U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

Subject: Airport Avian Radar Systems | **Date:** DRAFT | **AC No:** 150/5220-25
Initiated by: AAS-100 | **Change:**

1. PURPOSE. This advisory circular (AC) provides guidance on the use of avian radar systems to supplement an airport's wildlife hazard management program and reduce the potential wildlife threats to aircraft.

2. SCOPE. This AC describes how airports can select, procure, deploy, and manage an avian radar system. A chapter dedicated to each of the program areas is provided, as shown in the summaries below:

- Selection: Chapter 3 – Describes the factors that must be considered when choosing the proper system for a given set of airport conditions and requirements.
- Procurement: Chapter 4 – The minimum performance standards for airport avian radar systems are provided.
- Deployment: Chapter 5 – Discusses the process of installing a system in the location best suited to maximize system capabilities.
- Management: Chapter 6 – Outlines the effective use of avian radar system data using the fundamental principles of risk management.

The guidance in this AC is applicable to airport owners and operators, with the resultant program information impacting air carrier station managers and general aviation operators.

This AC is based on research conducted by the Federal Aviation Administration (FAA) Airport Technology Research and Development Program and the University of Illinois Center of Excellence in Airport Technology (CEAT) to examine the performance of several new avian radar technologies.

3. APPLICATION. The Federal Aviation Administration (FAA) recommends the guidance and specifications in this Advisory Circular for deploying and managing an avian radar system at an airport. In general, use of this AC is not mandatory. However, use of this AC is mandatory for the acquisition of avian radar systems through the Airport Improvement Program (AIP) or the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, *Policies, Standards, and Specifications*, and PFC Assurance No.9, *Standards and Specifications*.

4. COMMENTS OR SUGGESTIONS for improvements to this AC should be sent to:

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CHAPTER 1. TERMINOLOGY AND REFERENCES

1.1. DEFINITIONS.

a. Air Operations Area (AOA). All airport areas where aircraft can operate, either under their own power or while in tow. The AOA includes runways, taxiways, apron areas, and all unpaved surfaces within the airport's perimeter fence.

b. Airport Apron. A surface in the AOA where aircraft park and are serviced (refueled, loaded with cargo, and/or boarded by passengers).

c. Airport Ramp. See Airport Apron.

d. Avian Radar System. An avian radar system that integrates sensor data, data processing (including digitization), data management, and data display.

e. B-scan. Bearing scan designed to convert a polar-sampled image into a Cartesian format while retaining integrity of the geometry and content of the image. In radar this provides range, azimuth, and intensity data from radar in Cartesian coordinates.

f. Clutter. Undesired echoes returned from radar transmissions.

g. dBm². Decibel per meter squared, a measure of equivalent energy reflected by the target:

$$\text{RCS (dBm}^2) = 10 \cdot \log_{10}(\sigma/1\ \text{m}^2)$$

The reference point, 0 dBm, is defined as 1 milliwatt of electrical power dissipated by a 600 Ω load. According to this scale, 10 dBm is equal to 10 times the reference power, or 10 milliwatts; 20 dBm is equal to 100 times the reference power, or 100 milliwatts.

h. False negative. Failure to declare a target when a target is actually present, or failing to provide an alert, when a target alert is warranted.

i. False positive. Declaring a target, or providing an alert, when no target is present.

j. Hazard. A condition, object or activity with the potential for causing damage, loss, or injury.

k. L-band. Radar frequency in the 1-2 Ghz range, typical wavelength 23 cm.

l. Manufacturer. The manufacturer, distributor, lessor, or supplier of an avian radar system and/or associated support equipment. This includes any provider of an airport's wildlife hazard management program that incorporates an avian radar system.

m. Quality Assurance Plan (QAP). A part of a quality assurance program that contains detailed requirements and standards in order to assure that minimum standards of performance are met through quantitative measurement.

n. Radio signal. Electro-magnetic radiation consisting of a defined frequency and/or waveform.

o. Real-time. Update of data at the same time that it is generated; providing a steady flow of information.

