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COMMITTEE A

Agenda Item 3: Enhancing the global air navigation system
3.2: Flight and flow information for a collaborative environment (FF-ICE) and trajectory-based operations (TBO)

UNDERSTANDING AND LEVERAGING ON-GOING ATM INITIATIVES FOR TRAJECTORY-BASED OPERATIONS

(Presented by Singapore and Thailand)

EXECUTIVE SUMMARY

This paper advocates using various air traffic management (ATM) initiatives as building blocks for trajectory-based operations (TBO), to achieve ICAO's vision of an integrated, harmonised and globally interoperable ATM system as described in the *Global Air Traffic Management Operational Concept* (Doc 9854). The TBO transition roadmap can be designed on the foundation of interconnected ATM initiatives and practical implementation guidance to the aviation community.

Action: The Conference is invited to:

a) recognise the need for greater understanding of TBO in the context of on-going ATM initiatives to accelerate discussion and development;
b) request ICAO to develop a TBO transition roadmap that outlines the benefits envisaged and necessary implementation elements including development of Standards and Recommended Practices (SARPs), avionics and infrastructural requirements, and operational procedures; and
c) request ICAO to refine and develop existing concepts and guidance material further to guide States and other stakeholders in the implementation of TBO in both the pre-departure and post-departure phases of flight.

1. INTRODUCTION

1.1 The ICAO *Global Air Navigation Plan* (GANP, Doc 9750) is a strategic document that guides the efforts of States, Planning and Implementation Regional Groups (PIRGs), and international organisations in transitioning towards the global air traffic management (ATM) system envisaged in the *Global Air Traffic Management Operational Concept* (Doc 9854). Doc 9854 presents a vision for an integrated, harmonised, and globally interoperable ATM system and its high-level requirements are provided in the *Manual on Air Traffic Management System Requirements* (Doc 9882). One key requirement of the future ATM system is to consider the trajectory of an aircraft during all phases of flight and to manage the interaction of that trajectory with other trajectories or hazards. This would

achieve the optimum system outcome with the minimal deviation from the user-requested flight trajectory. TBO can thus be seen as the operationalisation of Doc 9854.

1.2 The 4-dimension trajectory concept is based on the integration of time into the spatial dimensions of an aircraft's trajectory from gate-to-gate. While this recognises that time gains/delays distort an aircraft trajectory as much as changes in vertical or horizontal positions, it is currently challenging for air traffic control (ATC) to exercise control of time due to a short look-ahead time relative to an entire flight. The aviation system block upgrade (ASBU) TBO thread in the fifth edition of the GANP attempts to resolve this by introducing time-based metering concepts and leverages on trajectory capabilities in the aircraft flight management system (FMS).

1.3 To achieve the vision in Doc 9854, TBO should go beyond a single trajectory or phase of flight, and involve more than replacing the imprecise ground-generated trajectories with accurate 4-D trajectories. All other flight and flow related information, including airspace and aerodrome operational information, meteorological information, and operational constraints, should be shared among all stakeholders to provide a consistent view to enable collaborative decision making (CDM).

1.4 This would address the limitations of tactical control in the current ATC operating paradigm. Especially for high density or constrained/congested airports, air navigation services providers (ANSPs) are turning to more pre-emptive or proactive measures to better manage high intensity arrival flows, such as with the concept of an extended arrival manager. Gradually, air traffic flow management (ATFM) operations will merge with tactical ATC operations; with TBO as the bridge between the two. However, knowledge of TBO's relevance and significance in the future ATM is not prevalent. It is timely to seek to understand TBO better in terms of on-going ATM initiatives as ANSPs embark on their respective modernisation programmes to enhance ATM systems worldwide.

2. DISCUSSION

2.1 CDM focuses on network operations and are a lead-up to TBO

2.1.1 Central to TBO is the recognition that airlines operate a network rather than individual aircraft. Previously, ATM evolved based on aggregating and predicting individual aircraft flows and defining airspace volumes and routes accordingly. Consequently, a commonly held notion now is that airspace is a scarce resource and should be better organised to accommodate growing traffic demands. Nonetheless by conducting CDM with reference to the gate-to-gate trajectory of a flight, a different paradigm to operations has evolved to enhance capacity and efficiency of air traffic operations. Using Singapore Changi Airport as an example, the implementation of airport collaborative decision making (A-CDM) has reduced an average of 90 seconds per flight during departure peak hours in spite of a 4per cent increase in traffic volume. The Distributed Multi-Nodal ATFM Network Project has also seen benefits in distributing delay equitably during operational trials for planned events, such as during the National Day of Singapore and large-scale annual joint military exercises in Thailand e.g. Cobra Gold, Cope Tiger, while maintaining operational predictability for stakeholders during such disruptions.

2.1.2 In Singapore and Thailand, it has become clear that there is synergy between A-CDM and ATFM that can be achieved to further optimise operations. Local and regional inter-connected networks of A-CDM and ATFM units will enable key stakeholders to exchange useful departure and arrival information to further improve predictability of events (as compared to standalone A-CDM or ATFM) to enhance the planning and overall situational awareness for all CDM partners and improve pre-tactical planning decisions such as stand and gate management for airport operators, re-timing of flights and slot swapping for airlines, and better allocation of resources for stakeholders including ground

handling agents. Likewise, with the awareness of ATFM measures, the A-CDM network will be able to facilitate slot adherence through optimal pushback times and provide early notice of delay in turnaround activities.

