

THE NEED FOR AN UUID REGISTRY IN AIM

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Introduction

Background

The aim of the **Aeronautical Information Service (AIS)** is to ensure the flow of aeronautical information/data necessary for safety, regularity, economy and efficiency of international air navigation. The importance of aeronautical information/data changed significantly with the implementation of area navigation (RNAV), performance-based navigation (PBN), airborne computer-based navigation systems and data link systems. Corrupt or erroneous aeronautical information/data can potentially affect the safety of air navigation.

The aeronautical information/data based on paper documentation and telex-based text messages cannot satisfy anymore the requirements of the Air Traffic Management (ATM) integrated and interoperable system and therefore the AIS is required to evolve from the paper product-centric service to the data-centric **Aeronautical Information Management (AIM)** with a different method of information provision and management.

Roadmap from AIS to AIM

The International Civil Aviation Organization (ICAO) has developed a roadmap to reflect the importance of the evolution and to address the required changes and is being referred to as the transition from AIS to AIM.

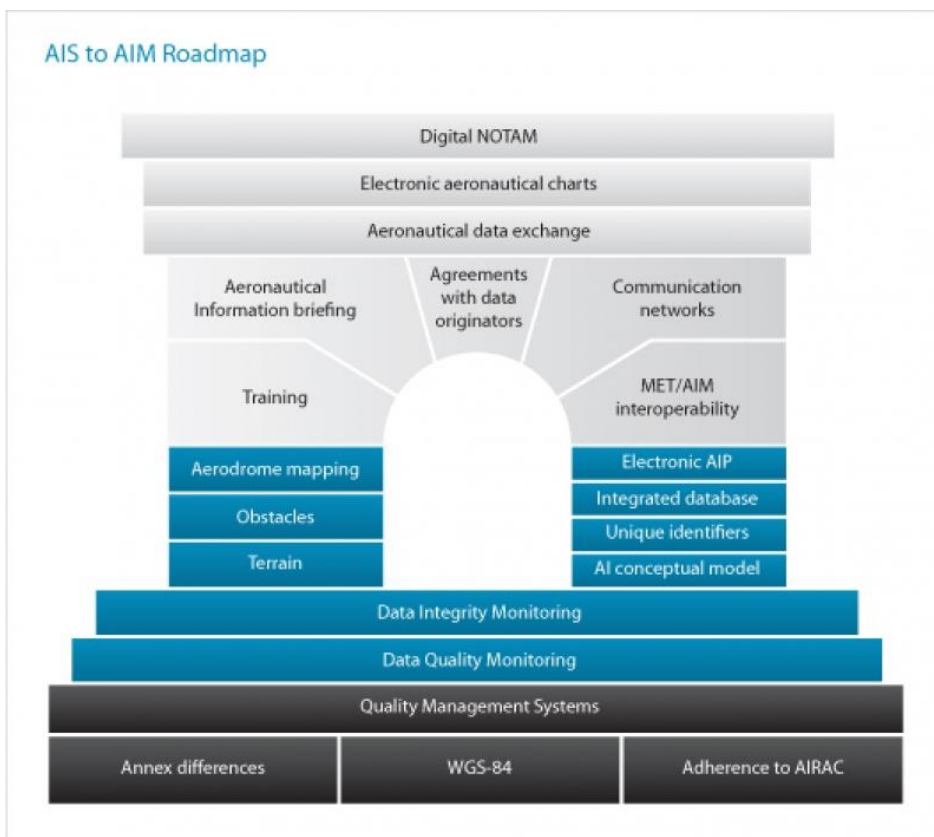


Figure 1 – Roadmap from AIS to AIM developed by ICAO

The transition to AIM will not involve many changes in terms of the scope of information to be distributed. The major change will be the increased emphasis on data distribution, which should place the future AIM in a position to better serve airspace users and ATM in terms of their information management requirements.

Three phases of action are envisaged for States and ICAO to complete the transition to AIM:

Phase 1 — Consolidation

Phase 2 — Going digital

Phase 3 — Information management

A minimum list of 21 major steps in relation to the three phases to achieve the transition to AIM is provided by ICAO.

During Phase 2 of the transition to AIM, the main focus will be on the establishment of data-driven processes for the production of the current products in all States. States that have not yet done so will be encouraged “to go digital” by using computer technology or digital communications and introducing structured digital data from databases into their production processes. The emphasis will, therefore, not be on the introduction of new products or services but will be on the introduction of highly structured databases and tools such as geographic information systems.

