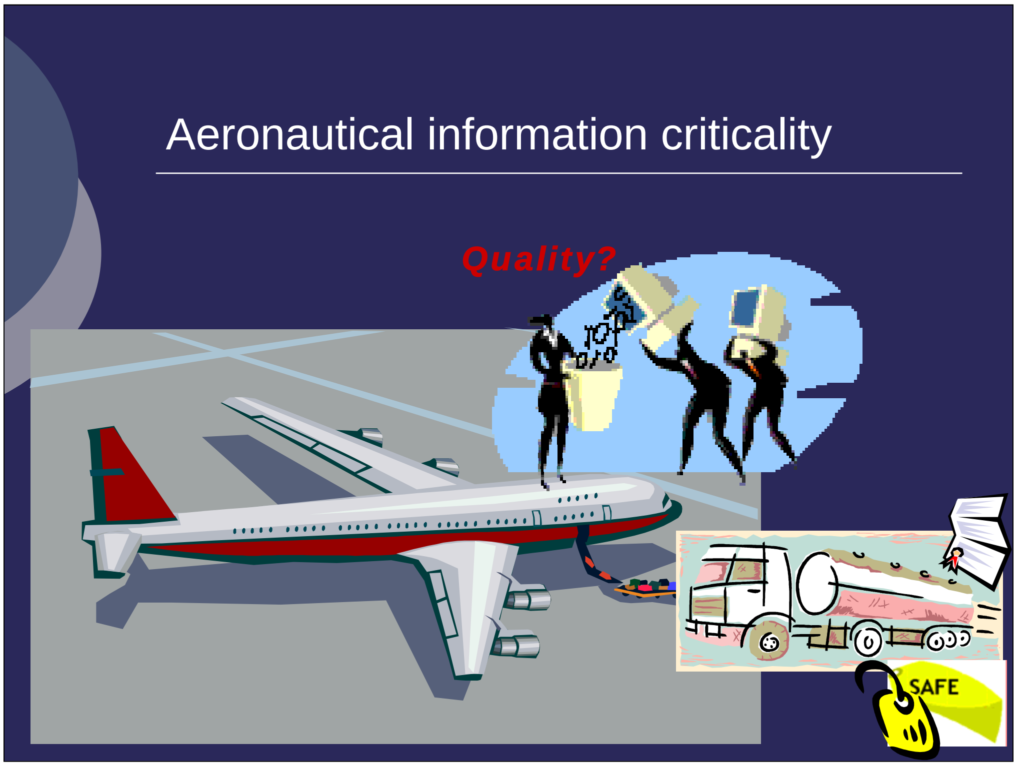
# AIS Data Standardization – AICM and AIXM

AIXM 5 Public Design Review
February 7-8, 2006
Washington DC

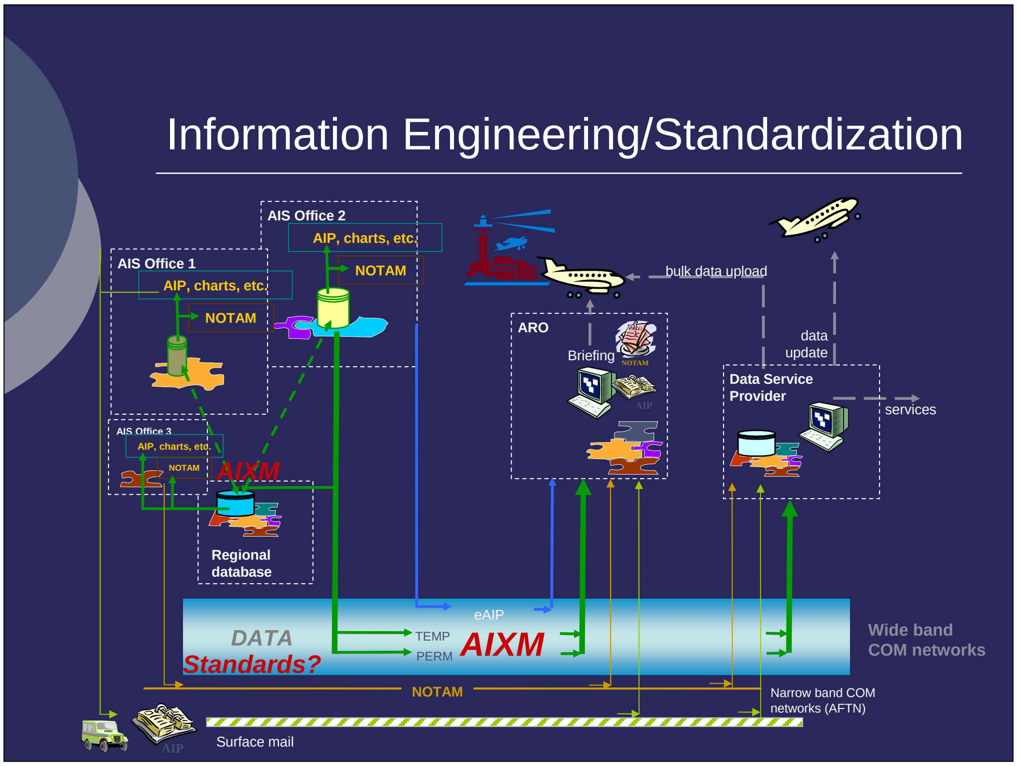
The purpose of this presentation is to discuss the need for AIS data standardization and to identify the role played by AICM and AIXM in this context.




Information provided by AIS is used for air navigation, ATC, ATM and other related services, which are essential to the safe movement of aircraft on the ground and in the air.

It has been identified many years ago that: "*The role and importance of aeronautical information/data changed significantly with the implementation of area navigation (RNAV), required navigation performance (RNP) and airborne computer based navigation systems. Corrupt or erroneous aeronautical information/data can potentially affect the safety of air Navigation*" [ICAO Annex 15].

The quality and certification of aeronautical information on board should be comparable with the quality and certification levels of physical aircraft components, spare parts, fuel, etc..




In order to ensure the quality of aeronautical information and also to improve cost-efficiency, automation started being introduced in the AIS world, in two directions:

•inside AIS – database based products – charts, AIP, NOTAM, etc. [Islands of data management]

•inter-AIS – Interoperability through data exchange/sharing [system wide perspective on information management]

The first direction is by far more developed than the second one. For example, the European AIS Database is a step in the second area, by the creation of a "regional reference database of quality assured AIS data".

•For many European States, it also provides the inside-AIS automation tools

When we look at a simplified picture of the data chain, information flows are increasingly complex and involve many actors. Aeronautical information is complex with multiple suppliers and consumers, interconnected systems and the need for real time information.

High quality, easy access to aeronautical data based on **world-wide agreed standards** is needed if we want to ensure:

•the quality of the aeronautical information required by modern air navigation and ATC systems

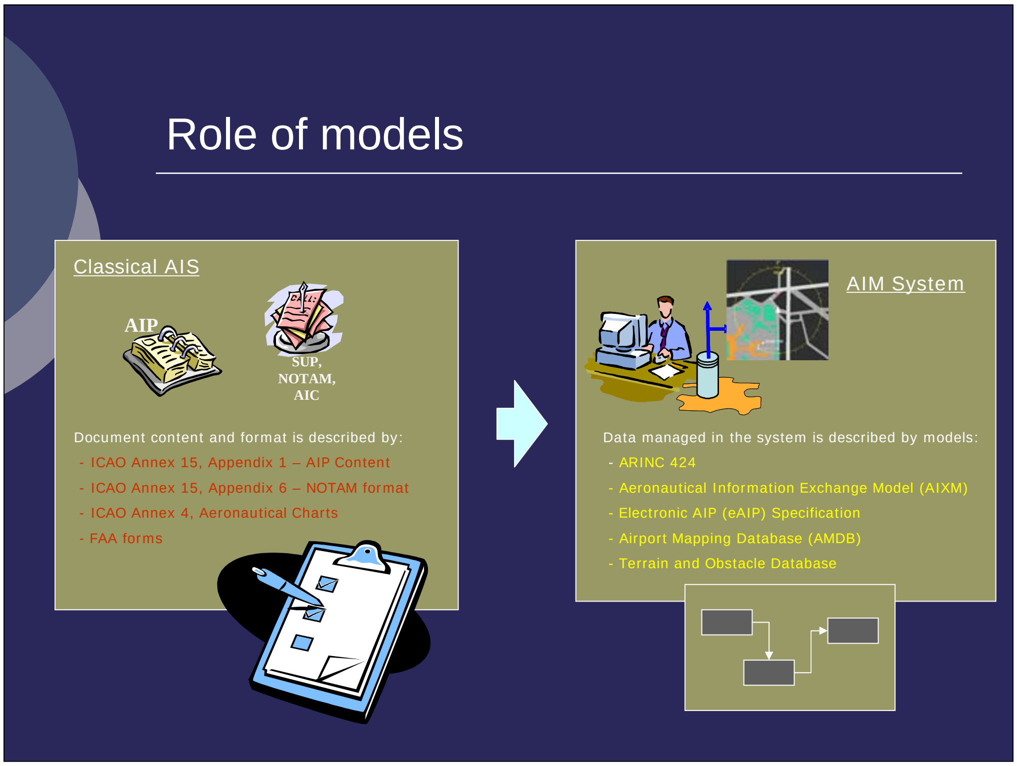
•the efficiency and the cost effectiveness of the system

[ICAO Annex 15] "*To satisfy the uniformity and consistency in the provision of aeronautical information/data that is required for the operational use by computer-based navigation systems, States shall, as far as practicable, avoid standards and procedures other than those established for international use.*"

The reality is that, today, there are no world-wide established standards for aeronautical data exchange - maybe except ARINC 424, which satisfy the information needs for Flight Management Systems data provision, but which is also used in practice as data feed for NOTAM reference database or as internal format for charting and AIP production databases.

