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

MODE S UPGRADE BY LIFE EXTENSION

(Presented by China)

SUMMARY

This paper briefly introduces the scheme of Mode S upgrading of secondary radar by means of life extension in China. The scheme is an effective way of Mode S upgrading of the legacy conventional radar.

1. INTRODUCTION

1.1 In order to further accelerate the application of Mode S surveillance and obtain the safety benefits, the CAAC ATMB conducted an evaluation and analysis of the current radars, and formulated a life extension plan for 3 legacy conventional mode secondary radars. By update the indoor electronic cabinets to Mode S capable, the radars meet EHS requirements.

1.2 These three radars are MK-II conventional SSR produced by Raytheon Company in the UK. They were put into service around 2000, and the equipment has been working continuously for more than 20 years. There are problems of performance degradation and high failure rate. At the same time, they cannot meet the requirements of DAPs.

1.3 Upgrade work was completed by the domestic radar manufacturers Enrit and Suncreat. They are the most experienced radar manufacturers in China, and have decades of experience in radar design, production, installation, commissioning and maintenance. This also ensures the quality of the upgrade.

1.4 The Mode S upgrade plan includes the on-site survey, technical plan preparation, equipment production, equipment factory acceptance test, on-site installation and commissioning, system optimization, on-site acceptance test, etc. The upgraded secondary radar equipment has undergone special flight test and surveillance data quality analysis, and the results show that it fully meets the requirements of the air traffic control surveillance.

2. DISCUSSION

2.1 Life extension upgrade is a common method to improve the efficiency use of radar and reduce investment costs to obtain maximum benefits. It is also a common method for technical upgrading of radar equipment. Civil aviation authorities such as the FAA operate and maintain a large radar surveillance network, and life extension is also a common method of its radar operation management. The FAA has budgeted more than $60 million for Mode S Service Life Extension Program (SLEP) between 2019 and 2022.

2.2 Radar life extension upgrade can realize refined management of radar service life and effectively save the investment costs, while keeping the system performance and operation mode. The corresponding installation and commissioning, system optimization, flight verification, signal evaluation and personnel training are consistent with the newly installed radar. It is an effective way to upgrade legacy conventional SSR to DAPs capable system in a short period of time.

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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Attachment: Mode S Update Business Case

On-site survey

1.1 Carry out on-site investigation and research on the radar station, confirm the technical status of the radar system, evaluate the operating status of the outdoor antenna feeder, and measure related signals. At the same time, confirm whether the site environment and roads can meet the transportation and installation conditions. Provide the coverage and evaluation analysis report of the radar system within one month after the site survey.

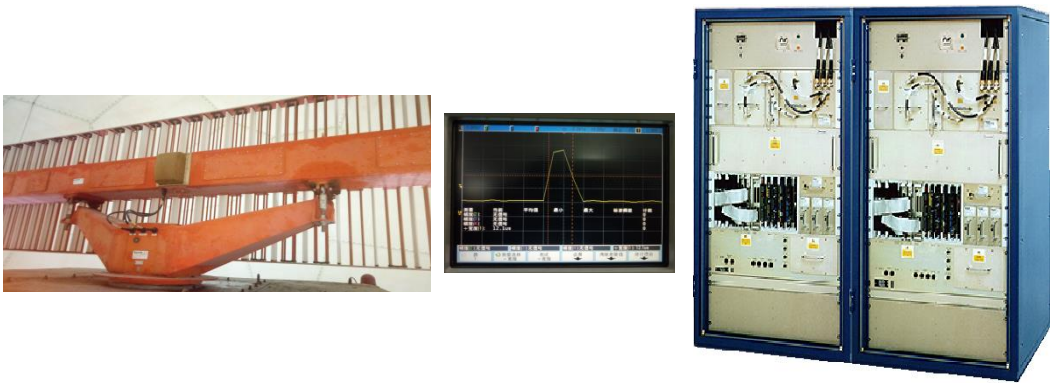

Figure 1 Equipment and signal conditions by site survey

Preparation of technical solutions

2.1 Prepare a detailed technical plan according to the upgrade requirements of Mode S functionalities. Firstly, according to the usage requirements, determine the functions that the upgraded radar equipment should have, including the basic surveillance capabilities, ELS, EHS and related functions of cooperative surveillance.

