



ICAO

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Agenda Item 7: Report on surveillance ground system and avionics performance monitoring and improvement in compliance

STUDY ON OPTIMIZATION AND IMPROVEMENT OF ADS-B APPLICATION IN CHINA

(Presented by China)

SUMMARY

This paper introduces some outcomes of the ADS-B application study carried out by ATMB CAAC between 2020 and 2021. This study is dedicated to standardize the construction and operation of ADS-B ground equipment in China, making them more in line with the needs of ADS-B operation in China.

1. INTRODUCTION

1.1 The National ADS-B Project has been constructed in the middle of 2019 and covers the whole Chinese Airspace. By the end of 2021, there are 332 ground stations, 2 level-1 national data processing centers, 8 level-2 regional data processing centers and 36 local data processing stations. The ADS-B ATC Operation included 2 phases according to the airspace surveillance coverage capabilities, the Phase I started from October 2019; and the Phase II tasks are ongoing now, the progress is a little bit later than the plan. For related information, please refer to Section 3 IP20 of the SURICG/6 Conference. The document hyperlinks is as follows:

https://www.icao.int/APAC/Meetings/2021%20SURICG%206/IP20_CHN%20AI.8a%20CHN%20The%20Update%20of%20ATC%20Surveillance%20in%20China-r2.pdf

1.2 The National ADS-B Project is the first ADS-B ATC Operation practice in nationwide. In the ADS-B ATC Operation practice from October 2019 to date, some troubles appeared and influenced the quality of ATC surveillance. Therefore, ATMB CAAC has carried out a study on the optimization and improvement of ADS-B applications. Through the one-year study, the main troubles can be attributed to three aspects, data outputting of ground stations, data pre-processing of the data centers, and application of ATM automation systems, and corresponding study outcomes have been obtained. Subsequently, ATMB CAAC carried out the verification of the study results in 2 ATM branches, and proved reasonable of the results.

2. DISCUSSION

Troubles and study results of ground stations

2.1 During the practical ADS-B ATC Operation, the following troubles were found:

- Although the ADS-B ground systems made by 4 domestic manufacturers generated and delivered the ADS-B target reports with ‘TECHNICAL SPECIFICATION FOR A 1090 MHz EXTENDED SQUITTER ADS-B GROUND SYSTEM’ (ED-129B) as the standard, due to their different understandings of the standard, a few ADS-B data items have been packaged differently within the method of assignment, the logic of assignment, etc.;
- The selection of ground station antennas (omnidirectional or directional) on some sites was not strictly demonstrated and matched with the operating environment/scenario, it lead to the trouble that a few ADS-B ground stations in the busy area lost surveillance target.

2.2 By this study, the following solutions have been developed:

- On the premise of meeting ICAO SARPs and related international technical standards, the unified rule was made to regulate the ADS-B Item output content of ADS-B ground stations provided by 4 manufacturers, to meet the needs of ADS-B operation in China; (See Appendix A for details)
- Considering the operating environment/scenario, make recommendations on the selection of ADS-B ground station antennas, as follow: when the quantity of targets in terminal airspace exceeds 50, and when the quantity of targets in en-route airspace exceeds 60, it is recommended to use the directional antenna system; other situations should use an omnidirectional antenna.

2.3 In addition, the study also covers the analysis of 1090 MHz occupancy at 2 busy airports in China. For related information, please refer to IP06 of DAPs WG/4 Conference. The document hyperlinks are as follows:

https://www.icao.int/APAC/Meetings/2021%20DAPs%20WG4/IP06_CHN%20AI.5%20-Intro%20to%20the%20Experiment%20of%201090%20MHz%20Occupancy%20at%20%20Airport%20in%20China.pdf

Troubles and study results of data processing centers

2.4 During the practical ADS-B ATC Operation, the following troubles were found:

- The pre-processing of abnormal ADS-B data (including MOPS missing, 24-bit address duplication, flight track hopping, Z-swing, low quality indicator) is not perfect in the ADS-B data processing centers.
- The data processing center didn’t refine the practical operational scenarios of downstream data users.

2.5 By this study, the following solutions have been developed:

- Pre-processing of ADS-B data that doesn’t meet operational requirements (including MOPS missing, 24-bit address duplication, flight track hopping, Z-swing, low quality indicator, etc.) shall be implemented in the data processing center, and drew up the discrimination criteria and thresholds;

- According to the requirements and operational scenarios of downstream data users, and also according to ICAO SARPs and related international technical standards, the output of the data processing center will be adjusted, and the data that doesn't meet the requirements will be pre-processed, as shown in table 1 and 2 below.

