



ICAO

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Coordination Group (SURICG/6)**

Video Teleconference, 24 – 27 August 2021

**Agenda Item 7:** Report on surveillance ground system and avionics performance monitoring and improvement in compliance

## DIAGNOSIS AND MAINTENANCE ABOUT A SSR TARGET DEVIATION FAULT

(Presented by China)

### SUMMARY

This paper introduces a case on the diagnosis and maintenance about a fault of the SSR target deviation. The case shows that the fault can be caused by the mechanical component inside the antenna pedestal. Furthermore, some suggestions for the prevention of this case are issued in this paper.

## 1. INTRODUCTION

1.1 From October 30, 2020, a Mode-S secondary radar in china has the phenomenon that the detection position of the aircraft deviates from its true position. The phenomenon is that the azimuth of detection target deviates from its true value, and the deviation changes irregularly over time, as shown in Figure 1.

1.2 After nearly 3 months of data analysis and fault diagnosis, it is finally concluded that the azimuth measurement error is caused by the poor horizontal stability of the mechanical transmission components inside the antenna pedestal. Upon inquiry, this phenomenon is an isolated case in the world for this type of SSR.

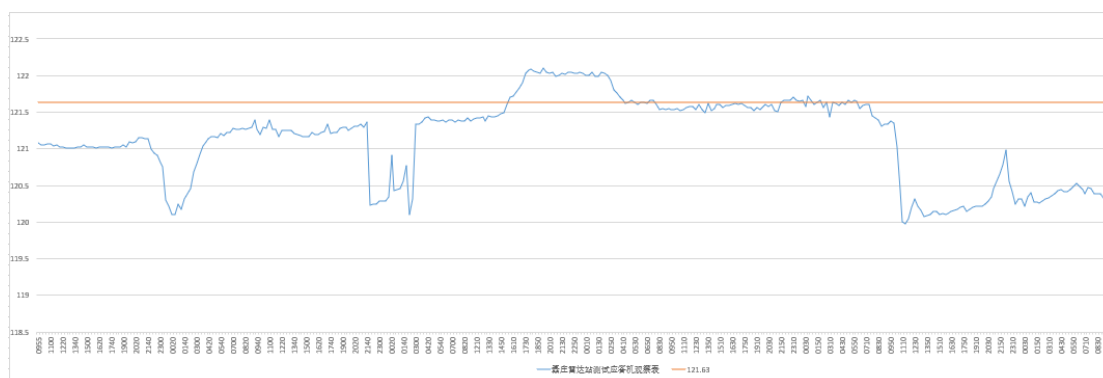


Figure 1A 120-hour azimuth data map of test transponder recorded by a faulty SSR

## 2. CASE ANALYSIS

2.1 After three months of fault diagnosis, through a series of methods such as cable inspection, equipment calibration, phase calibration, vibration test, channel switching,

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electromagnetic environment monitoring, electrical and mechanical spare parts replacement, the results eliminate the fault of SSR caused by indoor cabinet, mechanical drive components, antenna feed systems, connecting cables, electromagnetic interference and other factors.

2.2 At the same time, a sound response and monitoring mechanism has been established for this abnormal phenomenon, and multiple sets of abnormal data have been recorded, laying the foundation for further analysis.

2.3 It can be seen from Figure 1 that the difference between the maximum value and the minimum value of the recorded azimuth data for test transponder is  $1.9^\circ$ , and there is no obvious rule to follow the error trend.

a) Comparing this data of single radar with the fusion data of the ATM automation system: in each direction, there are different degrees of target deviation, and the azimuth deviation is not the same.

b) For example, the target in the northeast of the SSR deviates clockwise (the detective azimuth value is greater than the true value), and the target in the southwest of the SSR deviates counterclockwise (the detective azimuth value is less than the true value).

c) According to analyzing the raw data of multi-radar from the ATC Automation System, when the targets start to deviate of this SSR, the process of azimuthal change for each target is continuous.

2.4 It is preliminarily determined that the phenomenon of target deviation is caused by the failure of the mechanical component inside the antenna pedestal.

a) ATMB immediately started the special maintenance, after removing the antenna of SSR, it was found that the double diaphragm coupling of the principal axis was out of position.

b) In other words, the principal axis is not exactly at the center of the circle, as shown in Figure 2.

c) The top cover of the antenna pedestal was further disassembled, and it was found that some nuts of the coupling had fallen off, what caused the radial swing of the coupling. (Normally, the coupling can only axial swing.)

d) The comparison between the faulty double diaphragm coupling of the principal axis and the replacement parts is shown in Figure 3.



Figure 2



Figure 3

2.5 For reliable maintenance, on the basis of replacing the double diaphragm coupling of the principal axis, ATMB continued to replace mechanical parts such as main bearing, slip ring, and encoder synchronization gear.

2.6 Before and after maintenance, the gyroscope test of RASS was used to obtain the deviation data of ACP, the results show that the ACP deviation in all directions is significantly reduced, and the maximum value of ACP deviation drops from  $0.7557^{\circ}$  to  $0.1347^{\circ}$ . The test results before and after maintenance are shown in Figure 4 and Figure 5.

