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Geographic information — Reference model —

Part 1: Fundamentals

Information géographique — Modèle de référence —

Partie 1: Principes de base

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 211, *Geographic information/Geomatics*.

This first edition of ISO 19101-1, together with ISO/TS 19101-2:2008, cancels and replaces ISO 19101:2002.

ISO 19101 consists of the following parts, under the general title *Geographic information — Reference model*:

— *Part 1: Fundamentals*

— *Part 2: Imagery* [Technical Specification]

Introduction

Beyond the needs within traditional applications of digital geographic information, users of information technology recognize that indexing by location is fundamental in the organization and the use of digital data. Nowadays, digital data from multiple sources of a wide variety are being referenced to locations and used in various applications. Such data are now extensively distributed and shared over the Web. In fact, the Web is an important source of knowledge in which geographic information plays a significant role. Standardization in the field of geographic information is therefore imperative to support and simplify the sharing and usage of geographic information of different sources, i.e. interoperability.

Standardization in geographic information is a complex task that addresses multiple aspects encompassing the definition of interoperability of geographic information, fundamental data types such as for spatial and temporal information, modelling rules, the semantics of real world phenomena, metadata, services, etc. As such, a reference model is required in order to achieve this task in an integrated and consistent manner. A reference model in geographic information consists of a comprehensive view providing an abstract description of the elements that might compose the field of geographic information and their interrelations. One of the primary goals of this reference model is to define and describe interoperability of geographic information, addressing system, syntactic, structural, and semantic levels. The definition of interoperability of geographic information will then serve as the underpinning for standardization in geographic information. It contributes to

— increase the understanding and usage of geographic information,

— increase the availability, access, integration, and sharing of geographic information,

— promote the efficient, effective, and economic use of digital geographic information and associated hardware and software systems, and

— enable a unified approach to addressing global ecological and humanitarian problems.

This part of ISO 19101 defines the ISO reference model dealing with geographic information. This reference model provides a guide to structuring geographic information standards in a way that it will enable the universal usage of digital geographic information. It sets out the fundamentals for standardization in geographic information including description, management, and services, and how they are interrelated to support interoperability within the geographic information realm and beyond to ensure interoperability with other information communities. As such, this part of ISO 19101 develops a vision for the standardization in geographic information from which it would be possible to integrate geographic information with other types of information and conversely.

The description of the reference model is supported by a conceptual framework. The conceptual framework is a mechanism to structure the scope of the standardization activity in geographic information according to the interoperability description. It identifies the various facets of standardization and the relationships that exist between them.

This reference model settles the role of semantics, how the new technologies such as the Web and many emerging ways of accessing it, and how the Semantic Web can support interoperability in the field of geographic information. It also provides an umbrella under which additional specific reference models on particular facets of geographic information standardization would be required.

The reference model is organized in five clauses. Clause 5 describes interoperability in the context of geographic information from a communication and an e-government perspective. Clause 6 identifies the foundations of the reference model and sets the scope (requirements) for the ISO geographic information standardization activities. Clause 7 identifies the requirement for the abstraction of the real world. The reference model for ISO standardization in geographic information is specified in Clause 8 along with its specific requirements. Finally, profiles related to ISO geographic information standards are introduced in the Clause 9.

This part of ISO 19101 is the first part of the reference model. Additional parts can be developed to address concerns, elements, and structures in distinct areas. As such, part 2 of the reference model addresses specific aspects on imagery.

To achieve these goals, standardization of geographic information in the ISO geographic information standards is based on the integration of the concepts of geographic information with those of information technology. The development of standards for geographic information has to consider the adoption or adaptation of generic information technology standards whenever possible. It is only when this cannot be done that the development of geographic information standards becomes required.

This part of ISO 19101 identifies a generic approach to structuring the ISO geographic information standards. This reference model uses concepts from the Open Distributed Processing – Reference Model (RM ODP) described in ISO/IEC 10746-1[17] and other relevant International Standards and Technical Reports. This part of ISO 19101 does not prescribe any specific products or techniques for implementing geographic information systems.

