Chapter 16
Standards—Making Geographic Information Discoverable, Accessible and Usable for Modern Cartography

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Abstract Cartography relies on data. Today, data is generated in unprecedented volumes, velocity, and variety. As a result, cartographers need ever more assistance in finding appropriate data for their maps and in harmonizing heterogeneous data before functional maps can be produced. Spatial data infrastructures (SDIs) provide the fundamental facilities, services and systems for finding data. Implementing standards for geographic information and services plays a significant role in facilitating harmonization and interoperability in an SDI. This chapter reviews collaboration between standards development organizations in the field of geographic information, and describes resources available for a model-driven approach in the implementation of geographic information standards. Subsequently, good practice examples from Canada, Denmark, Japan, and Europe illustrate how

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standards implementation facilitates harmonization and interoperability, and how SDIs make geographic information discoverable, accessible, and usable for modern cartography.

Keywords Standards implementation · Spatial data infrastructure (SDI) Map production · Cartography · Model-driven approach · Geographic information

16.1 Introduction

To make a map, one needs data. Today, data is generated in unprecedented volumes, velocity, and variety. User-generated content, a plethora of satellite platforms, ubiquitous sensors and smartphones are adding to the ever-increasing volumes of data. Some data is continuously streamed at a rate that requires novel ways to process the data. The diversity of devices generating the data results in vastly heterogeneous data. The challenge for cartographers is to find appropriate data among the vast volumes of data, and to produce functional maps from these heterogeneous data sources using modern cartographic tools. For this, interoperability is required.

Standards are the foundation and building blocks for harmonization and interoperability of geographic information in a spatial data infrastructure (SDI). Through the implementation of standards, an SDI provides the fundamental facilities, services and systems that make geographic information available, accessible, and usable for modern cartographers.

Standardization in the field of geographic information is a complex task that addresses many different aspects of interoperability, including data types for representing geographic and temporal information, data product specifications, metadata, services, and encodings. In today's fast-moving technology-integrated world, a model-driven approach provides implementation efficiency by simplifying the design process through standardized data models and by promoting communication through standardized terminology and descriptions of good practices.

This chapter begins with brief sketches of the background of standards development organizations in the field of geographic information and services. Next, Sect. 16.3 describes the terminology, data models, schemas, and ontologies available from ISO/TC 211 for a model-driven approach in the implementation of geographic information standards. In Sect. 16.4, good practice examples of standards implementation from Canada, Denmark, Japan, and Europe illustrate how standards make geographic information discoverable, accessible, and usable for modern cartography. Section 16.5 discusses alternatives to national SDIs, namely volunteered geographic information (VGI) and open government data, and the influence of these new paradigms on modern cartography. Finally, Sect. 16.6 summarizes and concludes the chapter.

16.2 Standards Development Organizations

ISO/TC 211, Geographic information/Geomatics, is the technical committee of the International Organization for Standardization (ISO) and is responsible for the standardization of geographic information. Established in 1994, its work aims at establishing a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. ISO/TC 211 covers semantic, syntactic, and service issues, as well as procedural standards, at various levels of abstraction.

The Open Geospatial Consortium (OGC) is a voluntary consensus standards organization, also established in 1994. The focus of OGC work is to define, document, and test implementation specifications for use with geospatial content and services. OGC specifications leverage the abstract standards defined by ISO/TC 211. Approved OGC specifications, as well as any schemas (xsd, xslt, etc.) supporting them, are published and freely available on the OGC website (e.g. see Chap. 14, Baumann).

The International Hydrographic Organization (IHO) is an intergovernmental consultative and technical organization established in 1921 to support safety of navigation and the protection of the marine environment. Among its main objectives, IHO is tasked to bring about the greatest possible uniformity in nautical charts and documents (i.e. standardization).

OGC and ISO/TC 211 have a long history of collaboration and development of joint standards. For example, OGC specifications have been submitted to ISO/TC 211 for consideration for approval as International Standards. OGC focuses on specifications that can be directly implemented; many of these are based on the conceptual (or abstract) models defined by ISO/TC 211 or jointly between the organizations. The cooperation between IHO and ISO/TC 211 has been driven by the development of standards for digital hydrographical information and products. IHO standards are based on various standards in the ISO 19100 series of standards (ISO/TC 211 2013).

Collaboration with other standards developing organizations ensures that geographic information and services are aligned with state-of-the-art technologies in the era of modern cartography. For example, the Internet Engineering Task Force (IETF) develops and promotes standards for the Internet, which are widely used. Some of these, e.g. IETF RFC 3986, Uniform Resource Identifier (URI): Generic Syntax, are referenced in standards for geographic information. Similarly, standards by the World Wide Web Consortium (W3C) are referenced, such as editions of the W3C Recommendation, Extensible Markup Language (XML). The Geomatics Committee of the International Association of Oil and Gas Producers (OGP), through its Geodesy Subcommittee, maintains and publishes a dataset of parameters for coordinate reference system and coordinate transformation descriptions, collectively referred to as 'EPSG codes'. These codes are used to uniquely identify a coordinate reference system in various IHO, OGC and ISO standards.

16.3 Resources for Model-Driven Implementations of Geographic Information Standards

16.3.1 Terminology

A vocabulary is an important resource for all who seek an understanding of the community's cultures and practices. The terms and definitions identify the concepts that characterize the community's philosophies, technologies and activities. Its structure and supporting information identify relationships between concepts and the context for their intended used.

ISO/TC 211 has compiled a vocabulary for geographic information by aggregating the terminology clauses from each of the ISO/TC 211 International Standards and Technical Specifications. The vocabulary is published as ISO/TC 211 Multi-Lingual Glossary of Terms (MLGT) and is freely available on the Resources page of the ISO/TC 211 website (ISO/TC 211 2017). The MLGT currently includes terminology records in 14 different languages, namely Arabic, Chinese, Danish, Dutch, English, Finnish, French, German, Japanese, Korean, Polish, Russian, Spanish, and Swedish.

The development of the terminology needs to be carefully managed and coordinated. There are terms and concepts in general language dictionaries that correctly designate and describe geographic information concepts. Similarly, there are geographic information concepts that have already been designated and defined in standards or similar documentation. These are adopted whenever possible, avoiding the unnecessary proliferation of terminological entries.