2.2 Developing FF-ICE and system-wide information management (SWIM) today as enablers of TBO

2.2.1 Flight and flow information for a collaborative environment (FF-ICE) will deliver necessary communication capabilities and enable TBO through facilitating trajectory negotiation and dynamic, real-time information sharing between concerned stakeholders. Today, States have begun utilising the Flight Information Exchange Model (FIXM) to exchange ATFM-related data attributes central to the distributed ATFM concept of operations. In particular, the technical sub-group of the Distributed Multi-Nodal ATFM Network Project is working on a regional FIXM Extension for Asia/Pacific to include ATFM-related data attributes suitable for regional operations. Initial system connection tests indicate satisfactory results in supporting ATFM operations.. In addition, the group will also work on drafting interface control document scripting "what" and "how" ATFM-related elements should be exchanged; the draft interface control document (ICD) will be submitted for consideration and adoption by the Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG). Key target for the Multi-Nodal Technical Subgroup is to enable ATFM information exchange via SWIM-based technologies by 2020, as well as supporting harmonising and ensuring interoperability requirements with other ATFM groups, such as the Northeast Asia Regional ATFM Harmonisation Group (NARAHG).

2.2.2 In addition to the work by the Multi-Nodal Technical Subgroup, Member States of the Association of South-East Asian Nations (ASEAN) along with other partners in the Asia/Pacific region have also jointly embarked on the SWIM in ASEAN demonstration project, with a view to demonstrate the promising capabilities of SWIM-based information exchange as well as to trial a possible model for SWIM implementation in the Asia/Pacific region. At the core of the demonstration are operational scenarios showcasing the enhancements achievable with a more efficient information exchange network. Concepts to be shown include, inter alia, enhanced trajectory sharing across borders, smoother A-CDM operations, efficient distribution and management of ATFM data, and added capacities made possible through advanced flexible use of airspace. The demonstration is set to take place in 2019 and represents a major step toward the implementation of SWIM in Asia/Pacific.

2.2.3 Regional developments in Asia/Pacific region also feed into global FF-ICE and SWIM development through collaboration between the ICAO ATM Requirements and Performance Panel (ATMRPP), which Singapore is member of, and the ICAO ATM Operations Panel (ATMOPSP), which Singapore and Thailand are members of. The cross-panel collaboration enables further development of FF-ICE and SWIM to support ATFM operations as key enablers for TBO.

2.3 Current gaps in post-departure ATFM, prior to TBO

2.3.1 The next evolution involves the management of flight trajectories in the post-departure phase. Singapore has begun a collaborative and exploratory work on aong-range ATFM (LR-ATFM) that would incorporate long-haul flights into the existing regional ATFM framework. This initiative aims to widen the current local ATFM horizon and coverage to improve air traffic regulation and management. The ability to regulate airborne flight trajectories adds to the equation to provide a more complete ATFM solution. It also contributes to improved distribution of delays and results in more efficient long-haul flights through early delay absorption during cruise.

2.3.2 A LR-ATFM trial involving a total of fifty three flights from Singapore Airlines, departing mostly from Christchurch and Auckland, was conducted from 21 December 2017 to 5 January 2018. The aim of the trial was to support subsequent research phases – starting with basic factors and moving on to more complex models as results are established – to identify parameters such as flight trajectory estimate accuracy, communication processes, aircraft response and compliance, as well as establish the potential for efficiency gains. The trial focused on determining the feasibility of issuing ATFM delay through the issuance of a Target Time Over[1] (TTO) during the en-route phase through the Airline Operation Centre (AOC). Preliminary results indicated that: i) ATFM delay should be made known at least 4 to 5 hours before the TTO reference point to allow for meaningful delay absorption en-route without causing the flight to operate too far from their ideal operating speed envelope; and ii) early simulations of the network benefits indicated an average fuel saving of $2000 USD per day for long-haul flights operating into Changi Airport.

2.3.3 Parallels can be drawn from the TBO concept and objectives to ATFM (both pre and post departure). Viewed as a form of primary version of TBO, albeit currently limited in information exchange and scope, the ATFM trials aid in the appreciation of the operational requirement and dependencies for implementation of TBO. Future maturation of ground-ground SWIM and development of air-ground SWIM will enhance information sharing and exchange in support of TBO.

2.4 Next Steps

2.4.1 ICAO has done commendable work in providing high-level direction and ATM concepts, which have coordinated implementation of communications, navigation, and surveillance (CNS) and ATM technologies. These developments can be understood as enablers for TBO, which can then profile TBO as a concrete reality and not simply a conceptual construct. More can be done to raise awareness of TBO and encourage the implementation of ASBU elements as progress towards TBO.

— END —

[1] The term Target Time Over (TTO), although not a standard acronym recognised by ICAO, was specifically chosen to differentiate the trial from actual operation and to disassociate the issued time of a TTO as a mandatory time to meet as there are associated technicalities of the flights performing speed changes in upstream FIR that need to be resolved.