International Civil Aviation Organization

ICAO

Sixth Meeting of the Surveillance Implementation Coordination Group (SURICG/6)

Video Teleconference, 24 – 27 August 2021

Agenda Item 8 : Update on surveillance activities and explore potential cooperation opportunity

a) States/Administrations

A NON-COOPERATIVE METHOD FOR DAPS DATA RECOGNITION

(Presented by China)

SUMMARY

This paper introduces a non-cooperative DAPs data recognition and determination method. The method can be used for DAPs data interception, extraction and decoding. It can also play a certain role in avoiding the phenomenon of the BDS SWAP.

1. INTRODUCTION

1.1 During the "**Seminar on DAPs and Mode S DAPs WG/1 meeting"**in 2018, ANSP and related equipment manufacturers clearly introduced the benefits of DAPs. It was believed that DAPs-based surveillance will benefit the operation of air traffic management. At the same time, in that meeting, THALES Group proposed a collaborative DAPs extractionmethod byADS-B ground stationwithan additional transmitting device in non-radar coverage areas.

1.2 In 2019, **ENRI** proposed the BDS SWAP phenomenon in the APAC "**DAPs IGD"**, and at the "**Mode S DAPs WG/4meeting**" in 2021, China proposed SFL mismatch alarms and incorrect RA Code due to the BDS SWAP.

1.3 This paper introduces a non-cooperative DAPs data recognition and determination method. This method was proposed by **Dr. Junzi SUN** of Delft University of Technology. The method can be used for DAPs data interception and extraction. It can also play a certain role in avoiding the phenomenon of the BDS SWAP.

2. BDS CODE (THE TYPE OF THE DAPs)

2.1 For ground Mode S interrogator, DAPs data is extracted by means of interrogation and reply collaboratively. Each type of the DAPs information is identified by an 8-bit Comm-B Data Selector (BDS) code, which is only transmitted in the interrogation message but not included in the downlink reply. So the Mode S interrogator obtains the BDS code by pairing the interrogation and reply.

2.2 For example, if the Mode S interrogator requires BDS4,0, the aircraft should reply BDS4,0. At the same time, this mechanism is also the root cause of BDS SWAP.

2.3 If the Mode S transponder receives Roll-Call from different Mode S interrogators at almost the same time, the transponder will only reply once, and at this time, the BDS SWAP phenomenon may occur.

2.4 If the ground Mode S interrogator can determine that the received the BDS code does not match the interrogation required, the interrogator can reject that information, avoiding the wrong BDS data.

2.5 In addition, if the third-party monitoring device (ADS-B, MLAT etc.) is used to receive or monitor the DAPs information in the reply from the transponder to the Mode S interrogator, the determination of the BDS code will also be the basic condition for correct BDS information decoding.

2.6 Although ICAO proposed a method to determine the BDS code by using the BDS code and the 24-bit address code overlaid on (summed bit-by-bit modulo 2) with 24 parity check bits generated on the preceding 32 bits of the reply. But there are very few flights with this capability at present.

3. DETERMINATION THE BDS CODE

3.1 The following logic is based on ELS and EHS operational requirements, which means that the Mode S interrogator will extract the information of BDS 1,0 /BDS 1,7 /BDS 2,0 /BDS 3,0/ BDS 4,0 /BDS 5,0/ BDS 6,0 only.

3.2 Each type of BDS information has a predefined format and structure. At the same time, there are different data formats constraints and data range constraints for the BDS information required for ELS and EHS operation. In general, the data structure of BDS information related to EHS and ELS can be divided into three types: **Reserved bits**, **Status bits**, and **Value bits**.

a) **Reserved bits:** The bits in the different types of BDS that are reserved for future use. They all have to be zeros. If any of the bits is not zero, the possibility of a certain BDS code should be ruled out.

b) **Status bits:** Some fields in BDS messages have their corresponding status bits. When a status bit is set to zero, all bits in the field must be zero. If the field contains non-zero bits, the possibility of a certain BDS code can be ruled out.

c) **Value bits:** Different fields in the messages also have different physical ranges. For example, the Mach number in BDS 6,0 should not be higher than 1, and the roll angle value in BDS 5,0 should be between -50◦ and +50◦. These constants can then be used to exclude certain BDS codes.

