Guidelines for INSPIRE application schemas and feature chaining for TN.Air

Background, Theory and Praxis

Version: 2.0
Date: 26.11.19
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Version History

0.1	13.10.18	Basic doc with all classes
0.2	14.10.18	Updated info on derivation hierarchy, structured classes accordingly
0.3	15.10.18	A few more bits found in the derivation hierarchy, added to overview
0.4	17.10.18	Associations between LinkSequence and Link as well as between LinkSet and GeneralizedLink described. Association Chapter extended to differentiate between direct associations and indirect associations via a dataType
0.5	22.10.18	Association chapter restructured to reflect the two association types (feature chaining and joins vs. isMultiple and denormalized tables)
0.6	15.11.18	Addition of ACG Mapping
1.0	23.12.18	Finalization of Report
2.0	26.11.19	Corrections and editorial changes

Contents

1. Introduction

Resolvable URLs are an essential aspect of any distributed SDI, as individual features must be clearly referenceable and retrievable. This pertains to both direct access to a feature as well as to providing relevant interlinkages between features, supplying essential contextual information. While it is conceivable to utilize the service URLs made available via the Web Feature Service (WFS), these are complex, fragile and prone to change over time. URL rewriting is useful in those cases where one wishes to provide a compact and usable URL in place of a more complex service URL.

Example:

> In order to specify access to an explicit feature utilizing the service URL, one would need to provide a URL as follows:
>
> > http://service.datacove.eu:8080/geoserver/tn-a/ows?service=WFS&version=2.0&request=GetFeature&typeNames=tn-a:RunwayArea&outputFormat=gml32&FeatureId=1-2017-11-10
>
> Apart from being long and messy, this type of URL is prone to change over time as different technologies and versions are utilized for provision. Far nicer would be a URL in the following form:
>
> > http://guid.datacove.eu/tn.RunwayArea/1-2017-11-10

In this document, in addition to explaining the theory of URL rewriting and its utilization in the provision of complex data sources, we will also provide all information required to implement these concepts, both pertaining to the necessary rewriting to be performed via the web server providing basic HTTP functionality as well as the details of GeoServer Feature Chaining, to be configured via the GeoServer App Schema extension.

2. Relevance to INSPIRE

Within INSPIRE, the associations between featureTypes are provided via the xlink:href attribute. Utilizing a clean simple URL for this purpose not only provides cleaner more readable XML, it also gives duration to the reference, as technology can change over time, while this URL can continue to be resolved to the currently utilized technology. Thus, this URL can also be utilized as a persistent Globally Unique Identifier (GUID), not only providing a unique name for an object, but also the mechanisms for direct access through HTTP resolution.

This approach has already been adopted as one of two options within the Austrian INSPIRE metadata recommendations [INSPIRE-AT_Metadatenerfassungsleitfaden_v2-2.pdf] for the identification of a metadata record, whereby the following syntax has been recommended:

Basis-URL/Geodatenstelle/Ressourcenbezeichner

Examples:

https://data.inspire.gv.at/0002/37d564f9-5d63-4760-aae6-29d3f98ee1b4
Version mit UUID als Ressourcenbezeichner

https://data.inspire.gv.at/0019/HAZARD_AREA_HQ30
Version mit sprechendem Ressourcenbezeichner

This pattern is continued in the data recommendations, where the HTTP option is specified as follows:

Inspire Id:

Namespace: Metadata URL/[Theme].[FeatureType]

LocalId: Local ID of the feature, must be unique within the FeatureType

Resolvable URI:

Namespace/LocalId

Example:

https://data.inspire.gv.at/0019/HAZARD_AREA_HQ30/nz.HazardArea/K2494213

Theme: 2 character abbreviation of INSPIRE Theme

FeatureType: class name of the feature being provided

3. How to Configure URL Rewriting

For this type of rewriting, the web server must be configured with the proper rewriting rules. In the example, we have utilized Apache, but the same principles apply to all web servers.

Under Apache, the rewrite rule has the following syntax:

RewriteRule *Pattern Substitution [flags]*

Whereby the arguments of the rule are defined as follows:

1. Pattern: which incoming URLs should be affected by the rule, described as a regular expression;
2. Substitution: where should the matching requests be sent;
3. [flags]: options affecting the rewritten request.

The Apache rewrite rule for the example above as applied to the domain guid.datacove.eu is as follows:

RewriteRule ^/tn-a.RunwayArea/(.*)$ http://service.datacove.eu:8080/geoserver/tn-a/ows?service=WFS&version=2.0&request=GetFeature&typeNames=tn-a:RunwayArea&featureID=$1 [L]

The text “RewriteRule” tells the Apache Server that it is a rewrite rule. This is followed by the Pattern, a regular expression containing the pattern for the incoming URL, whereby the groups in parenthesis () specify individual variables to be extracted from the incoming URL, and the symbol ^ represents the base URL of the service. Thus, the pattern ^/tn-a.RunwayArea/(.*)$ corresponds to all incoming URLs of the form guid.datacove.eu/tn-a.RunwayArea/XXX, whereby everything after the “tn-a.RunwayArea/”, in this example “XXX” is assigned to the first variable.

The Substitution provides the final target URL, whereby the variables extracted from the Pattern can be dynamically inserted. In our example, $1 provides the identifier of the GeographicalName feature provided after the “tn-a.RunwayArea/” in the clean URI. Thus, the simple URL shown above resolves to the service URL described.

4. Some Background Thoughts

Backlink on Metadata

In order to allow a data user who has accessed a feature via the clean rewritten URL to also interrogate the service itself, access to the service URL should be provided. This allows the user to access other related features provided by this service, but not directly linked to the initial feature accessed; it also allows for filtering on these additional features.

A simple way of fulfilling this requirement is to provide a link to the metadata record of this feature within the gml:metadata element of the individual features. As the metadata record contains information on the service URL, additional features can be accessed in a fully automated and standardized manner.

Clean Base URL

In order to assure that the rewritten URLs are persistent, it is essential to assure that a clean base URL is utilized. A common mistake is taking one's agency's URL in some form, only to find one rebranded the next day, URL gone. As costs for a domain are quite low, it would be sensible to acquire a dedicated URL for the long-term provision of rewritten URLs.

5. Austro Control Identifiers and Links

In order to create a sustainable identifier scheme for the featureTypes to be served under TNA, we must first analyze the relevant identifiers. In addition, we must define which identifiers are utilized for the provision of a persistent URL-based GUID for referencing purposes.

Identifiers in INSPIRE

The following identifiers pertain to INSPIRE features:

- **gml:id:** cannot start with a number. It must be a letter or underscore "_", after this characters may be letters, numbers or one of "_", "-", "."
- **gml:identifier** (note: this is currently not utilized, but provided for completeness and future compatibility)
    - codespace: URI
    - id: string
- **net:inspireId**
    - namespace: URI, ideally related with the metadata URL
    - localId: string
    - version: string, ideally a timestamp

Identifiers in Austro Control

The following information is available locally to identify INSPIRE features:

- **<ACG_id>** (local Austro Control ID)
- **<featureType>**: <featureNS>.<featureType>
    - **<featureNS>:** this is either "tn" or "tn-a"
    - **<featureType>:** the class name of the feature being served
- **<ACG_metadata_URL>:** <ACG_URI>/<ProviderID>.<MD_UUID>
    - **<ACG_URI>:** Base URI for MD URL
    - **<ProviderID>:** AT.0012
    - **<MD_UUID>:** UUID of the Metadata Record
    - e.g.: https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1
- **<ACG_Version>:** timestamp as of which this version is valid

Identifier Mapping Austro Control -> INSPIRE

InspireId

- **<namespace>** = <ACG_metadata_URL>
- **<localId>** = <featureNS>.<featureType>.<ACG_id>
- **<version>** = <ACG_Version>

gml:id = AT.<ProviderID>.<MD_UUID>.<featureType>.<ACG_id>

gml:identifier

- **<codespace>** = <ACG_metadata_URL>
- **<identifier>** =<ACG_metadata_URL>/<featureNS>.<featureType>.<ACG_id>

gml:identifier alternative 2

- **<codespace>** = http://inspire.jrc.ec.europa.eu/ids
- **<identifier>** = <Resolvable URI>

<Resolvable URI> = <namespace>/<localId>

Example

Base Information:

- **<ACG_id>**: 1
- **<featureType>:** tn-a.AerodromeNode
    - **<featureNS>:** tn-a
    - **<featureType>:** AerodromeNode
- **<ACG_metadata_URL>:** https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1
    - **<ACG_URI>:** https://inspire.austrocontrol.at
    - **<ProviderID>:** AT.0012
    - **<MD_UUID>:** 6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1
- **<ACG_Version>:** 2018-06-22

InspireId:

- **Namespace** = https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/
- **LocalId** = tn-a.AerodromeNode.1
    - **featureNS**: tn-a
    - **featureType**: AerodromeNode
    - **id:** 1
- **Version** = 2018-06-22

gml:id:

- AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1.tn-a.AerodromeNode.1

gml:identifier:

- **<codespace>** = https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/
- **<identifier>** = tn-a.AerodromeNode.1

gml:identifier alternative 2:

- **<codespace>** = http://inspire.jrc.ec.europa.eu/ids
- **<identifier>** = https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.1

Resolvable URI:

https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.1

Resolvable URI with version: will not be available

Feature Metadata Link

In addition, the gml:metaDataProperty should be provided, whereby the xlink:href attribute should contain the Metadata URL.

Rewriting Rules

Due to the solidity of the metadata scheme described in the sections above, individual features can be accessed either via their inspireId or their gml:id, as shown in the following examples, both accessing the tn-a RunwayArea feature with id 1:

> https://sdigeo-free.austrocontrol.at/geoserver/tn-a/wfs?service=WFS&version=2.0.0&request=GetFeature&**STOREDQUERY_ID**=GetRunwayAreaInspireID2&localid=tn-a.RunwayArea/1&ns=https://sdigeo-free.austrocontrol.at/0012/6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/

> https://sdigeo-free.austrocontrol.at/geoserver/tn-a/wfs?service=WFS&version=2.0.0&request=GetFeature&typeNames=tn-a:RunwayArea&**featureID**=AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1.tn-a.RunwayArea.1.2017-11-10

The URI for this feature should be as follows (base URI for Austro Control to be adjusted):

https://sdigeo-free.austrocontrol.at/0012/6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.RunwayArea/1

Regex for rewriting:

^/0012/6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.(.+)/(.+)$

Output via featureID:

https://sdigeo-free.austrocontrol.at/geoserver/tn-a/wfs?service=WFS&version=2.0&request=GetFeature&typeNames=tn-a:AirRoute&**featureID**=AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1.tn-a.**$1**.**$2**

Output via inspireId:

https://sdigeo-free.austrocontrol.at/geoserver/tn-a/wfs?service=WFS&version=2.0.0&request=GetFeature&**STOREDQUERY_ID**=Get**$1**InspireID2&localid=tn-a.**$1**/**$2**&ns=https://sdigeo-free.austrocontrol.at/0012/6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/

Some examples

Metadata for a feature:

```
https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1
```

Translates via rewriting into:

```
https://sdimd-free.austrocontrol.at/geonetwork/srv/eng/csw-inspire?SERVICE=CSW&VERSION=2.0.2&REQUEST=GetRecordById&id=6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1&resulttype=results&outputSchema=http://www.isotc211.org/2005/gmd&typenames=gmd:MD_Metadata&constraint=%3CFilter%20xmlns=%22http://www.opengis.net/ogc%22%20xmlns:gml=%22http://www.opengis.net/gml%22/%3E&constraintlanguage=FILTER&constraint_language_version=1.1.0
```

Requesting **all** features of one particular feature type:

```
https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode
```

Translates via rewriting into:

```
https://sdigeo-free.austrocontrol.at/geoserver/tn-a/wfs?service=WFS&version=2.0.0&request=GetFeature&typeNames=tn-a:AerodromeNode&outputFormat=gml32&srsName=http://www.opengis.net/def/crs/EPSG/0/4258
```

Requesting **one** features of one particular feature type:

```
https://inspire.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.42
```

Translates via rewriting into:

```
https://sdigeo-free.austrocontrol.at/geoserver/tn-a/wfs?service=WFS&version=2.0.0&request=GetFeature&typeNames=tn-a:AerodromeNode&featureId=AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1.tn-a.AerodromeNode.42&outputFormat=gml32&srsName=http://www.opengis.net/def/crs/EPSG/0/4258
```

6.

