Open Geospatial Consortium Inc.

Date: 2005-01-28

Reference number of this OGC™ document: OGC 05-011

Version: 1.0.0

Category: OGC™ Recommendation Paper

Editor: Arliss Whiteside

Recommended XML/GML 3.1.1 encoding of common CRS definitions

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Document type: OGC™ Recommendation Paper
Document subtype: (none)
Document stage: Approved Recommendation Paper
Document language: English

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i. Preface

NOTE The previous version of this document was numbered 04-103r1, now renumbered 05-011 after approval and final editing in 2005.

This OGC™ Recommendation Paper specifies XML encoding of data defining some common-used coordinate reference systems and coordinate operations, based on GML 3.1.1 [OGC 04-092r4] . This document covers geographic, projected, vertical, and compound CRSs. Most of the CRSs defined in the EPSG database are of these types.

This Recommendation Paper replaces some parts of OGC Recommendation Paper 03-010r9, titled "Recommended XML encoding of coordinate reference systems and coordinate transformations". The CRS Schemas in that document are now specified in GML 3.1.1 [OGC 04-092r4]. The XML examples and Application Schemas in Annexes E and F of [OGC 03-010r9] that are relevant to common CRSs are included in this paper, updated to match GML 3.1.1 and the recommended uses of the “ogc” URN namespace [OGC 05-010].

Many key contents of this paper are provided in the attached set of files, in the same zip file. These files include:

a) The example XML documents included and XML Schemas referenced in Clause 6 “Common coordinate reference systems”

b) The example XML documents included in Annex C “More example XML Schemas”

c) The example Application Schema and XML documents for Annex D "Example application schemas"

ii. Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

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iii. Revision history

Date	Release	Editor	Primary clauses modified	Description
2004-12-17	0.0.0	Arliss Whiteside	All	Initial version
2005-01-07	0.0.0	Arliss Whiteside	6.2.2, 6.3.2, 6.5.2, C.2	Changes referencing of EPSG coordinate axis objects
2005-01-28	1.0.0	Arliss Whiteside	Cover, i, 6.2.2, 6.3.2, 6.5.2, C.2	Removed changes for referencing of EPSG coordinate axis objects, editing as approved Discussion Paper

iv. Changes to the OGC Abstract Specification

The OGC™ Abstract Specification does not require changes to accommodate the technical contents of this document.

v. Future work

Improvements of this document are needed to modify the XML schemas, and the corresponding XML examples, to reflect recent changes in the Topic 2 UML model [OGC 04-046r3].

Foreword

This OGC™ Recommendation Paper supersedes parts of the previous OGC Recommendation Paper numbered 03-010r9, titled "Recommended XML encoding of coordinate reference system definitions". This document is based on the GML 3.1.1 OGC Recommendation Paper [04-092r4]. That document uses XML Schemas as specified by the W3C.

This document contains five annexes, all informative except Annex B.

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.

Introduction

This document recommends standard XML encodings of data defining some commonly-used coordinate reference systems, including geographic, projected, and vertical CRSs. These recommended encodings are based on GML 3.1.1. These common CRS definitions will often be referenced in data transferred between client and server software that implements various standardised interfaces. This specified definition data encoding is expected to be used by multiple OGC Implementation Specifications. That is, each of these specifications is expected to use a subset and/or superset of this recommended definition data.

The position or location of a point can be described using coordinates. Such coordinates are unambiguous only when the coordinate reference system on which those coordinates are based is fully defined. Each position is described by a set of coordinates based on a specified coordinate reference system. Coordinates are often used in datasets in which all coordinates belong to the same coordinate reference system. This paper specifies XML encoding of data defining some coordinate reference systems.

Recommended XML/GML 3.1.1 encoding of common CRS definitions

1 Scope

This OGC™ Recommendation Paper specifies standard XML encodings of definition data for commonly-used coordinate reference systems (CRSs), including geographic, projected, and vertical CRSs. Compound CRSs combining a vertical CRS with a 2D geographic or projected CRS are also covered.

These recommended encodings are based on GML 3.1.1. This encoding is intended for use when referencing or transferring such definition data between client and server software that uses OGC standard interfaces, as specified in other documents. The expected uses of this definition data transfer include those described in Annex A of this document.

The scope of this encoding does not include geocentric, engineering, image, temporal, and derived CRSs.

This Recommendation Paper specifies standard XML encodings of common CRS definition data applicable to multiple separate OGC interface Implementation Specifications. Each such Implementation Specification should specify one or more subsets and/or supersets of the definition data specified herein, each to be used for one or more purposes. That is, for each operation specified, the Implementation Specification should specify which specific CRSs should be supported.

This document also defines a Profile of GML 3.1.1 for these commonly-used CRSs. That profile includes all the elements and types in all the XML Schema fragments listed herein. That profile omits essentially all the CRS-related GML 3.1.1 elements and types not discussed in this document.

2 Conformance

Conformance with this specification shall be checked using all the relevant tests specified in each separate specification that normatively references this specification, and specifically references the applicable parts of this specification. Those specifications are expected to expand and specialize the conformance requirements stated in Annex B (normative) of this document.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

European Petroleum Survey Group: *EPSG Geodesy Parameters* V 6.6, available through www.epsg.org

IETF RFC 2141 (May 1997), *URN Syntax*, R. Moats <http://www.ietf.org/rfc/rfc2141.txt>

IETF RFC 2396 (August 1998), *Uniform Resource Identifiers (URI): Generic Syntax*, Berners-Lee, T., Fielding, N., and Masinter, L., eds., <http://www.ietf.org/rfc/rfc2396.txt>

ISO 8601, *Data elements and interchange formats - Information interchange Representation of dates and times*

ISO 19105:2000, *Geographic information — Conformance and Testing*

ISO 19109:2004, *Geographic Information – Rules for Application Schemas*

ISO 19115:2003, *Geographic information — Metadata*

OGC 04-024, *Geographic information — Web Map Service interface*, v1.3.0

OGC 04-046r3, *The OpenGIS Abstract Specification, Topic 2: Spatial referencing by coordinates*

OGC 04-092r4, *Geography Markup Language (GML) version 3.1.1 schemas* (draft)

OGC 05-008, *OGC Web Services Common Specification*

OGC 05-010, *URNs of definitions in ogc namespace*

W3C Recommendation 6 October 2000, *Extensible Markup Language (XML) 1.0* (Second Edition), http://www.w3.org/TR/REC-xml

W3C Recommendation 2 May 2001: *XML Schema Part 0: Primer,* http://www.w3.org/TR/2001/REC-xmlschema-0-20010502/

W3C Recommendation 2 May 2001: *XML Schema Part 1: Structures,* http://www.w3.org/TR/2001/REC-xmlschema-1-20010502/

W3C Recommendation 2 May 2001: *XML Schema Part 2: Datatypes,* http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/

4 Terms and definitions

For the purposes of this specification, many of the definitions specified in Clauses 4 of the OGC Abstract Specification Topic 2 [04-046r3] and OWS Common Specification [OGC 05-008] shall apply. In addition, the following terms and definitions apply.

4.1
Application Schema
conceptual schema for data required by one or more applications [ISO 19101]

4.2
GML Application Schema
an XML Schema written according to the GML 3 rules for Application Schemas, which defines a vocabulary of geographic objects for a particular domain of discourse [GML 3.0]

4.3
object
an XML document element of a type derived from AbstractGMLType [GML 3.0]

4.4
profile
specified logical subset of XML Schema specified elements and types, defined to enhance interoperability and to curtail ambiguity [adapted from GML 3.0]

4.5
sequence
finite, ordered collection of related items (objects or values) that may be repeated [ISO 19107]

4.6
set
unordered collection of related items (**objects** or values) with no repetition [ISO 19107]

4.7
Uniform Resource Identifier (URI)
simple and extensible means for identifying a resource; a short string or address; classified as a name, a locator, or both [RFC 2396]

5 Conventions

5.1 Symbols (and abbreviated terms)

CRS	Coordinate Reference System
EPSG	European Petroleum Survey Group
GML	Geography Markup Language

IETF	Internet Engineering Task Force
ISO	International Organization for Standardization
OGC	Open Geospatial Consortium
OWS	OGC Web Service, or Open Web Service
TBD	To Be Determined
TBR	To Be Reviewed
UML	Unified Modeling Language
URI	Universal Resource Identifier
URL	Uniform Resource Locator
URN	Universal Resource Name
WKT	Well Known Text
XML	eXtensible Markup Language
1D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional

5.2 UML Notation

All diagrams in this document are Unified Modeling Language (UML) class diagrams, as described in Subclause 5.2 of [OGC 05-008].

5.3 Document terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 05-008].

6 Common coordinate reference systems

6.1 Introduction

This clause specifies how to define many commonly-used coordinate reference systems, including geographic, projected, and vertical CRSs. Compound CRSs combining a vertical CRS with a 2D geographic or projected CRS are also covered.

These CRS definitions are usually not required to be transferred between servers and clients that use OGC Web Services (OWS) Implementation Specifications. However, these definitions shall be used in defining coordinate operations, and shall be referenced by those coordinate operation definitions.

References to these CRSs shall be in the form of the anyURI data type specified by XML Schema. As specified in Subclause 10.3 of “OWS common implementation specification" [OGC 05-008], such an anyURI value can be either a URL with standard form or a URN in the "ogc" URN namespace. As specified in Subclause 7.1 of "URNs for definitions in the ogc namespace" [OGC 05-010], URNs in the "ogc" URN namespace can be used to reference any CRS defined in the EPSG database. As specified in Subclause 8.2 of the same document, URNs in the "ogc" URN namespace can be used to reference any CRS defined in Annex B of WMS 1.3 [OGC 04-024].

6.2 Geographic CRSs

6.2.1 Simple UML model

Figure 1 is a simplified UML class diagram extracted from Topic 2 that shows all the concrete (non-abstract) object classes and associations related to the SC_GeographicCRS class. To keep this diagram simple, none of the class attributes is displayed. This diagram shows that the SC_GeographicCRS uses a CS_GeodeticCS, which has either two or three usesAxis associations to CS_CoordinateSystemAxis.

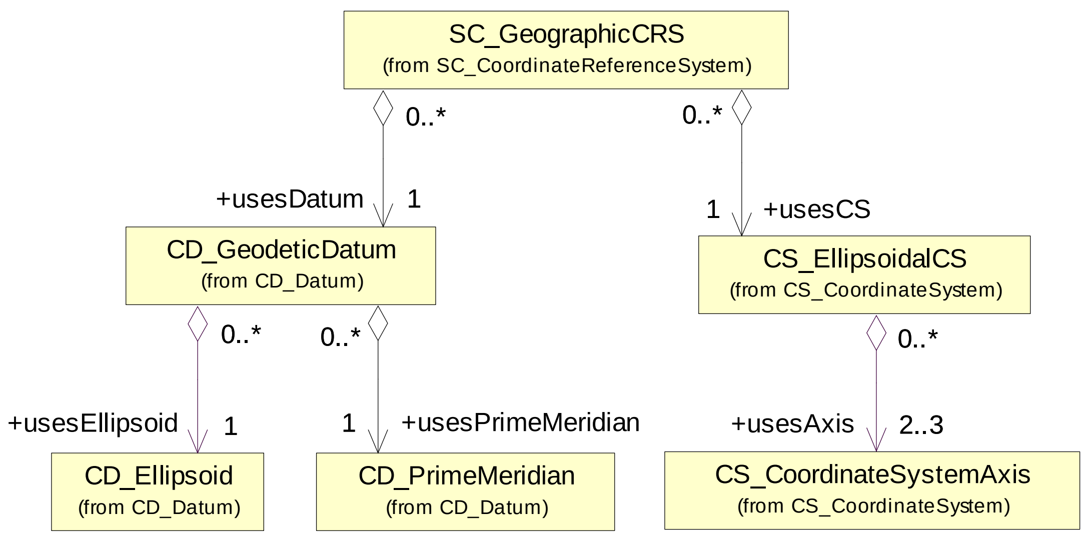

Figure 1 — GeographicCRS simple UML class diagram

Notice that the GeographicCRS class does NOT include or reference any coordinate operations, which can be used to transform or convert geographic coordinates into any other coordinate reference system.

6.2.2 XML document example

An example XML document defining a GeographicCRS is:

```
<?xml version="1.0" encoding="UTF-8"?>
<GeographicCRS xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/gml
fragmentGeographicCRSs.xsd" gml:id="EPSG4277">
```



```
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26-->
   <srsName>OSGB 1936</srsName>
   <srsID>
      <name codeSpace="urn:ogc:def:crs:EPSG:6.0:">4277</name>
   </srsID>
   <usesEllipsoidalCS>
      <EllipsoidalCS gml:id="EPSG6402">
         <csName>ellipsoidal</csName>
         <csID>
            <name codeSpace="urn:ogc:def:cs:EPSG:6.0:">6402</name>
         </csID>
         <usesAxis>
            <CoordinateSystemAxis gml:id="EPSG9901"
gml:uom="urn:ogc:def:uom:OGC:0.0:degree">
               <name>Geodetic latitude in north direction with degree
units</name>
               <axisID>
                  <name
codeSpace="urn:ogc:def:axis:EPSG:6.0:">9901</name>
               </axisID>
               <axisAbbrev>Lat</axisAbbrev>
               <axisDirection>north</axisDirection>
            </CoordinateSystemAxis>
         </usesAxis>
         <usesAxis>
            <CoordinateSystemAxis gml:id="EPSG9902"
gml:uom="urn:ogc:def:uom:OGC:0.0:degree">
               <name>Geodetic longitude in east direction with degree
units</name>
               <axisID>
                  <name
codeSpace="urn:ogc:def:axis:EPSG:6.0:">9902</name>
               </axisID>
               <axisAbbrev>Lon</axisAbbrev>
               <axisDirection>east</axisDirection>
            </CoordinateSystemAxis>
         </usesAxis>
      </EllipsoidalCS>
   </usesEllipsoidalCS>
   <usesGeodeticDatum>
      <GeodeticDatum gml:id="EPSG6277">
         <datumName>OSGB 1936</datumName>
         <datumID>
            <name codeSpace="urn:ogc:def:datum:EPSG:6.0:">6277</name>
         </datumID>
         <usesPrimeMeridian>
            <PrimeMeridian gml:id="EPSG8901">
               <meridianName>Greenwich</meridianName>
               <meridianID>
                  <name
codeSpace="urn:ogc:def:meridian:EPSG:6.0:">8901</name>
               </meridianID>
               <greenwichLongitude>
                  <angle uom="urn:ogc:def:uom:OGC:1.0:degree">0</angle>
               </greenwichLongitude>
            </PrimeMeridian>
         </usesPrimeMeridian>
```



```
         <usesEllipsoid>
            <Ellipsoid gml:id="EPSG7001">
               <ellipsoidName>Airy 1830</ellipsoidName>
               <ellipsoidID>
                  <name
codeSpace="urn:ogc:def:ellipsoid:EPSG:6.0:">7001</name>
               </ellipsoidID>
               <semiMajorAxis
uom="urn:ogc:def:uom:OGC:1.0:meter">6377563.396</semiMajorAxis>
               <secondDefiningParameter>
                  <inverseFlattening
uom="urn:ogc:def:uom:OGC:1.0:unity">299.3249646</inverseFlattening>
               </secondDefiningParameter>
            </Ellipsoid>
         </usesEllipsoid>
      </GeodeticDatum>
   </usesGeodeticDatum>
</GeographicCRS>
```

The corresponding GML 3.1.1 XML Schema fragment for defining a GeographicCRS is attached in the file fragmentGeographicCRSs.xsd.

NOTE GML 3.1.1 is not yet fully harmonized with Abstract Specification Topic 2, so the above XML document template and the referenced XML Schema fragment are not fully consistent with the following UML class diagram.

6.2.3 Full UML model

Figure 2 is a more complete UML class diagram extracted from Topic 2 that shows essentially all the classes and associations related to the SC_GeographicCRS class. This diagram again shows that the SC_GeographicCRS uses a CS_GeodeticCS, which has either two or three usesAxis associations to CS_CoordinateSystemAxis.

