

European Air Traffic Management



Terrain and Obstacle Data Working Group

TODWG9/WP3

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WORKING PAPER

Submitted by
Secretary TOD WG

eTOD Metadata Profile

Summary

This document contains a proposal for a metadata schema for electronic Terrain and Obstacle Data (eTOD). The schema is based on ISO 19115, allowing for data interchange in accordance with the AIXM standard. It can be regarded as a profile of ISO 19115. Once the schema is approved, guidelines for the collection of metadata, including data quality evaluation reporting, will be developed.

Recommendations

The TOD WG is invited to:

- Review the content of the paper;
- Submit comments on the content of the paper to the TOD WG Chairman and Secretary by the end of May 2009.

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1. Introduction

1.1 What is Metadata

The following text is an excerpt from ANZLIC Metadata Guidelines¹ describing the topic "Metadata":

"Metadata is data about data. In other words, it is a structured summary of information that describes the data. Metadata includes, but is not restricted to, characteristics such as the content, quality, currency, access and availability of the data. For spatial information or information with a geographic component, Metadata deals with the "what, when, who, where and how good" of the data.

The concept of Metadata is becoming increasingly familiar to people who deal with information and spatial information in particular. Library catalogues are a well established example of Metadata records that help with the discovery, use and management of collections of books, documents and other information. A map legend is another common example of Metadata that provides information about the publisher and publication date, scale, accuracy, datum and other characteristics of the map. Metadata is also commonly used at the level of a series of printed maps. In a similar way, Metadata is also applied to digital spatial data at the levels of series of datasets, individual datasets, tiles of datasets or even down to the feature level. The only major difference that exists between spatial Metadata and Metadata collected in conventional library catalogue systems is the emphasis on the spatial component – or the "where" element.

Metadata for spatial information is required for a range of purposes. Among other things, Metadata is used to provide:

- detailed information about data collection methods, integration and analysis techniques applied to source data that is required to support the preparation of scientific reports;
- information about the accuracy of source datasets, processing history, and archival procedures that is required to effectively manage and utilise data within custodian organisations;
- information about projection specifications, scale, exchange format, compression and file system format that should accompany data transfers to other organisations;
- adequate descriptions of the content, quality and geographic extent of datasets that are required so potential users of existing data can assess its suitability for their own purposes;
- summary descriptions of content and quality, as well as contact information, that are required for inclusion in directory systems; and
- information about access software for datasets as well as software parameters that are needed for direct online display and query of data.

Metadata needs to be collected at different levels to satisfy different purposes. These purposes can be broadly grouped into five distinct but complementary categories, each of which requires a different level of information:

- Data discovery

¹ See <http://www.anzlic.org.au/get/2358011755.pdf>

- Data assessment to determine fitness for use
- Data access
- Data use
- Data transfer
- Data management

In general, the amount of information and the degree of detail that is required increases from the “data discovery” level through to the “data management” level. Metadata for data discovery purposes represents the minimum amount of information required to convey to the enquirer the nature and content of the data resource. This falls into broad categories that answer the "what, when, who, where and how" questions about spatial data:

- *What* – title and description of the dataset.
- *When* – when the dataset was created and the update cycle, if any.
- *Who* – dataset originator or creator and supplier.
- *Where* – the geographical extent of the dataset based on lat / long coordinates geographical names or administrative areas.
- *How* – how to obtain more information about the dataset, how to order the dataset, available formats, access constraints etc.”

1.2 ISO 19115, Geographic information – Metadata

The ISO 19100 series is a multi-part international standard for geographic information that is being developed by Technical Committee 211 Geographic information/Geomatics of the International Organisation for Standardisation (ISO). ISO 19115, Geographic information – Metadata, is part of the ISO 19100 series.

In February 2001, the Technical Committee 211 Secretariat announced that the ISO 19115, Geographic information – Metadata, standard had been approved for publication as a Draft International Standard (DIS). This standard provides a procedure for describing digital geographic datasets using a comprehensive set of metadata elements. These elements support four major uses: discovery of data, determining data’s fitness for use, data access and use of data.