6. Stored Queries for Access via INSPIRE ID

Stored Query

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:CreateStoredQuery service="WFS" version="2.0.0"
xmlns="http://www.opengis.net/wfs/2.0"
xmlns:wfs="http://www.opengis.net/wfs/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:fes="http://www.opengis.net/fes/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:tn-a="http://inspire.ec.europa.eu/schemas/tn-a/4.0"
xmlns:tn="http://inspire.ec.europa.eu/schemas/tn/4.0"
xmlns:net="http://inspire.ec.europa.eu/schemas/net/4.0"
xmlns:base="http://inspire.ec.europa.eu/schemas/base/3.3"
xsi:schemaLocation="http://www.opengis.net/wfs/2.0 http://schemas.opengis.net/wfs/2.0/wfs.xsd
http://www.opengis.net/gml/3.2 http://schemas.opengis.net/gml/3.2.1/gml.xsd"
xmlns:ns1="http://www.opengis.net/ows/1.1">
  <wfs:StoredQueryDefinition id="GetAirRouteInspireID">
        <!-- Definition Template-Parameter -->
         <wfs:Parameter name="localid" type="xsd:string"/>
         <wfs:Parameter name="ns" type="xsd:string"/>
         <wfs:QueryExpressionText
        returnFeatureTypes="tn-a:AirRoute"
        language="urn:ogc:def:queryLanguage:OGC-WFS::WFS_QueryExpression">
                <wfs:Query typeNames="tn-a:AirRoute">
                        <fes:Filter>
                        <fes:And>
                                <fes:PropertyIsEqualTo>
                                        <fes:ValueReference>tn-
a:AirRoute/net:inspireId/base:Identifier/base:localId</fes:ValueReference>
                                        <fes:Literal>${localid}</fes:Literal>
                                </fes:PropertyIsEqualTo>
                                <fes:PropertyIsEqualTo>
                                        <fes:ValueReference>tn-
a:AirRoute/net:inspireId/base:Identifier/base:namespace</fes:ValueReference>
                                        <fes:Literal>${ns}</fes:Literal>
                                </fes:PropertyIsEqualTo>
                        </fes:And>
                        </fes:Filter>
                </wfs:Query>
         </wfs:QueryExpressionText>
  </wfs:StoredQueryDefinition>
</wfs:CreateStoredQuery>
```

Request

http://service.datacove.eu:8080/geoserver/ows?service=WFS&version=2.0.0&request=GetFeature&STOREDQUERY_ID=GetAirRouteInspireID2&localid=501&ns=http://guid.datacove.eu/TNA_MD/tn.AirRoute

7. Provision of xlinks

Feature Chaining

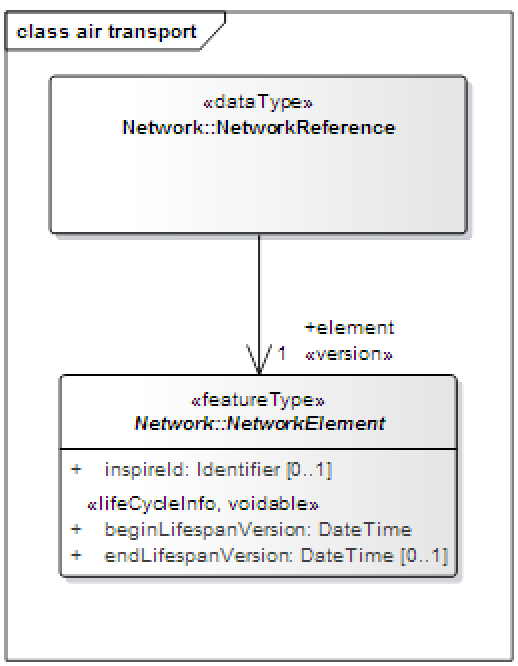
Feature Chaining applies for those cases where the association between featureTypes is done via an interim dataType. This pertains to the following associations:

- NetworkProperty.NetworkReference <–> NetworkElement
- LinkSequence.DirectedLink <-> Link

In this example we will explain Feature Chaining via the NetworkReference, that is a dataType that has been defined for linking a NetworkProperty feature to a NetworkElement. The same principles also apply to utilization of DirectedLink. The NetworkReference is utilized as an attribute of the NetworkProperty feature, and supplies the “element” association for provision of the reference to the NetworkElement.

While the multiplicity of the element association is constrained to 1, the cardinality of the networkRef element of type NetworkReference within NetworkProperty is 1..*, allowing one NetworkProperty derived featureType to reference multiple NetworkElement derived featureTypes.

Put simply, one AerodromeType feature can reference multiple AerodromeNode and AerodromeArea features.



Attribute Mapping

The attribute mapping using feature chaining consists of two parts:

- The complete FeatureTypeMapping for the featureType or dataType to be included, in our example the dataType NetworkReference.
- The reference to this additional FeatureTypeMapping from the FeatureTypeMapping of the base feature, in our example the FeatureTypeMapping for AerodromeType.

For more information on feature chaining, see the GeoServer documentation at:
http://docs.geoserver.org/stable/en/user/data/app-schema/feature-chaining.html

Attribute Mapping for NetworkReference

To create the link to the main feature, an AttributeMapping with targetAttribute "FEATURE_LINK" must be provided, where the sourceExpression is the foreign key referencing the main feature. The rest of the AttributeMapping follows the same schema as other AttributeMappings.

```
<FeatureTypeMapping>
  <sourceDataStore>idDataStoreInsp</sourceDataStore>
  <sourceType>tna_aerodromtype_netref</sourceType>
  <targetElement>net:NetworkReference</targetElement>
  <attributeMappings>
        <AttributeMapping>
              <targetAttribute>FEATURE_LINK</targetAttribute>
              <sourceExpression>
                    <OCQL>aerodrometype</OCQL>
              </sourceExpression>
        </AttributeMapping>
        <AttributeMapping>
              <targetAttribute>net:element</targetAttribute>
              <encodeIfEmpty>true</encodeIfEmpty>
              <ClientProperty>
                    <name>xlink:href</name>
                    <value>networkref</value>
              </ClientProperty>
        </AttributeMapping>
  </attributeMappings>
</FeatureTypeMapping>
```

Attribute Mapping for reference to NetworkReference

To serve as a base for linking a further feature under its targetAttribute, the Attribute Mapping contains two additional fields under the sourceExpression:

- linkElement: the featureType to be linked or embedded within the targetAttribute, our example net:NetworkReference. This must be the same featureType as specified in the targetAttribute of the AttributeMapping for the linked featureType.
- linkField: This must also contain the text “FEATURE_LINK”

The ID to which the foreign key links is provided in the OCQL of the sourceExpression.

```
<AttributeMapping>
   <targetAttribute>net:networkRef</targetAttribute>
   <sourceExpression>
         <OCQL>id</OCQL>
         <linkElement>net:NetworkReference</linkElement>
         <linkField>FEATURE_LINK</linkField>
   </sourceExpression>
</AttributeMapping>
```

DB Table

In the case of feature chaining, we are joining two tables in order to provide the links from the NetworkProperty to the NetworkElement. The table tna_aerodrometype provides an entry for each AerodromeType feature, while the table tna_aerodromtype_netref provides the link from an AerodromeType to the corresponding NetworkElement features, constrained in the case of AerodromeType to the types AerodromeNode and AerodromeArea.

tna_aerodromtype

```
CREATE TABLE public.tna_aerodrometype
(
        id character varying(100) COLLATE pg_catalog."default" NOT NULL,
        metadata character varying(100) COLLATE pg_catalog."default",
        localid character varying(100) COLLATE pg_catalog."default" NOT NULL,
        namespace character varying(100) COLLATE pg_catalog."default" NOT NULL,
        version character varying(100) COLLATE pg_catalog."default" NOT NULL,
        beginlsv timestamp with time zone,
        endlsv timestamp with time zone,
        validfrom date,
        validto date,
        name character varying(100) COLLATE pg_catalog."default",
        networkref character varying(100) COLLATE pg_catalog."default",
        aerodrometype character varying(100) COLLATE pg_catalog."default" NOT NULL,
        CONSTRAINT tna_aerodrometype_pk PRIMARY KEY (id)
);
```

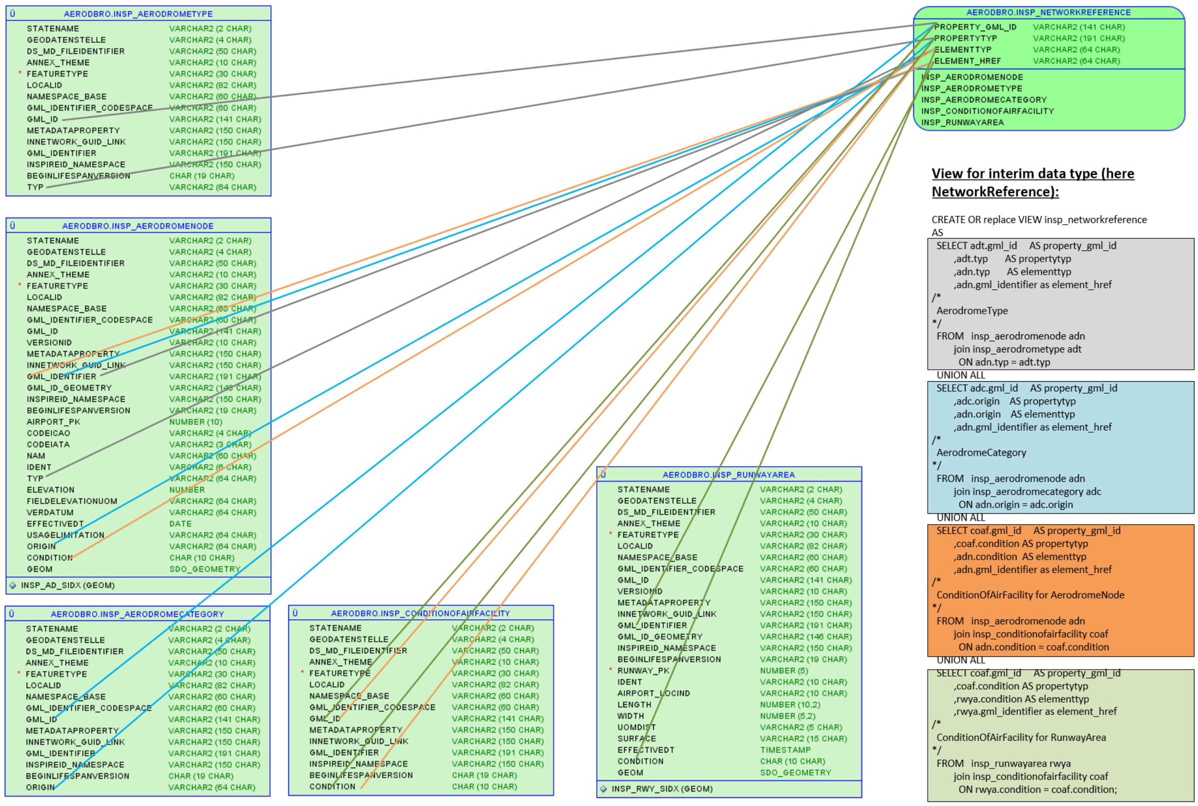
tna_aerodrometype_netref

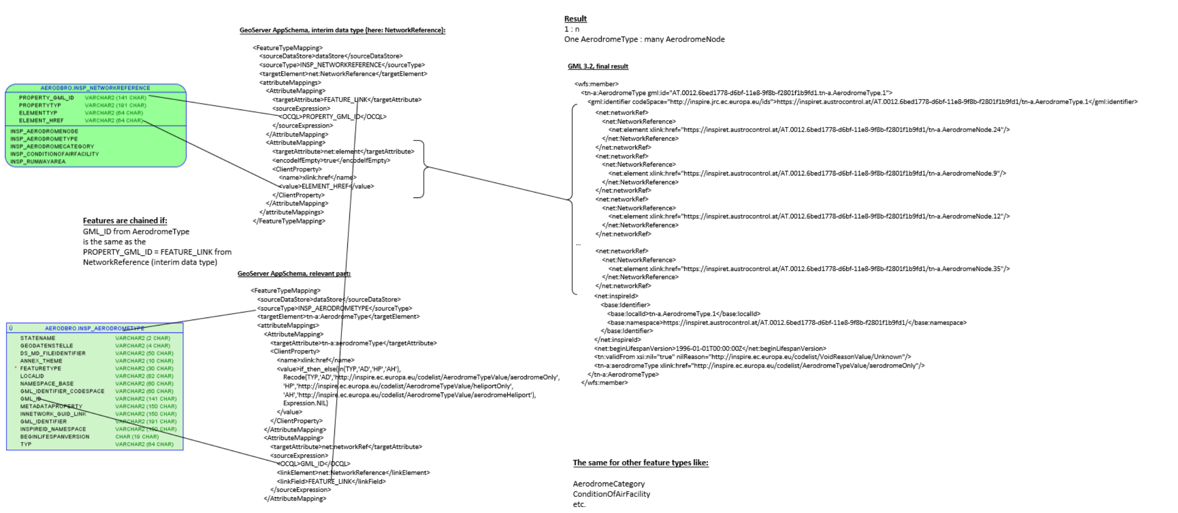
The two relevant columns are:

- networkref: resolvable URL providing an AerodromeNode and AerodromeArea that the AerodromeType applies to
- aerodrometype: id of AerodromeType the row is to be associated with, foreign key

```
CREATE TABLE public.tna_aerodrometype_netref
(
	id character varying(100) COLLATE pg_catalog."default" NOT NULL,
	networkref character varying(100) COLLATE pg_catalog."default",
	aerodrometype character varying(100) COLLATE pg_catalog."default",
	CONSTRAINT tna_aerodrometype_netref_new_pk PRIMARY KEY (id),
	CONSTRAINT fk_tna_aerodrometype_netref FOREIGN KEY (aerodrometype)
		REFERENCES public.tna_aerodrometype (id)
);
```

Feature Chaining ACG Example





Direct Association with Multiplicities

For direct association between featureTypes with a multiplicity over 1, direct attribute mapping can be utilized with denormalized tables and the isMultiple flag. This pertains to the following associations:

- Network <–> NetworkElement
- Link <–> Node
- LinkSet <-> GeneralisedLink

Attribute Mapping

In the example below, the value to be provided in the inNetwork xlink is stored in the column innetwork.

In addition to the targetAttribute and ClientProperty as usual for the provision of xlinks, the following elements must also be provided:

- encodeIfEmpty: this must always be set to true if only attributes are to be provided while the element itself remains empty. An example of such a case is the xlink:href, where the URI provided serves as a proxy for the nested class http://docs.geoserver.org/stable/en/user/data/app-schema/mapping-file.html#encodeifempty-optional
- isMultiple: this indicates to GeoServer that multiple entries may be available for this element; this assumes that the underlying table has been denormalized. http://docs.geoserver.org/stable/en/user/data/app-schema/mapping-file.html#ismultiple-optional

