site http://www.opengeospatial.org/standards. These can be used for implementation of OGS standards:

- The Discussion Papers present technology issues being considered in the Working Groups of the Open Geospatial Consortium Technical Committee.
- Best Practices Documents contain discussion of best practices related to the use and/or implementation of an adopted OGC document and for release to the public.

The OpenGIS® Specifications can be downloaded at no cost (not like ISO standards).

**The Open Geospatial Consortium and ISO Technical Committee 211**

The Open Geospatial Consortium (OGC) has worked closely with ISO/TC 211 since 1994. At their plenary meeting in Vienna, Austria in March 1999, ISO/TC 211 welcomed the satisfactory completion of the co-operative agreement between the OpenGIS Consortium and ISO/TC 211 and endorsed the terms of reference for an ISO/TC 211 / OGC co-ordination group. In 1999, OGC got a liaison class status for ISO/TC 211. ISO/TC 211 and OGS have formed a Joint

Advisory Group (**JAG**). Many common work items now exist between the OpenGIS Consortium and ISO TC 211 that will result in OGC specifications being adopted as International Standards or Technical Specifications.

ISO/TC 211 uses some OGC implementation specifications. Some OpenGIS® Specifications are being formalized as ISO 19100 series standards. For example, OGC Simple Feature Specification is used for ISO 19125 Simple feature access; OGC Web Map Service is used for ISO 19128 Web Map Server interface; etc.

In addition, OGC uses the elements of ISO/TC 211 standards for development of their own standards.

There are some differences between ISO and OGS procedures and products. ISO/TC 211 is the *de jure* formal standards technical committee. OGC is the *de facto* industry technical specification developer. ISO standards have a formal life cycle that includes official approval, publishing, and periodic revisiting once every few years. All international standards are reviewed at least once every three years (after publication) and every five years (after the first review) by all the ISO member bodies. OGC specifications can be used by users before formal approval and could be updated a few times in any given year.

While the OGC standards may not be perfect at the moment, they are quite functional and are certainly based on a solid understanding of geo-spatial disciplines (as a reading of the abstract documentation will show).

In the following lecture modules, we will discuss some OpenGIS® Specifications, especially those that are formalized in ISO standards, such as:

- Catalogue Service
- Filter Encoding
- Geography Markup Language
- Location Services (OpenLS)
- Simple Feature Access
- Styled Layer Descriptor
- Symbology Encoding
- Web Coverage Service
- Web Feature Service
- Web Map Service

**The World Wide Web Consortium**

Another international consortium that documents geo-spatial standards development is the World Wide Web Consortium (**W3C**). W3C develops standards for interoperable technologies that enable the delivery of geospatial information online.

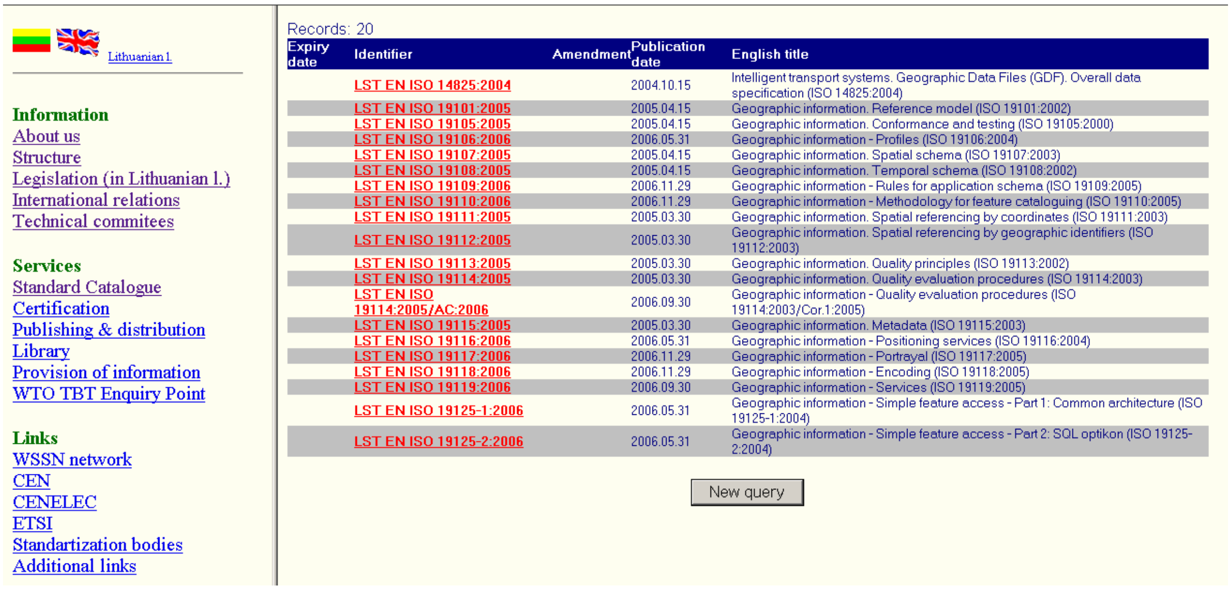
W3C standards are used for the development of geospatial standards, for example, Extensible Markup Language (XML) W3C specification is used for ISO/TS 19139:2007 Geographic information -- Metadata -- XML schema implementation and for the OpenGIS® Geography Markup Language (GML) Encoding Specification.

### 1.3.4 National Government Organizations

National government agencies, in all industrialized nations, have specific responsibility for approving of information system standards (and other types of standards) for use by their constituencies. In Europe, each nation has a national standards body.

The national standardization process in Lithuania is managed by the Lithuanian Standards Board (**LSD** (see http://www.lsd.lt/)). The Lithuanian Standards Board is a national standards body that follows international and European standardization principles in its activities and represents the Republic of Lithuania within the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN).

LSD has prepared and implemented the programs, based on the most important ISO and CEN standards. These have become Lithuanian standards, and Lithuania participates in the implementation of European Union directives. These may include standards of ISO 19100 Geographic information series.




| Expiry date | Identifier | Amendment | Publication date | English title |
|---|---|---|---|---|
| | LST EN ISO 14825:2004 | | 2004.10.15 | Intelligent transport systems. Geographic Data Files (GDF). Overall data specification (ISO 14825:2004) |
| | LST EN ISO 19101:2005 | | 2005.04.15 | Geographic information. Reference model (ISO 19101:2002) |
| | LST EN ISO 19105:2005 | | 2005.04.15 | Geographic information. Conformance and testing (ISO 19105:2000) |
| | LST EN ISO 19106:2006 | | 2006.05.31 | Geographic information - Profiles (ISO 19106:2004) |
| | LST EN ISO 19107:2005 | | 2005.04.15 | Geographic information. Spatial schema (ISO 19107:2003) |
| | LST EN ISO 19108:2005 | | 2005.04.15 | Geographic information. Temporal schema (ISO 19108:2002) |
| | LST EN ISO 19109:2006 | | 2006.11.29 | Geographic information - Rules for application schema (ISO 19109:2005) |
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| | LST EN ISO 19111:2005 | | 2005.03.30 | Geographic information. Spatial referencing by coordinates (ISO 19111:2003) |
| | LST EN ISO 19112:2005 | | 2005.03.30 | Geographic information. Spatial referencing by geographic identifiers (ISO 19112:2003) |
| | LST EN ISO 19113:2005 | | 2005.03.30 | Geographic information. Quality principles (ISO 19113:2002) |
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| | LST EN ISO 19114:2005/AC:2006 | | 2006.09.30 | Geographic information - Quality evaluation procedures (ISO 19114:2003/Cor.1:2005) |
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| | LST EN ISO 19117:2006 | | 2006.11.29 | Geographic information - Portrayal (ISO 19117:2005) |
| | LST EN ISO 19118:2006 | | 2006.11.29 | Geographic information - Encoding (ISO 19118:2005) |
| | LST EN ISO 19119:2006 | | 2006.09.30 | Geographic information - Services (ISO 19119:2005) |
| | LST EN ISO 19125-1:2006 | | 2006.05.31 | Geographic information - Simple feature access - Part 1: Common architecture (ISO 19125-1:2004) |
| | LST EN ISO 19125-2:2006 | | 2006.05.31 | Geographic information - Simple feature access - Part 2: SQL optikon (ISO 19125-2:2004) |



**Figure: List of standards from LSD - http://www.lsd.lt/.**

National Land Service is responsible for development of geo spatial specifications in Lithuan

In addition, it should be noted that another national government organization, which actively provides international leadership in implementing spatial data standards through sponsorship of international bodies such as ISO and OGC, is the United States Federal Geographic Data Committee (FGDC) (see http://www.fgdc.gov/standards). The most notable FGDC standard is the Spatial Data Transfer Standard (**SDTS**). This was developed to allow the encoding of digital spatial data sets for transfer between spatial data software (http://www.fgdc.gov/standards/projects/FGDC-standards-projects/index_html).

## 1.4 Types of Standards Impacting Spatial Data Infrastructure

No one standard will suffice to satisfy the complex needs of all participants in the field of Geo-Informatics. Compatible bridges are also needed for standards to other fields, such as Information Technology. Information technology standards have developed with, and are largely responsible for, the great improvements in computer technology over the past twenty-five years. No one standards organization will suffice either. Different groups have different foci. However, many standards' threads can be woven into a common standards fabric.

Standards that influence geospatial activities range from the details of computer hardware and networks to the design of databases and map products.

Standards may be categorized into low-level and high-level categories (URISA, 1998).

- The low-level standards cover detailed technical concerns in the following categories:
  - Hardware and physical connection standards
  - Network communication and management standards
  - Operating system software standards.

- High-level standards deal primarily with the database design, data exchange, and presentation topics and can relate to the following categories:
  - User interface standards
  - Data format/data exchange standards
  - Programming and application development standards
  - User design standards.

All the above-mentioned international, regional, and industrial standards have been established by computer hardware and software industry with support from independent standards bodies such as the Institute of Electrical and Electronic Engineers (IEEE), the Electronics Industry Association (EIA), the International Organization for Standardization (ISO), the American National Standards Institute (ANSI), etc.

User design standards relate to survey, accuracy, map compilation, design, and production. These are usually prepared by national agencies, however, some map production and specification standards are prepared by international organizations (e.g., Global Map Version 1.2 Specifications, http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi?action=ATTACH&page=Documentation&file=Global+Mapping+Specifications+v1.2.1.pdf).

*Hardware and network* standards contain standards and procurement requirements that affect the physical network and hardware to support GIS and spatial data storage and transfer. It provides workable specifications used to guide procurement and installation of computers and networks. These standards should take into account the standards already in place with the goal of not duplicating physical networks or services, unless necessary.

These standards include:

- Computer operating system standards
- Computer hardware standards and specifications
- Physical network and protocol standards
- Network interface requirements.

*System administration* standards include standards and conventions for operation system and database administration. These standards include:

- File and directory naming and organization standards
- System access and security

*Programming and application development* specifications and standards establish procurement requirements to ensure a high degree of interoperability. These standards include:
- Application software development and development tools;
- User interface standards;
- Application documentation standards, etc.

*Data format* standards pertain to the storage, management, database design, and exchange of geospatial data and metadata. These standards include:
- Geospatial data format
- Data content/data dictionary standards
- Data coding and classification standards
- Data exchange format standards
- Metadata standards

*User design* standards describe the content and format of the products to be generated from the system. They are defined in the design phase and can include the following standards:
- Database schemas
- Data coding system and classification (e.g. Land Cover Classification System of CORINE Land Cover project of European Environment Agency - http://reports.eea.europa.eu/COR0-part2/en/land_coverPart2.1.pdf)
- Metadata schemas
- Map production and accuracy standards
- Data/product distribution standards, etc..

### 1.4.1 The Standards Development Process, Profiling

Standards can be developed and implemented at different hierarchical levels:
- Various *manufacturers* can publish their interface standards and establish industrial standards.
- *Public domain* standards require that a consensus be reached within one or more public jurisdictions. This can be local, national, regional, or international.
- *Large organizations*, such as mapping agencies, can establish standards through their procurement processes.
- There are formal Standards Development Processes established in law in most *countries* for the creation of such standards.
- *International* and *regional* organizations are consolidating standard development.

**The Standards Development Process**

In general, there are three aggregated stages of the standard life-cycle can be outlined. These are:
- Stage of development and implementation - includes processes of:
    - Adaptation of Information Technology standards
    - Development of Geo-spatial standards
        - There are different approaches for standard development and implementation (see below).
        - The ISO Geographic Information standards are implemented mostly as abstract standards, the OGC specifications are more industry oriented.
- Stage of deployment can be done in all levels of government, industry, SDIs, professional organizations, UN agencies, IT community, etc.
- Stage of confirmation, revision, withdrawal.

In addition, standard development and implementation processes can include different approaches:

- Top-Down or *prescriptive* approach from paper specifications to implementation and testing.
  - Prescriptive standard implementation occurs when groups of experts meets and try to develop a standard, which prescribes the future. Such an approach is risky and can be isolated from reality.
- Bottom-Up or *descriptive* approach from test-beds and rapid proto-typing to paper specifications.
  - Descriptive standard implementation occurs when a standards committee endeavors to describe the existing state of technology as a standard. However, establishing standards in this manner is very expensive, since it requires the marketplace to work through the range of options.
- Compromise standards occur when a standards committee tries to broker a compromise position between various proponents of different systems.

The *ISO International* standards are developed and implemented by ISO technical committees (TC) and subcommittees (SC) by a six-step process (http://www.iso.org/iso/en/stdsdevelopment/whowhenhow/proc/proc.html):

- Stage 1: Proposal Stage - preparation of a new work item proposal for vote.
- Stage 2: Preparatory stage - preparation of a working draft by a working group project team
- Stage 3: Committee stage - distribution of the committee draft for comments and voting by participating members of the committee.
- Stage 4: Enquiry stage - distribution of the draft international standard for voting worldwide.
- Stage 5: Approval stage - distribution of the final draft international standard for final (yes/no) approval.
- Stage 6: Publication stage - publication of the standard.

The *OGC Process of* specification development includes the following stages (http://www.opengeospatial.org/ogc/process):

- Stage 1: The *Beginning* is the first step in the process - identifies an interoperability problem.
- Stage 2: On *Crafting a Solution* stage, the OGC members define requirements for a new interface specification or enhancements to an existing OpenGIS Specification. There are several formal OGC crafting processes that can be used:
  - OGC Members introduce candidate specifications via the OGC Request for Comment (RFC) process
  - Via OGC *Interoperability* Program initiative, members rapidly prototype (test bed or pilot) their ideas to come up with draft specifications
  - The Interoperability Program produces theoretical discussions and deliberations within OGC Working Groups that operate as part of OGC's Technical Committee. High-level of document writing is involved in this approach.
- Stage 3: On *Evaluating a Proposed Specification* stage, all OGC members, and ultimately the general public, have a chance to comment on it, provide input, and suggest changes. A final product draft specification can be put to a formal member vote and can become approved specifications.
- Stage 4: OGC's *Outreach and Community Adoption* program encourages developers to include the specifications in their products and software buyers to select products that do so.

*National, regional,* or even some *international* standards can be developed and implemented by the **adoption** of functioning international standards. As standards are costly to develop, this has been recognized by those involved in building the national SDIs and, in keeping with this philosophy, the *national* SDIs are focusing on contributing to the development of international standards. National and regional agencies of many countries are actively moving from self-dependent standard development into international collaboration and adaptation of international standards.

ISO, OGS, CEN and other international standards are often adopted by countries as voluntary standards, or included in national rules and regulations. Many trade agreements, including the World Trade Organization (**WTO**), call upon signatories to adopt these international standards wherever possible.

## Profiling

Some approaches to existing standards adaptation include mechanisms such as:

- **Profiling**
- **Extensions**
- **Registry**

A **profile** is a subset of one or more standards. A profile is used to narrow the range of applicability of a more general standard(s) for a particular application. A subset of one or more of the suite of TC211 standards may be defined as a profile corresponding to a standard for a given application area.

A *simple* profile is a selection of options from just one base standard.

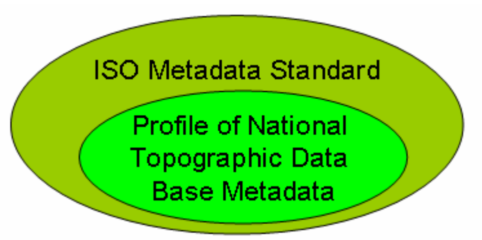



**Figure: A *simple* profile**

A *complex* profile is a selection of elements from several base standards.

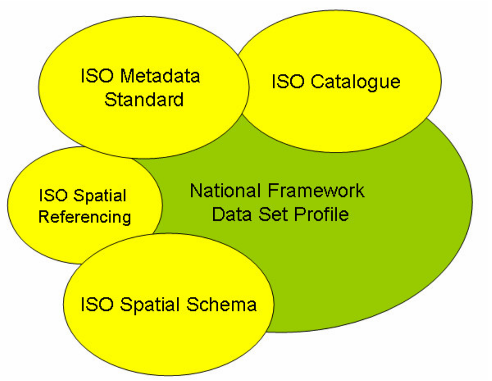



**Figure: A *complex* profile**

For example, a national SDI Framework Data Set specification might select elements of metadata, cataloguing, spatial referencing, and a common spatial schema from the options allowed in the base standards.

Profiles can be established at different international and national levels through the **registry** mechanism. Profiles may be registered through the International Organization for Standardization. Internationally Standardized Profiles are the responsibility of ISO TC211. Profiles can also be developed and registered nationally and privately. National Profiles are the responsibility of individual national bodies, who may establish their own national registration authorities. Private or industrial sub-sub-domains are the responsibility of individual nations.

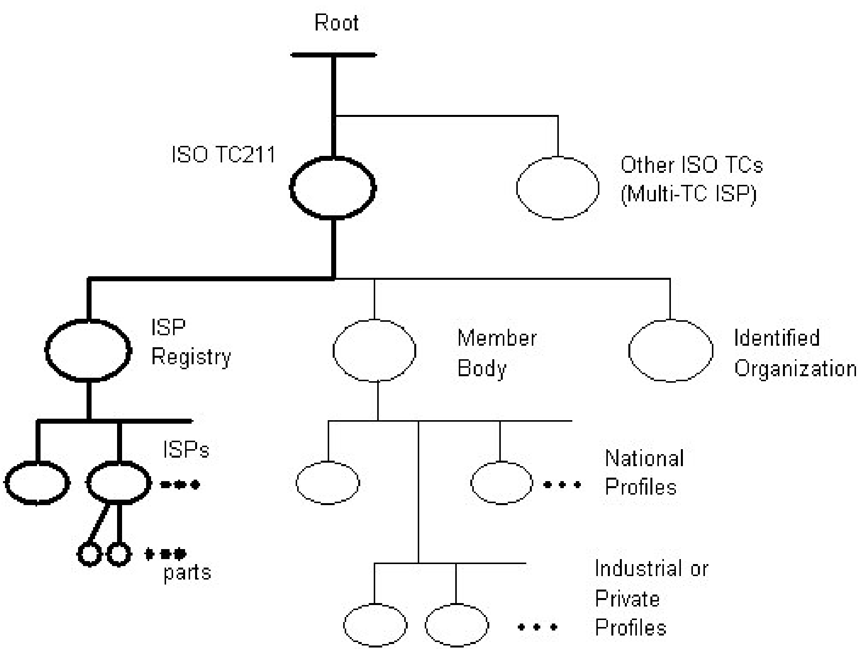



**Figure: The hierarchy of profiles**

A single instance of a product is unique. A product specification defines a class of such instances where only a narrow range of options are permitted. A profile that is specific and completed enough to create a data set (or data product) becomes a product specification.

A standard can contain requirements that define mandatory or/and optional *modules* of a standard for establishing profile from it. A profile can be extended by user-define **extension**. Extensions are a set of added elements that extend the standard to better serve the community or data type. For example, The Metadata standard can have an extension for Remote Sensing Metadata that can have extended elements to support the documentation of geospatial data directly obtained from remote sensing. This extension can include elements that describe the remote sensing platform and sensors.

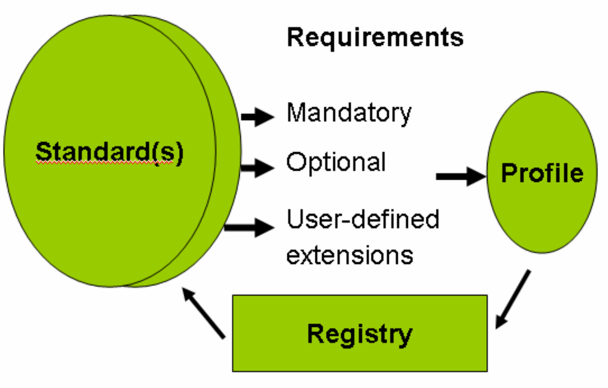



**Figure: Process of profile establishment**

The TC211 suite of standards cannot be used separately. Instances of the rules and subsets of the general schemata have to be used together in various situations and represented as a *profile* that may be registered internationally, nationally, or used privately. Thus, the TC211 suite of standards is implemented through *profiling*.

Standards in the TC211 *guidance* category control the overall standardization process but have only an indirect effect in the definition of a profile corresponding to a particular use of the suite of standards.

Standards in the TC211 *content and data* category are implemented by defining subsets (or sub-schemas) that apply to a given area of use.

Standards that define TC211 *services* (rules) must have the rules instantiated to be applied to a given area of use.

There are any number of possible combinations of standards' components and concrete instances when the rules of the TC211 suite become standards.

A TC211 *module* is a predefined set of elements that may be used to construct a profile. These predefined sets of elements are defined in the base TC211 standards.

- For example, the ISO 15046-7 - Spatial Sub-schema standard may define a module consisting of a set of spatial and topological elements and their relations corresponding to a planar graph vector representation. This module may then be used in profiles that require a planar graph vector spatial representation.

Thus, ISO 19106:2004 defines the concept of a profile of the ISO geographic information standards developed by ISO/TC 211 and provides guidance for the creation of such profiles. Only those components of specifications that meet the definition of a profile, contained herein, can be established and managed through the mechanisms described in this International Standard. These profiles can be standardized internationally using the ISO standardization process. This document also provides guidance for establishing, managing, and standardizing at the national level.

Under the rules set out in ISO 15046-6, TC211 member bodies may develop national profiles. This can be done under the authority of the member body. In Lithuania, this would be under the authority of the Lithuanian Standards Board. Industrial and private profiles may be registered with the national member body. Standards from international organizations, such OGC or from other ISO Class A liaison organizations may become International Profiles as well. The standards and product specifications for the Lithuanian Geographic Information Infrastructure (**LGII**) may become nationally registered profiles.

## *1.5 What Should A Nation Do? What Should Local Governments Do?*

An **adoption** of ISO/CEN standards and OGC specifications “enable recent ascension countries to gain rapid access to the needed technology, data, and applications – and become peer level members of European Union sooner” (Henry Tom). The national SDI cannot develop its own standards in isolation. Compatibility is needed with data base vendors, GIS equipment suppliers, and data producers, both internal and external to the nation. Thus, LGII standards are also needed for many for different types of products, applications, and services.

A common compatible base is the suite of ISO and other international standards. The national standards can be implemented through profiles and this mechanism is already defined within most of the international standards. This means that the LGII standards can simply be a set of profiles.

National geo-spatial profiles can be created from the TC211 standards. Particular product specifications can be, in effect, profiles of the more general national profiles. There is also a need for profiles at the federal and provincial level and potentially at the municipal and industrial level.

Instances of the international standards will need to be created to suit Lithuanian requirements. ISO TC211 has developed a very general suite of standards that allow for a large number of options so that they can be adapted to suit almost every requirement. Lithuania has specific needs that have to be expressed in the LGII. Profiles and instances of the international standards can be used in LGII. Designing mechanisms for LGII are needed in order to manage these profiles. Internationally standardized profiles can be used to serve as national LGII standards. These can be voted on nationally and registered through the Lithuanian Standards Board. This should be the national branch of the international hierarchy maintained by ISO.

This registry is essentially the core of the LGII infrastructure. By using standard components and customizing them to fit specific applications, a maximum degree of compatibility can be achieved. If a jurisdiction has specific reasons for doing something different in a particular application, it is free to do so, but the use of standard components for everything else ensures the highest level of compatibility.

Each of the LGII framework data sets (topographic, cadastral, etc.) requires a product specification. These product specifications can be profiles of the LGII standard profiles and base standards. These product specifications will need to be documented in a consistent manner and registered through the LSD.

## *1.6 Implications*

For designers and developers of geospatial information, the question is not whether standards should be adopted, the challenge is to choose suitable standards and a sensible approach for their implementation, to facilitate sharing of information, and to make systems easier to support and maintain.

International standards, that ISO and OGC develop, are very useful to industrial and business organizations of all types, to governments, regulatory bodies, trade officials, professionals, suppliers, and customers of products and services in both the public and private sectors, and, ultimately, to people in general in their roles as consumers and end-users.

ISO and OGC standards benefit society greatly. These standards contribute towards making the development, manufacturing, and supply of products and services more efficient, safer, and cleaner. They make trade between countries easier and fairer. They provide governments with a technical base for health, safety, and environmental legislation. They aid in transferring technology from one country to another.

Developing standards and employing them on a continuing basis takes time up front in the design process, as well as discipline and diligence to ensure that standards are adhered to as Geographic Information systems mature. There is also a danger of going too far in defining and dictating standards that are inappropriate or counter-productive to a specific user community. It is possible that an organization could create inflated overheads just to maintain and enforce a set of standards. There is also a risk that users will find complying with standards too time-consuming or inflexible. A well-designed set of standards has to take into account the specific needs of an organization within a broader community of users.

## Module self-study questions:

1. What are two significant differences between a "standard" and a "specification"?
2. Name two major international organizations that are involved in geo-spatial standards and specifications development?
3. Describe the relationship between OGC and ISO/TC 211?
4. What are standards' profiles, registries and extensions?
5. What makes it possible to build and adopt a national standard profile from ISO/TC 211 standards?
6. What does "TC" mean within an "SO/TC 211" framework?

## **Required Readings**:

[1] Developing Spatial Data Infrastructures: The SDI Cookbook, Editor: Douglas D. Nebert, Technical Working Group Chair, GSDI, Version 2.0 25 January 2004, page 28-30

[2] ISO/TC 211 Geographic information/Geomatics, Home page, http://www.isotc211.org/

[3] Spatial Data Standards around the World, http://ncl.sbs.ohio-state.edu/ica/3_spatial.html

## References

[1] Groot, Richard & McLaughlin, John, *Geospatial Data Infrastructure: Concepts, Cases, and Good Practice*. Oxford: Oxford University Press, 2000

[2] Developing Spatial Data Infrastructures: The SDI Cookbook, Editor: Douglas D. Nebert, Technical Working Group Chair, GSDI, Version 2.0 25 January, 2004.

[3] ISO/TC 211 Geographic information/Geomatics, http://www.isotc211.org/

[4] The Open Geospatial Consortium, Inc (OGC), http://www.opengeospatial.org/standards

[5] The European Committee for Standardization, http://www.cen.eu/CENORM/aboutus/index.asp

## Terms used

- Standard
- Specification
- SDI
- De jure
- De facto
- LGII
- ISO
- OGC
- ISO/TC 211
- ISO 19100 series
- Abstract specification
- Technical specifications
- INSPIRE
- UML
- XML/GML
- CEN/TC 287
- W3C
- LSD
- Profiling
- Extensions
- Registry

# 2 Guidance Category of Geospatial Standards

According to ISO/TC 211, there are 53 geospatial standards. Of these 53 standards, 33 have been published as of May 2007. Any combination of ISO 19100 series standards can be applied for the development of particular products or service specifications. This module reviews the ISO 19100 series of standards and provides categorizations of some of theses standards. This is helpful in building up a general understanding of the series structure and the relationships between the standards.

Seven geospatial standards from the Guidance category and one standard from the Content and Data category (ISO19103) are examined in this module. Most attention is paid to the ISO 19101 Reference model, ISO/TS 19103 - Conceptual Schema Language and ISO 19106 – Profiles. The 19101 Reference model is examined in great detail. One of the purposes of this module is to demonstrate why the creator of the 19100 series chooses the Model Driven Architecture (MDA) approach for the creation and use of geospatial standards and specifications.

Module Outline

Topic 8: ISO 19100 Standard Series Overview and Categorization
Topic 9: ISO 19101:2002 - Reference Model
Topic 10: ISO/TS 19104 - Terminology
Topic 11: ISO/TS 19103:2005 - Conceptual Schema Language
Topic 12: ISO 19105:2000 - Conformance and Testing
Topic 13: ISO 19106:2004 - Profiles
Topic 14: ISO/TR 19120:2001 - Functional Standards
Topic 15: ISO/TR 19122:2004 - Qualification and Certification Of Personnel
Topic 16: ISO 19135:2005 - Procedures for Item Registration

## 2.1 ISO 19100 Standard Series Overview and Categorization

As mentioned in Module 1, there is no reason for an organization to develop its own standards - it is more efficient to use established international standards and to profile them to particular application areas. For areas of GIS, remote sensing, cartography, and geomatics, the ISO 19100 series of standards is the most appropriate.

ISO 19100 is a series of standards for defining, describing, and managing geographic information (i.e. information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth). These standards may specify geographic information, methods, processes, tools, and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting, and transferring such data in digital/electronic form between different users, systems, and locations.

This series of standards makes it possible to define profiles in order to facilitate the development of geographic information systems and application systems that are used for specific purposes. Profiling consists of putting together “packages/subsets” of the total set of standards to fit individual application (schema) areas or users.

According to ISO/TC 211, there are 53 geospatial standards to be considered.

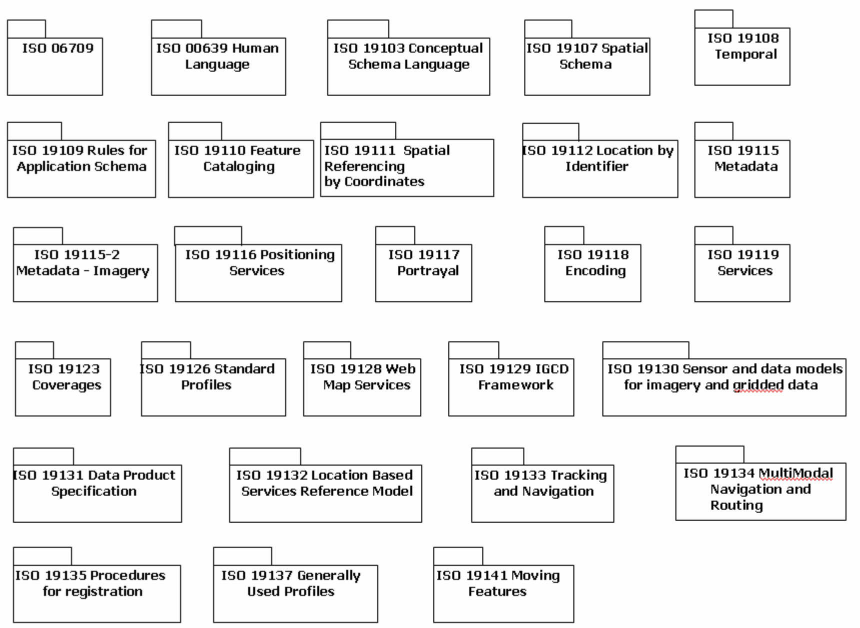



**Figure: The packages of ISO Series of International Standards for Geographic Information maintained on the ISO/TC 211 Harmonized Model Web server (http://www.isotc211.org/hmmg/HTML/root.html)**

The ISO 19100 standards can also be divided into 9 groups by application areas: framework and reference model, information management, information administration, geospatial data models and operators, imagery, geospatial services, information communities, location based services and profiles, and functional standards.

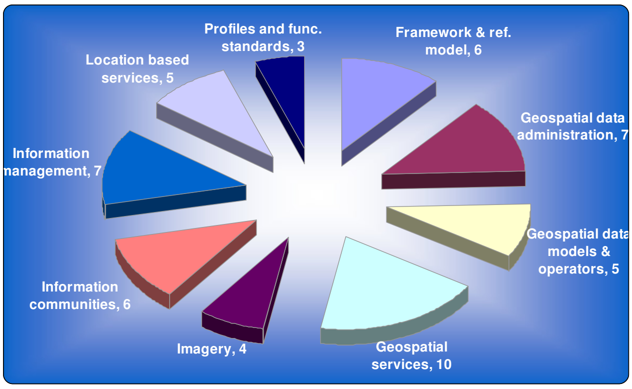



**Figure: Groups and counts of standards considered by ISO/TC 211 (on May 2007)**

Of these geospatial standards, 33 have been published (http://www.isotc211.org/); the rest (20) are still under development. Among the published 33 standards, 3 involve technical reports, 4 are address technical specifications, 3 require corrigendums, 1 has been amended, and 2 are in revision mode. Among the remaining 20, 13 of them have been targeted to be IS by 2009 and the last 6 items in the list have been approved since 2006.

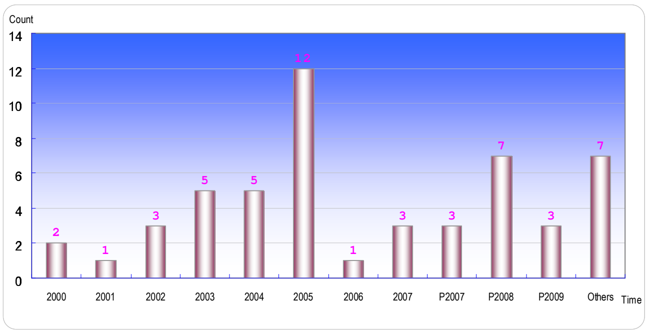



**Figure: The number of standards published, or planning to be published, every year since 2000 (May 2007)**

These standards go through various development stages and have different levels of implementation and acceptance. The standardization document for each development stage is marked in accordance with the following figure (e.g., DIS – Draft International Standard).

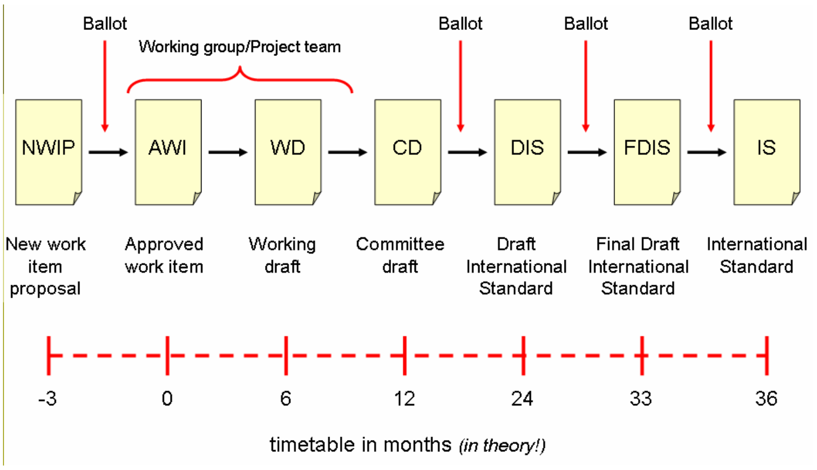



**Figure: The process of standard development**

In addition, some of these ISO standards are marked as ISO – International Standard, ISO/TS – Technical Specification, or ISO/TR – Technical Report.

The key standards that are most often used, and that will be discussed in detail in this course, are:

- ISO 19101:2002 Geographic information - Reference model
- ISO/TS 19103:2005 Geographic information - Conceptual schema language
- ISO 19106:2004 Geographic information - Profiles
- ISO 19107:2003 Geographic information - Spatial schema
- ISO 19109:2005 Geographic information - Rules for application schema
- ISO 19118:2005 Geographic information - Encoding
- ISO 19113:2002 Geographic information -- Quality principles
- ISO 19114:2003 Geographic information -- Quality evaluation procedures
- ISO 19115:2003 Geographic information -- Metadata

Many of theses standards interrelate to each other and create some connectivity structure. Different combinations of ISO 19100 series standards can be applied for development of particular products or service specifications. *ISO 19101 Geographic information - Reference model* is a guide to structuring geographic information standards in a way that will *enable the universal usage of digital geographic information*.

A typical example of an ISO 19100 application is the creation of a repeatable methodology for developing, adopting, and maintaining data products' specifications supporting the regional or national SDI (e.g. for INSPIRE project), in terms of the harmonization of heterogeneous data sources. The project, described below, is well documented in the context of the ISO 19100 series of standards.

For example, the following steps can define a process model for spiral development:

- At stage one, production requirements, expressed as capabilities, are described in use case scenarios. A *use case* defines a goal-oriented set of interactions between external actors () and the system under consideration (). Actors are parties outside the system that interact with the system. An actor may be a class of user, a roles user, or another system.

  These use cases are described according to a template for use case descriptions and a checklist for data harmonization aspects to be addressed in the description. There is a need for additional guidelines on how to apply use cases as the methodology to capture and identify requirements, as well as the process to go from the universe of discourse to a conceptual model. These guidelines come from ISO 19101 - Reference model. This reference standard introduces a conceptual formalism in order to describe a conceptual geospatial model.

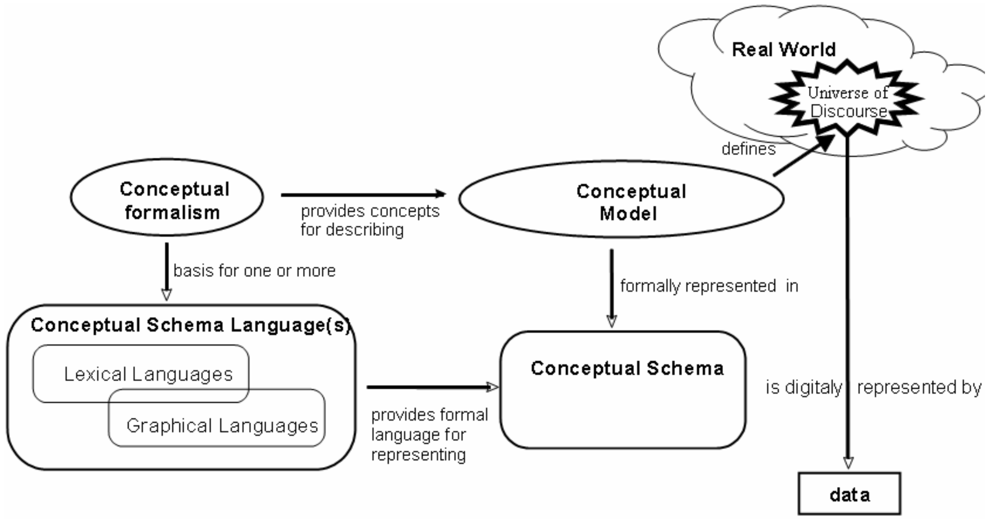



**Figure: From reality to conceptual schema – the ISO 1901 approach to conceptual modeling**

The figure above describes the relationship between modeling the real world and the resulting conceptual schema. A *universe of discourse* is a selected piece of the real world (or a hypothetical world) that is modeled. A *conceptual model* defines the concepts of a universe of discourse. The *conceptual schema* is a formal description of a *conceptual model* for some universe of discourse. The *conceptual formalism* is the basis for the *conceptual schema language*, consisting of a lexical and/or a graphical notation. For the ISO series of standards, the applicable *conceptual formalism* is object-oriented modeling. *Conceptual schemas* developed for the ISO 19100 series of standards are represented by *conceptual schema language*.

- These use cases describe the relevant universe of discourse These are then documented as an application schema (in accordance with ISO 19109) which is a model based on feature types and their properties (in accordance with ISO 19110 - Methodology for feature cataloguing). This results in a common terminology (in accordance with ISO19102) and is described in a *conceptual schema language* (in accordance with ISO 19103). The Unified Modeling Language (UML), as profiled by the ISO 19100 series of International Standards, is used as the *conceptual schema language*. This application schema constitutes a core component of a *Data Specification*.

- The *Data Specification* is documented according to ISO 19131, the International Standard specifying the contents of Data Product Specifications in the field of geographic information. A Data Product Specification includes at least the following sections: specification scopes, data product identification (in accordance with ISO 19112), data content and structure (in accordance with ISO 19107, 19108, 19137), reference systems (in accordance with ISO 19111), data quality (in accordance with ISO 19113, 19114, 19138), data product delivery (in accordance with ISO 19117), and metadata (in accordance with ISO 19115).

- In the next step, the application schema in UML will be encoded into a XML/GML (Geography Markup Language) schema (following the process documented in ISO 19118/19136). This can be used in conjunction with Web Feature Service interfaces (in accordance with ISO 19128, 19142). This transforms the abstract specification of the application schema into a XML-based implementation specification that can immediately be used, for example, in a web feature service. This will allow querying and selecting data according to the application schema, as well as inserting, deleting, and updating data in transactions.

- These results are then tested within a prototype under real world conditions and brought forward to the project, OGC, and industry for appropriate consideration and feedback. Incremental costs and benefits of the harmonization efforts will be tracked and documented as repeatable sustainable capability within the exploitation guidelines.

This process exemplifies a modeling approach where the requirements are first modeled on the conceptual/logical level and then converted to specifications on the implementation level. The process described above can be well documented in the context of the ISO 19100 series of standards.

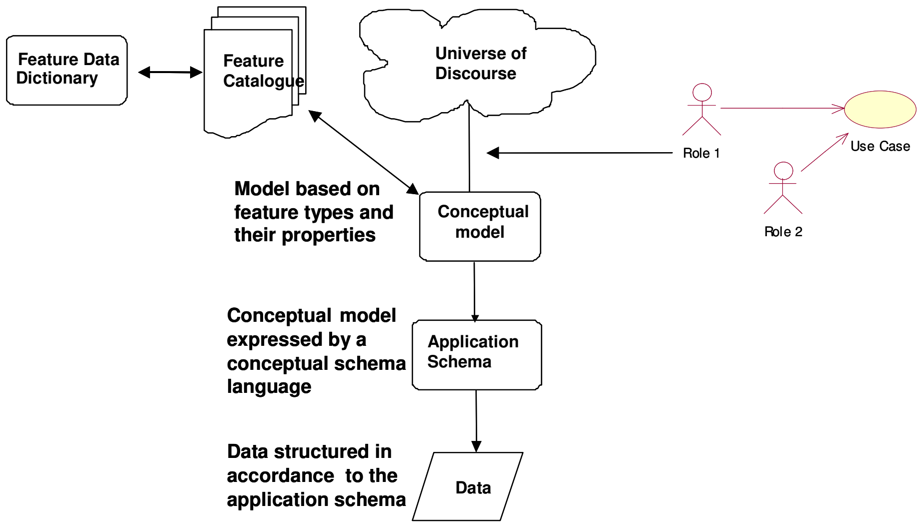
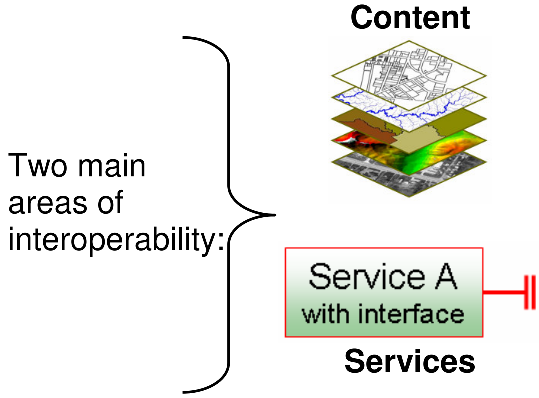



**Figure: The ISO 19100 Model Driven Architecture (MDA) approach for production process; where *Application schema* is conceptual schema for data required by one or more applications, and *Feature catalogue* containing definitions and descriptions of the feature types, feature attributes, and feature relationships occurring in one or more sets of geographic data, together with any feature operations that may be applied**

The ISO geographic information series of standards is flexible allowing a large number of options that may be tailored to suit any application. An ISO geographic information profile is a subset of one or several of the ISO 19100 standards. ISO 19106 describes the procedures for the development of profiles.

In this, and next modules, we will be discussing ISO/TC 211 standards. These standards are divided into the following groups and will be discussed in the following modules:

- Module 2: Guidance category of geospatial standards (organizational and educational standards)
- Module 3: Content and data category of geospatial standards
- Module 4: Services' and reports' categories of geospatial standards (access and technology standards)
- Module 5: Metadata and quality categories of geospatial standards.




In this module we discuss three standards related to *formalizing* methods for the concepts of geographic information: Reference model (ISO 19101), Conceptual schema language (ISO/TS 19103), UML, Terminology (ISO/TS 19104). One more standard related to *formalizing* methods will be examined in the next module: Rules of application schema (ISO 19109). In addition, in this module five more guidance category standards will be outlined.

## 2.2 ISO 19101:2002 - Reference Model

**ISO 19101:2002 - Reference Model** defines the *architectural framework* of the ISO 19100 series of standards in the field of geographic information and sets forth the *principles* by which *this standardization* takes place. This IS specifies the Reference Model of the ISO 19100 series. It describes how the contents of the different standards are related. Although structured in the context of information technology and information technology standards, ISO 19101 is independent of any application development method or technology implementation approach.

This standard contains the following clauses (chapters):

- 1 Scope
- 2 Conformance
- 3 Normative references
- 4 Terms and definitions
- 5 Symbols and abbreviated terms
- **6 Concepts and organization of the reference model**
- **7 Conceptual modeling**
- **8 The Domain reference model**
- **9 The Architectural reference model**
- **10 Profiles and functional standards**
- **Annex A (informative) The Conceptual Schema Modeling Facility**
- Annex B (informative) Focus of standardization in the ISO 19100 series of geographic information standards
- Bibliography

Each of the standards discussed in this course usually have a similar structure (e.g., first five and Bibliography clauses). Some of these clauses may not be outlined in detail like some of the other course standards discussed in this module. The bolded clauses of this standard (shown above) will be discussed.

In ISO 19100 standards, *Scope* clause outlines the content of each standard. *Conformance defines* the conformance and testing requirements that have to be satisfied in order to comply with that standard. *Normative references* list the normative documents and their contents which, through reference in the standard text, constitute provisions of that International Standard. The *terms and definitions* section contains definitions of terms that are applicable to that International Standard. *Symbols and abbreviated terms section* contains descriptions of symbols (e.g. UML notations) and abbreviations.

Thus, the scope of ISO 19101 is: “This International standard defines the framework for standardization in the field of geographic information and sets forth the basic principles by which this standardization takes place. This framework identifies the scope of the standardization activity being undertaken and the context in which it takes place. The framework provides the method by which what is to be standardized can be determined and describes how the contents of the standards are related” (Clause 1, ISO 19101).

General *conformance* and testing requirements for the ISO 19100 series of geographic information standards are described in ISO 19105 *Geographic information — Conformance and testing.* Specific conformance requirements are described in individual standards in the ISO 19100 series.

### 2.2.1 Clause 6 Concepts and Organization of the Reference Model

It is generally recognized that geographic information science is an integrated part of information technology. Standardization of geographic information can best be served by a set of standards that integrates a detailed description of the concepts of geographic information with the concepts of information technology. A goal of the ISO/TC 211 standardization effort is to facilitate interoperability of geographic information systems, including interoperability in distributed computing environments. The following figure depicts this approach.

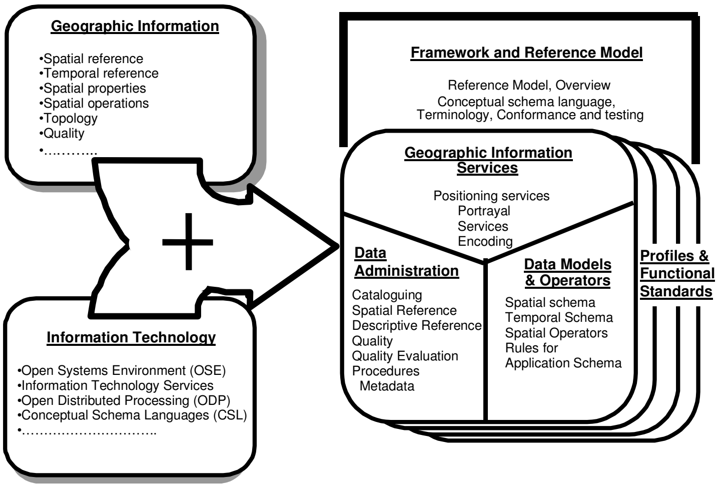



**Figure: Integration of geographic information and information technology**

As illustrated in the figure above, the ISO 19100 series of geographic information standards can be grouped into five major areas. Each of these areas incorporates information technology concepts into standardized geographic information. This categorization outlines different views on geospatial standardization compared to the categorizations outlined in Topic 1 of this module. The ISO 19100 series major areas are:

- *Framework and reference model* that covers the more general aspects of the ISO 19100 series of standards. The *framework* for the ISO 19100 series of geographic information standards includes the ISO 19101, *Geographic information - Reference model*. The *reference model* identifies all components involved and defines how they fit together. It relates the different aspects of the ISO 19100 series of standards together and provides a common basis for communication.

- *Geographic information services* define the encoding of information in transfer formats and the methodology for presentation of geographic information based on cartography and the old traditions of standardized visualizations.

- *Data administration* is concerned with the description of quality principles and quality evaluation procedures for geographic information datasets. Data administration also includes the description of the data itself, or metadata, together with feature catalogues. This area also covers the spatial referencing of geographical objects - either directly through coordinates, or more indirectly by use of, for instance, area codes like postal or zip codes, addresses, etc.

- *Data models and operators* are concerned with the underlying geometry of the globe and how geographic features and their spatial characteristics can be modeled. This area defines important spatial characteristics and how these are related to one other.

- *Profiles and functional standards* consider the technique of profiling. A profile is set of one or more base standards and – where applicable – the identification of chosen clauses, classes, options, and parameters of those base standards that are necessary for accomplishing a particular function. This supports rapid implementation and penetration in the user environments due to the comprehensiveness of the total set of standards. Equally important is the task of "absorbing" existing *de facto* standards from the commercial sector and harmonizing them with profiles of the emerging ISO standards.

In accordance with ISO 19101, the major focus of standardization in the ISO 19100 series of geographic information standards is to:

- Define the basic semantics and structure of geographic information for data management and data interchange purposes
- Define geographic information service components and their behavior for data processing purposes

These two points are compatible with the information viewpoint and computational viewpoint of ISO/IEC 10746:1995 RM_ODP (Reference model for Open Distributed Processing).

The major clauses of the Reference model are Conceptual modeling (clause 7), the Domain reference model (clause 8), the Architectural reference model (clause 9), and Profiles (clause 10). These clauses are detailed and discussed in ISO 19101 and relate to the major areas of the ISO 19100 series of geographic information standards. These models and their relationships are summarized in the following figure and are explained in the paragraphs that follow.

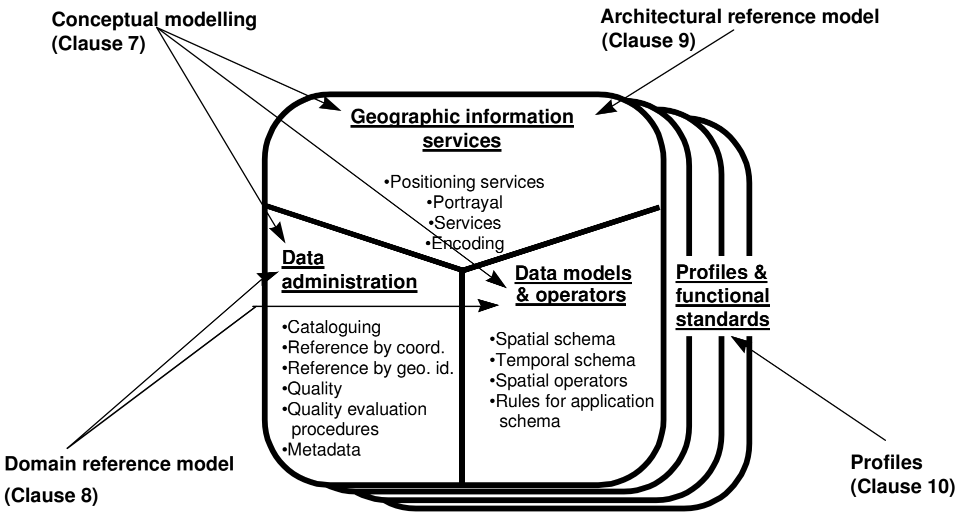



**Figure: Relationship of the Reference model to other standards in the ISO 19100 series of geographic information standards**

A key concept of ISO 19100 is the conceptual model. ISO 19101 defines conceptual modeling as the process of creating an abstract description of some portion of the real world and/or a set of related concepts. Such an abstract description of the real world is called a conceptual model and is described in a conceptual schema using a conceptual schema language. See the "Figure: From reality to conceptual schema" in Topic 1.

**Conceptual** modeling is critically important to the definition of the ISO 19100 series of geographic information standards. It is necessary for both the information and computational viewpoints. This family of standards uses conceptual modeling to formally describe geographic information. Conceptual modeling is also used to define services for transformation and exchange of geographic information. Conceptual modeling is used to describe both geographic information and geographic information services in profiles and functional specifications that specialize the ISO 19100 standards for particular purposes. A consistent application of conceptual modeling is necessary to assure that the standards in the ISO 19100 series are integrated with this reference model and with each other.

The approach to conceptual modeling in the ISO 19100 series is based on the Open Distributed Processing (ODP) Reference Model and the principles described in the *Conceptual Schema Modeling Facilities* (CSMF). The Open Distributed Processing (ODP) Reference Model is described in ISO/IEC 10746-1:1995. The CSMF is described in ISO/IEC 14481.

The **Domain reference model** in clause 8 of the ISO 19101 standard provides a high-level representation and description of the structure and content of geographic information. This model describes the scope of the standardization addressed by the ISO 19100 geographic information series and identifies the major aspects of geographic information that will be the subject of standardization activity. The *Domain reference model* encompasses both the information and computational viewpoints, focusing most closely on those standards in the ISO 19100 series of standards that standardize the:

- Structure of geographic information in data models and definition of operations
- Administration of geographic information

The *General feature model* defines a metamodel for features and their properties. The *Domain reference model* uses concepts of the *Information Resource Dictionary System (IRDS) Framework* in ISO/IEC 10027:1990, the *Conceptual Schema Modelling Facilities (CSMF)* in ISO/IEC 14481, and applies concepts from the *Unified Modeling Language (UML)*. In order to provide more precise definition and understanding, the *Domain reference model* is described using graphical notation of UML. This is intended for developers of geographic information standards who will use or extend the ISO 19100 series as well as for those who wish to have an in-depth knowledge of this family of standards.

In clause 9 of the ISO 19101 standard, the **Architectural reference model** describes the general types of services that will be provided by computer systems to manipulate geographic information and enumerates the service interfaces across which those services must interoperate. This model also provides a method of identifying specific requirements for standardization of geographic information that is processed by these services. Standardization at these interfaces enables services to interoperate with their environments and to exchange geographic information.

The *Architectural reference model* is based on concepts of (1) the *ISO Open Systems Environment (OSE)* approach for determining standardization requirements, described in ISO/IEC TR 14252:1996, and (2) the *Open Distributed Processing (ODP) Reference Model*, described in ISO/IEC 10746-1:1995. The *Architectural reference model* focuses primarily on the computational viewpoint.
To be complete, the reference model must provide an understanding of how it relates to other ISO reference model standards that describe key aspects of information technology upon which the ISO 19100 series is based. Clause 9 describes the relationship between the ISO 19100 series and the Open Systems Environment Reference Model.

**Profiles** and functional standards combine different standards in the ISO 19100 series and customize the information in these standards in order to meet specific needs. Profiles and functional standards facilitate the development of geographic information systems and application systems that are used for specific purposes. Clause 10 describes the approach to profiling the ISO 19100 series of standards.

**Interoperability** in the ISO 19100 series of geographic standards is also discussed in the clause 6. Interoperability is the ability of a system or system component to provide information sharing and inter-application co-operative process control. In order to support the goal of interoperability in the ISO 19100 series of geographic information standards, the use of conceptual schema language (namely UML) applies for application schema, data interchange, geographic information encoding and service implementations.

### 2.2.2 Clause 7 Conceptual Modeling and Annex A

The ISO 19101 approach to conceptual modeling was illustrated already, as an example, in Topic 1 of this module (Figure: From reality to conceptual schema).

The approach to conceptual modeling in the ISO 19100 series is based on the principles described in the *Conceptual Schema Modeling Facilities* (CSMF) of Annex A (informative). First CSMF is described and then CSMF is applied for ISO 19100.

The ISO CSMF includes four model levels: *Meta-meta* model, *Meta* model, *Application* model and *Data* level

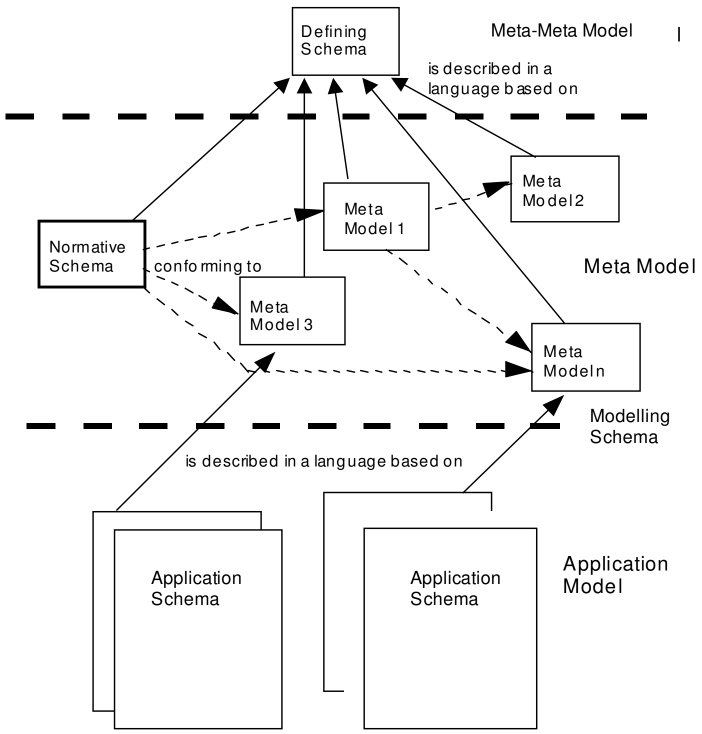



**Figure: ISO CSMF schema architecture**

The schema architecture outlined in the figure above is comprised of four distinct kinds of schemas. These are the *defining* schema, *normative* schema, *meta-model* or modelling schema, and *application* schemas. These schemas are situated in the three partitions or levels of abstraction called *Application model level*, *Meta-model level*, and the *Meta-meta model level*.

*Meta-meta Model Level* contains the *defining schema*, which specifies the concepts, terminology, operations, and assumptions needed to specify the basic constructs in the meta-model level. It is usually expressed in natural language and is not itself subject to standardization.

*Meta-Model Level* contains the definitions of the concepts, terminology, operations and assumptions needed to construct application schemas. The meta-model descriptions contain the syntax and semantics of various modeling or representation languages – *including conceptual schema languages*, schemes, or paradigms used for modeling. The *normative* schema is described in a language based on the fundamental concepts in the defining schema. The meta-models conform to the constructs defined in the *normative* schema.

*Application Model Level* schemas define the types of features and processes that are instantiated to produce datasets of geographic information. The application schema is expressed using the syntax and semantics of one or more conceptual schema languages represented at the meta-model level.

The "bottom" *Data level* contains that actual data that is defined by the application schema at the application model level. The relationship of the application model level to the data level is that of types to instances.

The guiding principle in the use of this architecture is that the information at any abstraction level is defined in terms of the types provided by a language at the next highest abstraction level. This principle is set forth in Information Resource Dictionary System (IRDS) framework in ISO/IEC 10027:1990.

The following figure shows how conceptual schema languages and conceptual schemas relevant to the ISO 19100 series of standards are mapped onto the CSMF architecture.