The standard provides information about the identification, extent, quality, spatial and temporal schema, spatial reference and distribution of digital geographic data. It is applicable to the cataloguing of datasets, dataset series and individual geographic features and feature properties. It is envisaged that in the future, all existing spatial metadata standards will converge through the ISO initiative. Indeed, most of the existing standards already have a great deal in common and a robust international discussion has ensured that the ISO standard has accommodated most international requirements.

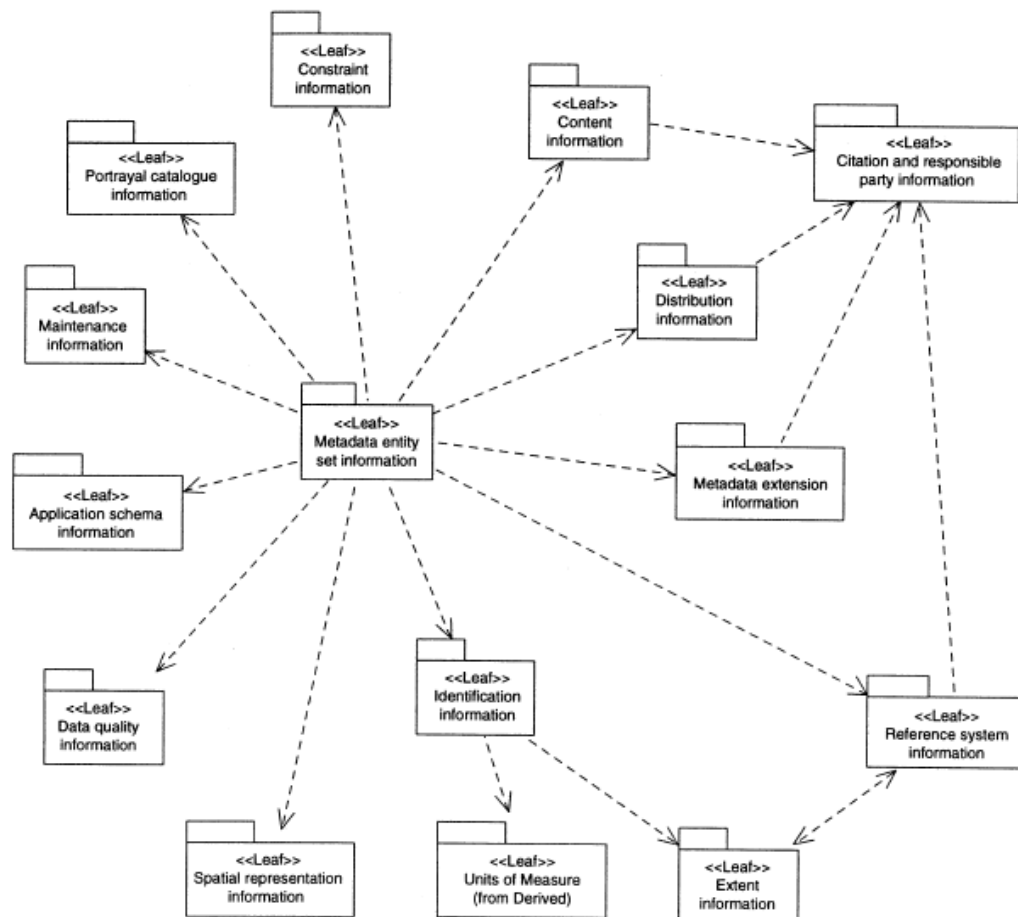


Figure 1: High Level Data Model for Metadata According to ISO 19115

The ISO 19100 series of standards allows tailoring of a standard to serve a particular application. The ISO 19115 standard does not cover all the requirements for the description of eTOD metadata; therefore, a profile of ISO 19115 is needed. An ISO geographic information profile is a subset of one or several of the ISO geographic information standards.

