



ICAO

**THE THIRD MEETING OF MODE S DOWNLINKED
AIRCRAFT PARAMETERS WORKING GROUP
(MODE S DAPs WG/3)**

Web-conference, 12 – 15 May 2020

Agenda Item 3: Sharing of State’s implementation on Mode S

MODE S RADAR PARAMETER SET AND DAPs EXTRACTION STRATEGY

(Presented by China)

SUMMARY

This paper presents the latest Mode S radar survey conducted by China. The survey aims to standardize the Mode S radar operation and related DAPs extraction strategy, the information provided in this paper may benefit the optimization of Mode S radar operation and DAPs extraction.

1. INTRODUCTION

1.1 China is operating and maintaining a radar surveillance network of more than 100 radars (74 of which are Mode S radar). Before to further implement Mode S Enhanced Surveillance, China conducted a serial of surveys of the Mode S radars, and tried to standardize the Mode S radar operation and related DAPs extraction strategy.

1.2 These radars were provided by several manufactures, including abroad companies like Thales, Leonardo, Indra, and also domestic companies like Nriet, Suncreat.

2. DISCUSSION

2.1 By analysing the radars’ survey reports, we found that different radar systems have some slight differences in Mode S realization, but the function of Mode S is more or less the same. All of them can support the Enhanced Surveillance.

2.2 Since the Mode S radar has a lot of parameters, and some of them are internally related, in order to standardize the Mode S radar’s operation, the Mode S Parameter Set was introduced to describe the Mode S radar’s operational status. The DAPs extraction strategy was also included by the end. The introduction of the Mode S Parameter Set please refers to the appendix of this paper.

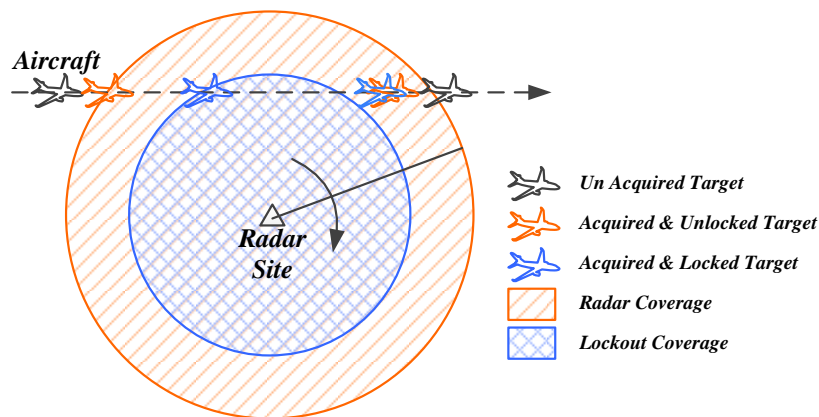
3. ACTION BY THE MEETING

3.1 The meeting is invited to note the information contained in this paper.

Appendix - Mode S Parameter Set

Radar Coverage R

1.1 The Mode S radar coverage is defined as the farthest target the radar will process. If the Mode S radar uses a lockout map, the difference of the two coverage ranges should be noticed.



1.2 The radar coverage will decide the minimal All-Call period, this is to say, the time of All-Call period should:

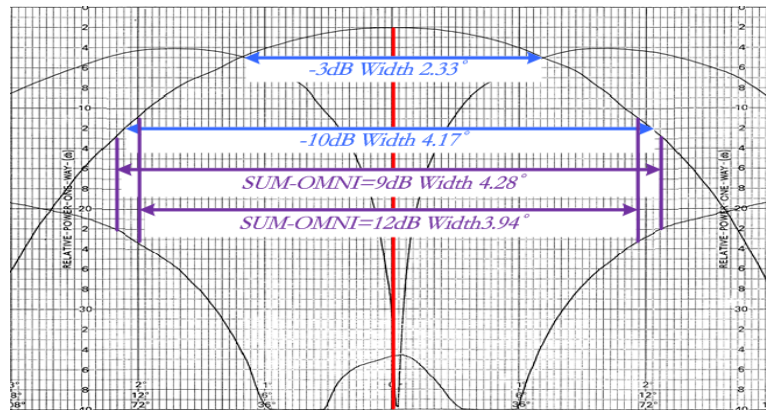
$$T \geq \frac{R * 2 * 1852}{3 * 10^8}$$

Antenna Period T_a

2.1 The antenna period is the time of a successful antenna rotation, this time actually has very important influence of the total time resource of the radar. Lower antenna rotation speed will provide rich antenna period, hence time resource of the radar. The most commonly used antenna period is 4000ms (15rpm) and 6000ms (10rpm) for terminal surveillance radar.

