

Open Geospatial Consortium

Submission Date: 2017-03-24

Approval Date: 2017-06-02

Publication Date: 2017-08-16

External identifier of this OGC® document: <http://www.opengis.net/doc/standard/infragml/part5/1.0>

Internal reference number of this OGC® document: 16-105r2

Version: 1.0

Category: OGC® Encoding Standard

Editor: Peter Axelsson/Lars Wikström

Contributors: Paul Scarponcini

OGC InfraGML 1.0: Part 5 - Railways - Encoding Standard

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Document type: OGC® Standard
Document subtype:
Document stage: Approved
Document language: English

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i. Abstract

This OGC InfraGML Encoding Standard presents the implementation-dependent, GML encoding of concepts supporting land and civil engineering infrastructure facilities specified in the OGC Land and Infrastructure Conceptual Model Standard (LandInfra), OGC 15-111r1. Conceptual model subject areas include land features, facilities, projects, alignment, road, railway, survey (including equipment, observations, and survey results), land division, and condominiums.

InfraGML is published as a multi-part standard. This Part 5 addresses the Railway Requirements Class from LandInfra.

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

OGC document, LandInfra, InfraGML, infrastructure, civil, railway, cant, super elevation, transition curves.

iii. Preface

In order to achieve consensus on the concepts supporting land and civil engineering infrastructure facilities, a UML Conceptual Model, LandInfra, was approved as an OGC standard in August, 2016. This model provides a unifying basis for encodings including but not limited to InfraGML, including similar work in buildingSMART International. It can also provide a framework for discussing how other software standards relate to LandInfra.

As an OGC standard, LandInfra follows the OGC modular specification standard, OGC 08-131r3. Because of the breadth of LandInfra, its subject areas are divided into separate Requirements Classes. This InfraGML encoding similarly is divided into Requirements Classes which are then grouped into Parts. A Part may address multiple LandInfra Requirements Classes but each Requirements Class is addressed in a single part. Because Requirements Classes may depend on other Requirements Classes (see LandInfra Figure 1, “Requirements Classes as UML Packages with their dependencies”), the reader of this InfraGML Part may need to conform to Requirements Classes in other Parts as well.

Note that this InfraGML encoding standard is a target of LandInfra and therefore this standard conforms to the Requirements Classes in LandInfra. On the other hand, an application claiming conformance to this InfraGML encoding standard must conform to the Requirements Classes contained in this InfraGML standard.

There are several reasons for separating InfraGML into Parts. Because they are likely to have separate authors, the rate at which each Part is completed may vary. It would not be advisable to wait until all Parts complete before any can be released as separate OGC standards. Multiple Parts will also allow each subject to have its own standards life cycle. One Part can be updated independent of other Parts, subject to dependency

constraints. And of course, it should be easier for the application software developer to only deal with Parts relevant to their application.

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

iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

Bentley Systems, Inc.

Leica Geosystems

Swedish Transport Administration

Trimble Inc.

Autodesk

v. Submitters

All questions regarding this submission should be directed to the editor or the submitters:

Name	Affiliation
Paul Scarponcini, SWG chair	Bentley Systems, Inc.
Hans-Christoph Gruler, SWG co-chair	Leica Geosystems
Peter Axelsson	Swedish Transport Administration
Lars Wikström	Swedish Transport Administration
Leif Granholm	Trimble Inc.
Johnny Jensen	Trimble Inc.
Thomas Liebich	buildingSMART International
Orest Halustchak	Autodesk

1. Scope

InfraGML is a GML encoding standard of the LandInfra Conceptual Model standard, OGC 15-111r1. InfraGML is provided as a set of individual though inter-dependent Parts, each of which is a GML standard.

The overall scope of this InfraGML Encoding Standard is infrastructure facilities and the land on which they are constructed. Also included is the surveying necessary for the setting out and as-built recording of these facilities and land interests. Primarily having a civil engineering point of view, InfraGML is relevant across all life cycle phases of a facility. Subject areas include land features, facilities, projects, alignment, road, railway, survey (including equipment, observations, and survey results), land division, and condominiums.

The scope of this Part 5 of InfraGML addresses the following subject area(s): railways. The InfraGML Railway Requirements Class is included. It is optional in that an application can conform to InfraGML without supporting it, for example by only supporting the Survey Requirements Classes in Part 6. However, to claim support for Railway, an application must also support the InfraGML Core and Facility Requirements Classes and may choose to support the Alignment Requirements Class.

2. Conformance

The InfraGML encoding standard defines requirements, grouped into Requirements Classes, for applications which read and write information about infrastructure facilities and the land on which they are constructed, including the surveying necessary for the setting out and as-built recording of these facilities and land interests.

The OGC modular specification (OGC 08-131r3) defines “standardization target” as the entity to which requirements of a standard apply. It further notes that the standardization target is the entity which may receive a certificate of conformance for a requirements class. The standardization target type for this standard is therefore:

- software applications which read/write data instances, i.e. XML documents that encode land, infrastructure facility, and survey data for exchange

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site¹.

¹ www.opengeospatial.org/cite

In order to conform to this OGC encoding standard, a standardization target shall choose to implement the core conformance class and any of the other conformance classes with their dependencies. Conformance classes are based on Requirements Classes which are specified in this and possibly other Parts of the InfraGML standard.

All requirements classes and conformance classes described in this document are owned by the standard(s) identified. Note that Conformance Classes for this Part of InfraGML may require conformance with Conformance Classes from other Parts of InfraGML.

3. References

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

OGC: OGC 07-036, *OpenGIS® Geography Markup Language (GML) Encoding Standard*, v3.2.1, 2007

OGC: OGC 10-129r1, *OGC® Geography Markup Language (GML) — Extended schemas and encoding rules*, v3.3, 2012

OGC: OGC 15-111r1, *OGC Land and Infrastructure Conceptual Model Standard (LandInfra)*, v1.0, 2016.