This part of ISO 19101 is intended to be used by information system analysts, program planners, and developers of geographic information standards that are related to ISO geographic information standards, as well as others in order to understand the basic principles of this series of standards and the overall requirements for standardization of geographic information.

This edition of the reference model differs from its previous edition by having a specific focus on the semantic aspects related to interoperability of geographic information by the way of ontologies and knowledge. As such, the definition of interoperability has been revisited in the context of communication. Three foundations for interoperability of geographic information are identified. Based on these foundations and the usual four levels of abstraction, a new conceptual framework is introduced to support the organization of the reference model. The architectural aspect of the previous reference model has been removed in this reference model and will be addressed more specifically in a revision of ISO 19119:2005. This version of the reference model has no backward compatibility impact on the ISO geographic information suite of standards.

Geographic information — Reference model —

Part 1: Fundamentals

1 Scope

This part of ISO 19101 defines the reference model for standardization in the field of geographic information. This reference model describes the notion of interoperability and sets forth the fundamentals by which this standardization takes place.

Although structured in the context of information technology and information technology standards, this part of ISO 19101 is independent of any application development method or technology implementation approach.

2 Conformance

General conformance and testing requirements for the ISO geographic information standards are described in ISO 19105.

Any standards and profiles claiming conformance to this part of ISO 19101 shall satisfy all the requirements described in the abstract test suites in Annex A.

Additional specific conformance requirements are described in individual ISO geographic information standards.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

4 Terms, definitions, and abbreviated terms

4.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1.1
application
manipulation and processing of data in support of user requirements

4.1.2
application schema
conceptual schema (4.1.6) for data required by one or more *applications* (4.1.1)

4.1.3
base standard
ISO *geographic information* (4.1.18) standard or other information technology standard that is used as a source from which a *profile* (4.1.27) might be constructed

[SOURCE: ISO 19106:2004, 4.2]

4.1.4
conceptual formalism
set of modelling concepts used to describe a *conceptual model* (4.1.5)

EXAMPLE 1 UML meta model.

EXAMPLE 2 EXPRESS[21] meta model.

Note 1 to entry: One conceptual formalism can be expressed in several *conceptual schema languages* (4.1.7).

4.1.5
conceptual model
model that defines concepts of a *universe of discourse* (4.1.38)

4.1.6
conceptual schema
formal description of a *conceptual model* (4.1.5)

4.1.7
conceptual schema language
formal language based on a *conceptual formalism* (4.1.4) for the purpose of representing *conceptual schemas* (4.1.6)

EXAMPLE 1 UML.

EXAMPLE 2 EXPRESS.

EXAMPLE 3 IDEF1X.

Note 1 to entry: A conceptual schema language can be lexical or graphical. Several conceptual schema languages can be based on the same conceptual formalism.

4.1.8
coverage
feature (4.1.11) that acts as a function to return values from its range for any direct position within its spatial, temporal, or spatiotemporal domain

EXAMPLE 1 *Raster* (4.1.30) image.

EXAMPLE 2 Polygon overlay.

EXAMPLE 3 Digital elevation matrix.

Note 1 to entry: In other words, 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.

[SOURCE: ISO 19123:2005, 4.1.7]

4.1.9
dataset
identifiable collection of data

[SOURCE: ISO 19115-1:2014, 4.3]

4.1.10
e-government
digital interaction between a government and citizens, government and businesses, and between government agencies

4.1.11
feature
abstraction of real world phenomena

Note 1 to entry: A feature can occur as a type or an instance. Feature type or feature instance will be used when only one is meant.

4.1.12
feature attribute
characteristic of a *feature* (4.1.11)

EXAMPLE 1 A feature attribute named "colour" can have an attribute value "green" which belongs to the data type "text".

EXAMPLE 2 A feature attribute named "length" can have an attribute value "82,4" which belongs to the data type "real".

Note 1 to entry: A feature attribute has a name, a data type, and a value domain associated to it. A feature attribute for a *feature instance* (4.1.14) also has an attribute value taken from the value domain.

Note 2 to entry: In a *feature catalogue* (4.1.13), a feature attribute can include a value domain but does not specify attribute values for feature instances.

