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Geographic information — Ontology

Part 4: Service ontology

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National foreword

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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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

A list of all parts in the ISO 19150 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The Semantic Web has introduced the Web of data. The Web of data is essentially an extension of the Web oriented towards machine-processable data as opposed to documents. It could be seen as a tremendous worldwide open database that people can query from their own perspective, understanding, or abstraction of real-world phenomena or events and get accurate, detailed, and appropriate answers as people communicate between each other. This approach involves reasoning capabilities based on ontologies. The Semantic Web brings new opportunities for the geographic information realm to lay out a new generation of standards in order to benefit from these in achieving semantic interoperability of geographic information.

Fundamentally, ontology comes from philosophy and refers to the study of the nature of the world itself. The information technology and artificial intelligence communities borrowed the term ontology for the explicit specification of a conceptualization[2]. In geographic information, ontology consists of a formal representation of phenomena of a universe of discourse with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships[1]. Information technology and artificial intelligence consider that reality may be abstracted differently depending on the context from which "things" are perceived and, as such, recognize that multiple ontologies about the same part of reality may exist. An ontology can be formalized differently ranging from weak to strong semantics: taxonomy, thesaurus, conceptual model, logical theory[2].

On the Semantic Web, ontology defines the meaning of data and describes it in a format that machines and applications can read. An application using data also has access to their inherent semantics through the ontology associated with it. Ontologies can support integration of heterogeneous data captured by different communities by relating them based on their semantic similarity. The W3C has proposed the Web Ontology Language (OWL) family of knowledge representation languages for authoring ontologies characterised by formal semantics on the Web[3][36].

ISO 19101-1 introduces the fundamental role of semantics in geographic information, and how the new technologies such as the Web, the Semantic Web, and many other emerging ways 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. This document, introduced by ISO/TS 19150-1, particularly contributes to the description of geographic information service components and their behaviour for data processing purposes over the Web and to cast ISO geographic information standards to benefit from and support the Semantic Web by the way of ontologies as identified in ISO 19101-1.

Geographic information Web services are important components that compose the Web. The Semantic Web can contribute to facilitate the interaction between them by introducing an ontology for geographic information Web Services. It can support geographic information Web services to automate their discovery, composition, and invocation in order to enable seamless machine interoperation with minimum human interaction. Through ontologies, semantic annotation of geographic information services in terms of capabilities, selection, access, composition, and invocation are required to support interoperability of geographic information Web services on the Semantic Web[24]. Accordingly, this document sets a framework for geographic information service ontology and the description of geographic information Web services in OWL.

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Geographic information — Ontology —

Part 4:
Service ontology

1 Scope

This document sets a framework for geographic information service ontology and the description of geographic information Web services in Web Ontology Language (OWL).

OWL is the language adopted for ontologies.

This document makes use of service metadata (ISO 19115-1) and service definitions (ISO 19119) whenever appropriate.

This document does not define semantics operators, rules for ontologies, and does not develop any application ontology.

In relation to ISO 19101-1:2014, 6.2, this document defines and formalizes the following purpose of the ISO geographic information reference model:

— geographic information service components and their behaviour for data processing purposes over the Web, and

— OWL ontologies to cast ISO/TC 211 standards to benefit from and support the Semantic Web.

In relation to ISO 19101-1:2014, 8.3, this document addresses the Meta:Service foundation of the ISO geographic information reference model.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19103, *Geographic information — Conceptual schema language*

ISO 19115-1, *Geographic information — Metadata — Part 1: Framework*

ISO 19119, *Geographic information — Service*

ISO 19150-2, *Geographic information — Ontology — Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)*

3 Terms, definitions, abbreviated terms, and namespaces

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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3.1 Terms and definitions

3.1.1
aggregation
<UML> special form of *association* (3.1.2) that specifies a whole-part relationship between the aggregate (whole) and a component part

Note 1 to entry: See <UML> *composition* (3.1.8).

[SOURCE: ISO 19103:2015, 4.1]

3.1.2
association
<UML> semantic relationship that can occur between typed instances

Note 1 to entry: A binary association is an association among exactly two classifiers (including the possibility of an association from a classifier to itself).

[SOURCE: UML 2]

3.1.3
attribute
<UML> feature within a classifier that describes a range of values that instances of the classifier may hold

[SOURCE: UML 1]

3.1.4
cardinality
<UML> number of elements in a set

Note 1 to entry: Contrast with *multiplicity* (3.1.17), which is the range of possible cardinalities a set may hold.