The proposed profile for eTOD consists of a selection of the metadata elements available in ISO 19115. ISO 19115 serves as a base standard for the development of the profile.

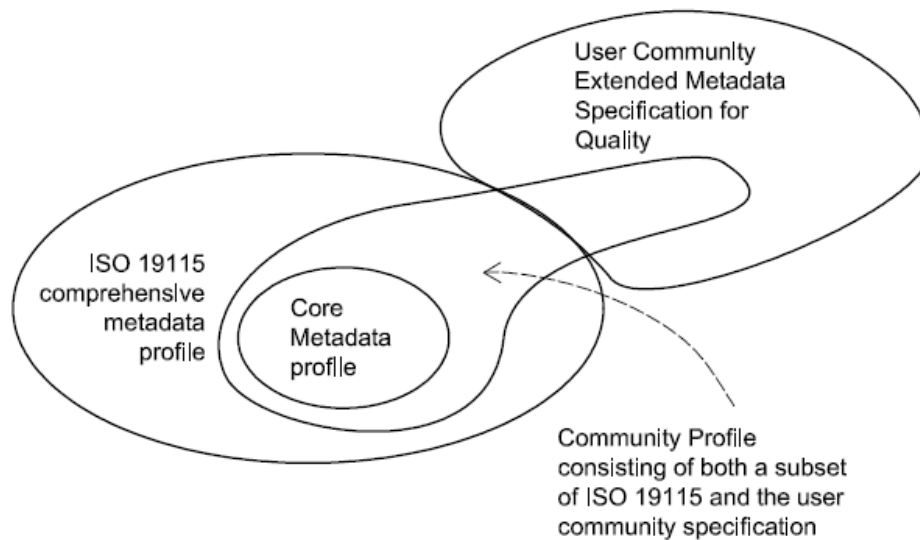


Figure 2: Possible Components for a “Community Profile” of ISO 19115

1.3 AIXM

In the aviation domain, AIXM has been developed to enable the management (AIXM Conceptual Model using UML) and the distribution of the Aeronautical Information Services (AIS) data in digital format (AIXM XML Schema). Both components encompass the metadata. The AIXM metadata schema, as defined in version “AIXM 5.0 Final”, is based on the ISO 19115 standard. In comparison with the pure ISO 19115 standard, the AIXM metadata schema has been modified to include some extensions, as well as restrictions. Some modifications target the transportation of a single message (e.g. a digital NOTAM), others arise from the aeronautical domain itself (e.g. the concept of “time slices”, see [AIXM Temporality Model](#)).

The modifications in the AIXM metadata schema that were required for the aeronautical domain are of relevance to the scope of this document. It makes sense to include similar modifications in an Aeronautical information Management (AIM) system. This ensures that metadata needed to compose a new message are actually present.

2. Proposal for a Metadata Schema for Obstacle and Terrain

The proposed metadata schema for eTOD is based on the ISO 19115 standard. Some extensions are defined to comply with the requirements of ICAO Annex 15. Additional extensions are proposed to accommodate metadata necessary for AIXM conformity. As the AIXM metadata schema is also based on ISO 19115, this allows concepts from the AIXM Metadata schema to be easily adopted.

The following chapters list AIM relevant modifications according to “AIXM 5.0 Final”, plus several other extensions that meet the requirements of ICAO Annex 15.

2.1 Aggregations of Features for Raster datasets

ISO 19115 allows metadata to be attached to individual datasets, a series of datasets, to individual features or even individual feature properties. With raster data, in particular, it makes sense to relate metadata to a group of features (i.e. cells or pixels). When these cells form contiguous spaces, the aggregation is best described by one or several polygon(s).