OGC: OGC 16-100, *OGC InfraGML 1.0: Part 0 – LandInfra Core – Encoding Standard*, v1.0, 2017

OGC: OGC 16-102, *OGC InfraGML 1.0: Part 2 – LandInfra Facilities and Projects – Encoding Standard*, v1.0, 2017

4. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

The LandInfra standard contains a long list of terms and definitions relevant to the scope of InfraGML. As these will not be repeated here, the reader is directed to Clause 4 of LandInfra. Only terms not already appearing there are listed below.

5. Conventions

5.1 Abbreviations

In this document the following abbreviations and acronyms are used or introduced:

GML	Geography Markup Language
ISO	International Organization for Standardization
OGC	Open Geospatial Consortium
UML	Unified Modeling Language
XML	eXtensible Markup Language

5.2 UML Package and Class Diagrams

The LandInfra standard contains UML diagrams for the concepts supported by InfraGML. As these will not be repeated here, the reader is directed to Clause 7 of LandInfra. UML will only appear in InfraGML in the rare cases where LandInfra is extended by InfraGML.

5.3 Requirements

When referred to in a Requirement or Requirements Class, the boxes contained in the LandInfra UML figures may all be called “Classes” even if they are data types, enumerations, code lists, unions etc. In most cases, these will be encoded as XML elements in InfraGML.

When an InfraGML Requirement states that “A conforming application shall support the [Requirements Class] XML elements listed in Table <n> in accordance with the GML XSD in this standard.”, the XSD was developed to support the UML for the corresponding LandInfra Requirements Class as follows:

- a) all classes shown as blue boxes for the corresponding LandInfra Requirements Class UML diagrams;
- b) all attributes, attribute cardinalities, and attribute data types of these classes (usually shown in subsequent diagrams);
- c) all associations, navigation, roles, and role cardinalities connected to the blue classes;
- d) all classes shown as beige boxes (another Requirements Class) in the diagrams connected to the blue box classes by association or used as attribute data types; and
- e) all classes shown as pink boxes (another Standard) in the figure connected to the blue box classes by association or used as attribute data types.

Note that, in rare cases, the OGC 15-111r1 UML may be altered. In such cases, the alterations are declared in the first subclause of each Requirements Class, entitled “Implementation decisions regarding OGC 15-111r1 UML”. Logical Model UML diagrams may be included if the implementation constraints of GML (or XML) dictate that the Conceptual Model cannot be implemented directly as shown in OGC 15-111r1.

In most cases, the InfraGML XML derived from the LandInfra UML follows the rules in OGC 07-036, GML, Annex E, UML-to-GML application schema encoding rules.

The only normative version of the GML XSD (XML schema definition) for all Parts of the InfraGML Encoding Standard is available from the official OGC XML schema repository at <http://schemas.opengis.net>. Any occurrences of all or part of this XSD contained within this document are to be considered to be informative only.

The URI base for the LandInfra Conceptual Model standard is <http://www.opengis.net/spec/landinfra/1.0>. All URIs of Requirements Classes, Requirements, and Conformance Classes contained in that standard are relative to this base.

The URI base for this InfraGML encoding standard is <http://www.opengis.net/spec/infragml/part5/1.0>. All URIs of Requirements Classes, Requirements, and Conformance Classes contained in this standard are relative to this base.

6. InfraGML Parts

The InfraGML encoding standard has been divided into Parts. These Parts enable the grouping of LandInfra subject areas (Requirements Classes) into individual OGC encoding standards. All of these InfraGML encoding standards have a similar name: “OGC 16-10n, OGC® InfraGML 1.0: Part n - <part name> Encoding Standard”, where Part numbers and names are as follows:

n	<part name>
0	LandInfra Core
1	LandInfra LandFeatures
2	LandInfra Facilities and Projects
3	LandInfra Alignments
4	LandInfra Roads
5	LandInfra Railways
6	LandInfra Survey
7	LandInfra LandDivision

Some InfraGML Parts depend upon other parts:

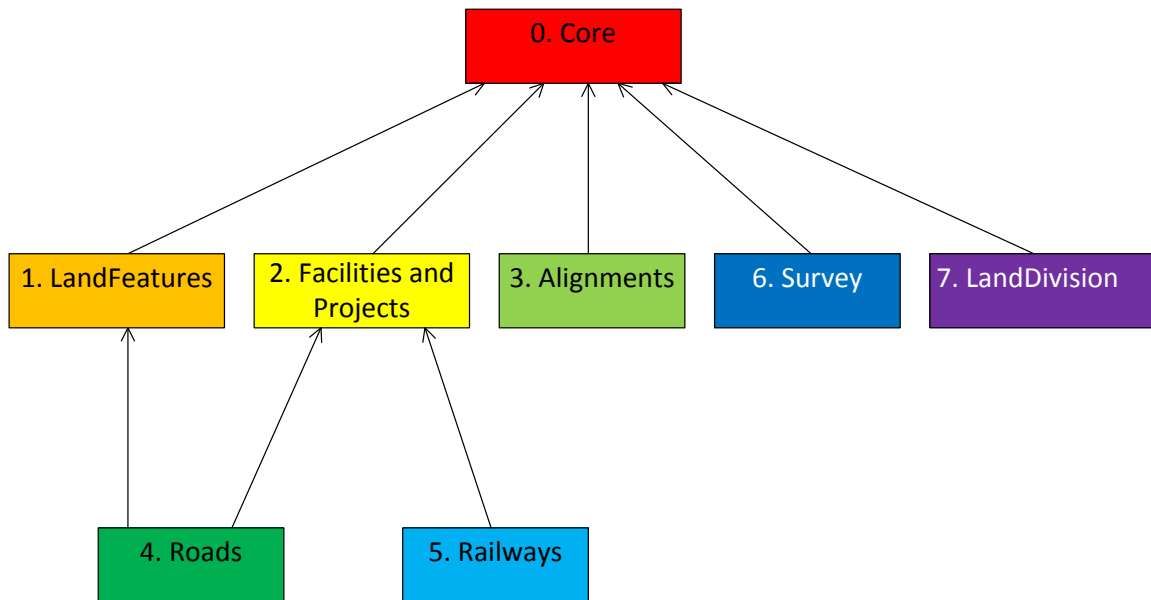


Figure 1. InfraGML Part Dependencies

The boxes above represent InfraGML Parts. Arrows show Part dependencies.