4. EXAMPLE OF THE DAPs DETERMINATION

4.1 Table 1 is excerpted from "**MODE S DOWNLINK AIRCRAFT PARAMETERS IMPLEMENTATION AND OPERATIONS GUIDANCE DOCUMENT**". The information of BDS4,0 is incorrectly matched to BDS5,0. That is a typical BDS SWAP phenomenon.

Table 1 Example Data of BDS Swap from ENRI

The type of BDS	Time of Scan		
	08:05:35	**08:05:45 (BDS swap occurred)**	**08:05:55**
BDS4,0	a3280030a40000	a3280030a40000	a3280030a40000
BDS5,0	fff8cf1f800489	a3280030a40000	ffb8cf1f80048a

4.2 The analysis of the BDS information (a3280030a40000) received at 08:05:45:

a) The 12th bit（Status bit） of the information is equal to “0” but the 13th bit is not “0”.So the information does not belong to BDS 5, 0.

b) At the same time, it can be found that the 24th bit of the information is equal to “0”, but the 25-34thbitsare not all “0”, so the information does not belong to BDS6, 0.

c) In addition, the data 1-8thbitsare not equal to “00010000”, “0010 0000” or “0011 0000”. So the information does not belong to BDS1,0, BDS 2, 0 or BDS 3, 0.

d) At last, the 29-56thbits of the data are not all “0”. It can be judged that the data does not belong to BDS1,7.

e) In summary, it can be predicted that the information received by the interrogator should belong to BDS4,0 with a greater probability.

4.3 Table 2 is excerpted from the information paper “**Analysis of False SFL Mismatch Alarm in ATM Automation System” in DAPs WG/4 Meeting**.The information of BDS5,0 is incorrectly matched to BDS4,0 by the YBNINR interrogator.

Table 2 Example Data of BDS Swap from China

Time	Interrogator	Register	Data
17: 52: 28	TORINR	BDS code 5,0	FF2D3456004E3
17: 52: 30	GUIGLR	BDS code 5,0	FF2D3456004E3
17: 52: 33	YBNINR	BDS code 4,0	FF2D3456004E3
17: 52: 34	FDSTHA	BDS code 5,0	FF2D3456004E3
17: 52: 36	TORINR	BDS code 5,0	FF2D3456004E3

4.4 According to the logic in figure 1, it can be found that the data in table 2 is likely to belong to BDS5,0under ELS or EHS condition.

