Transforming Flight Information Exchange via Flight Object and FIXM

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ABSTRACT

With the advent of the digital age, in which automation and data are transforming business operations, the international air traffic management (ATM) community has developed the concept of a complete flight data object, i.e., a virtual data object containing an accumulation of all acknowledged information about a flight. The Federal Aviation Administration (FAA), Eurocontrol, and industry partners, such as Harris, Mosaic ATM, Volpe, and Lockheed Martin, have participated in efforts to harmonize and standardize the flight information data model known as the Flight Information Exchange Model (FIXM). Particularly, the FAA has supported developments of FIXM-based Flight Object (FO) exchange through investments in research and development in NextGen test beds. The objective behind these research and development (R&D) efforts is to demonstrate an implementation of a shared FIXM FO, which can reduce complexity and improve how flight information is currently shared among Air Navigation Service Providers (ANSPs). This objective aligns with the International Civil Aviation Organization (ICAO)-defined Aviation System Block Upgrade (ASBU), B2-25 Globally Interoperable Systems and Data, which refers to the use of FO and System Wide Information Management (SWIM) for Flight & Flow Information for Collaborative Environment (FF-ICE) initiatives (Module Library of the Aviation System Block Upgrades, 2014).

The concept of a flight object is centered on a data-centric model of communication, in which information can be stored and managed in a centralized database accessible by Internet Protocol (IP)-based networks. Data centric means the information can be accessed from a centralized location and shared globally. SWIM provides the net-centric information technology (IT) infrastructure that enables the sharing of FO data where producers and consumers of flight information can exchange the data via an IP-based service oriented architecture (SOA) network. For example, the SWIM National Airspace System (NAS) Enterprise Messaging Service (NEMS) is a key enabling technology that can be used to exchange FO data with security and governance through tailored enterprise controls, service monitoring, and smart routing. The use of NEMS helps to reduce initial costs of connectivity and development, and improves interoperability of systems. One example where this is being demonstrated is in the FAA NextGen Mini Global demonstration, currently being conducted in the Florida NextGen Test Bed (FTB). The results of these demonstrations will identify the benefits of SWIM, FIXM, and FO, and help transform the way the FAA and international ATM community shares flight information in the digital age.

DATA STANDARDS & INTEROPERABILITY

IT is constantly evolving to meet the demand for cheaper and faster communication and data interfaces. One way to reduce development cost and schedule is to adopt standardized data schemas. Three exchange models have been defined in Extensible Markup Language (XML): Aeronautical Information Exchange Model (www.aixm.aero, 2014), Weather Exchange Model (www.wxxm.aero, 2014), and Flight Information Exchange Model (www.fixm.aero, 2014). Each of these exchange models work independently of each other to support the designated data type, but they work together to effectively describe the airspace. "FIXM, AIXM and WXXM should not overlap, but 'dovetail' together… The combination of FIXM, AIXM and WXXM is expected to cover the majority of data that needs to be exchanged within ATM. To allow greater interoperability between different data domains the models are expected to be based on common foundations" (EUROCONTROL - Flight

Information Exchange Model). Of these data models, AIXM and WXXM are the most mature models, containing Geospatial Markup Language (GML) elements and official adoption by the Open Geospatial Consortium (OGC) (OGC, 2014).

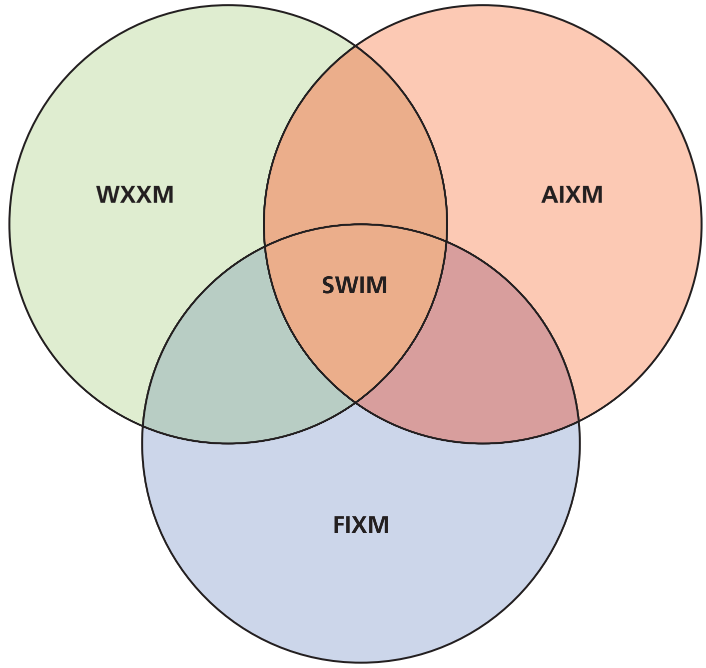

Figure 1: AIXM, WXXM, and FIXM Operating within SWIM (www.wxxm.aero)