A polygon can either be understood as a geographic collection of features or a geographic restriction on a dataset. The polygon identifies all included features and thus can be stored as part of the identity (MD_DataIdentification) of the metadata. ISO 19115 already defines an entity that describes the extent (EX_BoundingPolygon) of the data as part of the metadata identity (MD_DataIdentification.extent). If a dataset consists of multiple regions, multiple metadata entities are attached to it:

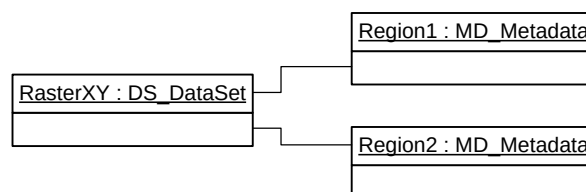


Figure 3: Regions with Dedicated Metadata Entities

When the metadata for Region1 and Region2 are very similar, there is no point in repeating the metadata information twice. In this case, it would make more sense to attach the metadata to the dataset and only attach the changed metadata to specific regions:

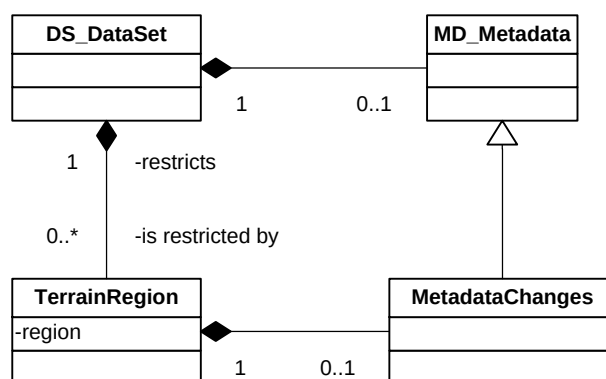


Figure 4: Regions with Metadata Changes

The entity MetadataChanges is basically identical to the entity MD_Metadata, with the difference being that all elements (also valid for all sub-elements) are optional. Only the elements that changed are listed.

When dealing with vector data, there is less need for modelling aggregations of features. Since every feature is stored in an AIM system as an explicit entity anyway, a metadata entity can be attached to each feature. The aggregation of features is defined implicitly by grouping features that relate to the same metadata. The above solution may also be applied to vector data.

2.2 Metadata Requirements of ICAO Annex 15

The document ICAO Annex 15 specifies eTOD to be included as part of an AIM system or data distribution. Some elements of this information are stored as a property of a feature; others are stored as metadata about a feature or as metadata about a dataset. The following table lists the elements specified in ICAO Annex 15, together with the corresponding storage location in an AIM system.

New elements will be described in more detail in sections 2.2.7 and 2.2.8.

2.2.1 Feature Properties (Terrain)

Element Name	Location in an AIM System
Horizontal position	<i>Not Metadata</i>
Elevation	<i>Not Metadata</i>
Surface type	<i>Not Metadata</i>
Date and time stamp	<i>Not Metadata</i>
Recorded surface	<i>Not Metadata</i>

Table 1: Terrain – Feature Properties

2.2.2 Metadata about a Feature (Terrain)

When dealing with raster data, a feature corresponds to a single raster cell. In most cases, it does not make sense to assign a metadata entity to every single cell of a raster. It makes more sense to group features to regions that share the same metadata (see section 2.1).

For the following elements, the region is used to restrict the scope of an element to a certain region. Different regions can be used for different elements and also different regions can be used for different values of the same element. Since only one element changes from one region to the other, it is not sensible to repeat the whole dataset metadata. Instead, only the changed element is listed (according to Figure 4: Regions with Metadata Changes).

