AIXM 5 Technical Proposal

- Obstacle Model -

DRAFT

Edition: 0.2
Date: 03 February 2006

Edition No.	Issue Date	Author	Reason for Change
0.1	2006/01/23	Eddy Porosnicu	First Draft – for AIXM 5 FG review
0.2	2006/02/03	Eddy Porosnicu	Revised version, incorporating comments from Focus Group #1 and Brett Brunk

Contents

1 Introduction

The purpose of this document is to analyse the current requirements for obstacle data and to propose a new conceptual schema for obstacle information, which satisfies the requirements of the international air navigation.

This proposal for a new obstacle conceptual schema is made in the context of AICM/AIXM version 5, in particular as described in the "AIXM 5 White Paper". All aspects discussed in the White Paper, such as temporality, object identification, use of GML, etc. are applicable and are not re-discussed in the current document. The current document focuses on the proposed AICM 5 - obstacle concept, which is presented in the form of a UML class diagram.

1.1 References

[1] Aeronautical Information Services. 12th Edition. Annex 15 to the Convention on International Civil Aviation. ICAO. July 2004.
[2] User Requirements for Terrain and Obstacle Data. RTCA DO276/EUROCAE ED-98.
[3] Interchange Standards For Terrain, Obstacle, And Aerodrome Mapping Data. RTCA DO-291/EUROCAE ED-119

2 Requirements analysis

The purpose of this section is to analyse the obstacle data publication requirements and to propose a design satisfying these requirements.

2.1 Sources

2.1.1 ICAO Annex 15 – Aeronautical Information Services

Amendment 33 to ICAO Annex 15 has introduced new provisions for obstacle data publication. These are largely based on the work of RTCA/EUROCAE, as reflected in the document DO-276/ED-98 – User Requirements for Terrain and Obstacle Data. The new requirements have extended the already existing ICAO Standards and Recommended Practices for obstacle data publication in national AIP.

ICAO Annex 15 requirements for obstacle data publication are mainly listed in Appendix 1 (Content of Aeronautical Information Publications) and in Chapter 10 - Electronic Terrain and Obstacle Data.

2.1.2 ICAO ANNEX 4 – Aeronautical Charts

The Annex contains requirements for obstacle publication on charts. Most of the requirements for obstacle data are the same as in Annex 15. There exist some additional requirements, such as the recommendation to indicate the reference obstacle for an instarumment approach procedure clearance heights/altitudes.

2.1.3 ICAO ANNEX 14 – Aerodromes

The Annex contains requirements for obstacle assesment, control and reporting. Most of the requirements for obstacle data publication are already included in Annex 15. In particular, there exist detailed requirements with regard to the marking and lighting of obstacles.

2.1.4 RTCA/EUROCAE – DO-276/ED-98 – User Requirements for Terrain and Obstacle Data

This document defines a set of minimal user (data integrators and system designers) requirements with regard to obstacle data publication. Although most of the requirements have been reflected in the ICAO Amendment 33 to Annex 15, the RTCA/EUROCAE document provides useful background information and detailed explanation for these requirements.

2.1.5 AICM version 4.5

AICM 4.5 was also considered as a source for requirements, for two reasons:

- it reflects how data has been published in the State AIPs before the introduction of the new Annex 15 requirements (Amendment 33) and also
- in order to facilitate backwards compatibility

2.1.6 ACCB – change proposals to version 4.5

To date, there exist only one open change proposal recorded in the AIXM Change Control, which is related to the obstacle model: AIXM00000125 “Obstacle markers”. This change proposal has been considered in this analysis.

2.1.7 IATA Standard Format

The format used by IATA in order to supply their users with aeronautical data includes two sections related to obstacle information:

- Section ARPOBS - Airport Obstacles
- Section RWYOBS - Runway Obstacles

The particularity of this format is that it includes information that could be deduced through calculation, such as “distance from ARP”, “Magnetic bearing from ARP”, “Height above airport elevation”, etc. These have not been retained as requirements.

