Open Geospatial Consortium Inc.

Date: 2008-04-05

Reference number of this document: OGC 08-008r1

Version: 0.2.0

Category: OpenGIS® Discussion Paper

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OpenGIS® Abstract Specification
Proposed Topic 19: General Reference Systems

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Document type: OpenGIS® Discussion Paper
Document subtype: Draft new Abstract Specification Topic
Document stage: Approved Discussion Paper
Document language: English

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i. Preface

This discussion paper is a draft new topic volume for the OGC Abstract Specification, which may also be used to propose a corresponding new standard to ISO/TC 211. This document proposes extensions to OGC Abstract Specification Topic 2 — Spatial referencing by coordinates, and thus to ISO 19111 — Spatial referencing by coordinates. This discussion paper is posted for comments on the contents. Revision of this draft is planned, to improve some details while supporting the same abilities.

These extensions allow specifying more general reference systems, beyond the constraints of ISO 19111 and 19111-2. A Coordinate Reference System (CRS) as specified in ISO 19111 (and encoded in GML 3.1+) is limited to spatial-temporal axes, without any axis redundancy. However, several existing OGC standards, such as GML, WCS, and WMS, could effectively use "coordinates" based on more general reference systems. For further discussion of potential uses of these general reference systems, see Annex B (informative).

NOTE I write "without any axis redundancy" based on Subclause 8.2.4.1 of ISO 19111:2007, in which the first sentence reads "For spatial coordinates, a number of constraints exist for the construction of Compound CRSs. Coordinate reference systems that are combined shall not contain any duplicate or redundant axes."

These extensions are specified in the same manner as the proposed extensions for parametric coordinate reference systems, in ISO 19111-2.

Suggested additions, changes, and comments on this draft are welcome and encouraged. Such suggestions may be submitted by email message or by making suggested changes in an edited copy of this document.

ii. Document terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 06-121r3], which is based on the ISO/IEC Directives, Part 2. Rules for the structure and drafting of International Standards. In particular, the word "shall" (not "must") is the verb form used to indicate a requirement to be strictly followed to conform to this specification.

iii. Document contributor contact points

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iv. Revision history

Date	Release	Editor	Primary clauses modified	Description
2008-02-05	08-008 0.1.0	Arliss Whiteside	All	First draft
2008-04-05	08-008r1 0.2.0	Arliss Whiteside	cover, i,	Change to approved discussion paper with explanation, correct some wording

Foreword

This document does not supersede any previously approved OGC document, but supersedes parts of some draft documents. This document proposes extensions to OGC Abstract Specification Topic 2 — Spatial referencing by coordinates, and thus to ISO 19111 — Spatial referencing by coordinates.

This document includes two annexes; Annex A is normative, and Annex B is informative.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium Inc. shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

Introduction

ISO 19111 describes the elements necessary to fully define various types of reference systems used for spatial referencing by coordinates. In ISO 19111, a coordinate is one of *n* scalar values that define the position of a point. ISO 19111 allows for coordinates which are angular such as latitude and longitude or linear such as easting and northing. ISO 19111 also describes the concept of a compound coordinate reference system. A compound coordinate reference system uses at least two independent coordinate reference systems to describe a 3-dimensional spatial position.

ISO 19111-2 extends 19111 to allow expressing spatial position in terms of one parameter or function. Such a parameter may be related to a spatial dimension, but this is not essential. ISO 19111-2 defines a single-axis parametric coordinate reference system using the concepts from ISO 19111. The provisions of ISO 19111 are then used to allow including one parametric coordinate reference system as part of a compound coordinate reference system.

This document is a draft new topic volume for the OGC Abstract Specification, which may also be used to propose a corresponding new standard to ISO/TC 211. This document proposes extensions to OGC Abstract Specification Topic 2 — Spatial referencing by coordinates. These extensions allow specifying more general reference systems, beyond the constraints of ISO 19111 and 19111-2. A Coordinate Reference System (CRS) as specified in ISO 19111 is limited to spatial-temporal axes, without any axis redundancy.