Quite often, however, definitions in general language dictionaries are insufficiently rigorous or concise to describe the concept. In such cases, the concept, term and definition are refined or adapted, as appropriate. To add a term to the vocabulary, the following steps are required: (1) the identification of a concept; (2) the nomination of a designation (usually a term) for that concept; and (3) the construction of a definition that unambiguously describes the concept.

The identification of concepts is arguably the most complex and demanding part of the terminology development process. The complexity stems from the fact that concepts do not exist in isolation but always in relation to each other, giving rise to a concept system—a set of concepts that are distinct but related to each other. Each concept is capable of separate description and may also be capable of further decomposition, as illustrated in Fig. 16.1. The process of decomposition ceases when the concepts become so basic that they do not need to be defined.

Once the concept has been identified, a single term, the '*Preferred Term*', is adopted as the primary designator. Sometimes there may also be a shortened form of the *Preferred Term*, referred to as the *Abbreviated Term*. The role of a definition is to precisely describe the content of an identified concept. It should be as brief as possible, containing only that information that makes the concept unique, focusing on encapsulation rather than exclusion.

The concept "**coordinate reference system**" is defined as

"*coordinate system that is related to an object by a datum*" [ISO 19111:2007. 4.8].

It associates the concepts "**coordinate system**", which is defined as

"*set of mathematical rules for specifying how coordinates are to be assigned to points [ISO 19111:2007, 4.10],*

and "**datum**", which is defined as

"*parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system" [ISO 19111:2007, 4.14].*

Further decomposition of "**coordinate system**" and "**datum**" into component concepts is possible (for example, into "**coordinate**", "**origin**", "**scale**", "***axis***")

In addition, "**coordinate reference system**" becomes the superordinate concept for more specific concept "**compound coordinate reference system**".

Fig. 16.1 Concept decomposition

In ISO/TC 211, the Terminology Repository is the principal information system for terminology maintenance and harmonisation. It incorporates six registers, shown in Fig. 16.2. The Document Register contains documents that contribute terminological entries to the Terminology Repository. The Terminology Spreadsheet contains the terminological entries from the most recent draft or published document for each ISO/TC 211 work item. The Terminology Archive contains the terminological entries from drafts and published documents that have been superseded. The Symbols and Abbreviations Registers respectively contain symbols and abbreviations from the most recent draft or published document for each ISO/TC 211 work item. The Packages Register identifies the bi-alpha prefixes associated with UML packages in ISO/TC 211 documents. From these registers, the MLGT is generated and published at regular intervals.

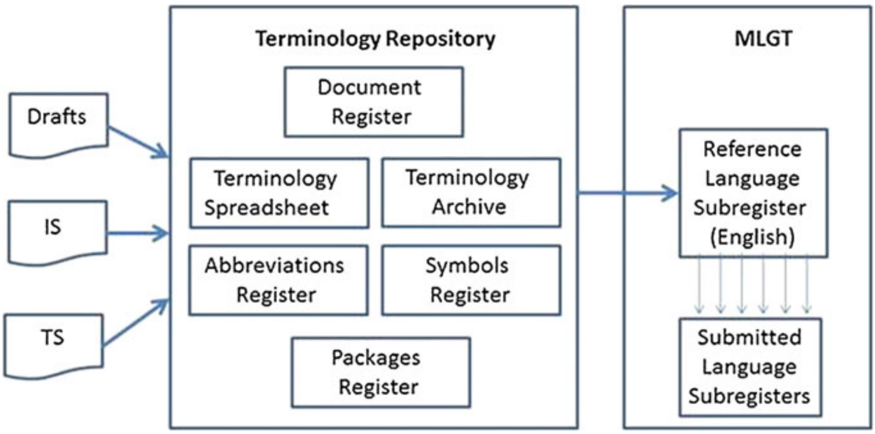

Fig. 16.2 ISO/TC 211 terminology registers (ISO/TC 211 2015)

16.3.2 Harmonized Model, Schemas, and Ontologies

Conceptual models in ISO/TC 211 documents are developed in the Unified Modeling Language (UML), based on the ISO/TC 211 profile of UML defined in ISO 19103:2015, *Geographic information—Conceptual schema language*. The UML models included in the different standards are maintained in a single harmonized model repository, commonly referred to as the *Harmonized Model*, under the responsibility of the Harmonized Model Maintenance Group (HMMG).

The GitHub (2017) repository of the HMMG (ISO/TC 211 HMMG 2017) provides guidance for using the *Harmonized Model*. From there, the models can be downloaded as Enterprise Architect (Sparx Systems 2017) projects or as XMI files for packages. In addition, an HTML view of the model is available, as shown in Fig. 16.3.

Implementation schemas for XML and RDF (Resource Description Framework) are generated from the *Harmonized Model*, based on encoding rules defined in ISO/TC 211 standards. To support the Semantic Web community, a suite of ontology standards for geographic information is currently under development. When completed, there will be six parts of ISO 19150, *Geographic information—Ontology*. Based on these standards, OWL (Web Ontology Language) versions of the ISO/TC