```
<AttributeMapping>
   <targetAttribute>net:inNetwork</targetAttribute>
   <encodeIfEmpty>true</encodeIfEmpty>
   <isMultiple>true</isMultiple>
   <ClientProperty>
           <name>xlink:href</name>
           <value>innetwork</value>
   </ClientProperty>
</AttributeMapping>
```

DB Table

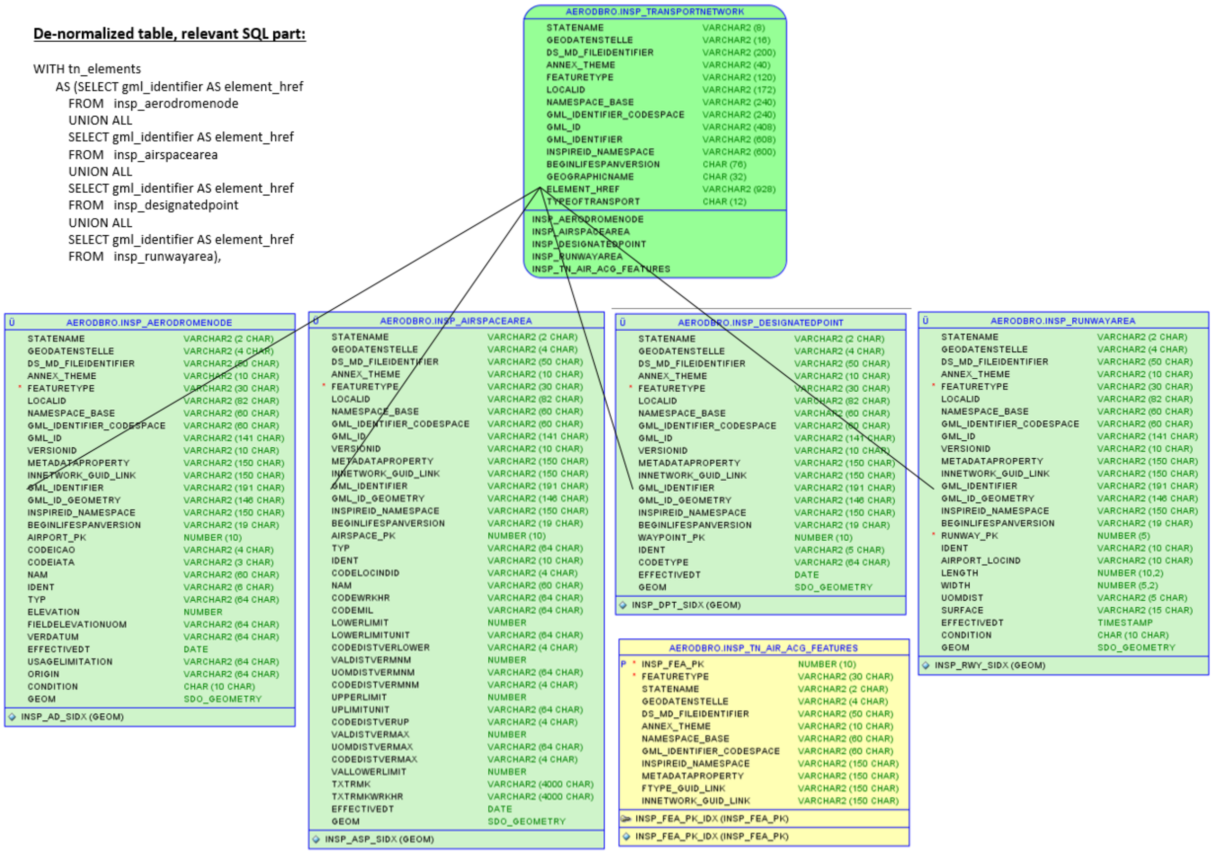
In order to provide multiple entries for the net:inNetwork element, there must be one row in the DB for each net:inNetwork entry, whereby all rows belonging to one feature must have the same id.

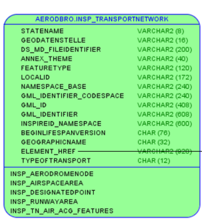
```
CREATE TABLE public.tna_runwayarea
(
	id character varying(100) COLLATE pg_catalog."default",
	localid character varying(100) COLLATE pg_catalog."default",
	namespace character varying(100) COLLATE pg_catalog."default",
	beginlsv timestamp with time zone,
	endlsv timestamp with time zone,
	name character varying(100) COLLATE pg_catalog."default",
	innetwork character varying(200) COLLATE pg_catalog."default",
	validfrom date,
	validto date,
	designator character varying(100) COLLATE pg_catalog."default",
	runwaytype character varying(100) COLLATE pg_catalog."default",
	metadata character varying(100) COLLATE pg_catalog."default",
	version character varying(100) COLLATE pg_catalog."default",
	extent geometry(Polygon,4258),
	extentid character varying(100) COLLATE pg_catalog."default"
);

CREATE TRIGGER id_update_tna_rwa
	BEFORE INSERT OR UPDATE
	ON public.tna_runwayarea
	FOR EACH ROW
	EXECUTE PROCEDURE public.set_id_tna();

CREATE FUNCTION public.set_id_tna()
	RETURNS trigger
	LANGUAGE 'plpgsql'
	COST 100
	VOLATILE NOT LEAKPROOF
AS $BODY$

  BEGIN
	 NEW.id := NEW.localid || '-' || NEW.version;
  RETURN NEW;
END

$BODY$;
```

Direct association with multiplicities ACG Example

De-normalized table, relevant SQL part:

```
WITH tn_elements
    AS (SELECT gml_identifier AS element_href
        FROM   insp_aerodromenode
        UNION ALL
        SELECT gml_identifier AS element_href
        FROM   insp_airspacearea
        UNION ALL
        SELECT gml_identifier AS element_href
        FROM   insp_designatedpoint
        UNION ALL
        SELECT gml_identifier AS element_href
        FROM   insp_runwayarea),
```





GeoServer AppSchema, relevant part:

```
<typeMappings>
    <FeatureTypeMapping>
        <sourceDataStore>dataStore</sourceDataStore>
        <sourceType>INSP_TRANSPORTNETWORK</sourceType>
        <targetElement>tn:TransportNetwork</targetElement>
        <attributeMappings>
            <AttributeMapping>
                <targetAttribute>net:elements</targetAttribute>
                <encodeIfEmpty>true</encodeIfEmpty>
                <isMultiple>true</isMultiple>
                <ClientProperty>
                    <name>xlink:href</name>
                    <value>ELEMENT_HREF</value>
                </ClientProperty>
            </AttributeMapping>
            <AttributeMapping>
                <targetAttribute>tn:TransportNetwork</targetAttribute>
                <idExpression>
                    <OCQL>GML_ID</OCQL>
                </idExpression>
```

GML 3.2, final result