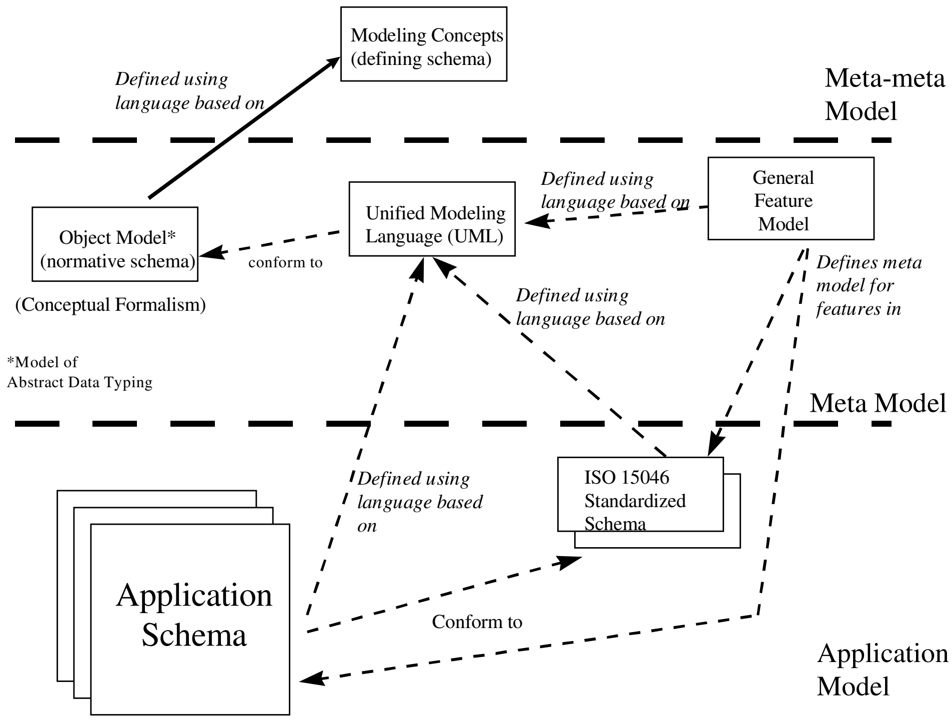



**Figure: CSMF schema architecture in ISO/TC 211**

In this mapping, the **meta-meta model** level contains concepts necessary for defining conceptual formalisms and conceptual models used by the ISO 19100 series of standards at the meta-model level. There are no standards in the ISO 19100 series that were developed for the meta-meta model level.

The **meta model** *level* identifies the *normative schema*, *models*, and *languages* used to describe geographic information. This is depicted in the above figure.

For the ISO 19100 series of standards, the *object model* is a conceptual formalism that plays the role of a *normative* schema at the meta model level.

This level includes the *conceptual schema languages* used to describe schemas at the *application model level* and the *General feature model*. For the ISO 19100 series, UML is the conceptual schema language whose meta-models conform to the *normative* object model conceptual formalism.

An example of geospatial meta-model is the *General feature model*. A fundamental concept of geographic data is the feature being defined as an abstraction of real world phenomena. The General feature model (GFM) (ISO 19109) is a meta-model for developing conceptual models of feature types, feature attributes, feature associations, and feature operations. It serves as a meta-model for feature catalogues (ISO 19110) containing the definition and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data, together with any feature operations that may be applied.

This meta-model, and the conceptual schema language it supports, is used to define conceptual schemas at the CSMF **application model** level. The *application model level* contains both *application schemas* and the *conceptual schemas* standardized in the ISO 19100 series of standards. The *conceptual schemas* standardized in the ISO series of standards are at the application model level. *Application schemas*, both those produced for individual geographic information systems, and those associated with profiles and product specifications, conform to the ISO 19100 series standardized schemas at the application model level.

The *application model level* schemas define the types of *instances* that exist at the *data level*. The metadata schema is also at this level.

*Application schemas* describe geographic information datasets. They consist of type definitions for collections of similar *instances* found at the *data level*. Examples of abstract type definitions include feature types, types of spatial objects, and data quality elements. Reference systems are also specified as part of the *application schema*. These type definitions may be obtained from standardized *conceptual schemas*.

The *application model level* also contains c*onceptual schemas* developed using the General Feature Model that serves as a basis for defining *application schemas.* The application level includes schemas standardized in the ISO 19100 series of standards, such as the spatial schema, temporal schema, metadata schema, or the quality schema, as well as schemas from other standards. Profiles and product specifications are also within the *application model level*. *Application schemas* are required to conform to conceptual schemas standardized in the ISO 19100 series of standards.

The *application schema* (ISO 19109) provides the formal description of the data structure and content of the dataset. The information model may be broken down into independent parts that can be integrated by a defined interface. The application schema is one part; other standardized schemas (e.g. ISO 19107, 19108, 19111, 19112 for spatial and temporal schemas) are other parts.

Metadata are defined as data about data. At the *application model* level, ISO 19115 provides a structure for describing the data, and defines the metadata element definitions (or types of metadata elements) for the metadata in a metadata dataset.

The following figure shows the relationship between features, metadata, and data within the ISO CSMF.

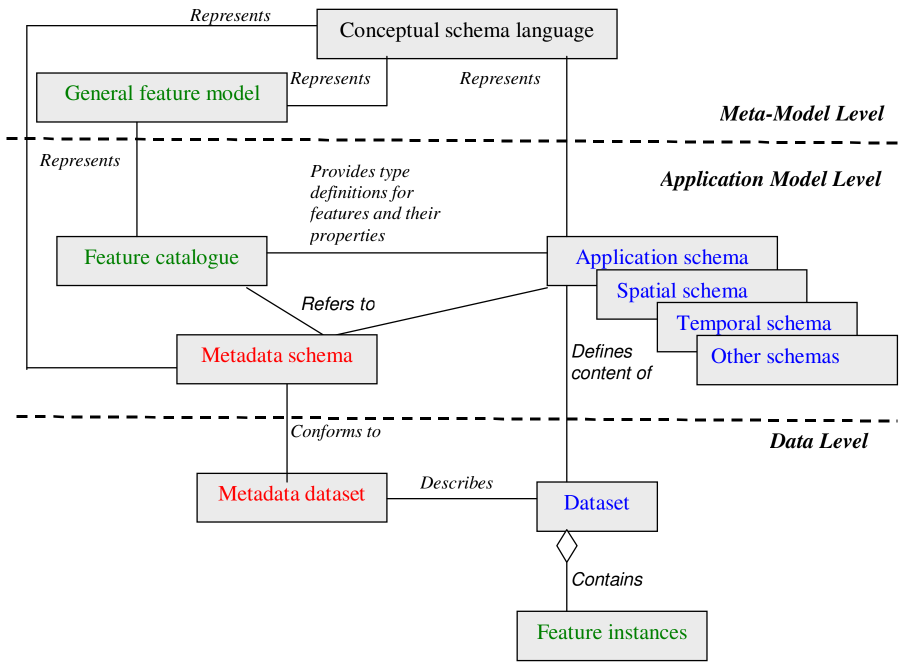



**Figure: Relationship between features, metadata, and data within the ISO CSMF**

The **data level** contains information describing specific features, or *instances*, found in reality. This includes *features*, the description of spatial aspects of features, and position.

Idea of CSMF schema architecture in ISO/TC 211 is again illustrated on the following figures.

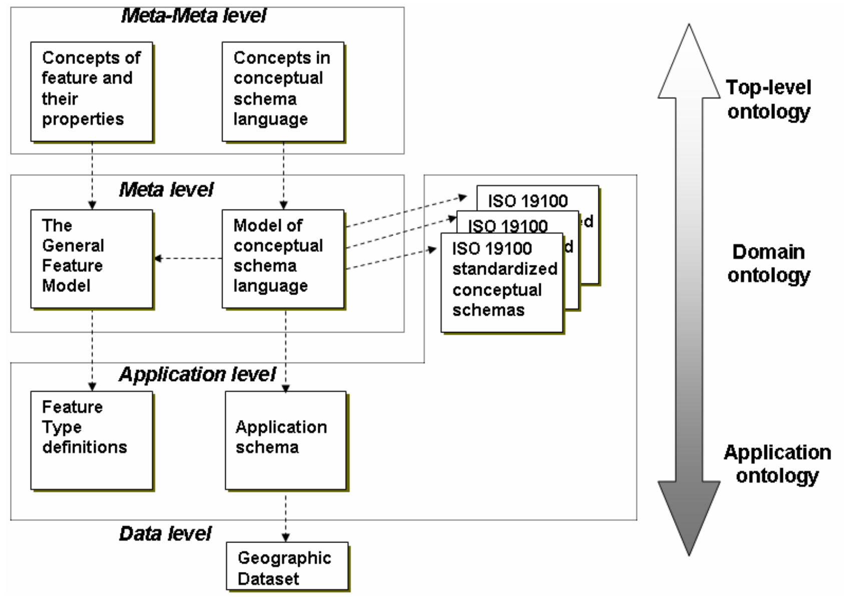



**Figure: Semantically coherent modeling processes**

- Adopting meta-model of Unified Modeling Language (UML) and creating a UML profile
    - ISO/TS 19103 Conceptual schema language
- Expressing concepts using ISO 19103
    - ISO 19107 Spatial schema
- By inheriting *feature types* in ISO 19107
- How can we model Application Level Data Model? - ISO 19109

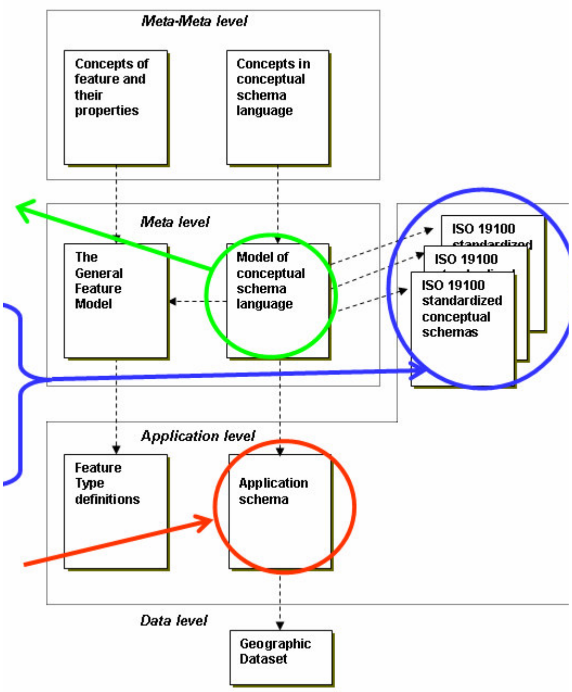



**Figure: ISO/TC 211 Modeling Processes**

### 2.2.3 Clause 8 The Domain Reference Model

The Domain reference model provides a high-level description of those aspects of geographic information that are addressed in the ISO 19100 series of standards. The *Domain reference model* shows the place of the General feature model in the context of geographic information (high-level description).

The high-level view of the domain of geographic information is shown in the following figure. All these entities are at the *data level,* with the exception of the application schema. The *application schema*, which may be referenced by the *metadata dataset*, is at *application model level*.

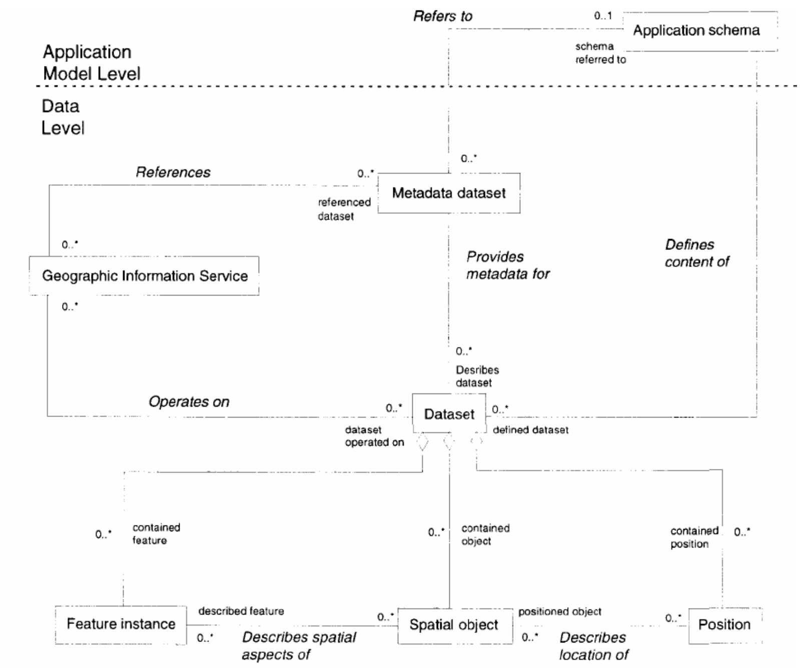



**Figure: High-level view of the Domain reference model**

The **dataset** contains ( ):

- *Feature instances*, including feature attributes, feature relationships, and feature operations (defined mathematical operations for computing information about features).
- *Spatial objects* that may describe the spatial aspects of *features*, or are complex data structures that associate values of attributes to individual positions within a defined space.
- Descriptions of the *position* of *spatial objects* in space and time, using units of measure provided by reference systems.

The **application schema** provides a description of the semantic structure of the *dataset*. The *application schema* also identifies the spatial object types and reference systems required to provide a complete description of geographic information in the *dataset*. Data quality elements and data quality overview elements are also included in the application schema.

The **metadata dataset** allows users to search for, evaluate, compare, and order geographic data. It describes the administration, organization, and contents of geographic information in *datasets*. The structure of the *metadata dataset* is standardized in a metadata schema that is defined in ISO 19115, *Geographic information metadata*.

**Geographic information Services** are implemented as software programs operate on geographic information contained in *datasets*. These services reference information in the *metadata datasets* in order to correctly perform retrieval operations, as well as manipulation operations such as transformation and interpolation. Services access data in a networked environment in which *datasets* are stored in distributed database management systems.

For the ISO 19100 series of standards, non-geographic features are also valid. Such features may be included in the *application schema* and not have spatial characteristics.

The information in the above figure, showing the high-level view of the *Domain reference model,* is expanded into *six* generalized views of the standardized schemas. The schemas describe the connections of the entities to respective standards in the ISO 19100 series and *point out interrelationships between different standards*. The following schemas are described in this clause of ISO 19101:

- Application schema
- Spatial objects and position
- Reference systems
- Quality
- Metadata
- General feature model

These schemas will be discussed, within the context of their respective standards in next modules.

### 2.2.4 Clause 9 The Architectural Reference Model

The Architectural reference model (ISO 19101) describes the general types of services that will be provided by computer systems to manipulate geographic information and enumerates the service interfaces across which those services must interoperate (ISO 19116, 19117, 19118, 19119). This model also provides a method of identifying specific requirements for standardization of geographic information that is processed by these services.

As an example for communication services, encoding rules (ISO 19118) allow geographic information defined in an application schema to be coded into an independent data structure system suitable for transport or storage. The encoding rule based on XML specifies the types of data to be coded and the syntax, structure, and coding schemes used in the resulting data structure.

These services will be discussed in Modules 4 and 5.

### 2.2.5 Clause 10 Profiles and Functional Standards

The comprehensiveness and large number of options available in various base standards make it difficult to combine them for practical applications. The concept of *profile* is a useful tool for actually establishing such combinations, thereby providing a mechanism to use the standards in the ISO 19100 series in real applications.

A profile integrates a set of base standards and/or modules (predefined subsets) of base standards to meet a specific implementation requirement. The concept and development of profiles of the ISO 19100 series of standards follows the guidelines set forth in ISO/IEC TR 10000-1:1998, *Framework and taxonomy of international standardized profiles Part 1: General principles and documentation framework*.

This clause includes general definitions as to how a product speciation can be created from the modules of standards. Standards related to profiling and functionality will be discussed later in this module. At this time, only base definitions related to profiling are provided:

A **profile** is a set of one or more base standards and, where applicable, the identification of chosen clauses, classes, subsets, options, and parameters of those base standards, that are necessary to accomplish a particular function or functions. A **base standard** is any standard in the ISO 19100 series or any other Information Technology standard that can be used as a source for components from which a profile may be constructed.

A **module** is a predefined set of elements in a base standard that may be used to construct a profile. Modules form the lowest level of granularity from which elements for a profile may be selected.

A **product specification** is a description of the universe of discourse and the specification for mapping the universe of discourse to a dataset. A product specification is similar to a profile, in as much as it consists of a selection of optional items from the series of 19100 standards. However, a product specification differs from a profile in that a product specification is a complete description of all of the elements required to define a particular geographic data product. A product specification may include information such as: data content and classification; standards and profiles; spatial referencing; data structures; sources and data capture; update; data presentation; data quality and integrity; applicability; and metadata.

**Functional standards** are some existing international geographic information standards (not ISO/TC 19100 series) that are currently in widespread use. These standards provide the capabilities and functions that are required in the standards in the ISO 19100 series and ensure that the base standards are compatible with the existing functional standards.

### 2.2.6 Annex B (informative) Focus of standardization in the ISO 19100 series of geographic information standards

This annex describes more precisely the focus of the ISO 19100 series of standards in terms of the ISO Open Distributed Processing (ODP) standard, described in ISO/IEC 10746-1:1995. The ISO ODP Reference Model identifies five viewpoints, or perspectives, on information technology:

- Enterprise viewpoint

- Information viewpoint
- Computational viewpoint
- Engineering viewpoint
- Technology viewpoint

A graphical depiction of the relationships between the viewpoints is provided in the following Figure.

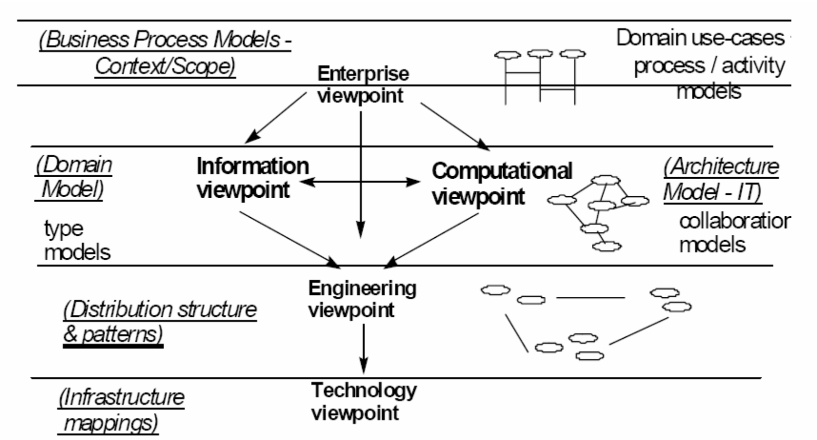



**Figure: ODP Viewpoints**

*ISO 19101 Geographic information - Reference model* is a guide to structuring geographic information standards mostly for vector data representation of feature. Currently, ISO/TC 211 is developing a Part 2 of ISO 19101 dealing with imagery.

## *2.3 ISO/TS 19104 - Terminology*

Scope of **ISO/TS 19104 Geographic information - Terminology** *technical specification* is to define a harmonized set of all specific terms that relate to the ISO/TC 211 family of standards. The purpose of this activity is standardization of the terminology used in the ISO/TC 211 suite of standards.

Creation of a common set of terms for geographic information standards is an important foundation for the work groups of ISO/TC 211 in the development of an integrated suite of standards. Standardized terminology also help standards users, especially a geographic information system and software developers who will implement the ISO/TC 211 standards.

Geographic information terminology is harmonized with both Information Technology and Data Management terminology. This standard is under the development with a target date for DTS in 2007-07. (DTS – draft technical specification). This task is generally feasible, but the existing use of multiple terms for the same concept or a single term for different concepts within the field of geographic information and related fields made this a difficult task. The work promotes international understanding of geographic information standards and better understanding of geographic information concepts among other disciplines.

This Technical Specification will provide the guidelines for collection and maintenance of terminology in the field of geographic information that includes:

- Criteria for selection of concepts to be included in other ISO/TC 211 standards
- The structure of the terminological record
- List of terms and definitions
- Principles for definition writing

Clause 6 *Criteria for the selection of concept* identifies conditions under which concept requiring a definition for the clarity of reading of any of the ISO/TC 211 Geographic information International Standards shall be included in ISO/TS 19104 International Standard and within the core list of entries. These conditions are:

- The term that represents the concept, is not a trade name, name of research project, or colloquial term (local informal term to describe a formal term e.g. "guy" instead of "man")
- The concept is not selected if its definition in general language dictionaries corresponds to its definition in the field of geographic information
- Only concepts with a single definition are included
- The concept is central to understanding the standard, used at least twice, and is not self-explanatory

Clause 7 *Structure of the terminological record* defines terminology record content such as:

- entry number – a terminological record identifier
- entry language identifier – the code representing natural language utilized for the terminological record based on ISO 639-2
- preferred term
- abbreviated term – if preferred, the abbreviated term shall precede the full form, otherwise an abbreviated form shall follow the full form
- admitted term(s) – national variants shall be followed by a country code as defined in ISO 3166-2
- definition
- deprecated or obsolete terms (in alphabetical order)
- references to related entries
- examples of term usage

Annex A (normative) *Maintenance of terminology* define procedures of amendments and additions to the ISO geographic information standards. It is predictable that amendments and additions will be an inevitable necessity to this Technical Specification. It is confirmed that terminology will be maintained within a Terminology Repository by the Terminology Maintenance Group. Maintenance mechanisms have been developed that will:

- Enable proposed terms (and their associated definitions) to be added to, or amended in, the Terminology Repository, as required
- Facilitate the assessment and harmonization of proposed terms prior to their parent draft standards becoming final

The Terminology Repository shall take the form of an online computer database that allows terminology entry and update under pre-defined administrative privileges and complies with specified structure (Clause 6).

Every term in the Terminology Repository shall have one of six classifications as follows:

| **Instance classification number** | **Classification description** |
|---|---|
| 001 | Candidate |
| 002 | Draft |
| 003 | Harmonized |
| 004 | Normative |
| 005 | Normative/Conflict |
| 006 | Deleted |

Terminology status review process is also described in the TS. Annex C (normative) Principles for definition writing (ISO 704:2000). This document defines the basic principles for definition writing and creates a terminology standard.

Annex B (normative) *Terms and Definitions* from ISO/TC 211 International Standards and Technical Specifications contains the terms that have been compiled from International Standards and Technical Specifications developed by ISO/TC 211. Its purpose is to encourage consistency in the use and interpretation of geospatial terms. It is freely available for use by all interested parties and organizations. The link to this list is http://www.isotc211.org/TC211_Terminology_Glossary-20060417-Published.xls

## *2.4 ISO/TS 19103:2005 - Conceptual Schema Language*

**ISO/TS 19103:2005** Technical Specification is concerned with the adoption and use of a conceptual schema language (CSL) for developing computer-interpretable models, or schemas, of geographic information. Standardization of geographic information requires the use of a formal CSL to specify unambiguous schemas that can serve as a basis for data interchange and the definition of interoperable services. An important goal of the ISO 19100 series is to create a framework in which data interchange and service interoperability can be realized across multiple implementation environments. The adoption and consistent use of a CSL to specify standardized geographic information is of fundamental importance in achieving this goal.

The chosen conceptual schema language is the **Unified Modeling Language** (**UML**). ISO/TS 19103:2005 provides a **profile** of UML for use with geographic information. ISO/TS 19103 further refines the use of UML in the domain of geographic information modeling. In addition, ISO/TC 19103 provides guidelines on how UML should be used to create standardized geographic information and service models that are a basis for achieving the goal of interoperability.

The ISO geographic information standards focus on abstract, implementation-**neutral** UML models that can serve as specifications for implementations using various implementation platforms.

UML diagram was already used in this course (e.g. for description of ISO 19101 High-level view of the Domain reference model). After studying the UML you may wish to come back to review this diagram again.

The following topics are defined with this standard for the domain of geographic information modeling with UML:

- Basic data types
- Stereotypes
- Naming
- Documentation of models
- Implementation neutral vs. implementation specific models
- Information modeling guidelines

This Technical Specification shows the combination of the **Unified Modeling Language** (**UML**) in the static structure diagram with its associated **Object Constraint Language** (**OCL**), and set of **ISO Interface Definition Language** (**IDL**) basic type definitions as conceptual schema language for the specification of geographic information. The whole UML specification can be downloaded from http://www.omg.org/cgi-bin/doc?formal/05-04-01.

### 2.4.1 Unified Modeling Language

The Unified Modeling Language (UML) is a language for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems. UML is a notation for object-oriented modeling that is standardized by Object Management Group (OMG) organization (http://www.omg.org). UML consists of more than a dozen different diagrams:

- **Package diagram**
- **Use case diagram**
- **Class diagram**
- Statechart diagram

- Sequence diagram
- Collaboration diagram
- Component diagram
- …

UML can be used for static and dynamic modeling. Static diagrams describe the static structure of a system and consist of a set of objects (classes) and their relationships (e.g. class diagram). A dynamic model describes the dynamic behavior of a system, such as state transitions and interactions (messages sent) and may be represented as state-chart diagrams, sequence diagrams, and collaboration diagrams.

Only those diagrams used in this course are defined below.

**UML Packages Diagram**
A *package* is a container of other coherent modeling elements and packages. A *package* is a grouping of model elements. The complexity of the UML metamodel is managed by organizing it into logical packages. A package is shown as a large rectangle with a small rectangle (a “tab”) attached to the left side of the top of the large rectangle.

ISO/TC 211 standards and clauses are often hierarchically organized in terms of UML packages. Diagrams showing only packages primarily serve the purpose of giving an overview of the different logical parts in the model and the interdependencies between those parts. When one package, acting as a client, uses another, acting as a server, to supply needed services, the client package is said to be dependent on the server package. This dependency occurs when an object class in the package accesses another object defined in the server package.

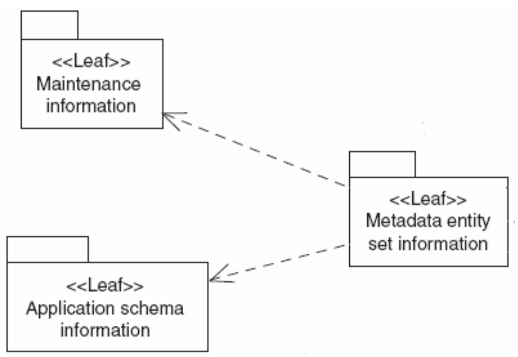



**Figure: Example of package structure**

A dependency between two packages is drawn as a dashed arrow with an open arrowhead. The figure above shows two packages where Package 2 is dependent of Package 1. In practice that means that Package 2 has definitions (for example classes) that are dependent on definitions in Package 1.

An optional stereotype keyword may be placed above the package name within guillemets (e.g. <<Leaf>>). We will discuss this feature below.

Because of this client-server relation, inter-package dependencies define the criterion for viable application schemas. An application schema that contains an implementation of any package defined from an ISO standard shall also contain implementations for all its dependencies.

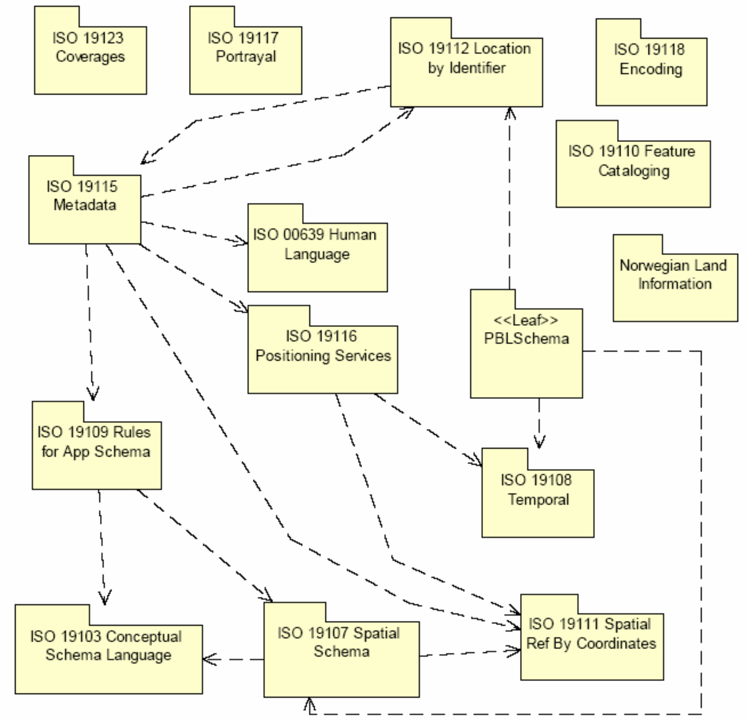



**Figure: ISO/TC 211 packages*:***

## UML Use Case Diagram

Use case diagrams show actors and use cases together with their relationships. The use cases represent functionality of a system or a classifier, like a subsystem or a class, as manifested to external interactors with the system or the classifier.

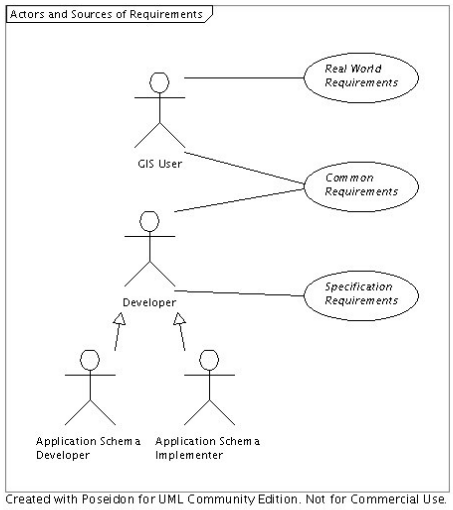



**Figure: Sample of use case diagram**

## UML Class Diagram

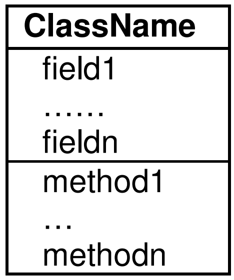
The UML class diagram is the most common diagram in object-oriented modeling. A class diagram is a graphical representation of a static view on declarative, static elements. A **class** is the description of a set of objects having similar **attributes**, **operations** (behavior or methods), and **relationships**. This diagram consists of nodes representing **classes**, links representing *five* **relationship** types (such as *inheritance*, *association*, including *aggregation* and *composition*, and *dependency*) among classes

### *UML Classes*

The UML notation for **classes** is a rectangular box with as many as three compartments.

The top compartment shows the class name.

- The middle compartment contains the declarations of the fields, or *attributes,* of the class
- The bottom compartment contains the declarations of the methods of the class



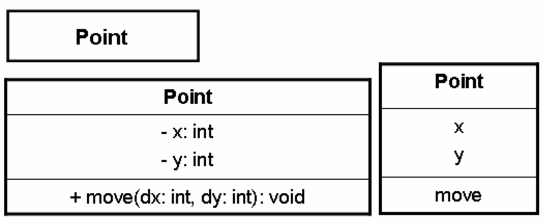




**Figure: Example of the Point class**

### *UML Classes attributes and operations*

Attributes and operations are presented in the UML diagrams in compliance with the UML Notation Guide. UML notation for an **attribute** has the form:

```
Attribute-declaration :==
      "«" stereotype "»" visibility name multiplicity " : "
      type = initial-value {property, …}
multiplicity :== "[" cardinality-range,… "]"
cardinality-range :== begin-value {".." end-value}
```

UML notation for an **operation** has the form:

```
Operation :== "«" stereotype "»" visibility
      name "(" parameterlist ")" " : " [return-type], …
      {"{" property{=value}, …"}"},…
parameterlist :== [direction] parameter-name " : " type ["=" default-value]
```

Where the various parts of the above syntax are as follows:

- `stereotype` - use tag for the attribute or operation being defined (see below).
- `visibility` - public (+), private (–) or protected (#) indicating the visibility of this attribute or operation from outside the object. If the visibility includes "/", then the attribute is derived from some other part of the model.
- `name` - the name of the attribute or operation.
- `multiplicity` - the number of values that this attribute can have, assumed to be organized as a set unless otherwise specified; this is an extension of and consistent with the "size" mechanism of ISO/IEC 11404, except for the use of "[..]" which is UML notation. To maintain consistency of concept, this International Standard uses a single multiplicity syntax (from UML) even when using it in conjunction with the "size" sub-typing of ISO/IEC 11404.

- `begin-value` - any integer, a valid multiplicity; if no end-value follows, then only the begin-value is added as a possible multiplicity.
- `end-value` - any integer bigger than the preceding begin-value, or "*n*" meaning infinity or an unbounded cardinality-range, the meaning of "*a*..*b*" is any integer *j* such that *a* u *j* u *b*; [*a*..*a*] is assumed to mean the same as [*a*].
- `parameterlist` - a comma separated list of parameter declarations.
- `parameter-name` - name of a parameter to the operation, usually indicative of the role of the parameter in the operation being defined. Note that the syntax structures for an operation and for an attribute are identical except than an operation includes a parameter list and an attribute includes a multiplicity.
- `direction` - optional indicator of direction flow for this parameter being 'in' (the value is set before invocation of and affects the operation), 'out' (the value is set during the operation and its value is accessible by the invoker upon completion of the operation) , or 'inout' (the value is set before the invocation, and affects the operations, and is reset by the operation by a value accessible by the invoker upon completion of the operation). The default direction of any parameter is "in".
- `type` - the type, either object or value of the preceding parameter or attribute.
- `default-value` - the value of an in or in-out parameter if not specified by the invoker. The value of an object's attribute if not set by any constructor.
- `return-type` - the type of the return value or object for the operation, essentially the type of the operation.
- `property` - additional information about the attribute or operation, such as NOT NULL or UNIQUE. Can be structured as a property name followed by a value, such as "{size = [0..n]}".
- **...** - the preceding can be repeated any number of times.
- `initial-value` - default value of the attribute, used when a new object is constructed unless specifically overridden by the constructor's parameter list.

In the text, notation from the Object Constraint Language (OCL) is used with some slight modifications (can be downloaded from http://www.omg.org/cgi-bin/doc?formal/05-04-01).

UML does not require all relationships or attributes to be displayed in all diagrams. When attributes intentionally have been left out, the attribute compartment in the class is not displayed at all in the diagram. That means that a class where the attribute compartment is displayed, but empty, actually has no attributes.

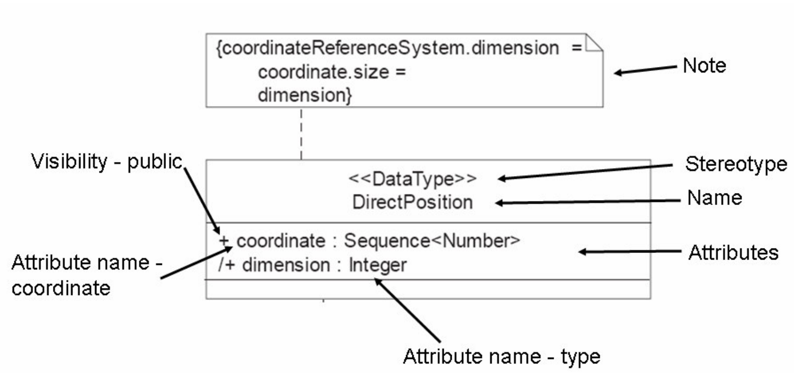



**Figure: Example of DirectPosition class (from ISO 19107): DirectPosition object data types hold the coordinates for a position within some coordinate reference system.**

### *UML relationships*

UML model supports the following *five* types of **relationships:**

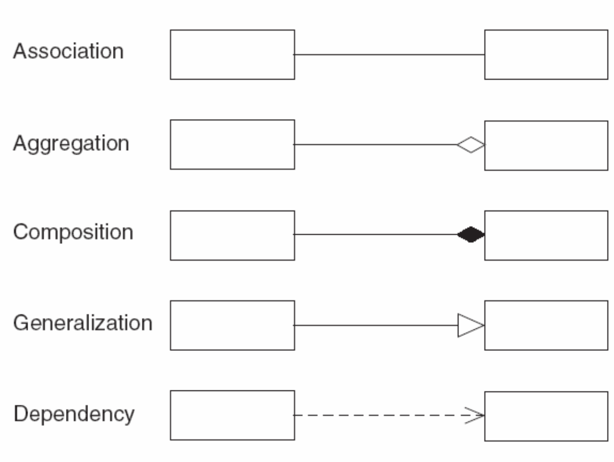



**Figure: UML relationship types**

An *ordinary* **association** is a semantic relationship between classes that concerns the connection (e.g., references) between its instances. Notation of **association** includes:

- Name
- Multiplicity (cardinality)
- User role description (extracted from use cases)

An ordinary ***association*** (just association) is used to represent a general relationship between two classes. A ***role*** in an association is a name describing the participation of the class in the association more exactly. If an association is navigable in a particular direction, the model shall supply a “role name” that is appropriate for the role of the target object in relation to the source object. Thus in a two-way association, two role names will be supplied.

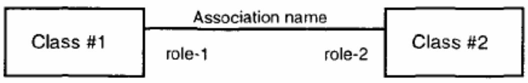



**Figure: Association name and roles**

The ***multiplicity*** of an association defines the valid range of values for the number of objects taking part in the association.

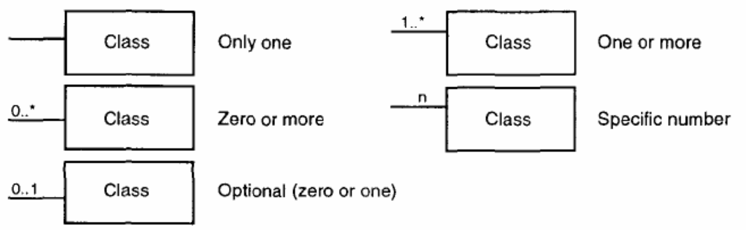



**Figure: Association (and aggregation) cardinalities**

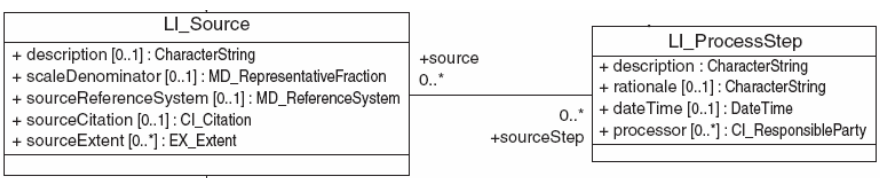


**Figure: Example form Lineage information (ISO19115) defines metadata required to describe the sources and production processes used in producing a dataset.**

An **aggregation** association is a relationship between two or more classes in which one of the classes plays the role of container and the other plays the role of a containee. This is a special form of association representing *has-a* or *part-whole* relationship and distinguishes the whole (aggregate class) from its parts (component class).

The empty diamond is drawn at the container end of the aggregation. There is no relationship in the lifetime of the aggregates which means that the components of aggregation *can exist separately*.

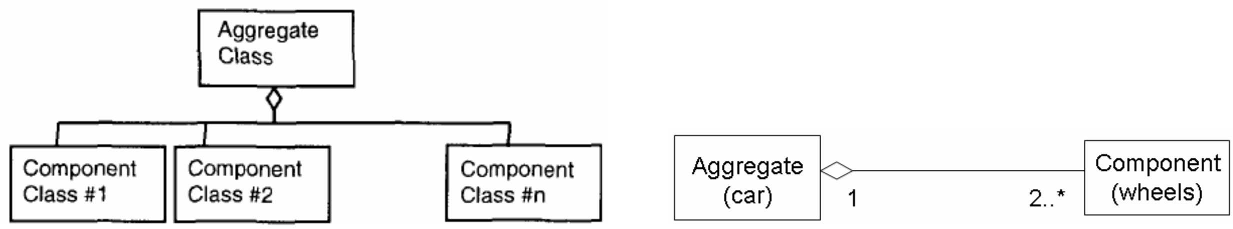



**Figure: Examples of aggregation association**

A **composition** association is a strong aggregation. In a composition association, if a container object is deleted, then all of its containee objects are deleted as well. The composition association shall be used when the objects representing the parts of a container object *cannot exist* without the container object.

The filled diamond is drawn at the container end of the composition.

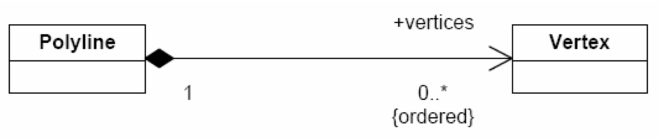



**Figure: Examples of composition association**

**Generalization** is a semantic relationship between a general concept **A** (***super class***) and a more special concept **B** (***sub class***). A generalization is a relationship between a super-class and the subclasses that may be substituted for it. The super-class is the generalized class, while the subclasses are specified classes and can inherit attributes and methods from super class.

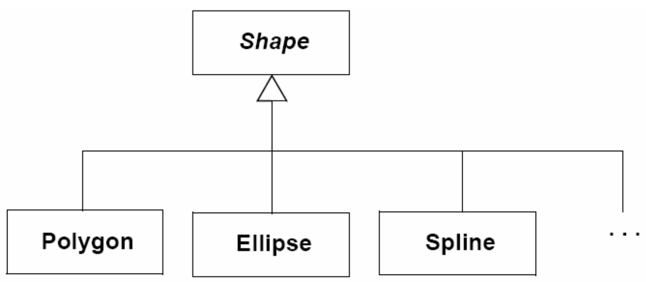



**Figure: Shape is abstract class for specified shapes**

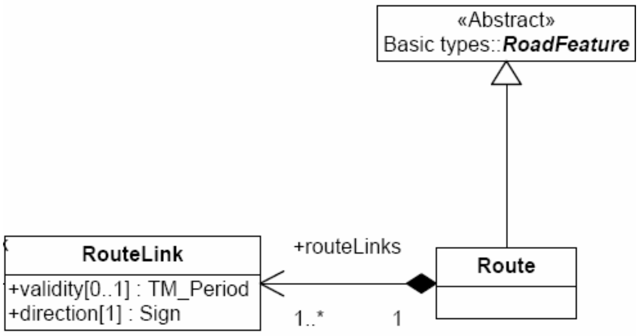



**Figure: The Route object inherits from RouteFeature abstract class, RouteLink direction is instantiated as a composition relationship so every route element owns its route links.**

**Dependency** is relationship between the entities such that the proper operation of one entity depends on the presence of the other entity, and changes in one entity would affect the other entity.

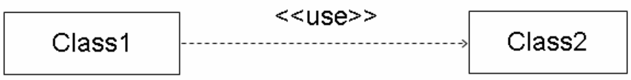



**Figure: The common form of dependency is the *use* relation among classes**

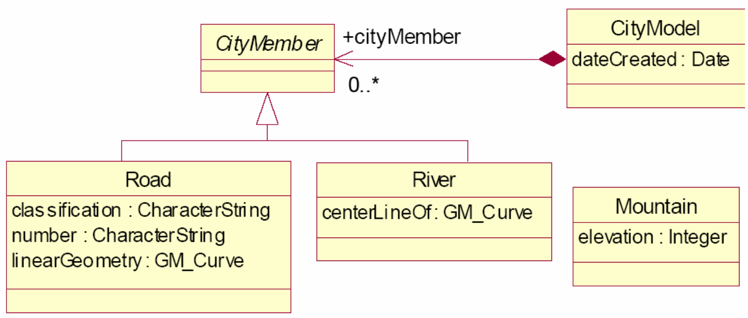



**Figure: Example of UML model**

### *UML Stereotype*

A **Stereotype** is a user-defined meta-element whose structure matches an existing UML meta-element (its "base class"). A UML stereotype is an extension mechanism for existing UML concepts. It is a model element that is used to classify (or mark) other UML elements so that they, in some respect, behave as if they were instances of new virtual or pseudo metamodel classes whose form is based on existing base metamodel classes.

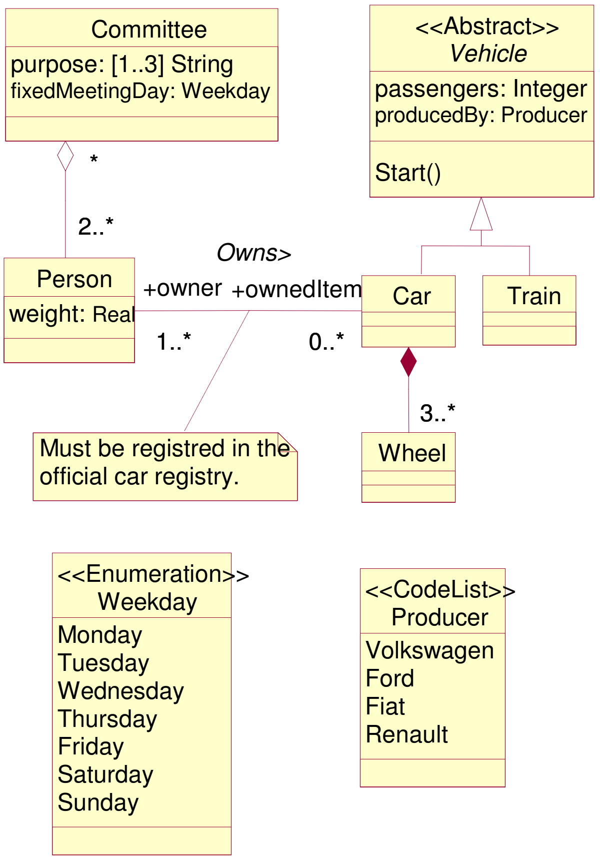
Stereotypes augment the classification mechanisms on the basis of the built-in UML metamodel class hierarchy. Name of "stereotype" is included near the name of the object and enclosed in guillemets "«" and "»". Below are brief descriptions of the most common stereotypes, for more detailed descriptions consult ISO/TS 19103.

- `«Abstract»` – (also represented in UML by the class name being in an *italics* font) the class cannot be instantiated.
- `<<Type>>` class used for specification of a domain of instances (objects), together with the operations applicable to the objects. A type may have attributes and associations.
- `«DataType»` – the class is directly instantiable and its primary purpose is the encapsulation of data. `«DataTypes»` do not have an identity of their own and must be

strongly aggregated into some sort of container such as being an attribute in another class, or being the target class of a strong aggregation.

- «Union» – a type consisting of one and only one of several alternatives (listed as member attributes).
- «Enumeration» - a type that defines a list of valid identifiers of mnemonic words. Attributes of an enumerated type can only take values from this list.
- «CodeList» – similar to an enumeration, in that one of a number of values is possible, but differs in intent, in that a code list may be expanded over time.
- <<Metaclass>> - class whose instances are classes. Metaclasses are typically used in the construction of metamodels. A metaclass is an object class whose primary purpose is to hold metadata about another class.
- <<Interface>> - named set of operations that characterize the behavior of an element.
- <<Package>> - cluster of logically related components, containing sub-packages.
- <<Leaf>> - package that contains definitions, without any sub-packages.

### *UML Notation Summary*




Object types:
The area of interest will be built from object types having the same attributes, relations or behavior. Committee, Person, ...

Attributes:
A Committee shall have at least one, and up to three purposes.
The Committee has a fixed meeting day, which is taken from a closed list.
A Person can have a given or measured attribute value for his/her weight.
A Vehicle can carry a number of passengers at any one time.
A Vehicle can have producedBy info, with value taken from an open list.

Aggregation:
A Committee consists of members who are Persons.
Committees must have at least two members. (2..*)
A Person can be a member of several Committees. (*)

Ordinary relation:
A Person can be the owner of zero or many cars. (0..*)
The ownership can have a note about some restrictions to the relation.
A Car must be owned by at least one person. (1..*)

Composition:
A Car has (as components) a minimum of three Wheels.

Subtyping:
Car is a subtype of Vehicle (Inherits relations, attributes and behavior.)
Vehicle is an abstract supertype of Car and Train.
Abstract means that a Vehicle cannot be instantiated directly.

Behavior:
A Vehicle shall have a Behavior as to Start().

Enumeration and CodeList
Weekday is a closed list where no new values can be added.
Producer is a list of all known producers, and opens for new producers.

**Figure: Example of some the most important modeling concepts used in UML class diagrams**

## 2.4.2 Object Constraint Language (OCL)

A UML diagram, such as a class diagram, is typically not refined enough to provide all the relevant aspects of a specification. Within the UML semantics, OCL is used in the well-formedness rules as invariants on the metaclasses in the abstract syntax. It is also used to define ‘additional’ operations that are used in the well-formedness rules. These additional operations can be formally defined using «definition» constraints and let-expressions. OCL is a pure expression language. A formal language used to express constraints.

In ISO/TC 211, notation from the Object Constraint Language (OCL) is used with some slight modifications. UML modelers can use OCL to specify application-specific constraints in their models. See Unified Modeling Language (UML), version 2.1.1 05-04-01.pdf, chapter 8 Object Constraint Language Specification and ISO 19103 for more details.

## 2.5 ISO 19105:2000 - Conformance and Testing

The Objective of standardization in the field of digital geographic information cannot be completely achieved unless data and systems can be tested to determine whether they conform to the relevant geographic information standards.

Conformance testing is the testing of a candidate product for the existence of specific characteristics required by an International Standard in order to determine the extent to which that product is a conforming implementation. It involves testing the capabilities of an implementation against both the conformance requirements in the relevant International Standards and the statement of the implementation's capabilities.

**ISO 19105:2000 - Conformance and Testing** provides the framework, concepts, and methodology for testing and the criteria to be achieved to claim conformance to ISO/TC 211 family of standards. Test methods are also addressed in this International Standard. Note that conformance testing does not include robustness testing, acceptance testing, and performance testing, as the geographic information family of standards does not establish requirements in these areas.

ISO 19105 is based, in part, on ISO 9646-1 that describes conformance and testing in Open System Interconnection (OSI), ISO 10303-31 that describes conformance and testing in industrial automation systems and integration; ISO 10641 describes conformance and testing for computer graphics and image processing.

ISO 19105 provides a framework for specifying abstract test suites (ATS) and for defining the procedures to be followed during conformance testing. Conformance may be claimed for data or software products or services or by specifications including any profile or functional standard. Standardization of test methods and criteria for conformance to geographic information standards will allow verification of conformance to those standards.

This International Standard is applicable to all the phases of conformance and testing. These phases are characterized by the following major activities:

- The definition of ATS for conformance to the ISO geographic information standards;
- The definition of test methods for conformance to the ISO geographic information standards
- The conformance assessment process carried out by a testing laboratory for a client, culminating in the production of a conformance test report

This International Standard specifies the requirements for, and gives guidance on, the procedures to be followed in conformance testing for the ISO geographic information standards. It includes only such information as is necessary to meet the following objectives:

- To achieve confidence in the tests as a measure of conformance
- To achieve comparability between the results of corresponding tests applied in different places at different times
- To facilitate communication between the parties responsible for the activities described in 1) and 2)

This International Standard provides a framework for certification (an administrative procedure that may follow conformance testing) in informative annex B.

Standardization of testing methods and criteria for conformance to selected geographic information standards will allow developers of geographic information systems and software to verify conformance to those standards. Conformance standards will not be needed until the standards are implemented but, to the extent possible, criteria for testing and conformance will be considered by the ISO/TC 211 work groups during the development of selected standards. Verifiable conformance is also important to geographic information users, in order to achieve data transfer and sharing.

## 2.6 ISO 19106:2004 - Profiles

A particular use of geographic information may only require a limited subset of geographic primitives and allow only geodetic referencing, not indirect referencing. The particular subset of ISO/TC 211 standards needed to support that use would be a profile. Definition of standardized profiles will enhance understanding of the family of standards, increase acceptance of the standards, promote interoperability, and make use of the standards more efficiently and cost effectively.

**ISO 19106:2004 Geographic information – Profiles** defines the concept and provides guidelines for the creation of profile/product within the ISO/TC 211 family of standards. A **profile** is a logical subset of one or several standards and components of standards within the family. By nature profile definitions follow the development of the family of standards of which they are a subset. Profile development can begin after completion of the first geographic information schemata and will continue even after completion of the initial suite of standards.

ISO 19106 document also provides guidance for establishing, managing, and standardizing at the national level (or in some other forum).

Specifications for implementing ISO geographic information standards, which are or contain specific instances of rules or methodologies and which are not derived entirely from the ISO geographic information standards, are treated differently from profiles. ISO 19106 does not address the creation of specifications for implementing ISO geographic standards in specific technical implementation environments.

Two classes of conformance are defined in this IS:

- Conformance class 1 is satisfied when a profile is established as a pure subset of the ISO geographic information or other ISO standards. Such a profile may be considered as an ISO geographic information standard in its own right.
- Conformance class 2 allows profiles to include not ISO ***extensions*** within the context permitted in the base standard. When such a profile will not be processed as an ISO standard but may be established under the authority of the standards organization, member body or liaison organization making the profile.

Any profile claiming conformance to this IS shall satisfy all the requirements found in the abstract **test** suite found in Annex A in accordance with the conformance class chosen.

Profiles promote integration of base standards by defining how to use a combination of ***base*** standards for a given functional environment. A profile may consist of a choice from the clauses, classes, options, and parameters of base standards, or other profiles. The conformance requirements of a profile shall relate to the conformance requirements in the base standards in the following ways:

- Mandatory requirements in the base standard shall remain mandatory in the profile
- Options in base standards may remain optional or may be changed within the profile

ISO 10106 Clause 7 describes the purpose of profiles. Clause 8 describes how profiles reference base standards. Clause 9 describes the content of a profile and Clause 10 describes conformance requirements. Clause 11 describes the method for identifying profiles. Clause 12 describes the structure of documentation for profiles. Clause 13 describes the procedures for the preparation and adoption of profiles. Annex A describes the abstract test suite for conformance to ISO 19106. Annex B presents examples of profiles; Annex C describes the conformance methodology.

A profile shall comprise the following elements and requirements:

- A concise definition of the scope of the function which the profile supports and the user requirements which it will satisfy
- A description of the context in which a profile is applicable
- A statement of the community of interest to which it is addressed
- Normative references to a set of base standards or profiles, including precise identification of the actual texts of the base standards or profiles being used, together with identification of any approved amendments and technical corrigenda (corrections), conformance to which is identified as potentially having impact on achieving interoperability or portability using the profile
- Specifications of the applications of each referenced base standard or profile, stating the choice of classes or conformance subsets, and the selection of options, ranges of parameter values, for profiles
- A statement defining the requirements to be observed by systems or data sets claiming conformance to the profile, including any remaining permitted options of the referenced base standards or profile
- Where relevant, a reference to the specification of conformance tests for the profile
- Informative reference to any amendments or technical corrigenda to the base standards referenced in the profile, which have been determined to not be relevant
- A profile shall be developed within the framework defined by ISO 19101

Profiles need to be uniquely identified so that they can be referenced in other profiles and implementations. If profiles of conformance class 1 are processed as standards, it will receive an ISO standard identification number. The identification of profiles with less formal status can be left to the organization, standards body, or member body of the liaison organization to establish.

Any document structure of a profile has to be specified in accordance with the criteria outlined in the following table.

| Clause number | Title or description |
|---|---|
| — | Foreword |
| — | Introduction |
| 1 | Scope |
| 2 | Conformance |
| 3 | Normative references |
| 4 | Terms and definitions |
| 5 | Symbols and abbreviations |
| 6 | Clauses defining requirements related to each base standard |
| Annexes | Providing additional normative information, such as, the profile conformance requirement or containing informative information, such as, explanatory and/or tutorial material as required |

The procedure for developing and publishing a profile is the same as for a standard. These procedures are detailed in the ISO/IEC Directives, Part 1.

The **conformance tests** for two classes of conformance are defined in the Appendix A of ISO 19106. To evaluate the conformance of a particular profile, it is necessary to have a statement of the chosen clauses, classes, options, and parameters, that have been used in the profile. This will allow the implementation to be tested for conformance against the relevant requirements and against only those requirements. The methodology for testing is given in ISO 19105:2000, Clause 8.

## 2.7 ISO/TR 19120:2001 - Functional Standards

The ISO 19100 series of geographic information standards provides a framework for the development of geographic information and related standards. There are a number of existing functional standards in use within the international community that would seek to achieve compliance with the emerging ISO 19100 series of standards.

**ISO/TR 19120 Technical Report (TR) - Functional Standards** seeks to identify how functional standards can be developed as profiles of the ISO 19100 series of standards and how this profiling process can promote harmonization between these functional standards. To provide assistance with the development of profiles, when the base standards of ISO/TC211 are available, which correspond to these recognized functional standards. The actual development of profiles is not included in scope of ISO/TR 19120.

The availability of a common frame of reference, as provided by the ISO 19100 series, may also present an opportunity for harmonization between the functional standards to the extent that such harmonization supports the primary goal of harmonization of the functional standards with the ISO 19100 series.  However, harmonization between functional standards is not the subject of ISO/TR 19120 report.

Within the context of this Technical Report, a functional standard has been identified as an existing geographic information standard, in active use within the international community. National standards have not been considered within this report.

This Technical Report seeks to identify the components of those recognized functional standards and to identify elements that can be harmonized between these standards and with the ISO/TC 211 base standards. This Technical Report provides a starting point for a feedback cycle between the functional standards communities and the ISO 19100 series component project teams

## 2.8 *ISO/TR 19122:2004 - Qualification and Certification of Personnel*

Given the changing technology and changing problem definitions (science), government and industry require a set of standards for the certification of their personnel. This task falls within the ISO/TC211 Geographic Information. The skills of technologists, professionals, and managers have to be defined to meet the tasks within the new conceptual and technology context.

The purpose of the ISO/TR 19122 work item is to reach agreement on the boundaries of Geographic Information / Geomatics through collaboration with other professional associations and appropriate accredited standards bodies. For each broad work task, the background, education, and work experience need to be identified for each individual before receiving certification. This effort can be complemented by a survey of staff in existing government agencies and private industry to determine who holds positions defined in terms of Geographic Information Science (GIS) / Geomatics. Part of the first phase can be a listing of all educational institutions that offer GIS/Geomatics education and training. A second phase, if accepted, would be an accreditation process for those institutions who wish their graduates to be eligible for certification. A number of national and international organizations are independently working towards certification (e.g. URISA, AGI, ACSM, ASPRS, UCGIS). ISO/TC211 can provide a coordination function.

**ISO/TR 19122:2004 Technical Report - Qualification and Certification of Personnel** describes and defines the following objectives of the field of Geographic Information/Geomatics:

- To develop a Type 3 report that describes a system for the qualification and certification, by a central independent body, of personnel in the field of Geographic Information/Geomatics
- To define the boundaries between Geographic Information/ Geomatics and other related disciplines and professions
- To specify technologies and tasks pertaining to Geographic Information /Geomatics
- To establish skill sets and competency levels for technologists, professional staff and management in the field
- To research the relationship between this initiative and other similar certification processes performed by existing professional associations
- To develop a plan for the accreditation of candidate institutions and programs, for the certification of individuals in the workforce, and for collaboration with other professional bodies

This Technical Report includes more then dozen case studies in encompass issues of certification and qualification of personnel.

## 2.9 ISO 19135:2005 - Procedures for Item Registration

ISO/IEC JTC1 defines registration as the assignment of an unambiguous ***name*** to an object in a way that makes the assignment available to interested parties. Items of geographic information that may be registered are members of object classes specified in technical standards such as those developed by ISO/TC 211.

**ISO 19135:2005 - Procedures for Item Registration** 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. In order to accomplish this purpose, ISO 19135:2005 specifies elements of information that are necessary to provide identification and meaning to the registered items and to manage the registration of these items.

Note, that in this International Standard, the definition of registration has been changed so that registration is the assignment of linguistically independent ***identifiers***, rather than ***names***, to items of geographic information. **Identifier** is, linguistically, an independent sequence of characters capable of uniquely and permanently identifying that with which it is associated (adapted from ISO/IEC 11179-3).

Registries enhance interoperability by making instances of classes defined in technical standards available for re-use by standards developers and implementers. Registration of items of geographic information offers several benefits to the geographic information community. The establishment of registers will increase the use of ISO/TC 211 series of standards and will be a significant contribution for helping the work of standards implementers in a manner that interoperability will be accomplished quickly in the most cost efficient manner.

There have been proposals for the registration of a wide variety of items specified by the TC211 technical standards. It has not been determined yet as to whether these items should be handled in a single register or in several different registers. However, even if several registers were required, similar procedures would apply, and therefore a single or multi-part procedure standard may be appropriate.

