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Airport Network Information Management

Draft ANCM/ANXM Models

Aeronautical Information Management

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CONTACT PERSON : Bruno Desart	**TEL :** 3137	**UNIT :** AIM

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The following table identifies all management authorities that have successively approved the present issue of this document.

AUTHORITY	NAME AND SIGNATURE	DATE
Author/Editor	Tudor Ivanov PULSAR Consulting	30th November 2007
Project Manager	Bruno Desart EUROCONTROL	6th December 2007
Head of Aeronautical Information Management Division	Ken Reid EUROCONTROL	
Director ATM Programmes	Guido Kerkhofs EUROCONTROL	

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0.1	29th November 2007	Initial Draft	Chapters 1 and 2
0.2	30th November 2007	Updated following review internally in contracting party	Chapters 1 and 2
0.3	6th December 2007	Updated following project manager's review	All

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GLOSSARY

AHCA	Airport Realised Handling Capability Analyzer
AIXM	Aeronautical Information Exchange Model
AMXM	Airport Mapping Exchange Model
ANCM	Airport Network Conceptual Model
ANIM	Airport Network Information Management Activity
ANXM	Airport Network Exchange Model
ATC	Air Traffic Service
GML	Geography Markup Language
PACS	Pan-European Airport Capacity and Delay Analysis Platform
TMA	Terminal Manoeuvring Area
TOD	Terrain & Obstacle Data
UML	Unified Modelling Language
WXXM	Weather Exchange Model
XMI	XML Metadata Interchange
XML	Extensible Mark-Up Language
XSD	XML Schema Definition

REFERENCES

Ref	**Title**	**Organisation**	**Edition**
1	ICAO Annex 14, Volume I	ICAO	amended up to 15/06/2006
2	ICAO Doc 4444, ATM501, Edition November 1, 2001	ICAO	amended up to 24/11/2005
3	AICM Manual, Edition 4.5-draft	EUROCONTROL	29 May 2006
4	ASIM Lexicon (available on-line at https://extranet.eurocontrol.int)	EUROCONTROL	30th November 2007
5	AIXM5, RC2	EUROCONTROL	
6	WXXM	EUROCONTROL	Feb-Jul 2007
7	AIXM5, RC1	EUROCONTROL	
8	AMXM 1.1	EUROCONTROL	
9	AIXM_UML_to_AIXM_XSD_Mapping, v0.3	EUROCONTROL	

Table 1: References

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1. INTRODUCTION

1.1 Purpose

In the context of the Airport Network Information Management Activity (ANIM), DAP/AIM Division is the focal point for activities designed to ensure consistency and quality of aeronautical information in the widest sense. To that purpose, the modeling activities performed within the AIM Division have been extended to encompass the System Wide Information Management (SWIM) concept. The AIM Strategy includes the development and maintenance of several data and exchange models and works towards their adoption as world wide standards.

Because airports are an integral and critical part of the ATM network, the Airport Network Information Management project (ANIM) is a major component of the AIM Strategy. This ANIM activities include the development of an airport network information conceptual model (ANCM) and airport network information exchange model (ANXM). The purpose of ANCM/ANXM is to address any kind of airport information required for the purpose of ATM network planning and management, covering the whole planning time horizon (at strategic, tactical and pre-operational levels) as well as overall ATM network performance monitoring (key performance indicators and post-operational information).

Within the AIM Division, the PACS (Pan-European Airports Capacity and delay Statistics) proof-of-concept has demonstrated (PACS workshop 28th February 2007) the feasibility and practicality of collecting timely and consistent information about European Airport Capacity. PACS provides airports with potential to growth on a coordinated basis, at the local, regional and pan-European levels. Following this mature proof-of-concept released at the 1st PACS workshop, 28th February 2007, it was decided to derive the ANCM/ANXM from it.

The project aims at developing both the ANCM and ANXM as well as related schemas, using the PACS data model as a basis. The project also analyses the interaction between the ANCM/ANXM to be developed and the existing models in AIM, i.e. Aeronautical Information (AIXM), Airport Mapping (AMXM) and MET information (WXXM).

1.2 Objective

This document is a guide to the Airport Network Conceptual Model (ANCM) and the Airport Network Exchange Model (ANXM) developed in the frame of the ANIM project. It offers a high-level explanation of what the models are, and also gives detailed information regarding the contents of each.

For complete understanding, this document should be read in conjunction with the models themselves.

1.3 Development Methodology

The ANCM/ANXM development is laid out in four phases:

Phase 1 : Development of Draft ANCM/ANXM

> In the first Phase, the ANCM/ANXM model is drafted, based on the PACS data model. Entities, associations and attributes of PACS are reviewed in detail: corrections, additions and checks on data types and ranges, verification of definitions. This review will compare the items with ICAO Annex 14, Volume I, ICAO Doc 4444 and make use of the ASIM domain of

the ATM Lexicon. The information to be, and not to be, included in ANCM/ANXM shall be identified with explicit justification for inclusion or omission.