The Part dependencies derive from the dependencies of the InfraGML Requirements Classes contained in these Parts. The reader should rely more on the InfraGML Requirements Class dependencies and only use the Part dependencies as a guide for knowing which InfraGML Part standards to consider.

InfraGML Parts include the following LandInfra 1.0 Requirements Classes (UML Packages):

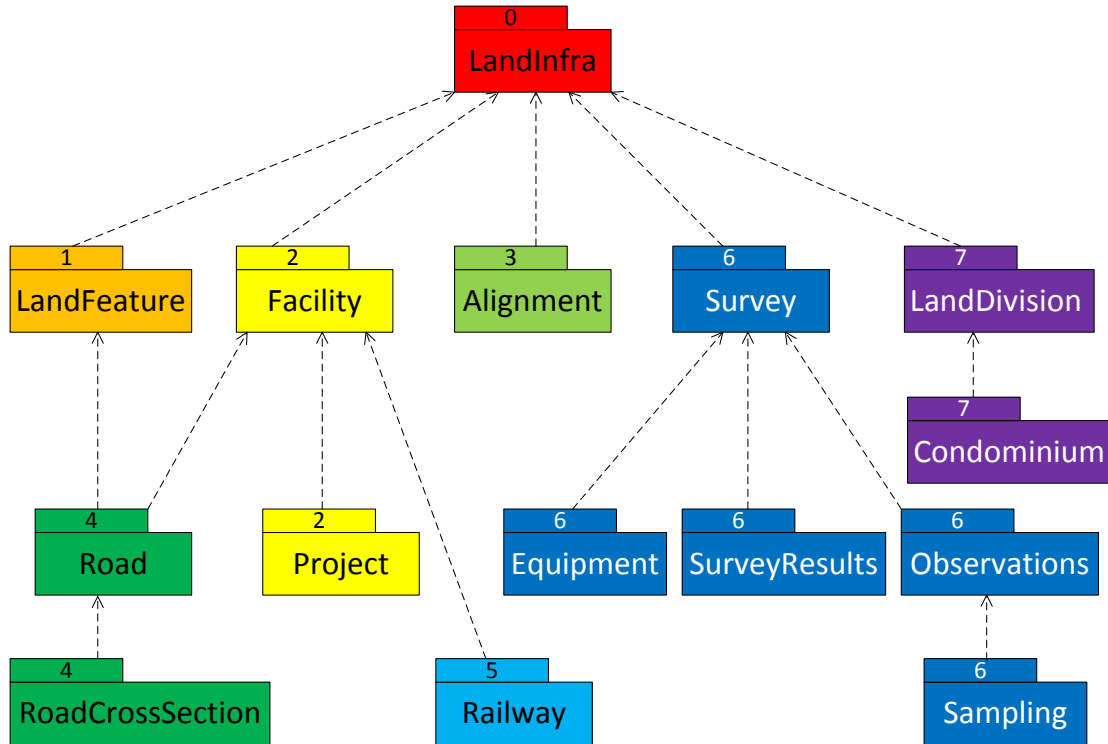


Figure 2. LandInfra Requirements Classes grouped into InfraGML Parts

The boxes above and their names represent LandInfra Requirements Classes. The numbers are InfraGML Part numbers. Dependency arrows shown above are dependencies between LandInfra Requirements Classes.

7. Requirements Classes for this Part

7.1 Structural Overview of Requirements Classes

The Requirements Classes for this Part of the InfraGML encoding standard (shown in blue in Figure 3 below) are defined in this Clause 7. Requirements Classes from other Parts upon which this Part's Requirements Classes are dependent (shown in beige in Figure 3 below) are listed here but defined in the documentation of their respective Parts. External OGC and ISO standards on which Requirements Classes in this Standard depend (shown in pink in Figure 3 below) are also listed. Below is a brief summary of the function of each of these Requirements Classes.

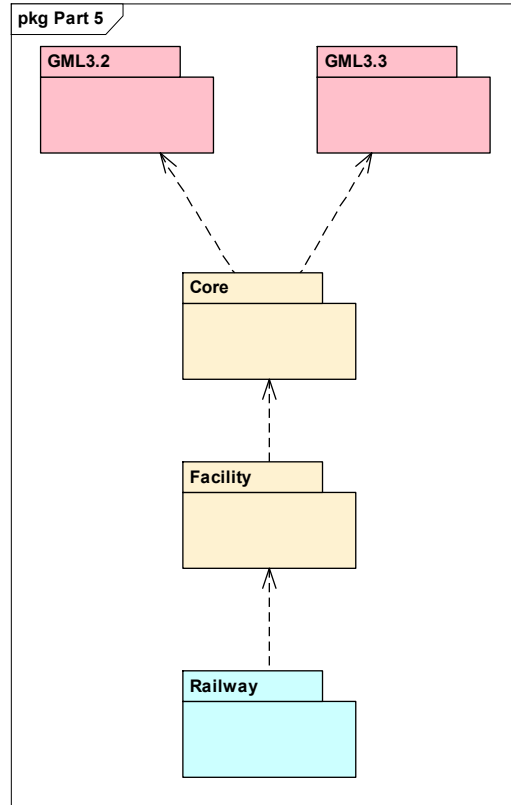


Figure 3. Requirements Classes for this Part and its Dependencies

7.1.1 Requirement Classes Defined in This Part

Railway

The Railway Requirements Class supports those use cases where a designer wishes to exchange the output of the design with someone who is likely to use it for purposes other than further design. On the other hand, a possible future RailwayDesign Requirements Class could support the more complex designer to designer information interchange, such as would exist when a designer other than the original designer takes over the design process to complete the design. Alternatively, this may be left to IFCs.