Table 1 List of upgraded functions

Function	before upgrade	after upgrade
SSR Surveillanc	capable	capable
Elementary Surveillance (ELS)	none	capable
Enhanced Surveillance (EHS)	none	capable
Data Link Function (DLF)	none	capable
Surveillance Coordination Function (SCF)	none	capable
data update interval	5 seconds	4 seconds

2.2 According to the results of on-site survey and investigation, combined with the specific functions to be realized, formulate a system integration plan, retain the outdoor part of the radar system, and update the whole indoor electronic cabinet. The specific content includes:

a) Retain and use the original radar outdoor equipment (including LVA antenna, three-way rotary joint, antenna base, azimuth encoder, azimuth motor and oil pump motor), RF cables, mains cables, control cables, outdoor cable racks, etc.;

b) The antenna drive unit in the original radar indoor equipment is no longer retained, and its two cabinets are replaced;

c) Using the new radar control and display terminal, set up a maintenance display terminal locally, and set up a remote maintenance display terminal in the equipment monitoring room in the ATC center.

Figure 2 Comparison of old and new systems (antenna, cabinet, and CMS)

2.3 Refine the adaptation scheme of the new indoor cabinet system and the old antenna system. It mainly includes antenna feeder system adaptation, azimuth signal adaptation, radio frequency switching unit adaptation, drive system and safety loop adaptation, etc.

a) The original radar antenna is protected by a radome, and its technical performance complies with ICAO and CAAC standards, so it is reserved. The original radar RF cable is LDF7-50A from Andrew Company, and the connector is N type. After testing, the technical performance meets the requirements. It is compatible with the new radar cabinet and is reserved for use.

b) The original radar azimuth encoder is a rotary transformer, and the tested technical performance meet the requirements, so it is reserved for use. The new radar drive cabinet provides two +24V power supplies, and the encoder provides two azimuth signals to the new radar cabinet. The new radar cabinet performs compatible processing on the azimuth signal, and adjusts the radar speed from 12 rpm to 15 rpm.

c) The original radar RF switching unit is no longer retained. The new radar cabinets include new designed RF switching unit. The switching unit not only has the function of RF switching, but also includes the components such as circulators and filters.

d) The original radar antenna control unit is no longer retained. The built-in drive system of the new radar cabinet controls the work of the drive motor, which is composed of a control unit, a drive unit, and a touch screen. The new radar is compatible with the safety loop of the original radar system, and uses the antenna status and control signals (including oil level, safety door and sound and light alarm) provided by the original radar system to form a safety loop.

2.4 Compile the list of upgraded equipment in Mode S. The list is shown in the table below:

Table 2 Equipment list

No.	Unit	Model	Quantity	Remark
1	LVA Antenna	807480/001	1	original
2	Rotational Joint	LV 801-3-000-000A	1	original
3	ADGU	807014/004	1	original
4	Antenna Base	808168/001	1	original
5	Safety Unit	807007/002	1	original
6	Power Distribution Unit	AOH2.930.5031MX	1	new
7	Interrogator	AOH2.088.5672MX	2	new
8	Transmitter Unit	AOH2.807.5397MX	4	new
9	Transmitter Monitor	AOH2.900.5198MX	2	new
10	Receiver Unit	AOH2.026.5322MX	2	new
11	Interrogator Power	4NIC-SCQ495	2	new
12	Digital IF Components	AOH2.088.5368MX	2	new
13	Switching Unit	AOH2.154.5002MX	1	new
14	Ventilation unit	AOH2.503.5132MX	2	new
15	Communication Server	E.VOVLE-3	2	new
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2.5 Compile the radar working principle and signal flow chart after the upgrade.

