

Open Geospatial Consortium Inc.

Date: 2004-12-06

Reference number of this OGC™ IP initiative document: **OGC 04-100**

Version: 0.0.4

Category: OGC™ Discussion Paper

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OWS-2 Application Schema Development

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Document type: OGC™ Discussion Paper
Document subtype: NA
Document stage: Approved
Document language: English

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iii. Revision history

Date	Release	Author	Paragraph modified	Description
2004-07-31	0.0.1	CP		First draft
2004-08-29	0.0.2	CP		Update based on comments by Dave Wesloh, Jody Hawkins and Nadine Alameh
2004-09-30	0.0.3	CP		Minor updates
2004-12-06	0.0.4	CH		Final cleanup and formatting

iv. Changes to the OpenGIS[®] Abstract Specification

The OpenGIS[®] Abstract Specification does not require changes to accommodate the technical contents of this document.

Introduction

This document contains a description of the process creating ISO 19109 Application Schemas in UML and, derived from these schemas, GML Application Schemas for NGA data during the OWS-2 initiative.

Information Interoperability — NGA Application Schema Development

1 Scope

This OpenGIS® document describes and discusses the process of creating application schemas for NGA data. The approach used to create the application schemas starts with the creation of ISO 19109 application schemas in UML and deriving GML application schemas from them.

2 Conformance

Not required for an IP IPR, DIPR, or Discussion Paper.

3 Normative references

The following normative documents contain provisions which, 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. However, parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

ISO DTS 19103, *Geographic Information – Conceptual Schema Language*

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

ISO CD 19136 (February 2004), *Geographic Information – Geography Markup Language*

4 Terms and definitions

Not applicable

5 Conventions

5.1 Symbols (and abbreviated terms)

ISO	International Organization for Standardization
OGC	Open GIS Consortium
GML	Geography Markup Language
UML	Unified Modeling Language
XML	eXtended Markup Language
1D	One Dimensional
2D	Two Dimensional
3D	Three Dimensional
NGA	National Geospatial Intelligence Agency
FACC	Feature and Attribute Coding Catalogue
VMAP	...
TLM	Topographic Line Map
DIGEST	Digital Geographic Information Exchange Standard

5.2 UML Notation

The diagrams that appear in this document are presented using the Unified Modeling Language (UML) static structure diagram based on the rules of ISO/DTS 19103 and ISO CD 19136 Annex E.

The UML notations used in this document are described in the diagram below.

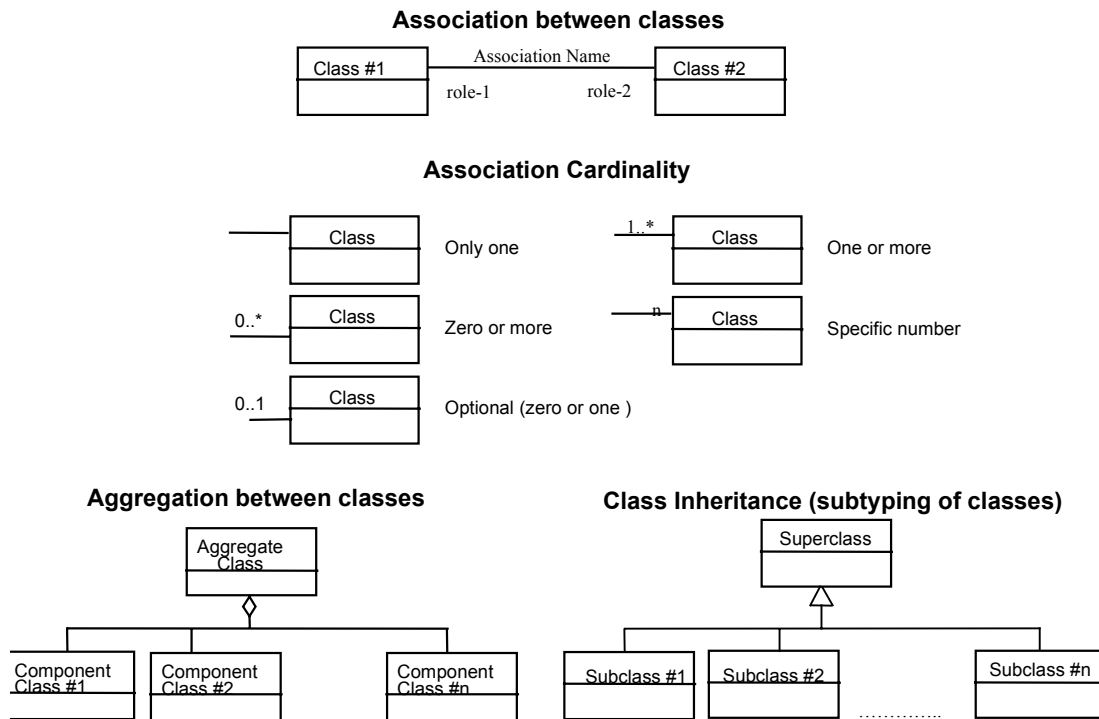


Figure 1 — UML notation

In the class diagrams, the following stereotypes of UML classes are used:

- a) <<DataType>> A descriptor of a set of values that lack identity (independent existence and the possibility of side effects). A DataType is a class with no operations whose primary purpose is to hold the information.
- b) <<BasicType>> A special type of a DataType that typically has a canonical representation in a computing platform, in this case XML Schema.
- c) <<CodeList>> is a flexible enumeration that uses string values for expressing a list of potential values.
- d) <<Enumeration>> is a fixed list of valid identifiers of named literal values. Attributes of an enumerated type can only take values from this list.
- e) <<Union>> is a list of attributes. The semantics is that only one of the attributes can be present at any time.

In this document, the following standard basic data types are used:

- a) CharacterString – A sequence of characters
- b) Integer – An integer number
- c) Real – A floating point number

d) Boolean – A boolean value (true or false)

6 Overview

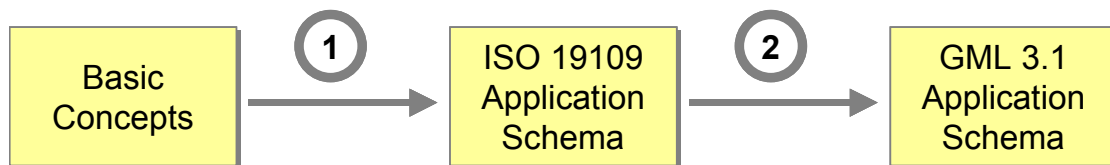
The task was to create a number of application schemas for NGA data – mostly based on existing data specifications used by NGA today. These application schemas were to be developed as GML application schemas (using GML version 3.1, ISO CD 19136).

These include:

- the NGA profile of the FACC
- product application schemas for VMAP0, VMAP1, VMAP2 and TLM
- an application schema for a mission specific dataset used in the OWS-2 demo

Since the application schemas are large in terms of the number of feature type and attribute definitions, the schemas were created automatically.

Also, since adherence to the concepts defined in the ISO 19100 series of international standards is relevant to NGA, the following process was followed:



Step (1) was executed using Scripts creating Rational Rose UML models from the input descriptions provided by NGA. These scripts were implemented in Visual Basic.

Step (2) was executed using the Open Source UGAS tool “Shapechange” of interactive instruments. More information about the tool including documentation can be found at <http://www.interactive-instruments.de/ugas/>. One document describes the mapping rules from UML to GML as implemented by the tool, while a second document describes the implementation of the ShapeChange tool, its installation and guidelines for using the tool.

7 Application Schema for the NGA FACC Profile

7.1 UML Application Schema

The NGA FACC Profile application schema is created from the MS Access databases maintained by Rex Buckley at NGA. An issue was to find versions of the data definitions that were consistent with each others. After some research it was decided that the version

from April 8th, 2002 was to be used. Therefore, the following MS Access databases were used

FACC_Manager_be.mdb: all tables

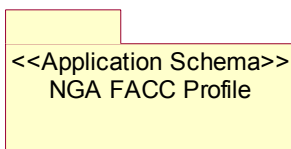
NGA_Profile_Manager_be.mdb: Master Table 4-8-2002

The Master Table in the NGA Profile database references all components of the FACC data dictionary that are used in the NGA FACC Profile.

In order to process these input databases a simple Visual Basic program was developed implementing the required steps to convert the NGA FACC Profile in the MS Access databases to a UML Application Schema in Rational Rose. The DAO interface was used to access the MS Access databases and the Rational Rose COM Interface was used to create the objects in Rational Rose. At the same time, the GML Dictionaries for the Feature Type names, the Attribute Type names and the Attribute Code descriptions were created by the program.

In its first step, the following UML packages were created by the program:

- A root package for the NGA FACC Profile (stereotype <<Application Schema>>). Pre-defined, tagged values were added to this package to associate the application schema with a namespace (“http://www.opengis.net/ows-2/nga”), a namespace prefix (“nga”) and a version number; see the ShapeChange documentation for details.



- Within the root package, one package per FACC category (e.g. “A”, “B”, etc.).



- Within each FACC category package another package for each FACC sub-category (e.g. “AA”, “AB”, etc.). As packages without sub-packages these were tagged with the stereotype <<Leaf>>.



In the second step, the classes were created by the program:

- A root class from which all NGA Feature Types are derived by inheritance. This feature type captures the common properties shared by all NGA feature types. Currently this is just a single property capturing a spatial representation of the feature. This may be one of the following:
 - o a point (GM_Point)
 - o a curve (GM_OrientableCurve)

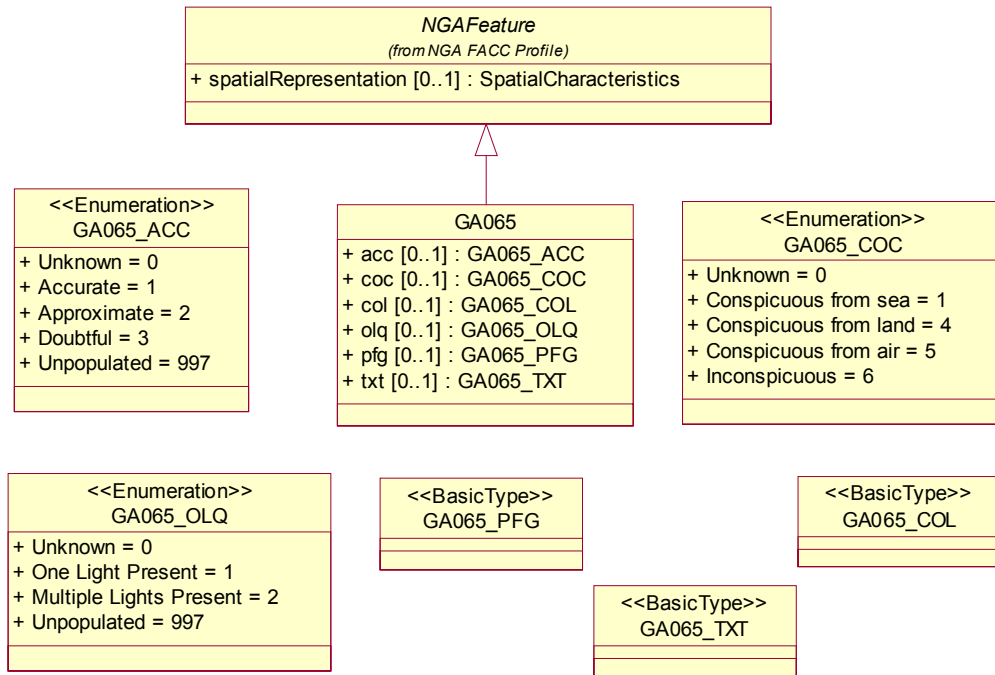
- a surface (GM_OrientableSurface)
- a geometric aggregate of points (GM_MultiPoint)
- a geometric aggregate of curves (GM_MultiCurve)
- a geometric aggregate of surfaces (GM_MultiSurface)
- one or more nodes (TP_Node)
- one or more sequences of connected directed edges (sequence<TP_DirectedEdge>)
- one or more sets of connected directed faces (set<TP_DirectedFace>)

<i>NGA_Feature</i>
+ spatialRepresentation [0..1] : SpatialCharacteristics

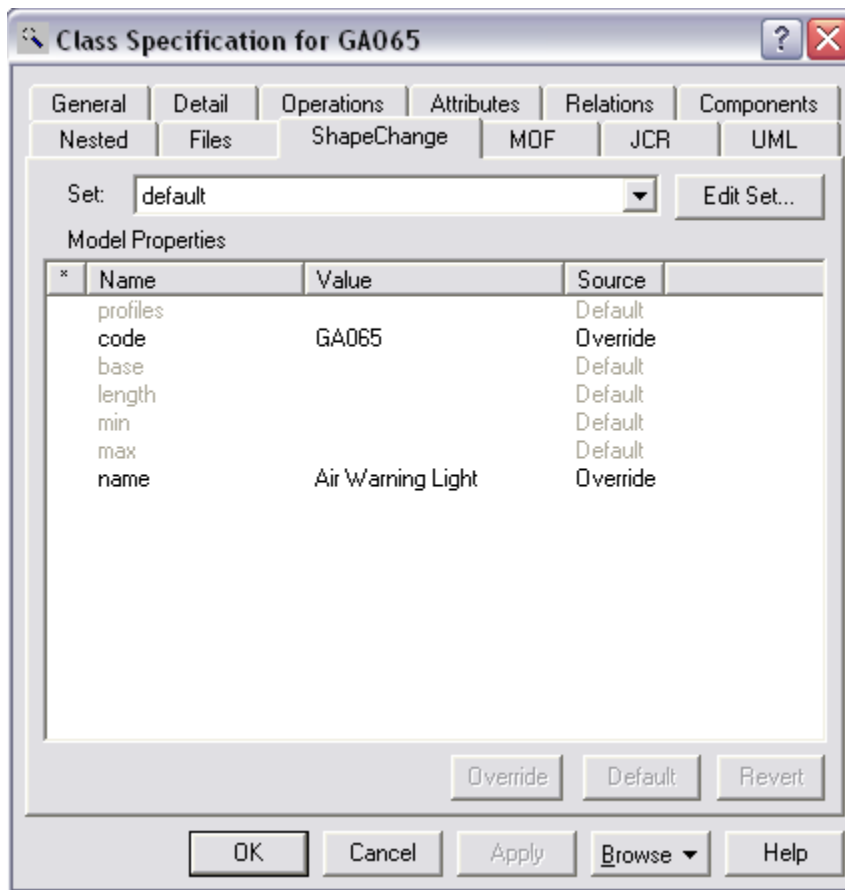
<<Union>> SpatialCharacteristics
+ pointGeometry : GM_Point
+ curveGeometry : GM_OrientableCurve
+ surfaceGeometry : GM_OrientableSurface
+ multiPointGeometry : GM_MultiPoint
+ multiCurveGeometry : GM_MultiCurve
+ multiSurfaceGeometry : GM_MultiSurface
+ nodeTopology [1..*] : TP_Node
+ edgeTopology [1..*] : sequence<TP_DirectedEdge>
+ faceTopology [1..*] : set<TP_DirectedFace>

- One class per feature type in the NGA FACC Profile. After some discussion, the DIGEST FACC feature codes of the feature type were used as the name of the feature type classes, e.g. “GA065”. For the name of the attributes also the FACC naming scheme was used, too.