Consequently, the Railway Requirements Class covers design output such as RailwayElements, track geometry including chainage discontinuities and superelevation (cant).

7.1.2 Dependent Requirement Classes Defined in Other Parts

The Requirements Classes defined in this Part are dependent on the following Requirements Classes from other Parts.

Part 0. LandInfra Core

LandInfra is the core Requirements Class and is the only mandatory Requirements Class. This class contains information about the Land and Infrastructure dataset that can contain information about facilities, land features, land division, documents, survey marks, surveys, sets, and feature associations. LandInfra also contains the definition of types common across other Requirements Classes, such as the Status CodeList.

Part 2. LandInfra Facility

Facilities include collections of buildings and civil engineering works and their associated siteworks. The Facilities Requirements Class includes the breakdown of facilities into discipline specific facility parts and introduces the notion of elements which make up these parts. The Facilities Requirements Class only provides general support for facilities themselves, allowing subsequent Requirements Classes to focus on specific types of the parts that make up facilities, such as road and railway. This Requirements Class is optional in order to allow for the condition where all of the LandInfra dataset information is not facility related, such as one containing only survey or land division information.

7.1.3 Other Standards upon which the Requirement Classes of this Part Depend

For external OGC and ISO standards on which Requirements Classes in this Standard depend, a brief summary of the function of each of these Standards is described below.

GML 3.2

OGC 07-036, OpenGIS® Geography Markup Language (GML) Encoding Standard, v3.2 provides most of the geometry types (e.g., Point, LineString, Polygon) used for spatial representations in this Standard. Defines Coordinate Reference Systems. Supports the General Feature Model upon which this Standard is based.

GML 3.3

OGC 10-129r1, OGC® Geography Markup Language (GML) — Extended schemas and encoding rules, v3.3 defines the linear referencing concepts (e.g., linear element, distance along, Linear Referencing Methods) used for linearly referenced locations in this Standard.

7.2 Requirements Class: Railway

Requirements Class	
/req/railway	
Target type	Conforming application
Name	Railway
Dependency	/req/facility (from InfraGML Part 2)
Dependency	/req/alignment (optional) (from InfraGML Part 3)
Requirement	/req/railway/elements
Requirement	/req/railway/alignment

7.2.1 Implementation decisions regarding OGC 15-111r1 UML

The following implementation decisions have been made regarding the OGC 15-111r1 Railway Requirements Class UML:

1. The explicit association between the Railway.alignment from the Railway class to the Alignment class in the conceptual model was implemented by instead re-using the Feature.spatialRepresentation element. Since the complexType AlignmentCurve is in the gml:AbstractCurve substitutionGroup it may optionally be used as the spatialRepresentation for a Railway element if the application supports the Alignment Requirements Class from LandInfra Part 3 (where AlignmentCurve is defined).
2. Because the Feature.FeatureID attribute was dropped from Core (see Part 0), Railway.railwayID has been added. Because Element was removed from Part 2 Facilities and Projects, Railway.railwayElementID has been added. IDs have also been added for RailwayElementSet.

7.2.2 Specific Requirements for this Requirements Class

Requirement	/req/railway/elements A conforming application shall support the Railway XML elements listed in Table 1 in accordance with the GML XSD specified in http://schemas.opengis.net/infragml/part5/1.0/railway.xsd .
--------------------	---

An application conforming to this standard shall support the Railway XML elements listed below in *Table 1* in accordance with the GML XSD specified in <http://schemas.opengis.net/infragml/part5/1.0/railway.xsd>. Railway XML element names are shown with a XML namespace prefix of “lifrw”. Corresponding LandInfra UML classes are shown with their LandInfra Requirements Class prefix of “Railway”.

InfraGML XML element	LandInfra UML Class
lifrw:CantEvent	Railway::CantEvent
lifrw:CantSpecification	Railway:: CantSpecification
lifrw:Railway	Railway::Railway
lifrw:RailwayElement	Railway::RailwayElement
lifrw:RailwayElementSet	Railway:: RailwayElementSet

Table 1. InfraGML Railway XML elements with corresponding LandInfra UML classes

A Railway FacilityPart is represented as RailwayElements. These can be specified relative to some linear element, in accordance with OGC Abstract Specification Topic 19,

Linear Referencing. If the application supports the InfraGML Alignment Requirements Class, then an Alignment can serve as the linearly locating linear element.

Requirement	/req/road/alignment If an application allows the linear element used for locating RailwayElements to be an Alignment, or if it allows the spatialRepresentation geometry to be of type AlignmentCurve, then that application shall support the Alignment Requirements Class.
--------------------	--

7.2.3 Railway with RailwayElement (switch) example

The RailwayElement example follows the OGC 15-111r1, Clause 7.7.3, [LandInfra] RailwayElement. The switch is described as a Railway FacilityPart which is a collection of RailwayElements, see Annex **Error! Reference source not found.**

7.2.4 Railway with Cant example

The cant of a railway track (also referred to as superelevation) is the difference in elevation (height) between the two rails. This is normally done where the railway is curved; raising the outer rail providing a banked turn. The superelevation development length is the distance over which superelevation is developed from the normal cross-fall to full superelevation.

