TECHNICAL INTRODUCTION TO SDI

Overview of SDI Standards

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KU LEUVEN

1. Why standards are needed
2. Who creates standards, how are they created, where can standards be found?
3. The foundation of ISO 19000
4. The interpretation of standards by example
5. The standards used in the different components of an SDI:
    1. Standards for data
    2. Standards for metadata
    3. Standards for services
6. Exercises on reading and interpreting standards: intro, different steps, practicing and discussing the results

Standards are …

*"Documented **agreements** containing technical **specifications** or other precise **criteria** to be used consistently as **rules, guidelines, or definitions of characteristics**, to ensure that materials, products, processes and services are fit for their purpose"*

(ISO, 2019)

… usually in the form of documents

They are implementation neutral

E.g. Adapter for the electricity net should work for any device

E.g. Any software should be able to use or implement standards

"The interesting thing about Standards is that there are so many to chose from …"

Standardization:

- lets stakeholders communicate and understand each other
- makes it easier to integrate new information
- facilitates the reuse of existing information
- Avoids errors due to misinterpretation
- Makes software development more efficient, promotes reuse of software components
- Allows communication between distributed services

Domain related geospatial standards

Many, like IHO, DGIWG, WMO, ICAO, but also OGC and ISO/TC 211

Generic geospatial standards

ISO/TC 211, OGC, but also others …

Basic ICT standards and other cross-discipline standards

W3C, OASIS, IETF, IEEE,ISO/IEC JTC1, OMG, etc.

38 Participating Members, 31 Observing Members
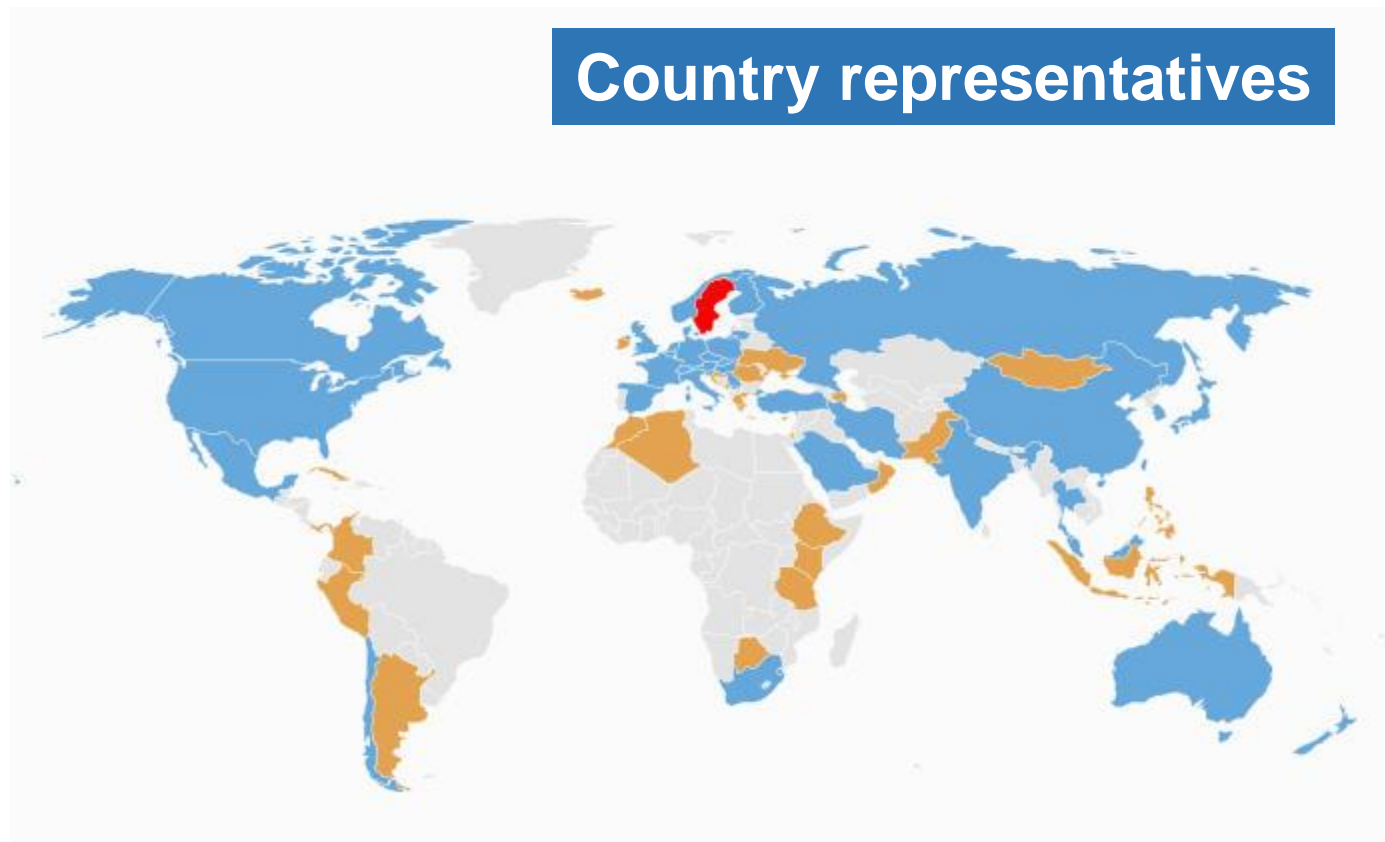
South-Africa (PM)

Tanzania (OM)

Kenia (OM)

Ethiopia (OM)

Botswana (OM)

Important stakeholder ☞

inno
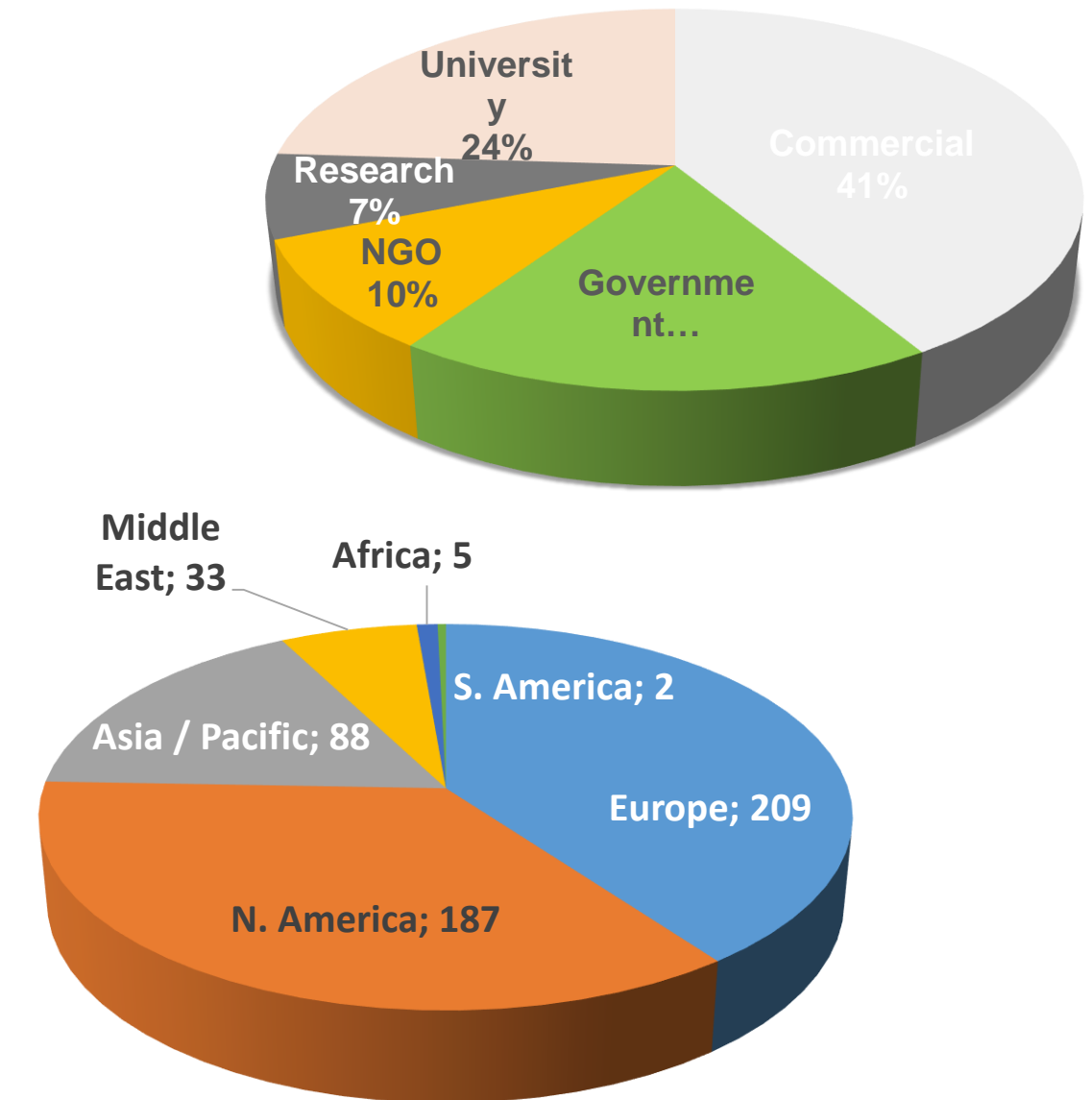Instituto Nacional de
Normalização e
Qualidade

