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GML 3.1.1 grid CRSs profile

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i. Preface

This document defines a profile of the Geography Markup Language (GML) version 3.1.1 for encoding definitions of grid coverage (including image) Coordinate Reference Systems (CRSs) plus related coordinate Transformations. This document also specifies some Universal Resource Names (URNs) for definitions in the “ogc” URN namespace, in addition to those specified in [OGC 05-010]. Additional specific URNs are defined for definitions of the datums, coordinate systems, and coordinate system axes which are often used in definitions of grid and image CRSs.

This profile can be used without a GML Application Schema, and such use is assumed in this document. However, a GML Application Schema that uses this profile could be specified. For example, an Application Schema could specify “GridCRS” as a better name for a DerivedCRS that uses a CartesianCS. Or an Application Schema could allow or require more information to be encoded for an OperationParameter (such as specified in Subclause 14.3.2 and wctcsOperationParameter.xsd of OGC Discussion Paper [OGC 05-013]).

Suggested additions, changes, and comments on this document are welcome and encouraged. Such suggestions may be submitted by email message or by using the formal Change Request Proposal process as defined in the TC Policies and Procedures.

ii. Document terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 05-008]. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this specification

iii. Document contributor contact points

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

Name	Organization
Arliss Whiteside	BAE Systems E&IS

iv. Revision history

Date	Release	Editor	Primary clauses modified	Description
2005-10-11	0.0.0	Arliss Whiteside	All	Initial release
2005-11-15	0.0.1	Arliss Whiteside	All	General editing

v. Changes to OGC Specifications

No previously approved OGC™ Specifications need to be changed to accommodate the technical contents of this document.

vi. Future work

Improvements in this document may be desirable. There will be a 30-day public comment period to solicit input and comments from the broader geospatial community.

Foreword

This document specifies a subset profile of the existing OGC Implementation Specification for the Geometry Markup Language (GML) version 3.1.1 [OGC 03-105r1 and 04-093r4], and does not modify it. This is a GML profile as specified in Subclause 22 of [OGC 03-105r1]. This document supersedes Recommendation Paper [OGC 05-027r1], titled “Recommended XML/GML 3.1.1 encoding of image CRS definitions”.

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

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

Introduction

This document specifies a GML profile for encoding definitions of grid coverage (including image) Coordinate Reference Systems (CRSs) plus related coordinate Transformations. This XML schema is a profile of the OGC Geography Markup Language (GML) version 3.1.1, using the separately specified “GML 3.1.1 common CRSs profile”. This profile supports XML encoding of definitions of Image and Derived (grid) CRSs, and definitions of coordinate Transformations for georeferencing images.

This document also specifies some Universal Resource Names (URNs) for definitions in the “ogc” URN namespace. Specific URNs are defined for definitions of the datums, coordinate systems, and coordinate system axes which are often used in definitions of grid and image CRSs.

GML 3.1.1 grid CRSs profile

1 Scope

This GML 3.1.1 profile is defined for encoding definitions of grid coverage (including image) Coordinate Reference Systems (CRSs) plus related coordinate Transformations. This profile supports XML encoding of definitions of:

- a) Unrectified image CRSs, using ImageCRS elements
- b) Georectified image and grid coverage CRSs, using DerivedCRS element
- c) Coordinate Transformations for georeferencing images, using Transformation elements

This document also specifies some Universal Resource Names (URNs) for definitions in the “ogc” URN namespace, in addition to those specified in [OGC 05-010]. Additional specific URNs are defined for definitions of the datums, coordinate systems, and coordinate system axes which are often used in definitions of grid and image CRSs. These definitions shall be used wherever applicable in XML encodings of definitions of grid and image CRSs.

This “GML 3.1.1 Grid CRSs profile” uses the separately specified “GML 3.1.1 common CRSs profile” [OGC 05-095], specified to support encoding the definitions of commonly used CRSs. This profile is designed for use by a future image application profile of the future Web Coordinate Transformation Service (WCTS).

This profile does not support encoding of geocentric, temporal, or engineering CRSs, or combining a temporal CRS with another CRS. It also does not support encoding of affine, spherical, cylindrical, linear, and user-defined coordinate systems, or engineering datums.

2 Compliance

All CRS and CRS-related definitions encoded using this profile shall produce XML documents that are fully compliant with the normative XML Schema Documents associated with this specification, named:

- a) gmlGridCRSsProfile.xsd
- b) coordinateOperations.xsd
- c) coordinateReferenceSystems.xsd
- d) dataQuality.xsd
- e) datums.xsd

Except for gmlGridCRSsProfile.xsd, all these XML Schema Documents contain the subset of the corresponding GML 3.1.1 document that is needed by this GML 3.1.1 Grid CRSs profile. This was done to facilitate checking that this profile is a strict subset of GML 3.1.1. This also facilitates comparing each document with the original, to determine which elements, attributes, and types were retained, and which were removed.

XML documents compliant with this profile shall (directly or indirectly) import the gmlGridCRSsProfile.xsd XML Schema Document schema, which will be available following approval of this document at <http://schemas.opengis.net/gml/3.1.1/Profiles/GridCRSs/1.0.0/>.

More specifically, compliance with this specification shall be checked using all the relevant tests specified in Annex A (normative).

3 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. 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*, available through <http://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 19105:2000, *Geographic information — Conformance and Testing*

OGC 03-105r1, *OpenGIS Geography Markup Language (GML) Implementation Specification*, Version 3.1.0

OGC 04-092r4, *GML 3.1.1 schemas*

OGC 05-008, *OGC Web Services Common Specification*, Version 1.0.0

OGC 05-010, *URNs of definitions in ogc namespace* (Recommendation Paper), Version 1.0.0

OGC 05-094r1, *GML 3.1.1 CRS support profile* (proposal)

OGC 05-095r1, *GML 3.1.1 common CRSs profile* (proposal)

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

W3C, *XML Schema Part 1: Structures*, <http://www.w3.org/TR/xmlschema-1>

W3C, *XML Schema Part 2: Datatypes*, <http://www.w3.org/TR/xmlschema-2>

W3C, *Namespaces in XML*, <http://www.w3.org/TR/1999/REC-xml-names-19990114>

In addition to this document, this specification includes several normative XML Schema Document files. Following approval of this document, these schemas will be posted online at the URL: <http://schemas.opengis.net/gml/3.1.1/Profiles/GridCRSs/1.0.0/>. These XML Schema Document files are also bundled with the present document. In the event of a discrepancy between the bundled and online versions of the XML Schema files, the online files shall be considered authoritative.

4 Terms and definitions

For the purposes of this specification, the definitions specified in Clause 4 of the GML 3.1.1 common CRSs profile [OGC 05-095] shall apply.

5 Conventions

5.1 Abbreviated terms

The abbreviated terms used in this document include:

CRS	Coordinate Reference System
GML	Geography Markup Language
EPSG	European Petroleum Survey Group:
IETF	Internet Engineering Task Force
ISO	International Organization for Standardization
OGC	Open Geospatial Consortium
OWS	OGC Web Service, or Open Web Service
WCTS	Web Coordinate Transformation Service
UML	Unified Modeling Language
URI	Universal Resource Identifier
URL	Uniform Resource Locator
URN	Universal Resource Name
XML	Extensible Markup Language
2D	Two Dimensional
3D	Three Dimensional

5.2 UML notation

The diagrams that appear in this specification are presented using the Unified Modeling Language (UML) static structure diagram, as described in Subclause 5.2 of [OGC 05-008].

6 Grid CRSs profile

6.1 Background

GML 3.1.1 includes six XML Schema Documents for encoding definitions of Coordinate Reference Systems (CRSs) and Coordinate Operations, namely: (listed alphabetically)

- a) coordinateOperations.xsd
- b) coordinateReferenceSystems.xsd
- c) coordinateSystems.xsd
- d) dataQuality.xsd
- e) datums.xsd
- f) referenceSystems.xsd

However, this set of XML Schema Documents supports many abilities that are rarely used. Therefore, multiple CRS-related profiles of this part of GML 3.1.1 are expected to be useful and specified, where each profile is significantly simpler and thus easier to understand and use. One such profile is the GML 3.1.1 Common CRSs profile, specified in [OGC 05-095r1], which includes the most commonly-used CRSs but not image and grid CRSs.

This GML 3.1.1 Grid CRSs profile was produced by building on the GML 3.1.1 Common CRSs profile, and adding those parts of the above listed XML Schema Documents which are needed by grid and image coordinate reference systems. This profile also indirectly builds on the GML 3.1.1 CRS Support profile, which includes the needed profile of referenceSystems.xsd.

6.2 Overview

This document specifies a GML 3.1.1 profile for XML encoding of the definitions of image and grid coordinate reference systems (CRSs), where a grid CRS is a DerivedCRS. More specifically, this profile adds the following XML elements:

- a) ImageCRS in coordinateReferenceSystems.xsd, which is used to define unrectified image CRSs
- b) DerivedCRS in coordinateReferenceSystems.xsd, which is used to define georectified grid and image CRSs

- c) Transformation in coordinateOperations.xsd, which is used to define the coordinate transformations required to georeference unrectified images
- d) ConcatenatedOperation and PassThroughOperation in coordinateOperations.xsd, which are used to combine multiple coordinate transformations and conversion(s) to georeference or georectify unrectified images

In addition to the above listed XML elements, the elements, attributes, and types needed to support those were also added. For example, other added non-abstract GML object elements include:

- a) ImageDatum in datums.xsd
- b) absoluteExternalPositionalAccuracy, relativeInternalPositionalAccuracy, and covarianceMatrix in dataQuality.xsd

This GML 3.1.1 Grid CRSs profile removes optional and alternative contents elements from the added XML elements and types, when these options and alternatives are rarely used for defining the supported Coordinate Reference Systems (CRSs) and Coordinate Operations. The removed contents elements included:

- a) metaDataProperty, from AbstractGeneralTransformationType in coordinateOperations.xsd

6.3 XML schema documents

This GML 3.1.1 Grid CRSs profile is specified in the five normative XML Schema Documents included in the zip file with this text document, which are named:

- a) gmlGridCRSsProfile.xsd
- b) coordinateOperations.xsd
- c) coordinateReferenceSystems.xsd
- d) dataQuality.xsd
- e) datums.xsd

NOTE Also included in the zip file with this document are copies of the GML 3.1.1 CRS Support and Common CRSs profiles XML Schema Documents, and of all the XML document examples listed in Clauses 7 through 9, so that those examples can be used as templates.

All these XML Schema Documents contain documentation of the meaning of each element and attribute, and this documentation shall be considered normative as specified in Subclause 11.6.3 of [OGC 05-008].

After OGC acceptance of a Version 1.0.0 of this specification, these XML Schema Documents will also be posted online at the URL <http://schemas.opengis.net/gml/3.1.1/Profiles/GridCRSs/1.0.0>. In the event of a discrepancy between the bundled and online versions of the XML Schema Documents, the online files shall be considered authoritative.

6.4 CRS definitions use

These CRS definitions are not always required to be transferred between servers and clients that use OGC Web Services (OWS) Implementation Specifications. However, these definitions shall be used when relevant in defining coordinate operations (including Conversions and Transformations), 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.

7 Unrectified image CRSs definition XML encoding

7.1 Overview

When using this GML 3.1.1 profile, the definition of each unrectified image coordinate reference system (CRS) shall be XML encoded using the ImageCRS element, defined in the attached normative XML Schema Document named coordinateReferenceSystems.xsd. The GML objects contained or referenced in this ImageCRS are indicated in this XML document skeleton:

```
<ImageCRS>
  <usesCartesianCS>
    <CartesianCS gml:id="Grid2dSquareCS">
      <usesAxis>
        <CoordinateSystemAxis></CoordinateSystemAxis>
      </usesAxis>
      <usesAxis>
        <CoordinateSystemAxis></CoordinateSystemAxis>
      </usesAxis>
    </CartesianCS>
  </usesCartesianCS>
  <usesImageDatum>
    <ImageDatum></ImageDatum>
  </usesImageDatum>
</ImageCRS>
```

NOTE The UML class diagrams contained in Subclause C.2 provide graphical views of the contents of the ImageCRS XML element.