Antenna Beamwidth B

3.1 Most of the secondary surveillance radar uses the same LVA antenna, the beam is more or less the same, and the standard interrogation beam has a -3dB width of $2.45^\circ \pm 0.25^\circ$. In Mode S interrogation, the suppression requirement actually allow to use a wider beam width than -3dB width, most of the radar choose 3.8° or roughly the -10dB beam width.



Time on Target T_t

4.1 The time on target is the total time amount the radar beam covers the target during one scan, it defines the time resource upper limit for one dedicated target, it is determined by both the antenna period and the beamwidth, and the relation is as follows:

$$T_t = \frac{T_a}{360} * B$$

4.2 It should be noticed that during a mix air operation (Conventional targets and Mode S targets flying in the same area in the same time), there is a need for the Necessary Transaction. That is during an antenna scan, there should be at least 4 transactions between the radar and the conventional target, in order not to miss conventional target.

All-Call Period T_{ac} and Roll-Call Period T_{rc}

5.1 The All-Call period and Roll-Call period setting are different radar by radar, but there should be some principles:

- 1) All-Call period should long enough to allow the coverage requirement;
- 2) During the time on target, the Necessary Transaction should be guaranteed;
- 3) Time resource should allocate to Roll-Call as much as possible; and
- 4) Algorithm should be used to optimize the scheduling in the Roll-Call period.

Mode Interlace Pattern MIP

6.1 Mode Interlace Pattern defines the radar operating mode setting. The setting is related to the specific radar environment, hence there is no standard MIP.

6.2 All the modes Mode S radar can use is listed in the following table:



No.	Mode	Description	Pulse Used
1	A	Mode A interrogation	8μs between P1 and P3
2	C	Mode C interrogation	21μs between P1 and P3
3	A _S	Mode A Only All-Call	8μs between P1 and P3, and short P4
4	C _S	Mode C Only All-Call	21μs between P1 and P3, and short P4
5	S _L	Mode ACS All-Call	8μs, 21μs between P1 and P3, and Long P4
6	S _{PO}	Mode S Only All-Call P for PR,O for LO	2μs between P1 and P2, and P6 UF11 inside P6
7	R	Mode S Roll-Call	2μs between P1 and P2, and P6 UF0/4/5/16/20/21 inside P6

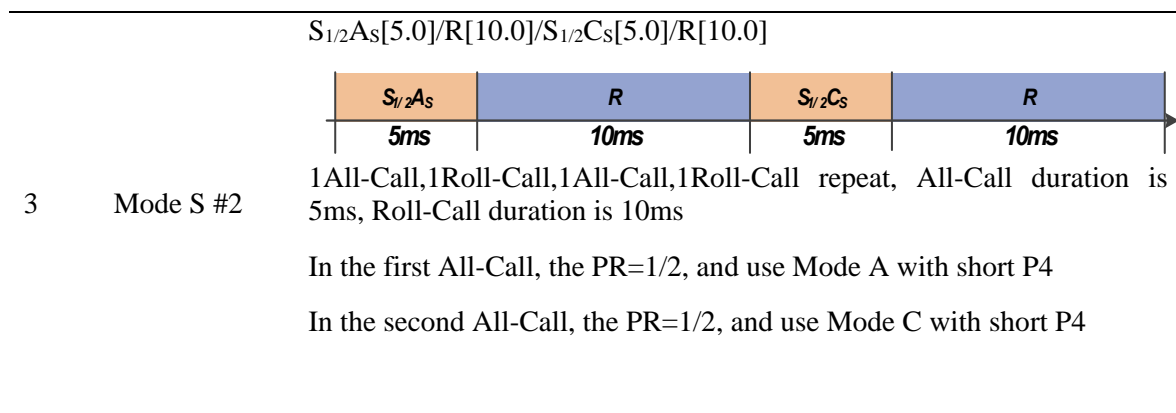
6.3 For a specific MIP, the describe phraseology defines as follows, and also one example is listed below:

Mode[Time]/ Mode[Time]/ Mode[Time]/.....