Country representatives

Not-for-profit, international voluntary consensus standards organization; leading development of geospatial standards

- Founded in 1994

- 520+ members and growing

- 50+ standards

- Thousands of implementations

- Broad user community implementation worldwide

- Alliances and collaborative activities with ISO and many other SDO's

Pie chart 1:
- Commercial 41%
- Government...
- NGO 10%
- Research 7%
- University 24%

Pie chart 2:
- Middle East; 33
- Africa; 5
- S. America; 2
- Europe; 209
- N. America; 187
- Asia / Pacific; 88

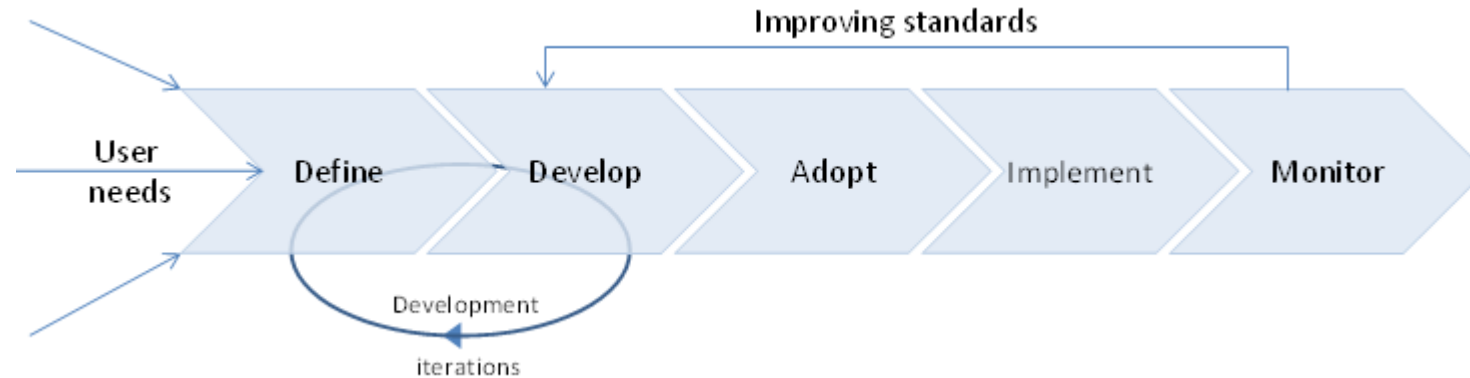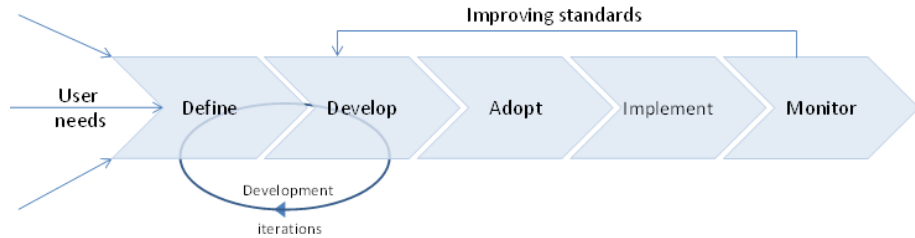|	
HTML	XML
HTTP	XML Query
PNG	XML Schema
SOAP/XMLP	XPath
SVG	XPointer
URI/URL	XSL and XSLT
XHTML	CSS
XLink	DOM

- Define requirements
- Create, discuss, approve, publish (after many iterations)
- Adaption by the user community
- Implementation in products and processes
- Monitor the impact

- Adaption is only a decision; implementation is the real uptake
- Edges between the process steps are fuzzy, e.g. OGC testbeds, pilots: implement to support the development
- The process is continuous:
  - new standards built on top of existing
  - standards are revised
  - standards become obselete

OGC Standards Roadmap

Search

Progress of Official OGC Standards 2019-11-20

Proposed Standards

	SWG Work	OAB Review	OGC-NA Review	Public Review	Prepare for Approval	TC Approval to Vote	TC Vote	PC Vote	Public Release
Abstract Spec Topic 0 04-084		✔	✔	✔	✔	❓			
Abstract Spec Topic 2 - Referencing by Coordinates 18-005		✔	✔	✔	✔	✔	✔	✔	✔
CDB 1.2		❓							
CDB 2.0		❓							
CityGML 3.0		❓							
Common Object Model Container SWG		❓							
EO Extension for OpenSearch 13-026r9		✔	✔	✔	✔	✔	✔	✔	❓
EO Product Metadata GeoJSON/JSON-LD Encoding 17-003		✔	✔	✔	✔	✔	✔	✔	❓
GeoAPI 09-083r4		❓							
GeoPackage 1.3 12-128r16		❓							
GeoTIFF 19-008		✔	✔	✔	✔	✔	✔	✔	✔
GroundwaterML2 v2.3 19-013		✔	✔	✔	✔	✔	✔	✔	❓
HDF5 Core 18-043		✔	✔	✔	✔	✔	✔	✔	❓
IndoorGML 1.1 19-011		✔	✔	✔	❓				

ISO

https://www.iso.org/home.html

The online browing platform allows to previous some parts of the standard.

https://www.iso.org/obp/ui

OGC

https://www.opengeospatial.org/

under menu standards. Not only standards, also supporting documents etc.

Some concepts (valid for all ISO standards):

Scope

Defines the subject of the document and the aspects covered

Normative reference

A document to which reference is made in the standard in such a way as to make it indispensable for the application of the standard.

Some concepts (valid for all ISO standards):

Mandatory (M): has to be present

Conditional (C): has to be present in certain conditions

Optional (O): may choose to include.

Requirements:

Shall: it is required to; it is necessary

Shall not: it is not allowed/permitted to, do not

Recommendation

Should: it is recommended that

Should not: it is not recommended that; ought not to

Permission

May: is allowed to

Need not: is not requited to

Scope of the ISO 19100 series (from ISO 19101):

The focus of this family of standards is to:

a) define the basic semantics and structure of geographic information for data management and data interchange purposes

and

b) define geographic information service components and their behavior for data processing purposes.