However, the semantically more meaningful name used in the FACC database was used for the name of the class diagram, e.g. “Air Warning Light”.



Both the descriptive name and the FACC code were stored in tagged values of the class (“name” and “code”) which are processed by the UGAS tool and therefore represented also in the GML Application Schema, too.



For every attribute of the feature type in the NGA FACC Profile, one attribute was added to the class. Again, the three letter FACC code was used, e.g. “acc”. All attributes are optional.

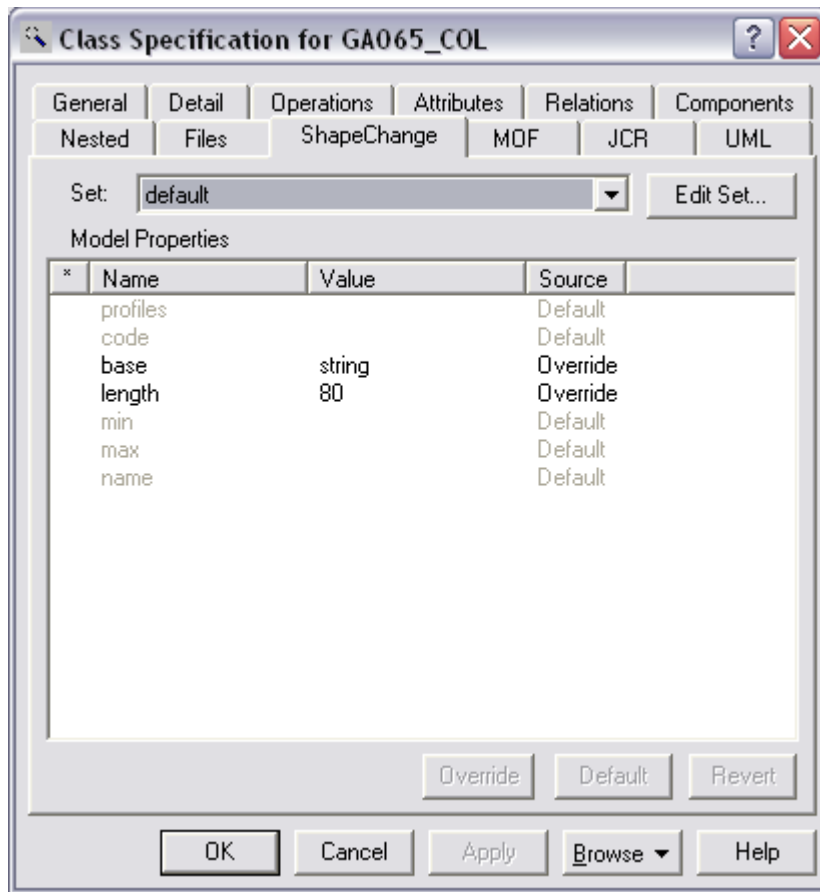
The following attribute types can be distinguished:

- Attributes with coded values: In this case, the allowed coded values for the respective feature type are captured in an enumeration class (stereotype <<Enumeration>>). Since the coded values are different for each class, the uniqueness is guaranteed by naming the class by a concatenation of the feature type name and the attribute name. Each coded value is represented with its textual description and code value.

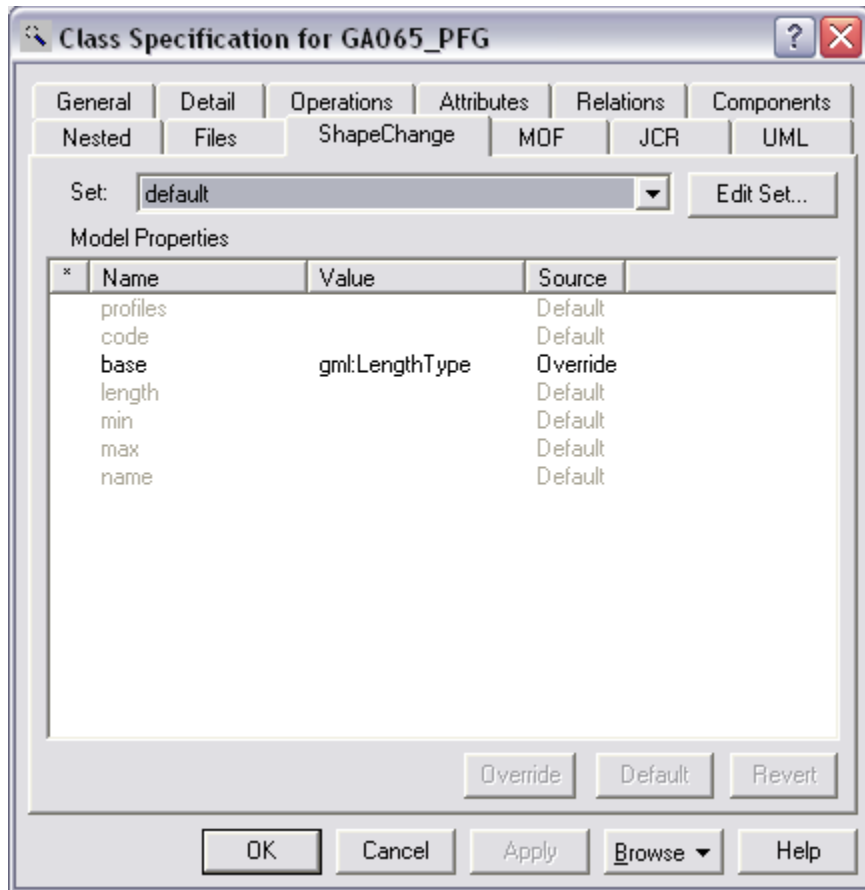
<<Enumeration>> GA065_ACC
+ Unknown = 0
+ Accurate = 1
+ Approximate = 2
+ Doubtful = 3
+ Unpopulated = 997

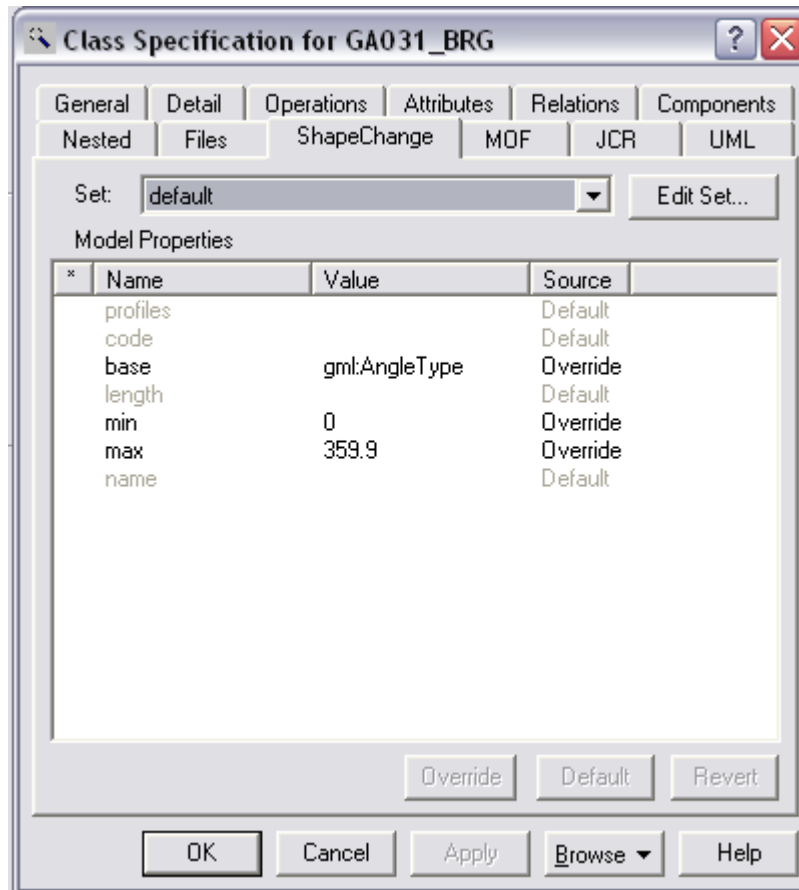
- Other Attributes: These attributes are attributes with either a string or numeric value. String values are often associated with a maximum length. Numeric values are often values associated with a unit of measurement, a minimum and maximum value. If existing, this information is captured in tagged values of classes for the attribute type, where the <<Basic Type>> stereotype indicates a canonical representation in XML Schema as a simple type. The XML Schema or GML simple type to be used is stored in the tagged value “base”, in case of a string value, the maximum length is stored in a tagged value “length”. Tagged names “min” and “max” are used to store minimum and maximum values in case of a numeric type.

```
<<BasicType>>
GA065_COL
```



```
<<BasicType>>
GA065_PFG
```





The feature type definitions of the NGA FACC Profile Application Schema are relatively simple. All properties are single valued and cannot occur multiple times, i.e. a feature type can be represented as a single table in a relational database.

To be consistent with the product specifications used in OWS-2 (see below) the following changes to the NGA FACC Profile were made manually in the UML application schema:

- Feature Type “BH080”, attribute “ZV2” was added.
- Feature Type “BH130”, attribute “ZV2” was added.
- Feature Type “ZD015” added

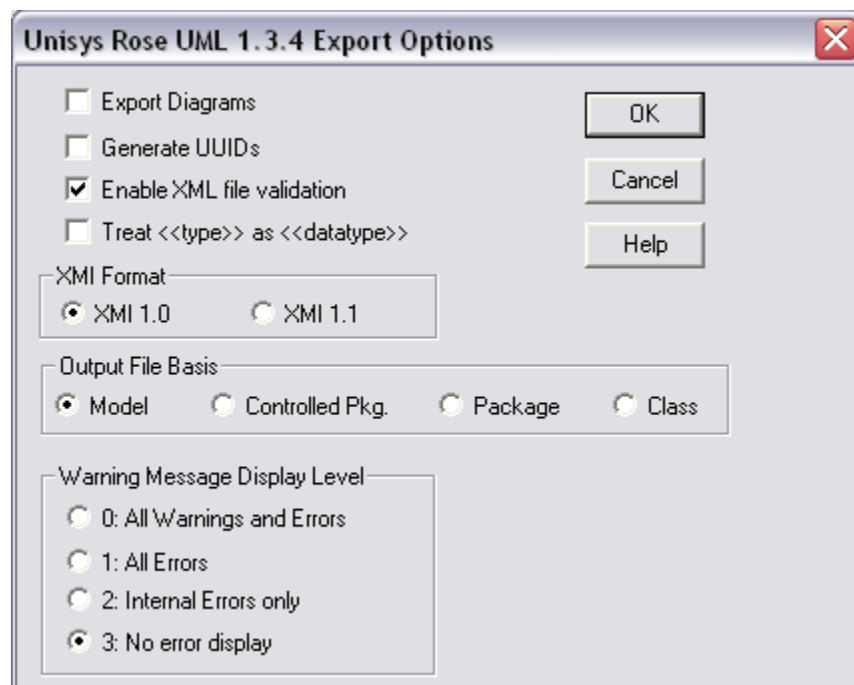
7.2 GML Application Schema

The UML Application Schema was mapped to a GML Application Schema using the UGAS tool ShapeChange, originally developed as part of the GOS-TP initiative.

The version used to create the NGA schemas (version 0.2) was

- updated to GML 3.1 (ISO CD 19136) and ISO PDTS 19139;
- enhanced to support additional encoding styles, most notably to support local (anonymous) definitions of basic types and enumerations so that the NGA FACC Profile feature types could be specified in a way where all components used in feature type definition are embedded in the complex type definition of the content model of the feature type;
- enhanced to map the tagged values described above into facets of simple types (length, min, max) or annotations (name, code).

The tool reads XMI 1.0 (UML 1.3) input files. The Rational Rose UML Application Schema was exported to XMI using these options:



The GML Application Schema was then created using the UGAS tool by the following command:

```
java -Xms128m -Xmx1024m -jar ShapeChange.jar -E -C -D -G -X -o "nga"
-m "NGA FACC Profile" "xmi\OWS2-IIGS.xml"
```

The memory allocation of the Java Virtual Machine (Sun JDK 1.4) had to be increased since the NGA FACC Profile is a very large application schema (XMI file size close to 100MB).

The following options were used:

“-G” maps classes with stereotype <<Union>> to a group

“-X” maps attributes to a global group instead of local elements

NOTE The -X option was added in a late stage of the initiative after it was discovered that the use of local elements creates schemas that are not accepted by some XML parsers (e.g. MSXML and Xerces with strict validation). Therefore, global groups were used instead to enable restrictions in mission specific application schemas based on the NGA FACC Application Schema restricting the contents of the NGA FACC feature types. This is a general issue with XML Schema: the use of local elements in a complex prohibits that the complex type may be restricted in another namespace. Therefore, local elements can only be used in GML application schemas if the type definitions in the schema are not intended to be restricted in other application schemas.