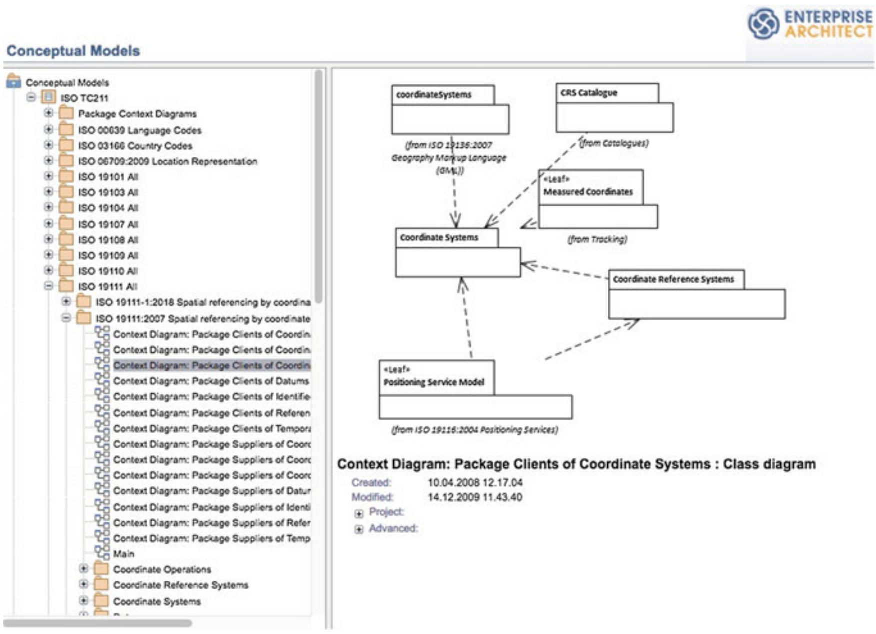

Fig. 16.3 HTML view of the harmonized model in the GitHub repository of the HMMG (ISO/TC 211 HMMG 2017)

211 UML conceptual models have been generated and are published in the GitHub repository of the ISO/TC 211 Group on Ontology Maintenance (GOM).

The models, schemas and ontologies are readily available for anyone who wants to follow a model-driven approach in an implementation of ISO/TC 211 standards. Further implementation guidance is provided on the Standards Wiki (2017).

16.4 Examples of Good Practice

16.4.1 Canada

The Standards user's guide for geographic information published by Natural Resources Canada (2016) was written to support the proper use of geographic information standards. The guide provides background and practical knowledge about standards that support an SDI implementation and, in this specific case, the implementation of the Canadian Geospatial Data Infrastructure (CGDI). The guide addresses three main topics: (1) the establishment of a Geospatial Information Environment, (2) the creation of a Data Product, and (3) the implementation of Web Services.

Geospatial Information Environment. This is the fundamental notion supporting an SDI; it comprises individuals, organizations, and systems that collect, process, disseminate, or act on geographic information, and includes the information itself (Joint Chiefs of Staff 2014). The Geospatial Information Environment, portrayed in Fig. 16.4, includes (1) data structures and schemas described in a standardized application schema; (2) data descriptions and semantics in standardized feature catalogues; (3) standardized metadata; (4) data and metadata capture operations; (5) data (the data elements); (6) data management; (7) discovery; (8) access; and (9) transformation. All these components are well covered by both ISO/TC 211 and OGC standards.

Using a hydrographic network as an example to illustrate a Geospatial Information Environment, first, the required feature types (e.g. river, lake, waterbody, watercourse, stream, creek, bridge, island, obstacle to navigation, geographical name, etc.), their characteristics (e.g. geometry, flow direction, permanency, height, accuracy, etc.), and the associations between feature types (e.g. lake ↔ geographical name, river ↔ bridge, etc.) need to be identified as part of an application schema. Second, these feature types, their characteristics, and the role they play in an association must be defined in a feature catalogue and as appropriate in a concept dictionary to define their semantics for appropriate uses.

Typically, different topics and layers of geographic information are defined and maintained by various stakeholders within a Geospatial Information Environment. Therefore, it is appropriate to set a schema repository that documents all the application schemas and their related feature catalogues, including code lists (permitted attribute values), metadata elements, and encoding types. Additional

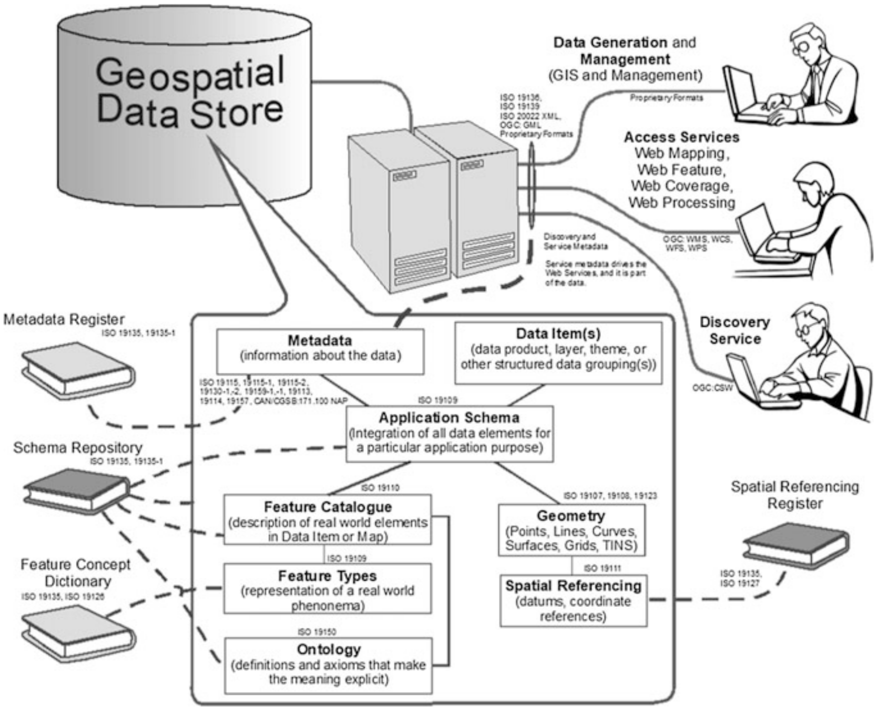

Fig. 16.4 Geospatial information environment (Natural Resources Canada 2016)

information can be included in the schema repository, to support, for instance portrayal application (symbol sets and style sheets), and Semantic Web applications (e.g. ontologies). Data is then acquired and compiled according to the application schema and its feature catalogue. Geospatial data, along with the schema repository, is maintained in a geospatial data store. The geospatial data store supports the management, maintenance, discovery, access, and use of the geospatial data in this Geospatial Information Environment.

Data Products. Geospatial data products are based on the content of the geospatial data store. Ideally, a data product is detailed in a data product specification, comprising application schema, metadata elements, feature catalogues, conformance tests, encoding and portrayal information. The data product specification also provides details on the process for data acquisition (e.g., capture criteria), post processing (e.g., quality control, validation, error correction), and maintenance processes (e.g., revision cycle and methodology).