This skeleton XML document indicates that:

- a) An ImageCRS element shall contain one usesCartesianCS and one usesImageDatum XML elements (in addition to other mandatory and optional information).
- b) That usesCartesianCS element shall reference or contain the definition of one CartesianCS.

- c) That CartesianCS definition element shall contain an ordered sequence of two usesAxis elements.
- d) Each of those usesAxis elements shall reference or contain the definition of one CoordinateSystemAxis. The referenced or listed axis order shall be used for position coordinates in that image, with the specified units of each axis, normally grid spacing units.
- e) That usesImageDatum element shall reference or contain the definition of one ImageDatum.

This ImageCRS XML element specifies how to define the CRS of each unrectified image. ImageCRS definitions are not always required to be transferred between OGC web servers and clients. However, these definitions shall be used in defining georeferencing coordinate transformations, and shall be referenced by those coordinate transformation definitions. This unrectified image CRS shall be identified as the CRS of feature geometries measured or computed in that unrectified image.

7.2 Full XML document template

An example template XML document completely defining an ImageCRS is:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageCRS 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 ../gridCRSsProfile.xsd"
gml:id="ImageTBDCRSpixelCenter">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <srsName>Image TBD CRS pixel centers</srsName>
  <!-- Specific image or group shall be identified by "TBD" in this
srsName. -->
  <srsID>
    <name
codeSpace="urn:ogc:def:crs:OGC:1.0:ImageCRSpixelCenter:">ImageTBDCRSpix
elCenter</name>
    <!-- Specifies the URN that can be used to reference this image
CRS. This URN includes the image name as a parameter. The specific
image or group shall be identified by the "TBD" in the "name" value. --
>
  </srsID>
  <remarks>Parameterized definition of 2D image coordinate reference
systems with the origin at the center of the first pixel in the image
file. This CRS definition can be used for any size image, since no
image size is specified.
  </remarks>
  <usesCartesianCS>
    <CartesianCS gml:id="Grid2dSquareCS">
```

```

        <csName>2D square-cell grid based coordinate system</csName>
        <csID>
            <name
codeSpace="urn:ogc:def:cs:OGC:1.0:">Grid2dSquareCS</name>
        </csID>
        <remarks>A 2D grid-based coordinate system for use by an image
or other continuous grid coverage. It can be used for a grid of any
size, since no grid size is defined. This coordinate system specifies
that each row coordinate value shall be listed before the column
coordinate value. The grid cells are assumed to be square, with the
same grid spacing or pixel spacing in each direction.

```

In a grid coverage file, the "row" axis shall be the first axis by which grid points are sequenced, and the "column" axis shall be the second axis, as could be specified by the "scanDirection : Sequence(CharacterString)" attribute of the CV_SequenceRule class in Clause 8 of ISO 19123. With linear sequencing, the grid points in the first row shall be listed first, followed by other rows, with the grid points in each row listed in column number order. This relationship between the "row" and "column" names and the first grid points shall apply whether this Grid2dSquareCS is associated with a grid file before or after that file is recorded.

The "row" and "column" axis names are used here although the "scanDirection : Sequence(CharacterString)" attribute may provide other axis names. Use of other axis names would require defining different CartesianCSs for other names, or adding other names as additional axisID values. The following XML includes the axis names "line" and "sample" as additional axisID values.

If not otherwise identified in an image file, the "row" axis shall be the first axis whose number of pixels is identified, and the "column" axis shall be the second axis, as could be specified by the "extent[0..1] : CV_GridEnvelope" attribute of the CV_Grid class in Clause 8 of ISO 19123. In either case, the first point in the grid coverage file is assumed to be numbered (1, 1), meaning row 1, column 1.

The first row in a grid is sometimes called the "top" row, the first column is sometimes called the "left" column, and the first grid point is then called the "upperLeft" point. If desired, those names can be used with this Grid2dSquareCS. However other names can also be used, since this Grid2dSquareCS has been defined so that it does not depend on such left/right, top/bottom, and up/down names. </remarks>

```

        <usesAxis>
            <CoordinateSystemAxis gml:id="Row"
gml:uom="urn:ogc:def:uom:OGC:1.0:GridSpacing">
                <name>Grid row axis</name>
                <axisID>
                    <name
codeSpace="urn:ogc:def:axis:OGC:1.0:">Row</name>
                </axisID>
                <remarks>For this grid axis, row coordinate values match
grid row numbers, but allow fractional coordinate values between grid
points. The first row in a grid is sometimes called the "top" row, so
the direction of this axis is "down", but these terms are not required.
</remarks>
                <axisAbbrev>R</axisAbbrev>

```

```

    <axisDirection>urn:ogc:def:axisDirection:OGC:1.0:rowPositive</axisDi
rection>
    </CoordinateSystemAxis>
  </usesAxis>
  <usesAxis>
    <CoordinateSystemAxis gml:id="Column"
gml:uom="urn:ogc:def:uom:OGC:1.0:GridSpacing">
      <name>Grid column axis</name>
      <axisID>
        <name
codeSpace="urn:ogc:def:axis:OGC:1.0:">Column</name>
      </axisID>
      <remarks>For this grid axis, column coordinate values
match grid column numbers, but allow fractional coordinate values
between grid points. The first column is sometimes called the "left"
column, so the direction of this axis is "right", but these terms are
not required. </remarks>
      <axisAbbrev>C</axisAbbrev>

    <axisDirection>urn:ogc:def:axisDirection:OGC:1.0:columnPositive</axi
sDirection>
    </CoordinateSystemAxis>
  </usesAxis>
</CartesianCS>
</usesCartesianCS>
<usesImageDatum>
  <ImageDatum gml:id="ImageDatumPixelCenter">
    <datumName>Origin at center of first pixel</datumName>
    <datumID>
      <name
codeSpace="urn:ogc:def:datum:OGC:1.0:">ImageDatumPixelCenter</name>
    </datumID>
    <remarks>A 2D image datum with the origin at the center of the
first pixel in the image file. In an image file, the pixels in the
first row are assumed to be listed first, followed by other rows, with
pixels in each row listed (and collected) in column number order.
</remarks>
    <anchorPoint>center of first pixel</anchorPoint>
    <pixelInCell
codeSpace="urn:ogc:def:pixelInCell:OGC:1.0:">cellCenter</pixelInCell>
    </ImageDatum>
  </usesImageDatum>
</ImageCRS>

```

7.3 Recommended simple XML document template

The above template XML document can be simplified by referencing the standard XML documents specified in Clause 9, becoming:

```

<?xml version="1.0" encoding="UTF-8"?>
<ImageCRS 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 ../gridCRSsProfile.xsd"
gml:id="ImageTBDCRSPixelCenter">

```

```

    <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
    <srsName>Image TBD CRS pixel centers</srsName>
    <!-- Specific image or group shall be identified by "TBD" in this
srsName. -->
    <srsID>
      <name
codeSpace="urn:ogc:def:crs:OGC:1.0:ImageCRSPixelCenter:">ImageTBDCRSpix
elCenter</name>
      <!-- Specifies the URN that can be used to reference this image
CRS. This URN includes the image name as a parameter. The specific
image or group shall be identified by the "TBD" in the "name" value. --
>
    </srsID>
    <remarks>Parameterized definition of 2D image coordinate reference
systems with the origin at the center of the first pixel in the image
file. This CRS definition can be used for any size image, since no
image size is specified.

This CRS definition is designed to be used for ungeorectified images,
and is not expected to be used for a georectified image. This
definition can be used for a georeferenced or ungeoreferenced image,
where a georeferenced image CRS is associated with the coordinate
Transformation(s) that georeference it. </remarks>
    <usesCartesianCS
xlink:href="urn:ogc:def:cs:OGC:1.0:Grid2dSquareCS"/>
    <usesImageDatum
xlink:href="urn:ogc:def:datum:OGC:1.0:ImageDatumPixelCenter"/>
</ImageCRS>

```

This simplified template XML document is recommended for use in defining the CRSs of unrectified images. Of course, the included XML comments and <remarks> elements can be removed or edited.

8 Georectified grid CRSs definition XML encoding

8.1 Overview

When using this GML 3.1.1 profile, the definition of each georectified image or grid coverage coordinate reference system (CRS) shall be XML encoded using the DerivedCRS element, defined in the attached normative XML Schema Document named coordinateReferenceSystems.xsd. The GML objects contained or referenced in this DerivedCRS are indicated in this XML document skeleton:

NOTE 1 This profile specifies use of the DerivedCRS element for georectified image CRSs to support georectified images which are directly ready for image mosaicking. For image mosaicking, multiple georectified images must use exactly the same pixel positions wherever they (do or might) overlap. This means that the grids must have the same baseCRSs, grid point spacings in that CRS, and grid rotation in that CRS. When different origins are used, these origins must be grid points in the same SC_DerivedCRS.

```

<DerivedCRS>
  <baseCRS>
    <ProjectedCRS></ProjectedCRS> or <GeographicCRS></GeographicCRS>
  </baseCRS>
  <definedByConversion>
    <Conversion>
      <usesMethod>

```



```

        <OperationMethod>
            <usesParameter> (one or more)
                <OperationParameter></OperationParameter>
            </usesParameter>
            <usesParameter> or
                <OperationParameterGroup></OperationParameterGroup>
            </usesParameter>
        </OperationMethod>
    </usesMethod>
    <usesValue></usesValue> (one or more)
</Conversion>
</definedByConversion>
<usesCS>
    <CartesianCS>
        <usesAxis>
            <CoordinateSystemAxis></CoordinateSystemAxis>
        </usesAxis>
        <usesAxis>
            <CoordinateSystemAxis></CoordinateSystemAxis>
        </usesAxis>
    </CartesianCS>
</usesCS>
</DerivedCRS>

```

NOTE 2 The UML class diagrams contained in Subclause C.3 provide graphical views of the contents of the DerivedCRS XML element.

This skeleton XML document indicates that:

- a) A DerivedCRS element shall contain one baseCRS, one definedByConversion, and one usesCS XML elements (in addition to other mandatory and optional information).
- b) That baseCRS element shall reference or contain the definition of either a ProjectedCRS or a 2D GeographicCRS, as specified in the GML 3.1.1 Common CRSs profile.

NOTE 3 The two axes of a GeographicCRS are usually named geodetic latitude and geodetic longitude, with coordinates listed in that order and with both latitude and longitude values given in decimal degrees. The two axes of a ProjectedCRS are often named Easting and Northing, not always in that order, with values often given in metres.

- c) That definedByConversion element shall reference or contain the definition of one Conversion, as specified in the GML 3.1.1 Common CRSs profile.
- f) That usesCS element shall reference or contain the definition of one CartesianCS.
- g) That CartesianCS definition element shall contain an ordered sequence of two usesAxis elements, as specified in the GML 3.1.1 common CRSs profile.
- h) Each of those usesAxis elements shall reference or contain the definition of one CoordinateSystemAxis. The referenced or listed axis order shall be used for position coordinates in that image, with the specified units of each axis, normally grid spacing units. Non-integer values for these axes shall be used to specify positions between the pixels.

This `DerivedCRS` element specifies how to define the CRS of each georectified image. These definitions are not always required to be transferred between OGC web servers and clients. However, these definitions shall be used in defining the `definedByConversion` Conversion and the georeferencing coordinate Transformations, and shall be referenced by those coordinate transformation definitions.

This CRS for a georectified image shall be identified as the CRS of feature geometries measured or computed in that georectified image. This CRS should also be used for identification of the georeferencing coordinate transformations discussed in Subclause 7.2.2.1 of the “WCTS profile for unrectified images” [draft].

NOTE 4 The `gml:RectifiedGrid` element in `grids.xsd` of GML 3.1.1 specifies the locations of a grid of points in a base or external CRS. The relationship between those grid points and the image or grid coverage pixels is largely defined by `gml:coverageFunction`. However, a `gml: _Coverage` is not a CRS, so does not define a CRS suitable for positions that are measured or computed in that georectified image. Also, it does not define a CRS that can be used as the `sourceCRS` or `targetCRS` of a coordinate Transformation.

8.2 Full XML document template

An example template XML document completely defining a `DerivedCRS` for a georectified image is:

```
<?xml version="1.0" encoding="UTF-8"?>
<DerivedCRS 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 ../gridCRSsProfile.xsd"
gml:id="GeorectifiedImageXXXXCRS">
  <!-- Specific georectified image or grid must be identified in this
gml:id. -->
  <!-- Last updated 2005-10-04 -->
  <!-- ===== -->
  <srsName>Georectified Image XXXX CRS</srsName>
  <!-- Specific georectified image or grid must be identified in
srsName. -->
  <srsID>
    <name
codeSpace="urn:opengis:def:crs:OGC:0.20:GeorectifiedImageXXXXCRS">Geore
ctifiedImageXXXXCRS</name>
    <!-- Specific image must be identified in "name" value. -->
  </srsID>
  <remarks>Template for georectified 2D image coordinate reference
system definition. In this CRS, the origin is at the center of the
first pixel in the georectified image file. This CRS template can be
used for any size georectified image, since no image size is specified.
A CRS definition using this template is expected to be needed and thus
created before the georectified image pixels are produced. The
coordinate Conversion used by this CRS definition is expected to NOT
closely approximate the reverse of the coordinate Transformation used
to georectify this image. This CRS template is not expected to be
useful for an ungeorectified image. </remarks>
  <baseCRS xlink:href="urn:opengis:def:crs:EPSG:6.3:YYYY"/>
  <!-- Specific 2D CRS that was georectified into must be identified
in baseCRS, usually a ProjectedCRS or GeographicCRS -->
  <!-- ===== -->
```

```

<definedByConversion>
  <Conversion gml:id="GeorectifiedImageXXXXConversion">
    <!-- Specific georectified image or grid must be identified in
this gml:id. -->
    <coordinateOperationName>Georectified image XXXX
conversion</coordinateOperationName>
    <!-- Specific image must be identified in this
coordinateOperationName. -->
    <usesMethod>
      <OperationMethod gml:id="EPSG9624">
        <methodName>Affine general parametric
transformation</methodName>
        <methodID>
          <name
codeSpace="urn:opengis:method:EPSG:6.3:">9624</name>
          </methodID>
          <methodFormula>
XT    =  A0  +  A1. XS  +  A2.YS;
YT    =  B0  +  B1. XS  +  B2.YS;
where XT , YT are the coordinates of a point P in the target coordinate
system;
      XS , YS are the coordinates of P in the source coordinate system.

Reversibility: The parameter values for an affine transformation cannot
be used for the reverse transformation. However, the reverse
transformation is another affine transformation using the same formulas
but with different parameter values. The reverse parameter values,
indicated by a prime ('), can be calculated from those of the forward
transformation as follows:
D      =  A1 . B2    -   A2 . B1;
A0'    =  (A2 . B0    -   B2 . A0) / D;
B0'    =  (B1 . A0    -   A1 . B0) / D;
A1'    =  +B2 / D;
A2'    =  - A2 / D;
B1'    =  - B1 / D;
B2'    =  +A1 / D.

See Section 2.4.2.1 of EPSG Guidance Note 7. </methodFormula>
      <sourceDimensions>2</sourceDimensions>
      <targetDimensions>2</targetDimensions>
      <!-- ===== -->
      <usesParameter>
        <OperationParameter gml:id="EPSG8623">
          <parameterName>A0</parameterName>
          <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8623</name>
            </parameterID>
          </OperationParameter>
        </usesParameter>
      <!-- ===== -->
      <usesParameter>
        <OperationParameter gml:id="EPSG8624">
          <parameterName>A1</parameterName>
          <parameterID>
            <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8624</name>
            </parameterID>

```

```

        </OperationParameter>
    </usesParameter>
    <!-- ===== -->
    <usesParameter>
        <OperationParameter gml:id="EPSG8625">
            <parameterName>A2</parameterName>
            <parameterID>
                <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8625</name>
            </parameterID>
        </OperationParameter>
    </usesParameter>
    <!-- ===== -->
    <usesParameter>
        <OperationParameter gml:id="EPSG8639">
            <parameterName>B0</parameterName>
            <parameterID>
                <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8639</name>
            </parameterID>
        </OperationParameter>
    </usesParameter>
    <!-- ===== -->
    <usesParameter>
        <OperationParameter gml:id="EPSG8640">
            <parameterName>B1</parameterName>
            <parameterID>
                <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8640</name>
            </parameterID>
        </OperationParameter>
    </usesParameter>
    <!-- ===== -->
    <usesParameter>
        <OperationParameter gml:id="EPSG8641">
            <parameterName>B2</parameterName>
            <parameterID>
                <name
codeSpace="urn:ogc:def:parameter:EPSG:6.3:">8641</name>
            </parameterID>
        </OperationParameter>
    </usesParameter>
    </OperationMethod>
</usesMethod>
    <!-- ===== -->
    <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be inserted
-->
        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8623"/>
    </usesValue>
    <!-- ===== -->
    <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be inserted
-->

```

```

        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8624"/>
    </usesValue>
    <!-- ===== -->
    <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be
inserted.
        The value of this parameter is often 0.0. -->
        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8625"/>
    </usesValue>
    <!-- ===== -->
    <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be inserted
-->
        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8639"/>
    </usesValue>
    <!-- ===== -->
    <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be
inserted.
        The value of this parameter is often 0.0. -->
        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8640"/>
    </usesValue>
    <!-- ===== -->
    <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be inserted
-->
        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8641"/>
    </usesValue>
    </Conversion>
</definedByConversion>
    <!-- ===== -->
    <derivedCRSType
codeSpace="#DerivedCRSTypeValues">#image</derivedCRSType>
    <!-- ===== -->
    <usesCS>
        <CartesianCS gml:id="Grid2dSquareCS">
            <csName>2D square-cell grid based coordinate system</csName>
            <csID>
                <name
codeSpace="urn:ogc:def:cs:OGC:1.0:">Grid2dSquareCS</name>
            </csID>
            <remarks>A 2D grid-based coordinate system for use by an image
or other continuous grid coverage. It can be used for a grid of any
size, since no grid size is defined. This coordinate system specifies
that each row coordinate value shall be listed before the column
coordinate value. The grid cells are assumed to be square, with the
same grid spacing or pixel spacing in each direction.

```

In a grid coverage file, the "row" axis shall be the first axis by which grid points are sequenced, and the "column" axis shall be the second axis, as could be specified by the "scanDirection : Sequence(CharacterString)" attribute of the CV_SequenceRule class in Clause 8 of ISO 19123. With linear sequencing, the grid points in the first row shall be listed first, followed by other rows, with the grid points in each row listed in column number order. This relationship between the "row" and "column" names and the first grid points shall apply whether this Grid2dSquareCS is associated with a grid file before or after that file is recorded.

The "row" and "column" axis names are used here although the "scanDirection : Sequence(CharacterString)" attribute may provide other axis names. Use of other axis names would require defining different CartesianCSs for other names, or adding other names as additional axisID values. The following XML includes the axis names "line" and "sample" as additional axisID values.

If not otherwise identified in an image file, the "row" axis shall be the first axis whose number of pixels is identified, and the "column" axis shall be the second axis, as could be specified by the "extent[0..1] : CV_GridEnvelope" attribute of the CV_Grid class in Clause 8 of ISO 19123. In either case, the first point in the grid coverage file is assumed to be numbered (1, 1), meaning row 1, column 1.

The first row in a grid is sometimes called the "top" row, the first column is sometimes called the "left" column, and the first grid point is then called the "upperLeft" point. If desired, those names can be used with this Grid2dSquareCS. However other names can also be used, since this Grid2dSquareCS has been defined so that it does not depend on such left/right, top/bottom, and up/down names. </remarks>

```

    <usesAxis>
      <CoordinateSystemAxis gml:id="Row"
gml:uom="urn:ogc:def:uom:OGC:1.0:GridSpacing">
        <name>Grid row axis</name>
        <axisID>
          <name
codeSpace="urn:ogc:def:axis:OGC:1.0:">Row</name>
        </axisID>
        <remarks>For this grid axis, row coordinate values match
grid row numbers, but allow fractional coordinate values between grid
points. The first row in a grid is sometimes called the "top" row, so
the direction of this axis is "down", but these terms are not required.
</remarks>
        <axisAbbrev>R</axisAbbrev>

```

```

      <axisDirection>urn:ogc:def:axisDirection:OGC:1.0:rowPositive</axisDi
rection>
    </CoordinateSystemAxis>
  </usesAxis>
  <usesAxis>
    <CoordinateSystemAxis gml:id="Column"
gml:uom="urn:ogc:def:uom:OGC:1.0:GridSpacing">
      <name>Grid column axis</name>
      <axisID>
        <name
codeSpace="urn:ogc:def:axis:OGC:1.0:">Column</name>

```

```

        </axisID>
        <remarks>For this grid axis, column coordinate values
match grid column numbers, but allow fractional coordinate values
between grid points. The first column is sometimes called the "left"
column, so the direction of this axis is "right", but these terms are
not required. </remarks>
        <axisAbbrev>C</axisAbbrev>

        <axisDirection>urn:ogc:def:axisDirection:OGC:1.0:columnPositive</axisDirection>
    </CoordinateSystemAxis>
    </usesAxis>
    </CartesianCS>
    </usesCS>
</DerivedCRS>

```

The above template XML document uses the operation Method catalogued by the EPSG using code 9624, because that EPSG method seems closest to the desired Method. However, various other operation Methods could be used, including Methods specified by the OGC. For example, one or more operation Methods could be defined that use parts of the gml:RectifiedGrid element as operation Parameters.

8.3 Recommended simple XML document template

The above example template XML document can be simplified by referencing the standard XML documents specified in Clause 9, and referencing the EPSG 9624 Operation Method, becoming:

```

<?xml version="1.0" encoding="UTF-8"?>
<DerivedCRS 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 ../gridCRSsProfile.xsd"
gml:id="GeorectifiedImageXXXXCRS">
    <!-- Specific georectified image or grid must be identified in this
gml:id. -->
    <!-- Last updated 2005-10-04 -->
    <!-- ===== -->
    <srsName>Georectified Image XXXX CRS</srsName>
    <!-- Specific georectified image or grid must be identified in
srsName. -->
    <srsID>
        <name
codeSpace="urn:opengis:def:crs:OGC:0.:GeorectifiedImageCRS">GeorectifiedImageXXXXCRS</name>
        <!-- Specific image must be identified in "name" value. -->
    </srsID>
    <remarks>Template for georectified 2D image coordinate reference
system definition. In this CRS, the origin is at the center of the
first pixel in the georectified image file. This CRS template can be
used for any size georectified image, since no image size is specified.
A CRS definition using this template is expected to be needed and thus
created before the georectified image pixels are produced. The
coordinate Conversion used by this CRS definition is expected to NOT
closely approximate the reverse of the coordinate Transformation used

```