“-C” suppresses property types for feature and data types (not required for the NGA FACC Profile as there are not relationships between the different feature types.

“-D” is like “-C” only for property-by-value types.

“-E” maps an <<Enumeration>> class to an anonymous simpleType with enumeration facets.

The hierarchy of the application schema is also represented in the XML Schema files. Any GML instance document implementing features of the NGA FACC Profile application schema would reference the schema document “NGAFACCProfile.xsd”:

```
<schema targetNamespace="http://www.opengis.net/ows-2/nga" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:smXML="http://metadata.dgiwg.org/smXML" xmlns:nga="http://www.opengis.net/ows-2/nga"
xmlns:gml="http://www.opengis.net/gml" xmlns="http://www.w3.org/2001/XMLSchema"
elementFormDefault="qualified" version="0.4">
  <annotation>
    <documentation>NGA Profile of the FACC. Automatically created.</documentation>
  </annotation>
  <include schemaLocation="C.xsd"/>
  <include schemaLocation="G.xsd"/>
  <include schemaLocation="I.xsd"/>
  <include schemaLocation="O.xsd"/>
  <include schemaLocation="K.xsd"/>
  <include schemaLocation="O.xsd"/>
  <include schemaLocation="A.xsd"/>
  <include schemaLocation="Z.xsd"/>
  <include schemaLocation="B.xsd"/>
  <include schemaLocation="E.xsd"/>
  <include schemaLocation="S.xsd"/>
  <include schemaLocation="D.xsd"/>
  <include schemaLocation="F.xsd"/>
  <import namespace="http://www.opengis.net/gml" schemaLocation="base/gml3.xsd"/>
  <!--Type and element definitions of this package-->
  <complexType name="NGAFeatureType" abstract="true">
    <annotation>
      <documentation>Abstract supertype of all feature types in the NGA profile.</documentation>
    </annotation>
    <complexContent>
      <extension base="gml:AbstractFeatureType">
        <sequence>
          <group ref="nga:SpatialCharacteristicsGroup" minOccurs="0"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <element name="NGAFeature" type="nga:NGAFeatureType" abstract="true"
    substitutionGroup="gml:_Feature"/>
  <group name="SpatialCharacteristicsGroup">
    <choice>
      <element name="pointGeometry" type="gml:PointPropertyType"/>
    </choice>
  </group>
</schema>
```

```

    <element name="curveGeometry" type="gml:CurvePropertyType"/>
    <element name="surfaceGeometry" type="gml:SurfacePropertyType"/>
    <element name="multiPointGeometry" type="gml:MultiPointPropertyType"/>
    <element name="multiCurveGeometry" type="gml:MultiCurvePropertyType"/>
    <element name="multiSurfaceGeometry" type="gml:MultiSurfacePropertyType"/>
    <element name="nodeTopology" type="gml:TopoPointPropertyType" maxOccurs="unbounded"/>
    <element name="edgeTopology" type="gml:TopoCurvePropertyType" maxOccurs="unbounded"/>
    <element name="faceTopology" type="gml:TopoSurfacePropertyType" maxOccurs="unbounded"/>
  </choice>
</group>
</schema>

```

This file includes the categories, e.g. “G.xsd”

```

<schema targetNamespace="http://www.opengis.net/ows-2/nga" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:smXML="http://metadata.dgiwg.org/smXML" xmlns:nga="http://www.opengis.net/ows-2/nga"
xmlns:gml="http://www.opengis.net/gml" xmlns="http://www.w3.org/2001/XMLSchema"
elementFormDefault="qualified" version="unknown">
  <annotation>
    <documentation>G - Aeronautical Information</documentation>
  </annotation>
  <include schemaLocation="GB.xsd"/>
  <include schemaLocation="GA.xsd"/>
  <import namespace="http://www.opengis.net/gml" schemaLocation="base/gml3.xsd"/>
</schema>

```

which in turn includes the sub-categories, e.g. “GB.xsd” (here, only a part of the feature type GB005 is shown):

```

<?xml version="1.0" encoding="UTF-8"?>
<schema targetNamespace="http://www.opengis.net/ows-2/nga" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:smXML="http://metadata.dgiwg.org/smXML" xmlns:nga="http://www.opengis.net/ows-2/nga"
xmlns:gml="http://www.opengis.net/gml" xmlns="http://www.w3.org/2001/XMLSchema"
elementFormDefault="qualified" version="unknown">
  <annotation>
    <documentation>GB - Aeronautical Information-Aerodrome</documentation>
  </annotation>
  <import namespace="http://www.opengis.net/gml" schemaLocation="base/gml3.xsd"/>
  <!-- Type and element definitions of this package-->
  <!-- ... -->
  <complexType name="GB005Type">
    <annotation>
      <documentation>US-Airport/Airfield UK-Airport/Airfield/Airstrip: A defined area of land or water used
for landing, take-off, and movement of aircraft including associated buildings and facilities.</documentation>
      <appinfo source="urn:x-ShapeChange:code">GB005</appinfo>
      <appinfo source="urn:x-ShapeChange:name">US-Airport/Airfield UK-Airport/Airfield/Airstrip</appinfo>
    </annotation>
    <complexContent>
      <extension base="nga:NGAFeatureType">
        <sequence>
          <group ref="nga:GB005__apt_Group" minOccurs="0"/>
          <group ref="nga:GB005__exs_Group" minOccurs="0"/>
          <group ref="nga:GB005__nam_Group" minOccurs="0"/>
          <group ref="nga:GB005__use_Group" minOccurs="0"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <group name="GB005__apt_Group">
    <sequence>
      <element name="apt">
        <annotation>
          <documentation>Airfield Type: Unique airfield type.</documentation>
        </annotation>
      </element>
    </sequence>
  </group>

```

```

    <appinfo source="urn:x-ShapeChange:code">APT</appinfo>
    <appinfo source="urn:x-ShapeChange:name">Airfield Type</appinfo>
  </annotation>
  <simpleType>
    <restriction base="string">
      <enumeration value="0">
        <annotation>
          <documentation>Unknown</documentation>
        </annotation>
      </enumeration>
      <enumeration value="1">
        <annotation>
          <documentation>Major Airfield</documentation>
        </annotation>
      </enumeration>
      <enumeration value="2">
        <annotation>
          <documentation>Minor Airfield</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
</element>
</sequence>
</group>
<group name="GB005__exs_Group">
  <sequence>
    <element name="exs">
      <annotation>
        <documentation>Existence Category: The state or condition of the feature.</documentation>
        <appinfo source="urn:x-ShapeChange:code">EXS</appinfo>
        <appinfo source="urn:x-ShapeChange:name">Existence Category</appinfo>
      </annotation>
      <simpleType>
        <restriction base="string">
          <enumeration value="0">
            <annotation>
              <documentation>Unknown</documentation>
            </annotation>
          </enumeration>
          <!--...-->
          <enumeration value="28">
            <annotation>
              <documentation>Operational</documentation>
            </annotation>
          </enumeration>
        </restriction>
      </simpleType>
    </element>
  </sequence>
</group>
<group name="GB005__nam_Group">
  <sequence>
    <element name="nam">
      <annotation>
        <documentation>Name: Any identifier or code.</documentation>
        <appinfo source="urn:x-ShapeChange:code">NAM</appinfo>
        <appinfo source="urn:x-ShapeChange:name">Name</appinfo>
      </annotation>
      <complexType>
        <simpleContent>
          <restriction base="gml:CodeType">
            <maxLength value="80"/>
          </restriction>
        </simpleContent>
      </complexType>
    </element>
  </sequence>
</group>

```

```

        </simpleContent>
      </complexType>
    </element>
  </sequence>
</group>
<group name="GB005__use_Group">
  <sequence>
    <element name="use">
      <annotation>
        <documentation>Usage: Use (identifies the primary user, function, or controlling
authority).</documentation>
        <appinfo source="urn:x-ShapeChange:code">USE</appinfo>
        <appinfo source="urn:x-ShapeChange:name">Usage</appinfo>
      </annotation>
      <simpleType>
        <restriction base="string">
          <enumeration value="0">
            <annotation>
              <documentation>Unknown</documentation>
            </annotation>
          </enumeration>
          <enumeration value="8">
            <annotation>
              <documentation>Military</documentation>
            </annotation>
          </enumeration>
          <enumeration value="22">
            <annotation>
              <documentation>Joint Military/Civilian</documentation>
            </annotation>
          </enumeration>
          <enumeration value="49">
            <annotation>
              <documentation>Civilian/Public</documentation>
            </annotation>
          </enumeration>
          <enumeration value="999">
            <annotation>
              <documentation>Other</documentation>
            </annotation>
          </enumeration>
          <!--...-->
        </restriction>
      </simpleType>
    </element>
  </sequence>
</group>
<!--...-->
<element name="GB005" type="nga:GB005Type" substitutionGroup="nga:NGAFeature"/>
<!--...-->
</schema>

```

These GML feature type definitions contain all the information represented in the UML Application Schema.

Later in the initiative it has been identified that the encoding of the SpatialRepresentation union class as a choice block of GML properties to distinguish the different types of spatial properties (geometric primitive, geometric aggregate, topology) is difficult to handle for WFS clients both in parsing the data and in creating queries. In a revision of the application schemas this should be replaced by a single geometric property whose value is a choice of the geometry of topology object elements. The UML-to-GML encoding rule should be updated accordingly.

In addition, three GML dictionaries are created which can be used to map codes to long names and descriptions. These can be used by applications:

FeatureTypeDictionary.xml:

```
<Dictionary xmlns="http://www.opengis.net/gml" xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/gml
base/gml3.xsd">
  <description>Dictionary</description>
  <name>NGA Dictionary of the NGA Profile</name>
  <dictionaryEntry>
    <DefinitionCollection gml:id="NGAFeatureTypes">
      <description>Dictionary of the feature types of the NGA Profile</description>
      <name>NGA Feature Types</name>
      <definitionMember>
        <Definition gml:id="AA010">
          <description>Mine</description>
          <name>AA010</name>
        </Definition>
      </definitionMember>
      ...
      <definitionMember>
        <Definition gml:id="GA065">
          <description>Air Warning Light</description>
          <name>GA065</name>
        </Definition>
      </definitionMember>
      ...
    </DefinitionCollection>
  </dictionaryEntry>
</Dictionary>
```

AttributeTypeDictionary.xml:

```
<?xml version="1.0"?>
<Dictionary xmlns="http://www.opengis.net/gml" xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/gml
base/gml3.xsd">
  <description>Dictionary of the NGA Profile</description>
  <name>NGA Dictionary</name>
  <dictionaryEntry>
    <DefinitionCollection gml:id="NGAAttributeTypes">
      <description>Dictionary of the attribute types of the NGA Profile</description>
      <name>NGA Attribute Types</name>
      <definitionMember>
        <Definition gml:id="ACC">
          <description>Accuracy Category</description>
          <name>ACC</name>
        </Definition>
      </definitionMember>
      ...
      <definitionMember>
        <Definition gml:id="COC">
          <description>Conspicuous Category</description>
          <name>COC</name>
        </Definition>
      </definitionMember>
      ...
    </DefinitionCollection>
  </dictionaryEntry>
</Dictionary>
```

CodeValueDictionary.xml:

```

<Dictionary xmlns="http://www.opengis.net/gml" xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/gml
base/gml3.xsd">
  <description>Dictionary of the NGA Profile</description>
  <name>NGA Dictionary</name>
  <dictionaryEntry>
    <DefinitionCollection gml:id="NGACodeValues">
      <description>Dictionary of the coded values of the NGA Profile</description>
      <name>NGA Code Values</name>
      <definitionMember>
        <Definition gml:id="ACC_0">
          <description><![CDATA[Unknown]]></description>
          <name codeSpace="urn:x-ShapeChange:Attribute:ACC">0</name>
        </Definition>
      </definitionMember>
      <definitionMember>
        <Definition gml:id="ACC_1">
          <description><![CDATA[Accurate]]></description>
          <name codeSpace="urn:x-ShapeChange:Attribute:ACC">1</name>
        </Definition>
      </definitionMember>
      <definitionMember>
        <Definition gml:id="ACC_2">
          <description><![CDATA[Approximate]]></description>
          <name codeSpace="urn:x-ShapeChange:Attribute:ACC">2</name>
        </Definition>
      </definitionMember>
      ...
    </DefinitionCollection>
  </dictionaryEntry>
</Dictionary>

```

8 GML Profile for the NGA FACC Profile

Since the GML 3.1 schema offers a wide range of components that may be used by geospatial application schemas, almost all application schemas will use only a very limited part of the full GML schema.

To specify and document the usage of GML by an application schema typically a profile of the GML schema is created and used instead of the full schema.

The GML profile of NGA was created in a two step process, based on the document “DGIWG_2D_profile_of_ISO_19107.doc”. Since GML is an implementation of all parts of ISO 19107 used by the DGIWG 2D profile, the GML objects implementing the relevant classes of the spatial schema plus the general types and elements for feature type definitions were extracted from the full GML schema by using the tool that is part of the GML specification, annex G (first step).

In the second step, the schema definitions were manually edited to reflect the descriptions and OCL constraints of the ISO 19107 profile in the document mentioned above relevant for the OWS-2 application schemas (while adhering to the rules for profiles in GML).

