technical note technical note

Avian Radar Maintenance: Magnetron Life Assessment

January 2013

DOT/FAA/TC-TN12/60

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

This report is available at the Federal Aviation Administration William J. Hughes Technical Center’s Full-Text Technical Reports page: actlibrary.tc.faa.gov in Adobe Acrobat portable document format (PDF).

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/TC-TN12/60		

4. Title and Subtitle	5. Report Date
AVIAN RADAR MAINTENANCE: MAGNETRON LIFE ASSESSMENT	January 2013
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Wendell Bunch and Edwin E. Herricks	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Center of Excellence for Airport Technology Department of Civil and Environmental Engineering University of Illinois at Urbana Champaign 205 N. Mathews, MC-250 Urbana, IL 61801	
	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Federal Aviation Administration Airport Engineering Division (AAS-100) 800 Independence Avenue SW Washington, DC 20591	Technical Note
	14. Sponsoring Agency Code AAS-100

15. Supplementary Notes

The Federal Aviation Administration Technical Monitor for this project was Ryan King.

16. Abstract

Magnetrons are a critical component of current avian radar technologies, providing avian radar systems with the radio energy that is transmitted and received to identify targets. The current avian radar systems used in an avian radar performance assessment use X-band marine radars that are based on magnetron technology. Manufacturers recommend regular replacement of magnetrons to maintain radar detection effectiveness. The University of Illinois Center of Excellence for Airport Technology (CEAT) examined the operational life of magnetrons in 12 avian radar systems deployed as a part of an avian radar performance assessment program. Based on typical marine radar use, manufacturers recommend replacing magnetrons between 2,000 and 6,000 transmitting hours. However, CEAT found that magnetrons used in avian radar typically could be used for 12,000 hours of continuous operation before needing replacement. Therefore, CEAT recommends that avian radar users schedule magnetron replacement at approximately 12,000–15,000 hours, or every 18–24 months.

17. Key Words	18. Distribution Statement
Avian radar, Radar maintenance, Radar detection, Magnetron service life	This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	10	

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS

CEAT	University of Illinois Center of Excellence for Airport Technology
FAA	Federal Aviation Administration
JFK	New York John F. Kennedy International Airport
NASWI	Naval Air Station Whidbey Island, Oak Harbor, WA
ORD	Chicago O'Hare International Airport
SEA	Seattle Tacoma International Airport

EXECUTIVE SUMMARY

Magnetrons are a critical component of some current avian radar technologies, providing avian radar systems with the radio energy that is transmitted and received to identify targets. The current avian radar systems used in an avian radar performance assessment use X-band marine radars that are based on magnetron technology. Based on discussions with radar repair technicians and the experience University of Illinois Center of Excellence for Airport Technology (CEAT) has gained though the deployment of avian radar systems, it is suggested that the operational life expectancy of magnetrons in avian radar applications often greatly exceeds manufacturer-recommended replacement intervals, which are based on typical marine use. Data from CEAT's operational experience with avian radar systems support this finding. Considering CEAT's experience in preventative maintenance and in troubleshooting radar failure modes, CEAT suggests a preventative maintenance replacement for magnetrons in avian radar systems at approximately 12,000-15,000 hours, or every 18-24 months.

This technical note provides a summary of CEAT's maintenance experience with off-the-shelf X-band marine radars used in avian radar systems deployed at several airports. The objective of this technical note is to use CEAT's operational experience to develop maintenance requirements for magnetron-based avian radar systems used at civil airports.

INTRODUCTION

In 2006, the University of Illinois Center of Excellence for Airport Technology (CEAT) was tasked to develop a performance assessment program for commercially available avian radars by the Federal Aviation Administration (FAA) Airport Safety Research Program at the William J. Hughes Technical Center. The deployment of avian radars began in 2007 and includes avian radars at Seattle-Tacoma International Airport (SEA), Chicago O'Hare International Airport (ORD), New York John F. Kennedy International Airport (JFK), and the Naval Air Station Whidbey Island (NASWI) in Oak Harbor, WA. An avian radar system began operation at Dallas-Fort Worth International Airport in 2011, but was not included in this technical note because of its brief operational history.

As part of the overall performance assessment, CEAT kept records of the maintenance performed on the radar units deployed as part of avian radar systems, which include a radar unit and a radar digital processor. In total, CEAT has operated 15 radar units for time periods ranging from several months to more than 4 years. These radar units are commercial off-the-shelf X-band marine radars that use magnetrons to generate the necessary microwave radiation for target detection and tracking. Magnetrons use strong magnetic fields and high voltages to excite and release energy. The energy is emitted as microwave radiation, which is directed by the radar antenna. Over time, this operation results in a depletion of electrons from the cathode section of the magnetron. When the available electrons decrease, so do the energies emitted by the magnetron, which may produce degradation in detection performance. To ensure that sufficient performance capability exists in typical marine radar applications, the manufacturer recommends magnetron replacement intervals ranging from 2000-6000 transmitting hours. Although this replacement interval may be appropriate to shipboard operations (where radar transmissions are not continuous), the requirement may be too conservative for continuously operating avian radars. Based on discussions with radar repair technicians and CEAT's experience in avian radar system deployment, it was suggested that the operational life expectancy of magnetrons often greatly exceeds manufacturer-recommended replacement intervals.