Such standards start to appear covering particular areas – such as through the RTCA/EUROCAE work to standardise airport mapping, terrain and obstacle data requirements and exchange formats.

AIXM and AICM, the subject of this presentation, have emerged from the need of the European States to implement regional AIS interoperability.




The world today: business processes and computer systems

> Moving from paper-based system ==> electronic based one will help all actors in the data chain reference the same data in the same format, promoting accurate and fast exchange

Paper products are based on checklists. AIM is based on models and data formats.

ARINC 424, AMDB, terrain & obstacle databases are limited in scope – focused on a particular application or information category. The aim of AICM & AIXM is to be applicable to a wide range of applications, with an exhaustive coverage of the aeronautical information domain.

The role of AICM is to enable systems to manage aeronautical information and to enable humans to communicate and understand the information that is managed. AICM describes the features, properties and relationships in the conceptual areas. Main benefits:

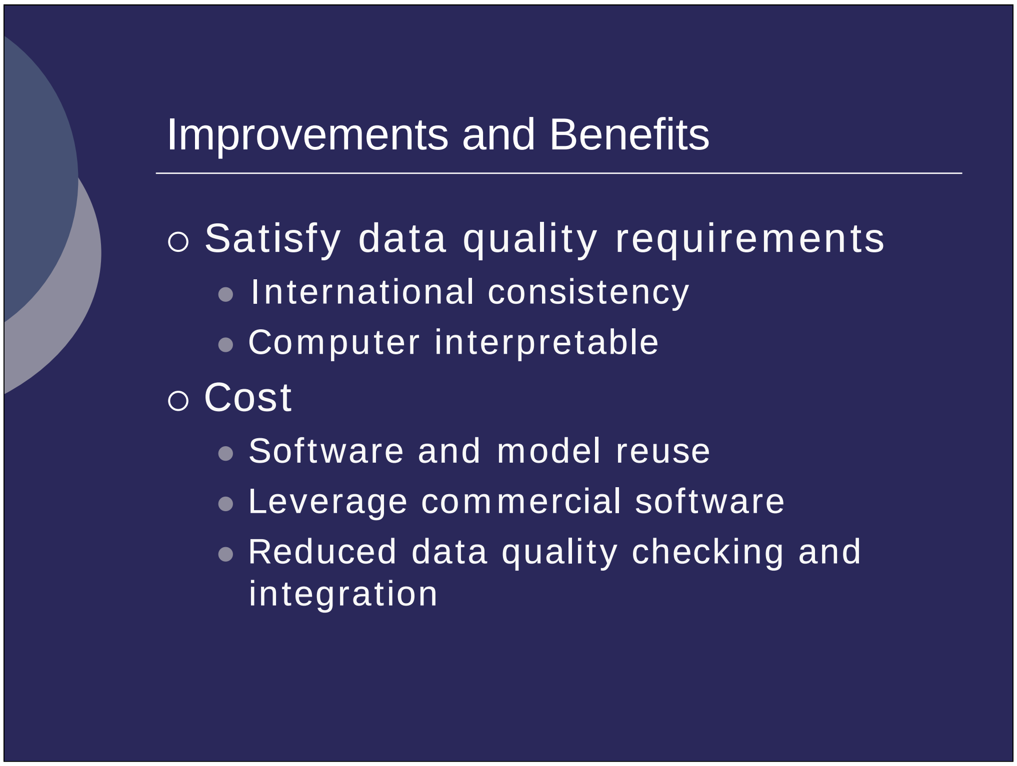
•represent real world concepts as a theoretical construct which can be represented and understood by automated systems

•provide a basis for logical data structures used during the software implementation

•achieve neutrality against applications and their local views of the data

•standardise the conceptual understanding of aeronautical data by all actors - “speak the same language"

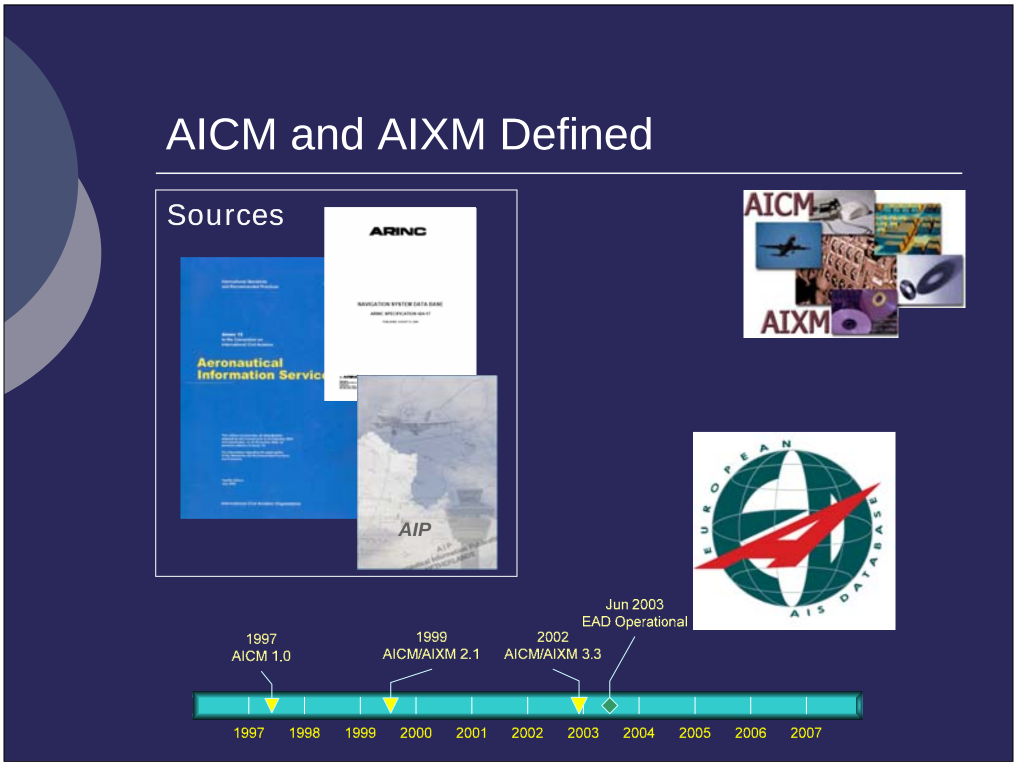
The role of AIXM is to enable systems to exchange aeronautical information in the form of XML encoded data. AIXM is an implementation of the Aeronautical Information Conceptual Model (AICM) as an XML schema.




If we can computerize aeronautical information based on AIXM as world-wide agreed standard, we stand to gain several benefits:

Improved safety: Reduced data inconsistencies, a computer interpretable means fewer errors for pilots and other aviation system users.

Reduced costs: The AIXM model can be reused in software systems. By basing AIXM on industry standards, adopters can leverage existing commercial and open source tools. By enabling digital input and output, we can reduce data quality checking and data integration costs.




AICM and AIXM are standards for aeronautical information dissemination that are based on:

•ICAO Annex 15 “data to support international air navigation”

•Industry standards like ARINC 424 for encoding terminal procedures

•Other standards and best practices

•Real world aeronautical information publications

  •Take into consideration aspects that are not subject to formal requirements. Examples: route usage restrictions, declared distances from runway/taxiway intersections, airspace aggregations, fuel types, etc.