```

to georectify this image. This CRS template is not expected to be
useful for an ungeorectified image. </remarks>
  <baseCRS xlink:href="urn:opengis:def:crs:EPSG:6.3:YYYY"/>
  <!-- Specific 2D CRS that was georectified into must be identified
in baseCRS, usually a ProjectedCRS or GeographicCRS -->
  <!-- ===== -->
  <definedByConversion>
    <Conversion gml:id="GeorectifiedImageXXXXConversion">
      <!-- Specific georectified image or grid must be identified in
this gml:id. -->
      <coordinateOperationName>Georectified image XXXX
conversion</coordinateOperationName>
      <!-- Specific image must be identified in this
coordinateOperationName. -->
      <usesMethod xlink:href="urn:opengis:method:EPSG:6.3:9624"/>
      <!-- ===== -->
      <usesValue>
        <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
        <!-- Specific uom code and parameter value must be inserted
-->
        <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8623"/>
        </usesValue>
        <!-- ===== -->
        <usesValue>
          <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
          <!-- Specific uom code and parameter value must be inserted
-->
          <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8624"/>
          </usesValue>
          <!-- ===== -->
          <usesValue>
            <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
            <!-- Specific uom code and parameter value must be
inserted.
            The value of this parameter is often 0.0. -->
            <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8625"/>
            </usesValue>
            <!-- ===== -->
            <usesValue>
              <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
              <!-- Specific uom code and parameter value must be inserted
-->
              <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8639"/>
              </usesValue>
              <!-- ===== -->
              <usesValue>
                <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
                <!-- Specific uom code and parameter value must be
inserted.
                The value of this parameter is often 0.0. -->
                <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8640"/>
                </usesValue>
                <!-- ===== -->

```



```

        <usesValue>
            <value uom="urn:opengis:def:uom:EPSG:6.3:ZZZZ">9999</value>
            <!-- Specific uom code and parameter value must be inserted
-->
            <valueOfParameter
xlink:href="urn:opengis:def:parameter:EPSG:6.3:8641"/>
        </usesValue>
    </Conversion>
</definedByConversion>
<!-- ===== -->
    <derivedCRSType
codeSpace="#DerivedCRSTypeValues">#image</derivedCRSType>
    <usesCS xlink:href="urn:ogc:def:cs:OGC:1.0:Grid2dSquareCS"/>
</DerivedCRS>

```

This simplified template XML document is recommended for use in defining the CRSs of georectified images. Of course, the OperationMethod can be changed, and the included XML comments and <remarks> elements can be removed or edited.

9 Georeferencing Transformations definition XML encoding

9.1 Overview

An unrectified image can be georeferenced by at least one coordinate transformation, between the CRS of the unrectified image and a reference CRS for positions relative to the earth (or other planet or moon). This georeferencing coordinate transformation can be represented by a coordinate Transformation in GML. A frequent alternative to using one Transformation is using a ConcatenatedOperation that sequentially combines two or more Transformations. PassThroughOperations and Conversions can also be used in such a ConcatenatedOperation.

This reference CRS is assumed to be 3D, while the unrectified image is only 2D. The georeferencing coordinate transformation is thus assumed to be from the reference 3D CRS to the 2D image CRS. If the reference CRS were 2D, that would be equivalent to combining the georeferencing coordinate transformation with the elevation model coordinate transformation discussed later in this clause.

When using this GML 3.1.1 profile, the definition of each georeferencing coordinate transformation shall be XML encoded using the Transformation or ConcatenatedOperation element, defined in the attached normative XML Schema Document named coordinateOperations.xsd. The GML objects contained or referenced in such a Transformation are indicated in this XML document skeleton:

```

<Transformation>
    <sourceCRS>
        <CompoundCRS></CompoundCRS> or <GeographicCRS></GeographicCRS>
    </sourceCRS>
    <targetCRS>
        <ImageCRS></ImageCRS>
    </targetCRS>
    <usesMethod>
        <OperationMethod>
            <usesParameter> (one or more)

```

```

        <OperationParameter></OperationParameter>
      </usesParameter>
    <usesParameter>
      <OperationParameter></OperationParameter>
    </usesParameter>
  </OperationMethod>
</usesMethod>
<usesValue></usesValue> (one or more)
<usesValue></usesValue>
</Transformation>

```

NOTE 1 The UML class diagrams contained in Subclause C.4 provide graphical views of the contents of the Transformation and ConcatenatedOperation XML elements.

This skeleton XML document indicates that:

- a) A Transformation element shall contain one sourceCRS, one TargetCRS, one usesMethod, and one or more usesValue XML elements (in addition to other mandatory and optional information).
- b) That sourceCRS element shall reference or contain the definition of one CompoundCRS or 3D GeographicCRS, as specified in the GML 3.1.1 Common CRSs Profile.
- c) That targetCRS element shall reference or contain the definition of one ImageCRS.
- d) That usesMethod element shall reference or contain the definition of one OperationMethod.
- e) That OperationMethod definition element shall contain an unordered sequence of one or more usesParameter elements.
- f) Each of those usesParameter elements shall reference or contain the definition of one OperationParameter.
- g) Each of those usesValue elements shall contain one parameterValue element.
- h) Each of those parameterValue elements shall contain the value of one parameter with one of several allowed data types. Alternately, a parameterValue element can reference a file containing a set of parameter values.

The GML objects contained or referenced in such ConcatenatedOperation are indicated in this XML document skeleton:

```

<ConcatenatedOperation>
  <sourceCRS>
    <ProjectedCRS></ProjectedCRS> or <GeographicCRS></GeographicCRS>
  </sourceCRS>
  <targetCRS>
    <ImageCRS></ImageCRS>
  </targetCRS>
  <usesSingleOperation> (two or more)
    <Transformation></Transformation>

```

```

    </usesSingleOperation> or
    <usesSingleOperation>
      <Conversion></Conversion>
    </usesSingleOperation>
  </ConcatenatedOperation>

```

This skeleton XML document indicates that:

- a) A ConcatenatedOperation element shall contain one sourceCRS, one TargetCRS, and an ordered sequence of two or more usesSingleOperation elements (in addition to other mandatory and optional information).
- b) That sourceCRS element shall reference or contain one 3D CompoundCRS or GeographicCRS element.
- c) That targetCRS element shall reference or contain one ImageCRS element.
- d) Each of those usesSingleOperation elements shall reference or contain one Transformation or Conversion element. The contents of that Transformation or Conversion shall be as outlined above or in Subclause 9.1 of the GML 3.1.1 Common CRSs profile [OGC 05-095].

This Transformation or ConcatenatedOperation element specifies how to define a georeferencing coordinate transformation for an unrectified image. These definitions are often required to be transferred between OGC web servers and clients. These georeferencing coordinate transformations shall be defined using the definitions of the unrectified image CRS, and the definition of the reference CRS. For a Transformation or ConcatenatedOperation performing georectification, the definition of the DerivedCRS for the georectified image shall also be used, including the definition of the definedByConversion used by that DerivedCRS.

9.2 Image georeferencing Transformation full template

An example template XML document defining a Transformation for image georeferencing is:

```

<?xml version="1.0" encoding="UTF-8"?>
<Transformation 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 ../gridCRSsProfile.xsd"
  gml:id="TemplateGeoreferencingTransformation">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <coordinateOperationName>Example template for image georeferencing
coordinate Transformations</coordinateOperationName>
  <operationVersion>1.0</operationVersion>
  <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
    <!-- This sourceCRS must be 3D. -->
  </sourceCRS>
  <targetCRS
xlink:href="urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD"/>
  <usesMethod>

```

```

        <OperationMethod gml:id="ReplacementSensorModel">
          <methodName>Replacement Sensor Model (RSM) coordinate
Transformation</methodName>
          <methodID>
            <name
codeSpace="urn:ogc:def:method:OGC:0.0:">ReplacementSensorModel</name>
          </methodID>
          <remarks>This operation method is for a coordinate
Transformation that georeferences an unrectified image using the
Replacement Sensor Model (RSM). </remarks>

          <methodFormula>urn:ogc:def:method:OGC:0.0:ReplacementSensorModel.
</methodFormula>
          <sourceDimensions>3</sourceDimensions>
          <targetDimensions>2</targetDimensions>
          <usesParameter>
            <OperationParameter gml:id="RSMPParameters">
              <parameterName>Parameters for Replacement Sensor Model
(RSM). </parameterName>
              <parameterID>
                <name
codeSpace="http://baesystems.com/rsm/rsmParameters"/>
              </parameterID>
              <remarks>The value of this operation parameter is the
URL of a file containing all the parameters for the Replacement Sensor
Model (RSM) for the specific image. </remarks>
            </OperationParameter>
          </usesParameter>
        </OperationMethod>
      </usesMethod>
    <usesValue>

      <valueFile>http://baesystems.com/rsm/rsmParameterValues/TBD.xml</val
ueFile>
      <valueOfParameter
xlink:href="http://baesystems.com/rsm/rsmParameters"/>
      </usesValue>
    </Transformation>

```

This example template uses the “Replacement Sensor Model (RSM)” Operation Method for georeferencing Transformations. That example method uses one parameter named “RSMPParameters” that contains the URL of a file containing all the RSM parameters for a specific image. That RSM Operation Method is an extension of the “Universal image geometry model transformation” described in OGC Discussion Paper [OGC 04-071].

9.3 Image georeferencing Transformation recommended simple template

That Operation Method could be specified elsewhere and referenced by this georeferencing Transformations template, instead of being included in-line. Doing this produces the simplified template XML document:

```

<?xml version="1.0" encoding="UTF-8"?>
<Transformation 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 ../gridCRSsProfile.xsd"
gml:id="TemplateGeoreferencingTransformation">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <coordinateOperationName>Example template for image georeferencing
coordinate Transformations</coordinateOperationName>
  <operationVersion>1.0</operationVersion>
  <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
    <!-- This sourceCRS must be 3D. -->
  </sourceCRS>
  <targetCRS
xlink:href="urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD"/>
    <usesMethod
xlink:href="urn:ogc:def:method:OGC:0.0:ReplacementSensorModel"/>
    <usesValue>

    <valueFile>http://baesystems.com/rsm/rsmParameterValues/TBD.xml</val
ueFile>
    <valueOfParameter
xlink:href="http://baesystems.com/rsm/rsmParameters"/>
    </usesValue>
</Transformation>

```

This simplified template XML document is recommended for use in defining the image georeferencing coordinate Transformations. Of course, the OperationMethod can be changed, and the included XML comments and <remarks> elements can be removed or edited.

9.4 Grid elevation model Transformation full template

A template XML document defining a Transformation for a grid elevation model is:

```

<?xml version="1.0" encoding="UTF-8"?>
<Transformation 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 ../gridCRSsProfile.xsd"
gml:id="TemplateGridElevationModelTransformation">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <coordinateOperationName>Template for grid elevation model
coordinate Transformations</coordinateOperationName>
  <operationVersion>1.0</operationVersion>
  <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
    <!-- This sourceCRS must be 2D. -->
  </sourceCRS>
  <targetCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
    <!-- This targetCRS must be 3D. -->
  </targetCRS>
  <usesMethod>
    <OperationMethod gml:id="GridElevationModel">
      <methodName>Grid elevation model</methodName>
      <methodID>
        <name
codeSpace="urn:ogc:def:method:OGC:0.0:">GridElevationModel</name>
      </methodID>
    </OperationMethod>
  </usesMethod>
</Transformation>

```

```

    <remarks>This operation method is for a coordinate
Transformation that implements an elevation model using grid elevation
data. </remarks>
    <methodFormula>The elevation value for the input horizontal
position shall be bilinear interpolated between the surrounding four
grid points, and added to the input horizontal coordinates.
</methodFormula>
    <sourceDimensions>2</sourceDimensions>
    <targetDimensions>3</targetDimensions>
    <usesParameter>
        <OperationParameter gml:id="GridElevationData">
            <parameterName>Grid Elevation Data</parameterName>
            <parameterID>
                <name
codeSpace="urn:ogc:def:parameter:OGC:0.0:">GridElevationData</name>
                </parameterID>
            <remarks>The value of this operation parameter is the
URL of a source of grid elevation data, in the 3D targetCRS of the
coordinate Transformation that contains the value of this operation
parameter. </remarks>
        </OperationParameter>
    </usesParameter>
</OperationMethod>
</usesMethod>
<usesValue>
    <valueFile>http://baesystems.com/DEM/TBD</valueFile>
    <valueOfParameter
xlink:href="urn:ogc:def:parameter:OGC:0.0:GridElevationData"/>
    </usesValue>
</Transformation>

```

This example template uses the “GridElevationModel” Operation Method. That example method uses one parameter named “GridElevationData” that contains the URL of a file containing the grid elevation data.

9.5 Grid elevation model Transformation recommended simple template

That Operation Method could be specified elsewhere and referenced by this GridElevationModel Transformations template, instead of being included in-line. Doing this produces the simplified template XML document:

```

<?xml version="1.0" encoding="UTF-8"?>
<Transformation 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 ../gridCRSsProfile.xsd"
gml:id="TemplateGridElevationModelTransformation">
    <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
    <coordinateOperationName>Template for grid elevation model
coordinate Transformations</coordinateOperationName>
    <operationVersion>1.0</operationVersion>
    <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
        <!-- This sourceCRS must be 2D. -->
    </sourceCRS>
    <targetCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
        <!-- This targetCRS must be 3D. -->
    </targetCRS>

```

```

    </targetCRS>
    <usesMethod
xlink:href="urn:ogc:def:method:OGC:0.0:GridElevationModel"/>
    <usesValue>
        <valueFile>http://baesystems.com/DEM/TBD</valueFile>
        <valueOfParameter
xlink:href="urn:ogc:def:parameter:OGC:0.0:GridElevationData"/>
        </usesValue>
    </Transformation>

```

This simplified template XML document is recommended for use in defining grid elevation model coordinate Transformations. Of course, the OperationMethod can be changed, and the included XML comments and <remarks> elements can be removed or edited.

9.6 Concatenated operation full template

A template XML document defining a ConcatenatedOperation that combines the two full transformation templates above is:

```

<?xml version="1.0" encoding="UTF-8"?>
<ConcatenatedOperation 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 ../gridCRSsProfile.xsd"
gml:id="TBD">
    <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
    <coordinateOperationName>Template for
ConcatenatedOperation</coordinateOperationName>
    <remarks>Template for coordinate ConcatenatedOperation to
unrectified image coordinates from ground CRS coordinates. </remarks>
    <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
        <!-- This sourceCRS must be 2D. -->
    </sourceCRS>
    <targetCRS
xlink:href="urn:ogc:def:crs:OGC:0.0:ImageCRSpixelCenter:TBD"/>
    <usesSingleOperation>
        <Transformation
gml:id="TemplateGridElevationModelTransformation">
            <coordinateOperationName>Template for grid elevation model
coordinate Transformations</coordinateOperationName>
            <operationVersion>1.0</operationVersion>
            <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
                <!-- This sourceCRS must be the same as the sourceCRS
above. -->
            </sourceCRS>
            <targetCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
                <!-- This targetCRS must be 3D. -->
            </targetCRS>
            <usesMethod>
                <OperationMethod gml:id="GridElevationModel">
                    <methodName>Grid elevation model</methodName>
                    <methodID>
                        <name
codeSpace="urn:ogc:def:method:OGC:0.0:">GridElevationModel</name>
                    </methodID>
                </OperationMethod>
            </usesMethod>
        </Transformation>
    </usesSingleOperation>

```

```

        <remarks>This operation method is for a coordinate
Transformation that implements an elevation model using grid elevation
data. </remarks>
        <methodFormula>The elevation value for the input
horizontal position shall be bilinear interpolated between the
surrounding four grid points, and added to the input horizontal
coordinates. </methodFormula>
        <sourceDimensions>2</sourceDimensions>
        <targetDimensions>3</targetDimensions>
        <usesParameter>
            <OperationParameter gml:id="GridElevationData">
                <parameterName>Grid Elevation Data</parameterName>
                <parameterID>
                    <name
codeSpace="urn:ogc:def:parameter:OGC:0.0:">GridElevationData</name>
                    </parameterID>
                <remarks>The value of this operation parameter is
the URL of a source of grid elevation data, in the 3D targetCRS of the
coordinate Transformation that contains the value of this operation
parameter. </remarks>
            </OperationParameter>
        </usesParameter>
    </OperationMethod>
</usesMethod>
<usesValue>
    <valueFile>http://baesystems.com/DEM/TBD</valueFile>
    <valueOfParameter
xlink:href="urn:ogc:def:parameter:OGC:0.0:GridElevationData"/>
    </usesValue>
</Transformation>
</usesSingleOperation>
<usesSingleOperation>
    <Transformation gml:id="TemplateGeoreferencingTransformation">
        <coordinateOperationName>Template for image georeferencing
coordinate Transformation</coordinateOperationName>
        <operationVersion>1.0</operationVersion>
        <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
            <!-- This sourceCRS must be the same as the targetCRS
above. -->
        </sourceCRS>
        <targetCRS
xlink:href="urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD"/>
        <usesMethod>
            <OperationMethod gml:id="ReplacementSensorModel">
                <methodName>Replacement Sensor Model (RSM) coordinate
Transformation</methodName>
                <methodID>
                    <name
codeSpace="urn:ogc:def:method:OGC:0.0:">ReplacementSensorModel</name>
                    </methodID>
                <remarks>This operation method is for a coordinate
Transformation that georeferences an unrectified image using the
Replacement Sensor Model (RSM). </remarks>
            </OperationMethod>
        </usesMethod>
    </Transformation>
</usesSingleOperation>
</usesMethod>
<methodFormula>urn:ogc:def:method:OGC:0.0:ReplacementSensorModel.
</methodFormula>
    <sourceDimensions>3</sourceDimensions>
    <targetDimensions>2</targetDimensions>

```



```

        <usesParameter>
          <OperationParameter gml:id="RSMParameters">
            <parameterName>Parameters for Replacement Sensor
Model (RSM). </parameterName>
            <parameterID>
              <name
codeSpace="http://baesystems.com/rsm/rsmParameters"/>
            </parameterID>
            <remarks>The value of this operation parameter is
the URL of a file containing all the parameters for the Replacement
Sensor Model (RSM) for the specific image. </remarks>
          </OperationParameter>
        </usesParameter>
      </OperationMethod>
    </usesMethod>
    <usesValue>

      <valueFile>http://baesystems.com/rsm/rsmParameterValues/TBD.xml</val
ueFile>

      <valueOfParameter
xlink:href="http://baesystems.com/rsm/rsmParameters"/>
    </usesValue>
  </Transformation>
</usesSingleOperation>
</ConcatenatedOperation>

```

9.7 Concatenated operation recommended simple template

The above template uses the “Replacement Sensor Model (RSM)” and “GridElevationModel” Operation Methods. Those Operation Methods could be specified elsewhere and referenced by this template, instead of being included in-line. Doing this produces the simplified template XML document:

```

<?xml version="1.0" encoding="UTF-8"?>
<ConcatenatedOperation 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 ../gridCRSsProfile.xsd"
gml:id="TemplateConcatenatedOperation">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <coordinateOperationName>Template for
ConcatenatedOperation</coordinateOperationName>
  <remarks>Template for coordinate ConcatenatedOperation to
unrectified image coordinates from ground CRS coordinates. </remarks>
  <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
    <!-- This sourceCRS must be 2D. -->
  </sourceCRS>
  <targetCRS
xlink:href="urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD"/>
  <usesSingleOperation>
    <Transformation
gml:id="TemplateGridElevationModelTransformation">
      <coordinateOperationName>Template for grid elevation model
coordinate Transformations</coordinateOperationName>
      <operationVersion>1.0</operationVersion>
      <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">

```

```

        <!-- This sourceCRS must be the same as the sourceCRS
above. -->
        </sourceCRS>
        <targetCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
            <!-- This targetCRS must be 3D. -->
        </targetCRS>
        <usesMethod
xlink:href="urn:ogc:def:method:OGC:0.0:GridElevationModel"/>
        <usesValue>
            <valueFile>http://baesystems.com/DEM/TBD</valueFile>
            <valueOfParameter
xlink:href="urn:ogc:def:parameter:OGC:0.0:GridElevationData"/>
        </usesValue>
        </Transformation>
    </usesSingleOperation>
    <usesSingleOperation>
        <Transformation gml:id="TemplateGeoreferencingTransformation">
            <coordinateOperationName>Template for image georeferencing
coordinate Transformation</coordinateOperationName>
            <operationVersion>1.0</operationVersion>
            <sourceCRS xlink:href="urn:ogc:def:crs:EPSG:6.3:TBD">
                <!-- This sourceCRS must be the same as the targetCRS
above. -->
            </sourceCRS>
            <targetCRS
xlink:href="urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD"/>
            <usesMethod
xlink:href="urn:ogc:def:method:OGC:0.0:ReplacementSensorModel"/>
            <usesValue>

                <valueFile>http://baesystems.com/rsm/rsmParameterValues/TBD.xml</val
ueFile>
                <valueOfParameter
xlink:href="http://baesystems.com/rsm/rsmParameters"/>
            </usesValue>
        </Transformation>
    </usesSingleOperation>
</ConcatenatedOperation>

```

This simplified template XML document is recommended for use in defining such concatenated Transformations. Of course, the OperationMethod(s) can be changed, and the included XML comments and <remarks> elements can be removed or edited.

10 Standard URNs and XML definitions

10.1 Overview

This clause specifies a standard set of definitions and corresponding URNs that shall be used whenever applicable for unrectified and georectified images. Most of these definitions are encoded using this GML 3.1.1 Grid CRSs profile.

Whenever applicable, CRS definitions for images shall use the eight URNs in the “ogc” URN namespace that are specified in Table 1. The first two these URNs use the format for not-completely-specified objects specified in Subclause 7.2 of “URNs of definitions

in ogc namespace” [OGC 05-010]. The remaining six of these URNs use the format for single objects specified in Subclause 7.1.

Table 1 — Standard URNs for unrectified images CRSs

URN	Object name & gml:id	Definition specified in
urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD ^a	ImageTBDCRSPixelCenter	Subclause 9.2
urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCorner:TBD ^a	ImageTBDCRSPixelCorner	Subclause 9.3
urn:ogc:def:cs:OGC:0.0:Grid2dSquareCS	Grid2dSquareCS	Subclause 9.4
urn:ogc:def:axis:OGC:0.0:Row	Row	Subclause 9.5
urn:ogc:def:axis:OGC:0.0:Column	Column	Subclause 9.6
urn:ogc:def:datum:OGC:0.0:ImageDatumPixelCenter	ImageDatumPixelCenter	Subclause 9.7
urn:ogc:def:datum:OGC:0.0:ImageDatumPixelCorner	ImageDatumPixelCorner	Subclause 9.8
urn:ogc:def:uom:OGC:0.0:GridSpacing	GridSpacing	Subclause 9.9
^a This “TBD” shall be replaced by the image identifier alphanumeric character string.		

10.2 Image CRSs with origin in centre of first pixel

The URN value “urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCenter:TBD” shall reference the definition of an (unrectified) image CRS with its origin in the centre of the first pixel in the image file. This image CRS shall be for the image, or image group, whose alphanumeric character string identifier is substituted for the “TBD” in this URN.

NOTE 1 This document does not specify any format for an image alphanumeric identifier, since many different formats are used for such identifiers. One such format could concatenate a camera identifier with the image collection date and time.

The definitions of these image CRSs shall be the same as can be XML encoded using this GML 3.1.1 Grid CRSs profile as:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageDatum 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 ../gridCRSsProfile.xsd"
gml:id="ImageDatumPixelCenter">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <datumName>Origin at center of first pixel</datumName>
  <datumID>
    <name
codeSpace="urn:ogc:def:datum:OGC:1.0:">ImageDatumPixelCenter</name>
  </datumID>
  <remarks>2D image datum with the origin at the center of the first
pixel in the image file, usually the first pixel collected by the image
sensor. In an image file, the pixels in the first row are assumed to be
listed first, followed by other rows, with pixels in each row listed
(and collected) in column number order. </remarks>
  <anchorPoint>center of first pixel</anchorPoint>
  <pixelInCell
codeSpace="urn:ogc:def:pixelInCell:OGC:1.0:">cellCenter</pixelInCell>
```

</ImageDatum>

NOTE 2 It is not expected to be necessary in most cases to produce an XML document that specifies the image CRS for a specific image identifier, since this CRS definition can be referenced using the specified URN value with the “TBD” replaced by the specific image identifier. However, it is possible to do this, as shown in the following example.