STANDARDS THAT SPECIFY THE INFRASTRUCTURE FOR GEOSPATIAL STANDARDIZATION

ISO 19101 Geographic information – Reference model

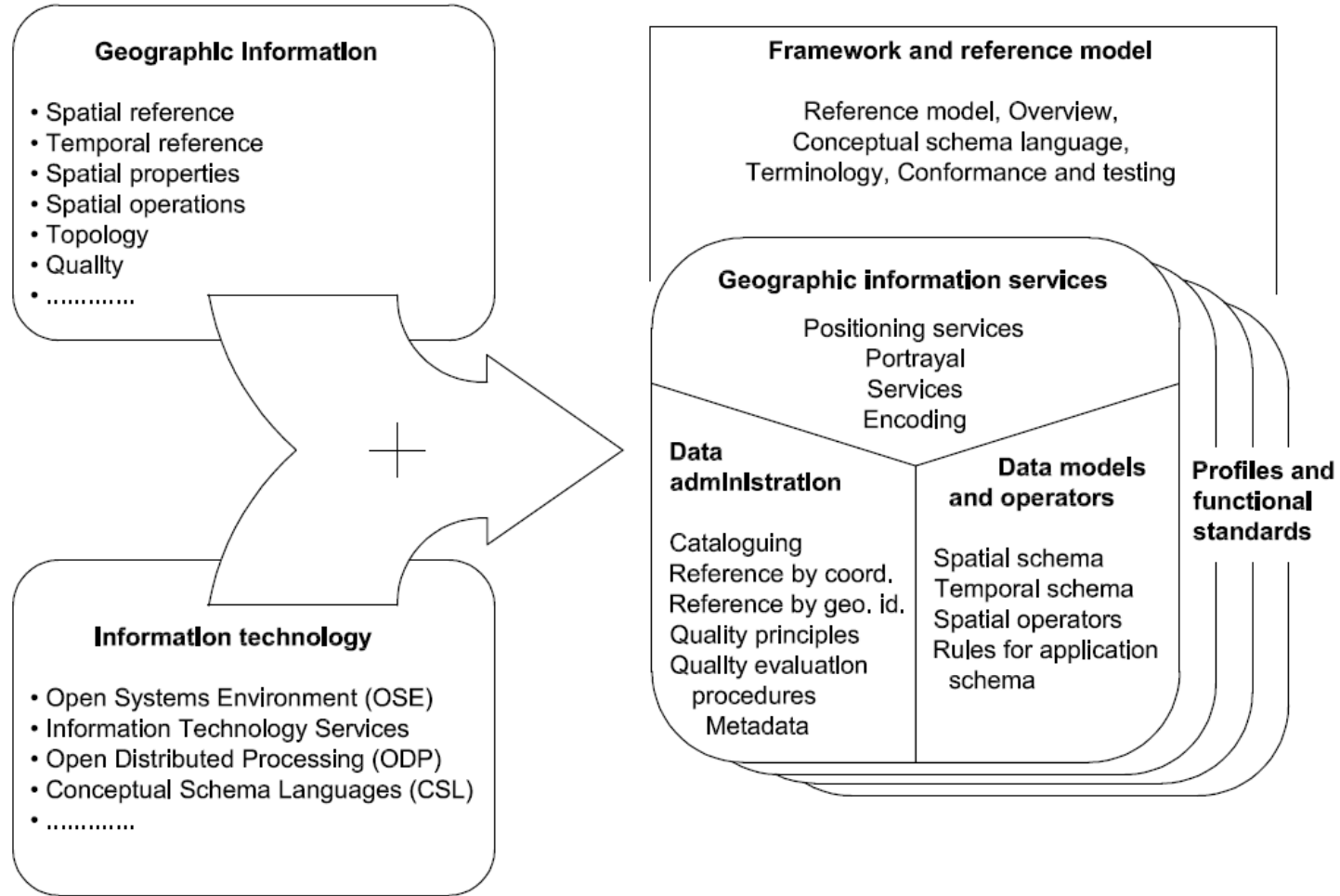ISO 19103 Geographic information – Conceptual schema language

ISO 19104 Geographic information – Terminology

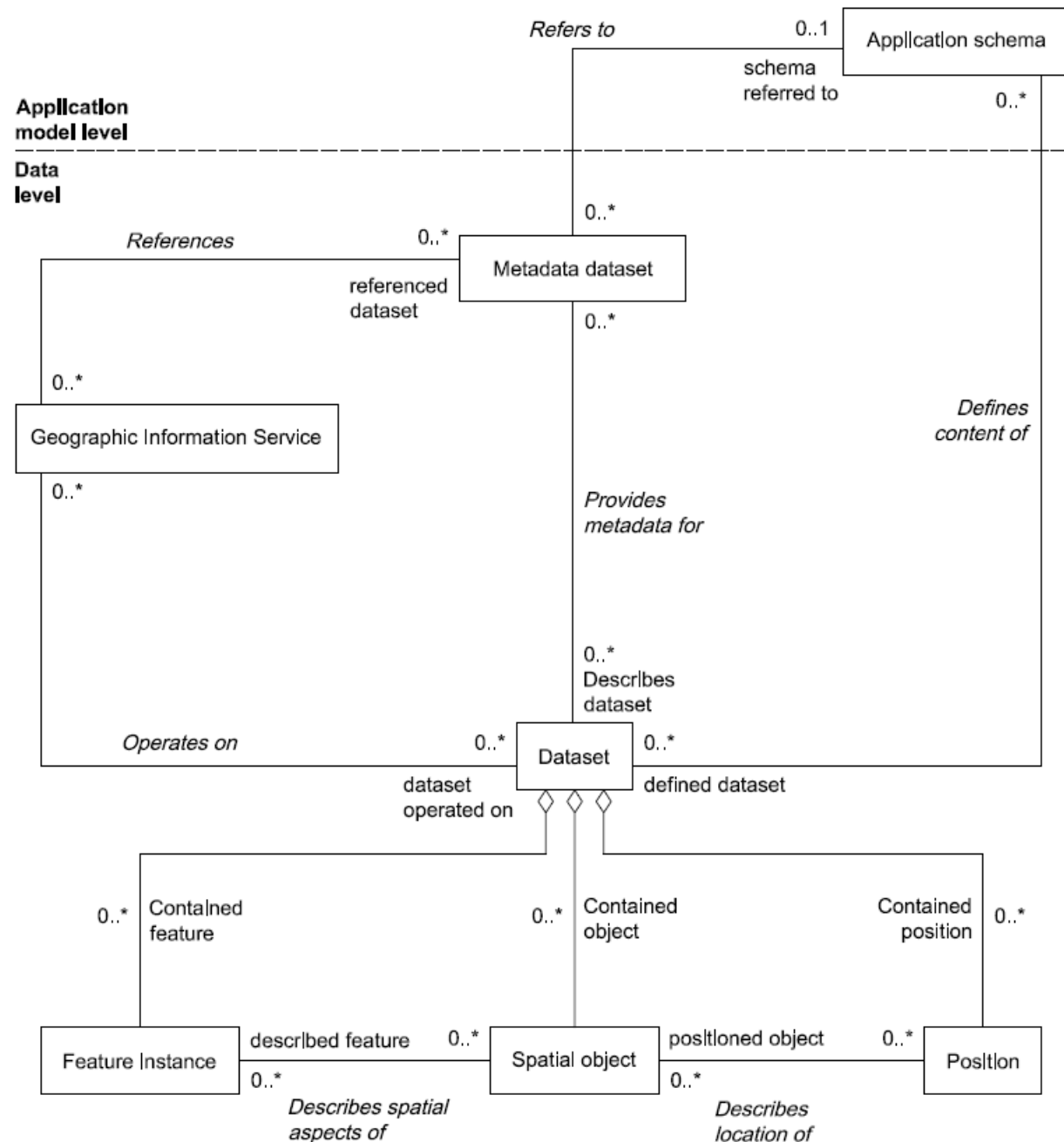ISO 19105 Geographic information – Conformance and testing

ISO 19106 Geographic information – Profiles

Defines the scope of work in ISO/TC211 and resulting 19000 series of standards

The reference model identifies all components involved and defines how they fit together

Geographic Information

- Spatial reference
- Temporal reference
- Spatial properties
- Spatial operations
- Topology
- Quality
- ....

Information technology

- Open Systems Environment (OSE)
- Information Technology Services
- Open Distributed Processing (ODP)
- Conceptual Schema Languages (CSL)
- ....

Framework and reference model

Reference model, Overview,
Conceptual schema language,
Terminology, Conformance and testing

Geographic information services

Positioning services
Portrayal
Services
Encoding

Data administration

Cataloguing
Reference by coord.
Reference by geo. id.
Quality principles
Quality evaluation
  procedures
  Metadata

