INFORMATION SERVICES FOR AIRSPACE ELEMENTS

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ABSTRACT

In order to support the increasing air transport, Air Traffic Control and Management (ATC/ATM) systems worldwide will implement new technologies and concepts. The System Wide Information Management (SWIM) will be a network enabled platform connecting aircrafts, airports, operators and ATC/ATM centers. The seamless integration of systems will be achieved with data shared using information exchange standards currently under development. This new network enabled platform that adopts well-known standards and protocols improves the amount and quality of air traffic data and fosters the development of new solutions. This paper presents the development of an Information System designed with the SWIM concept, which will provide airspace data for operational ATC/ATM systems.

Keywords: SWIM, ATC/ATM Exchange Models, Airspace Information, Interoperability, ATM Modernization.

1. INTRODUCTION

The growth of the air transport is a global trend. Air traffic control and management will go through many changes to keep this trend feasible in the near future. According to Enea and Porretta the air traffic systems will have to radically change from the current solutions (Enea, 2012).

ATC/ATM worldwide modernization follows ICAO's Global Air Navigation Plan (ICAO, 2013), that has four main fields: communication, navigation, surveillance and ATM. The plan is a global guide and each country will implement the changes gradually and in accordance with its needs. Modernization projects in many countries are researching and implementing both infrastructure and systems.

The two main programs are NextGen and SESAR, led by the U.S. and the European Union, respectively. The programs are similar in many ways; both deal with the same problem (Enea, 2012) and have similar objectives (Ky, 2009): expand capacity, global aviation harmonization, ensure safety (with increasing capacity), protect the environment and improve service for aviation customers. Brazilian Departamento de Controle do Espaço Aéreo (DECEA) manages and executes the SIRIUS program based on two documents: Concepção Operacional ATM Nacional (DECEA, 2011) and Plano de Implementação ATM Nacional (DECEA, 2012).

An essential concept for the future systems is SWIM (System Wide Information Management), the so-called ATM intranet enables air traffic information to be shared amongst Air Navigation Service Providers (ANSP), airline operators, aircrafts, military and civil authorities, airports and flow management centers. Unlike present-day systems that have point-to-point communication interfaces, SWIM-enabled applications are more flexible to changes between information producers and consumers, this way, adding new stakeholders will require much less effort. ICAO Manual on SWIM Concept (ICAO, 2015) defines it as "SWIM consists of standards, infrastructure and governance enabling the management of ATM-related information and its exchange between qualified parties via interoperable services." SWIM assures that the right information will be available with the right quality to the right person at the right time.

International demonstration events are being held in order to harmonize the modernization programs through conceptual exercises and to show global interoperability capabilities of SWIM. In 2016, Brazil took part at two demonstrations representing DECEA, Mini Global II Demonstration organized by FAA and the SESAR SWIM Global Demonstration held by EUROCONTROL. Atech developed the systems for the events in association with DECEA. (Koroishi et. al., 2016)

This year DECEA provided Atech with digital air space data formatted as the new information exchange models. The data will be used to improve the algorithms and solutions of Atech's ATC/ATM systems. First research has been conducted and prototypes have been developed in order to create a base for the Brazilian SWIM.

2. METHODOLOGY

2.1. System Wide Information Management

Figure 1 presents the five-layered SWIM Global Interoperability Framework.