```
<wfs:member>
  <tn:TransportNetwork gml:id="AT.0012.243b6e36-d14a-11e8-a8d5-f2801f1b9fd1.tn.TransportNetwork.1">
    <gml:identifier codeSpace="http://inspire.jrc.ec.europa.eu/ids">https://inspiret.austrocontrol.at/AT.0012.243b6e36-d14a-11e8-a8d5-f2801f1b9fd1/tn.TransportNetwork.1</gml:identifier>
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      <gn:GeographicalName>
        <gn:language>eng</gn:language>
        <gn:nativeness xsi:nil="true" nilReason="http://inspire.ec.europa.eu/codelist/VoidReasonValue/Unpopulated"/>
        <gn:nameStatus xsi:nil="true" nilReason="http://inspire.ec.europa.eu/codelist/VoidReasonValue/Unpopulated"/>
        <gn:sourceOfName>AIP Austria</gn:sourceOfName>
        <gn:pronunciation xsi:nil="true" nilReason="http://inspire.ec.europa.eu/codelist/VoidReasonValue/Unpopulated"/>
        <gn:spelling>
          <gn:SpellingOfName>
            <gn:text>FIR Wien</gn:text>
            <gn:script xsi:nil="true" nilReason="http://inspire.ec.europa.eu/codelist/VoidReasonValue/Unpopulated"/>
            <gn:transliterationScheme xsi:nil="true" nilReason="http://inspire.ec.europa.eu/codelist/VoidReasonValue/Unpopulated"/>
          </gn:SpellingOfName>
        </gn:spelling>
      </gn:GeographicalName>
    </net:geographicalName>
    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.87"/>
    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.416"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.33"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AerodromeNode.57"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.AirspaceArea.93"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.DesignatedPoint.803"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.RunwayArea.215"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.RunwayArea.4"/>
    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.RunwayArea.5"/>
    ...
    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.DesignatedPoint.1098"/>
    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.DesignatedPoint.1109"/>
    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.DesignatedPoint.1131"/>
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    <net:elements xlink:href="https://inspiret.austrocontrol.at/AT.0012.6bed1778-d6bf-11e8-9f8b-f2801f1b9fd1/tn-a.RunwayArea.9"/>
    <tn:inspireId>
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        <base:localId>tn.TransportNetwork.1</base:localId>
        <base:namespace>https://inspiret.austrocontrol.at/AT.0012.243b6e36-d14a-11e8-a8d5-f2801f1b9fd1/</base:namespace>
      </base:Identifier>
    </tn:inspireId>
    <tn:typeOfTransport>air</tn:typeOfTransport>
  </tn:TransportNetwork>
</wfs:member>
```

8. Associations

All associations in Air Transport Network (TNA) stem from the Network Model in the INSPIRE Generic Conceptual Model (GCM). This can cause difficulties in interpretation of the thematic UML models, as the associations between classes are not immediately visible. In the following sections, we detail the associations defined in the GCM.

At present it is not clear if a Network feature is foreseen in TNA; AirLinkSequence and AirRoute both carry a constraint that “All components belong to the same transport network”, which can be construed to indicate the existence of an explicit Network feature, while no AirNetwork featureType has been specified, leaving the TransportNetwork specialization of Network for implementation.
Note: this has been clarified, one TransportNetwork will be provided for the Austrian Air Transport Network.

Association Types

Before we detail the various associations foreseen in the TNA Model, the two different structures for the provision of associations within TNA:

- Direct associations: direct associations are defined in the UML model directly from one featureType to another; in the XML serialization this leads to an element within the featureType providing an xlink:href attribute with the link to the other featureType. This type of association is provided by GeoServer utilizing denormalized tables and the isMultiple flag in the mapping file. This structure is utilized by the following associations:
    - Network <–> NetworkElement
    - Link <–> Node
    - LinkSet <-> GeneralisedLink
- Indirect associations utilizing a dataType for provision of the association: several dataTypes have been specified in the Network Model for providing an association between features while providing additional information to this link, these dataTypes are utilized for attributes within the featureTypes. This type of association is provided by GeoServer utilizing Feature Chaining in the mapping file. This structure is utilized by the following associations:
    - NetworkProperty.NetworkReference <–> NetworkElement
    - LinkSequence.DirectedLink <-> Link

Network <–> NetworkElement

Links AirLinkSequence and AirRoute to their corresponding TransportNetwork.

Implementation via denormalized tables and the isMultiple flag.

inNetwork 1..*

The networks in which a network element is a member.

elements 0..*
The collection of elements that constitutes the network.

Link <–> Node
Implementation via denormalized tables and the isMultiple flag.

Link <–> Node – Start

*spokeStart 0..**
The links that leave the node.

startNode 0..1
The optional start node for this link.

Link <–> Node – End

*spokeEnd 0..**
The links that enter the node.

endNode 0..1
The optional end node for this link. The end node may be the same instance as the start node.

LinkSet <-> GeneralisedLink
Multiple GeneralisedLink based features (pertains to all features based on Link or LinkSequence) can be joined to a LinkSet feature via the link association.

Implementation via denormalized tables and the isMultiple flag.

LinkSet <-> GeneralisedLink 1..*
Multiple Link or LinkSequence features can be linked via the link association.

NetworkProperty.NetworkReference <–> NetworkElement
Utilized by NetworkProperty types to reference the appropriate NetworkElement.

Implementation via joined tables and Feature Chaining.

Element 1
The referenced network element.

LinkSequence.DirectedLink <-> Link
The DirectedLink dataType is utilized for linking a LinkSequence to 1..* Link features. The DirectedLink dataType is nested within the link element of the LinkSequence featureType. In addition, the DirectedLink dataType provides information on the direction of the link in the direction attribute of type Sign (GML enumeration with the following values: '+', '-').

Implementation via joined tables and Feature Chaining.

link 1

An association to one featureType derived from Link

9. Classes

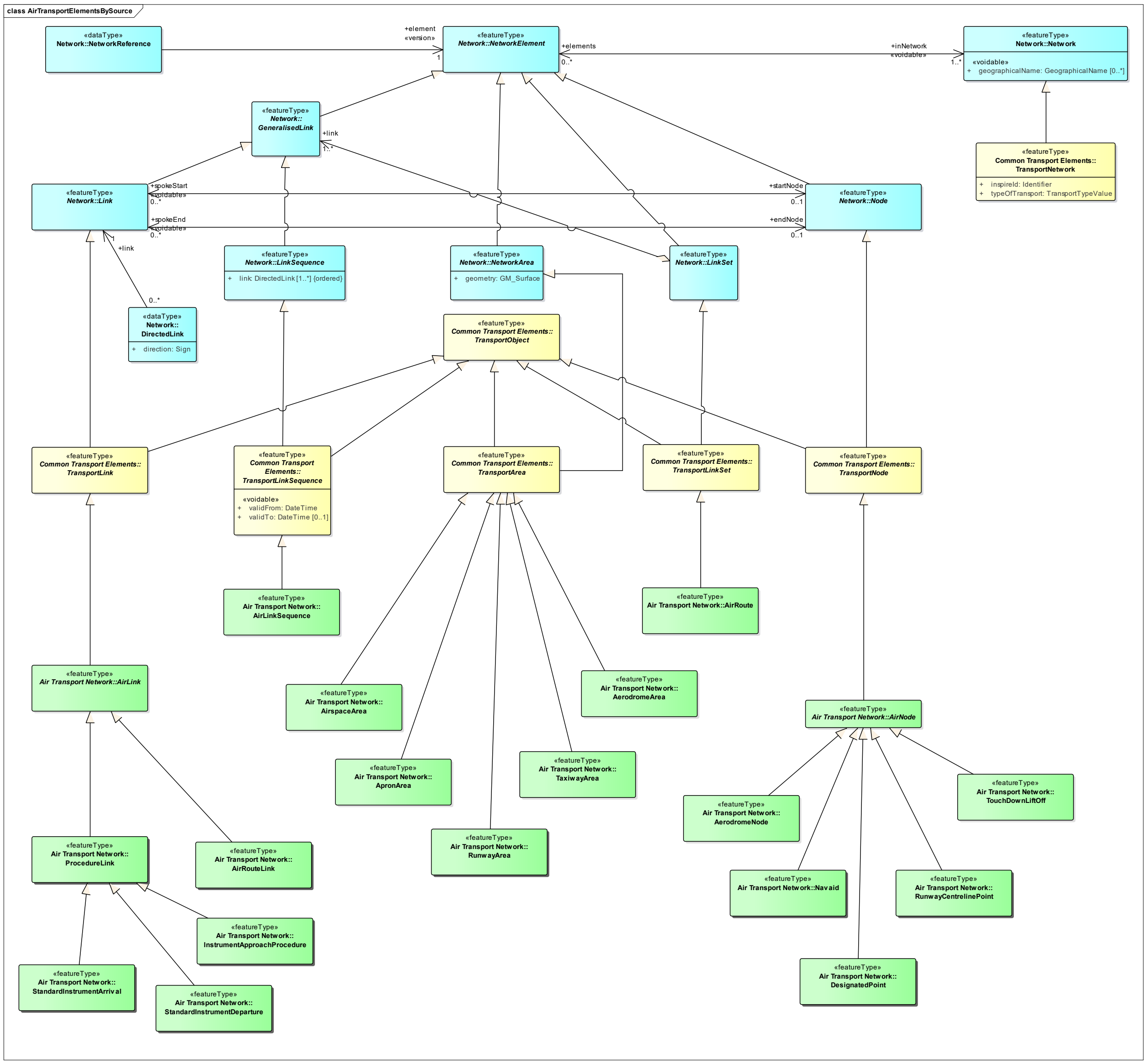
Overview

One of the difficulties in interpreting the TNA model stems from the complex derivation hierarchy spanning multiple models. Many of the base classes from with the TNA featureTypes have been derived from are defined in the Network Model provided in the GCM. These classes are further specialized in the Common Transport Elements application schema, before the final TNA featureTypes are derived.

All associations between classes are defined in the Network Model provided in the GCM, and apply to all classes derived from these base types. The subsections describing the individual featureTypes have been structured based on the complex derivation hierarchy, to make it easier to identify which of the associations apply to which of the featureTypes.

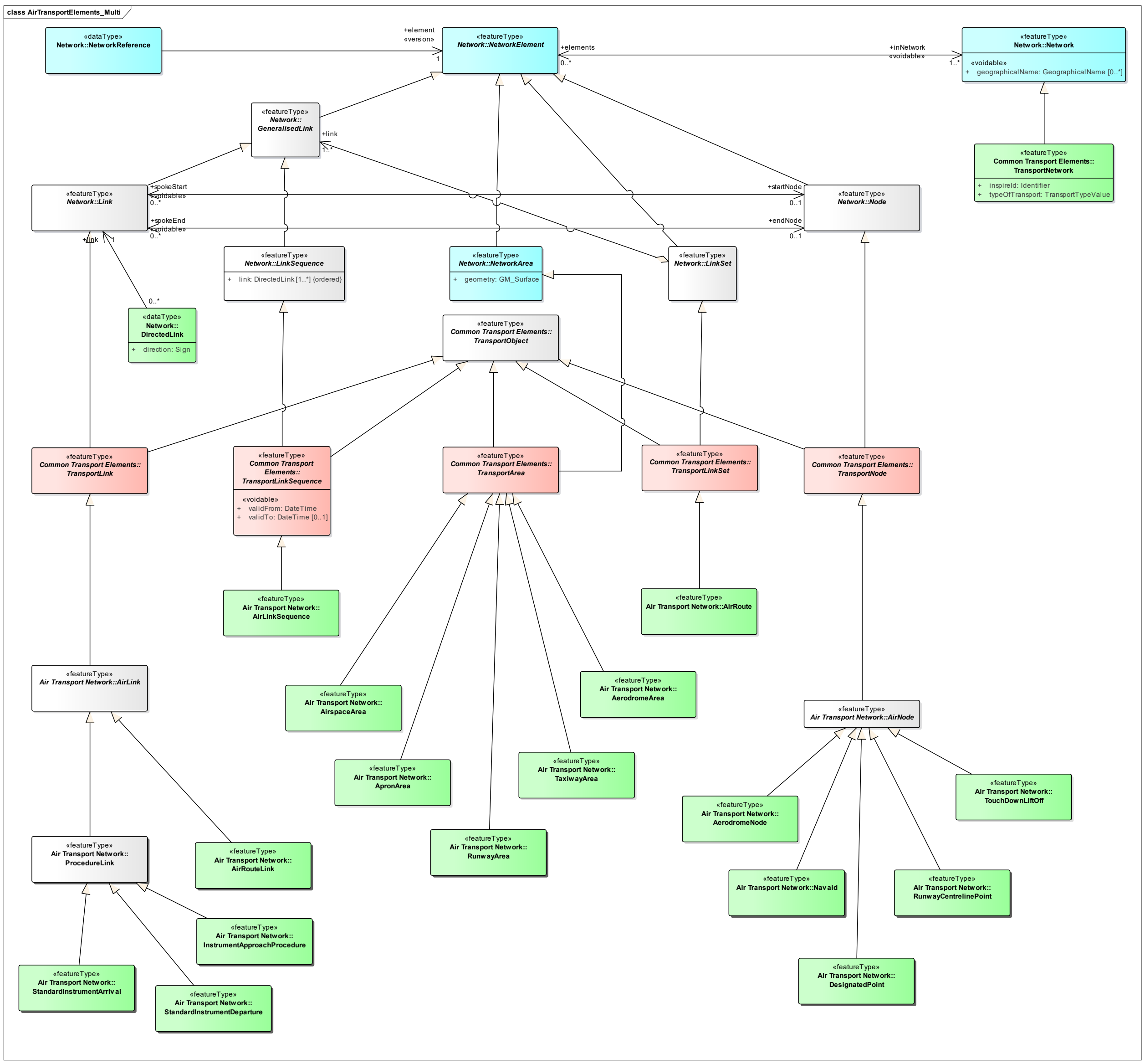
In the following diagram, the classes have been color coded based on their origin, utilizing the following coloring scheme:

- Network Model from the GCM: Blue
- Common Transport Elements: Yellow
- Air Transport Network: Green



