International Civil Aviation Organization

The Second Meeting of the Asia/Pacific Air Traffic Management Automation System Task Force (APAC ATMAS TF/2)

Video Tele-Conference, 14 - 16 September 2021

Agenda Item 4: ATM Automation System Implementation by States

4.3 System Design and Architecture
Including: Contingency and Fallback Design philosophy; Safety Nets (Ground-Based Safety Nets, DAPS etc.)

EXPLORATION ON THE APPLICATION OF MODE S DAPs IN SAFETY NET OF ATMAS

(Presented by China)

SUMMARY

This paper introduces the research and practice of using Mode S downlink aircraft parameters (DAPs) which enhances the safety net of ATMAS. In addition, the benefits and some issues that should be paid attention to in application are also presented.

1. INTRODUCTION

1.1 In the past few years, the Mode S surveillance technology has been fully implemented in the civil aviation industry of China. Using DAPs to improve civil aviation operation safety is one of the practical research objectives. This paper will share some practical experiences.

1.2 DAPs can be used to enhance the safety nets of ATMAS from two aspects;(1) Enhance safety nets based on trajectory prediction, such as STCA, MSAW, APW, and etc.;(2) Detect air-ground inconsistency, and reduce the instruction deviation events caused by human factors.

1.3 According to the practice, the appropriate use of DAPs can enhance the safety nets of ATMAS, improve the accuracy of the alarm, and help reduce the workload of controllers.

1.4 Existing problems of DAPs, such as BDS SWAP, should be considered to avoid nuisance and false alerts.

2. MODE S DAPs OVERVIEW

2.1 Mode S DAPs refer to the operational parameters of airborne equipment transmitted to ground via a Mode S datalink. At present, ATMAS in CAAC has been fully connected with Mode S radar and ADS-B, and obtains Mode S DAPs through these two types of equipment.

2.2 Of the Mode S radars in service in China, some older models only support elementary surveillance (ELS), while newer and future models will fully support enhanced surveillance (EHS). The ADS-B transponder's version number of aircraft flying in Chinese airspace are mainly version 0 and version 2. So the high available DAPs data items are as follows:

Equipment and Operation Mode	High available Data Items	Note
ELS Radar	24bit-address,Aircraft Identification, Emergency/Priority Status, ACAS active resolution advisory	
EHS Radar	Selected Altitude，Barometric Pressure Setting，Roll Angle，True Track Angle，Ground Speed，Track Angle Rate，True Air Speed，Magnetic Heading，Indicated Air Speed，Mach Number，Barometric Altitude Rate	Limited by the capacity of the airborne equipment, the highly available data items are the data in the BDS40, 50 and 60 registers of the airborne transponder.
ADS-B V0	24bit-address,Aircraft Identification, Emergency/Priority Status, ACAS active resolution advisory，GNSS position，GNSS positional accuracy，Ground Speed、True Track Angle，Vertical Rate	
ADS-B V2	Selected Altitude，Barometric Pressure Setting, Selected Heading	

3. ENHANCED SAFETY NETs BASED ON TRAJECTORY PREDICTION

3.1 The safety nets of ATMAS, such as STCA, MSAW and APW, are based on the trajectory prediction. The prediction model used by most of the existing ATMAS is a linear model, which is not suitable for hazard detection in maneuvering flight. As the forward probing time increases, the aircraft is more likely to maneuver which will cause the decrease of prediction accuracy. Therefore, the prewarning time based on the linear prediction model is usually short. DAPs can be used to improve the prediction accuracy for maneuvering flight, and thus enhance the warning performance.

3.2 DAPs can be used to optimize the performance of trajectory prediction in two aspects: (1) real-time detection or prediction of aircraft maneuvering flight, so as to select a more reasonable model for position prediction. (2) The measured velocity vector in DAPs is used to replace the calculated velocity vector based on position to improve the accuracy of position prediction.

3.3 We developed a model to identify maneuvering flight and predict maneuvering flight position based on DAPs data. The key mechanism of this model is as follows:

a) Predict whether the aircraft will carry out maneuvering flight by using the pilot input data such as selected heading and selected altitude，

b) Detect aircraft’s undergoing maneuvering flight by using track angle rate, roll angle, airspeed and etc.，

c) Use DAPs instead of parameters calculated by tracking model to obtain better position prediction performance. For example, using the track angle rate instead of the rate calculated can better predict the position of the aircraft starting to turn.