This document specifies a Nonspatial Reference System that is not spatial, but may be temporal and/or parametric, and may contain multiple axes. This document also specifies a General Compound Reference System which may add one or more Nonspatial Reference Systems to a compound coordinate reference system. Furthermore, a General Compound Reference System may include redundant axes in the spatial, temporal, and nonspatial reference systems that are combined, when that is useful.

OpenGIS® Abstract Specification
Topic 19: General Reference Systems

1 Scope

This draft OGC Abstract Specification topic specifies the conceptual schema for more general (coordinate) reference systems. It extends the schema of ISO 19111 to define a nonspatial reference system that is not spatial, but may be temporal and/or parametric, and may contain multiple axes. It also extends ISO 19111 to define a general compound reference system which may add one or more nonspatial reference systems to a compound coordinate reference system. Furthermore, a general compound reference system may include redundant axes in the spatial, temporal, and nonspatial reference systems that are combined, when that is useful.

Like OGC Abstract Specification Topic 2 and ISO 19111, this Abstract Specification topic is applicable to producers and users of environmental information.

2 Conformance requirements

Any general reference system claiming conformance to this Abstract specification shall satisfy the requirements of Annex A.

3 Normative references

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

ISO/TS 19103, *Geographic information – Conceptual schema language*

ISO 19108, *Geographic information – Temporal schema*

ISO 19111, *Geographic information – Spatial referencing by coordinates*

ISO 19111-2, *Geographic information – Spatial referencing by coordinates – Part 2: Extension for parametric values*

4 Terms and definitions

For the purposes of this document, the terms and definitions of ISO 19111, 19111-2, and the following terms and definitions apply:

4.1
general compound reference system
compound reference system which may include one or more **nonspatial reference system** components and may include redundant (spatial, temporal, and nonspatial) coordinate axes

NOTE In most uses, at least one included reference system will be a spatial coordinate reference system, but that is not required.

4.2
nonspatial coordinate system
one or more dimensional coordinate system for a **nonspatial reference system,** which combines coordinate axes that are not spatial

4.3
nonspatial datum
datum for a **nonspatial reference system,** which identifies the meanings of the zero values of the axes in a **nonspatial reference system**

4.4
nonspatial reference system
one or more dimensional (coordinate) reference system which uses a nonspatial coordinate system and optional nonspatial datum

NOTE A nonspatial reference system does not include any spatial axes, but may include temporal and/or parametric axes.

5 Conventions

5.1 Abbreviated terms

CRS coordinate reference system

GML Geography Markup Language

UML Unified Modelling Language

5.2 UML notation

In this Abstract Specification, the conceptual schema for describing general reference systems is modelled with the Unified Modelling Language (UML). The basic data types and UML diagram notations are defined in ISO/TS 19103 and ISO/IEC 19501.

5.3 Attribute status

In this Abstract Specification, class attributes are given an obligation status:

Obligation	Definition	Meaning
M	Mandatory	This attribute shall be supplied.
C	conditional	This attribute shall be supplied if the condition (given in the attribute description) is true. It may be supplied if the condition is false.
O	Optional	This attribute may be supplied.

In this Abstract Specification, the Maximum Occurrence column indicates the maximum number of occurrences of attribute values that are permissible, with N indicating no upper limit.

6 General reference systems

6.1 Background

ISO 19111, *Geographic information - Spatial referencing by coordinates*, defines a *coordinate reference system* as a coordinate system which is related to an object (such as the Earth) by a datum. *A coordinate system* is a set of mathematical rules for specifying how coordinates are to be assigned to points. A coordinate system will have one or more axes. A *datum* defines the position of the origin, the scale, and the orientation of a coordinate system. ISO 19111 describes several subtypes of coordinate reference system, coordinate system and datum. This Abstract Specification defines more subtypes of each to accommodate more general reference systems.

6.2 General reference systems

6.2.1 Overview

A General Compound Reference System is a multi-coordinate reference system that can include nonspatial coordinate axes values, and is not limited to spatial-temporal axes without any axis redundancy. This new GeneralCompoundRS generalizes the existing (spatial-temporal) SC_CompoundCRS to include non-spatial reference systems containing nonspatial coordinates. This generalized compound reference system also generalizes a CompoundCRS to allow including zero or more (spatial-temporal) coordinate reference systems (CRSs), including allowing combinations of coordinate reference systems (CRSs) that together include redundant axes.