The phase will close with a workshop where representatives of pan-European organisations/associations and local airports will be invited for comments and review on the draft model.

Phase 2 : Survey and collection of user requirements for Airport Information Exchange

Based on the output of the workshop in which the draft ANCM/ANXM will be presented, a detailed survey and collection of additional user requirements for airport information exchange will be undertaken, with additional identified stakeholders. These will include other Eurocontrol Divisions, the European Commission and aviation industry associations.

The resultant Users' Requirement Document shall show an updated ANCM business information flow and contain a clear description of the requirements, their originators, the intention, the relationship with existing information, as well as an example.

Phase 3 : Review and gap analysis of ICAO Annex 15

A gap analysis between ICAO Annex 15 and the entities, associations and attributes of the draft ANCM/ANXM shall identify corrections and additions as compared to ICAO standards and recommended practices. Differences in ANCM/ANXM and ICAO Annex 15 in both directions shall be described and form the basis for a proposal for a possible amendment of Annex 15.

This phase will be performed in parallel with the 2nd Phase.

Phase 4 : Development of final ANCM/ANXM

The draft ANCM/ANXM developed in the first Phase will be updated with the additional requirements defined in Tasks 2 and 3 to arrive at a final version. This will be the basis for submission to ICAO for possible amendment of Annex 15.

1.4 Decisional Guidelines & Scope Definition

1.4.1 Interdependency with other models (AIXM, PACS)

When entities were present in other models, preference was given to establish links, rather than import all full data information.

1.4.2 Physical delimitation

1.4.2.1 Airspace

TMA (Terminal Manoeuvring Area) is kept as a link to AIXM in order to connect with other airspaces, routes and ATC information in general. A link for identifying the authority that is responsible for ATC services in the TMA area is also included for this purpose.

Holding position information is not retained.

Flight paths to meeting point (per runway) are not retained.

1.4.2.2 Ground surface

Description is limited to the surface where airport operations (airside, landside) take place. The landside operations are cut off after the gates of the terminal(s). For the terminal(s), some information on services is included (e.g. check-in desks, border crossings).

Fence perimeter geography is not documented.

Nature and position of ATC installations on the ground are not mentioned.

1.4.3 Geographic positioning

All geographic positions from runway(s) to stand(s), etc. have been included if they were already present; no new items were added.

All geographic data have attributes referring to accuracy, integrity and cyclic redundancy check.

1.4.4 Authorities

Name and data for the following authorities have been included

- Airport authority
- ATC authority (control tower at airport)

Two alternate airports have been included, concerning the destinations normally used as deviation airports.

1.4.5 Operations

Information referring to operational practices is included if it is related to physical characteristics (layout) of the airport (e.g. for runways their operational modes, interdependency, …).

Other operational information is often just limited to a listing in available services.

Sometimes operational information could be of relevance in building statistics that then are useful as general information. Entities and/or attributes for this purpose are available in the model.

1.4.6 Meteorological data

In principle these relate to a (very) temporary observation, and hence would not be required in the model. However, meteorological statistics are a fundamental part of the model, in order to enable the impact of weather conditions on airport capacity to be analysed.

1.4.7 Airport equipment

Airport equipment itself is not listed, but services available from specific equipment are given in the different area attributes (e.g. docking guidance system at the stand).

1.4.8 Airport services

This entity is included, but its existing listing was limited to fire and rescue, other services will be added to the list (e.g. marshalling service); this listing needs to be further expanded.

Commercial services landside are not included (e.g. pharmacy, except when they may have bearing on airport functionality (see Ground surface 1.4.2.2 above).

1.4.9 Calendar / timetable

Calendar and timetable enable the introduction of events of situations (e.g. large works) in order to reflect the possible change of status of some entities for a long period of time or on a recursive basis.

1.4.10 Statistics

Some entities (e.g. monthly data, meteorological data) have been retained because they are useful for building statistical information.

2. TECHNICAL PRESENTATION

2.1 Work Packages

The work package WP1 of the ANIM project includes among other, the following set of files for the Draft ANCM/ANXM:

- the present report giving an explicit description of the ANCM/ANXM model
- the complete ANCM/ANXM model in Rational Rose format (.mdl file)
- an HTML publication of ANCM including UML diagrams
- a data dictionary (in HTML format) including
    - entity and attributes definitions
    - domain and range of values
    - data syntax
- the XMI format of the model (.xml files)
- the XML structure files of ANXM (*.xsd files)
- the semantic rules (or constraints) of the ANCM/ANXM model are included in the present document.

For the purpose of review, the following files are made available on www.eurocontrol.int/pacs web site:

- EC-ANIM-draft-ANXM.zip = present document, Rational Rose mdl file, HTML data dictionary
- EC-ANIM-draft-ANXM-Publication.zip = HTML publication
- EC-ANIM-draft-ANXM-XMI.zip = XMI export (*.xml files)
- EC-ANIM-draft-ANXM-XSD.zip = XML structure files (*.xsd files)

2.2 Model Definitions

The Airport Network Conceptual Model (ANCM) consists of a set of UML diagrams that define elements of airport network information.