2.1.8 ICAO DOC 8126 - AIS Manual - NOTAM Selection Criteria

The goal of the new conceptual schema is to include all the elements necessary for modelling not only the static data but also the dynamic information. The NOTAM selection criteria (NSC) provide the list of the most likely temporary conditions that can occur in relation with an obstacle. These are grouped under the NSC codes with ‘OB’ (Obstacle), ‘OL’ (Obstacle lights) as second and third letter.

The only condition that requires a specific attribute, not already covered by the static data requirements, is related to the status of the feature:

- for obstacle – may be under construction or completed
- for obstacle lights – may be under construction, completed, or unserviceable.

2.2 Requirements

2.2.1 Obstacle - Definition

Source	ICAO Annex 15, Chapter 2 - Definitions
Description	The obstacle feature shall be defined as “*all fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.*”
Comments	This definition does not exclude “natural obstacles”, such as trees or natural highpoints, for example. Chapter 10 of Annex 15 contains the following sentence: “*Obstacle data shall comprise the digital representation of the vertical and horizontal extent of man-made objects*.” However, ICAO Annex 4 contains references to trees and relief features that may be considered as obstacles. Therefore, it may be concluded that obstacles are not limited to man-made objects. The following note should be added to the definition: “*Obstacles include both natural and man-made features that have vertical significance in relation to adjacent and surrounding features*”. This requirement is already satisfied in AICM 4.5.

2.2.2 Obstacle identifier

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10; ICAO Annex 15, Appendix 8, table A8-4; IATA Standard Format

Description	Each obstacle feature must have an identifier
Comments	ENR 5.4 and AD 2.10 requirements indicate that each obstacle shall have identification or designation. In table A8-4, the identifier is listed as a mandatory attribute, in the context of an obstacle database. Therefore, this attribute is considered mandatory for AIXM. During the 11th meeting of the AIS Technical Subgroup of the EUROCONTROL AIS Team, the participants supported the view that this identifier should be a global unique identifier, published in the national AIP. AIXM 5 will allow (through xlink:href) the use of both natural identifying properties and artificial identifiers. Therefore, whether this identifier is worldwide unique or not, it does not have an immediate impact on the model. However, if unique, it could be used as single global identifying feature property.

2.2.3 Obstacle designator (name)

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10
Description	Each obstacle feature may have a textual designator (name)
Comments	According to the AIP Sample included in the ICAO AIS Manual, the "designator" is a name\location associated with the obstacle. This interpretation is supported by the data available in many national AIP. AIP Specimen ENR 5.4-1 10 JUN 2004 **ENR 5.4 Air navigation obstacles - en-route** **1 (elevation/height 100m AGL or more)** **Designation** | **Type of obstacle** | **Coordinates** | **ELEV/HGT GND (M)** | **OBST LGT Type/Colour** 1 | 2 | 3 | 4 | 5 Justine | Mast | 510136N 0311932W | 277/163 | OBST/R Rainby | Chimney | 553208N 0310225W | 178/136 | OBST/R Kipol | Antenna mast | 462021N 0250000W | 505/454 | Hazard light/ FLG W Woodbank | Bridge tower | 425015N 0364952W | 170/110 | Illuminated (flood light) This attribute is not listed in table A8-4 of Annex 15. As the purpose of AIXM is to also support AIP publication processes, this attribute should be included in the model (optional). This requirement is already satisfied in AICM 4.5 (TXT_NAME attribute).

2.2.4 Obstacle type

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10; ICAO Annex 15, Appendix 8, table A8-4; IATA Standard Format
Description	Each obstacle feature shall have a type
Comments	ICAO Annexes do not include any standardised list of obstacle types. RTCA/EUROCAE – DO-276/ED-98 provides a coded list of 39 obstacle types (plus one value for 'other'). This list will be used in this model as a basis. It might be extended with additional types from other relevant standards, such as "DIGEST". Annex 4 contains symbology for a number of cartographic features that appear in the RTCA/EUROCAE list of obstacle types.