A Nonspatial Reference System is a reference system that does not include any spatial axes, but may contain temporal and/or parametric axes. This NonspatialRS combines a Nonspatial Coordinate System having one or more axes with an optional Nonspatial Datum. That Nonspatial Datum specifies the meaning of the zero value of each coordinate system axis, when that axis does not have a (well-known) natural zero value meaning.

6.2.2 General compound reference systems

The General Compound Reference System (GeneralCompoundRS) data structure shall contain the parameters described in Figure 1 and specified in Table 1 and Table 2. As indicated, the GeneralCompoundRS shall combine one or more concrete subclasses of the abstract SC_CRS class. Those subclasses include the:

a) Existing SC_CompoundCRS, SC_GeodeticCRS, SC_EngineeringCRS, and any other concrete subclass of the abstract SC_SingleCRS, allowing redundant axes

b) New NonspatialReferenceSystem class described below

c) Another GeneralCompoundRS, except direct or indirect inclusion of itself is prohibited

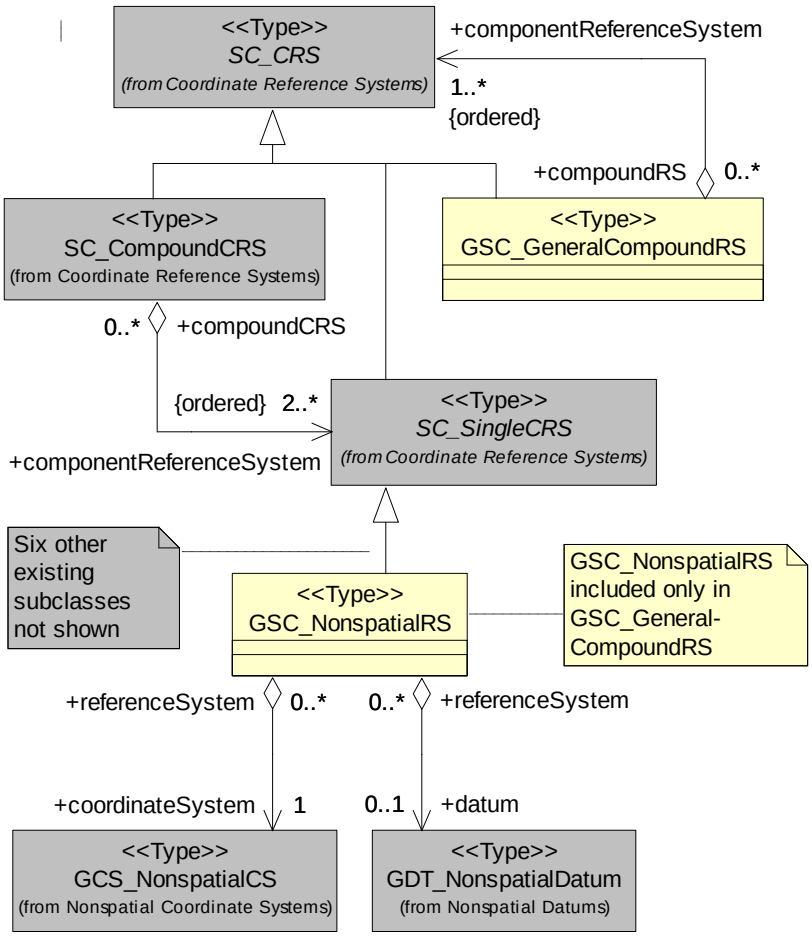

Figure 1 — UML class diagram for general reference systems

EDITORS NOTE The SC_CRS and SC_SingleCRS classes in the above diagram are abstract, so the class names should be in italics. Sometimes these italics get lost when copying a Rose class diagram into a Word document.