CantEvent marks a location along the linear element where an applied cant value is specified. If two succeeding CantEvents have the same applied cant value, then that value applies to the entire linear element segment between those two events. If two succeeding CantEvents have different applied cant values, then the cant value is assumed to vary linearly between the two events. CantSpecification is a collection of CantEvents along a single linear element for a single Railway, see Annex B. 1.

8. Media Types for any data encoding(s)

Data for all Parts of the InfraGML encoding standard is encoded in GML-conformant XML documents. The standard MIME-type and sub-type for GML data should be used to indicate the encoding in internet exchange, as specified in MIME Media Types for GML, namely ‘application/gml+xml’.

Annex A: Conformance Class Abstract Test Suite (Normative)

A.1 Conformance class: Railway

/conf/road		
Requirements	/req/railway	
Dependency	/conf/facility (from InfraGML Part 2)	
Dependency	/conf/alignment (optional) (from InfraGML Part 3)	
Test	/conf/railway/elements	
	Requirement	/req/railway/elements
	Test purpose	Verify that the conforming application supports the Railway XML elements listed in Table 1 in accordance with the GML XSD specified in http://schemas.opengis.net/infragml/part5/1.0/railway.xsd .
	Test method	Inspect the GML output to verify the above requirement.
	Test type	Capability
Test	/conf/railway/alignment	
	Requirement	/req/railway/alignment
	Test purpose	Verify that if the application allows the linear element used for locating RailwayElements to be an Alignment or if the spatialRepresentation to be an AlignmentCurve then that application shall support the Alignment Requirements Class. Verify that the conforming application supports the /req/alignment requirements class in part3-alignments-encoding standard.
	Test method	Inspect the application to verify the above requirement is satisfied.
	Test type	Capability

Annex B: Sample XML (Informative)

B.1 Railway alignment, cant and kilometer connections example

```
<?xml version="1.0" encoding="UTF-8"?>
<li:LandInfraDataset xmlns:lifr="http://www.opengis.net/infragml/railway/1.0"
xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:gmd="http://www.isotc211.org/2005/gmd"
xmlns:gsr="http://www.isotc211.org/2005/gsr" xmlns:gss="http://www.isotc211.org/2005/gss"
xmlns:gts="http://www.isotc211.org/2005/gts" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:lr="http://www.opengis.net/gml/3.3/lr" xmlns:lro="http://www.opengis.net/gml/3.3/lro"
xmlns:li="http://www.opengis.net/infragml/core/1.0"
xmlns:lip="http://www.opengis.net/infragml/project/1.0"
xmlns:lif="http://www.opengis.net/infragml/facility/1.0"
xmlns:lia="http://www.opengis.net/infragml/alignment/1.0" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/infragml/railway/1.0 Part5Railway0410.xsd
http://www.opengis.net/infragml/alignment/1.0 Part3Alignment0410.xsd" gml:id="ds1">
  <li:datasetID>
    <li:ID>
      <li:identifier>Example dataset for kilometer connections, alignment and cant for a
railway</li:identifier>
    </li:ID>
  </li:datasetID>
  <li:dateTime>2016-11-17T12:00:00Z</li:dateTime>
  <li:datasetVersion>1.0</li:datasetVersion>
  <li:application>Example</li:application>
  <li:author>Lars Wikström, Triona/Trafikverket</li:author>
  <li:infraVersion>1.0</li:infraVersion>
  <li:language>en</li:language>
  <li:defaultCRS xlink:href="urn:ogc:def:crs:EPSG:3006"/>
  <!--SWEREF 99 TM-->
  <li:linearElement>
    <li:LinearElement gml:id="lah1">
      <lr:curve xlink:href="#ah1"/>
      <lr:defaultLRM>
        <lr:LinearReferencingMethod gml:id="lrm1">
          <lr:name>stationing</lr:name>
          <lr:type>absolute</lr:type>
          <lr:units>meter</lr:units>
        </lr:LinearReferencingMethod>
      </lr:defaultLRM>
      <lr:measure uom="meter">1234</lr:measure>
      <lr:startValue lrm="#lrm1">32164.197</lr:startValue>
    </li:LinearElement>
    <li:referent>
      <lr:Referent gml:id="KM32">
        <lr:name>KM32+</lr:name>
        <lr:type>referenceMarker</lr:type>
        <lr:location>
          <lr:PositionExpression gml:id="pe1">
            <lr:linearElement xlink:href="#ah1"/>
            <lr:lrm xlink:href="#lrm1"/>
            <lr:distanceExpression>
              <lr:DistanceExpression gml:id="de1">
                <!-- The alignment starts between the referents. Therefore the distanceAlong is
negative -->
```

```

        <lr:distanceAlong>-164.197</lr:distanceAlong>
        </lr:DistanceExpression>
    </lr:distanceExpression>
    </lr:PositionExpression>
</lr:location>
    <lr:ownedBy xlink:href="ah1"/>
</lr:Referent>
</li:referent>
<li:referent>
    <lr:Referent gml:id="KM33">
        <lr:name>KM33+</lr:name>
        <lr:type>referenceMarker</lr:type>
        <lr:location>
            <lr:PositionExpression gml:id="pe2">
                <lr:linearElement xlink:href="#ah1"/>
                <lr:lr:lr xlink:href="#lrm1"/>
                <lr:distanceExpression>
                    <lr:DistanceExpression gml:id="de2">
                        <lr:distanceAlong>999.858</lr:distanceAlong>
                        <lr:referent xlink:href="#KM32"/>
                    </lr:DistanceExpression>
                </lr:distanceExpression>
            </lr:PositionExpression>
        </lr:location>
        <lr:ownedBy xlink:href="ah1"/>
    </lr:Referent>
</li:referent>
<li:referent>
    <lr:Referent gml:id="KM34">
        <lr:name>KM34+</lr:name>
        <lr:type>referenceMarker</lr:type>
        <lr:location>
            <lr:PositionExpression gml:id="pe3">
                <lr:linearElement xlink:href="#ah1"/>
                <lr:lr:lr xlink:href="#lrm1"/>
                <lr:distanceExpression>
                    <lr:DistanceExpression gml:id="de3">
                        <lr:distanceAlong>1000.641</lr:distanceAlong>
                        <lr:referent xlink:href="#KM33"/>
                    </lr:DistanceExpression>
                </lr:distanceExpression>
            </lr:PositionExpression>
        </lr:location>
        <lr:ownedBy xlink:href="ah1"/>
    </lr:Referent>
</li:referent>
<li:referent>
    <lr:Referent gml:id="KM35">
        <lr:name>KM35+</lr:name>
        <lr:type>referenceMarker</lr:type>
        <lr:location>
            <lr:PositionExpression gml:id="pe4">
                <lr:linearElement xlink:href="#ah1"/>
                <lr:lr:lr xlink:href="#lrm1"/>
                <lr:distanceExpression>
                    <lr:DistanceExpression gml:id="de4">