Note: The All-Call and Roll-Call periods are separated by “/”, the “Mode” is one of the Modes listed above, and the “[Time]” stands for the duration of the periods.

6.4 An example is show as follows:

No.	Mode	MIP
1	Conventional	<p>A[5.0]/C[5.0]</p>  <p>Mode A and Mode C repeat, both duration are 5ms</p>
2	Mode S #1	<p>S_{1/2}A_S[5.0]/S_{1/2}C_S[5.0]/R[10.0]</p>  <p>2All-Call periods and 1 Roll-Call period repeat, All-Call duration is 5ms, Roll-Call duration is 10ms</p> <p>In the first All-Call, the PR=1/2, and use Mode A with short P4</p> <p>In the second All-Call, the PR=1/2, and use Mode C with short P4</p>



Interrogation Repetition Frequency **IRF**

7.1 The Mode S introduced the Roll-Call period, which makes the interrogation repetition frequency a little bit different from the Conventional Mode. There is a need to define the interrogation repetition frequency by Mode IRF_{Mode} . Normally use IRF stands for the IRF_{AC} of Conventional mode and IRF_s of the Mode S All-Call. One example is listed below:

No.	MIP	IRF
1		$IRF_A=100Hz$
		$IRF_C=100Hz$
		$IRF_{AC}=200Hz$
2	$S_{1/2}A_s[5.0]/R[10.0]/S_{1/2}C_s[5.0]/R[10.0]$ 	$IRF_A=38.5Hz$
		$IRF_C=38.5Hz$
		$IRF_{AC}=76.9Hz$
		$IRF_s=76.9Hz$
		$IRF_R=76.9Hz$

DAPs Extraction Strategy

8.1 The DAPs extraction strategy normally includes the BDS number, extraction priority, extraction period, and re-extraction.

1) BDS number stands for the setting of the number of BDSs which radar is going to extract. It doesn't include the ELS registers, these registers should not be extract periodically;

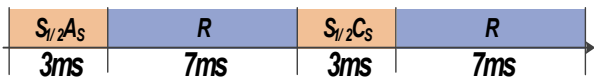
2) Extraction priority stands for the priority of each BDS when the radar is performing extraction, the priority should be in accordance to the user's needs;

3) Extraction period stands for the period of the dedicated BDS extraction, normally described by the antenna scan number;

4) Re-extraction stands for the function of re-extraction of the dedicated BDS in the same beam dwell when the extraction is failed, but it's not recommend to re-extraction of more than 2 times.

Mode S Parameter Set Example

9.1 The following is an example of the Mode S Parameter Set:

No.	Parameter	Unit	Value	Note
1	R Coverage Range	NM	200	Equivalent All-Call Time $\frac{200 * 2 * 1852}{3 * 10^8} * 10^3 \approx 2.47ms$
2	Ta Antenna Period	ms	3800	Antenna Rotation Period
3	B Work Beamwidth	°	3.8	Mode S Work Beamwidth Normally Greater Than -3dB width of 2.45°
4	Tt Time on Target	ms	40.1	The Time on Target In One Scan $\frac{3.8}{360} * 3800 \approx 40.1ms$
5	Tac All-Call Period	ms	3.0	Equivalent Coverage Range $\frac{3 * 10^8 * 3.0 * 10^{-3}}{1852 * 2} \approx 243NM$
6	Trc Roll-Call Period	ms	7.0	This Period Related To The Extraction Efficiency
7	MIP	—	—	$S_{1/2}A_s[3.0]/R[7.0]/S_{1/2}C_s[3.0]/R[7.0]$ 
8	IRF _{AC}	Hz	100	Interrogation Repetition Frequency of Mode S All-Call
9	DAPs Extraction	—	—	No. of BDS: 3 (BDS 4,0 5,0 6,0) Extra. Priority: BDS 4,0 6,0 5,0 Extra. Period: 1 Scan Re-Extraction: Yes