Data models and operators

Spatial schema
Temporal schema
Spatial operators
Rules for application
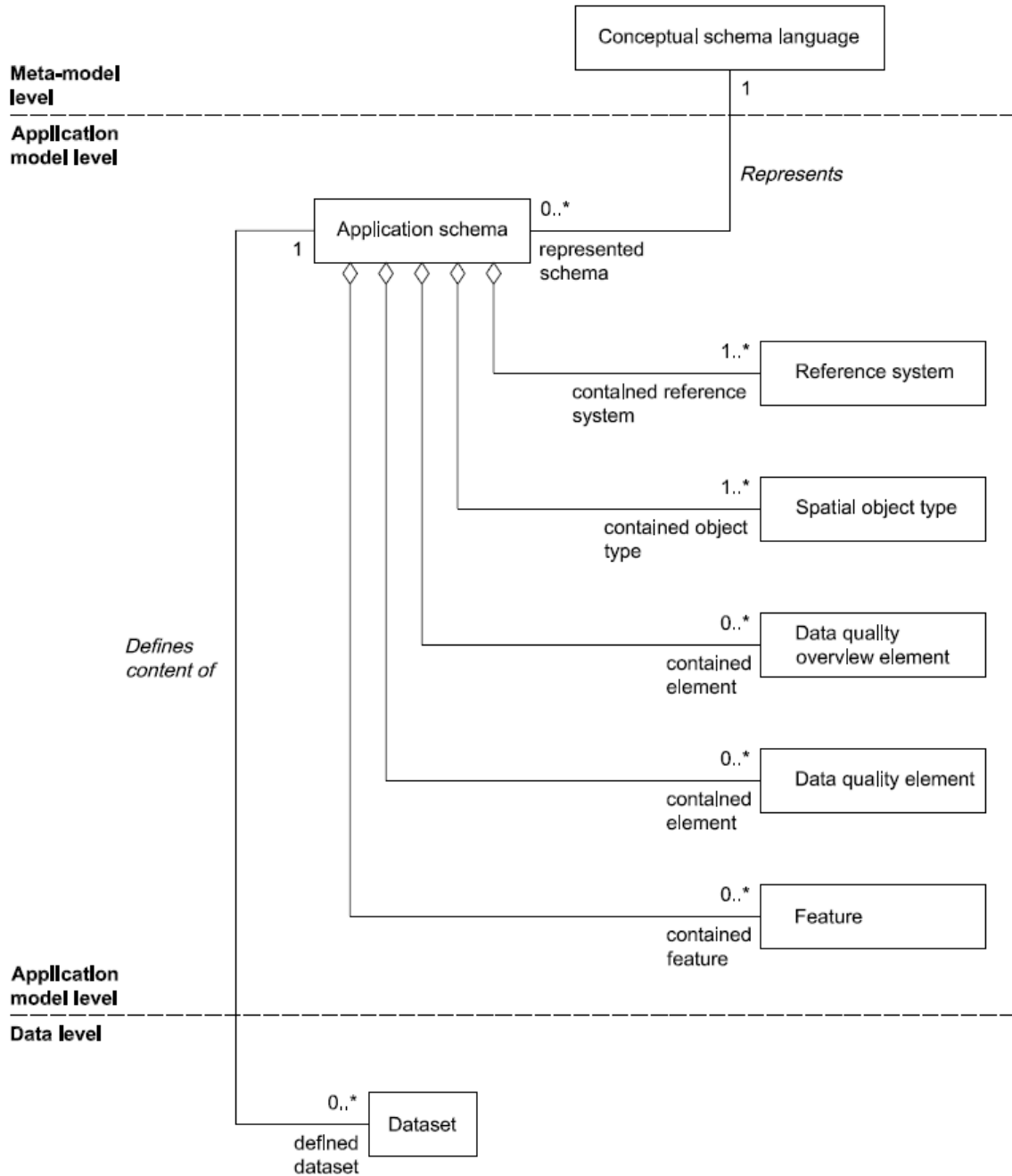 schema

Profiles and functional standards

Source: ISO 19101:2002

How are the different items connect

- Application schema
- Dataset
  - Feature
  - Spatial object
  - Position
- Metadata
- Services

Meta-model level

Application model level

Conceptual schema language

1

Represents

0..*

Application schema

1

represented schema

1..*   Reference system
contained reference system

1..*   Spatial object type
contained object type

0..*   Data quality overview element
contained element

0..*   Data quality element
contained element

0..*   Feature
contained feature

Defines content of

Application model level

Data level

0..*   Dataset
defined dataset

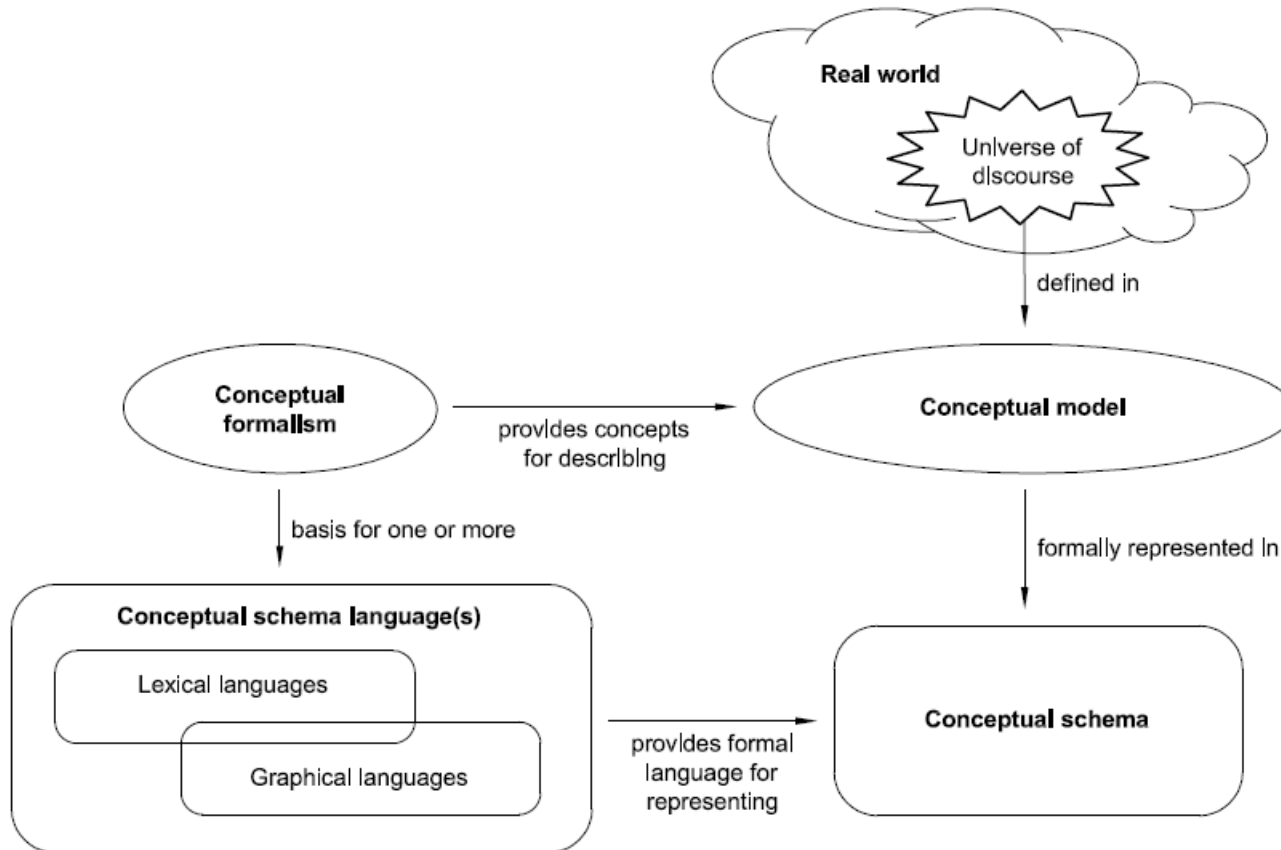ISO 19101 also gives conceptual model for Reference system, spatial object type etc.

Figure 4 — From reality to conceptual schema

ISO 19103: UML will be used as conceptual schema language

Also tells how, with which contraints etc.

Example:

B.15
application schema
conceptual schema (B.65) for **data** (B.103) required by one or more **applications** (B.14)

[ISO 19101:2002]

B.16
association
⟨UML⟩ semantic **relationship** (B.395) between two or more **classifiers** (B.41) that specifies connections among their **instances** (B.254)

NOTE   A binary association is an association among exactly two classifiers (including the possibility of an association from a classifier to itself).