The Airport Network Exchange Model (ANXM) is an XML Schema implementation of the Airport Network Conceptual Model (ANCM), and thereby constitutes an exchange format for Airport Network Information.

In order to clear up potential misunderstandings, several points need to be emphasised at this stage. Firstly, the models are not software; they are abstract formalisations of the concepts involved in airport network information. By themselves, they perform no function in the software sense. They have been created to facilitate the development and usage of cross-platform applications. Secondly, the models are not mandated in any way, nor do they make existing systems or data formats redundant. It is hoped that they will be used alongside such systems by providing a common basis for exchanging data, thus increasing interoperability.

It is also important to understand that the ANCM/ANXM model was developed in the context of the future AIM and SWIM. In order to ensure inter-operability with the existing models (AIXM, AMXM, WXXM and TOD), many components of the AICM/AIXM models were reused, and in particular

- many airport-related classes,
- many data types, and
- the metadata structure.

2.3 Modelling Methodology

2.3.1 Approach

The ANCM/ANXM models were developed on the following basis:

- the PACS model, including
    - the last PACS version, and
    - a preliminary version containing
        - additional information about airport
        - apron statistics
        - taxiway capacity analysis
- the comparison between AMXM 1.1. and AIXM 5 - RC1
- the feasibility study regarding the inter-operability and gap analysis between the Taxiway Network Builder (TNB) and AMXM 1.1 (report 200300-REP-05-0939-A-PACS-AMXS)
- the review of both ICAO 14 and ICAO 4444 documents
- the review of AIXM5 - RC2
- compliance assurance with
    - AIXM 5 – RC2
    - WXXM
    - AIXM5 – RC1 (as long as not in contradiction with its counterpart in AIXM 5 – RC2)
    - AMXM 1.1 (as long as not in contradiction with its counterpart integrated into AIXM 5)

2.3.2 Conventions

In order to keep complete compliance with AIXM, some rules and conventions applied. These should be well known for full understanding of the ANCM/ANXM model.

2.3.2.1 Derivations

When an entity already existing in AIXM or WXXM required some additional attributes for ANXM, then a new class was derived taking these new attributes and inheriting the existing ones. This allowed keeping a clear distinction between the entities pertaining to one model or the other.

2.3.2.2 Colors in Diagrams

The following color convention was used for the ANXM diagrams:

- light grey background for classes coming from other models (AIXM, WXXM)
- dark grey background with white font for ANXM classes derived from AIXM classes
- white background for other ANXM classes

This convention does not apply to the existing AIXM diagrams included in the presentation.

2.3.2.3 Naming

- Feature and Object names are written in UpperCamelCase e.g. RunwayDirection.
- Simple property names (i.e. attributes) are written in lowerCamelCase e.g. operationMode.
- Relationship names are written in lowerCamelCase but as present tense verbs e.g. isSituatedAt.
- Datatype names are written in UpperCamelCase and end with 'Type' e.g. RwyDirectionInterdependencyType.

2.3.2.4 Stereotypes

In compliance with ISO19100 and OGC standards, and following AIXM conventions, the main stereotypes in use are:

- <<feature>>
- <<object>>
- <<datatype>>
- <<enumeration>>
- <<extension>>

Features describe real world entities and are fundamental in the model. They can be concrete and tangible, or abstract and conceptual and can change in time. Examples are given in Figure 1 - Example of Features.

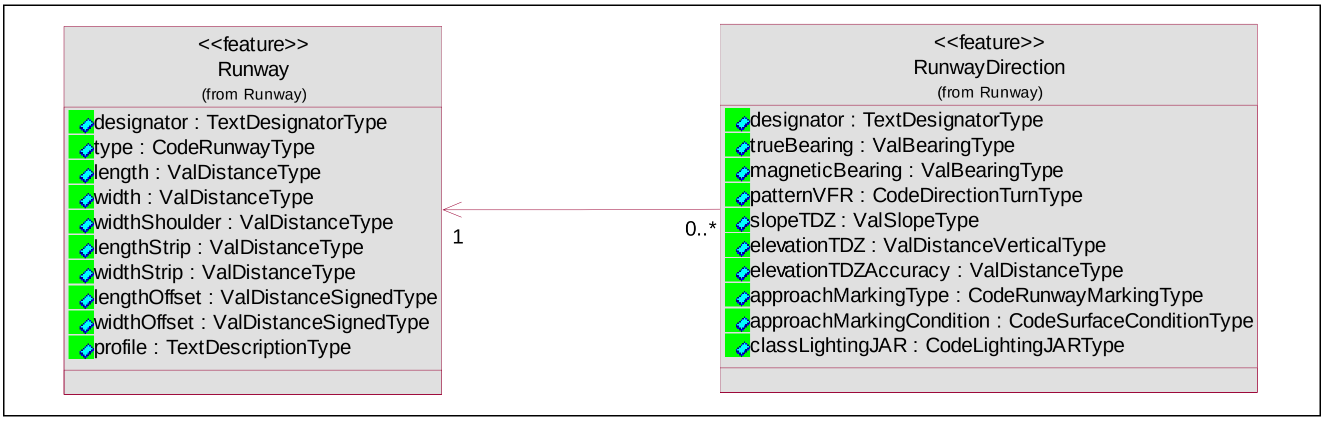

Figure 1 - Example of Features

Objects are abstractions of real world entities or, more frequently, of properties of these entities, which do not exist outside of a feature. So Objects are linked to features with the UML composition relationship. Examples are given in Figure 2 - Example of Composition.