```

```

        </lr:distanceAlong>999.64</lr:distanceAlong>
        </lr:referent xlink:href="#KM34"/>
    </lr:DistanceExpression>
</lr:distanceExpression>
</lr:PositionExpression>
</lr:location>
</lr:ownedBy xlink:href="ah1"/>
</lr:Referent>
</li:referent>
</li:LinearElement>
</li:linearElement>
</li:feature>
<lifrw:Railway gml:id="Railway_1">
    <li:spatialRepresentation>
        <li:SpatialRepresentation>
            <li:geometry>
                <lia:AlignmentCurve gml:id="c1">
                    <lia:horizontal>
                        <lia:Alignment2DHorizontal gml:id="ah1">
                            <lia:location>rail centerline</lia:location>
                            <lia:description/>
                            <lia:state>proposed</lia:state>
                            <lia:segment>
                                <lia:Alignment2DHorSegment>
                                    <lia:tangentialContinuity>true</lia:tangentialContinuity>
                                    <lia:geometry>
                                        <lia:LineSegment>
                                            <gml:pos>6526199.001758687 192937.67920498108</gml:pos>
                                            <gml:pos>6525902.264203765 192157.7974792793</gml:pos>
                                        </lia:LineSegment>
                                    </lia:geometry>
                                </lia:Alignment2DHorSegment>
                            </lia:segment>
                            <lia:segment>
                                <lia:Alignment2DHorSegment>
                                    <lia:tangentialContinuity>true</lia:tangentialContinuity>
                                    <lia:geometry>
                                        <lia:TransitionSegment gml:id="ahs4">
                                            <lia:referenceLocation>
                                                <gml:AffinePlacement>
                                                    <gml:location>6525902.264203765
192157.7974792793</gml:location>
                                                    <gml:refDirection/>
                                                    <gml:inDimension>2</gml:inDimension>
                                                    <gml:outDimension>2</gml:outDimension>
                                                </gml:AffinePlacement>
                                            </lia:referenceLocation>
                                            <lia:length uom="m">106.0</lia:length>
                                            <lia:startCurvature>INF</lia:startCurvature>
                                            <lia:endCurvature>833.0</lia:endCurvature>
                                            <lia:transitionType>clothoid</lia:transitionType>
                                        </lia:TransitionSegment>
                                    </lia:geometry>
                                </lia:Alignment2DHorSegment>
                            </lia:segment>
                            <lia:segment>

```

```

<lia:Alignment2DHorSegment>
  <lia:tangentialContinuity>true</lia:tangentialContinuity>
  <lia:geometry>
    <lia:CircularArcSegment>
      <lia:circularArcSegment>
        <lia:CircularArcByCenterPoint numArc="1">
          <gml:pos>6525862.483385857 192059.56589581826</gml:pos>
          <gml:radius uom="m">500</gml:radius>
          <gml:startAngle uom="gon">0</gml:startAngle>
          <gml:endAngle uom="gon">50</gml:endAngle>
        </lia:CircularArcByCenterPoint>
      </lia:circularArcSegment>
    </lia:CircularArcSegment>
  </lia:geometry>
</lia:Alignment2DHorSegment>
</lia:segment>
</lia:Alignment2DHorizontal>
</lia:horizontal>
<lia:vertical>
  <lia:Alignment2DVertical gml:id="av1">
    <lia:location>railway centerline</lia:location>
    <lia:description/>
    <lia:state>proposed</lia:state>
    <lia:segments>
      <lia:Alignment2DVertSegment>
        <lia:tangentialContinuity>true</lia:tangentialContinuity>
        <lia:startDistAlong>
          <lr:DistanceExpression gml:id="sda1">
            <lr:distanceAlong>0</lr:distanceAlong>
          </lr:DistanceExpression>
        </lia:startDistAlong>
        <lia:startHeight uom="meter">50</lia:startHeight>
        <lia:startGradient>-1.0</lia:startGradient>
        <lia:horizontalLength uom="meter">100</lia:horizontalLength>
      </lia:Alignment2DVertSegment>
    </lia:segments>
    <lia:measuredAlong xlink:href="#ah1"/>
  </lia:Alignment2DVertical>
</lia:vertical>
</lia:AlignmentCurve>
</li:geometry>
</li:SpatialRepresentation>
</li:spatialRepresentation>
<lif:facilityPartID>
  <lif:ID>
    <li:identifier>Railway_1</li:identifier>
  </lif:ID>
</lif:facilityPartID>
<lif:type xlink:href="http://example.com/facilityPart#lrailway"/>
<lif:status xlink:href="http://example.com/status#planned"/>
<lifrw:railwayID>
  <lifrw:ID>
    <li:identifier>Railway_1</li:identifier>
  </lifrw:ID>
</lifrw:railwayID>
<lifrw:cantSpecification>