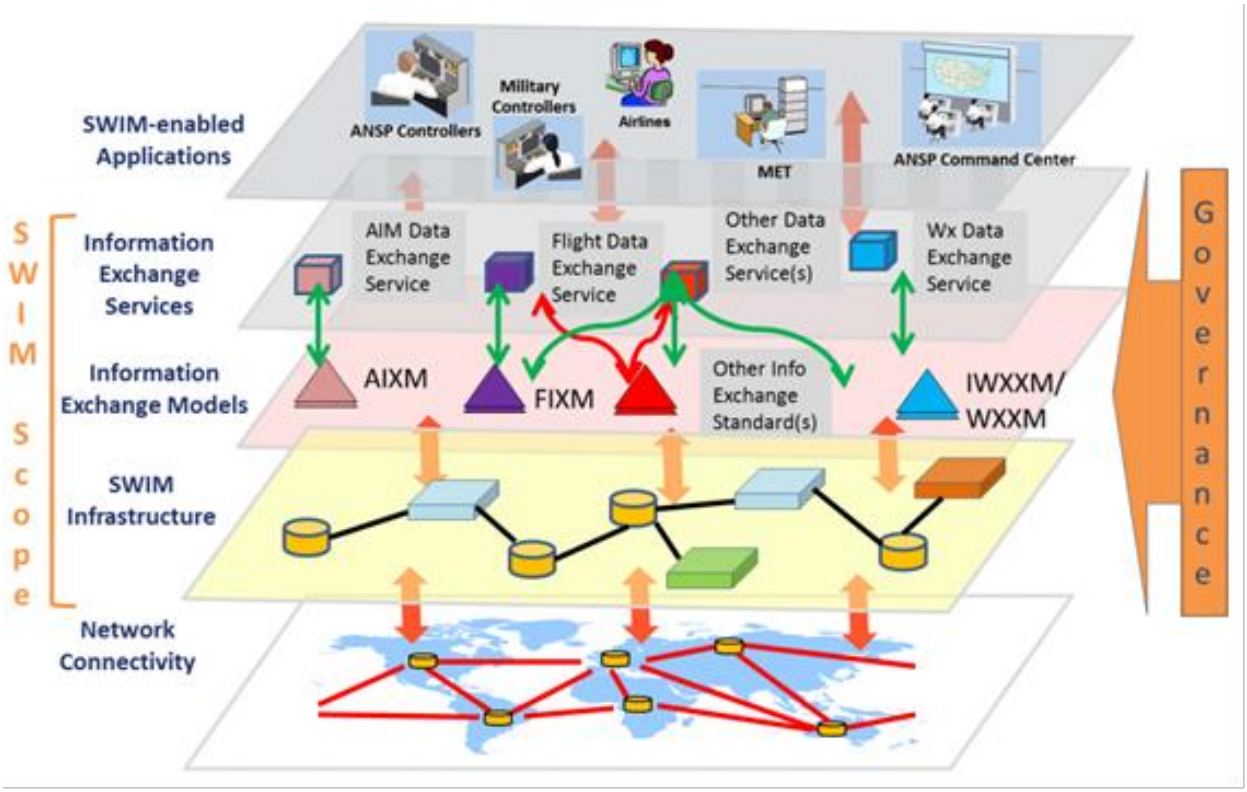


Figure 1: SWIM Global Interoperability Framework (from ICAO, 2015)

The first layer corresponds to SWIM-enabled applications used by stakeholders to provide and consume information. The second one includes the information exchange services to be used by the applications. The third one is formed by the information exchange (they will be specified in the following section). The fourth layer is the SWIM infrastructure that provides messaging, service security, and enterprise service management. The last layer corresponds to the network connectivity, composed by Internet Protocol (IP) networks. The three middle layers and their governance are the SWIM Scope.

The framework's architecture removes the coupling between the data and its producer or consumer and avoids the need of implementing new interfaces every time a new system is added to the network. The use of Service Oriented Architecture and open standards also simplify the development of new applications. This interoperability improves the quantity and quality of the data available for the ATM/ATC systems.

2.2. Information Exchange Models: AIXM/FIXM/WXXM

Current ATC/ATM systems do not have a common representation for the data, sometimes the same entity is named or represented differently in each system, and a translation layer is required to communicate (EUROCONTROL, 2015). SWIM defines a standardization of the air traffic domain, resulting in less effort required when developing or modifying a system interface.

The Information Exchange Models for SWIM are AIXM (Aeronautical Information Exchange Model), FIXM (Flight Information Exchange Model) and WXXM (Weather Information Exchange Model). They consist of two parts; the first one is a conceptual model that describes the features and their properties (attributes and associations), defining an unambiguous terminology and stablishing common vocabulary and representation within the domain. The second part is a XML (Extensible Markup Language) Schema, an implementation of the conceptual model also used to validate the data.

