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INFORMATION PAPER

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Agenda Item 6: Research, development and other initiatives

DERIVING AND USING WIND AND TEMPERATURE DATA FROM MODE S DAP AND ADS-B DATA IN HONG KONG, CHINA

(Presented by Hong Kong, China)

SUMMARY

This paper introduces the work of the Hong Kong Observatory (HKO) on deriving wind and temperature data from Mode S Downlink Aircraft Parameter (DAP) and ADS-B data in real-time and its potential applications in supporting air navigation.

1. INTRODUCTION

1.1 Mode S (Select) is an extension of conventional SSR which permits selective addressing of individual aircraft equipped with Mode S transponders. Additional data known as Downlink Aircraft Parameters (DAPs) may also be extracted from the aircraft. The ICAO APAC Mode S DAPs Working Group has developed the *Mode S Downlink Aircraft Parameters Implementation and Operations Guidance Document*[1] to provide guidance materials to States and airspace users on the use of Mode S DAPs in the Asia and Pacific Region from both operational and technical perspectives.

1.2 The Working Group further came out with a roadmap on Mode S related topics[2]. Those relevant to meteorological observations include:

a) Mode S mandate: States are encouraged to mandate Enhanced Mode S forward fit.
b) Weather reporting capability: As there are no service bulletins available to upgrade aircraft with the weather reporting capability, there is no roadmap to mandate weather reporting capability.

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[1] See document at https://www.icao.int/APAC/Documents/edocs/cns/Mode%20S%20DAPs%20Implementation%20and%20Operations%20Guidance%20Document%20Edition%204.0.pdf

[2] See DAPs WG/6 – WP/06 at https://www.icao.int/APAC/Meetings/2023%20Mode%20S%20and%20DAPs%20WG6/WP06_SGP_CHN%20AI.10%20-%20Achievement%20of%20Mode%20S%20DAPS%20WG.pdf

1.3 This paper focuses on the derivation of wind and temperature data from Mode S Enhanced Surveillance (EHS) and ADS-B data and their possible applications.

2. DISCUSSION

2.1 Mode S messages in ASTRIX CAT048[3] format from the Secondary Surveillance Radar (SSR) in Shenzhen are passed in real-time via the Hong Kong Civil Aviation Department (CAD) to HKO. Mode S interrogation of each aircraft is carried out once every 4 seconds, and data relevant to the derivation of wind and temperature data is contained in the BDS[4] registers. Among the registers, BDS 5,0 and 6,0 contain the necessary data for the calculation of wind and temperature:

BDS 5,0: Roll angle, track angle, ground speed, rate of track angle and true airspeed
BDS 6,0: Magnetic heading, indicated airspeed, Mach number, barometric altitude rate, inertial vertical velocity

2.2 Not every interrogation involves both BDS 5,0 and 6,0 registers at the same time; it happened on average once every 24 seconds (i.e. 6 interrogations). Furthermore, the location of an aircraft (latitude, longitude and geometric altitude) is extracted separately from the ADS-B CAT021 messages received by the HKO ADS-B ground station. The method of derivation of meteorological data from Mode S can be found in the WMO *Guide to Aircraft-based Observation* (WMO No.1200).

2.3 An initial review of the Mode S DAP derived data suggested that it is comparable with those coming from the WMO Aircraft Meteorological Data Relay (AMDAR) programme in which wind and temperature data are extracted directly from the Flight Management System (FMS) and sent via an air-ground data link, e.g. ACARS.

2.4 Regarding applications, Mode S DAP derived data as well as AMDAR data are being used to combine with wind and temperature data from NWP models and serve as input to Hong Kong CAD's new Approach Spacing Management System (ASMS) to manage approaching aircraft spacing[5]. Furthermore, the low available latency as well as high sampling frequency makes Mode S DAP derived wind data also suitable for real-time applications like wind shear alerting.

[3] ASTRIX (All-purpose structured EUROCONTROL surveillance information exchange) CAT048 are formats for transmission of Monoradar Service Messages
[4] Comm-B Data Selector
[5] For details see ICAO APAC ATMAS TF/4 – IP/05 at https://www.icao.int/APAC/Meetings/2023ATMASTF4/IP05_HKG%20AI.%204.3%20-%20Integration%20of%20Meteorological%20Data%20in%20Approach%20Spacing%20Management%20System.pdf

Figure: Mode S DAP derived wind and temperature (enclosed in circles) of a flight

2.5 Looking forward, further enhancements including raising the frequency of interrogation of BDS 5,0 and 6,0 registries to once every 4 seconds, as well as trial implementation of Mode S Meteorological Routine Air Report (MRAR) and Meteorological Hazard Report (MHR) in APAC and conducting Mode S interrogation of the corresponding BDS 4,4 and 4,5 registers for meteorological routine air reports and hazard reports respectively (see Appendix for details on the payload) should open more opportunities of real-time application of aircraft-based reports.

