



International Civil Aviation Organization

WORKING PAPER

A41-WP/499

TE/179

8/9/22

(Information paper)

English only

ASSEMBLY — 41ST SESSION

TECHNICAL COMMISSION

Agenda Item 33: Other issues to be considered by the Technical Commission

VALIDATING TRAJECTORY BASED OPERATIONS: MULTI-REGIONAL TBO DEMONSTRATION

(Presented by Canada, Japan, Singapore, Thailand, and the United States)

EXECUTIVE SUMMARY

The Global Air Traffic Management (ATM) Operational Concept (GATMOC) lays out a vision for the future of aviation. Since the publication of the GATMOC, ICAO Panels continue to expand on the development of concepts and concept elements to enable the vision. TBO is one such concept. TBO is the shared, managed and execution of the aircraft trajectory – through TBO, efficient operations and environmental benefits can be realized.

This information paper provides a quick summary of multiple partners (AeroThai, CAAS, FAA, JCAB and NAVCANADA) across multiple regions (Asia and North America) jointly conducted validation and demonstration activities to better define how TBO will be applied in their local and regional operations and collaborations. ICAO members should note the work that was completed, kicked-off similar validation activities in their respective airspace and region. Finally, publishing lessons learned to support knowledge sharing across the aviation community to ensure progress is beneficial.

<i>Strategic Objectives:</i>	This information paper relates to the Strategic Objective of Air Navigation Capacity and Efficiency
<i>Financial implications:</i>	None
<i>References:</i>	ICAO Doc. 9854, <i>Global Air Traffic Management (ATM) Operational Concept</i>

1. INTRODUCTION

1.1 The GATMOC (ICAO Doc. 9854) describes a range of innovative changes needed as the ATM system evolves to realize the vision. TBO is one of the significant changes.

“Air traffic management (ATM) considers the trajectory of a manned or unmanned vehicle during all phases of flight and manages the interaction of that trajectory with other trajectories or hazards to achieve the optimum system outcome, with minimal deviation from the user-requested flight trajectory, whenever possible.”

1.2 The ICAO Global TBO Concept also identified shortfalls in the global aviation system, such as:

- a) lack of information sharing between AU and ASP, within ASP systems and between ASPs. Voice clearances may not be input into automation and systems may not share known information of relevance to trajectory prediction;
- b) the above results in disparate information across participants and automation systems, which leads to inconsistent and inaccurate trajectory predictions. No single, consistent view of an expected trajectory is maintained using the best-known information; and
- c) decision-making is not trajectory-based or is based on and affects local trajectories that are not shared and collaboratively-obtained.”

1.3 TBO has been matured to address these shortfalls. Specifically, TBO is founded on:

- a) sharing of trajectory information and providing access to the best data, eventually leading to a common more accurate view of the trajectory;
- b) managing trajectory information using collaborative decision-making (CDM); and
- c) using the trajectory that is shared and managed as a common plan for the flight by providing a common intent to be achieved during execution of the flight.

2. DISCUSSION

2.1 The Aeronautical Radio of Thailand (AEROTHAI), Civil Aviation Authority of Singapore (CAAS), Federal Aviation Administration (FAA), Japan Civil Aviation Bureau (JCAB), NAV CANADA and multiple Airspace Users (AUs) jointly conducted a series of validation activities related to the maturing of TBO concept elements and envisioned capabilities across the Asia Pacific and North American regions. The Multi-Regional TBO validation activities were also supported by aviation system manufacturing industry partners, from airlines to system manufacturers and telecommunications provider.

2.2 The objective of the Multi-Regional TBO demonstration was to assess methods and technologies to overcome the identified shortfalls. The validation scenarios consisted of multiple flights across FIRs as they encounter constraints along their flight trajectories. Early and more accurate sharing of information by the air navigation services providers (ANSPs), supporting the AUs’ strategic re-

planning of the flight trajectory, resulted in more efficient, predictable operations. The richer, shared information environment was used to:

- a) access to the “best” data:
 - 1) SWIM and connected aircraft for sharing of information; and
 - 2) global exchange protocols for common exchange messages and format;
- b) manage the trajectory:
 - 1) FF-ICE and airport CDM for flight plan filing and trajectory revision/collaboration between the airspace users and multiple ANSPs; and
- c) use the trajectory to develop a common plan for the flight:
 - 1) incorporated ATFM capabilities, including AMAN integration for flow management and sequencing.
- d) Integrate the Trusted Framework for cyber security measures

2.3 **Tabletop Exercises**

2.3.1 Participants held multiple tabletop exercises to work through the required changes in the operation and associated procedures. These resulted in the development of scenarios that reflect how TBO would operate in each partner’s region, as well as the interaction between ANSPs and AUs. The scenarios showcased the capabilities of interest such as the Asia-Pacific Cross-Border Multi-Nodal Air Traffic Flow Management Collaboration (AMNAC) in the Asia Pacific region and rerouting around weather and constrained airspace for flights between North America and Asia. They also presented how the processes/business rules will evolve to make use of the data rich digital environment where information will be widely available and is able to support the flexibility of airspace users’ decision-making to deviate from the flight plan when better alternatives become available. Tabletop exercises focused on several of the operational capabilities, including:

- a) pre and post departure negotiation;
- b) trajectory revision; and
- c) traffic synchronization on long distance flights.

2.4 **Laboratory Testing and Demonstration**

2.4.1 Laboratory testing exhibited the connectivity of planned systems for data and message exchange. A foundational enabler of TBO is system wide information management (SWIM), using the various globally recognized exchange models. In the laboratory environment, ANSPs’ lab research and prototype systems were connected reflecting intra and inter facility exchanges making up to date information widely shared and available across ground and air systems for collaborative decision making. In the laboratory environment, it allowed engineers to test prototype services such as flight and flow information for a collaborative environment (FF-ICE), utilizing the latest exchange model extensions. Participating in the laboratory experiment allowed ANSPs to understand the new system capabilities and

to begin identifying the level of effort needed for operational deployment. The experience can be used to support local and regional roadmap development. A successful laboratory demonstration can be conducted when all the technical and procedural building blocks are in place. The demonstration day showcased the operational scenarios, and connected online systems with information flowing between the labs and across the regions supporting the TBO capabilities.

2.5 **Live Flight Demonstration**

2.5.1 The final step to the Multi-Regional TBO demonstration will be to illustrate the future is now through operational, non-revenue flight(s) executing selected TBO capabilities. A live flight demonstration will bring TBO one-step closer to implementation with a richer data-sharing environment between air and ground systems. It will also depict real-time interactions between the test pilots and controllers.

3. **CONCLUSION**

3.1 The Assembly is invited to take note of these activities and how, through these validation exercises, the aviation community can develop technologies and methods to overcome the shortfalls. To address the area of lack of information sharing among systems and users – SWIM, connected aircraft and information exchange protocols were used to demonstrate technologies to mitigate the information shortfall. To address the need for managing the trajectory, methods for trajectory planning, negotiation and trajectory revision as described in FF-ICE were demonstrated. Finally, the combined package showed how trajectory synchronization can pull together a common operating plan and enable TBO.

3.2 As global aviation continues to evolve and when ICAO puts forward new concepts of operations, there will be many questions. Validation activities with multiple partners will support research and implementation of these concepts. Knowledge sharing through webinar and workshops will further support the understanding and adoption of these concepts.

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