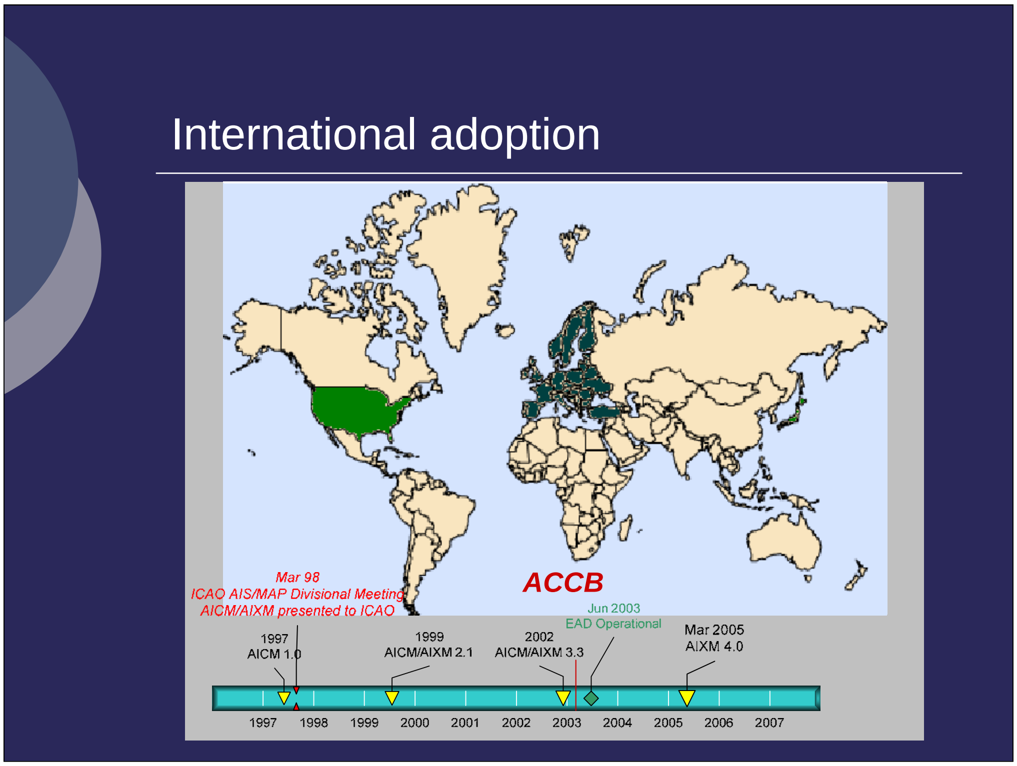
AICM - Started by Eurocontrol in 1996

AIXM – started in 1997

•First attempt “SQL based”

•Move to XML in 1999

•EAD operational since 2003 – some 30 European States are expected to have joined the EAD by 2007




First steps towards internationalisation of AICM/AIXM

•Proposed by EUROCONTRIL with the support of United States) to AIS Map Divisional Meeting of 1998

•Considered by Japan JCAB for internal implementation

•Industry re-use of the AICM e-r model in local AIS implementations

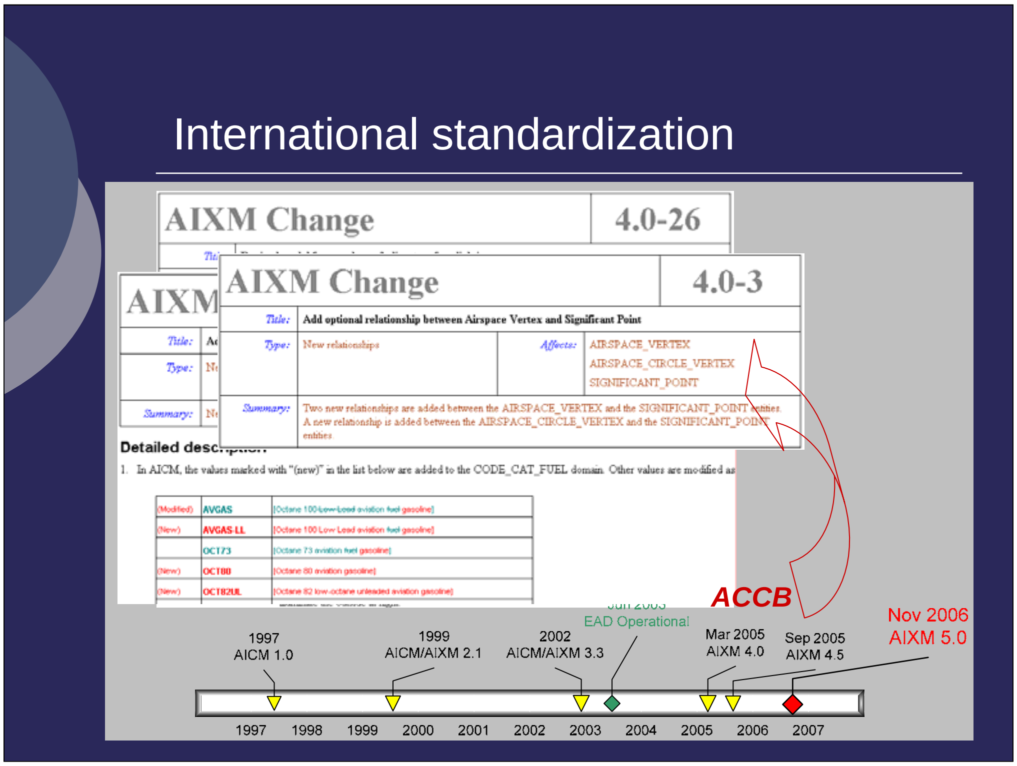
•All documentation was from the beginning free of charge and publicly available

The internationalization of AICM and AIXM really began in 2003 after the release of AICM/AIXM 3.3.

•Set-up of the AIXM Change Control Board (ACCB) with international participation (States and industry)

The United States Federal Aviation Administration, United States National Geospatial Intelligence Agency and EUROCONTROL began to collaborate on expanding AICM and AIXM to cover global civilian and military aviation needs. Major early activities included assessing AICM and AIXM model coverage and updating lists of values.

In March 2005 AICM and AIXM 4 was released. This was the first major release that incorporated suggestions from the international community and was a good test of consensus based configuration management.




The international community continued to enhance AIXM and AICM throughout 2005 and in September 2005 AICM and AIXM 4.5 were released. Highlights of this release included improved lighting system models, more complete models of surface conditions and surface composition, updates to lists of values and enhancements to the traffic flow restriction model.

Currently the AIXM international partners are focused on AICM and AIXM 5. Version 5 is intended to be a global standard for international exchange that will eventually be endorsed by the international community (ICAO) as the *de facto* standard for aeronautical information. Major improvements in version 5:

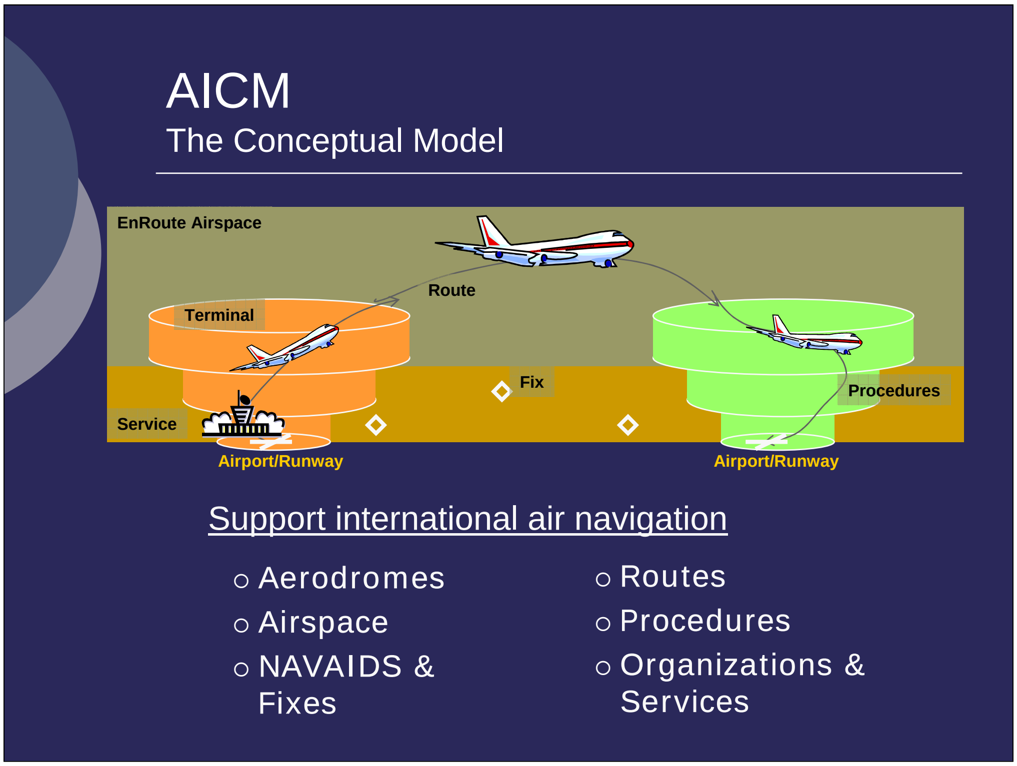
•Inclusion of a temporality model, including support for the temporary information contained in NOTAM

•Alignment with ISO standards for geospatial information, including the use of the Geographical Mark-up Language (GML)