This paper puts a focus on the step “**Unique identifiers**” of Phase 2, which is defined as follows:

Improvements to the existing mechanisms for the unique identification of aeronautical features are required to increase the effectiveness of information exchange without the need for human intervention.

AIXM

The **Aeronautical Information Exchange Model (AIXM) 5.1** specification supports the data-centric environment. It supports aeronautical information collection, dissemination and transformation throughout the data chain.

The AIXM 5.1 is a Geography Markup Language (GML) 3.2 application schema meant to allow for the machine-to-machine exchange of aeronautical information in a structured format. As services that disseminate information in AIXM 5.1 to consumers are developed, the ability to manage the linkages between aeronautical features is key. This encompasses the concepts of **feature identification** and feature reference.

For feature identification, the AIXM 5.1 schema relies on the use of **Universal Unique Identifiers (UUID)** as artificial identifiers for AIXM features. In fact, they do not identify the feature itself, but the data that represents that feature in digital aeronautical information management systems.

Problem Statement

Feature Identification (UUID)

The gml:identifier property

Each AIXM Feature is identified through the use of the **identifier** property. According to the AIXM Temporality Concept, the identifier property is the only time-invariant property of a feature.

```
<gml:identifier codeSpace="urn:uuid:">6384a4e0-8497-4f83-8eaa-  
d73ef549d90e</gml:identifier>
```

Figure 2 – Example of the gml:identifier property

There are two essential requirements for the identifier property:

1. **to be unique** – there should exist a reasonable confidence that an identifier will never be unintentionally used by anyone for anything else;
2. **to be universal** – the same identifier should be used in all systems to identify a given AIXM Feature.

Use of UUID

The first requirement can be satisfied through the use of Universal Unique Identifiers (UUID). UUID generation algorithms can guarantee that the risk for the same UUID value to be generated by another system, for another feature, is extremely low.

Concerning the second requirement, it is important to note that the identifier does not identify a feature. It **identifies the data that someone has about a feature!** In order to get maximum benefit from UUID, they should be generated by the primary originator (authoritative source) for that feature data.

Responsibility

The aeronautical information data process chain extends from the original data sources (e.g. surveyors, procedure designers, etc) through Aeronautical Information Services (AIS) and publication to the end users of the data for aeronautical applications.