Table 1. Pre-processing rules for DO-260A/B Quality Indicators

Quality Indicators	Non-Radar airspace		Radar and ADS-B mixed airspace	
	En-route (5NM)	Terminal (3NM)	En-route (5NM)	Terminal (3NM)
NACp	NACp≥5	NACp≥6	NACp≥7	NACp≥8
NIC	NIC≥4	NIC≥5	NIC≥5	NIC≥6
SIL	SIL≥2	SIL≥2	SIL=3	SIL=3
NACv			NACv=1 or 2	NACv=1 or 2
SDA			SDA=2 or 3 (only DO-260B)	SDA=2 or 3 (only DO-260B)

Table 2. Pre-processing rules for DO-260 Quality Indicators

Quality Indicators	Non-Radar airspace		Radar and ADS-B mixed airspace	
	En-route (5NM)	Terminal (3NM)	En-route (5NM)	Terminal (3NM)
NUCp	NUCp≥4	NUCp≥5	NUCp≥5	NUCp≥6

Troubles and study results of ATM automation systems

2.6 During the practical ADS-B ATC Operation, the following troubles were found:

- The data fusion of ADS-B and Radar in ATM Automation System is not perfect, and leads to troubles of target splitting and unsmooth track;

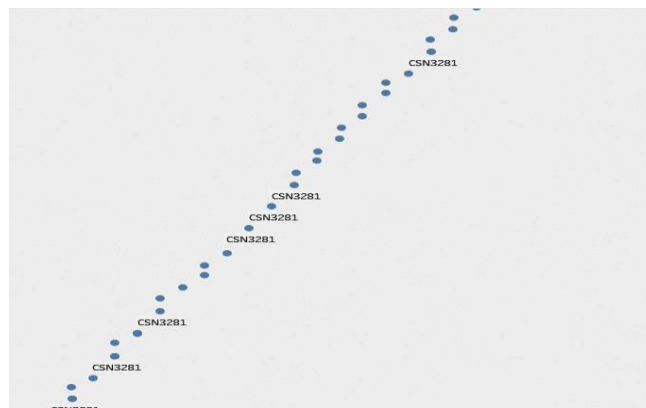


Figure 1. Schematic diagram of an unsmooth track

- The application scenarios of ADS-B data needed to be improved, and the ADS-B ATC Operation has not been fully benefited.

2.7 By this study, the following solutions have been developed:

- It is recommended that the ATM automation systems complete the pre-processing of ADS-B data first, and then perform the fusion of ADS-B and radar data. In the pre-processing stage, key information in the ADS-B target reports such as 24-Bits Address, Target Identification, Position, Speed, Heading, and Mode 3/A Code shall be tracked, and abnormal conditions such as target missing and track hopping shall be checked. An abnormal ADS-B report will not participate in the fusion calculation or be discarded according to the threshold.
- Putting forward recommendations on the application of 15 data items such as Selected Altitude, Quality Indicators, Airborne Ground Vector, and ACAS Resolution Advisory Report, etc., considering the potential requirements of the application and functions of the 15 data items, and drawing up the technical guidance materials to standardize the upgrades of ATM automation systems.

Actual Validation of Study Results

2.8 ATMB CAAC built a test platform at two ATM branches in Nanjing and Chongqing, ran the new version of the software on the test platform, and used actual flight data to compare and analyze before and after adjustment. The adjustment contents included the data output rules of ADS-B ground stations, the enhanced pre-processing of abnormal ADS-B data by the data processing centers, and upgraded fusion algorithm and couple functions by ATM automation systems. The experimental results show that the study conclusions are reasonable. The troubles mentioned above can be well solved by those adjustments, and the fusion effect of ADS-B and radar data can be improved.

3. ACTION BY THE MEETING

3.1 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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The following data items are mandatory, ADS-B ground stations are required to be capable to decode the items and the items must be encoded in every ASTERIX Category 021 record.

Data Items	Description
I021/010	Data Source Identification
I021/040	Target Report Descriptor
I021/080	Target Address
I021/090	Quality Indicators
I021/161	Track Number
I021/077	Time of Report Transmission

The following data items shall not be output by ADS-B ground stations.

Data Items	Description
I021/015	Service Identification
I021/071	Time of Applicability for Position
I021/072	Time of Applicability for Velocity
I021/110	Trajectory Intent
I021/148	Final State Selected Altitude
I021/165	Track Angle Rate
I021/220	Met Information
I021/230	Roll Angle
I021/250	Mode S MB Data
I021/400	Receiver ID

The following data item shall be output by the ADS-B ground stations, when meeting certain conditions.