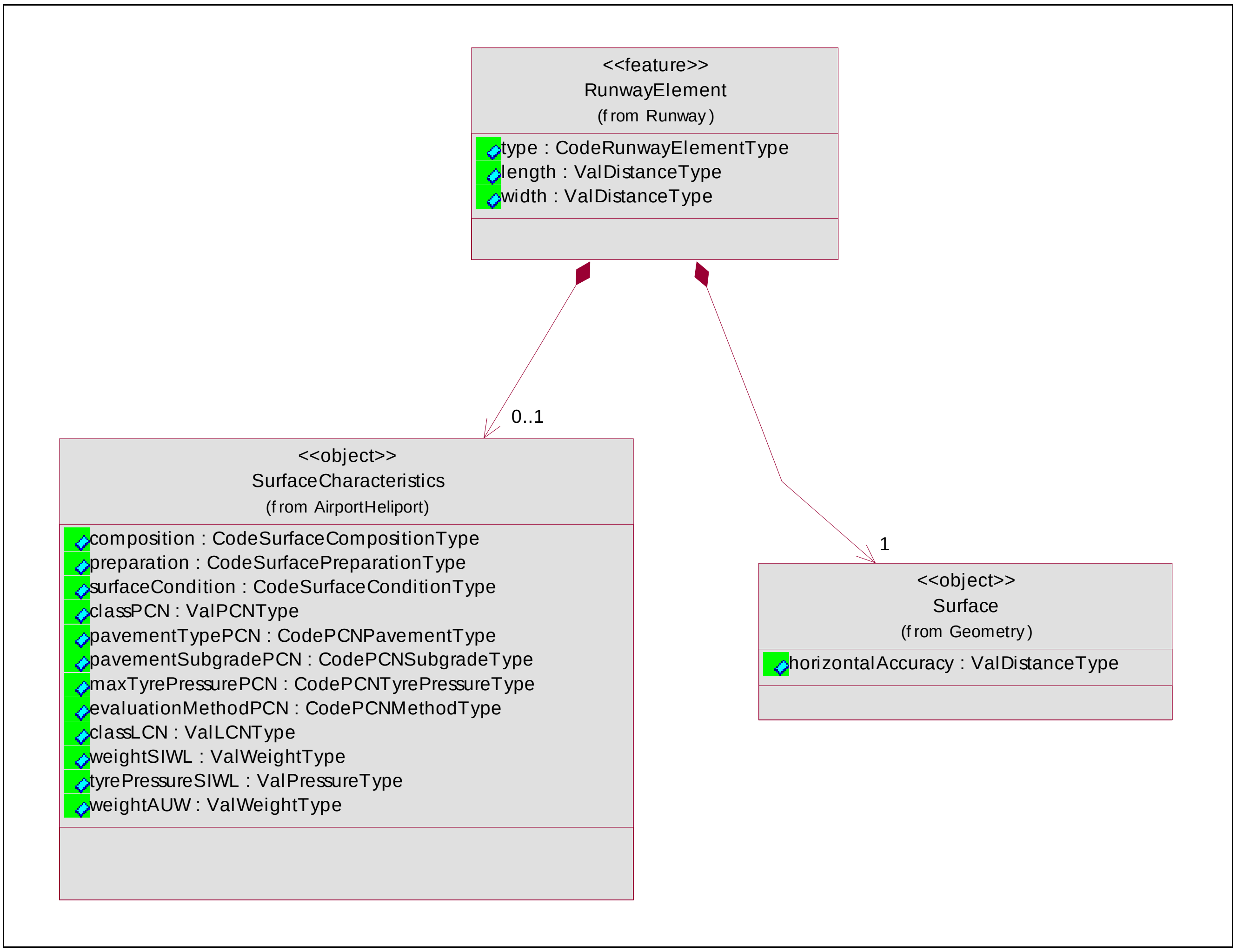

Figure 2 - Example of Composition

Datatypes are the basic data types that specify the pattern an attribute value should follow. Enumerations code a fixed list of values an attribute can take. Examples are given in Figure 3 - Example of Datatype and Enumeration.