Data governance assures the quality of the data, while the usage of UUID avoids the segmentation or duplication of an entity (EUROCONTROL and FAA, 2011). A temporality model

provides support to current, scheduled and past information and “enables a precise representation of the states and events of aeronautical features.”(EUROCONTROL and FAA, 2010).

Figure 2 is an example of an AIXM message with information of a VOR equipment, highlighting the feature identifier, the valid time and the geographical information. AIXM/FIXM/WXXM use the ISO19136:2007 (Geography Markup Language - GML) that standardizes an implementation of the geometry-related standard of the 19100 family and the ISO 19139:2007 (Metadata – Implementation Specification) (Kresse and Fadaie, 2004) to represent geographical properties (Open Geospatial Consortium, 2012). GML is a consolidated language used by Geographical Information Systems.

Besides being global models, they foresee the adaptability of them for regional purposes through the extension of the features. FIXM for instance has extensions for United States and Europe. The three standards are still under development and are in different stages of maturity, SWIM demonstrations serve to validate and to improve them by making recommendations for updates.



Figure 2: AIXM formatted data of a VOR equipment

2.3. Global Enterprise Messaging System

The global SWIM is built through the integration of GEMS (Global Enterprise Messaging System) that provide services of governance, security, validation and routing for multiple Local SWIM (countrywide). Multiple GEMS connect to each other forming a worldwide cloud that connects all the SWIM-enabled applications as presented in figure 3.