An example: The profile requires that all topology primitives have a geometry representation. So, where the GML schema defines an “edge” as

```
<complexType name="EdgeType">
```

```

<complexContent>
  <extension base="gml:AbstractTopoPrimitiveType">
    <sequence>
      <element ref="gml:directedNode" minOccurs="2" maxOccurs="2"/>
      <element ref="gml:directedFace" minOccurs="0" maxOccurs="unbounded"/>
      <element ref="gml:curveProperty" minOccurs="0"/>
    </sequence>
  </extension>
</complexContent>
</complexType>

```

the NGA profile removes the `minOccurs="0"` in the “curveProperty” property:

```

<xsd:complexType name="EdgeType">
  <xsd:complexContent>
    <xsd:extension base="gml:AbstractTopoPrimitiveType">
      <xsd:sequence>
        <xsd:element ref="gml:directedNode" minOccurs="2" maxOccurs="2"/>
        <xsd:element ref="gml:directedFace" minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element ref="gml:curveProperty"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

```

The resulting GML profile is captured in the schema document “gml3NGAProfile.xsd”. All NGA application schemas documented in this DIPR used this profile.

Not represented in the GML profile is annex A (“Predefined sets”) of the DGIWG profile as these classes are not used in the OWS-2 application schemas.

9 Application Schema for NGA Product Profiles (VMAP levels 0-2, TLM)

9.1 UML Appliation Schema

The application schemas for all four products were created in the same way, always based on two inputs: the NGA FACC Profile application schema described above and a description of the product.

This product description were tables of the form:

Theme	Area	Line	Point	FACC	Attribute	Attribute Value for coded types (enumerations)	Units	NOTES
POP	Area			AK040	N/A			
POP	Area			AK130	N/A			
POP			Point	AK160	TXT			
POP			Point	AL015	TXT			
POP	Area		Point	AL020	NAM			
POP			Point	AL025	TXT			

POP			Point	AL105	TXT			
POP			Point	AL130	TXT			
POP	Area		Point	AL135	NAM			
POP			Point	AL200	TXT			
TRANS		Line	Point	AL210	TUC		3	
TRANS		Line	Point	AL210	TUC		4	
IND			Point	AL240	TXT			
BND		Line		AL260	N/A			
BND			Point	AL260	TXT			
IND			Point	AM010	TXT			
IND			Point	AM070	TXT			
IND			Point	AM080	TXT			
TRANS		Line		AN010	ACC		2	
TRANS		Line		AN010	ACC	NULL		
TRANS		Line		AN010	COE		2	
TRANS		Line		AN010	COE	NULL		
...

The four product descriptions are:

- VMAP0: VMAP0_NGAProfile_V2.xls
- VMAP1: VMAP1_NGAProfile_V2.xls
- VMAP2: VMAP2_NGAProfileApr02_V4.xls
- TLM: TLM_NGAProfile.xls

These tables were converted to CSV files and processed by a simple Rational Rose Script implementing the actions described below:

For every feature type in the profile, one or more feature type classes are created based on the template in the NGA FACC Profile. One class is created for every NGA FACC Profile feature type per spatial dimension. Therefore, a maximum of three feature types are possible: surface (2D), curve (1D) or point (0D). To distinguish the subtypes, a prefix is added to the name of the feature types, e.g. “A” for a feature with 2D geometry, “L” for 1D and “P” for 0D.

The respective <<Union>> classes for spatial representations of a certain dimensionality have been added to the NGA FACC Profile Application Schema, too.

Basic types are directly used from the NGA FACC Profile and coded values are restricted to the values defined in the profile.

PGB005
+ spatialRepresentation : SpatialCharacteristics0D
+ iko : GB005_IKO
+ nam : GB005_NAM
+ use : PGB005_USE_VMAP0
+ zv3 : GB005_ZV3

<<Enumeration>> PGB005_USE_VMAP0
+ Unknown = 0
+ Military = 8
+ Joint Military/Civilian = 22
+ Civilian/Public = 49
+ Other = 999

<<Union>> SpatialCharacteristics0D (from NGA FACC Profile)
+ pointGeometry : GM_Point
+ multiPointGeometry : GM_MultiPoint
+ nodeTopology : TP_Node

So, basically, the new feature type classes are restricted copies of feature types defined in the NGA FACC Profile. Since it was considered unnecessary to express this relationship this was not modelled using inheritance. See the MSDS application schema below for an alternative approach using specialization relationships.

9.2 GML Application Schema

Again, the GML application schema was automatically derived from the UML Application Schema using the UGAS tool (using the same settings). One XML Schema file was created per product.

Preliminary support for the themes in the product profiles was added manually. This requires further analysis how this would be best mapped to ISO 19109 UML. The themes were modelled as feature collections based on the tables shown above (see first column) where all features in a theme are in the same topological complex.

As an example, an excerpt from the VMAP0 product application schema:

```
<schema targetNamespace="http://www.opengis.net/ows-2/nga/vmap0"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:vmap0="http://www.opengis.net/ows-2/nga/vmap0"
xmlns:smXML="http://metadata.dgiwg.org/smXML" xmlns:nga="http://www.opengis.net/ows-2/nga"
xmlns:gml="http://www.opengis.net/gml" xmlns="http://www.w3.org/2001/XMLSchema"
elementFormDefault="qualified" version="0.3">
  <import namespace="http://www.opengis.net/gml" schemaLocation="base/gml3.xsd"/>
  <!--Type and element definitions of this package-->
  ...
  <element name="ThemeELEV" type="vmap0:ThemeELEVType"
    substitutionGroup="gml:_FeatureCollection"/>
  <complexType name="ThemeELEVType">
    <annotation>
      <documentation>Feature Collection for Theme ELEV</documentation>
    </annotation>
    <complexContent>
      <restriction base="gml:AbstractFeatureCollectionType">
```

```

    <sequence>
      <group ref="gml:StandardObjectProperties"/>
      <element ref="gml:boundedBy" minOccurs="0"/>
      <element ref="vmap0:themeELEVMember" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
  </restriction>
</complexContent>
</complexType>
<complexType name="themeELEVMember" type="vmap0:ELEVMemberPropertyType"
  substitutionGroup="gml:featureMember"/>
<complexType name="ELEVMemberPropertyType">
  <complexContent>
    <restriction base="gml:FeaturePropertyType">
      <sequence>
        <choice minOccurs="0">
          <element ref="vmap0:LCA010"/>
          <element ref="vmap0:PCA030"/>
          <element ref="vmap0:PCA035"/>
          <element ref="vmap0:AZD040"/>
          <element ref="vmap0:AZD045"/>
          <element ref="vmap0:LZD040"/>
          <element ref="vmap0:LZD045"/>
          <element ref="vmap0:PZD040"/>
          <element ref="vmap0:PZD045"/>
        </choice>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>
...
<complexType name="AAA010Type">
  <annotation>
    <documentation>Mine: An excavation made in the earth for the purpose of extracting natural deposits.
(See also AQ090)</documentation>
    <appinfo source="urn:x-ShapeChange:code">AA010</appinfo>
    <appinfo source="urn:x-ShapeChange:name">Mine</appinfo>
  </annotation>
  <complexContent>
    <extension base="gml:AbstractFeatureType">
      <sequence>
        <choice>
          <element name="surfaceGeometry" type="gml:SurfacePropertyType"/>
          <element name="multiSurfaceGeometry" type="gml:MultiSurfacePropertyType"/>
          <element name="faceTopology" type="gml:TopoSurfacePropertyType"
maxOccurs="unbounded"/>
        </choice>
        <element name="min">
          <annotation>
            <documentation>Mining Category: Unique mining characteristic.</documentation>
            <appinfo source="urn:x-ShapeChange:code">MIN</appinfo>
            <appinfo source="urn:x-ShapeChange:name">Mining Category</appinfo>
          </annotation>
          <simpleType>
            <restriction base="string">
              <enumeration value="0">
                <annotation>
                  <documentation>Unknown</documentation>
                </annotation>
              </enumeration>
              <enumeration value="8">
                <annotation>
                  <documentation>Peat Cuttings</documentation>
                </annotation>
              </enumeration>
            </restriction>
          </simpleType>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>

```

```

        </restriction>
      </simpleType>
    </element>
  </sequence>
</extension>
</complexContent>
</complexType>
<element name="AAA010" type="vmap0:AAA010Type" substitutionGroup="gml:_Feature"/>
<complexType name="AAA052Type">
  <annotation>
    <documentation>Oil/Gas Field: An area where oil and/or gas is pumped or otherwise removed from
the ground.</documentation>
    <appinfo source="urn:x-ShapeChange:code">AA052</appinfo>
    <appinfo source="urn:x-ShapeChange:name">Oil/Gas Field</appinfo>
  </annotation>
  <complexContent>
    <extension base="gml:AbstractFeatureType">
      <sequence>
        <choice>
          <element name="surfaceGeometry" type="gml:SurfacePropertyType"/>
          <element name="multiSurfaceGeometry" type="gml:MultiSurfacePropertyType"/>
          <element name="faceTopology" type="gml:TopoSurfacePropertyType"
maxOccurs="unbounded"/>
        </choice>
      </sequence>
    </extension>
  </complexContent>
</complexType>
...
</schema>

```

10 MSDS Application Schema

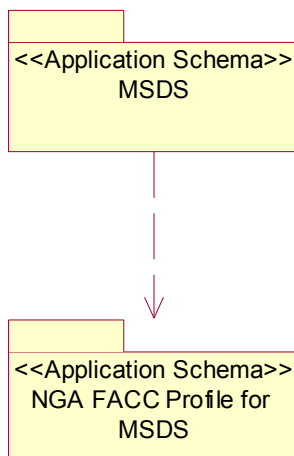
10.1 UML Application Schema

The application schema for the mission specific data (used for the OWS-2 demonstration) was built to fit the data provided. The data was based on actual data, but edited to explore some additional capabilities of GML 3. However, due to the software used to manipulate the dataset, only limited changes to the demo data were possible. However, the data represent a case where additional information not captured in the NGA FACC Profile has to be added.

Therefore, the NGA FACC Profile was copied and reduced to a subset of the full NGA FACC Profile based on the data. A Rational Rose script was used to do this, but this could also be done manually by someone with knowledge about the captured data.

The additional information not captured in the FACC profile is added in the MSDS application schema. Again, in OWS-2 this was done using a Rational Rose script to be able to repeat the process with changes (to take feedback into account and to test alternative approaches), but this can be done manually, too.

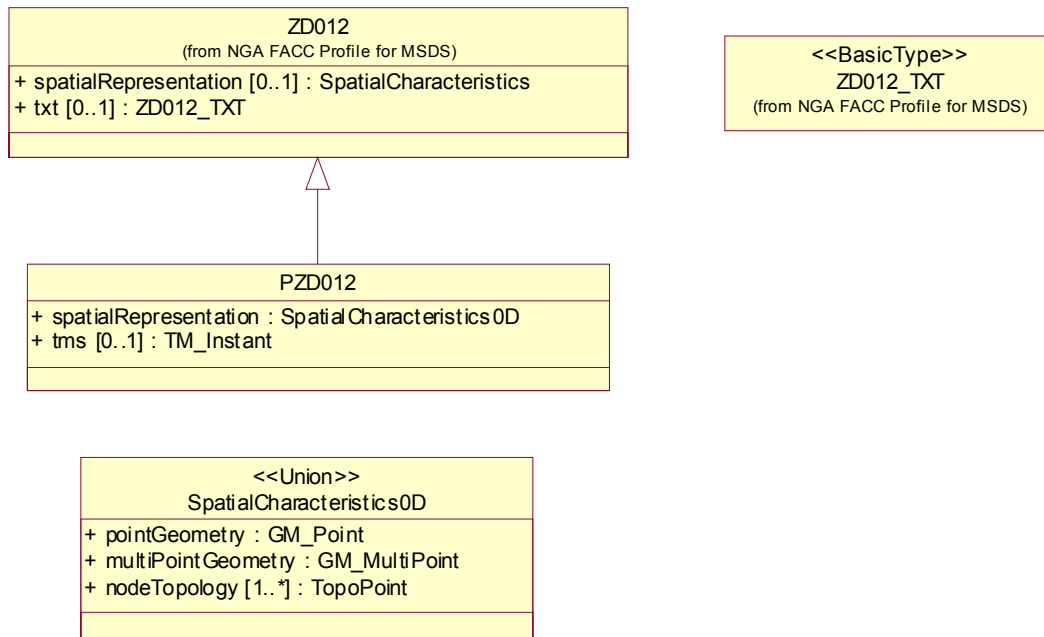
The Rose script used in the process is shown in Annex A.



Since the data contained a distinction between the dimensionality of the spatial representation of the features, the structure used in the product application schemas with distinct feature types and a “A”, “L” or “P” prefix was used here, too.

The typical feature type definition in the MSDS application schema is shown in the class diagram below.

- The ZD012 feature type has been reduced to the attributes in the mission specific data (an equivalent representation would have been to restrict the multiplicity of the unused attributes to “[0..0]”).
- The mission specific data contains only features with a 0D spatial representation of the feature type. Therefore, a class “PZD012” has been defined as a specialization of ZD012.
- In PZD012 the spatialRepresentation property has been reduced to the 0D characteristics.
- The additional property contained in the data, but not part of the NGA FACC Profile has been added. In this case, an attribute containing a time stamp.



10.2 GML Application Schema

Again, the GML application schema was automatically derived from the UML Application Schema using the UGAS tool. As above, support for themes was added manually.