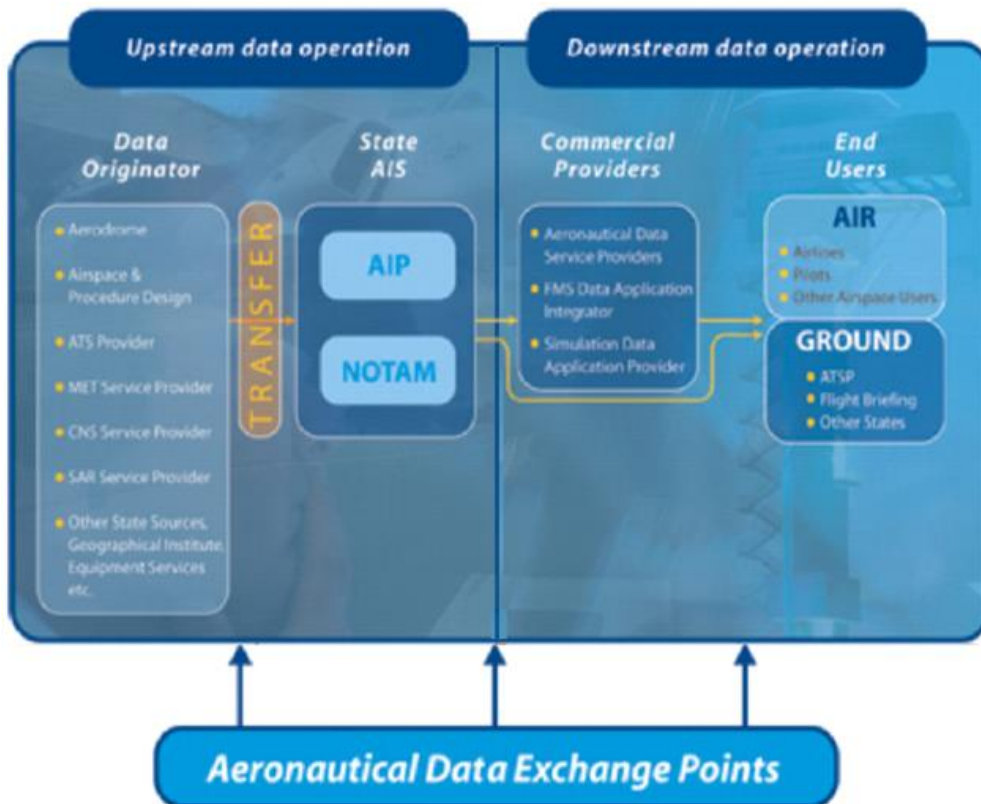


Figure 3 – Aeronautical Data Chain

The beforehand given advice, stating that the UUID should be generated by the primary originator (authoritative source) of the feature data, is **ambiguous**. The primary originator of a feature could be the submitter of its raw data (e.g. the surveyor), while the authoritative source might be interpreted as being the AIS office, responsible for the publication of the data. The responsibility for UUID generation becomes even more **unclear** in case the data about a feature is provided by more than one originator of raw data.

The Aeronautical Data Quality (ADQ) Regulation (EU) No 73/2010 gives the following definitions of terms:

- *‘data originator’ means an entity responsible for data origination;*
- *‘data origination’ means the creation of a new data item with its associated value, the modification of the value of an existing data item or the deletion of an existing data item;*
- *‘data item’ means a single attribute of a complete data set, which is allocated a value that defines its current status.*

Without further specification, the raw data originator of the very first attribute of a new feature would be responsible for its UUID generation. Looking at the variety of possible entities responsible for data origination (e.g. Aerodrome, Procedure Design, ATS Provider, other State Sources), it is quite obvious that we need a more clear definition of the responsibility for the UUID creation of a feature.

Multiple Information Sources

Ideally, all stakeholders should have the same data about a given feature. However, as multiple “pseudo-primary” information sources may exist for the same data item or because the digital data transmission chain may be broken or duplicated, this cannot be guaranteed, at least on short term. Ensuring that the same gml:identifier is used in all systems for a given AIXM feature is a requirement for the information management process; therefore, it needs to be taken care through the **process** rules.

It is therefore possible that two or more information sets (list of TimeSlices) exists for the same AIXM feature, in two different systems, with different gml:identifier values.

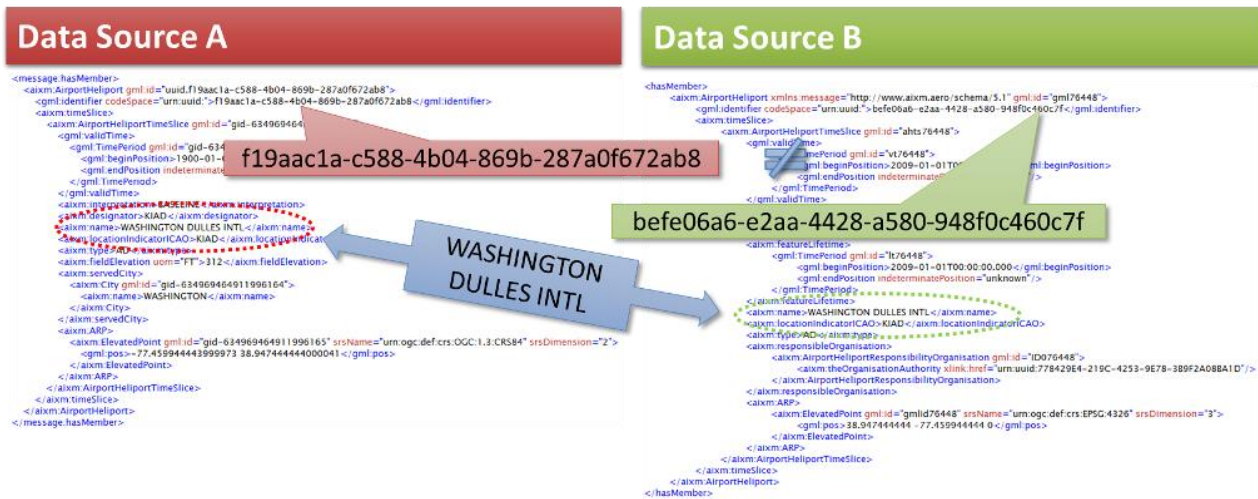


Figure 4 – Sample AIXM 5.1 Data – Duplicate feature data

When data from different sources is merged in a single system, the owner of that system might be confronted with the need to **identify and merge duplicate feature data**, based on actual properties of the feature, not on the gml:identifier.