EXAMPLE If this XML document were modified to specify the image CRS with its origin in the centre of first pixel for an image with the identifier “C543D041201T084027”, this XML document could be:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageCRS 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
../gridCRSsProfile.xsd"
gml:id="ImageC543D041201T084027CRSPixelCenter">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <srsName>Image C543D041201T084027 CRS pixel centers</srsName>
  <srsID>
    <name
codeSpace="urn:ogc:def:crs:OGC:1.0:ImageCRSPixelCenter:">C543D041201T084027</na
me>
    <!-- This name specifies the URN by which this CRS can be referenced. -->
  </srsID>
  <usesCartesianCS xlink:href="urn:ogc:def:cs:OGC:1.0:Grid2dSquareCS"/>
  <usesImageDatum
xlink:href="urn:ogc:def:datum:OGC:1.0:ImageDatumPixelCenter"/>
</ImageCRS>
```

10.3 Image CRSs with origin in corner of first pixel

The URN value “urn:ogc:def:crs:OGC:0.0:ImageCRSPixelCorner:TBD” shall reference the definition of an (unrectified) image CRS with its origin in the outside corner of the first pixel in the image file. This image CRS shall be for the image, or image group, whose identifier is substituted for the “TBD” in this URN.

The definitions of these image CRSs shall be the same as can be XML encoded using this GML 3.1.1 Grid CRSs profile as:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageCRS 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 ../gridCRSsProfile.xsd"
gml:id="ImageTBDCRSPixelCorner">
  <!-- Specific image or group shall be identified by "TBD" in this
gml:id. -->
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <!-- ===== -->
  <srsName>Image TBD CRS pixel corner</srsName>
  <!-- Specific image or group shall be identified by "TBD" in this
srsName. -->
  <srsID>
    <name
codeSpace="urn:ogc:def:crs:OGC:1.0:ImageCRSPixelCorner:">TBD</name>
    <!-- Specifies the URN that can be used to reference this image
CRS. This URN includes the image name as a parameter. The specific
```

image or group shall be identified by the "TBD" in the "name" value. -->

```
</srsID>
<remarks>Parameterized definition of 2D image coordinate reference
systems with the origin at the outside corner of the first pixel in the
image file. This CRS definition can be used for any size image, since
no image size is specified.
```

This CRS definition is designed to be used for ungeorectified images, and is not expected to be used for a georectified image. This definition can be used for a georeferenced or ungeoreferenced image, where a georeferenced image CRS is associated with the coordinate Transformation(s) that georeference it. </remarks>

```
<usesCartesianCS
xlink:href="urn:ogc:def:cs:OGC:1.0:Grid2dSquareCS"/>
<usesImageDatum
xlink:href="urn:ogc:def:datum:OGC:1.0:ImageDatumPixelCorner"/>
</ImageCRS>
```

EXAMPLE If this XML document were modified to specify the image CRS with its origin in the outside corner of first pixel for an image with the identifier "C543D041201T084027", this XML document could be:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageCRS 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 ../gridCRSsProfile.xsd"
gml:id="ImageC543D041201T084027CRSPixelCorner">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <srsName>Image C543D041201T084027 CRS pixel corners</srsName>
  <srsID>
    <name
codeSpace="urn:ogc:def:crs:OGC:1.0:ImageCRSPixelCorner:">C543D041201T084027</na
me>
    <!-- This name specifies the URN by which this CRS can be referenced. -->
  </srsID>
  <usesCartesianCS xlink:href="urn:ogc:def:cs:OGC:1.0:Grid2dSquareCS"/>
  <usesImageDatum
xlink:href="urn:ogc:def:datum:OGC:1.0:ImageDatumPixelCorner"/>
</ImageCRS>
```

10.4 Grid 2D square coordinate system

The URN "urn:ogc:def:cs:OGC:0.0:Grid2dSquareCS" shall reference the definition of a Coordinate System for a 2D grid with square grid cells. The definition of this grid shall be the same as can be XML encoded using the GML 3.1.1 Common CRSs profile as:

```
<?xml version="1.0" encoding="UTF-8"?>
<CartesianCS 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
../commonCRSsProfile.xsd"
gml:id="Grid2dSquareCS">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <csName>2D square-cell grid based coordinate system</csName>
  <csID>
```

```
<name codeSpace="urn:ogc:def:cs:OGC:1.0:">Grid2dSquareCS</name>
</csID>
```

```
<remarks>2D grid-based coordinate system for use by an image or
other continuous grid coverage. It can be used for a grid of any size,
since no grid size is defined. This coordinate system specifies that
each row coordinate value will be listed before the column coordinate
value. The grid cells are assumed to be square, with the same grid
spacing or pixel spacing in each direction.
```

In a grid coverage file, the "row" axis shall be the first axis by which grid points are sequenced, and the "column" axis shall be the second axis, as could be specified by the "scanDirection : Sequence(CharacterString)" attribute of the CV_SequenceRule class in Clause 8 of ISO 19123. With linear sequencing, the grid points in the first row shall be listed first, followed by other rows, with the grid points in each row listed in column number order. This relationship between the "row" and "column" names and the first grid points shall apply whether this Grid2dSquareCS is associated with a grid file before or after that file is recorded.

The "row" and "column" axis names are used here although the "scanDirection : Sequence(CharacterString)" attribute may provide other axis names. Use of other axis names would require defining different CartesianCSs for other names, or adding other names as additional axisID values. The following XML includes the axis names "line" and "sample" as additional axisID values.

If not otherwise identified in an image file, the "row" axis shall be the first axis whose number of pixels is identified, and the "column" axis shall be the second axis, as could be specified by the "extent[0..1] : CV_GridEnvelope" attribute of the CV_Grid class in Clause 8 of ISO 19123. In either case, the first point in the grid coverage file is assumed to be numbered (1, 1), meaning row 1, column 1.

The first row in a grid is sometimes called the "top" row, the first column is sometimes called the "left" column, and the first grid point is then called the "upperLeft" point. If desired, those names can be used with this Grid2dSquareCS. However other names can also be used, since this Grid2dSquareCS has been defined so that it does not depend on such left/right, top/bottom, and up/down names. </remarks>

```
<usesAxis xlink:href="urn:ogc:def:axis:OGC:1.0:Row"/>
<usesAxis xlink:href="urn:ogc:def:axis:OGC:1.0:Column"/>
</CartesianCS>
```

This xml document references the two standard grid axes specified below.

10.5 Row coordinate axis

The URN "urn:ogc:def:axis:OGC:0.0:Row" shall reference the definition of the row coordinate axis for a 2D square grid coordinate system. The definition of this row axis shall be the same as can be XML encoded using the GML 3.1.1 Common CRSs profile as:

```

<?xml version="1.0" encoding="UTF-8"?>
<CoordinateSystemAxis 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
../commonCRSsProfile.xsd"
gml:id="Row" gml:uom="urn:ogc:def:uom:OGC:1.0:GridSpacing">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <name>Grid row axis</name>
  <axisID>
    <name codeSpace="urn:ogc:def:axis:OGC:1.0:">Row</name>
  </axisID>
  <axisID>
    <name codeSpace="urn:ogc:def:axis:OGC:1.0:">Line</name>
  </axisID>
  <remarks>For this first grid axis, row coordinate values match grid
row numbers, but allow fractional coordinate values between grid
points. The first row in a grid is sometimes called the "top" row, so
the direction of this axis is "down", but these terms are not required.
</remarks>
  <axisAbbrev>R</axisAbbrev>
  <axisDirection>urn:ogc:def:axisDirection:OGC:1.0:rowPositive</axisDi
rection>
</CoordinateSystemAxis>

```

10.6 Column coordinate axis

The URN “urn:ogc:def:axis:OGC:0.0:Column” shall reference the definition of the column coordinate axis for a 2D square grid coordinate system. The definition of this column axis shall be the same as can be XML encoded using the GML 3.1.1 Common CRSs profile as:

```

<?xml version="1.0" encoding="UTF-8"?>
<CoordinateSystemAxis 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
../commonCRSsProfile.xsd"
gml:id="Column" gml:uom="urn:ogc:def:uom:OGC:1.0:GridSpacing">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04 -->
  <name>Grid column axis</name>
  <axisID>
    <name codeSpace="urn:ogc:def:axis:OGC:1.0:">Column</name>
  </axisID>
  <axisID>
    <name codeSpace="urn:ogc:def:axis:OGC:1.0:">Sample</name>
  </axisID>
  <remarks>For this second grid axis, column coordinate values match
grid column numbers, but allow fractional coordinate values between
grid points. The first column is sometimes called the "left" column, so
the direction of this axis is "right", but these terms are not
required. </remarks>
  <axisAbbrev>C</axisAbbrev>
  <axisDirection>urn:ogc:def:axisDirection:OGC:1.0:columnPositive</axi
sDirection>

```

```
</CoordinateSystemAxis>
```

10.7 Image datum at pixel center

The URN “urn:ogc:def:datum:OGC:0.0:ImageDatumPixelCenter” shall reference the definition of an image datum with the origin at the centre of the first pixel. The definition of this image datum shall be the same as can be XML encoded using this GML 3.1.1 Grid CRSs profile as:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageDatum 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 ../gridCRSsProfile.xsd"
gml:id="ImageDatumPixelCenter">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <datumName>Origin at center of first pixel</datumName>
  <datumID>
    <name
codeSpace="urn:ogc:def:datum:OGC:1.0:">ImageDatumPixelCenter</name>
  </datumID>
  <remarks>2D image datum with the origin at the center of the first
pixel in the image file, usually the first pixel collected by the image
sensor. In an image file, the pixels in the first row are assumed to be
listed first, followed by other rows, with pixels in each row listed
(and collected) in column number order. </remarks>
  <anchorPoint>center of first pixel</anchorPoint>
  <pixelInCell
codeSpace="urn:ogc:def:pixelInCell:OGC:1.0:">cellCenter</pixelInCell>
</ImageDatum>
```

10.8 Image datum at pixel corner

The URN “urn:ogc:def:datum:OGC:0.0:ImageDatumPixelCorner” shall reference the definition of an image datum with the origin at the outside corner of the first pixel. The definition of this image datum shall be the same as can be XML encoded using this GML 3.1.1 Grid CRSs profile as:

```
<?xml version="1.0" encoding="UTF-8"?>
<ImageDatum 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 ../gridCRSsProfile.xsd"
gml:id="ImageDatumPixelCorner">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <datumName>Origin at outside corner of first pixel</datumName>
  <datumID>
    <name
codeSpace="urn:ogc:def:datum:OGC:1.0:">ImageDatumPixelCorner</name>
  </datumID>
  <remarks>2D image datum with the origin at the outside corner of the
first pixel in the image file, usually the first pixel collected by the
image sensor. In an image file, the pixels in the first row are assumed
```



```

to be listed first, followed by other rows, with pixels in each row
listed (and collected) in column number order. </remarks>
  <anchorPoint>outside corner of first pixel</anchorPoint>
  <pixelInCell
codeSpace="urn:ogc:def:pixelInCell:OGC:1.0:">cellCorner</pixelInCell>
</ImageDatum>

```

10.9 Grid spacing unit of measure

The URN “urn:ogc:def:uom:OGC:0.0:GridSpacing” shall reference the definition of the grid spacing unit of measure (uom). The definition of this unit shall be the same as can be XML encoded using GML 3.1.1 (not this profile) as:

```

<?xml version="1.0" encoding="UTF-8"?>
<BaseUnit 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
http://schemas.opengis.net/gml/3.1.1/base/units.xsd"
gml:id="GridSpacing">
  <!-- Primary editor: Arliss Whiteside. Last updated 2005-10-04-->
  <name>Spacing between adjacent grid points, or between centers of
adjacent pixels</name>
  <name codeSpace="urn:ogc:def:uom:OGC:1.0:">GridSpacing</name>
  <quantityType>Length</quantityType>
  <unitsSystem xlink:href="urn:ogc:def:uom:OGC:1.0:GridSpacing"/>
</BaseUnit>

```

Annex A
(normative)

Abstract test suite

An abstract test suite is not provided in this version of this Profile Implementation Specification.

