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AGENDA ITEM 4: AIR NAVIGATION

TBO VALIDATION ACHIEVEMENTS OF CHINA

(Presented by the People's Republic of China)

INFORMATION PAPER

SUMMARY

This paper presents the achievements of TBO (Trajectory Based Operations) application research in China.

TBO VALIDATION ACHIEVEMENTS OF CHINA

1. INTRODUCTION

1.1 On 23 October 2023, 10 signatories including Air Navigation Service Providers (ANSPs) from China, Indonesia, Japan, New Zealand, the Philippines, Singapore, Thailand and the United States, as well as the Civil Air Navigation Services Organisation (CANSO) and the International Air Transport Association (IATA), signed the Asia-Pacific Trajectory Based Operations (TBO) Pathfinder Project Agreement. The initiative outlines a 4-year plan to collaboratively define, develop and demonstrate TBO concepts and applications across the Asia-Pacific region.

1.2 Following the successful completion of the first Initial 4D Trajectory (i4D) trial flight in the Asia-Pacific region in March 2019, China conducted a series of initial TBO validations in 2022 within the Shanghai TWA. The validation focused on 3 key aspects based on existing onboard avionics capabilities and datalink infrastructure: precise time control through integrated air-ground coordination, intent sharing and runway misalignment prevention, and datalink ATC services.

1.3 In November 2024, China launched LID validations at Shanghai Pudong and Hongqiao International airports. Leveraging air-ground datalink, the system enabled the datalink pre-distribution of arrival procedures, with an average of 1,230.25 messages transmitted per day. The system supports complex datalink commands delivery via ACARS ATS and real-time downlink of crew intent, forming a technical basis for TBO implementation.

1.4 On 30 December 2024, China successfully conducted a dual-aircraft TBO validation from Ürümqi to Beijing Daxing Airport. As the first dual-aircraft short-separation TBO validation in the Asia-Pacific region, this milestone marked a significant advancement following the initial 4D trajectory (i4D) trial flight conducted by China in 2019. This validation crossed multiple control sectors and involved automation systems from different vendors, validating an extended operational concept featuring coordination across air-ground, ground-ground, and air-air domains. It demonstrated a representative multi-stakeholder operational scenario involving ATC units, airlines and airports. The results confirmed the technical feasibility of TBO application using existing avionics capabilities on commercial flights, laying a solid foundation for large-scale implementation of TBO technologies in the future.

2. DISCUSSION

Avionic Systems

2.1 Regarding onboard TBO operational protocols, validations have been carried out based on the FMS Datalink, leveraging the avionics, air-ground communication, and ground ATC systems that China is expected to deploy at scale within the next five years. In the short term, efforts focus on maximizing the capabilities of the existing avionics to support preliminary operations of the TBO concept. In the medium to long term, in line with ICAO's planning framework, China aims to achieve a gradual transition toward full-standard TBO through progressive upgrades to avionic onboard systems, datalink networks and ground automation platforms.

Air-Ground Data-Link Communication Network

2.2 For the air-ground datalink network, all validations referenced above were conducted using China's existing VDL Mode 2 infrastructure, which is compatible with the ACARS air-ground datalink. Both VDL Mode 2 and ACARS networks currently provide coverage across major airports and air routes within China.

ATC Information System

2.3 In 2023, Based on the validation objectives, the simulation validation platform enabling the operation of Multi-Aircraft TBO has been built by the Technical Centre of ATMB, CAAC. The platform is composed of an airborne simulation system and an automatic trajectory control system supporting the operation of TBO (Figure 1). The airborne simulation system supports the generation of multiple TBO flights. The automatic trajectory control system can receive, process, and display multi-aircraft airborne predicted trajectory, and is of the functions of conflict detection, consistency monitoring, arrival management and intelligent flight Required Time of Arrival (RTA) allocation based on airborne predicted trajectory. The platform provides a validation environment for the multi-aircraft TBO simulation operation, and can support the studies on the system function, operation process, human-machine interface, and other contents under the multi-aircraft TBO operation.

2.4 In 2024, a dual-aircraft TBO simulation platform integrating flight simulators with ATC automation systems, trajectory visualization guidance on the crew side, and datalink airport systems was built in a lab setting. It simulated the full process of the Ürümqi–Beijing Daxing dual-aircraft TBO validation, validating the feasibility of the plan.