[SOURCE: UML 1]

3.1.5
class
<OWL> set of individuals (3.1.14)

[SOURCE: OWL]

3.1.6
class
<UML> description of a set of objects that share the same *attributes* (3.1.3), operations, methods, relationships, and semantics

[SOURCE: UML 1]

3.1.7
codelist
value domain including a code for each permissible value

[SOURCE: ISO 19136:2007, 4.1.7]

3.1.8
composition
<UML> *aggregation* (3.1.1) where the composite object (whole) has responsibility for the existence and storage of the composed objects (parts)

[SOURCE: UML 2]

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3.1.9
constraint
<UML> condition or restriction expressed in natural language text or in a machine readable language for the purpose of declaring some of the semantics of an element

[SOURCE: UML 2]

3.1.10
data property
<OWL> semantic *association* (3.1.2) between an *individual* (3.1.14) and a typed *literal* (3.1.15)

Note 1 to entry: Data properties were sometimes referred to as 'concrete properties' in Description Logic.

[SOURCE: OWL]

3.1.11
data type
specification of a value domain with operations allowed on values in this domain

EXAMPLE xsd:string, xsd:integer, xsd:decimal.

Note 1 to entry: Datatypes are distinct from classes of *individuals* (3.1.14), the latter are denoted by URIs and may be used by reference.

[SOURCE: ISO 19103:2015, 4.14, modified — EXAMPLE and Note 1 to entry have been replaced.]

3.1.12
domain
<ontology> restriction to constrain the subject class which participates in a subject-predicate-object triple

3.1.13
generalization
<UML> taxonomic relationship between a more general element and a more specific element of the same element type

Note 1 to entry: An instance of the more specific element can be used where the more general element is allowed.

[SOURCE: UML 2]

3.1.14
individual
instance of a class (3.1.5)

Note 1 to entry: "Individual" refers to a resource belonging to the extension of the class.

[SOURCE: OWL Web Ontology Language Guide — modified]

3.1.15
literal value
literal
constant, explicitly specified value

EXAMPLE "1"^^xsd:integer, "abc"^^xsd:string.

Note 1 to entry: This contrasts with a value that is determined by resolving a chain of substitution (e.g. a variable).

[SOURCE: ISO 19143:2010, 4.15]

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3.1.16
metadata
information about a resource

[SOURCE: ISO 19115-1:2014, 4.10]

3.1.17
multiplicity
<UML> specification of the range of allowable cardinalities that a set may assume

[SOURCE: ISO 19103:2015, 4.24]

3.1.18
object property
<OWL> semantic *association* (3.1.2) between a pair of *individuals* (3.1.14)

Note 1 to entry: Object properties have sometimes been referred to as 'abstract properties' in Description Logic.

[SOURCE: OWL]

3.1.19
ontology
formal representation of phenomena of a universe of discourse (3.1.23) with an underlying vocabulary including definitions and axioms that make the intended meaning explicit and describe phenomena and their interrelationships

[SOURCE: ISO 19101-1:2014, 4.1.26]

3.1.20
property
<RDF> relation between subject resources and object resources

[SOURCE: RDF]

3.1.21
property restriction
<OWL> special kind of *class* (3.1.5) description through the definition of constraints on values and cardinalities

[SOURCE: OWL]

3.1.22
range
<ontology> restriction to constrain the class of objects which participate in a subject-predicate-object triple

Note 1 to entry: A range restriction can be thought of as a type constraint on the value of a function or range of a relation.

3.1.23
universe of discourse
view of the real or hypothetical world that includes everything of interest

[SOURCE: ISO 19101-1:2014, 4.1.38]

3.2 Abbreviated terms

OWL Web Ontology Language (version 2)

RDF Resource Description Framework

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RDFS	RDF Schema
SKOS	Simplified Knowledge Organization System
UML	Unified Modeling Language
URI	Universal Resource Identifier

3.3 Namespaces

19150-4service	Requirements class for the identification and description of GeoWeb services http://standards.isotc211.org/iso19150/-4/1/req/geoweb-ServiceIdenficationAndDescription/
19150-4service-conf	Conformance class for the identification and description of GeoWeb Services http://standards.isotc211.org/iso19150/-4/1/conf/geoweb-ServiceIdentificationAndDescription/
19150-4capabilities	Requirements class for the capabilities of GeoWeb services http://standards.isotc211.org/iso19150-4/req/geowebServiceIdenfication-AndDescription/
19150-4capabilities-conf	Conformance class for the capabilities of GeoWeb Services http://standards.isotc211.org/iso19150/-4/1/conf/GeoWebServiceCapabilitiesgeowebServiceCapabilities/
19150-4metadata	Requirements class for the metadata of GeoWeb services http://standards.isotc211.org/iso19150/-4/1/req/geowebServiceMetadata/
19150-4metadata-conf	Conformance class for the metadata of GeoWeb Services http://standards.isotc211.org/iso19150/-4/1/conf/geowebServiceMetadata/
19150-4owl	Requirements class for the OWL ontology http://standards.isotc211.org/iso19150/-4/1/req/owl/
19150-4owl-conf	Conformance class for the OWL ontology http://standards.isotc211.org/iso19150/-4/1/conf/owl/