	According to Annex 4, 16.9.3.2 “when considered of importance to visual flight, prominent transmission lines and permanent cable car installations, which are obstacles, shall be shown.” “Cable car” has the same meaning as the American English term”cable railway”. It is recommended that this list is not implemented as a fixed enumeration in the AIXM XML schema. It should be a recommended code list only. Therefore, the value ‘other’ is not necessary and was not included in the list below.			
	Arch	Elevator	Transmission Line	Cable Car/Railway
	Tethered Balloon	Monument	Tower	Fence
	Bridge	Power Plant	Tramway	Grain Elevator
	Building	Pole	Windmill	Lighthouse
	Catenary	Rig	Antenna	Navaid
	Cooling Tower	Refinery	Tree	Nuclear Reactor
	Crane	Sign	Vegetation	Water Tower
	Control Tower	Spire	Natural Highpoint	Stadium
	Dam	Stack	Windmill Farms	
	Dome	Tank	Wall	
	This requirement is already satisfied in AICM 4.5 (attribute TXT_DESCR_TYPE), but without a predefined list of obstacle types.			

2.2.5 Obstacle horizontal geometry

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10; ICAO Annex 15, Appendix 8, table A8-4;
Description	Each obstacle feature must have a horizontal projection described as point, circle, line or polygon.
Comments	According to Annex 15 Appendix 1, it is required to publish the position of an obstacle as geographical coordinates in degrees, minutes, seconds and eventually tenths of seconds. On the other side, in an Obstacle data product build according to the Annex 15 – Chapter 10 requirements: “*Obstacle data elements are features that shall be represented in the database by points, lines or polygons.*” Obviously, for obstacles of type line or polygon it does not make sense to publish a single latitude/longitude value as position. For the purpose of this model, it is considered that the requirements in Chapter 10 prevail over the less sophisticated requirements in the Appendix 1 of Annex 15. In addition, when discussing the list of obstacle attributes, the concept of ‘horizontal extent’ is mentioned for an obstacle of type point. According to RTCA/EUROCAE – DO-276/ED-98 “*the horizontal extent is the footprint of or the area subtended by the obstacle, e.g. area covered by mast guy wires, or weather balloon*”. In ED-119 this was interpreted as “*the radius of circle around the centre of the feature including the body of the feature and associated structures such as guy wires*”. Therefore an obstacle may also have a circle as horizontal projection. The question is whether this requires a distinction between prism like obstacles and cone like obstacles. This distinction was not retained as a requirement, just the possibility to describe the horizontal shape as circle (centre point with radius). In the Annex 15 Table A.8-4, the ‘geometry type’ is listed as a mandatory attribute for each obstacle. The geometry type (point/circle/line/polygon) is likely to be specific part of the position encoding. For example, in GML, a specific element will be used for each type of geometry. Therefore, it is not considered necessary to include a dedicated attribute in the

	model to specify the geometry type. This requirement is partially satisfied in AICM 4.5 (GEO_LAT and GEO_LONG attributes; not possible to describe obstacles that are projected as lines or polygons).

2.2.6 Obstacle horizontal geometry reference system

Source	ICAO Annex 15, 3.7.1; ICAO Annex 15, Appendix 8, table A8-4;
Description	Each obstacle feature must have a specified horizontal reference system (datum).
Comments	Although the Annex 15 requires that "*published aeronautical geographical coordinates (indicating latitude and longitude) shall be expressed in terms of the WGS-84 geodetic reference datum*", the obstacle data published world-wide does not yet comply with this requirement. Therefore, for this model, it is still necessary to recognise the use of other datum. This requirement is already satisfied in AICM 4.5 (CODE_DATUM attribute).