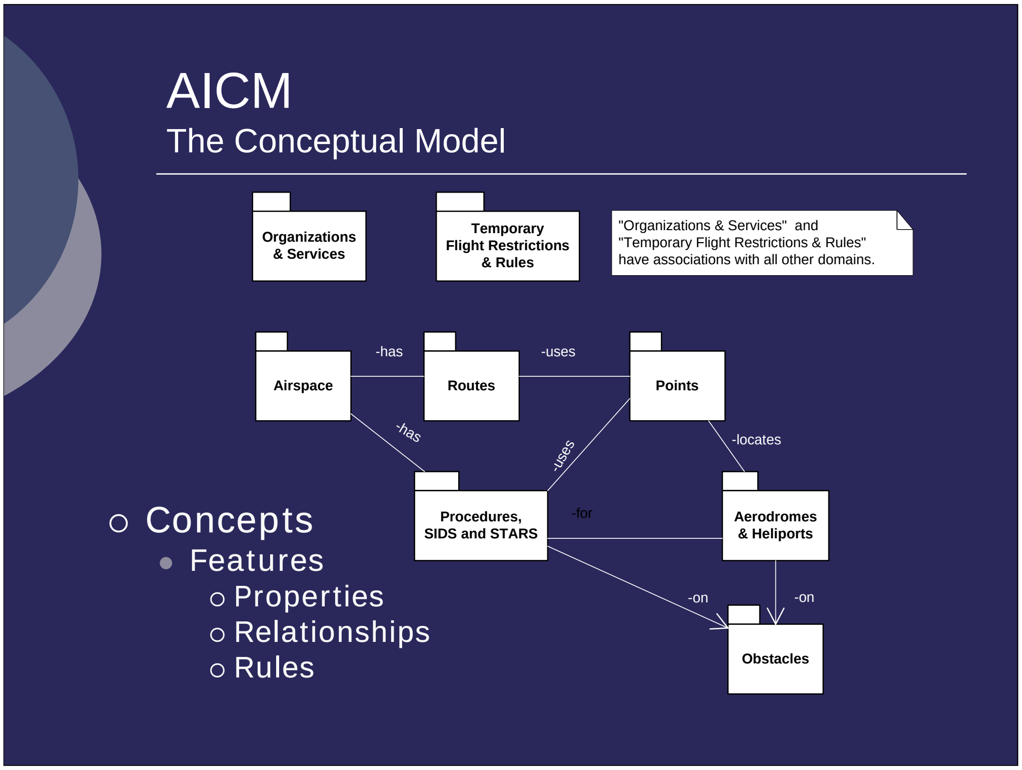
•use of UML as conceptual schema language (instead of entity-relationship)

•Support for the latest industry and ICAO requirements for aeronautical data including obstacles, terminal procedures and airport mapping databases

•Modular and extensible to support current and future aeronautical information messaging requirements and additional data attributing requirements.




The role of AICM is to enable systems to manage aeronautical information and to enable humans to communicate and understand the information that is managed. AICM describes the features, properties and relationships in a number of conceptual areas as indicated on the diagram.

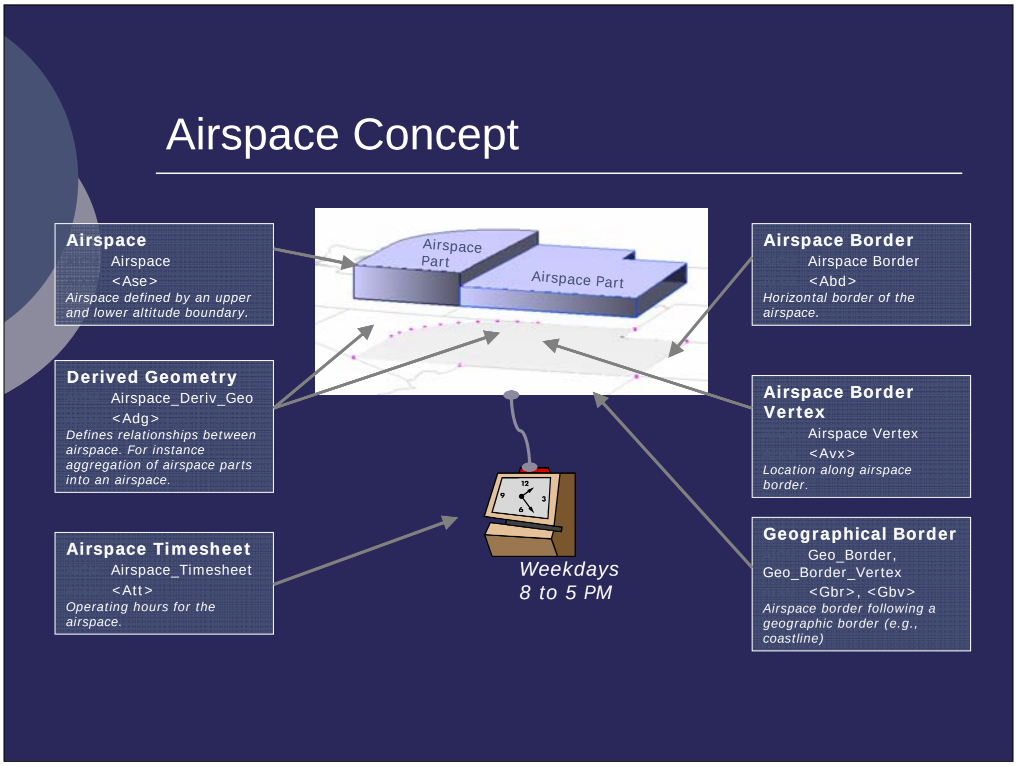



The AICM conceptual model may be split into several conceptual areas: Aerodromes, Airspace, Routes, etc..

Each conceptual area contains **Features** that describe important aeronautical entities. Features include Runways, Aerodromes, Routes and procedures. Features have **properties** that characterize the feature. A Runway feature may have a runway width and surface type. An aerodrome may have name and operating hour properties. **Relationships** describe how features are related. A runway is on an aerodrome. A runway has runway lighting. Finally the model includes **rules** or checks on the data. It remains a decision of each implementation which of these are mandatory and some are plausibility checks. For example, in the EAD:

•Each runway should be within 25 nm of the aerodrome reference point (data plausibility check)

•Any new 5-letter waypoint identifier shall be unique world-wide (mandatory rule).



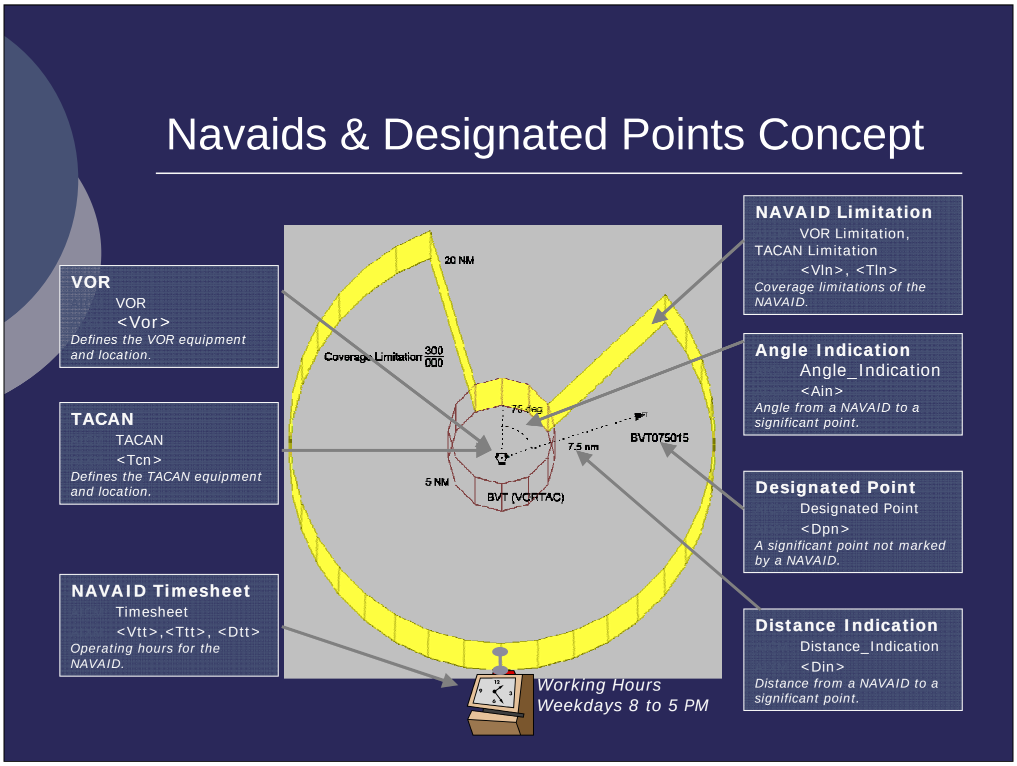

According to the AICM Manual, “Airspace is a generic entity representing variously ‘regions’ (ICAO and otherwise), ‘areas’, ‘zones’, ‘sectors’ (elementary and/or consolidated)…” Basically the airspace concept can be used to represent any three dimensional geographic space. Examples: FIR, air traffic control sector, an ARTCC boundary, a military operating area or a temporary flight restriction.

This example illustrates a complex airspace made of two parts. The part on the left is semicircular while the piece on the right is shaped like the state of Utah. Together these two airspace parts make up a single more complex airspace. Within AIXM and AICM any 3D airspace definition is modeled as an AIRSPACE object. The AIRSPACE object can define a simple airspace polygon made from an altitude range and a horizontal airspace border or the airspace might be a complex combination of more primitive airspace definitions.

