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

AIRCRAFT PARAMETERS AVAILABILITY IN MODE S DAPS AND ADS-B ADD

(Presented by China)

SUMMARY

This paper presents aircraft downlink parameters in Mode S DAPs and ADS-B Aircraft Derived Data (ADD). And a study has been conducted in China to confirm which parameters are available at present.

1. INTRODUCTION

1.1 In the past few years, China has put 78 Mode S radars and more than 300 ADS-B ground stations into operation. A study about ADS-B ADD and Mode S DAPs has been conducted to confirm which parameters are available.

1.2 China has about 50 Mode S radars with EHS capability configured to extract BDS4,0, BDS5,0 and BDS6,0.

1.3 ADD is a surveillance application in which avionics data is transmitted from the aircraft to the ground and possibly other aircraft. ADS-B ADD in this paper means the BDS data broadcasted by the ADS-B transponder. Data that needs to be interrogated is not considered.

1.4 Some parameters in ADS-B ADD, such as selected altitude, barometric pressure setting, MCP/FCU mode and selected heading, are not defined in ADS-B version 0. These parameters' capable percentages will increase a lot when transponders are all upgraded to the latest version.

2. CORRESPONDING BDS REGISTERS

2.1 The BDS registers corresponding to the aircraft downlink parameters are shown in table-1:

Table-1 Parameters Registers

Parameter	Mode S DAPs	ADS-B ADD
Barometric Altitude	Mode C	0,5
Longitude and Latitude		0,5/0,6
Ground Speed	5,0	0,6/0,9
True Track Angle	5,0	0,6

Parameter		**Mode S DAPs**	**ADS-B ADD**
			0,9 (see 2.1.1)
Aircraft Identification (Flight Ident.)		2,0	0,8
Vertical Rate	Barometric Altitude Rate	6,0	0,9
	Inertial Vertical Velocity	6,0	
	GNSS Vertical Rate		0,9
GNSS Height (HAE) (see 2.1.2)			0,5+0,9
			0,5
True Airspeed		5,0	0,9 (see 2.1.3)
Indicated Airspeed		6,0	
Selected Altitude	MCP/FCU Selected Altitude	4,0	6,2 (see 2.1.4)
	FMS selected altitude		
Target Altitude		4,0 (see 2.1.5)	6,2 (see 2.1.6)
MCP/FCU mode (see 2.3)		4,0	6,2
Barometric Pressure Setting (BPS)		4,0	6,2
Roll Angle		5,0	
Track Angle Rate		5,0	
Magnetic Heading		6,0	0,9 (see 2.1.3)
Mach No.		6,0	
Selected Heading/Target Heading			6,2 (see 2.1.7)

2.1.1 True track angle could be calculated by the ground speed in BDS 0,9.

2.1.2 HAE could be downlinked in BDS 0,5, or be calculated by barometric altitude in BDS 0,5 and GNSS altitude difference from barometric altitude in BDS 0,9.

2.1.3 Airspeed and magnetic heading in ADS-B ADD are transmitted only if ground speed is unavailable.

2.1.4 Selected altitude is available after ADS-B version 2.

2.1.5 Target altitude in Mode S DAPs could be calculated by target altitude source bits and selected altitude in BDS4,0.

2.1.6 Target altitude in ADS-B ADD is available after ADS-B version 1.

2.1.7 Selected heading/target heading is available after ADS-B version 1.

2.2 The parameters received from Mode S radar are updated at a different rate than the ADS-B ground station.

2.2.1 Mode S DAPs' update rate is determined by the radar's extraction strategy, which may up to once per radar scan.

2.2.2 ADS-B ADD's update rate is shown in Table-2

Table-2 ADS-B Message Update Interval

BDS	Assignment	Maximum Update Interval
0,5	Extended Squitter Airborne Position	0.2s
0,6	Extended Squitter Surface Position	0.2s
0,8	Extended Squitter Identification and Category	15s
0,9	Extended Squitter Airborne Velocity	1.3s
6,2	Target State and Status Information	0.5s
6,5	Aircraft Operational Status	1.7s (Version 0) 2.5s (Version 1 and 2)

2.3 There is more information about MCP/FCU mode in ADS-B ADD. It would be helpful to use the intent data. MCP/FCU mode in ADS-B ADD is available after ADS-B version 2.

Table-3 MCP/FCU Mode in Mode S DAPs and ADS-B ADD

Mode	MCP/FCU Mode in Mode S DAPs	MCP/FCU Mode in ADS-B ADD
Autopilot	×	✓
VNAV Mode	✓	✓
Altitude Hold Mode	✓	✓
Approach Mode	✓	✓
TCAS/ACAS Operational	×	✓
LNAV Mode	×	✓

3. AVAILABLE PARAMETERS

3.1 In the study, we did data collection and analysis work twice. 1763 aircraft's data were collected and analyzed in 2018, and 2289 aircraft's data were collected in 2023. Mode S DAPs were collected from ASTERIX CAT 048 from a Mode S radar. ADS-B ADD were collected from DF messages from an ADS-B ground station. Aircrafts detected by both radar and ADS-B were considered. And a statistical analysis was made to identify which parameters are available.

3.2 Barometric altitude and Flight Ident. from Mode S radar, longitude, latitude and Flight Ident. from ADS-B were highly available based on practical. So, they were not counted.