Annex B (informative)

UML model

B.1 Introduction

This annex provides UML models of the primary XML elements included in this GML 3.1.1 Grid CRSs profile, using the OGC/ISO profile of UML summarized in Subclause 5.3 of [OGC 05-008]. These UML models are all extracted from OGC Abstract Specification Topic 2 [OGC 05-046r3]. The capitalization of attribute names uses the OGC/ISO profile of UML.

NOTE GML 3.1.1 is not yet fully harmonized with Abstract Specification Topic 2, so the XML document examples in Clauses 7-9 are not fully consistent with the following UML class diagrams.

B.2 Unrectified image CRSs

B.2.1 Simple UML model

Figure B.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_ImageCRS class. To keep this diagram simple, none of the class attributes are displayed. This diagram does not show that the SC_ImageCRS class can use the CS_AffineCS class, which is not supported by this profile.

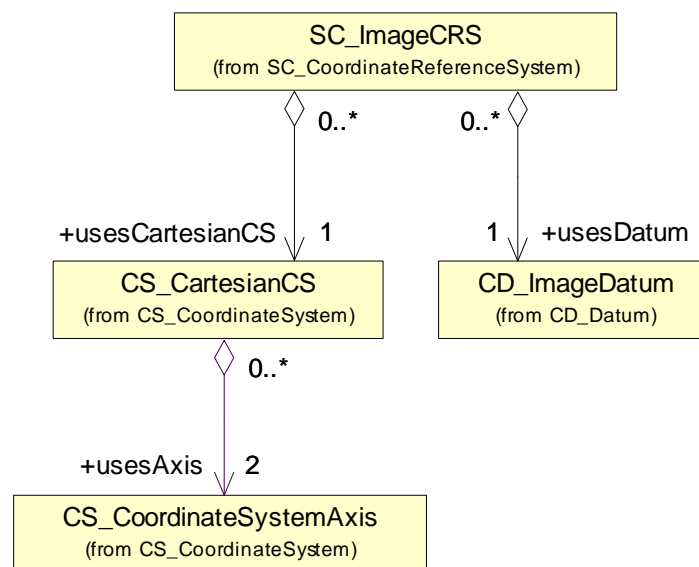


Figure B.1 — ImageCRS simple UML class diagram

Notice that the ImageCRS class does NOT include or reference any coordinate Transformations or operations which can be used to georeference this image. However,

the coordinate Transformations or operations available to georeference an unrectified image can be saved with that image. These transformations must reference or include the ImageCRS used for that unrectified image.

B.2.2 Full UML model

Figure B.2 is a more complete UML class diagram extracted from Topic 2 that shows essentially all the classes and associations related to the SC_ImageCRS class.

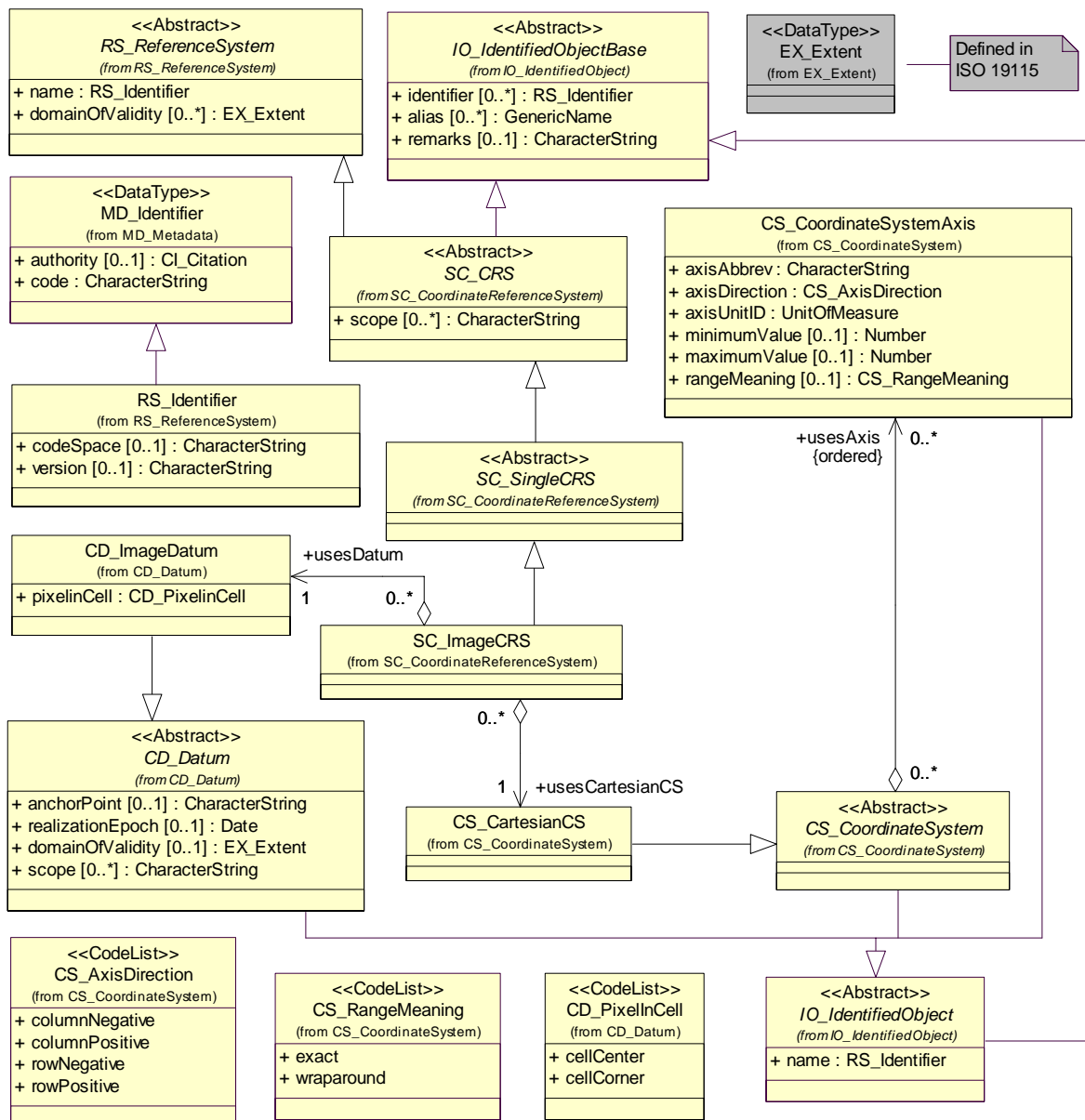


Figure B.2 — ImageCRS full UML class diagram

B.3 Georectified image coordinate reference systems

B.3.1 Simple UML model

Figure B.3 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_DerivedCRS class when used for a georectified image or other grid coverage. To keep this diagram simple, none of the class attributes are displayed. This diagram shows that the SC_DerivedCRS class can use as its baseCRS either a SC_GeographicCRS or SC_ProjectedCRS. The CC_Conversion class is detailed in Subclause B.4, the SC_GeographicCRS class is detailed in Subclause B.2, and the SC_ProjectedCRS class is detailed in Subclause B.3, all in [OGC 05-095r1].

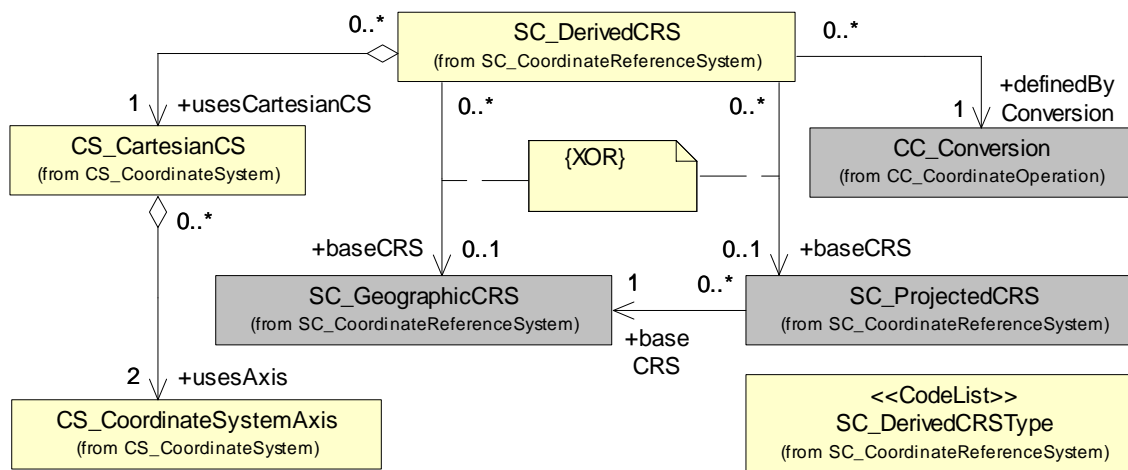


Figure B.3 — DerivedCRS simple UML class diagram

Notice that this SC_DerivedCRS class does NOT include or reference any coordinate Transformations or operations which could be used to georeference the original image that was georectified. However, the coordinate Transformations and operations used to georeference and georectify the original image should be saved with the georectified image. One of these transformations must reference or include the SC_DerivedCRS used for that georectified image.

NOTE The image georectification process must use a georeferencing coordinate Transformation (or ConcatenatedOperation). That georeferencing Transformation must have the unrectified image CRS (ImageCRS) as its source (or target) CRS. That georeferencing Transformation could have the georectified image CRS (DerivedCRS) as its target (or source) CRS; in this case, the definedByConversion might not be used to perform the georectification. Alternately, that georeferencing Transformation could have the (GeographicCRS or ProjectedCRS) baseCRS of the georectified image CRS (DerivedCRS) as its target (or source) CRS; in this case (discussed in Clause 8), the definedByConversion must also be used to perform the georectification. There are probably other useful alternatives.

B.3.2 Full UML model

Figure B.4 is a more complete UML class diagram extracted from Topic 2 that shows essentially all the classes and associations related to the SC_DerivedCRS class. Again, the CC_Conversion class is detailed in Subclause B.4, the SC_GeographicCRS class is detailed in Subclause B.2, and the SC_ProjectedCRS class is detailed in Subclause B.3, all in [OGC 05-095r1].