Harris has been working on developing FIXM since its inception, starting with FIXM version 0.9, demonstrated in FAA projects such as Flight Object Early Access Validation (FO EAV). Additionally, Harris was active in the FIXM 1.0 specification and continues to demonstrate industry leadership in current FIXM development activities. Feedback from R&D efforts using FIXM in a SWIM environment is provided as "lessons learned" back to the FIXM working group stakeholders, to the benefit of FAA and the data standardization community.

The FIXM working group is targeting an aggressive annual release schedule for the FIXM specification. The latest version to be released by the FIXM working group is FIXM version 3.0 on August 28, 2014. FIXM version 2.0 contains flight information data elements from ICAO 2012 Air Traffic Service (ATS) messages as defined by ICAO DOC4444, position and track information, and boundary coordination information based on ATS Inter-Facility Data Communications (AIDC) exchange. With FIXM 3.0, flight trajectory models are initially introduced, but won't be completed until FIXM 4.0. Also with FIXM 3.0, the implementation of backwards compatibility is expected. The FIXM working group provides a FO data dictionary for semantic mapping of data fields to the FIXM schema elements. Additional features included in the data model are provenance (data history and modifications) metadata, dangerous goods (hazardous cargo), and fleet priority data fields.

Standard data models ensure that information can be more easily processed, but the method of transmission is not defined, nor is the messaging format. ICAO DOC4444 defines ATS messaging and AIDC defines cross-boundary coordination, but the FIXM working group does not currently define a messaging scheme for exchanging flight information. This leaves the implementation of FIXM messaging to the developers of FIXM systems.

Two approaches have been identified for exchange of FIXM information: 1) Retain the current messaging approach of legacy systems relying on systems controls, while modeling the information in FIXM. 2) Implement enterprise controls based on data-driven events from data updates to a FO construct. The first approach is easily understood as a transformation of flight information from a legacy message type into the FIXM schema format and transmitted to the intended recipient. The second approach is a data-centric method of store-and-forward updates based on the change from a current data state of a flight data object. "The Flight Object will be a virtual data object consisting of many individual physical data elements. For example, a Flight Object will contain a current route of flight and a controlled departure time. The current route of flight may be maintained by ERAM, and the controlled departure time may be maintained by TFMS. A third system should have seamless access to the current values for these two fields." (Howard, 2010). In this second approach, information is conflated into an FO and changes to the data are distributed via publish-subscribe to update other FO database stores via SWIM.

SWIM ENABLES THE EXCHANGE OF FLIGHT OBJECT

SWIM NEMS is a key enabling technology that provides a service-oriented architecture (SOA) for the management and exchange of data on a net-centric infrastructure. NEMS uses the Harris Data Exchange (DEX) platform to implement SOA enterprise messaging patterns such as publish-subscribe and request-response. A key aspect of the FAA FO initiative is the messaging definition for both request-response and publish-subscribe in the implementation approaches to FO data distribution (Llewellyn, 2012). Three approaches are defined for FO messaging: 1) Full Flight Object, 2) Flight Object Elements (clustered), and 3) Individual/Traditional Messages.