Element Name	Location in an AIM System
Acquisition method	LI_ProcessStep, description = "Acquisition Method: ..."
Horizontal accuracy	DQ_PositionalAccuracy
Horizontal confidence level	<i>New Element</i> ; DQ_PositionalAccuracy, description "Confidence Level" ²
Vertical accuracy	DQ_PositionalAccuracy
Vertical confidence level	<i>New Element</i> ; DQ_PositionalAccuracy, description "Confidence Level"
Known variations	<i>New Entity</i> : KnownVariations

Table 2: Terrain – Feature Metadata Linked to ISO 19115

The element KnownVariations is different to all the other elements. Whilst, in general, a metadata element stores a fact about a very specific topic (defined by the element name), the element KnownVariations is not bound to a specific topic. The topic of a KnownVariations element must be provided by specifying the element name as an element itself:

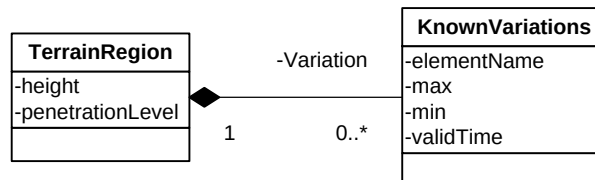


Figure 5: UML Model of New Metadata Entity KnownVariations

² The statements on accuracy and confidence level can be regarded as summary of a quality report. A more comprehensive report on data quality evaluation can be stored in DQ_DataQuality

Here is an example:

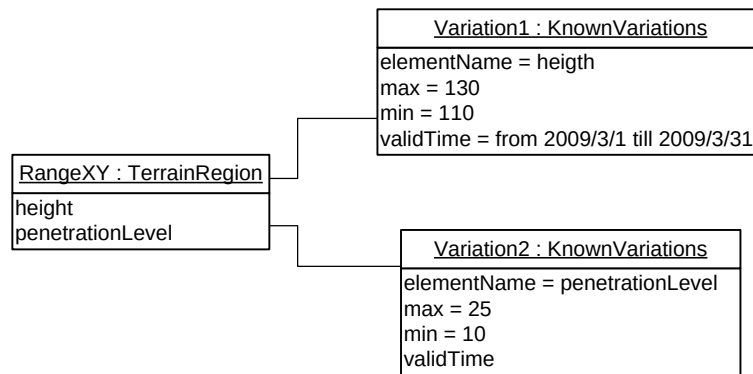


Figure 6: Sample data for KnownVariations

By specifying the topic through the storage of the element name as a text element, the information becomes less useful. For example it is not easy to query an AIM system with following question: What is the min/max height of FeatureXY as of 2009/4/1?

2.2.3 Metadata about a Dataset (Terrain)

Element Name	Location in an AIM System
Area of coverage	MD_DataIdentification.extent
Data originator identifier	MD_Usage.userContactInfo, role=CI_RoleCode.originator
Acquisition method	<i>defined as item Metadata</i>
Horizontal resolution	DQ_DomainConsistency
Elevation reference	MD_GeoRectified.pointInPixel
Elevation representation	<i>New Element:</i> MD_GridSpatialRepresentation.elevationRepresentation
Vertical reference system	Assumption : MD_ReferenceSystem.referenceSystemIdentifier
Vertical resolution	DQ_DomainConsistency
Penetration level	<i>New Entity & Element:</i> DS_Sensor.TerrainPenetration.penetrationLevel
Integrity	<i>New Element:</i> LI_Lineage. integrity
Unit of measurement used	Z: EX_VerticalExtent.unitOfMeasure X, Y: See: Horizontal reference system
Horizontal reference system	MD_ReferenceSystem.referenceSystemIdentifier
Post Spacing	MD_GridSpatialRepresentation.axisDimensionProperties

Table 3: Terrain – Dataset metadata linked to ISO 19115

2.2.4 Feature Properties (Obstacle)

Element Name	Location in an AIM System
Horizontal position	<i>Not Metadata</i>
Elevation	<i>Not Metadata</i>
Date and time stamp	<i>Not Metadata</i>
Operations (hours of)	<i>Not Metadata</i>
Geometry type	<i>Not Metadata</i>
Obstacle type	<i>Not Metadata</i>
Effectivity	<i>Not Metadata</i>
Obstacle identifier	<i>Not Metadata</i>