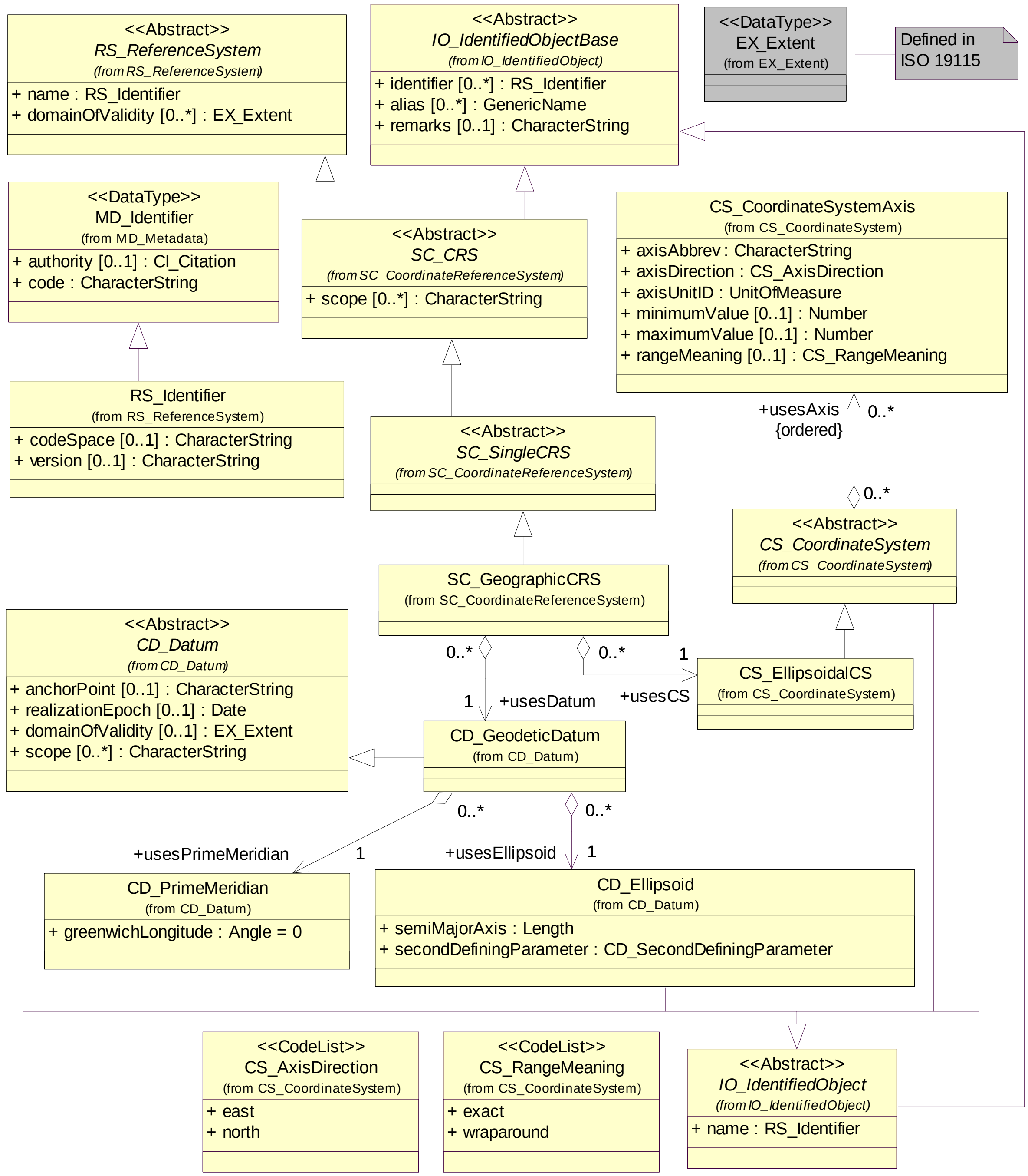

Figure 2 — GeographicCRS full UML class diagram

6.3 Projected CRSs

6.3.1 Simple UML model

Figure 3 is a simplified UML class diagram for projected CRSs extracted from Topic 2. This diagram shows the concrete (non-abstract) object classes and associations related to the SC_ProjectedCRS class, except for the classes and associations for the

CC_Conversion class (discussed in Subclause 6.4) used as the definedByConversion and the SC_GeographicCRS class (discussed in Subclause 6.2) that serves as the baseCRS.

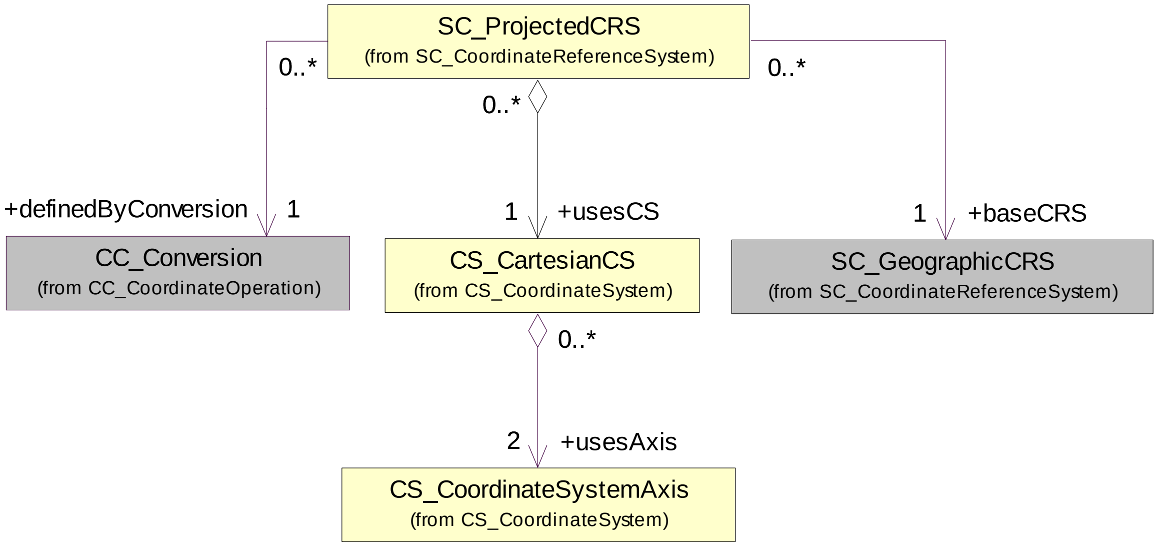

Figure 3 — ProjectedCRS simple UML class diagram

6.3.2 XML document example

An example XML document defining a ProjectedCRS is:

```
<?xml version="1.0" encoding="UTF-8"?>
<ProjectedCRS xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/gml
fragmentProjectedCRSs.xsd" gml:id="EPSG27700">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26-->
   <srsName>OSGB 1936 / British National Grid</srsName>
   <srsID>
      <name codeSpace="urn:ogc:def:crs:EPSG:6.0:">27700</name>

   </srsID>
   <baseCRS xlink:href="urn:ogc:def:crs:EPSG:6.0:4277"/>
   <definedByConversion
xlink:href="urn:ogc:def:coordinateOperation:EPSG:6.0:19916"/>
   <usesCartesianCS>
      <CartesianCS gml:id="EPSG4400">
         <csName>Easting and Northing in metres</csName>
         <csID>
            <name codeSpace="urn:ogc:def:cs:EPSG:6.0:">4400</name>
         </csID>
         <usesAxis>
            <CoordinateSystemAxis gml:id="EPSG9906"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
               <name>Easting in east direction with metre units </name>
               <axisID>
```

```
                  <name
codeSpace="urn:ogc:def:axis:EPSG:6.0:">9906</name>
               </axisID>
               <axisAbbrev>E</axisAbbrev>
               <axisDirection>east</axisDirection>
            </CoordinateSystemAxis>
         </usesAxis>
         <usesAxis>
            <CoordinateSystemAxis gml:id="EPSG9907"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
               <name>Northing in north direction with metre units
</name>
               <axisID>
                  <name
codeSpace="urn:ogc:def:axis:EPSG:6.0:">9907</name>
               </axisID>
               <axisAbbrev>N</axisAbbrev>
               <axisDirection>north</axisDirection>
            </CoordinateSystemAxis>
         </usesAxis>
      </CartesianCS>
   </usesCartesianCS>
</ProjectedCRS>
```

This example references the baseCRS, which is a GeographicCRS such as discussed in Subclause 6.2. This example also references the definedByConversion, which is a coordinate Conversion such as discussed in Subclause 6.4.

The corresponding GML 3.1.1 XML Schema fragment for defining a ProjectedCRS is attached in the file fragmentProjectedCRSs.xsd.

6.3.3 Full UML model

Figure 4 is a more complete UML class diagram for projected CRSs extracted from Topic 2. This diagram shows the classes and associations related to the SC_ProjectedCRS class, except for the classes and associations for the CC_Conversion class (discussed in Subclause 6.4) used as the definedByConversion and the SC_GeographicCRS class (discussed in Subclause 6.2) that serves as the baseCRS.

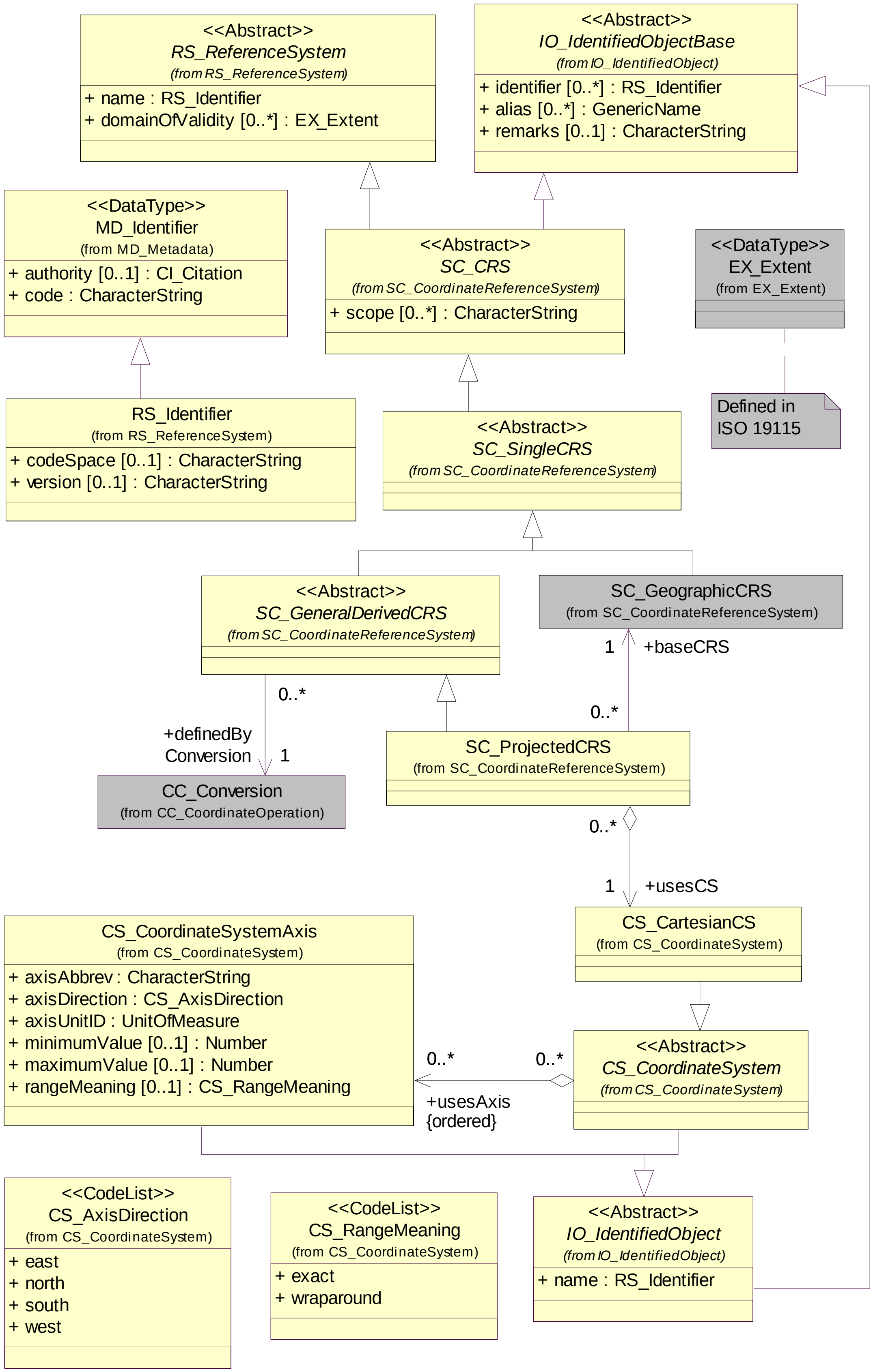

Figure 4 — ProjectedCRS full UML class diagram

6.4 Coordinate conversions

6.4.1 Simple UML model

A SC_ProjectedCRS is defined by a CC_Conversion, which is a concrete subtype of the CC_CoordinateOperation class. Figure 5 is a simplified UML class diagram for a CC_Conversion used for a projected CRS. This diagram shows the concrete (non-abstract) objects classes and associations related to the CC_Conversion class when used to define a SC_ProjectedCRS, except for the CC_ParameterValueGroup and CC_OperationParameterGroup classes, which are not normally useful in defining a projected CRS.

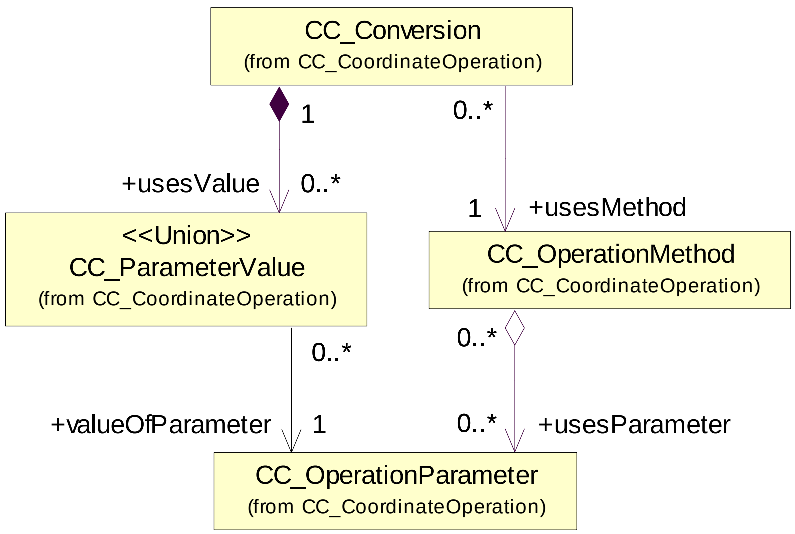

Figure 5 — Conversion UML simple UML class diagram

To keep this diagram simple, none of the class attributes are displayed. The definedByConversion association from the SC_ProjectedCRS class (inherited from the abstract SC_GeneralDerivedCRS class) is also not shown. For a projected CRS, this Conversion is usually defined by about five instances of the CC_OperationParameter and CC_ParameterValue classes, as needed.