Table 1 — Defining elements of GSC_GeneralCompoundRS class

Description:	General compound reference system which may include GSC_NonspatialRS components and may include redundant (spatial, temporal, and nonspatial) coordinate axes.				
Stereotype:	Type				
Class attribute:	Concrete				
Inheritance from:	SC_CRS				
Association roles:	(aggregation) componentReferenceSystem to SC_CRS [1..*] [ordered]				
Public Attributes:	6 attributes inherited from SC_CRS:				
Attribute name	**UML identifier**	**Data type**	**Obligation**	**Maximum Occurrence**	**Attribute description**
CRS name	Name	RS_Identifier	M	1	This is the primary name for the CRS. Aliases and other identifiers may be given through the attributes alias and identifier.
CRS alias	Alias	GenericName	O	N	An alias by which this CRS is known.
CRS identifier	Identifier	RS_Identifier	O	N	An identifier which references elsewhere the CRS's defining information; alternatively an identifier by which this CRS can be referenced.
CRS scope	Scope	CharacterString	M	N	Description of usage, or limitations of usage, for which this CRS is valid. If unknown, enter "not known".
CRS validity	domainOfValidity	EX_Extent	O	N	Area or region or timeframe in which this CRS is valid.
CRS remarks	Remarks	CharacterString	O	1	Comments on or information about this CRS, including data source information.

NOTE Some of the class attributes listed above are defined in ISO 19111 to provide high flexibility, but may be rarely used. For example, a GSC_GeneralCompoundRS may include values for only the Name, Scope, and Remarks attributes.

6.3 Nonspatial reference system

A nonspatial reference system (NonspatialRS) is a concrete subtype of an abstract single CRS. Figure 1 shows the UML class diagram. A NonspatialRS shall consist of one nonspatial coordinate system and one optional nonspatial datum; these elements are described in 6.3 and 6.4. Table 2 describes the attributes of a NonspatialRS inherited from SC_SingleCRS.

Table 2 — Defining elements of GSC_NonspatialRS class

Description:	One or more dimensional nonspatial reference system which uses a nonspatial coordinate system and optional nonspatial datum, not including any spatial coordinates but may include temporal and/or parametric coordinates.
Stereotype:	Type
Class attribute:	Concrete
Inheritance from:	SC_SingleCRS
Association roles:	(aggregation) datum to GCD_NonspatialDatum [0..1] (aggregation) coordinateSystem to GCS_NonspatialCS [1] (associations inherited from SC_SingleCRS)
Public Attributes:	6 attributes inherited from SC_SingleCRS:

Attribute name	UML identifier	Data type	Obligation	Maximum Occurrence	Attribute description
CRS name	Name	RS_Identifier	M	1	This is the primary name for the CRS. Aliases and other identifiers may be given through the attributes alias and identifier.
CRS alias	Alias	GenericName	O	N	An alias by which this CRS is known.
CRS identifier	Identifier	RS_Identifier	O	N	An identifier which references elsewhere the CRS's defining information; alternatively an identifier by which this CRS can be referenced.
CRS scope	Scope	CharacterString	M	N	Description of usage, or limitations of usage, for which this CRS is valid. If unknown, enter "not known".
CRS validity	domainOfValidity	EX_Extent	O	N	Area or region or timeframe in which this CRS is valid.
CRS remarks	Remarks	CharacterString	O	1	Comments on or information about this CRS, including data source information.

NOTE Some of the class attributes listed above are defined in ISO 19111 to provide high flexibility, but may be rarely used. For example, a GSC_NonspatialRS may include values for only the Name, Scope, and Remarks attributes.

6.4 Nonspatial coordinate system

A nonspatial coordinate system (NonspatialCS) contains one or more coordinate system axes that are not spatial, but may be temporal and/or parametric. A NonspatialCS shall be a concrete subtype of an abstract CS_CoordinateSystem, and shall be included only in a GeneralCompoundRS (not in a SC_CompoundCRS). Figure 2 shows the UML class diagram, and Table 3 describes the NonspatialCS class attributes, inherited from CS_CoordinateSystem as defined in ISO 19111.