This standard defines some principles of registration, alternative register structures, register items, unique and non-reusable register identifiers, cultural and linguistic adaptability, status of register items, and state of a register.

Thus, register structures can be accomplished in three alternative ways:

- A simple register that contains items of a single item class
- A multi-part register in which different parts contain items from different item classes
- A hierarchical register, the upper level of which contains a list of lower level registers

*Clause 5 Roles and responsibilities in the management of registers* of the ISO 19135 defines the role model used to manage a register. This role model is shown on the following figure.

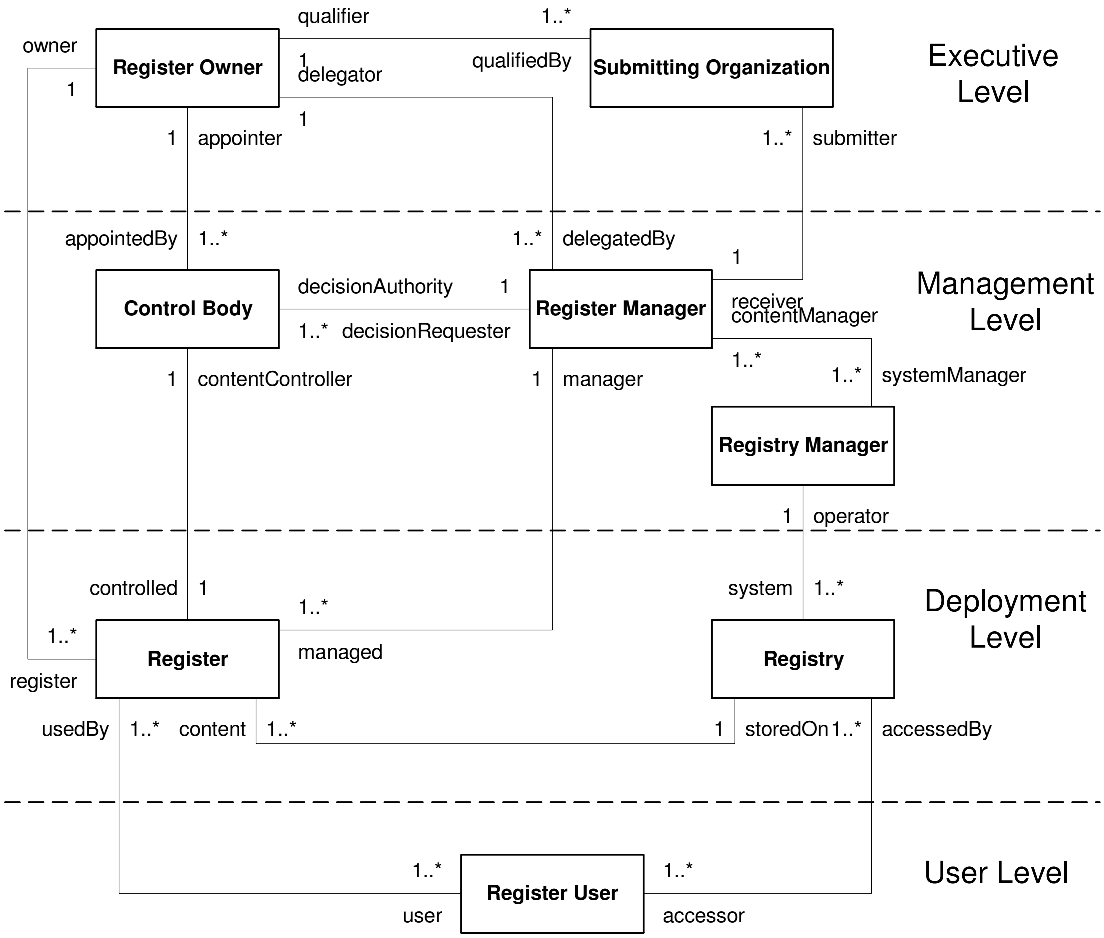



**Figure: Organizational Relationships**

This figure shows the overall structure of the Data Dictionary Registry that contains one or more Registers. The individual Registers must be established and managed by organizations that need a register.

**Registration** is an assignment of a permanent, unique, and unambiguous ***identifier*** to an item. A **register** is a set of files containing identifiers assigned to items with descriptions of the associated items. A **registry** is an information system on which a ***register*** is maintained. **Register owner** is an organization that establishes a ***register*.** **Register manager** is an organization to which management of a ***register*** has been delegated by the ***register owner*.** A **submitting organization** manages the submission of proposals for registration from within the respective communities or organizations. Proposed changes to the ***register*** must meet the submission procedures established by the ***register owner***. A **control body** is a group of technical experts appointed by a ***register owner*** to decide on the acceptability of proposals for changes to the content of a register. A **register user** is any person or organization interested in accessing or influencing the content of a register.

*Clause 6 Management of registers* of ISO 19135 defines the register management process: establishment of registers, processing of proposals, list of submitting organizations, publication, integrity, and registration proposals. Submitting organizations may submit requests for the addition, clarification, modification, and retirement of registered items. The following figure depicts the processes for proposal submitting, approval, and appeal for registration of items of geographic information.

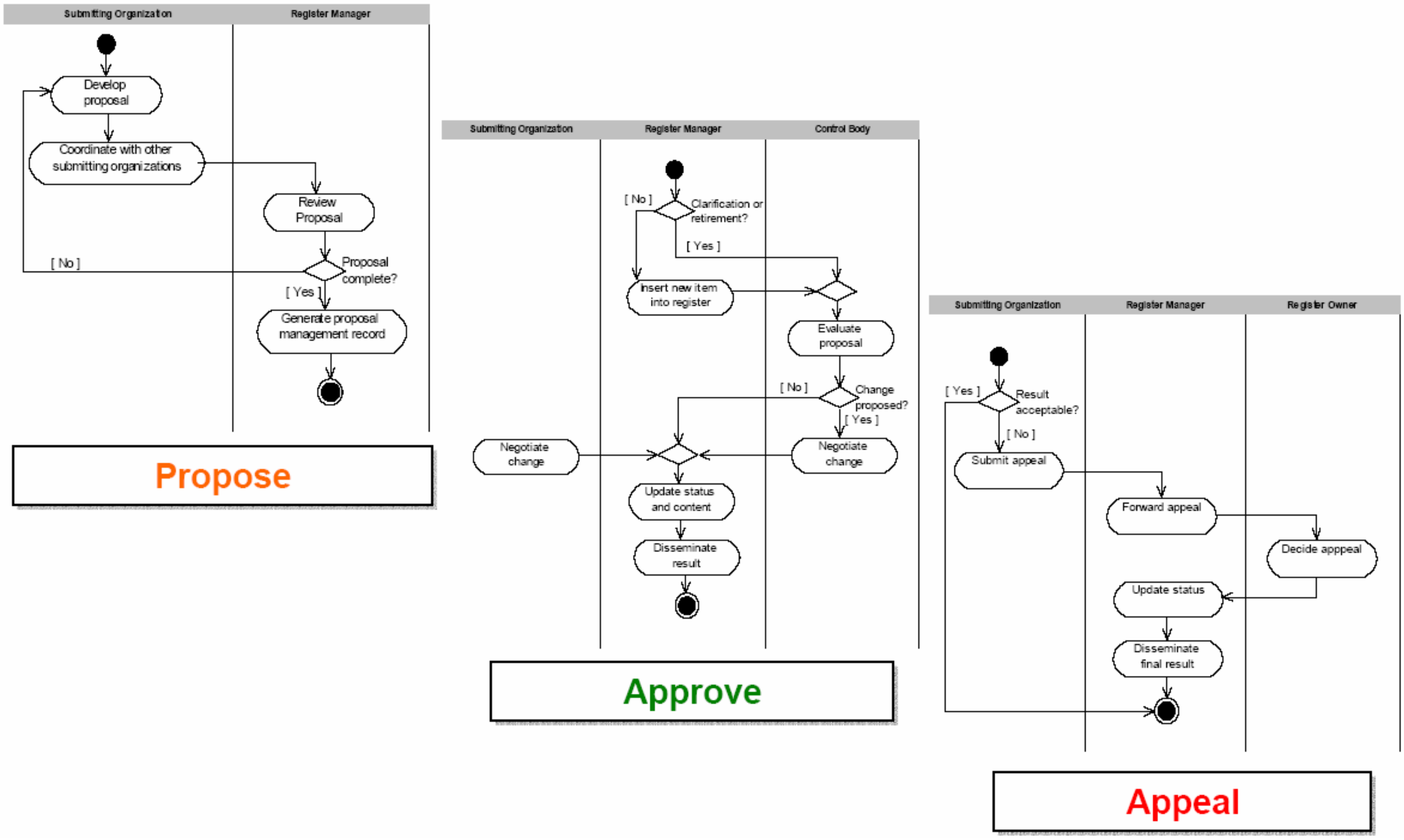



**Figure: Register management processes – processing of proposal**

A register is simply a managed list. It is easier to maintain than a fixed document, because new items can be added as needed to the register, and current items in the register can be modified or retired. The register item would have a "date stamp" that would indicate the date at which it was added to the register. For an item that is indicated as “retired” in the register, the item would remain in the register with an indication of the date at which it was retired. For an item that is “modified” in the register the original instance of the item would be rendered as superseded with a "date stamp" and a new changed item entered in the register with a new item identifier. There would be a forward reference from the superceded item to the modified item that replaced it. This means that a product specification, defined at a given date, would reference an item in the register in a stable manner.

*Clause 8 Register schema* of ISO 19135 contains UML model schemas that defines the conceptual model for a Register. The following figures illustrate conceptual models and class diagrams for RegisterItem and ItemClass.

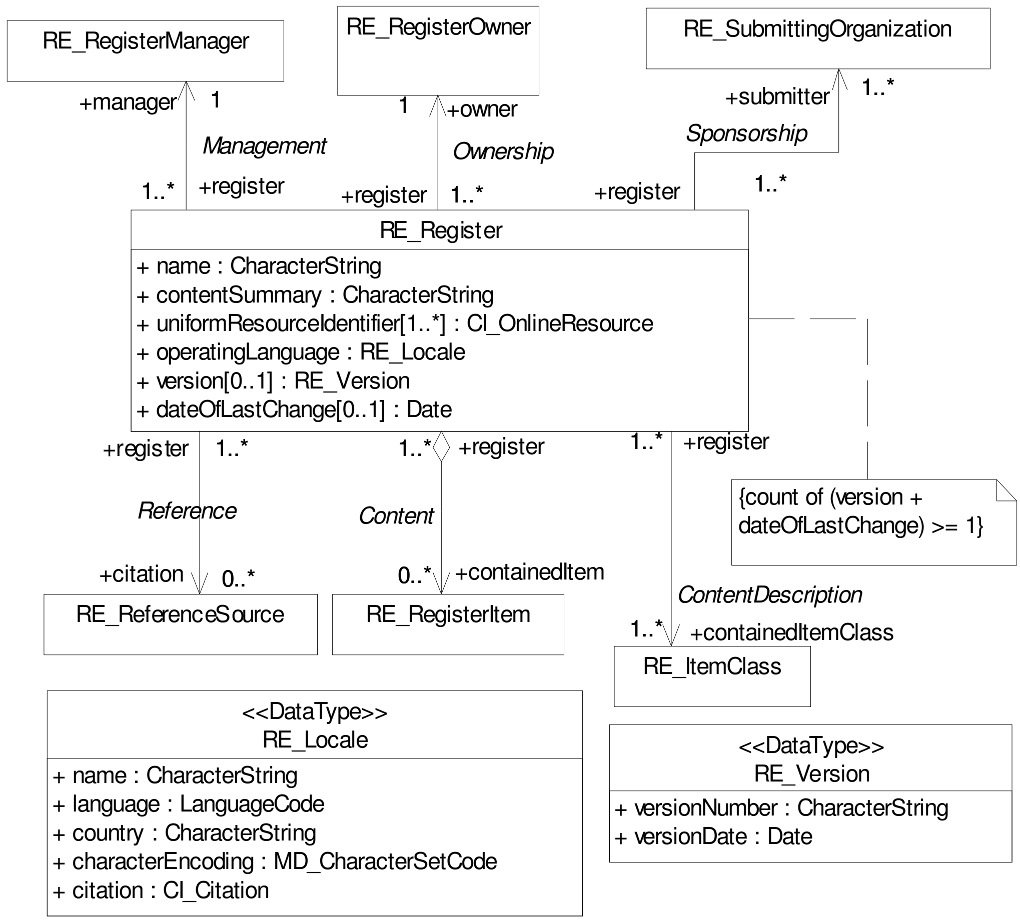



**Figure: RE_Register UML schema**

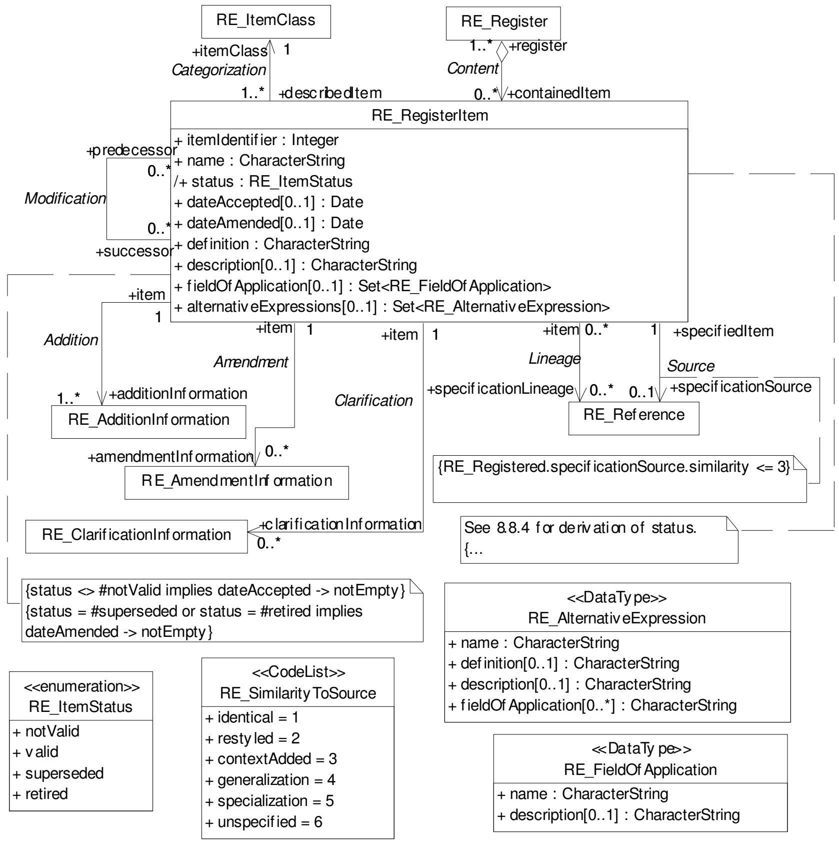



**Figure: RE_RegisterItem UML schema**

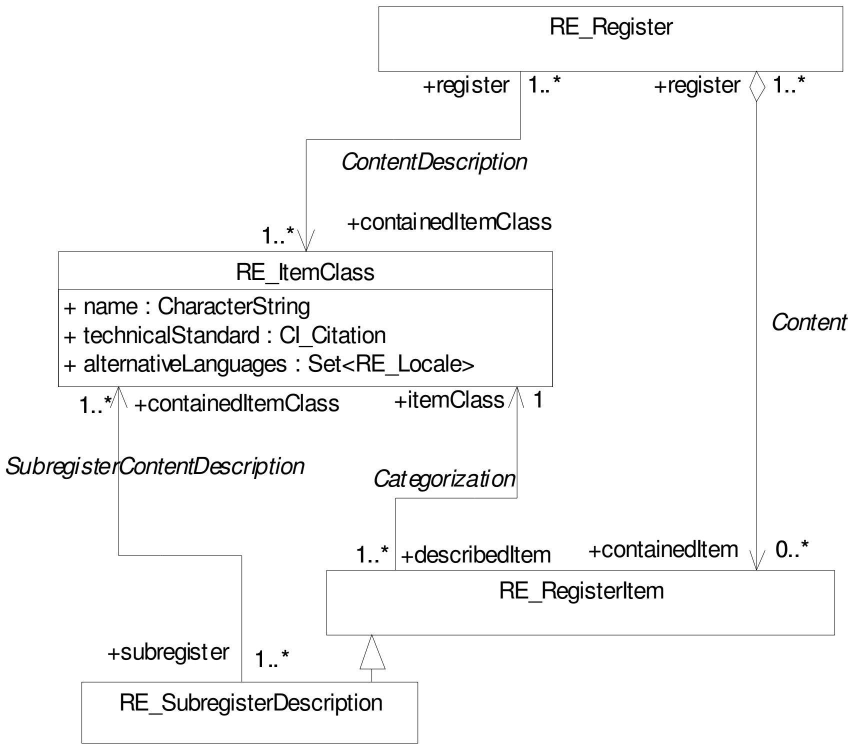



**Figure: RE_ItemClass UML schema**

Metadata also can be maintained through the Metadata Register system. This system contains information about the register, information describing metadata items of interest for the profile, and information describing code lists and values. Such register systems can be composed of sub-systems for Metadata Register Management Application, Metadata Register XML Document, and Metadata Register Web Services.

## 2.10 Conclusion

Different combinations of ISO 19100 series standards can be applied for the development of particular products or services specifications. ISO 19101 Reference model standard is a guide to structuring geographic information standards in a way that will enable the universal usage of digital geographic information. The Model Driven Architecture (MDA) approach is chosen to define geospatial standardization processes and products. ISO 19101 provides conceptual views on how to model geospatial products, processes, and services on four model levels: meta meta model, meta model, application model, and data model. These four levels include all stages from abstraction and formalization of universe of discourse to product manufacturing. ISO/TC 19100 series provides standards for modeling on three-bottom levels.

Suitable conceptual schema language used for MDA is Unified Modeling Language. The UML is also inheriting multi-level organizational structure and supplemented by Object Constraint Language (OCL) in order to refine geospatial specifications.

In this module, Guidance Category of Geospatial Standards, that includes organizational and educational standards, was examined. The three most important ISO standards were discussed in detail:

- ISO 19101:2002 - Reference model:
  - It defines a framework for standardization of the ISO 19100 series and describes how the different standards are related
- ISO/TS 19103:2005 - Conceptual schema language:
  - It defines the profile of the Unified Modeling Language for ISO geographic information modeling
- ISO 19106:2004 – Profiles:
  - It provides guidance for establishing, managing, and standardizing at the national and organizational level

Use link to ISO/TS 19104 – Terminology http://www.isotc211.org/TC211_Terminology_Glossary-20060417-Published.xls to find terms for standards in all of the following modules.

## Module self-study questions:

7. What kind of documents are provided with ISO19100 series (IS, TS, TR)?
8. What are the four steps of the Model Driven Architecture approach that are used in the ISO ISO19100 series?
9. In accordance of the ISO 19101, what are the five major areas (categories) into which the ISO 19100 series of geographic information standards can be grouped?
10. What is your understanding of the “Reference Model” notion in terms of its ISO 19101 content?
11. Profiles of what languages are defined within ISO/TS 19103Technical Specification?
12. What are “base standards” and what are “functional standards”?
13. What is register for geospatial data?

## Required Readings:

[4] Interoperability & Open Architectures: An Analysis of Existing Standardisation Processes & Procedures, OGC White Paper, http://www.personal.psu.edu/users/a/j/ajk279/Geog488Lesson6WhitePaper1.pdf.

[5] Methodology and Guidelines on Use Case and Schema Development, Reference Information Specifications for Europe (RISE), http://www.eurogeographics.org/eng/documents/RISE19_Methodology_Guidelines_v1.1.doc.

[6] Markus SEIFERT, On the Use of ISO Standards in Cadastral Information Systems in Germany, http://www.fig.net/pub/fig_2002/JS4/JS4_seifert.pdf.

[7] Feature Data Dictionary Component, Registry of the International Hydrographic Organization (IHO), http://www.iho.shom.fr/COMMITTEES/CHRIS/TSMAD/TSMAD14/TSMAD14-7A.pdf.

## References

[6] ISO 19101:2002 Geographic information - Reference model
[7] ISO/TS 19104 Geographic information - Terminology
[8] ISO 19105:2000 Geographic information - Conformance and testing
[9] ISO 19106:2004 Geographic information - Profiles
[10] ISO/TR 19120:2001 Geographic information - Functional standards
[11] ISO/TR 19122:2004 Geographic information / Geomatics - Qualification and certification of personnel
[12] ISO 19135:2005 Geographic information - Procedures for item registration
[13] ISO/TS 19103:2005 Geographic information - Conceptual schema language
[14] Unified Modeling Language (UML), ISO/IEC 19501:2005(E), OMG

## Terms used

- NWIP
- AWI
- WD
- CD
- DIS
- FDIS
- IS
- TS
- TR
- Use case
- Universe of discourse
- Conceptual schema
- Conceptual formalism
- Conceptual schema language
- Application schema
- Feature catalogue
- Metadata
- Reference model
- Base standard
- Functional standard
- Domain reference model
- Meta-meta model
- Meta-model
- Standard's module
- Product specification
- UML
- OCL
- Package diagram
- Use case diagram
- Class diagram
- Association
- Multiplicity and cardinality
- Aggregation
- Composition
- Generalization
- Dependency
- Stereotype
- Identifiers
- Register

# 3 Content and Data Categories of Geospatial Standards

The ISO 19100 Contents category of the International Standards and Technical Specifications describes geographic data, related format, and structures. In this module, eleven ISO standards are examined. Discussion begins with one of the most popular standard - ISO 19109 - Rules for Application Schema. This standard defines the rules on how to create data structure schema for particular applications. ISO 19109 applies conceptual modeling principles from ISO 19101 on how to create application schema based, for example, on comprehensive vector feature models from ISO 19107 - Spatial Schema. Related ISO 19107 standards, such as ISO 19111 (Spatial Referencing by Coordinates) are also discussed in this module. Other data structure schemas, such as grid and coverages, are described when several respective standards are outlined. The last topic of this module relates to ISO 19131 - requirements for the specification of geographic data products. This standard incorporates data product descriptions that are based on other ISO 19100 standards.

<u>Module Outline</u>

Topic 17: Overview of Content and Data Categories of Geospatial Standards
Topic 18: ISO 19109 - Rules for Application Schema
Topic 19: ISO 19107 - Spatial Schema
Topic 20: ISO 19137 - Core Profile of the Spatial Schema
Topic 21: ISO 19108 - Temporal Schema
Topic 22: ISO 19111 - Spatial Referencing by Coordinates
Topic 23: ISO 19112 - Spatial Referencing by Geographic Identifiers
Topic 24: Coverages and Gridded Data
Topic 25: ISO 19123 - Schema for Coverage Geometry and Functions
Topic 26: ISO 19101-2 - Reference Model - Part 2: Imagery
Topic 27: ISO/TR 19121 - Imagery and Gridded Data
Topic 28: ISO/TS 19127 - Geodetic Codes and Parameters
Topic 29: ISO 19131 - Data Product Specifications

### *3.1 Overview of Content and Data Categories of Geospatial Standards*

ISO 19100 is a family of standards that tries to cover all aspects of localization. In a previous module, Organization and Education categories of ISO 19100 series were discussed. These standards (IS) and specifications (TS) provide the basic infrastructure to develop higher-level IS and TS and deals with ways to ensure that standards will be applied properly. In addition, ISO 19103, from the Content category, was examined. When working with the ISO 19100 series of standards, one has to know UML notations, in order to understand IS or TS.

In this module, the ISO 19100 Contents category IS and TS will be analyzed. It describes geographic data, related format and structures. Standards that relate to metadata, feature cataloging, and quality will be examined in the last module. The ISO 19100 Services (Access & Technology) category of IS and TS will be examined in the next module. This category relates to the accessibility of the data (sharing, exchange) and services enabling access to data.

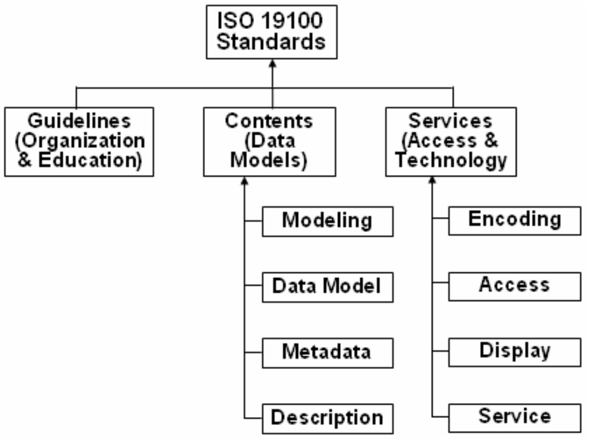



**Figure: ISO 19100 categorization used in this course**

The ISO 19100 standards specify methods, tools, and data management services (including the definition and description of the data) related to the acquisition, processing, analysis, access to, rendering, and transfer of data between users, systems, and places. The ISO 19100 refers to other existing IT related standards, when possible.

In this and the last modules, we will be discussing the content and data category of geospatial standards. The main goal of ***data interoperability*** is to enable the exchange of geographic related data between the producers and the users. The ISO Content category of IS and TS provides common schemas of spatial data structure and a framework for the development of applications in the domain (ISO 19109) that makes use of geographic related data.

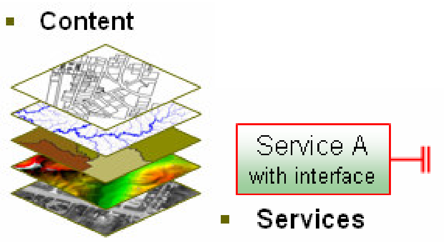



**Figure: Two main areas of interoperability, this module deals with the first area - Content**

The main geo-data (geo product) contents that are covered within the ISO 19100 Content category of IS and TS are shown in the following figure:

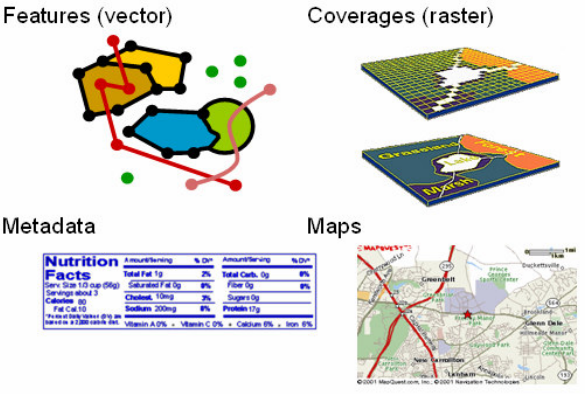



**Figure: Geospatial information content**

Content related standards that will be discussed or mentioned in the course (Modules 3 and 5) are:

ISO 19103 - Conceptual schema language
ISO 19107 - Spatial schema
ISO 19108 - Temporal schema
ISO 19109 - Rules for application schema
ISO 19110 - Feature cataloguing methodology
ISO 19111 - Spatial referencing by coordinates
ISO 19112 - Spatial referencing by geographic identifiers
ISO 19113 - Quality principles
ISO 19114 - Quality evaluation procedures
ISO 19115 - Metadata
ISO 19115-2 - Metadata - extensions for imagery and gridded data
ISO/TR 19121 - Imagery and gridded data
ISO 19123 - Schema for coverage geometry and functions
ISO 19124 - Imagery and gridded data components
ISO 19127 - Geodetic codes and parameters
ISO 19129 - Imagery, gridded and coverage data framework
ISO 19130 - Sensor and data model for imagery and gridded data
ISO 19131 - Data product specification
ISO 19138 - Data quality measures

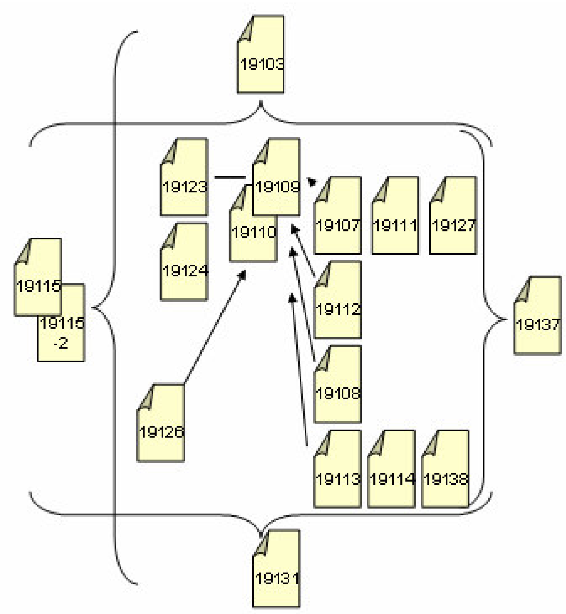


**Figure: Organization of Content Related Standards**

Lets looks on other partitioning (categorization) of the “Standards Space” in order to better understand the idea behind spatial data interoperability. As mentioned in the first module, standards can take two forms: abstract document and concrete technical (implementation) specification. In addition, interoperability is required in two areas of data inter-exchange – modeling of data content (organization of data structure) and data transfer via services. Categorization of geo-spatial standards by these two factors – levels of abstraction (IS or TS) and viewpoints on interoperability - are demonstrated in the following figure.

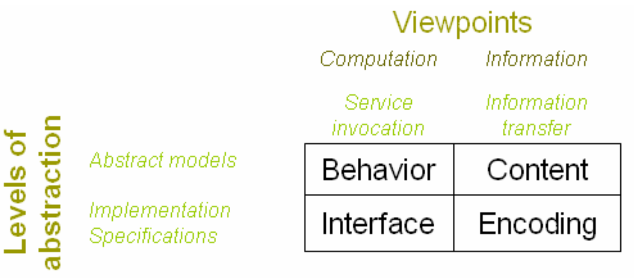



**Figure: One more categorization of standards is Abstract: theory - guidance for design; Implementation: practice - software “recipes”.**

| | Service invocation | Information transfer |
|---|---|---|
| **Implementation specifications** | *Interface:*<br>ISO 19125-2, & OGC Simple Features access (SQL option a.k.a.)<br>ISO 19142 and OGC Web Feature Service<br>ISO 19143 and OGC Filter encoding | *Encoding:*<br>ISO 19118, Encoding<br>ISO 1936, OGC Geography Markup Language (GML)<br>FGDC Spatial Data Transfer Standard (SDTS)<br>VPF, DIGEST |
| **Abstract models** | *Behavior:*<br>ISO 19125-1, Simple Features: Common Architecture<br>ISO 19119, Services | *Content:*<br>ISO 19109, General feature model & schema<br>ISO 19107, Spatial Schema (a.k.a. OGC Topic 1, Feature Geom.)<br>ISO 19108, Temporal Schema<br>ISO 19110, Feature Cataloguing |

**Figure: One more categorization of standards**

The interoperability “stack”: Data - Services - Applications:

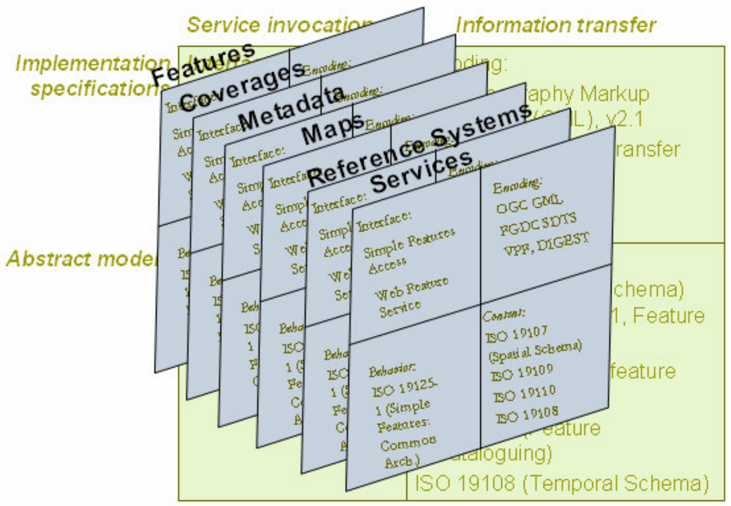



**Figure: One more categorization of standards**

In accordance with ISO 19100, data interchange between information systems may take place in two ways:

- Data **transfer** model - the data supplier creates a dataset that is transferred to the user. The structure and the content of data are described in the *application schema* for the dataset. The dataset is sent in a transfer format.

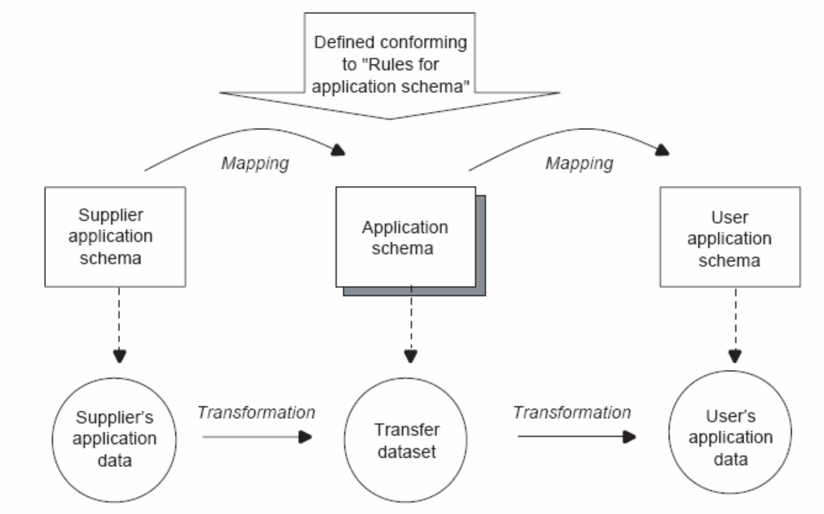



**Figure: Data interchange by transfer (ISO 19109)**

- Interoperability model - the user application communicates with the supplier application through a common communication protocol via services. The application schema describes not only the structure and content of the exchanged data but also the structure of the interfaces involved in the **transaction**.

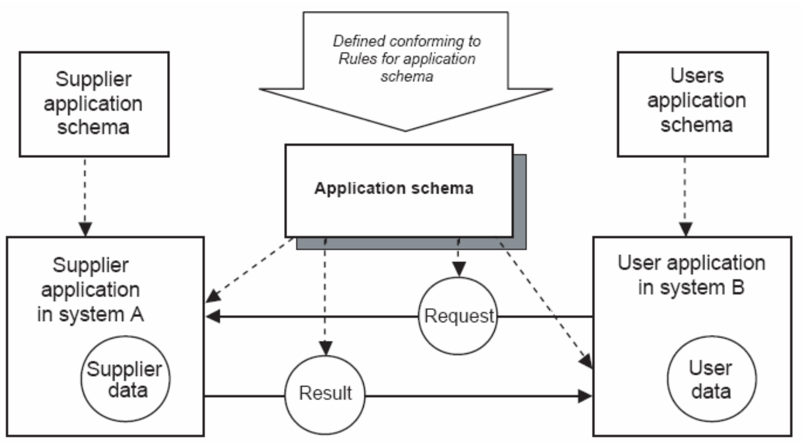



**Figure: Data interchange by transactions (ISO 19109)**

## 3.2 ISO 19109 - Rules for Application Schema

An application schema provides a formal conceptual description of the data structure and content required by one or more applications. An application schema contains the descriptions of both geographic data and other related data. In the following sections, ISO complete schemas will be discussed, ISO 19109 can be applied to create application schema for specific organizational case studies based on an ISO complete schema or schemas.

**ISO 19109:2005 Geographic information - Rules for application schema** defines **rules** for creating and documenting **application schemas**, including principles for the definition of features. Its scope includes the following:

- Conceptual modeling of features and their properties from a universe of discourse (similar modeling concept was discussed within ISO 19101 in module 2)
- Definition of application schemas
- Use of the conceptual schema language for application schemas (UML was also discussed within ISO 19103 in module 2)
- Transition from the concepts in the conceptual model to the data types in the application schema
- Integration of standardized schemas from other ISO geographic information standards with the application schema

Interoperability of data requires a definition of standardized rules when constructing an application schema*. It does not standardize application schemas; it only defines rules for creating application schemas in a consistent manner.* The rules in this standard will assist the users of applications with similar data requirements in creating a common application schema for the interface between their systems and data.

This International Standard describes how to create an application schema that integrates conceptual schemas defined in the ISO 19100 series of standards for geographic information. In addition to stating the rules for creating application schemas, this International Standard provides guidance through examples.

ISO 19109 guides the creation of application schemas, which is outside the scope of ISO 19106. An application schema by definition is not a profile but may integrate subsets of standardized schemas that are profiles.

### 3.2.1 Clause 7 - Principles for defining features

An application schema defines and serves the following purposes:

- Content and structure of data: provide a computer-readable data description defining the data structure, which makes it possible to apply automated mechanisms for data management
- Specifications of operations for manipulating and processing data by an application: achieve a common and correct understanding of the data, by documenting the data content of the particular application field, thereby making it possible to clearly retrieve information from the data.

Clause 7 outlines again (similar to ISO 19101) that a feature is a fundamental unit of geographic information and, in accordance with ISO 19109, a feature is modeled according to a 4-layer architecture (as discussed in ISO 19101). Features have different meanings on different modeling levels (see the figure below).

| Level in architecture | Use of the term "feature" |
|---|---|
| Meta Meta level | Feature as general concept; no specified being, type, or instance |
| Meta level | A Class in the UML-expressed General Feature Model, with the CLASS-name “GF_FeatureType” |
| Application level | A specific feature type representing a class of real world phenomena (e.g. “Road” – an instance where the Class “GF_FeatureType” of the General feature Model is expressed in an application schema). The result in the application schema in UML is a Class called “Road” |
| Data level | A feature representing a set of data for an instance of the feature type, e.g. the road “Route 66” |

**Figure: Feature used in different levels with different meanings**

As shown in Module 2, the feature modeling process from universe of discourse to data can be depicted in the following steps:

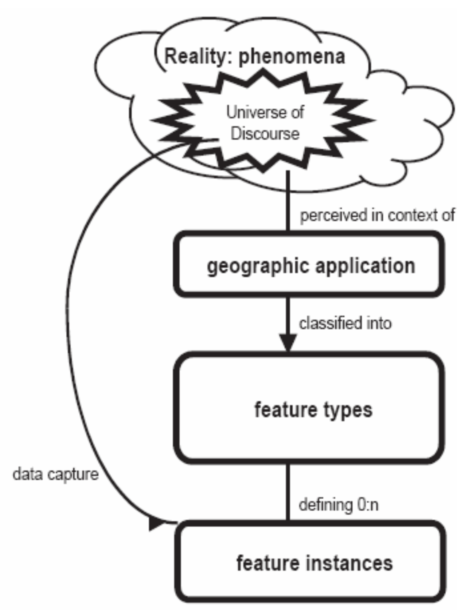



**Figure: The process from universe of discourse to data (ISO 19109)**

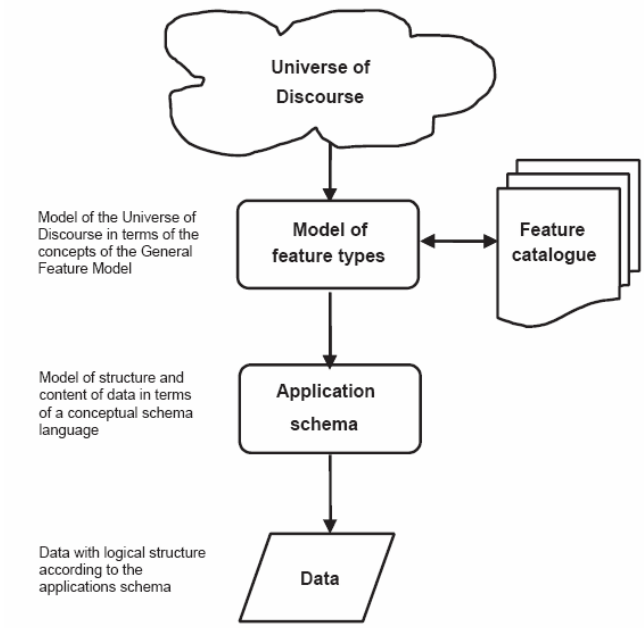



**Figure: From reality to geographic data (ISO 19109)**

These steps can be briefly described as:

- Surveying the requirements from the intended field of application (universe of discourse).
- Making a conceptual model of the application with concepts defined in the General Feature Model. This task consists of identifying feature types, their properties and constraints.
- Describing the application schema in a formal modeling language (for example UML and OCL) according to rules defined in this IS.
- Integrating the formal application schema with other standardized schemas (spatial schema, quality schema, etc.) into a complete application schema.

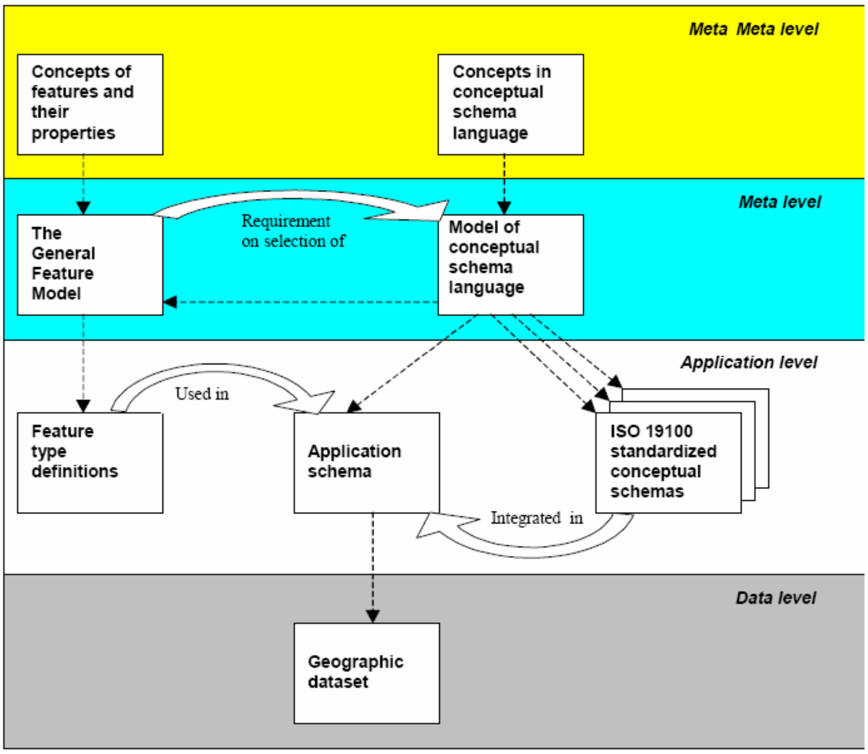



**Figure: The 4-layer architecture of feature modeling in accordance with ISO 19109**

ISO 19109 defines features (structure and behavior) with respect to their representation in data structures, as defined by application schemas. An application schema (ISO 19109) defines the logical structure of data and may define operations that can be performed on or with the data. An application schema did not address the physical data organization. A feature catalogue (ISO 19110) documents the feature types. UML as a conceptual schema language (ISO 10103) is used to express the application schema.

ISO 19109 identifies the concepts of the General Feature Model (GFM). The GFM is a model of the concepts required to classify a view of the real world. ISO 19110 uses GFM for a description in the feature catalogue structure. ISO 19117 also uses these concepts for specifying the portrayal of geographic information.

ISO 19109 distinguishes four aspects of defining a general model for features:

- The **feature type** - the definitions or description used to group features into types (e.g. Roads)
- The **attributes** associated with each type
- The **relationships** among the types
  - Feature association roles characterizing the feature type
- The **behavior** of the feature type

Additional concepts included in GFM are:

- Feature associations between the feature type and itself or other feature types
- Generalization and specialization relationships to other feature types
- Constraints on the feature type

A complete ISO 19109 GFM is presented on the follow figure:

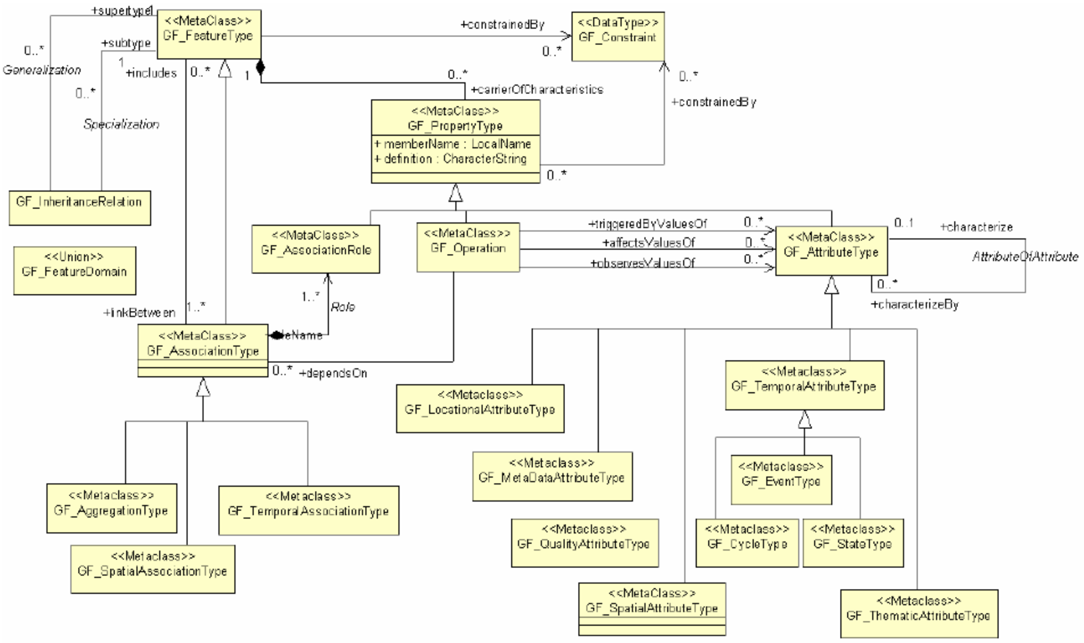



**Figure: The General Feature Model**

Core extract of the General Feature Model is shown on the following figure:

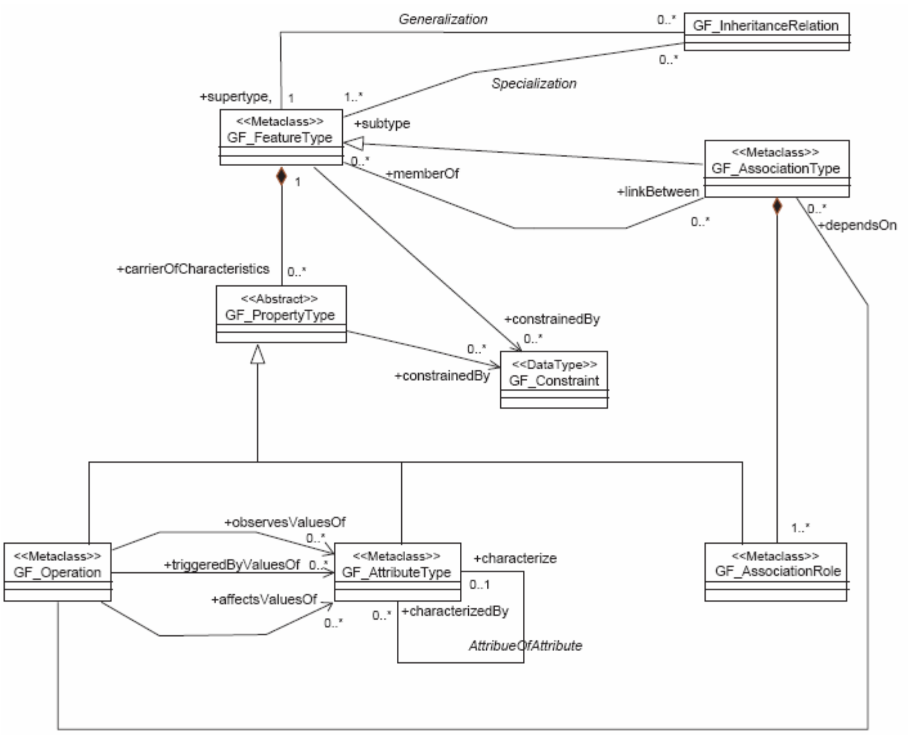



**Figure: The kernel of the General Feature Model**

Where, GF_FeatureType is a metaclass that is instantiated as classes that represent individual feature types. A feature is an abstraction of real world phenomena. A certain feature type is the class for all instances of that feature type. The instances of a class that represents an individual feature type are feature instances.

GF_PropertyType is the metaclass for any class of property of a feature type that describes characteristics of the feature, the behavior of a feature, or the association roles that the feature is in. GF_AttributeType is the metaclass for attribute definitions of a feature type. GF_AssociationRole is the metaclass for the classes of roles that are part of a

GF_AssociationType. GF_Operation is the metaclass for describing behavior of feature types in terms of operations. GF_AssociationType is the metaclass for describing associations between feature types. GF_InheritanceRelation is the class for a generic relationship between a more general feature type (supertype) and one or more specialized feature types. GF_Constraint is the class for constraints that may be associated with feature types and the properties of feature types.

The attributes carry all static spatial and non-spatial properties information of a feature. Some attribute types in ISO 19100 can use subtypes of GF_AttributeType. The attribute is the object interface to these other ISO 19100 standards by using their schemas. The attribute type will get the value type definition from those schemas and the value domain according to those schemas. For example, a spatial attribute type (GF_SpatialAttributeType) will have its value type and value domain according to the definition of GM_Object or TP_Object described in ISO 19107 Spatial schema.

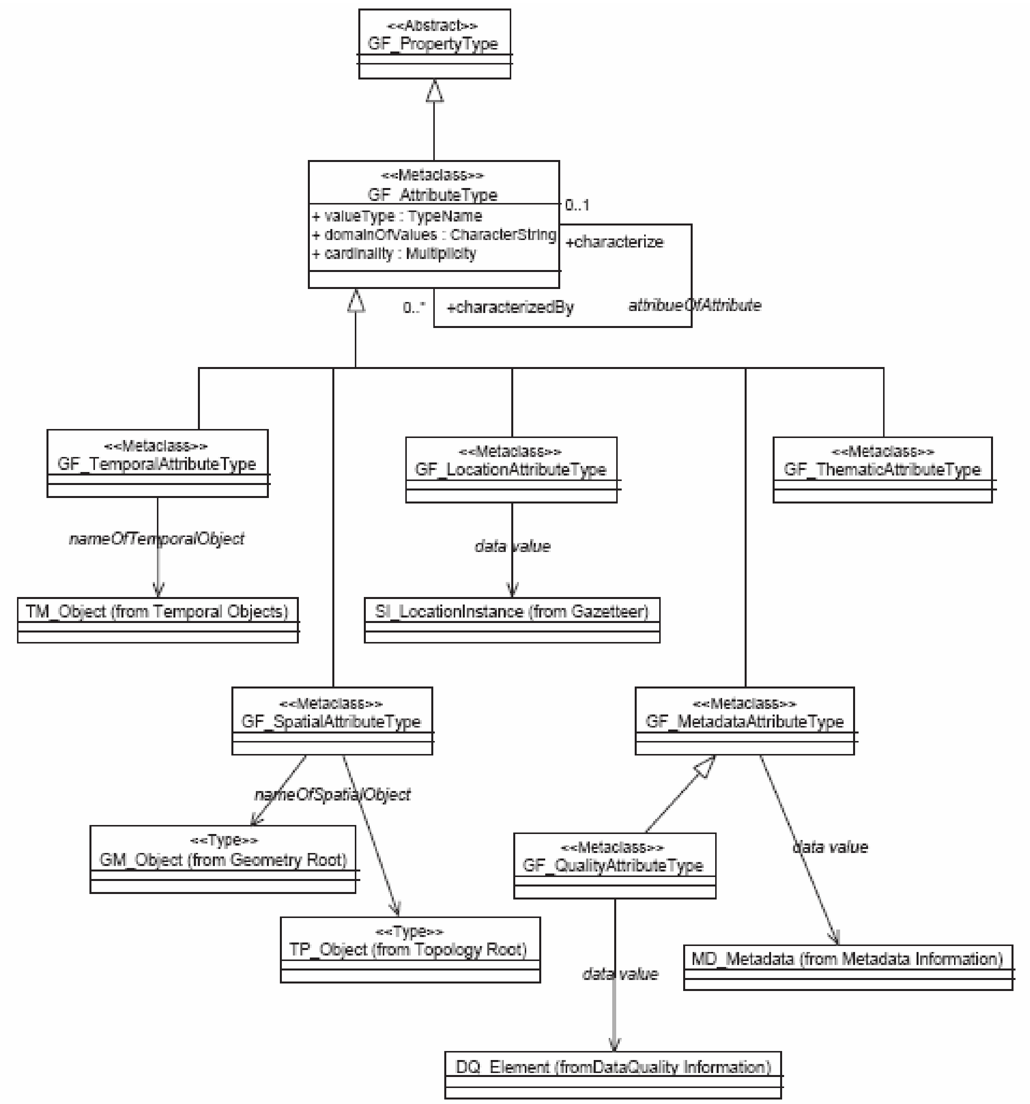



**Figure: UML schema of attributes of feature types**

### 3.2.2 Clause 8 - Rules for application schema

The four-step process (see the figure: The 4-layer architecture) for creating application schemas requires two sets of rules:

- How to map the feature types expressed in the concepts of the General Feature Model to the formalism used in the application schema
- How to use schemas defined in other ISO 19100 series of standards

This ISO clause addresses these rules.

When developing a large information model, the work is often broken down into independent parts that can be integrated by a defined interface. The application schema is one part; the other standardized schemas in the ISO 19100 series of standards are other parts. For example, integration of an application schema and standard schemas are shown on the following figure.

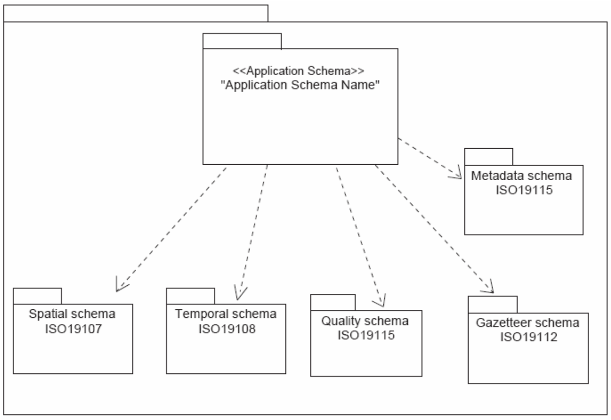



**Figure: Example of application schema integration**

Examples of ISO 190109 **Rules** are:

- The data structures of the application shall be modeled in the application schema
- The dependency mechanism in UML shall be used to describe the integration of the application schema with the other standard schemas that are required to form the complete definition of the data structure
- All classes used within an application schema for data transfer shall be instantiable, that is, the integrated class must not be stereotyped <<interface>>

**8.7 Spatial rules**
**8.7.1 General spatial rules**
**Rule:**

1) The value domain of spatial attribute types shall be in accordance with the specifications given by ISO 19107, which provides conceptual schemas for describing the spatial characteristics of features and a set of spatial operators consistent with these schemas.

…

2) Spatial characteristics of a feature shall be described by one or more spatial attributes. In an application schema, a spatial attribute is a subtype of a feature attribute, and the taxonomy of its values is defined in the spatial schema, ISO 19107.

...

3) A spatial attribute shall take a spatial object as its value. Spatial objects are classified as geometric objects or topological objects, both of which are subclassed as primitives, complexes, or aggregates (for geometric objects).

**Figure: Extract from ISO 19109 Rules sections**

The ISO 19109 appendices contain examples of a simplified description of a data model of different application areas (e.g. utility system and administrative units).

### *3.3 ISO 19107- Spatial Schema*

**ISO 19107:2003 Geographic information - Spatial schema** specifies conceptual schemas for describing the *spatial characteristics* of ***geographic features***, as well as a set of *spatial operations* consistent with these schemas.

ISO 19107 treats **vector geometry** and **topology** up to **three** dimensions. It defines standard spatial operations for use in accessing, querying, managing, processing, and exchanging geographic data and information for spatial (geometric and topological) objects of up to three topological dimensions and embedded in coordinate spaces of up to three axes.

Vector data consists of geometric and topological primitives used, separately or in combination, to construct objects that express the spatial characteristics of geographic features.

There are 39 conformance options for application schemas that define types for the instantiation of *geometric* or *topological* objects. Geometric or topological objects are differentiated on the basis of three criteria:

- Level of data complexity
- Dimensionality
- Level of functional complexity

The first criterion is level of data complexity. Four levels are identified:

- Geometric primitives
- Geometric complexes
- Topological complexes
- Topological complexes with geometric realization

The second criterion is dimensionality. There are four levels for simple geometry:

- 0-dimensional objects
- 0- and 1-dimensional objects
- 0-, 1-, and 2-dimensional objects
- 0-, 1-, 2- and 3-dimensional objects

The third criterion is level of functional complexity. There are three levels.

- Data types only
- Simple operations
- Complete operations

The third criterion (functional complexity) determines the member elements (attributes, association roles, and operations) of those types that are to be implemented.

ISO 19107 geometric and topologic objects are organized in eight packages. The leaf packages correspond to the normative clauses of this IS. The clauses in this document are organized in terms of UML packages.