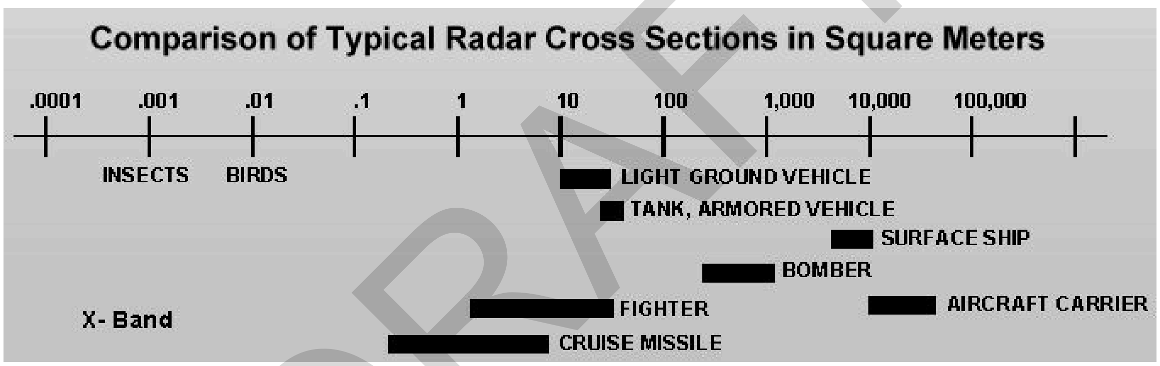
p. RCS. Radar cross section, a measure of target reflectivity based on the power equation: RCS of a radar target is the hypothetical area required to intercept the transmitted power density at the target such that if the total intercepted power were re-radiated isotropically, the power density actually observed at the receiver is produced. This is a complex statement that can be understood by examining the monostatic (radar transmitter and receiver co-located) radar equation one term at a time:

$$P_r = \frac{P_t G_t}{4\pi r^2}\sigma\frac{1}{4\pi r^2}A_{eff}$$

where:

P_t = power transmitted by the radar (watts)
G_t = gain of the radar transmit antenna (dimensionless)
r = distance from the radar to the target (meters)
σ = radar cross section of the target (meters squared)
A_{eff} = effective area of the radar receiving antenna (meters squared)

- P_r = power received back from the target by the radar (watts)



q. Risk. The chance of loss or injury measured in terms of severity (or hazard) and probability (or frequency).

r. S-band. Radar frequency in the 2-4 Ghz range, typical wavelength 10 cm.

s. Standard Avian Target (SAT). A theoretical object used as a standard for evaluating the performance of avian radar systems. The SAT has the following characteristics, which approximate the physical features of an average crow: a Radar Cross Section (RCS) of -16 dBm^2; and a mass of 1.1 lb (.50 kg).

t. X-band. Radar frequency in the 8-12 Ghz range, typical wavelength 3 cm.

1.2. ACRONYMS AND TERMS.

ACM	Airport Certification Manual
ATIS	Automatic Terminal Information Service
DRSP	Digital radar signal processor

FAA	Federal Aviation Administration
GIS	Geographic Information System
ICAO	International Civil Aviation Organization
ISP	Internet service provider
PPI	Plan position indicator
QAP	Quality Assurance Plan
RDBMS	Relational Database Management System
RF	Radio frequency
TDV	Track Data Viewer
TVW	Track Viewer Workstation
UPS	Uninterruptable power supply
AGL	Above Ground Level
ARL	Above Radar Level
ASCII	American Standard Code for Information Interchange
CBS	Crow Biomass Standard
CFAR	Constant False Alarm Rate
CONOPS	Concept of Operations
COP	Common Operational (or Operating) Picture
COTS	Commercial Off-The-Shelf
dBms	Decibel per square meter
DRSP	Digital Radar Processor
FTR	Firm Track Range
GHz	10^9 cycles per second
GIS	Geographical Information Systems
GMT	Greenwich Mean Time; see also UTC
GPS	Global Positioning System

GUI	Graphical User Interface
IVAR	Integration and Validation of Avian Radars
KML	Keyhole Markup Language
LAN	Local Area Network
NEXRAD	Next Generation Weather Radar
NTP	Network Time Protocol
nm	Nautical Mile
RCS	Radar Cross Section
RST	Radar Sensor Transceiver
SMS	Safety Management Systems
TB	Terabyte
TDWR	Terminal Doppler Weather Radar
UAV	Unmanned Aerial Vehicle
UTC	Coordinated Universal Time
WAN	Wide Area Network
WiFi	Wireless Fidelity
WGS84	World Geodetic System, 1984 Revision

1.3. APPLICABLE DOCUMENTS.

The following documents form part of this specification and are applicable to the extent specified:

a. FAA Orders, Specifications, Drawings, and Advisory Circulars (ACs).