[ISO/TS 19103:2005 – adapted from ISO/IEC 19501]

Conformance

What are the conditions you have to meet to comply with this standard

Testing

How can that conformance be tested
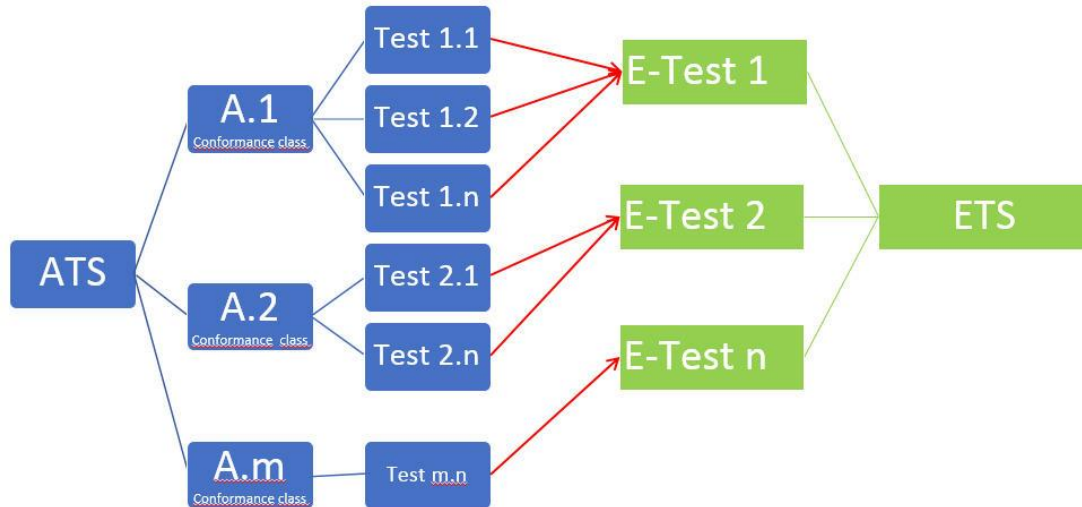
Abstract test suite (ATS):

Set of related abstract test cases specifying all the requirements to be satisfied for conformance

ATS is implemented in an Executable test suite (ETS)

Every standard of the 19105 series has a conformance defined, and it contains in annex een abstract test suite for that standard.
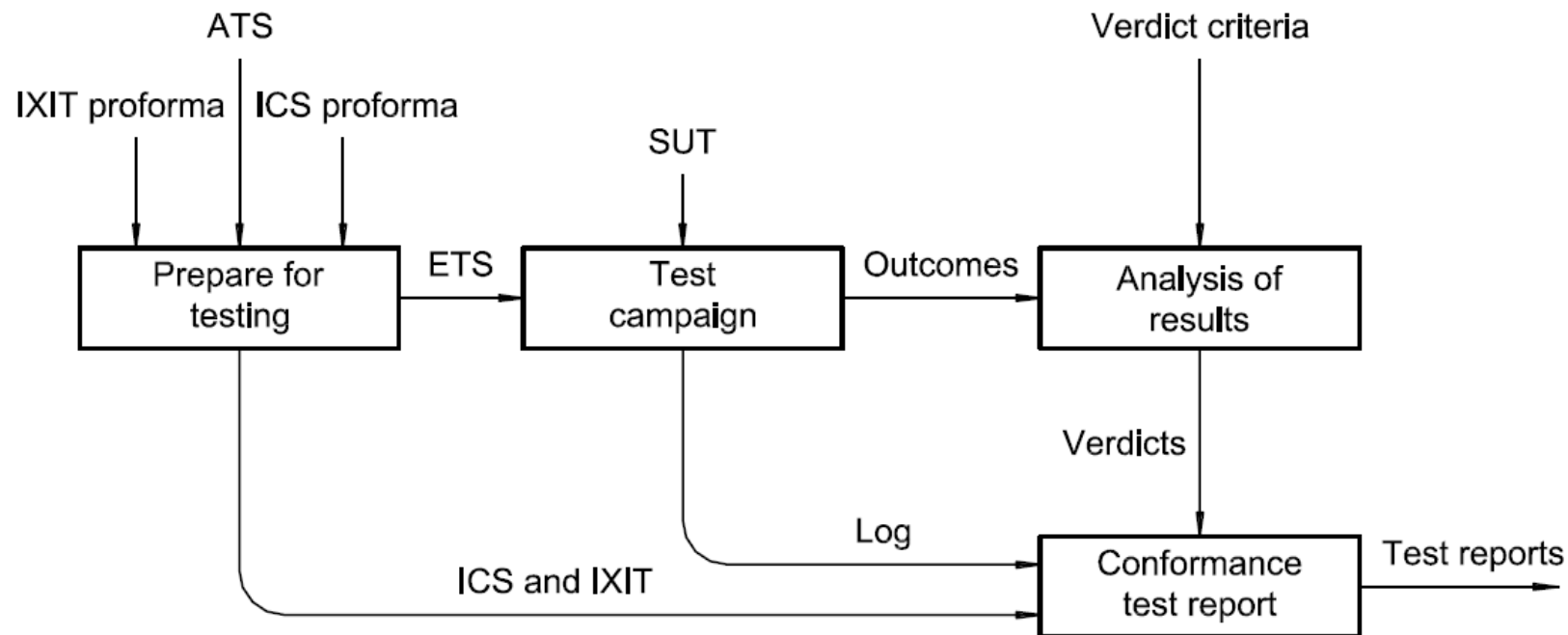
Validation by testing

Conformance Class	Tests
A.1 Application Schema Conformance Class	A.1.1 Schema element denomination test
	A.1.2 Value type test
	A.1.3 Value test
	A.1.4 Attributes/associations completeness test
	A.1.5 Abstract spatial object test
	A.1.6 Constraints test
	A.1.7 Geometry representation test
A.2 Reference Systems Conformance Class	A.2.1 Datum test
	A.2.2 Coordinate reference system test
	A.2.3 Grid test
	A.2.4 View service coordinate reference system test
	A.2.5 Temporal reference system test
	A.2.6 Units of measurements test
A.3 Data Consistency Conformance Class	A.3.1 Unique identifier persistency test
	A.3.2 Version consistency test
	A.3.3 Life cycle time sequence test
	A.3.4 Validity time sequence test
	A.3.5 Update frequency test
A.4 Data Quality Conformance Class	A.4.1 Data quality target results test
A.5 Metadata IR Conformance Class	A.5.1 Metadata for interoperability test
A.6 Information Accessibility Conformance Class	A.6.1 Code list publication test
	A.6.2 CRS publication test
	A.6.3 CRS identification test
	A.6.4 Grid identification test
A.7 Data Delivery Conformance Class	A.7.1 Encoding compliance test
A.8 Portrayal Conformance Class	A.8.1 Layer designation test

The standard itself defines a profile as:

profile

set of one or more base standards or subsets of 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

NOTE: A profile is derived from base standards so that by definition, conformance to a profile is conformance to the base standards from which it is derived.

By profiling standards are adapted to a specific application

2 types of profiles:

when a profile is established as **a pure subset** of the ISO geographic information standards, possibly together with other ISO standards

class 2 allows profiles to include **extensions** within the context permitted in the base standard and permits the profiling of non-ISO geographic information standards as parts of profiles.

Makes the standards "flexible", adaptable to a requirement

7   Purpose of profiles

Profiles define combinations of elements derived from a set of one or more base standards for the following purposes:

—   identifying those base standards, together with appropriate classes, conforming subsets, options and parameters, which are necessary to accomplish identified functions for purposes such as interoperability;

—   providing a means to enhance the availability of consistent implementations of functionally defined groups of base standards, which are expected to be the major components of real application systems;

—   promoting uniformity in the development of conformance tests for systems that implement the functionality of profiles.

A profile shall provide a clear identification of the specific user requirements that are satisfied by that profile.

Recognize the items from the metadata infrastructure standards   in any other ISO 19100 standard

What is the scope, which other standards are normatively referenced, see how UML is used, what are the different tests in the abstract test suite

STANDARDS THAT DESCRIBE DATA MODELS FOR GEOGRAPHIC INFORMATION

ISO 19109 Geographic information – Rules for application schema

ISO 19107 – Geographic information – Spatial schema

ISO 19137 Geographic information – Core profile of the spatial schema

ISO 19123 Geographic information – Schema for coverage geometry and functions

ISO 19108 Geographic information – Temporal schema

ISO 19141 Geographic information - Schema for moving features

ISO 19111 Geographic information – Spatial referencing by coordinates

ISO 19112 Geographic information – Spatial referencing by geographic identifiers

Data should be standardized according to an agreed data model (schema)

UML

Series of interconnected standards:
ISO 19101 – Reference model
ISO/TS 19103 - Conceptual schema language
ISO 19107 – Spatial schema
ISO 19108 – Temporal schema
ISO 19109 – Rules for application schema
ISO 19110 - Feature cataloguing methodology
ISO 19117 - Portrayal
ISO 19118 – Encoding
ISO 19157 - Quality
…