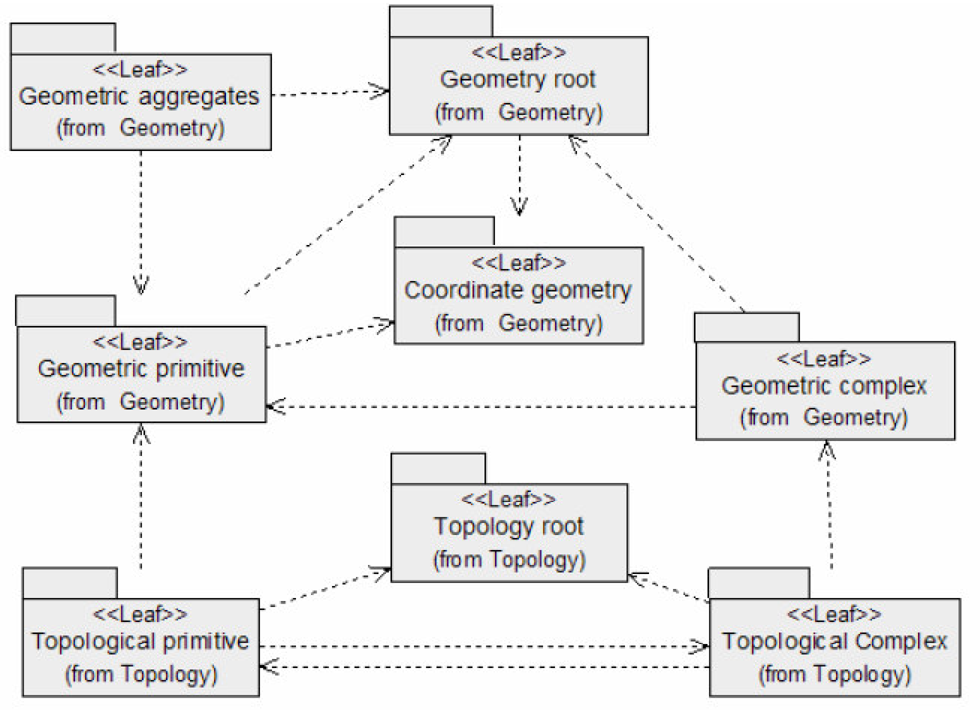



**Figure: ISO 19107 Geometry packages**

The following figure summarizes the packages specified in this International Standard. Geometry and Topology packages for an application schema are defined in ISO19107. Additional packages are referenced from other standards, such as the Spatial Referencing by Coordinates package from ISO 19111 and the Basic Types package from ISO TS 19103. They are replicated in the document to the extent needed to provide a complete and readable picture of potential spatial schemas.

| Clause number | Package Name | Major classes included |
|---|---|---|
| 6 | Geometry | geometry classes |
| 6.2 | Geometry root | root classes for geometry |
| 6.3 | Geometric primitive | geometric primitives |
| 6.4 | Coordinate geometry | coordinate geometry classes |
| 6.5 | Geometric aggregates | aggregates |
| 6.6 | Geometric complex | geometric complexes and composites |
| 7 | Topology | topology classes |
| 7.2 | Topology root | root classes for topology |
| 7.3 | Topological primitive | topological primitives |
| 7.4 | Topological complex | topological complexes |

**Figure: Package and classes**

**Geometry** packages contain geometry content classes and their internal dependencies.

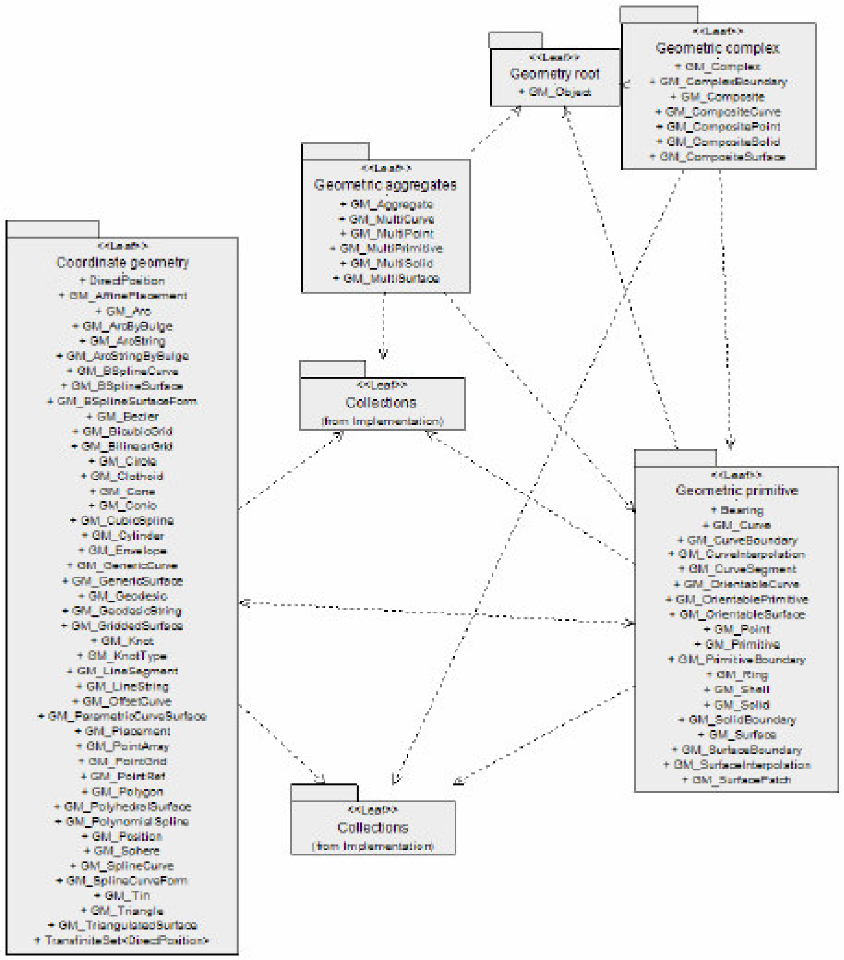



**Figure: Geometry package**

The geometry packages contain the various classes for coordinate geometry. All of these classes, through the root class GM_Object, inherit an optional association to a *coordinate reference system*. All elements of a geometric complex, composite, or aggregate shall be associated with the same coordinate reference system.

The geometry package has several internal packages that separate primitive geometric objects, aggregates, and complexes - all have a more elaborate internal structure than simple aggregates.

Geometry classes with specialization relations are presented in the following figure:

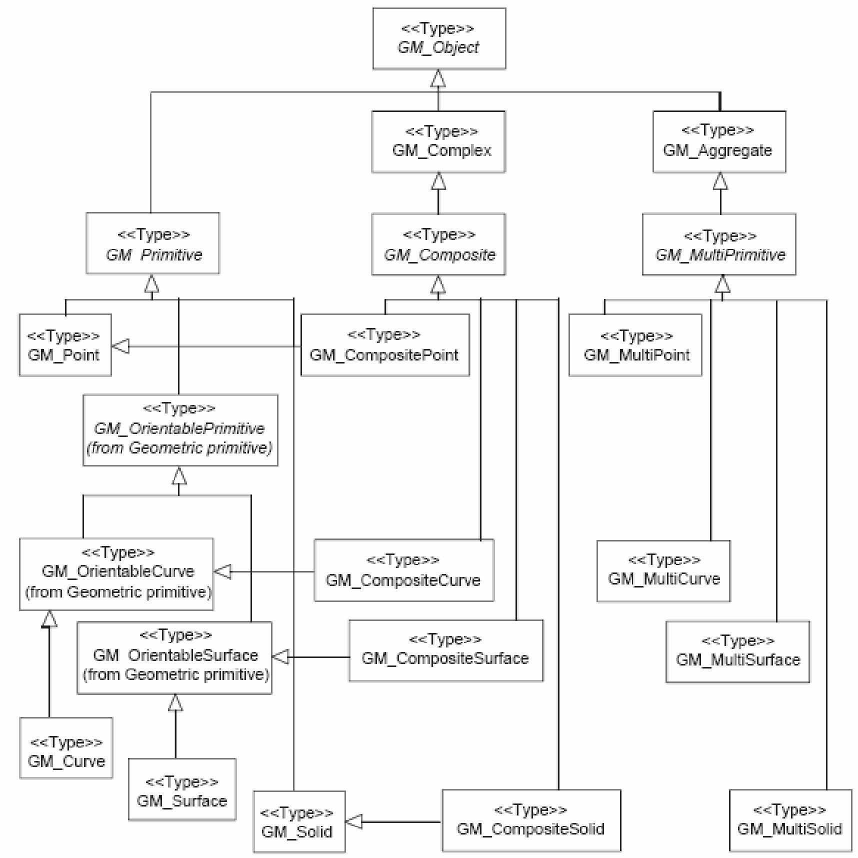



**Figure: Geometry basic classes with specialization relations**

**Geometry Root** package contains GM-Object class.

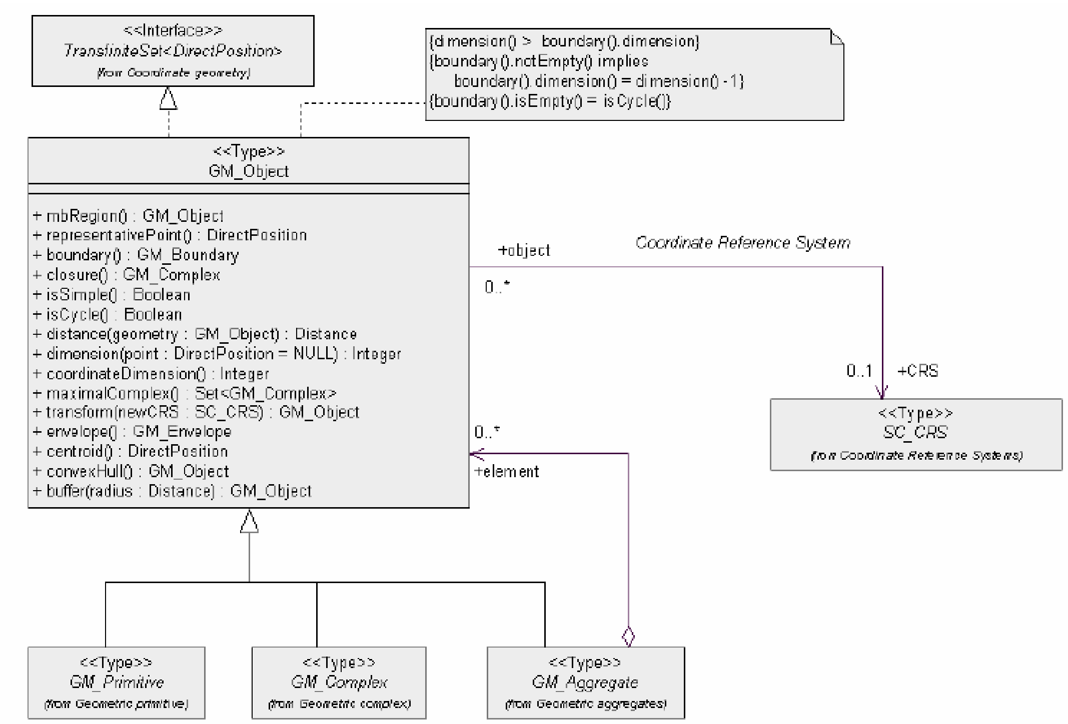



**Figure: Geometry Root package**

A geometric object shall be a combination of a coordinate geometry and a coordinate reference system. In general, a geometric object is a set of geometric points, represented by

DirectPosition (described below). GM_Object and GM_Primitive are purely abstract in the sense that no object or data structure from an application schema can instantiate them directly. Instances of these classes must be instances of one of their non-abstract subtypes, such as GM_Point, GM_Curve, or GM_Surface. This is not the case for GM_Complex, which can be directly instantiated by an application schema, and need not be an instance of one of the non-abstract subclasses of GM_Composite.

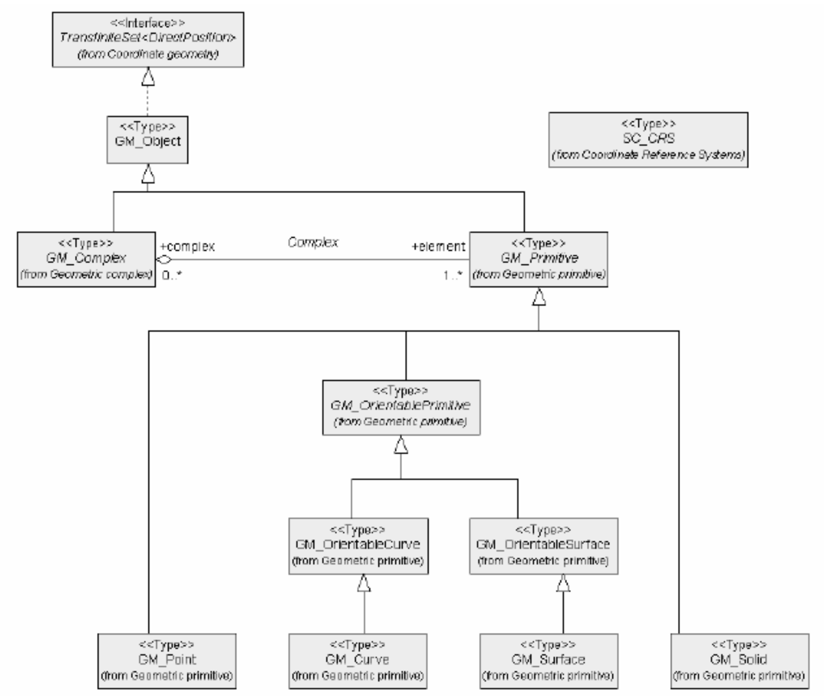



**Figure: Geometry Object**

The **Geometric primitive** package contains all the geometric primitives and supporting data types used in describing their boundaries, for example, Geometric Point and Geometric Curve.

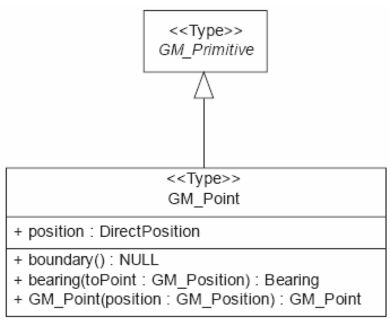



**Figure: Geometric Point (GM_Point) primitive**

GM_Point is the basic data type for a geometric object consisting of one and only one point.

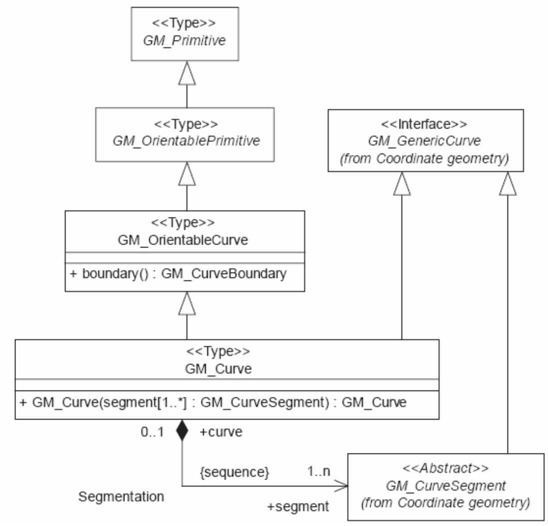



**Figure: Geometric Curve (GM_Point) primitive**

GM_Curve is a descendent subtype of GM_Primitive through GM_OrientablePrimitive. It is the basis for 1-dimensional geometry. Curves are continuous, connected, and have a measurable length in terms of the coordinate system.

**Coordinate geometry** package contains DirectPosition class.

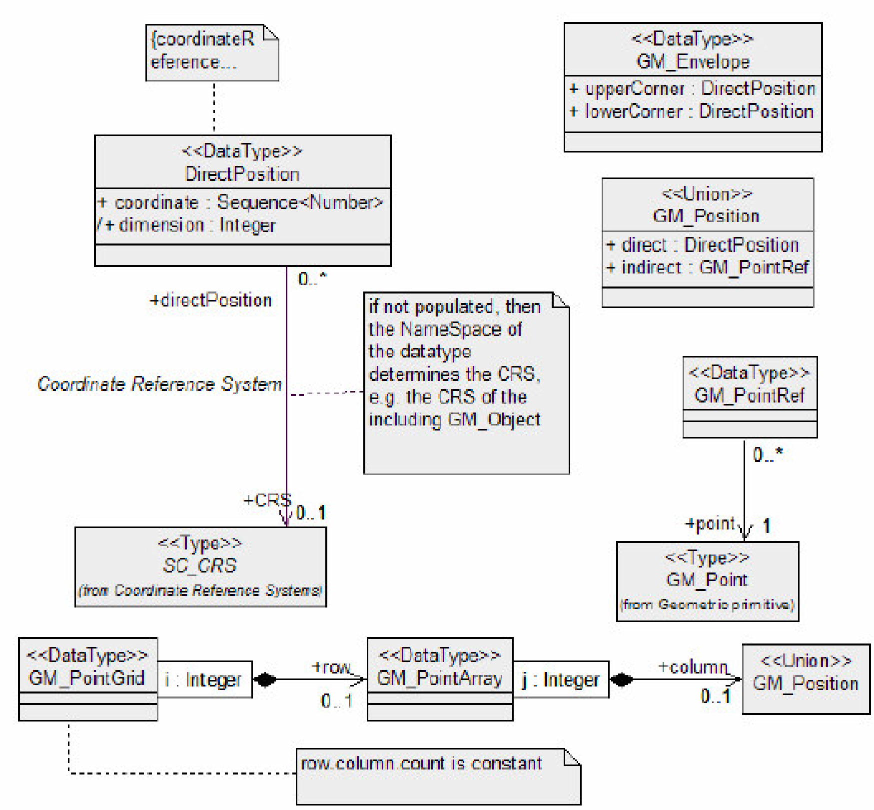



**Figure: DirectPosition class (object data types) from Coordinate geometry package**

DirectPosition object data types hold the coordinates for a position within some coordinate reference system. The coordinate reference system will be described within ISO 19111.
A set of other spatial object data types defined in Coordinate geometry package include existing point reference, envelope, line string, arc, polygon, etc.

**Geometric aggregate** package is about **the** arbitrary aggregation of geometric objects that are possible when interiors are jointed. These are not assumed to have any additional internal structure and are used to “collect” pieces of geometry of a specified type. Operations on these aggregations shall be for features that use multiple geometric objects in their representations, such as a collection of points to represent, for example, an orchard.

**Geometric complex** package describes a geometric complex (GM_Complex) - a set of primitive geometric objects (in a common coordinate system) whose interiors are disjointed. A GM_Complex is a collection of geometrically disjointed, simple GM_Primitives. Further, if a primitive is in a geometric complex, then there exists a set of primitives in that complex whose point-wise union is the boundary of this first primitive.

**Topology Packages** contains topology classes of relations for geometry.

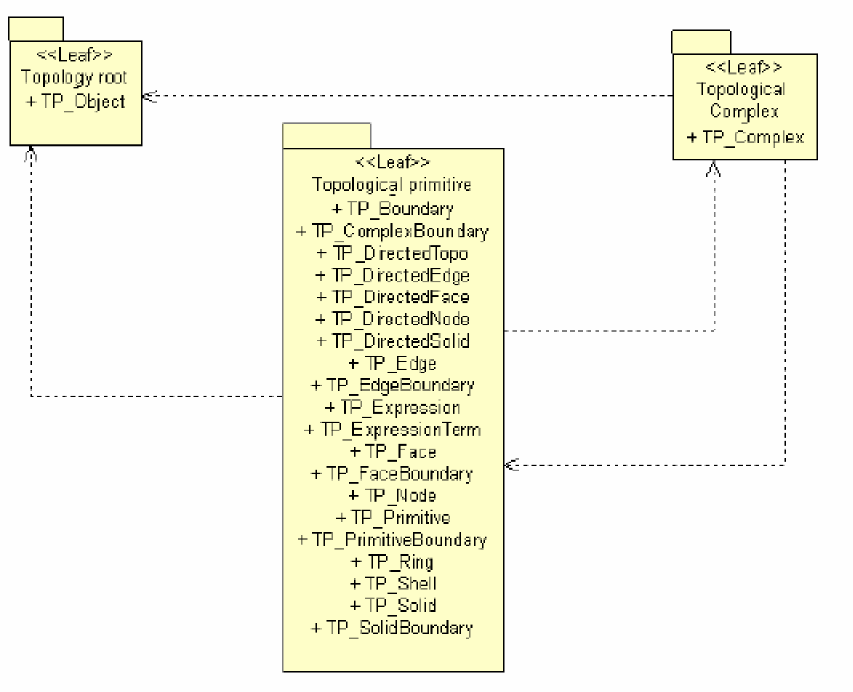



**Figure: Topology packages, class, content, and internal dependencies**

The most productive use of topology is to accelerate computational geometry. The method by which this is accomplished is to associate explicitly feature instances and geometric object instances in a manner consistent with and derived from their implicit geometric relations. In some cases, these associations are derived from a conceptual geometry that does not agree with the representation of the feature instances. For this purpose, it is necessary to define topology packages that parallel the geometry packages.

Topological class diagram shows the class structure of the basic topological packages.

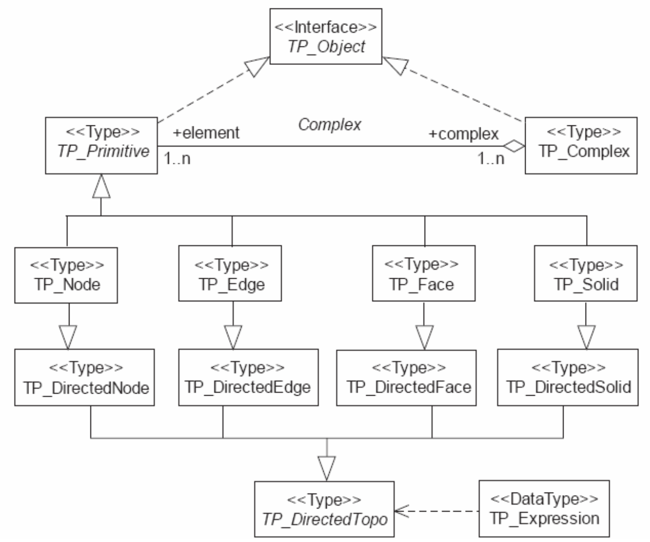



**Figure: An overview of the class structure of the basic topological packages**

The root class of the diagram is TP_Object. Under this, there are TP_Primitive, and TP_Complex, which are related in ways similar to the GM_Primitive and GM_Complex, so that a TP_Complex is an organized structure of TP_Primitives. The major difference being that a GM_Primitive is more loosely coupled to a GM_Complex, allowing it to stand alone, whereas a TP_Primitive must be in at least one TP_Complex. An instance of TP_DirectedTopo shall contain a reference to a TP_Primitive and an orientation parameter. Since only two orientations are possible, regardless of dimension, each primitive is associated to two directed topological entities. To conserve on the number of objects and to make the natural identification of a primitive with its positive orientation, each primitive in each dimension is subclassed under its corresponding directed topological object.

**Clause 8 Derived topological relations** of ISO 190107 specifies a mechanism for characterizing topological relations as operators to be used in query. These query operators can be calculated using the set theoretic operations defined on GM_Object and its subtypes and on algebraic operations defined on TP_Expression.

### 3.4 ISO 19137 - Core Profile of the Spatial Schema ISO

**ISO 19137:2007 Geographic information - Core profile of the spatial schema** project defines a core profile of ISO 19107 (Spatial schema). In accordance with ISO 19106 (Profiles), it specifies a minimal set of geometric elements necessary for an efficient creation of application schemata. The status of the document is currently **DIS** (Draft for International Standard).

## *3.5 ISO 19108 - Temporal Schema*

**ISO 19108:2002 Geographic information - Temporal schema** defines concepts for describing temporal characteristics of geographic information. ISO 19108 provides a basis for defining **temporal feature** attributes, feature operations, and feature associations, and for defining the temporal aspects of metadata about geographic information. It adds naturally a 4th-dimension to the spatial schema, both geometrical and topological, and emphasizes valid time rather than transaction time.

The temporal schema consists of two packages:

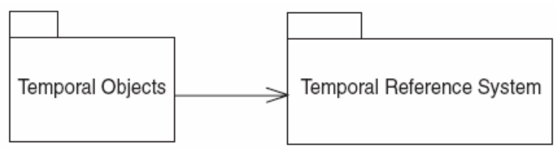



**Figure: Two packages of the temporal schema**

The package Temporal Objects defines temporal geometric and topological objects that shall be used as values for the temporal characteristics of features and data sets. The temporal position of an object shall be specified in relation to a temporal reference system. The package Temporal Reference System provides elements for describing temporal reference systems.

Time in ISO 19108 is measured on two types of scales: ordinal and interval. An ordinal scale provides information only about relative position in time, while an interval scale offers a basis for measuring duration.

An overview of **Temporal object** schema is illustrated on the following figure:

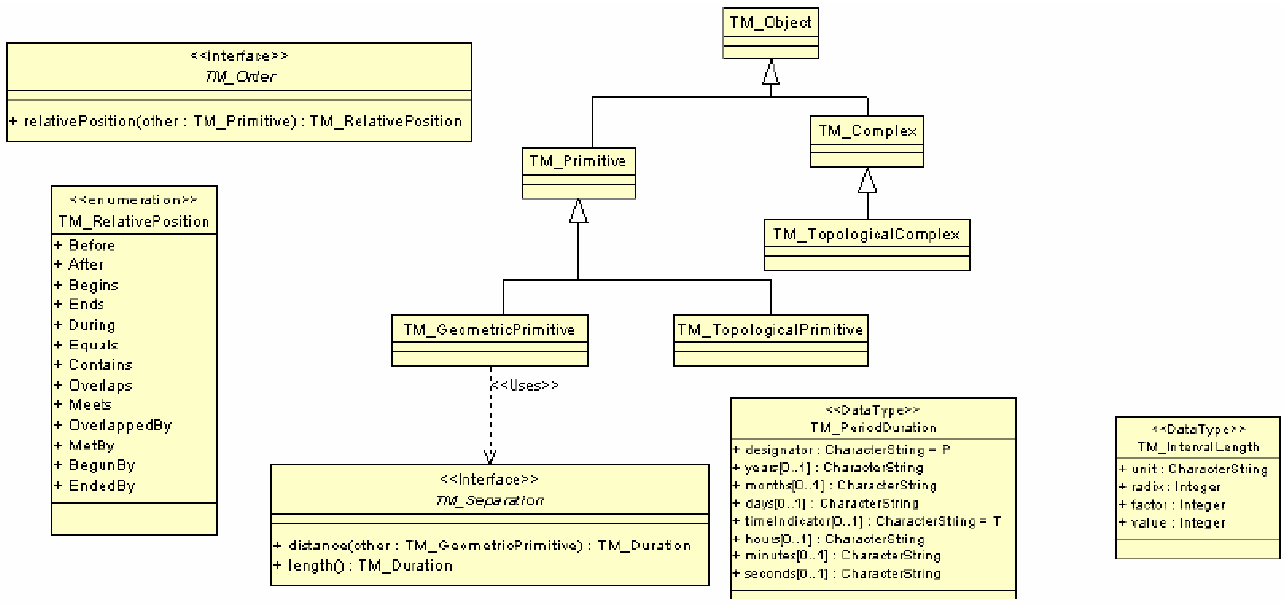



**Figure: Temporal object schema**

Temporal geometric and topological objects are to be used as values for the temporal characteristics of features and data sets. TM_Object is an abstract class that has two subclasses. TM_Primitive is an abstract class that represents a non-decomposed element of geometry or topology of time. There are two subclasses of TM_Primitive. A

TM_GeometricPrimitive provides information about temporal position. A TM_TopologicalPrimitive provides information about connectivity in time. A TM_Complex is an aggregation of TM_Primitives.

Temporal object schema uses the following **Temporal reference systems** package**.**

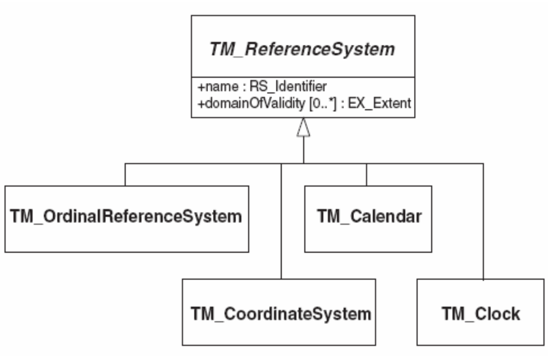



**Figure: Temporal reference systems**

The Temporal reference system package includes three common types of temporal reference systems: calendars (used with clocks for greater resolution), temporal coordinate systems, and ordinal temporal reference systems.

## *3.6 ISO 19111 - Spatial Referencing by Coordinates*

**ISO 19111:2007 Geographic information - Spatial referencing by coordinates** defines the conceptual schema for the description of spatial referencing by coordinates. ISO 19111 describes the minimum data required to define 1-, 2-and 3-dimensional coordinate reference systems. It also describes the information required to change coordinate values from one coordinate reference system to another.

ISO 19111 is applicable to producers and users of geographic information. Although it is applicable to digital geographic data, its principles can be extended to many other forms of geographic data such as maps, charts, and text documents.

Geographic information contains spatial references that relate the features represented in the data to positions in the real world. Spatial references fall into two categories:

- Those using coordinates
- Those based on geographic identifiers (geographical names)

This IS deals only with spatial referencing by coordinates. Coordinates are unambiguous only when the coordinate reference system to which those coordinates are related has been fully defined. A coordinate reference system is a coordinate system that has a reference to the Earth or other planetary body.

Coordinates supplied in a dataset shall belong to the same coordinate reference system. A description of this coordinate reference system shall be supplied with the dataset. Coordinate data shall be accompanied by information sufficient to make the coordinates unambiguous. This information varies by **coordinate system** type and **datum** type (consult GII-06 course Module 4 for more information).

In accordance with ISO 19111, a coordinate reference system may be either single or compound.

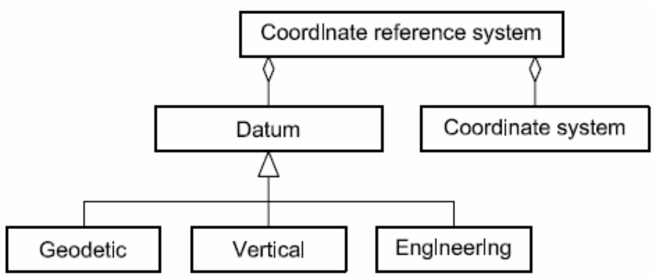



**Figure: Single coordinate reference system (ISO 19111)**

The horizontal and vertical components of a description of position in three dimensions may sometimes come from different coordinate reference systems rather than through a single three-dimensional coordinate reference system. Vertical datum and gravity-related height are an example of a datum and coordinate system for coordinate reference system 2. See more about vertical datum in GII-06 course Module 4.

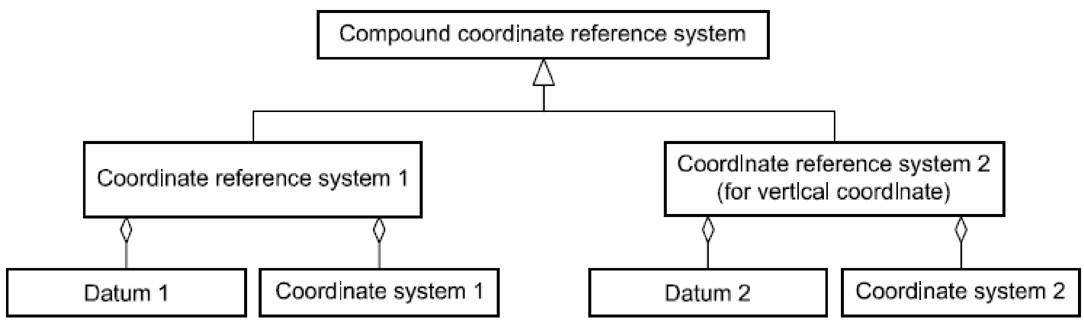



**Figure: Compound coordinate reference system**

This standard defines requirements and elements for describing the type of coordinate reference system, datum, prime meridian, ellipsoid, etc.

ISO 19111 classifies a datum as geodetic, vertical, or engineering. A *geodetic* datum gives the relationship of a coordinate system to the Earth and is used as the basis for two- or three-dimensional systems. This is horizontal datum measured from the center of the ellipsoid. In most cases, it shall require an ellipsoid definition.

A *vertical* datum gives the relationship of gravity-related heights to a surface known as the geoid. The geoid is a surface close to mean sea level.

In this IS, a datum shall be *engineering* if it is neither geodetic nor vertical.

UML schema for describing coordinate reference systems are presented below:

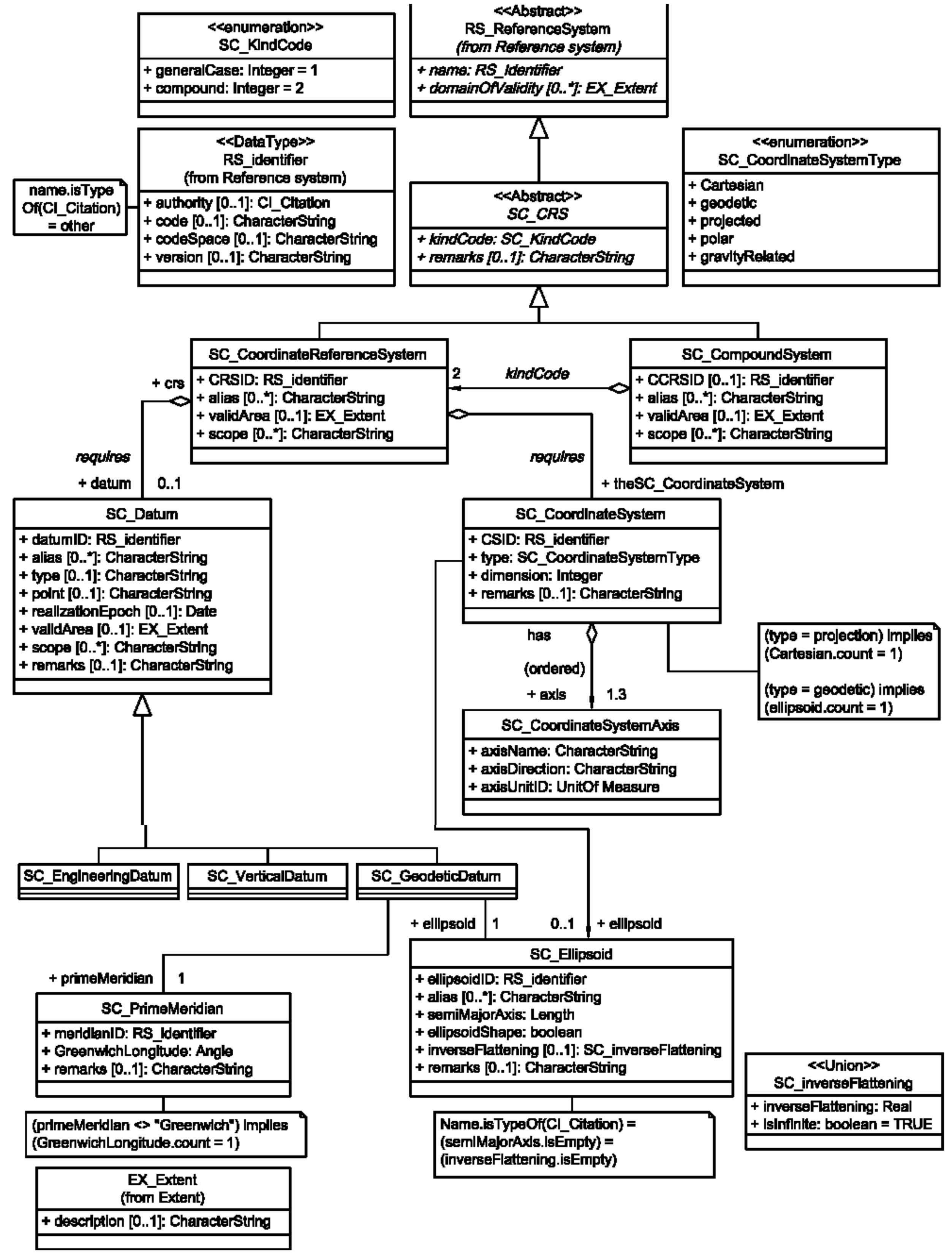



**Figure: Coordinate reference systems**

ISO 19111 UML model of Coordinate System are presented on the following figure:

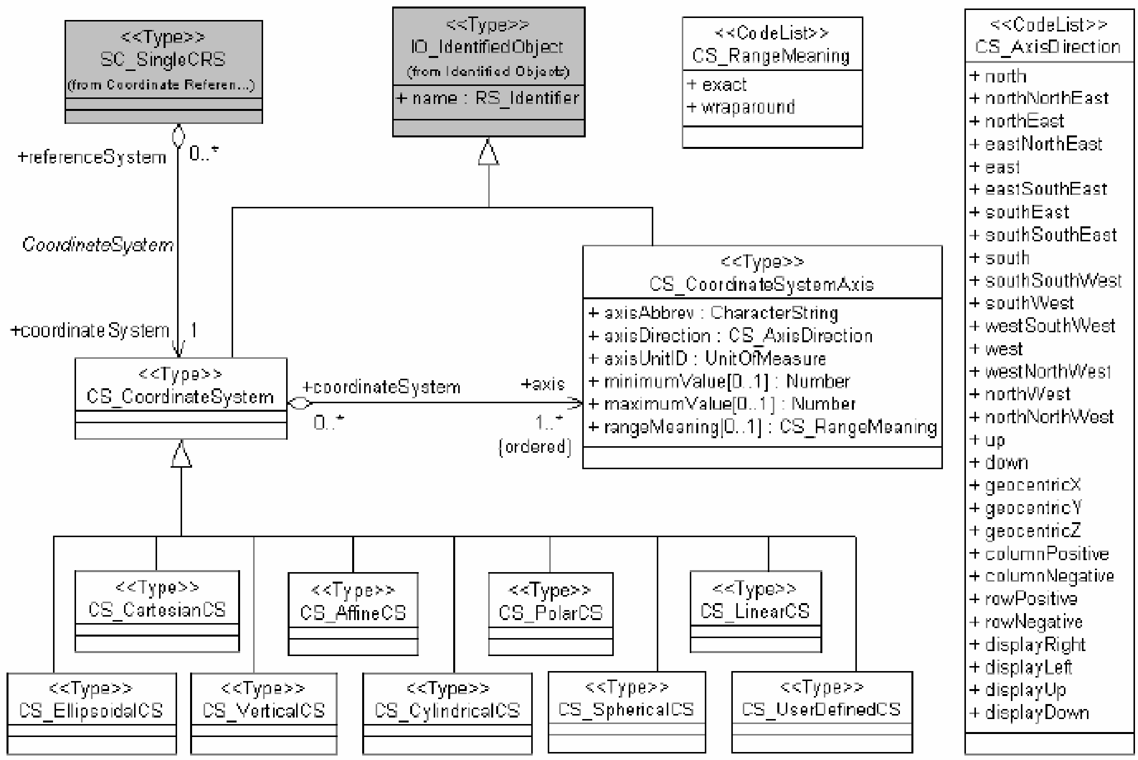



**Figure: Coordinate System**

A coordinate system is described by the name, units, direction, and sequence of the axes. Coordinates in a set are listed according to this sequence. Coordinates based on a projected coordinate reference system are the result of a coordinate conversion.

Optionally, coordinate operation information (conversion or transformation) may be given, if datasets having coordinates using different coordinate reference systems are to be merged.

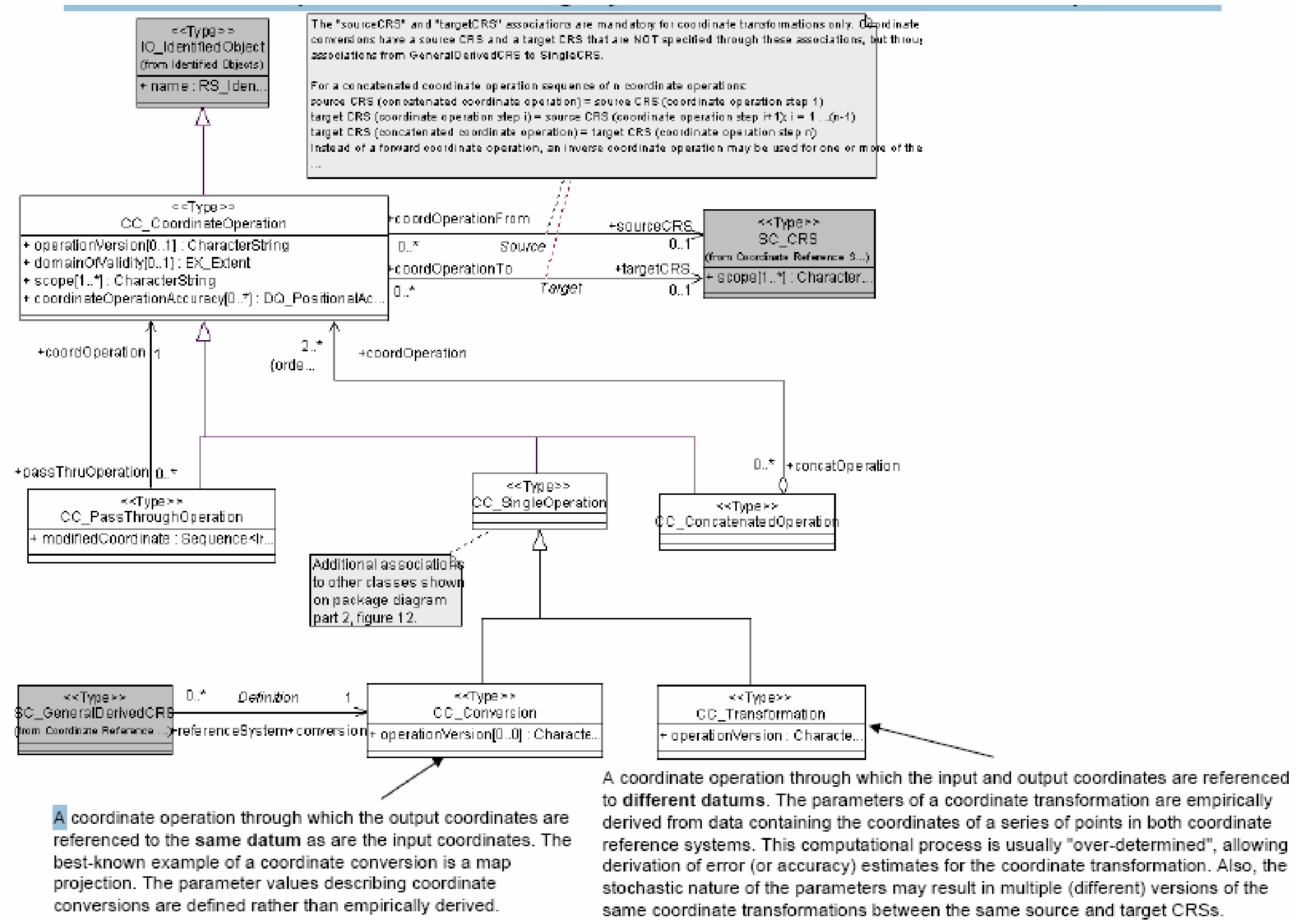



**Figure: Coordinate operations**

### 3.7 ISO 19112 - Spatial Referencing by Geographic Identifiers

**ISO 19112:2003 Geographic information - Spatial referencing by geographic identifiers** defines the conceptual schema for the description of spatial referencing by coordinates. ISO 19112 describes the minimum data required to define 1-, 2-, and 3-dimensional coordinate reference systems. It also describes the information required to change coordinate values from one coordinate reference system to another.

ISO 19112 is applicable to producers and users of geographic information. Although it is applicable to digital geographic data, its principles can be extended to many other forms of geographic data such as maps, charts, and text documents.

This IS deals only with spatial referencing by geographic identifiers. This type of spatial reference is sometimes called "indirect”. Spatial reference systems using geographic identifiers are not based explicitly on coordinates but on a relationship with a location defined by a geographic feature or features. In the GIS world, such types of spatial referencing are also called address matching, and assume that existing specially organized spatial dataset are used for pinning features to a particular location by geographic name (see GII-04 Module 3 for more information).

ISO 19112 can be used, for example, in the construction of gazetteers. A **gazetteer** is a directory of instances of a class or classes of features containing some information regarding position. A gazetteer is a dictionary of geographic identifiers together with their locations and other descriptive information. The NSDI can provide gazetteer services for users, to find geographic regions based on place names or postal codes. Geographic names of natural features and human constructs are mapped to coordinate-based geographic locations. Digital gazetteers have expanded the notion of “name” to include any identifying ‘label’ for a place or feature: street addresses, postal codes, named of temporal events, etc. Primarily gazetteers are used to search for data:

- To find a place given all or part of its name
- To find all places in a given region
- To find places that have some kind of a relationship to a known place

Two major activities form the basis of *feature-based model for access to named features* (gazetteer) specification and standardization:

- An OGC draft Implementation Specification *Gazetteer Service, Profile of the Web Feature Service Implementation Specification* on gazetteers (http://www.opengeospatial.org/standards/requests/36).
- ISO 19112:2003 Geographic information -- Spatial referencing by geographic identifiers that defines an abstract model to be implemented by a gazetteer service.

ISO 19112 enables gazetteers to be constructed in a consistent manner.

The position of a feature is identified by a spatial reference based on locations of other spatial features.

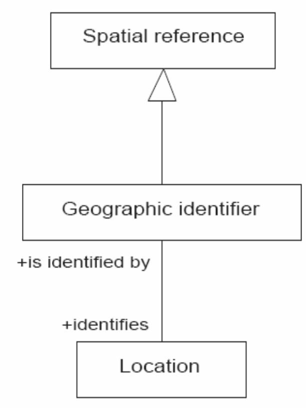



**Figure: The concepts of spatial referencing using geographic identifiers**

A spatial reference system using geographic identifiers comprises a related set of one or more location types, together with their corresponding geographic identifiers. These location types may be related to each other through aggregation or disaggregation, possibly forming a hierarchy.

A gazetteer provides a master record of all location instances for a particular location type or types. It contains additional information regarding position of each location instance. This may include a coordinate reference or/and it may be purely descriptive.

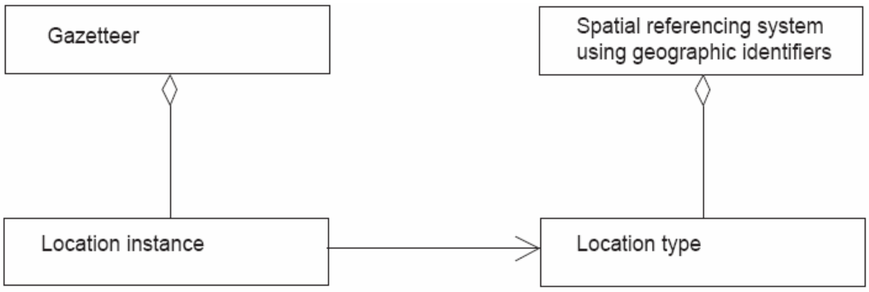



**Figure: Spatial reference system using geographic identifiers**

If gazetteer contains a coordinate reference, this will enable transformation from the spatial reference system using geographic identifiers to the coordinate reference system. If gazetteer contains a descriptive reference, this will be a spatial reference using a different spatial reference system using geographic identifiers, for example the postcode of a property.

A spatial reference system using geographic identifiers shall comprise one or more location types (which may be related), for example, names for an administrative area, town, locality, street, and property. Each location instance shall be uniquely identified by means of a geographic identifier.

UML model of spatial referencing using geographic identifiers is presented on the following figure:

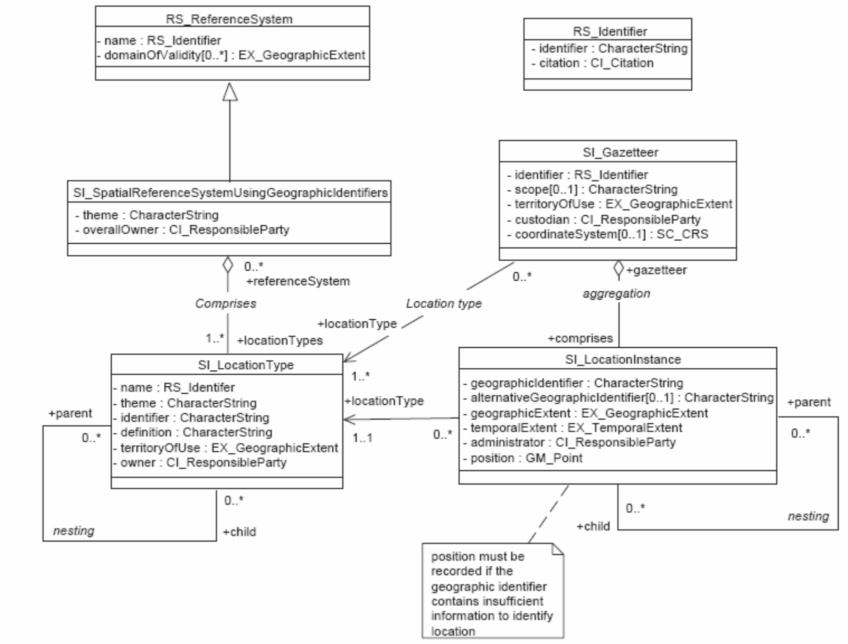



**Figure: Spatial referencing using geographic identifiers**

For each location type in the spatial reference system, the following attributes shall be identified:

- Name
- Theme
- Identifier
- Definition
- Territory of use
- Owner

An example of a spatial referencing system using geographic identifiers would be the addressing of properties in Lithuania. This can be described as follows:

- Name - Lithuanian property address
- Theme - property
- Overall owner - office for the Ministry of Agriculture
- Territory of use - Lithuania
- Location types - administrative area, town, locality, street, property

| Name | Theme | Identifier | Definition | Territory of use | Owner | Parent | Child |
|---|---|---|---|---|---|---|---|
| administrative area | local administration | name | area of responsibility of highest level local authority | Lithuania | Lithuania government | none | town |
| town | built environment | name | city or town | Lithuania | Ministry of Agriculture | administrative area | locality |
| locality | community | name | neighbourhood, suburb, district, village, or settlement | Lithuania | local authority | town | street |
| street | access | unique street reference number | thoroughfare providing access to properties | Lithuania | Highway Authority | locality, town or administrative area | basic land and property unit |
| property | built environment | geographic address | land use | Lithuania | local authority | street | none |

**Figure: Example description of location types**

All instances of each location type in a spatial reference system shall be described in a gazetteer. A gazetteer shall have the following attributes:

- Name
- Territory of use
- Custodian

The following may also be recorded:

- Scope
- Coordinate reference system

Examples of gazetteer data are:

**C.1 Administrative areas**

A gazetteer of administrative areas would be described as follows:

- identifier - administrative area
- scope - local authority areas
- territory of use - Lithuania
- custodian - Ministry of Agriculture
- coordinate reference system - LKS 1994
- location types - Municipality district

The following would be a valid record:

- geographic identifier - MinistryLandAgriculture
- temporal extent - 19960401
- alternative geographic identifier - CC
- geographic extent - 5300 2370, 5630 2470, 5460 3190, 5020 3060
- position - 5448 2583
- administrator - Ministry of Agriculture
- parent location instance - Lithuania

The following steps can execute spatial referencing by geographic identifiers according to ISO 19109:

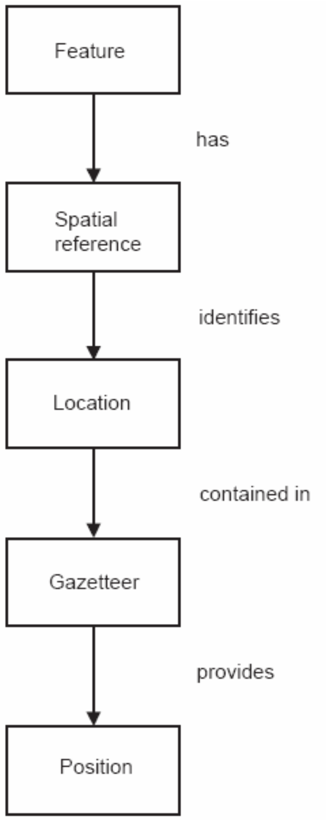



**Figure: The concept of spatial referencing using geographic identifiers where coordinate information is provided**

With spatial referencing using geographic identifiers, the position is found by a reference to a location. A label or a code identifies the location. A dataset that depends upon spatial referencing by geographic identifiers does not explicitly contain coordinates. A gazetteer may contain the location and provide the corresponding coordinates, thereby enabling the data to be displayed or manipulated geographically.

## 3.8 Coverages and Gridded Data

The data schemas discussed above deals with the **vector** data modeling. However, ISO TC 211 also addresses other data structures, such as imagery and gridded data, in an integrated manner within the ISO 19100 series of geographic information standards.

The following standards address data organization and behaviors within not-vector schemes:

- ISO 19101-2 - Reference model - Part 2: Imagery
- ISO 19115:2003 Geographic information – Metadata
- ISO 19115-2 - Metadata - Part 2: Extensions for imagery and gridded data
- ISO/TR 19121:2000 Imagery and gridded data
- ISO 19123:2005 Schema for coverage geometry and functions
- ISO 19129 - Imagery, gridded and coverage data framework
- ISO 19130 - Sensor and data models for imagery and gridded data

**ISO 19115-2 Geographic Information – Metadata – Part 2 Extensions for Imagery and Gridded Data** is under development. This IS extends *ISO 19115:2003 Geographic Information – Metadata* by defining the schema and additional metadata required for imagery and gridded data. Current ISO 19115 Metadata, which will be examined in Module 5, supports some aspects for geospatial imagery, but a detailed imagery metadata definition is purposely deferred. Leverage existing elements where possible and appropriate. Part 2 of ISO 19115 will contain a UML model of new imagery elements, as well as existing classes. New elements will not interfere with existing implementations.

**ISO 19129 - Imagery, gridded, and coverage data framework** technical report is also under development. It is preliminary work for imagery and gridded data standards and contains definitions of the interaction of the imagery standards of ISO and of individual standardization projects.

**ISO 19130 - Sensor and data models for imagery and gridded data** defines minimum requirements for the georeferencing of imagery and gridded data. It will describe models for the following sensors: Laserscanning (Lidar), Radar (SAR, InSAR), Hydrographic Sonar, Scan linear arrays, Photogrammetric camera, and Paper- and Film-scanners.

### 3.8.1 General Interoperability Data Model

Historically, geographic information has been treated in terms of two fundamental types called vector data and raster data. Raster is used to map continuous phenomenon. This data structure (raster) is not the only one that can be used to represent phenomena that vary continuously over space (e.g. grid, TIN, etc).

ISO have released geo-information standard models that are conceived to support **general interoperability**. These efforts lead to the definition of “more general” models for geographic information. Such models distinguish two kinds of geographic information: **boundary** and **coverage** data. Boundary data is often called "**vector** data" and is usually feature-oriented.

ISO 19123 uses the term “coverage,” adopted from the Abstract Specification of the OGC, to refer to any data representation that assigns values directly to spatial position. A **coverage** is a feature that associates positions within a bounded space (its domain) to feature attribute values (its range). In other words, it is both a feature and a function. Examples include a raster image, a polygon overlay, or a digital elevation matrix (ISO 19123). In many cases, coverages are grid-oriented.

Coverages support mapping from a spatial, temporal, or spatiotemporal domain to feature attribute values where feature attribute types are common to all geographic positions within the domain. A coverage domain consists of a collection of direct positions in a coordinate space that may be defined in terms of up to three spatial dimensions as well as a temporal dimension. Examples of coverages include rasters, triangulated irregular networks, point coverages, and polygon coverages. Coverages are the prevailing data structures in a number of application areas, such as remote sensing, meteorology, and mapping of bathymetry, elevation, soil, and vegetation.

A coverage can be derived from a collection of discrete features with common attributes, the values of the coverage at each position being the values of the attributes of the feature located at that position.

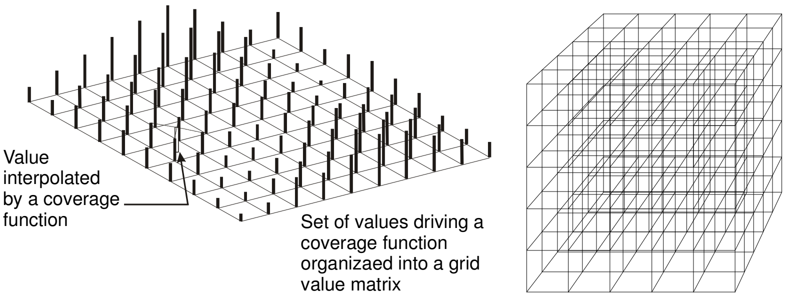



**Figure: Coverages**

In the OGC framework, a coverage is considered to be a subclass of a feature. A coverage may also act as a collection of features with homogeneous attributes.

There are two major categories of coverages: discrete and continuous.

**Discrete** coverages are essentially feature collections where all of the contained objects have exactly the same feature type. The responsibility of a discrete coverage is to present the contents of this collection for efficient retrieval of one or more elements with reference to the coverage's spatiotemporal coordinates. The simplest type of discrete coverage is one that is defined only at a discrete collection of points. Generally, the domain is a set of irregularly distributed points; the principal use of discrete point coverages is to provide a basis for continuous coverage functions.

Just as in mathematics, **continuous** coverages return defined values everywhere within the domain of validity and discrete coverages are only defined in certain places. Continuous coverage types are shown in the following figure:

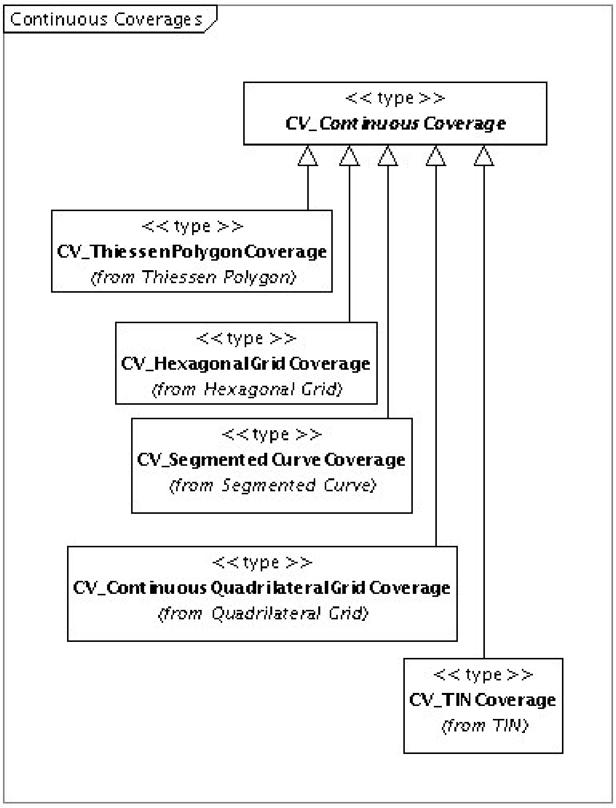



**Figure: Continuous coverages defined by 19123**

In the ISO 19100, a **raster**, **image,** or **gridded** data is a type of **coverage.** An **image** is a gridded coverage whose attribute values are a numerical representation of a physical parameter. The parameters are the result of measurement by an instrument or from a prediction by a physical model. Raster data is based on the division of the extent covered into small units according to a tessellation of the space and the assignment to each unit of an attribute value.

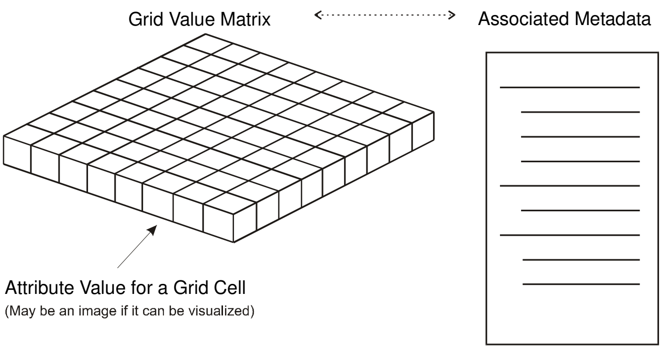



**Figure: Gridded data**

The definition ‘image’ (or ‘digital image’) is defined in ISO/IEC 12087-1: Common architecture for imaging.

## *3.9 ISO 19123 - Schema for Coverage Geometry and Functions*

**ISO 19123:2005 Geographic information - Schema for coverage geometry and functions** defines a conceptual schema for the spatial characteristics (geometry and functions) of coverages. ISO 19123 is defining this application schema provides a general-purpose model of phenomena parameterized by location and time. A tool is provided by which *any* spatiotemporally variable phenomenon may be represented. Standard methods for querying the phenomenon at a particular location are defined and are valid regardless of whether the phenomenon is described by a formula or by a collection of data points.

ISO 19123 defines the relationship between the domain of a coverage and an associated attribute range. The characteristics of the spatial domain are defined whereas the characteristics of the attribute range are not part of ISO 19123.

In this IS, coverage is a subtype of feature. A coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type. For example, the city feature may be represented as a coverage that returns values such as population density, land value, or air quality index for each position in the city.

ISO 19123 will require seven packages:

1. Coverage Core
2. Quadrilateral Grid
3. Hexagonal Grid
4. Discrete Coverages
5. Thiessen Polygon
6. TIN
7. Segmented Curve

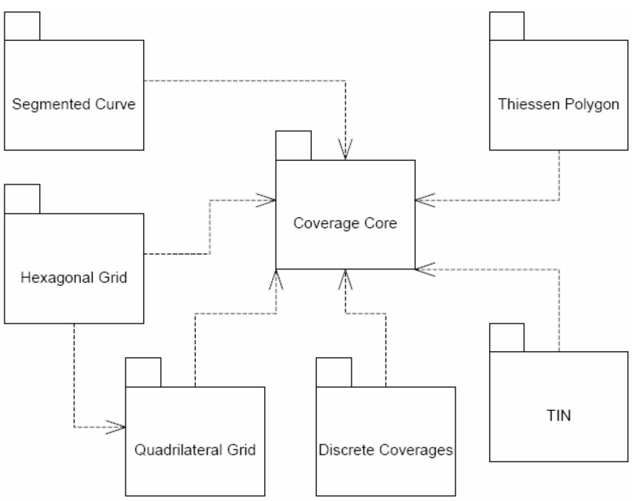



**Figure: Packages of the coverage schema**

Where, **coverage** is **feature** that acts as a **function** to return values from its **range** for any **direct position** within its **spatiotemporal domain. Discrete coverage** is **coverage** that returns the same **feature attribute** values for every **direct position** within any single **spatiotemporal object** in its **spatiotemporal domain. Thiessen polygon** is polygon that encloses one of a set of **points** on a plane to include all **direct positions** that are closer to that point than to any other point in the set. **Triangulated irregular network (TIN)** is tessellation composed of triangles. **Grid** is network composed of two or more sets of **curves** in which the members of each set intersect the members of the other sets in an algorithmic way. **Curve** is 1-dimensional **geometric primitive**, representing the continuous image of a line. The curves are called grid lines; the points at which they intersect are grid points, and the interstices between the grid lines are grid cells.