Printed maps, map series in various scales, GML (Geography Markup Language) files, and ESRI Shape™ files are examples of data products. In Canada, the GeoBase series is an example of an integrated data product. It includes the Canadian Digital Elevation Data (CDED), the National Hydro Network (NHN), the National Road Network (NRN), the National Railway Network (NRWN), Land

Cover—circa 2000-Vector (LCC2000-V), the Canadian Geographical Names, the Aboriginal Lands of Canada, the Municipal Boundaries, the Canadian Geopolitical Boundaries, the GeoBase Orthoimage 2005–2010, the GeoBase Raw Imagery 2005–2010, the Landsat-7 Orthoimage, the Landsat-7 Level 1-G, the RADARSAT-1 Orthorectified Imagery, and the Control Points for Landsat 7 Imagery (Natural Resources Canada 2017). Each of the above is documented in a data product specification compliant with ISO 19131:2007, *Geographic information—Data product specifications*. It is also good practice to include the data product specifications in the schema repository.

Web Services. Nowadays, printed maps have mostly been replaced by digital maps or digital data, which are both accessible online or downloadable via services on the Internet. Relevant web service standards include the Catalogue Service for the Web (CSW) (OGC 2007a) for data discovery by the way of metadata; Web Map Service (WMS) (OGC 2006) for delivering image maps via the Internet; Web Feature Service (WFS) (OGC 2002) for delivering (vector based) geographic feature data via the Internet; Web Coverage Services (WCS) (OGC 2012) for delivering images and other kinds of coverage data via the Internet; and Web Processing Service (WPS) (OGC 2007b) for processing geospatial data, e.g. converting data from one encoding format to another, or transforming it from one projection to another.

As part of the Canadian Geospatial Data Infrastructure, Canada has released Open Maps on its Open Government Portal (Government of Canada 2017b). Various maps can be browsed and data can be downloaded. More recently, a geospatial data extraction tool (Government of Canada 2017a) with similar functionalities has been launched. A screenshot is included in Fig. 16.5.

16.4.2 Denmark

In the Danish eGovernment Strategy for the period 2011–2015 (Digitalisering sstyrelsen 2011), the vision was to create a simple, more efficient and coherent public sector (government agencies and municipalities). The aim was to achieve this through digitalization and reuse of data across domains. The data covered by the strategy, called *basic data*, originate from five different governmental organizations: the Danish Geodata Agency; the Agency for Data Supply and Efficiency; the Danish Business Authority; the Civil Registration System; and the Danish Taxation Authority.

Over the years, each of the organizations had developed their own environment and conditions for data modelling, information security, distribution of data, and conditions for the access and use of data. To provide their data for reuse across domains, the environments and conditions had to be harmonized. One way of achieving this was through the use of standards, either Danish national standards and/or Danish profiles of international standards.

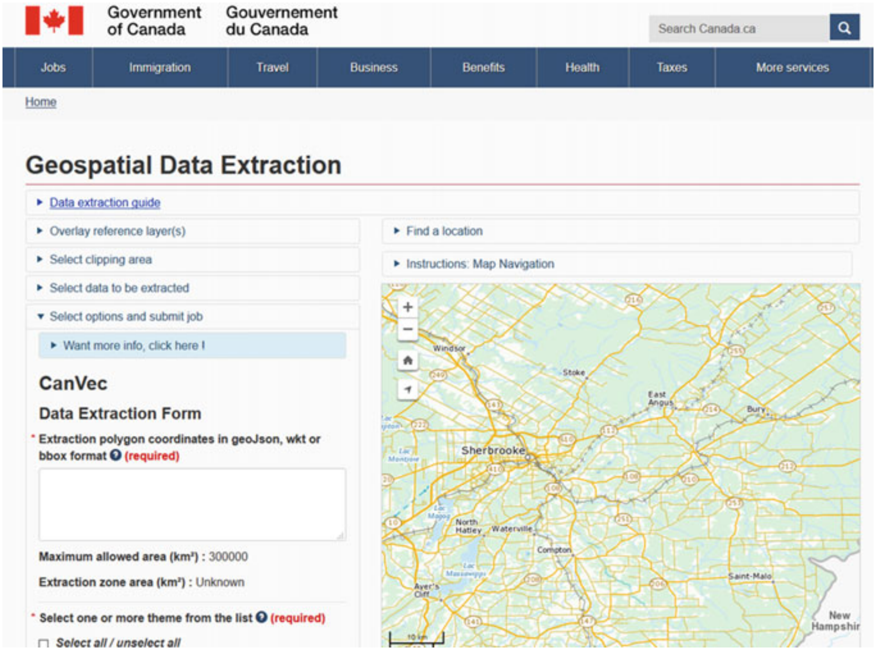

Fig. 16.5 Geospatial data extraction (Government of Canada 2017a)

Data Modelling. The first step in the implementation of the strategy was the development of a single coherent data model of all the basic data. The purpose was to provide an overview and terminology of the basic data and its attribute information, and to show how the basic data fit together across the domains (Datafordeler 2017). Given that the data from the different organizations were historically modelled in different ways and documented in different modelling languages, it was decided to use a common modelling language. UML, or a profile thereof, was selected because it is internationally recognized and used in e.g. ISO/TC211, OGC and INSPIRE (INfrastructure for SPatial InfoRmation in Europe).

In addition to using the same modelling language for all the basic data, various rules for modelling were also developed (OIO Arkitekturguiden 2017a). These rules were based on international standards from ISO, OGC, INSPIRE and Danish national standards (OIO Arkitekturguiden 2017b). The rationale for these modelling rules was to ensure a common approach to the modelling task by the various stakeholders. The rules ensure that the modelling of data objects is based on a common set of guidelines, and that the entire model is based on common normative properties. The result enabled the basic data to be interoperable and re-used across various domains.

Information Security. Since 2014, it is mandatory for all governmental organizations to use a national standard for information security. In 2016, this national standard was replaced by ISO/IEC 27001, *Information security management*.

Among the many reasons for this change, was to ensure uniform and high-level security across the Danish eGovernment and to ensure that Danish citizens trusted the Danish eGovernment solution. In addition, the use of an international standard would pave the way for international interoperability.