3. ACTION BY THE MEETING

3.1 Note the information contained in this paper.

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Appendix

(Extracted from ICAO Doc 9871 – *Technical Provisions for Mode S Services and Extended Squitter)*

Table A-2-68. BDS code 4,4 — Meteorological routine air report

MB FIELD

1	MSB	
2	FOM/SOURCE	
3		
4	LSB	
5	STATUS (wind speed and direction)	
6	MSB = 256 kt	
7		
8		
9	WIND SPEED	
10		
11	Range = [0, 511] kt	
12		
13		
14	LSB = 1 kt	
15	MSB = 180°	
16		
17		
18	WIND DIRECTION (True)	
19		
20	Range = [0, 360]°	
21		
22		
23	LSB =180/256°	
24	SIGN	
25	MSB = 64°C	
26		
27		
28		
29	STATIC AIR TEMPERATURE	
30		
31	Range = [–128, +128] °C	
32		
33		
34	LSB = 0.25°C	
35	STATUS	
36	MSB = 1 024 hPa	
37		
38		
39		
40	AVERAGE STATIC PRESSURE	
41		
42	Range = [0, 2 048] hPa	
43		
44		
45		
46	LSB = 1 hPa	
47	STATUS	
48	MSB	TURBULENCE (see 1)
49	LSB	
50	STATUS	
51	MSB = 100%	
52		
53	HUMIDITY	
54	Range = [0, 100]%	
55		
56	LSB = 100/64%	

PURPOSE: To allow meteorological data to be collected by ground systems.

FOM/SOURCE coding:

The decimal value of the binary coded (figure of merit) FOM/SOURCE parameter shall be interpreted as follows:

0 = Invalid
1 = INS
2 = GNSS
3 = DME/DME
4 = VOR/DME
5 to 15 = Reserved

1) The interpretation of the two bits assigned to TURBULENCE shall be as shown in the table for register 45_{16}.

Note 1.— The average static pressure is not a requirement of Annex 3.

Note 2.— Two's complement coding is used for all signed fields as specified in §A.2.2.2.

Note 3.— The requirement for the range of wind speeds in Annex 3 is from 0 to 250 kt.

Note 4.— The requirement for the range of static air temperature in Annex 3 is from –80° C to +60° C.

Table A-2-69. BDS code 4,5 — Meteorological hazard report

MB FIELD

1	STATUS	
2	MSB	TURBULENCE
3	LSB	
4	STATUS	
5	MSB	WIND SHEAR
6	LSB	
7	STATUS	
8	MSB	MICROBURST
9	LSB	
10	STATUS	
11	MSB	ICING
12	LSB	
13	STATUS	
14	MSB	WAKE VORTEX
15	LSB	
16	STATUS	
17	SIGN	
18	MSB = 64°C	
19		
20	STATIC AIR TEMPERATURE	
21		
22	Range = [–128, +128] °C	
23		
24		
25		
26	LSB = 0.25°C	
27	STATUS	
28	MSB = 1 024 hPa	
29		
30		
31		
32	AVERAGE STATIC PRESSURE	
33		
34	Range = [0, 2 048] hPa	
35		
36		
37		
38	LSB = 1 hPa	
39	STATUS	
40	MSB = 32 768 ft	
41		
42		
43		
44	RADIO HEIGHT	
45		
46	Range = [0, 65 528] ft	
47		
48		
49		
50		
51	LSB = 16 ft	
52		
53		
54	RESERVED	
55		
56		

PURPOSE: To provide reports on the severity of meteorological hazards, in particular for low flight.

Hazard coding:

The interpretation of the two bits assigned to each hazard shall be as defined in the table below:

Bit 1	Bit 2	
0	0	NIL
0	1	LIGHT
1	0	MODERATE
1	1	SEVERE

The definition of the terms LIGHT, MODERATE and SEVERE shall be those defined in the PANS-ATM (Doc 4444), where applicable.

Note 1.— The requirement for the range of static air temperature in Annex 3 is from –80° C to +60° C.

Note 2.— Two's complement coding is used for all signed fields as specified in §A.2.2.2.