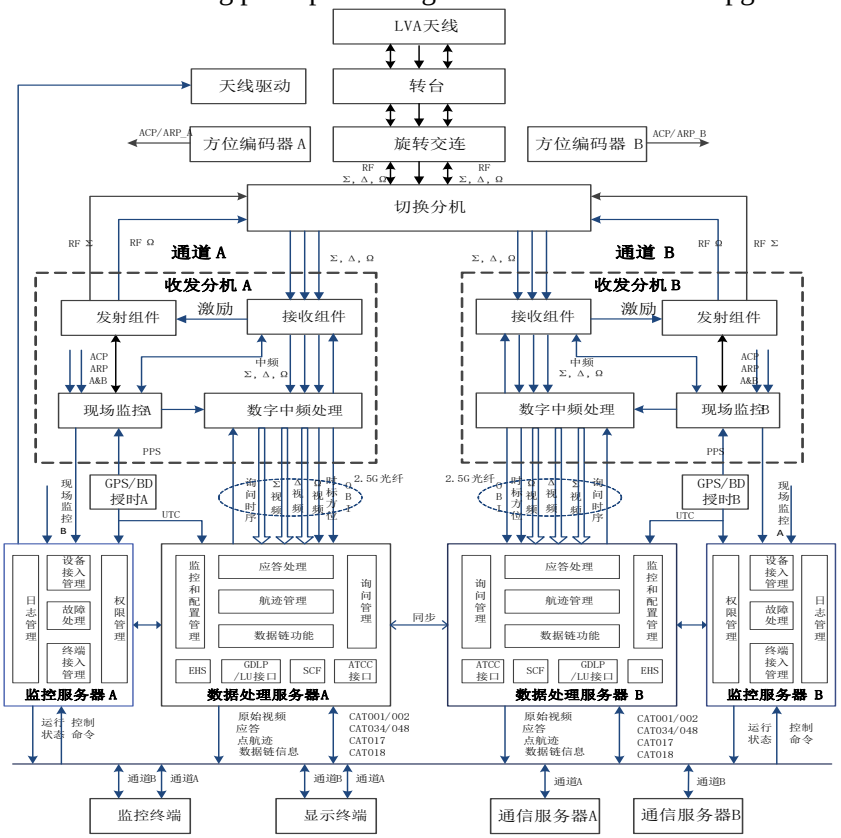

Figure 3 Radar system diagram after the upgrade

2.6 Compile the equipment software list after the upgrade. The list is shown in the table below:

Table 3 Software List

No.	Software
1	CMS Client Software
2	RMM
3	On-site Parameter Configuration Tool
4	CMS Server Software
5	Extractor Data Processing Software
6	Data Link Processing Software
7	Surveillance Coordination Processing Software
8	System Software Recovery Disk

2.7 Prepare a list of equipment documents and manuals after the upgrade. The list is shown in the table below:

Table 4 List of system documents

No.	Profile Name	Quantity	Remark
1	Radar technical specification	3	Including detailed system and subsystem technical manuals, system and LRU level circuit schematic diagrams, component block diagrams and component distribution diagrams.
2	Radar Instruction Manual	3	Including the installation, operation and instructions of the system and subsystems (including hardware and software), and the description of system parameter settings.
3	Radar Maintenance Manual	3	Including system and subsystem maintenance instructions; detailed steps for regular testing, inspection and adjustment of various equipment, and parameter setting; detailed operating procedures for maintenance work, solutions to common faults; detailed instructions for operation, maintenance, repair, and testing of important components such as rotary joint.
4	Radar Atlas	3	Including on-site installation wiring diagram, block diagram, power distribution system circuit diagram, etc.
5	Radar Software Installation CD	3	
6	Radar Software Recovery CD	3	
7	Radar Interface Control File	3	Describing in detail the physical characteristics, electrical performance and ICD descriptions of the radar data interface, interface data format and parameters, and provide a list of radar system CMS operations and parameter items.
8	Radar Test Equipment Brochure	3	Including additional test tools and accessories instructions

Radar System Optimization

3.1 On-site optimization of the system after the equipment installation and commissioning is completed. On-site optimization is to perfectly present the system performance at the equipment installation site to meet the design and user requirements. Mainly include:

a) Antenna pitch fine-tuning;
b) Radar north calibration;

c) Three-channel amplitude and phase correction ;
d) STC/PPC configuration;
e) Reflector scanning and parameter configuration of fixed reflection area and dynamic reflection area;
f) Parameter configuration for special areas such as air routes and airport areas;
g) SAC/SIC configuration;
h) Mode S interrogator code configuration;
i) Mode S interrogation strategy and interrogation mode configuration;
j) Mode S data format, data item configuration.