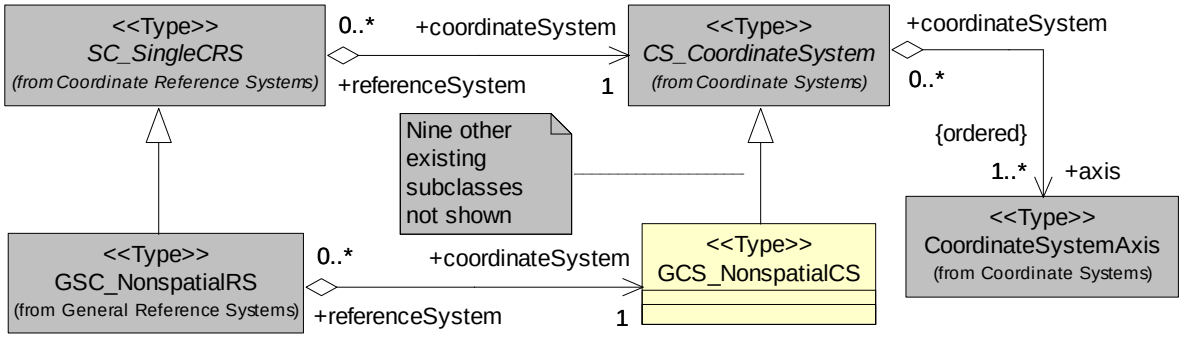

Figure 2 — UML class diagram for a nonspatial coordinate system

EDITORS NOTE The SC_SingleCRS and CS_CoordinateSystems classes in the above diagram are abstract, so the class names should be in italics. Sometimes these italics get lost when copying a Rose class diagram into a Word document.

Table 3 — Defining elements of GCS_NonspatialCS class

Description:	One or more dimensional coordinate system which combines coordinate axes that are not spatial, but may be temporal or parametric.
Stereotype:	Type
Class attribute:	Concrete
Inheritance from:	CS_CoordinateSystem
Association roles:	(aggregation) coordinateSystem from GSC_NonspatialRS [1 (associations inherited from CS_CoordinateSystem, including *(aggregation) axis to CS_CoordinateSystemAxis [1..*]*)
Public attributes:	4 attributes inherited from CS_CoordinateSystem:

Attribute name	UML identifier	Data type	Obligation	Maximum Occurrence	Attribute description
CS name	Name	RS_Identifier	M	1	This is the primary name for the CS. Aliases and other identifiers may be given through the attributes alias and identifier.
CS alias	Alias	GenericName	O	N	An alias by which this CS is known.
CS identifier	identifier	RS_Identifier	O	N	An identifier which references elsewhere the CS's defining information; alternatively an identifier by which this CS can be referenced.
CS remarks	Remarks	CharacterString	O	1	Comments on or information about this CS, including data source information.

6.5 Nonspatial datum

A nonspatial datum (NonspatialDatum) shall be a subtype of a CD_Datum. A NonspatialDatum shall be used only as a part of a NonspatialRS. Figure 3 shows the UML class diagram, and Table 4 describes the NonspatialDatum attributes, inherited from CD_Datum as defined in ISO 19111.