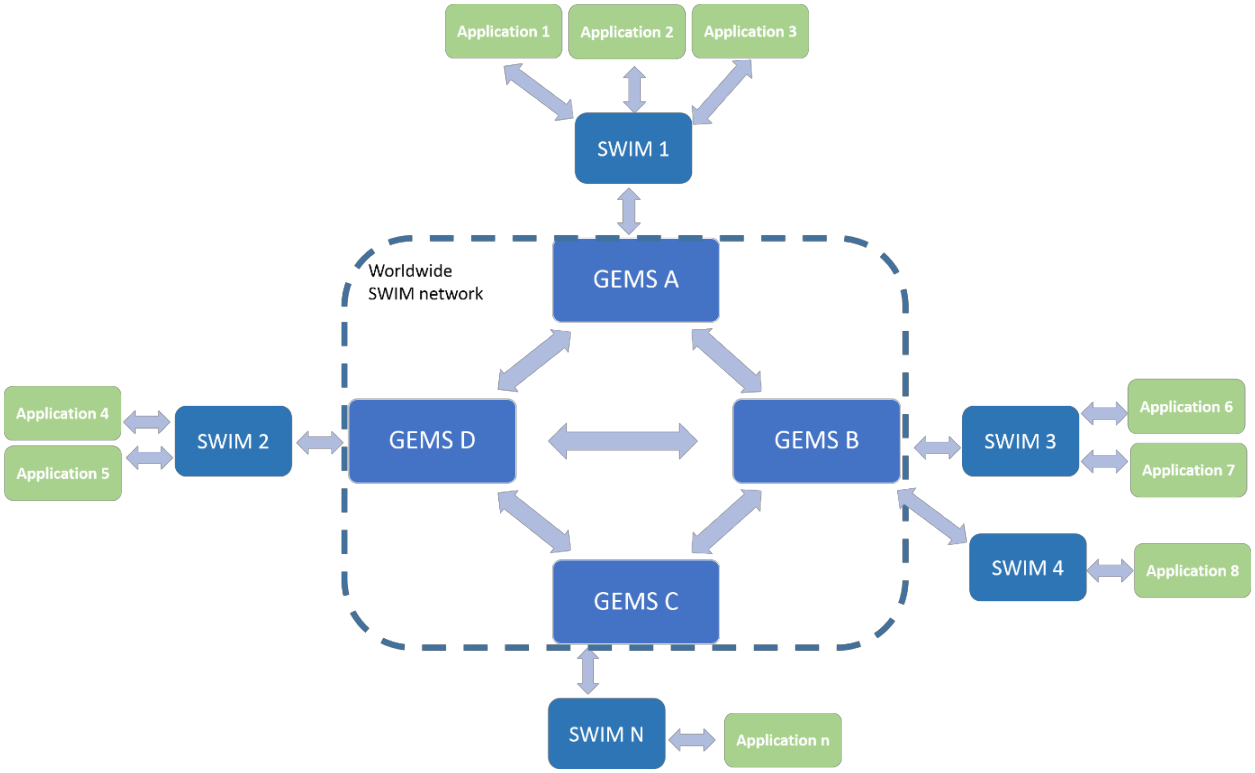


Figure 3: GEMS connectivity

2.4. System architecture

Atech's Information Server receives the digital data in AIXM/FIXM/WXXM documents. Nowadays a managed mean to retrieve this document is not available, but files with the solely purpose of providing support to tests and demonstrations were available for download from AISWeb site. In order to provide information to operational systems, the information server persists the data and performs tasks to validate the information. This information validation is done from the operation perspective, and therefore, the available information must be also enriched to fulfill the operation needs. As this server must provide information for more than one operational system and the use of information must be controlled and monitored, the server must be provided with governance tools. The managed query interface offers services to the clients (applications and systems). The services are authenticated web-services built to allow the information retrieval and update.

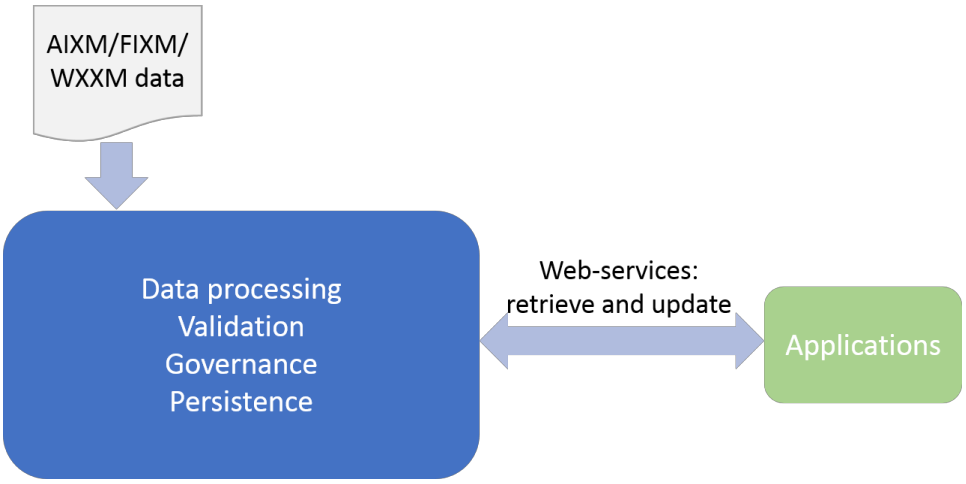


Figure 4: Information Server and Client

3. RESULTS

The information server that Atech is developing initially import information through the ingest of AIXM documents received from DECEA. The received data set contains multiple air space elements described in table 1, the first column describes the feature type, the second one the number of feature of the given type and the last column indicates the feature's geometry.

Table 1: Air space elements

Type	Quantity	Presentation
Airspace	182	Volume
Information Service	101	Point
Air Traffic Control Service	147	Point
Airport/Heliport	3791	Point
Route	253	Line/Volume
Route Segment	3608	Line/Volume
Navaid	300	Point
DME	125	Point
VOR	91	Point
Localizer	50	Point
Marker Beacon	14	Point
Glidepath	45	Point
NDB	143	Point
Designated Point	5127	Point
Organization Authority	102	-
Unit	347	Point/-
Air Ground Service	223	Point
Fire Fighting Service	60	Point
Airport Supplies Service	45	Point
Passenger Service	132	Point
Taxiway	265	Surface
Apron	118	Surface
Apron Element	29	Surface
Runway	3820	Surface
Runway Direction	395	Surface
Runway Protect Area	333	Surface