**Quadrilateral** grid is a network composed of two or more sets of equally spaced parallel lines in which the members of each set intersect the members of the other sets at right angles. **Hexagonal** grid is based on tessellations composed of regular hexagons. **Segmented** curve coverages are used to model phenomena that vary continuously or discontinuously along curves, which may be elements of a network. The spatiotemporal domain of a segmented curve coverage is described by a set of curves and includes all the direct positions in all of the curves in the set.

## *3.10 ISO 19101-2 - Reference Model - Part 2: Imagery*

**ISO/TS 19101-2:2004 - Geographic information - Reference Model - Part 2: Imagery** provides a reference model for geographic imagery. This reference model identifies the scope of the standardization activity being undertaken and the context in which it takes place. The scope includes gridded data with an emphasis on imagery.

ISO 19101-2 Technical Specification is extension of existing ISO 19101 “Reference model”, and is based upon models of information science, remote sensing, and photogrammetric principles. This TS is currently under development.

## *3.11 ISO/TR 19121 - Imagery and Gridded Data*

**ISO/TR 19121:2000 Geographic information - Imagery and gridded data** reviews the manner in which raster and gridded data are currently being handled in the Geomatics community in order to propose how this type of data should be supported by geographic information standards.

This Technical Report identifies those aspects of imagery and gridded data that have been standardized or are being standardized in other ISO committees and external standards organizations, and that influence or support the establishment of raster and gridded data standards for geographic information. It also describes the components of those identified ISO and external imagery and gridded data standards that can be harmonized with the ISO 19100 series of geographic information/geomatics standards.

## *3.12 ISO/TS 19127 - Geodetic Codes and Parameters*

Currently, many lists of geodetic codes and parameters exist in national standards, standards of liaison organizations, and industrial specifications and software products. Little guidance is provided on applicability and appropriate use of these geodetic codes and parameters. Applicability and appropriate use are of great concern, as geographic information systems become more widely available to non-experts in cartography and geodesy.

Also, ISO 19135 specifies procedures for the registration of items of geographic information. ISO 19111 describes elements necessary to define fully coordinate reference systems and coordinate systems so that coordinates for positions on or near the Earth's surface can be unambiguously referenced. ISO 19111 also describes elements to define coordinate operations that change coordinate values from one coordinate reference system to coordinate values based on another coordinate reference system.

**ISO/TS 19127:2005 Geographic information - Geodetic codes and parameters** describes how the procedures specified in *ISO 19135 - Procedures for item registration* are to be applied to registers of elements applicable to spatial referencing by coordinates in compliance with ISO 19111. Some elements that are optional in ISO 19111 become mandatory in this Technical Specification to provide guidance on applicability and appropriate use.

This Technical Specification defines rules for the population and maintenance of registers of geodetic codes and parameters and identifies the data elements, in compliance with ISO 19111 and ISO 19135, required within these registers. Recommendations for the use of the registers, the legal aspects, the applicability to historic data, the completeness of the registers, and a mechanism for maintenance are specified by the registers themselves.

## *3.13 ISO 19131 - Data Product Specifications*

The scope of **ISO 19131:2007 Geographic information - Data product specifications** is to describe requirements for the specification of geographic data products, based upon the concepts of other ISO 19100 standards. It also provides help in the creation of data product specifications, so that they are easily understood and fit for their intended purpose.

ISO 19131 specifies nine UML packages, some are mandatory, some optional.

A data product specification is a detailed description of a dataset or dataset series together with additional information that will enable it to be created, supplied to, and used by another party. *It is a precise technical description of the data product in terms of the requirements that it will or may fulfil.* However, the data product specification only defines **how the dataset should be**. For various reasons, compromises may need to be made in the implementation. The metadata, associated with the product dataset, should reflect how the product dataset actually is. Which means that the result of the business model and requirement model to a large extent will be reflected in a data product specification – and the applications schema is only a part of the product specification.

The following figure (from ISO 19131**)** shows the sequence from a data product specification that specifies a data product, implemented as a dataset described by metadata.

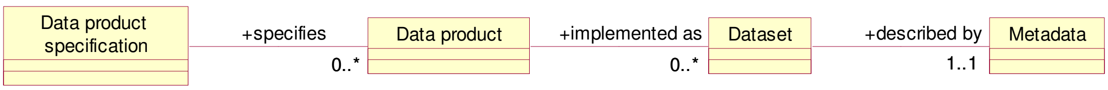



**Figure: Relationship of data product specification to metadata**

UML ISO 19131 packages are shown on the following figure:

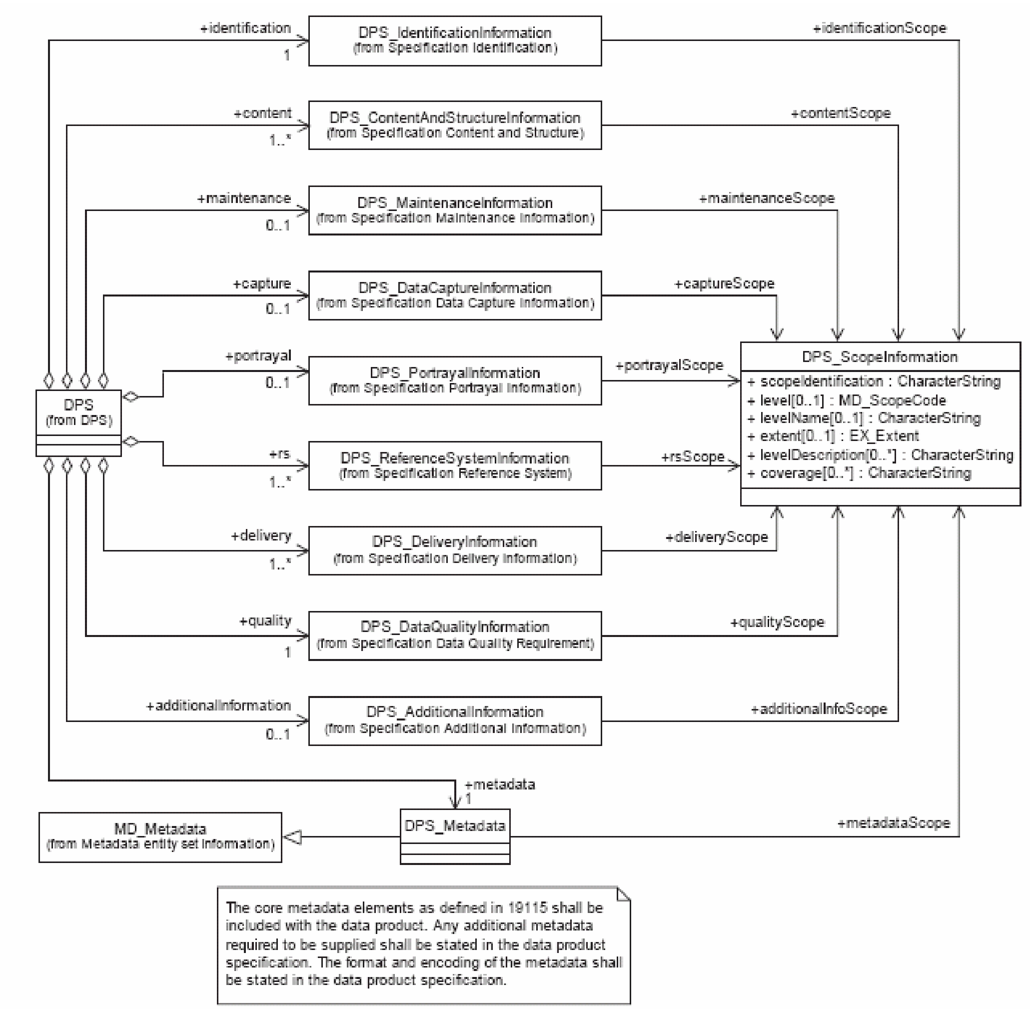



**Figure: ISO 19131 packages and relationship of data product specification to metadata**

In general, a product specification may have different requirements on different parts of a product. DPS_ScopeIdentification defines which part of a product a requirement is related to. It could be a geographic extent or part of a product identified by the scope code.

ISO 19131 states that all product specifications shall state the requirements for:

- Content and structure
- Reference System
- Delivery
- Quality
- Identification Information
- Metadata

**Content** and **structure** package contains the application schema requirements according to ISO 19109 (Rules for application schemas) and ISO 19110 (Methodology for feature cataloguing) for feature data in general as well as ISO 19123 for coverage and imagery data.

Some of the INSPIRE principles for data content and structure give overall guidance on the design constraints by stating (RISE: Reference Information Specifications for Europe):

- Data should be collected once and maintained at the level where this can be done most effectively

- It must be possible to combine seamlessly spatial information from different sources across Europe and share it between many users and application
- It must be possible for information collected at one level to be shared between all the different levels, e.g. detailed for detailed investigations, general for strategic purposes

One of the main questions regarding the framework design constraints on the content is whether a data product should fulfil the requirements of a large and general community or a small and specialized community.

**Reference system** package contains requirements on choosing a reference system for a data product. A user may have requirements related to which spatial referencing system should be applied. The choice is usually related to national or local systems that are applied, together, with the data.

Most of these requirements may be fulfilled by a coordinate transformation service (a service offering coordinate conversions between two coordinate reference systems according to ISO 19111). The next question is:  Will the quality of the transformation service have any significant impact on the requirement on data quality per se?

Another aspect of reference systems involves temporal reference systems. It is sometimes questioned whether there are any requirements for temporal characteristics of geographic information, including feature attributes, feature operations, feature associations, and metadata elements that take on a value in the temporal domain.

Information from **Delivery packages** has two components - delivery medium and delivery format. Both of these may be of interest for the requirement model. In particular, this item is also related to the topic of service interfaces used to deliver the data products.

**Data quality** is a difficult issue. Often, available data has only a few quality statements and hardly relates to any standard. ISO/TC 211 has standardized a quality model, modeled as part of the metadata. The model consists of data quality information according to 5 quality elements and lineage information.

**Maintenance information** package is optional. **I**t describes the principles and criteria applied in the maintenance of the data once it has been captured. This includes the maintenance and update frequency (frequency with which changes and additions are made to the data product). This section, if provided, is simply a textual description and does not provide for or require any substructure in the information to be provided in the data specification.

**Data capture information** package is also optional. Where this section is included, it contains a data capture statement, that is, a general description of the sources and the processes to be used. It may allow freedom of choice for the data capture process, or it may specify one particular data capture process. This section, if provided, is simply a textual description and does not provide for or require any substructure in the information to be provided in the data specification.

**Portrayal information** package is optional. If included, this section provides information on how the data held within the dataset is to be presented - graphic output as a plot or as an image expressed as a reference to a set of portrayal rules in conformance with ISO 19117.

**Additional information package** is optional too. This may be one of the challenges and covers all kinds of requirements that are not predefined in the ISO 19131 or underlying standards. It is expected that a lot can be learned from use cases / business models outside the spatial domain as well.

From a business / requirement model point of view, the model of ISO 19131 could, in principle, be extended to cover both data and services - often required to fulfill all user requirements. The UML model for data product specifications, a similar model, may be developed – considering *ISO 19119 - Services* – to describe more precisely the output from the requirement / business model in form of services.

One example where a service is required is the following:

- User requirement: Data in a European datum
- Data Product: Data is in a national datum

The data product, as such, does not fulfill the user requirement but a transformation service would definitely do so by transforming data from the national datum to the European datum. There will be several examples where the data product, as such, does not fulfill the user requirements. Rather, different kinds of services will transform data to the requested model, like semantic interoperability and ontology.

## *3.14 Conclusion*

Standards of Content category are defined conceptual schemas and requirements for modeling **vector** and **raster** geospatial data.

ISO 19109 defines **only** rules for creating and documenting application schemas. These standards provide guidelines on how to create data models for particular applications by using the ISO 19100 series of standards.

The UML profile defined in ISO 19103 is used for descriptions in such modeling.

Geo-spatial reference systems for spatial data are defined by coordinates or/and geographic identities in accordance with ISO 19111 and ISO 19112, respectively.

A data product specification defines a precise technical description of the data product considering ISO 19131.

ISO 19123 standard tries to define the general notion of a geospatial data model (commonly it is vector and raster) that can incorporate notions of feature and “continuous" coverage that includes gridded data, TIN, etc.

## Module self-study questions:

14. What are two ways of data interchange between information systems? What additional information is needed for transaction via web services?
15. What is an application schema? How does ISO 19109 define the development of an application schema? Why does ISO 19109 not *standardize* application schema per se?
16. What is a GFM and feature type? Are feature classes and feature types the same thing?
17. What are two types of information described within ISO 19107 Spatial schema? What type of spatial data model does this schema define? What three criteria are used for differentiating ISO 19107 geometric or topological objects? How do these conform to ISO application schemas?
18. What two types of spatial referencing are possible within ISO 19100 series of standards?
19. What is "coverage" from ISO 19100 point of view? What two types of coverages does ISO 19100 define? Is Landsat imagery considered "coverage"?
20. What are the technical requirements described by ISO 19131? Is this requirement created before or after the production process?

## Required Readings:

[8] Chapter Two: Geospatial Data Development: Building data for multiple uses: The SDI Cookbook, Editor: Douglas D. Nebert, Technical Working Group Chair, GSDI, Version 2.0 25 January 2004, page 13-23, http://www.gsdi.org/docs2004/Cookbook/cookbookV2.0.pdf.

[9] Methodology & Guidelines on Use Case & Schema Development, Reference Information Specifications for Europe (RISE), 2006, http://www.eurogeographics.org/eng/documents/RISE19_Methodology_Guidelines_v1.1.doc.

## References

[15] ISO 19107:2003 Geographic information - Spatial schema
[16] ISO 19108:2002 Geographic information - Temporal schema
[17] ISO 19109:2005 Geographic information - Rules for application schema
[18] ISO 19111:2007 Geographic information - Spatial referencing by coordinates
[19] ISO 19112:2003 Geographic information - Spatial referencing by geographic identifiers
[20] ISO/TR 19121:2000 Geographic information - Imagery and gridded data
[21] ISO 19123:2005 Geographic information - Schema for coverage geometry and functions
[22] ISO/TS 19127:2005 Geographic information - Geodetic codes and parameters
[23] ISO 19131:2007 Geographic information - Data product specifications
[24] ISO 19137:2007 Geographic information - Core profile of the spatial schema

## Terms used

- Interoperability
- Transfer
- Transaction
- Application schemas
- Feature type
- GFM
- Attribute type
- Property type
- Spatial schema
- Geometric aggregate
- Geometric complex
- Geographic Identifier
- Gazetteer
- Coverage
- Gridded Data
- Quadrilateral Grid
- Hexagonal Grid
- Thiessen Polygon

# 4 Services' and Reports' Categories of Geospatial Standards

An application schema is compiled by integrating elements from a set of standardized conceptual schemas developed in ISO 19107, ISO 19108, ISO 19110, ISO 19111, ISO 19112, ISO 19113, ISO 19115, and ISO 19117. How this integration takes place is described in ISO 19109. The ISO 19100 series of standards also defines a set of common services that are available when developing geographic information applications. Common services are generally defined in ISO 19119 and cover access to, and the processing of, geographic information, according to the common information model. Two service areas are defined more closely in ISO 19116 and ISO 19117. ISO 19105, ISO 19106, ISO 19114, and ISO 19136 cover implementation issues. Users of ISO 19136 develop application schemas to capture the semantics of geographic information.

It is not the intention of this module to examine the architectures of web map and feature services or the XML/GML language used for the modeling of spatial schemas and data encoding. Only the main principles of web services and encoding are explained here. The GII-08 course module addresses these issues in depth. .

<u>Module Outline</u>

Topic 30: Overview Services' and Reports' Categories of Geospatial Standards
Topic 31: ISO 19119 - Services
Topic 32: ISO 19118 - Encoding
Topic 33: ISO 19136 - Geography Markup Language
Topic 34: ISO 19116 - Positioning Services
Topic 35: ISO 19117 - Portrayal
Topic 36: ISO 19128 - Web Map Server Interface
Topic 37: ISO 19142 - Web Feature Service
Topic 38: ISO 19143 - Filter Encoding
Topic 39: Location Based Services

## *4.1 Overview Services' and Reports' Categories of Geospatial Standards*

Spatial Data Infrastructures support the discovery, access, and use of geographic information in the decision-making process. ISO 19100 provides a second way of data interchange. The ISO interoperability model between information systems may take place when the user application communicates with the supplier application through a common communication protocol via **services**. In this case, the user application schema has to describe not only the structure and content of the exchanged data but also the structure of the **interfaces** involved in the **transaction**.

For example, INSPIRE requires each EU member state to provide access to national sets of geospatial information. INSPIRE states that network services are needed for the sharing of spatial data between public authorities in the EU. The architecture envisioned by INSPIRE deploys *interoperable services* that will help to produce and publish, find and access, and eventually, use and understand geographic information over the Internet across European Union and Association Countries at local, national, and European levels. INSPIRE is based on geospatial standards. This module discusses current and evolving geospatial standards for geospatial web services that are candidates for implementing some of the network services required by INSPIRE.

Geo-enabled services or distributed mapping has to present and analyze information using different vendor's technology and rendering methods. These services can be:

- Map (+ coverage and terrain) services
    - Web Map Services (WMS, WCS, WTS)
- Geographic object services, transactions
    - Web Feature Services
- Models, encoding, and transport of geographic information
    - GML
- Presentation, dynamic legend, symbology, …
    - Portrayal, styling, … services
- Registry, discovery, and chaining of data and services
    - Catalog services

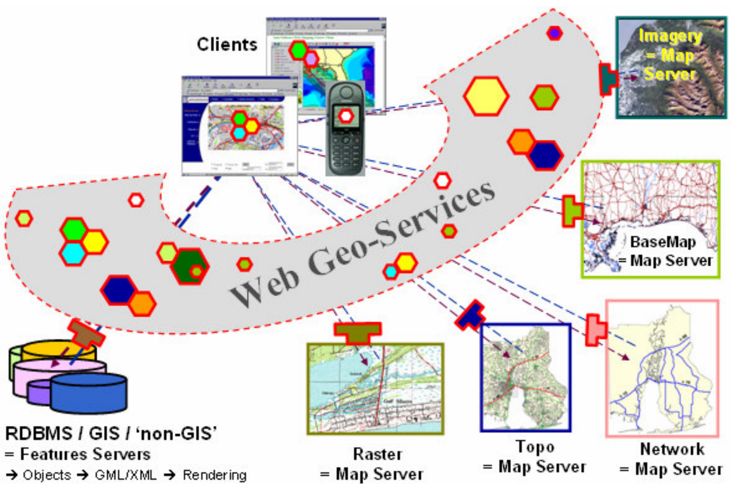



**Figure: Distributed mapping or geo-enabled services present and analyze information from "Geo-Servers" using different vendors' technology and rendering methods (http://www.isotc211.org/WorkshopLisbon/Dessard.ppt)**

Standards are required for interoperability of geo-web services and data transaction. Standards can boost the value chain and enable better access to geographic information. The following ISO TC211 and OGC standards and specifications are design for interoperability of geo-web services:

- Metadata (ISO 19115,19139 / OGC)
- WMS : Web Map Service (OGC / ISO 19128)
- WFS : Web Feature Service (+ filters) (OGC / ISO…starting)
- Feature Model, incl. geometry model (ISO 19109/110,19125 / OGC )
- GML & Encoding (OGC / ISO 19136)
- WCS, WTS : Coverages, Terrain (OGC)
- Catalog / WRS : Catalog & Registry (ISO 19110 / OGC)
- Service metadata, model, chaining (ISO 19119 / OGC-OWS)

*What is a Web Map Server?* A WMS is a service, that on request, dynamically produces a map of spatially referenced data. A map, in the WMS context, is defined as a presentation of geographic information in a digital image file format suitable for display on a computer screen. Hence, a WMS does not produce actual geographic information as a response to a request, but rather maps as raster images that are representations of such information.

The OpenGIS Web Map Server Specification and ISO 19128 is a set of interface specifications that provide uniform access by web clients to maps rendered by map servers on the Internet. Thus, WMS is a service interface specification that:

- Enables the dynamic construction of a map as a picture, as a series of graphical elements, or as a packaged set of geographic feature data
- Answers basic queries about the content of the map
- Can inform other programs about the maps it can produce and which of those can be queried further

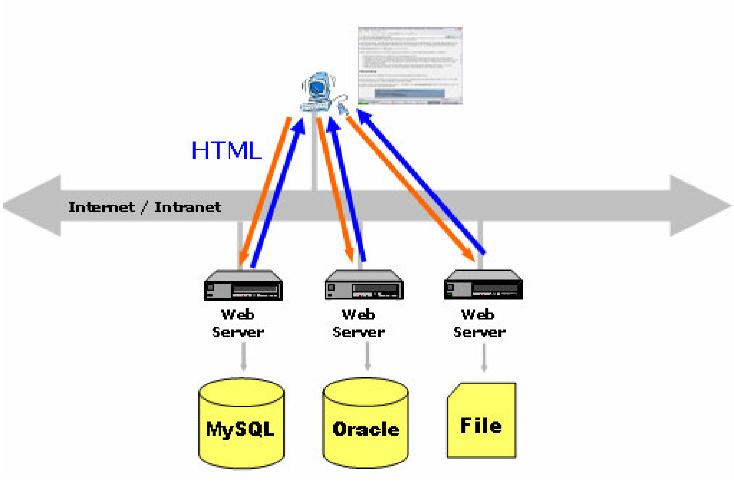



**Figure: The HTML Web Map Services**

*What is a Web Feature Server?* A Web Feature Service (WFS) provides access and manipulation operations on geographic features using HTTP as the underlying protocol. WFS provides access to vector data and is therefore fundamentally different from a WMS which produces more raster image representations of geospatial data as maps. WFS can be cascaded; it can serve data that is located at some remote WFS. When transporting geospatial data, the interchange format can be the Geography Markup Language (GML) and conforms to some GML application schema. GML is described below.

Whereas WMS delivers a picture, WFS supports the direct exploitation and access of feature data and associated attributes on the Web. The WFS is a service interface that describes data manipulation on geographic features. Data Manipulation operations include the ability to insert, delete, update, retrieve, and query features on spatial and non-spatial constraints.

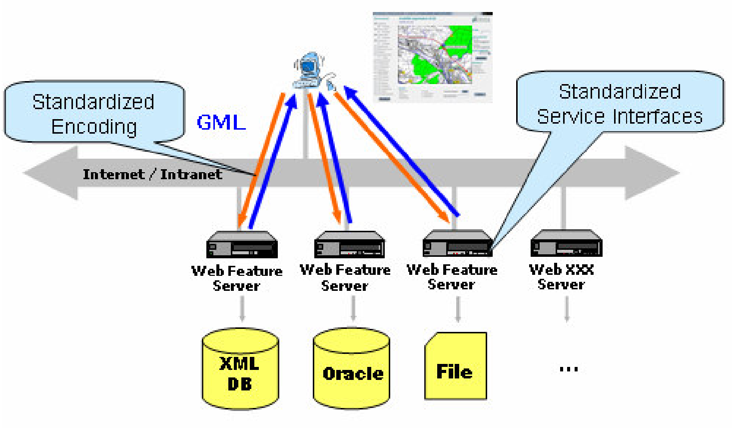



**Figure: WFS uses GML as the lingua franca of the geospatial web. GML defines content: there is no mix between content and presentation**

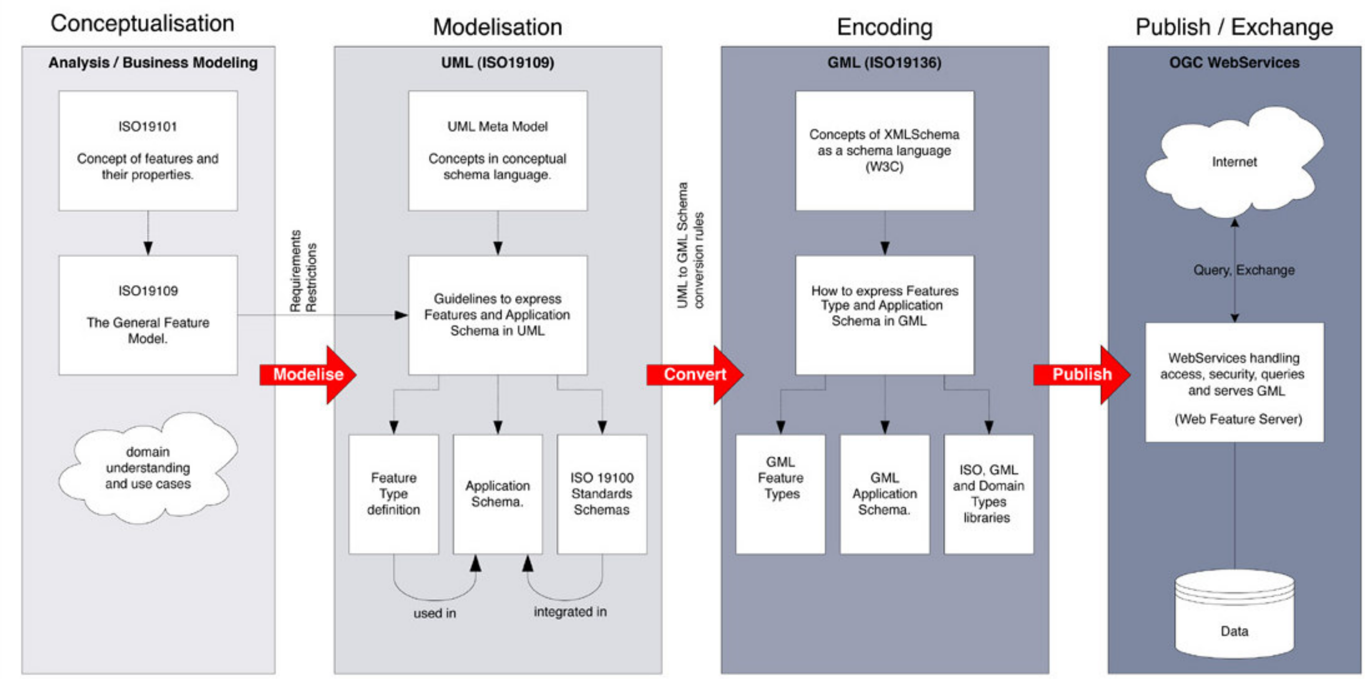



**Figure: Interoperable data models of geo-spatial data publishing via WFS (http://www.isotc211.org/WorkshopLisbon/Dessard.ppt)**

You may remember Module 2, ISO 19101 – Reference model. This *Architectural reference model* describes the general types of services that are provided by computer systems that have the ability to manipulate geographic information and enumerate service interfaces. These services must be interoperable.

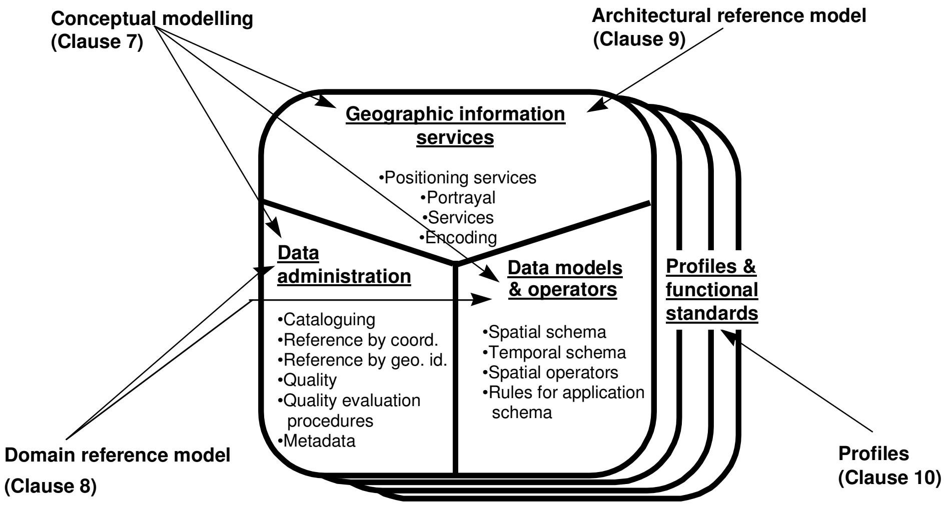



**Figure: Relationship of the Reference model to other standards in the ISO 19100 series of geographic information standards (ISO 19101)**

The *Architectural reference model* is based on concepts of (1) the *ISO Open Systems Environment (OSE)* approach for determining standardization requirements, described in ISO/IEC TR 14252:1996, and (2) the *Open Distributed Processing (ODP) Reference Model*, described in ISO/IEC 10746-1:1995. The *Architectural reference model* focuses primarily on the computational viewpoint.

The *Architectural reference model* is a specialization of the Open Systems Environment (OSE) Reference Model for geographic information services in distributed computing environments (ISO 19101).

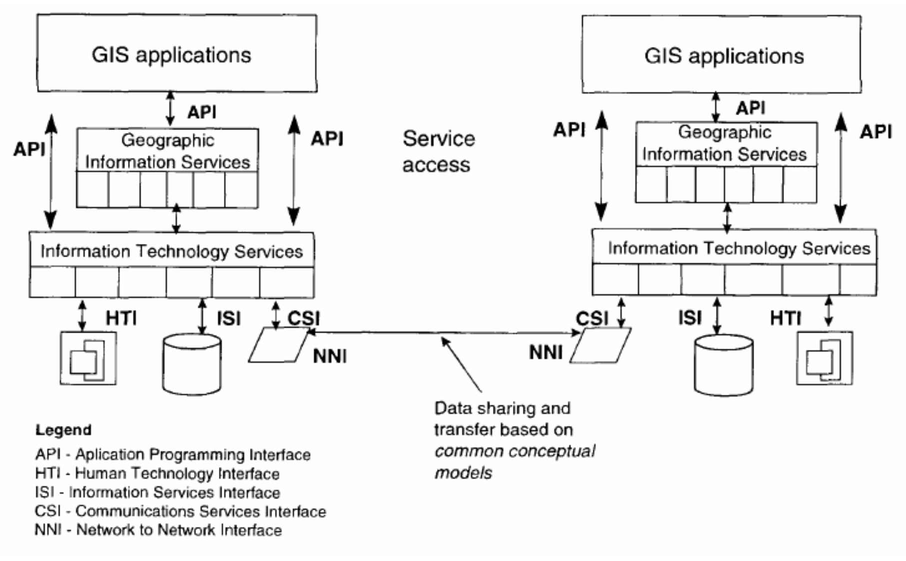



**Figure: The Architectural reference model (ISO 19101)**

The application systems and services residing at different computing sites are linked by a network. *Services* are capabilities provided for manipulating, transforming, managing, or presenting information. *Service interfaces* are boundaries across which services are invoked and across which data is passed between a service and an application, external storage device, communications network, or a human being.

The above figure shows four interfaces (ISO 19101):

The *Application Programming Interface* (API) is the interface between services and application systems. This is the interface used by application systems to invoke geographic information services. Standardization of the API for geographic information services is central to the ISO 19100 series of geographic information standards.

The *Communications Services Interface* (CSI) is the interface across which applications and services access data transport services to communicate across a network. Different computing networks may be connected through a special interface known as the network-to-network interface.

The *Human Technology Interface* (HTI) allows the human end user to access the computing system. This interface includes graphic user interfaces and keyboards.

The *Information Services Interface* (ISI) is a boundary across which database services are provided, allowing persistent storage of data.

The ISO 19100 series of geographic information standards identifies six classes of generic information technology services of particular importance for geographic information.

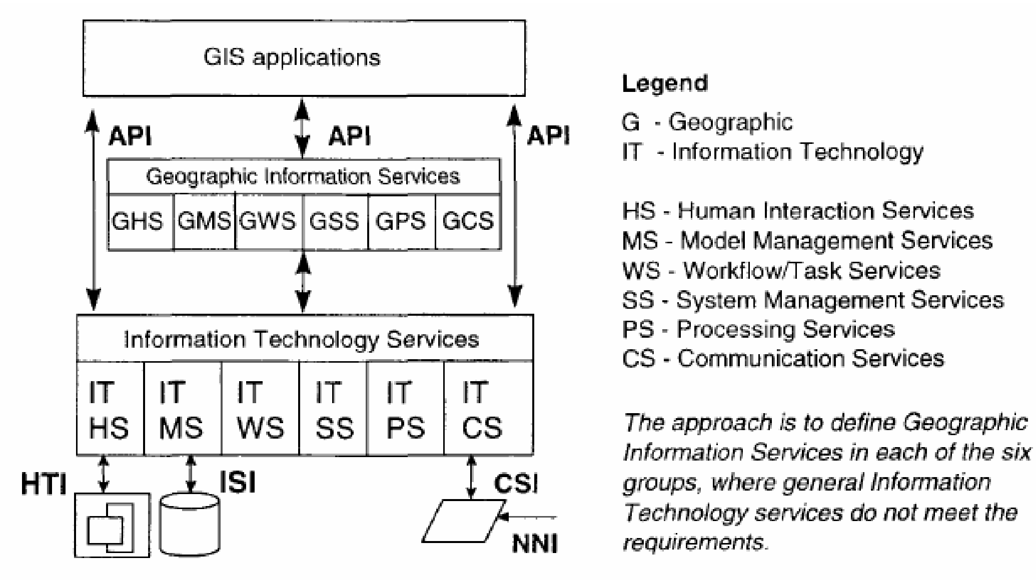



**Figure: The six classes of services (ISO 19101)**

*Geographic Information Model/Information Management* services focus on management and administration of geographic information, including conceptual schemas and data. Specific services within this class are identified in ISO 19119, *Geographic Information Services*. Examples of such services are a query and update service for access and manipulation of geographic information and a catalogue service for management of feature catalogues.

*Geographic Information Human Interaction* services focus on providing capabilities for managing the interface between humans and Geographic Information Systems. This class includes graphic representation of features, described in ISO 19117, *Geographic Information Portrayal*.

*Geographic Information Workflow/Task Management* services focus on workflow for tasks associated with geographic information - involving processing of orders for buying and selling of geographic information and services. These services are described in more detail in ISO 19119, *Geographic Information* Services.

*Geographic Information Communication* services focus on the transfer of geographic information across a computer network. Requirements for Transfer and Encoding services are found in ISO 19118, *Geographic Information* Encoding.

*Geographic Information Processing* services focus on processing of geographic information. ISO 19116, *Geographic Information* Positioning *services*, is an example of a processing service. Other examples include services for coordinate transformation, metric translation, and format conversion.

*Geographic Information System Management* services focus on user management and performance management. These services are described in more detail in ISO 19119, *Geographic Information* Services.

The identification of combinations of geographic information services and service interfaces define standardization requirements for geographic information. The standardization requirements are identified for service interface of a particular geographic information service needs. Figure 14 depicts the static relationships that form the basis for this approach.

For any combination of service classes and service interfaces, standardization requirements may consist of specifying:

- The function provided by the service
- How a geographic information service is invoked and the protocol messages for communicating with a service
- The metadata description of the information that is sent or received by the service
- The semantic content of the information that is sent by or received from the service, including description of quality information
- The encoding, or transfer format, for the data that is sent or received by the service.

In this and next module, we will discuss a few standards from the Services category:

- Module 4 is completely dedicated to Services' and reports' categories of geospatial standards (access and technology standards).
- The Feature cataloging service will be discussed in Module 5.

## 4.2 ISO 19119 - Services

**ISO 19119:2005 Geographic information – Services** identifies and defines the architecture patterns for service interfaces used for geographic information, as well as the definition of relationships to the Open Systems Environment (OSE) model, as defined by ISO 19101. This International Standard (IS) presents a geographic services' taxonomy and a list of examples of geographic services placed in the services taxonomy.

IS0 19119 prescribes how to create a platform-neutral service specification, and how to derive platform-specific service specifications that are conformant with this. This IS provides guidelines for the selection and specification of geographic services from both platform-neutral and platform-specific perspectives.

ISO 19119 define s**ervice** as a distinct part of the functionality that is provided by an entity through interfaces. **Interface** is any named set of operations that characterize the behavior of an entity. In addition, **operation** is a specification of a transformation or query that an object may be called to execute; each has a name and a list of parameters.

ISO 19119 involves mapping ISO 19100 series standards to extended OSE service categories. This mapping procedure is presented in the following table.

| **Extended OSE Service Category** | **Relevant ISO 19100 series standard** |
|---|---|
| *Geographic human interaction services* | 19117 Geographic information - Portrayal |
| | 19128 Geographic information - Web Map server interface |
| *Geographic model/Information management services* | 19107 Geographic information - Spatial schema |
| | 19110 Geographic information - Methodology for feature cataloguing |
| | 19111 Geographic information - Spatial referencing by coordinates |
| | 19112 Geographic information - Spatial referencing by geographic identifiers |
| | 19115 Geographic information - Metadata |
| | 19123 Geographic information - Schema for coverage geometry and functions |
| | 19125-1 Geographic information - Simple feature access - Part 1: Common architecture |
| | 19128 Geographic information - Web Map server interface. |
| *Geographic Workflow/Task management services* | (no relevant ISO 19100 series standards) |
| *Geographic processing service* | 19107 Geographic information - Spatial schema |
| | 19108 Geographic Information - Temporal schema |
| | 19109 Geographic information - Rules for application schema |
| | 19111 Geographic information - Spatial referencing by coordinates |
| | 19116 Geographic information - Positioning services |
| | 19123 Geographic information - Schema for coverage geometry and functions |
| | 19118 Geographic information - Encoding |
| *Geographic communication services* | (no relevant ISO 19100 series standards) |
| *Geographic system management services* | (no relevant ISO 19100 series standard) |

**Figure: Mapping ISO 19100 series standards to extended OSE service categories**

## 4.3 ISO 19118 - Encoding

Actual spatial data must be coded. These codes must be based on a certain rule in the format so that the computer can understand them. When spatial data is interchanged, it must be coded using the common coding method. This is called the encoding rule in data interchange. Actually, the internal data format (the item that specifies this is called internal schema) of each GIS is converted to the common data format using conversion software. The side that receives this data must convert it to the internal database specific to the system. This common coding rule for data format is the encoding rule.

**ISO 19118:2005 Geographic information - Encoding** specifies the requirements for defining encoding rules that are used for the interchange of geographic data within the ISO 19100 series of standards. An encoding rule allows geographic information defined by application schemas and standardized schemas to be coded into a system independent data structure suitable for transport and storage. The XML-based encoding rule is intended to be used for neutral data interchange and relies on the Extensible Markup Language (XML) and the ISO/IEC 10646 character set standards.

Many coding methods for data are available, but they must also have meaning in the future and enable representation of various data structures without being effective for only a specific GIS. The geographic information standard adopts XML (eXtensible Markup Language) as the coding method for data. While HTML (Hyper Text Markup Language) is the internationally standardized coding method for various documents, XML is considered the coding method most suitable for coding while giving meaning to the document structure. The validity of XML for such data, including diagrams as spatial data, is also recognized and specified by ISO/TC211. This XML is the coding method that can represent the meaning of data and enables the user to be free to add meanings. In other words, XML has the portion that defines the contents of XML, and the creator can be free to define this portion. This is why XLM is called *extensible*. XML puts data between codes called tags to clarify the meaning of the data.

An XML schema is a W3C standard that defines the structure of an XML document (see http://www.w3.org/XML/Schema).

The encoding rule specifies the types of data to be coded and the syntax, structure, and coding schemes used in the resulting data structure. The resulting data structure may be stored on digital media or transferred using transfer protocols.

An encoding rule is an identifiable collection of specifications that defines the encoding for a particular data structure. An encoding service is a software component that has implemented the encoding rule and provides an interface to encoding and decoding functionality. It is an integrated part of data interchange.

A conversion rule specifies how a data instance in an input data structure is converted to a data instance in the output data structure. Two sets of conversion rules may exist. The first one is the *schema conversion rules*, which define a mapping from the UML schema to the schema of the output data structure. The second is the *instance conversion rules*, which defines a mapping from instances of the instance model into instances of the resulting data structure.

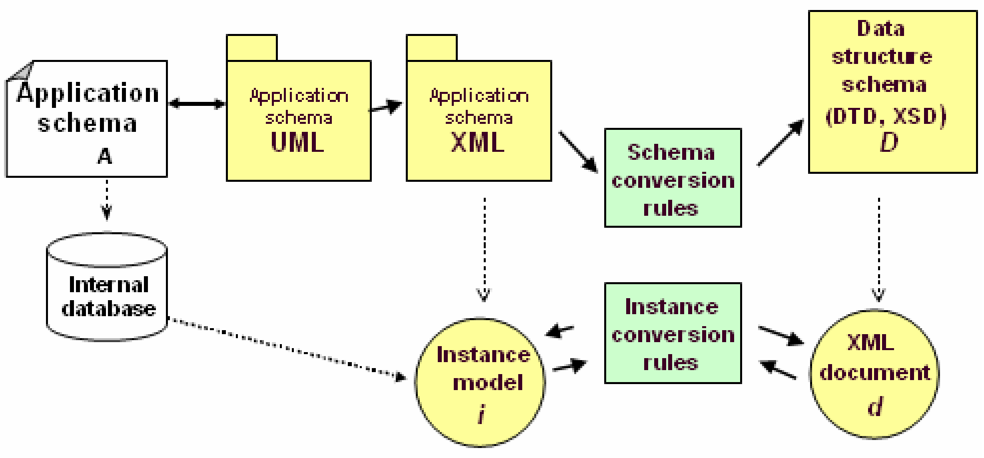



**Figure: Two sets of conversion rules**

The conversion rules are based on the idea that the class definitions in the application schema are mapped to type declarations in XML Schema, and that the objects in the instance model are mapped to corresponding element structures in the XML document. The figure above depicts the two types of conversion rules.

A Document Type Declaration (**DTD**) declares the valid XML elements, their structure, and the XML entities that can be used by a class of XML documents. An XML document can have an external DTD subset defined in a separate file and/or an internal DTD subset defined as a part of the header information of the XML document. The DTD mechanism of XML has been criticized for lack of semantic expressiveness. XML Schema (XSD) has been developed to solve that problem. An XML Schema is an XML document that defines the allowed elements and structures of XML documents. A type can be used to define the content model of an element.

The schema conversion rules define how to produce an XML Schema Document (**XSD**) according to an application schema expressed in UML. An XSD defines a number of complex types, simple types, and element declarations that define the allowable structure and data instances of an XML document. The XML Schema conversion rules are defined in ISO 19018. The main purpose of the XSD is to ensure that XML documents produced using the data conversion rules are valid.

The XSD may physically be represented in a single schema document or divided into several separate (sub) schema documents. Logically it shall be referred to as a single schema utilizing the import or include mechanisms of XML Schema.

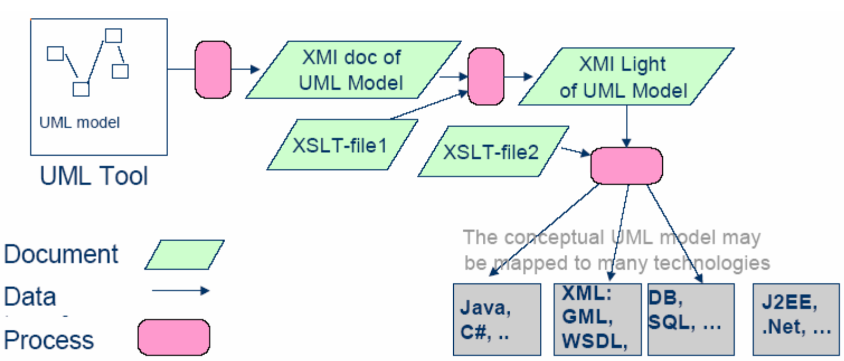



**Figure: Example of Model Driven Architecture approach**

ISO 19118 recommends that the XML Metadata Interchange (XMI) developed by the Object Management Group (OMG) is used as an electronic method for application schema data interchange. **XMI** is an XML based exchange standard for exchange of object-oriented metadata models. The purpose of XMI is to facilitate UML model data interchange between different modeling tools in a vendor neutral way. It is based on OMG's Meta Object Facility and on CORBA data types. XMI can in theory be used to exchange data based on UML models, but are not primarily designed for this purpose.

XSLT is eXtensible Stylesheet Language Transformations. The **Extensible Stylesheet Language** (XSL) is intended to control the appearance of XML documents. XSL is a language for expressing stylesheets. A stylesheet expresses rules for presenting a class of XML documents. Thus, a stylesheet contains descriptions on how XML elements can be rendered by an XML browser. ISO 19117 defines port rail of XML schema.

Example of mapping UML model to XML schema is:

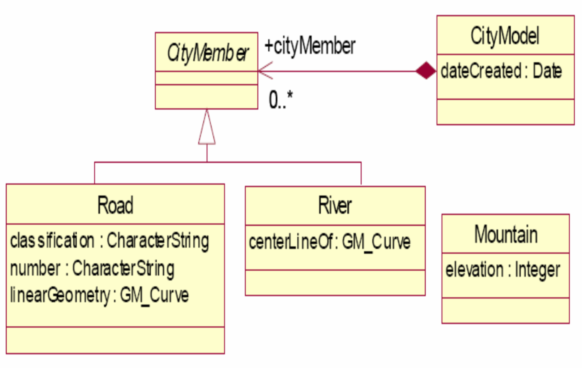



**Figure: UML model of features**

```
<class name="Road" superClass="CityFeature" abstract="false">
      <attribute name="classification" type="CharacterString"/>
      <attribute name="number" type="CharacterString"/>
      <attribute name="linearGeometry" type="GM_Curve"/>
</class>
<class name="River" superClass="CityFeature" abstract="false">
      <attribute name="centerLineOf" type="GM_Curve"/>
</class>
      <class name="CityModel" abstract="false">
      <attribute name="dateCreated" type="Date"/>
      <relationship name="cityMember" otherClass="CityFeature"
      cardinality="0..*" collectionType="set"
      aggregationType="composite"/>
</class>
```

**Figure: Encoding with simple XMI**

```
<complexType name="Road">
      <sequence>
      <element name="classification" type="CharacterString"/>
      <element name="number" type="CharacterString"/>
      <element name="linearGeometry" type="GM_Curve"/>
      </sequence>
      <attributeGroup ref="IM_ObjectIdentification"/>
</complexType>
```

**Figure: Example of ISO 19118 encoding is based on the simple XMI approach**

Web Services currently being done as XML request and response documents that specified by DTD and/or XML Schema. However, the OGC "GML" community not accepted way of ISO 19118 XML encoding for geo-spatial data. A new ISO/TC211 work item proposal has been accepted to create a new harmonized version of encoding that is Geography Markup Language (GML) and ISO 19136.

XML can transfer any type of data, and has been used to create the following languages for different application areas:

- CML: Chemical Markup Language
- SBML: Systems Biology Markup Language
- RSS: Really Simple Syndication
- GML: Geography Markup Language
- ArcXML: Arc eXtensible Markup Language
- SVG: Scalable Vector Graphics
- VRML: Virtual Reality Modeling Language
- …

## 4.4 ISO 19136 - Geography Markup Language

The Geography Markup Language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modeled according to the conceptual modeling framework used in the ISO 19100 series and including both the spatial and non-spatial properties of geographic features. The GML is primary designed for the web and web-based services. *GML is focused on content*.

Initially GML was developed as an OpenGIS Implementation Specification. Later GML became a work item of ISO/TC 211, and is on its way to being published as ISO 19136. GML is based on XML technologies (W3C). GML is extensible and supports the definition of profiles (proper subsets) of the full GML capabilities.

GML supports the description of geospatial *application schemas* for *information communities* and enables the creation and maintenance of *linked* geographic application schemas and datasets. GML supports the *transport and storage* of application schemas and data sets and increases the ability of organizations to *share* geographic application schemas and the information they describe. GML leaves it to implementers to decide whether application schemas and datasets are stored in native GML or whether GML is used only for schema and data transport.

**ISO 19136:2007 - Geography Markup Language** defines the XML schema syntax, mechanisms, and conventions. If an ISO 19109 conformant application schema described in UML is used as the basis for the storage and transportation of geographic information, ISO 19136 provides normative rules for the mapping of such an application schema to a GML application schema.

The mapping from an ISO 19109 conformant UML application schema to the corresponding GML application schema is based on a set of encoding rules. These encoding rules are identical with those specified in GML 3.x (ISO 19136) Annex E plus experimental extensions. The schema encoding rules are based on the general idea that the class definitions in the application schema are mapped to type and element declarations in XML Schema, so that the objects in the instance model can be mapped to corresponding element structures in the XML document.

GML version 3 is over eight times as large as the base schemas for GML version 2 and represents geospatial phenomena in addition to simple 2D linear features. GML version 3 is more than Simple Features, and plus supports conformance ISO 19100 series of standards.

The following figure describes the generation of application schemas in a pure GML environment.

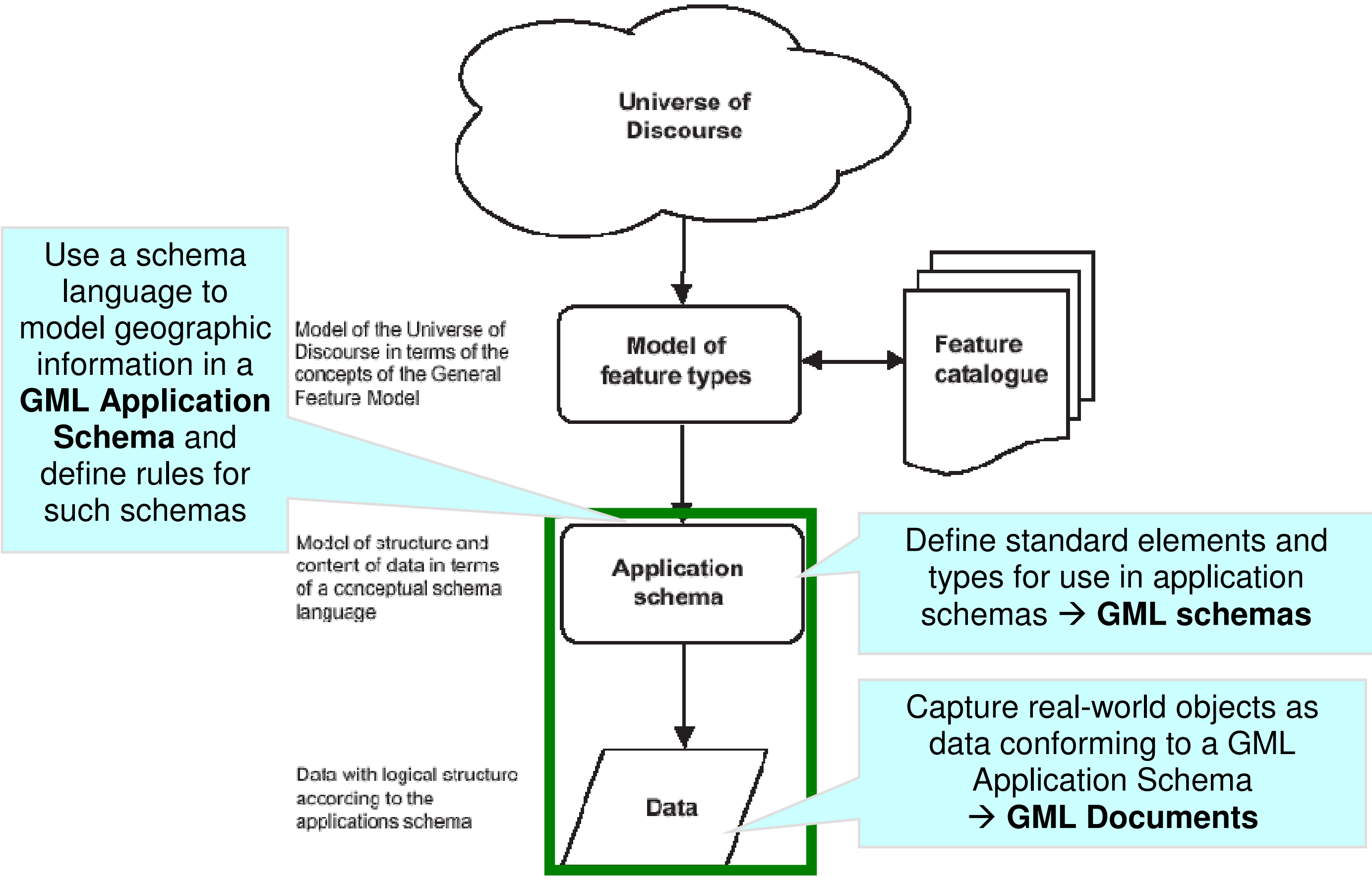



**Figure: GML Schemas, Application Schemas and Documents – two sets of encoding for schema (model structure) and data**

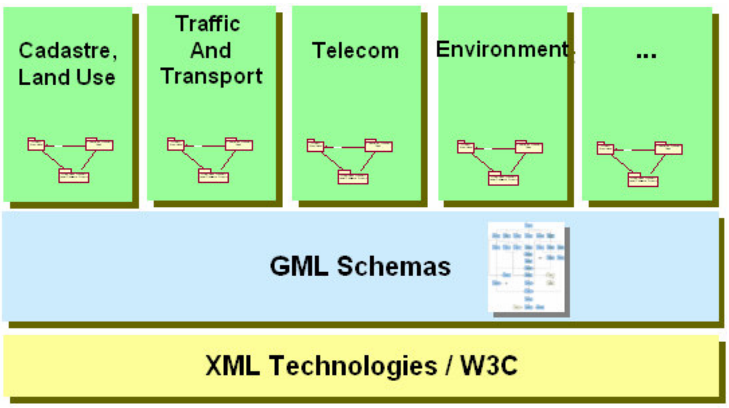



**Figure: GML Application Schemas**

GML defines the various entities such as features, geometries, topologies, etc. through a hierarchy of GML objects, as shown in the UML diagram. GML provides a conceptual model based on the ISO feature model. A GML application must reuse core GML features defined in the conceptual model.

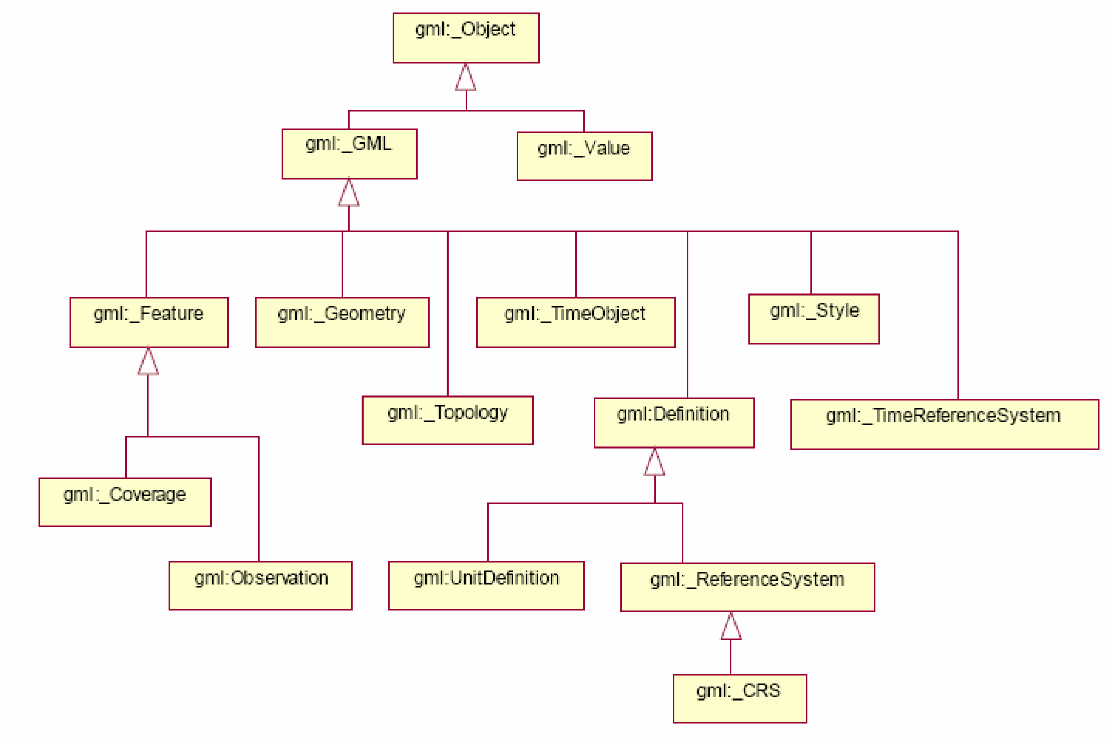



**Figure: GML Class Hierarchy**

If you are modeling a particular class of object, you will need a specific XML Schema Document (XSD). For example, if geographic features are modeled you will need the feature.xsd. Each model complies with respective ISO standards (e.g. the geometry model of GML complies with ISO 19107). Several schemas can be brought together in the same document.

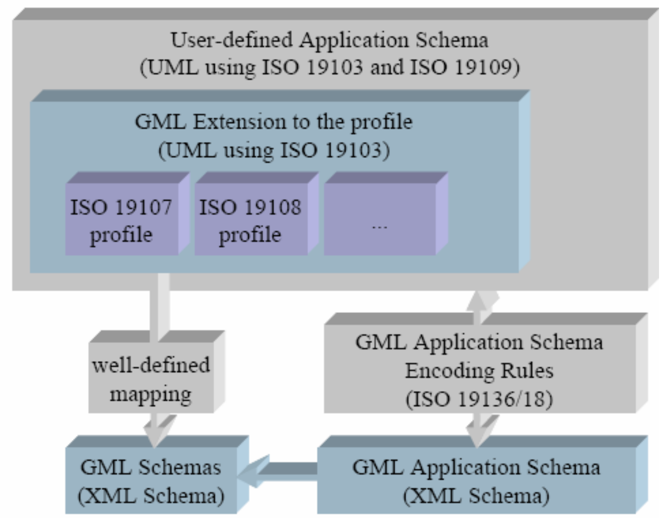



**Figure: Mapping from UML to XML Schema (ISO 19136)**

The following figure shows a UML representation of a simple feature - a *Street* - that is modeled. The street inherits from the abstract GML feature and reuses standard GML spatial geometries and property structures for the new street features. By inheriting the Street from a GML Feature, street is turned into a formal GML feature.