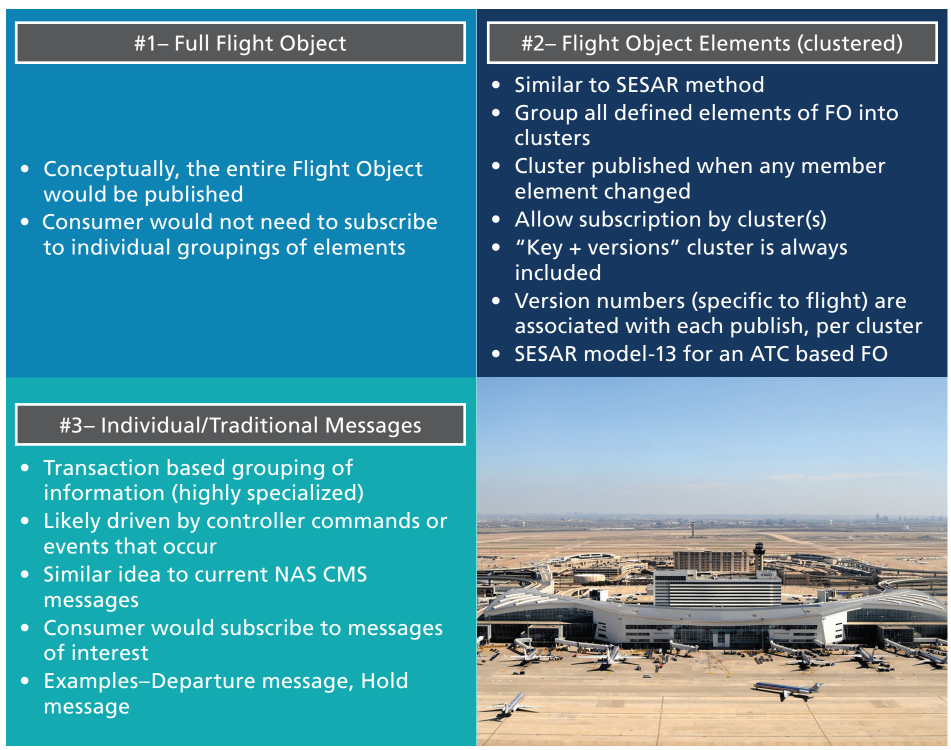

Figure 2: Flight Object Data Messaging Approaches

Approach 1 is the simplest approach in which a consumer of the FO can effectively replace the entire database entry with the newly received FO If the consumer also maintains an FO database with authoritative legacy systems, a compare-and-match process would be conducted first. The resulting difference would be compared and updated based on the business process management (BPM) or a delta message could be generated for the legacy systems. The disadvantage of this approach is the overhead cost of bandwidth consumption due to duplicated information upon every full FO transmission.

Approach 2 describes a method of clustering similar data elements together, such as a departure element or a route element. These elements can be transmitted similarly to Approach 1. Once again, a full replacement of that cluster element can occur or a differential can be calculated to perform a delta message exchange with legacy systems. The change to ATM system processing is based on the differential through enterprise data-driven controls. This approach is the preferred method to balance bandwidth utilization and performance.

Approach 3 describes a legacy transition approach based on using legacy messaging models. ATS messages or AIDC messages can be converted to FIXM and use the same transactional exchange as the legacy counterparts. The advantage of this method is the well-defined exchange of messages and required content of each message. The disadvantage is the limitations this imposes upon what is considered a new data model standard. This approach does not fully implement the concept of FO.

Despite the approaches mentioned, SWIM can be used to standardize the interfaces for implementing any of the three approaches. One thing is for certain, each ANSP may decide to implement FIXM in their corresponding systems in their own way. This should be avoided in order to standardize on the messaging exchange and maintain interoperability. For example, if one ANSP implements Approach 3 and a second ANSP implements Approach 2, the systems will not be able to communicate due to the difference in the transactional messaging process and the enterprise data-driven process. The service messaging should also take into consideration the routing controls implemented within the SWIM infrastructure. For example, the FAA NEMS provides content-based routing capability that allows for multiple consumers to consume data from a single publication feed. If the messaging required transactional request/response, then the publish-once, subscribe-by-many model does not work.