2.2.7 Obstacle horizontal geometry data quality

Source	ICAO Annex 15, Appendix 8, table A8-4;
Description	Each obstacle feature must have the following data quality attributes for the horizontal geometry: accuracy, confidence level, resolution.
Comments	These data quality elements may be specified either for an obstacle feature instance or for an obstacle data set. The conceptual schema included in this document does not model the data set properties. In addition, it is obvious that this set of attributes is applicable to any other surveyed position that might appear in the other concept areas of the AICM 5 model (for example, the position of an aerodrome reference point). The need for the 'confidence level' attribute is debateable. The Annex 15 imposes the value of 95% confidence level when specifying data accuracy requirements: "*The order of accuracy for aeronautical data, based upon a 95 per cent confidence level, shall be as specified in Annex 11, Chapter 2, and Annex 14, Volumes I and II, Chapter 2.*" It is very likely that in a practical implementation this attribute will be used only when the confidence level is different from 95%. This requirement is partially satisfied in AICM 4.5 (the VAL_GEO_ACCURACY attribute; the resolution is implicit, as all values are modelled as formatted strings of characters).

2.2.8 Obstacle elevation

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10; ICAO Annex 15, Appendix 8, table A8-4; IATA Standard Format
Description	Each obstacle feature must have an elevation value, measured from the Mean Sea Level (MSL).
Comments	For obstacles that have a horizontal projection of type line or polygon, is it required to enable the provision of a distinct elevation value at each line or the polygon vertex? For example, in the case of certain bridges supported by cables or in the case of transmission lines, the elevation may change significantly along the horizontal path. This requirement could not be identified either in Annex 15 or in the RTCA-EUROCAE documents. The typical approach in the aeronautical data domain is to use a 2.5D vertical model, by which a volume is represented as a horizontal boundary, complemented by attributes that define the vertical extent. These considerations would favour a single

	elevation value for the whole obstacle. On the other side, it is obvious that obstacles of type wire would be badly represented by a single elevation value for the whole obstacle. Therefore, the requirement is reformulated as "Each obstacle must have an elevation value. In the case of obstacles that are represented in the horizontal projection as line or polygon, this shall be the maximum elevation over the whole obstacle extent. In addition, for such obstacles, it shall be possible to indicate a specific vertical position at every vertex." In GML, this would imply the use of gml:pos elements with x,y,z values. The overall height remains a distinct feature property. It should be noted that such gml:pos z values would be ellipsoidal heights, while the overall elevation would be a geoidal height. This requirement is already satisfied in AICM 4.5 (attribute VAL_ELEV).

2.2.9 Obstacle elevation reference system

Source	ICAO Annex 15, 3.7.2;
Description	Each obstacle feature must have a specified elevation reference system (datum).
Comments	According to Annex 15, the Earth Gravitational Model — 1996 (EGM-96) shall be used as the global gravity model for international air navigation. In addition, regional, national or local geoid models containing high resolution (short wavelength) gravity field data shall be developed and used where necessary to meet the accuracy requirements specified by ICAO. In AICM 4.5, this requirement was taken into consideration through the inclusion in the models of a free text field (TXT_VER_DATUM). In the AIXM 5 version, it is recommended that an exhaustive list of vertical reference datums used around the world is included, in the form of an enumeration that also contains 'other'. If 'other' is used, details should be provided in a dedicated elevationDatumRemarks. This concept shall be applied consistently in all other conceptual areas.

2.2.10 Obstacle height

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10; ICAO Annex 4, 11.10.2.2; IATA Standard Format
Description	Each obstacle feature may have height (the physical extent of the obstacle, between the Earth surface and the top of te obstacle).
Comments	For obstacles of type line or polygon, the height should be the maximum height through the whole extent of the obstacle. This attribute should only be used for obstacles that have the bottom on the surface of the Earth. For obstacles that float in the air, such as wires, it does not make sense to provide a height value. According to Annex 4, Instrument Approach Charts should indicate the height of the each obstacle above the aerodrome reference point or the above the runway threshold, if the threshold elevation is more than 2 m (7 ft) below the aerodrome elevation). This value may be calculated and it is specific foe each chart. Therefore, it has not been considered necessary to allow other references for the obstacle height. It shall be always provided with reference to the Earth surface below the obstacle. This requirement is already satisfied in AICM 4.5 (attribute VAL_HGT).