Data Items	Description	Output Conditions
I021/073	Time of Message Reception of Position	Shall be included in the report when Position is reported.
I021/074	Time of Message Reception of Position-High Precision	Shall be included in the report when UTC coupled and Position is reported.
I021/075	Time of Message Reception of Velocity	Shall be included in the report when Velocity is reported.
I021/076	Time of Message Reception of Velocity-High Precision	Shall be included in the report when UTC coupled and Velocity is reported.
I021/130	Position in WGS-84 co-ordinates	Shall be included in the report when Airborne Position Messages updated.
I021/131	Position in WGS-84 co-ordinates, high res.	Shall be included in the report when Surface Position Messages updated.
I021/150	Air Speed	Shall be included in reports only when the subtype of the last unexpired Airborne Velocity Message is 3 or 4, the "Airspeed Type" is 0 and the value in the "Airspeed" subfield does not equal 0 or 1023 decimal. The I021/150 "IM" subfield shall be 0 ("IAS").

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I021/151	True Air Speed	Shall be included in the report when an Airborne Velocity Message has been received and the True Air Speed data from the last airborne velocity message has not expired.
I021/152	Magnetic Heading	Shall be included only when the subtype of the last unexpired Airborne Velocity Message is 3 or 4 and the “Magnetic Heading” and “Heading” and “Horizontal Reference Direction” equals 1.
I021/140	Geometric Height	1. If the FTC of the last airborne position message is 20-22 and the “Altitude” data is valid 2. If the FTC of the last airborne position message is 9-18 and the data in the “Altitude,” “Difference From Baro Altitude Sign,” and “Difference from Baro Altitude” fields are all valid.
I021/145	Flight Level	When received Airborne Position Messages with barometric altitude, and Flight Level field is available.
I021/210	MOPS Version	If receive no available information about Version Number in 60 seconds, ground station shall assign it to zero. When the version number is received, two cycles of confirmation are required. This item will not be output until the version is confirmed.
I021/070	Mode 3/A Code	1. Mode 3/A Code can be obtained from DF5, DF17, DF18 and DF21. 2. Received Mode 3/A Code and the change of Mode 3/A Code requires more than two cycles of confirmations, and the item can be output after the sameness.
I021/200	Target Status	When the ground station receives the Position Message, Velocity Message, Target State and Status Message or Extended Squitter Aircraft Status Message, and the messages are unexpired, it will output the content of the corresponding data item.
I021/155	Barometric Vertical Rate	An Airborne Velocity Message has been received and the information for Vertical Rate has not expired, and the Source Bit for Vertical Rate in the Airborne Velocity Message equals 1, and the Vertical Rate in the Airborne Velocity Message does not equal 0.
I021/157	Geometric Vertical Rate	An Airborne Velocity Message has been received and the information for Vertical Rate has not expired, and the Vertical Rate Source Bit in the Airborne Velocity Message equals 0, and the Vertical Rate in the Airborne Velocity Message does not equal 0.
I021/160	Airborne Ground Vector	An Airborne Velocity Message with a subtype of 1 or 2 has been received since the last ASTERIX Category 021 report for the target, and the data in that Airborne Velocity Message has not expired, and neither the N/S Velocity nor the E/W Velocity subfields contain all zeros.
I021/170	Target Identification	When the Aircraft Identity and Type Message data has been received and has not expired.

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I021/020	Emitter Category	After receiving the Aircraft Identity Message, shall be assigned as TABLE-11 of ED-129B, and maintaining.
I021/146	Selected Altitude	when the “Target State and Status” message has been received, and has not expired, and SAS is available.
I021/016	Service Management	1. In data driven mode the report period item shall be set to zero. 2. In periodic mode the report period shall be encoded in accordance with the ASTERIX specification.
I021/008	Aircraft Operational Status	1. target in the air; 2. after receiving the Position Message, Target State and Status Message, or Aircraft Operational Status Message, and has not expired, it will output the content of the corresponding data item.
I021/132	Message Amplitude	If it is implemented, it should contain the amplitude of the ES message that triggered the current report, and the amplitude shall be the reference level determined by the preamble detector, encoded in dBm.
I021/271	Surface Capabilities and Characteristics	1. target in the surface; 2. After receiving the Aircraft Operational Status Message, and has not expired, it will output the content of the corresponding data item.
I021/260	ACAS Resolution Advisory Report	When the ground station receives the Extended Squitter Aircraft Status Message (1090ES TCAS RA Broadcast Message), and the messages are unexpired.
I021/295	Data Ages	Refer to Section 3.4.4.6.34 of ED-129B.