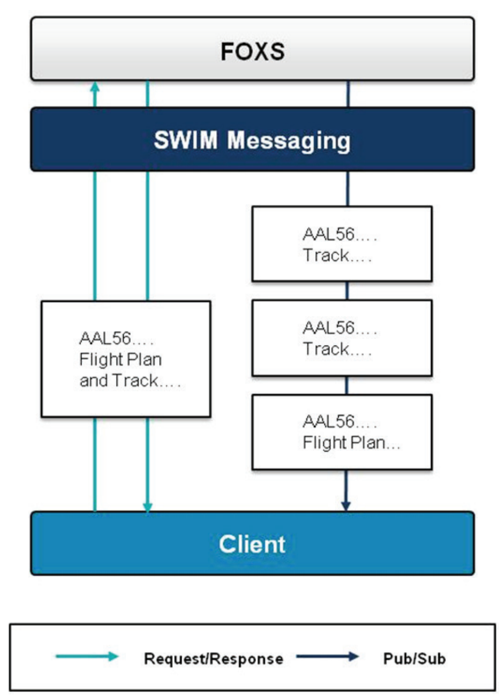

Figure 3: Enterprise Flight Object Exchange Service (FOXS) Messaging

FLIGHT OBJECT TRANSFORMATION VIA ENTERPRISE SERVICE

Another consideration is data mediation and transformation. Through the advances in research and development at the FTB, Harris is leading the forefront of SWIM and FIXM mediation services for transforming the exchange of flight information. One example is the development of a data-centric enterprise flight object exchange service (FOXS) to provide data transformation and mediation of legacy flight information from SWIM into FIXM FOs. This enterprise service can provision FOs by consuming legacy flight information data and centralizing the information within a data store.

FOXS is considered an "enterprise" service because it resides as a construct of the SWIM service oriented architecture, consuming and producing to and from the SWIM enterprise. In this architecture, flight data is accumulated within SWIM net-centric infrastructure and then merged via a business process management called conflation. The conflated FO can then be redistributed via SWIM in any FIXM version required. This is also true for FIXM version to FIXM mediation in which the data transformation can provide backwards compatibility for consumers of FIXM that are not ready to upgrade to the next version.

BENEFITS AND IMPACTS

The benefits of standardizing the exchange protocols via SWIM interfaces and adopting data standards are clear. With standard data models, ATM applications can be built with known schemas and, upon release, be immediately interoperable across multiple ANSPs, airlines, and aviation consumers. Because the data models are well known, the cost and schedule of developing these applications is significantly reduced.

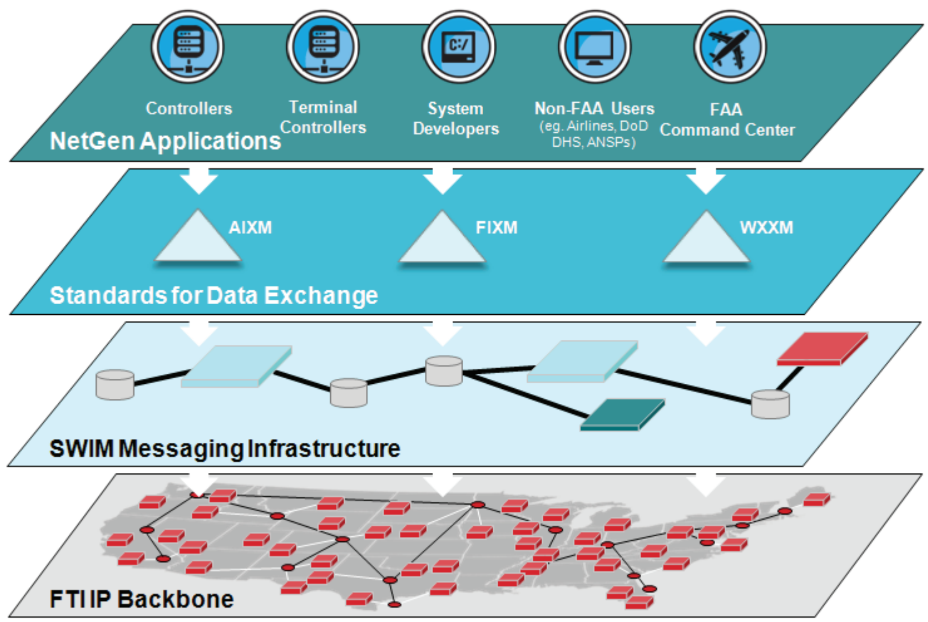

Figure 4: Layered Data Standards Exchange over SWIM

The same concept applies to adoption of SWIM interfaces to standardize message and data exchange. In addition, once standardized data is produced to the SWIM infrastructure, developers can rapidly create value-added data through net-centric information sharing.

CONCLUSION

The FO has been a goal for ATM starting with its first implementation, detailed in EUROCAE Document, ED-133 Flight Object Interoperability Specification (EUROCAE, 2009). Now that SWIM and FIXM have matured, FO can now be implemented using these technologies. Data-centric FO exchange improves communications between ANSPs and airlines by enabling centralized flight plan distribution, flight-and-flow data sharing, and strategic boundary coordination. Net-centric SWIM exchange reduces the cost of maintaining proprietary connections and reduces overall operational bandwidth consumption through smart routing and security. SWIM, standard data models, and FOs are transforming the way ATM information will be shared in the future.

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