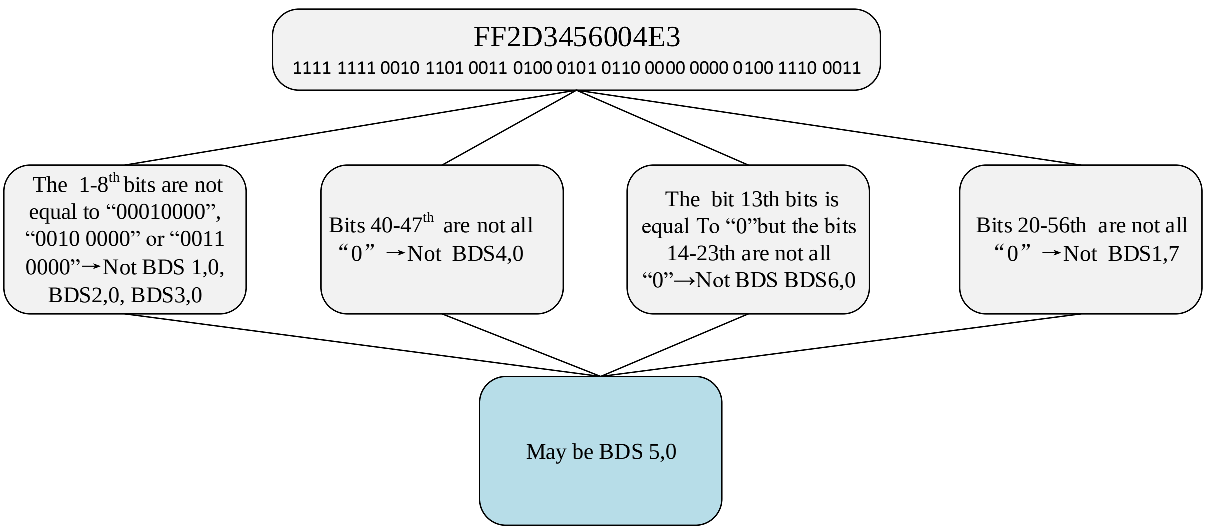

Figure1.BDS codes identification logics

4.5 In summary, this method not only reduces the probability of BDS SWAP occurrence, but also makes it possible for third-party monitoring equipment to correctly decode the DAPs data.

5. FURTHER WORKS

5.1 Analyze the relationship between the DAPs according to the performance of the jet transport aircraft(For example: Calculate the track angle rate from true air speed and the roll angle information).Try to use the relationship between the parameters to determine the BDS type.

6. ACTION BY THE MEETING

6.1 The meeting is invited to discuss any relevant matter as appropriate.

– – – – – – – – – – – – –

Appendix

Table 1. BDS data logic for ELS

BDS CODE	MB bits	Parameter	Rules
BDS1,0	1-8	BDS code	Equal to “0001 0000”
	10-14	Reserved	Must be all “0”
BDS1,7	7	BDS 2,0 enabled	Equal to “1”
	29-56	Reserved	Must be all “0”
BDS2,0	1-8	BDS code	Equal to “0010 0000”
	9-56	Callsign	Only contains “0–9”, “A–Z”, or “space”
BDS3,0	1-8	BDS code	Equal to “0011 0000”
	29-30	Threat type	Not equal to “11”
	16–22	ACAS	less than “48”

Table 2. BDS data logic for EHS

BDS CODE	MB bits	Parameter	Rules
BDS4,0	2-13	MCP selected altitude	If bit 1=0，bit 2-13 shallbe all “0”
	15–26	FMS selected altitude	If bit 14=0，bit 15-26 shallbe all “0”
	28-39	Barometric pressure	If bit 27=0，bit 28-39 shallbe all “0”
	40-47	Reserved	shall be all “0”
	52-53	Reserved	shall be all “0”
BDS5,0	2-11	Roll angle	If bit 1=0，bit 2-11 shall be all “0” If bit 1≠0，bit 2-11 should between -50 and 50 degrees
	13–23	True track angle	If bit 12=0，bit 13-23 shallbe all “0”
	25-34	Ground speed	If bit 24=0，bit 25-34 shallbe all “0” If bit 24≠0，bit 25-34 should between 0-600 kt
	36-45	Track angle rate	If bit 35=0，bit 36-45 shall be all “0”
	47–56	True airspeed	If bit 45=0，bit 47-56 shall be all “0” If bit 45≠0，bit 47-56 should between 0-500 kt
BDS6,0	2-12	Magnetic heading	If bit 1=0，bit 2-12 shall be all “0”
	14-23	Indicated airspeed	If bit 13=0，bit 14-23 shall be all “0” If bit 13≠0，bit 14-23 should between 0-500 kt
	25-34	Mach number	If bit 14=0，bit 25-34 shall be all “0” If bit 14≠0，bit 25-34 should between 0-1
	36-45	Barometric vertical rate	If bit 35=0，bit 25-34 shall be all “0” If bit 35≠0，bit 14-23 should between -6000-6000 fpm
	47-56	Inertial vertical rate	If bit 46=0，bit 47-56shall be all “0” If bit 46≠0，bit 47-56 should between -6000-6000 fpm