Feature Identification (Properties)

However, the identification of a feature based on actual properties can be quite challenging as well, because in AIXM 5.1 all feature **attributes are optional**.

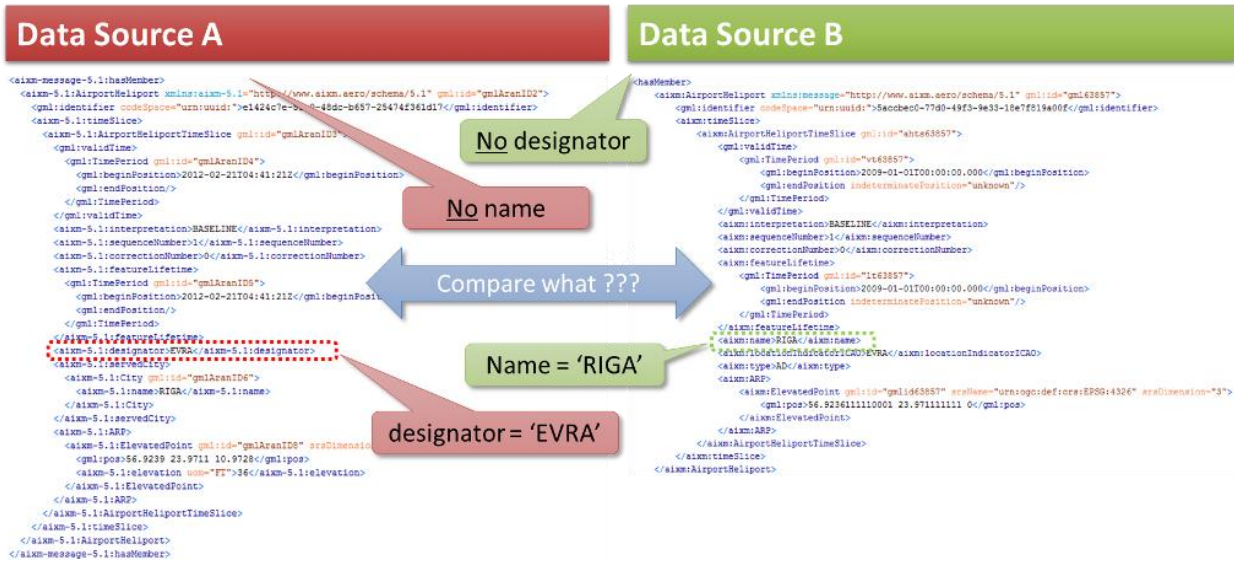


Figure 5 – Sample AIXM 5.1 Data – Challenging feature identification

The situation becomes even worse when looking at the current 56 Day NASR Subscription Files in AIXM 5.1 format, made available on the National Flight Data Center (NFDC) web site, because there is **no gml:identifier provided** in the source data for the features contained within the Subscriber Files.

Solutions

To summarise the problem statement outlined above, there are two main issues to be solved:

1. Responsibility for UUID generation;
2. Feature identification based on properties.

Although the first issue rather looks like an operational issue and the second one tends to be a technical problem, we are going to show that both topics will need operational as well as technical measures.

Operational

Awareness Campaign

One of the biggest issues to be addressed is the fact that the problem regarding unique identification isn't yet recognised as such at the operational level. On the one hand, the topic of UUIDs is easily to be ignored by operational people, because it is "just" technical stuff, and on the other hand, the terms "universally" and "unique" seem to be like a self-fulfilling prophecy. So we need to make the community aware about the problem at first.

White Paper

The initial part of our awareness campaign is already in your hands, when reading these lines. This White Paper tries to outline the problem and propose solutions in a way to be understood by all stakeholders of the AIM business. So **please distribute it** to your boss, your colleagues, your suppliers, your regulators and to whomever you might have in mind.