3.3 BDS 0,6 is transmitted only when the aircraft is on the ground. So, it's not available in most situations. It was not considered in this statistical analysis.

3.4 Capable percentage in Mode S DAPs is shown in Table-4.

Table-4 Capable Percentage in Mode S DAPs

Parameter	2023			2018		
	Capable Aircrafts	Total Aircrafts	Capable Percentage	Capable Aircrafts	Total Aircrafts	Capable Percentage
Barometric Altitude	Not Counted					
Longitude and Latitude	No Information					
Ground Speed	2287	2289	99.91%	1760	1763	99.83%
True Track Angle	2287	2289	99.91%	1760	1763	99.83%
Aircraft Identification (Flight Ident.)	Not Counted					
Vertical Rate	2287	2289	99.91%	1758	1763	99.72%
GNSS Height (HAE)	No Information					

Parameter	2023			2018		
	Capable Aircrafts	**Total Aircrafts**	**Capable Percentage**	**Capable Aircrafts**	**Total Aircrafts**	**Capable Percentage**
True Airspeed	2287	2289	99.91%	1760	1763	99.83%
Indicated Airspeed	2287	2289	99.91%	1758	1763	99.72%
Selected Altitude	2285	2289	99.83%	1757	1763	99.66%
Target Altitude (see 2.1.5)	195	2289	8.52%	31	1763	1.76%
MCP/FCU mode	335	2289	14.64%	68	1763	3.86%
Barometric Pressure Setting	2287	2289	99.91%	1757	1763	99.66%
Roll Angle	2285	2289	99.83%	1760	1763	99.83%
Track Angle Rate	2143	2289	93.62%	1760	1763	99.83%
Magnetic Heading	2285	2289	99.83%	1758	1763	99.72%
Mach No.	2285	2289	99.83%	1758	1763	99.72%
Selected Heading/Target Heading	No Information					

3.5 Capable percentage in ADS-B ADD is shown in Table-5. The Capable Percentage calculated by 1763 aircrafts' ADS-B ADD were collected in 2018, and 2289 aircrafts' ADS-B ADD were collected in 2023.

Table-5 Capable Percentage in ADS-B ADD

Parameter	2023			2018		
	Capable Aircrafts	**Total Aircrafts**	**Capable Percentage**	**Capable Aircrafts**	**Total Aircrafts**	**Capable Percentage**
Barometric Altitude	2279	2289	99.56%	1644	1763	93.25%
Longitude and Latitude	Not Counted					
Ground Speed	2280	2289	99.61%	1651	1763	93.65%
True Track Angle	2280	2289	99.61%	1651	1763	93.65%
Aircraft Identification (Flight Ident.)	Not Counted					
Vertical Rate	2282	2289	99.69%	1656	1763	93.93%
GNSS Height (HAE) (see 2.1.2)	2272	2289	99.26%	1637	1763	92.85%
True Airspeed	4	2289	0.17%	5	1763	0.28%
Indicated Airspeed	10	2289	0.44%	3	1763	0.17%
Selected Altitude	1980	2289	86.50%	313	1763	17.75%
Target Altitude (see 3.5.1)	15	2289	0.66%	55	1763	3.12%
MCP/FCU mode	167	2289	7.30%	70	1763	3.97%
Barometric Pressure Setting (BPS)	1969	2289	86.02%	313	1763	17.75%
Roll Angle	No Information					
Track Angle Rate						
Magnetic Heading	13	2289	0.57%	7	1763	0.40%
Mach No.	No Information					
Selected Heading/Target Heading	1762	2289	76.98%	283	1763	16.05%

3.5.1 Target altitudes were defined in ADS-B version 1. Only aircraft with version 1 transponder transmitted this parameter in this statistic.

4. CONCLUSION

4.1 As the ADS-B V2 installation proportion grows, the available percentage of some ADS-B ADD grows substantially. However, the available percentage of Mode S DAPs remains unchanged.

4.2 Capable percentage of parameters in Mode S DAPs and ADS-B ADD in Chinese airspace up to 2023 are shown in Table-6:

Table-6 Mode S DAPs and ADS-B ADD Availability

Parameter	**Capable Percentage in Mode S DAPs**	**Capable Percentage in ADS-B ADD**
Barometric Altitude	Not Counted	99.56%
Longitude and Latitude	No information	Not Counted
Ground Speed	99.91%	99.61%
True Track Angle	99.91%	99.61%
Aircraft Identification (Flight Ident.)	Not Counted	
Vertical Rate	99.91%	99.69%
GNSS Height(HAE)	No information	99.26%
True Airspeed	99.91%	0.17%
Indicated Airspeed	99.91%	0.44%
Selected Altitude	99.83%	86.50%↑
Target Altitude	8.52%	0.66%
MCP/FCU mode	14.64%	7.30%
Barometric Pressure Setting	99.91%	86.02%↑
Roll Angle	99.83%	No information
Track Angle Rate	93.62%	No information
Magnetic Heading	99.83%	0.57%
Mach No.	99.83%	No information
Selected Heading/Target Heading	No information	76.98%↑

5. ACTION BY THE MEETING

5.1 The Meeting is invited to

a) Note the above information; and

b) Discuss any relevant matters as appropriate; and

c) Further research is needed.

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