Distribution of Data. In order to distribute the basic data, a single point of access website was created, called the *Data Distributor*. This access point contains all the basic data and receives geospatial and other data from the organizations mentioned above in XML and GML formats. These formats imply that the organization responsible for handling the data works with a single standardized format and does not have to handle all kinds of proprietary formats used by owners of the basic data.

For the distribution of the Danish basic data, a service-oriented solution was chosen, i.e. the user can either obtain the basic data via a file download, a web service solution, or an event driven solution. For the file download, the common FTP (File Transfer Protocol) is used.

For the web services, solutions were chosen that relied heavily on standards originating from both OGC and ISO/TC 211. The suite of download services consists of the following: REST (REpresentational State Transfer), WFS (Web Feature Service), WMS (Web Map Service), WMTS (Web Map Tile Service), and WCS (Web Coverage Service). These web services provide online access to the basic data, thereby allowing users to always have access to the latest version of the basic data. The event driven solution is based on an event driven architecture.

Conditions for Access and Use. These conditions are closely related to the distribution of basic data. For some data, users only need to register to gain access to the data, whereas for other types of data, access is restricted due to the sensitivity of the data. Adding to these requirements, Denmark must also conform to the EU Regulation 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, which can be regarded, in some ways, as a standard.

16.4.3 Japan

Japan has been active in ISO/TC 211 as a participating member since 1994, led by the Geospatial Information Authority of Japan (GSI) in the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Domestically, the organization of TC 211 activities in Japan is carried out under the auspices of the Japan TC 211 National Body. This committee is administered by the Association of Precise Survey and Applied Technology (APA) whose broad membership includes geospatial experts from the public, private and academic sectors.

Recognizing the benefit of using standards for the delivery and exchange of geospatial data, the ISO/TC 211 suite of standards was adopted and translated for domestic use as Japanese Industrial Standards (JIS). The work was guided first by a public-private research project for geospatial standardization and later by the

Geographic Information Standardization Committee for JIS from the late 1990s. Following this, the first edition of the tentative *Japanese Standard for Geographic Information* (JSGI 1.0) was released in 1999. These activities continued to produce translated versions of a number of ISO/TC 211 standards as JIS documents (GSI 2015).

Following ISO/TC 211's program of work, translations and registrations of new standards continued in Japan, resulting in the first release of the *Japan Profile for Geographic Information Standards* (*JPGIS*) in 2005 (GSI 2017g). Having a narrower structure than JSGI, JPGIS is applicable to actual deliverable data requirements. JPGIS continues to be actively updated with the latest revision, JPGIS2014, from April 2014 (GSI 2014b).

By using JPGIS, it is possible to create product specifications for data exchange that clearly describe the definition, structure, quality, recording method, and other characteristics of the data according to neutral and common rules. JPGIS consolidates constructs from the following ISO/TC 211 standards (GSI 2017f):

- ISO/TS 19103, Geographic information—Conceptual schema language
- ISO 19105, Geographic information—Conformance and testing (replaced by JIS X 7105)
- ISO 19107, Geographic information—Spatial schema (replaced by JIS X 7107)
- ISO 19108, Geographic information—Temporal schema (replaced by JIS X 7108)
- ISO 19109, Geographic information—Rules for application schema (replaced by JIS X 7109)
- ISO 19110, Geographic information—Methodology for feature cataloguing (replaced by JIS X 7110)
- ISO 19111, Geographic information—Spatial referencing by coordinates (replaced by JIS X 7111)
- ISO 19112, Geographic information—Spatial referencing by geographic identifiers (replaced by JIS X 7112)
- ISO 19115, Geographic information—Metadata (replaced by JIS X 7115)
- ISO 19118, Geographic information—Encoding
- ISO 19123, Geographic information—Schema for coverage geometry and functions (replaced by JIS X 7123)
- ISO 19131, Geographic information—Data product specifications (replaced by JIS X 7131)
- ISO 19136, Geographic information—Geography Markup Language (GML) (replaced by JIS X 7136)

In addition, JPGIS compliant product specifications for deliverable data must be used to clarify contract requirements and enhance data exchange for all public (national or local level) surveying contracts in Japan. Since mid-2008, GSI has been using product specifications compliant with JPGIS as a data exchange format for the Fundamental Geospatial Data (FGD) product, with distribution of seamless data beginning in 2014 (GSI 2014a). FGD is a standards-based digital dataset offering complete domestic coverage of Japan by seamlessly integrating data at two scales: 1:2500 data collected from municipalities for areas where urban planning data is available; and 1:25,000 data for areas without urban planning data (GSI 2017d).

The FGD consists of the following vector layers: geodetic control points, hydrology, coast/shore lines, administrative boundaries (town, community and street-blocks with centroids), road edges, railroad track centrelines, known ground surface elevation points, and building footprints.

GSI maintains a rigorous revision schedule with quarterly releases of the data (GSI 2017a). In addition, as stipulated by regulations of the *Basic Act on the Advancement of Utilizing Geospatial Information* (Act No. 63 of May 30, 2007), the data is available via the Internet and can be used by anyone free of charge (Japan 2007).

In keeping with current technology trends and for convenience, GSI offers an online web-based end-user interface, *GSI Maps* (GSI 2017d) Fig. 16.6, an application programming interface (API) for developers along with web map tile services of pre-rendered image tile sets for the current FGD, in addition to a number of other map products produced by GSI (2017b). Currently, the distribution of vector tile sets is being tested (GSI 2017c).