An additional level of confusion is added by the multiple derivation hierarchy of many of the TNA featureTypes, as these types are derived both from the NetworkElement featureType as well as from the TransportObject featureType.

In the diagram below, the primary featureTypes (based on gml abstractFeature) are displayed in blue, while the featureTypes relying on multiple derivation are shown in red. The featureTypes to be implemented for TNA are shown in green.

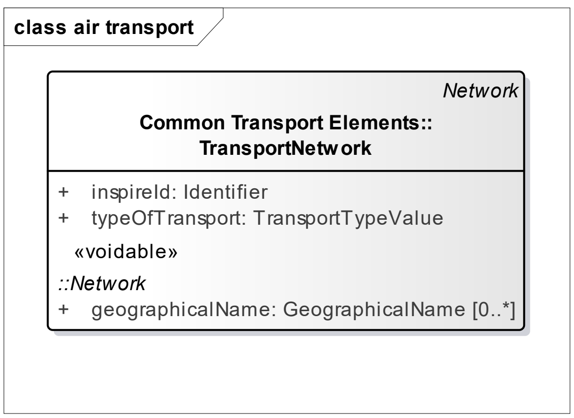


TransportNetwork

Collection of network elements that belong to a single mode of transport.

NOTE Road, rail, water and air transport are always considered separate transport modes. Even within these four categories, multiple modes of transport can be defined, based on infrastructure, vehicle types, propulsion system, operation and/or other defining characteristics.

EXAMPLE All road transport can be considered one mode of transport for some applications. For other applications, it might be necessary to distinguish between different public road transport networks. Within water transport, marine and inland water transport can be considered to be separate modes of transport for some applications, as they use different types of ships.

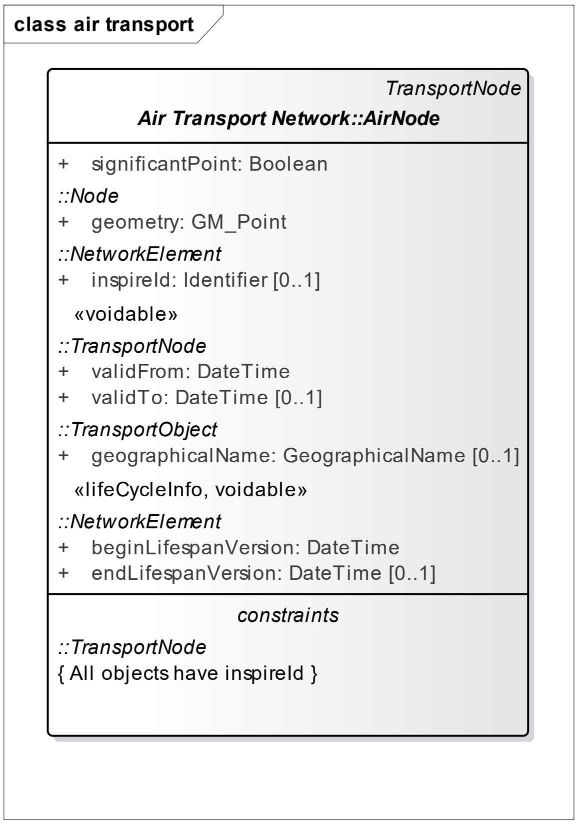


NetworkElement

TransportNode

AirNode

A node which occurs in an air network.



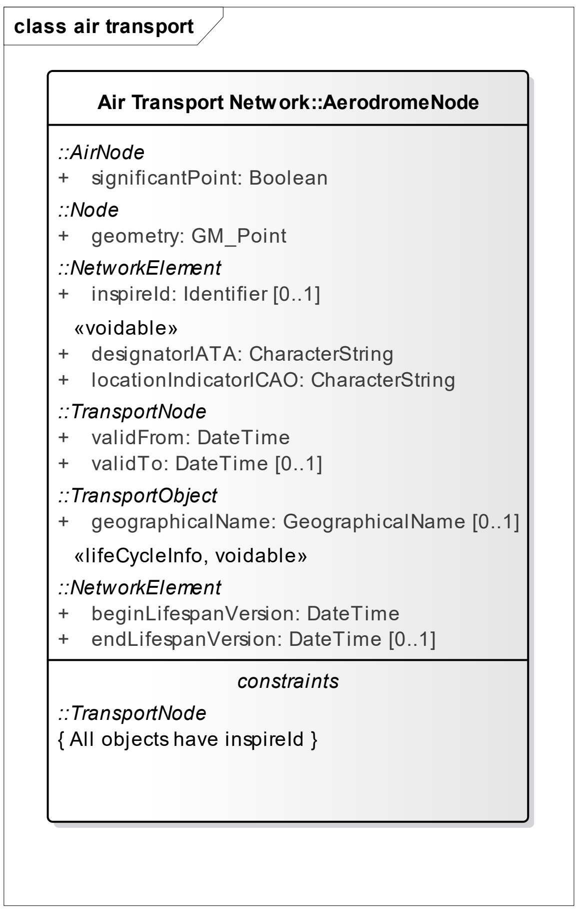
AerodromeNode

Node located at the aerodrome reference point of an airport/heliport, which is used to represent it in a simplified way.

DEFINITION Aerodrome Reference Point (ARP): The designated geographical location of an aerodrome, located near the initial or planned geometric centre of the aerodrome and normally remaining where originally established [AIXM3.3].

DEFINITION Airport/heliport: A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft/helicopters [AIXM5.0].

SOURCE [AIXM5.0].

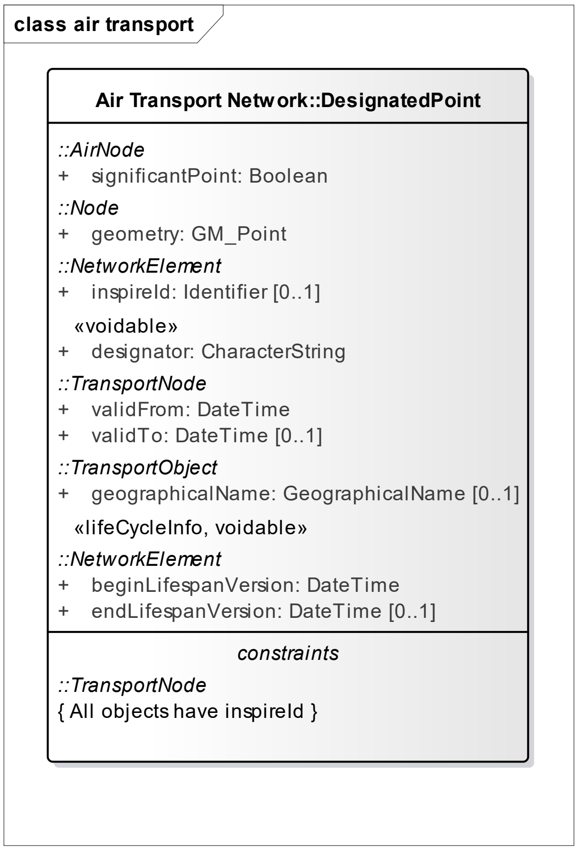


DesignatedPoint

A geographical location not marked by the site of a radio navigation aid, used in defining an ATS route, the flight path of an aircraft or for other navigation or ATS purposes.

SOURCE [AIXM5.0].

NOTE Examples of Designated points are compulsory and non-compulsory reporting points.



Navaid

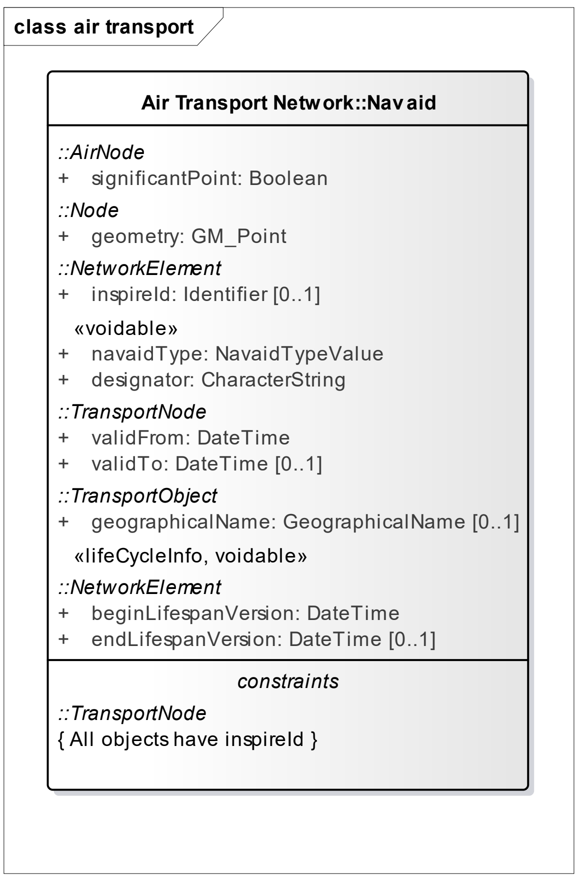
One or more Navaid Equipments providing navigation services.

DEFINITION Navaid equipment: A physical navaid equipment like VOR, DME, localizer, TACAN or etc.

SOURCE [AIXM5.0].

NOTE 1

The Navaid Equipment share business rules like paired frequencies [AIXM5.0].



RunwayCentrelinePoint

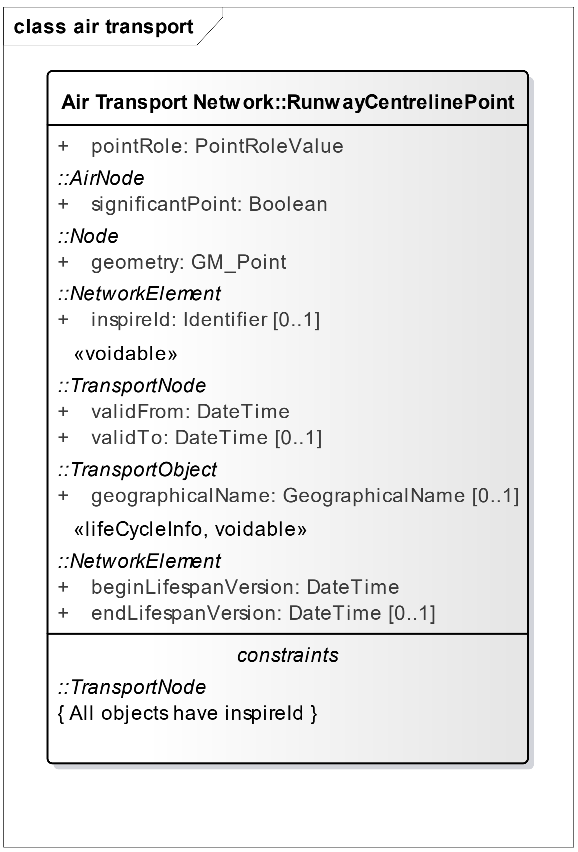
An operationally significant position on the center line of a runway direction.

SOURCE [AIXM5.0].

NOTE 1 The role of the point along the runway direction centreline is indicated within the pointRole attribute.

NOTE 2 Runway centreline points are used to connect the Procedure Links that connect an airport/heliport to the rest of the air network.

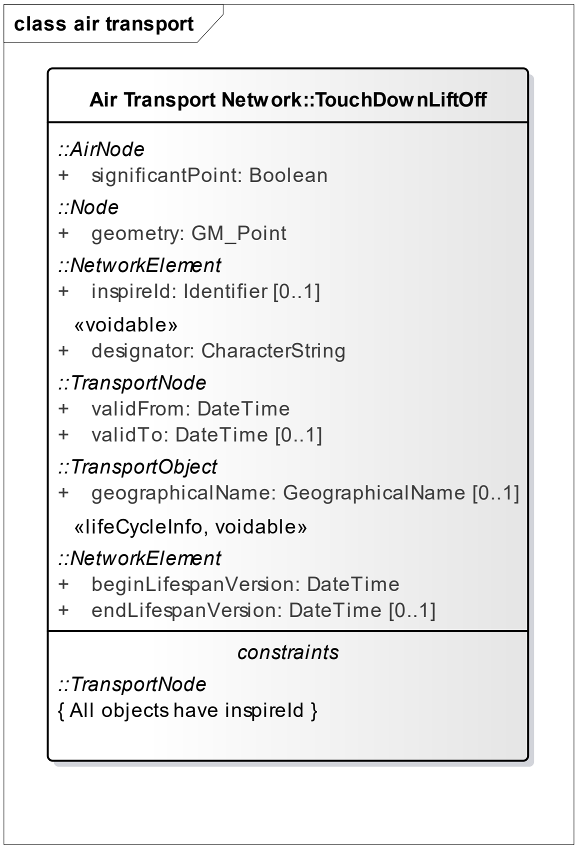
EXAMPLE A typical example is the runway threshold [AIXM5.0].



TouchDownLiftOff

A load bearing area on which a helicopter may touch down or lift-off.

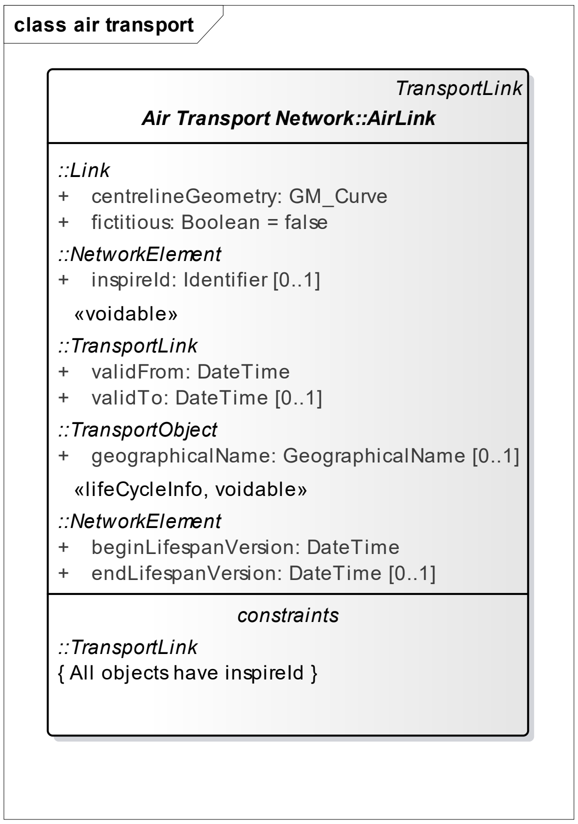
SOURCE [AIXM5.0].



TransportLink

AirLink

A linear spatial object that describes the geometry and connectivity of the air network between two points in the network.

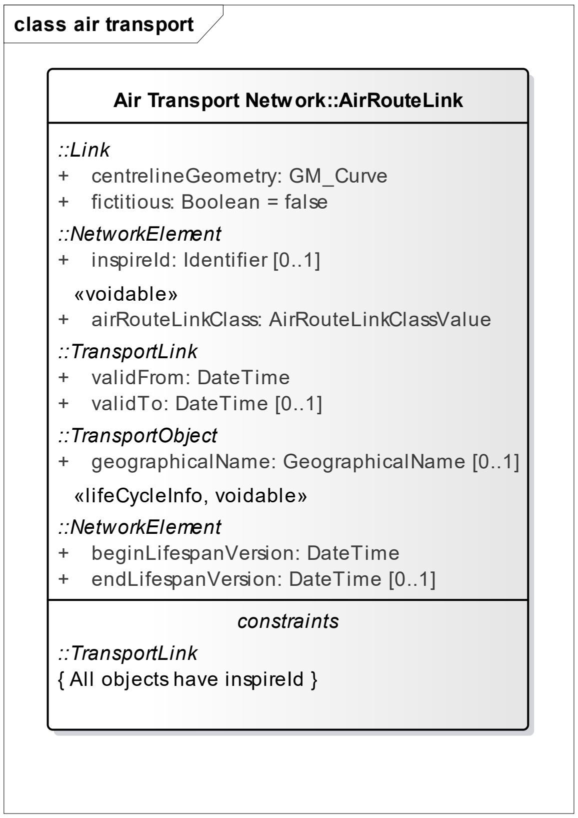


AirRouteLink

A portion of a route to be flown usually without an intermediate stop, as defined by two consecutive significant points.

SOURCE [AirRouteSegment - AIXM5.0].

NOTE The presence of air nodes (normally defining Significant Points) is not mandated.



InstrumentApproachProcedure

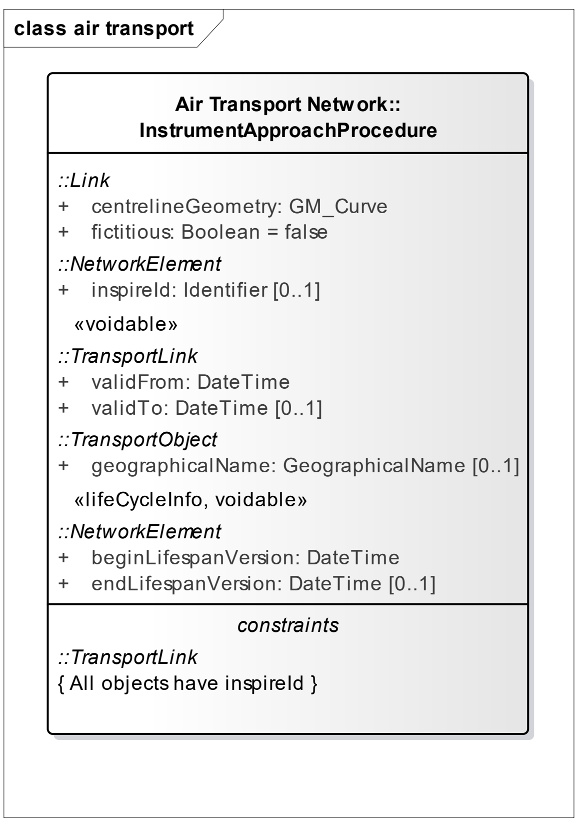
A series of predetermined manoeuvres by reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of a defined arrival route to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which holding or en-route obstacle clearance criteria apply.

