Summary of Questions and Answers for
APAC Regional Workshop on Mode S Implementation
Video Tele-Conference, 22 March 2022

Following answers were provided by Mr CHEN Yang (Isaac), the presenter of the Workshop.

1. **What is the difference between the UK and the US in the development of Mode S in 1970s?**

As far as I know, at that time, the United Kingdom paid more attention to the improvement of the surveillance function of the conventional secondary radar system, while the United States paid more attention to the data link function.

For example, the Cossor Company from the UK developed LVA antenna system and monopulse receiver. Compared with the traditional linear array or hogtrough antenna, the LVA greatly reduces the reflection of the interrogation and reply on the ground. So, reduce the multipath effect. Using monopulse receiver, the accurate angle information can be obtained in only one interrogation and reply transaction. So, it is possible to make one-by-one ROLL- CALL, which was impossible for hogtrough antenna.

For the Lincoln Laboratory in the United States, they used monopulse technology to design a method to solve the garbling problem. At the same time, it carried out research on the coding and modulation, error detection and correction and communication protocols of the data-link.

2. **For the stochastic acquisition, how to choose a suitable PR? When to use lockout override?**

If there are frequent capture failures due to garbling situation. At this time, the capture experiment can be carried out according to the principle of response probability from high to low. And observe whether there is improvement.

Lockout override may be used in situations where it is believed that the lockout activities of an adjacent ground station are preventing Mode S acquisition by the local ground station. For example, the adjacent ground station may be using the same II code as the local ground station. Use of this mode must be strictly limited since it elicits Mode S all-call replies from acquired as well as unacquired aircraft and therefore can cause a substantial level of Mode S all-call FRUIT. So, it is better to use the lockout override function with reply probability. For example PR=9-12.

3. **Will the Mode S radar keep transmitting all-call and roll-call interrogation after it is turned on?**

The Mode S radar shall transmit the all-call interrogation continuously, because there may be a newcomer aircraft entering the coverage at any time, and the radar must capture it by the all call. For roll call, if there is not any captured aircraft in the coverage, the radar will not transmit any roll-call interrogation.

So for a conventional Mode A/C radar the transmit duty cycle is the same no matter what situation, but for the Mode S radar duty cycle of transmitting is related to the amount of the aircraft in the coverage.

4. **For a newcomer aircraft entering the radar coverage, when should the lock command be send to lock it out?**

Two principles are followed for the lock command: 1st. Roll-call interrogation carries the lockout

command, 2nd. The earlier the better.

So the lock command is sent depending on when the radar can transmit the roll call interrogation. Some radars can send the roll call interrogation on the second scan and some radars on the third scan after newcomer enter into the coverage. This depends on the radar's ability to track and predict the position of the aircraft.

But it is worth noting that since the II only capable transponder still exists, it is best to decide whether to send the lockout command after obtaining its BDS1, 0 information. This means that the lock command can be sent as soon as the second roll-call

5. **Compared with the traditional AC mode, is the S mode operation more beneficial to relieve the spectrum congestion of 1090MHz?**

No, I don't think so. For Mode S ELS and EHS operation, if the three onboard registers of BDS4, 0, 5, 0 and 6, 0 need to be updated every scan, at least 3 roll-call must be completed for each aircraft within one beam dwell time. For example, there are 10 aircrafts in the beam, then DF11 will be triggered 30 times , and the length of each DF11 carrying MB information is 5 times that of the conventional AC reply, which is equivalent to trigger 150 AC mode reply in the beam. This is equivalent to the replies triggered by a conventional secondary radar with an interrogation rate of 375 Hz.

6. **How to check these functions in the flight inspection?**

For GICB, you just need to observe whether the radar can extract the onboard register information according to your plan programmed to the radar.

For Comm-B broadcast. The pilot change the aircraft identification, you check if the radar immediately extract the changed aircraft identification in the most recent reply to the roll-call interrogation.

About the stochastic acquisition. In the acquisition phase, observe the number of raw videos reply by the transponder, combined with the all-call rate and beam width, it is possible to determine whether the stochastic acquisition is completed. For the lockout override. After the aircraft is locked out. Turn on the lockout override while continuing to send the lock command to see if the DF11 can be triggered.

7. **In what scenario would there be aircraft only II capable?**

I would like to express my point of view from three aspects.

1st. The requirements of the ELS and EHS operation: Aircraft compliant with Mode S ELS operation shall have SI code operation capability. Because the aircraft that meets the EHS must meet the ELS operation capability. So, if the aircraft with ELS and EHS operation capability shall have SI code operation. These information can be found in the document '**Mode S Elementary Surveillance (ELS) Operations Manual' Edition 1.0.**

2nd. The table below is from ICAO 9871 Edition 2. It can be found that if the 35th bit is "1", then the transponder has SI operation capability, and vice versa. This means that transponders that can report the BDS1, 0 message may not have SI code operation capability.