Note 3 to entry: In UML, attributes, associations, and operations are representation types and are not fundamental to the type of a characteristic nor to the type of feature. All three are equally capable of representing the same characteristic of a feature. Every implementation of a characteristic is allowed to use the representation type that is most appropriate and can use several different representations for a single characteristic if required. Feature associations and *feature operations* (4.1.15), therefore, are different types of feature attribute, the distinction between them being based on storage and access mechanisms rather than semantics.

4.1.13
feature catalogue
catalogue containing definitions and descriptions of the *feature types* (4.1.16), *feature attributes* (4.1.12), and feature relationships occurring in one or more sets of geographic data, together with any *feature operations* (4.1.15) that can be applied

4.1.14
feature instance
individual of a given *feature type* (4.1.16) having specified *feature attribute* (4.1.12) values

4.1.15
feature operation
operation that every instance of a *feature type* (4.1.16) can perform

EXAMPLE A feature operation upon a "dam" is to raise the dam. The results of this operation are to raise the height of the "dam" and the level of water in a "reservoir".

Note 1 to entry: Feature operations provide a basis for feature type definition.

[SOURCE: ISO 19110:2005, 4.5]

4.1.16
feature type
class of *features* (4.1.11) having common characteristics

[SOURCE: ISO 19156:2011, 4.7]

4.1.17
functional standard
existing *geographic information* (4.1.18) standard, in active use by an international community of data producers and data users

EXAMPLE 1 GDF[22].

EXAMPLE 2 S-57[15].

EXAMPLE 3 DIGEST[6].

4.1.18
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

4.1.19
geographic information service
service (4.1.36) that transforms, manages, or presents *geographic information* (4.1.18) to users

4.1.20
geographic information system
information system (4.1.23) dealing with information concerning phenomena associated with location relative to the Earth

4.1.21
graphical language
language whose syntax is expressed in terms of graphical symbols

4.1.22
grid
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

Note 1 to entry: The curves partition a space into grid cells.

[SOURCE: ISO 19123:2005, 4.1.23]

4.1.23
information system
information processing system, together with associated organizational resources such as human, technical, and financial resources, that provides and distributes information

[SOURCE: ISO/IEC 2382-1:1993, 01.01.22]

4.1.24
lexical language
language whose syntax is expressed in terms of symbols defined as character strings

4.1.25
module
predefined set of elements in a base standard that can be used to construct a profile

[SOURCE: ISO/TR 19120:2001, 3.3]

4.1.26
ontology
formal representation of phenomena of a *universe of discourse* (4.1.38) with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships

4.1.27
profile
set of one or more *base standards* (4.1.3) 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

[SOURCE: ISO 19106:2004, 4.5]

4.1.28
quality
degree to which a set of inherent characteristics fulfils requirements

Note 1 to entry: The term "quality" can be used with adjectives such as poor, good, or excellent.

Note 2 to entry: "Inherent", as opposed to "assigned", means existing in something, especially as a permanent characteristic.

[SOURCE: ISO 9000:2005, 3.1.1]

4.1.29
quality schema
conceptual schema (4.1.6) defining aspects of *quality* (4.1.28) for geographic data

4.1.30
raster
usually rectangular pattern of parallel scanning lines forming or corresponding to the display on a cathode ray tube

Note 1 to entry: A raster is a type of *grid* (4.1.22).

[SOURCE: ISO 19123:2005, 4.1.30]

4.1.31
reference model
framework for understanding significant relationships among the entities of some environment, and for the development of consistent standards or specifications supporting that environment

Note 1 to entry: A reference model is based on a small number of unifying concepts and can be used as a basis for education and explaining standards to a non-specialist.

[SOURCE: ISO 14721:2012, 1.7.2, modified]

4.1.32
register
set of files containing identifiers assigned to items with descriptions of the associated items

[SOURCE: ISO 19135:2005, 4.1.9]

4.1.33
registry
information system (4.1.23) on which a *register* (4.1.32) is maintained

[SOURCE: ISO 19135:2005, 4.1.13]

4.1.34
schema
formal description of a model

4.1.35
Semantic Web
Web (4.1.40) of data with meaning

Note 1 to entry: The association of meaning allows data and information to be understood and processed by automated tools as well as by people.