In this example the two airspace parts are primitive AIRSPACE objects with altitude limits and an AIRSPACE BORDER. The AIRSPACE BORDER object is made from a sequence of AIRSPACE VERTEX objects. Each AIRSPACE VERTEX object can reference a GEOGRAPHICAL BORDER object or it can define a geographical point and a path towards the next AIRSPACE vertex. The paths between AIRSPACE VERTEX objects can be great circle routes, arcs or rhumblines.

A GEOGRAPHIC BORDER object is used to define a known geographical border like a state boundary or a river course.

Finally airspaces may have an TIMESHEET associated with them. The timesheet gives the operating/activation hours for the airspace.




The NAVAID and Points Domain defines points in space used for navigational and air traffic control purposes. An abstract concept called the "Significant Point" is defined by ICAO as a "specified geographical location used to define an ATS route, the flight path of an aircraft or for other navigation/ATS purposes." Within the abstract concept of Significant Points are those points marked by a radio navigation aid and those points that are not marked by a navigational aid.

•NAVAIDS include VOR, DME, TACAN, NDB, MKR

  •It also includes landing aids such as ILS, MLS

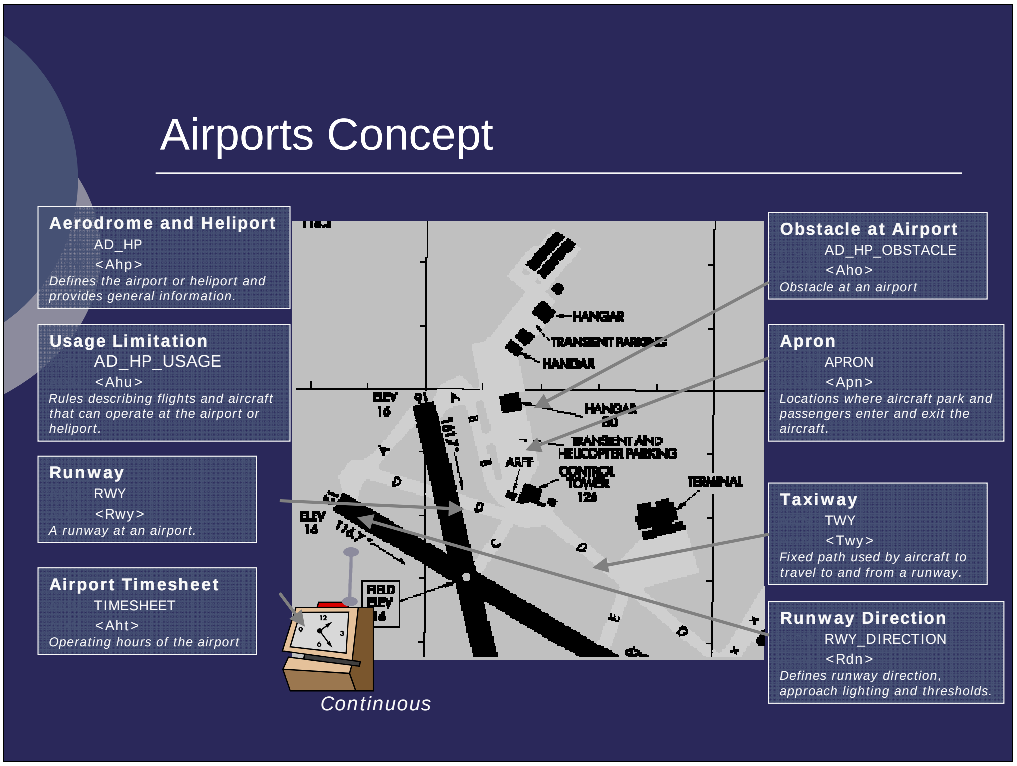
  •Closely related is the concept of navigation systems (GNSS, LORAN, DECCA)

•The phrase "Designated Points" is used to represent locations that are not sited at a NAVAID.

This example illustrates a NAVAID called BVT which happens to be a TACAN collocated with a VOR (also called a VORTAC). The BVT NAVAID has specific performance limitations outlined by the orange and yellow volumes. Within 5 nm of BVT there is full coverage from 0 to FL300, but from 5 to 15 nm from BVT there is a gap in coverage between the 355 and 25 degree radials. The coverage definition is termed a LIMITATION.

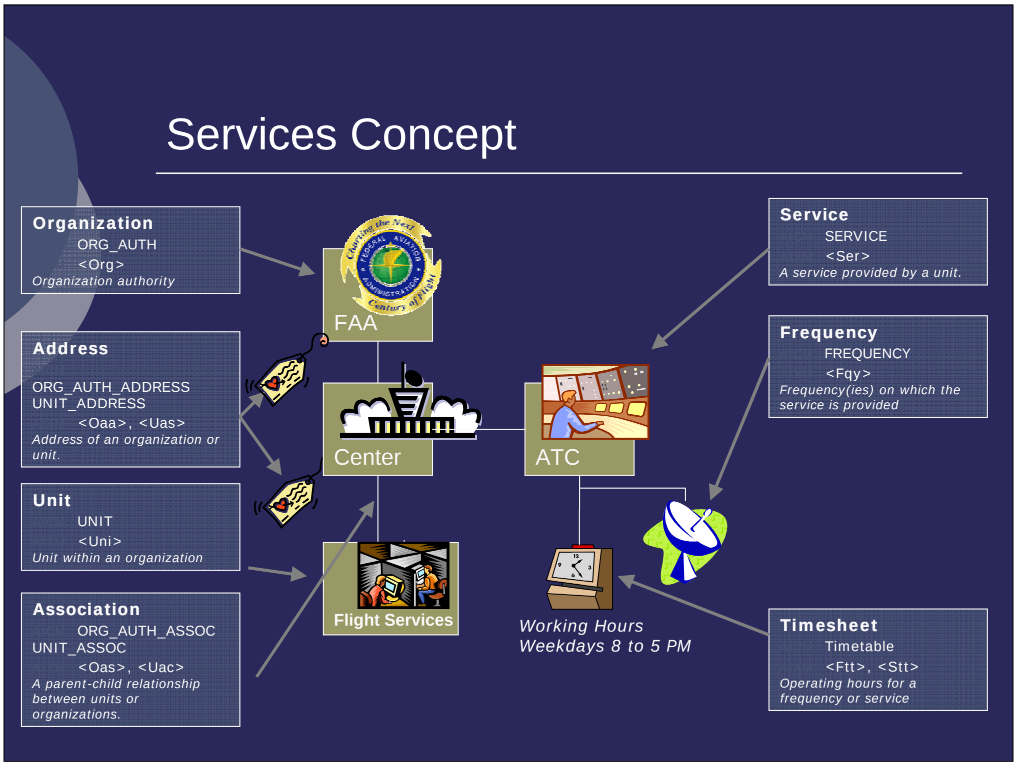
Here we see that the BVT NAVAID has working hours from 8:00 AM to 5:00 PM on weekdays.

In addition, this diagram shows a point in space called BVT075015, this is a DESIGNATED_POINT. This designated point can be defined as an angular reference (called ANGLE_INDICATION) from the VORTAC and a distance (called DISTANCE_INDICATION) from the co-located TACAN.

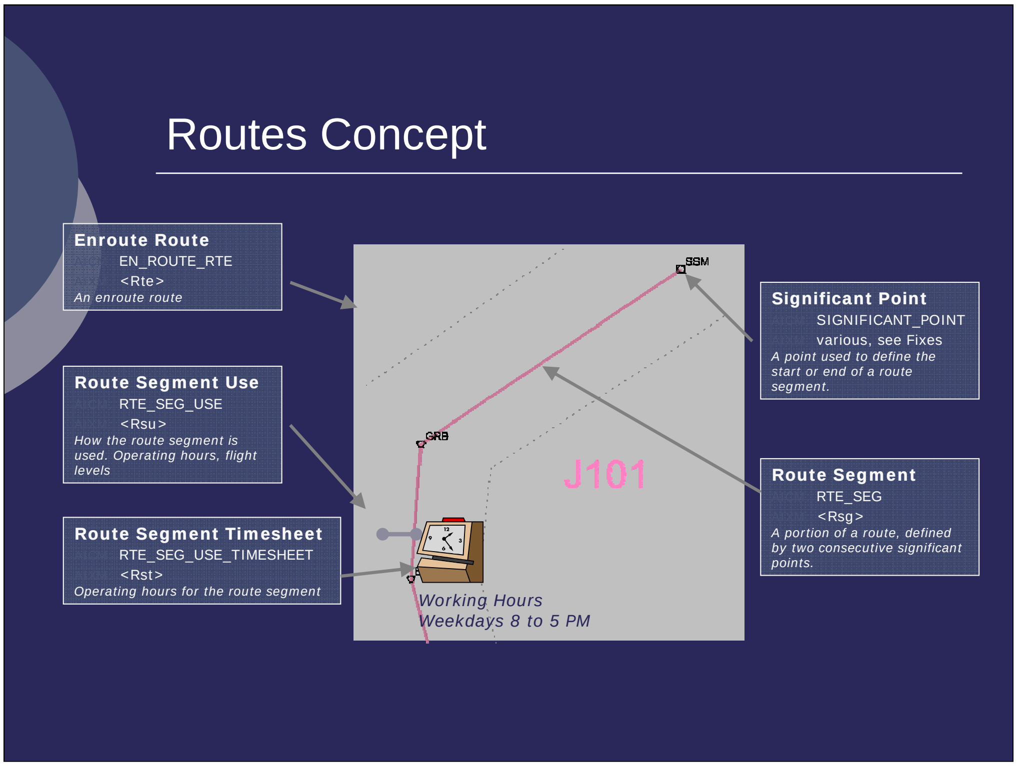



The Aerodrome and Heliport data concept area is a complex area describing the makeup of airports and heliports. Within this concept area are definitions of airports, runways, final approach and takeoff areas, aprons, taxiways and lighting systems. The illustration highlights some of the major features of the Aerodrome domain, but this illustration is by no means exhaustive.

