International Civil Aviation Organization

SIXTH MEETING OF MODE S AND DOWNLINKED AIRCRAFT PARAMETERS WORKING GROUP (MODE S AND DAPS WG/6)

Bangkok, Thailand, 28 – 30 March 2023

Agenda Item 3: Sharing of State's implementation on Mode S and related issues in APAC region

A CASE ANALYSIS OF MANEUVERING AIRCRAFT TRACK MISSING

(Presented by China)

SUMMARY

This paper presents a case of Mode S secondary radar (MSSR) missing a maneuvering aircraft for a long time due to the error of DAPs data, resulting in false extrapolated track. And proposes suggestions to solve the problem.

1. INTRODUCTION

1.1 The Lockout and Roll Call functions require the MSSR to predict the position of aircraft in next scan accurately, after that can update the track inside a correlation window. Theoretically, MSSR cannot predict the maneuver flight of aircraft and can only use a large correlation window to ensure the aircraft located into it. Limited by the characteristics of antenna pattern and Mode S scheduling management, it is possible that the short-range aircraft flying along the radial direction of MSSR will be out of the correlation window when the aircraft making a high-maneuver flight turn to tangential direction, and the track cannot be updated, then the aircraft missing. The terminal area is most likely to have this problem.

1.2 In order to improve the stability of aircraft tracking, some MSSR manufacturers use the track and turn report (BDS 5,0) to assist in predicting position of Lockout aircraft in the next scan.

1.3 The following situations may occur when a short-range aircraft making a high-maneuver flight:

a) The MSSR does not use BDS 5,0 data to assist position prediction, and the aircraft is out of the correlation window;

b) The MSSR uses BDS 5,0 data to assist position prediction, but in the current scan, the MSSR does not extract BDS 5,0 data, so the position prediction is wrong;

c) The MSSR uses BDS 5,0 data to assist position prediction, but the error of BDS 5,0 data leads to the error of position prediction.

As a result of the above situations, the MSSR misses the aircraft and the false track extrapolated.

1.4 For the situation mentioned in 1.3(c), 1090MHz signal occupation, DAPs data errors, BDS SWAP, etc. all may cause the BDS 5,0 data errors.

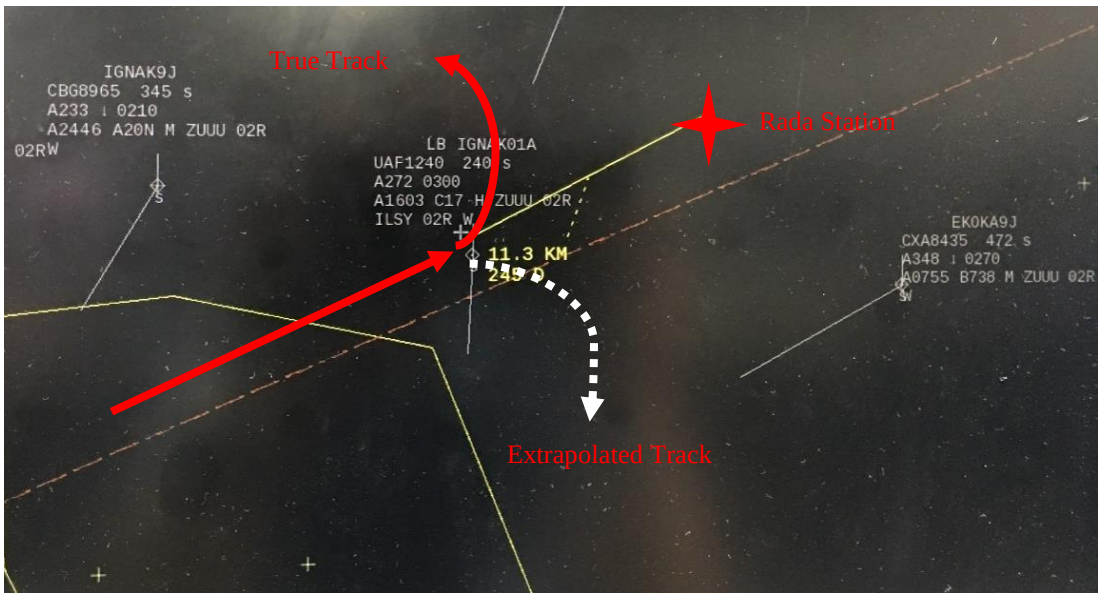
1.5 When the MSSR misses the Lockout target during Roll Call period, the track will be lost for a long time due to the 18s lockout duration of the transponder, track initialization for MSSR and ATM Automation System, which has a serious impact on Air Traffic Control.

