59th CONFERENCE OF
DIRECTORS GENERAL OF CIVIL AVIATION
ASIA AND PACIFIC REGIONS

Cebu, Philippines
14 to 18 October 2024

AGENDA ITEM 4: AIR NAVIGATION

MULTI-AIRCRAFT TBO SIMULATION VALIDATION

(Presented by the People's Republic of China)

INFORMATION PAPER

SUMMARY

This paper presents the development of multi-aircraft TBO simulation validation in China, mainly including multi-aircraft TBO simulation validation objectives, platforms, scenarios and results, etc. The validation focuses on analysing how ground control system can make safer and more intelligent decisions based on airborne predicted trajectory.

MULTI-AIRCRAFT TBO SIMULATION VALIDATION

1. INTRODUCTION

China carried out its first initial four-dimensional trajectory flight test on March 20, 2019. To promote the research and application of global TBO, the Technical Centre of ATMB, CAAC, carried out relevant simulation validation around multi-aircraft TBO operation, focusing on analysing how ground air traffic control system can make safer, more efficient, more collaborative, and more intelligent decisions on the basis of airborne predicted trajectory.

1.1 Validation Objective

As the main link of TBO, airborne high-precision predicted trajectory plays an extremely important role in improving the intelligent decision-making capabilities of ground ATC systems. The multi-aircraft TBO operation simulation validation mainly studies and explores how the automatic ground automation system uses airborne predicted trajectory to improve the capabilities of conflict detection, consistency monitoring, and arrival management so as to assist air traffic controllers in making intelligent decisions and to improve the safety level and efficiency of ATC systems.

1.2 Validation Platform

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.

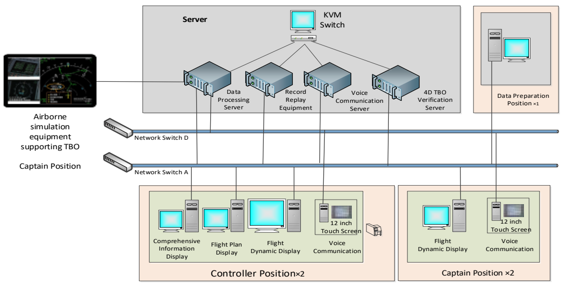

Figure 1: Structure diagram of TBO simulation and validation platform

1.3 Validation Scenario

A batch of 4D flight plans are formulated and uploaded to the airborne simulation system. The system calculates the airborne predicted trajectory prediction according to the aircraft attributes, flight plans and other information, and transmits the airborne predicted trajectory to the automatic ground trajectory control system according to the Automatic Dependent Surveillance-Contract (ADS-C).

1.3.1 Scenario 1: Mid-term conflict detection on the basis of airborne predicted trajectory

When the simulation scenario is in operation, the airborne simulation system will transmit the current location and predicted trajectory of the aircraft, and the automatic trajectory control system will turn on the option of mid-term conflict detection, carry out conflict detection according to the predicted trajectory, provide a reminder after identifying the conflict, and display the space and time range of the conflict.

1.3.2 Scenario 2: Flight consistency monitoring on the basis of airborne predicted trajectory

When the simulation scenario is in operation, the airborne simulation system will transmit the predicted trajectory of the aircraft, and the automatic trajectory control system will make a real-time comparison between the agreed trajectory and the predicted trajectory and provide a consistency monitoring alert when deviation exceeds the set tolerance.

1.3.3 Scenario 3: Arrival management on the basis of airborne predicted trajectory

When the simulation scenario is in operation, the airborne simulation system will transmit the current location and predicted trajectory of the aircraft. When a flight enters the arrival sequence, the ground control will request the Estimated Time of Arrival (ETA) window of the aircraft. Arrival management (AMAN)module will allocate the flight slot according to ETA window, slot allocation rules and other factors, generate the flight RTA intelligently, and transmit it to the aircraft through CPDLC. The aircraft will automatically adjust its speed according to the RTA and transmit the new airborne predicted trajectory.

2. DISCUSSION

2.1 Mid-term conflict detection on the basis of airborne predicted trajectory

In the operation of the scenario, the automatic trajectory control system implements the conflict detection function on the basis of airborne predicted trajectory while the traditional conflict detection function is based on ground prediction. In the figure below, EPCP represents the conflict detection module based on airborne predicted trajectory, and FPCP represents the conflict detection module based on traditional ground prediction. The alert window of EPCP and FPCP respectively demonstrate the time and space range of the conflict between flight AIB1234 and flight AIB1235 under two different conflict detection modes. For example, EPCP demonstrates that the conflict will start at 07:18 and end at 07:19. The conflict will be located at 39.43.41N117.03.41E (AIB1234) and 39.42.57N117.03.32E (AIB1235), and come to an end at 39.49.57N116.57.45E (AIB1234) and 39.49.04N116.57.26E (AIB1235). It is obvious that EPCP and FPCP predictions have certain differences in the time and space range of the conflict, and the experimental data show that the conflict information predicted by EPCP is more accurate.