6.4.2 XML document example

An example XML document defining a CC_Conversion is:

```
<?xml version="1.0" encoding="UTF-8"?>
<Conversion xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml fragmentConversions.xsd"
gml:id="EPSG19916">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26-->
   <!-- SourceCRS: EPSG:4277 OSGB 1936 -->
   <!-- TargetCRS: EPSG:27700 OSGB 1936 / British National Grid -->
```



```
   <coordinateOperationName>Transverse
Mercator</coordinateOperationName>
   <coordinateOperationID>
      <name
codeSpace="urn:ogc:def:coordinateOperation:EPSG:6.3:">19916</name>
   </coordinateOperationID>
   <usesMethod>
      <OperationMethod gml:id="EPSG9807">
         <methodName>Transverse Mercator</methodName>
         <methodID>
            <name codeSpace="urn:ogc:def:method:EPSG:6.3:">9807</name>
         </methodID>
         <methodFormula>See Section 1.4.6 "Transverse Mercator" of EPSG
Guidance Note 7, December 2000. </methodFormula>
         <sourceDimensions>2</sourceDimensions>
         <targetDimensions>2</targetDimensions>
         <usesParameter>
            <OperationParameter gml:id="EPSG8801">
               <parameterName>Latitude of natural
origin</parameterName>
               <parameterID>
                  <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8801</name>
               </parameterID>
            </OperationParameter>
         </usesParameter>
         <usesParameter>
            <OperationParameter gml:id="EPSG8802">
               <parameterName>Longitude of natural
origin</parameterName>
               <parameterID>
                  <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8802</name>
               </parameterID>
            </OperationParameter>
         </usesParameter>
         <usesParameter>
            <OperationParameter gml:id="EPSG8805">
               <parameterName>Scale factor at natural
origin</parameterName>
               <parameterID>
                  <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8805</name>
               </parameterID>
            </OperationParameter>
         </usesParameter>
         <usesParameter>
            <OperationParameter gml:id="EPSG8806">
               <parameterName>False Easting</parameterName>
               <parameterID>
                  <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8806</name>
               </parameterID>
            </OperationParameter>
         </usesParameter>
         <usesParameter>
            <OperationParameter gml:id="EPSG8807">
               <parameterName>False Northing</parameterName>
```

```
               <parameterID>
                  <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8807</name>
               </parameterID>
            </OperationParameter>
         </usesParameter>
      </OperationMethod>
   </usesMethod>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:degree">49</value>
      <valueOfParameter xlink:href="#EPSG8801" xlink:title="Latitude of
natural origin"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:degree">-2</value>
      <valueOfParameter xlink:href="#EPSG8802" xlink:title="Longitude
of natural origin"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:unity">0.999601272</value>
      <valueOfParameter xlink:href="#EPSG8805" xlink:title="Scale
factor at natural origin"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:metre">400000</value>
      <valueOfParameter xlink:href="#EPSG8806" xlink:title="False
Easting"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:metre">-100000</value>
      <valueOfParameter xlink:href="#EPSG8807" xlink:title="False
Northing"/>
   </usesValue>
</Conversion>
```

The corresponding GML 3.1.1 XML Schema fragment for defining a CC_Conversion is attached in the file fragmentConversions.xsd. That XML Schema fragment omits the encoding of the CC_OperationParameterGroup and CC_ParameterValueGroup classes, plus the validArea and positionalAccuracy attributes, in the UML model.

6.4.3 Full UML model

Figure 6 is a more complete UML class diagram for a CC_Conversion used for a projected CRS. This diagram shows the classes and associations related to the CC_Conversion class when used to define a SC_ProjectedCRS, except for the:

a) Contents of the DQ_PositionalAccuracy and EX_Extent classes, defined in ISO 19115

b) CC_ParameterValueGroup and CC_OperationParameterGroup classes, which are not normally useful in defining a projected CRS

c) Details of the SC_GeneralDerivedCRS class, because they are shown on the diagram in Figure 4

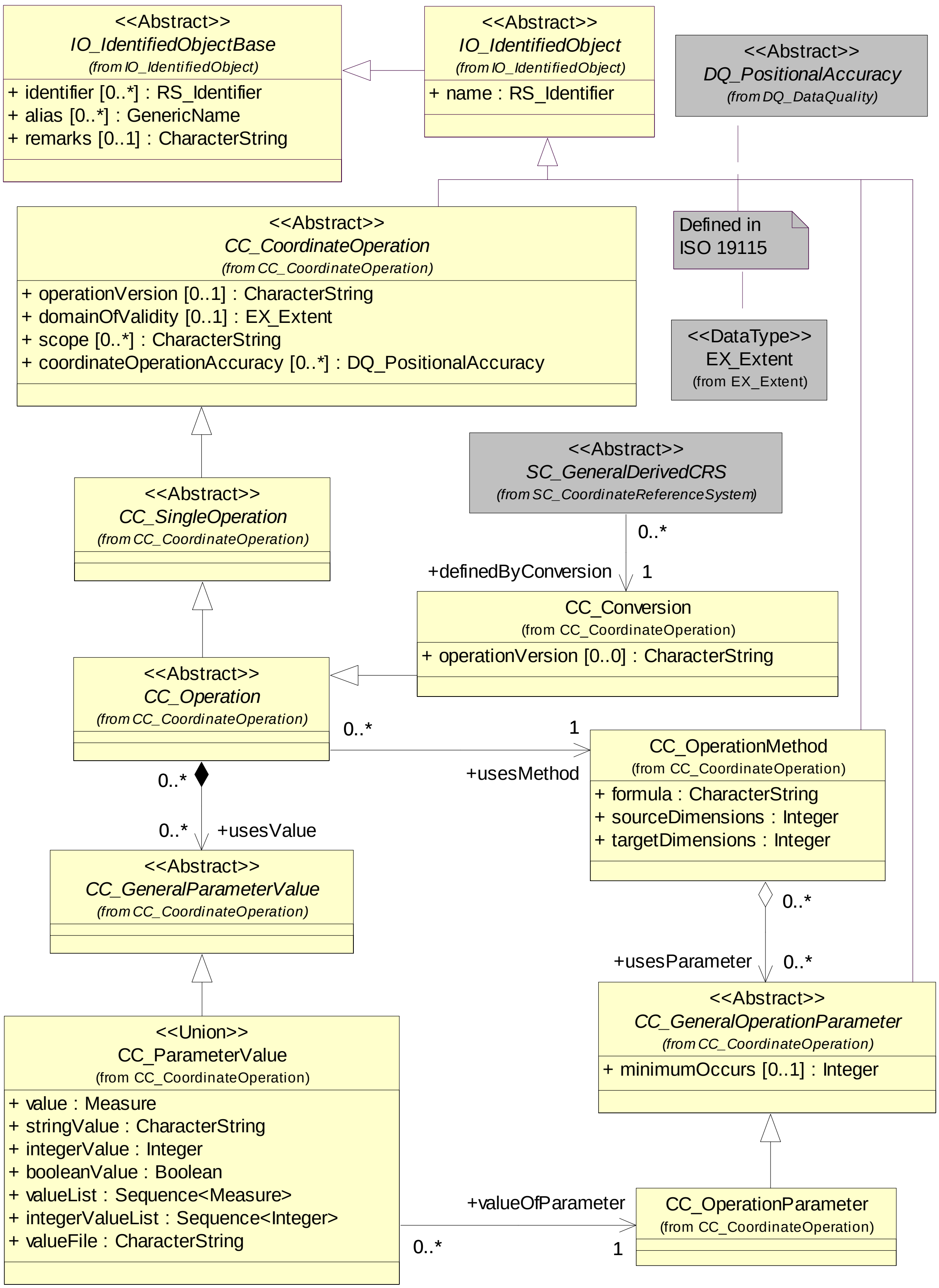

Figure 6 — Conversion full UML class diagram

6.5 Vertical CRSs

6.5.1 Simple UML model

Figure 9 is a simplified UML class diagram for Vertical CRSs extracted from Topic 2. This diagram shows the concrete (non-abstract) object classes and associations related to the SC_VerticalCRS class.

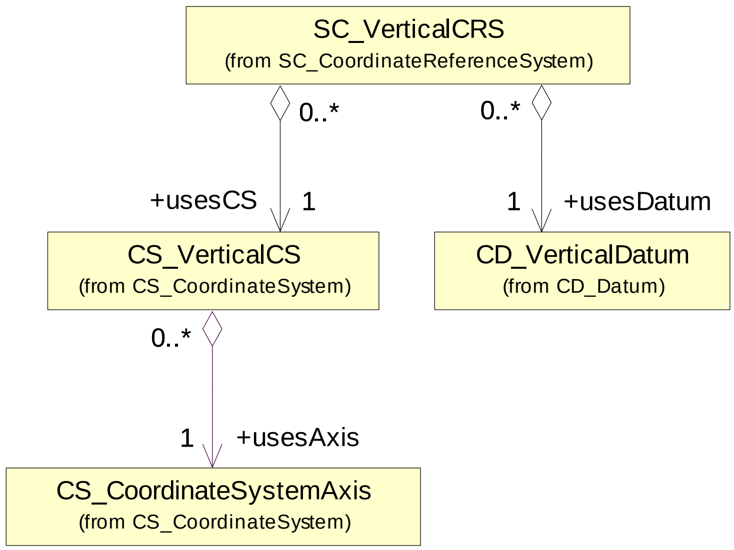

Figure 7 — VerticalCRS simple UML class diagram

6.5.2 XML document example

An example XML document defining a VerticalCRS is:

```
<?xml version="1.0" encoding="UTF-8"?>
<VerticalCRS xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/gml
fragmentVerticalCRSs.xsd" gml:id="EPSG5701">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26-->
   <srsName>Newlyn</srsName>
   <srsID>
      <name codeSpace="urn:ogc:def:crs:EPSG:6.0:">5701</name>
   </srsID>
   <usesVerticalCS>
      <VerticalCS gml:id="EPSG6499">
         <csName>Height up in metres</csName>
         <csID>
            <name codeSpace="urn:ogc:def:cs:EPSG:6.0:">6499</name>
         </csID>
         <usesAxis>
            <CoordinateSystemAxis gml:id="EPSG9904"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
```



```
                <name>Gravity-related height in up direction with metre
units</name>
                <axisID>
                   <name
codeSpace="urn:ogc:def:axis:EPSG:6.0:">9904</name>
                </axisID>
                <axisAbbrev>H</axisAbbrev>
                <axisDirection>up</axisDirection>
             </CoordinateSystemAxis>
          </usesAxis>
       </VerticalCS>
   </usesVerticalCS>
   <usesVerticalDatum>
       <VerticalDatum gml:id="EPSG5101">
          <datumName>Ordnance Datum Newlyn</datumName>
          <datumID>
             <name codeSpace="urn:ogc:def:datum:EPSG:6.0:">5101</name>

          </datumID>
          <verticalDatumType
codeSpace="urn:ogc:def:verticalDatumType:OGC:1.0:">geoidal</verticalDat
umType>
       </VerticalDatum>
   </usesVerticalDatum>
</VerticalCRS>
```

The corresponding GML 3.1.1 XML Schema fragment for defining a VerticalCRS is attached in the file fragmentVerticalCRSs.xsd.

6.5.3 Full UML model

Figure 10 is a more complete UML class diagram extracted from Topic 2 that shows more of the classes and associations related to the SC_VerticalCRS class.

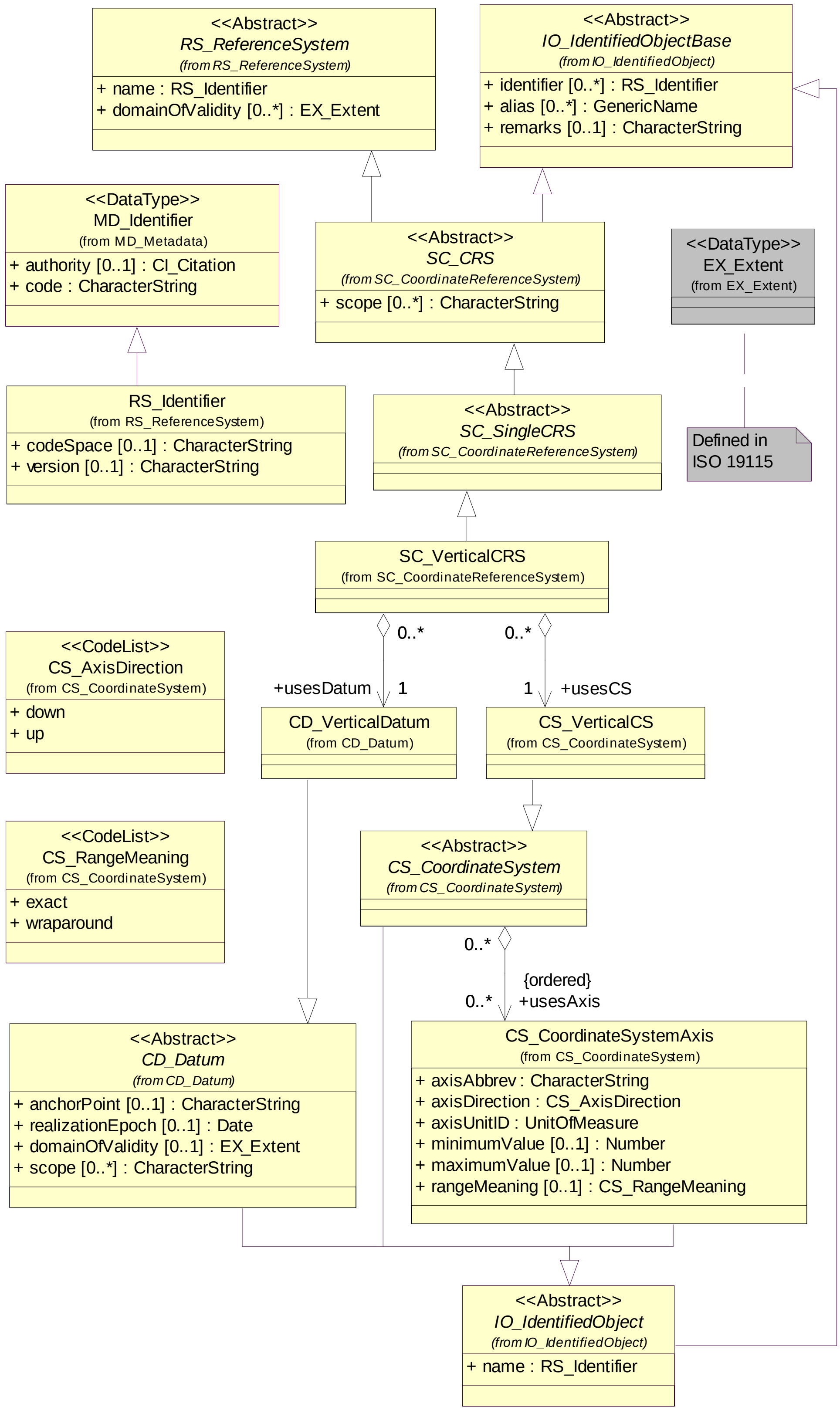

Figure 8 — VerticalCRS full UML class diagram

6.6 Compound CRSs

6.6.1 Simple UML model

Figure 9 is a simplified UML class diagram for Compound CRSs extracted from Topic 2. This diagram shows the concrete (non-abstract) object classes and associations related to the SC_CompoundCRS class, when it combines a SC_ProjectedCRS and a SC_VerticalCRS. Similarly, a 2D SC_GeographicCRS could be combined with a SC_VerticalCRS. This figure does not detail the SC_ProjectedCRS class which is discussed in Subclause 6.3, or the SC_VerticalCRS class which is discussed in Subclause 6.5.

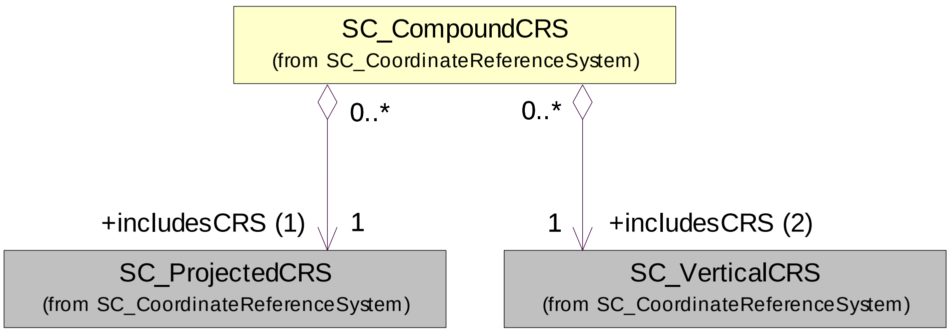

Figure 9 — CompoundCRS simple UML class diagram

6.6.2 XML document example

An example XML document defining a CompoundCRS is:

```
<?xml version="1.0" encoding="UTF-8"?>
<CompoundCRS xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/gml
fragmentCompoundCRSs.xsd" gml:id="EPSG7405">
   <!-- Primary editor: Arliss Whiteside. Last updated 2004-01-26-->
   <srsName>OSGB36 /British National Grid + ODN</srsName>
   <srsID>
      <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">7405</name>
   </srsID>
   <validArea>
      <description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man.
</description>
   </validArea>
   <includesCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:27700"
xlink:title="OSGB 1936 / British National Grid"/>
   <includesCRS xlink:href="urn:ogc:def:cs:EPSG:6.3:6499"
xlink:title="Newlyn"/>
</CompoundCRS>
```

This example uses URNs referencing the two included CRSs. Alternately, the complete definitions of those CRSs could be XML encoded (as shown in above examples) within the two includesCRS elements.