1.6 This paper presents a case of false target caused by DAPs data error, analyzes the relevant situation that may lead to similar events, and puts forward some suggestions to solve it.

2. DISCUSSION

Case analysis

2.1 In the airspace of Chengdu, China, an aircraft flying towards MSSR missed and a false extrapolated track appeared while the aircraft making a high-maneuver turn. It takes 18s for the transponder to release the Lockout status automatically, and 8s for MSSR track initialization, and 12s for the Automation System track initialization. Therefore, the aircraft missed for about 38s in the Automation System when it's landing.



2.2 By analyzing the MSSR data with the other two MSSRs, it was found that when the aircraft turned, the True Track Angle in the BDS 5,0 data extracted by the three MSSRs are greater than 180°, indicated that the DAPs data was wrong.

Radar Station	TOD	BDS 5,0	True Track Angle (°)
MSSR under analyzed	03:45:22.601	e8 5e 43 1a 3c b4 67	219.2
MSSR 1	03:45:25.257	ec 9d e5 1a 3d 0c 68	227.46
MSSR 2	03:45:23.085	e8 9e 31 1a 3c b4 68	220.78

2.3 Through analysis, we know that the MSSR under analyzed uses BDS 5,0 data to assist aircrafts position prediction. Due to the error of the BDS 5,0 data, the aircraft missed. (See the appendix for details)

Suggestion

2.4 To solve the problem, it is suggested that:

For the MSSR manufacturers

a) The MSSR manufacturers who uses DAPs data to assist aircraft position prediction should find some methods to verify the DAPs data, and the false DAPs data should not be used.
(China presented a non-cooperative DAPs data recognition and determination method in IP19 at the 6th Meeting of the Surveillance Implementation and Coordination Group (SURICG/6) in 2021. The method was evaluated in DAPs WG/5-IP11 by ENRI, Japan, in 2022, which showed a good performance.)

b) If the MSSR missed the Lockout targets during Roll Call period, it's better to use Lockout Override in specified sector to assist aircraft position prediction.

For the MSSR users

a) The MSSR stations should be built as far as possible away from the route turning point and avoid along the route, especially in the terminal area.

b) BDS 5,0 data extraction period should not be larger than 2 scans, it's better to extract every scan.

3. ACTION BY THE MEETING

a) note the information contained in this paper; and

b) discuss any relevant matter as appropriate

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Appendix

Hypothesis 1: The MSSR under analyzed does not use BDS 5,0 to assist position prediction:

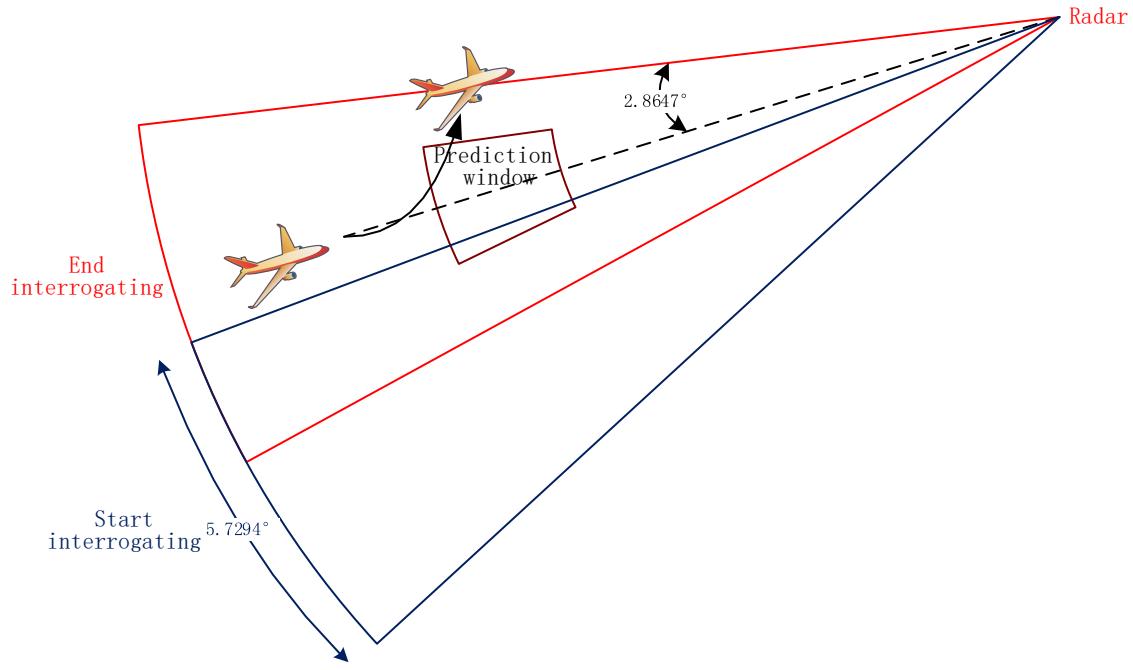
The antenna scan duration of the MSSR is 4s, and the aircraft is 11.3km away from the MSSR. The beam width at this distance is set to 5.7294°. According to the track history, the radar predicted that the aircraft position would still be in the radial direction in the next scan. In order to update the track, the aircraft should be located in the main beam:

$$\Delta\theta \le \frac{5.7294^{\circ}}{2} = 2.8647^{\circ}$$

$$\Delta\theta = \frac{180VT}{D\pi} = \frac{180 \times V \times 4}{11300 \times \pi} \le 2.8647^{\circ}$$

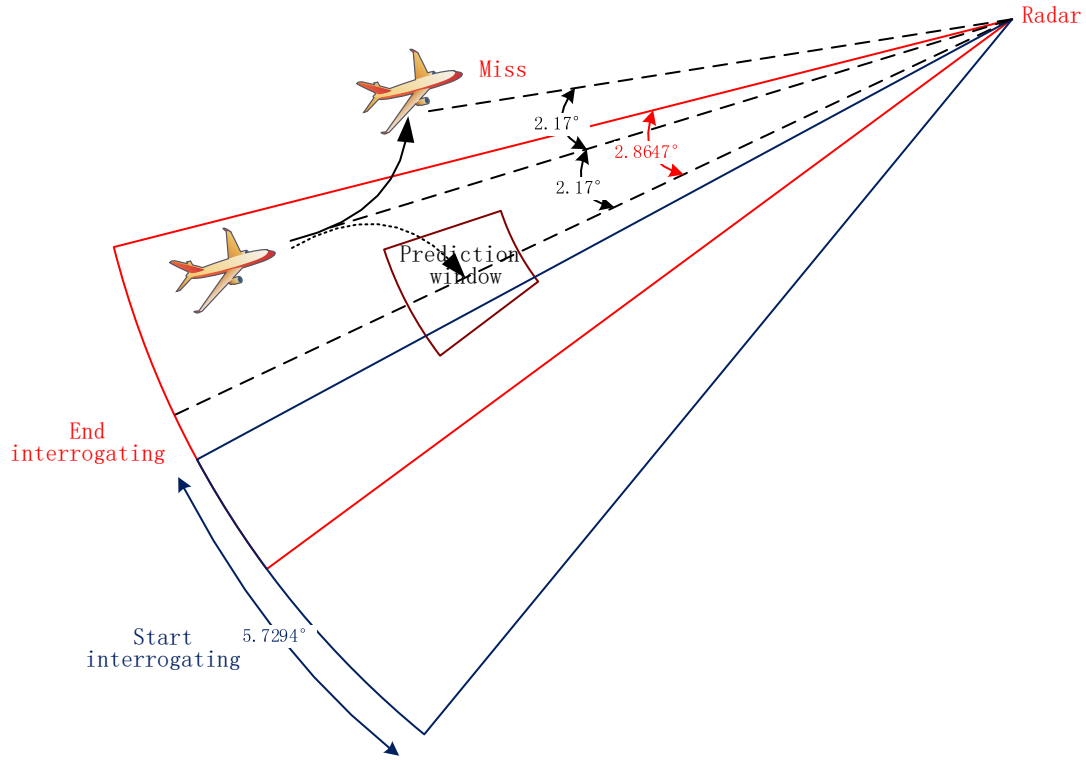
$$V \le 141.25m/s = 274.56knots$$

The V is the tangential speed of the aircraft, T is the antenna scan duration of the MSSR, and D is the distance between the aircraft and the MSSR. The tangential speed of the aircraft is 208knots, which is within the speed limitation. Therefore, if the MSSR under analyzed does not use BDS 5,0 to assist position prediction, the target will not miss.



Hypothesis 2: The MSSR being analyzed uses BDS 5,0 to assist position prediction:

According to the BDS 5,0 data, the True Track Angle of the aircraft is 219.2°. If it exceeds 180°, according to the <Technical Provisions for Mode S Services and Extended Squitter>, 180° is used instead. Therefore, the MSSR under analyzed predicted that the aircraft will turn to south, resulting in the missing of the aircraft (the same direction as the false extrapolation track displayed in Automation System):



Conclusion: The MSSR under analyzed uses the True Track Angle come from BDS 5,0 data to assist aircrafts position prediction. Due to the error of BDS 5,0 data, the aircraft missed.