4 Conformance

Any service description claiming conformance with this document shall pass the requirements described in the abstract test suite, presented in Annex A.

The abstract test suite is organized in four conformance classes (name and namespace) that address the following purposes:

— Geographic information Web service identification and description (19150-4service-conf);

— Geographic information Web service capabilities (19150-4capabilities-conf);

— Geographic information Web service metadata (19150-4metadata-conf); and

— Geographic information Web service ontology (19150-4owl-conf).

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5 GeoWeb service ontology framework

5.1 General

Clause 5 sets the framework for the description of GeoWeb services. This framework is based on ISO 19119 for the description of geospatial services and ISO 19115-1 which defines the elements for the documentation of such services through service metadata. These two international standards set a foundation for the definition of GeoWeb service ontology framework. This framework is hereafter illustrated in UML. It also has been developed with consideration of the following documents:

— OWL-S: Semantic Markup for Web Services (OWL-S 1.1) (W3C Member Submission 22 November 2004);

— OWL-S: Semantic Markup for Web Services (OWL-S release 1.2);

— Semantic Web Services Ontology (SWSO) (W3C Member Submission 9 September 2005);

— Web Service Modeling Ontology (WSMO) (W3C Member Submission 3 June 2005);

— WSMO-Lite: Lightweight Semantic Descriptions for Services on the Web (W3C Member Submission 23 August 2010);

— OGC Web Service Common Implementation Specification, version 2.0.0, document #06-121r9.

This framework has been developed to support the use cases that are documented in Annex B.

The GeoWeb service framework consists of four elements that are GeoWeb service identification, GeoWeb service description, GeoWeb service capabilities, GeoWeb service metadata.

This document requires the use of standard HTTP URIs to identify resources in geographic information for the purpose of ontologies. The URI structures are defined in ISO 19150-2:2015, Annex B.

The requirements for representing GeoWeb Services in OWL ontologies comprise three requirements classes, identified as http://standards.isotc211.org/iso19150/-4/1/req/geowebServiceIdenficationAndDescription/ (i.e. 19150-4service), http://standards.isotc211.org/iso19150/-4/1/req/geowebServiceCapabilities/ (i.e. 19150-4capabilities) and http://standards.isotc211.org/iso19150/-4/1/req/geowebServiceMetadata/ (i.e. 19150-4metadata).

5.2 GeoWeb service identification and description

5.2.1 General

The requirements for the identification and description of GeoWeb services are listed in Table 1 and illustrated in UML in Figure 1.

Table 1 — Requirements class for GeoWeb service identification and description

Requirements class	
19150-4service = http://standards.isotc211.org/iso19150/-4/1/req/geowebServiceIdenficationAndDescription/	
Target type	Ontology Framework
Dependency	http://standards.iso.org/iso/19103/ed-2/en/ (Conceptual schema language)
Dependency	http://standards.iso.org/iso/19119/ed-2/en/ (Service), clause 10
Requirement	19150-4service:GeoWebServiceIdentification
Requirement	19150-4service:GeoWebServiceDescription
Requirement	19150-4service:TaxonomyAndFunction
Requirement	19150-4service:GeoWebServiceTaxonomy

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Requirements class	
Requirement	19150-4service:GeoWebServiceFunction
Requirement	19150-4service:GeoWebServiceLifeCycle
Requirement	19150-4service:ServiceParameters
Requirement	19150-4service:ServiceCost