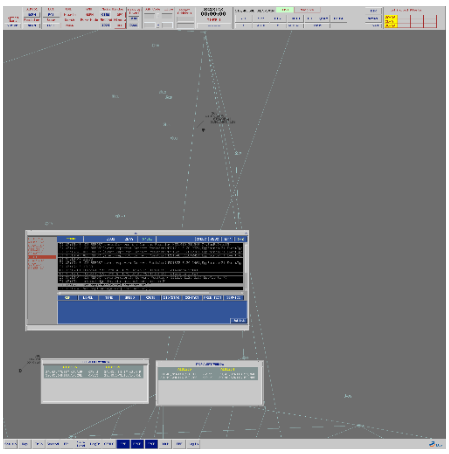

Figure 2: Schematic diagram of mid-term conflict detection

2.2 Flight consistency monitoring on the basis of airborne predicted trajectory

The ground automation system monitors the airborne predicted trajectory and agreed trajectory in real time. When the deviation of the estimated arrival time of any waypoint exceeds the tolerance (the tolerance set in the scenario is 20 minutes), an alert will arise. As shown in the figure below, when flight CCA2341 is expected to pass the waypoints ABTUB and DALIM and the deviation between the estimated arrival time and the agreed arrival time exceeds 20 minutes, the estimated arrival time on the waypoints on the interface will turn red, and a warning will be given to inform air traffic controllers of the deviation of this flight to make adjustments in time.

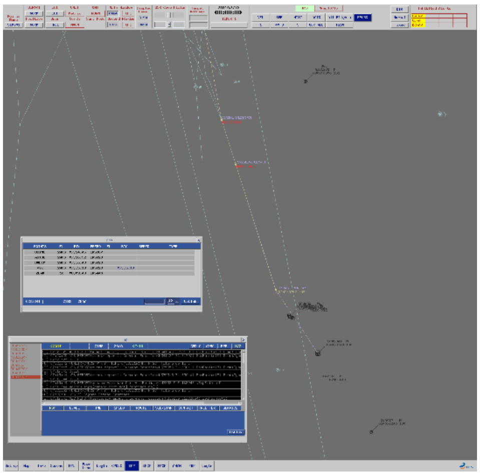

Figure 3: Schematic diagram of flight consistency monitoring

2.3 Arrival management on the basis of airborne predicted trajectory

In the operation of this scenario, an ETA window of any flight can be requested at a certain point. As can be seen in the figure below, the ETA window of flight CCA2341 passing VYK is 07:31:23-07:54:55. AMAN module allocates flight slots according to ETA window of all arriving flights, slot allocation rules and other factors, and then generates flight RTA intelligently. It can be seen in the figure that the RTA allocated for flight CCA2341 is 07:39:32. In the CPDLC communication, we can see the aircraft accepts the RTA, and a new airborne predicted trajectory is transmitted. And the expected time of passing VYK is adjusted to 07:39:31, strictly in accordance with RTA.

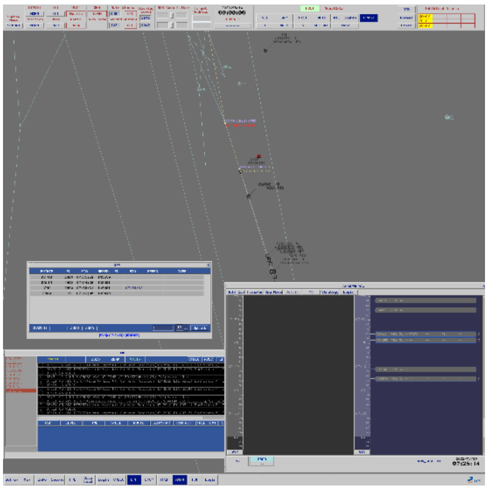

Figure 4: Schematic diagram of arrival management

2.4 In this paper, the multi-aircraft TBO simulation validation process has been elaborated in detail, and the operation scenarios such as conflict detection, consistency monitoring, arrival management and intelligent flight RTA allocation based on the airborne predicted trajectory are validated, exploring the system function, operation process and human-machine interface of the new generation ATC system in the future operation environment. The validation shows that the airborne predicted trajectory can effectively assist air traffic controllers in making intelligent decisions, and improve the safety level and efficiency of flight operation.

3. ACTION BY THE CONFERENCE

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

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