SESAR SWIM Master Class 2015

As award winning company of last year's SESAR SWIM Master Class, we want to take the opportunity of being in the front rank in this year's competition for showcasing not just the problem, but also to demonstrate possible solutions. It is essential for us to be **partnered with** one or more **Air Navigation Service Provider** (ANSP) in this competition, in order to evidence the operational relevancy.

AIM Events

Another good forum for addressing the issues to a broad audience could be giving a **speech at a conference** within the aviation domain. We will monitor the EUROCONTROL calendar of AIM/SWIM related events, and based on the initial feedback on this White Paper and the submission dates for speeches for upcoming conferences, we will try to make awareness also in that regard. It could be beneficial for the campaign if such a speech is already given or at least supported by one of our operational partners.

ICAO

Finally, and because the AIM business is not just a local or European one (flights usually don't stop at state or continental borders), but a global one, we will try to make also awareness at the topmost organisational level of the AIM, which is the ICAO. Some years ago, ICAO has established the **AIS-AIM Study Group** (AIS-AIMSG) in order to support the development of a global strategy/roadmap for the transition from AIS to AIM and to specify Standards and Recommended Practices (SARPs), guidance material and training material necessary to support AIM implementation. In one of their latest meetings (AIS-AIMSG/10), one of the study notes aimed at clarifying the relations between the organisation that provides the AIS and the data

originators. As such topics are on the agenda of the AIS-AIMSG, it would make sense to submit this White Paper to the ICAO study group for further considerations.

Supplementary Feature Identification

Although the “Feature Identification and Reference” supporting document of AIXM 5.1 doesn’t strictly disregard the use of natural keys, it recommends to use them only for abstract feature references during transition periods and on a limited scale.

Overall, the most important advantage of using the UUID as gml:identifier in AIXM seems to be for software development. It is much simpler and less error prone to write code that relies on UUIDs for feature identification and reference, as compared to the use of any kind of “natural key” combination. While artificial identifiers, like UUIDs, might be good for computer systems, they are for sure not appropriate **for human beings**, which are still very important actors in the data operation, and who also have the need for identifying features.



Figure 6 – Example of error message with UUID

The above mentioned supporting document of AIXM 5.1 suggests indeed the use of the attribute xlink:title, providing a human-readable description of the referenced aeronautical feature, but it discourages to use this attribute for feature identification.

However, as we have shown in the problem statement before, the **solely use of the UUID for feature identification is not sufficient** in the AIM. So we clearly need a supplementary method for feature identification when exchanging aeronautical data in AIXM format.

Domain Key

In relational model database design, a natural key is a key that is formed of attributes that already exist in the real world. Using a natural key (when one can be identified) **simplifies data quality**: It ensures that there can only be one feature for a key; this "one version of the truth" can be verified, because the natural key is based on a real-world observation. A natural key is sometimes called domain key. We propose to use this alternate term, because people associate natural keys usually just with database design and implementation.

So basically we propose not to choose between either UUID or domain key for feature identification, but to **use both methods** altogether.

AIXM Change Control Board

The further evolution of the AIXM is managed by a Change Control Board (CCB) with international participation, in relation with a Change Control Advisory Board (CCAB).

Being a member of this AIXM CCB, we will submit the following three change proposals:

1. The AIXM CCB to acknowledge **domain keys as permanent supplementary feature identification method**, by updating the corresponding supporting documentation (e.g. “Feature Identification and Reference”);
2. **Define** domain keys and **incorporate** them within the **AIXM UML Model** (i.e. the domain model);
3. Define **business rules for ensuring the availability** of the domain key attributes.

As these changes do not have an impact on the AIXM XML Schema, thus no direct impact on any AIXM implementation, they could be candidates for the publication of a new minor AIXM version update. Version 5.1.1 of AIXM has been approved by the CCB recently, so the next possible version for these changes to be incorporated is **AIXM 5.1.2**.

Clarify responsibility

As outlined in the corresponding paragraph of the problem statement, there is the need for a **clear and unambiguous definition** of the responsibility for the UUID creation of a feature, regardless of any technical solution or any kind of implementation details.

The AIS-AIM Study Group (AIS-AIMSG), established by ICAO, had at least the clear definition of terms and relations on its agenda recently. The study note “Relationship between the AIS organisation and Data Originators” *aims at clarifying the relations between the organisation that provides the AIS and the data originators, including the actions to be undertaken when an error is detected in the data. It also intends to define the terms “data originator” that are presently used in Annex 15 and it proposes new and/or amended provisions at Annex and/or PANS-AIM level.*

By submitting the White Paper to this ICAO group in the scope of the mentioned awareness campaign, we hope that they acknowledge the need of adding the responsibility for feature identification to their current work.