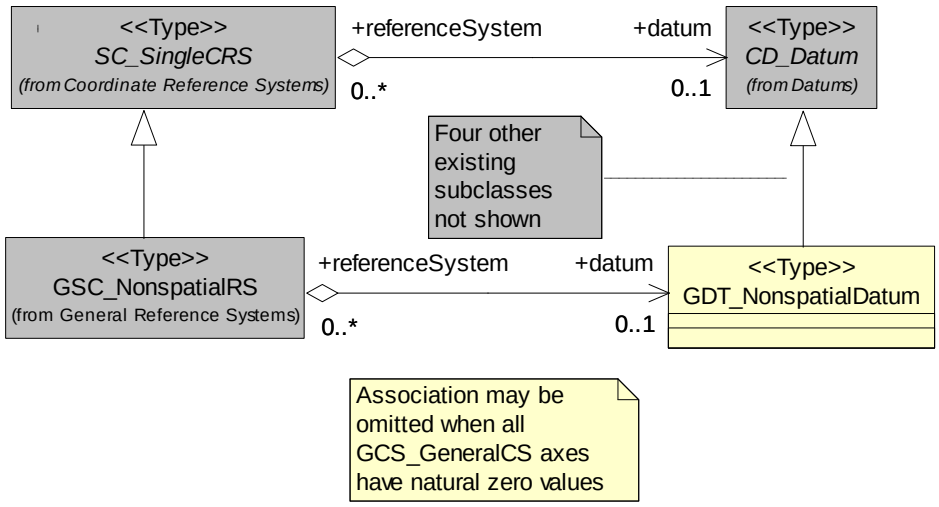

Figure 3 — UML class diagram for a nonspatial datum

EDITORS NOTE The SC_SingleCRS and CD_Datum classes in the above diagram are abstract, so the class names should be in italics. Sometimes these italics get lost when copying a Rose class diagram into a Word document.

Table 4 — Defining elements of GCD_NonspatialDatum class

Description:	A textual description and/or a set of parameters identifying the meanings of the zero values of the axes in a nonspatial reference system.
Stereotype:	Type
Class attribute:	Concrete
Inheritance from:	CD_Datum
Association roles:	(aggregation) datum from GCD_NonspatialRS [0..1], may be omitted when all GCS_NonspatialCS axes have natural zero value
Public attributes:	8 attributes inherited from CD_Datum:

Attribute name	UML identifier	Data type	Obligation	Maximum Occurrence	Attribute description
Datum name	Name	RS_Identifier	M	1	This is the primary name for the datum. Aliases and other identifiers may be given through the attributes alias and identifier.
Datum alias	Alias	GenericName	O	N	An alias by which this datum is known.
Datum identifier	Identifier	RS_Identifier	O	N	An identifier which references elsewhere the datum's defining information; alternatively an identifier by which this datum can be referenced.
Datum anchor	anchorDefinition	CharacterString	O	1	The datum definition – a description, possibly including coordinates of an identified point or points, of the relationship used to anchor the coordinate system to the Earth or alternate object. - For a parametric datum, the anchor may be an identified physical surface with the orientation defined relative to the surface.
Datum realization epoch	realizationEpoch	Date	O	1	The time after which this datum definition is valid. This time may be given to any precision.
Datum scope	Scope	CharacterString	M	N	Description of usage, or limitations of usage, for which this datum is valid. If unknown, enter "not known".
Datum validity	domainOfValidity	EX_Extent	O	1	Area or region or timeframe in which this datum is valid.
Datum remarks	Remarks	CharacterString	O	1	Comments on or information about this datum, including data source information.

NOTE Many of the class attributes listed above are defined in ISO 19111 to provide high flexibility, but may be rarely used. For example, a GCD_NonspatialDatum may include values for only the Name, anchorDefinition, and Scope attributes.

6.6 Coordinate operations on general reference systems

ISO 19111 describes the schema for changing coordinates from one coordinate reference system to another. This schema may be applied to nonspatial reference systems (NonspatialRS) and general compound reference systems (GeneralCompoundRS).

Annex A
(normative)

Abstract test suite

A.1 Conformance class A: General reference systems

A.1.1 Nonspatial reference system test module

To check that general reference system (NonspatialRS and GeneralCompoundRS) descriptions that include parametric and temporal axes are in conformance with this specification, check that descriptions satisfy the requirements given in A.1.2 and A.1.3

A.1.2 Nonspatial reference system (NonspatialRS) test

a) Test purpose: To determine whether all of the relevant entities and elements which are specified to be mandatory or mandatory under the conditions specified have been provided in the descriptions.

b) Test method: Check nonspatial reference system (NonspatialRS) descriptions that include one or more parametric and/or temporal axes to ensure that each includes as a minimum all of the elements indicated as mandatory or conditional in Tables 2 to 4.

c) Reference: 6.3 to 6.5 and ISO 19111 clause A.1.

d) Test type: capability.

A.1.3 General compound reference system (GeneralCompoundRS) test

a) Test purpose: To determine whether all of the relevant entities and elements which are specified to be mandatory or mandatory under the conditions specified have been provided in the descriptions.

b) Test method: Check general compound reference system (GeneralCompoundRS) descriptions that include one or two nonspatial reference systems with one or two spatial coordinate reference systems to ensure that each includes as a minimum all of the elements indicated.as mandatory or conditional in Table 1.

c) Reference: 6.2 and ISO 19111 clauses 8 and A.1.

d) Test type: capability.