An excerpt from the MSDS application schema showing the definition of the PZD012 feature type:

```

<schema targetNamespace="http://www.opengis.net/ows-2/nga/msds"
  xmlns="http://www.w3.org/2001/XMLSchema" xmlns:gml="http://www.opengis.net/gml"
  xmlns:msds="http://www.opengis.net/ows-2/nga/msds" xmlns:nga="http://www.opengis.net/ows-2/nga"
  xmlns:smXML="http://metadata.dgiwg.org/smXML" xmlns:xlink="http://www.w3.org/1999/xlink"
  elementFormDefault="qualified" version="0.2">
  <import namespace="http://www.opengis.net/ows-2/nga" schemaLocation="NGAFACCProfileforMSDS.xsd"/>
  <import namespace="http://www.opengis.net/gml" schemaLocation="base/gml3.xsd"/>
  <!-- Type and element definitions of this package-->
  <!-- .....-->
  <complexType name="PZD012RestrictionType" abstract="true">
    <complexContent>
      <restriction base="nga:ZD012Type">
        <sequence>
          <element ref="gml:metaDataProperty" minOccurs="0" maxOccurs="unbounded"/>
          <element ref="gml:description" minOccurs="0"/>
          <element ref="gml:name" minOccurs="0" maxOccurs="unbounded"/>
          <element ref="gml:boundedBy" minOccurs="0"/>
          <group ref="nga:SpatialCharacteristics0DGroup"/>
          <group ref="nga:ZD012__txt_Group" minOccurs="0"/>
        </sequence>
      </restriction>
    </complexContent>
  </complexType>
  <complexType name="PZD012Type">
  
```

```

    <annotation>
      <documentation>Geographic Information Point: A location where geographic information or statistics
may apply.</documentation>
      <appinfo source="urn:x-ShapeChange:code">ZD012</appinfo>
      <appinfo source="urn:x-ShapeChange:name">Geographic Information Point</appinfo>
    </annotation>
    <complexContent>
      <extension base="msds:PZD012RestrictionType">
        <sequence>
          <group ref="msds:PZD012__tms_Group" minOccurs="0"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <group name="PZD012__tms_Group">
    <sequence>
      <element name="tms" type="gml:TimeInstantPropertyType">
        <annotation>
          <documentation>Extraction Timestamp: The date on which the feature was extracted followed
by an increment specific to each source.</documentation>
          <appinfo source="urn:x-ShapeChange:code">TMS</appinfo>
          <appinfo source="urn:x-ShapeChange:name">Extraction Timestamp</appinfo>
        </annotation>
      </element>
    </sequence>
  </group>
  <element name="PZD012" type="msds:PZD012Type" substitutionGroup="nga:ZD012"/>
  <!--...-->
</schema>

```

11 Discussion of GML Level 0 and the NGA Application Schemas

It was discussed whether the Application Schemas should use the proposed Level 0 profile. After an analysis it was identified that Level 0 is in many aspects not sufficient for the requirements of NGA. The major issues are:

- The DGIWG spatial profile, the basis for the GML profile used by the application schemas, goes far beyond the spatial elements allowed in Level 0. This includes the use of curve segments, non-linear interpolation types, topology objects, rings, etc.
- The NGA Application Schema requires the use of temporal objects.
- Level 0 uses elements which were deprecated with GML 3.0.
- Level 0 requires that the srsName attribute is set in geometries. On the other hand, the DGIWG profile requests that the coordinate reference system is not specified for geometric primitives, but only once for collections.
- NGA is interested in using temporal topology in future application schemas, but this is not allowed in Level 0.
- NGA is interested in using metadata in future application schemas, but this is not allowed in Level 0.

- The use of dictionaries is not allowed in Level 0. However, dictionaries are used to represent information from the FACC as well as for a units dictionary.
- Requirements for basic types in Level 0 do not match the requirements of NGA and the FACC. Not included are, for example, minimum and maximum numeric values (“min” and “max” facets), types with units of measurements (gml:MeasureType and derived types) and coded values (“enumeration” facet). Also, Level 0 *requires* the use of facets which are not used (or useful) for the NGA FACC Profile.
- The rule that all feature types must directly derive from gml:AbstractFeatureType is not necessarily what meets the requirements of mission specific application schemas where existing feature types of the NGA FACC Profile will typically be extended with additional properties (like in the demo data). This is not possible in Level 0.
- The application schemas as shown in the previous sections do not comply with the rules for using XML namespaces in Level 0.
 - o While it would be easily possible to change the namespace prefixes to the values prescribed by the Level 0 draft, the restrictions imposed by Level 0 are debatable.
 - o Since only a single namespace for all application specific declarations is allowed, all mission specific schemas would be required to use the same namespace as the NGA FACC Profile, which is not appropriate.
- The use of a GML profile schema is not allowed in Level 0.
- The rules for the names of complex types is slightly different for the rules of GML 3.1 (ISO CD 19136) Annex E, which were applied for the NGA application schemas.
- Level 0 does not allow nesting of feature collections, a capability that is of interest to NGA (see below).

It was therefore decided not to consider Level 0 as the basis for the application schemas of NGA.

12 Temporal Topology

It was originally planned to include also temporal topology in the mission specific application schema. However, since it was not possible to prepare appropriate data as well as missing support for temporal topology in clients, temporal topology information is not part of the MSDS application schema.

This clause illustrates, how temporal topology could have been integrated in the application schema. As an example, assume that the temporal validity and succession of features describing the flooding situation shall be represented using temporal topology, so that for every point in time.


```

<complexType name="FloodStatusType">
  <complexContent>
    <extension base="gml:AbstractFeatureType">
      <sequence>
        <group ref="nga:SpatialCharacteristics2DGroup"/>
        <group ref="msds:FloodStatus__temporalValidity_Group"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<group name="FloodStatus__temporalValididy_Group">
  <sequence>
    <element name="temporalValididy" type="gml:TimeEdgePropertyType"/>
  </sequence>
</group>
<element name="FloodStatus" type="msds:FloodStatusType" substitutionGroup="gml:_Feature"/>

```

An instance could then, for example, look like:

```

<FloodStatus gml:id="o1">
  <spatialRepresentation>
    <gml:Polygon>
      <!-- ... flooded area ... -->
    </gml:Polygon>
  </spatialRepresentation>
  <temporalValidity>
    <gml:TimeEdge gml:id="te2">
      <gml:start>
        <gml:TimeNode gml:id="tn2">
          <gml:previousEdge xlink:href="#te1"/>
          <gml:nextEdge xlink:href="#te2"/>
          <gml:position>
            <gml:TimeInstant>
              <gml:timePosition>2004-08-28T01:04:28Z</gml:timePosition>
            </gml:TimeInstant>
          </gml:position>
        </gml:TimeNode>
      </gml:start>
      <gml:end>
        <gml:TimeNode gml:id="tn3">
          <gml:previousEdge xlink:href="#te2"/>
          <gml:nextEdge xlink:href="#te3"/>
          <gml:nextEdge xlink:href="#te4"/>
          <gml:position>
            <gml:TimeInstant>
              <gml:timePosition>2004-08-28T23:46:10Z</gml:timePosition>
            </gml:TimeInstant>
          </gml:position>
        </gml:TimeNode>
      </gml:end>
      <gml:extent>
        <gml:TimePeriod>
          <gml:beginPosition>2004-08-28T01:04:28Z</gml:beginPosition>
          <gml:endPosition>2004-08-28T23:46:10Z</gml:endPosition>
        </gml:TimePeriod>
      </gml:extent>
    </gml:TimeEdge>
  </temporalValidity>
</FloodStatus>

```

13 Complex Features

It is often of interest to group a collection of NGA FACC Profile features in the dataset. Examples could be a hospital complex, a highway system or an oil field.

The definition of these feature collections will typically depend on specific type, so the following definitions may be seen as examples. Note that these feature collections are features themselves and can be retrieved from a WFS, too.

If the highway system is just a collection of the road features then it may be defined as:

```
<element name="HighwaySystem" substitutionGroup="gml:_FeatureCollection">
  <complexType>
    <annotation>
      <documentation>A highway system</documentation>
    </annotation>
    <complexContent>
      <restriction base="gml:AbstractFeatureCollectionType">
        <sequence>
          <group ref="gml:StandardObjectProperties"/>
          <element ref="gml:boundedBy"/>
          <element ref="msds:roads" minOccurs="0" maxOccurs="unbounded"/>
        </sequence>
      </restriction>
    </complexContent>
  </complexType>
</element>
<element name="roads" substitutionGroup="gml:featureMember">
  <complexType>
    <complexContent>
      <restriction base="gml:FeaturePropertyType">
        <sequence>
          <element ref="msds:LAP030" minOccurs="0"/>
        </sequence>
        <attributeGroup ref="gml:AssociationAttributeGroup"/>
      </restriction>
    </complexContent>
  </complexType>
</element>
```

Then, an instance document could contain highway system as well as the road features.

```
<gml:FeatureCollection xmlns="http://www.opengis.net/ows-2/nga/msds"
  xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:gml="http://www.opengis.net/gml"
  xmlns:msds="http://www.opengis.net/ows-2/nga/msds" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.opengis.net/ows-2/nga/msds ./MSDS.xsd">
  <gml:boundedBy>
    <gml:Envelope srsName="EPSG:4329">
      <gml:lowerCorner>32.80 44.40 25.60</gml:lowerCorner>
      <gml:upperCorner>32.88 44.50 88.48</gml:upperCorner>
    </gml:Envelope>
  </gml:boundedBy>
  <gml:featureMember>
    <gml:HighwaySystem gml:id="HS.1">
      <gml:boundedBy>
        <gml:Envelope srsName="EPSG:4329">
          <gml:lowerCorner>32.80 44.40 25.60</gml:lowerCorner>
          <gml:upperCorner>32.88 44.50 88.48</gml:upperCorner>
        </gml:Envelope>
      </gml:boundedBy>
```

```

    <msds:roads xlink:href="#LAP030.1"/>
    <msds:roads xlink:href="#LAP030.2"/>
    <msds:roads xlink:href="#LAP030.3"/>
    <msds:roads xlink:href="#LAP030.4"/>
    <msds:roads xlink:href="#LAP030.5"/>
  </gml:HighwaySystem>
</gml:featureMember>
<gml:featureMember>
  <msds:LAP030 gml:id="LAP030.1">
    <nga:edgeTopology>
      <gml:TopoCurve>
        <gml:directedEdge orientation="+">
          <gml:Edge gml:id="E1">
            <gml:directedNode orientation="-">
              <gml:Node gml:id="N1">
                <gml:directedEdge orientation="-" xlink:href="#E1"/>
                <gml:pointProperty>
                  <gml:Point srsName="EPSG:4329">
                    <gml:pos>32.8065719604493 44.469554901123
31.2497463226318</gml:pos>
                  </gml:Point>
                </gml:pointProperty>
              </gml:Node>
            </gml:directedNode>
            <gml:directedNode orientation="+">
              <gml:Node gml:id="N2">
                <gml:directedEdge orientation="+" xlink:href="#E1"/>
                <gml:pointProperty>
                  <gml:Point srsName="EPSG:4329">
                    <gml:pos>32.8065490722657 44.469596862793
31.2484951019287</gml:pos>
                  </gml:Point>
                </gml:pointProperty>
              </gml:Node>
            </gml:directedNode>
            <gml:curveProperty>
              <gml:Curve srsName="EPSG:4329">
                <gml:segments>
                  <gml:LineStringSegment>
                    <gml:posList>32.8065719604493 44.469554901123
31.2497463226318 32.8065490722657 44.469596862793 31.2484951019287 </gml:posList>
                  </gml:LineStringSegment>
                </gml:segments>
              </gml:Curve>
            </gml:curveProperty>
          </gml:Edge>
        </gml:directedEdge>
      </gml:TopoCurve>
    </nga:edgeTopology>
    <nga:rtt>1</nga:rtt>
  </msds:LAP030>
</gml:featureMember>
<gml:featureMember>
  <msds:LAP030 gml:id="LAP030.2">
    <!-- ... -->
  </msds:LAP030>
</gml:featureMember>
<!-- ... -->
</gml:FeatureCollection>

```

Similarly, this could be done for a hospital complex consisting of different base features or any other meaningful aggregation of features.

14 Using a Topology Complex

An alternative approach to encoding the topology could be using explicit topology complexes so that the topology primitives would be separate from the features. In this case, the instance document in the previous clause would be changed, for example to:

```
<gml:FeatureCollection xmlns="http://www.opengis.net/ows-2/nga/msds"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:gml="http://www.opengis.net/gml"
xmlns:msds="http://www.opengis.net/ows-2/nga/msds" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/ows-2/nga/msds ./MSDS.xsd http://www.opengis.net/gml
./base/gml3.xsd">
  <gml:boundedBy>
    <gml:Envelope srsName="EPSG:4329">
      <gml:lowerCorner>32.80 44.40 25.60</gml:lowerCorner>
      <gml:upperCorner>32.88 44.50 88.48</gml:upperCorner>
    </gml:Envelope>
  </gml:boundedBy>
  <gml:featureMember>
    <gml:HighwaySystem gml:id="HS.1">
      <gml:boundedBy>
        <gml:Envelope srsName="EPSG:4329">
          <gml:lowerCorner>32.80 44.40 25.60</gml:lowerCorner>
          <gml:upperCorner>32.88 44.50 88.48</gml:upperCorner>
        </gml:Envelope>
      </gml:boundedBy>
      <msds:roads xlink:href="#LAP030.1"/>
      <msds:roads xlink:href="#LAP030.2"/>
      <msds:roads xlink:href="#LAP030.3"/>
      <msds:roads xlink:href="#LAP030.4"/>
      <msds:roads xlink:href="#LAP030.5"/>
      <msds:topoComplex xlink:href="#TC"/>
    </gml:HighwaySystem>
  </gml:featureMember>
  <gml:featureMember>
    <gml:msds:LAP030 gml:id="LAP030.1">
      <nga:edgeTopology>
        <gml:TopoCurve>
          <gml:directedEdge orientation="+" xlink:href="#E1"/>
        </gml:TopoCurve>
      </nga:edgeTopology>
      <nga:rtt>1</nga:rtt>
    </gml:msds:LAP030>
  </gml:featureMember>
  <gml:featureMember>
    <gml:msds:LAP030 gml:id="LAP030.2">
      <!-- ... -->
    </gml:msds:LAP030>
  </gml:featureMember>
  <!-- ... -->
  <gml:msds:topoComplex>
    <gml:TopoComplex gml:id="TC">
      <gml:maximalComplex xlink:href="#TC"/>
      <gml:topoPrimitiveMembers>
        <gml:Node gml:id="N1">
          <gml:directedEdge orientation="-" xlink:href="#E1"/>
          <gml:pointProperty>
            <gml:Point srsName="EPSG:4329">
              <gml:pos>32.8065719604493 44.469554901123 31.2497463226318</gml:pos>
            </gml:Point>
          </gml:pointProperty>
        </gml:Node>
        <gml:Node gml:id="N2">
          <gml:directedEdge orientation="+" xlink:href="#E1"/>
        </gml:Node>
      </gml:topoPrimitiveMembers>
    </gml:TopoComplex>
  </gml:msds:topoComplex>
</gml:FeatureCollection>
```

```

    <gml:pointProperty>
      <gml:Point srsName="EPSG:4329">
        <gml:pos>32.8065490722657 44.469596862793 31.2484951019287</gml:pos>
      </gml:Point>
    </gml:pointProperty>
  </gml:Node>
  <gml:Edge gml:id="E1">
    <gml:directedNode orientation="-" xlink:href="#N1"/>
    <gml:directedNode orientation="+" xlink:href="#N2"/>
    <gml:curveProperty>
      <gml:Curve srsName="EPSG:4329">
        <gml:segments>
          <gml:LineStringSegment>
            <gml:posList>32.8065719604493 44.469554901123 31.2497463226318
            32.8065490722657 44.469596862793 31.2484951019287 </gml:posList>
          </gml:LineStringSegment>
        </gml:segments>
      </gml:Curve>
    </gml:curveProperty>
  </gml:Edge>
</gml:topoPrimitiveMembers>
</gml:TopoComplex>
</msds:topoComplex>
</gml:FeatureCollection>

```

However, embedding the geometric (and topological) primitives in the XML encoding of the feature is probably easier to parse for clients.