Visual Glide Slope Indicator	695	-
Runway Centreline Point	278	Point
Event (Digital NOTAM)	1	Surface

Figure 5 presents the configuration of the server with two clients. The first client is the 3D viewer where the georeferenced AIXM data is presented according to its geometrical property, in this case, the client is able to consume information provided in AIXM documents without translation. The second client receives the information in AIXM document and converts it to formats that other operational systems are able to use.

No application needs all information maintained by the server. Each application consumes only the part of the stored data that is necessary to its operation. The Information Services must therefore be able to allow the client to retrieve only the required airspace elements. The elements are selected based on input parameters that can be temporal, geographical or any element's attribute. Examples:

- Temporal: read NOTAMs valid at a picked moment;
- Geographical: filtering only airports inside a control area;
- Attribute: show route segments linked to a given route.

The server also gives a possibility to insert new information, update existing information and turn an information from valid to invalid. This is done respecting some rules:

- Before inserting a new information, the server assures that the created identifier respects the principles of UUID.
- To update an information, the server checks the consistency of the informed data and also of its associations;
- To invalidate a certain feature, the server first checks if the latter is a dependency of another feature.

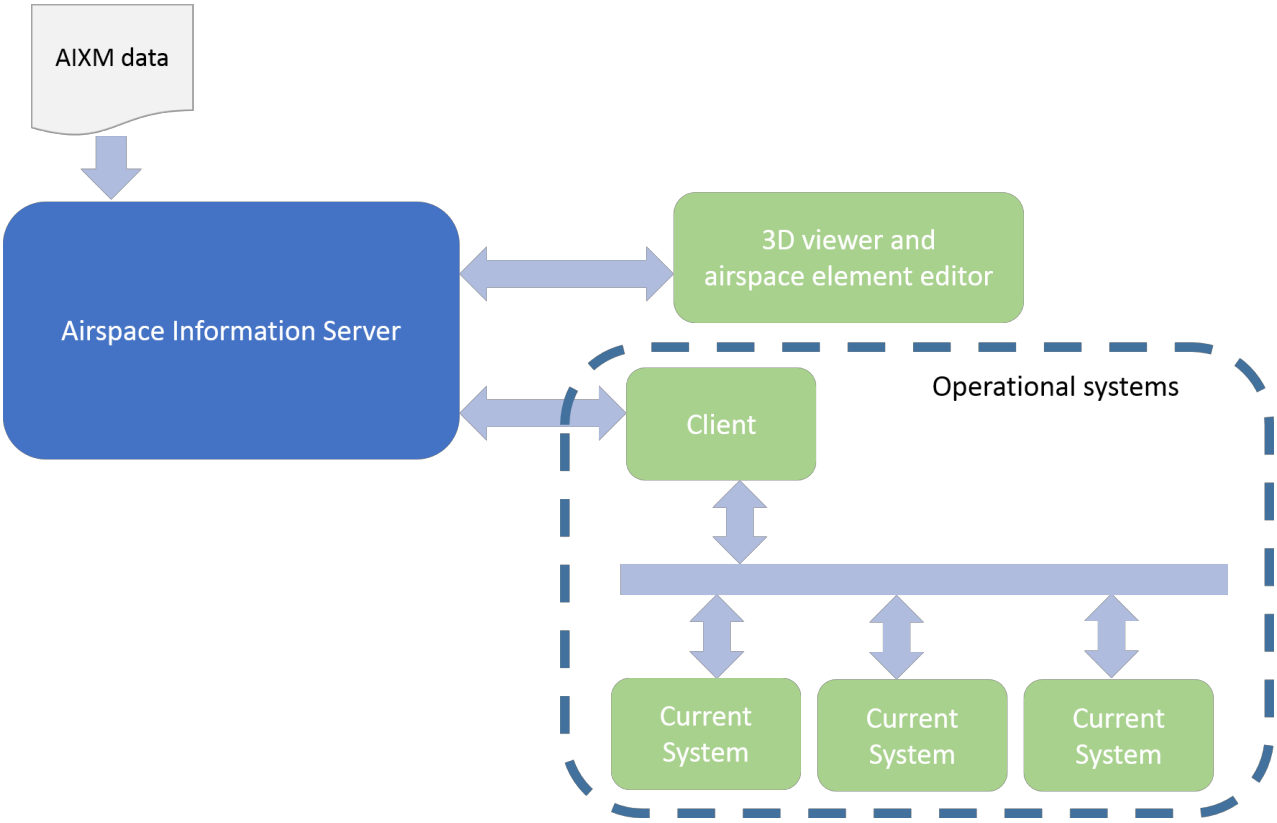


Figure 5: Initial systems integration

3.1. Providing data to operational systems

Each operational systems have their own representation of the airspace elements but they can receive the AIXM data after a translation made by the client application. A mapping study between the operational data and the AIXM data, performed in the scope of this work, showed that the elements are not necessarily mapped in a one-to-one basis; some elements need to be combined or split in order to be consumed by the operational systems. Table 2 has the results of this preliminary mapping considering operational systems for air traffic control and air traffic flow management.

Table 2: Mapping

	ATC System	ATFM System
Entities	74	346
AIXM Correspondences	20	33
FIXM and WXXM	12	166
System parameters	25	83

System parameters are not within this project's scope and the entities not modeled by the AIXM/FIXM/WXXM will be represented by extensions of them. The AIXM and its translated data is being used only for research purpose at the moment, being able to improve our systems later on. The following sections explain three cases that were implemented to integrate the data to our systems.