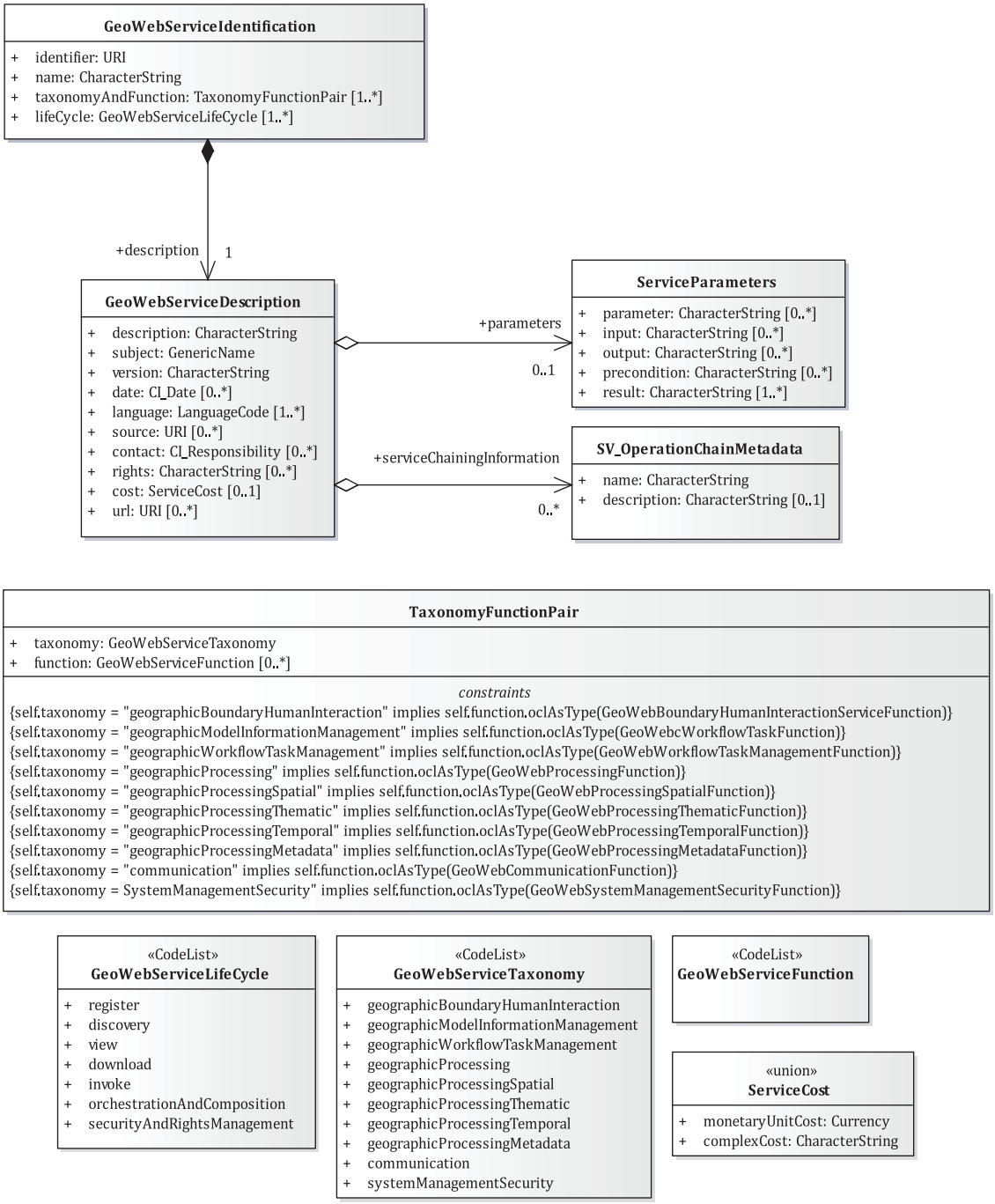

Figure 1 — UML diagram for GeoWeb service identification and description

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5.2.2 GeoWeb service identification

5.2.2.1 Semantics

A GeoWeb service is a computational entity which is able (by invocation) to achieve a user's goal related to geographic information. The class GeoWebServiceIdentification provides basic information about the GeoWeb service.

5.2.2.2 Requirements

Table 2 lists the requirements for the identification of GeoWeb services.

Table 2 — GeoWeb service identification requirements

Requirement
19150-4service:GeoWebServiceIdentification
A GeoWeb service shall be described by a class and identified with the following properties which are further described in 5.2.2.3: — identifier; — name; — taxonomyAndFunction; — lifeCycle; and — description.

5.2.2.3 Properties

Table 3 sets the properties for the identification of GeoWeb services.

Table 3 — GeoWeb service identification properties

Name	Semantics	Multiplicity	Range
identifier	Unambiguous reference to the GeoWeb service.	1..1	URI
name	Name identifying the GeoWeb service that is being offered.	1..1	CharacterString
taxonomyAndFunction	A pair of taxonomy and function(s) values.	1..*	TaxonomyFunctionPair
lifeCycle	Usage oriented life cycle perspective description.	1..*	GeoWebServiceLifeCycle
description (role)	Account of the content of the GeoWeb service.	1..1	GeoWebServiceDescription

5.2.3 GeoWeb service description

5.2.3.1 Semantics

The class GeoWebServiceDescription provides detailed information about the GeoWeb Service.