SOURCE [AIXM5.0].

NOTE 1 Acronym: IAP.

NOTE 2 It corresponds to the final approach and arrival during the landing phase.

NOTE 3 A specific runway of an airport/heliport usually has more than one IAP, depending on the landing direction on it.



ProcedureLink

A series of predetermined manoeuvres with specified protection from obstacles.

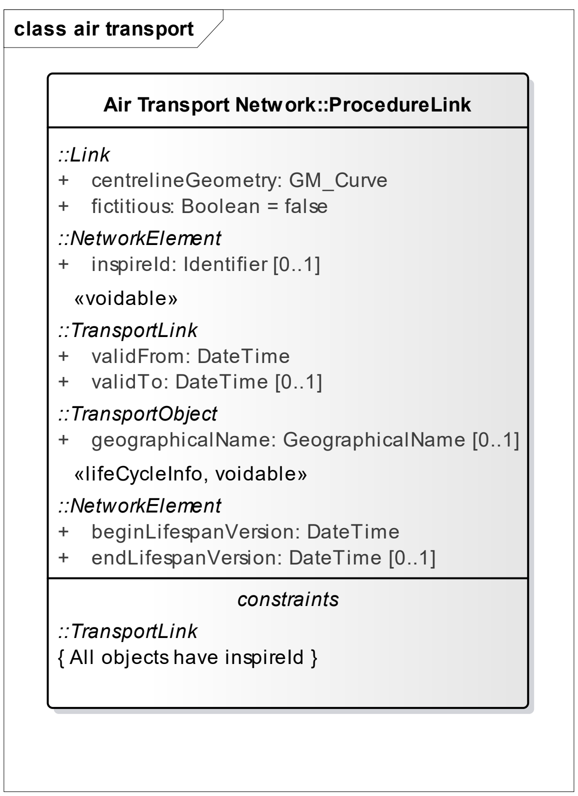
SOURCE [Procedure - AIXM5.0].

NOTE 1 A defined airway connector designed for channelling the flow of traffic as necessary for the provision of air traffic services during the take-off or landing phase, which links an airport/heliport to a significant point, usually connected to one or more air routes.

NOTE 2 When an airport/heliport is not connected with a standardized airway connector to the rest of the air network, this object can be used as a fictitious connector between the airport/heliport and a significant point on one or more ATS routes - for example for VFR (Visual Flight Rules) flights.

NOTE 3 Nevertheless, three main types of standardized Procedures are usually defined for IFR (Instrument Flight Rules) flights:

- Standard Instrument Departure (SID), corresponding to the take-off phase.
- Standard Instrument Arrival (STAR), corresponding to the initial approach during the landing phase.
- Instrument Approach Procedure (IAP), corresponding to the final approach and arrival during the landing phase.



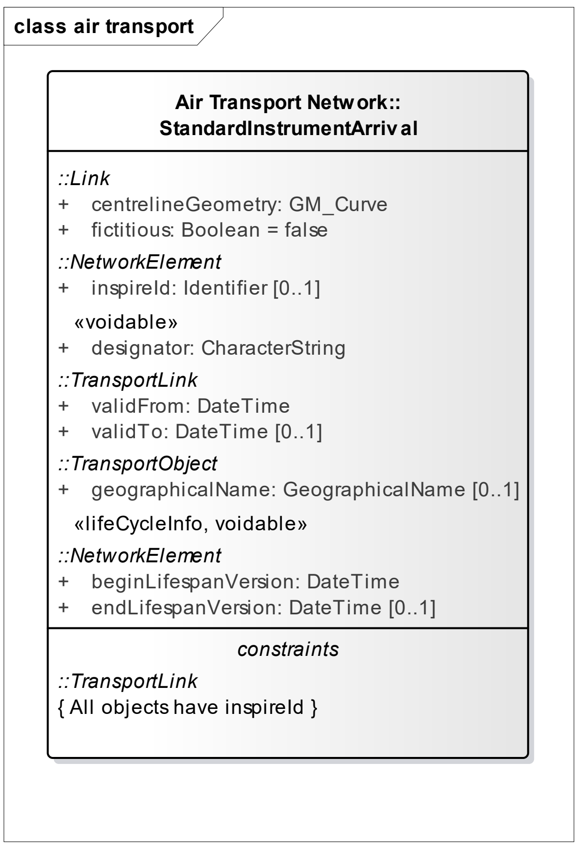
StandardInstrumentArrival

A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

SOURCE [AIXM5.0].

NOTE 1 Acronym: STAR.

NOTE 2 It corresponds to the initial approach during the landing phase. Each airport/heliport could have various STAR linking significant points (usually connected to air routes) to the points designated to start the landing on a specific runway.



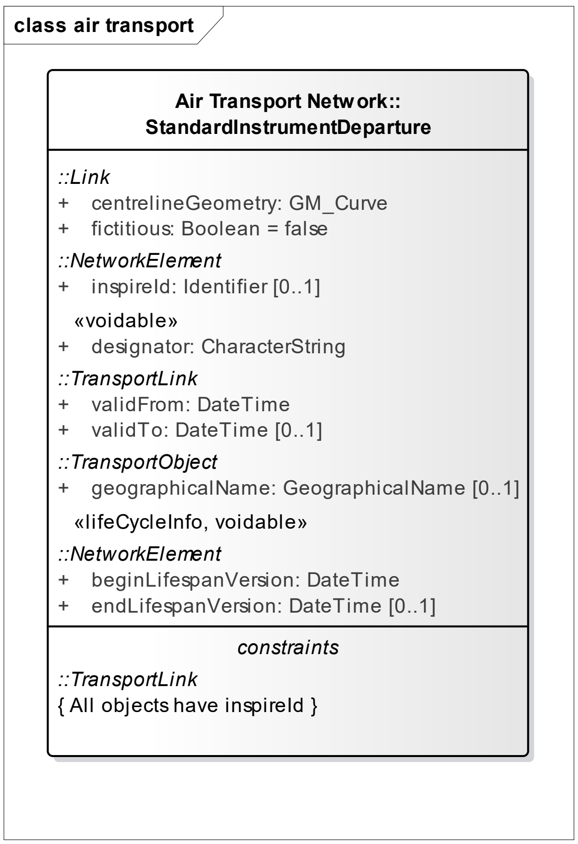
StandardInstrumentDeparture

A designated instrument flight rule (IFR) departure route linking the aerodrome or a specific runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.

SOURCE [AIXM5.0].

NOTE 1 Acronym: SID.

NOTE 2 It corresponds to the take-off phase. Each airport/heliport could have various SID linking the different runways to one or various significant points, usually connected to air routes.



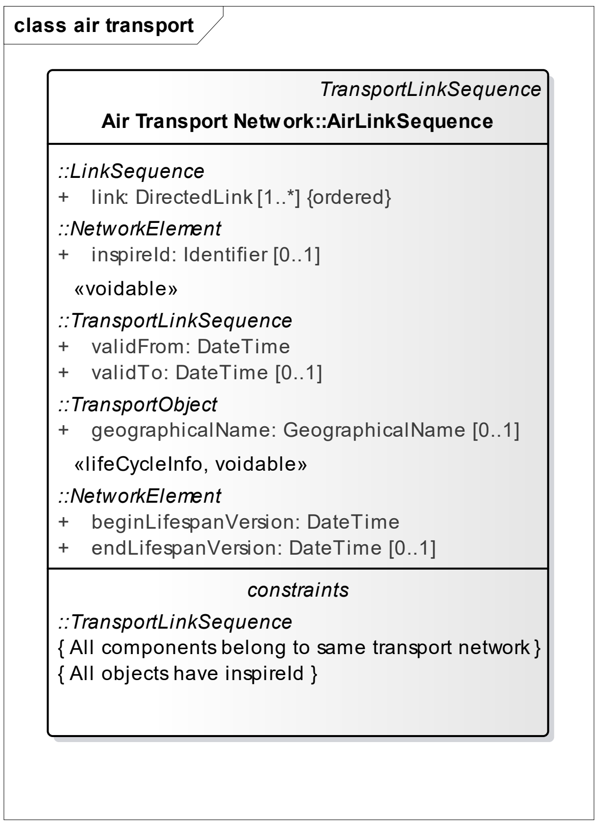
TransportLinkSequence

AirLinkSequence

A linear spatial object, composed of an ordered collection of air links, which represents a continuous path in the air network without any branches.

NOTE 1 The element has a defined beginning and end and every position on the air link sequence is identifiable with one single parameter such as length. It describes an element of the air network, which could be characterized by one or more thematical identifiers and/or properties.

NOTE 2 This collection of air links is equivalent to RoutePortion feature in AIXM5.0. RoutePortion: A group of two or more consecutive segments of the same route, which have the usage and/or the same flight restrictions [AIXM5.0].



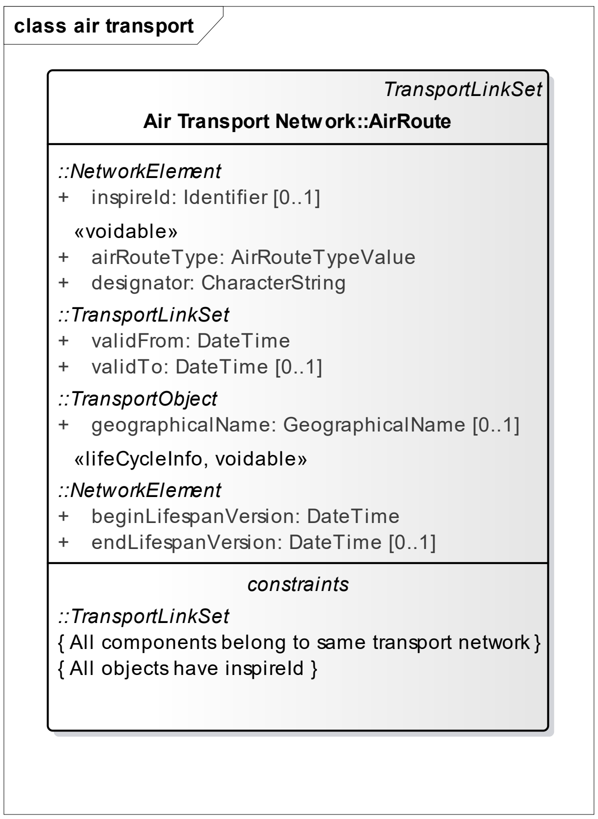
TransportLinkSet

AirRoute

A specified route designed for channelling the flow of traffic as necessary for the provision of air traffic services, from the end of the take-off and initial climb phase to the commencement of the approach and landing phase.

SOURCE [Route - AIXM5.0].

NOTE A collection of air link sequences and or individual air links that are characterized by one or more thematic identifiers and /or properties, which perform a Route.



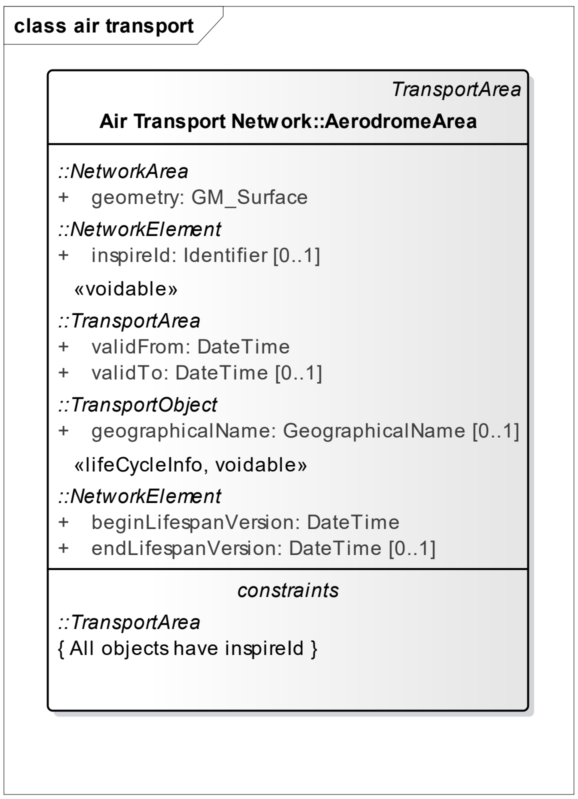
TransportArea

AerodromeArea

A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft and/or helicopters.

SOURCE [AIXM5.0].

NOTE An area spatial object which is used to represent the physical limits of all the facilities which form part of an inland aerodrome.



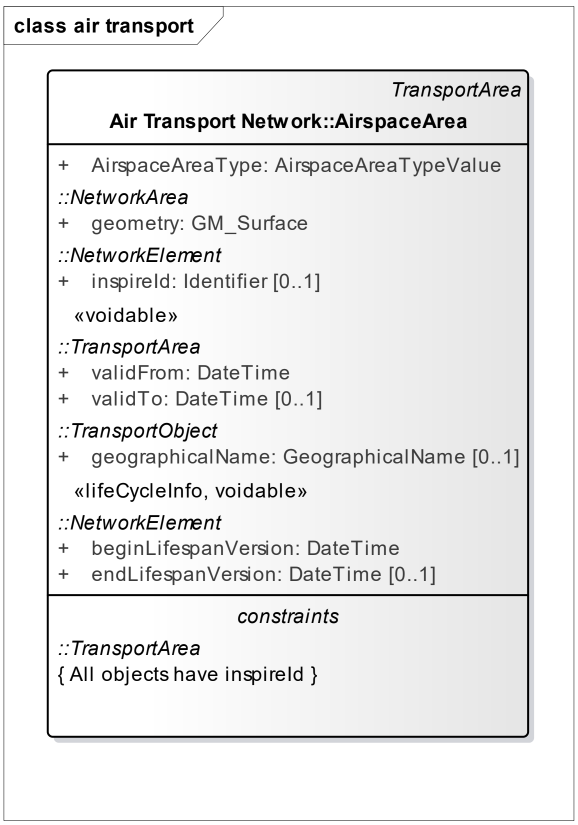
AirspaceArea