The corresponding GML 3.1.1 XML Schema fragment for defining a CompoundCRS is attached in the file fragmentCompoundCRSs.xsd.

6.6.3 Full UML model

Figure 10 is a more complete UML class diagram extracted from Topic 2 that shows more of the classes and associations related to the SC_CompoundCRS class, when it combines a Projected CRS and a VerticalCRS. Again, this figure does not detail the SC_ProjectedCRS class which is discussed in Subclause 6.3, or the SC_VerticalCRS class which is discussed in Subclause 6.5.

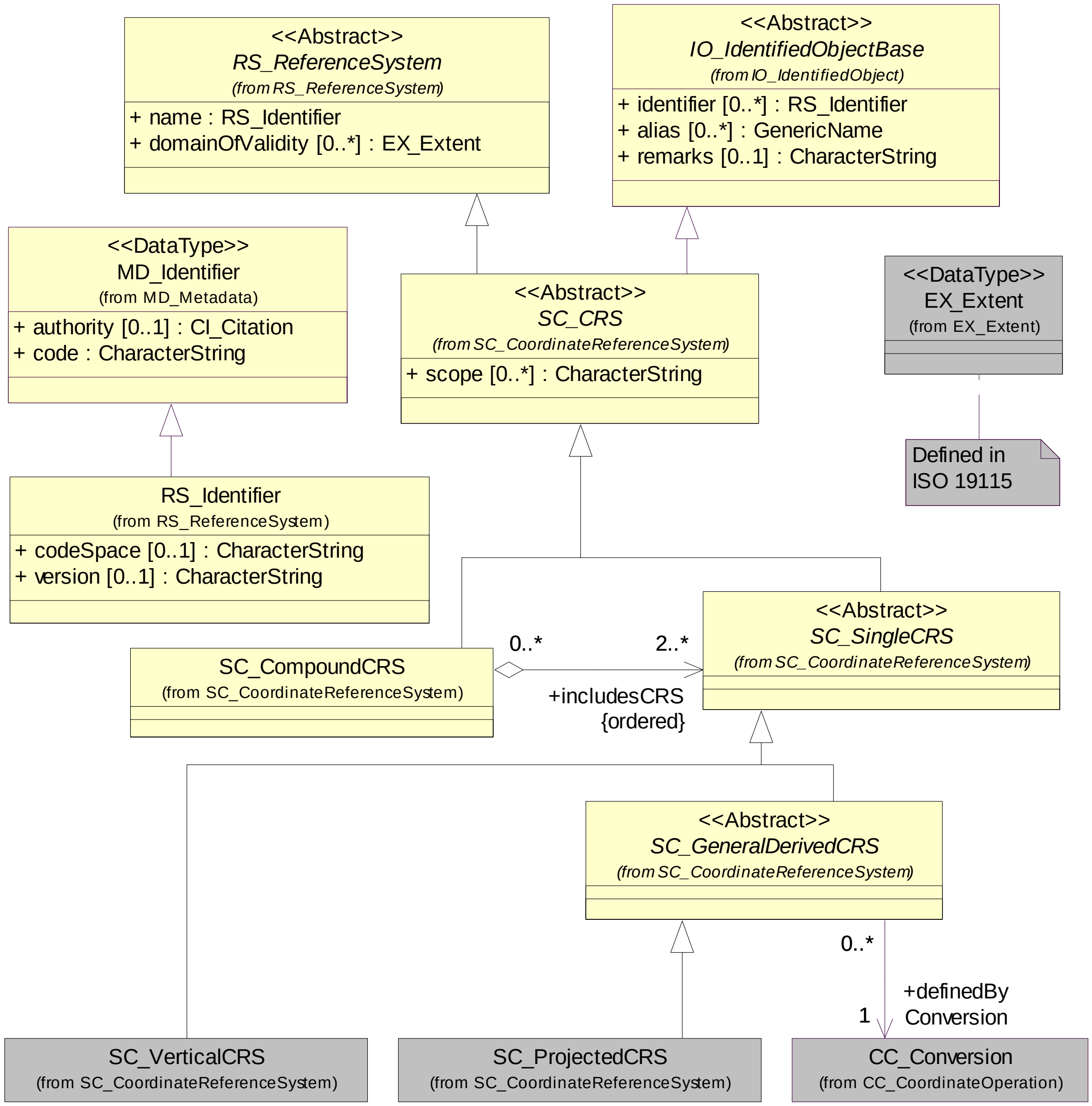

Figure 10 — CompoundCRS full UML class diagram

7 Supporting information

This clause introduces information provided in the annexes supporting the encoding described in Clause 6:

- Annex A (informative) describes the expected OGC uses (or use cases) for transferring CRS and coordinate operation definition data.
- Annex B (normative) specifies the requirements for OGC Implementation Specification conformance to the CRS portions of GML 3.1.1, and an abstract test suite for checking such conformance. Requirements are also specified for compliance of Application Schemas.

- Annex C (informative) provides more example XML documents using the CRS Schemas.
- Annex D (informative) provides an example application schema based on the CRS Schemas, with corresponding example XML documents and UML models.
- Annex E (informative) describes some example operation methods.

Annex A
(informative)

Expected uses of CRS definition data

A.1 Introduction

The expected OGC uses (or use cases) for transferring CRS and coordinate operation definition data produce requirements to be satisfied by the XML encoding of that data. Three broad uses of such definition data transfer have been identified:

a) Use to transfer definition of a Coordinate Reference System (CRS), used by other geospatial data

b) Use to transfer definition of a Coordinate Transformation (CT), that can be performed by a coordinate transformation service

c) Use to transfer lineage or history of other geospatial data

Additional OGC uses of the proposed CRS and coordinate operation definition data might be identified in the future. These expected OGC uses assume the OGC is standardizing software-to-software interfaces (or Application Programming Interfaces, APIs) and associated data transfer formats, but is not (currently) trying to standardize human-computer interfaces.

Each OGC standard interface must allow both server and client software to be written that implements that interface. Simplicity of the interfaces is highly desirable, to simplify client software. Simplicity of server implementation software is somewhat important, but not as important as interface simplicity.

The following subclauses first discuss the multiple uses of definition data, the alternate ways in which definition data can be transferred, and then the three data transfer uses listed above.

A.2 Multiple uses of definition data

CRS and CT definition data can be used in at least three broad overlapping ways, to:

a) Describe a specific CRS or CT to a human user. Note that different human users need different degrees of definition detail.

b) Uniquely identify a specific CRS or CT to software. For a CRS, such identification can be used by software to check if different geospatial datasets are recorded using the same CRS, or to find additional data about a CRS that is stored elsewhere.

c) Provide data for performing coordinate transformations and conversions, useful to transformation software. For a CT, such data might be used to perform that transformation. For a CRS, such data might be used in transforming point positions to or from that CRS.

A.3 Alternative ways to transfer definition data

CRS and CT definition data can be transferred in three alternative ways:

a) Transfer only identifier and perhaps name, of each CRS or CT

b) Transfer complete definition, of each CRS or CT

c) Transfer partial definition with identifiers (and perhaps names) for remaining parts, of each CRS or CT

Only an identifier needs to be transferred for a complete CRS or CT, or for any part thereof, for any part that is well-known to the receiving software. Well-known usually means that some recognized authority has produced and published a complete specification of that part. Server software could have those well-known definitions coded into the software. Alternately, server software could be coded to access those definitions when needed from a separate service known to the server. Such a separate service may be maintained by the authority or by a third party.

In general, there will be several CRS and CT specification authorities that one server or client might use, separately and together. Of course, some software implementations may use no such authority, or only one such authority. One widely-used, publicly-available authority is the European Petroleum Survey Group (EPSG), and use of this authority is currently specified in several OGC Implementation Specifications. However, other and more private authorities exist and must be supported by some OGC standard interfaces, including military affiliated authorities (e.g., DIGEST). Somewhat private authorities are expected to be used for many engineering and image coordinate reference systems.

A complete CRS or CT specification must be transferred for a CRS or CT, or for any part thereof, for any part that is not well-known to the receiving software. Some server or client implementations could support no well-known CRS and/or CT definitions. More likely, some applications are expected to use some non-well-known CRS or CT definitions. For example, a grid coverage can use a CRS specific to that coverage. Also, an image coordinate transformation is likely to be specific to one image, and may not be supported by any authority that makes that CT well-known.

A.4 Use to transfer coordinate reference system definition

XML can be used to transfer the definition of a Coordinate Reference System (CRS) used by other geospatial data, especially data encoded using XML. In most cases, one geospatial dataset will use only one CRS. The definition of a CRS for a geospatial dataset can be transferred (usually through an OGC interface) for several different purposes, including:

a) Coordinate Transformation (CT) interface. The current Coordinate Transformation (CT) server interface allows use of XML to transfer definitions of CRSs. That is, a client can send the definition of one CRS that the client is requesting access, to server software. Similarly, the server software can send to a client the definition of one CRS that the client currently has access to.

b) Geography Markup Language (GML). The encoding of features in XML, now specified in the GML Implementation Specification, might use this CRS XML to define the CRS of a feature collection or feature.

c) Web Map Server (WMS) interface. A future version of the WMS interface might use XML to define the CRS that the client is requesting “map” data in. (The WMS interface does not currently use XML for this purpose.) In the current WMS interface, only well-known CRSs are supported, so only the identifier of that well-known CRS is transferred in a Get Map request.

d) Grid Coverage (GC) interface. A future version of the GC (access) interface might use XML to define the CRS used by a coverage, when requested by a client. (The current GC interface does not use XML for this purpose.) In the current draft GC interface, the CRS can be defined for one specific grid coverage, requiring transfer of a more complete specification of that CRS. That grid CRS is usually specified as a custom affine coordinate conversion or transformation from another CRS.

A.4.1 Current CRS transfer by low-level CT interface

The current low-level Coordinate Transformation (CT) Implementation Specification (OGC document 01-009) supports XML transfer of a CRS definition in one operation and in one attribute.

The createFromXML operation of the CS_CoordinateSystemFactory <<Interface>> class creates a CS_CoordinateSystem object from a XML character string. One server will implement one CS_CoordinateSystemFactory object. The signature of this UML operation is:

```
createFromXML (xml:CharacterString) : CS_CoordinateSystem
```

The “XML” read-only UML attribute of the CS_Info class allows a client to get an XML character string representation of an object, which can be either a CS_CoordinateSystem or a CS_Unit UML object. Objects of both the CS_CoordinateSystem and CS_Unit UML classes can be instantiated by multiple other objects visible to one client. Note that a CS_CoordinateSystem object can be created in several ways other than use of the createFromXML operation. The signature of this UML attribute is:

```
XML : CharacterString
```

In the createFromXML operation, and when the UML attribute is used to get XML for a CS_CoordinateSystem object, the XML DTD for CS_CoordinateSystem provided in Section 15.1.1 (pages 113 through 115) of 00-007r4 is used. Example XML using that XML DTD is provided in Section 15.1.2 (pages 116 and 117) of 01-009. (Because that XML DTD and example XML are each more than one page, they are not copied here.)

NOTE A future version of the Coordinate Transformation (CT) Implementation Specification could use XML in additional places, especially where use of WKT is now supported but use of XML is not now supported.

A.4.2 Current CRS transfer by ICT and high-level CT interfaces

A draft high-level Coordinate Transformation (CT) Implementation Specification (OGC document 01-013r1) supports XML transfer of a CRS definition by two operations. The same two operations are supported by the draft Image Coordinate Transformation (ICT) interface (OGC document 00-045r1). These two operations are provided to clients by the one Ground Coordinate Transformation Service <<Interface>> object. The UML operation signatures of these two operations are:

```
addTransformation (metadata : TransformationMetadata,
     format : TextFormat) : TransformationID
transformationMetadata (transformation : TransformationID,
     format : TextFormat) : TransformationMetadata
```

XML is one possible format used by the Transformation Metadata <<DataType>> class that is used by these two operations. The Transformation Metadata class contains three UML attributes, with the signatures:

```
sourceCS : CoordinateSystemDefinition
targetCS : CoordinateSystemDefinition
transformation [0..1]: TransformationDefinition
```

The CoordinateReferenceSystem XML element, with all its contents, specified in this document could to be used for each Coordinate System Definition instance in the Transformation Metadata. (However, the Transformation XML element specified in GML 3.1.1, with all their contents, alternately could be used for complete Transformation Metadata, including both the source and target CoordinateReferenceSystems.)

A.5 Use to transfer coordinate transformation (CT) definition

XML can be used to transfer the definition of a Coordinate Transformation (CT) in the interfaces to Coordinate Transformation (CT) services. These interfaces include the accepted (low level) CT Implementation Specification, OGC document 01-009. These interfaces also include a high-level CT interface now proposed in document 01-013, plus draft Image Coordinate Transformation interfaces documented in 00-045r1. These CT interfaces use XML to transfer CT definitions with and without associated source and target CRSs.

A.5.1 Current CT transfer by low-level CT Interface

The current low-level Coordinate Transformation (CT) Implementation Specification (OGC document 01-009) supports XML transfer of a CT definition in one operation and one attribute.

The createFromXML operation of the CT_MathTransformFactory <<Interface>> class creates a CT_MathTransform object from a XML character string. One server will implement one CT_MathTransformFactory object. The UML signature of this operation is:


```
createFromXML (xml:CharacterString) : CT_MathTransform
```

The “XML” read-only UML attribute of the CT_MathTransform class allows a client to get an XML character string representation of this UML object. Objects of the CT_MathTransform class can be instantiated by multiple UML objects visible to one client. Note that a CT_MathTransform object can be created in several ways other than use of the createFromXML operation. The signature of this UML attribute is:

```
XML : CharacterString
```

For both of these XML uses, the XML DTD for CT_MathTransform provided in Section 15.1.1 (page 113) of 01-009 is used. Example XML using that XML DTD is not provided in 01-009. The XML DTD for CT_MathTransform now in Section 15.1.1 is:

```
<!DOCTYPE CT_MathTransform [
<!ELEMENT CT_MathTransform (
   CT_ConcatenatedTransform |
   CT_InverseTransform |
   CT_ParameterizedMathTransform |
   CT_PassThroughTransform) >

<!ELEMENT CT_ParameterizedMathTransform (CT_Parameter*)>
<!ATTLIST CT_ParameterizedMathTransform
   ClassName           CDATA    #REQUIRED
   >

<!ELEMENT CT_PassThroughTransform (CT_MathTransform)>
<!ATTLIST CT_PassThroughTransform
   FirstAffectedOrdinate   CDATA    #REQUIRED
   >

<!ELEMENT CT_ConcatenatedTransform (CT_MathTransform*)>
<!ELEMENT CT_InverseTransform (CT_MathTransform)>

<!ELEMENT CT_Parameter EMPTY>
<!ATTLIST CT_Parameter
   Name                CDATA    #REQUIRED
   Value               CDATA    #REQUIRED
   >
]>
```

NOTE This CT_MathTransform does not include any information on the source and target coordinate systems. Also, a future version of the low-level Coordinate Transformation (CT) Implementation Specification could use XML in additional places, especially where use of WKT is now supported but use of XML is not now supported.)