The example illustrates the Beaumont-Port Arthur (BPT) airport located in Southeastern Texas. The overall airport is represented with a AD_HP feature that captures information on the airport name, type and location. The AD_HP has relationships to the major components of the airport. The airport includes with RUNWAYS and each runway has two RUNWAY DIRECTIONS. The runways are connected to each other and the other airport facilities via TAXIWAYS. The APRON defines areas of the airport where passengers enter and exit the aircraft. Significant vertical obstructions are identified by the OBSTACLE feature and these can be linked to the airport in general or associated with a specific takeoff/landing direction on a runway or final approach/takeoff area (FATO). Finally, the airport has associated operating hours. In this case, BPT airport operates continuously.



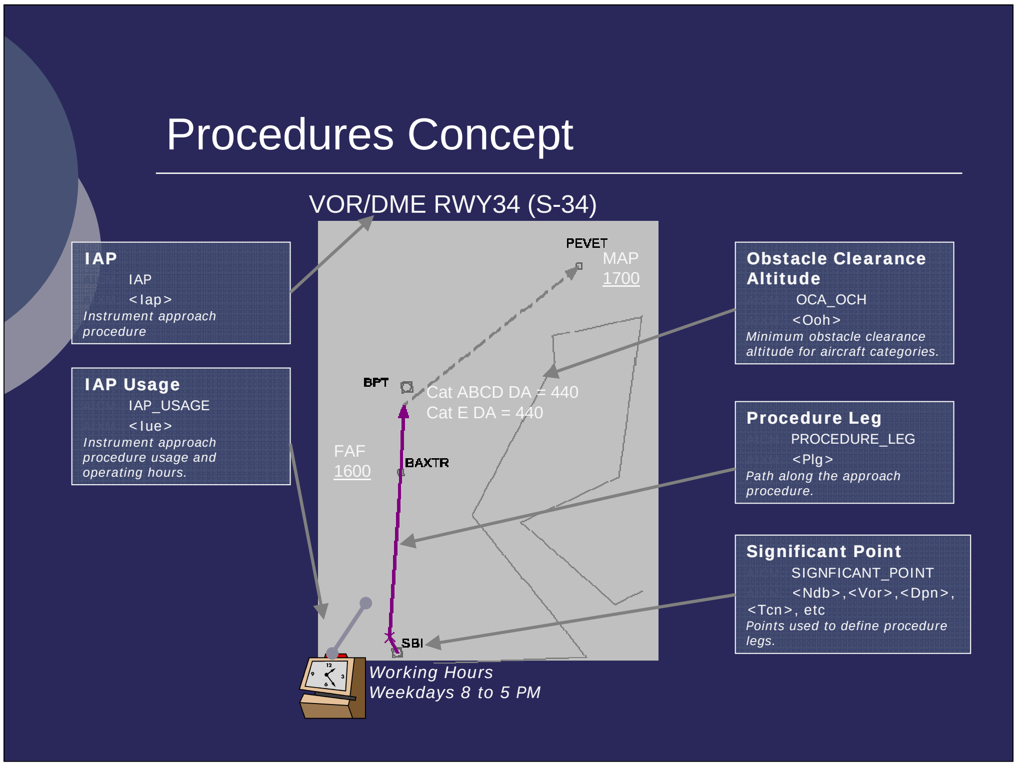

The services data concept area is used to describe organizations, divisions, units and the services that they provide. Services are connected to other aeronautical elements such as airspace, airports, procedures and routes. This diagram illustrates a model of an air traffic control service located at a Federal Aviation Administration en route facility. The FAA is the parent ORGANIZATION for the En Route Control Center UNIT. Both UNITS and ORGANIZATIONS can have addresses and associations. A sample association is shown for the En Route Control Center where the Flight Service UNIT may be a child of the En route UNIT. The En Route Control Center will have many SERVICES, one of which is air traffic control services. These services may include FREQUENCIES and operating hours.




The Routes data concept area is used to define an en-route routes. Within the United States this includes jetways and airways used to traverse the en route airspace structure. Note that approach procedures and departure procedures are modeled separately in the procedures data concept area.

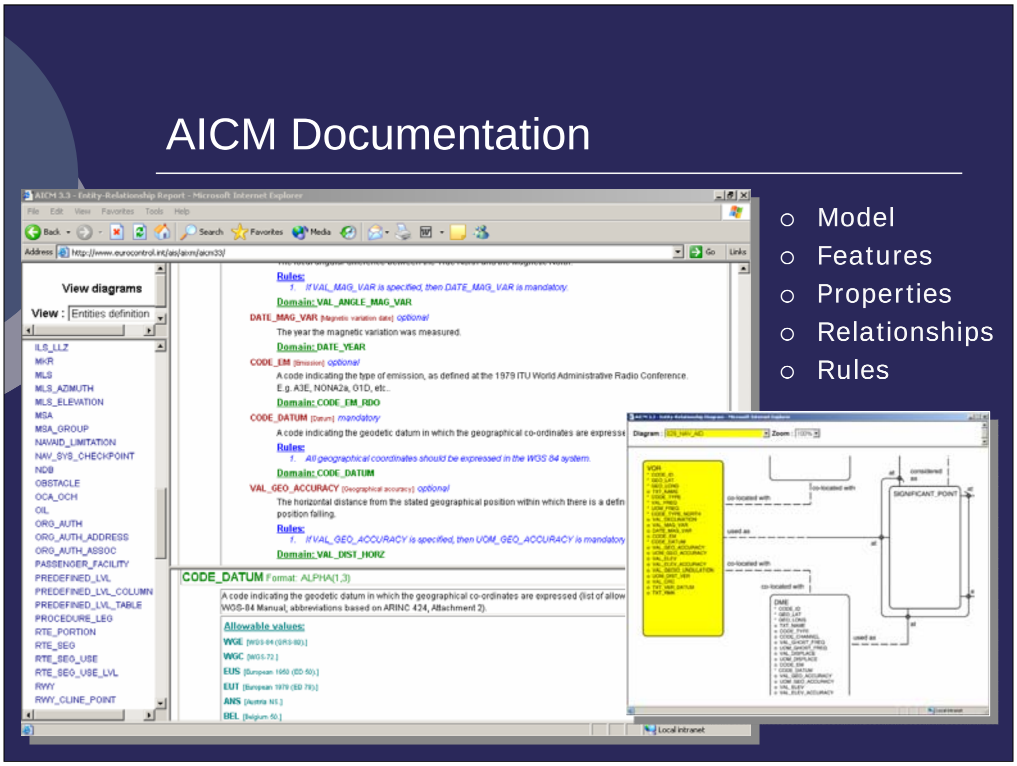
This example shows a part of J101 which is a north-south route in the central United States. The ROUTE is made up of a series of SIGNIFICANT POINTS, for simplicity only the NAVAIDS that make up the route are shown in this example. Pairs of joined SIGNIFICANT POINTS are called ROUTE SEGMENTS. A ROUTE SEGMENT can include altitude limits and a width. Each segment can have a complex usage of flight level and operating hours. In this case, the ROUTE SEGMENT between GRB and BAE as a timesheet indicating that the SEGMENT USAGE is weekdays between 8 and 5 PM.

Not shown in this diagram is the concept of traffic flow restrictions. These restrictions can be tied to route segments and are used to restrict traffic along the route based on complex criteria like aircraft city pair. In Europe, such restrictions are contained in a document called “Route Availability Document (RAD)”.




The Procedures data concept area defines instrument approach procedures, departure procedures and standard terminal arrive routes. AIXM uses the ARINC 424 standard as the basis for the data model used to create procedures in AICM and AIXM.

This example shows a conventional procedure (IAP) to runway 34 at the Beaumont-Port Arthur (BPT) airport. For this example the procedure is assumed to be active from 8 AM to 5 PM weekdays and this is modeled as a time sheet in the IAP USAGE. The procedure includes 3 PROCEDURE LEGs starting at the SBI NAVAID. For instance the final PROCEDURE LEG goes from BAXTR to the decision altitude (DA) at which point the pilot must determine whether to land for take the missed approach to PEVET. Each PROCEDURE LEG is define by SIGNIFICANT POINTS and a leg type. The decision altitude for the pilot is determined by their aircraft category. Decision altitudes are modeled in the OBSTACLE CLEARANCE ALTITUDE entity.




