



ICAO

International Civil Aviation Organization

**Fourth Meeting of the Asia/Pacific Air Traffic
Management Automation System Task Force (APAC
ATMAS TF/4)**

Bangkok, Thailand, 28 – 30 June 2023

Agenda Item 4: ATM Automation System Implementation Experience by States

- 4.1 ATM Automation System Implementation Issues sharing
- 4.4 Development of New Technology

ARCHITECTURE DESIGN TO ADDRESS SYSTEM UPGRADE AND INTEROPERABILITY CHALLENGES

(Presented by Singapore)

SUMMARY

This paper discusses the constraints of current system architecture to meet the needs for frequent system upgrades and encourages the use of open architecture and modern technologies to improve the implementation of upgrades and interoperability in the modernization of ATM systems.

1. INTRODUCTION

- 1.1 Air Traffic Management Automation systems (ATMAS) are critical components that support Air Navigation Services, which ensure safe and efficient air transportation. In general, ATMAS adopt a modular design and distributed architecture to ensure redundancy and robustness under demanding operating conditions. However, ATMAS system architecture is traditionally based on closed system architecture which constraints system upgrade options and adoption of new technologies to address new operational requirements and interoperability with other systems. Moreover, it is usually developed by a single vendor, mainly based on proprietary technology and bespoke design accumulated from previous solutions.
- 1.2 In recent years, there are increasing emphasis for innovation and demands for seamless interoperability across different regions and States, especially with the need to support sustainability initiatives and enablers such as Wake Turbulence Re-Categorisation (RECAT), System wide information management (SWIM) and Flight and Flow in a Collaborative Environment (FF-ICE) and other ASBU elements for Trajectory Based Operations (TBO).
- 1.3 However, there will be significant cost and effort to procure new ATMAS every few years in order to support these new requirements. Instead, system upgrades are usually preferred. With the introduction of ICAO ASBU, it is envisaged that there will be more

frequent system upgrades, hence there is a need to relook the design of system architecture, among other considerations such as contracting mechanisms, in order to prepare and facilitate future system upgrades with less effort and cost. The need applies to ATMAS as well as other associated systems that support operations such as Aeronautical Information Management (AIM), Air Traffic Flow Management (ATFM), Flight Plan Filing and FF-ICE.

2. DISCUSSION

2.1 Recognizing that each State has its own unique operational requirements, the challenge is to create a system architecture that is flexible to ensure safety, resiliency and interoperability, while addressing unique local requirements. Moreover, there is a need to address operational requirements in a timely manner.

2.2 Hence, it is envisaged that the next generation of ATM systems would be designed and built with emerging IT technologies to allow upgrades and add-on modules to address such needs. Modern architecture designs that emphasize on modularity, flexibility and common data exchange standards will ease the introduction of new operation by allowing modules to be replaced with less effort and cost, while permitting add-on modules to be deployed, thereby increasing the opportunity to source for best-in-class options and enable different industry partners to work together seamlessly. We define this architecture as Open Architecture.

Open Architecture to Address Upgrade Challenges

2.3 An implementation of Open Architecture could be based on the industry model of microservices architecture. Microservices is an architecture style where complex software modules are decomposed or broken down into smaller independent functional services. In the commercial world, Netflix, Amazon and Airbnb are some of the early adopters of microservices to increase scalability and flexibility.

2.4 For ATMAS and associated systems, software modules (e.g. Flight Data Processor, Aeronautical Information Processing) can be broken down into smaller independent processes/services which communicate with each other using operating system-agnostic interfaces. Moreover, microservices can be deployed independently of one another and are loosely coupled - changes to one microservice can be deployed to production environment independently of changes to other microservices. In addition, microservices can be implemented using different technologies where there is little restriction on the programming language for each microservice.

2.5 For a start, microservices can ease experimentation and innovation by allowing processes/services to be swapped and deployed easily, especially in proof-of-concept platforms to trial new operational concepts.

2.6 In the future, once there is sufficient knowledge and confidence gained with microservices, ATMAS and associated systems could potentially be designed and implemented based on microservices architecture. The system upgrades effort and cost would then be reduced because of the benefits offered in terms of the ease and flexible deployment to operation and co-existence of different programming languages and industry providers.

Open Architecture to Address Interoperability Challenges

- 2.7 System interoperability is the ability to exchange data and information across systems. This process of data exchange would be enhanced by the adoption of common data exchange models (e.g. FIXM, AIXM, IWIXM etc), i.e. an Open Architecture. This standardization of data exchange models supporting the adoption of FF-ICE and SWIM will enable an efficient flow of ATM information among States and stakeholders in enabling TBO and other ATM initiatives in the future.
- 2.8 In the APAC region, the use cases of SWIM revolve around sharing of information pertaining to Air traffic flow management (CTOT, CTO etc), Aeronautical (FF-ICE, AFTN messages) and meteorological information on SWIM. This serves as an initial step for cross border application of SWIM, leading to further close collaboration and sharing of information among states/administration.

Challenges and Opportunities

- 2.9 At ATMAS TF 2, the meeting was presented with WP-10 on Singapore's initiatives to explore the use of Open Architecture and to conduct Proof-of-Concept (POC) together with industry partners.
- 2.10 The POCs demonstrated the benefits of Open Architecture through the implementation of microservices on cloud. The microservice platform was able to run multiple instances of the same service, with the microservice platform managing the load balancing and fail-over. This helped to ensure redundancy and the easing of maintenance effort. In addition, rolling deployment could be performed, allowing services to be updated and deployed one at a time, and thus ensuring availability and robustness of the system.
- 2.11 However, as microservices was relatively new to the team, there were a few challenges faced in the POCs. First, there was upfront cost and effort to set up the platform. In addition, there was a need to identify and decompose the functionalities from a complex software module to services so that each service is standalone and independently deployable to perform specific functionalities.
- 2.12 Also, there is a need to consider the function of each service and find the right balance in terms of the number of microservices. While more microservices could increase adaptability and flexibility, it will also result in increased maintenance effort. In addition, the effort to deploy microservice is not trivial, especially for networking and cybersecurity configurations on a cloud environment.
- 2.13 Moreover, as microservices technology is relatively new in aviation and real-time environment, it has not been applied beyond prototypes and POCs. Further assessment will need to be conducted on the performance (e.g. availability, resilience, integrity) and safety aspects on the use of microservices.

2.14 Nevertheless, there is great potential of adopting Open Architecture on microservices to reduce cost and effort and increase the flexibility to support frequent system upgrades. It is recommended that interested States could start with a POC or non-critical system, before progressing to implement Open Architecture on ATMAS and associated systems.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information provided in this working paper;
- b) share experience on the design of system architecture and use of technology and common data exchange model that simplify modifications and upgrades, as well as increase system interoperability;
- c) explore opportunities to synchronise planning for the design of open architecture for ATM automation systems and consider updates to the ATM Automation System Implementation and Operations Guidance Document (ATMAS IGD), where applicable; and
- d) discuss any relevant matter as appropriate.