AC 150/5200-18	*Airport Safety Self-Inspection*
AC 150/5200-32	*Reporting Wildlife Aircraft Strikes*
AC 150/5200-33	*Hazardous Wildlife Attractants On or Near Airports*
AC 150/5300-13	*Airport Design*
Order JO 7110.65	*Air Traffic Control, Bird Activity Information*

AIM, Section 7-4-6	*Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures. Flights Over Charted U.S. Wildlife Refuges, Parks, and Forest Service Areas*,

b. Industry Publications.

Herricks, E.E. and Key, G.	*Avian Radar Systems*
Gauthreaux, S.A.	*Radar Ornithology – The Past, Present, and Future: A Personal Viewpoint*
Skolnik, M. I., ed.	*Radar Handbook*

c. Sources.

(1) FAA ACs may be obtained from: U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave., Landover, MD 20785. Telephone: (301) 322-4961, FAX: (301) 386-5394, website: www.faa.gov

(2) FAA Orders, Specifications, and Drawings may be obtained from: Federal Aviation Administration, ATO-W CM-NAS Documentation, Control Center, 800 Independence Avenue, SW, Washington, DC 20591. Telephone: (202) 548-5502, FAX: (202) 548-5501, website: www.faa.gov/cm/dcc

(3) Herricks, E.E. and Key, G., *Avian Radar Systems*, International Airport Review, Vol. 6, 2007, pp. 56-59.

(4) Gauthreaux, S.A., *Radar Ornithology – The Past, Present, and Future: A Personal Viewpoint*, Applying Radar Technology to Migratory Bird Conservation and Management: Strengthening and Expanding a Collaborative, Ruth, J.M., ed., Open-File Report 2007–1361, 2007, pp. 50-54.

(5) Skolnik, M. I., ed., *Radar Handbook*, Second Edition, McGraw-Hill, New York, 1990, pp. 6.8.

(6) [2] *USDA Wildlife Services Protects Property*, US Department of Agriculture Animal and Plant Health Inspection Service, FY 2004. This is available online at www.aphis.usda.gov/ws/ca/usda_fact_sheets/usda_fact_sheet_property_protection.pdf

(7) [3] Klope, Matthew W., *Bird Aircraft Strike Hazard (BASH) Prevention Program*, Naval Safety Center, undated. This is available online at www.safetycenter.navy.mil/aviation/operations/bash/newsletter.htm

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CHAPTER 2. INTRODUCTION

2.1. GENERAL.

The importance of wildlife management and how it affects aircraft safety has been well documented. Wildlife hazards include many different species of animals with birds the most common hazard and the primary focus of aviation safety. The proper management of wildlife on and around airports can do much to reduce the risk of bird strikes, which damage planes and threaten the lives of passengers, air crews, and birds, including protected species. In support of these goals, specific radar-based detection systems have been developed to support two critical efforts: the monitoring of bird movements in support of wildlife management programs and the surveillance of airspace to identify potential threats to the safe operation of aircraft.

2.2. SYSTEM BENEFITS AND LIMITATIONS.

a. Benefits. In the past, the only tool available at airports to perform these monitoring and surveillance tasks was limited to human observation by airport personnel. These individuals then had to manually document wildlife species and numbers and perform in-depth scientific investigations on the results to obtain useful, actionable, information. With the advent of radar technologies and the availability of relatively inexpensive radar systems, a new tool was introduced to airports to aid in their wildlife hazard mitigation program.

(1) Avian radar provides an opportunity to extend observational capabilities to around-the-clock operation and the ability to expand spatial coverage in both distance and altitude. For example, avian radars can be used in a surveillance mode for providing coverage of approach and departure corridors. This surveillance will improve understanding of bird movement dynamics in critical corridors and help in assessing the real threat to aircraft safety posed by birds. Because avian radars significantly expand the capabilities of wildlife managers to observe bird movement and dynamics on and around the airport, avian radars can immediately meet the needs of wildlife management programs. Wildlife management may use avian radar systems to monitor the movement dynamics of wildlife on and around the airport, providing consistent information for trend assessments, identification of areas for focused management, and – depending on airport communications capabilities – information about active wildlife management efforts at the airport.