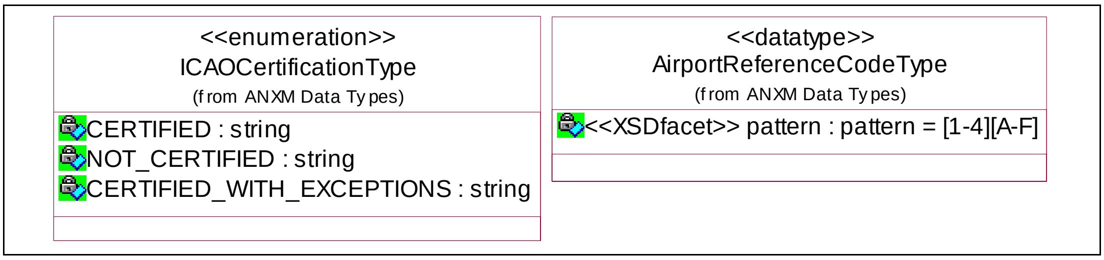

Figure 3 - Example of Datatype and Enumeration

Extensions are ANCM features or objects derived from AICM features or objects respectively. Examples are given in Figure 4 - Example of derivation.

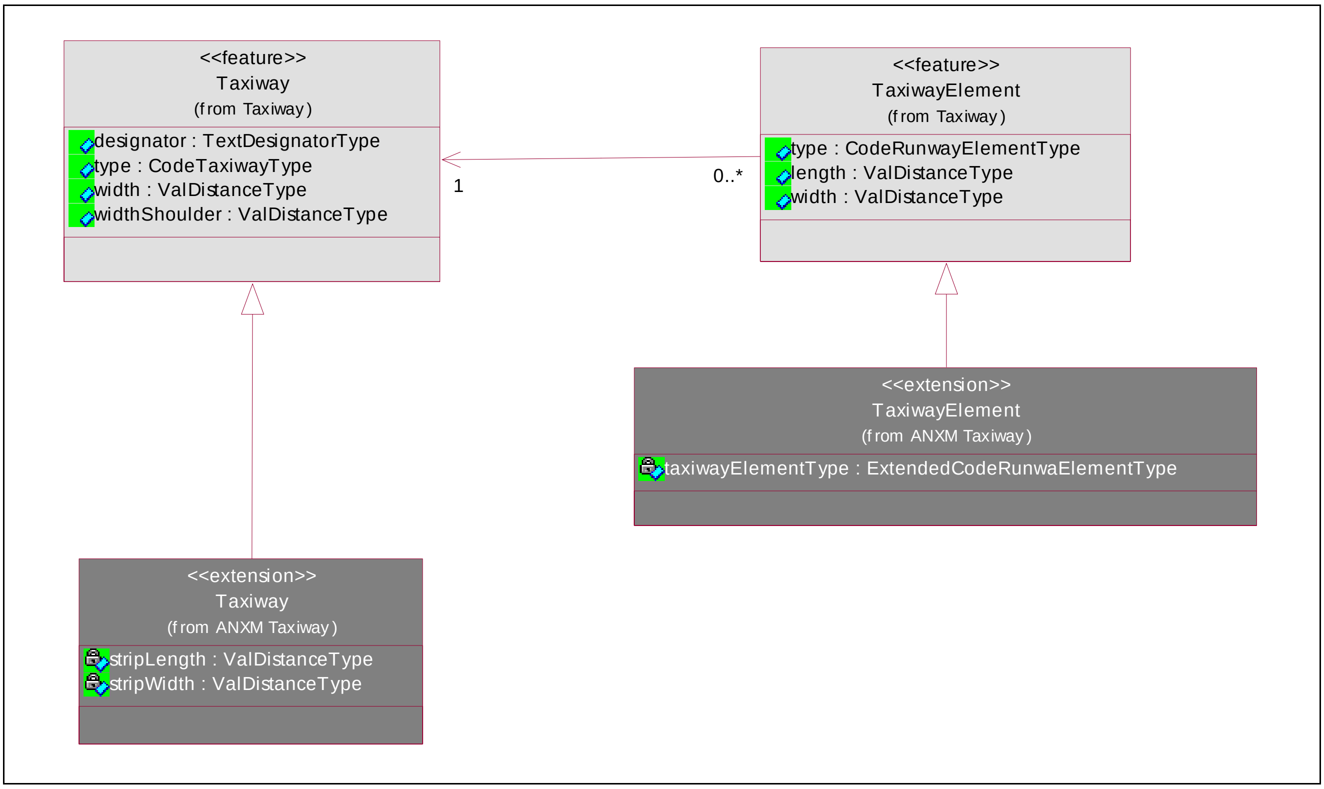

Figure 4 - Example of derivation

2.3.2.5 metadata

The AIXM model includes already an extended set of classes to store metadata. These will be reused in ANXM.

Features (like defined in AIXM) are dynamic, and Timeslice objects are used to describe the changes that affect the feature over time. For example, the validity period will be encoded in the "validTime" attribute of the AIXMTimeSlice, like shown in Figure 5 - Metadata.

Other metadata properties defined in AIXM need further specification for each model reusing them. ANXM will use them to specify data sources and whether a version is official and/or frozen.