A.5.2 Current CT transfer by ICT and high-level CT interfaces

A draft high-level Coordinate Transformation (CT) interface specification (OGC document 01-013) supports XML transfer of a CT definition by two operations. The same two operations are supported by the draft Image Coordinate Transformation (ICT) interface (OGC document 00-045r1). These two operations are provided to clients by the one Ground Coordinate Transformation Service <<Interface>> object. The signatures of these two UML operations are:

```
addTransformation (metadata : TransformationMetadata,
     format : TextFormat) : TransformationID
transformationMetadata (transformation : TransformationID,
     format : TextFormat) : TransformationMetadata
```

XML is one possible format used by the Transformation Metadata <<DataType>> class that is used by these two operations. The Transformation Metadata class contains three UML attributes, with the signatures:

```
sourceCS : CoordinateSystemDefinition
targetCS : CoordinateSystemDefinition
transformation [0..1]: TransformationDefinition
```

The Transformation XML element specified in GML 3.1.1, with all their contents, could be used for a complete Transformation Metadata instance, including both the source and target CoordinateReferenceSystems. The Conversion XML element, with all its' contents probably can also be used for each Transformation Metadata instance.

A.6 Use to transfer dataset lineage or history

XML can be used to transfer the lineage or history of geospatial data, especially data encoded using XML. Such lineage information is specified by ISO 19115: Geographic information – Metadata to be part of the useful metadata about a dataset, and that metadata could be recorded in XML. (The OGC encourages use of ISO 19115 Metadata, but there are no uses of XML to transfer dataset lineage or history in current draft or accepted OGC Implementation Specifications.)

The lineage of a dataset, or of a part of a larger dataset, is likely to include the original CRS of the positions in that data, plus the sequence of coordinate transformations used to change these positions into the CRS in which the data is now recorded. Alternately, one concatenated coordinate transformation could be recorded that includes the original CRS and the sequence of coordinate transformations used. Similar metadata might be recorded for data still in the original CRS, but planned to be converted into a different CRS.

Annex B
(normative)

Conformance

B.1 Conformance requirements

Each OGC Implementation Specification that uses XML encoding to transfer data defining coordinate reference systems and/or coordinate operations shall transfer definition data that conforms to this Recommendation Paper. Each relevant data transfer situation specified by such a specification shall transfer data that contains the entire applicable subset of the definition data specified in this Paper. Each such data transfer should include any additional data needed. Each relevant OGC Implementation Specification shall clearly specify the contents, structure, and format of the XML encoded data transferred in each specified data transfer situation, usually partially specified as an Application Schema based on these CRS schemas.

NOTE 1 In many cases, an Implementation Specification will specify the Application Programming Interface (API) to service software. In those cases, each specified data transfer situation is each input and output argument of each operation in a UML model of the service interface. Of course, multiple operation arguments will often transfer the same possible data, and thus use the same subset of the definition data specified here. Also, multiple arguments may use the same subset of the definition data specified here, although different arguments use different subsets of that data.

NOTE 2 Many of the concrete XML elements defined in the CRS Schemas can be used without Application Schemas, if no contents extensions or restrictions are needed. However, the Conversion, Transformation, ParameterValue, and ParameterValueGroup elements should not be used for well-known coordinate operation methods having many element instances. Instead, an Application Schema that defines operation-method-specialized element names and contents should be prepared and standardized, see Subclause B.3.

Whenever coordinate reference system and/or coordinate operation definition data is transferred using XML encoding, the data contents and structure specified in GML shall be used wherever applicable. The data contents and structure aspects specified that shall be used include:

a) Name of each specified XML element and attribute

NOTE 3 When an Application Schema is used, the same name can be used in different namespaces.

b) Meaning of each specified name

c) Contents of each specified complexType

d) Sequence of elements included within each specified complexType

e) Multiplicity and optionality of each element and attribute in each specified complexType

f) Data type of each specified individual data item

When a data transfer situation requires a subset of the definition information specified, a suitable subset profile can be used. When a data transfer situation requires a superset of the definition information specified, a suitable Application Schema shall be specified, and its' use shall be required. Each such Application Schema shall conform to the Rules for Application Schemas specified in Subclause B.3. The changes permitted in an Application Schema include:

a) Add additional elements to a specified complexType, containing additional information

b) Omit a specified element, when not needed and that element is specified as being optional (minOccurs="0")

c) Remove some of the set of alternative elements in a specified <choice> data structure

d) Make an optional element required (minOccurs not specified, default ="1")

e) Reduce specified maximum number-of-repetitions of an element

f) Change data type of an element to a more restrictive type

g) Restrict the meaning of a specified name, to match a restriction of an Implementation Specification

h) Specify standard contents and contents patterns for selected elements and attributes, for interoperability.

i) Specify standard XML and other documents to be referenced or otherwise used, for interoperability.

Many possible changes to the definition data specified here are not allowed, such as:

a) Completely change the definition of a specified name

b) Expand the set of alternative contents in a specified <choice> data structure

c) Make optional an element or attribute required in a specified complexType

d) Increase maximum number-of-repetitions of an element

e) Change data type of a specified element to a less restrictive type

f) Change the required order of elements in a specified complexType

B.2 Abstract test suite

Conformance of each application of these CRS Schemas shall be tested by inspecting the specification of each transferred XML encoded data structure and individual data item. The tested specification of XML encoded data shall include all Application Schemas used. This testing shall be done for each XML element and attribute that can be included in each specified data transfer. For each such XML element and attribute, the following questions shall be answered:

a) What is the (complete) meaning of this XML element or attribute?

b) Is this meaning part of the definition of an XML element or attribute specified herein? If not related, this data structure or item IS conformant.

c) Is this meaning similar to the meaning of any XML element or attribute specified herein? If not similar, this data structure or item IS conformant.

d) Is this meaning the same as, or a restriction of, the most similar meaning specified herein? If not the same or restricted, this data structure or item is NOT conformant.

e) Is the name of this XML element or attribute the same as the name of the corresponding item specified herein? If not the same name, this data structure or item is NOT conformant.

f) Is the type of this XML element or attribute the same as the type of the corresponding item specified herein, a subtype of that type, or a type with all the relevant contents of that type? If the type is not the same or equivalent, this item is NOT conformant.

If an individual XML element or attribute with a simpleType is being inspected, the questions continue:

g) Is the data type of this item the same as, or a subset of, the data type of the corresponding item specified here? If not the same or a subset, this data item is NOT conformant.

h) Does this element have a specified multiplicity range that extends outside the allowed multiplicity of the corresponding element specified here? If a larger multiplicity range is allowed, this element is NOT conformant.

If a XML element with a complexType is being inspected, the questions continue:

g) Do the contents of this complexType include all or a subset of the XML elements and attributes included in the corresponding complexType specified here? If doesn't include all or a subset, this complexType is NOT conformant.

h) Do the contents of this complexType include the corresponding XML elements in the same required order? If not the same order, this complexType is NOT conformant.

i) If this complexType extends a complexType specified here, and the <documentation> element in that complexType specified here states constraints on inclusion of additional elements, and those constraints are not all satisfied, this complexType is NOT conformant.

j) For each XML element or attribute included in this complexType that has a corresponding item in the complexType specified here, is the element or attribute multiplicity (including optionality) compatible?

    1) If the multiplicity and optionality are the same, this item IS conformant.

    2) If an element or attribute is now omitted instead of optional, this item IS conformant.

    3) If an element or attribute is now required instead of optional, this item IS conformant.

    4) If an element or attribute is now optional instead of required, this item is NOT conformant.

5) If an element is now not repeated instead of being repeated one or more times, this item IS conformant.

6) If an element can now be repeated instead of not being repeated, this item is NOT conformant.

7) If the <documentation> element in the complexType specified here states a constraint on the multiplicity of this item and this constraint is not satisfied, this item is NOT conformant.

B.3 Rules for application schemas

B.3.1 Introduction

An Application Schema is an XML Schema that imports and builds upon one or more of the GML Schemas. Such an Application Schema defines one or more XML elements useful for transfer of encoded geospatial data. An Application Schema can specify a single top level element for use by an XML document, with the XML elements and types that it uses. That single top level XML element can be an object with identity, but this is not required. Such a Schema with its imported GML Schemas defines a vocabulary for a particular domain of discourse by defining and describing the terms of that vocabulary (see ISO TC/211 19109).

Most of the concrete XML elements defined in the CRS Schemas within GML can be used without Application Schemas, whenever no content extensions or restrictions are needed. An Application Schema shall be used whenever element contents extension is required, and should be used in some other cases to specify needed restrictions. That is, an Application Schema should be defined to extend and/or restrict elements as needed for a specific application, or a set of applications, to:

a) Add elements to contents of existing elements, for recording additional data about that item needed for that application.

b) Restrict the multiplicity of current contents elements, to eliminate flexibility not needed and perhaps confusing for that application.

c) Use a different element name, to be more easily understood in that specific application, primarily for elements that will be instantiated many times.

d) Specify standard contents and contents patterns for selected elements and attributes, as needed to improve interoperability.

e) Specify standard XML and other documents to be referenced or otherwise used, as needed to improve interoperability.

Application Schemas can thus be used for XML document contents extensions, restrictions, or both. Contents extension is expected to be often used to record additional data needed for applications. Contents restriction is expected to be frequently used to increase interoperability and reduce ambiguity when greater flexibility is not needed for applications. Extensions of existing concrete elements can be defined by extending that concrete element. In many cases, restrictions of existing concrete elements can be done by extending the abstract element from which that concrete element is derived, by adding somewhat different but corresponding extensions.

Application Schemas could define an additional concrete element using by extending an abstract element, if needed. However, an additional concrete element using or extending an abstract element should not be defined if that concrete element is largely similar to an existing element, and thus probably should extend or use an existing concrete element. In many cases, the existing concrete elements that use an abstract element are believed to be largely exhaustive. This is particularly true when the existing concrete elements include one element that is quite general, such as the elements EngineeringCRS, DerivedCRS, EngineeringDatum, UserDefinedCS, OperationParameter, and OperationParameterGroup.

The Conversion, Transformation, ParameterValue, and ParameterValueGroup elements can be used for well-known coordinate operation methods, especially when only one instance of that element is needed for that operation method. However, these elements probably should not be used for well-known coordinate operation methods when many instances of that element are needed for one operation method. Instead, an Application Schema that defines operation-method-specialized element names and contents should be prepared for each such operation method. Subclause D.2 provides an example of such an Application Schema. For interoperability, a suitable geospatial information community should standardize each such Application Schema.

NOTE This use of Application Schemas follows the GML 3 patterns. This GML pattern is to generally use Application Schemas, especially when use of Application Schemas allows definition of XML Schema having: 1) complexTypes with more specific restrictions on the contents of elements, sometime in ways that allow XML parsers to more completely check for correct contents of XML documents, and 2) elements with more specific and understandable names, to make XML documents easier to understand by humans.

Conformance of an application of these CRS Schemas shall be tested by inspecting each Application Schema used, if any. Notice that the CRS set of GML Schemas can be used without an Application Schema, and such use is allowed whenever appropriate. To use those CRS Schemas without an Application Schema, any defined XML concrete element can be used as the basis for an XML document. There are about 30 such concrete elements defined that may be directly useful. In addition, all of those concrete elements can be used inside a GML 3 Dictionary element. Furthermore, all of those concrete elements or a Dictionary can be used inside a GenericMetaData element inside a metaDataProperty element, which can be included in many other elements.

The remainder of this subclause specifies the requirements (or rules) for an Application Schema to be considered conformant with this Recommendation Paper. Notice that it is clearly possible to develop Application Schemas that use the CRS Schemas specified herein which are valid XML Schemas but do not follow all these rules, and are thus not conformant with this Recommendation Paper.

B.3.2 General rules

All conformant Application Schemas shall be constructed by building upon one or more of the CRS set of GML 3.1.1 Schemas. Such a Schema shall be a valid XML Schema, as specified in the XML Schema specification.

Each application schema must declare a target namespace. This is the namespace in which the XML elements or terms of the vocabulary “live”. This shall not be the GML namespace (http://www.opengis.net/gml). It is conventional for the namespace identifier to be a URL controlled by the application schema author’s organization. A target namespace is declared in the application schema using the targetNamespace attribute of the schema element from XML Schema.

B.3.4 Import needed schemas

An Application Schema must import the necessary XML Schemas from GML 3, with the correct namespace assignment. For example, in order to define coordinate reference systems, it is necessary to import coordinateReferenceSystems.xsd, either directly or indirectly. Direct import is done by including the declaration:

```
<xsd:import namespace="http://www.opengis.net/gml"
schemaLocation="../coordinateReferenceSystems.xsd"/>
```

Notice that the <import> element specifies that the components described in coordinateReferenceSystems.xsd are in the GML namespace http://www.opengis.net/gml. This namespace identifier must match the target namespace specified in the schema being imported, to ensure XML Schema validity.

The schemaLocation of the imported .xsd file can be a local reference or a URI reference to the file. A URI reference can be to some remote repository, such as the repository http://schemas.opengis.net/gml on the OGC web site. The above example assumes that the coordinateReferenceSystems.xsd file is stored locally at a location relative to this Application Schemas .xsd file.

In addition, the required import of a GML schema may be provided by the import of an equivalent subset schema as described in Subclause 7.14 of the GML 3.0 Implementation Specification, or by the import of an equivalent schema from a GML profile. These are all equivalent schemas with respect to satisfying the schema import requirements.

The above example imports coordinateReferenceSystems.xsd, which (directly and indirectly) includes the other five CRS Schemas plus nine other GML 3.1 Schemas. For some Application Schemas, coordinateReferenceSystems.xsd may not be needed, but one or more of the other CRS Schemas may be needed.

B.3.5 GML objects and properties

The content models of almost all (about 30) concrete elements are derived from gml:DefinitionType. These elements are ultimately derived from the AbstractGMLType and are thus GML Objects. These elements shall thus follow the GML class/property model, as specified in Subclause 7.2.2 of the GML 3.0 Implementation Specification. That is, the children of these elements must not be elements whose content models derive directly or indirectly from AbstractGMLType. The children of these elements are properties that describe that component.

B.3.6 Global and local names

Note that elements included in complex types that are defined with local names in an Application Schema will prevent derivation by restriction in another namespace, unless the local names are dropped in the restriction. Such complex types are appropriate for elements intended for use “as is” in their own namespace, and should be declared to be final=”restriction”. Elements included in complex types by reference to global elements support derivation by restriction in another namespace, allowing restriction of cardinality, and/or replacement by a member of a substitution group. Such complex types designed for derivation by restriction are appropriate “library types” for elements in substitution groups that cross namespaces.

B.4 UML models for application schemas

Each Application Schema can be produced by converting a UML model (or part of such a model), as required to comply with ISO 19118. If such a UML model is encoded, the XML encoding rules used should be similar to the encoding rules used for GML, as described in Annex G of [03-010r9].

To comply with this specification, each such UML model shall be based on the same UML model as these CRS Schemas. For Application Schemas, subclasses can be defined for most non-abstract classes in this UML model. A subclass can extend and/or restrict a current concrete class to:

a) Add UML attributes and/or navigable associations, for recording additional data about that class needed for that application.

b) Restrict the multiplicity of current attributes and/or navigable associations, to eliminate flexibility not needed and perhaps confusing for that application.

c) Use a different class name, to be more easily understood in that specific application, primarily for classes that will be instantiated many times.

d) Specify standard or default contents for selected UML attributes, for interoperability.

Application Schemas could define additional concrete subclasses of abstract classes in this UML model, if needed. However, additional concrete subclasses should not be defined that are largely similar to existing subclasses, and thus probably should be a subclass of an existing concrete subclass. In most cases, the existing concrete subclasses of an abstract class are believed to be largely exhaustive. This is particularly true when the existing subclasses include one subclass that is quite general, such as the classes SC_EngineeringCSR, SC_DerivedCRS, CD_EngineeringDatum, CS_UserDefinedCS, and CC_OperationParameter.