```

```

<lifrw:CantSpecification gml:id="cs_1">
  <lifrw:gauge uom="m">1.5</lifrw:gauge>
  <lifrw:name>Hmmm</lifrw:name>
  <lifrw:cantEvent>
    <lifrw:CantEvent gml:id="ce_1">
      <lifrw:eventAt>
        <lr:DistanceExpression gml:id="cde_1">
          <lr:distanceAlong>37148.967</lr:distanceAlong>
        </lr:DistanceExpression>
      </lifrw:eventAt>
      <lifrw:appliedCant uom="mm">0</lifrw:appliedCant>
      <lifrw:cantSide>neither</lifrw:cantSide>
    </lifrw:CantEvent>
  </lifrw:cantEvent>
  <lifrw:cantEvent>
    <lifrw:CantEvent gml:id="ce_2">
      <lifrw:eventAt>
        <lr:DistanceExpression gml:id="cde_2">
          <lr:distanceAlong>37983.39416</lr:distanceAlong>
        </lr:DistanceExpression>
      </lifrw:eventAt>
      <lifrw:appliedCant uom="mm">0</lifrw:appliedCant>
      <lifrw:cantSide>neither</lifrw:cantSide>
    </lifrw:CantEvent>
  </lifrw:cantEvent>
  <lifrw:cantEvent>
    <lifrw:CantEvent gml:id="ce_3">
      <lifrw:eventAt>
        <lr:DistanceExpression gml:id="cde_3">
          <lr:distanceAlong>38089.394159999996</lr:distanceAlong>
        </lr:DistanceExpression>
      </lifrw:eventAt>
      <lifrw:appliedCant uom="mm">140</lifrw:appliedCant>
      <lifrw:cantSide>left</lifrw:cantSide>
    </lifrw:CantEvent>
  </lifrw:cantEvent>
  <lifrw:cantEvent>
    <lifrw:CantEvent gml:id="ce_4">
      <lifrw:eventAt>
        <lr:DistanceExpression gml:id="cde_4">
          <lr:distanceAlong>38128.33288999999</lr:distanceAlong>
        </lr:DistanceExpression>
      </lifrw:eventAt>
      <lifrw:appliedCant uom="mm">140</lifrw:appliedCant>
      <lifrw:cantSide>left</lifrw:cantSide>
    </lifrw:CantEvent>
  </lifrw:cantEvent>
  <lifrw:cantEvent>
    <lifrw:CantEvent gml:id="ce_5">
      <lifrw:eventAt>
        <lr:DistanceExpression gml:id="cde_5">
          <lr:distanceAlong>38234.33288999999</lr:distanceAlong>
        </lr:DistanceExpression>
      </lifrw:eventAt>
      <lifrw:appliedCant uom="mm">0</lifrw:appliedCant>
      <lifrw:cantSide>neither</lifrw:cantSide>
    </lifrw:CantEvent>
  </lifrw:cantEvent>
</lifrw:CantSpecification>

```

```
</lifrw:CantEvent>
</lifrw:cantEvent>
<lifrw:locatedAlong xlink:href="#ah1"/>
</lifrw:CantSpecification>
</lifrw:cantSpecification>
</lifrw:Railway>
</li:feature>
</li:LandInfraDataset>
```