3.2. Remote Aerodrome Flight Information Service

The Remote Aerodrome Flight Information Service (R-AFIS) System assist aerodromes that do not have an ATC unit or it is closed, providing Flight Information Service and Alerts. This system gathers the following information:

- Meteorological information that affect landing and take-off,
- Runways' attributes conditions,
- Other airplanes' positions and procedures,
- Equipments' information and
- Other data for secure operations at the aerodrome.

Tests were carried out with DECEA's data being provided to the RAFIS system. When the RAFIS system makes a query, it receives only the information relevant to the aerodrome it is assisting. Therefore, results matched the expectations. In this case, the information ingested to the server is provided by the related ATC system.

3.3. Medium-Term Conflict Detector

The Medium-Term Conflict Detector (MTCD) analyses two or more flights in order to detect if the safety separation is violated. This system consults the following data:

- Departure and arrival procedures of the selected airports,
- Navaids and designated points

AIXM was the chosen input format as it offers a pattern that ought to be obeyed by its consumers and sources, leading up to a more secure and precise information.

Historical flight data can also enhance the trajectory prediction. Flight intent modeling determines aircraft flight rates of climb and descent based on flight analysis (Souza et. al., 2017). Later on, the Airspace Information Server will be able to provide this data in the FIXM format. FIXM carrying predicted trajectories as payload is already being exchanged between modules within the analysis and development framework for ATM systems modernization, (Fattori et. al., 2017).

3.4. Current Airspace Information Sharing Platform

Through this platform under development, Brazil exchanges AIXM/FIXM/WXXM data with foreign organizations about flights that cross both airspaces. The system aggregates data from ATC, ATM and AIS systems.

Nowadays the insertion and update of information is a manual and tiring process, which demands a number of changes in different systems, that happens due to the systems' isolation. Data representation is also a barrier that systems have to break in order to communicate. The unified Information Service avoids inconsistencies through the multiple systems and simplifies how updates are broadcasted.

To this day, the client that works as a translator between the server and the ATC system has been successfully implemented and tested with all the elements that can be represented in AIXM's format: Airports, Navaids, Fixes, Flight Information Region (FIR), FIR sectors, Terminal Maneuvering Area (TMA) and TMA sectors.