XML, GML

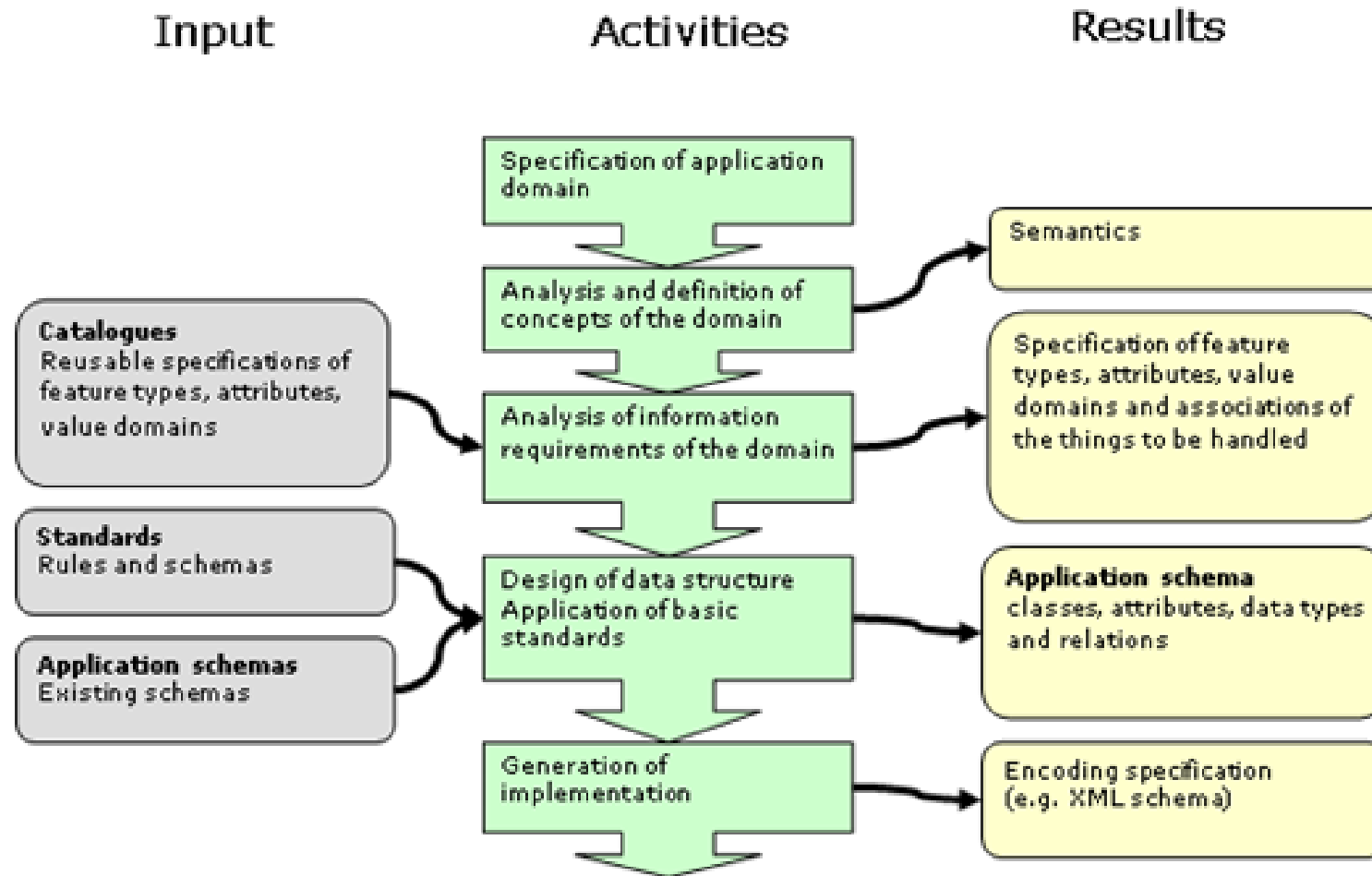|		
(A) INSPIRE Principles	(B) Terminology	(C) Reference model
(D) Rules for application Schemas and feature catalogues	(E) Spatial and temporal aspects	(F) Multi-lingual text and cultural adaptibility
(G) Coordinate referencing and units model	(H) Object referencing modelling	(I) Identifier Management
(J) Data transformation	(K) Portrayal model	(L) Registers and registries
(M) Metadata	(N) Maintenance	(O) Quality
(P) Data Transfer	(Q) Consistency between data	(R) Multiple representations
(S) Data capturing	(T) Conformance	

Reconized by
World Bank

DATA SPECIFICATION

=

Synonym to data product specification

Detailed description of a data set or data set series together with additional information that will enable it to be created, supplied to and used by another party

[ISO 19131]

Input

Activities

Results

Catalogues
Reusable specifications of feature types, attributes, value domains

Standards
Rules and schemas

Application schemas
Existing schemas

Specification of application domain

Analysis and definition of concepts of the domain

Analysis of information requirements of the domain

Design of data structure Application of basic standards

Generation of implementation

Semantics

Specification of feature types, attributes, value domains and associations of the things to be handled

Application schema
classes, attributes, data types and relations

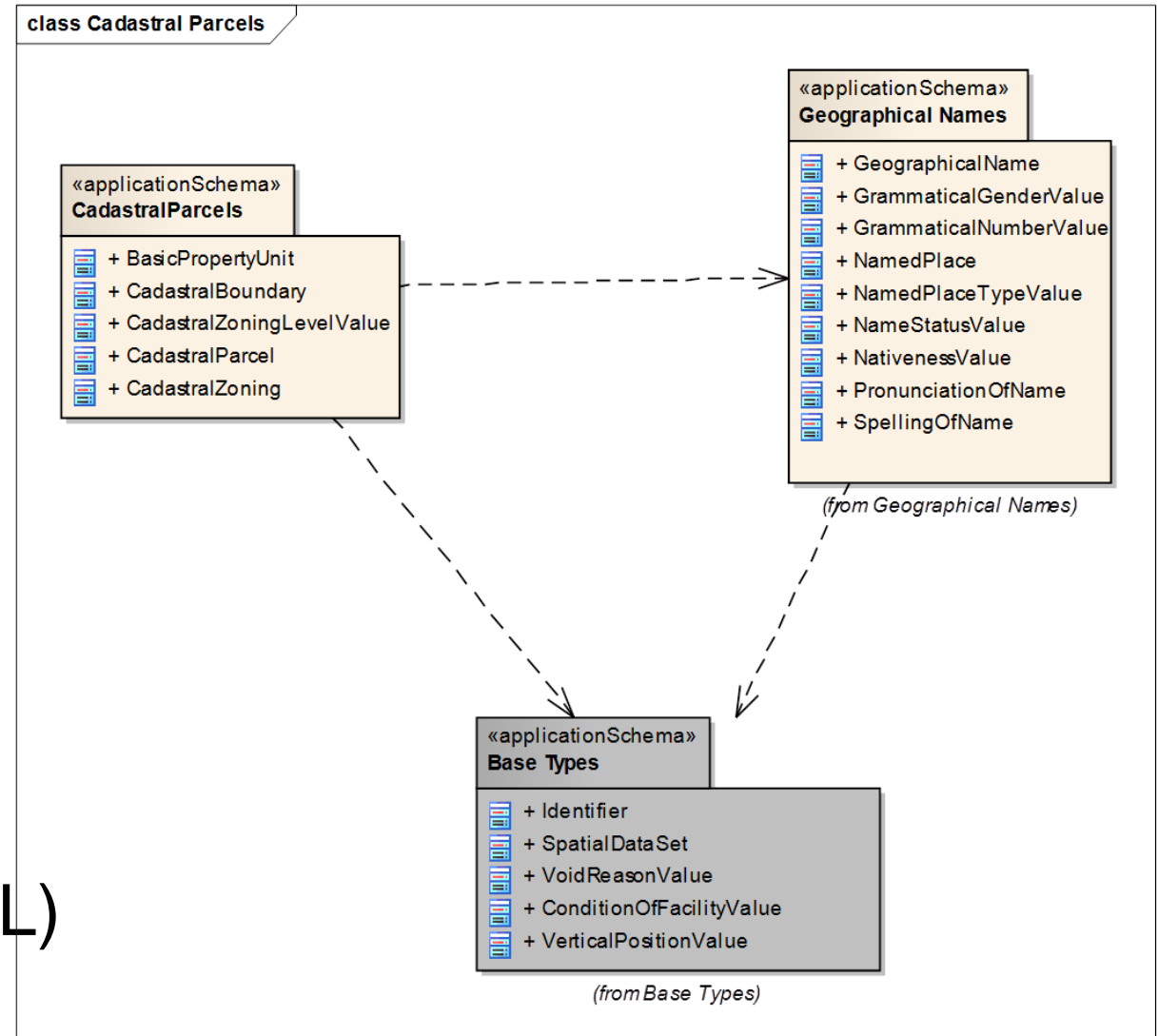Encoding specification (e.g. XML schema)