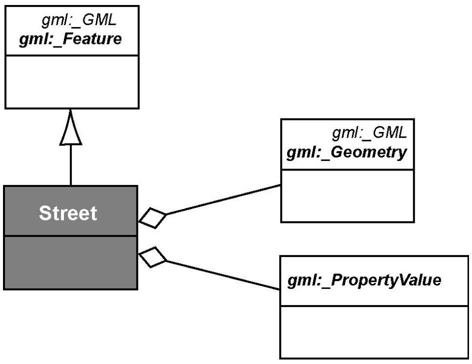
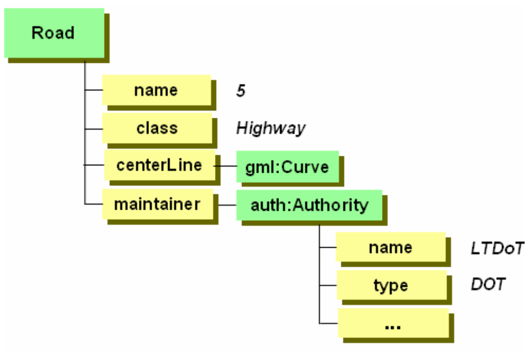



**Figure: UML schema representing how GML components are reused in a specific application. This diagram is read as follows: "A Street is a kind of GML feature that has geometry and property".**

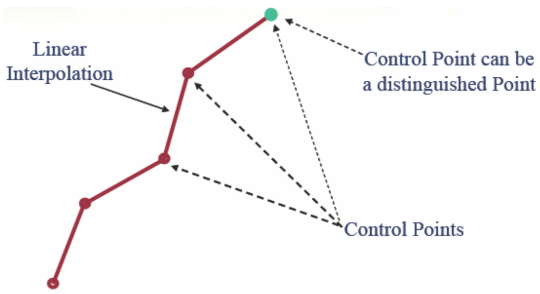
Example of modeling Road Feature types is shown below:




```
<Road gml:id="o.5r67ab">
      <name>5</name>
      <class>Highway</class>
      <centerLine>
            <gml:Curve>...</gml:Curve>
      </centerLine>
      <maintainer>
            <auth:Authority gml:id=„o.1f32a3">
                  <name>LTDoT</name>
                  <type>   DepartmentOfTransportaion
                  </type>
            </auth:Authority>
      </maintainer>
</Road>
```

**Figure: GML encoding of Application schema of Road feature**

Sample of GML data encoding is presented below:




```
Point<gml:LineString>
      <gml:pointPropertyxlink:href = "…"/>
      <gml:posList>100  200  150  300  567  565
      677</:gml:posList>
</gml:LineString>
```

**Figure: Curve in GML**

The object is either a child element of the property or referenced by an xlink:href attribute in the property element. The xlink:href attribute is interpreted in the way that the value of the property is the object referenced in the link. The object can be part of the same GML document or anywhere in the internet/intranet

Sample of school represented in GML is shown below:

```
<Feature fid="142" featureType="school" >
   <Description>Lithuanian 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">
      <CData>
      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
      </CData>
      </LineString>
      </Polygon>
</Feature>
```

**Figure: Polygonal feature in GML document**

GML modeling and encoding provides support for conceptual design of application schema and for software developers. Support for application schema designers includes:

- Rules for application schemas:
    - Guidelines for the usage of XML Schema
    - GML documents can be interpreted more easily by software (“GML parsers”)
- Tools to map from UML or other modeling languages to GML (Open Source tools are available)
- GML profile usage in an application schema
    - A declaration of the subset of GML used by an application
    - GML itself includes a simple tool that allows for the creation of a GML profile automatically

Support for software developers includes:

- XML Parsers, XSLT processors, etc. are available (including Open Source ones); as XML is popular in general many developers know how to work with and process XML documents
- GML Parsers (i.e. GML-aware XML parsers understanding the GML model and syntax) are emerging
- Most major GIS products have, in their latest releases, built-in support for GML; in addition a significant number of new products providing OGC Web Service interfaces and serving GML documents are available

## *4.5 ISO 19116 - Positioning Services*

**ISO 19116:2004 Geographic information - Positioning services** specifies the *data structure* and *content of an interface* that permits communication between position-providing device(s) and position-using device(s) so that the position-using device(s) can obtain and unambiguously interpret position information and determine whether the results meet the requirements of the user. This IS allows the integration of positional information from a variety of positioning technologies into a variety of geographic information applications.

Positioning services provide a means to obtain position information regarding a point or object. Positioning services can produce several types of observation: position, orientation (attitude), motion, and rotation (angular motion).

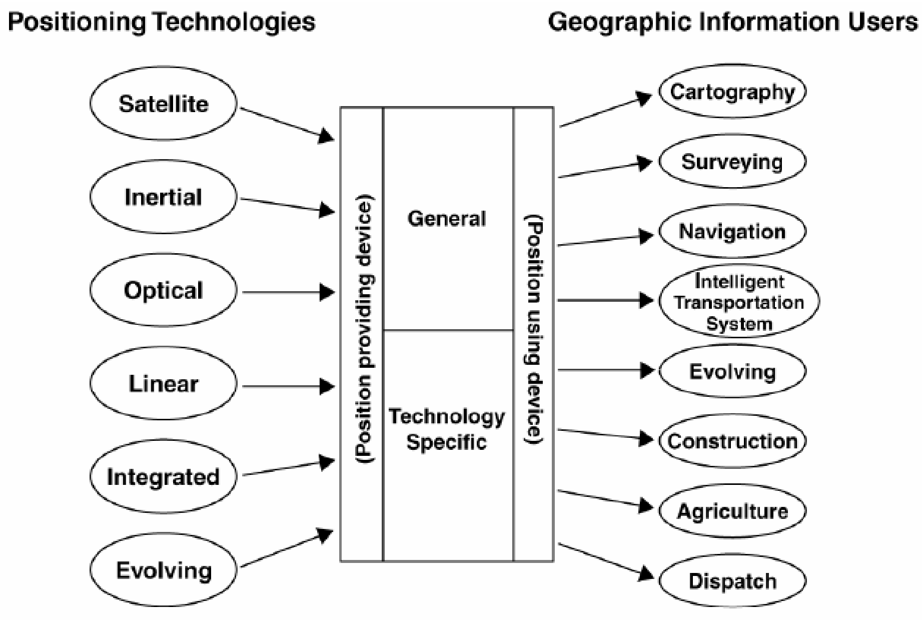



**Figure: Positioning services interface allows communication of position data for a wide variety of positioning technologies and users (ISO 19116)**

Although positioned technologies covered by ISO 19116 differ in many respects, there are important items of information that are common among them and serve common needs of these application areas, such as the position data, time of observation, and its accuracy.

The positioning service interface carries out the operations of create, set, get, and end (destroy) instances of these service operations as needed to convey the configuration and observation information. The positioning services interface specified in this IS provides data structures and operations that allow spatially oriented systems, such as GIS, to employ these technologies with greater efficiency by permitting interoperability among various implementations and various technologies.

One of the primary operations of a positioning service is getObservation, which returns an instance of the PS_Observation. Among the attributes of the PS_Observation class are the positioning result values, offsets, and object identification.

## 4.6 ISO 19117 - Portrayal

*Portrayal* is presentation of information to humans. **ISO 19117:2005 Geographic information - Portrayal** is an abstract document that gives general guidelines about the mechanism that is used to portray the feature instances of a dataset. This work does not include standardization of cartographic symbols, and their geometric and functional description.

The portrayal information is handled as portrayal **specifications** and is applied according to specific portrayal **rules,** as defined in this standard. *Portrayal rules* are applied to features in order to determine what portrayal specification to use. *Portrayal specification* is a collection of operations applied to the feature instance in order to portray it.

The portrayal mechanism makes it possible to portray the same dataset in different ways without altering the dataset itself. Definition of a schema involves describing the portrayal of geographic information in a form understandable by humans, including the methodology for describing symbols and mapping of the schema to an application schema.

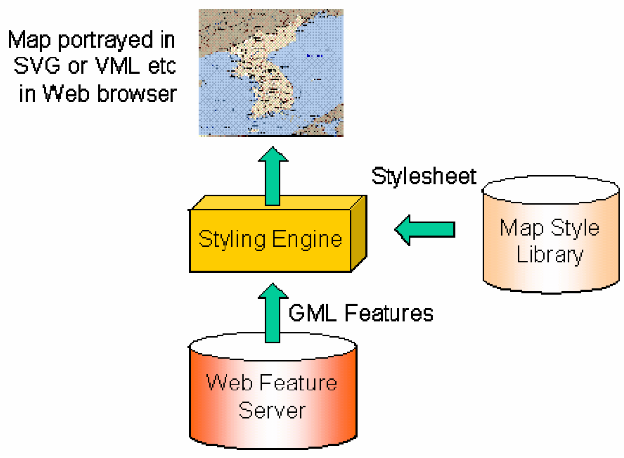



**Figure: The portrayal specifications and portrayal rules shall not be part of the dataset. XSLD is used to portray GML data ([http://www.galdosinc.com/files/MakingMapsInGML2.pdf](http://www.galdosinc.com/files/MakingMapsInGML2.pdf))**

The portrayal **specifications** and portrayal **rules** shall not be part of the dataset. The portrayal rules are stored in a portrayal catalogue. A **portrayal catalogue** is **a** collection of all defined portrayals. The portrayal rules are specified for the feature class or feature instances that they will be applied on. The portrayal specifications may be stored externally and referenced using a universal reference standard, such as a network based URL.

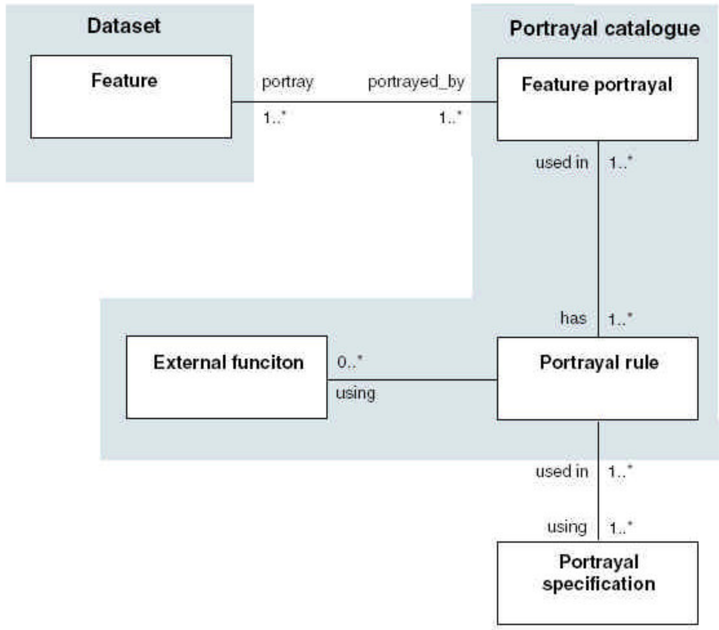
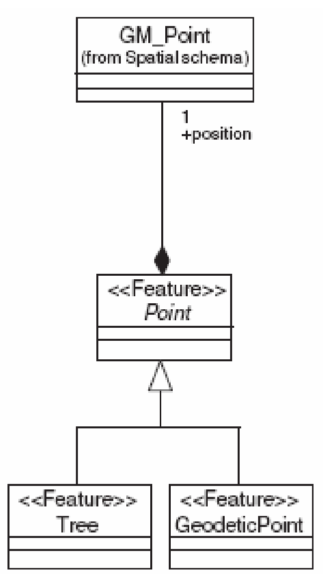



**Figure: Portrayal UML diagram from ISO 19117**




```
'RULES FOR POINT FEATURES
pr3: PortrayalRule
{
      ruleName="Tree"
      priority="110"
      description"Use Tree symbol"
      queryStatement=("FACC_CODE='Tree'")
      portrayalAction=("ISO_STYLE.SYMBOL_STYLE.Tree")
}
pr4: PortrayalRule
{
      ruleName="GeodeticPoint"
      priority="110"
      description"Use GeodeticPoint symbol"
      queryStatement=("FACC_CODE='GeodeticPoint'")
      portrayalAction=("ISO_STYLE.SYMBOL_STYLE.GP")
}
} 'end PortrayalRule_Sets
} 'end FeaturePortrayal_Sets
} 'end PortrayalCatalogue
```

**Figure: Example of portrayal rules for point features**

## 4.7 ISO 19128 - Web Map Server Interface

**ISO 19128:2005 Geographic information - Web Map Server Interface** specifies the behavior of a service that produces spatially referenced maps dynamically from geographic information. It specifies operations to retrieve a description of the maps offered by a server, to retrieve a map, and to query a server about features displayed on a map. ISO 19128 is applicable to pictorial renderings of maps in a graphical format; it is not applicable to retrieval of actual feature data or coverage data values.

The document describes the operations to be supported by a compliant WMS implementation. These are:

- GetMap: Specifies communication protocols to merge many web map views into one view.
- GetCapabilities: Explains what a map server can do (so integrators know what to ask for).
- GetFeatureInfo: Specifies how to ask for more information about web map features.
- DescribeLayer: Describes the data underlying each layer.

## *4.8 ISO 19142 - Web Feature Service*

**ISO 19142:2009 - Web Feature Service** defines the interfaces of a Web service enabling the retrieval and update of GML-encoded geospatial data. The development of the standard is carried out within the ISO 19142-19143 Project Team that works jointly with the OGC Web Feature Service Revision Working Group. It corresponds to the 1.2 version of the OpenGIS Web Feature Service Implementation Specification.

The document describes the operations to be supported by a compliant WFS implementation. These are:

- GetCapabilities: A web feature service needs to be able to describe its capabilities. Specifically, it should indicate which feature types it can service and what operations are supported on each feature type.
- DescribeFeatureType: A web feature service should be able, upon request, to describe the structure of any feature type it can service.
- GetFeature: A web feature service should be able to service a request to retrieve feature instances. A GetFeature request should specify which feature types to query and what constraints (both spatial and non-spatial) to apply to those feature type instances.
- GetGmlObject: A web feature service can optionally service a request to retrieve element instances by traversing XLinks that refer to their XML IDs. In addition, the client should be able to specify whether nested XLinks embedded in returned element data should also be retrieved.
- Transaction: A web feature service can optionally 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 can optionally 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.

## *4.9 ISO 19143 - Filter Encoding*

**ISO 19143:2009 - Filter Encoding** describes an XML encoding which will be used by the Web Feature Service. This standard corresponds to the 1.2 version of the OGC Filter Encoding Implementation Specification. The document describes an XML encoding of a system neutral predicate syntax. The term filter is used to describe this encoding since such predicates are typically used in query operations to specify how data instances in a source dataset should be filtered to produce a result set.

Such an encoding is considered system neutral because using the numerous XML tools, an XML encoded filter expression can be easily validated, parsed, and then transformed into whatever target predicate language is required to retrieve or modify object instances stored in some persistent object store.

The filter encoding described in this document is a common component that can be used by a number of web services. Any service that requires the ability to query objects from a web-accessible repository can make use of the XML filter encoding described in this specification. It is used in ISO 19142 to encode conditions on feature types during a request to a Web Feature Service.

This standard is developed by the ISO 19142-19143 Project Team, in coordination with the OGC Web Feature Service Revision Working Group. In practice, experts from both organizations are involved and meet either in ISO or in OGC meetings.

## 4.10 Location Based Services

Location-based services (LBS) are a technology combining information technology, GIS, and ITS. An enormous market is foreseen in this field, including the market for tracking, route-finding and guiding, notification, and alert services.

LBS combine hardware devices and wireless communication networks with geographic information and software applications to provide location-related guidance for customers. It differs from mobile position determination systems, such as global positioning systems (GPS), in that LBS provides broader application-oriented location services.

The term 'location based service' has been used to define a wide range of applications and often describes situations where mobile users are connected to the Internet via a human computer interface device, which has access to multiple positioning devices or services. In the broadest sense, a location-based service can be regarded as any service, query, or process whose return is dependent on the location of the client requesting the service and/or of some other things, objects, or persons (often collectively referred to as the targets).

The ISO has been working on a number of specifications to standardize Location Based Services. Below is some information related to these.

**ISO 19132 - Location Based Services - Reference Model** report seeks to identify the manner by which ISO/TC 211 should handle the development of standards for LBS and aims to identify areas in which standards for LBS could be required. The increasing popularity and availability of LBS without a standards framework could lead to a digression of services and service quality, which may ultimately be critical for a mobile user.

The intent for the reference model for location-based services is to build an abstract model independent of implementation and communication paradigms that can allow to build integrated services for today while preparing for the changes in processing and communication realities in the future.

**ISO 19133:2005 - Location-Based Services - Tracking and Navigation** describes the data types, and operations associated with those types, for the implementation of tracking and navigation services. It is designed to specify web services that can be made available to wireless devices through web-resident proxy applications, but is not restricted to that environment.

**ISO 19134:2006 - Location-Based Services - Multimodal Routing and Navigation** specifies the data types and their associated operations for the implementation of multimodal location-based services for routing and navigation. It is designed to specify web services that may be made available to wireless devices through web-resident proxy applications, but is not limited to that environment. This standard relies on interoperability between two or more standardized single mode services for tracking, routing and navigation.

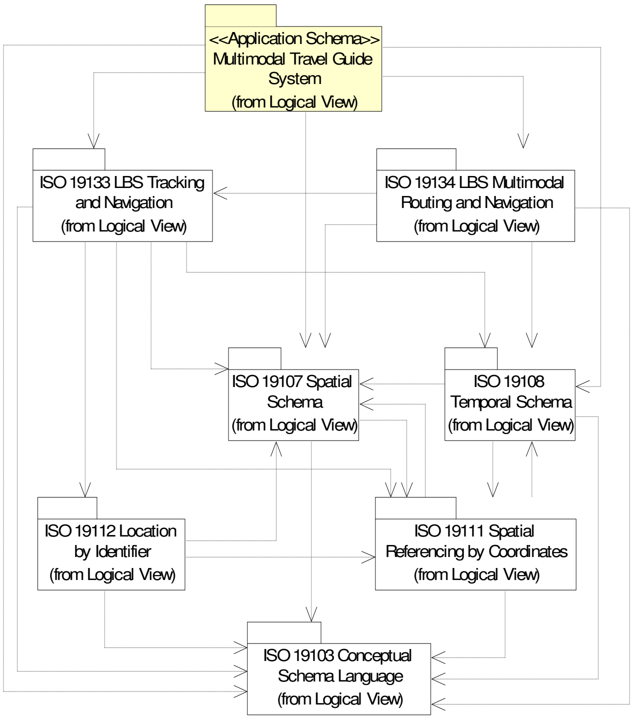



**Figure: Example of application schema for Multimodal Travel Guide System based on ISO standards and specification**

## 4.11 Conclusion

To support harmonization of data modeling, exchange, and transactions, Model Harmonization Team (ISO) and Documentation committee (OGC) have to produce the following:

- Rules for well-defined and precise UML models (ISO 19103 – Conceptual Schema Language)
- Rules for how to do application specific modeling (ISO 19109 – Rules for application schema)
- Rules for service modeling for platform independent and platform specific models (ISO 19119 - Services)
- Automatic encoding of models into XML and other representations (i.e. binary, proprietary) (ISO 19118 - Encoding), OGC GML
- Rules for mapping to platform specific models for the most important platforms: Web services/XML, CORBA, J2EE/EJB, SQL, etc.
- Tool-support and tool-neutral diagram interchange format to give a development and usage advantage

Moving from generic XML encoding to GML has been beneficial for several reasons:

- It allows encoding of the model to follow broadly accepted standards and specification from ISO and OGC
- It provides a much needed design pattern that resolves many consistency issues
- ISO 19136 brings together many ISO TC 211 standards in one modeling environment

## Module self-study questions:

21. What type of map does WMS produce on a client's machine?
22. What type of data does WFS return (parse) to a client?
23. How do ISO standards define services and interfaces?
24. What is a DTD and/or XML Schema used for and how are they related to XML or GML documents?
25. Can portrayal specifications and portrayal rules be a part of a GML document?

## Required Readings:

[10] Johansson J., Standardised Access to Geospatial Information and Services, Master's Thesis Project, 2006, http://www.cs.umu.se/education/examina/Rapporter/JonasJohansson.pdf

[11] Chapter 5: Encoding Specification, User's Manual for Spatial Data Product Specification Description, 2002, http://www.gsi.go.jp/ENGLISH/RESEARCH/GIS/jsgi-manual.pdf

[12] Lake, R., GML and Building the GeoWeb, 2006, http://www.isotc211riyadh.org.sa/present/BuildingGeoWebRiyadhISONov2006.pdf

## *References*

[25] ISO 19119 - Services
[26] ISO 19116 - Positioning Services
[27] ISO 19118 - Encoding
[28] ISO 19136 - Geography Markup Language
[29] ISO 19117 - Portrayal
[30] ISO 19128 - Web Map Server Interface
[31] ISO 19142 - Web Feature Service
[32] ISO 19143 - Filter Encoding
[33] ISO 19132 - Location Based Services - Reference Model
[34] ISO 19133 - Location-Based Services - Tracking and Navigation
[35] ISO 19134 - Location-Based Services - Multimodal Routing and Navigation

## Terms used

- Service
- Interface
- Web Map Server
- Web Feature Server
- API
- XML
- DTD
- XSD
- Extensible Stylesheet Language
- GML
- Encoding
- Portrayal
- Filter Encoding
- LBS

# 5 Metadata and Quality Category of Geospatial Standards

The role of metadata in geospatial data management is multifunctional and very important on any level of data use within SDI. The ISO 19115 Metadata is the best-known standard of the ISO 19100 family. This module discusses a few topics related to metadata and respective standardization efforts, as well as data quality principles and procedures.

In the first part of the module, a detailed discussion of topics related to geospatial metadata, geospatial metadata standards and geospatial metadata tools are examined. These include: roles, content, and organization of geospatial standardization; ISO 19115 and ISO 19139 metadata standard and specification; structure and content of ISO 19115;  and the process of metadata creation and metadata management tools. These are all described in nitty-gritty detail.

The second part of the module outlines Feature Catalogue Methodology Standard, Quality Principles Standard, Quality Evaluation Procedures Standard and Data Quality Measures Standard. Only the main content features of these standards are defined in the module. Some quality elements are presented in the first part of the module in the "Examples of Metadata Entities" section.

Module Outline

Topic 40: Definitions
Topic 41: Metadata of Geospatial Data, Geo-Applications and Services
Topic 42: Geospatial Metadata Standards
Topic 43: Geospatial Metadata Tools
Topic 44: Feature Catalogue
Topic 45: Quality Standards

## 5.1 Definitions

In this module, service information will be discussed; this service information contains pieces of information that make service interactions more useful or meaningful. Before discussing the service information and its respective standards and specifications, some general terms need to be defined. These terms are related to the organization of service information. Definitions of these terms are needed to fully understand the nature of service information and interactions.

**Metadata** literally means “data about data”. Meta-information communicates the structure, syntax, and semantic content of information to be processed (or processing instructions). Metadata is the term used to describe the summary information or characteristics of a set of data. Metadata is an associated piece of information, or description, that serves to make the essential piece of information more useful or more meaningful.

In general, metadata is information that describes the following:

- What type of format is the resource available (e.g. digital image, hard copy report, etc.)?
- Who created it and for what purpose?
- When was it created?
- Where does the data apply, that is, what is the geographic context?
- How does one obtain it (e.g. file download, hard copy sent through the mail)?
- How much does it cost to acquire?

A geospatial metadata record includes core library *catalogue* elements such as Title, Abstract, and Publication Data; geographic elements such as Geographic Extent and Projection Information; and database elements such as Attribute Label Definitions and Attribute Domain Values, etc.

**Catalogue** is an organized, detailed, descriptive list of items arranged systematically that could be enumerated with a specific numbering scheme.

**Thesaurus** (or **Thesauri**) is a list of every important term (single-word or multi-word) and related terms (e.g. synonyms) in a given domain of knowledge.

**Controlled Vocabulary** is a carefully selected list of *words* and *phrases*, which are used to *tag* units of information so that they may be more easily retrieved by a search.

**Gazetteer** is a geographical dictionary, an important reference for information about places and place-names (toponomy).

## *5.2 Metadata of Geospatial Data, Geo-Applications and Services*

The term *metadata* has become widely used over the past 15 years. Library catalogues represent an established variety of metadata that has served for decades as collection management and resource discovery tools. A map legend is one representation of metadata, containing information about the publisher of the map, the publication date, the type of map, a description of the map, spatial references, the map's scale and its accuracy, among other things. These types of descriptive information are also applicable to a digital geospatial files. Geospatial metadata are used to document geographic digital resources such as Geographic Information System (GIS) files, geospatial databases, and Earth imagery.

Metadata is a key component of any geospatial data set. It carries critical information as to the dataset's purpose, location, content, and lineage. Modern GIS software and analysts increasingly rely on metadata to ingest, display, and manage data. Perhaps most significantly, metadata is the consumer information needed by a rapidly growing geospatial data market to locate available geospatial data resources and assess their fitness for a particular use. Metadata instills data accountability and limits data liability. The timely capture of metadata is fundamental to the quality of the data set as a whole. Metadata are both a component of the data and a Geospatial Information Science best practice.

Most digital geospatial files now have some associated metadata. In the area of geospatial information, this normally means the *what*, *who*, ***where***, *why*, *when* and *how* of the data. The major difference between geospatial and metadata sets collected for libraries, academia, professions and elsewhere is the emphasis on the spatial component - or the ***where*** element.

As was already mentioned, the National Spatial Data Infrastructure (NSDI) is composed of:

- Data Access Policies
- Clearinghouse
- **Metadata**
- Data Protection
- Geospatial data
- Partnerships
- Leadership
- Standards
- Communication Network (e.g. a Portal)

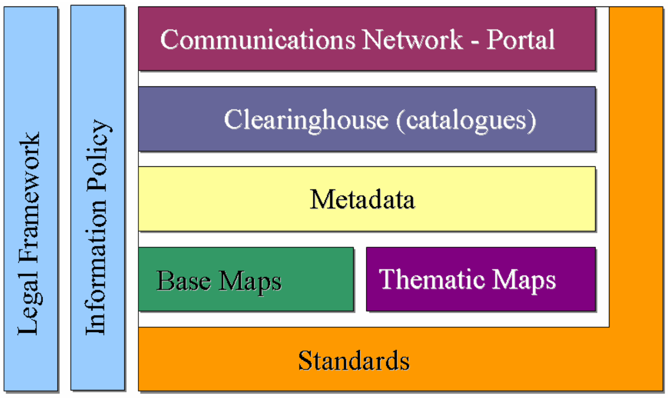



**Figure: The National SDI components**

And as you can see from the figure above, metadata is the core element of a NSDI. Countries are now making an effort to implement national SDI's; some countries have been using it for years in an effort to constitute or maintain their national metadata and associated standards.

### 5.2.1 Roles of Geospatial Metadata

The roles of metadata to geospatial data management can be categorized into four key components:

- Data exchange, discovery and reuse
- Data archive, maintenance and update
- Data accountability and assessment
- Data liability

Data exchange, discovery and reuse:

- Metadata is the primary means of locating available geospatial data resources via the Internet. Metadata is a primary public information resource as it is a non-technical means of presenting technical information.
- Coordinated metadata development avoids duplication of effort by ensuring the organization is aware of the existence of data sets.
- Through the online data catalogues, users can post metadata documentation about their data holdings and can query for available data using metadata parameters, such as geography, time, and theme.
- Once potential data resources are discovered, users can access the metadata to learn more about the data content and content structure, situate geospatially, identify versions, availability, and limitation and better assess the appropriateness of use of the data to meet their specific need.

Data archive, maintenance, management and update:

- Data are the most expensive components of a GIS. Metadata is a means of preserving the value of data investments. This is of particular significance to local and regional governments experiencing rapid staff changes.
- Metadata enables organizations to retrieve in-house data resources by specific criteria for global edits and annual updates.
- Data control and maintenance for data update, archive, or removal can be performed using temporal and data processing metadata elements. Metadata can describe data process, status and used for data management.
- Metadata temporal elements can be used to identify data that were developed prior to some period of currency such as "five years or older", administrative events such as enforcement of new data standard that resulted in new data organization, etc.

Data accountability and assessment:

- GIS data development has shifted from data producers to data consumers. From a consumer perspective, metadata is the label required to assess available data products. From the producer's perspective, metadata is a means of declaring data limitations and serves as a form of liability insurance.
- Without metadata, it is difficult to determine what spatial data exists, the quality of the data, how appropriate the data are for a given use, and who to contact about the data.
- Metadata can serve to support data quality and reliability assessments, certify authenticity by providing indications how and who creates data and records metadata.
- Metadata data processing elements can be used to identify data that were developed using outdated source data or analytical methodologies that are no longer considered current or adequate.

Data liability:

- Metadata have to provide information about the appropriate and misappropriate applications of the data use.
- Limitations of data use can be defined to express scale, geographic, or temporal limitations to the data.
- Liability statements should be written by legal staff to ensure that the legal requirements for use of the data are fully outlined.

### 5.2.2 Content of Metadata

In general, three main types of metadata can be identified (NISO, 2004):

- *Descriptive metadata* describes a resource for purposes such as discovery and identification.
    - Includes such elements as title, abstract, author, and keywords.

- *Structural and Technical* metadata indicates how compound objects are put together,
    - Includes file size, software needed, file type(s), presentation instructions, etc.

- *Administrative* (a.k.a. “meta-metadata”) metadata provides information to help manage a resource, such as when and how it was created, and who can access it. There are several subsets of administrative metadata that are sometimes listed as separate metadata types:
    - *Rights* metadata deals with intellectual property rights (e.g. copyright ownership, use privileges, etc.)
    - *Management* metadata, typically by/for owning agency, price paid, circulation restrictions, etc.
    - *Preservation metadata,* which contains information needed to archive and preserve a resource.

## *5.3 Geospatial Metadata Standards*

There are many types of metadata in many different arrangements. To take full advantage to share and manage data effectively, it is essential that the data providers and data users employ common metadata elements to describe datasets. A metadata standard is needed to facilitate the exchange of data and provide common ground for the development of organizational metadata specifications and collection tools.

By building metadata in compliance with national standards, organizations can participate in the Global Spatial Data Clearinghouse. Participation promotes the agency and frees staff from answering data inquiries.

Standards for geographic metadata provide a common framework for the documentation of geographic information in terms of terminology, definition, and structure. The consistency in the metadata ***content*** and ***style*** is recommended to ensure that data users can make comparisons quickly as to the suitability of data from different sources. Ideally, metadata structures and definitions should be referenced to a standard. The various standards are truly ***content*** standards.

The information included in the standard has to support the following data or services use (OGC, 2007):

- Discovery – data needed to identify and locate the sets of geographic data that exist for a geographic location.
- Access – data needed to acquire an identified set of geographic data.
- Fitness for use – data needed to determine if a set of geographic data meets the user's need and to support the user in applying the geographic information appropriately.
- Transfer – data needed to get a copy of a set of geographic data.

### 5.3.1 What Organizations Develop Geospatial Metadata Standards?

Many efforts are being undertaken to establish national and international standards relating to the composition of metadata. Many organizations and groups are active in the field of standardization. Detailed metadata standards that provide for an exhaustive definition of all aspects of various types of geospatial data are prepared by a number of bodies, as are profiles of these standards as reference models to be adopted for international use. Few main metadata standards exist or are in development that are of broad international scope and usage and provide detail for all levels of metadata mentioned earlier. In this module, the following standardization efforts are mentioned:

- *Dublin Core* – fifteen properties of resource discovery from the international community*.*
- *The Content Standards for Digital Geospatial Metadata* (CSDGM) from the United States Federal Geographic Data Committee (FGDC).
- TC 287 Pre-standard "*ENV (Euro-Norme Voluntaire) 12657 Geographic information - Data description – Metadata*" from CEN.
- *ISO 19115* and *19139* - Metadata standards and implementation specification.

The **Dublin Core** Metadata Initiative (DCMI, http://dublincore.org/) is intended to facilitate discovery of electronic resources. Originated for author-generated description of Web resources, it has attracted the attention of formal resource description communities such as museums, libraries, government agencies, and commercial organizations. DCMI is made up of working interest groups and committees drawn from the international community. Groups actively use an open consensus building process. There are 13 "key participating organizations" including CNI (Coalition for Networked Information), DSCT (Distributed Systems Technology Centre), the National Library of Canada, and OCLC (Online Computer Library Center, Inc.), etc. Dublin Core metadata is specifically intended to support general-purpose *resource discovery.*

The DCMI provides simple standards to facilitate the finding, sharing, and management of information. The Dublin Core Metadata Element Set consists of 15 elements and two classes of qualifiers: element refinements (24) and encoding schemes (20). All elements are optional, repeatable, and extensible. Simple core set of descriptors, but through extensibility, can potentially have more functionality. DCMI uses both HTML and RDF/XML for structuring information and Z39.50 for search and retrieval.

One of the DCMI elements is **coverage.** This DCMI element supports only a basic geospatial definition. DCMI Coverage is the spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant. A spatial topic may be a named place or a location specified by its geographic coordinates. A temporal period may be a named period, date, or date range. A jurisdiction may be a named administrative entity or a geographic place to which the resource applies. Recommended best practice is to use a controlled vocabulary such as the Thesaurus of Geographic Names [TGN]. Where appropriate, named places or time periods can be used in preference to numeric identifiers such as sets of coordinates or date ranges (http://www.getty.edu/research/tools/vocabulary/tgn/index.html).

The DCMI fifteen element descriptions have been formally endorsed in the ISO Standard 15836-2003 (February 2003, http://www.niso.org/international/SC4/n515.pdf). Dublin Core elements can be derived from more detailed ISO 19115 metadata models and can support geospatial information discovery of books, reports, and other Web objects.

Other standards exist in the broader topic of metadata that do not specifically apply to geospatial information.

The **Content Standards for Digital Geospatial Metadata** (CSDGM) from the United States Federal Geographic Data Committee (FGDC), approved in 1994, and revised in 1998 (FGDC-STD-001-1998, http://www.fgdc.gov/). Metadata sets are outlined at http://www.fgdc.gov/metadata/csdgm/ and are maintained by the FGDC. This is a national spatial metadata standard developed to support the activities within the National Spatial Data Infrastructure (NSDI).

CSDGM is made up of 334 different metadata elements. The standard uses both SGML and XML for structuring information and Z39.50 for search and retrieval. Major sections of the CSDGM are:

- Identification information
- Data quality information
- Spatial data organization information
- Spatial reference information
- Entity and attribute information
- Distribution information
- Metadata reference information
- Citation information
- Time period information
- Contact information

CSDGM standard has also been adopted and implemented in the other countries (e.g. United Kingdom, Canada) through the National Geographic Data Framework (NGDF).

Currently FGDC is harmonizing the CSDGM with ISO 19115 metadata standards resources. The draft North American profile (NAP) of ISO 19115 is open for review comments now (http://www.fgdc.gov/standards/projects/incits-l1-standards-projects/NAP-Metadata/NAP_Metadata). ISO 19115 elements closely match elements in FGDC-STD-001-1998, version 2.0. Once this draft standard is approved by ballot and a public review, it will be approved and published as an American National Standard (ANS) and a Canadian National Standard, simultaneously. The ANS will then become known as the U.S. National Profile of ISO 19115:2003, Geographic information – Metadata. Following publication as an ANS, the U.S. National Profile will replace the current CSDGM, FGDC-STD-001-1998, version 2.0.

The CEN Pre-standard Technical Committee 287 adopted "**ENV (Euro-Norme Voluntaire) 12657 Geographic information - Data description - Metadata**" in 1998 (http://forum.afnor.fr/afnor/WORK/AFNOR/GPN2/Z13C/indexen.htm). CEN TC 287 was reconvened in 2003 to address the development of European profiles of ISO TC 211 standards. In 2005, EN ISO 19115 Geographic Information - Metadata (ISO 19115:2003) was published as ISO 19115 profile by CEN TC 287.

As part of its draft "**OpenGIS Abstract Specification**", the Open Geospatial Consortium has adopted ISO 19115 as the abstract model for metadata management within the consortium. OGC is working closely with FGDC and ISO/TC 211 to develop formal, global spatial metadata standards. OGC is developing *Imagery Metadata* specifications that in the future could be adopted as ISO 19115, part 2 and provides imagery-related metadata elements, among them descriptions of algorithms and processing, of ground pixel properties, and of mission/platform/sensor identification. When ISO has accepted part 2 of 19115, a part 2 of ISO 19139 will be developed that will provide XML implementation for imagery metadata.

### 5.3.2 ISO 19115 and 19139 - Metadata Standards

One of positive effects of globalization is the leveraging countries to conform to international standards, such as ISO metadata standards. The international community, through the International Organization of Standards (ISO), has developed and approved international metadata standards.

The ISO metadata standards were derived from inputs from the various national bodies and their implementations of the respective metadata standards assisted by metadata software. The following participants were involved: 33 ISO TC211 Principle Member countries, 14 Observing/Corresponding Member countries, 10 Internal Liaisons (other ISO committees), and 14 External Liaisons, including the OGC.

The ISO Technical Committee TC 211 developed ISO standard **19115**, **Geographic Information - Metadata.** This was designed for international use and the standard attempts to satisfy the requirements of all well-known metadata standards. ISO 19115 is more "discovery" (search) than "markup" (use) standard.

ISO 19115 is a ***content*** standard that discusses what information should be included in metadata. It allows for detailed descriptions of geographic resources, but has a small number of mandatory elements. There are about 400 (minus) metadata elements (86 classes, 282 attributes, 56 relations). ISO 19115 provides an abstract or logical model for the organization of geospatial metadata. It does not provide for rigorous compliance testing, as there is no normative guidance on formatting the metadata included in the standard.

A companion specification, ISO 19139, standardizes the expression of 19115 metadata using the Extensible Markup Language (XML) and includes the logical model (UML) derived from ISO 19115. ISO standard **19139**, **Geographic Information - Metadata - Implementation Specification**, provides an XML schema that says how ISO 19115 metadata should be stored in XML format.

In some cases, the ISO Metadata project team worked with the project teams from the other work items in the implementation of ISO 19115 and 19139. For example, for data quality package the metadata team worked with Work Item 13 Data Quality Principles and Work Item 14 Quality Evaluation Procedures; for Spatial Representation elements with the Imagery and Gridded team; for Reference system info with the Spatial Reference by Coordinates and Spatial Reference by geographic identifiers teams; and, for Portrayal Catalog with the Portrayal Project team and Application Schema with the Rules for Applications team.

**ISO 19115: Geographic Information - Metadata Standard**

The ISO 19115 Metadata is the best-known standard of the ISO 19100 family. ISO 19115 was published as an international standard in 2003. It provides the *schema* for describing geographic *information* and *services*. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of *digital geographic data*.

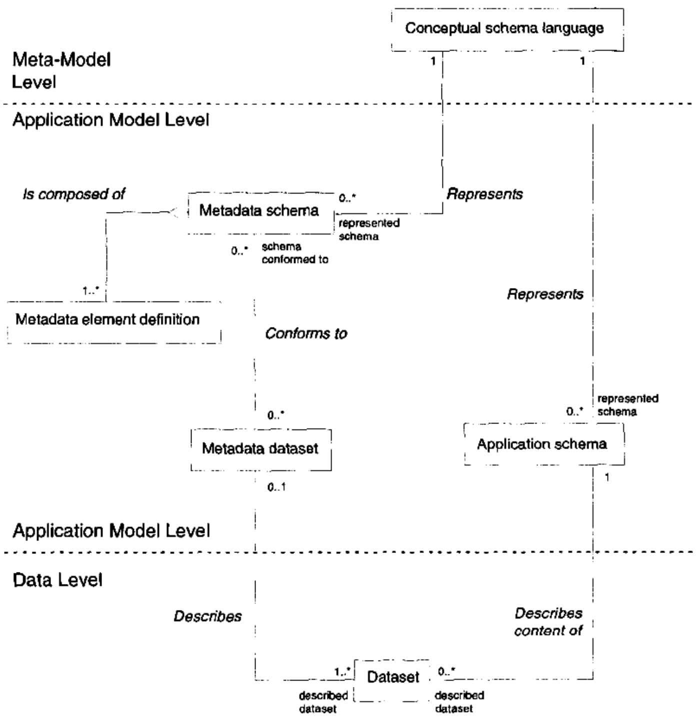



**Figure: Detail of metadata relationships from ISO 19101**

In figure, a *conceptual schema language* at the *meta-model level* represents a *metadata schema*, a standardized schema at the *application model level*. The *metadata schema* is a standardized schema described in ISO 19115. This schema provides the *metadata element definitions* (or types of metadata elements) for the metadata in a *metadata dataset*.

A *metadata dataset*, in turn, describes the administration, organization, and content of a *dataset* at the *data level*. The *metadata dataset* provides necessary information in order to support access to, and transfer of, the *dataset*.

The *application schema* may be referred to, or included in, by the *metadata dataset*. In figure, the *metadata dataset* is shown as conforming to the standardized *metadata schema*.

ISO 19115 is applicable to the *cataloguing* of datasets, *clearinghouse* activities, and the full description of datasets for a wide range of geographic applications. It is also applicable to describe the elements of geographic *datasets* and *dataset series*, along with individual geographic *features* and *attributes (feature properties).* It may be used for other forms of geographic data such as *maps, charts,* and *textual documents.* ISO 19115 uses for metadata documentation of the following recognized content types (ISO, 2007):

- Live Data and Maps – 001
- Downloadable Data - 002
- Offline Data - 003
- Static Map Image - 004
- Other Document 005
- Application - 006
- Geographic Service - 007
- Clearinghouse - 008
- Map File - 009
- Geographic Activity - 010

The following OGS and ESRI products and services are also contained within ISO 19115:

- WCS Coverage Data Service
- WFS Vector Data Service
- WMS Image Service
- ArcIMS Image Service
- ArcGIS Server Image Service

This International Standard defines:

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

**ISO 19115: Clause 6 Requirements Clause**

ISO 19115 standard contains the mandatory clauses (sections) that are Introduction, Scope, Conformance**,** Normative References, Terminology and Definitions, Symbols and Abbreviated Terms, and Annexes, but the heart of the standard is ***Clause 6: Requirements***, which is the metadata content section. We will examine this clause in detail.

The Clause 6 contains the following sections that will be discussed below:

- Metadata **application** section describes the UML model that defines how metadata applies to datasets, aggregate datasets, features and attributes.

- Metadata **packages** section defines the metadata package and entity relationships, also includes descriptions of extent, citation, and responsible party information.
- Metadata **datatypes** and **data dictionary (codelists)** are used within the metadata packages.
- Recommended **core** metadata for geographic datasets outlines a short list of recommended metadata elements in simple language.

### *Metadata Application Section*

**Metadata Application Information of Requirements Clause** section defines how metadata is related to geographic information. The following UML model defines how metadata applies to datasets, aggregate datasets, and general feature types. Figure is a UML class diagram defining the classes of geographic information to which metadata applies.

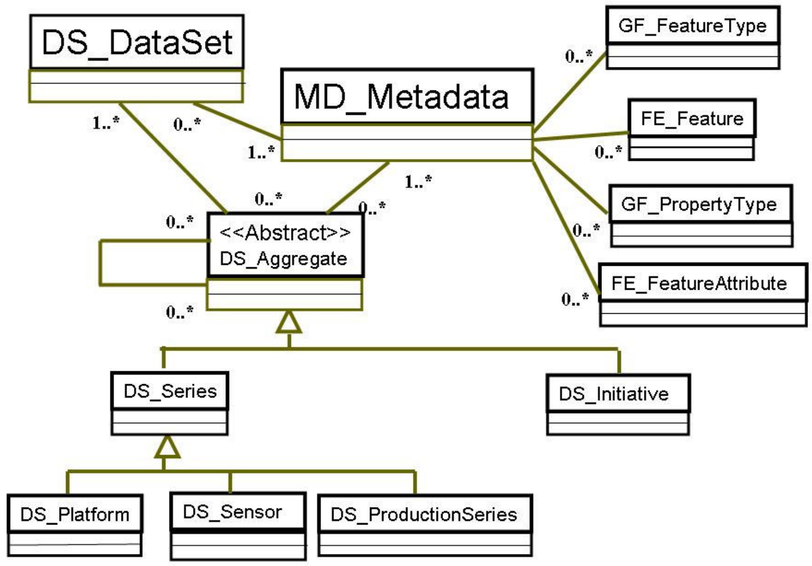



**Figure: The Metadata Application UML model, where (DS = dataset and GF = general feature, ISO 19115)**

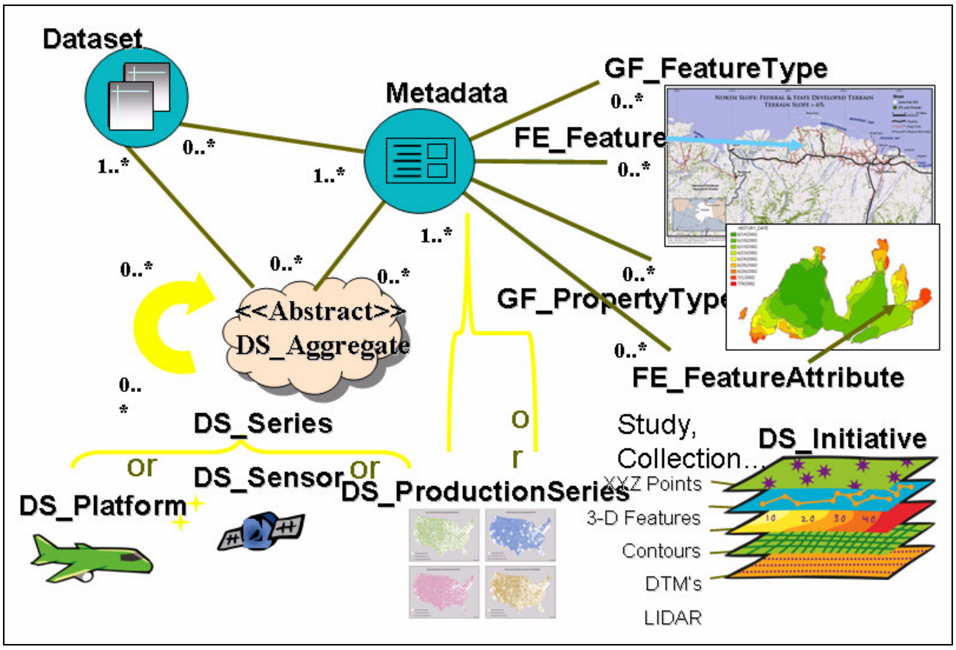



**Figure: The Metadata Application (Danko, D., ESIP Federation Meeting, 2007)**

Here are some definitions related to the above model: **Dataset** is an identifiable collection of data (ISO 19115). A geographic dataset is a dataset with features depicted geometrically (OGC, 2006). **Feature** or feature instance is an abstraction of individual real world phenomena. A feature may occur as a type or an instance. **Geographic feature** is a representation of real world phenomenon associated with a location relative to the Earth. **Feature attribute** is a characteristic of a feature. A feature attribute has a name, a data type, and a value domain attached to it. A feature attribute for a feature instance also has an attribute value taken from the value domain. The “geometries” associated with features are just one type of feature attribute. **Feature type** describes rules for application schema metaclass is used for the representation of a class of features (e.g. “road”, “river”, and “building”).

The above schema specifies that a dataset (DS_DataSet) must have one or more related Metadata entity sets (MD_Metadata). Metadata may optionally relate to a Feature, Feature Attribute, Feature Type, Feature Property Type (a Metaclass instantiated by Feature association role, Feature attribute type, and Feature operation), and aggregations of datasets (DS_Aggregate). Dataset aggregations may be specified (subclassed) as a general association (DS_OtherAggregate), a dataset series (DS_Series), or a special activity (DS_Initiative). MD_Metadata also applies to other classes of information and services not shown in this diagram.

***Metadata Packages***

Metadata is composed of one or more Metadata Sections (UML Packages) containing one or more Metadata Entities (UML classes). Eleven major Geographic metadata *packages* of metadata have been developed. Detailed metadata content for geographic information are defined with UML models for each of the packages. Each package contains one or more entities (UML Classes), which can be specified (subclassed) or generalized (superclassed). Entities contain elements (UML class attributes) which identify the discrete units of metadata. Entities may be related to one or more other entities. Entities can be aggregated and repeated as necessary to meet: the mandatory requirements stated in this International Standard; additional user requirements. The metadata is fully specified in the UML model diagrams and data dictionary for each package, which can be found in Annexes A and B respectively. The following metadata *packages* include:

- MD_Identification Information
- MD_Resource Constraint Information
- MD_Data Quality Information (related to ISO 19113,14)
- MD_Maintenance Information
- MD_Spatial Representation Information
- MD_Reference System Information (related to ISO 19108, 11, 12)
- MD_Content Information (related to ISO 19110, 21, 23, 24)
- MD_Portrayal Catalog Information
- MD_Distribution Information
- MD_Metadata Extension Information
- MD_Application Schema Information (related to ISO 19109)

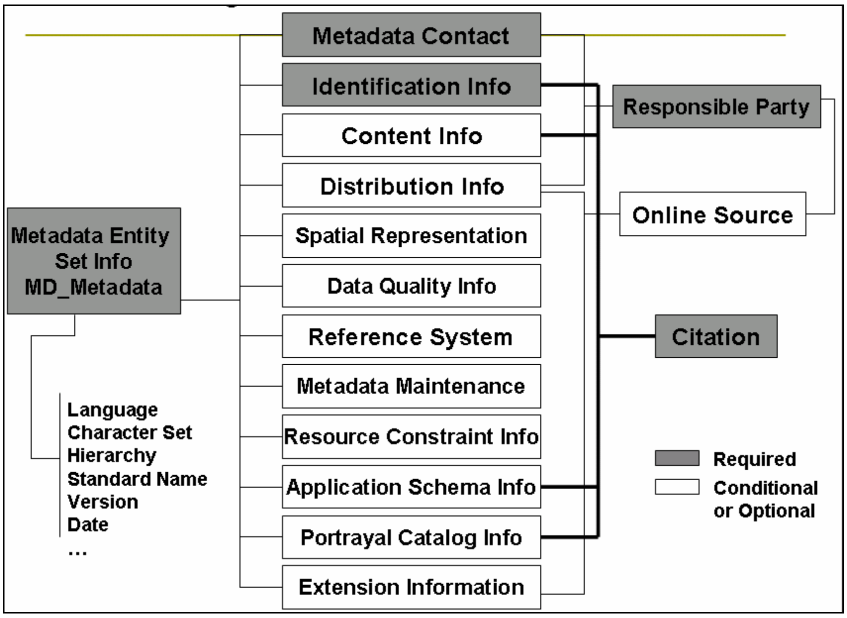



**Figure: ISO 19115 Metadata *Packages* Organization**

*Identification Information* contains information to uniquely identify the data. Identification information includes information about the citation for the resource, an abstract, the purpose, credit, the status and points of contact. Examples include title, geographic area covered, currentness, and rules for acquiring or using the data.

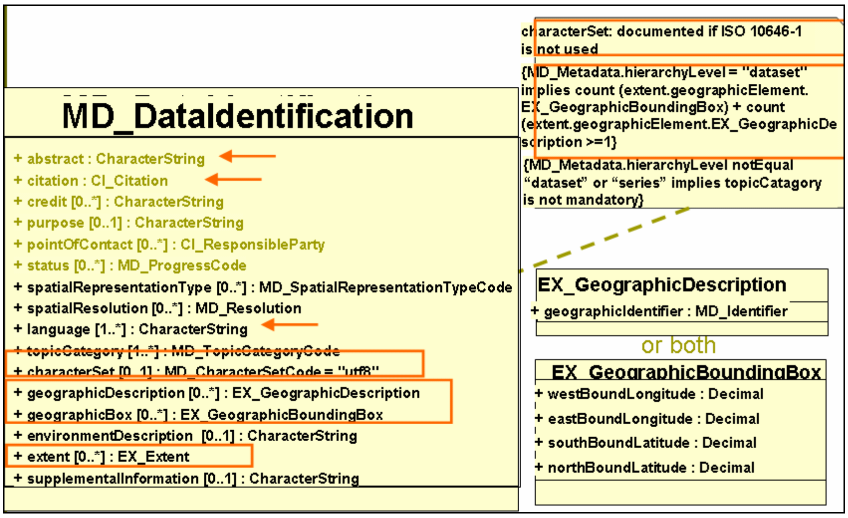



**Figure: DataIdentification sub-package (from MD_Identification package) details and its metadata entities (UML classes)**

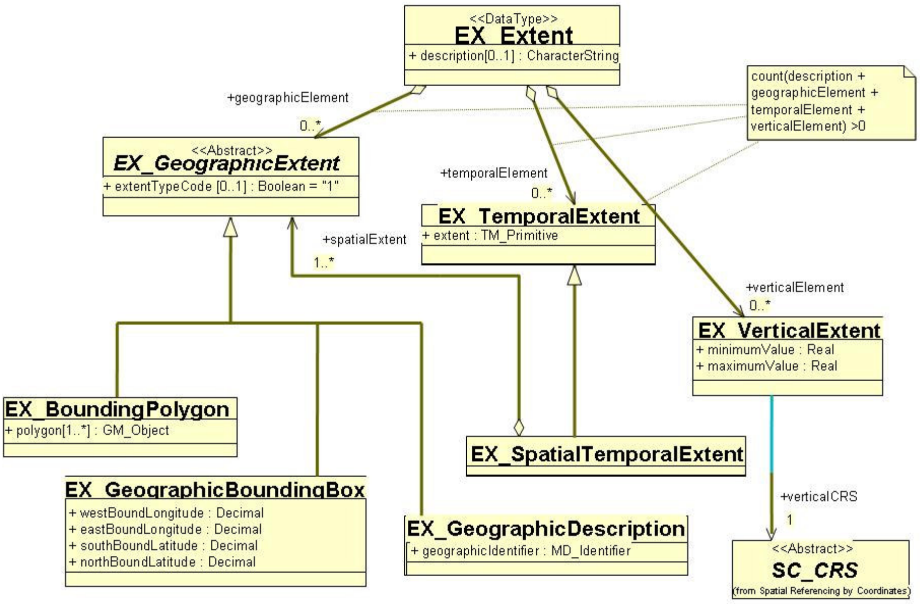



**Figure: Extent data types. The datatype in this package is an aggregate of the metadata elements that describe the spatial and temporal extent of the referring entity**

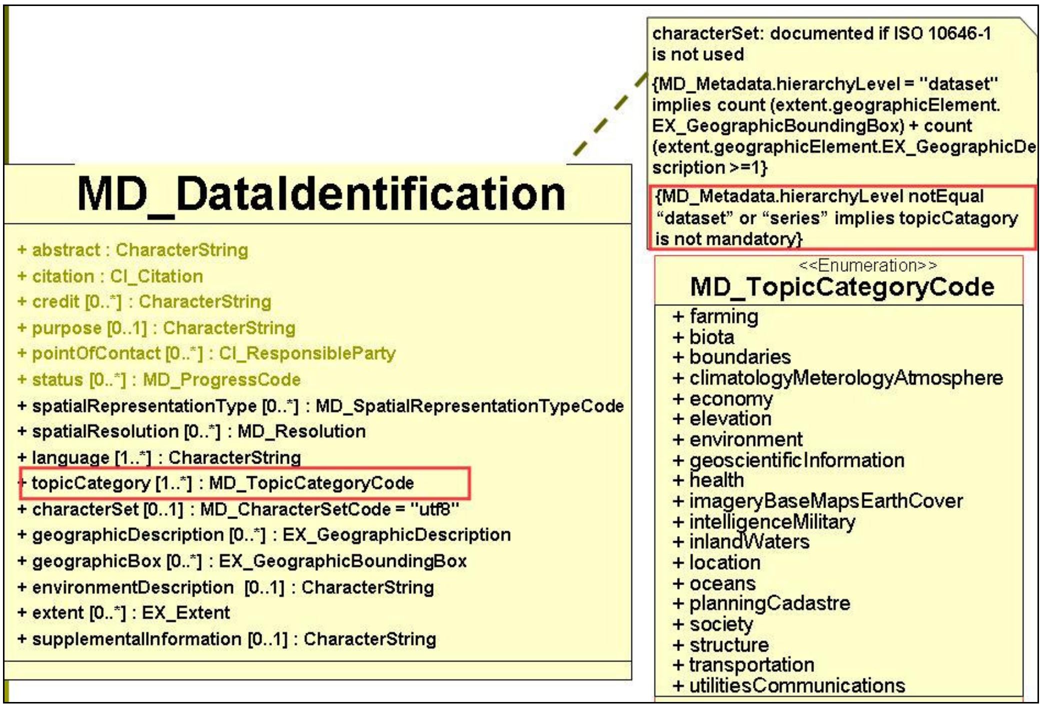



**Figure: MD_TopicCategoryCode**

*Data Quality Information* a general assessment of the quality of the dataset. Examples include positional and attribute accuracy, completeness, consistency, sources of information, and methods used to produce the data. The DQ_DataQuality entity is optional and contains the scope of the quality assessment. DQ_DataQuality is an aggregate of LI_Lineage and DQ_Element. DQ_Element can be specified as DQ_Completeness, DQ_LogicalConsistency, DQ_PositionalAccuracy, DQ_ThematicAccuracy and DQ_TemporalAccuracy. Those five entities represent Elements of data quality and can be further subclassed to the sub-Elements of data quality. Users may add additional elements and sub-elements of data quality by sub-classing DQ_Element or the appropriate subelement.

*Spatial Reference Information* is a description of the reference frame for, and means of encoding, coordinates in the data set. Examples include the name of and parameters for map projections or grid coordinate systems, horizontal and vertical datums, and the coordinate system resolution.

*Distribution Information* contains information about the distributor of, and options for obtaining, a resource. Examples include contact information for the distributor, available formats, information about how to obtain data sets online or on physical media (such as cartridge tape or CD-ROM), and fees for the data.

*Extensibility* is the standard that provides a methodology and process for data producers or the user community to profile and extend the metadata standard beyond the base standard to meet individual organizations and discipline metadata requirements.

*Constraints* are reported through metadata constraint information and/or legal constraints and/or security constraints. For example, the limitations, restrictions or statement on the resource fitness for use, and the legal restrictions or prerequisites required to use the resource or access the metadata.

*Maintenance* information is information about the frequency of changes and additions made to the resource after the initial completion, the scheduled revision date for the resource, as well as the identification of, and means of communicating with, person(s) and organization(s) with responsibility for maintaining the resource.

*Spatial representation* information section contains information concerning the mechanisms used to represent spatial information in a dataset.

*Content* package contains information identifying the feature catalogue used (MD_FeatureCatalogueDescription) and/or information describing the content of a coverage dataset (MD_CoverageDescription). Both description entities are subclasses of the MD_ContentInformation entity. MD_CoverageDescription may be subclassed as MD_ImageDescription, and has an aggregate of MD_RangeDimension. MD_RangeDimension may additionally be subclassed as MD_Band.

*Portrayal catalogue* information section describes attributes that provide information about how to identify and locate the portrayal catalogue. Examples include bibliographic citation for the portrayal catalogue.

*Application schema* information section describes attributes that provide information about the application schema used to develop the dataset. Examples include citation for the application schema, identification of the schema language, full application schema given as an ASCII file, a graphics file, a software development file.

*Extension* information package contains information about user specified extensions.

The following elements repeat itself in the standard. For this reason in the application profile, someone has decided to locate them at the end of the document.

- *CI_Citation*
- *CI_ResponsibleParty*
- *MD_Distributor*

*Citation* section describes attributes that provide information about bibliographic information to reference the resource.

*Responsible party* section describes attributes that provide information about those responsible for the resource and the party's role in the resource.

*Online resource* section describes attributes that provide information about information on the Internet available resource.