Technical

“Yellow Pages”

The “Yellow Pages” is a telephone directory. It lists telephone subscribers of a geographical area. Its purpose is to allow the telephone number of a subscriber identified by name and address (i.e. the domain key in that case) to be found.

Use Cases

If we put telephone subscribers and aeronautical features on the same level, and compare telephone numbers with UUIDs, we can already derive essential use cases for our sought technical solution:

- **Register** aeronautical feature;
- **Find UUID** of aeronautical feature by domain key;
- **Find domain key** of aeronautical feature by UUID.

In software and systems engineering, a use case is a list of steps, typically defining interactions between a role (known in Unified Modeling Language (UML) as an "actor") and a system, to achieve a goal. The actor can be a human, an external system, or time.

Actors

Looking at our use cases, we will presumably have to deal with the following actors in such a directory for aeronautical features:

- AIS organisation;
- Data originator;
- External AIS/AIM system;
- Directory provider.

We have left out end users of aeronautical data on purpose, as they should already be served with properly identified data by AIS/AIM systems.

Scope

A domain model in software engineering serves as a conceptual model to show the scope and meaning of the concepts in the problem domain.

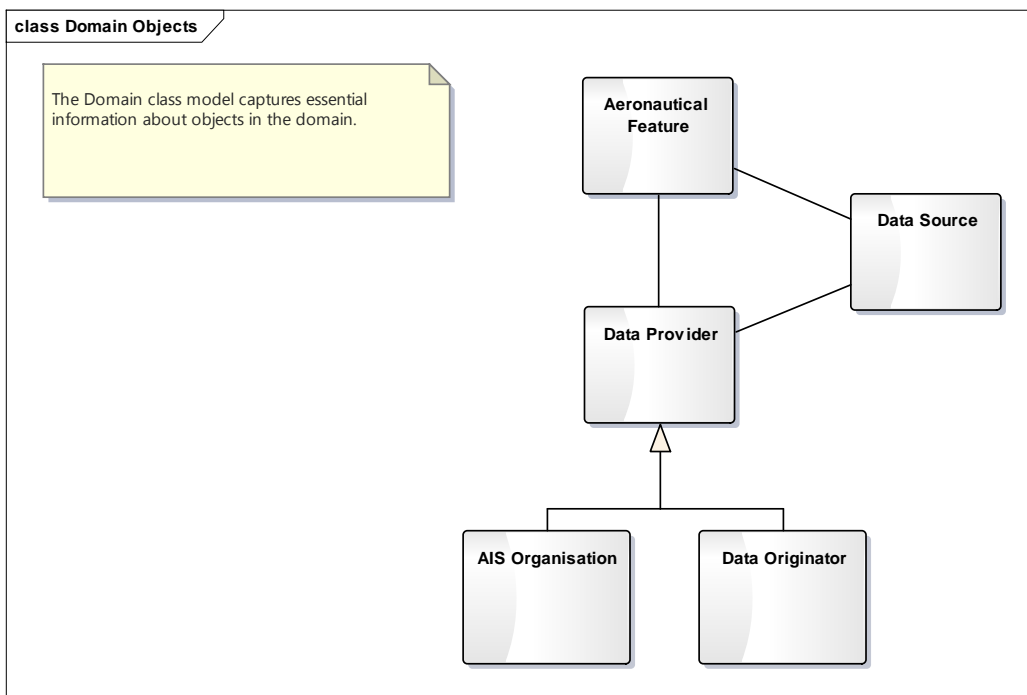


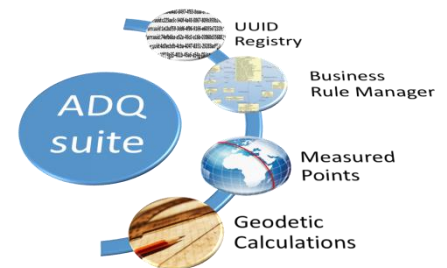
Figure 7 – Domain model of directory service

We can see in this domain model that the information needed for our directory service is quite simple. We need of course the UUID of an **aeronautical feature** together with its domain key to serve the use cases "Find UUID" and "Find domain key". As we have learned that the UUID does not identify a feature, but it just identifies the data that someone has about a feature, we also have to capture the "someone". From the perspective of the directory service we treat the one who is registering a feature as **data provider**. Later on, once the responsibility for UUID creation has been clarified on operational level, we will need this information to identify whether a feature was registered by the responsible or a third party. We propose to

record also the **data source** of our information, meaning the system where the data originated from. This can be used in an automated environment to identify where the complete feature data (not just UUID and domain key) can be obtained from. The combination of a responsible data provider with its provided data source is what we finally could call the **authoritative source of data**.