So what is AICM? AICM is a data model and a list of important features, properties, relationships and rules that make up aeronautical information.

The documentation includes.

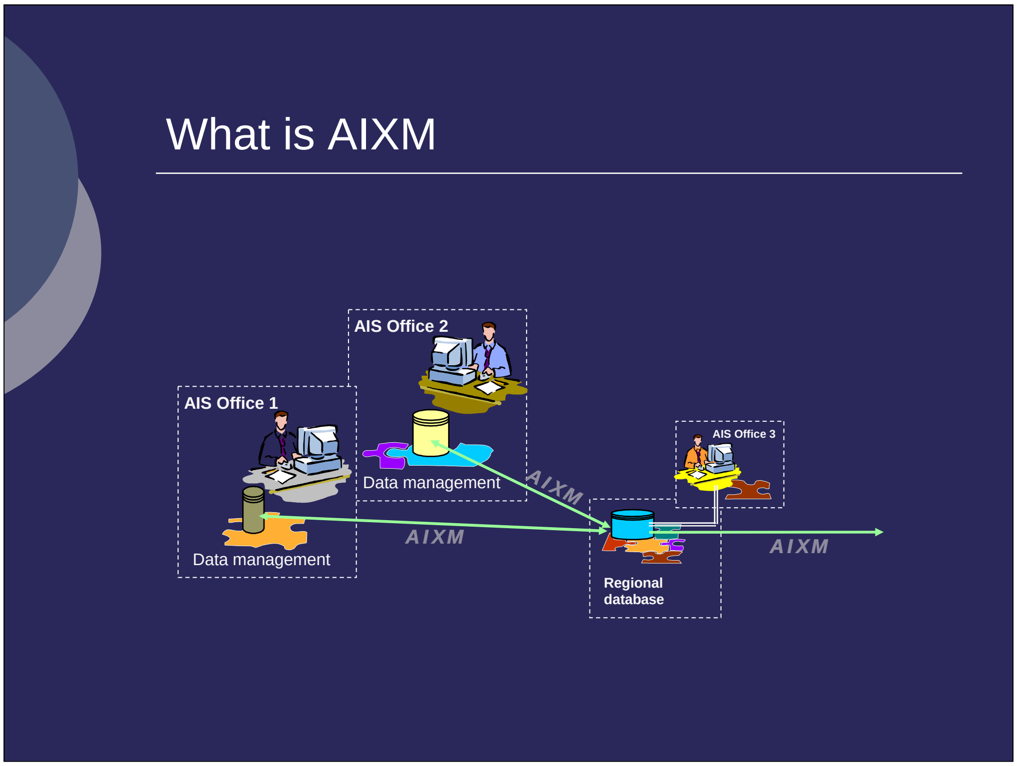
- reports
- entity-relationship diagrams (UML view – through automatic conversion - also available)
- AICM Manual

The documentation for versions 3.3 – 4.5 is freely available on the EUROCONTROL Web site:

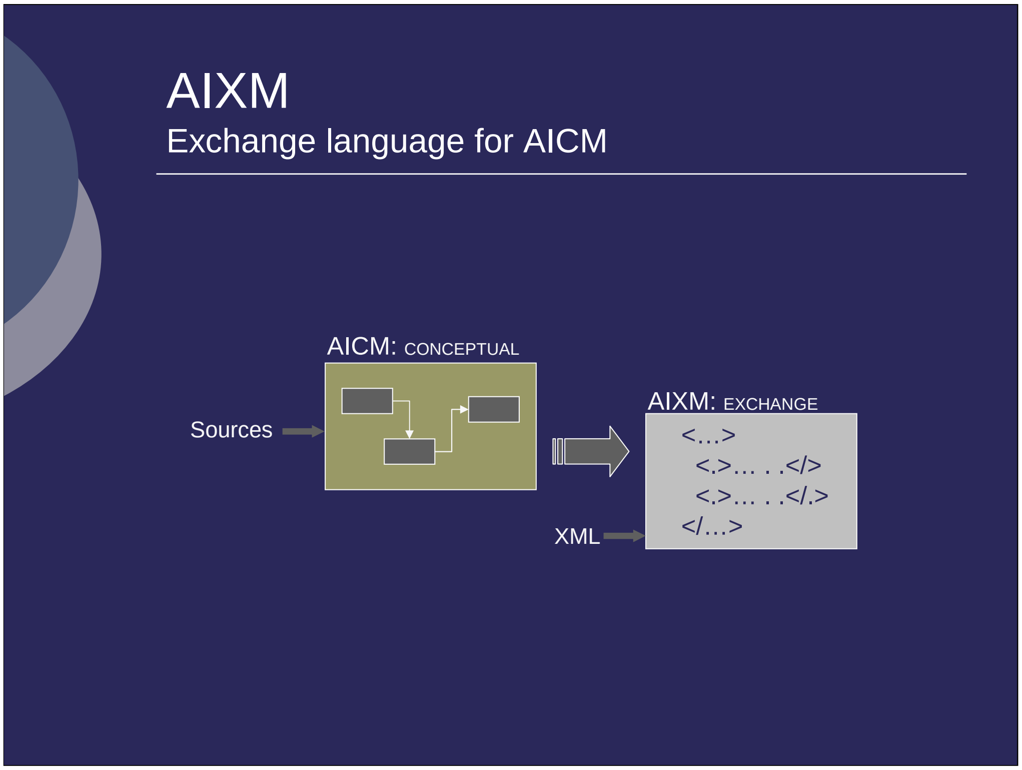
-Version 3.3: www.eurocontrol.int/ais/aixm

-Version 4.5: EUROCONTROL Extranet - OneSky Teams (extranet.eurocontrol.int or http://www.eurocontrol.int/aim/public/standard_page/interop_aicm.html)

An AICM Web based training is available from the EUROCONTROL Institute of Air Navigation Services (IANS) – Luxembourg: http://elearning.eurocontrol.int

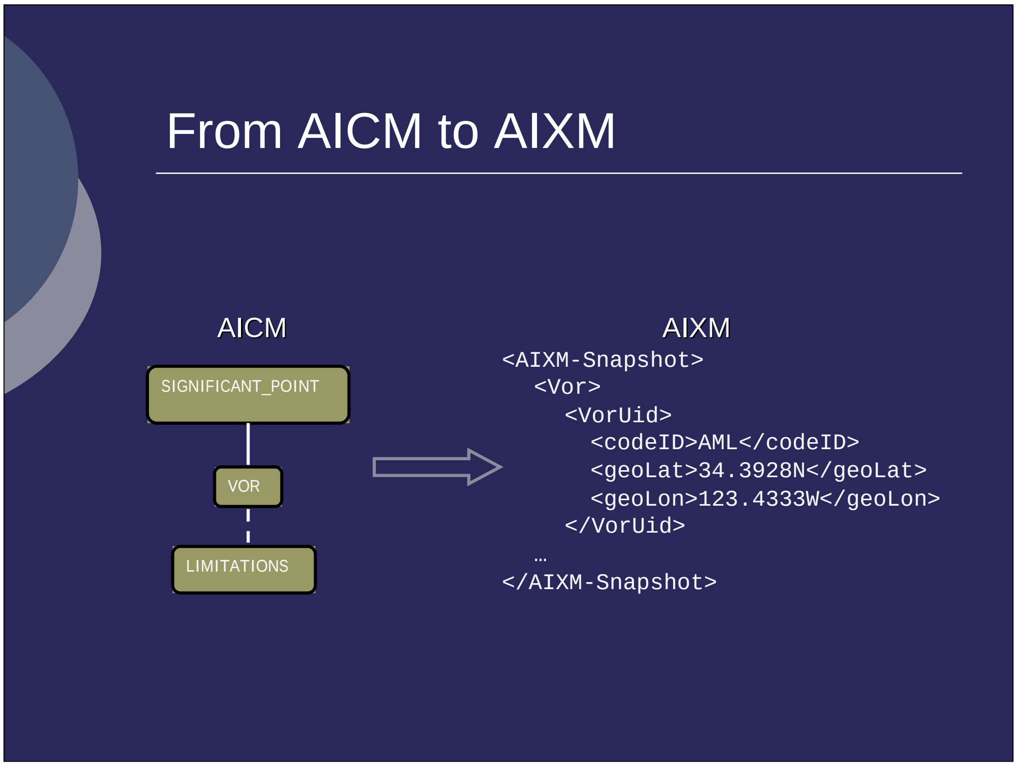



AICM is not enough, we need a standard way to encode the information so a computer can transmit and receive it.  AIXM is based on AICM and it is the system to system exchange specification for aeronautical information.  AIXM is based on XML.