B. 2 Railway switch example

```
<?xml version="1.0" encoding="UTF-8"?>
<li:LandInfraDataset xmlns:lifrw="http://www.opengis.net/infragml/railway/1.0"
xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:gmd="http://www.isotc211.org/2005/gmd"
xmlns:gsr="http://www.isotc211.org/2005/gsr" xmlns:gss="http://www.isotc211.org/2005/gss"
xmlns:gts="http://www.isotc211.org/2005/gts" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:lr="http://www.opengis.net/gml/3.3/lr" xmlns:lro="http://www.opengis.net/gml/3.3/lro"
xmlns:li="http://www.opengis.net/infragml/core/1.0"
xmlns:lip="http://www.opengis.net/infragml/project/1.0"
xmlns:lif="http://www.opengis.net/infragml/facility/1.0"
xmlns:lia="http://www.opengis.net/infragml/alignment/1.0" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/infragml/railway/1.0 Part5Railway0410.xsd"
gml:id="ds_switch_example_1">
  <li:datasetID>
    <li:ID>
      <li:identifier>Example dataset for a railway switch specifying a number of parameters and identified
points</li:identifier>
    </li:ID>
  </li:datasetID>
  <li:dateTime>2016-11-16T12:00:00Z</li:dateTime>
  <li:datasetVersion>1.0</li:datasetVersion>
  <li:application>Example</li:application>
  <li:author>Lars Wikström/Peter Axelsson, Triona/Trafikverket</li:author>
  <li:infraVersion>1.0</li:infraVersion>
  <li:language>en</li:language>
  <li:defaultCRS xlink:href="urn:ogc:def:crs:EPSG:3006"/>
  <!--SWEREF 99 TM-->
  <li:feature>
    <lif:Facility gml:id="facility_1">
      <lif:facilityID>
        <lif:ID>
          <li:identifier>Borlänge</li:identifier>
        </lif:ID>
      </lif:facilityID>
      <lif:type>railway</lif:type>
      <lif:status xlink:href="http://example.com/status#planned"/>
      <lif:part>
        <lifrw:Railway gml:id="railway_1">
          <lif:facilityPartID>
            <lif:ID>
              <li:identifier/>
            </lif:ID>
          </lif:facilityPartID>
          <lif:type xlink:href="http://example.com/facilityPart#lrailway"/>
          <lif:status xlink:href="http://example.com/status#planned"/>
          <lifrw:railwayID>
            <lifrw:ID>
              <li:identifier/>
            </lifrw:ID>
          </lifrw:railwayID>
          <lifrw:element>
            <lifrw:RailwayElement gml:id="switch_1">
              <li:property>
                <li:Property gml:id="ps10">
```

```

        <li:valueType>code</li:valueType>
        <li:value>EV-UIC60-760-1:15-H</li:value>
    </li:Property>
</li:property>
<li:property>
    <li:Property gml:id="ps11">
        <li:valueType>trackpart</li:valueType>
        <li:value>306</li:value>
    </li:Property>
</li:property>
<li:property>
    <li:Property gml:id="ps12">
        <li:valueType>curvature</li:valueType>
        <li:value>IBV</li:value>
    </li:Property>
</li:property>
<lif:part>
    <lifrw:RailwayElement gml:id="MKP">
        <li:spatialRepresentation>
            <li:SpatialRepresentation>
                <li:geometry>
                    <gml:Point gml:id="sp1">
                        <gml:pos>6882688.47200 57322.84400 55.80200</gml:pos>
                    </gml:Point>
                </li:geometry>
            </li:SpatialRepresentation>
        </li:spatialRepresentation>
        <lifrw:railwayElementID>
            <lifrw:ID>
                <li:identifier/>
            </lifrw:ID>
        </lifrw:railwayElementID>
        <lifrw:railwayElementType
xlink:href="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType#MKP"/>
    </lifrw:RailwayElement>
</lif:part>
<lif:part>
    <lifrw:RailwayElement gml:id="TSP">
        <li:spatialRepresentation>
            <li:SpatialRepresentation>
                <li:geometry>
                    <gml:Point gml:id="sp2">
                        <gml:pos>6882687.27200 57313.66000 55.73800</gml:pos>
                    </gml:Point>
                </li:geometry>
            </li:SpatialRepresentation>
        </li:spatialRepresentation>
        <lifrw:railwayElementID>
            <lifrw:ID>
                <li:identifier/>
            </lifrw:ID>
        </lifrw:railwayElementID>
        <lifrw:railwayElementType
xlink:href="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType#TSP"/>
    </lifrw:RailwayElement>
</lif:part>

```

```
<lifrw:railwayElementID>
  <lifrw:ID>
    <li:identifier>23a</li:identifier>
  </lifrw:ID>
</lifrw:railwayElementID>
<lifrw:railwayElementType xlink:href="urn:x-
ogc:specification:gmlas:LandInfra:Railway:1.0/RailwayElementType#switch"/>
</lifrw:RailwayElement>
</lifrw:element>
</lifrw:Railway>
</lif:part>
</lif:Facility>
</li:feature>
</li:LandInfraDataset>
```

B.3 Example codelist from Trafikverket

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href='./CodelistDictionary-v32.xsl'?>
<Dictionary xmlns="http://www.opengis.net/gml/3.2" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" gml:id="RailwayElementType"
xsi:schemaLocation="http://www.opengis.net/gml/3.2
http://schemas.opengis.net/gml/3.2.1/gml.xsd">
  <description>-- Definition --&#13;
Types of railway elements.&#13;
</description>
  <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0">RailwayElementType</identifier>
  <dictionaryEntry>
    <Definition gml:id="MKP">
      <description>Matematisk korsningspunkt</description>
      <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">MKP</identifier>
      <name>MKP</name>
    </Definition>
  </dictionaryEntry>
  <dictionaryEntry>
    <Definition gml:id="FSK">
      <description>Främre stödrällsskarv</description>
      <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">FSK</identifier>
      <name>FSK</name>
    </Definition>
  </dictionaryEntry>
  <dictionaryEntry>
    <Definition gml:id="BKS1">
      <description>Bakre korsningsskarv 1</description>
      <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">BKS1</identifier>
      <name>BKS1</name>
    </Definition>
  </dictionaryEntry>
  <dictionaryEntry>
    <Definition gml:id="BKS2">
      <description>Bakre korsningsskarv 2</description>
      <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">BKS2</identifier>
      <name>BKS2</name>
    </Definition>
  </dictionaryEntry>
  <dictionaryEntry>
    <Definition gml:id="TSP">
      <description>Tungspets</description>
      <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">TSP</identifier>
      <name>TSP</name>
    </Definition>
  </dictionaryEntry>
  <dictionaryEntry>
    <Definition gml:id="HIP">
```

```

    <description>Hinderpåle</description>
    <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">HIP</identifier>
    <name>HIP</name>
  </Definition>
</dictionaryEntry>
<dictionaryEntry>
  <Definition gml:id="SLS1">
    <description>Sista långsliper 1</description>
    <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">SLS1</identifier>
    <name>SLS1</name>
  </Definition>
</dictionaryEntry>
<dictionaryEntry>
  <Definition gml:id="SLS2">
    <description>Sista långsliper 2</description>
    <identifier
codeSpace="urn:trafikverket:LandInfra:Railway:1.0/RailwayElementType">SLS2</identifier>
    <name>SLS2</name>
  </Definition>
</dictionaryEntry>
</Dictionary>

```

Annex C: Revision history

Date	Release	Author	Paragraph modified	Description
20170307	105r1	Scarponcini	Figure 2	Dependency changes in Part 6
20170410	105r2	Wikström	Annex B	Updated the example datasets based on the restructuring (striping) in the xml schemas where occurrences of structures like: “property->property” has been restructured to: “Object->property->Object”.

Annex D: Bibliography

- [1] OGC: OGC 08-131r3 The Specification Model — A Standard for Modular specifications, Open Geospatial Consortium, 2009