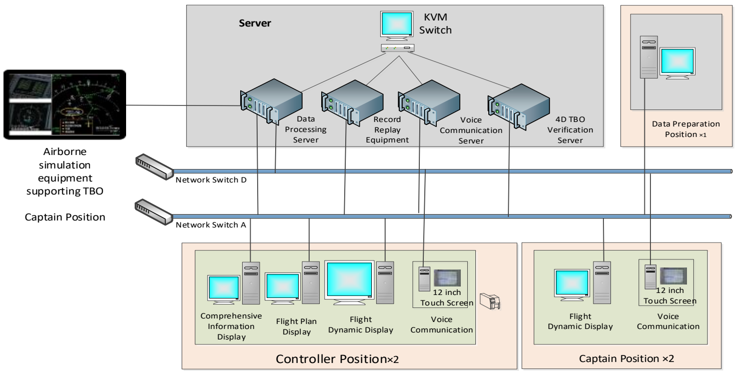

Figure 1: Structure diagram of TBO simulation and validation platform

2.5 On 30 December 2024, China successfully completed a dual-aircraft TBO validation flight from Urumqi to Beijing Daxing Airport. The leading aircraft was a Boeing 737 and the trailing aircraft an Airbus 320. Both aircraft operated as scheduled passenger flights and without avionics modification. The flights departed 20 minutes apart and successfully completed validation tasks under a collaborative operational environment, including flight and flow information for a collaborative environment（FF-ICE, integration of 4D trajectory management into ATC decision-making, precise waypoint time control, between-aircraft and air-ground situational awareness, visualization of ATC commands via electronic flight bag (EFB), and en-route hazardous weather alerts.

2.6 During the validation, 31 items were completed, 28 datalink ATC messages and commands were transmitted with a 100% success rate and an average latency of 2.0 seconds. Both aircraft successfully received RTA instructions for 3 designated waypoints with a control accuracy of ±8 seconds. A total of 586 subsequent waypoint reports were downlinked, with an average prediction deviation within ±10 seconds. All performance indicators met or exceeded expected targets.

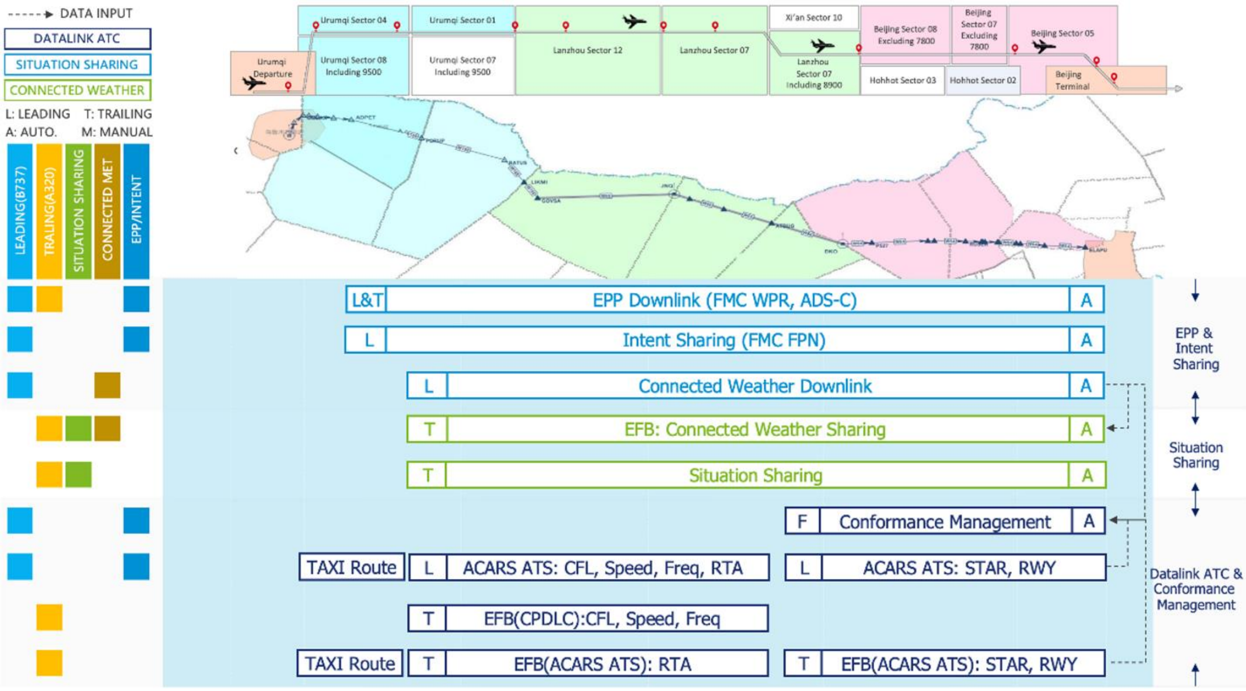

Figure 2:Dual-aircraft TBO validation Procedure

2.7 In terms of TBO application strategy, the operational phase focuses on the entire flight lifecycle, proposing TBO strategies for each ATC task. During the transition phase, a hybrid model combining TBO and non-TBO operations has been proposed, supported by technical policies and feasibility validations based on existing avionics and air-ground datalink networks.

3. ACTION BY THE CONFERENCE

3.1 The Conference is invited to note the information contained in this Paper.

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