2.2.11 Obstacle vertical data quality

Source	ICAO Annex 15, Appendix 8, table A8-4;

Description	Each obstacle feature shall have the following data quality attributes for the vertical geometry: accuracy, confidence level, resolution.
Comments	These data quality elements may be specified either for an obstacle feature instance or for an obstacle data set. The conceptual schema included in this document does not model the data set properties. The Annex 15 imposes the value of 95% confidence level when specifying data accuracy requirements: "*The order of accuracy for aeronautical data, based upon a 95 per cent confidence level, shall be as specified in Annex 11, Chapter 2, and Annex 14, Volumes I and II, Chapter 2.*" On the other side, in table A8-2, it is indicated that, for obstacle data, the required confidence level is only 90%. This requirement is partially satisfied in AICM 4.5 (the VAL_ELEV_ACCURACY attribute; the resolution is implicit, as all values are modelled as formatted strings of characters).

2.2.12 Obstacle geoid undulation

Source	ICAO Annex 15. AICM 4.5.
Description	Each obstacle feature may have a value for geoid undulation.
Comments	The VAL_GEOID_UNDULATION attribute has been consistently added in AICM in all entities that had a vertical distance property. However, Annex 15 requires this value to be recorded only for a specified number of locations, which does not include obstacles locations. For the sake of model uniformity and backwards compatibility, this attribute should be kept in the model.

2.2.13 Obstacle lighting

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10
Description	Each obstacle feature may have lighting. Each light may have a horizontal position, an elevation, a colour, intensity and a type (flood or strobe).
Comments	Depending on the type of obstacle, some of the attributes might be left empty. For example, for an obstacle of type point, the horizontal position may be left empty as it is assumed to be the same as for the obstacle itself. However, there could exist several lights, situated at different elevations. There should also exist the possibility to complement this structured description of the lighting with free text remarks. This requirement is partially satisfied in AICM 4.5 (attribute TXT_DESCR_LGT). In the new model, the free text description would get a secondary role, only as a complement of the structured description (position, elevation, colour, type) of each light. The SURFACE_LGT_GROUP entity from AICM 4.5 should be generalised and re-used for this purpose: create an abstract class LightElement, from which both ObstacleLight element and SurfaceLightGroup are derived.

2.2.14 Obstacle marking (painting) - pattern and colour

Source	ICAO Annex 15, Appendix 1, ENR 5.4; ICAO Annex 15, Appendix 1, AD 2.10; ICAO Annex 14, Vol 1, Chapter 6. Visual aids for denoting obstacles
Description	Each obstacle feature may have marking.
Comments	Annex 14 contains requirements with regard to the marking of an obstacle. The marking

	types indicated in the Annex may be used as a code list: o painted - single colour o painted - chequered pattern o painted - horizontal bands o painted - vertical bands o flag with chequered pattern o markers (for cables, wires, etc.) However, it is recommended that this code list is not hardcoded in the AIXM XML Schema (not a fixed enumeration). In general, marking is done with two strongly contrasting colours, such as white/orange or white red. The two colours may be changed in order to ensure the best contrast with the environment of the obstacle. This could be modelled with two additional optional attributes: o first colour o second colour

2.2.15 Obstacle associated with MKR

Source	AIXM Change Control Board [AIXM00000125 - Obstacle markers]
Description	Each obstacle feature may be associated with a MKR navaid
Comments	The site of an obstacle that has significance for approach, landing or departure procedures may be marked by a MKR navaid. Examples may be found in AIP Ukraine (UKCC Donetsk aerodrome to mark a critical obstacle (pit refuse heap after coal mining).

2.2.16 Controlling Obstacle for Instrument Approach Procedure

Source	ICAO Annex 4, 11.10.2.3
Description	Each obstacle feature may be determining the obstacle clearance altitude/height of one or more procedures.
Comments	According to Annex 4, If one or more obstacles are the determining factor of an obstacle clearance altitude/height, those obstacles should be identified.

2.2.17 Obstacle data temporal characteristics

Source	ICAO Annex 15, Appendix 8, table A8-4;
Description	Each obstacle feature must have, as a minimum, start and end of validity date and time.
Comments	The general temporality model of AIXM 5 shall be applied.