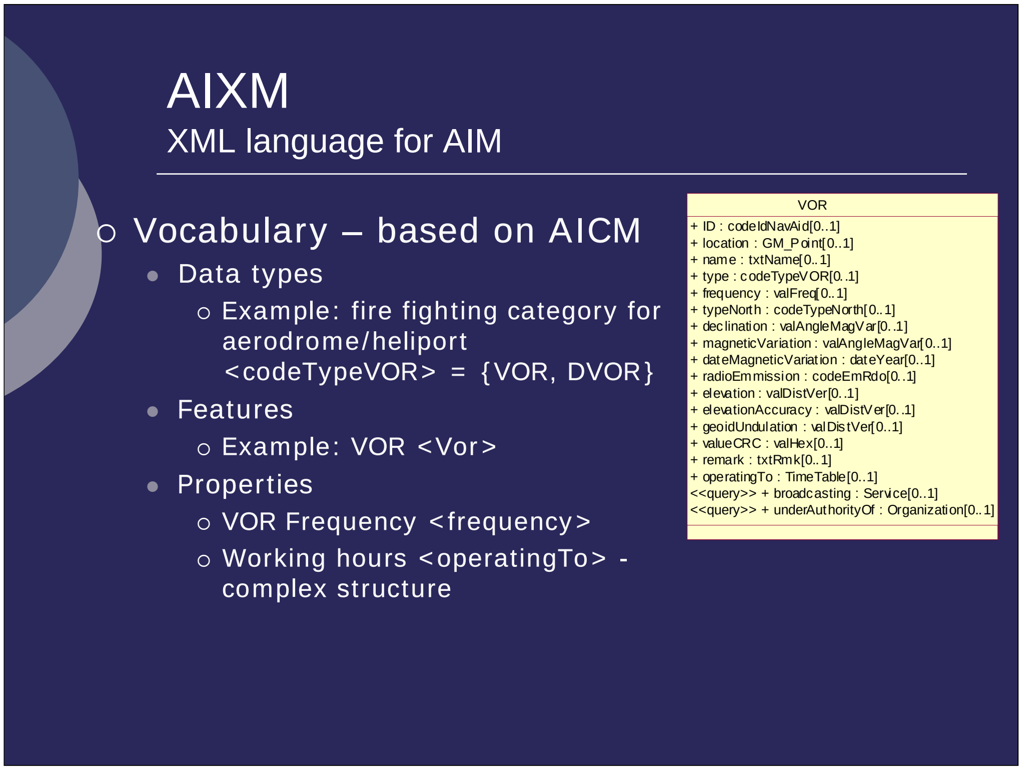

AIXM derives from AICM by mapping the AICM features, properties, relationships and rules into XML.

XML is a standardized non-proprietary format suitable for computers.

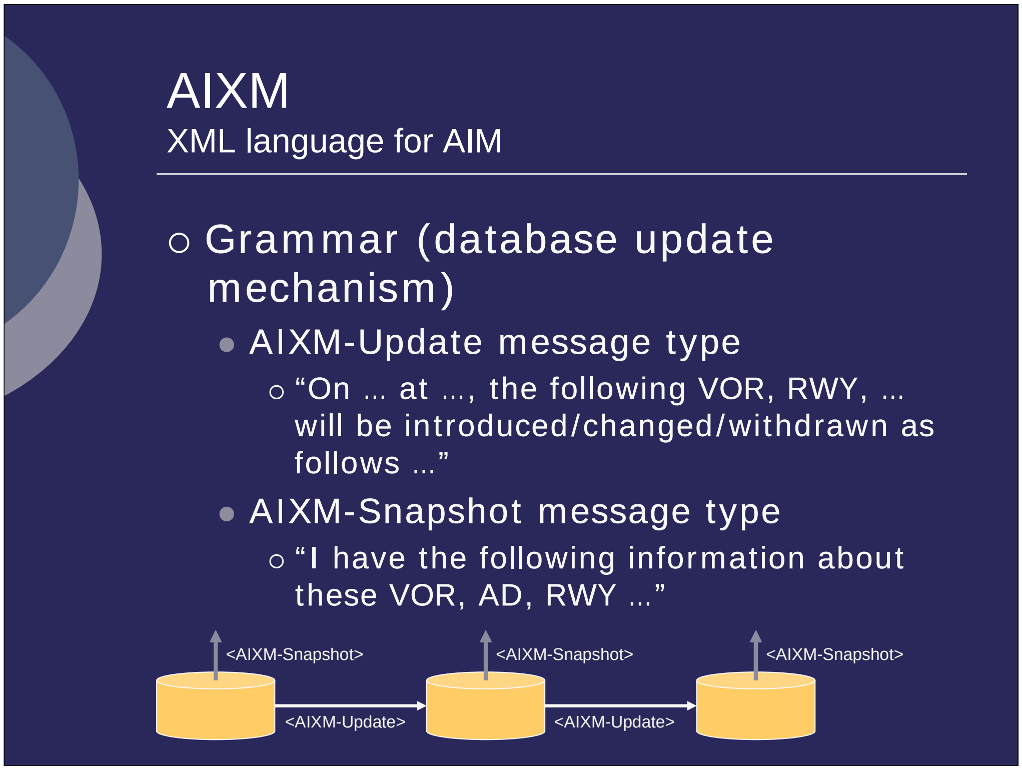



AIXM is the physical implementation of AICM in XML (Extensible Markup Language). The diagram shows how the VOR entity-relationship diagram is converted into AIXM. In AIXM, the VOR is called a feature.

Current releases of AIXM have a grammar that contains two messages: Snapshots and Updates. A snapshot is used to transmit a complete aeronautical data set valid at a specific time. Updates are used to communicate changes.

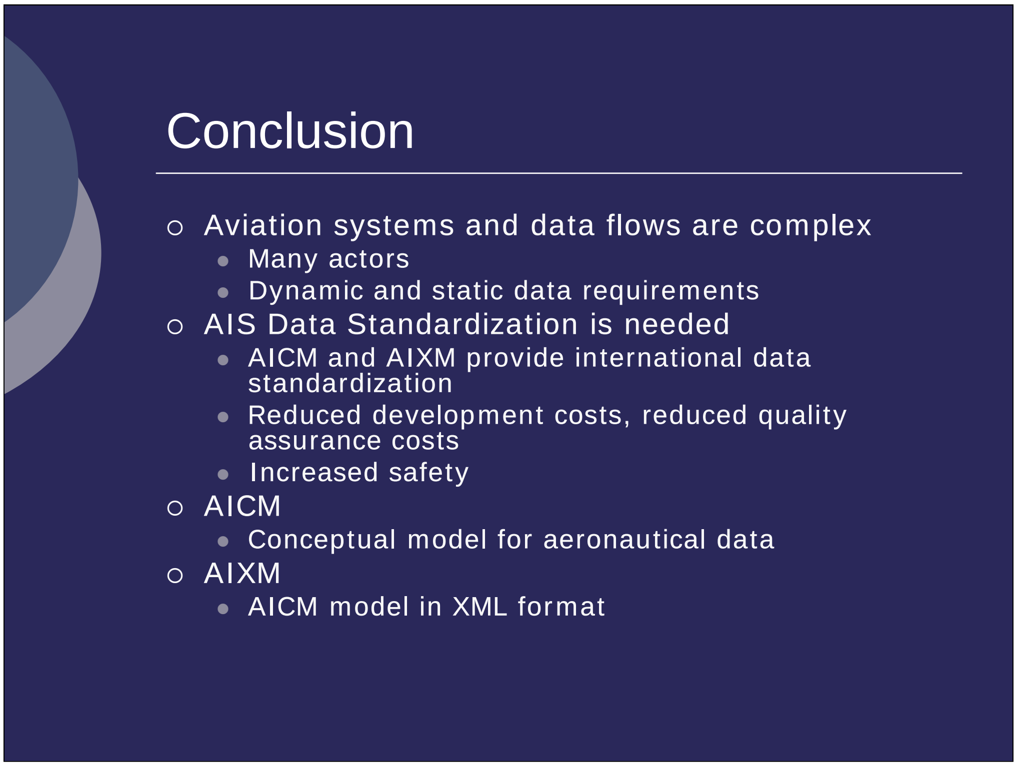



The XML language includes a vocabulary based on AICM. It includes data types such as the codeTypeVOR which specifies whether the VOR is conventional or a Doppler VOR. It includes AIXM Features. The AICM VOR feature is translated to an XML Feature, <Vor>. It also includes feature properties and relationships. The VAL_FREQ and WORKING HOURS are two properties and relationships that are converted to XML.




AIXM also includes a grammar. AIXM 4.5 has a limited grammar based on database management and synchronization. The <AIXM-Update> message type allows a system to indicate new, removed or updated features. For example, “on April 1, 2006 the following VOR, RWY, IAP will be added and the following SIA and RSG will be updated.”

The <AIXM-Snapshot> message type provides the baseline of the database at a point in time. For example, “on April 1, 2006 my database contains the following aeronautical features…”




To conclude, we note that aviation systems and data flow are very complex and often involve many actors and temporal requirements. AIS Data Standardization is required if we are going to improve and integrate the aviation system. AICM and AIXM provide international data standardization. Using AIXM will reduce development costs and reduce quality assurance costs. Using a common format for data can improve safety because all systems have a clear understanding of the data.

AICM is the aeronautical information conceptual model – basically a data model and definitions for aeronautical information. The Aeronautical Information Exchange Model (AIXM), is based on AICM and encodes AICM as XML.