Table 4: Obstacle – Feature properties

2.2.5 Metadata about a Feature (Obstacle)

Element Name	Location in an AIM System
Acquisition method	LI_ProcessStep, description = "Acquisition Method: ..."
Horizontal accuracy	DQ_PositionalAccuracy
Horizontal confidence level	<i>New Element</i> ; DQ_PositionalAccuracy, description "Confidence Level"
Vertical accuracy	DQ_PositionalAccuracy
Vertical confidence level	<i>New Element</i> ; DQ_PositionalAccuracy, description "Confidence Level"
Unit of measurement used	Z: EX_VerticalExtent.unitOfMeasure X, Y: See: Horizontal reference system
Integrity	<i>New Element</i> : LI_Lineage. integrity
Horizontal extent	MD_DataIdentification.extent

Table 5: Obstacle – Feature metadata linked to ISO 19115

2.2.6 Metadata for a Dataset (Obstacle)

Element Name	Location in an AIM System
Area of coverage	MD_DataIdentification.extent
Data originator identifier	MD_Usage.userContactInfo, role=CI_RoleCode.originator
Horizontal resolution	DQ_DomainConsistency
Vertical reference system	MD_ReferenceSystem.referenceSystemIdentifier
Vertical resolution	DQ_DomainConsistency
Integrity	<i>New Element:</i> LI_Lineage.integrity
Vertical resolution	MD_GridSpatialRepresentation.axisDimensionProperties
Unit of measurement used	Z: EX_VerticalExtent.unitOfMeasure X, Y: See: Horizontal reference system
Horizontal reference system	MD_ReferenceSystem.referenceSystemIdentifier

Table 6: Obstacle – Dataset metadata linked to ISO 19115

2.2.7 New Metadata about a Dataset

ISO 19115 allows metadata to be attached to a dataset (entity DS_DataSet). When the dataset contains obstacle or terrain data, new elements are introduced to the metadata schema by extending several existing entities or adding new entities.

These elements are new:

Element Name	Description
Integrity	The degree of assurance that the data and its value have not been lost nor altered since the data origination or authorized amendment.
penetrationLevel	The distance between the bare earth and top of the canopy of the surface. Since the penetration level depends on the sensor (and currently only applicable for Radar-based sensors), this information is placed on the dataset level. (for Terrain data only)
elevationRepresentation ³	The function applied to the cell area to get the representational value (e.g. Min, Max, Mean etc). (for Terrain data only)

Table 7: New metadata on dataset level extending ISO 19115

³ The new element elevationRepresentation contains “half” of the information from the item *elevation reference* in the TOD application schema. The second purpose is to reference the elevation information to the pixel (e.g., centre, lower left corner). This is stored in the entity MD_Georectified, element pointInPixel. For improved distinction, the item has been renamed.

Below are some extracts of the UML diagram showing the new elements:

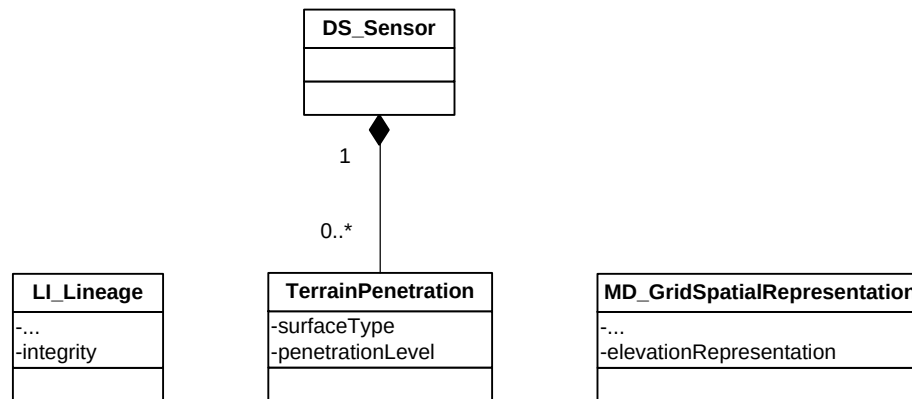


Figure 7: UML Model of New Metadata on Dataset Level

2.2.8 New Metadata about a Feature (or Feature TimeSlice)

An important aspect of aeronautical information is the temporal validity. Almost every piece of aeronautical information has an effectivity date attached to it. While ISO 19115 provides some means of modelling temporal extents, aeronautical information can benefit more from an extended model with strong emphasis on temporal validity. AIXM presents a model that allows for explicit modelling of temporal validity.

The AIXM Temporality Model defines the entity “AIXMTimeSlice” which allows all changes during a feature’s lifetime to be associated with the corresponding feature. The grouping of a feature’s changes allows for a complete history of the evolution of a single feature. When applying the concept of “time slices” to an AIM system, it is possible to query the AIM system with questions, such as “show me the information about this feature as of 2008/01/02”.

If the time slice concept is not implemented in an AIM system, the ability to track the changes of a single feature is lost. Depending on the update policy for the AIM database, it may or may not be possible to query the AIM system with questions, such as “show me a map of this extent as of 2008/01/02”.

Here is a UML diagram of the time slice concept:

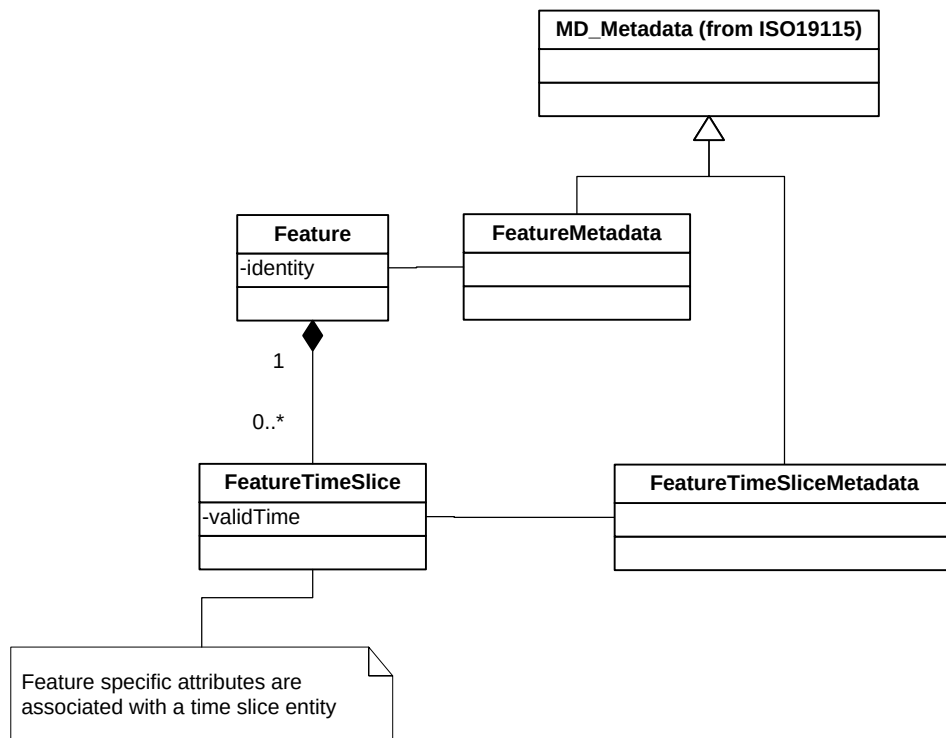


Figure 8: UML Model of the AIXM Time Slice Concept

The entities **FeatureMetadata** and **FeatureTimeSliceMetadata** are currently identical to the **MD_Metadata** entity and could be removed. However, future applications may want to add additional elements to these entities (see chapter 2.2.9). As a result, these entities have been included in the diagram for reference purposes.