2.2.18 Obstacle effectivity

Source	ICAO Annex 15, Appendix 8, table A8-4;
Description	Each obstacle feature may be effective according to a specified timetable.
Comments	The general timetable/timesheet concept shall be applied.

2.2.19 Obstacle status

Source	ICAO DOC 8126 – NOTAM Selection Criteria
Descriptio	Each obstacle feature may have an operational status

n	
Comments	The list of values include: “in construction”, “completed”.

2.2.20 Obstacle lighting status

Source	ICAO DOC 8126 – NOTAM Selection Criteria
Description	Each obstacle feature light may have an operational status.
Comments	The list of values include: “in construction”, “completed”, “unserviceable”.

2.2.21 Obstacle lighting effectivity

Source	ICAO DOC 8126 – NOTAM Selection Criteria
Description	Each obstacle feature light may be effective according to a specified timetable.
Comments	The general timetable/timesheet concept shall be applied.

2.2.22 Data originator identifier

Source	ICAO Annex 15, Appendix 8, table A8-4;
Description	The originator of each obstacle feature instance and of each obstacle data set shall be explicitly recorded.
Comments	The requirement comes from the traceability requirement within DO-200A. Auditing the trail of the obstacle data is important. One question is whether it is necessary to provide full structured details – name and contact details (for example, provided by a relationship to Organization/Authority in AICM). A simple text string might not be appropriate. Another question is whether it is necessary to provide the full trail or just sufficient information for identifying the latest originator in the chain. Traceability requirements for obstacle data are not different in any way from the traceability requirements for navaid or runway data, as an example. There should be a consistent approach to this issue in AICM 5 with regard to all the features. Therefore, this requirement was left for being satisfied by the overall approach in AICM 5 for traceability, as part of the metadata.

2.2.23 Area of coverage for obstacle data set

Source	ICAO Annex 15, Appendix 8, table A8-4;
Description	Each obstacle data set may have an area of coverage
Comments	According to RTCA-EUROCAE documents, the area of coverage of a data set shall be described as free text, being intended for human interpretation. This requirement is applicable to an obstacle data set only. A similar requirement exists for any other aeronautical data set: list of airports, list of navaids, etc. Therefore, this requirement is left for being satisfied by the overall AICM 5 model and it is not dealt with in the obstacle conceptual schema presented in this document.

2.2.24 (Deprecated) group indicator

Source	AICM 4.5
Description	Each obstacle feature may have an indicator whether it consists of a group of similar obstacle items (for example, a group of trees, a group of poles, etc.)
Comments	This attribute already exists in AICM 4.5. In the new model, each component of a group of obstacles should be described individually. However, for backwards compatibility reason, this attribute should be kept in the model, but marked as 'Deprecated'.

2.2.25 (Deprecated) Obstacle associated with aerodrome

Source	ICAO Annex 15, Appendix 1, AD 2.10; AICM 4.5; IATA Standard Format
Description	Each obstacle feature may be associated with an aerodrome. Additionally, obstacles situated in Area 3 may also be associated with a specified runway. Area 2 and 3 should become airspace types. A relationship should be established between Airspace and Aerodrome/Heliport.
Comments	Following Annex 15 AMDT 33, obstacles in AIP AD 2.10 must be presented separately per Area 2 and 3. In order to be able to make this separation, it is necessary to have the possibility to associate an obstacle with the airport instance and to indicate whether it is situated in either Area 2 or Area 3 (attribute of the association). An obstacle may be in Area 2 of one or more airports. An obstacle can be in Area 3 of a single airport (except for co-located airports). In order to support old style AIP, which do not indicate in which Area (2 or 3) the obstacle is located, the corresponding attribute should be optional. In order to support old style AIP, in which it was requested to indicate whether an obstacle affects approach, departure or circling operations, there should be an optional association with runway direction, with an attribute indicating the type of operations affected (Approach, Departure or Circling). This relationship already exists in AICM 4.5. It is considered that this spatial relationship may be deduced as result of a spatial query. This requires knowing the precise shape of the Area 2 or 3 involved – to be retained as a requirement for the Airspace concept area.