4.1.36
service
distinct part of the functionality that is provided by an entity through interfaces

[SOURCE: ISO 19119:2005, 4.1]

4.1.37
tessellation
partitioning of a space into a set of conterminous subspaces having the same dimension as the space being partitioned

Note 1 to entry: A tessellation composed of congruent regular polygons or polyhedra is a regular tessellation. One composed of regular, but non-congruent, polygons or polyhedra is a semi-regular tessellation. Otherwise, the tessellation is irregular.

[SOURCE: ISO 19123:2005, 4.1.39]

4.1.38
universe of discourse
view of the real or hypothetical world that includes everything of interest

4.1.39
vector
quantity having direction as well as magnitude

Note 1 to entry: A directed line segment represents a vector if the length and direction of the line segment are equal to the magnitude and direction of the vector. The term vector data refers to data that represents the spatial configuration of *features* (4.1.11) as a set of directed line segments.

[SOURCE: ISO 19123:2005, 4.1.43]

4.1.40
World Wide Web
Web
universe of network-accessible information and *services* (4.1.36)

4.1.41
Web service
service (4.1.36) that is made available through the *Web* (4.1.40)

Note 1 to entry: A Web service usually includes some combination of programming and data. It can also include human resources.

4.2 Abbreviated terms

COM	Component Object Model
CORBA	Common Object Request Broker Architecture
CSMF	Conceptual Schema Modelling Facility
DL	Description Language
DXF	Drawing eXchange Format

ebXML RIM	Electronic Business XML Registry Information Model
ebXML RS	Electronic Business XML Registry Services
EIF	European Interoperability Framework
FTP	File Transfer Protocol
GeoRSS	Geo Really Simple Syndication
GFM	General Feature Model
GIS	Geographic Information System
GML	Geography Markup Language
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
ICT	Information and Communication Technology
IDEF1X	Integration DEFinition for Data Modelling
IDL	Interface Definition Language
IT	Information Technology
JDBC	Java Database Connectivity
KML	Keyhole Markup Language
MS	Microsoft Corporation
OCL	Object Constraint Language
ODBC	Open Database Connectivity
ODL	Object Definition Language
ODMG	Object Data Management Group
ODP	Open Distributed Processing
OMG	Object Management Group
OWL	Web Ontology Language
RDF	Resource Description Framework
RM-ODP	Reference Model – Open Distributed Processing
RPC	Remote Procedure Call
SDAI	Standard Data Access Interface
SDI	Spatial Data Infrastructure
SQL	Structured Query Language
TCP/IP	Transmission Control Protocol/Internet Protocol

UML	Unified Modelling Language
URI	Universal Resource Identifier
W3C SWEO	World Wide Web Consortium Semantic Web Education and Outreach
XML	eXtensible Markup Language

5 Interoperability

5.1 Interoperability of geographic information

5.1.1 Conceptual framework

Interoperability has been widely defined in various contexts related to information technology. The most fundamental definitions come from the Institute of Electrical and Electronics Engineers and ISO/IEC 2382-1:1993.

— The ability of two or more systems or components to exchange information and to use the information that has been exchanged[10].

— The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units[16].

In these definitions, the capability to use the information exchanged and the communication capability between units are meaningful elements. As such, this part of ISO 19101 compares interoperability of geographic information to an interpersonal communication process and establishes a framework for interoperability of geographic information, which is detailed hereafter. Interoperability of geographic information in the suite of ISO geographic information standards shall be founded on this framework.

Interoperability is presented here within the wider scope of human communication and cognition since people usually end up understanding each other when interacting using different representations of observable phenomena. Typically, a human communication process is about the transmission of details on something that one has in mind to another. It comprises the following parts:

— a human source;

— a human destination;

— physical signals;

— a communication channel;

— a source of noise;

— a feedback mechanism.