A.2 Conformance class B: Coordinate operations

A.2.1 Coordinate operation test module

To check that a coordinate transformation or coordinate conversion or concatenated operation that operates on a general reference system (NonspatialRS and

GeneralCompoundRS) is in conformance with this specification, check that it satisfies the requirements given in A.2.2 and A.2.3.

A.2.2 Coordinate operation on a nonspatial reference system (NonspatialRS) test

a) Test purpose: To determine whether all of the relevant entities and elements which are specified to be mandatory or mandatory under the conditions specified have been provided in the description.

b) Test method: Check the coordinate operation description to ensure that it includes as a minimum all of the all of the elements indicated as mandatory or conditional.

c) Reference: 6.6 and ISO 19111 clauses 11 and A.1.

d) Test type: capability.

A.2.3 Coordinate operation on a general compound reference system (GeneralCompoundRS) test

a) Test purpose: To determine whether all of the relevant entities and elements which are specified to be mandatory or mandatory under the conditions specified have been provided in the description.

b) Test method: Check the coordinate operation description to ensure that it includes as a minimum all of the all of the elements indicated as mandatory or conditional.

c) Reference: 6.6 and ISO 19111 clauses 11 and A.2.

d) Test type: capability.

Annex B
(informative)

Uses of nonspatial reference systems

B.1 Overview

A Coordinate Reference System (CRS) as specified in ISO 19111 (and encoded in GML 3.1.1 and 3.2.1) is limited to spatial-temporal axes, without any axis redundancy. However, several OGC specifications, such as GML, WCS, and WMS, could effectively use "coordinates" based on more nonspatial reference systems. For example, the CRS limitation to spatial-temporal axes, without any axis redundancy, limits current OGC specifications:

a) The Web Coverage Service (WCS) is limited to spatial-temporal coverage domains stored, requested, and output. It cannot now use non-spatial-temporal grid coverage domain dimensions, separate or combined with spatial-temporal dimensions. It also cannot use redundant spatial-temporal grid coverage domain dimensions, such as two temporal dimensions.

b) The Geography Markup Language (GML) is limited to recording spatial-temporal position coordinates, in (feature) geometries. It is not now possible to attach velocity, acceleration, etc. to the position coordinates. It is also not possible to attach values of other variable feature properties to position coordinates, in (feature) geometries.

c) The Web Map service (WMS) is limited to producing maps in two horizontal coordinates. It is not now possible to specify a map slice cutting through a 3D or 4D layer space.

A disadvantage of supporting these nonspatial reference systems is that they could be misused, by mistake or intentionally, creating new problems. Therefore, these nonspatial reference systems should be used only with considerable care. If a spatial or spatial-temporal CRS would meet the needs, only a CRS should be used. If a Nonspatial reference System with only one axis would meet the needs, only one axis should be used. If a General Compound Reference System with only one Nonspatial reference System would meet the needs, only one should be included. Furthermore, each General Compound Reference System and Nonspatial Reference System used should be carefully documented, to minimize the likely confusion.

B.2 OWS Common

One expected use of these general reference systems is a new GeneralBoundingBox subclass of the OWS Common BoundingBox UML class and XML element. That new GeneralBoundingBox will be able to reference any GeneralCompoundRS or NonSpatialRS.

B.3 Web Coverage Service (WCS)

General reference systems are excpected to be used to support more general (grid) coverage domains in the Web Coverage Service (WCS). Specifically, referencing a nonspatial reference system (GeneralCompoundRS or NonspatialRS) in a BoundingBox allows a grid coverage domain, or domain subset, to include dimensions that are neither spatial nor temporal, and to include multiple temporal dimensions.

WCS [1] currently supports spatial and temporal domain dimensions (or coordinate axes). An offered coverage can have 1, 2, or 3 dimensions in space. Further, at most one temporal dimension is allowed. Situations exist, however, where a more flexible and extended selection of domain dimensions is needed.

Bibliography

[1] ISO/IEC 19501-1, *Information technology — Unified Modelling Language (UML) — Part 1: Specification*