Annex C
(informative)

More XML document examples

C.1 Introduction

This annex provides additional example XML documents using the GML 3.1.1 Schemas. These XML examples omit some optional XML elements and attributes that might be included, and include some optional elements and attributes that might be omitted. This omission or inclusion was partially based on whether reasonable values were known for optional elements and attributes. The optional elements that are omitted in these examples XML include:

a) The “remarks” element in all IdentifierType and object elements.

b) The "scope" element in all elements that could include it.

These XML examples use patterns that are not specified in this document for values of the "gml:id" and "xlink:title" XML attributes.

NOTE For interoperability, the patterns or formats used for the values of these attributes must be specified somewhere, perhaps in or with an Application Schema.

C.2 Extended example XML for compound coordinate reference system

This subclause provides a more complete example XML document using the Coordinate Reference System subtype CompoundCRS XML element, with its contained elements, applied to a 3D compound coordinate reference system that combines a Projected and a Vertical CRS. Note that this Compound CRS Definition contains three other CRS definitions, for a Vertical CRS, a Geographic 2D CRS, and a Projected CRS.

```
<?xml version="1.0" encoding="UTF-8"?>
<CompoundCRS xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml
gml/3.1.1/base/coordinateReferenceSystems.xsd" gml:id="EPSG7405">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26 -->
   <srsName>OSGB36 /British National Grid + ODN</srsName>
   <srsID>
      <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">7405</name>
   </srsID>
   <validArea>
      <description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man. </description>
   </validArea>
   <includesCRS>
      <ProjectedCRS gml:id="EPSG27700">
```



```
        <srsName>OSGB 1936 / British National Grid</srsName>
        <srsID>
           <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">27700</name>
        </srsID>
        <validArea>
           <description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man. </description>
        </validArea>
        <baseCRS>
           <GeographicCRS gml:id="EPSG4277">
              <srsName>OSGB 1936</srsName>
              <srsID>
                 <name
codeSpace="urn:ogc:def:crs:EPSG:6.3:">4277</name>
              </srsID>
              <validArea>
                 <description>United Kingdom (UK) - Great Britain -
England Scotland Wales - onshore; Isle of Man. </description>
              </validArea>
              <usesEllipsoidalCS>
                 <EllipsoidalCS gml:id="EPSG6402">
                    <csName>ellipsoidal</csName>
                    <csID>
                       <name
codeSpace="urn:ogc:def:cs:EPSG:6.3:">6402</name>
                    </csID>
                    <usesAxis>
                       <CoordinateSystemAxis gml:id="EPSG9901"
gml:uom="urn:ogc:def:uom:OGC:1.0:degree">
                          <name>Geodetic latitude in north direction
with degree units</name>
                          <axisID>
                             <name
codeSpace="urn:ogc:def:axis:EPSG:6.3:">9901</name>
                          </axisID>
                          <axisAbbrev>Lat</axisAbbrev>
                          <axisDirection>north</axisDirection>
                       </CoordinateSystemAxis>
                    </usesAxis>
                    <usesAxis>
                       <CoordinateSystemAxis gml:id="EPSG9902"
gml:uom="urn:ogc:def:uom:OGC:1.0:degree">
                          <name>Geodetic longitude in east direction
with degree units</name>
                          <axisID>
                             <name
codeSpace="urn:ogc:def:axis:EPSG:6.3:">9902</name>
                          </axisID>
                          <axisAbbrev>Lon</axisAbbrev>
                          <axisDirection>east</axisDirection>
                       </CoordinateSystemAxis>
                    </usesAxis>
                 </EllipsoidalCS>
              </usesEllipsoidalCS>
              <usesGeodeticDatum>
                 <GeodeticDatum gml:id="EPSG6277">
                    <datumName>OSGB 1936</datumName>
                    <datumID>
```



```
                        <name
codeSpace="urn:ogc:def:datum:EPSG:6.3:">6277</name>
                     </datumID>
                     <usesPrimeMeridian>
                        <PrimeMeridian gml:id="EPSG8901">
                           <meridianName>Greenwich</meridianName>
                           <meridianID>
                              <name
codeSpace="urn:ogc:def:meridian:EPSG:6.3:">8901</name>
                           </meridianID>
                           <greenwichLongitude>
                              <angle
uom="urn:ogc:def:uom:OGC:1.0:degree">0</angle>
                           </greenwichLongitude>
                        </PrimeMeridian>
                     </usesPrimeMeridian>
                     <usesEllipsoid>
                        <Ellipsoid gml:id="EPSG7001">
                           <ellipsoidName>Airy 1830</ellipsoidName>
                           <ellipsoidID>
                              <name
codeSpace="urn:ogc:def:ellipsoid:EPSG:6.3:">7001</name>
                           </ellipsoidID>
                           <semiMajorAxis
uom="urn:ogc:def:uom:OGC:1.0:metre">6377563.396</semiMajorAxis>
                           <secondDefiningParameter>
                              <inverseFlattening
uom="urn:ogc:def:uom:OGC:1.0:unity">299.3249646</inverseFlattening>
                           </secondDefiningParameter>
                        </Ellipsoid>
                     </usesEllipsoid>
                  </GeodeticDatum>
               </usesGeodeticDatum>
            </GeographicCRS>
         </baseCRS>
         <definedByConversion>
            <Conversion gml:id="EPSG19916">
               <coordinateOperationName>Transverse
Mercator</coordinateOperationName>
               <coordinateOperationID>
                  <name
codeSpace="urn:ogc:def:coordinateOperation:EPSG:6.3:">19916</name>
               </coordinateOperationID>
               <usesMethod>
                  <OperationMethod gml:id="EPSG9807">
                     <methodName>Transverse Mercator</methodName>
                     <methodID>
                        <name
codeSpace="urn:ogc:def:method:EPSG:6.3:">9807</name>
                     </methodID>
                     <methodFormula>See Section 1.4.6 "Transverse
Mercator" of EPSG Guidance Note 7, December 2000. </methodFormula>
                     <sourceDimensions>2</sourceDimensions>
                     <targetDimensions>2</targetDimensions>
                     <usesParameter>
                        <OperationParameter gml:id="EPSG8801">
```

```
                           <parameterName>Latitude of natural
origin</parameterName>
                           <parameterID>
                              <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8801</name>
                           </parameterID>
                        </OperationParameter>
                     </usesParameter>
                     <usesParameter>
                        <OperationParameter gml:id="EPSG8802">
                           <parameterName>Longitude of natural
origin</parameterName>
                           <parameterID>
                              <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8802</name>
                           </parameterID>
                        </OperationParameter>
                     </usesParameter>
                     <usesParameter>
                        <OperationParameter gml:id="EPSG8805">
                           <parameterName>Scale factor at natural
origin</parameterName>
                           <parameterID>
                              <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8805</name>
                           </parameterID>
                        </OperationParameter>
                     </usesParameter>
                     <usesParameter>
                        <OperationParameter gml:id="EPSG8806">
                           <parameterName>False Easting</parameterName>
                           <parameterID>
                              <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8806</name>
                           </parameterID>
                        </OperationParameter>
                     </usesParameter>
                     <usesParameter>
                        <OperationParameter gml:id="EPSG8807">
                           <parameterName>False
Northing</parameterName>
                           <parameterID>

                              <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8807</name>
                           </parameterID>
                        </OperationParameter>
                     </usesParameter>
                  </OperationMethod>
               </usesMethod>
               <usesValue>
                  <value
uom="urn:ogc:def:uom:OGC:1.0:degree">49</value>
                  <valueOfParameter xlink:href="#EPSG8801"
xlink:title="Latitude of natural origin"/>
               </usesValue>
               <usesValue>
```

```
                  <value uom="urn:ogc:def:uom:OGC:1.0:degree">-
2</value>
                  <valueOfParameter xlink:href="#EPSG8802"
xlink:title="Longitude of natural origin"/>
               </usesValue>
               <usesValue>
                  <value
uom="urn:ogc:def:uom:OGC:1.0:unity">0.999601272</value>
                  <valueOfParameter xlink:href="#EPSG8805"
xlink:title="Scale factor at natural origin"/>
               </usesValue>
               <usesValue>
                  <value
uom="urn:ogc:def:uom:OGC:1.0:metre">400000</value>
                  <valueOfParameter xlink:href="#EPSG8806"
xlink:title="False Easting"/>
               </usesValue>
               <usesValue>
                  <value uom="urn:ogc:def:uom:OGC:1.0:metre">-
100000</value>
                  <valueOfParameter xlink:href="#EPSG8807"
xlink:title="False Northing"/>
               </usesValue>
            </Conversion>
         </definedByConversion>
         <usesCartesianCS>
            <CartesianCS gml:id="EPSG4400">
               <csName>Easting and Northing in metres</csName>
               <csID>
                  <name
codeSpace="urn:ogc:def:cs:EPSG:6.3:">4400</name>
               </csID>
               <usesAxis>
                  <CoordinateSystemAxis gml:id="EPSG9906"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
                     <name>Easting in east direction with metre
units</name>
                     <axisID>
                        <name
codeSpace="urn:ogc:def:axis:EPSG:6.3:">9906</name>
                     </axisID>
                     <axisAbbrev>E</axisAbbrev>
                     <axisDirection>east</axisDirection>
                  </CoordinateSystemAxis>
               </usesAxis>
               <usesAxis>
                  <CoordinateSystemAxis gml:id="EPSG9907"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
                     <name>Northing in north direction with metre
units</name>
                     <axisID>
                        <name
codeSpace="urn:ogc:def:axis:EPSG:6.3:">9907</name>
                     </axisID>
                     <axisAbbrev>N</axisAbbrev>
                     <axisDirection>north</axisDirection>
                  </CoordinateSystemAxis>
```

```
            </usesAxis>
         </CartesianCS>
      </usesCartesianCS>
   </ProjectedCRS>
</includesCRS>
<includesCRS>
   <VerticalCRS gml:id="EPSG5701">
      <srsName>Newlyn</srsName>
      <srsID>
         <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">5701</name>
      </srsID>
      <usesVerticalCS>
         <VerticalCS gml:id="EPSG6499">
            <csName>Gravity-related height up in metres</csName>
            <csID>
               <name
codeSpace="urn:ogc:def:cs:EPSG:6.3:">6499</name>
            </csID>
            <usesAxis>
               <CoordinateSystemAxis gml:id="EPSG9904"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
                  <name>Gravity-related height in up direction with
metre units</name>
                  <axisID>
                     <name
codeSpace="urn:ogc:def:axis:EPSG:6.3:">9904</name>
                  </axisID>
                  <axisAbbrev>H</axisAbbrev>
                  <axisDirection>up</axisDirection>
               </CoordinateSystemAxis>
            </usesAxis>
         </VerticalCS>
      </usesVerticalCS>
      <usesVerticalDatum>
         <VerticalDatum gml:id="EPSG5101">
            <datumName>Ordnance Datum Newlyn</datumName>
            <datumID>
               <name
codeSpace="urn:ogc:def:datum:EPSG:6.3:">5101</name>
            </datumID>
            <verticalDatumType codeSpace="
urn:ogc:def:verticalDatumType:OGC:1.0:">geoidal</verticalDatumType>
         </VerticalDatum>
      </usesVerticalDatum>
   </VerticalCRS>
</includesCRS>
</CompoundCRS>
```

C.3 Simplified example XML for conversion

The coordinate Conversion example in Subclause 6.4.2 contains most details within the usesMethod element. If the details of that Transverse Mercator operation method are sufficiently available elsewhere, a much shorter example XML document can be used:

```
<?xml version="1.0" encoding="UTF-8"?>
```

```xml
<Conversion xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml
gml/3.1.1/base/coordinateOperations.xsd" gml:id="EPSG19916">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26-->
   <!-- SourceCRS: EPSG:4277 OSGB 1936 -->
   <!-- TargetCRS: EPSG:27700 OSGB 1936 / British National Grid -->
   <coordinateOperationName>Transverse
Mercator</coordinateOperationName>
   <coordinateOperationID>
      <name
codeSpace="urn:ogc:def:coordinateOperation:EPSG:6.3:">19916</name>
      <version>6.0</version>
   </coordinateOperationID>
   <usesMethod xlink:href="urn:ogc:def:method:EPSG:6.3:9807"
xlink:title="Transverse Mercator"/>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:degree">49</value>
      <valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8801" xlink:title="Latitude
of natural origin"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:degree">-2</value>
      <valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8802" xlink:title="Longitude
of natural origin"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:unity">0.999601272</value>
      <valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8805" xlink:title="Scale
factor at natural origin"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:metre">400000</value>
      <valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8806" xlink:title="False
Easting"/>
   </usesValue>
   <usesValue>
      <value uom="urn:ogc:def:uom:OGC:1.0:metre">-100000</value>
      <valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8807" xlink:title="False
Northing"/>
   </usesValue>
</Conversion>
```

This example assumes that information for the Transverse Mercator OperationMethod is available elsewhere. Example XML for this method is given in the following subclause.

C.4 Example XML for operation method

This subclause provides an example XML document using the OperationMethod element, with data for the Transverse Mercator conversion method.

```
<?xml version="1.0" encoding="UTF-8"?>
<OperationMethod xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml
gml/3.1.1/base/coordinateOperations.xsd" gml:id="EPSG9807">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26 -->
   <methodName>Transverse Mercator</methodName>
   <methodID>
      <name codeSpace="urn:ogc:def:method:EPSG:6.3:">9807</name>
      <version>6.0</version>
   </methodID>
   <methodFormula>See Section 1.4.6 "Transverse Mercator" of EPSG
Guidance Note 7, December 2000. </methodFormula>
   <sourceDimensions>2</sourceDimensions>
   <targetDimensions>2</targetDimensions>
   <usesParameter>
      <OperationParameter gml:id="EPSG8801">
         <parameterName>Latitude of natural origin</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8801</name>
         </parameterID>
      </OperationParameter>
   </usesParameter>
   <usesParameter>
      <OperationParameter gml:id="EPSG8802">
         <parameterName>Longitude of natural origin</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8802</name>
         </parameterID>
      </OperationParameter>
   </usesParameter>
   <usesParameter>
      <OperationParameter gml:id="EPSG8805">
         <parameterName>Scale factor at natural origin</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8805</name>
         </parameterID>
      </OperationParameter>
   </usesParameter>
   <usesParameter>
      <OperationParameter gml:id="EPSG8806">
         <parameterName>False Easting</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8806</name>
         </parameterID>
      </OperationParameter>
```

```
   </usesParameter>
   <usesParameter>
      <OperationParameter gml:id="EPSG8807">
         <parameterName>False Northing</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8807</name>
         </parameterID>

      </OperationParameter>
   </usesParameter>
</OperationMethod>
```