The structure and relations between 11 major Geographic metadata *packages* and MD_Metadata entity set information classes are shown on the following ISO Metadata UML models:

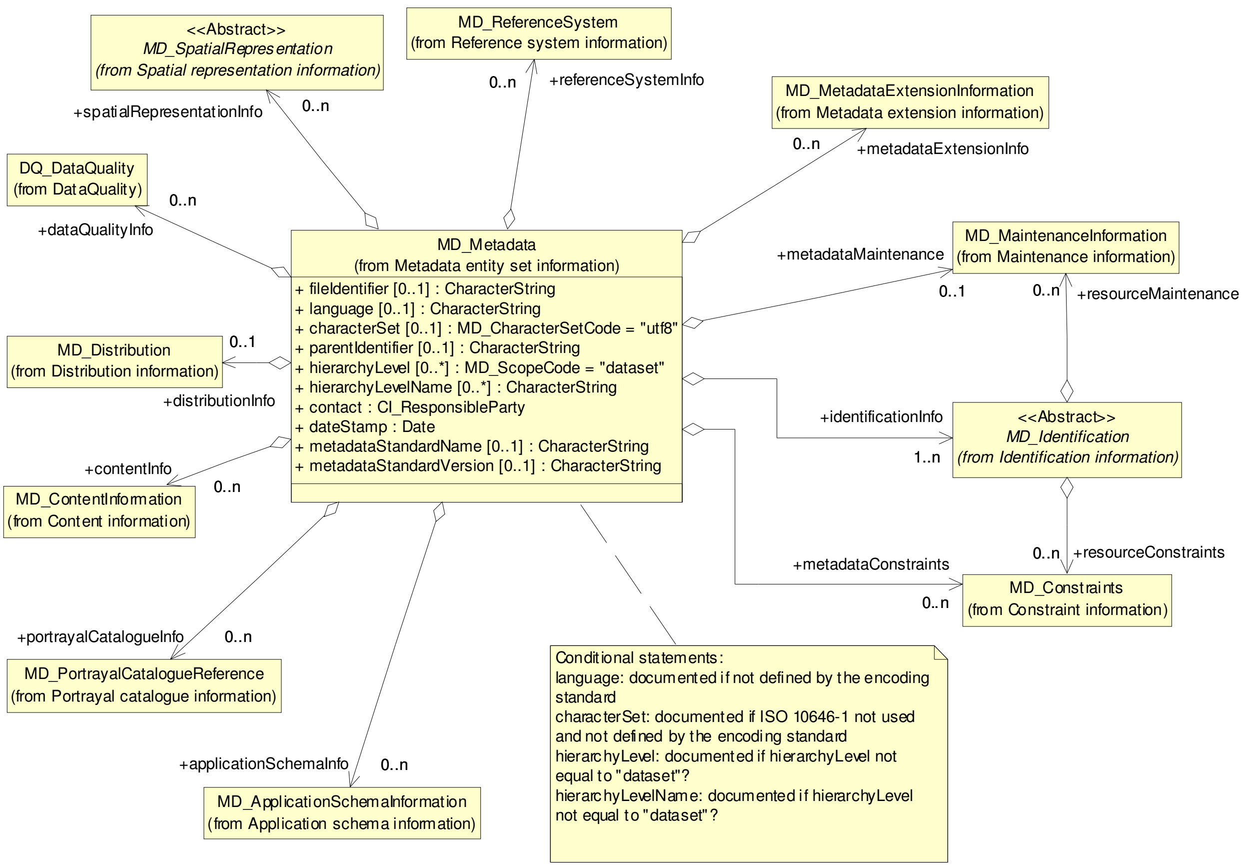



**Figure: The layout of the metadata packages: Metadata entity set information**

About 400 attributes and components provide information about metadata entity set information.

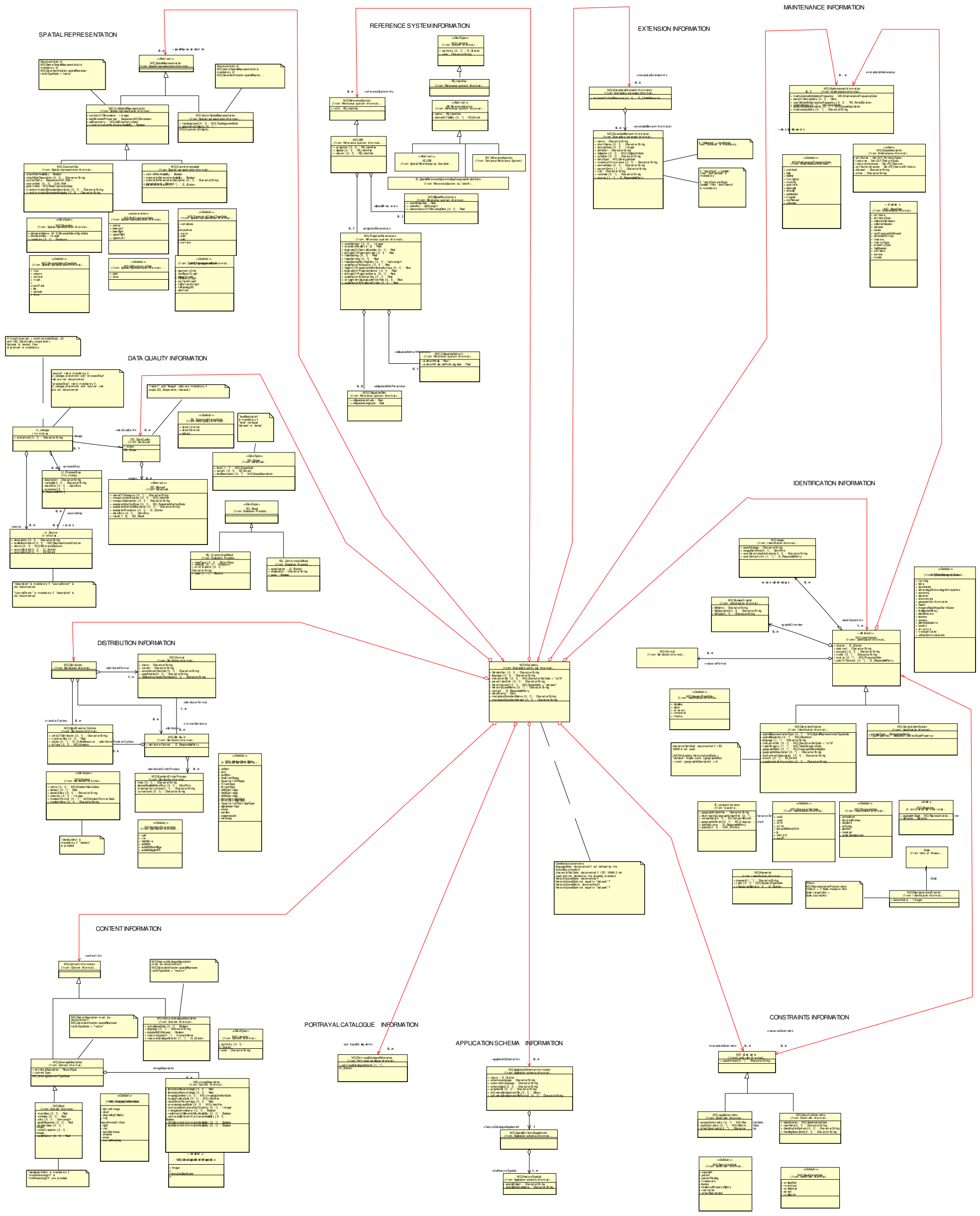



**Figure: The overall ISO diagram**

All the sub elements of metadata packages are created as classes and attributes in a logical model. Theses classes can be organized in a hierarchical fashion, as shown in the following example:

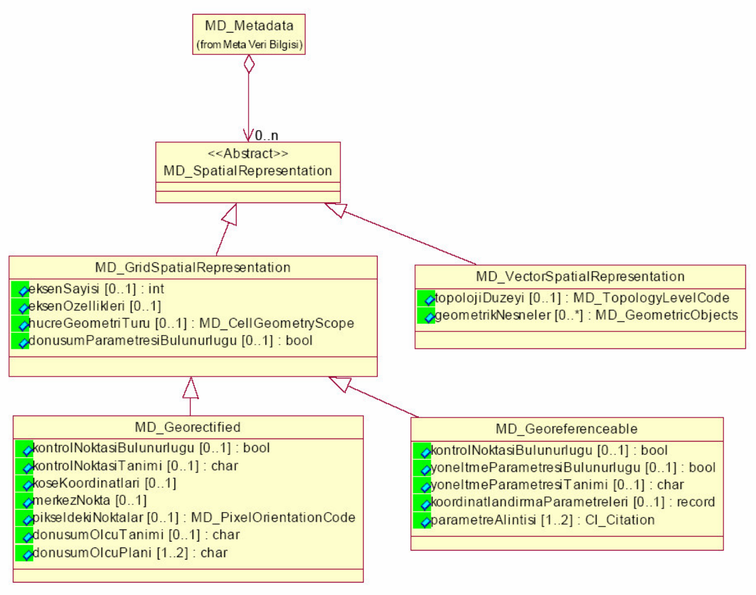



**Figure: Part of a Metadata Logical Model.**

## *Metadata Data Dictionary, DataTypes, , and CodeLists*

ISO 19115 is published as a UML diagrams. A Data Dictionary supports these UML models. Data dictionary establishes a common set of metadata terminology and definitions, which fully define each class, attribute, association, etc. This data dictionary was developed following the rules defined in the ISO 11179 standard, which was developed by ISO/IEC JTC1 SC32. It shows DataTypes and CodeLists.

Annex B contains the element and entity definitions for the metadata schemas. This dictionary, in conjunction with the diagrams presented in Annex A, serve to fully define the total abstract model for metadata. This data dictionary describes the characteristics of the metadata defined in Clause 6 and Annex A. The dictionary is specified in a hierarchy to establish relationships and an organization for the information.

| | Name/Role Name | Short Name | Definition | Obligation / Condition | Maximum occurrence | Data type | Domain |
|---|---|---|---|---|---|---|---|
| 29 | MD_Identification | ident | basic information required to uniquely identify a resource | Use obligation from referencing object | Use maximum occurrence for referencing object | Aggregated Class (MD_Metadata) <<Abstract>> | Lines 30-41 |
| 30 | citation | idCitation | citation data for the resource | M | 1 | Class | CI_Citation <<DataType>> (B3.2) |
| 31 | abstract | idAbs | brief narratiave summary | M | 1 | CharacterString | Free text |
| 32 | purpose | idPurp | summary of the intentions with which the resource was developed | O | 1 | CharacterString | Free text |
| 33 | credit | idCredit | recognition of those who contributed to the resource | O | 1 | CharacterString | Free text |
| 34 | statusCode | idStatCode | status of resource | O | N | Class | MD_ProgressCode <<CodeList>> (B.6.26) |

**Figure: Samples of Metadata Data Dictionary**

In the Data Dictionary, Data type specifies a set of distinct values for representing the metadata elements; for example, integer, real, string, DateTime, and class. The data type attribute is also used to define metadata entities, stereotypes, and metadata associations.

In order to standardize allowable textual values for metadata elements, ISO Metadata makes use of code lists. A code list is an open enumeration of values. It is a flexible mechanism that allows for the extension of code lists, as needed.

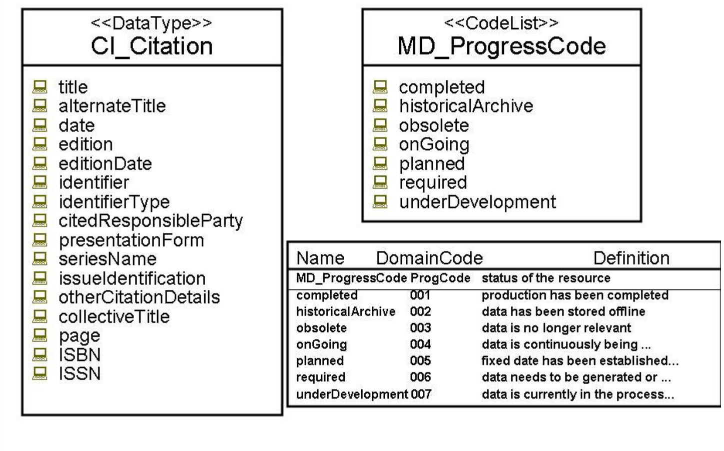



**Figure: Example of DataTypes and CodeLists**

For example, the attributes for the Citation data type was derived from various library communities - Anglo-American, Finnish, DIN library standard, etc. Code lists can be used extensively to allow users to pick from well-formed lists. There are still many “Free Text” fields, and users can add many code lists and have a good recommendation of what should be provided in the field. Code lists are extensible in community profiles. In cases where the list cannot be extended, enumeration data types (like days of the week) is used. Each item in a list is given a number to be used by implementers to provide language/semantic interoperability.

| | Name | Domain code | Definition |
|---|---|---|---|
| 1. | MD_SpatialRepresentation TypeCode | SpatRepTypCd | method used to represent geographic information in the dataset |
| 2. | vector | 001 | vector data is used to represent geographic data |
| 3. | grid | 002 | grid data is used to represent geographic data |
| 4. | textTable | 003 | textual or tabular data is used to represent geographic data |
| 5. | tin | 004 | triangulated irregular network |
| 6. | stereoModel | 005 | three-dimensional view formed by the intersecting homologous rays of an overlapping pair of images |
| 7. | video | 006 | scene from a video recording |

**Figure: Sample of MD_SpatialRepresentationTypeCode <<CodeList>>**

| | Name | Domain code | Definition |
|---|---|---|---|
| 1. | MD_TopicCategoryCo de | TopicCatC d | high-level geographic data thematic classification to assist in the grouping and search of available geographic data sets. Can be used to group keywords as well. Listed examples are not exhaustive. NOTE It is understood there are overlaps between general categories and the user is encouraged to select the one most appropriate. |
| 2. | farming | 001 | rearing of animals and/or cultivation of plants Examples: agriculture, irrigation, aquaculture, plantations, herding, pests and diseases affecting crops and livestock |
| 3. | biota | 002 | flora and/or fauna in natural environment Examples: wildlife, vegetation, biological sciences, ecology, wilderness, sealife, wetlands, habitat |
| 4. | boundaries | 003 | legal land descriptions Examples: political and administrative boundaries |
| 5. | climatologyMeteorolog yAt mosphere | 004 | processes and phenomena of the atmosphere Examples: cloud cover, weather, climate, atmospheric conditions, climate change, precipitation |
| 6. | economy | 005 | economic activities, conditions and employment Examples: production, labour, revenue, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas |
| 7. | elevation | 006 | height above or below sea level Examples: altitude, bathymetry, digital elevation models, slope, derived products |
| 8. | environment | 007 | environmental resources, protection and conservation Examples: environmental pollution, waste storage and treatment, environmental impact assessment, monitoring environmental risk, nature reserves, landscape |
| 9. | geoscientificInformatio n | 008 | information pertaining to earth sciences Examples: geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth’s rocks, risks of earthquakes, volcanic activity, landslides, gravity information, soils, permafrost, hydrogeology, erosion |
| 10. | health | 009 | health, health services, human ecology, and safety Examples: disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services |

**Figure: Extract from MD_TopicCategoryCode << Enumeration>>**

***Core Metadata Section***

ISO 19115 provides a large basket of metadata elements that are needed in applications of geographic information. The ISO 19115 consolidates well-known sources such as the metadata listing of the FGDC in one standard. The metadata-model of the ISO 19115 distinguishes between about 20 core metadata elements and the comprehensive listing with about 400 elements (ISO/TC 211, 2005). Use of this common set of defined elements helps promote interoperability among geographic data users and producers worldwide.

With the goal of profiling, ISO 19115 metadata elements can be divided by each element's conditionality:

- **Core** metadata:
  - **Mandatory** (**M**) elements:
    - The metadata element shall be documented.
  - **Conditional** (**C**) elements:
    - Specifies an electronically manageable condition under which at least one metadata element is mandatory. "Conditional" is used for one of the three following possibilities:
      - Expressing a choice between two or more options. At least one option is mandatory and must be documented.
      - Documenting a metadata element if another element has been documented.
      - Documenting a metadata element if a specific value for another metadata element has been documented.
- **Optional** (**O**) elements:
  - The metadata element may or may not be documented. Optional metadata elements have been defined to provide a guide to those looking to fully document their data.

"**Core** metadata" or "**Discovery** metadata" is a limited set of metadata that organizations should use, as a minimum, to improve the knowledge, awareness, and accessibility of the available geospatial data resources. Core elements are those metadata elements that must be included within each national profile in order to be considered compliant with ISO 19115.

The standard defines several items considered the basis of the standard, however, only about half are mandatory. Core elements include approximately 50 fields that can be filled. Core elements may not be adequate for detailed description requirements. The ISO 19115 Core metadata elements are listed in the following figure.

| Mandatory Elements: | Conditional Elements: |
|---|---|
| Dataset title<br>Dataset reference date<br>Dataset language<br>Dataset topic category<br>Abstract<br>Metadata point of contact<br>Metadata date stamp | Dataset responsible party<br>Geographic location by coordinates<br>Dataset character set<br>Spatial resolution<br>Distribution format<br>Spatial representation type<br>Reference system<br>Lineage statement<br>On-line resource<br>Metadata file identifier<br>Metadata standard name<br>Metadata standard version<br>Metadata language<br>Metadata character set<br>Additional extent info (vertical / temp) |

**Figure: ISO 19115 Core Metadata Elements**

| | |
|---|---|
| **Dataset title**(M)<br>(MD_Metadata > MD_Identification.citation ><br>CI_Citation.title) | **Spatial representation type**(O)<br>(MD_Metadata ><br><br>MD_DataIdentification.spatialRepresentationType) |
| **Dataset reference date** (M)<br>(MD_Metadata > MD_Identification.citation ><br>CI_Citation > CI_Date.date and CI_dateType) | **Reference system**(O)<br>(MD_Metadata > MD_ReferenceSystem) |
| **Dataset responsible party**(O)<br>(MD_Metadata ><br>MD_Identification.pointOfContact ><br>CI_ResponsibleParty) | **Lineage statement**(O)<br>(MD_Metadata > DQ_DataQuality ><br>LI_Lineage.statement) |
| **Geographic location of the dataset (by four coordinates or by geographic identifier)**(C)<br>(MD_Metadata ><br>MD_DataIdentification.geographicBox or<br>MD_DataIdentification.geogrphicIdentifier) | **On-line resource**(O)<br>(MD_Metadata > MD_Distribution ><br>MD_DigitalTransferOption.onLine ><br>CI_OnlineResource) |
| **Dataset language**(M)<br>(MD_Metadata ><br>MD_DataIdentification.lauguage) | **Metadata file identifier**(O)<br>(MD_Metadata.fileIdentifier) |
| **Dataset character set**(C)<br>(MD_Metadata ><br>MD_DataIdentification.characterSet) | **Metadata standard name**(O)<br>(MD_Metadata.metadataStandardName) |
| **Dataset topic category**(M)<br>(MD_Metadata ><br>MD_DataIdentification.topicCategory) | **Metadata standard version**(O)<br>(MD_Metadata.metadataStandardVersion) |
| **Spatial resolution of the dataset**(O)<br>(MD_Metadata ><br>MD_DataIdentification.spatialResolution ><br>MD_Resolution.equivalentScale or<br>MD_Resolution.distance) | **Metadata language**(C)<br>(MD_Metadata.language) |
| **Abstract describing the dataset**(M)<br>(MD_Metadata ><br>MD_Identification.abstract) | **Metadata character set**(C)<br>(MD_Metadata.characterSet) |
| **Distribution Format**(O)<br>(MD_Metadata > MD_Distribution ><br>MD_Format.name and MD_Format.version) | **Metadata point of contact**(M)<br>(MD_Metadata.contact ><br>CI_ResponsibleParty) |
| **Additional extent information for the dataset (vertical and temporal)**(O)<br>(MD_Metadata ><br>MD_DataIdentification.extent > EX_Extent) | **Metadata date stamp**(M)<br>(MD_Metadata.dateStamp) |

**Figure: Core metadata for geographic datasets**

Many nations will use some of these elements at particular levels, however, not with each dataset. Therefore, some national framework metadata standards need to be compliant with ISO 19115. Some elements are listed as optional in ISO 19115; others are mandatory for a national metadata standard. Example include: metadata standard name, metadata standard version, dataset purpose, dataset progress, dataset maintenance, and update frequency.

***The metadata annexes***

The real detailed information is found in the annexes. Two kinds of annexes are provided: normative and informative.

| Normative | Informative |
|---|---|
| ▪ Metadata schemas<br>    ▪ Abstract Object Model (UML)<br>▪ Data dictionary and **code lists**<br>▪ Extensions and profiles<br>▪ Abstract test suite<br>▪ Comprehensive dataset metadata application profile | ▪ Metadata extension methodology<br>▪ Metadata implementation<br>▪ Hierarchical levels of metadata<br>▪ Implementation examples |

**Figure: The Metadata Annexes**

## Multi-level metadata

Hierarchical metadata enables metadata roll-up. These issues of data set granularity and the need for software cataloging tools necessary to support inheritance, entry, update, and reporting of metadata at the ***data series***, ***data set***, or ***feature*** level. A ***data set*** is consisting of hundreds of ***features*** that are the basic unit of data. Individual ***data sets*** are parts of the **data series** that is a collection of datasets sharing the same product specification (ISO 19115 Annex F and H).

Multi-level metadata can be written for each metadata level (example of each provided):

- Data series - Wetlands
  - May include “project: level metadata such as purpose and distribution information
- Data set for one geographic area – Vancouver Island Wetlands
  - May include “site: level metadata such as geographic extent and site specific data collection methods
- Feature type - Marsh
  - May include “feature” level metadata such as feature schema (entities and attributes) and measurements of accuracy for the feature class “marsh”
- A single instance of the feature - Nanaimo’s Marsh
  - May include feature specific metadata such field verification methods, dates, and assessments for the specific marsh feature
- Attribute Type - Salinity
  - May include attribute level metadata such as methods used to determine salinity and attribute specific definitions
- A single instance of the attribute - actual salinity measure for Nanaimo’s Marsh
  - May include attribute specific metadata such as wide variability in sampling values and methods to average the values, or the late addition of the value to the data set.

In addition, a metadata hierarchy can be built within the same feature type. For example, the variety in metadata will be quite different for differing map scales.

ISO19115 Annex H provides methods for efficiently handling metadata for datasets with metadata requirements at different levels.

### 5.3.3 Examples of Metadata Entities

Below is an UML model that lists some samples of ISO 19115 metadata packages and elements:

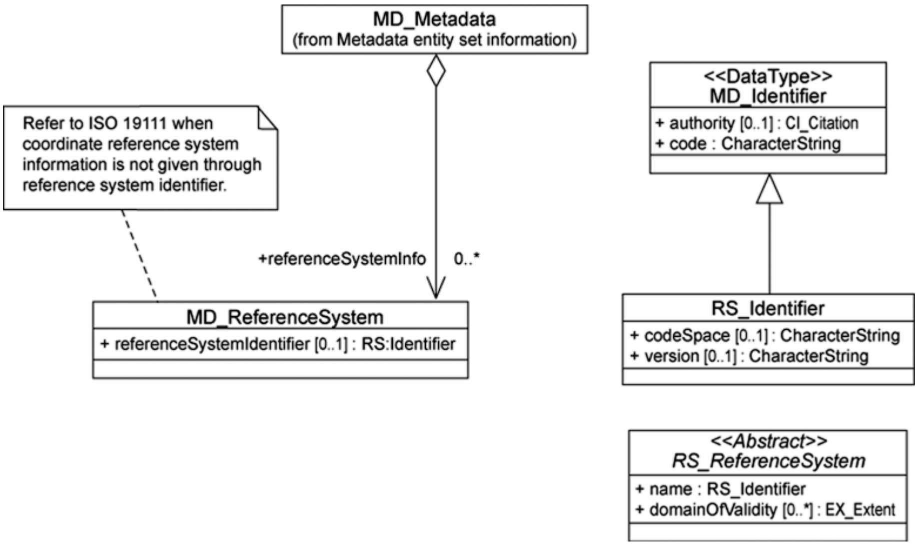



**Figure: UML Schema of Reference System Package**

## X.X. Reference system Information

### X.X.1. Introduction

This section describes attributes that provide information about reference system information.
Type: MD_ReferenceSystem
Description: Identification of the spatial and temporal reference systems used.

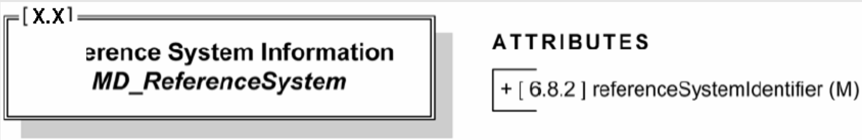



Figure XX: Reference System Information

The following attributes provide information about reference system.

### 6.8.2. referenceSystemIdentifier (M)

Type: RS_Identifier
Description: Identifier of the Reference System.
BP: If a coordinate reference system (CRS) is not describe in a register and as such as no identifier,
then that CRS shall be described according to ISO19111 and ISO/TS19127. A code with an authority is then defined and used here as reference. A dataset that has both a horizontal and a vertical CRS shall use a compound reference system with the horizontal CRS documented first and
the vertical CRS documented second.

Note: A CRS identifier should be taken from a register such as EPSG (www.epsg.org).

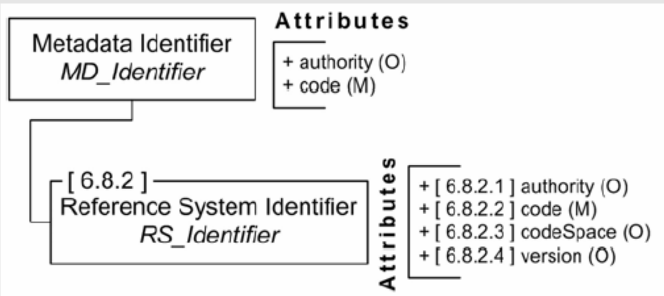



Figure XX: Reference system identifier

### 6.8.2.1. authority (O)

Type: CI_Citation (see 6.14)
Description: The party responsible for maintenance of the reference system resource.
BP: Strongly recommend to provide contact information (see X.XX.X contactInfo).

### 6.8.2.2. code (M)

Type: free text
Description: The alphanumeric value identifying the source reference system.

### 6.8.2.3. codeSpace (O)

Type: free text
Description: The name organization or party responsible for the reference system resource.

### 6.8.2.4. version (O)

Type: free text
Description: The cited reference system version.

**Figure: Content of Reference System Metadata Information (some notations: (O, *) = Optional, Repeatable; (M, *) = Mandatory, Repeatable; (C, *) = Conditional, Repeatable), (ISO 19115)**

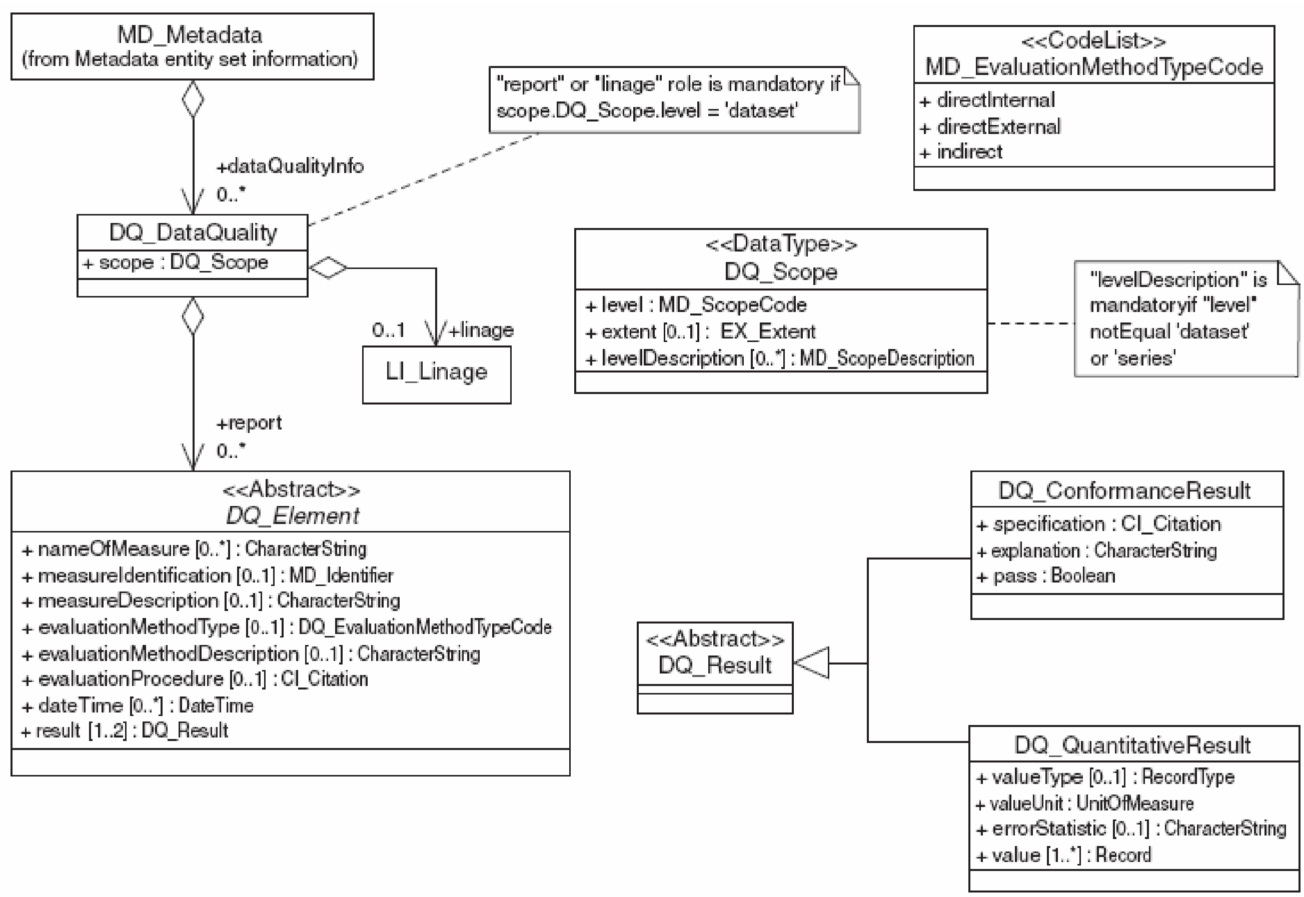



**Figure: General UML Schema of Data Quality Package**

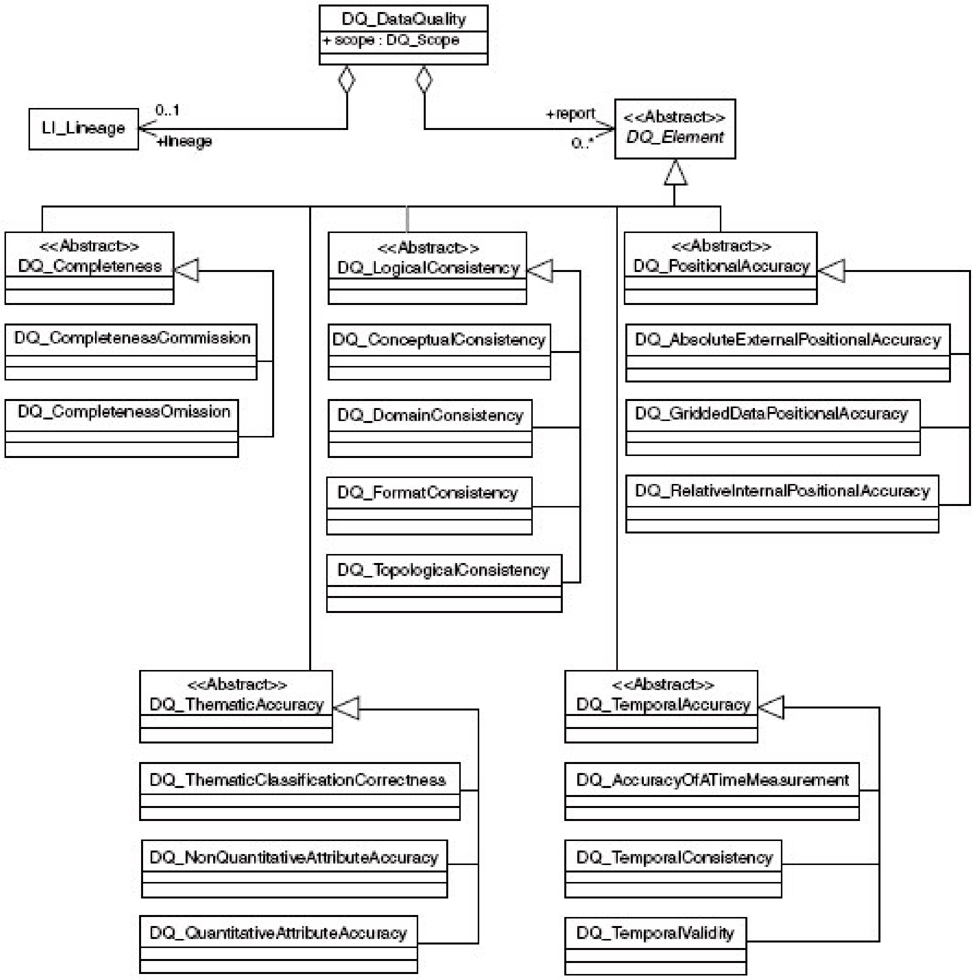



**Figure: Data Quality Classes and Subclasses (Lineage information or lack of information on the events and source data used to construct the dataset within the specified scope)**

## X.X. Data quality information

### X.X.1. Introduction

This section describes attributes and components that provide information about data quality.

Type: DQ_DataQuality

…

### X.X.10. Absolute External Positional Accuracy

Type: DQ_AbsoluteExternalPositionalAccuracy

Description: Description of the methods, procedures, date stamp, conformance results or quantitative results, and date stamp of the positional measurement in the dataset.

#### X.X.10.1. nameOfMeasure (O,Repeatable)

Type: free text

Description: Name of the test applied to the data to assure data quality.

#### X.X.10.2. measureIdentification (O)

Type: MD_Identifier (see X.XX)

Description: Code which identifies a registered standard data quality procedure.

**X.X.10.3. measureDescription (O)**
Type: free text
Description: Description of the measure applied to the dataset to assure quality.

**X.X.10.4. evaluationMethodType (O)**
Type: CodeList napDQ_EvaluationMethodTypeCode
Description: Method type used to evaluate data quality in the dataset.
BP: Select *evaluationMethodType* from napDQ_EvaluationMethodTypeCode.

**X.X.10.5. evaluationMethodDescription (O)**
Type: free text
Description: Description of the evaluation method applied to the dataset.

**X.X.10.6. evaluationProcedure (O)**
Type: CI_Citation (see X.XX)
Description: Citation for the evaluation procedure.
BP: Strongly recommend to provide contact information (see 6.15.5 contactInfo).

**X.X.10.7. dateTime (O,Repeatable)**
Type: DateTime (see Annex X – X.X)
Description: Date and time at which the test was completed.
BP: DateTime cannot support the description of duration, only single time is allowed.

**X.X.10.8. result (M,2)**
Type: DQ_QuantitativeResult (see X.X.XX) and/or DQ_ConformanceResult (see X.X.XX)
Description: Value(s) obtained from data quality test or outcome from applying data quality
measure against a specified/acceptable quality conformance level.

**Figure: Extraction from Content of Data Quality Package (ISO 19115)**

| | Name / Role Name | Short Name | Definition | Obligation / Condition | Maximum occurrence | Data type | Domain |
|---|---|---|---|---|---|---|---|
| 121. | DQ_AccuracyOfATime Measurement | DQAccTime Meas | correctness of the temporal references of an item (reporting of error in time measurement) | Use obligation from referencing object | Use maximum occurrence from referencing object | Specified Class (DQ_Temporal Accuracy) | Lines 100-107 |
| 122. | DQ_TemporalConsistency | DQTempConsis | correctness of ordered events or sequences, if reported | Use obligation from referencing object | Use maximum occurrence from referencing object | Specified Class (DQ_Temporal Accuracy) | Lines 100-107 |
| 123. | DQ_TemporalValidity | DQTempValid | validity of data specified by the scope with respect to time | Use obligation from referencing object | Use maximum occurrence from referencing object | Specified Class (DQ_Temporal Accuracy) | Lines 100-107 |
| 124. | DQ_ThematicAccuracy | DQThemAcc | accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships | Use obligation from referencing object | Use maximum occurrence from referencing object | Specified Class (DQ_Element) <<Abstract>> | Lines 100-107 |
| 125. | DQ_ThematicClassification Correctness | DQThemClass Cor | comparison of the classes assigned to features or their attributes to a universe of discourse | Use obligation from referencing object | Use maximum occurrence from referencing object | Specified Class (DQ_Thematic Accuracy) | Lines 100-107 |
| 126. | DQ_NonQuantitativeAttribute Accuracy | DQNonQuanAtt Acc | accuracy of non-quantitative attributes | Use obligation from referencing object | Use maximum occurrence from referencing object | Specified Class (DQ_Thematic Accuracy) | Lines 100-107 |

**Figure: Extract from the Data Dictionary for Data quality element information Annex B section**

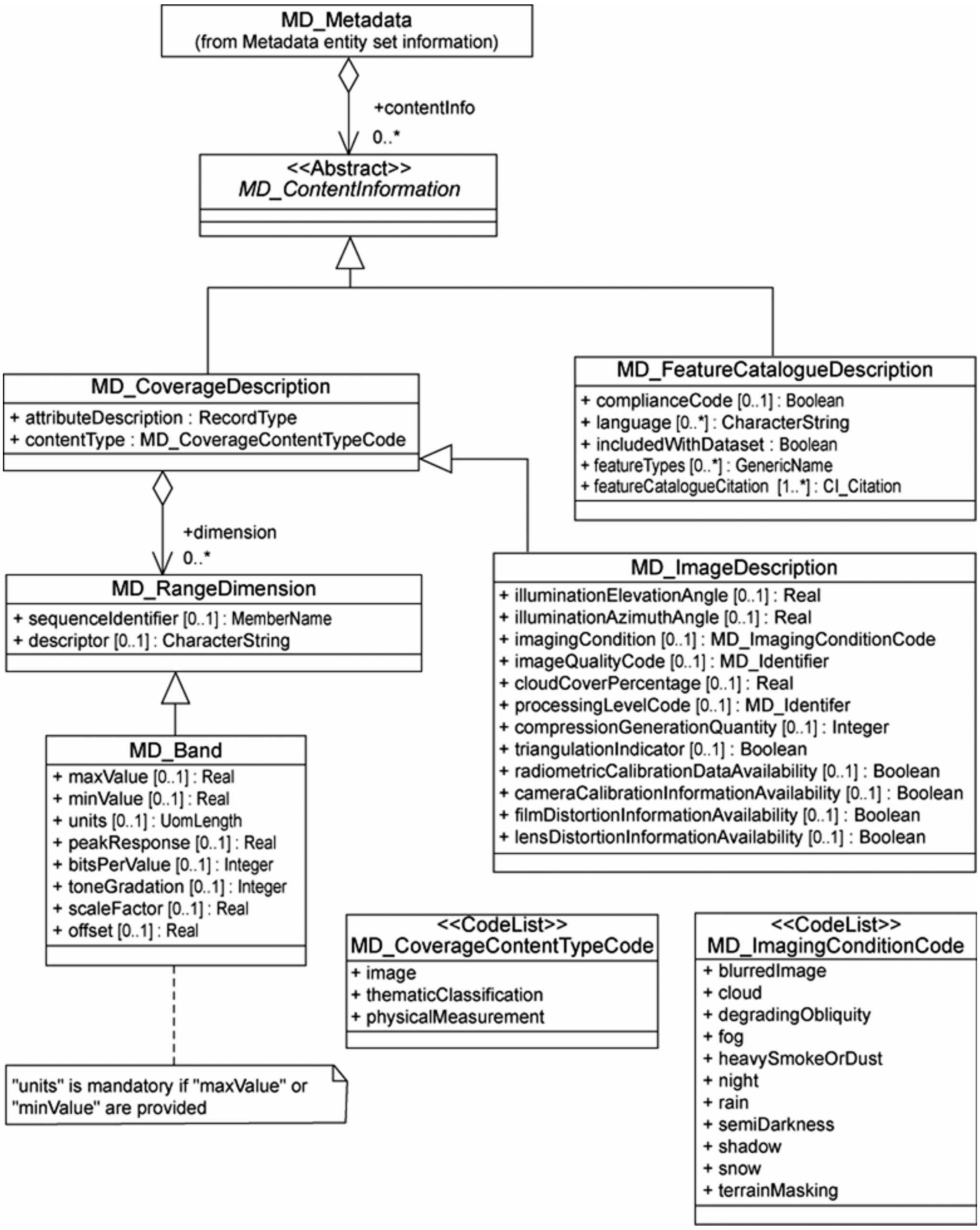
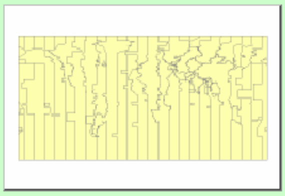



**Figure: Content information package with code list**

## *Sample of Metadata (in ESRI style sheet)*

### World Time Zones



**Data format:** SDC Feature Database

**Coordinate system:** GCS_WGS_1984

**Theme keywords:** polygon, time, time zone, greenwich mean time, location, transportation, regions

**Abstract:** World Time Zones represents the time zones of the world. The time zones are best displayed with World Countries or World Administrative Units.

**Figure: The header of the ESRI Style sheet metadata presentation in ArcCatalog**

**Metadata Information**

*__Metadata language:__ English
*__Metadata character set:__ utf16 - 16 bit UCS Transfer Format

*__Last update:__ 20050227

**Metadata contact:**
- **Individual's name:** Data Team
- **Organization's name:** ESRI
- **Contact's position:** Data Team
- **Contact's role:** publisher

- **Contact information:**
  - **Phone:**
    - **Voice:** 909-793-2853
    - **Fax:** 909-793-5953
  - **Address:**
    - **Delivery point:**
      - 380 New York Street
    - **City:** Redlands
    - **Administrative area:** California
    - **Postal code:** 92373-8100
    - **Country:** United States
    - **e-mail address:** info@esri.com

*__Scope of the data described by the metadata:__ dataset
*__Scope name:__ dataset

*__Name of the metadata standard used:__ ISO 19115 Geographic Information - Metadata
*__Version of the metadata standard:__ DIS_ESRI1.0

*__Metadata identifier:__ {79255D88-0EEA-4268-95CF-DDB3365DC706}

**Theme keywords:**
**Keywords:** polygon, time, time zone, greenwich mean time, location, transportation, regions

**Place keywords:**
**Keywords:** World

**Temporal keywords:**
**Keywords:** 2001, 2001, 2000, 1992, 1992, 1996, 1991

**Abstract:**
World Time Zones represents the time zones of the world. The time zones are best displayed with World Countries or World Administrative Units.

***Dataset language:** English

**Resource constraints:**
**Constraints:**
**Limitations of use:** See legal constraints.

**Legal constraints:**
**Access constraints:** license

**Use constraints:** other restrictions

**Other constraints:**
The data are provided by multiple, third party data vendors under license to ESRI for inclusion on ESRI Data & Maps for use with ESRI® software. Each data vendor has its own data licensing policies and may grant varying redistribution rights to end users. Please consult the redistribution rights below for this data set provided on ESRI Data & Maps. As used herein, "Geodata" shall mean any digital data set consisting of geographic data coordinates and associated attributes.

## Spatial Representation - Vector:

***Level of topology for this dataset:** geometry only
**Geometric objects:**
***Name:** timezone
***Object type:** complexes
***Object count:** 38

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## Reference System Information:

**Reference system identifier:**
***Value:** GCS_WGS_1984

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## Data Quality Information:

**Scope of quality information:**
**Level of the data:** dataset

**Lineage:**
**Lineage statement:**
www.nunavutcourtofjustice.ca (source 1 of 8)

Commissioner of Nunavut, 20010329, An Act to Amend the Interpretation Act (Time Zones): Commissioner of Nunavut, online.

Online links:
http://www.nunavutcourtofjustice.ca/library/statutes/2001ch4.pdf

Other citation details:
FIFTH SESSION FIRST LEGISLATIVE ASSEMBLY OF NUNAVUT, GOVERNMENT BILL. BILL 4

**Figure: An extraction of metadata from the ESRI Style sheet metadata presentation in ArcCatalog**

### 5.3.4 ISO Metadata: 19139 XML Schema

For the metadata record to be truly useful, it must be capable of being readily exchanged and of being read by software that indexes, searches, and retrieves the metadata records. To achieve this, the metadata record must be available in a well-structured and reliable format. The format should be software and hardware independent, in a particular standard, flexible and receptive to the extensions.

XML covers those requirements. A metadata record is a file of information, usually presented as an XML document, which captures the basic characteristics of a data or information resource. XML is a plain-text format that is independent of computing platforms, vendors, and software. XML is a so-called “meta-markup language” that has been developed to convey data. It is used to encapsulate data into files that can be:

- Displayed within web browsers
- Exchanged across the Internet between different computer applications and businesses
- Stored in and retrieved from databases

There is a consensus that metadata should be exchanged in Extensible Markup Language (XML) conforming to a Document Type Declaration (**DTD**) or in a more modern successor, the XML Schema Document (**XSD**).

Early drafts of ISO 19115 contained implementation information in the form of an annex with a Document Type Description. However, as ISO 19115 was developing, practice in the usage of XML was shifting from the use of DTDs to XML schema. Rather than delay progress of the ISO standard any further, it was decided to produce a separate technical specification with an XML schema that could be used to generate XML for ISO 19115 compliant metadata. This project was approved as ISO 19139.

ISO standard **19139, Geographic Information - Metadata - Implementation Specification***,* provides an ***XML Schema*** or Document Type Definition that says how ISO 19115 metadata should be stored in XML format. The Document Type Definition or XML Schema Document defines the set of structural rules and relationships and allows for the validation of metadata structure and codes. This document should govern XML implementation of ISO 19115: uses ISO 19118 rules to produce ISO 19139 XML from ISO 19115 UML Schemas.

There are typically three representations of metadata that should be supported in systems:

- The ***physical*** representation within a database or file system;
- The ***encoding*** representation designed for the transfer of metadata between software, (e.g. the Extensible Markup Language (XML) with structural rules enforced through a control DTD or XSD file to validate document structure);
- The ***display*** presentation in a particular style through a companion standard Extensible Stylesheet Language (**XSL**) that is suitable to viewing by users. Discussion about XSL will follow.

Metadata systems can support metadata creation and storage, standard encoding for exchange, and permits reporting views. The companion ISO 19139 Technical Specification provides normative guidance in the form of an annotated XML Schema Document, and by example, as to how the metadata must be *structured* as XML for validation and exchange. A metadata entry can be rendered in many ways from the same, single structured encoding.

*Structured* metadata has to be *parseable*. That is, standard elements within metadata must be clearly separated from each other. To *parse* information is to analyze it by disassembling it and recognizing its components. In addition, the elements' values have to be clearly related to the corresponding element names. In addition, the element names are clearly related to each other as they are in the standard. A metadata are usually arranged in a hierarchy, in the same way as elements are in the standard. They must use standard names for the elements as a way to identify the information contained in the element values. The parseability of metadata confirms the interoperability of metadata. DTD or XSD are used to control parseability or structure of metadata within the XML file.

The DTD defines the tags, constraints, attributes, structure, domains, etc. The tags are used as separators within XML documents. The XML document defines the content (the dataset metadata), the DTD defines the XML document structure. The DTM can be located: within the document, within the same folder/computer/server (e.g. C:\My Documents\My_Metadata.dtd) or from the Internet (e.g. http://www.opengis.net/geographicMetadata.dtd).

Metadata XML schema is published as supporting documentation within ISO 19139 standard. Clause 6.4.8 presents a detailed description of how to implement codelists.

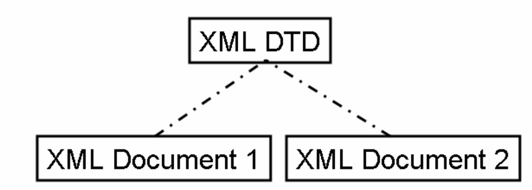


**Figure: Different XML encoding documents can be confirmed with one DTD schema**

Usually a single text file for each metadata record is created. Typically, a software program is used to assist the entry of information so that the metadata conforms to the standard. XML supports consistent and robust implementation via software tools for formatting and exchange, metadata harvesting, and other automated features. The new metadata formats (XML, DTD, XSD, XSL) are better supported by digital geospatial technologies (GIS, remote sensing, CAD, GPS, etc.). Before metadata were created in multiple formats (txt, doc, html, etc.) with the least robust structure and support.

```
<?xml version="1.0" ?>
<!-- <!DOCTYPE metadata SYSTEM
"http://www.esri.com/metadata/esriprof80.dtd"> -->
- <metadata xml:lang="en">
  - <Esri>
      <MetaID>{CEEAA4B9-6AD0-4444-8147-AFC972FF2301}
        </MetaID>
      <CreaDate>20000920</CreaDate>
      <CreaTime>15021200</CreaTime>
      <SyncOnce>FALSE</SyncOnce>
      <SyncDate>20040115</SyncDate>
      <SyncTime>20510500</SyncTime>
      <ModDate>20050227</ModDate>
      <ModTime>19145300</ModTime>
      <Sync>FALSE</Sync>
      <PublishedDocID>{79255D88-0EEA-4268-95CF-DDB3365DC706}
        </PublishedDocID>
    </Esri>
  - <idinfo>
      <native Sync="TRUE">Microsoft Windows 2000 Version 5.0
        (Build 2195) Service Pack 3; ESRI ArcCatalog
        8.3.0.800</native>
    - <descript>
        <langdata Sync="TRUE">en</langdata>
        <abstract>World Time Zones represents the time zones of the
          world. The time zones are best displayed with World
          Countries or World Administrative Units.</abstract>
        <purpose>World Time Zones provides time zones for
          countries and cities within them. Note that daylight-
          savings time is not shown.</purpose>
      </descript>
```


**Figure: XML view of a metadata file in ArcCatalog**

## 5.3.5 ISO Metadata Standard Profiling

As mentioned in Module 1, one does not need to invent independent standards; it is far better to select, wherever possible, international standards. International standards have very detailed metadata elements, sometimes more than necessary, for spatial data. However, there is always the opportunity to create unique profiles to meet national needs. It takes great to create a perfect profile of standard markers.

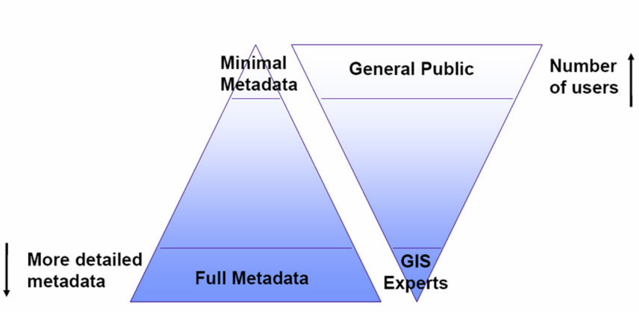


**Figure: Metadata completeness**

ISO 19115 Metadata standard became the “building code” for constructing national metadata standards. Each member of ISO, can craft their own profile of ISO 19115 with the requirement that it include the core elements. Many countries, regions, and communities are adopting profiles of ISO 19115 or ISO 19139 as their national standard. Each profile will make some modifications to the original 19115 or 19139 standards, and will typically have its own *XML Schema* or *Document Type Definition* (DTD) defining how metadata following that profile should be formatted.

A national profile will include:

- All ISO core elements
- Own selection of the non-core ISO elements

- Possible non-ISO extended elements

The last two customization options can also include conditionality upgrade, extend or/and establish code-lists.

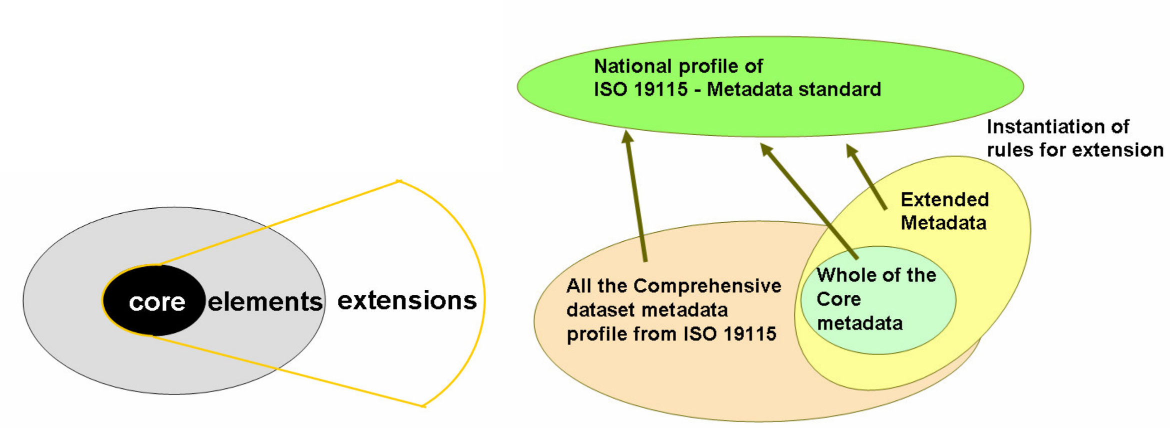


**Figure: Building the national profile:**

In accordance with ISO19115 Annex C, the rules for creating a profile are:

1) Before creating a profile, the user shall check registered profiles.
2) A profile must adhere to the rules for defining an extension.
3) A profile shall not change the name, definition, or data type of a metadata element.
4) A profile shall include:
   - the core metadata collected for a digital geographic dataset
   - all mandatory metadata elements in all mandatory sections
   - all conditional metadata elements in all mandatory sections, if the dataset meets the condition required by the metadata element
   - all mandatory metadata elements in all conditional sections, if the dataset meets the condition required by the section
   - all conditional metadata elements in all conditional sections, if the dataset meets the condition required by the metadata element and the section
5) Relationships, as provided in Annex A, shall be defined so that a structure and schema can be determined.
6) A profile shall be made available to anyone receiving metadata that was created according to that profile.

ISO profiles are scalable; they were used to create profiles for a variety of applications. The comprehensive metadata profile can be working through the establishment of one DTD, which can serve a wide variety of metadata XML documents. The ISO standard DTD exists on a globally accessible website (e.g. http://www.esri.com/metadata/esriprof80.dtd). XML metadata documents may have any amount of metadata and will work with the DTD as long as they have the minimum mandatory elements required by the DTD.

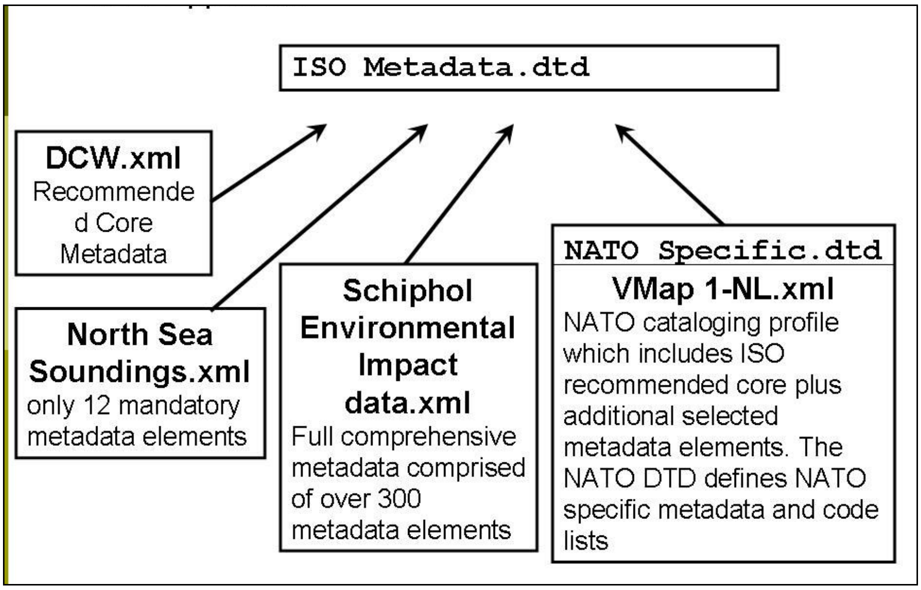


**Figure: Examples of profile applications**

ISO 19115 Annex C provides the rules for defining and applying additional metadata to better serve special user needs; Annex F provides guidance on extending metadata; additional metadata elements shall be defined according to the rules described in Annex C.

ISO 19115 Annex E and F provides sample for creation of *Comprehensive dataset metadata application profile* and *Metadata extension methodology respectively*.

### Profile Implementation Process

The steps required for the implementation of a profile are as follows:

- Creating draft metadata profiles (ISO 19115 Annex F)
- Designing and coding DTD or/and XML Schema Document (XSD) schemas for XML
- Designing and coding of Extensible Stylesheet Language (XSL) schemas
- Modeling and implementing the multifunction metadata tool

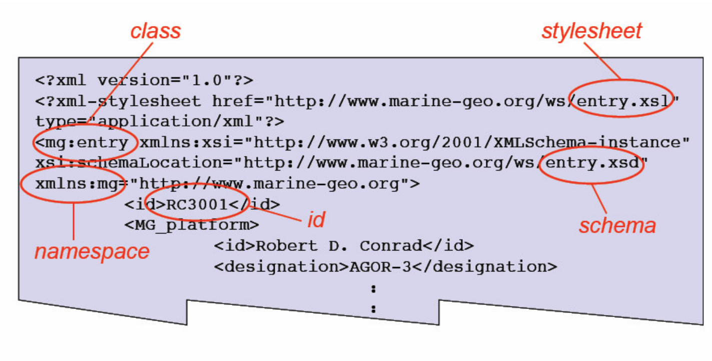


**Figure: Metadata XML record structure (www.marine-geo.org)**

UML tools can be used for the implementation of the first three steps noted above – the conceptual, logical, and physical (DTD and XSL) metadata models. XML DTD schema is prepared for standard metadata forms using UML. For flexible structure all the metadata components are defined as elements in DTD, however domains are attributes.

Since the metadata tool was considered web-based, the structure should have been conformed to the web environment. Therefore, XSL files are prepared for presenting the metadata on web browsers. XSL schemas are coded flexible as well, since users may want to avoid seeing the null data or unrelated elements of the metadata.

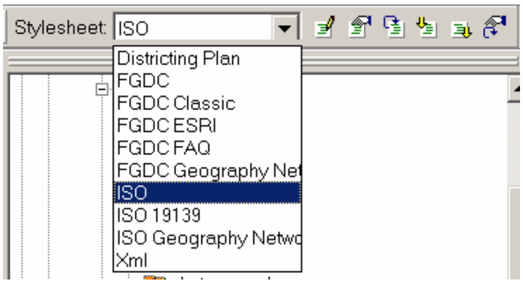


**Figure: Stylesheet (XSL) selection in ArcCatalog**

### 5.3.6 Making Metadata Part of the Geospatial Production Process

Metadata creation must be incorporated into the data development workflow process. Metadata capture and production can be distributed throughout the data development process. The responsibility for metadata production is distributed among those responsible for various stages of the process. Metadata collection tools have to be developed or adopted to meet the specific needs of the organization.

The major uses of metadata:

- Organize and maintain an organization's internal investment in spatial data
- Provide information about an organization's data holdings to data catalogues, clearinghouses, and brokerages
- Provide information to process and interpret data received through a transfer from an external source

Internal organizational initiatives in the use of metadata standards can be adapted to particular working environments. Core metadata provides sufficient information to enable an inquirer to ascertain what data is suitable for specific purposes. If, after core metadata is considered, more detail is needed for individual data sets then more comprehensive and more specific metadata can be added. It is possible that organizations may wish to develop metadata at different but complementary levels - at one level core metadata for external use and for in-house use more detailed metadata. To avoid duplication of effort, those elements common to both can be flagged.

During the organization and maintenance of metadata, the individual documenting the data set must fully understand error analyses and data quality assessment, the character and limitations of the source data, and the definitions and domains of all attributes. Even the contribution of each team member has to be recorded and the individual accountability, often lost in in-group projects, must be maintained. The data processing steps and variables have to be recorded as well. Metadata creation processes have to be mapped to data production workflows:

| Data Development Stage | Metadata Information |
|---|---|
| Data Planning | Identification Information |
| | Title, originator, abstract, purpose, keywords, time period |
| | Data Organization |
| | Point, raster, vector |
| | Spatial Referencing |
| | Coordinate system and datum |
| | Entity and Attributes (planned) |

| | |
|---|---|
| Data Processing | Data Quality<br>Completeness, positional accuracy, geoprocessing steps |
| Data Analysis | Data Quality<br>Attribute accuracy, analysis steps<br>Entity and Attributes (results)<br>Metadata Reference |

**Figure: Metadata mapped to workflow (Wayne, 2005)**

Metadata provides many benefits to organizational and individual geospatial data producers. However, quality metadata production requires additional resources and changes to existing data development procedures and policies.

However, there are obstacles to metadata production such as metadata standards are too extensive and difficult to implement; metadata production requires time and other resources; there are few tangible benefits and incentives to produce metadata, etc.

The following operational measures can be utilized to better integrate metadata production into the geospatial data development process: build administrative and staff support, create organizational metadata templates, map metadata fields to workflow and distribute production, develop/integrate metadata collection tools, and establish metadata procedures and policies (Wayne, 2005).

ISO19115 Annex G provides an overview of methods and ideas for the implementation and management of metadata for the purposes of search and retrieval, metadata exchange, and presentation.