A defined volume in the air, described as horizontal projection with vertical limits.

SOURCE [AirspaceVolume - AIXM5.0].

NOTE 1 Definition of Airspace: A defined three dimensional region of space relevant to air traffic [AIXM5.0].

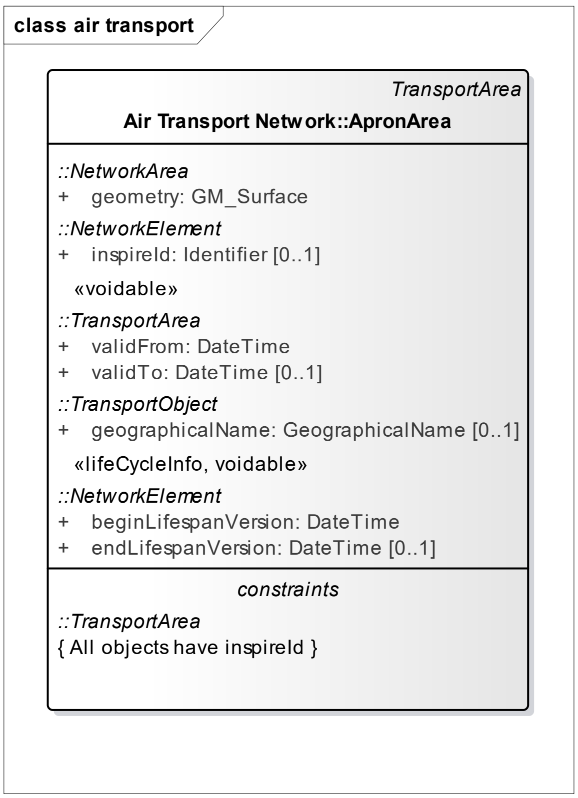
NOTE 2 Airspace regions are managed by air traffic control systems to provide a safe IFR (Instrument Flight Rules) navigation for air traffic services and aircrafts.



ApronArea

A defined area, on a land aerodrome/heliport, intended to accommodate aircraft/helicopters for purposes of loading and unloading passengers, mail or cargo, and for fuelling, parking or maintenance.

SOURCE [Apron - AIXM5.0].



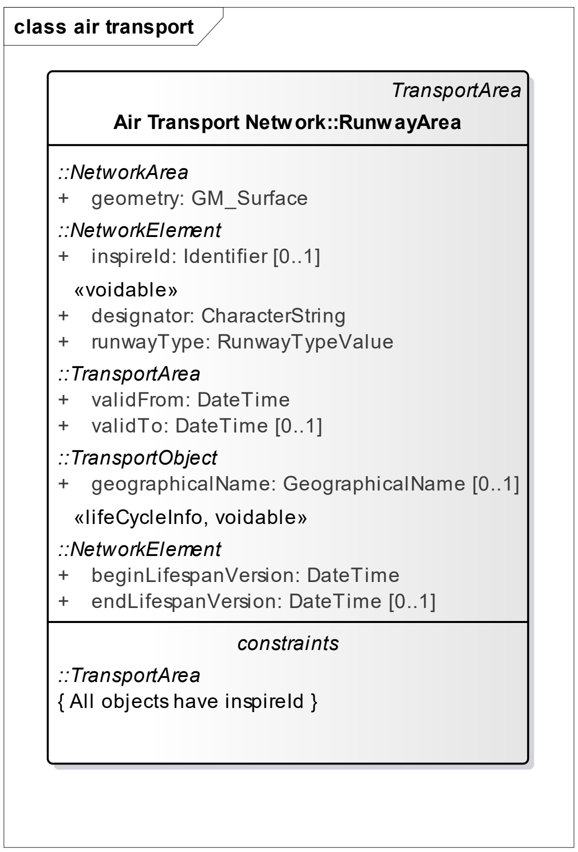
RunwayArea

A defined rectangular area on a land aerodrome/heliport prepared for the landing and take-off of aircraft.

SOURCE [Runway - AIXM5.0].

NOTE 1 This includes the concept of Final Approach and Take-Off Area (FATO) for helicopters [Runway - AIXM5.0].

NOTE 2 The runway strip is a defined area including the runway and stopway, if provided, intended : a) to reduce the risk of damage to aircraft running off a runway; and b) to protect aircraft flying over it during take-off or landing operations [ICAO].

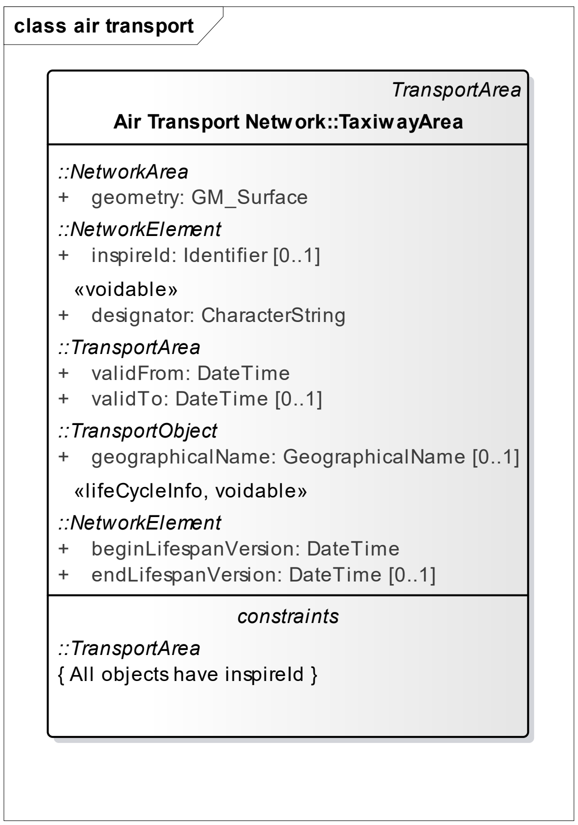


TaxiwayArea

A defined path at an aerodrome/heliport established for the taxiing of aircraft/helicopters and intended to provide a link between one part of the aerodrome and another.

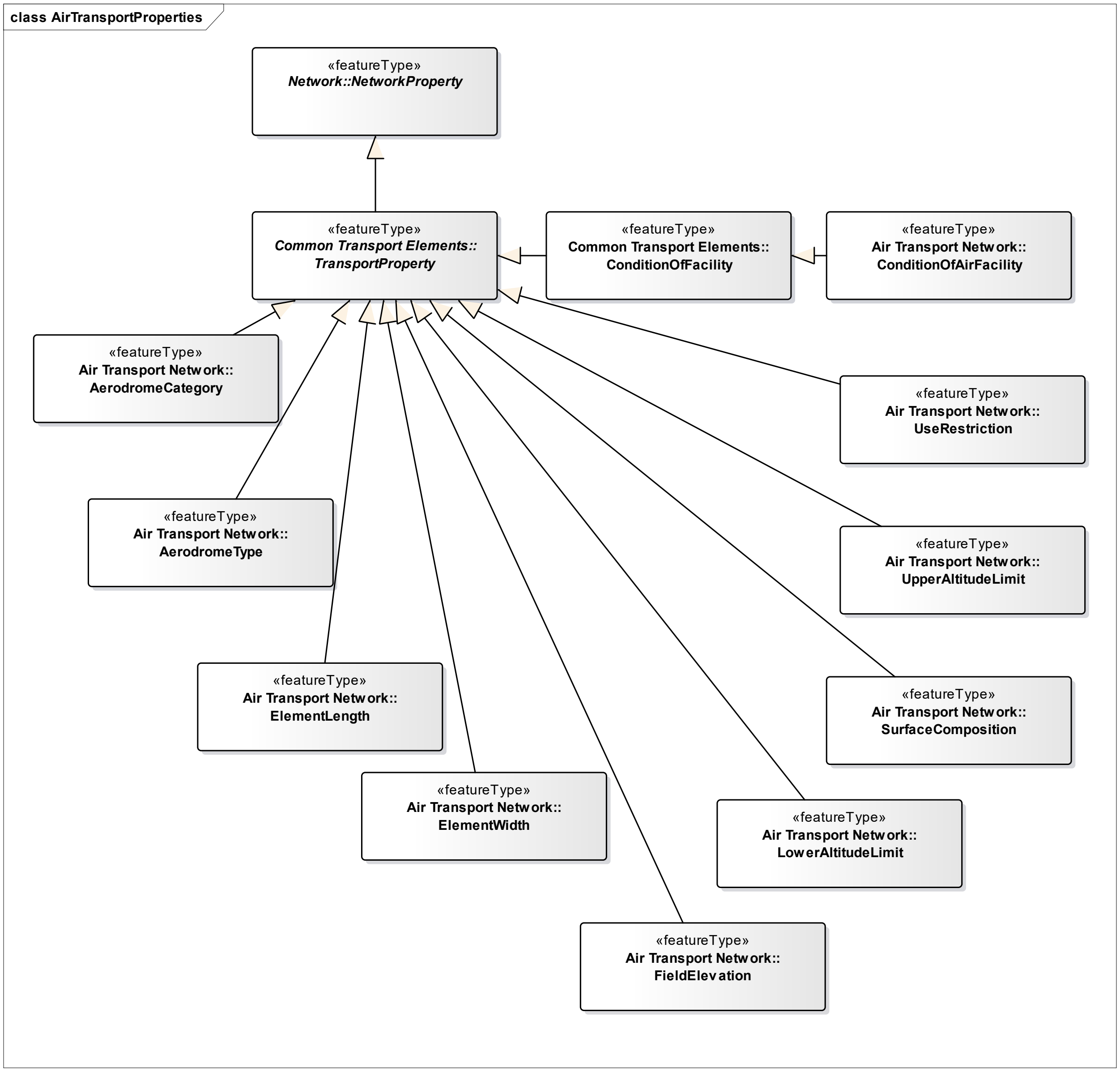
SOURCE [Taxiway - AIXM5.0].

NOTE This includes aircraft/helicopter stand taxilines, apron taxiways, rapid exit taxiways, air taxiways etc.



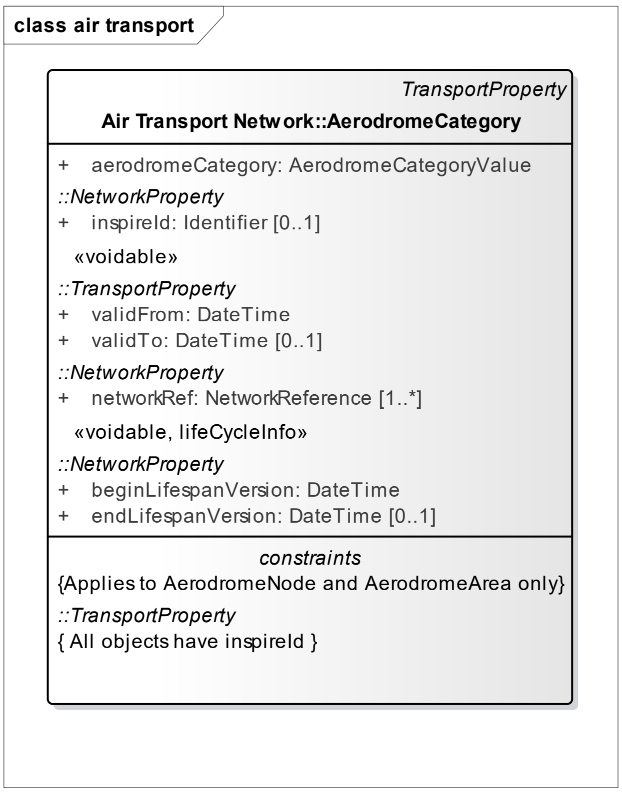
NetworkProperty

Most of the NetworkProperty derived classes within TNA are directly derived from Network::NetworkProperty; However, the ConditionOfAirFacility is derived from the more specialized ConditionOfFacility Class, that is in turn derived from NetworkProperty. All NetworkProperty derived classes within TNA are shown together with their derivation hierarchy in the diagram below.



AerodromeCategory

Aerodrome category concerning the scope and importance of the air traffic services offered from and to it.

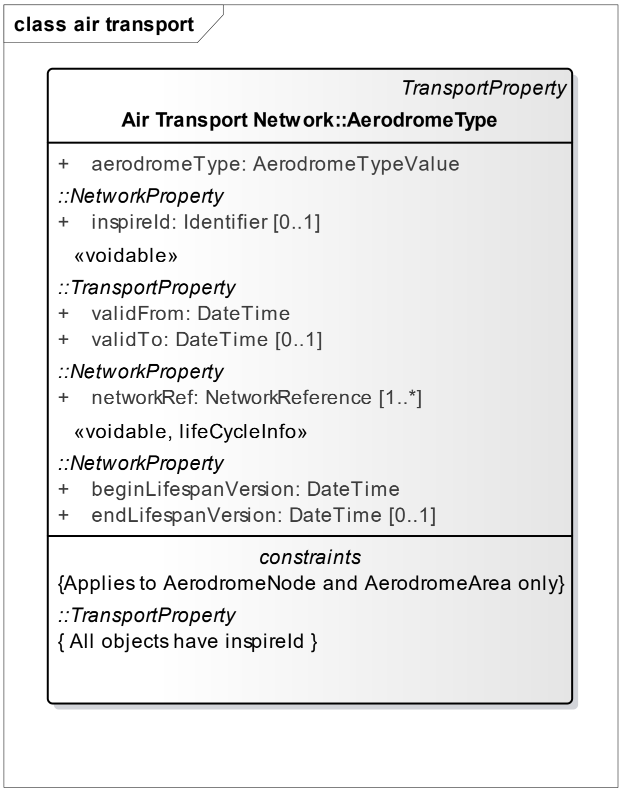


AerodromeType

A code specifying the type of aerodrome.

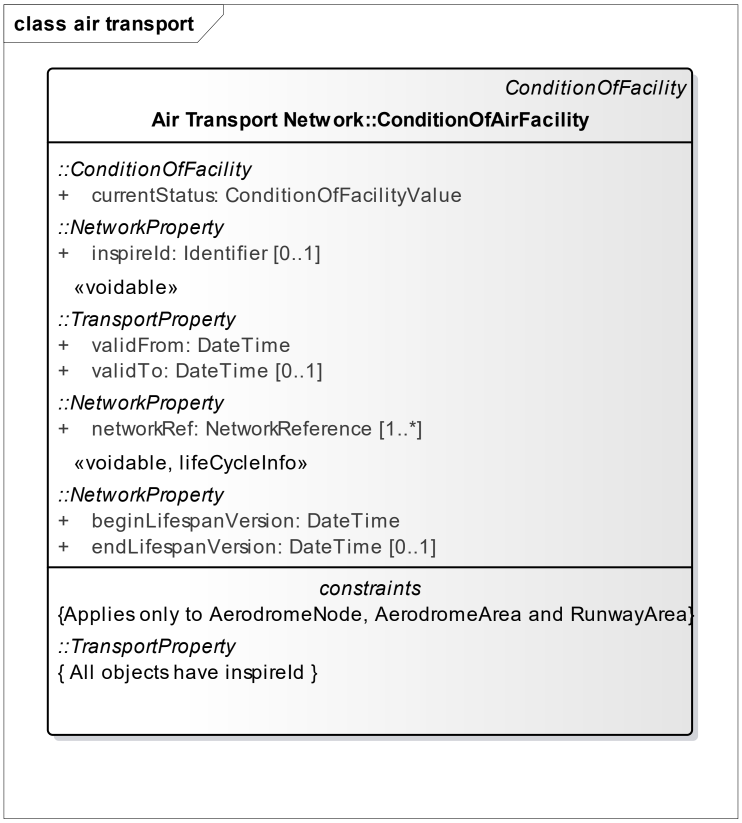
SOURCE [AIXM5.0].

EXAMPLE Aerodrome only, combined aerodrome/heliport or simple landing site.



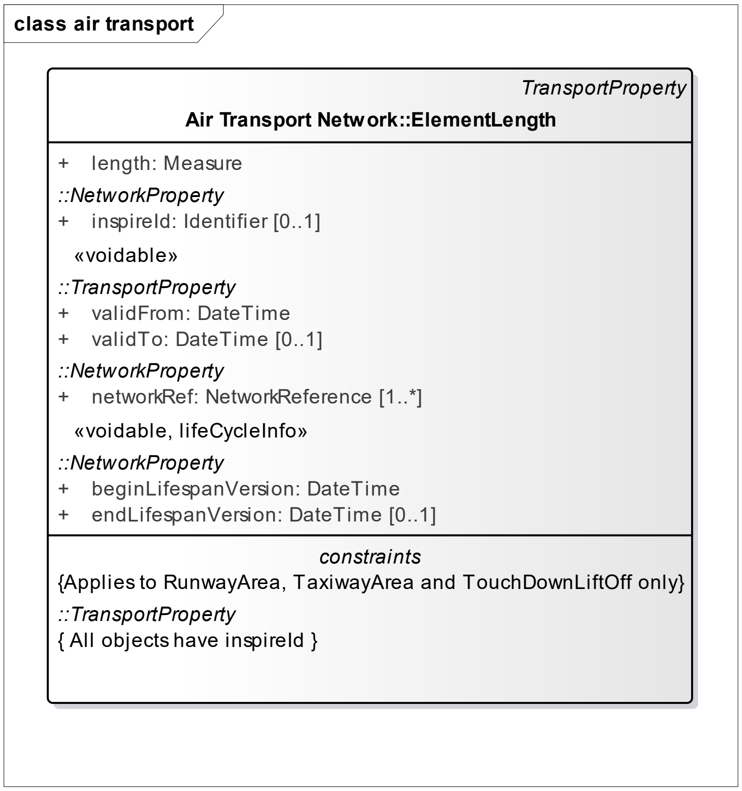
ConditionOfAirFacility

State of an air transport network element with regards to its completion and use.



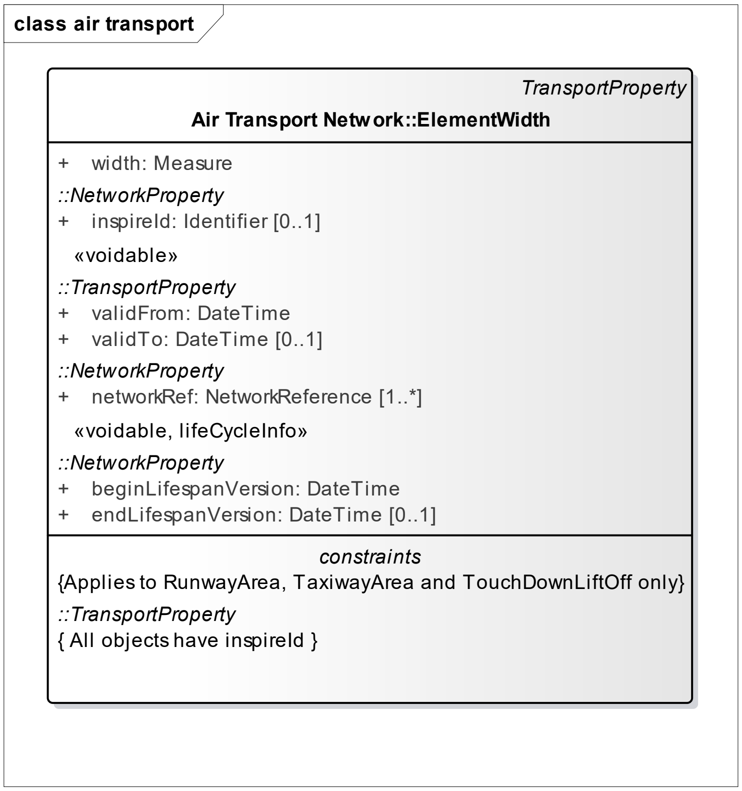
ElementLength

The physical length of the element.



ElementWidth

The physical width of the element.

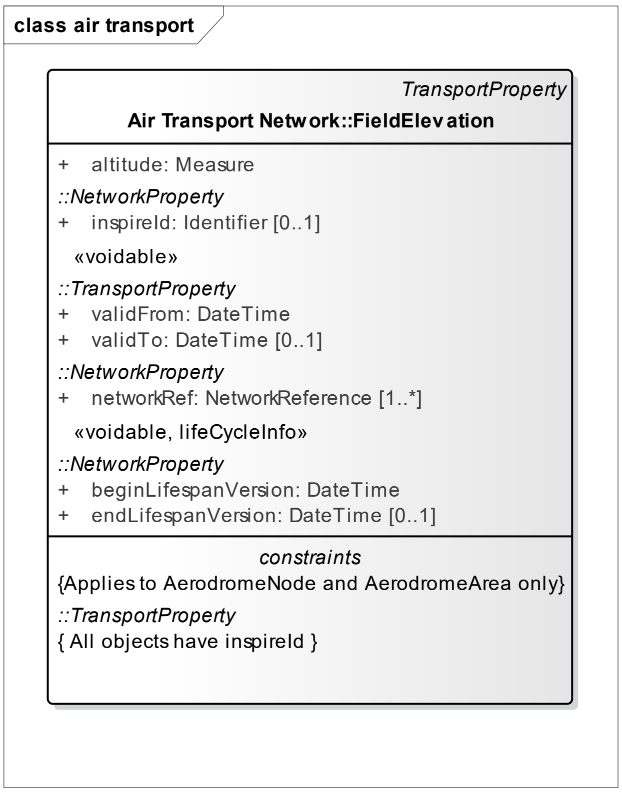


FieldElevation

The aerodrome elevation as the vertical distance between the highest point of the landing area of an aerodrome and mean sea level.

SOURCE [AIXM5.0].

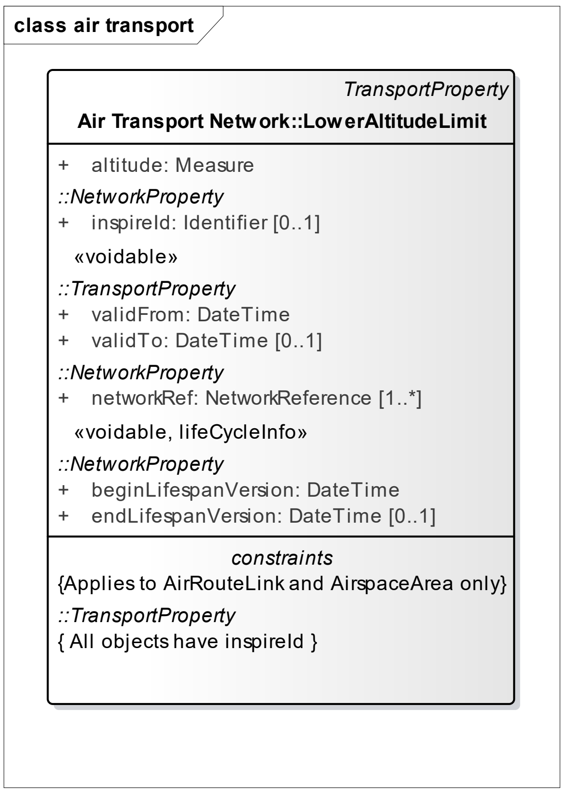
NOTE This might be different from the elevation of the Aerodrome Reference Point.



LowerAltitudeLimit

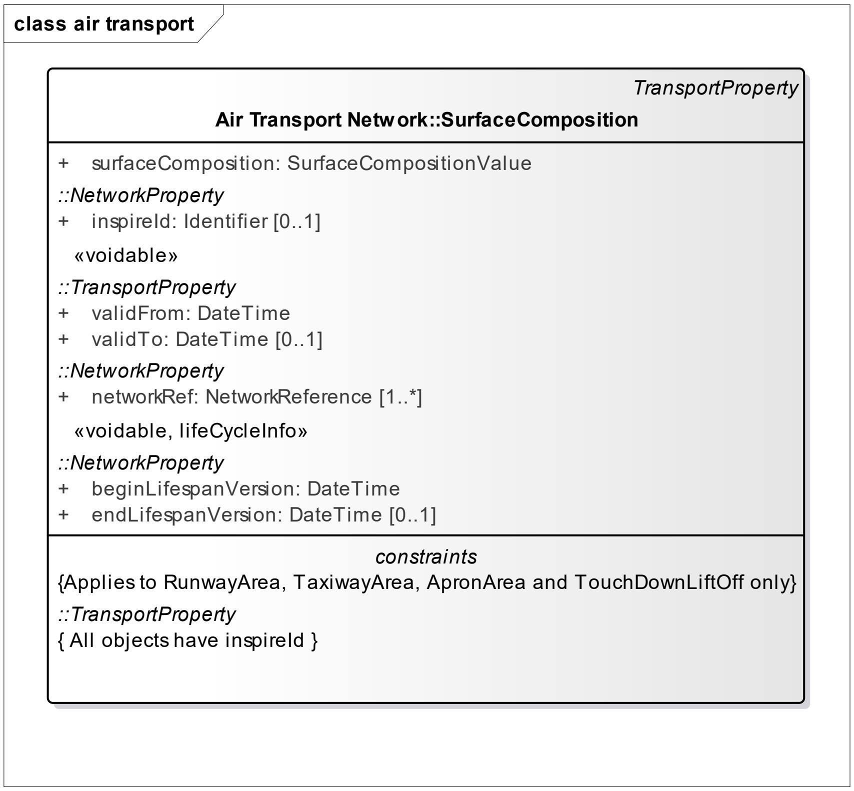
Altitude that defines the lower limit of an air transport network object.

NOTE When applied to an AirRouteLink it corresponds to the Lowest Safe Altitude, which is defined in order to provide safety for navigation.



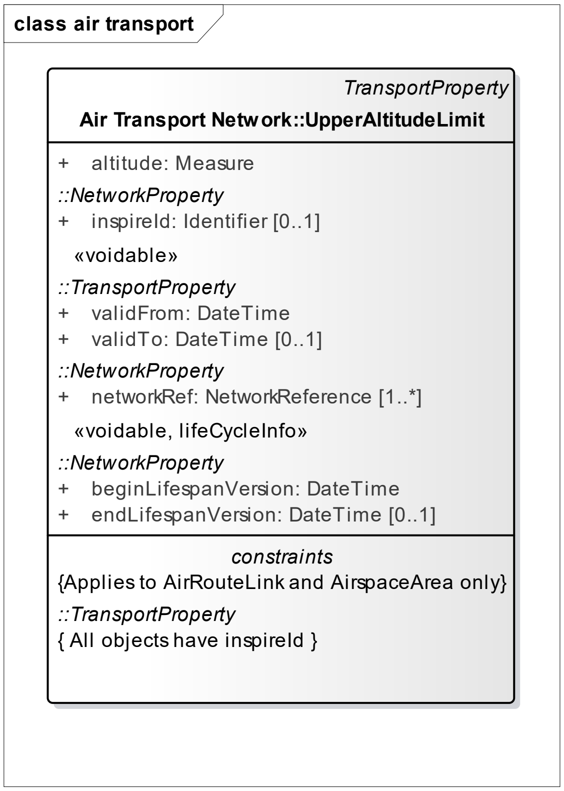
SurfaceComposition

The composition of an aerodrome/heliport related surface.



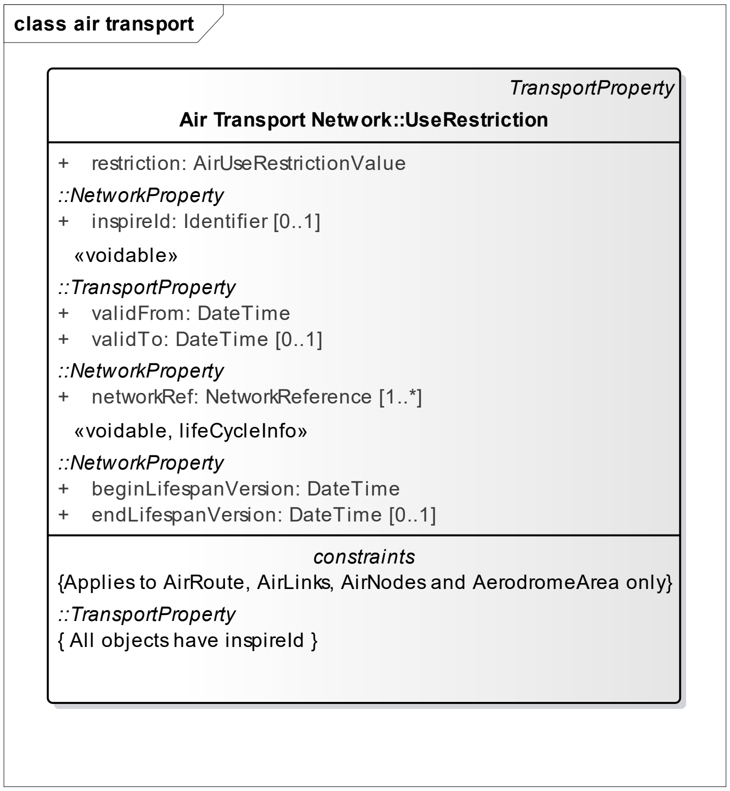
UpperAltitudeLimit

Altitude that defines the upper limit of an air transport network object.



UseRestriction

The restrictions to the use of an air network object.



NetworkReference / NetworkElement

NetworkReference

A reference to a network element.

NetworkElement

Abstract base type representing an element in a network. Every element in a network provides some function that is of interest in the network.