ADQsuite::UUID Registry

The Aeronautical Data Quality Suite or short “**ADQsuite**” is a package of software tools and complementary services developed by SOLITEC to support the exchange of aeronautical data along the whole data chain from the data originator to the end user. The tools and services are based on state of the art technologies and designed to apply the most current AIM standards for the exchange of aeronautical data, such as AIXM 5. The „ADQsuite“ is following the requirements laid down in COMMISSION REGULATION (EU) No 73/2010 on the quality of aeronautical data and aeronautical information for the Single European Sky.



The component **UUID Registry** of the ADQsuite is a web based service for the allocation and registration of unique identifiers for aeronautical data.

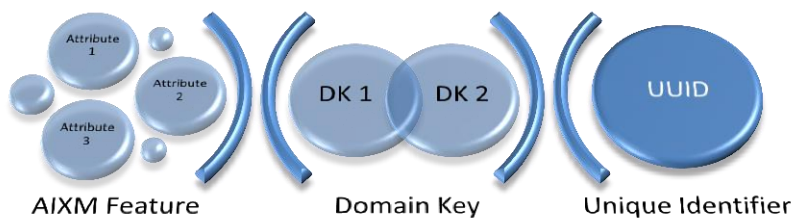


Figure 8 – UUID Registry concept

The service is designed to fit into the architecture of the System Wide Information Management (SWIM). SWIM provides the basis for information exchange between systems based on the principles of a Service Oriented Architecture (SOA).

The main features of the UUID Registry are

- Definition and administration of domain keys for all AIXM 5 features;
- Recording and managing of domain keys for AIXM 5 data;
- Allocation of new UUIDs for AIXM 5 data;
- Validation of existing UUIDs;
- UUID or domain key based query of AIXM 5 data.

We believe that the UUID Registry is an important **missing link** in the ICAO Roadmap from AIS to AIM.

Conclusion

The International Civil Aviation Organization (ICAO) has developed a roadmap to reflect the importance of the evolution from the paper product-centric service of the Aeronautical Information Service (AIS) to the data-centric Aeronautical Information Management (AIM) with a different method of information provision and management. In the second phase (out of three) of this transition to AIM, the main focus will be on the establishment of data-driven processes for the production of the current products in all States. States that have not yet done so will be encouraged “to go digital” by using computer technology or digital communications and introducing structured digital data from databases into their production processes. Improvements to the existing mechanisms for the unique identification of aeronautical features are required to increase the effectiveness of information exchange without the need for human intervention.

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As outlined in this papers problem statement, there are two main issues to be solved:

1. Responsibility for UUID generation;
2. Feature identification based on properties.

Although the first issue rather looks like an operational issue and the second one tends to be a technical problem, the paper shows that both topics will need operational as well as technical measures.

One of the biggest issues to be addressed is the fact that the problem regarding unique identification isn't yet recognised as such at the operational level. Being part of our awareness campaign, this White Paper tries to outline the problem and propose solutions in a way to be understood by all stakeholders of the AIM business. As the solely use of the UUID for feature identification is not sufficient in the AIM, there is the need for a supplementary method for feature identification when exchanging aeronautical data in AIXM format.

Ideally, all stakeholders should have the same data about a given feature. However, as multiple “pseudo-primary” information sources may exist for the same data item or because the digital data transmission chain may be broken or duplicated, this cannot be guaranteed, at least on short term. Ensuring that the same identifier is used in all systems for a given AIXM feature is a requirement for the information management process. The sought technical solution for the outlined issues is a kind of “Yellow Pages” for aeronautical features.

The UUID Registry, part of SOLITECs portfolio “ADQsuite”, is an important missing link in the ICAO Roadmap from AIS to AIM.

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