Since 2013, APA has operated the *Certification of Professionals in Standards for Geographic Information* (S-GI-Cert) framework (APA 2017). The S-GI-Cert comprises three levels: *Beginner*, *Intermediate*, and *Advanced*. *Beginner* level applicants are required to understand the purpose of geographic information standards and have basic geospatial and geodesy knowledge. At the *Intermediate* level, applicants are required to show knowledge of how to develop a geographic data specification in accordance with geographic information standards. Finally,

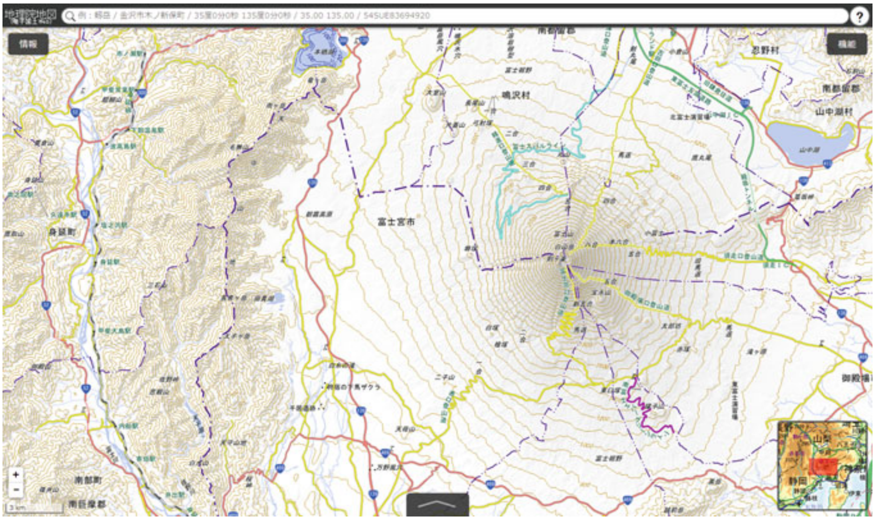

Fig. 16.6 Mount Fuji area, *GSI Maps* Web Interface (GSI 2017e)

Advanced level applicants are required to utilize geographic information standards to an even more advanced technical level to create new standards. In addition, the three certification levels have an expiration date of five years, giving applicants an incentive to maintain their certification.

Year on year, the number of certified professionals has increased. In 2014, GSI recognized this certification as one of the prerequisites for bidding on their surveying, topographic map compilation and other cartographic and geospatial related contracts. Currently, professionals who have already obtained beginner level certification are encouraged to progress to a higher level of certification. To facilitate this, opportunities for learning how to utilize geographic information standards and new training techniques to further improve *skill building* are being developed.

Another certification program in Japan was established by the GIS Association (GISA) in cooperation with seven academic associations and non-profit organizations. The GIS Certification Association (GISCA) program (GISA 2017), launched in 2014, organizes educational courses introducing geographic information technology based on geographic information (GI) standards (Ota and Plews 2015; Ota 2017) for industry professionals and students in higher education.

16.4.4 INSPIRE in Europe

INSPIRE is an EU-Directive established by the European Parliament and EU Council in 2007 that addresses 34 spatial data themes needed for environmental applications (INSPIRE 2007, see Chap. 3). The main objective is to facilitate access to cross border harmonized spatial datasets and services at a defined quality level with clearly formulated and concise usage rights.

To support objectives of the Directive, Implementation Rules (IR) were developed for metadata, data specifications, network services, data and service sharing, spatial dataset services and monitoring, and reporting issues. The Implementing Rules have been adopted as Commission Decisions or Regulations and are binding in their entirety. They specify the requirements at an abstract and generic level, while the Technical Guidelines (TG) describe how legal obligations could be implemented based on international standards for geographic information. The relationship between the IR and the TG documents is shown in Fig. 16.7.

Syntactic and sematic interoperability. Data specifications for each theme were developed with the aim to guarantee the best possible level of syntactic and semantic interoperability. For each of the themes, experts developed a UML data model, based on ISO 19103:2015, *Geographic information—Conceptual schema* and ISO 19109:2015, *Geographic information—Rules for application schema*. After a consolidation phase, the UML models were automatically translated into GML application schemas. In various cases, more than one application schema was generated for the same theme, accommodating the different aspects of that theme. For example, five GML schemas are published for the land use data specification, accommodating existing land use, planned land use, gridded land use, sampled land

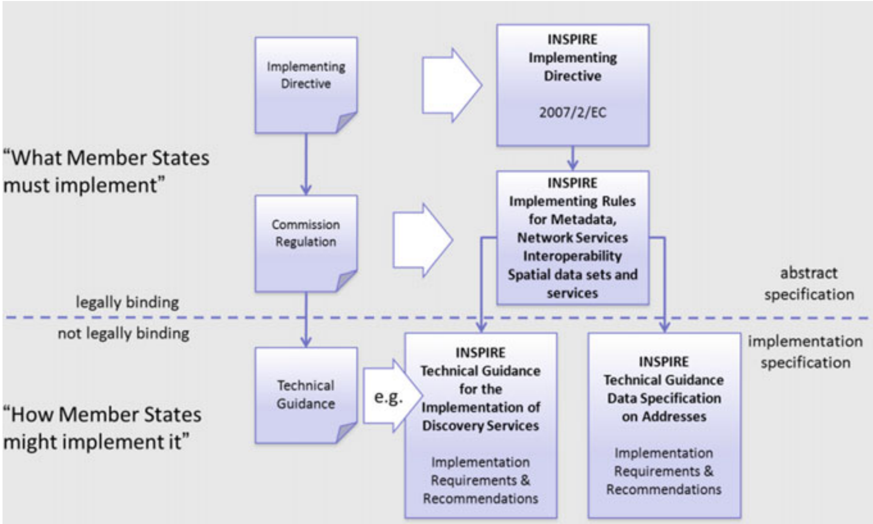

Fig. 16.7 Relationship between INSPIRE implementing rules and technical guidance documents (INSPIRE Thematic Working Group *Addresses* 2009)

use, and land use nomenclatures. The different application schemas incorporate the semantics of the data models, a first step towards syntactic harmonisation of datasets for a specific theme.

To ensure the highest possible semantic interoperability for a specific theme, existing and domain agreed terminology is required. One critical fact within the whole INSPIRE modelling process was that domain specific terminology did not exist for all themes. If a domain agreed terminology was available, semantic interoperability was established by defining a mapping between domain terms and national or local terms used in the source datasets. For all other themes, there is a placeholder for the term in the data model so that source terminology can be considered during harmonization. For such themes, the degree of semantic interoperability is lower and cross-border use of the dataset requires pre-processing.