Relevant:
ISO 19107
ISO 19108
ISO 19109

Application schema

- Defines the model

Data harmonization

- Getting your data in the reference (standard) model
- Data transformations might be necessary (ETL)

class Cadastral Parcels

«applicationSchema»
CadastralParcels
- + BasicPropertyUnit
- + CadastralBoundary
- + CadastralZoningLevelValue
- + CadastralParcel
- + CadastralZoning

«applicationSchema»
Geographical Names
- + GeographicalName
- + GrammaticalGenderValue
- + GrammaticalNumberValue
- + NamedPlace
- + NamedPlaceTypeValue
- + NameStatusValue
- + NativenessValue
- + PronunciationOfName
- + SpellingOfName

(from Geographical Names)

«applicationSchema»
Base Types
- + Identifier
- + SpatialDataSet
- + VoidReasonValue
- + ConditionOfFacilityValue
- + VerticalPositionValue

(from Base Types)

OGC

- 36 core implementation standards
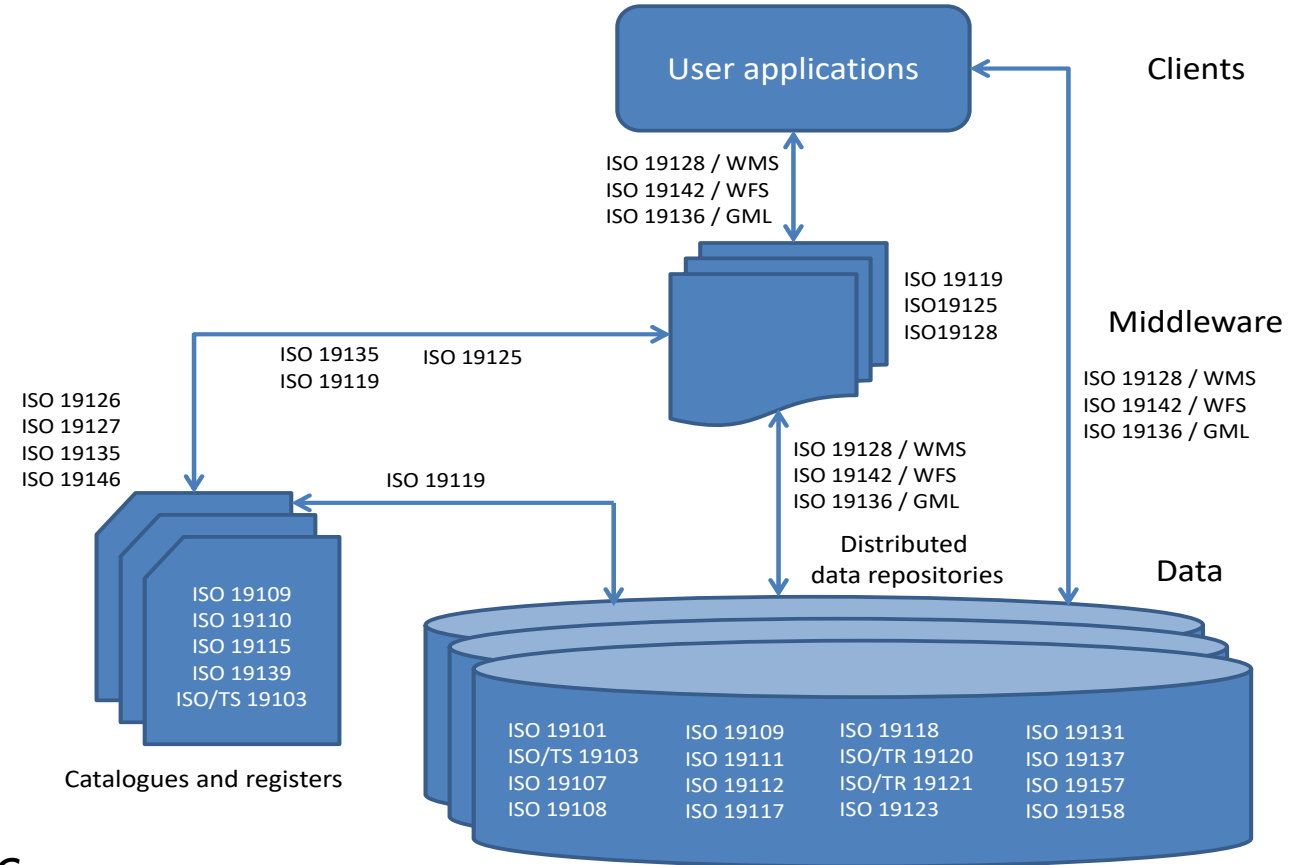- 21 abstract specifications

ISO/TC 211

- 51 international standards and technical specifications

CEN/TC 287

- adopted more than 40 ISO standards

(Figures 2015)

Note:
All relevant ISO 19100 standards cost > 7.000€

User applications

Clients

ISO 19128 / WMS
ISO 19142 / WFS
ISO 19136 / GML

ISO 19119
ISO19125
ISO19128

Middleware

ISO 19128 / WMS
ISO 19142 / WFS
ISO 19136 / GML

ISO 19135
ISO 19119

ISO 19125

ISO 19126
ISO 19127
ISO 19135
ISO 19146

ISO 19119

ISO 19128 / WMS
ISO 19142 / WFS
ISO 19136 / GML

Distributed
data repositories

Data

ISO 19101	ISO 19109	ISO 19118	ISO 19131
ISO/TS 19103	ISO 19111	ISO/TR 19120	ISO 19137
ISO 19107	ISO 19112	ISO/TR 19121	ISO 19157
ISO 19108	ISO 19117	ISO 19123	ISO 19158

ISO 19109
ISO 19110
ISO 19115
ISO 19139
ISO/TS 19103

Catalogues and registers

STANDARDS FOR GEOGRAPHIC INFORMATION SERVICES

ISO 19119 Geographic information – Services

ISO 19116 Geographic information – Positioning services

ISO 19117 Geographic information – Portrayal

ISO 19125-1 Geographic information – Simple feature access – Part 1: Common architecture

ISO 19125-2 Geographic information – Simple feature access – Part 2: SQL option

ISO 19128 Geographic information – Web map server interface

ISO 19132 Geographic information – Location based services – Reference model

ISO 19133 Geographic information – Location based services – Tracking and navigation

ISO 19134 Geographic information – Location base services – Multimodal routing and navigation

But also additional OGC standards

Remote procedure calls (RPC)

- A **Client** sends a **request** message to a known remote server to execute a specified procedure with supplied parameters
- The **remote server** sends a **response** to the client

http://giswebservices.massgis.state.ma.us/geoserver/wms?VERSION=1.1.1
&REQUEST=GetMap&SERVICE=WMS&LAYERS=massgis:
GISDATA.TOWNS_POLYM,massgis:GISDATA.NAVTEQRDS_ARC,m
assgis:GISDATA.NAVTEQRDS_ARC_INT
&SRS=EPSG:26986&BBOX=232325.38526025353,898705.3447384972,
238934.49648710093,903749.1401484597&WIDTH=570&HEIGHT=435
&FORMAT=image/png&STYLES=Black_Lines,
GISDATA.NAVTEQRDS_ARC::ForOrthos,GISDATA.NAVTEQRDS_ARC_INT::Default
&TRANSPARENT=TRUE