Note: INDRA has also conducted relevant studies and obtained similar results. See *ICAO DAPs WG/1 SP04- DAPs CONCEPTS, USAGE AND BENEFITS.*

3.4 Based on this model, we developed the flight conflict alert function based on DAPs and use it in Guangzhou area control center. According to the application in the past two years, compared with the existing STCA function, the flight conflict alert function based on DAPs can significantly advance the prewarning time on the premise of maintaining similar alert accuracy.

4. AIR-GROUND MISMATCH ALERT

4.1 Air-ground mismatch alert enables controllers to discover the inconsistency between DAPs and corresponding parameters in the ATMAS. The following alert functions have been implemented.

PSA-CFL Mismatch Alert

4.2 When the Pilot Selected Altitude (PSA) does not correspond with the Cleared Flight Level (CFL), an alert is triggered at the controller station.

BPS-QNH/QFE Mismatch Alert

4.3 When the barometric pressure setting (BPS) from airborne equipment does not correspond with QNH/QFE of the current airspace, an alert is triggered at the controller station.

4.4 The procedure for setting BPS recommended by ICAO is as follows：

a) States may specify a transition altitude. In flight, when an aircraft is at or below the transition altitude, its vertical position is expressed in terms of altitude, which is determined from an altimeter set to sea level pressure (QNH).

b) In flight above the transition altitude, the vertical position of an aircraft is expressed in terms of flight levels, which are surfaces of constant atmospheric pressure based on an altimeter setting of 1 013.2hPa.

c) The change in reference from altitude to flight levels, and vice versa, is made:
1) at the transition altitude, when climbing; and
2) at the transition level, when descending.

Note: Reference: ICAO Doc 8168 Sixth Edition Volume III Section 2 Chapter 1.

4.5 The solution for BPS-QNH/QFE Mismatch alert is as follows：

a) When PSA>=Transition Level, BPS should be set to 1013.2hPa;
b) When PSA<=Transition Altitude, BPS should be set to QNH/QFE.

4.6 The air-ground mismatch alert can effectively reduce the potential risk caused by human error and reduce the monitoring burden of the controllers. For example, errors in the following situations can be detected and corrected by using the alerts:

a) Controller enter the right CFL, but send the wrong instruction via voice;
b) Pilot do the right “read-back”, but take the wrong action;
c) Read-back and take action by the wrong pilot;
d) Pilot forget to set the BPS when descend below transition level.

4.7 The air-ground mismatch alerts had been used in Guangzhou area control center since 2018, and the number of "level burst" incidents decreased significantly.

5. PROBLEMS TO BE NOTED WHILE USING DAPs

5.1 DAPs data error due to BDS SWAP. BDS SWAP is a phenomenon radar may acquire wrong DAPs when multiple radars inquire about different BDS registers of the same aircraft. The cause and effect of this problem, see the following files:

a) ICAO DAPs WG/1 IP10-SSR MODE S DAPS VALIDATION AND EVALUATION CONDUCTED BY ENRI.

b)ICAO DAPs WG/4 IP03-ANALYSIS OF INCORRECT RA CODE ON MODE S RADAR.

c)ICAO DAPs WG/4 IP04-ANALYSIS OF FALSE SFL MISMATCH ALARM IN ATM AUTOMATION SYSTEM.

BDS SWAP will cause wrong DAPs acquisition of a single aircraft from one radar for a short period which usually last no more than one antenna cycle. This problem can affect most of the DAPs data items. ATMAS should filter such wrong data to avoid false alerts.

5.2 Abnormal data due to imperfect airborne equipment, such as BPS data downlinked by some aircraft above the transition level is not consistent with the actual BPS used.

See：*EASA Safety Information Bulletin SIB-6-05R2.*

5.3 For other known DAPs problems that may affect the safety nets of ATMAS.
See: *Mode S DAPs Implementation and Operation Guidance Document* (Appendix 2).

5.4 DAPs from ADS-B transponders on different versions vary greatly. When using the DAPs from ADS-B, attention should be paid to the proportion of aircraft in the airspace. For example, only the version 2 ADS-B transponder which is currently equipped with about 50% of the aircraft in China's airspace, can downlink the selected heading parameter. The safety nets using the selected heading can only be applied to these aircraft.

6. ACTION BY THE MEETING

6.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matter as appropriate

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