- Data Sources will be encoded in the "contact" attribute of the FeatureTimeSliceMetadata class.
- Official or frozen versions will be identified thanks to the "dataStatus" attribute of the IdentificationFeature class. The possible values (already available in AIXM) will take the following meaning in ANXM:
    - underDevelopment may be used for non-official versions,
    - while onGoing would be used for official but non-frozen versions,
    - and completed will be the frozen official version that may become obsolete when replaced by a new one.

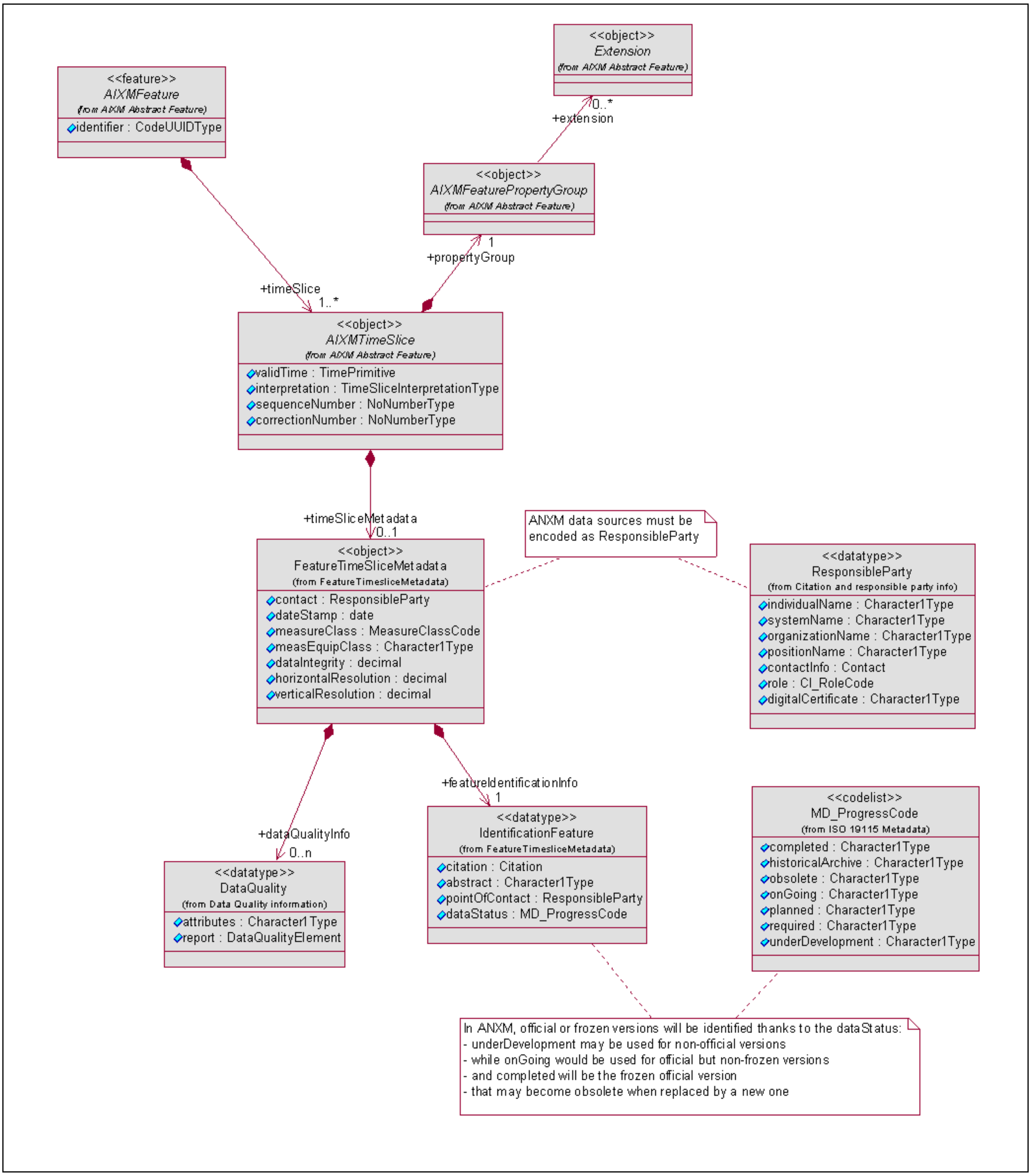

Figure 5 - Metadata

2.4 Exchange Model Generation

The XML Schemas that make up the exchange model were derived programmatically from the UML. The process was automated using scripts to provide a speedy and consistent interpretation of the model. These scripts were provided by Eurocontrol since they were developed for AIXM.

As previously stated, the ANCM/ANXM model reuses many components of the AICM/AIXM model. This is certainly very productive when applying the conversion scripts from ANCM to ANXM.

The first component automatically inherited from AICM are its abstract classes. An abstract class cannot be realised in an implementation such as an XML document. Abstract classes are used as base classes in an inheritance hierarchy. For example, the AIXMFeature abstract class describes the basic properties of an AIXM Feature. The ANXM Features inherit also automatically from it because they are declared with the stereotype <<feature>>.