Data quality validation. Quality issues are addressed by the implementation of a validation procedure. For each theme, conformance classes were defined in the form of Abstract Test Suites (ATS). These were translated into Executable Test Suites (ETS) and implemented in the validation platforms, such as the INSPIRE Validator (INSPIRE 2017). The validation procedure is based on international standards in the ISO 19100 series. When datasets are encoded according to ISO 19136:2007, *Geographic information—Geography Markup Language* (*GML*), a fully automatic validation of many quality aspects is possible, including not only geometry and data consistency, but also semantic issues like the validation of code list values.

16.5 Discussion

In the last decade, new methods for the acquisition of spatial data and the creation of maps have become prevalent. Specifically, Volunteered Geographic Information (VGI) and Open Government Data initiatives have had a positive impact on the modern cartographic process. For example, the OpenStreetMap Project (OpenStreetMap 2017b) is a worldwide topographic map built by volunteers. The data is released with an open-content license, which has revolutionized modern cartography. A myriad of projects and services around the project have emerged (OpenStreetMap 2017a).

Additionally, in many European Member States, Open Government Data initiatives have emerged. Open Government Data are those where public sector data are made freely accessible by the state and the public administration in the interest of the public, without any restrictions on the use, further dissemination, and reuse (Von Lucke 2010). The influence of Open Government Data on cartography can be seen on the Austrian Open Data website (Bundeskanzleramt Österreich 2017), which lists 408 map-related projects, ranging from simple web map visualisations to more complex mobile apps.

The most problematic aspects when working with volunteered geographic information is the reliability of data, which is directly connected to quality issues, such as completeness, semantic heterogeneity and positional accuracy (Dorn et al. 2015; Shudan and Jianghua 2014). These shortcomings restrict the use of VGI to applications.

In contrast, a certain quality level is guaranteed in Open Government Data, because they are produced by governmental organisations with legal obligations. However, quality levels are designed to meet the quality needs of legal obligations (only); no additional processing or harmonization is done. This leads to a low level of semantic interoperability between different datasets of the same theme. The implication is that cartographers are often required to harmonize the data before maps can be produced.

Also, complete national coverage of Open Government Data is not typically provided. Open Government Data for selected themes are commonly made available by federal states, and in many cases themes are available for large cities only. As a result, national- or pan-European mapping applications are not always possible.

16.6 Conclusion

In this chapter we illustrated that standards are the foundation and building blocks for harmonization and interoperability in an SDI, resulting in geographic information being discoverable, accessible, and usable by cartographers.

Through the cooperation between ISO/TC 211, OGC, and IHO, knowledge is shared and re-used, and standards are mostly harmonized with each other. As a result, cartographic tools and technologies can be developed to work with both marine and terrestrial data, and the tools and technologies are usable across many different domains and communities.

Standardized terminology further facilitates work across different domains and communities. ISO/TC 211's standardized terminology achieves this not only in English, but also in the 14 languages into which the terminology has been translated. In a globalized world, a standardized terminology facilitates cartographic communication beyond linguistic boundaries.

The terminology, models, schemas and ontologies are readily available for anyone who wants to follow the proven model-driven approach in the implementation of ISO/TC 211 standards. The Harmonized Model simplifies the design process for standards implementation and for the development of profiles of standards. The examples from the different countries in this chapter show that profile development is often required.

The example from Canada illustrates that ISO and OGC standards are the foundation on which a Geospatial Information Environment is established. Each component of the Environment is supported by specific standards; together the standards facilitate interoperability of geographic information at the syntactic level, as well as at the semantic level.

In Denmark, basic data from various domains was harmonized and integrated. In this way, a single source of data for cartographers was established. The implementation of the Danish eGovernment Strategy would not have succeeded without ISO and OGC standards and profiles.

Japan's continued participation in ISO/TC 211 and the domestic use of standards-based product specifications demonstrates how standards support geoinformation management. It also illustrates how standards are used to make data accessible to developers, cartographers, end users and the public. The certification programs are proof that standards are relevant and important for modern cartographers and geoinformation managers.

The INSPIRE Technical Guidelines are based on international standards published by ISO and OGC. These standards form the backbone of the INSPIRE framework. Implementation of the Technical Guidelines by the member states will maximize cross-border interoperability of the INSPIRE spatial datasets and data services. In this way, diverse data sources are harmonized and available for cartographers to produce maps.

Standards and SDIs have impacted modern cartography in many ways. Amongst others, they have led to quality spatial data of national coverage, available for map production, thus enriching modern cartographic output.

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References

Association of Precise Survey and Applied Technology (APA) (2017) Certification of professionals in standards for geographic information (S-GI-Cert) framework (in Japanese). https://www.sokugikyo.or.jp/geographic_information/index.html. Accessed 18 Aug 2017

Bundeskanzleramt Österreich (2017) Applications (in German). https://www.data.gv.at/anwendungen/. Accessed 30 Aug 2017

Datafordeler (2017) Om grunddata, Fælles datamodel, http://datafordeler.dk/om-grunddata/faelles-datamodel/. Accessed 1 Aug 2017

Digitaliseringsstyrelsen (2011) The digital path to future welfare, e-Government strategy 2011–2015. www.digst.dk/~/media/Files/Strategier/Engelsk_strategi_tilgaengelig.pdf. Accessed 24 June 2017

Dorn H, Törnros T, Zipf A (2015) Quality evaluation of VGI using authoritative data—a comparison with land use data in Southern Germany. ISPRS Int J Geo-Inf 4:1657–1670

ISO/TC 211, Geographic information/Geomatics (2015) Report from WG 1—Framework and reference model, and TMG to the ISO/TC 211 plenary, Shenzhen, 2014-11-27/28. ISO/TC 211 document N3945

ISO/TC 211, Geographic information/Geomatics (2017) Website. https://committee.iso.org/home/tc211. Accessed 30 Aug 2017