### 5.3.7 Thesaurus and Controlled Vocabularies

When searching for information, the inquirer may not find any references based on the words used to describe the information sought. This problem can be overcome by use of a thesaurus. In the context of metadata and other electronic documents, a thesaurus is a tool for the organization and retrieval of information in electronic materials. For example, it will allow improved information retrieval by providing successful searching on synonyms. Consistent searching for metadata will be achieved if all those who prepare metadata use the same thesaurus. ISO 19155 specifies content guidance for field vocabulary.

Controlled vocabulary is a carefully selected list of *words* and *phrases*, which are used to *tag* units of information so that they may be more easily retrieved by a search. As discussed above, ISO 19155 provides extensible data dictionary and code lists that were derived from various library standards.

**Figure: Controlled vocabulary using code lists**

To improve the quality of search results the keyword thesauri (for example thematic thesauri CERES, http://www.ceres.ca.gov/thesaurus/), gazetteers (for example GNIS http://geonames.usgs.gov/redirect.html, etc.), resource types controlled vocabularies (ISO, etc.) can be used to fill a vocabulary of standard profiles.

## *5.4 Geospatial Metadata Tools*

Information collection tools are required to effectively implement metadata production. The metadata tools include functions for entering and editing metadata and utilities for pre-processing, extracting, post-processing, validating, and viewing metadata. Several metadata tools have been tuned to produce specific local metadata profiles.

Metadata tools should be selected or/and designed to meet the specific needs of the organization. Such tools include:

- Customary designed and programmed
- Existing software:
    - *Shareware metadata software*: Many government agencies developed in-house metadata production software when faced with federal requirements for metadata. Most of these products are freely distributed to the public.
    - *Commercial metadata software* fall into two categories: stand-alone and GIS-internal.

Stand-alone products generally allow the user to “harvest” some metadata information directly from the geospatial data set and provide a user-interface for additional data entry. These programs are typically robust production tools that facilitate the building of templates and libraries and enable interaction with a range of data types. As such, they are particularly useful to organizations that produce and manage data using multiple data development software.

The software providers for GIS have begun to incorporate the ISO 19115 in their system enabling the automated and back-grounded generation of metadata elements while the GIS data are updated. GIS-internal products also provide a data entry interface but, due to their proprietary nature, are able to harvest more information directly from the data set. Some metadata management systems use databases to minimize user input requirements.

A number of metadata editors have been written for different user communities on different computer platforms, and have been evaluated over time for their compliance and performance. Overview and links to metadata tools for geospatial data are published on independent metadata software evaluation site maintained by Hugh Philips and hosted by the Wisconsin Land Information Clearinghouse (http://sco.wisc.edu/wisclinc/metatool/).

When acquiring metadata production software, consumers should consider the functionality of software:

- What features are most important to you?
    - Create metadata
    - Edit metadata
    - Publish metadata
    - Bundle metadata with data
    - Create and use templates
    - Easy to use interface
    - Robust help systems and tutorials
- Does a metadata editor save or export metadata into an XML format?
- Does a metadata editor use Document Type Declaration (DTD) and XML Schema Document (XSD) representations to assist in validating the structure and content of the metadata?
- Does a metadata editor use XSL stylesheets to assist in the representation of content of the metadata? What stylesheets are supported?

- Does software provide an internal data/metadata management utility that supports the auto-capture of data set properties (e.g., extent, projection, attribute labels, etc.)?
- Do you need a tool that supports one or more ISO profiles or extensions?
- Do you need a tool that is easily distributed to partners?
- Does a metadata tool support conversion between different data standards?


**Figure: Conversion between Duplin Core via ISO 19115 (XSLT – XSL Transformation, http://www.w3.org/TR/xslt)**

| Dublin Core Element | ISO 19115 Element |
|---|---|
| DC.Creator/DC.Contributor/ DC.Publisher | Metadata.mdContact (CI_Contact) |
| DC.Date.created | Metadata.mdTimeSt |
| DC.Title | Metadata.idInfo.citation.title |
| DC.Date | Metadata.idInfo.citation.date |
| DC.Description | Metadata.idInfo.abstract |
| DC.Subject | Metadata.idInfo.descKeys |
| DC.Type | Metadata.idInfo.citation. presFormCd |
| DC.Format | Metadata.idInfo.dsFormat.formatName |
| | Metadata.idInfo.dsFormat.formatVer |
| DC.Identifier | Metadata.idInfo.citation.citId |
| DC.Source | Metadate.idInfo.citation.citedRespParty |
| DC.Relation | Metadata.(partOf/compOf/superset/subset) |
| DC.Language | Metadata.contentInfo.catLangCode |
| DC.Coverage | Metadata.dataIdent.geoBox |
| | Metadata.dataIdent.geoDesc |
| ? | Metadata.dataIdent.datExt.exDesc |
| | Metadata. dataIdent.datExt.geoEle.(westBL/eastBL/southBL/northBL) |
| | Metadata.dataIdent.datExt.tempEle |
| | Metadata.dataIdent.datExt.vertEle |
| DC.Rights | Metadata.idInfo.resConst.prpRtsCode |
| | Metadata.idInfo.resConst.useConsts |

**Figure: Mapping Duplin Core via ISO 19115**

Generally speaking, metadata is collected in a metadata editor that provides a user with input forms to enter, update, and output metadata. A metadata management system can be selected based on organizational computer environment, business practices, and expertise.

### 5.4.1 Adding Metadata in ESRI ArcGIS ArcCatalog

Few leading GIS software vendors incorporated metadata tools in their products or created standalone metadata tools. For example, ESRI and Intergraph are registered ISO reviewers and are poised for the transition. ESRI ArcCatalog offers ISO-style metadata options. Intergraph is developing the ISO conversion tool.

ESRI's ArcGIS ArcCatalog provides metadata management tools that include:

- Metadata creation and editing functions
- Data search and discovery functions
- Auto-capture of data properties from ESRI data

- Auto-update to metadata when data is edited (synchronization)
- Bundling of metadata with data upon export
- The ability to create metadata in ISO (not US Profile) and CSDGM formats

Because many metadata standards and profiles exist, metadata in ArcGIS is not required to meet any specific standard. However, it gives an option to produce metadata that follows a specific standard. For example, the XML generated by the ISO ArcCatalog metadata editor, follows the structure outlined by the DTD that accompanied the Final Draft version of the ISO 19115 standard.

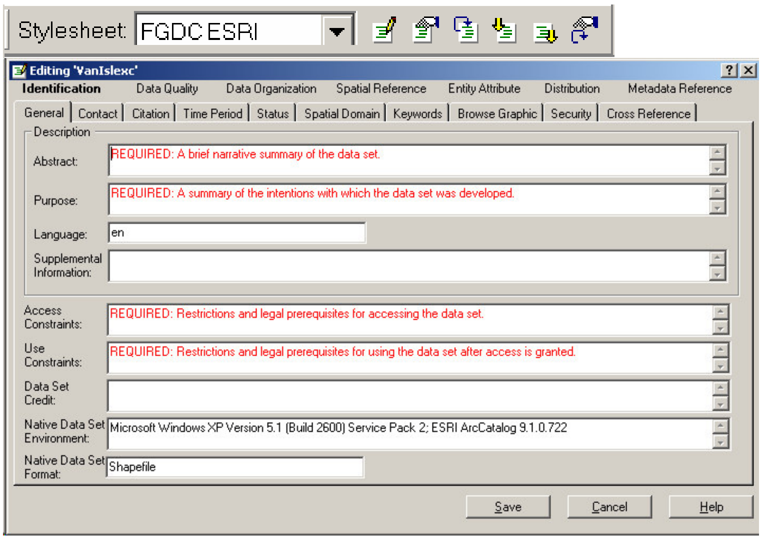


**Figure: ArcCatalog metadata management tools**

It is anticipated that the widespread adoption of the ISO 19115/19139 metadata standards will further encourage the development of an international base of free and commercial tools around a common standard.

### 5.4.2 Metadata: Conclusion

ISO 19115 development is based on a solid foundation of national, regional, and information community standards. It has broad global participation and gone through formal development cycles.

ISO 19115 Standard is based on a harmonized object model that is designed to fill a broad range of requirements. The standard has extensive use of codelists for language interoperability. ISO 19115 is a recommended core with a full comprehensive profile.

ISO 19115 Metadata is comprehensive. Most of what you need is already there. Adopt or build a national profile of the ISO 19139 Technical Specification based on the abstract ISO 19115 metadata standard. Progress in the definition of metadata and specifications for its implementation continues.

However, it may be a situation that you cannot find what you need. There is a risk that extension mechanisms can be used to define new metadata elements even if there are standard mechanisms that fulfill your requirements. Some ‘core’ metadata experts are needed to assist in the usage of metadata or national profiles.

As a GIS professional, you should create metadata any time that you create or edit a new data set that will be used by others. Data that you obtain from the Web will often have metadata attached.

## 5.5 Feature Catalogue

Interoperability task of data management has several areas of concern:

- Technical: “hardware/software compatibility”
- Institutional: “rules of engagement”
- Political: “requires common decisions”
- Legal: “what is allowed what is not”
- Semantic: “common understanding of data”
    - Feature Catalogues
    - Metadata

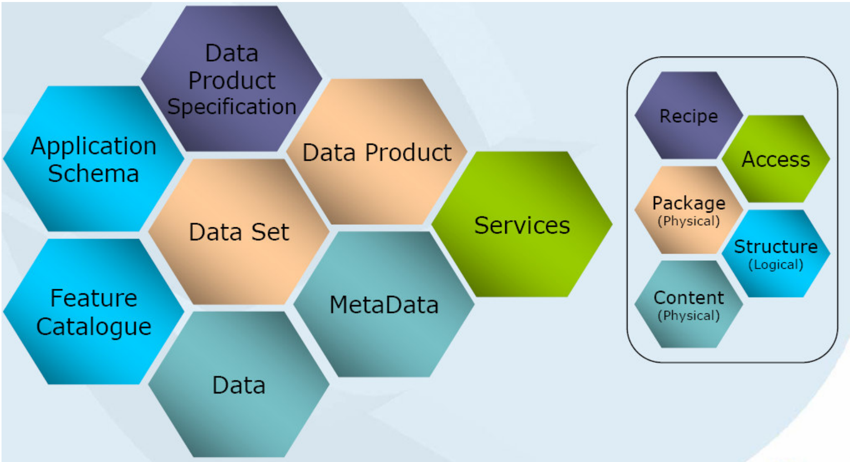


**Figure: Metadata and Feature catalogues positioning**

Metadata support and standards were discussed in previous sections. Other information about data organization required for Interoperability is catalogues. **Feature catalogues** defining the types of features, their operations, attributes, and relationships represented in geographic data are indispensable to turning the data into usable information (ISO 19110). **Feature catalogues** contain definitions and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data, together with any feature operations that may be applied.

Geographic features are real world phenomena associated with a location relative to the Earth, about which data are collected, maintained, and disseminated. Feature catalogues promote the dissemination, sharing, and use of geographic data by providing a better understanding of the *content* and *meaning* of the data. Unless suppliers and users of geographic data have a shared understanding of the kinds of real world phenomena represented by the data, users will be unable to access usefulness of the data supplied (ISO 19110).

Any set of geographic data is an abstraction of a complex and diverse world. A catalogue of feature types can never capture the richness of geographic reality. However, such a feature catalogue should present the particular abstraction represented in a given dataset clearly, precisely, and in a form readily understandable and accessible to users of the data.

A feature catalogue forms a repository for a set of definitions to classify real world phenomena of significance to a particular universe of discourse. The catalogue provides a means for organizing the data that represent these phenomena into categories so that the resulting information is as unambiguous, comprehensible, and useful as possible.

Within service-oriented architecture of geospatial data, catalogues provide feature descriptions for metadata search and retrieval. A feature is an abstraction of real world phenomena with common properties. The phenomenon “Eiffel Tower” may be classified, with other similar phenomena, into a “tower” feature type. In a feature catalogue, the basic level of classification is the feature type (e.g. “tower”).

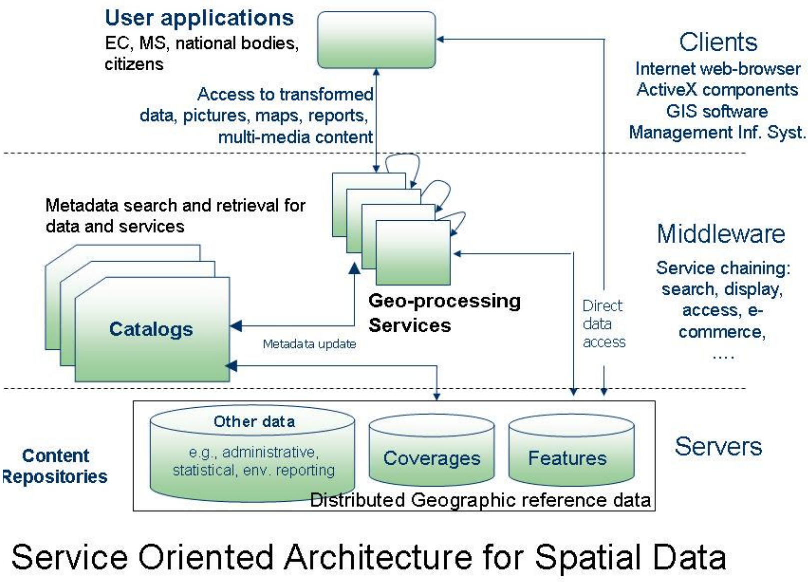


**Figure: Conceptual model service-oriented architecture for geospatial data**

There are three related ISO19100 standards that have to be taken into consideration in order to build and support feature catalogues. They are:

- ISO 19109 Geographic Information: Rules for application schema
- ISO 19110 Geographic Information: Methodology for feature cataloguing
- ISO 19115 Geographic Information: Metadata

ISO 19109 and 19115 were discussed in a previous module. In this section, ISO 19110 will be outlined, along with its relations to the other two ISO standards. The following figure shows the relationships among Feature Catalogue – Features – Application Schema – Metadata – Data.

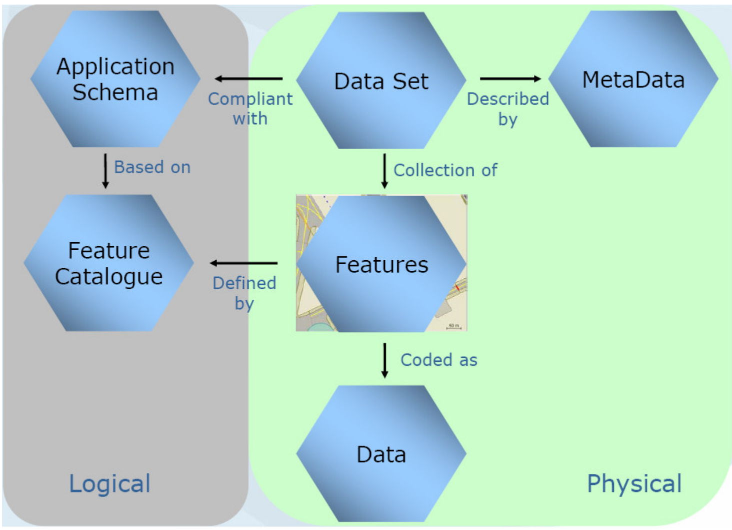


**Figure: Relationships among ISO 19109, 19110 and 19115**

### 5.5.1 ISO 19110: Methodology for Feature Cataloguing

**ISO 19110:2005 - Methodology for Feature Cataloguing** provides a standard framework for organizing and reporting the classification of real world phenomena in a set of geographic data. This standard defines the methodology for cataloguing feature types and specifies how the classification of feature types is organized into a feature catalogue and presented to the users of a set of geographic data (ISO 19110).

ISO 19110 is applicable
- To creating catalogues of feature types in previously un-catalogued domains
- To revising existing feature catalogues to comply with standard practice

ISO 19110 applies to the cataloguing of feature types that are represented in *digital* form. A feature catalogue is available in electronic form for any set of geographic data that contains feature types. Its principles can be extended when cataloguing other forms of geographic data.

Geographic features occur at two levels: instances and types. At the instance level, a geographic feature is represented as a discrete phenomenon that is associated with its geographic and temporal coordinates and may be portrayed by a particular graphic symbol. These individual feature instances are grouped into classes with common characteristics - feature types.

As already mentioned above, the basic level of classification in the ISO 19110 feature catalogue shall be the feature type ("tower", not specific feature like "Eiffel Tower"). This standard is not applicable to the representation of individual *instances* of each type and excludes *spatial*, *temporal*, and *portrayal* schemas as specified in ISO 19107, ISO 19108, and the future ISO 19117, respectively. It also excludes collection criteria for feature instances.

ISO 19910:2005 may be used as a basis for defining the *universe of discourse* being modeled in a particular application, or to standardize general aspects of real world features being modeled in more than one application. The feature catalogue shall present the abstraction of reality represented in one or more sets of geographic data as a defined classification of phenomena.

Feature Catalogue ISO 19110 standards provides the following guidelines:
- Feature catalogue template for the organization of feature catalogue information:
  - The template is presented as a table of feature catalogue contents
  - Obligations and conditions are stated for each element of the contents (M, C, O)
- The template defines the semantics and attributes for:
  - Feature Catalogue elements - identification and contact information for feature catalogue
  - Feature Type - class of real world phenomena with common properties
  - Feature Operation - operation that every instance of a feature type may perform
  - Feature Attribute - characteristic of the feature type
  - Attribute Value - value for the enumerated feature attribute value domain
  - Feature Association - relationship that links instances of the feature type with instances of the same or a different feature type

A feature catalogue is a catalogue containing the definition and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data, together with any feature operations that may be applied (ISO 19110).

Feature Attributes provide measures of the state of a feature as it exhibits certain kinds of behavior over time, not just static measures of the differences among features at a given instant in time. Some feature attributes are derived directly from feature operations. For example, the volume of traffic over the road section is a measure of its behavior. All road sections exhibit the operation of carrying traffic, making this property a part of the definition of the feature.

Feature operations are presented as a fourth major aspect of feature classification (together with feature types, the attributes associated with each type, and the relationships among the types). Feature operations are of two kinds: observer functions and constructor functions. Observer functions return the current values of attributes. Constructor functions include actions that change those values. For example, an observer function may be used to find the height of a bridge. Re-surfacing the bridge is a constructor function that changes the surface of the bridge and also affects the attributes of the road and the traffic associated with the bridge. Within this general framework, the operations (also called 'behaviors' or 'functions') of the features have generally been included as part of the definitional criteria, and have been expressed only in terms of the natural language definitions.

Feature relationships among the types may be one of two kinds – generalization or association. Associations may include aggregations or other logical relationships. Feature operations, attributes, and associations are properties that are inherited through generalization relationships. For example, the feature type “bridge” may belong both to the general class of 'transportation feature' for road features and to the general class of 'hazards' for navigation features.

| | Feature Catalogue Element | Definition | Obligation/ Condition | Maximum occurrence | Data type | Domain |
|---|---|---|---|---|---|---|
| | **Feature Attribute** | **Characteristic of the feature type** | **C/ feature attribute name occurs in ‘feature attribute names’ list?** | **N** | | |
| 31 | Name | Text string uniquely identifying feature attribute within the catalogue | M | 1 | text | free text |
| 32 | Definition | Definition of the feature attribute in a natural language | C/ Definition not provided by definition source? | 1 | text | free text |
| 33 | Code | Code that uniquely identifies the feature attribute within the catalogue | O | 1 | text | free text |
| 34 | Value Data Type | Data type of attribute values | C/ Definition not provided by definition source? | 1 | text | free text |

**Figure: The extract from feature catalogue content template**

The feature catalogue template is also illustrated in the form of a UML package.

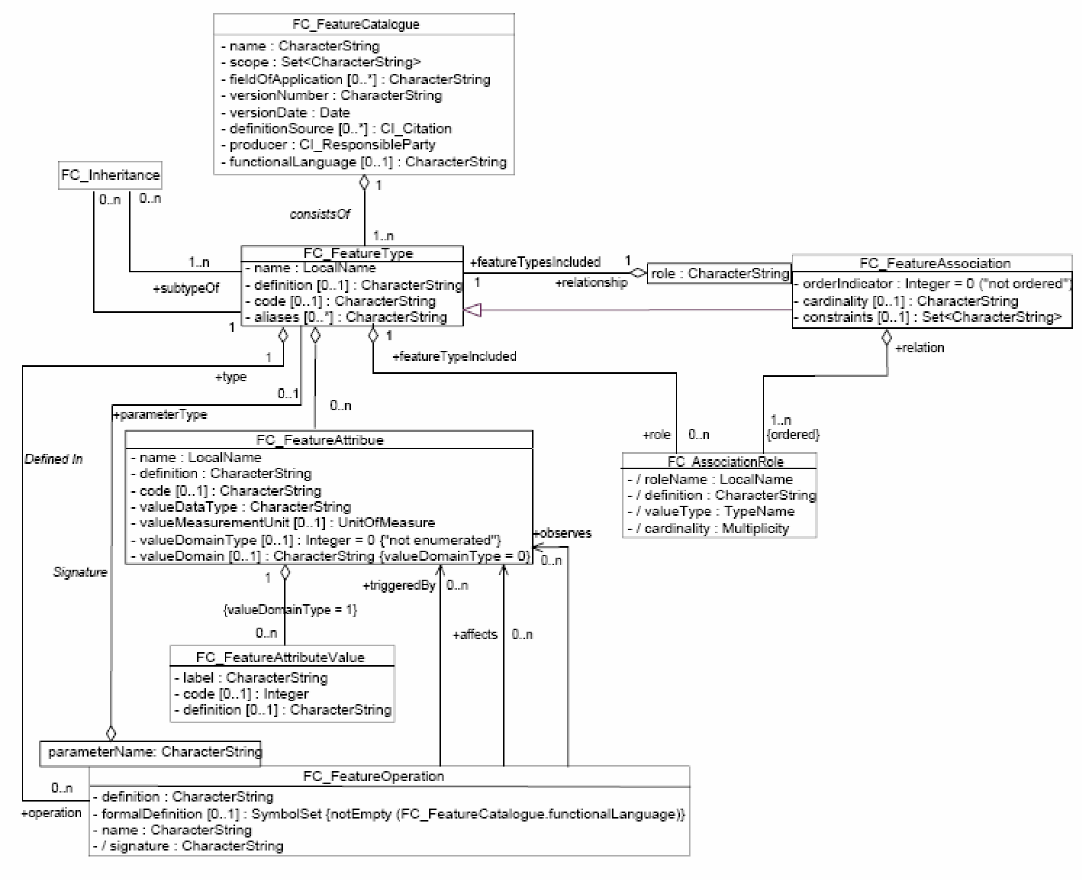


**Figure: Conceptual model of feature catalogue (ISO1910),**

This figure includes the kernel of the General Feature Model (GFM; ISO 19109) and illustrates that the concepts in the feature catalogue are realizations of General Feature Model elements. Feature Type realizes the GFM metaclass *feature type*. Feature Attribute realizes the GFM metaclass *attribute type*. Feature Association realizes the GFM metaclass *association type*. Association Role realizes the GFM metaclass *association role*. The feature catalogue relation 'subtype of' realizes the 'specialization' role of the GFM class *inheritance relation*. Feature Operation realizes the GFM metaclass *operation* (ISO 19110*)*.

It is recognized that geographic information is subjectively perceived and that its content depends upon the needs of particular applications. The needs of particular applications determine the way instances are grouped into types within a particular classification scheme. **ISO 19109, Geographic information - Rules for application schema** specifies how data shall be organized to reflect the particular needs of applications with similar data requirements.

As described in a previous module about ISO 19109, the application schema provides a formal description appearing as a data model or a formal description of the data structure and content of data sets. ISO 19109 provides the method designed with a purpose. The feature catalogue provides an inventory of the features according a normalized document.

The following extract's provide examples of Obstacle feature types and Obstacle attributes from a feature catalogue.

| | |
|---|---|
| Name: | Obstacle Feature Catalog |
| Scope: | Features as specified in " ED-98/DO-276 User Requirements for Terrain and Obstacles". |
| Version Number: | 1.0 |
| Version Date: | |
| Definition Source: | ED-98 / DO-276 "User Requirements for Terrain and Obstacle Data". |
| Definition Type: | |
| Producer: | RTCA SC-193 / EUROCAE WG44. |

**Feature Type: 'PointObstacle'**

| | |
|---|---|
| Name: | PointObstacle |
| Aliases: | OB_PointObstacle |
| Definition: | Obstacle with a limited horizontal extend represented as a point. |
| Attribute Names: | feattype, source, hres, hacc, hsttderv, hbias, hstnddev, hconf, vres, vacc, vsttderv, vbias, vstnddev, vconf, integr, revdate, revtime, efstdate, efsttime, efendate, efentime, elev, height, radius, obstype, status, geopnt, |

**Figure: Obstacle Feature Type**

**Feature Attribute: 'source'**

| | |
|---|---|
| Name: | source |
| Definition: | Name of entity or organization that supplied data according to EUROCAE ED-76/RTCA DO 200A. In case of initial data origination, name of data originator. |
| Value Data Type: | CharacterString |
| Value Measurement Unit: | |
| Value Domain Type: | 0 |
| Value Domain: | maximum 64 characters |
| Feature Attribute Values: | |

**Feature Attribute: 'hres'**

| | |
|---|---|
| Name: | hres |
| Definition: | Horizontal resolution of coordinates (latitude, longitude) defining the feature. |
| Value Data Type: | Real |
| Value Measurement Unit: | as specified in metadata horzUnit attribute. |
| Value Domain Type: | 0 |
| Value Domain: | [0.00000001, 1] |
| Feature Attribute Values: | |

**Figure: Obstacle Feature Attribute**

ISO 19115 full Metadata includes catalogue elements and structures.

- .

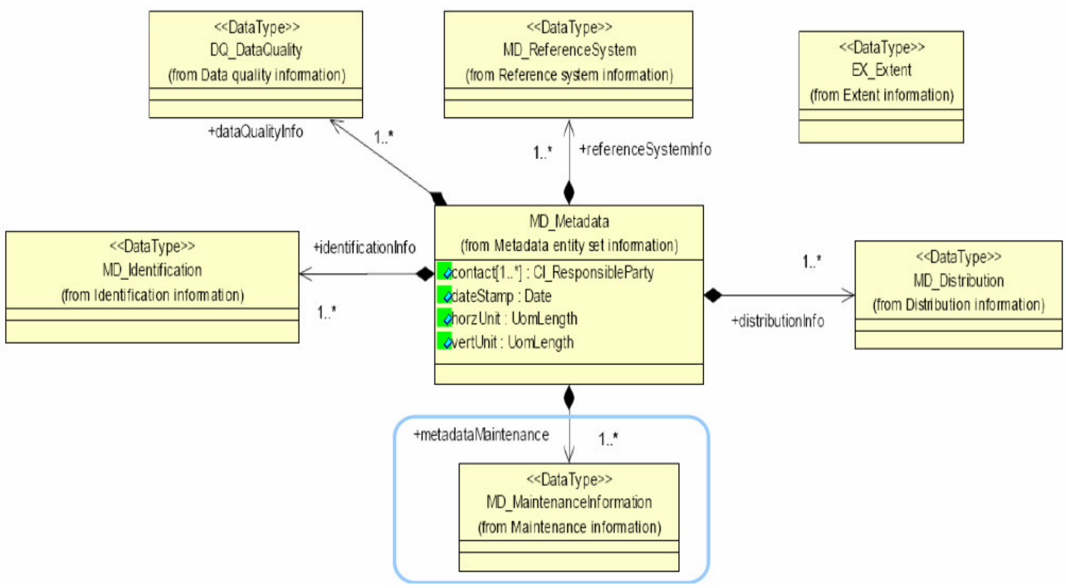


**Figure: Obstacle metadata example**

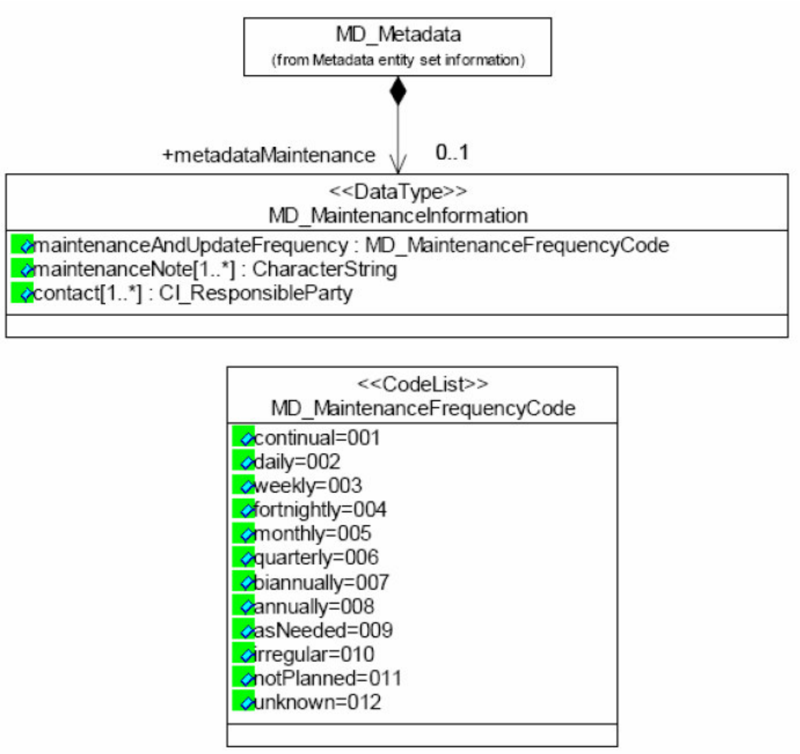


**Figure: Obstacle metadata example: Maintenance information**

ISO 19100. in combination with Open Geospatial Consortium (OGC) specifications, allows one to achieve both standardized digital products and services. Thus, ISO 19109 serves for the standardization of data descriptions within feature catalogues and OGC provides specification on how to create feature-cataloging services.

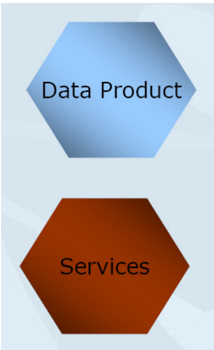


**Figure: ISO standards and OGC specifications define cataloging product and process for service-oriented geospatial data architecture**

## 5.5.2 ISO 19110: OpenGIS® Catalogue Services Specification

**OpenGIS® Catalogue Services Specification 07-006r1**, 2007, (http://www.opengeospatial.org/standards/cat), defines the interfaces between clients and catalogue services, through the presentation of abstract and application-specific models. **Catalogue services** support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogues represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. Catalogue services are required to support the discovery and binding to registered information resources within an information community (OGC, 2007).

OGC 07-006r1 specification defines (OGC, 07-006r1):

- Catalogue abstract information model provides:
  - Query language support:
    - The query capabilities of the OGC General Catalogue Model provide a minimum set of data types and query operations that can be assumed of OGC Compliant Catalogue implementations.
    - The minimal query language syntax is based on the SQL WHERE clause in the SQL SELECT statement. Implementations of query languages that are transformable to the OGC_Common Catalogue Query Language are the OGC Filter Specification and the CIP and GEO profiles of Z39.50 Type-1 queries.

  - Core catalogue schema:
    - A metadata schema (structures, relationships, and definitions) provides a common vocabulary that supports search, retrieval, display, and association between the description and the object being described.
    - Catalogues that handle geographic dataset descriptions should conform to published metadata standards and encodings, for example, ISO 19115:2003 and support XML encoding per ISO 19139 or profiles thereof. Service metadata elements should be consistent with ISO 19119.

- General catalogue interface models:
  - **Service interface** is shared boundary between an automated system or human being and another automated system or human being (ISO 19101).
  - OGC 07-006r1 defines a standard Application Programming Interfaces (API) for creating, updating, deleting and querying catalogue records.
  - The specification provides a set of abstract service interfaces on top of existing servers (CORBA, Z39.50, or HTTP) that support the discovery, access, maintenance, and organization of catalogues of geospatial information and related resources.
  - The interfaces specified allow users or application software to find information that exists in multiple distributed computing environments, including the www environment. All behavior requiring sessions is expressed by a dynamic model of conversation state and state transitions. The model expresses the states and messages that trigger the changes in state.
  - Implementation design guidance is included in the protocol binding clauses of this specification. Each protocol binding includes a mapping from the general interfaces, operations and parameters specified to the constructs available in a chosen protocol. Application profiles are intended to further document implementation choices.

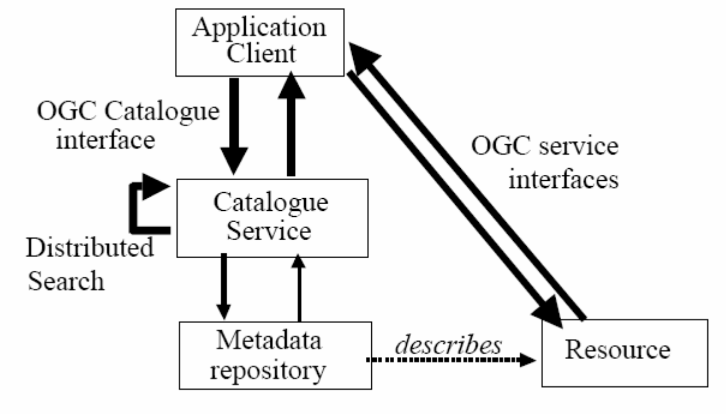


**Figure: Reference model architecture (OGC, 07-006r1)**

The figure above represents the Reference Architecture assumed for development of the OGC Catalogue Interface. The architecture is a multi-tier arrangement of clients and servers. To provide a context, the architecture shows more than just catalogue interfaces. The bold lines illustrate the scope of OGC Catalogue and Features interfaces.

The Application Client is shown with the Catalogue Service using the OGC Catalogue Interface. The Catalogue Service may draw on one of three sources to respond to the Catalogue Service request: a Metadata Repository local to the Catalogue Service, a Resource service, or another Catalogue Service. The interface to the local Metadata Repository is internal to the Catalogue Service. The interface to the Resource service can be a private or OGC Interface. The interface between Catalogue Services is the OGC Catalogue Interface. In this case, a Catalogue Service is acting as both a client and server. Data returned from an OGC Catalogue Service query is processed by the requesting Catalogue Service to return the data appropriate to the original Catalogue request.

The following operations are defined for the web catalogue service:

- **GetCapabilities**: provides service metadata
- **DescribeRecord**: allows clients to get a schema description of the catalogue's IM
- **GetDomain**: allows clients to discover the runtime value space for API parameters as well as other element within the information model
- **GetRecords** : the primary method for querying the catalogue. Supports distributed query
- **GetRecordById**: convenience request for getting records using their identifier
- **Push:** the primary method for creating, updating and deleting catalogue records
- **Pull**: allows the catalogue service to retrieve web-accessible metadata and register it in the catalogue. Supports periodic re-Harvesting of the resource

### 5.5.3 ISO 19110: Feature Catalogue: Conclusion

Feature Catalogues are interoperability cornerstones. Feature catalogues are important repositories of semantics. Without common semantics, interoperability cannot be achieved. Feature catalogues are interoperability enablers. Standardized ISO/OGC Spatial Data Infrastructures enable interoperable data exchange of geo-referenced information.

## 5.6 Quality Standards

Quality is an intrinsic property of any product. The quality of the geospatial data is important information for data reliability, interoperability, and accountability on all stages of data creation, distribution, and use. A product has to meet to the specific requirements for the intended use. In order to maintain product quality in a production process over time, standardization processes have to be introduced. The international standards ISO 9000 series are dealing with quality management and describe guidelines, terms, and quality models (ISO 9000, 2000).

ISO 9001:2000 standard specifies requirements for a quality management system for any organization that needs to demonstrate its ability to consistently provide a product that meets customer and applicable regulatory requirements. The standard is used for certification and contractual purposes for organizational quality management

When implementing a quality management system for geospatial information, the following ISO 9000 series of standards principles have to be addressed:

- Customer focus
- Leadership
- Involvement of people
- Process approach
- System approach to management
- Continual improvement
- Factual approach to decision making
- Mutually beneficial supplier relationship

ISO 19101 provides a graphical description of the essential relationship of quality to geographic data. Quality is described in details in the other ISO quality standards.

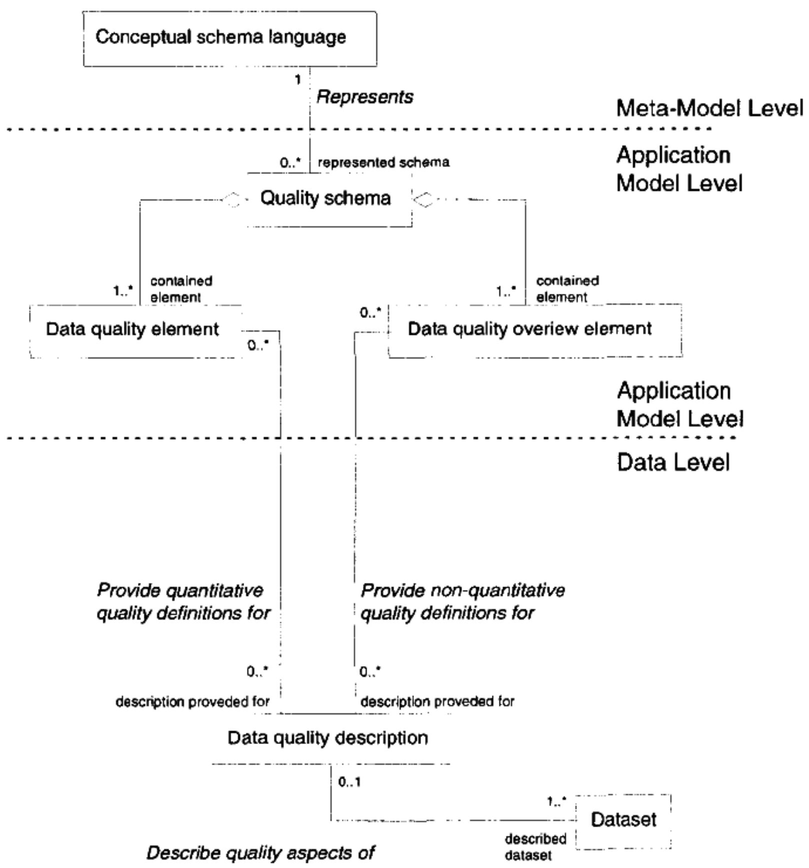

**Figure: Data quality and geographic information (ISO19101)**

*Data quality elements* and *data quality overview elements* are defined in the *quality schema*, a standardized schema at the *application model level*. The quality information for applicable *data quality elements* (that describe quantitative quality information) and *data quality overview elements* (that describe non-quantitative quality information) is reported in the *data quality description*, placed at the data level. The *data quality description* reports quality information for:

- geographic *datasets*, and
- individual *features*, *feature attributes*, or *feature relationships*.

Quality information may or may not be provided for geographic data; hence the relationship is denoted as being optional.

The ISO/TC 211 program of work contains several work items that are related to quality aspects of geospatial information. ISO/TC 211 provides a series of standards that deal with various aspects of geographical information / geomatics dataset products. The ISO/TC 211 Committee has produced a series of international standards dealing with quality. These are:

- **ISO 19113:2002 Geographic information -- Quality principles**
- **ISO 19114:2003 Geographic information -- Quality evaluation procedures**
- **ISO/TS 19138:2006 Geographic information -- Data quality measures**

Also, the international ISO 19115 standard on metadata for geospatial data contains a package dealing with data quality. Metadata quality elements are listed, as examples, in the metadata section of this module. ISO 19115 contains the only UML diagram that models the concepts of data quality. Metadata elements are defined to report quality evaluation results.

This section gives an overview of existing quality-related standards and how these standards interact.

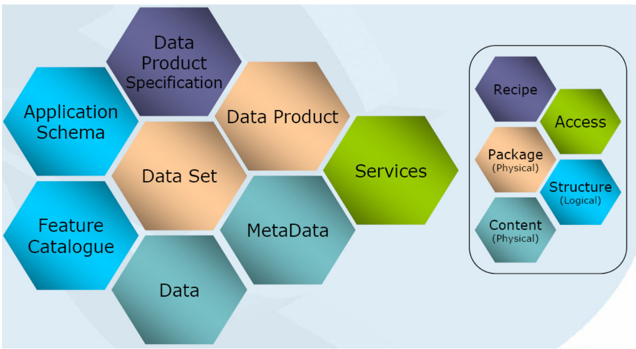


**Figure: Quality standards positioning (Data Product Specification)**

The following figure illustrates ISO standards related to Quality

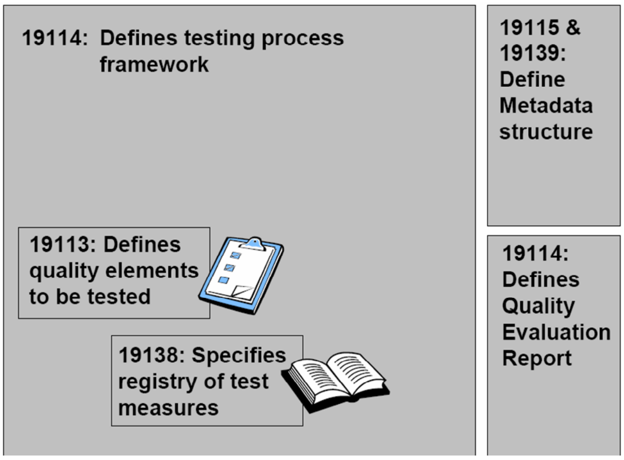


**Figure: Uses: product specifications / data models**

### 5.6.1 ISO 19113: Quality Principles Standard

The quality of a dataset describes how closely the information in an actual dataset represents the situation in the real world. The real world is too complex to comprehend as a whole and it is only possible to model as a product specification, based on user requirements. The product specification defines the content and the structure of the dataset. This is called the *universe of discourse* by ISO/TC teams. Any difference between actual data and the ideal in the *universe of discourse* model can be considered an error. ISO 19113 categorizes these errors into different elements and sub-elements depending on the nature of the error.

The universe of discourse is view of the real or hypothetical world that includes everything of interest (ISO 19104). The *universe of discourse* is an abstract concept that represents the targeted dataset for capturing of geographical reality**.** It can be envisioned as the ideal rather than the existing dataset. The actual data has to get as close as possible to this universe of discourse.

ISO 19113:2002 establishes the principles for describing the quality of geographic data. It specifies *components* for reporting quality information and provides an *approach to organizing* information about data quality.

Data producers can use this international standard when:

- Identifying and reporting quality information
- Evaluating the quality of a dataset:
  - Together with ISO 19114 that provides the framework for evaluating the quality of a dataset
- Developing product specifications and user requirements
- Specifying application schemas:
  - Together ISO 19114 and ISO 19115 describe schemas for reporting quality information.

ISO 19113 is applicable to data producers providing quality information to describe and assess how well a dataset meets its mapping of the universe of discourse as specified in the product specification, formal or implied, and to data users attempting to determine whether or not specific geographic data are of sufficient quality for their particular application. This international standard should be considered by organizations involved in data acquisition and purchase, in such a way that it makes it possible to fulfill the intentions of the product specification. It can, additionally, be used for defining application schemas and describing quality requirements (ISO 19113).

As well as being applicable to digital geographic data, the principles of ISO 19113 can be extended to identify, collect, and report the quality information for a geographic dataset. In addition, its principles can be extended and used to identify, collect, and report quality information for a dataset series or smaller groupings of data that are a subset of a dataset (ISO 19113).

Although ISO 19113:2002 is applicable to digital geographic data, its principles can be extended to many other forms of geographic data, such as maps, charts, and textual documents.

ISO 19113:2002 does not attempt to define a minimum acceptable level of quality for geographic data. The ISO 19113 standardizes the names and a scheme under which all differences of a dataset and the corresponding universe of discourse can be categorized. The following list of components used to categorize data quality aspects are defined in ISO 19113.

| |
|---|
| **Completeness** – presence and absence of features, their attributes and relationships:<br>▪ commission – excess data present in a dataset<br>▪ omission – data absent from a dataset |
| **Logical consistency** – degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical)<br>▪ conceptual consistency – adherence to rules of the conceptual schema<br>▪ domain consistency – adherence of values to the value domains<br>▪ format consistency – degree to which data is stored in accordance with the physical structure of the dataset<br>▪ topological consistency – correctness of the explicitly encoded topological characteristics of a dataset |
| **Positional accuracy** – accuracy of the position of features:<br>▪ absolute or external accuracy – closeness of reported coordinate values to values accepted as or being true:<br>▪ relative or internal accuracy – closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true<br>▪ gridded data position accuracy – closeness of gridded data position values to values accepted as or being true |
| **Temporal accuracy** – accuracy of the temporal attributes and temporal relationships of features:<br>▪ accuracy of a time measurement – correctness of the temporal references of an item (reporting of error in time measurement):<br>▪ temporal consistency – correctness of ordered events or sequences, if reported<br>▪ temporal validity – validity of data with respect to time |
| **Thematic accuracy** – accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships:<br>▪ classification correctness – comparison of the classes assigned to features or their attributes to a universe of discourse (e.g. ground truth or reference dataset)<br>▪ non-quantitative attribute correctness – correctness of non-quantitative attributes<br>▪ quantitative attribute accuracy – accuracy of quantitative attributes |

**Figure: Elements and sub-elements to categorize data quality aspects in ISO 19113**

### 5.6.2 ISO 19114: Quality Evaluation Procedures Standard

ISO 19113 provides only the principles as to how geospatial data can be described in terms of quality. ISO 19114:2003 gives guidance on assessing the quality of actual datasets. This international standard provides a framework of procedures for determining and evaluating quality that is applicable to digital geographic datasets, consistent with the data quality principles defined in ISO 19113.

Part of the scope of ISO 19114 is to establish a framework for evaluating and reporting data quality results, either as part of data quality metadata only, or also as a quality evaluation report. ISO 19114 is applicable to data producers when providing quality information on how well a dataset conforms to the product specification, and to data users attempting to determine, whether or not, the dataset contains data of sufficient quality to be fit for use in their particular applications.

This international standard recognizes that a data producer and a data user may view data quality from different perspectives. Conformance quality levels can be set using the data producer's product specification or a data user's data quality requirements. If the data user requires more data quality information than that provided by the data producer, the data user may follow the data producer's data quality evaluation process flow to get the additional information. In this case, the data user requirements are treated as a product specification for the purpose of using the data producer process flow.

Scope of this ISO 19114 is applicable to data producers when providing quality information on how well a dataset conforms to the product specification, and to data users attempting to determine whether or not the dataset contains data of sufficient quality to be fit for use in their particular applications.

Clause 6 of ISO 19114 defines five steps for quality evaluation. The quality evaluation process is a sequence of steps taken to produce a quality evaluation result. A quality evaluation process may be used in different phases of a product life cycle, having different objectives in each phase. The phases of the life cycle considered in ISO 19114 are specification, production, delivery, use and update. ISO 19114 Annex B describes some specific dataset-related operations to which quality evaluation procedures are applicable. Processes for evaluating data quality are applicable to static datasets and to dynamic datasets (that receive updates frequently). Annex C describes the application of the process to evaluate data quality to dynamic datasets.

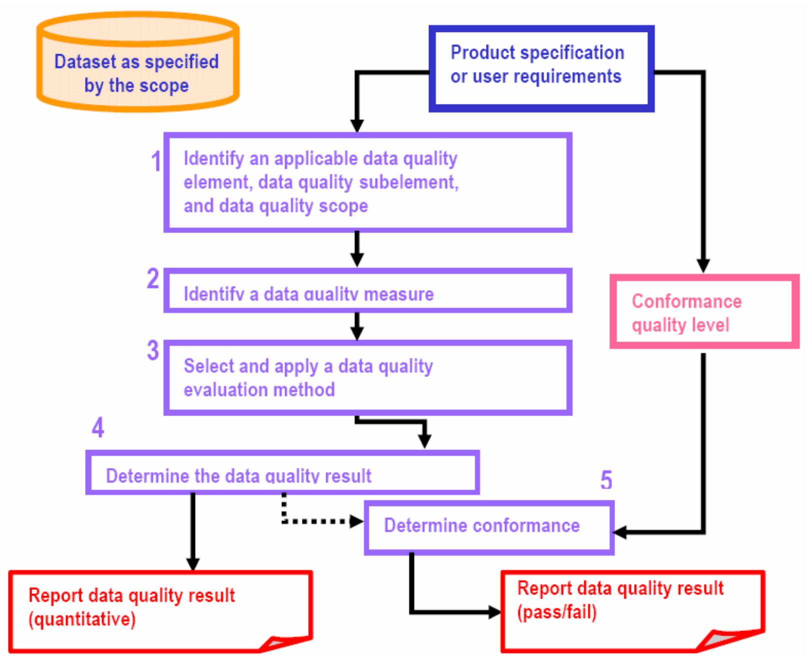


**Figure: Five steps of the process flow for evaluating and reporting data quality results according ISO 19114 (Joos, 2006)**

| Process step | Action | Description |
|---|---|---|
| 1 | Identify an applicable data quality element, data quality sub-element, and data quality scope | The data quality element, data quality sub-element, and data quality scope to be tested is identified in accordance with the requirements of ISO 19113. This is repeated for as many different tests as required by the product specification or user requirements. |
| 2 | Identify a data quality measure | A data quality measure, data quality value type and, if applicable, a data quality value unit is identified for each test to be performed. Annex D provides examples of data quality measures for the data quality elements and data quality sub-elements given in ISO 19113. Annex D, by these examples, provides assistance to the user in selection of a measure. |
| 3 | Select and apply a data quality evaluation method | A data quality evaluation method for each identified data quality measure is selected.<br>NOTE A spatial description of the results (achievable by spatial interpolation of the results, graphical portrayal, etc.) might be useful, corresponding not to a result, but to a different, although related, dataset. |
| 4 | Determine the data quality result | A quantitative data quality result, a data quality value or set of data quality values, a data quality value unit and a date are the output of applying the method. |
| 5 | Determine conformance | Whenever a conformance quality level has been specified in the product specification or user requirements, the data quality result is compared with it to determine conformance. A conformance data quality result (pass-fail) is the comparison of the quantitative data quality result with a conformance quality level. |

**Figure: ISO19114 Process steps**

How a *product specification* for quality evaluation elements has to be written by a quality evaluator is determined by the ISO 19131 standard. A quality evaluator has to decide:

- Which parts of the dataset have to be evaluated (scope):
    - This evaluation part of dataset is called data quality scope
- What aspects of the data quality (data quality elements and sub-elements) should be evaluated
- Selected data quality measures:
    - Step 2 shows the importance of data quality measures.
- Choose suitable evaluation methods that fit to the selected data quality measures
- The evaluation method is applied to determine the data quality result that can either be used to decide if the dataset fulfills certain quality requirements expressed as conformance quality level or to report the determined result as metadata or in a specific quality report.

A data quality evaluation procedure is accomplished through the application of one or more data quality evaluation methods. Data quality evaluation methods are divided into two main classes: direct and indirect. Direct methods determine data quality through the comparison of the data with internal and/or external reference information. Indirect methods infer or estimate data quality using information on the data, such as lineage. The direct evaluation methods are further subclassified by the source of the information needed to perform the evaluation into internal and external.

All the data needed to perform an internal direct data quality evaluation method are internal to the dataset being evaluated. External direct quality evaluation requires reference data external to the dataset being tested. For both external and internal evaluation methods, there are two considerations, automated or non-automated and full inspection or sampling.

The basis for all quality evaluations is the product specification since this specifies the universe of discourse that is the reference for the determination of data quality. ISO 19114 gives annexes with examples on data quality evaluations. ISO 19114 Annex B provides examples of stages of a product's life cycle during which quality evaluation procedures may be applied. ISO 19114 Annex F illustrates a quality evaluation procedure in use for measurement of thematic accuracy and completeness in a national topographic dataset. ISO 19114 Annex I annex describes the content of a detailed quantitative quality evaluation report. The quality evaluation report provides more detail about the quality results and the procedures used to compute them than is recorded in metadata.

A quality evaluator has to consider the following issues:

- Test scope:
  - Understand the scope of a testing exercise before starting:
    - Data series, data set, or data item
    - Testing points in relation to system architecture
  - Be clear what are testing:
    - Data or process
  - Product specification and maintained data are not necessarily the same
  - Agree formats for documentation and reporting

- Test design:
  - Sampling has to be used appropriately
  - Randomness assumptions do not necessarily apply
  - Full inspection may be expensive and/or time consuming
  - Clearly define the unit of testing:
    - Geographic features may require context to be measured
    - Features may be divided at sample boundaries
  - Building tests:
    - Automation will save time but may be difficult to set up
    - Ensure that process checks between systems are working on comparable items

- Determining conformance:
  - Acceptance Quality Limits (AQLs) should be defined independently of tests

- Reporting:
  - Check whether customers understand ISO quality terminology
  - Ensure that tests are adequately defined
  - Is the magnitude of a result understood
    - A small percentage error will mean large numbers of features are affected in a large dataset

 

### 5.6.3 ISO 19138: Data Quality Measures Standard

The data quality measures have to be defined in order to be able to compare quality information results. Quality evaluation results are expressed by data quality measures.

ISO 19113 only provides the principles and the levels of data quality sub-elements. In order to make data quality evaluation results applicable, it is important to use standardized data quality measures. ISO 19138 gives a structure how data quality measures can be built.

ISO/TS 19138:2006 defines a set of data quality measures. These can be used when reporting data quality for the data quality sub-elements identified in ISO 19113. Multiple measures are defined for each data quality sub-element and the choice of which to use will depend on the type of data and its intended purpose.

The data quality measures are structured so that they can be maintained in a register established in conformance with ISO 19135. ISO/TS 19138:2006 does not attempt to describe every possible data quality measure, only a set of commonly used ones.

In an normative annex, ISO/TS 19138:2006 provides *base* quality measures that can be used as an initial input that can be accessed to query data quality measures. There are principles that can be applied to most data quality measures. For example, for an error classification of type Boolean it is possible to report whether something is either correct or incorrect or it is possible to count all errors of the same category. The count result can then be used as a measure for this certain aspect of data quality. ISO 19138 provides a set of counting related data quality base measures that can be used to build a data quality measure without unnecessary duplication.

There are also data quality base measures for uncertainty related topics. They may be used to describe the uncertainty of arbitrary one or more dimensional random variables. To construct actual data quality measures the random variables have to be specified for any quantitative attribute value, uncertainty, or for positional accuracy.

The base measures are used for the measures that are provided in the standard and they can be used to build new measures to fulfill the user's requirements. Anybody constructing new data quality measures, for example in a maintenance process of a register, has to check to determine if a data quality base measure exists on which a new data quality measure can be based.

Each data quality measure is described by 13 components. Some of them are optional. These components are defined in conformance with the ISO 19135 standard for registration of geographic information items.

| Line | Component | Description |
|---|---|---|
| 1 | Name | Number of incorrectly classified features |
| 2 | Alias | – |
| 3 | Data quality element | Quality element to which measure applies (thematic accuracy) |
| 4 | Data quality sub-element | Classification correctness |
| 5 | Data quality basic measure | Error count, percentage etc |
| 6 | Definition | Definition of calculation method (e.g. number of incorrectly classified features) |
| 7 | Description | Including formulae used etc |
| 8 | Parameter | – |
| 9 | Data quality value type | E.g., integer. Duplicates description in ISO 19114. |
| 10 | Data quality value structure | – |
| 11 | Source reference | External reference (if applicable) |
| 12 | Example | – |
| 13 | Identifier | E.g., 62 |

**Figure: Examples of Data Quality Measures: Number of incorrectly classified features**

The *register* is the preferred way of providing data quality measures since it can be used by a user and by software. The software can reference to this register in order to avoid repetitive description of the same measure. Data quality measures have to be an extendable set due to fast development of geo-informatics field. Thus, a printed standard is only reviewed every 5 years. Therefore, a web repository tool can solve this problem. The ISO 19135 standard gives all the organizational requirements to set up and maintain such a web register. A registration authority could be responsible for new data quality measured to be added to the register, or existing ones changed or deprecated.

### 5.6.4 Data Quality Standards: Conclusion

There exist a number of quality-related standards as part of the ISO 19100 series of standards developed by ISO/TC 211. The different functions of these standards have to take into account the ISO 9000 quality management principles. The slight inconsistencies in minor technical aspects between the listed standards exist. ISO/TC 211 is aware of this open task and has started efforts to harmonize the listed standards.

A publicly available register for data quality measures is important for standard up-to-date maintenance. The implementation and publication of such a register for use by the geo-community is also an open issue.

## Module self-study questions:

26. What is geospatial data and how are they used?
27. What metadata standard is adopted within OGC?
28. What are the relationships between ISO9115 and ISO9139? What documents can be considered as a standard and what kind of document is more look like a specification?
29. What are discovery metadata? Name the ISO synonym for that term.
30. What is a feature catalogue and what is it indented for? What is the relationship between a catalogue and metadata?
31. What is the difference between an ISO "feature" and a "feature type"?
32. What is a Universe of Discourse? How is it used to define quality principles?
33. What standards define geospatial data and process quality? How does one build relationships among them? What is relationship between theses standards and metadata?

## Required Readings:

[13] *Chapter Three: Metadata -- Describing geospatial data* and *Chapter Four: Geospatial Data Catalogue -- Making data discoverable*, Developing Spatial Data Infrastructures: The SDI Cookbook, Editor: Douglas D. Nebert, Technical Working Group Chair, GSDI, Version 2.0 25 January, 2004, http://www.gsdi.org/docs2004/Cookbook/cookbookV2.0.pdf.

[14] Introduction to Metadata for NJDEP Employees, http://www.state.nj.us/dep/gis/metadata/intro_metadata/frame.htm.

[15] IDEC, ISO 19115 – compatible metadata schema, http://www.geoportal-idec.net/geoportal/eng/docs/perfilideceng.pdf

[16] OpenGIS® Catalogue Services Specification 07-006r1, 2007, (http://www.opengeospatial.org/standards/cat).

## References

[36] *Chapter Three: Metadata -- Describing geospatial data* and *Chapter Four: Geospatial Data Catalogue -- Making data discoverable*, Developing Spatial Data Infrastructures: The SDI Cookbook, Editor: Douglas D. Nebert, Technical Working Group Chair, GSDI, Version 2.0 25 January, 2004.
[37] ISO 9000:2005, Quality management systems - Fundamentals and vocabulary.
[38] ISO 9001:2000, Quality management systems – Requirements.
[39] ISO 9004:2000, Quality management systems - Guidelines for performance improvements.
[40] ISO 19113:2002, Geographic information - Quality principles.
[41] ISO 19114:2003, Geographic information - Quality evaluation procedures.
[42] ISO 19114:2003/Cor. 1:2005, Geographic information - Quality evaluation procedures – Corrigendum 1.
[43] ISO 19115:2003 19115, Geographic information – Metadata.
[44] ISO 19115:2003/Cor. 1:2005, Geographic information - Metadata - Corrigendum 1.
[45] ISO 19131:2006, Geographic information - Product specification.
[46] ISO 19135:2005, Geographic information - Procedures for item registration.

[47] ISO 19138:2006, Geographic information - Data quality measures.
[48] ISO/TS 19139:2007, Geographic information -- Metadata -- XML schema implementation
[49] OpenGIS® Catalogue Services Specification 07-006r1, 2007, (http://www.opengeospatial.org/standards/cat).
[50] Joos, G., Data Quality Standards, Proceeding of XXIII FIG Congress, 2006.

## Terms used

- Metadata
- Thesaurus
- Controlled Vocabulary
- Dublin Core
- CSDGM
- Metadata application
- Metadata packages
- Metadata datatypes and codelists
- Core or Discovery metadata
- Geospatial Metadata Tools
- Universe of discourse
- Feature
- Feature type
- Feature catalogue
- Feature attribute
- Feature association
- Feature operation
- Data product
- Service
- Service interface
- Quality principles
- Quality evaluation procedures
- Data quality measures
- Completeness
- Logical consistency
- Positional accuracy
- Temporal accuracy
- Thematic accuracy