These abstract AIXM classes are used as the building blocks for the AIXM XML Schema. However, for simplicity, these relationships are not shown on any diagram and do not really exist in the UML. They are just assumed to exist, when converting from the UML model to the XML Schema of AIXM.

The AIXM exchange model is an XML exchange standard based on a subset of GML. Essentially:

- AIXM Features are GML features;
- AIXM Objects are GML objects;
- AIXM follows the GML object-property concept.

An XML Schema (XSD) group is generated for each feature containing all of the properties (attributes and relationships) of the feature, included the ones inherited either from a more generalized class or from an abstract class.

For more details, please consult the AIXM documentation.

2.5 Model Components

2.5.1 Packages

The ANCM/ANXM is divided into a hierarchy of packages:

package	content
ANXM	• introduction notes • package dependencies diagram • metadata diagram
• ANXM Data Types	all new data types defined for ANXM
• ANXM Features	
o ANXM AirportHeliport	• airport classes derived from AIXM • diagram of airport geodata coming from AIXM • airport areas and their availability • airport-related information • guidance line classes derived from AIXM
▪ ANXM Apron	• apron classes derived from AIXM • diagram of apron geodata coming from AIXM • apron statistics
▪ ANXM Runway	• runway classes derived from AIXM • diagram of runway geodata coming from AIXM • runway theoretical capacity
▪ ANXM	• taxiway classes derived from AIXM

Taxiway	• diagram of taxiway geodata coming from AIXM • taxiway theoretical capacity and, most importantly, ground traffic efficiency analysis • diagram for navigation system check point from AIXM
o ANXM Movement	• aircraft type classes derived from AIXM • airport movement analysis
o ANXM Service	service classes derived from AIXM
o ANXM Weather	• weather observation classes generalized from WXXM • weather statistics and impact analysis

The ANXM package can be found at the same level as the AIXM and WXXM packages. All of them should be taken together as ANXM reuses entities coming from other models.

Some diagrams are included in ANCM presentation while they do show only classes coming from AIXM. Indeed, many airport-related information existed already in AIXM, and in particular geodata. The ANCM model doesn't need to reinvent them, but it appeared be very useful to put them in a new perspective, showing the modelled information with a focus on airport network information.

2.5.2 Main New ANCM Entities

2.5.2.1 airport-related information

ANCM presents the airport entity surrounded by :

- its terminals
- its runway configurations
- properties such as
  - its declared capacities
  - its ATM procedure implementation levels
- theoretical capacity scenarios for the purpose of airport planning and management
- operational scenarios
- experienced delay cases
- planning scenarios

2.5.2.2 apron statistics

ANCM presents apron statistics as the result of a theoretical capacity case based on a set of airport movements during a defined period of time.

The stand statistics may include, for each hour

- the number of each kind of movements
- the stand occupancy
- the queue length
- the sustained capacity
- the apron utilization

2.5.2.3 runway theoretical capacity

ANCM presents runway system theoretical capacities as capacity curves resulting from a theoretical capacity case and based on a runway system capacity scenario.

A static theoretical capacity shows a snapshot of capacity at a certain moment. A dynamic theoretical capacity shows capacity variations along a time period, based on the dynamic fluctuation of the influencing factors.

2.5.2.4 taxiway & ground traffic efficiency analysis

ANCM presents taxiway system theoretical capacities as the results of a theoretical capacity case based on a taxiway system capacity scenario.

The ground traffic efficiency information enables situational awareness to be enhanced. This information includes:

- the taxiway utilisation
- the taxi time
- the lost time
- the unconstrained capacity
- the sustained capacity
- the average queue length on taxiway segments
- the maximum queue length on taxiway segments
- the overload of taxiway segments
- the number of conflicts on taxiway nodes
- the medium conflict time on taxiway nodes
- the maximum conflict time on taxiway nodes.

2.5.2.5 movement analysis

ANCM presents movement analysis as the results of a throughput case, including

- maximum realised handling capability curves,
- throughput distribution curves,

- o statistics giving the number of movements per class of aircrafts, and services.

2.5.2.6 weather statistics and impact analysis

ANCM presents weather statistics as the results of a meteo case based on meteo observations.

Weather statistics give frequency and probability distribution of meteo conditions.

A classification can be built by grouping some meteo condition on the basis of customizable criteria. Each of the so-defined class can then be mapped to a theoretical capacity case.

Note that a theoretical capacity case may also be mapped to classes of any type of classification. The other one specifically foreseen in ANCM is a classification based on aircraft types.

2.5.3 Data Types

The ANXM Data Types package contains the definition of all domains and range of values specific to ANXM:

- o enumerations give list of possible values
- o other data types may define 2 different aspects:
  - ▪ a range of values defines the tolerance interval of the related date by giving a minimum and maximum value
  - ▪ a data syntax may be defined with a pattern.

Certain <<datatype>> might have an associated Unit Of Measurement. This is indicated in the model by the inclusion of a “uom” attribute in the definition of the <<datatype>> class. The type of the uom attribute is typically an <<enumeration>> class.