Geospatial Information Authority of Japan (GSI) (2014a) Fundamental geospatial data (FGD) (in Japanese). Geospatial information authority of Japan. www.gsi.go.jp/kiban/towa.html. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2014b) JPGIS2014 specification document (in Japanese). Geospatial information authority of Japan. www.gsi.go.jp/common/000091216.pdf. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2015) Japan profile for geographic information standards (JPGIS) (in Japanese), Geospatial Information Authority of Japan. www.gsi.go.jp/GIS/jpgis-jpgidx.html. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017a) Coverage and seamless description of FGD. Geospatial information authority of Japan. www.gsi.go.jp/kokusaikoryu/kokusaikoryu-e30057.html. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017b) Description of GSI maps available tiles and data layers (in Japanese). Geospatial information authority of Japan. http://maps.gsi.go.jp/development/ichiran.html. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017c) Experimental vector tiles for GSI Maps platform. Geospatial information authority of Japan. https://github.com/gsi-cyberjapan/vector-tile-experiment/blob/gh-pages/README_en.md. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017d) FGD dissemination and release schedule (in Japanese). Geospatial information authority of Japan. www.gsi.go.jp/kiban/index.html. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017e) GSI maps web based map browser (in Japanese). Geospatial information authority of Japan. https://maps.gsi.go.jp. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017f) Standardization activities. Geospatial information authority of Japan. www.gsi.go.jp/ENGLISH/page_e30210.html. Accessed 18 Aug 2017

Geospatial Information Authority of Japan (GSI) (2017g) Standardization activities (in Japanese). Geospatial information authority of Japan. www.gsi.go.jp/GIS/stdindex.html. Accessed 18 Aug 2017
GIS Association of Japan (GISA) (2017) GIS Certification Association (GISCA) program (in Japanese). www.gisa-japan.org/gisca. Accessed 18 Aug 2017
GitHub (2017) GitHub website. www.github.com. Accessed 30 Aug 2017
Government of Canada (2017a) Geospatial extraction tool. http://maps.canada.ca/czs/index-en.html. Accessed 30 Aug 2017
Government of Canada (2017b) Open government portal. http://open.canada.ca/data/en/dataset?collection=fgp. Accessed 30 Aug 2017
INSPIRE (2007) INSPIRE directive. http://inspire.ec.europa.eu/inspire-directive/2. Accessed 2 Aug 2017
INSPIRE (2017) INSPIRE validator. http://inspire-sandbox.jrc.ec.europa.eu/validator/. Accessed 20 Aug 2017
INSPIRE Thematic Working Group Addresses (2009) D2.8.I.5 Data specification on addresses—guidelines. http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AD_v3.0.pdf. Accessed 30 Aug 2017
ISO 19103:2015 Geographic information—conceptual schema language
ISO 19109:2015 Geographic information—rules for application schema
ISO (19131:2007) Geographic information—data product specifications
ISO (19136:2007) Geographic information—Geography Markup Language (GML)
ISO/TC 211 HMMG (2017) GitHub repository of the ISO/TC 211 harmonized model maintenance group (HMMG). https://github.com/ISO-TC211/HMMG. Accessed 30 Aug 2017
ISO/TC 211, Geographic information/Geomatics, in cooperation with the Open Geospatial Consortium (OGC) and the International Hydrographic Organization (IHO) (2013) The UN-GGIM inventory of issues and geographic information standardization. Background document for the third session of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) in Cambridge, United Kingdom, July 2013. http://ggim.un.org/ggim_committee.html. Accessed 29 June 2017
Japan (2007) Basic Act on the Advancement of Utilizing Geospatial Information (Act No. 63 of May 30, 2007). Ministry of Justice, Government of Japan. Japanese Law Translation Database System. http://www.japaneselawtranslation.go.jp/law/detail/?id=2311&vm=04&re=02. Accessed 18 Aug 2017
Joint Chiefs of Staff (2014) Information Operations. Joint Publication 3–13, Washington, DC. www.dtic.mil/doctrine/new_pubs/jp3_13.pdf. Accessed 27 July 2017
Natural Resources Canada (2016) Standards user's guide for geographic information. Canadian geospatial data infrastructure, information product 46e, 120 pages. https://doi.org/10.4095/297543. Accessed 27 July 2017
Natural Resources Canada (2017) Download directory and documentation. www.nrcan.gc.ca/earth-sciences/geography/topographic-information/free-data-geogratis/download-directory-documentation/17215. Accessed 27 July 2017
OGC (2002) Web feature service 1.0.0. OGC document 02-058
OGC (2006) OpenGIS web map service implementation specification 1.3.0. OGC document 06-042
OGC (2007a) OpenGIS catalogue service implementation specification 2.0.2 - Corrigendum 2. OGC document 07-006r1
OGC (2007b) Web processing service 1.0.0. OGC document 05-007r7
OGC (2012) OGC WCS® 2.0 Interface Standard—Core, Version 2.0.1. OGC document 09-110r4
OIO Arkitekturguiden (2017a) Grunddata Modelregler. http://arkitekturguiden.digitaliser.dk/grunddata-modelregler. Accessed 1 Aug 2017
OIO Arkitekturguiden (2017b) Eksisterende Standarder. http://arkitekturguiden.digitaliser.dk/eksisterende-standarder. Accessed 1 Aug 2017
OpenStreetMap (2017a) List of OSM-based services. OpenStreetMap Wiki. http://wiki.openstreetmap.org/wiki/List_of_OSM-based_services. Accessed 30 Aug 2017

OpenStreetMap (2017b) OpenStreetMap website. www.openstreetmap.org. Accessed 30 Aug 2017

Ota M (2017) Conceptual modeling and its implementation in an education assistance software tool for geographic information technology. Int J Cartography (online: 2017/05/13):1–25. https://doi.org/10.1080/23729333.2017.1308693

Ota M, Plews R (2015) Development of a software tool as an introduction to geospatial information technology based on geospatial standards. Cartography Geogr Inf Sci 42(5):419–434. https://doi.org/10.1080/15230406.2015.1031701

Shudan Z, Jianghua Z (2014) Assessing the completeness and positional accuracy of OpenStreetMap in China. In: Bandrova T, Konecny M, Zlatanova S (eds) Thematic cartography for the society. Springer International Publishing, Berlin. ISBN 978-3-319-08180-9

Sparx Systems (2017) Enterprise architect. www.sparxsystems.com/products/ea/. Accessed 30 Aug 2017

Standards Wiki (2017) http://wiki.icaci.org/index.php?title=Standards. Accessed 29 June 2017

Von Lucke J (2010) Open government. Öffnung von Staat und Verwaltung. Zeppelin University gGmbH, Germany