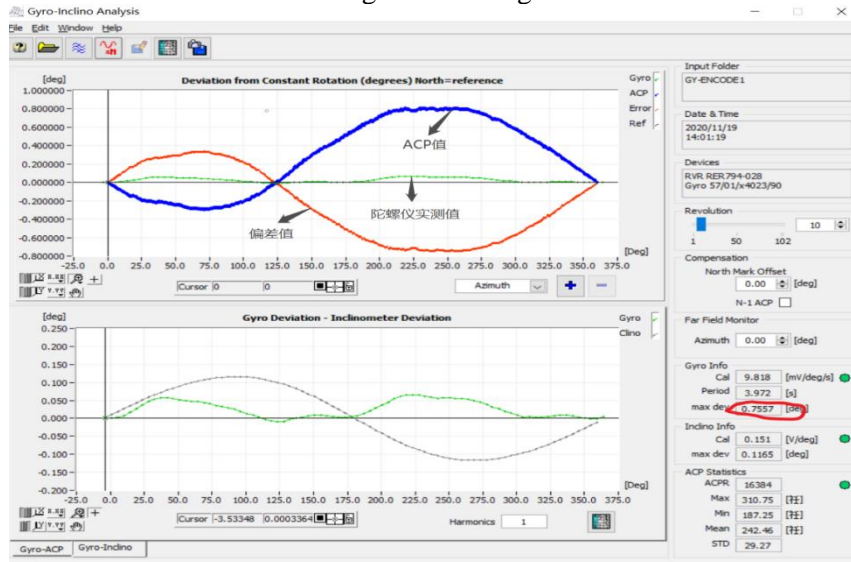


Figure 4 the maximum value of ACP deviation is  $0.7557^{\circ}$  (Before maintenance)

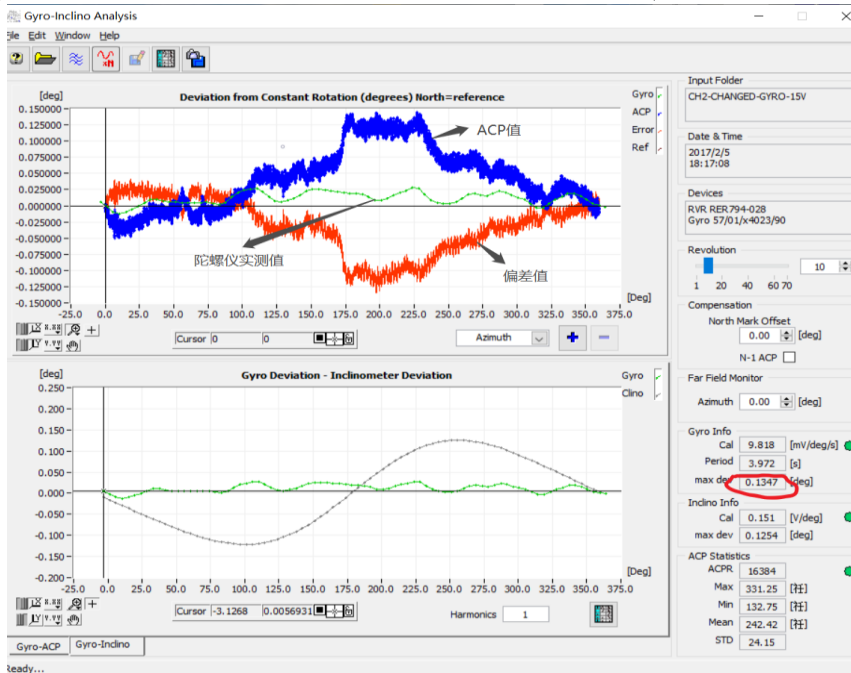


Figure 5 the maximum value of ACP deviation is  $0.1347^{\circ}$ (After maintenance)

2.7 After the maintenance was completed, a 7-day monitoring for signal quality of the SSR was shown that the signal is stable and usable after maintenance of the SSR. So far, after more than half a year, the SSR is operating normally.

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**3. CONCLUSIONS AND RECOMMENDATIONS**

3.1 The result shows that the main cause of target deviation for this SSR is as follows: Some nuts of the double diaphragm coupling had fallen off, what caused the radial swing of the coupling. During the operation of the antenna with load, the radial swing of the coupling caused the irregular radial deviation of the principal axis. As a result, the speed ratio of the double diaphragm coupling, encoder synchronization gear and main bearing inside the antenna pedestal was non-uniform, what resulted in excessive ACP deviation of the SSR and the fault of target deviation.

3.2 The recommendations are as follows:

a) **Improving the regular monitoring methods of azimuth data for SSR:** It is recommended to pay attention to, and regularly monitor the changes of indicators which are related with detection azimuth of SSR in daily maintenance and inspection. For example, Figure 1. If conditions permit, it is recommended to carry out the gyroscope test of RASS regularly, and the recommended test cycle is once a year.

b) **Experience sharing for fault diagnosis about target deviation of SSR:** It is recommended to focus on indoor cabinet, the OBA table, rotary joints, antenna feeder system, connecting cables and the mechanical transmission system inside antenna pedestal, which are related to azimuth detection. The change of test transponder's azimuth data is an important reference for fault diagnosis about target deviation of SSR. It is suggested to consider the possible faults of rotary hinge, feeder and antenna feeder system. Discontinuous change: it is recommended to consider the fault possibilities of rotary joints, antenna feeder system, connecting cables. Continuous change: it is recommended to consider the fault possibilities of the mechanical components inside the antenna pedestal.

c) **Improving the overhaul of SSR:** For every 6 to 8 years, it is recommended to replace motor, reduction gearbox, and the mechanical transmission system inside antenna pedestal, such as main bearing, double diaphragm coupling of the principal axis, and encoder synchronization gear, etc. Ensuring the reliability of azimuth data through the overhaul of SSR.

d) **Enhancing the capabilities of data analysis and remote collaborative diagnosis:** It is recommended that the ATM automation system shall have the function of comparing the multi radar raw-data .

**4. ACTION BY THE MEETING**

4.1 The meeting is invited to:

- a) note the information contained in this paper; and
- b) discuss any relevant matter as appropriate.

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