Avian radars operate 24 hours a day, 7 days a week, and exceed 9000 total operational hours annually. A replacement every 4000 hours (i.e., 166 days of continuous operation) would require a minimum replacement of 2 magnetrons per year per radar unit used in avian radar systems. The average cost of a magnetron replacement, including associated labor, is approximately $1500, assuming that the repair technician is located within an hour of the radar site. Clearly, if magnetron performance exceeds manufacturer recommendations and a magnetron can be operated for longer periods of time before replacement, the expected maintenance costs for avian radars can be reduced.

This technical note provides a summary of CEAT's maintenance experience with off-the-shelf X-band marine radars used in avian radar systems deployed at several airports. The objective of this report is to use CEAT's operational experience to develop maintenance requirements for magnetron-based avian radar systems used at civil airports.

METHODS

Operational and maintenance logs from 12 radar units deployed in avian radar systems were reviewed by CEAT. These included radar units deployed at NASWI, SEA, ORD, and JFK. Radar unit operations meters, which provided information on hours-of-operation for the magnetron in each unit, tracked magnetron transmission time. Hours were tracked for the 12 radar systems that had at least a 3-year operational history or that had magnetrons replaced as a part of CEAT's ongoing maintenance program. The avian radar systems were supplied by Accipiter Radar Technologies, Inc., using a Furuno FR8252 X-band marine radar as the radar unit. Furuno's recommended magnetron replacement interval is 2000 transmitting hours for this radar. Maintenance records were reviewed for total operational hours at the time of replacement and the reason for replacement.

RESULTS AND DISCUSSION

Four radar units, the AR2C-2 at NASWI and the AR1, AR2-1, and AR2-2 units at JFK, had relatively short operational histories and did not require magnetron replacement. Eleven magnetrons were replaced in the other radar units, with three older units requiring more than one magnetron replacement. Magnetrons were replaced twice in the AR1-W, the AR2-S1, and the AR2-S2. The date of replacement, magnetron transmitting hours at the time of replacement, and the reason for replacement are provided in table 1. For all radar units assessed, the current average operational time recorded for magnetrons was 10,428.6 hours; continuous operation time for the radar units ranged from 4,312 to 15,517 hours at the time of this data compilation. The reasons for replacement included operational failure and preventative maintenance. Operational failure in the magnetron was confirmed for only one unit, the AR1-W, which was the first radar deployed in March 2007. Other replacements involved magnetron replacement when other radar components failed and the magnetrons were replaced as a part of standard repair procedures. The remaining replacements were associated with preventative maintenance. Average transmitting time for units experiencing system failure or as a result of replacement coupled with other maintenance was 12,196 hours. Excluding identified failures, the average operational time for the five magnetrons replaced in preventative maintenance was 13,695 hours. Current average transmit times on all systems is 6,358 hours.

Table 1. Replacement History of Magnetrons and Reason for Replacement on CEAT Avian Radars

Radar Unit	Date of Magnetron Change	Magnetron Hours	Reason for Change
NASWI			
AR1W (AR1C)	03/18/2009	14,712.7	Failure
	12/15/2009	6,600.0	Sensitivity loss
AR2C-1 (AR1W)	03/15/2009	14,088.0	No rotation
AR2C-2	None		
SEA			
AR2S-1	03/16/2009	13,381.3	Sensitivity loss
	12/22/2010	11,888.1	Preventative maintenance
AR2S-2	03/16/2009	13,321.5	Preventative maintenance
	12/28/2009	12,869.0	Preventative maintenance
AR1S	12/22/2010	15,517.0	Preventative maintenance
ORD			
AR1	04/05/2011	13,703.5	Preventative maintenance
AR2-1	04/05/2011	13,952.4	Preventative maintenance
AR2-2	04/05/2011	14,637.9	Preventative maintenance
JFK			
AR1	None		
AR2-1	None		
AR2-2	None		

Average Hours of Operation	Average Hours to Failure	Other Replacement Hours Average
10,428.60	12,196.0	13,695

CONCLUSIONS

The data from the University of Illinois Center of Excellence for Airport Technology's (CEAT) operational experience with avian radar systems suggest that manufacturer-recommended replacement intervals for magnetrons are too conservative. CEAT's maintenance records did identify a single magnetron failure in as little as 6600 hours. However, in general, magnetrons were still producing acceptable performance with longer operational times of up to 15,000 hours. This far exceeded the manufacturer's recommendation for the specific radar units used in the study. Considering experience in preventative maintenance and experience gained in troubleshooting radar failure modes, CEAT suggests a preventative maintenance replacement for magnetrons used in avian radar applications at approximately 12,000 hours or every 18 months.