Some complex data types may take advantage of all these properties, like shown in Figure 6 - Example of complex data types:

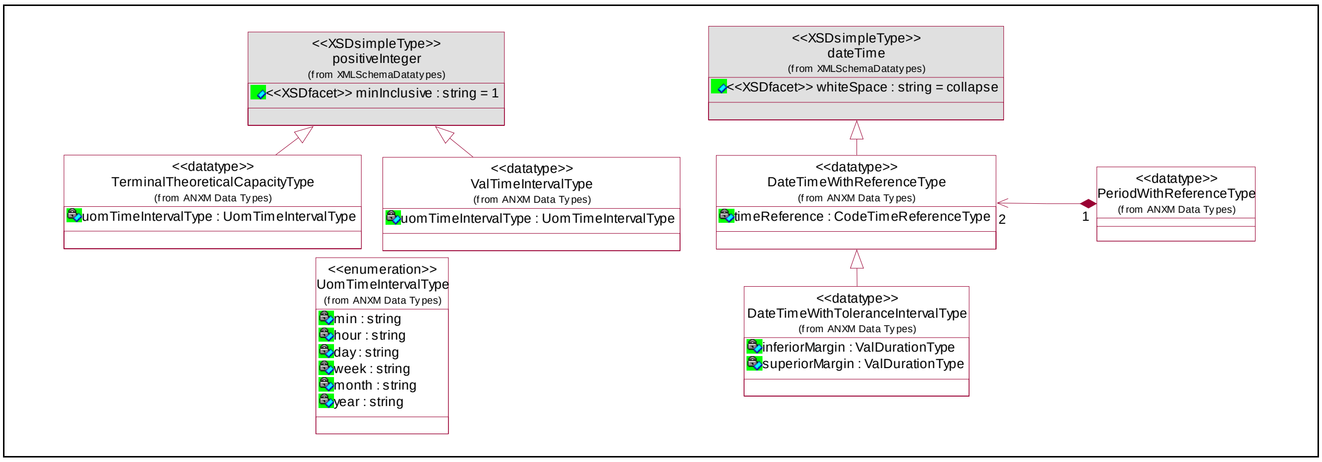

Figure 6 - Example of complex data types

Data of type TerminalTheoreticalCapacityType or ValTimeIntervalType will both take as value an integer above 1 and a timpe interval unit among the listed ones.

2.5.4 semantic rules

As many constraints as possible are expressed in the UML model by the multiplicity of the attributes and associations. However this is not always sufficient for more complex business rules. That’s why we have some additional semantic rules.

In any case, all such business rules will not be incorporated in the XML Schema, because XML Schema are not good for validating business rules. The scripts provided by Eurocontrol to generate the exchange model generate only optional associations, even if in UML it is mandatory. Instead, the policy decided at Eurocontrol will be to provide a Schematron XSLT that enables the validation of a file against such business rules.This will come later in time.

Below are given some semantic rules not expressed in the UML. These are shown as notes in the diagrams though, and they are encoded as text in the UDP tab of the class specification.

2.5.4.1 ClassificationCriteria

The optional one-to-one relation "hasNext" must define a classification as a set of classes showing contiguous ranges without overlaps nor gaps.

2.5.4.2 TheoreticalCapacityCase

A TheoreticalCapacityCase must take as input at least one scenario:

- o StandSystemCapacityScenario
- o RunwaySystemCapacityScenario
- o TaxiwaySystemCapacityScenario

A TheoreticalCapacityCase having results for apron, runway or taxiway theoretical capacity, must take as input respectively a StandSystemCapacityScenario, a TaxiwaySystemCapacityScenario or a RunwaySystemCapacityScenario, which is regulated by the following implication rules:

- o If a TheoreticalCapacityCase hasResults StandStatistics, then it hasInput a StandSystemCapacityScenario.
- o If a TheoreticalCapacityCase hasResults a TheoreticalCapacity, then it hasInput a RunwaySystemCapacityScenario.
- o If a TheoreticalCapacityCase hasResultsFor a Taxiway, a GuidanceLine or a TaxiNode, then it hasInput a TaxiwaySystemCapacityScenario.

The only condition where a TheoreticalCapacityCase doesn't need to analyse a TrafficCase is when generating only a theoretical runway static capacity curve, which is regulated by the following implication rules:

- o If a TheoreticalCapacityCase hasInput a StandSystemCapacityScenario, then it analyses a TrafficCase.
- o If a TheoreticalCapacityCase hasInput a TaxiwaySystemCapacityScenario, then it analyses a TrafficCase.

- o If a TheoreticalCapacityCase hasResults a TheoreticalCapacity with theorRwyCapType = DYNAMIC and hasInput a RunwaySystemCapacityScenario which considers a ScenarioAircraftClass with no value defined for inboundFleetMix or outboundFleetMix, then it analyses a TrafficCase.

2.5.4.3 AHCACase

The time interval is required for throughput distribution and maximum realised handling capability analysis but not for statistics by classes of aircraft.

End of Document