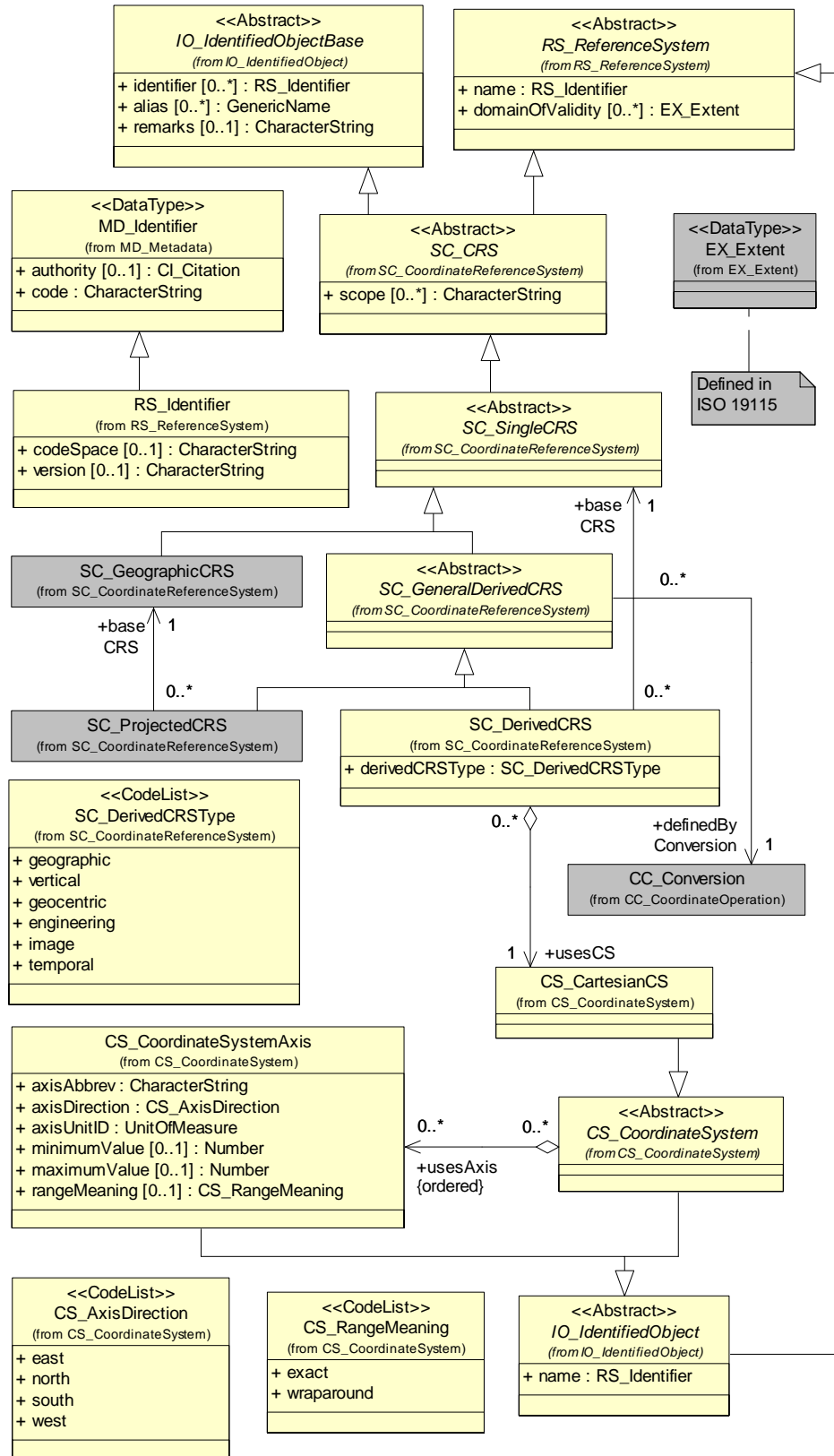


Figure B.4 — DerivedCRS full UML class diagram

The reference CRS is assumed to be 3D, while the unrectified image is only 2D. The georeferencing coordinate transformation is thus assumed to be from the reference 3D CRS to the 2D image CRS. If the reference CRS is 2D, that would be equivalent to combining the georeferencing coordinate transformation with the elevation model coordinate transformation discussed later in this clause.

B.4 Georeferencing coordinate transformations

B.4.1 Simple UML model

Figure B.5 is a simplified UML class diagram extracted from Topic 2 for a CC_Transformation and CC_ConcatenatedOperation. This diagram shows most of the concrete (non-abstract) classes and associations related to the CC_Transformation and CC_ConcatenatedOperation classes, except for the CC_ParameterValueGroup and CC_OperationParameterGroup classes. The CC_ParameterValueGroup and CC_OperationParameterGroup classes are rarely useful, and are not included in this profile.

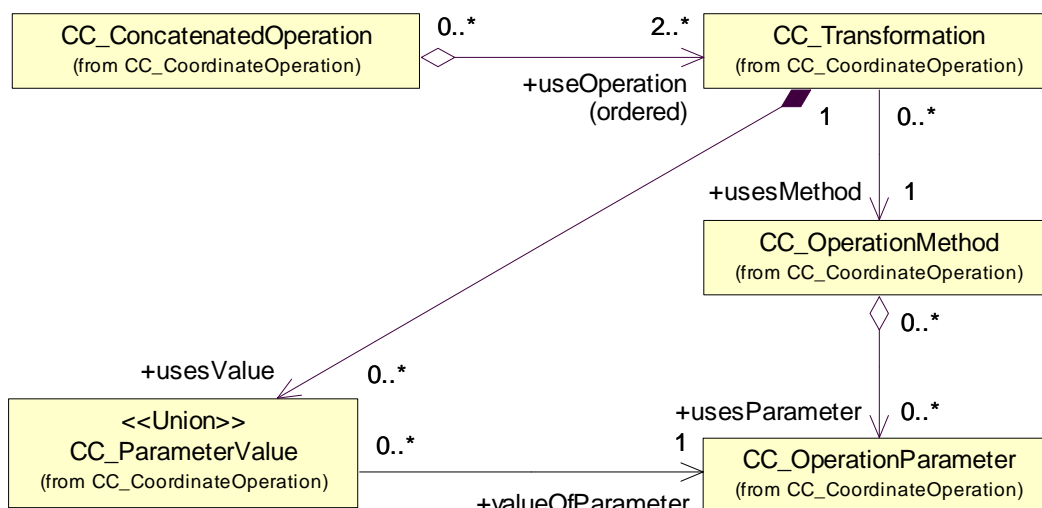


Figure B.5 — Transformation and ConcatenatedOperation simple class diagram

To keep this diagram simple, none of the class attributes are displayed. The CC_ConcatenatedOperation class can also have usesOperation associations to the CC_Conversion class, with each associated object of CC_Conversion class substituting for an object of CC_Transformation class in this UML model.

This simplified UML diagram does not include the two associations with the role names sourceCRS and targetCRS, required to the abstract SC_CRS class from both the CC_Transformation and CC_ConcatenatedOperation classes. For a georeferencing Transformation, the targetCRS will be a SC_ImageCRS and the sourceCRS will be the reference CRS used in that georeferencing, both being non-abstract subclasses of the SC_CRS class.

B.4.2 Full UML model

Figure B.6 is a more complete UML class diagram extracted from Topic 2 for a coordinate CC_Transformation and CC_ConcatenatedOperation. This diagram shows essentially all the classes and associations related to the CC_Transformation and CC_ConcatenatedOperation classes, except for the:

- a) Contents of the DQ_PositionalAccuracy and EX_Extent classes, defined in ISO 19115
- b) Contents of the SC_CRS class, such as defined in Subclauses B.2.2 and B.3.2

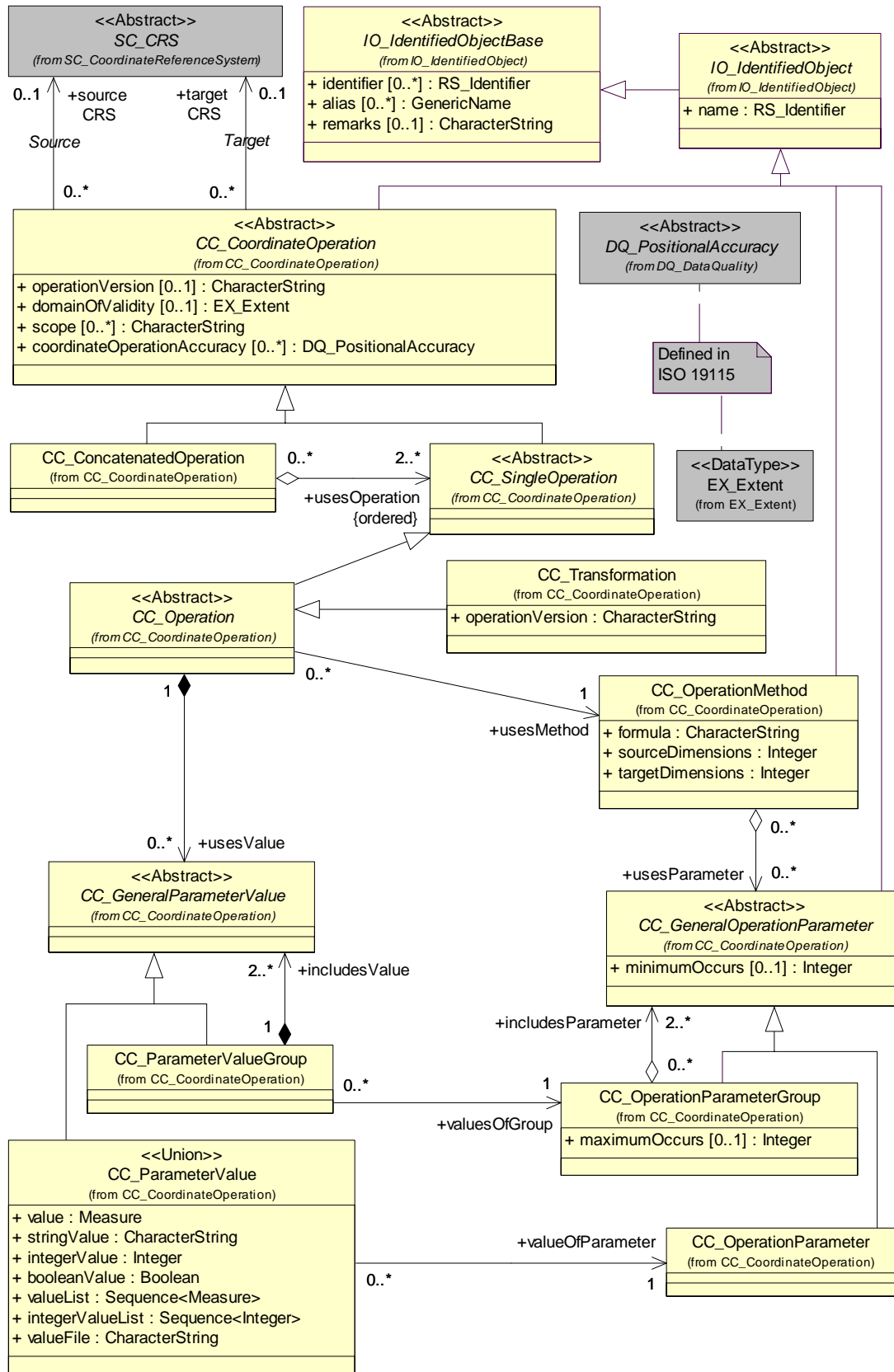


Figure B.6 — Transformation and ConcatenatedOperation full UML class diagram

Notice that each Transformation and ConcatenatedOperation inherits two associations with the role names sourceCRS and targetCRS, required to the abstract SC_CRS class from both the CC_Transformation and CC_ConcatenatedOperation classes. For a georeferencing Transformation, the targetCRS will be a SC_ImageCRS and the sourceCRS will be the reference CRS used in that georeferencing, both being non-abstract subclasses of the SC_CRS class.

Bibliography

- [1] OGC 04-071, *Some image geometry models*
- [2] OGC 04-046r3, *OGC Abstract Specification Topic 2, Spatial referencing by coordinates*
- [3] OGC 05-011, *Recommended XML/GML 3.1.1 encoding of common CRS definitions*
- [4] OGC 05-013, *Web Coordinate Transformation Service (WCTS) draft Implementation Specification*
- [5] OGC 05-027r1, *Recommended XML/GML 3.1.1 encoding of image CRS definitions*