Table A-2-16. BDS code 1,0 — Data link capability report

MB FIELD

1	MSB	
2		
3		
4	BDS Code 1,0	
5		
6		
7		
8	LSB	
9	Continuation flag (see 9)	
10		
11		
12	RESERVED	
13		
14		
15	Overlay Command Capability (OCC) (see 19)	
16	Reserved for ACAS (see 1 and 15)	
17	MSB	
18		
19		
20	Mode S subnetwork version number (see 12)	
21		
22		
23	LSB	
24	Transponder enhanced protocol indicator (see 4)	
25	Mode S specific services capability (see 2)	
26	MSB	
27	Uplink ELM average throughput capability (see 13)	
28	LSB	
29	Downlink ELM: throughput capability of downlink ELM	
30	containing the maximum number of ELM segments that the	
31	transponder can deliver in response to a single requesting	
32	interrogation (UF = 24). (see 14)	
33	Aircraft identification capability (see 11)	
34	Squitter capability subfield (SCS) (see 5)	
35	Surveillance identifier code (SIC) (see 6)	
36	Common usage GICB capability report (see 7)	
37		
38	RESERVED FOR ACAS (see 1, 16, 17 and 18)	
39		
40		
41	MSB	
42		
43		
44		
45		
46		
47	Bit array indicating the support status of DTE	
48	Sub-addresses 0 to 15 (see 3 and 8)	
49		

PURPOSE: To report the data link capability of the Mode S transponder/data link installation.

The coding of this register shall conform to:

1) Annex 10, Volume IV, §3.1.2.6.10.2 and §4.3.8.4.2.2.2.

2) When bit 25 is set to 1, it shall indicate that at least one Mode S specific service (other than GICB services related to registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16}) is supported and the particular capability reports shall be checked.

Note.— Registers accessed by BDS Codes 0,2; 0,3; 0,4; 1,0; 1,7 to 1,C; 2,0 and 3,0 do not affect the setting of bit 25.

3) Starting from the MSB, each subsequent bit position shall represent the DTE sub-address in the range of 0 to 15.

4) The enhanced protocol indicator shall denote a Level 5 transponder when set to 1, and a Level 2 to 4 transponder when set to 0.

5) The squitter capability subfield (SCS) shall be set to 1 if both registers 05_{16} and 06_{16} have been updated within the last 10, plus or minus 1 second. Otherwise, it shall be set to 0.

Note.— Registers 05_{16} and 06_{16} are used for the extended squitter Airborne and surface position reports, respectively.

6) The surveillance identifier code (SIC) bit shall be interpreted as follows:

0 = no surveillance identifier code capability
1 = surveillance identifier code capability

7) Bit 36 shall be toggled each time the common usage GICB capability report (register 17_{16}) changes. To avoid the generation of too many broadcast capability report changes, register 17_{16} shall be sampled at approximately one minute intervals to check for changes.

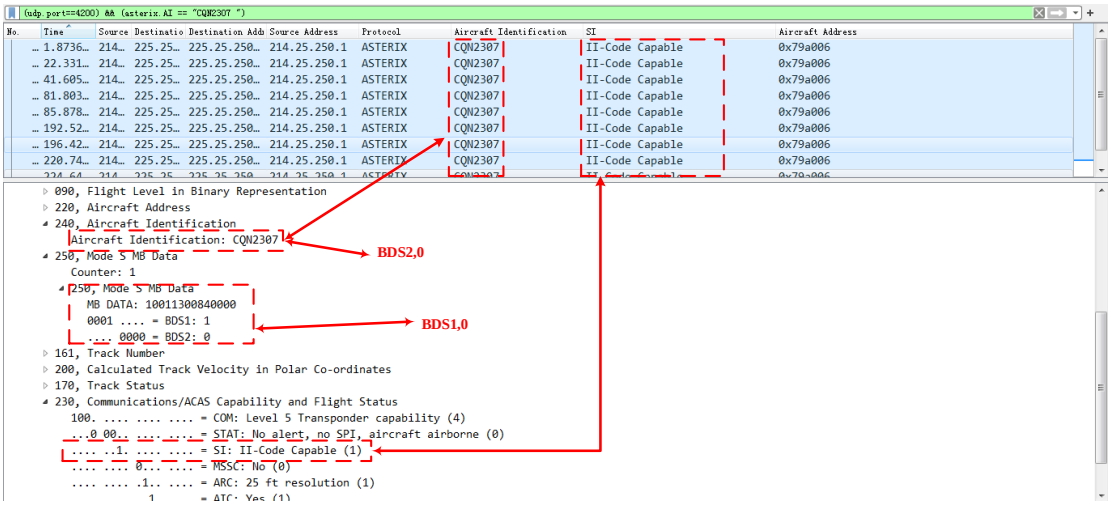
8) The current status of the on-board DTE shall be periodically reported to the GDLP by on-board sources. Since a change in this field results in a broadcast of the capability report, status inputs shall be sampled at approximately one minute intervals.

9) In order to determine the extent of any continuation of the data link capability report (into those registers reserved for this purpose: register 11_{16} to register 16_{16}), bit 9 shall be reserved as a continuation flag to indicate if the subsequent register shall be extracted. For example: upon detection of bit 9 = 1 in register 10_{16}, then register 11_{16} shall be extracted. If bit 9 = 1, in register 11_{16}, then register 12_{16} shall be extracted, and so on (up to register 16_{16}). Note that if bit 9 = 1 in register 16_{16}, then this shall be considered as an error condition.

10) The Mode S transponder may update bits 1-8, 16, 33, 35 and 37-40 independent of the ADLP. These bits are provided by the transponder when the data link capability report is broadcast as a result of a transponder detected change in capability reported by the ADLP (§3.1.2 of Annex 10, Volume IV).

(Requirements are continued on the next page)

3rd. Data analysis of actual operating conditions. From the data below, it can be find that the aircraft has the ability to report BDS2, 0 and BDS1, 0 but cannot meet the requirements of SI operation capability. There are very few such aircraft.



Summary:

- If the aircraft meets the ELS or EHS OPERATION requirements, it must be capable of SI operation.
- I have observed that there are two type of aircraft that are II only capable, the first are the level 1 transponders which cannot to provide any BDS message. The second is that some transponders have all of the ELS capabilities except the SI capabilities.