In the near future, other elements from Atech's ATM and AIS systems will have their own translators.

3.5. 3D Viewer and Airspace Element Editor

Figure 6 is a screenshot of the 3D viewer with a couple of Route elements that represent the airways informed by DECEA's data.

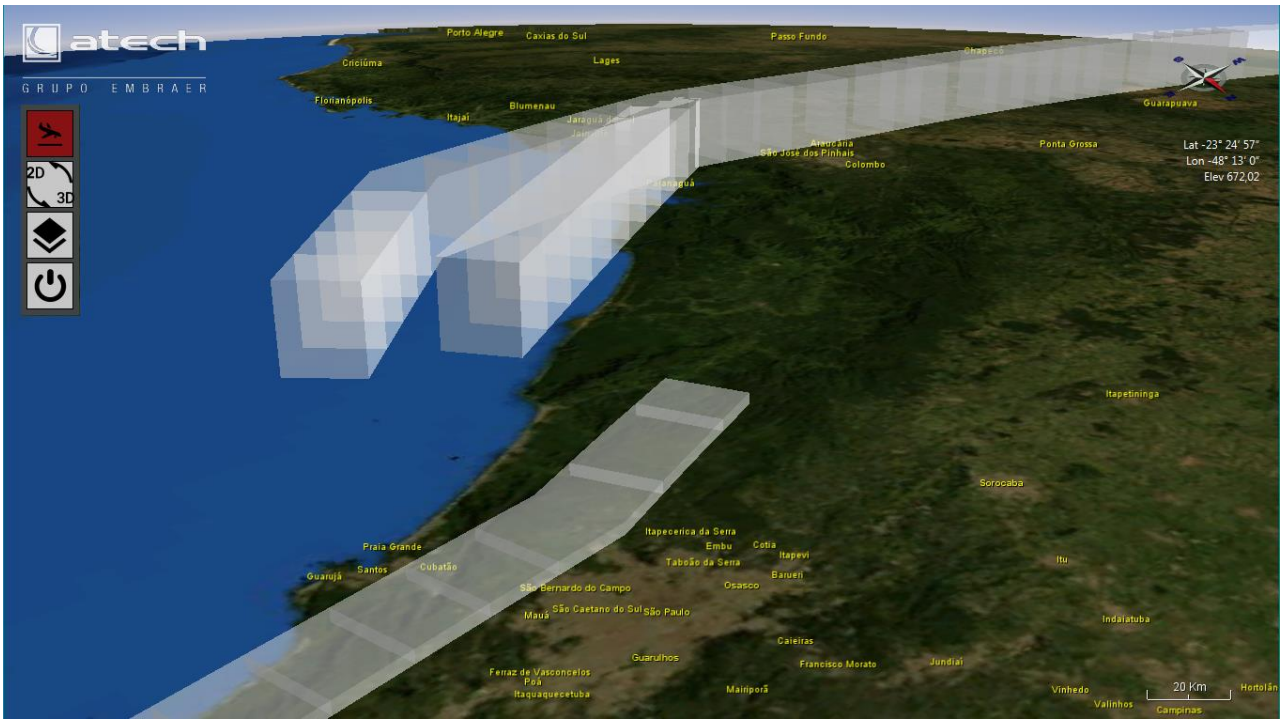


Figure 6: Routes

Figure 7 shows all airports and heliports in the Brazilian territory.



Figure 7: Airports and Heliports

Figure 8 illustrates Curitiba Flight Information Region. Figure 9 is a result of a query made, which requested the server to only retrieve Airports and Heliports in a Flight Information Region (Curitiba).



Figure 8: Curitiba Flight Information Region



Figure 9: Airports and Heliports in Curitiba Flight Information Region

Figure 10 contains volumes that represent obstacles near Vitoria's Airport (Eurico de Aguiar Salles)



Figure 10: Obstacles

Figure 11 shows how the update for Airspace's information is done. Through the HMI it is possible to alter attributes, such as the name. When the user alters something and clicks on the "save" button, the new information is sent to the server and the updating process begins on the backend. After the process is finished, the new information will be available on the next request.