C.5 Example XML for CRS dictionary

This subclause provides an example XML document using the Dictionary element from the dictionary.xsd schema of GML 3.1, with its' contained elements, applied to the example CompoundCRS used in Subclause C.2 with all of its components separated in the dictionary.

```
<?xml version="1.0" encoding="UTF-8"?>
<Dictionary xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml
gml/3.1.1/base/coordinateReferenceSystems.xsd" gml:id="CrsDictionary">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26-->
   <description>Example GML Dictionary of some coordinate reference
systems and components. </description>
   <name>CRS Dictionary</name>
   <dictionaryEntry>
      <CompoundCRS gml:id="EPSG7405">
         <srsName>OSGB36 /British National Grid + ODN</srsName>
         <srsID>
            <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">7405</name>
         </srsID>
         <validArea>
            <description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man. </description>
         </validArea>
         <includesCRS xlink:href="#EPSG27700" xlink:title="OSGB 1936 /
British National Grid"/>
         <includesCRS xlink:href="#EPSG5701" xlink:title="Newlyn"/>
      </CompoundCRS>
   </dictionaryEntry>
   <dictionaryEntry>
      <ProjectedCRS gml:id="EPSG27700">
         <srsName>OSGB 1936 / British National Grid</srsName>
         <srsID>
            <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">27700</name>
         </srsID>
         <validArea>
            <description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man. </description>
```

```
         </validArea>
         <baseCRS xlink:href="#EPSG4277" xlink:title="OSGB 1936"/>
         <definedByConversion xlink:href="#EPSG19916"
xlink:title="Transverse Mercator"/>
         <usesCartesianCS xlink:href="#EPSG4400"
xlink:title="Cartesian"/>
      </ProjectedCRS>
   </dictionaryEntry>
   <dictionaryEntry>
      <GeographicCRS gml:id="EPSG4277">
         <srsName>OSGB 1936</srsName>
         <srsID>
            <name codeSpace="urn:ogc:def:crs:EPSG:6.3:">4277</name>
         </srsID>
         <validArea>
            <description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man. </description>
         </validArea>
         <usesEllipsoidalCS xlink:href="#EPSG6402"
xlink:title="ellipsoidal"/>
         <usesGeodeticDatum xlink:href="#EPSG6277" xlink:title="OSGB
1936"/>
      </GeographicCRS>
   </dictionaryEntry>
   <dictionaryEntry>
      <EllipsoidalCS gml:id="EPSG6402">
         <csName>ellipsoidal</csName>
         <csID>
            <name codeSpace="urn:ogc:def:cs:EPSG:6.3:">6402</name>
         </csID>
         <usesAxis xlink:href="#EPSG9901northDegreeEPSG9901"
xlink:title="Geodetic latitude in north direction with degree
unitsGeodetic latitude"/>
         <usesAxis xlink:href="#EPSG9902eastDegreeEPSG9902"
xlink:title="Geodetic longitude in east direction with degree
unitsGeodetic longitude"/>
      </EllipsoidalCS>
   </dictionaryEntry>
   <dictionaryEntry>
      <CoordinateSystemAxis gml:id="EPSG9901"
gml:uom="urn:ogc:def:uom:OGC:1.0:degree">
         <name>Geodetic latitude in north direction with degree
units</name>
         <axisID>
            <name codeSpace="urn:ogc:def:axis:EPSG:6.3:">9901</name>
         </axisID>
         <axisAbbrev>Lat</axisAbbrev>
         <axisDirection>north</axisDirection>
      </CoordinateSystemAxis>
   </dictionaryEntry>
   <dictionaryEntry>
      <CoordinateSystemAxis gml:id="EPSG9902"
gml:uom="urn:ogc:def:uom:OGC:1.0:degree">
         <name>Geodetic longitude in east direction with degree
units</name>
         <axisID>
            <name codeSpace="urn:ogc:def:axis:EPSG:6.3:">9902</name>
         </axisID>
```

```
         <axisAbbrev>Lon</axisAbbrev>
         <axisDirection>east</axisDirection>
      </CoordinateSystemAxis>
   </dictionaryEntry>
   <dictionaryEntry>
      <GeodeticDatum gml:id="EPSG6277">
         <datumName>OSGB 1936</datumName>
         <datumID>
            <name codeSpace="urn:ogc:def:datum:EPSG:6.3:">6277</name>
         </datumID>
         <usesPrimeMeridian xlink:href="#EPSG8901"
xlink:title="Greenwich"/>
         <usesEllipsoid xlink:href="#EPSG7001" xlink:title="Airy
1830"/>
      </GeodeticDatum>
   </dictionaryEntry>
   <dictionaryEntry>
      <PrimeMeridian gml:id="EPSG8901">
         <meridianName>Greenwich</meridianName>
         <meridianID>
            <name
codeSpace="urn:ogc:def:meridian:EPSG:6.3:">8901</name>
         </meridianID>
         <greenwichLongitude>
            <angle uom="urn:ogc:def:uom:OGC:1.0:degree">0</angle>
         </greenwichLongitude>
      </PrimeMeridian>
   </dictionaryEntry>
   <dictionaryEntry>
      <Ellipsoid gml:id="EPSG7001">
         <ellipsoidName>Airy 1830</ellipsoidName>
         <ellipsoidID>
            <name
codeSpace="urn:ogc:def:ellipsoid:EPSG:6.3:">7001</name>
         </ellipsoidID>
         <semiMajorAxis
uom="urn:ogc:def:uom:OGC:1.0:metre">6377563.396</semiMajorAxis>
         <secondDefiningParameter>
            <inverseFlattening
uom="urn:ogc:def:uom:OGC:1.0:unity">299.3249646</inverseFlattening>
         </secondDefiningParameter>
      </Ellipsoid>
   </dictionaryEntry>
   <dictionaryEntry>
      <Conversion gml:id="EPSG19916">
         <coordinateOperationName>Transverse
Mercator</coordinateOperationName>
         <coordinateOperationID>
            <name
codeSpace="urn:ogc:def:coordinateOperation:EPSG:6.3:">19916</name>
         </coordinateOperationID>
         <usesMethod xlink:href="#EPSG9807" xlink:title="Transverse
Mercator"/>
         <usesValue>
            <value uom="urn:ogc:def:uom:OGC:1.0:degree">49</value>
            <valueOfParameter xlink:href="#EPSG8801"
xlink:title="Latitude of natural origin"/>
```

```
          </usesValue>
          <usesValue>
             <value uom="urn:ogc:def:uom:OGC:1.0:degree">-2</value>
             <valueOfParameter xlink:href="#EPSG8802"
xlink:title="Longitude of natural origin"/>
          </usesValue>
          <usesValue>
             <value
uom="urn:ogc:def:uom:OGC:1.0:unity">0.999601272</value>
             <valueOfParameter xlink:href="#EPSG8805" xlink:title="Scale
factor at natural origin"/>
          </usesValue>
          <usesValue>
             <value uom="urn:ogc:def:uom:OGC:1.0:metre">400000</value>
             <valueOfParameter xlink:href="#EPSG8806" xlink:title="False
Easting"/>
          </usesValue>
          <usesValue>
             <value uom="urn:ogc:def:uom:OGC:1.0:metre">-100000</value>
             <valueOfParameter xlink:href="#EPSG8807" xlink:title="False
Northing"/>
          </usesValue>
       </Conversion>
    </dictionaryEntry>
    <dictionaryEntry>
       <OperationMethod gml:id="EPSG9807">
          <methodName>Transverse Mercator</methodName>
          <methodID>
             <name codeSpace="urn:ogc:def:method:EPSG:6.3:">9807</name>
          </methodID>
          <methodFormula>See Section 1.4.6 "Transverse Mercator" of EPSG
Guidance Note 7, December 2000. </methodFormula>
          <sourceDimensions>2</sourceDimensions>
          <targetDimensions>2</targetDimensions>
          <usesParameter xlink:href="#EPSG8801" xlink:title="Latitude of
natural origin"/>
          <usesParameter xlink:href="#EPSG8802" xlink:title="Longitude
of natural origin"/>
          <usesParameter xlink:href="#EPSG8805" xlink:title="Scale
factor at natural origin"/>
          <usesParameter xlink:href="#EPSG8806" xlink:title="False
Easting"/>
          <usesParameter xlink:href="#EPSG8807" xlink:title="False
Northing"/>
       </OperationMethod>
    </dictionaryEntry>
    <dictionaryEntry>
       <OperationParameter gml:id="EPSG8801">
          <parameterName>Latitude of natural origin</parameterName>
          <parameterID>
             <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8801</name>
          </parameterID>
       </OperationParameter>
    </dictionaryEntry>
    <dictionaryEntry>
       <OperationParameter gml:id="EPSG8802">
          <parameterName>Longitude of natural origin</parameterName>
```

```
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8802</name>
         </parameterID>
      </OperationParameter>
   </dictionaryEntry>
   <dictionaryEntry>
      <OperationParameter gml:id="EPSG8805">
         <parameterName>Scale factor at natural origin</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8805</name>
         </parameterID>
      </OperationParameter>
   </dictionaryEntry>
   <dictionaryEntry>
      <OperationParameter gml:id="EPSG8806">
         <parameterName>False Easting</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8806</name>
         </parameterID>
      </OperationParameter>
   </dictionaryEntry>
   <dictionaryEntry>
      <OperationParameter gml:id="EPSG8807">
         <parameterName>False Northing</parameterName>
         <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8807</name>
         </parameterID>
      </OperationParameter>
   </dictionaryEntry>
   <dictionaryEntry>
      <CartesianCS gml:id="EPSG4400">
         <csName>Easting and Northing in metres</csName>
         <csID>
            <name codeSpace="urn:ogc:def:cs:EPSG:6.3:">4400</name>
         </csID>
         <usesAxis xlink:href="#EPSG9906eastMetreEPSG9906"
xlink:title="Easting in east direction with metre unitsEasting"/>
         <usesAxis xlink:href="#EPSG9907northMetreEPSG9907"
xlink:title="Northing in north direction with metre unitsNorthing"/>
      </CartesianCS>
   </dictionaryEntry>
   <dictionaryEntry>
      <CoordinateSystemAxis gml:id="EPSG9906"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
         <name>Easting in east direction with metre units</name>
         <axisID>
            <name codeSpace="urn:ogc:def:axis:EPSG:6.3:">9906</name>
         </axisID>
         <axisAbbrev>E</axisAbbrev>
         <axisDirection>east</axisDirection>
      </CoordinateSystemAxis>
   </dictionaryEntry>
   <dictionaryEntry>
```



```
      <CoordinateSystemAxis gml:id="EPSG9907"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
         <name>Northing in north direction with metre units</name>
         <axisID>
            <name codeSpace="urn:ogc:def:axis:EPSG:6.3:">9907</name>
         </axisID>
         <axisAbbrev>N</axisAbbrev>
         <axisDirection>north</axisDirection>
      </CoordinateSystemAxis>
   </dictionaryEntry>
   <dictionaryEntry>
      <VerticalCS gml:id="EPSG6499">
         <csName>Height up in metres</csName>
         <csID>
            <name codeSpace="urn:ogc:def:cs:EPSG:6.0:">6499</name>
         </csID>
         <usesAxis xlink:href="urn:ogc:def:axis:EPSG:6.0:9904"/>
      </VerticalCS>
   </dictionaryEntry>
   <dictionaryEntry>
      <CoordinateSystemAxis gml:id="EPSG9904"
gml:uom="urn:ogc:def:uom:OGC:1.0:metre">
         <name>Gravity-related height in up direction with metre
units</name>
         <axisID>
            <name codeSpace="urn:ogc:def:axis:EPSG:6.0:">9904</name>
         </axisID>
         <axisAbbrev>H</axisAbbrev>
         <axisDirection>up</axisDirection>
      </CoordinateSystemAxis>
   </dictionaryEntry>
   <dictionaryEntry>
      <VerticalDatum gml:id="EPSG5101">
         <datumName>Ordnance Datum Newlyn</datumName>
         <datumID>
            <name codeSpace="urn:ogc:def:datum:EPSG:6.0:">5101</name>
         </datumID>
         <verticalDatumType
codeSpace="urn:ogc:def:verticalDatumType:OGC:1.0:">geoidal</verticalDat
umType>
      </VerticalDatum>
   </dictionaryEntry>
</Dictionary>
```

C.6 Example XML for units dictionary

This subclause provides an example XML document using the Dictionary element from the dictionary.xsd schema of GML 3, with its contained elements, applied to the units of measure used in the preceding XML examples.

```
<?xml version="1.0" encoding="UTF-8"?>
<Dictionary xmlns="http://www.opengis.net/gml"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml
```



```
gml/3.1.1/base/coordinateReferenceSystems.xsd"
gml:id="UnitsDictionary">
   <!-- Primary editor: Arliss Whiteside. Last updated 2005-01-26 -->
   <description>Example GML Dictinary of unit
definitions.</description>
   <name>Units Dictionary</name>
   <dictionaryEntry>
      <ConventionalUnit gml:id="degree">
         <name>degree</name>
         <name codeSpace="urn:ogc:def:parameter:EPSG:6.3:">9102</name>
         <name codeSpace="urn:ogc:def:uom:OGC:1.0:">degree</name>
         <quantityType>angle</quantityType>
         <conversionToPreferredUnit uom="#radian">
            <factor>1.74532925199433E-02</factor>
         </conversionToPreferredUnit>
      </ConventionalUnit>
   </dictionaryEntry>
   <dictionaryEntry>
      <BaseUnit gml:id="radian">
         <name>radian</name>
         <name codeSpace="urn:ogc:def:uom:OGC:1.0:">radian</name>
         <quantityType>angle</quantityType>
         <unitsSystem xlink:href="urn:ogc:ToBeSupplied"/>
      </BaseUnit>
   </dictionaryEntry>
   <dictionaryEntry>
      <BaseUnit gml:id="metre">
         <name>metre</name>
         <name codeSpace="urn:ogc:def:parameter:EPSG:6.3:">9001</name>
         <name codeSpace="urn:ogc:def:uom:OGC:1.0:">metre</name>
         <quantityType>length</quantityType>
         <unitsSystem xlink:href="urn:ogc:SI"/>
      </BaseUnit>
   </dictionaryEntry>
   <dictionaryEntry>
      <BaseUnit gml:id="unity">
         <name>unity</name>
         <name codeSpace="urn:ogc:def:uom:EPSG:6.3:">8805</name>
         <name codeSpace="urn:ogc:def:uom:OGC:1.0:">unity</name>
         <quantityType>scale factor</quantityType>
         <unitsSystem xlink:href="urn:ogc:ToBeSupplied"/>
      </BaseUnit>
   </dictionaryEntry>
</Dictionary>
```

Annex D
(informative)

Application schema example

D.1 Introduction

This annex provides an example Application Schema based on the CRS Schemas in GML 3.1.1. This example includes a corresponding example XML document using that Application Schema plus the example UML model from which that Application Schemas was converted. For more information on Application Schemas, see Subclauses B.3 and B.4 of this document.

These XML examples use URNs to reference known objects by "xlink:href" and "gml:uom" XML attributes, based on “URNs of definitions in ogc namespace” [OGC 05-010].

D.2 Transverse Mercator conversion

D.2.1 Introduction

Standardized XML encoding is desirable for a number of commonly-used types of coordinate conversions and transformations. This subclause provides an example of one such encoding, applied to one commonly-used conversion type, namely the Transverse Mercator map projection. The following subclauses contain:

a) A draft class diagram of a UML package for the Transverse Mercator type of map projection, which builds on the UML model in OGC Abstract Specification Topic 2.

b) A draft XML Schema for encoding a Transverse Mercator projection, produced by converting this UML package.

c) Two example XML documents based on this draft XML Schema for encoding an example Transverse Mercator map projection

D.2.2 UML package

Figure D.1 is a draft class diagram of a UML package for Transverse Mercator map projections. This class diagram is incomplete in that many of the needed association role names and multiplicities are not shown due to lack of space. This UML package builds on the UML model in OGC Abstract Specification Topic 2 [04-046r3].