2.3 Not retained as requirements

The purpose of this section is to document other possible issues related to obstacle data, which have not been retained as formal requirements.

2.3.1 Aggregated obstacle

Most real-world obstacles have complex 3D geometries. For example, a bridge may have towers, cables, horizontal surfaces – polygons, etc. Based on the RTCA-EUROCAE documents, it is not required to represent each such geometrical volume individually. In the case of a bridge, its representation as a polygon with elevation seems to be sufficient for the aeronautical information domain.

Therefore, the representation of an obstacle as an aggregation of obstacle parts has not been retained as a requirement.

2.3.2 Annex 15 – Table A.8-4"Elevation reference"

ICAO Annex 15, Appendix 8, table A8-4 lists 'elevation reference' as mandatory attribute for an obstacle. This attribute is not the vertical reference system (such as EGM-96, for example) – this being modelled by the "vertical reference system" attribute.

The elevation reference seems to be an attribute applicable only to terrain data, in which case it would indicate the point of the grid (centre, edge, etc.) where the elevation of each cell is provided. It is likely that this is an error in the Annex 15 and was therefore not retained as a requirement.

2.3.3 Data integrity as attribute of the obstacle

ICAO Annex 15, Appendix 8, table A8-4 lists 'integrity' as mandatory attribute for an obstacle.

Data integrity is a characteristic of a data storage or data transfer process, not a property of the feature. For example, a data set may have a level of 10^{-5} integrity at the moment when the data set instance was ready to be transferred by the data originator. If the same data set is transmitted to several users, the integrity with which this data is received may be different for each user, depending on the specific transmission channel. Through data transfer, the integrity might be downgraded to 10^{-4} for certain users. Therefore, it does not make much sense to put an integrity value inside the file, as it does not reflect the end-of-data-transfer situation, which depends on the data transfer process.

Therefore, the possibility to indicate the integrity of the data for each individual obstacle feature instance was not considered appropriate as requirement.

2.3.4 Moving obstacles

There exist obstacles that are moving in a certain area or along a given trajectory. Examples of such obstacles include:

- a meteo balloon climbing on a vertical trajectory
- a large ship that crosses the departure or arrival area of a runway

If the position of the obstacle along the trajectory is predictable, then it might be interesting to include in the model the possibility to provide the exact position according to a timetable. However, no requirement in this sense has been identified, either in the RTCA/EUROCAE documents or in the ICAO Annex 15. Moving obstacles (such as a crane) can be modelled by providing the geometry of the maximum area in which the obstacle may be situated.

2.3.5 Obstacles with variable geometry

Similarly, there may exist obstacles that change shape/volume, such as a mobile bridge. No requirement in this sense has been identified either in Annex 15 or in the RTCA/EUROCAE documents. Obstacles than change their geometry can be modelled by providing the geometry of the maximum volume in which the obstacle may be situated. Eventually, obstacles, which have 2-3 clearly distinct shapes that are activated according to precise timetables, can be modelled as individual obstacles. This procedure could be applied for example for a mobile bridge, which would be modelled as two obstacles: closed bridge and open bridge.

2.3.6 Obstacle operations

ICAO Annex 15, Appendix 8, table A8-4 lists 'operations' as optional attribute for (mobile) obstacles. Operations are defined as

In the UML context, “operations” is equivalent to “methods” and indicates a function (not an attribute!) that can be performed by a class of features. An operation is not a relevant characteristic for data exchange.

Therefore, it has not been considered necessary to include an ‘operations’ attribute.