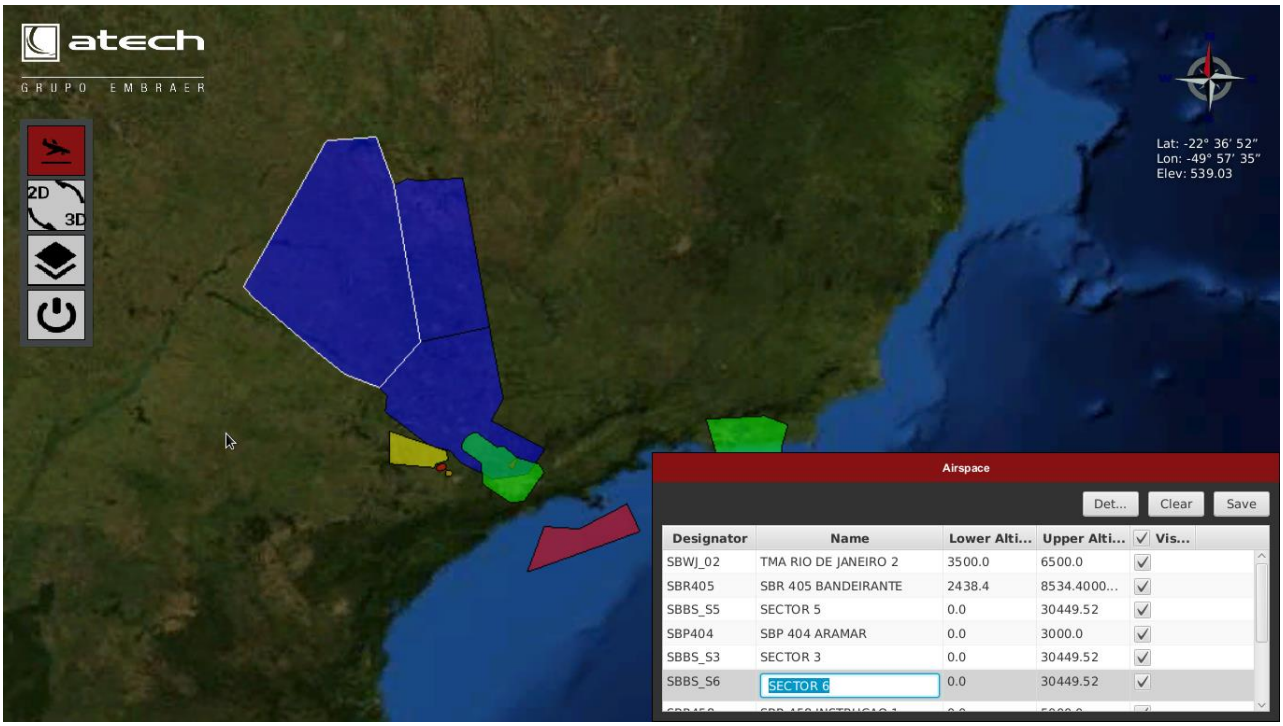


Figure 11: Editor

4. COMMENTS AND CONCLUSIONS

The presented project is still under development, but the benefits of using the AIXM/FIXM/WXXM standards are already noticeable during the process of developing new applications. By the time of the Mini Global II and the SESAR SWIM Global Demonstrations, there were not any Brazilian Navaid data formatted as AIXM and this necessary information was manually registered. Had we had the data we have now, it would have required much less effort to manipulate the information.

Efforts are being taken so that Brazil can meet ICAO's requirements and be part of a worldwide movement of air traffic modernization. In order to achieve that, the following steps must be taken: validate the server; finish up the clients that consume AIXM data; integrate the existing operational systems and implement the same structure for FIXM and WXXM.

The Information Services that will be available by the end of its implementation will improve our ATC/ATM systems communications and data quality, integrating the Brazilian air traffic to the SWIM network.

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