In a human communication process, different features are involved especially at the source and destination cognitive models and at the different physical signals constituting the message transmitted between the source and its destination.

Similarly to human communication, interoperability is a process by which independent systems manipulate, exchange, and integrate information that are received from others automatically. Accordingly, the conceptual framework of interoperability of geographic information is presented hereafter.

Interoperability of geographic information is depicted as a communication process that occurs between two agents, a user agent and a provider agent, interacting together about geographic information. Consider that the user agent is interested in getting information about geographic features in a specific area, say points of interest in Paris. Then, the user agent sends a query to the provider agent through the communication channel (e.g. the Internet) using its own concepts and vocabulary. Once the message reaches its destination, the provider agent interprets the request. This means that the provider agent identifies concepts it knows that correspond to the request and for which it has information, and uses them to answer the request (e.g. Eiffel Tower, Champ de Mars, Paris, 48°51’29” Latitude, 2°17’40” Longitude). Then, the provider agent assembles the information in a response that is sent back to the user agent. In turn, at the time when the user agent receives the response from the provider agent, it interprets and assesses it according to its initial request. Interoperability happens in this scenario between the two agents only if the answer of the provider agent satisfies the user agent query.

Figure 1 illustrates the interaction between a user agent and a provider agent in the conceptual framework for the interoperability of geographic information. First, it considers the reality (R) as it is at a given time and about which the user agent is interested to have information.

Second, the user agent model of the reality (R′) results from a set of observed signals and the frame of reference that is used to build it, i.e. the set of rules and knowledge used to abstract phenomena. The user agent model is made of properties considered meaningful that are organized or structured into concepts. A concept is an abstract, generalized, and simplified representation of similar real world phenomena. A concept is entirely fictional, i.e. it does not exist in reality.

Because concepts are purely abstractions, the user agent cannot communicate concepts directly to the provider agent. Therefore, the user agent’s concepts shall be transformed into physical representations, which then can be transmitted through the communication channel. In communication, this refers to the encoding operation. Essentially, this operation represents only the user agent concepts’ properties required to describe the concepts in a specific situation. The concepts’ properties are transformed into signals (e.g. words, abbreviations, punctuations, images, sounds, etc.) and ordered following specific rules, i.e. a grammar, to shape the representation of user agent’s concepts (R″) to constitute the message. This becomes the data transmitted by the user agent to interoperate with the provider agent. Once released on the communication channel, the message representing the user agent’s query, “What is interesting to see in Paris?”, is freed from the user agent’s intended meaning.

When the message reaches its destination, the provider agent begins the decoding operation, which consists of the recognition of and the assignment of an appropriate meaning to the message’s physical representations. Although under perfect conditions representations of concepts induce user agent’s isomorphic concepts to the provider agent, typically, representations of concepts induce concepts to the provider agent (R‴) that are of similar meaning to user agent’s concepts. These concepts are then used to answer the user agent’s query.

Based on these concepts, the provider agent begins the retrieval of information. Similarly to R′, the retrieved information (either concepts or instances of them) cannot be communicated directly since it consists of features. Consequently, it shall be encoded into physical representations, arranged in a message (R‴′) to be placed as a reply (e.g. an XML encoding of Eiffel Tower, Champ de Mars, Paris, 48°51’29” Latitude, 2°17’40” Longitude) on the communication channel towards the user agent. Once again here when placed on the communication channel, the physical representations are freed of their provider agent’s meaning.

In turn, at the time the response message is received, the user agent initiates the decoding operation to recognize the components of the message and to give them a meaning and, after, assesses if that meaning infers the concepts in R′. If it is the case, the user and the provider agents interoperate successfully.

This conceptual framework describes interoperability of geographic information from an interpersonal communication perspective between two agents. Interoperability of geographic information consists of a bi-directional process that includes feedback in both directions to ensure that messages get to their destination and are understood properly. Each agent uses its own knowledge and vocabulary to express and interpret features. As long as the two agents have a common background and a common set of symbols, they regularly end up understanding each other. This conceptual framework agrees with the IEEE and ISO/IEC 2382-1:1993 definitions of interoperability.