15 Coordinate Reference Systems

In case of 2D data representations, the coordinate reference system with the EPSG code 4326 was used (WGS84 geographic). For 3D (or 2.5D) data representations, the coordinate reference system with the EPSG code 4329 was used (WGS84 geographic with metric heights).

16 Units of measurements

The FACC describes the units used by different attributes. The unit descriptions were used to map the attribute type to the appropriate base type of GML. For example, length values were mapped to `gml:LengthType` (e.g. the SHC attribute). If no pre-defined type in GML was available, the types were mapped to `gml:MeasureType` (e.g. the LTN attribute).

To support a common encoding of unit references in *uom* attributes across the different Web Feature Servers hosting the data, a units dictionary was specified and hosted on a public URL. The units dictionary used is shown in annex B.

A SHC value would then be encoded for example as

```
<nga:shc uom="http://testschemas.opengis.net/ows2/NGA_FACC_Profile_Units_Dictionary.xml#m">1.3</nga:shc>
```

Attribute types like LTN play a special role, since their unit is not a typical unit in terms of ISO 31 units like metres, seconds, etc. A significant number of units in the FACC are

unitless count values. The LTN attribute, a count of the number of tracks, is an example. It was decided to use `gml:MeasureType` as the data type for these attributes for the OWS-2 application schemas since the FACC associates them with a unit. A unit “count” was added to the units dictionary for these cases.

17 Summary

The approach using an automated, repeatable capability to create/derive the UML and GML application schemas proved very helpful for the various iterations until the final schemas were fixed and used in the demonstration.

This process also enhanced the understanding of the details of the schema definitions and created very reliable and uniform schemas. Therefore, such an approach for the generation of GML Application Schemas which also yielded additional results

- ISO 19109 UML Application Schemas
- GML dictionaries for feature type names, attribute type names and coded value descriptions

is highly recommended for application schema developments like the NGA FACC Profile and product profiles like VMAP 0/1/2 or TLM which are intended to be a basis for a wide range of applications and are relatively stable.

For mission specific application schema which often have to be developed very quickly and without regard to the framework of the NGA FACC Profile, it should be decided on a cases by case basis if it is more appropriate to create the application schema manually with tools like the Schema Subsetting Tool (actually more a GML Applications Schema editor) or any standard XML Schema editor. This will depend on the size of the changes relative to the NGA FACC Profile (the fewer the more appropriate is an interactive editor) and of the “lifespan” of the schemas (and associated data).

The approach involving ISO 19109 UML Application Schemas as an intermediate step also requires knowledge about the ISO 19100 series and a UML tool which is able to export XMI 1.0 (UML 1.3).

Some remaining issues at the end of initiative are:

- Some XML Parsers (MSXML and Xerces-J with strict validation) identified issues with the use of XML Schema during the TIEs. These issues were previously unnoted (Xerces with standard validation does not report any issues, for example) and affect also the GML Schema as well as the UML-to-GML-Application-Schema mapping rules (currently under review in the ISO 19136 editing process).
- Software support for several of the more advanced GML capabilities were and are an issue.

- The use of a choice block of GML properties to distinguish the different types of spatial properties (geometric primitive, geometric aggregate, topology) as it has been used in the encoding should be replaced by a single geometric property whose value is a choice of the geometry of topology objects. The current encoding is difficult to handle for clients both in parsing the data and in creating queries.
- See also the associated DIPR discussing findings with respect to the Web Feature Service interface.

Annex A

(informative)

Rose Script to create the MSDS UML Application Schema

The script requires that the Rose model contains three packages:

- the “NGA FACC Profile” package
- an empty package for the profile of the NGA FACC Profile used by the mission specific schema (“NGA FACC Profile for MSDS”)
- an empty package for the changes (restrictions / extensions) relative to the NGA FACC Profile by the mission specific schema (“MSDS”)

In addition, a CSV file is required, documenting the contents of the mission specific use of the FACC definitions.

```

Const WithThemes As Boolean = true
Const Product As String = "MSDS"
Const Char As String = ";"

Function SplitString (ByRef part1 As String, ByRef part2 As String, split As String) As Boolean
    If Len(split)<=Len(part1) Then
        Pos = InStr(part1, split)
        If Pos > 0 Then
            part2 = Right(part1, Len(part1)-Len(split)-Pos+1)
            part1 = Left(part1, Pos-1)
        End If
    Else
        Pos = 0
    End If
    SplitString = (Pos<>0)
End Function

Function CreateAttribute(theClass As Class, ngaAttribute As Attribute, AttName As String,
DType As String) As Attribute
    Dim theAttribute As Attribute
    Set theAttribute = theClass.AddAttribute(AttName, DType, "")
    If ngaAttribute Is Not Nothing Then
        Dim b As Boolean
        b = theAttribute.OverrideProperty("ShapeChange", "code",
ngaAttribute.FindProperty("ShapeChange", "code").Value)
        b = theAttribute.OverrideProperty("ShapeChange", "name",
ngaAttribute.FindProperty("ShapeChange", "name").Value)
        theAttribute.documentation = ngaAttribute.documentation
    End If
    theAttribute.ExportControl.Name = "PublicAccess"
    Set CreateAttribute = theAttribute
End Function

Function CreateClass(theCategory As Category, ClassName As String, ngaClass As Class) As Class
    Dim theClass As Class
    Dim ngaAttribute As Attribute
    Dim theAttribute As Attribute
    Dim nam As String
    Set theClass = theCategory.AddClass(ClassName)

```



```

    Dim b As Boolean
    b = theClass.OverrideProperty("ShapeChange", "code",
ngaClass.FindProperty("ShapeChange", "code").Value)
    b = theClass.OverrideProperty("ShapeChange", "name",
ngaClass.FindProperty("ShapeChange", "name").Value)
    theClass.documentation = ngaClass.documentation
    theClass.Persistence = True
    Set ngaAttribute = Nothing
    Set theAttribute = CreateAttribute(theClass, ngaAttribute, "spatialRepresentation
[0..1]", "SpatialCharacteristics")
    For i = 1 To ngaClass.Attributes.Count
        Set ngaAttribute = ngaClass.Attributes.GetAt(i)
        nam = Left(ngaAttribute.name, Len(ngaAttribute.name) - 6) + "[0..0]"
        Set theAttribute = CreateAttribute(theClass, ngaAttribute, nam,
ngaAttribute.type)
    Next i
    Set CreateClass = theClass
End Function

Function CreateSubClass(theCategory As Category, ClassName As String, ngaClass As Class)
As Class
    Dim theClass As Class
    Dim inhRel As InheritRelation
    Dim ngaAttribute As Attribute
    Dim theAttribute As Attribute
    Dim nam As String
    Set theClass = theCategory.AddClass(ClassName)

    Dim b As Boolean
    b = theClass.OverrideProperty("ShapeChange", "code",
ngaClass.FindProperty("ShapeChange", "code").Value)
    b = theClass.OverrideProperty("ShapeChange", "name",
ngaClass.FindProperty("ShapeChange", "name").Value)
    theClass.documentation = ngaClass.documentation
    Set inhRel = theClass.AddInheritRel("", ngaClass.GetQualified_name())
    theClass.Persistence = True
    If Left(ClassName, 1) = "A" Then
        Set theAttribute = CreateAttribute(theClass, ngaAttribute,
"spatialRepresentation", "SpatialCharacteristics2D")
    ElseIf Left(ClassName, 1) = "L" Then
        Set theAttribute = CreateAttribute(theClass, ngaAttribute,
"spatialRepresentation", "SpatialCharacteristics1D")
    ElseIf Left(ClassName, 1) = "P" Then
        Set theAttribute = CreateAttribute(theClass, ngaAttribute,
"spatialRepresentation", "SpatialCharacteristics0D")
    End If
    Set CreateSubClass = theClass
End Function

Function CreateEnumeration(theCategory As Category, ClassName As String) As Class
    Dim theClass As Class
    Set theClass = theCategory.AddClass(ClassName)
    theClass.Stereotype = "Enumeration"
    Set CreateEnumeration = theClass
End Function

Function CreateEnum(theClass As Class, ngaClass As Class, InitVal As String) As Attribute
    Dim theAttribute As Attribute
    Dim ngaAttribute As Attribute
    Set theAttribute = Nothing
    For i% = 1 To theClass.Attributes.Count
        Set theAttribute = theClass.Attributes.GetAt(i)
        If theAttribute.InitValue = InitVal Then
            Set CreateEnum = theAttribute
            Exit Function
        End If
    Next i%
    Dim b As Boolean
    b = false
    For i% = 1 To ngaClass.Attributes.Count

```

```

    Set ngaAttribute = ngaClass.Attributes.GetAt(i)
    If ngaAttribute.InitValue = InitVal Then
        Set theAttribute = theClass.AddAttribute(ngaAttribute.name, "", InitVal)
        b = true
    Exit For
End If
Next i%
If Not b Then
Set theAttribute = theClass.AddAttribute(InitVal, "", InitVal)
Print theClass.name+" - "+InitVal+" not found"
End If
If theAttribute Is Not Nothing Then
    theAttribute.ExportControl.Name = "PublicAccess"
End If
Set CreateEnum = theAttribute
End Function

```

```

Sub LoadProfile(ngaPackage As Category, ngaProfPackage As Category, prodPackage As
Category, prod As String)

```

```

    Dim s0 As String
    Dim s1 As String
    Dim s2 As String
    Dim s3 As String
    Dim s4 As String
    Dim slx As String
    Dim slalp As String
    Dim b As Boolean
    Dim i As Integer
    Dim s0x As String

    Dim theClass As Class
    Dim ngaProfClass As Class
    Dim ngaClass As Class
    Dim theAttribute As Attribute
    Dim ngaAttribute As Attribute
    Dim theEnum As Class
    Dim ngaEnum As Class
    Dim theCode As Attribute

    Dim Themes() As String
    Dim FeatureTypes() As String
    Dim idx As Integer

    Do While Not EOF(1)
        Line Input #1, zeile$
        s0 = zeile$
        s1 = ""
        s2 = ""
        s3 = ""
        s4 = ""
        If SplitString(s0,s1,Char) Then
            If SplitString(s1,s2,Char) Then
                If SplitString(s2,s3,Char) Then
                    b = SplitString(s3,s4,Char)
                End If
            End If
        End If
        s0 = trim(s0)
        s1 = trim(s1)
        s2 = trim(s2)
        s3 = trim(s3)
        s4 = trim(s4)
        Print s0+"|"+s1+"|"+s2+"|"+s3+"|"+s4

        slx = Right(s1,5)
        slalp = Left(s1,1)

        i = ngaPackage.GetAllClasses.FindFirst(slx)
        If i>0 Then
            Set ngaClass = ngaPackage.GetAllClasses.GetAt(i)

```

```

Else
    Print slx+" not found"
    s1 = ""
    s2 = ""
    s3 = ""
End If

Set theClass = Nothing
i = prodPackage.GetAllClasses.FindFirst(s1)
If i>0 Then
    Set theClass = prodPackage.GetAllClasses.GetAt(i%)
    Set ngaProfClass =
ngaProfPackage.GetAllClasses.GetAt(ngaProfPackage.GetAllClasses.FindFirst(s1x))
Else
    i = ngaProfPackage.GetAllClasses.FindFirst(s1x)
    If i>0 Then
        Set ngaProfClass = ngaProfPackage.GetAllClasses.GetAt(i)
    Else
        Set ngaProfClass = CreateClass(ngaProfPackage, slx, ngaClass)
    End If
    Set theClass = CreateSubClass(prodPackage, s1, ngaProfClass)
    Set ngaAttribute = Nothing
    If WithThemes Then
        Do While s0<>""
            b = SplitString(s0,s0x,"/")
            s0 = trim(s0)

            idx = -1
            If arraydims(Themes) = 0 Then
                ReDim Themes( 0 )
                ReDim FeatureTypes( 0 )
                Themes(0) = s0
                FeatureTypes( 0 ) = theClass.name+";"
            Else
                For i = 0 To Ubound(Themes)
                    If Themes(i) = s0 Then
                        idx = i
                        Exit For
                    End If
                Next i
                If idx = -1 Then
                    idx = Ubound(Themes)+1
                    ReDim Preserve Themes( idx )
                    ReDim Preserve FeatureTypes( idx )
                    Themes(idx) = s0
                    FeatureTypes( idx ) = theClass.name+";"
                Else
                    FeatureTypes( idx ) = FeatureTypes( idx )+theClass.name+";"
                End If
            End If
            If b Then
                s0 = trim(s0x)
            Else
                s0 = ""
            End If
        Loop
    End If
End If

If s2 <> "" And ngaProfClass Is Not Nothing Then

    Set theAttribute = Nothing
    i = ngaProfClass.Attributes.FindFirst(LCase$(s2)+" [0..0]")
    If i>0 Then
        Set theAttribute = ngaProfClass.Attributes.GetAt(i)
        theAttribute.name = Left(theAttribute.name,Len(theAttribute.name)-
6)+"[0..1]"
    Else
        i = ngaProfClass.Attributes.FindFirst(LCase$(s2)+" [0..1]")
        If i>0 Then
            Set theAttribute = ngaProfClass.Attributes.GetAt(i)