OGC:
CSW - Catalogues
WMS, WMTS - Maps
WFS, WCS - Download
WPS – Processing
SOS, SPS - Sensors
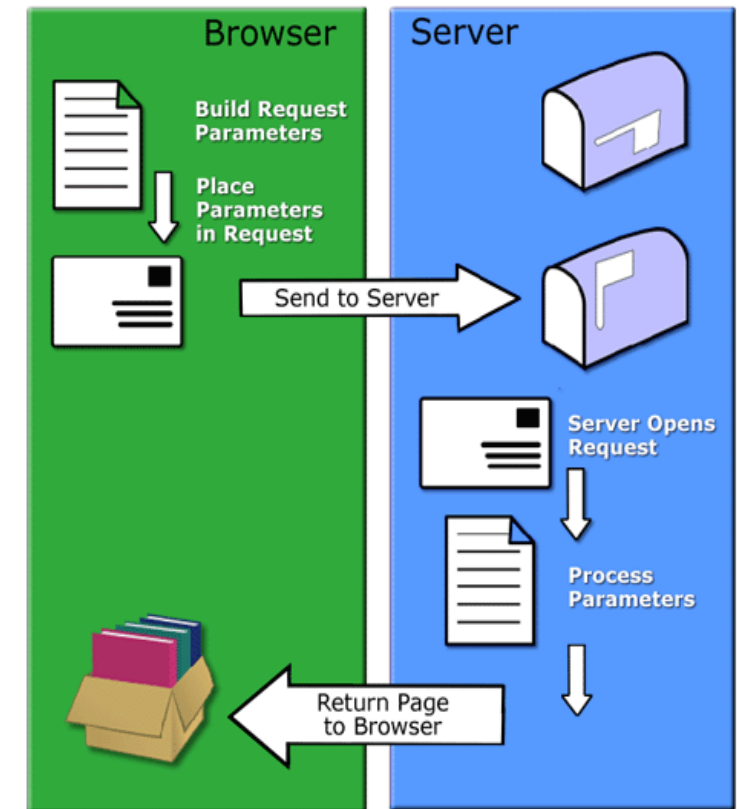
Service-oriented architecture (SOA)

STANDARDS FOR METADATA

ISO 19110 Geographic information – Methodology for feature cataloguing

ISO 19115 Geographic information – Metadata

ISO 19119 Geographic information – Services

ISO 19139 Geographic information – Metadata – XML schema implementation

ISO 19119 sets the metadata elements for services

Content

Relevant standards:
ISO 19115: 2003
ISO 19139: 2007 (encoding)
ISO 19115-1: 2014 (fundamentals)
ISO 19115-2: 2019 (extension)
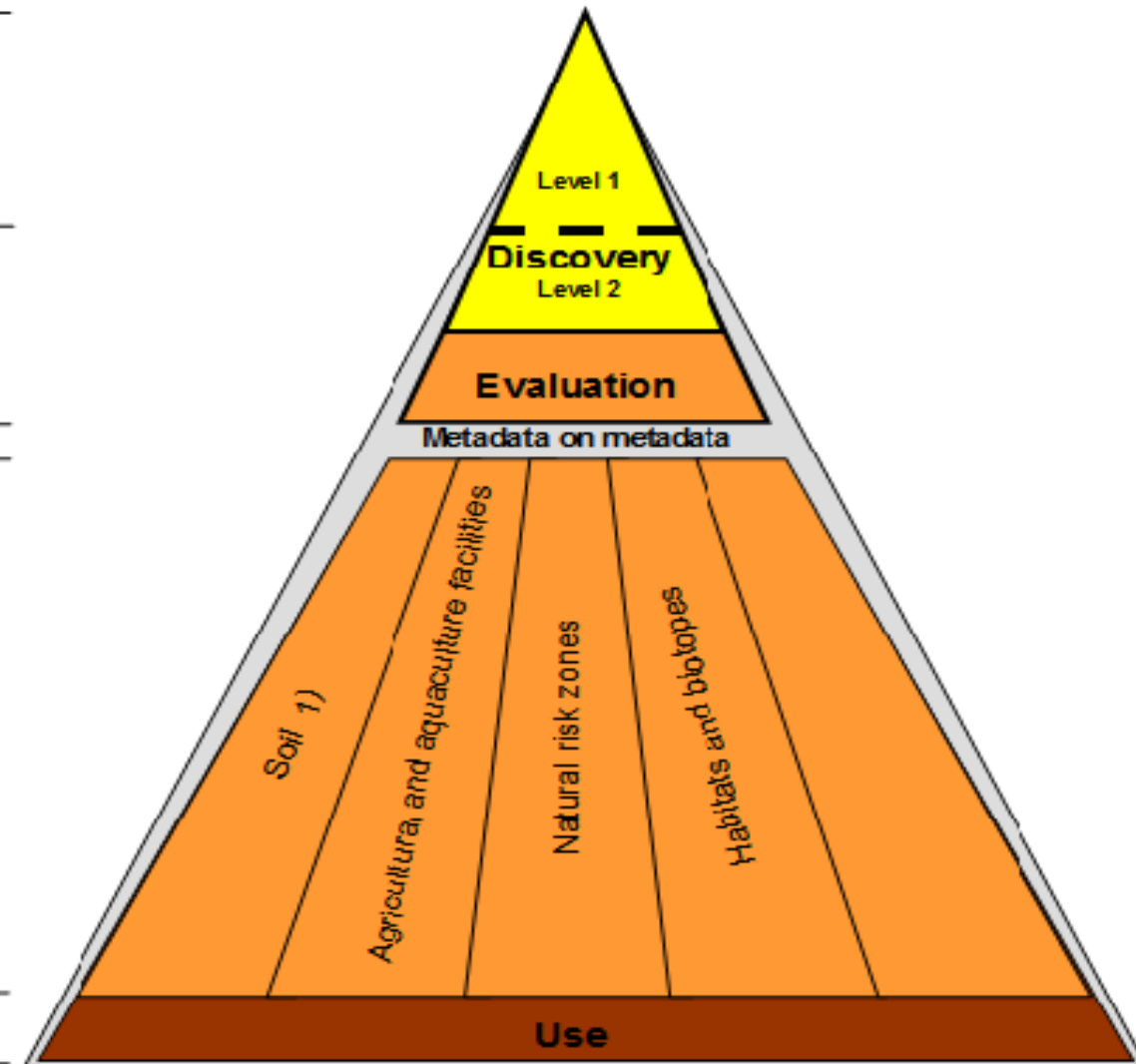ISO 19115-3: 2016 (XML)

Format

Mandatory/
Conditional

Conditional

Mandatory/
Conditional

Optional (within
an INSPIRE
Spatial Data
Theme
community the
possibility exists
to make some
metadata
elements
Mandatory or
Conditional

IR Data
specifications

Level 1

Discovery
Level 2

Evaluation

Metadata on metadata

Soil 1)

Agriculture and aquaculture facilities

Natural risk zones

Habitats and biotopes

Use

* The mentioned INSPIRE Spatial Data Themes are pointed out as examples to give an impression

Metadata elements:
Some are manda[tory]
Multiplicity
Some use code l[ists]

Note 1:
Metadata standard is enforced by a tool:
Separate editor or within a GIS

Note 2:
Other metadata standards exist:
Dublin Core
DCAT, DCAT-AP and GeoDCAT-AP
…

Metadata for spatial data sets and spatial data set series

Reference	Metadata elements	Multiplicity	Condition
1.1	Resource title	1	
1.2	Resource abstract	1	
1.3	Resource type	1	
1.4	Resource locator	0..*	Mandatory if a URL is available to obtain more information on the resource, and/or access related services.
1.5	Unique resource identifier	1..*	
1.7	Resource language	0..*	Mandatory if the resource includes textual information.
2.1	Topic category	1..*	
3	Keyword	1..*	
4.1	Geographic bounding box	1..*	
5	Temporal reference	1..*	
6.1	Lineage	1	
6.2	Spatial resolution	0..*	Mandatory for data sets and data set series if an equivalent scale or a resolution distance can be specified.
7	Conformity	1..*	
8.1	Conditions for access and use	1..*	
8.2	Limitations on public access	1..*	
9	Responsible organisation	1..*	
10.1	Metadata point of contact	1..*	
10.2	Metadata date	1	
10.3	Metadata language	1	

ISO

https://www.iso.org/home.html

The online browing platform allows to previous some parts of the standard.

https://www.iso.org/obp/ui

OGC

https://www.opengeospatial.org/

under menu standards. Not only standards, also supporting documents etc.

W3C (not geospatial, but XML etc)

https://www.w3.org/standards/

Standards guide by ISO/TC 211

https://trac.osgeo.org/geonetwork/raw-attachment/ticket/189/ISO%20TC%20211%20-%20Standards%20Guide.pdf

ISO online browsing platform

https://www.iso.org/obp/ui

ISO document on how to write standards (can be useful when reading them)

https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/how-to-write-standards.pdf

OGC Guide to the role of Geospatial standards

https://www.opengeospatial.org/unggim