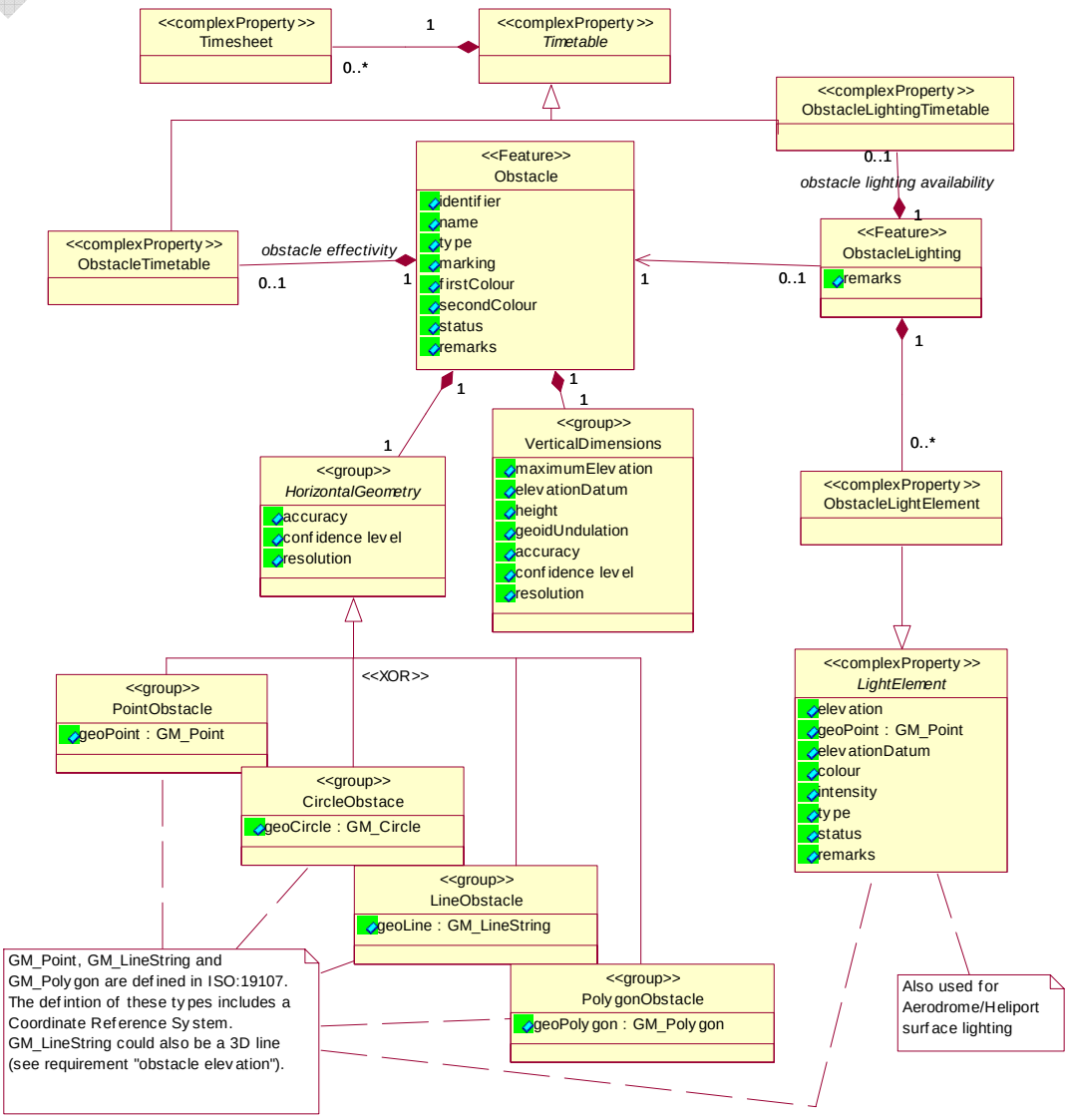
2.3.7 Obstacle associated with State/Territory

Following AMDT 33 to Annex 15, the AIP ENR 5.4 table should contain the obstacles in Area 1 (the whole State/Territory). This spatial relationship may be deduced as result of a spatial query and it was therefore not retained as a requirement for the Obstacle model. This relationship did not exist in AICM 4.5, therefore it is not necessary either for backward compatibility.

3 Proposed conceptual schema

The UML class diagrams included in this section document the conceptual schema for obstacle information, which was developed based on the requirements listed in section 2.2.

3.1 Obstacle class



3.2 Obstacle Associations