```

```

Else
    Dim origAttribute As Attribute
    For j = 1 To ngaPackage.GetAllClasses.Count
        Dim tmpClass As Class
        Set tmpClass = ngaPackage.GetAllClasses.GetAt(j)
        For k = 1 To tmpClass.Attributes.Count
            Set origAttribute = tmpClass.Attributes.GetAt(k)
            If origAttribute.name = LCase$(s2)+" [0..1]" Then
                Set theAttribute = CreateAttribute(theClass,
origAttribute, origAttribute.name, origAttribute.type)
                Exit For
            End If
        Next k
        If theAttribute Is Not Nothing Then
            Exit For
        End If
    Next j
    If theAttribute Is Nothing Then
        Set origAttribute = Nothing
        Set theAttribute = CreateAttribute(theClass, origAttribute,
LCase$(s2)+" [0..1]", "Unknown")
    End If
End If

If s3 <> "" Then
    i = ngaProfPackage.GetAllClasses.FindFirst(s1x+"_"+s2+"_"+Product)
    If i>0 Then
        Set theEnum = ngaProfPackage.GetAllClasses.GetAt(i%)
    Else
        Set theEnum = CreateEnumeration(ngaProfPackage,
s1x+"_"+s2+"_"+Product)
        theAttribute.type = theEnum.GetQualified_name()
    End If

    i = ngaPackage.GetAllClasses.FindFirst(s1x+"_"+s2)
    If i>0 Then
        Set ngaEnum = ngaPackage.GetAllClasses.GetAt(i%)
        Set theCode = CreateEnum(theEnum, ngaEnum, s3)
    Else
        Print ">>> "+s1+"_"+s2+" not found"
    End If
End If
End If
Loop

Dim cc As New ClassCollection
For i = 1 To ngaProfPackage.GetAllClasses.Count
    Set theClass = ngaProfPackage.GetAllClasses.GetAt(i)

    For j = 1 To theClass.Attributes.Count
        Set theAttribute = theClass.Attributes.GetAt(j)
        If Right(theAttribute.name,6) <> "[0..0]" Then
            k = ngaPackage.GetAllClasses.FindFirst(theAttribute.type)
            If k > 0 Then
                cc.Add ngaPackage.GetAllClasses.GetAt(k)
            End If
        End If
    Next j
Next i
For i = 1 To cc.Count
    Print ">>> "+cc.GetAt(i).name
    ngaProfPackage.RelocateClass cc.GetAt(i)
Next i

For i = 1 To ngaProfPackage.GetAllClasses.Count
    Set theClass = ngaProfPackage.GetAllClasses.GetAt(i)

    Dim notDone As Boolean
    notDone = false
    If theClass.stereotype = "" Then

```

```

        notDone = true
    End If
    While notDone
        notDone = false
        For j = 1 To theClass.Attributes.Count
            Set theAttribute = theClass.Attributes.GetAt(j)
            If Right(theAttribute.name,6) = "[0..0]" Then
                b = theClass.DeleteAttribute(theAttribute)
                notDone = true
            Exit For
        End If
    Next j
Wend
Next i

Open "C:\NGA_Profile\"+Product+"Themes.xsd" For Output As #2

Dim ns As String
ns = LCase$(Product)+":

Print #2, "<?xml version=""1.0"" encoding=""UTF-8""?>"
Print #2, "<schema targetNamespace=""http://www.opengis.net/ows-2/nga/"+LCase$(Product)+"""
Print #2, " xmlns=""http://www.w3.org/2001/XMLSchema""
xmlns:gml=""http://www.opengis.net/gml""
Print #2, " xmlns:"+LCase$(Product)+"=""http://www.opengis.net/ows-2/nga/"+LCase$(Product)+"""
Print #2, " xmlns:nga=""http://www.opengis.net/ows-2/nga"">"
Print #2, " <include schemaLocation="""+Product+".xsd"/>"
Print #2, " <import namespace=""http://www.opengis.net/gml""
schemaLocation=""base/gml3.xsd"/>"
For i = 0 To Ubound(Themes)
    Print #2, "<element name=""Theme"+Themes(i)+"""
substitutionGroup=""gml:_FeatureCollection"">"
    Print #2, " <complexType>"
    Print #2, " <annotation>"
    Print #2, " <documentation>Feature Collection for Theme
"+Themes(i)+"</documentation>"
    Print #2, " </annotation>"
    Print #2, " <complexContent>"
    Print #2, " <restriction base=""gml:AbstractFeatureCollectionType"">"
    Print #2, " <sequence>"
    Print #2, " <group ref=""gml:StandardObjectProperties""/>"
    Print #2, " <element ref=""gml:boundedBy"" minOccurs=""0""/>"
    Print #2, " <element ref="""+ns+"themeMember"+Themes(i)+""" minOccurs=""0""
maxOccurs=""unbounded""/>"
    Print #2, " </sequence>"
    Print #2, " </restriction>"
    Print #2, " </complexContent>"
    Print #2, " </complexType>"
    Print #2, "</element>"
    Print #2, "<element name=""themeMember"+Themes(i)+"""
substitutionGroup=""gml:featureMember"">"
    Print #2, " <complexType>"
    Print #2, " <complexContent>"
    Print #2, " <restriction base=""gml:FeaturePropertyType"">"
    Print #2, " <sequence>"
    Print #2, " <choice minOccurs=""0"">"
    s0 = FeatureTypes(i)
    Do While s0 <> ""
        b = SplitString(s0,s0x,";")
        Print #2, " <element ref="""+ns+trim(s0)+"""/>"
        If b Then
            s0 = trim(s0x)
        Else
            s0 = ""
        End If
    Loop
    Print #2, " </choice>"
    Print #2, " </sequence>"
    Print #2, " <attributeGroup ref=""gml:AssociationAttributeGroup""/>"

```

```

        Print #2, "    </restriction>"
        Print #2, "    </complexContent>"
        Print #2, "  </complexType>"
        Print #2, "</element>"
      Next i
      Print #2, "</schema>"
      Close #2

End Sub

Sub Main
  Dim ngaPackage As Category
  Dim ngaProfPackage As Category
  Dim prodPackage As Category
  Set ngaPackage =
RoseApp.CurrentModel.GetAllCategories().GetAt(RoseApp.CurrentModel.GetAllCategories().Find
dFirst("NGA FACC Profile"))
  Set ngaProfPackage =
RoseApp.CurrentModel.GetAllCategories().GetAt(RoseApp.CurrentModel.GetAllCategories().Find
dFirst("NGA FACC Profile for "+Product))
  Set prodPackage =
RoseApp.CurrentModel.GetAllCategories().GetAt(RoseApp.CurrentModel.GetAllCategories().Find
dFirst(Product))
  FileName$ = OpenFilename$ ("CSV", "File:*.csv")
  If FileName$ <> "" Then
    Viewport.Open
    Open FileName$ For Input As #1
    Set ClassesProcessed = New ClassCollection
    Call LoadProfile(ngaPackage,ngaProfPackage,prodPackage,Product)
    Close #1
    Print "Loading finished ..."
  End If
End Sub

```

Annex B

(informative)