These elements are new:

Element Name	Description
horizontalConfidenceLevel	The probability that the position values are within the stated horizontal accuracy of the true position. In general this information is part of the data quality reporting but can be regarded together with the horizontal accuracy as a quick mean of testing the fitness for use.
verticalConfidenceLevel	The probability that the position values are within the stated vertical accuracy of the true elevation.
integrity	The degree of assurance that the data and its value have not been lost nor altered since the data origination or authorized amendment.
knownVariations	Predictable changes to the data e.g., seasonal elevation changes due to snow accumulations or vegetation growth. (for Terrain data only)

Table 8: New Metadata on Feature Level Extending ISO 19115

All information about a feature is stored in “**FeatureTimeSlice**” entities, and therefore, most metadata about a feature is stored in specialized

“FeatureTimeSliceMetadata” entities. From this point of view, there is no need for the entity “FeatureMetadata”. In future applications, this entity may become meaningful, for example when adding CRC checksums to metadata elements to track unauthorised database changes. The next section provides more information about this aspect.

2.2.9 Consistency Checks with CRC Checksums

Data is generally well protected while being stored in a database (e.g. an AIM system). As soon as data is transferred, it is much more exposed to the risk of unauthorised modifications. Prevention of modification is sometimes impossible or very costly. It is much simpler to allow modifications but at least be able to detect if any modifications have been applied. That is where the application of CRC checksums can be helpful. It is a simple mechanism that supports the detection of unauthorised modifications. For this purpose, a checksum is created for a certain data range. The checksum is stored in the metadata for the data range. When the data range is transferred, a checksum is created by the receiver. When the receiver's checksum equals the checksum stored in the originator's database, there is a high probability there were no modifications applied to the data range during transfer.

The following metadata could be used to store CRC checksums:

- FeatureTimeSlice (derived from the time slice elements plus all feature elements)
- Feature (including all FeatureTimeSlice entities)

In the case where AIXM messages are stored in the AIM system as well, the AIXM message metadata would also store a CRC checksum (derived from all data in the message).

2.2.10 ISO 19115 Metadata that is not Used

Besides the above extensions, the general ISO 19115 model is capable of holding the metadata for eTOD. In fact, the ISO 19115 model defines entities and elements that are not needed for eTOD. These unused entities and elements are marked as optional so there is no issue when these entities and elements are omitted. Indeed, removing such entities from the profile could lead to inconsistencies where eTOD is part of a national spatial data infrastructure.

3. Conclusions

The implementation of eTOD metadata as a new domain in the AIM system does not have a large impact on AIXM. The following metadata elements and/or entities have been identified as missing from ISO 19115 and, therefore, also from AIXM:

- Horizontal and vertical confidence level;
- Known variations;
- Elevation representation;
- Penetration level;
- Integrity.

For all of these, appropriate integration with the metadata model has been proposed.

Some packages of the ISO 19115 metadata model which are not needed for eTOD are designed as optional and, therefore, their adoption is not required.

Once the profile of the metadata model is approved, guidelines for the collection of metadata will be developed.

4. List of Abbreviations

The following abbreviations are used within this paper:

<u>Abbreviation</u>	<u>Meaning</u>
AIXM	Aeronautical Information Exchange Model
eTOD	electronic Terrain and Obstacle Data
EUROCAE	European Organisation for Civil Aviation Equipment
ICAO	International Civil Aviation Organisation
ISO	International Organisation for Standardisation
TC	Technical Committee
TIXM	Terrain Data Exchange Model
TOD	Terrain and Obstacle Data
TOD WG	Terrain and Obstacle Data Working Group
UML	Unified Modelling Language
XML	Extensible Markup Language

Table 9: Abbreviations Used

5. Recommendations

The TOD WG is invited to:

- Review the content of the paper;
- Submit comments on the content of the paper to the TOD WG Chairman and Secretary by the end of May 2009.