5.2.3.2 Requirements

Table 4 lists the requirements for the description of GeoWeb services.

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Table 4 — GeoWeb service description requirements

Requirement
19150-4service:GeoWebServiceDescription
A GeoWeb service shall be described with the following properties which are further described in 5.2.3.3: — description; — subject; — version; — date; — language; — source; — contact; — rights; — cost; — url; — parameters; and — ServiceChainingInformation.

5.2.3.3 Properties

Table 5 sets the properties for the description of GeoWeb services.

Table 5 — GeoWeb service description properties

Name	Semantics	Multiplicity	Range
description	Brief account of the content of the GeoWeb service which may include a summary of what the service offers and any requirements that the service has.	1..1	CharacterString
subject	Topic of the GeoWeb service.	1..1	GenericName
version	Identifier for the specific release of the GeoWeb service at a precise time.	1..1	CharacterString
date	Date of an event in the life cycle of the GeoWeb service.	0..*	CI_Date
language	ISO 639-1 2 letter code or ISO 639-2 3 letter code identifier of the language of the GeoWeb service.	1..*	LanguageCode
source	Reference to an element from which the present GeoWeb service is derived.	0..*	URI

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Name	Semantics	Multiplicity	Range
contact	Reference to humans or individuals responsible for the GeoWeb service or to some aspects of the service.	0..*	CI_Responsibility
rights	Information about rights held in and over the GeoWeb service.	0..*	CharacterString
cost	Cost information requested for accessing the GeoWeb service. NOTE The service may be free.	0..1	ServiceCost
url	URL associated with the GeoWeb service.	0..*	URI
parameters (role)	Parameters required to invoke the GeoWeb service.	0..1	ServiceParameters
serviceChainingInformation (role)	Description of the GeoWeb service chaining.	0..*	SV_OperationChainMetadata

5.2.4 Taxonomy and function

5.2.4.1 Semantics

TaxonomyFunctionPair provides synchronized function values to the taxonomy value.

5.2.4.2 Requirements

Table 6 lists the requirements for the taxonomy and function pair.

Table 6 — Taxonomy and function pair requirements

Requirement
19150-4service:TaxonomyFunctionPair
A taxonomy and function pair shall be described with the following properties which are further described in 5.2.4.3: — taxonomy; and — function. The function property value shall be synchronized with the taxonomy property value:

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Requirement
— use the codelist GeoWebBoundaryHumanInteractionServiceFunction when taxonomy is set to "geographicBoundaryHumanInteraction"; — use the codelist GeoWebcWorkflowTaskFunction when taxonomy is set to "geographicModelInformationManagement"; — use the codelist GeoWebWorkflowTaskManagementFunction when taxonomy is set to "geographicWorkflowTaskManagement"; — use the codelist GeoWebProcessingFunction when taxonomy is set to "geographicProcessing"; — use the codelist GeoWebProcessingSpatialFunction when taxonomy is set to "geographicProcessingSpatial"; — use the codelist GeoWebProcessingThematicFunction when taxonomy is set to "geographicProcessingThematic"; — use the codelist GeoWebProcessingTemporalFunction when taxonomy is set to "geographicProcessingTemporal"; — use the codelist GeoWebProcessingMetadataFunction when taxonomy is set to "geographicProcessingMetadata"; — use the codelist GeoWebCommunicationFunction when taxonomy is set to "communication"; — use the codelist GeoWebSystemManagementSecurityFunction when taxonomy is set to "SystemManagementSecurity.

5.2.4.3 Properties

Table 7 sets the properties for taxonomy and function of GeoWeb services.

Table 7 — GeoWeb service taxonomy and function properties

Name	Semantics	Multiplicity	Range
taxonomy	Nature of the GeoWeb service.	1..1	GeoWebServiceTaxonomy
function	Purpose of the GeoWeb service.	0..*	GeoWebServiceFunction

5.2.5 GeoWeb service taxonomy

5.2.5.1 Semantics

GeoWebServiceTaxonomy is a codelist providing taxonomy code values.

5.2.5.2 Requirements

Table 8 lists the requirements for GeoWeb service taxonomy.

Table 8 — GeoWeb service taxonomy requirements

Requirement
19150-4service:GeoWebServiceTaxonomy
The code values for GeoWebServiceTaxonomy shall include the following values which are further described in 5.2.5.3:

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