Units Dictionary

The script requires that the Rose model contains three packages:

```
<Dictionary xmlns="http://www.opengis.net/gml" xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gml http://schemas.opengis.net/gml/3.1.0/base/gml.xsd"
gml:id="UnitsDictionary">
  <description>A dictionary of units of measure for the NGA FACC Profile for OWS-2.</description>
  <name>NGA FACC Profile Units Dictionary</name>
  <dictionaryEntry>
    <DefinitionCollection gml:id="SIBaseUnits">
      <description>The Base Units from the SI units system.</description>
      <name>SI Base Units</name>
      <dictionaryEntry>
        <BaseUnit gml:id="m">
          <description>The metre is the length of the path travelled by light in vacuum during a time
interval of 1/299 792 458 of a second.</description>
          <name codeSpace="http://www.bipm.fr/en/si">metre</name>
          <name>meter</name>
          <quantityType>length</quantityType>
          <catalogSymbol codeSpace="http://www.bipm.fr/en/si">m</catalogSymbol>
          <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
        </BaseUnit>
      </dictionaryEntry>
      <dictionaryEntry>
        <BaseUnit gml:id="kg">
          <description>The kilogram is the unit of mass; it is equal to the mass of the international
prototype of the kilogram. </description>
          <name codeSpace="http://www.bipm.fr/en/si">kilogram</name>
          <quantityType>Mass</quantityType>
          <catalogSymbol codeSpace="http://www.bipm.fr/en/si">kg</catalogSymbol>
          <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
        </BaseUnit>
      </dictionaryEntry>
      <dictionaryEntry>
        <BaseUnit gml:id="s">
          <description>The second is the duration of 9 192 631 770 periods of the radiation
corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133
atom.</description>
          <name codeSpace="http://www.bipm.fr/en/si">second</name>
          <quantityType>Time</quantityType>
          <catalogSymbol codeSpace="http://www.bipm.fr/en/si">s</catalogSymbol>
          <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
        </BaseUnit>
      </dictionaryEntry>
      <dictionaryEntry>
        <BaseUnit gml:id="A">
          <description>The ampere is that constant current which, if maintained in two straight parallel
conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would
produce between these conductors a force equal to  $2 \times 10^{-7}$  newton per metre of length.
</description>
          <name codeSpace="http://www.bipm.fr/en/si">Ampere</name>
          <quantityType>Electric current</quantityType>
          <catalogSymbol codeSpace="http://www.bipm.fr/en/si">A</catalogSymbol>
          <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
        </BaseUnit>
      </dictionaryEntry>
    </DefinitionCollection>
  </dictionaryEntry>
</Dictionary>
```

```

    </BaseUnit>
  </dictionaryEntry>
</dictionaryEntry>
  <BaseUnit gml:id="K">
    <description>The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the
thermodynamic temperature of the triple point of water.</description>
    <name codeSpace="http://www.bipm.fr/en/si">kelvin</name>
    <quantityType>Thermodynamic temperature</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">K</catalogSymbol>
    <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
  </BaseUnit>
</dictionaryEntry>
</dictionaryEntry>
  <BaseUnit gml:id="mol">
    <description>1. The mole is the amount of substance of a system which contains as many
elementary entities as there are atoms in 0.012 kilogram of carbon 12.
2. When the mole is used, the elementary entities shall be specified and may be atoms, molecules, ions, electrons,
other particles, or specified groups of such particles.</description>
    <name codeSpace="http://www.bipm.fr/en/si">mole</name>
    <quantityType>Amount of substance</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">mol</catalogSymbol>
    <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
  </BaseUnit>
</dictionaryEntry>
</dictionaryEntry>
  <BaseUnit gml:id="cd">
    <description> The candela is the luminous intensity, in a given direction, of a source that emits
monochromatic radiation of frequency 540 × 1012 hertz and that has a radiant intensity in that direction of 1/683
watt per steradian.</description>
    <name codeSpace="http://www.bipm.fr/en/si">candela</name>
    <quantityType>Luminous intensity</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">cd</catalogSymbol>
    <unitsSystem xlink:href="http://www.bipm.fr/en/si"/>
  </BaseUnit>
</dictionaryEntry>
</DefinitionCollection>
</dictionaryEntry>
</dictionaryEntry>
  <DefinitionCollection gml:id="SIDerivedUnits">
    <description>The Derived Units from the SI units system. These are all derived as a product of SI
Base Units, except degrees Celsius in which the conversion formula to the SI Base Unit (kelvin) involves an
offset.</description>
    <name>SI Derived Units</name>
    <dictionaryEntry>
      <DerivedUnit gml:id="rad">
        <name codeSpace="http://www.bipm.fr/en/si"> radian</name>
        <quantityType>plane angle</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">rad</catalogSymbol>
        <derivationUnitTerm uom="#m" exponent="1"/>
        <derivationUnitTerm uom="#m" exponent="-1"/>
      </DerivedUnit>
    </dictionaryEntry>
    <dictionaryEntry>
      <DerivedUnit gml:id="sr">
        <name codeSpace="http://www.bipm.fr/en/si">steradian</name>
        <quantityType>solid angle</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">sr</catalogSymbol>
        <derivationUnitTerm uom="#m" exponent="2"/>
        <derivationUnitTerm uom="#m" exponent="-2"/>
      </DerivedUnit>
    </dictionaryEntry>
    <dictionaryEntry>
      <DerivedUnit gml:id="Hz">
        <name codeSpace="http://www.bipm.fr/en/si">hertz</name>
        <quantityType>frequency</quantityType>

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        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">Hz</catalogSymbol>
        <derivationUnitTerm uom="#s" exponent="-1"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="N">
        <name codeSpace="http://www.bipm.fr/en/si">newton</name>
        <quantityType>force</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">N</catalogSymbol>
        <derivationUnitTerm uom="#m" exponent="1"/>
        <derivationUnitTerm uom="#kg" exponent="1"/>
        <derivationUnitTerm uom="#s" exponent="-2"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="Pa">
        <name codeSpace="http://www.bipm.fr/en/si">pascal</name>
        <quantityType>pressure, stress</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">Pa</catalogSymbol>
        <derivationUnitTerm uom="#N" exponent="1"/>
        <derivationUnitTerm uom="#m" exponent="-2"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="J">
        <name codeSpace="http://www.bipm.fr/en/si">joule</name>
        <quantityType>energy, work, quantity of heat</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">J</catalogSymbol>
        <derivationUnitTerm uom="#N" exponent="1"/>
        <derivationUnitTerm uom="#m" exponent="1"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="W">
        <name codeSpace="http://www.bipm.fr/en/si">watt</name>
        <quantityType>power, radiant flux</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">W</catalogSymbol>
        <derivationUnitTerm uom="#J" exponent="1"/>
        <derivationUnitTerm uom="#s" exponent="-1"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="C">
        <name codeSpace="http://www.bipm.fr/en/si">coulomb</name>
        <quantityType>electric charge, quantity of electricity</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">C</catalogSymbol>
        <derivationUnitTerm uom="#s" exponent="1"/>
        <derivationUnitTerm uom="#A" exponent="1"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="V">
        <name codeSpace="http://www.bipm.fr/en/si">volt</name>
        <quantityType>electric potential difference, electromotive force</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">V</catalogSymbol>
        <derivationUnitTerm uom="#W" exponent="1"/>
        <derivationUnitTerm uom="#A" exponent="-1"/>
    </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
    <DerivedUnit gml:id="F">
        <name codeSpace="http://www.bipm.fr/en/si">farad</name>
        <quantityType>capacitance</quantityType>
        <catalogSymbol codeSpace="http://www.bipm.fr/en/si">F</catalogSymbol>
        <derivationUnitTerm uom="#C" exponent="1"/>

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    <derivationUnitTerm uom="#V" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="ohm">
    <name codeSpace="http://www.bipm.fr/en/si">ohm</name>
    <quantityType>electric resistance</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si"> $\Omega$ </catalogSymbol>
    <derivationUnitTerm uom="#V" exponent="1"/>
    <derivationUnitTerm uom="#A" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="S">
    <name codeSpace="http://www.bipm.fr/en/si">siemens</name>
    <quantityType>electric conductance</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">S</catalogSymbol>
    <derivationUnitTerm uom="#A" exponent="1"/>
    <derivationUnitTerm uom="#V" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="Wb">
    <name codeSpace="http://www.bipm.fr/en/si">weber</name>
    <quantityType>magnetic flux</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">Wb</catalogSymbol>
    <derivationUnitTerm uom="#V" exponent="1"/>
    <derivationUnitTerm uom="#s" exponent="1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="T">
    <name codeSpace="http://www.bipm.fr/en/si">tesla</name>
    <quantityType>magnetic flux density</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">T</catalogSymbol>
    <derivationUnitTerm uom="#Wb" exponent="1"/>
    <derivationUnitTerm uom="#m" exponent="-2"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="H">
    <name codeSpace="http://www.bipm.fr/en/si">henry</name>
    <quantityType>inductance</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">H</catalogSymbol>
    <derivationUnitTerm uom="#Wb" exponent="1"/>
    <derivationUnitTerm uom="#A" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="degC">
    <name codeSpace="http://www.bipm.fr/en/si">degree Celsius</name>
    <quantityType>Celsius temperature</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si"> $^{\circ}$ C</catalogSymbol>
    <conversionToPreferredUnit uom="#K">
      <formula>
        <a>273.16</a>
        <b>1</b>
        <c>1</c>
      </formula>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="lm">
    <name codeSpace="http://www.bipm.fr/en/si">lumen</name>

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    <quantityType>luminous flux</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">lm</catalogSymbol>
    <derivationUnitTerm uom="#cd" exponent="1"/>
    <derivationUnitTerm uom="#sr" exponent="1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="lx">
    <name codeSpace="http://www.bipm.fr/en/si">lux</name>
    <quantityType>illuminance</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">lx</catalogSymbol>
    <derivationUnitTerm uom="#lm" exponent="1"/>
    <derivationUnitTerm uom="#m" exponent="-2"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="Bq">
    <name codeSpace="http://www.bipm.fr/en/si">becquerel</name>
    <quantityType>activity (referred to a radionuclide)</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">Bq</catalogSymbol>
    <derivationUnitTerm uom="#s" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="Gy">
    <name codeSpace="http://www.bipm.fr/en/si">gray</name>
    <quantityType>absorbed dose, specific energy (imparted), kerma</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">Gy</catalogSymbol>
    <derivationUnitTerm uom="#J" exponent="1"/>
    <derivationUnitTerm uom="#kg" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="Sv">
    <name codeSpace="http://www.bipm.fr/en/si">sievert</name>
    <quantityType>dose equivalent, ambient dose equivalent, directional dose equivalent,
personal dose equivalent, organ equivalent dose</quantityType>
    <catalogSymbol codeSpace="http://www.bipm.fr/en/si">Sv</catalogSymbol>
    <derivationUnitTerm uom="#J" exponent="1"/>
    <derivationUnitTerm uom="#kg" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="m2">
    <name>square metre</name>
    <quantityType>Area</quantityType>
    <catalogSymbol>m²</catalogSymbol>
    <derivationUnitTerm uom="#m" exponent="2"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="m3">
    <name>cubic metre</name>
    <quantityType>Volume</quantityType>
    <catalogSymbol>m³</catalogSymbol>
    <derivationUnitTerm uom="#m" exponent="3"/>
  </DerivedUnit>
</dictionaryEntry>
<dictionaryEntry>
  <DerivedUnit gml:id="mps">
    <name>metres per second</name>
    <quantityType>speed</quantityType>
    <catalogSymbol>m/s</catalogSymbol>
    <derivationUnitTerm uom="#m" exponent="1"/>
    <derivationUnitTerm uom="#s" exponent="-1"/>
  </DerivedUnit>

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    </DerivedUnit>
  </dictionaryEntry>
</dictionaryEntry>
  <DerivedUnit gml:id="kmh">
    <name>kilometres per hour</name>
    <quantityType>speed</quantityType>
    <catalogSymbol>km/h</catalogSymbol>
    <derivationUnitTerm uom="#km" exponent="1"/>
    <derivationUnitTerm uom="#h" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
</dictionaryEntry>
  <DerivedUnit gml:id="knot">
    <name>knot</name>
    <quantityType>speed</quantityType>
    <catalogSymbol>knot</catalogSymbol>
    <derivationUnitTerm uom="#nauticalMile" exponent="1"/>
    <derivationUnitTerm uom="#h" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
</dictionaryEntry>
  <DerivedUnit gml:id="mph">
    <name>miles per hour</name>
    <quantityType>speed</quantityType>
    <catalogSymbol>mph</catalogSymbol>
    <derivationUnitTerm uom="#mile" exponent="1"/>
    <derivationUnitTerm uom="#h" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
</dictionaryEntry>
  <DerivedUnit gml:id="m3ph">
    <name>cubicmetre per hour</name>
    <quantityType>volume per time unit</quantityType>
    <catalogSymbol>m3/h</catalogSymbol>
    <derivationUnitTerm uom="#mile" exponent="1"/>
    <derivationUnitTerm uom="#h" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
</dictionaryEntry>
  <DerivedUnit gml:id="kgpm3">
    <name>kilogram per cubicmetre</name>
    <quantityType>density</quantityType>
    <catalogSymbol>kg/m3</catalogSymbol>
    <derivationUnitTerm uom="#kg" exponent="1"/>
    <derivationUnitTerm uom="#m3" exponent="-1"/>
  </DerivedUnit>
</dictionaryEntry>
</dictionaryEntry>
  <DerivedUnit gml:id="km_2">
    <name>count per square kilometre</name>
    <quantityType>density per area</quantityType>
    <catalogSymbol>1/km2</catalogSymbol>
    <derivationUnitTerm uom="#km" exponent="-2"/>
  </DerivedUnit>
</dictionaryEntry>
</DefinitionCollection>
</dictionaryEntry>
</dictionaryEntry>
  <DefinitionCollection gml:id="ConventionalUnitsDictionary">
    <description>A collection of Conventional Units. These are units of measure which are either widely used or important within a specific community. For most of these there is
    1. a known derivation from more primitive units, which may or may not be SI Base Units, or
    2. a known conversion to a preferred unit, which may or may not be an SI Base or Derived unit, through rescaling and offset,
    or both. </description>
  </DefinitionCollection>

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<name>Conventional units.</name>
<dictionaryEntry>
  <ConventionalUnit gml:id="GHz">
    <name>GigaHertz</name>
    <quantityType>frequency</quantityType>
    <catalogSymbol>GHz</catalogSymbol>
    <conversionToPreferredUnit uom="#Hz">
      <factor>1.e9</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="MHz">
    <name>MegaHertz</name>
    <quantityType>frequency</quantityType>
    <catalogSymbol>MHz</catalogSymbol>
    <conversionToPreferredUnit uom="#Hz">
      <factor>1.e6</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="kHz">
    <name>KiloHertz</name>
    <quantityType>frequency</quantityType>
    <catalogSymbol>kHz</catalogSymbol>
    <conversionToPreferredUnit uom="#Hz">
      <factor>1.e3</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="t">
    <name>Tons</name>
    <quantityType>weight</quantityType>
    <catalogSymbol>t</catalogSymbol>
    <conversionToPreferredUnit uom="#kg">
      <factor>1.e3</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="cm">
    <name>centimetre</name>
    <quantityType>length</quantityType>
    <catalogSymbol>cm</catalogSymbol>
    <conversionToPreferredUnit uom="#m">
      <factor>0.01</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="dm">
    <name>decimetre</name>
    <quantityType>length</quantityType>
    <catalogSymbol>dm</catalogSymbol>
    <conversionToPreferredUnit uom="#m">
      <factor>0.1</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="km">
    <name>kilometre</name>
    <quantityType>length</quantityType>

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        <catalogSymbol>km</catalogSymbol>
        <conversionToPreferredUnit uom="#m">
          <factor>1.e3</factor>
        </conversionToPreferredUnit>
      </ConventionalUnit>
    </dictionaryEntry>
  </dictionaryEntry>
  <ConventionalUnit gml:id="mile">
    <name>mile</name>
    <quantityType>length</quantityType>
    <catalogSymbol>mile</catalogSymbol>
    <conversionToPreferredUnit uom="#ft">
      <factor>5280</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</dictionaryEntry>
  <ConventionalUnit gml:id="ft">
    <name>foot</name>
    <quantityType>length</quantityType>
    <catalogSymbol>ft</catalogSymbol>
    <conversionToPreferredUnit uom="#m">
      <factor>0.3048</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</dictionaryEntry>
  <ConventionalUnit gml:id="nauticalMile">
    <name>nautical mile</name>
    <quantityType>length</quantityType>
    <catalogSymbol>nauticalMile</catalogSymbol>
    <conversionToPreferredUnit uom="#m">
      <factor>1852</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</dictionaryEntry>
  <ConventionalUnit gml:id="min">
    <name>minute</name>
    <quantityType>time</quantityType>
    <catalogSymbol>min</catalogSymbol>
    <conversionToPreferredUnit uom="#s">
      <factor>60</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</dictionaryEntry>
  <ConventionalUnit gml:id="h">
    <name>hour</name>
    <quantityType>time</quantityType>
    <catalogSymbol>h</catalogSymbol>
    <conversionToPreferredUnit uom="#s">
      <factor>3600</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</dictionaryEntry>
  <ConventionalUnit gml:id="deg">
    <name>degree</name>
    <quantityType>angle</quantityType>
    <conversionToPreferredUnit uom="#rad">
      <factor>1.74532925199433E-02</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>

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<dictionaryEntry>
  <ConventionalUnit gml:id="">
    <name>litre</name>
    <quantityType>Volume</quantityType>
    <conversionToPreferredUnit uom="#m3">
      <factor>0.001</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="ha">
    <name>hectare</name>
    <quantityType>Area</quantityType>
    <conversionToPreferredUnit uom="#m2">
      <factor>1.e4</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="gal">
    <name>US Gallons</name>
    <quantityType>Volume</quantityType>
    <catalogSymbol>gal</catalogSymbol>
    <conversionToPreferredUnit uom="#l">
      <factor>3.785412</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="kV">
    <name>Kilo Volt</name>
    <quantityType>electric potential difference, electromotive force</quantityType>
    <catalogSymbol>kV</catalogSymbol>
    <conversionToPreferredUnit uom="#V">
      <factor>1.e3</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="MW">
    <name>Mega Watt</name>
    <quantityType>power, radiant flux</quantityType>
    <catalogSymbol>MW</catalogSymbol>
    <conversionToPreferredUnit uom="#W">
      <factor>1.e6</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="kip">
    <name>kilopound</name>
    <quantityType>force</quantityType>
    <catalogSymbol>kip</catalogSymbol>
    <conversionToPreferredUnit uom="#N">
      <factor>4.4482e3</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</DefinitionCollection>
</dictionaryEntry>
<dictionaryEntry>
  <DefinitionCollection gml:id="UnitlessUnits">
    <description>A collection of unitless units.</description>
    <name>unitless units</name>
  </DefinitionCollection>
</dictionaryEntry>

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    <BaseUnit gml:id="unity">
      <name>unitless</name>
      <quantityType>scale factor</quantityType>
      <unitsSystem xlink:href="http://www.opengis.net/ows-2/nga"/>
    </BaseUnit>
  </dictionaryEntry>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="percent">
    <name>percent</name>
    <quantityType>scale factor</quantityType>
    <catalogSymbol>%</catalogSymbol>
    <conversionToPreferredUnit uom="#unity">
      <factor>0.01</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</dictionaryEntry>
<dictionaryEntry>
  <ConventionalUnit gml:id="count">
    <name>count</name>
    <quantityType>scale factor</quantityType>
    <catalogSymbol/>
    <conversionToPreferredUnit uom="#unity">
      <factor>1</factor>
    </conversionToPreferredUnit>
  </ConventionalUnit>
</dictionaryEntry>
</DefinitionCollection>
</dictionaryEntry>
</Dictionary>

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