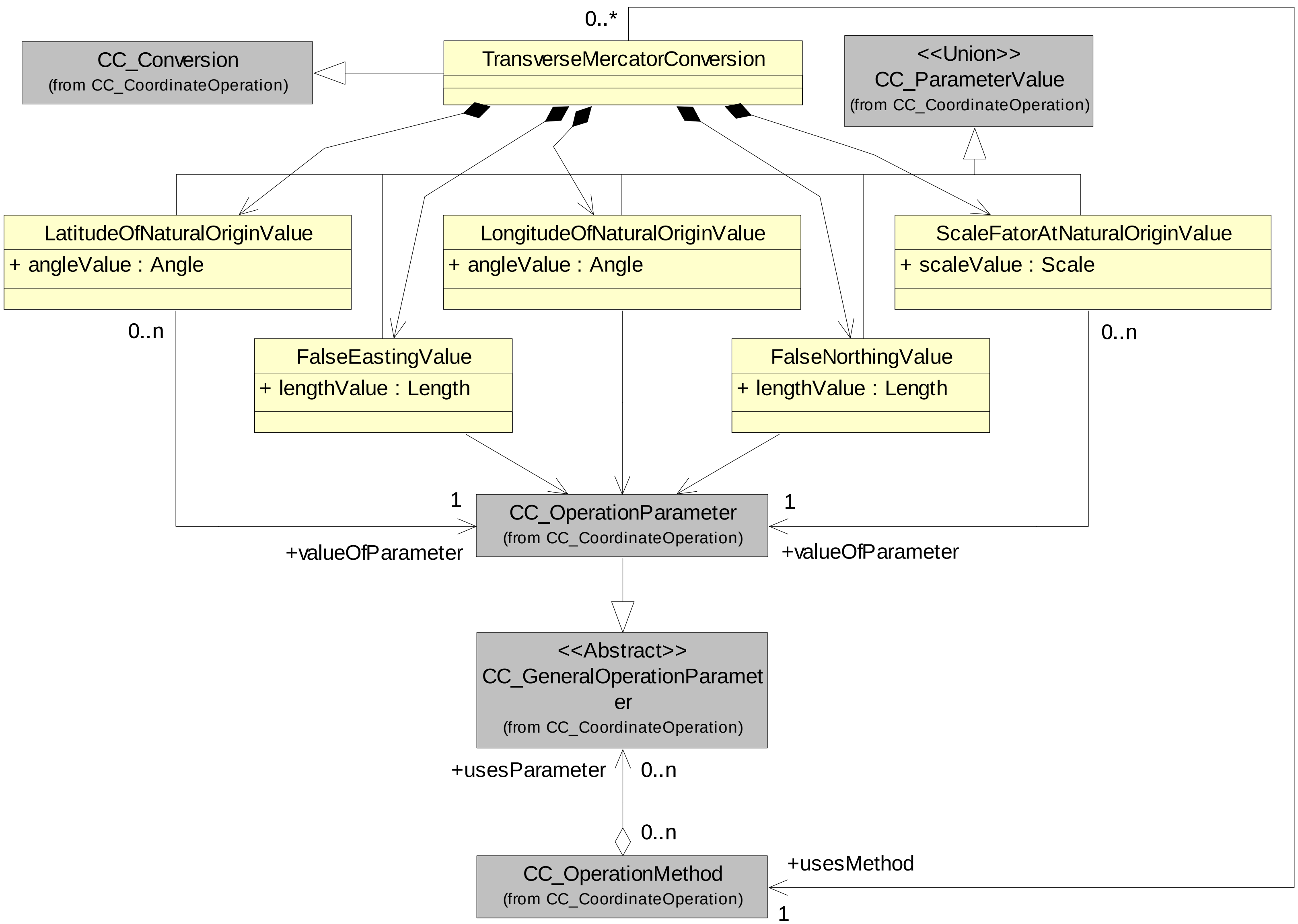

Figure D.1 — UML package for Transverse Mercator projection

D.2.3 Application schema

This subclause contains an example XML Schema for encoding a Transverse Mercator projection, produced by converting the above UML package. This XML Schema builds on the coordinateOperations.xsd GML Schema. This draft Application Schema is written following the same GML 3 patterns and ISO 19118 XML encoding rules as used in the CRS Schemas in GML 3.1.1. As required, this draft Application Schema is written in a different namespace. Of course, it could be rewritten as an additional XML Schema in the GML namespace, and would be similar.

EDITORS NOTE: In this draft XML Schema, I included documentation element text based on my limited understanding of the Transverse Mercator map projection. I urge John Bobbitt, Roel Nicolai, and others to suggest improvements in the wording of these documentation elements.

This draft Application Schema is:

```
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:ex="http://www.opengis.net/examples"
targetNamespace="http://www.opengis.net/examples"
elementFormDefault="qualified" xml:lang="en">
   <annotation>
      <documentation>
         <name>transverseMercator.xsd</name>
         <scope>How to encode definition of specific Transverse
Mercator conversion. </scope>
         <description>Example Application Schema to encode the data
needed to define a specific Transverse Mercator type of map projection,
which is a coordinate conversion. Builds on coordinateOperations.xsd,
and follows same GML 3 patterns and ISO 19118 encoding. Written in the
"ex" namespace. Primary editor: Arliss Whiteside. Last updated 2005-01-
28</description>
         <reference>Guidance Note Number 7 "Coordinate Conversions and
Transformations including Formulas" (available through
http://www.epsg.org/), especially Section 1.4.6 "Transverse Mercator".
</reference>
         <copyright>Copyright (c) Open Geospatial Consortium (2005)
</copyright>
         <conformance>This schema encodes a draft Transverse Mercator
package that builds on the Coordinate Operation (CC_) package of the
extended UML Model for OGC Abstract Specification Topic 2: Spatial
Referencing by Coordinates. That draft package defines restricted
subtypes of the CC_Conversion and CC_ParameterValue classes as needed
for the Transverse Mercator map projection conversion. </conformance>
      </documentation>
   </annotation>
   <!-- =======================================================
       includes and imports
   ======================================================= -->
   <import namespace="http://www.opengis.net/gml"
schemaLocation="../gml/3.1.1/base/coordinateOperations.xsd"/>
   <import namespace="http://www.w3.org/1999/xlink"
schemaLocation="../gml/3.1.1/xlink/xlinks.xsd"/>
```

```
   <!-- ======================================================
        elements and types
   ====================================================== -->
   <element name="TransverseMercatorConversion"
type="ex:TransverseMercatorConversionType"
substitutionGroup="gml:_GeneralConversion"/>
   <!-- ====================================================== -->
   <complexType name="TransverseMercatorConversionType">
      <annotation>
         <documentation>Specific Transverse Mercator map projection.
Uses the AbstractGeneralConversionType with restricted values for
included elements, including elements in the coordinateOperationID
element with the IdentifierType. If appropriate, the "codeSpace"
element should have the string value "EPSG", and the "code" element
should then have the appropriate EPSG code value. The other elements in
the IdentifierType can be omitted. The "coordinateOperationName"
element shall have a string value that names a specific Transverse
Mercator map projection. The "_PositionalAccuracy" and
"metaDataProperty" elements can be omitted. </documentation>
      </annotation>
      <complexContent>
         <extension base="gml:AbstractGeneralConversionType">
            <sequence>
               <element ref="ex:usesTransverseMercatorMethod"/>
               <element ref="ex:usesLatitudeOfNaturalOriginValue"/>
               <element ref="ex:usesLongitudeOfNaturalOriginValue"/>
               <element ref="ex:usesScaleFactorAtNaturalOriginValue"/>
               <element ref="ex:usesFalseEastingValue"/>
               <element ref="ex:usesFalseNorthingValue"/>
            </sequence>
         </extension>
      </complexContent>
   </complexType>
   <!-- ====================================================== -->
   <!-- ====================================================== -->
   <element name="usesTransverseMercatorMethod">
      <annotation>
         <documentation>Reference to Transverse Mercator operation
method. </documentation>
      </annotation>
      <complexType>
         <sequence/>
         <attribute ref="xlink:href" use="required"
fixed="urn:ogc:def:method:EPSG:6.3:9807"/>
      </complexType>
   </element>
   <!-- ====================================================== -->
   <element name="usesLatitudeOfNaturalOriginValue"
type="ex:AngleValueType"
substitutionGroup="gml:_generalParameterValue">
      <annotation>
         <documentation>Value of the Latitude of the natural origin
parameter for a specific coordinate conversion. </documentation>
      </annotation>
   </element>
   <!-- ====================================================== -->
```

```
   <element name="usesLongitudeOfNaturalOriginValue"
type="ex:AngleValueType"
substitutionGroup="gml:_generalParameterValue">
      <annotation>
         <documentation>Value of the Longitude of the natural origin
(or central meridian) parameter for a specific coordinate conversion.
</documentation>
      </annotation>
   </element>
   <!-- ==================================================== -->
   <element name="usesScaleFactorAtNaturalOriginValue"
type="ex:ScaleValueType"
substitutionGroup="gml:_generalParameterValue">
      <annotation>
         <documentation>Value of the scale factor at the natural origin
(on the central meridian) parameter for a specific coordinate
conversion. </documentation>
      </annotation>
   </element>
   <!-- ==================================================== -->
   <element name="usesFalseEastingValue" type="ex:LengthValueType"
substitutionGroup="gml:_generalParameterValue">
      <annotation>
         <documentation>Value of the false Easting coordinate of the
origin parameter for a specific coordinate conversion. </documentation>
      </annotation>
   </element>
   <!-- ==================================================== -->
   <element name="usesFalseNorthingValue" type="ex:LengthValueType"
substitutionGroup="gml:_generalParameterValue">
      <annotation>
         <documentation>Value of the false Northing coordinate of the
origin parameter for a specific coordinate conversion. </documentation>
      </annotation>
   </element>
   <!-- ==================================================== -->
   <!-- ==================================================== -->
   <complexType name="AngleValueType">
      <annotation>
         <documentation>Angle measure operation parameter value.
</documentation>
      </annotation>
      <complexContent>
         <extension base="gml:AbstractGeneralParameterValueType">
            <sequence>
               <choice>
                  <element ref="ex:angleValue"/>
                  <element ref="gml:dmsAngleValue"/>
               </choice>
               <element ref="gml:valueOfParameter"/>
            </sequence>
         </extension>
      </complexContent>
   </complexType>
   <!-- ==================================================== -->
   <complexType name="ScaleValueType">
      <annotation>
```

```
         <documentation>Scale measure operation parameter value.
</documentation>
      </annotation>
      <complexContent>
         <extension base="gml:AbstractGeneralParameterValueType">
            <sequence>
               <element ref="ex:scaleValue"/>
               <element ref="gml:valueOfParameter"/>
            </sequence>
         </extension>
      </complexContent>
   </complexType>
   <!-- ================================================== -->
   <complexType name="LengthValueType">
      <annotation>
         <documentation>Length measure operation parameter value.
</documentation>
      </annotation>
      <complexContent>
         <extension base="gml:AbstractGeneralParameterValueType">
            <sequence>
               <element ref="ex:lengthValue"/>
               <element ref="gml:valueOfParameter"/>
            </sequence>
         </extension>
      </complexContent>
   </complexType>
   <!-- ================================================== -->
   <!-- ================================================== -->
   <element name="angleValue" type="gml:AngleType"
substitutionGroup="gml:value">
      <annotation>
         <documentation>Angle value of an operation parameter, recorded
as a single number, with a unit of measure suitable for an angle, such
as degrees or radians. </documentation>
      </annotation>
   </element>
   <!-- ================================================== -->
   <element name="scaleValue" type="gml:ScaleType"
substitutionGroup="gml:value">
      <annotation>
         <documentation>Scale factor value of an operation parameter,
with a unit of measure suitable for a scale factor, such as percent,
permil, or parts-per-million. </documentation>
      </annotation>
   </element>
   <!-- ================================================== -->
   <element name="lengthValue" type="gml:LengthType"
substitutionGroup="gml:value">
      <annotation>
         <documentation>Length value of an operation parameter, with a
unit of measure suitable for a length, such as metres or feet.
</documentation>
      </annotation>
   </element>
   <!-- ================================================== -->
</schema>
```


D.2.4 Example XML document

An example XML document based on this example XML Schema for encoding an example Transverse Mercator map projection is:

```
<?xml version="1.0" encoding="UTF-8"?>
<TransverseMercatorConversion xmlns="http://www.opengis.net/examples"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/examples
transverseMercator.xsd" gml:id="EPSG19916">
   <!-- Example XML document. Primary editor: Arliss Whiteside. Last
updated 2005-01-28-->
   <!-- SourceCRS: EPSG:4277 OSGB 1936 -->
   <!-- TargetCRS: EPSG:27700 OSGB 1936 / British National Grid -->
   <gml:coordinateOperationName>Transverse
Mercator</gml:coordinateOperationName>
   <gml:validArea>
      <gml:description>United Kingdom (UK) - Great Britain - England
Scotland Wales - onshore; Isle of Man. </gml:description>
   </gml:validArea>
   <usesTransverseMercatorMethod
xlink:href="urn:ogc:def:method:EPSG:6.3:9807"/>
   <usesLatitudeOfNaturalOriginValue>
      <angleValue uom="urn:ogc:def:uom:degree">49</angleValue>
      <gml:valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8801"/>
   </usesLatitudeOfNaturalOriginValue>
   <usesLongitudeOfNaturalOriginValue>
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   </usesLongitudeOfNaturalOriginValue>
   <usesScaleFactorAtNaturalOriginValue>
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   </usesScaleFactorAtNaturalOriginValue>
   <usesFalseEastingValue>
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   </usesFalseEastingValue>
   <usesFalseNorthingValue>
      <lengthValue uom="urn:ogc:def:uom:OGC:1.0:metre">-
100000</lengthValue>
      <gml:valueOfParameter
xlink:href="urn:ogc:def:parameter:EPSG:6.3:8807"/>
   </usesFalseNorthingValue>
</TransverseMercatorConversion>
```

Annex E
(informative)

Coordinate operation methods

E.1 Introduction

This annex contains brief descriptions of some conversion and transformation operation methods. It references the methods defined in the EPSG v 6.3 database, and lists some methods applicable to the transformation of coordinates.

Each operation method should uniquely specify the algorithm to be used for a coordinate transformation. This specification may comprise two algorithms, forward and inverse, as is sometimes used for map projection algorithms. Each conversion and transformation, and each operation method, should use a well-known data set in referencing such algorithms.

NOTE Of course, referencing a well-known algorithm does not imply that software which implements these algorithms has correctly implemented it, or has implemented all referenced algorithms. Similarly, referencing a well-known set of parameter values does not imply that software which implements these values uses the correct values.

E.2 EPSG defined operation methods

The well-known database from EPSG (version 6.3) specifies a number of operation methods. Please note that the EPSG data set is neither prescriptive, nor exhaustive. This document mentions a small subset of the methods in the EPSG data set. Methods not listed in this document, but listed in the EPSG data set, can easily be implemented using the OperationMethod and OperationParameter elements, making use of the method name and parameter names specified in the EPSG data set.

These operation methods are defined making use of well-defined operation parameters. When a coordinate operation is specified referencing an EPSG defined operation method, the detailed specification in an XML document should adhere to the EPSG definitions of the operation parameters.

The detailed definition of these operation method algorithms, with their formulas and a worked example is included in the EPSG data set, available on the Web, through the reflector: http://www.epsg.org/.

These and other information on coordinate operation methods is available on: http://www.remotesensing.org/geotiff/proj_list/. See also http://www.posc.org/Epicentre.2_2/DataModel/ExamplesofUsage/eu_cs.html.

E.3. Other operation methods

E.3.1 Introduction

The following operation methods are not specified in any well-known data set but are implied in the specification of Coordinate Systems and Coordinate Reference Systems.

a) Polar / Cartesian (2D) conversion

b) Spherical / Cartesian (3D) conversion

c) Cylindrical / Cartesian conversion

d) Geographic3D to Geographic2D/GravityRelatedHeight conversion

E.3.2 Polar / Cartesian (2D) conversion

This method converts two-dimensional polar coordinates to plane Cartesian coordinates and vice versa (the inverse algorithm is implied in this transformation method).

E.3.3 Spherical / Cartesian (3D) conversion

This method converts spherical coordinates (sometimes referred to as polar 3D coordinates) to 3D Cartesian coordinates and vice versa (the inverse algorithm is again implied in this transformation method). Please bear in mind that when the spherical coordinate system is used in a local context (e.g.., in an EngineeringCRS); the converted Cartesian coordinate system can only be used in the same context: there is no datum change involved. Transformation to a Geocentric Cartesian system is possible only when the spherical coordinate system is also geocentric.

E.3.4 Cylindrical / Cartesian conversion

This method converts (3D) cylindrical coordinates to 3D Cartesian coordinates and vice versa. The area of use of the cylindrical coordinate system is unlikely to be other than local. The Cartesian coordinate system will therefore also be associated with an EngineeringCRS. A further (or indeed a one-step) transformation to a Geocentric system will be incorrect, although it may seem mathematically correct.

Bibliography

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[3] OGC 00-045r1, Draft RFC on Image Coordinate Transformations

[4] OGC 01-009, Implementation Specification: Coordinate Transformation Services

[5] OGC 03-010r9, Recommended XML encoding of coordinate reference systems and coordinate transformations

[6] OGC 04-071, Some image geometry models

[7] OGC 05-014, Image CRSs for IH4DS