(2) While providing a tremendous resource, the effective management of avian radars at civil airports is a complex process. The successful use of avian radars therefore requires a clear understanding of the system's capabilities and limitations as well as its physical, technological, and personnel requirements.

b. Limitations. Avian radar is a tool that can be used to improve safety at airports. However, radar as a technology is subject to technological, as well as physical, limitations. The two primary limitations occur as a result of the physics underlying the transmission and reception of the radar pulse. The first phenomena include the generation of erroneous returns, or echoes, and the second phenomena involves the time-delay observed during object detection. A radar operator must therefore have a clear understanding of what the radar is "seeing" to distinguish bird tracks from tracks produced by insects, airport vehicles, multiple echoes, or objects no longer in the expected position due to time-lag. A lack of training and poor interpretation of the radar screen can result in the most severe limitation of any technology – bad data.

(1) Erroneous returns. The physics of the RF signal, the transmission characteristics of that signal, the antenna that sends and receives the signal, and the sensitivity of the receiver all influence detection capability and the tracking of targets. A radar's beam-width detection capability is related to the energy of the radar antenna's beam and the characteristics of the target. Unpredictable data can sometimes be generated and are exhibited when large targets are detected well outside a radar antenna's expected beam geometry, and energies from the beam (due to side-lobe energies) sometimes create echoes from unexpected places. Other types of interference can occur during the movement of large aircraft on the ground at slow speeds, which can produce multiple echoes (multipath interference) and potentially misleading track information.

(2) Time-delay. Avian radar has time limitations in terms of response times for target identification and tracking. Because the technology relies on a rotating beam and computer computations, there are lags between an echo return, detection, and eventual display. Users must be aware that a displayed target may no longer be in the location identified by the radar at that time. For example, the relative closing velocity of a bird and an aircraft is very rapid. A closing velocity of 250 mph covers a distance of over 350 ft, the length of a football field, in a second. If the antenna is rotating 24 times a minute, once every 2.5 seconds, and there is time needed for digital processing, a 3- or 4-second delay in target acquisition translates to a 1/4 mile of distance traveled by an aircraft. This is a critical issue that impedes the use of current avian radars as sense-and-alert systems in the air traffic control environment, where the rapid verification of targets, position, and direction of movement is needed in order to warn of imminent bird/aircraft collision threats.

(3) Site limitations. In addition, the construction requirements on airports present limitations on where the radar system can be installed. Since safety areas are critical areas where obstructions to aircraft must be limited, installations in the most ideal locations to maximize performance may not be possible. Radar technologies are also bound by physical laws that require line-of-site positioning and adjustment of radar radio frequency (RF) characteristics to the airport environment where multiple permanent and mobile reflectors of RF energy challenge the interpretation of radar information.

c. In summary, the applications and limitations of avian radars are still being discovered. At this time, the advantage to understanding the movement dynamics of birds on and around the airport outweighs the limitations identified for this technology. The FAA and University of Illinois radar performance assessments have shown that avian radars can provide much needed information to wildlife management programs. Radars have revealed unexpected patterns of movement and have confirmed existing assumptions underlying wildlife management programs. Although not yet sophisticated enough for time-sensitive applications such as sense-and-alert to warn of imminent bird/aircraft collision threats, the radars are improving information resources on wildlife movement, leading to improvement in the quality of the threat condition information at airports. In providing improved information on wildlife movement and dynamics, avian radars are constantly redefining their future role in wildlife management and airport operations.

2.3. Regulatory Requirements.

a. The need for wildlife hazard management at certificated airports is based on the requirements outlined in 14 CFR Part 139, *Certification of Airports*. The presence of wildlife in the airport environment is discussed in §139.339, and if certain conditions are met, requires airports to conduct a wildlife hazard assessment and/or implement a wildlife hazard management plan. Both the assessment and management plans require the observation of wildlife populations and types that pose a threat to aircraft. It should be noted that while Part 139 requirements are mandatory for a holder of a Part 139 Airport Operating Certificate, the regulation contains many safety practices the FAA recommends for use at all airports.

b. Other FAA guidance documents, such as the Bird Activity Information section (2-1-22) of FAA Order JO 7110.65S *Air Traffic Control*, tasks air traffic controllers to issue advisory information on "pilot-reported, tower-observed or radar-observed and pilot-verified" bird activities. Also, the FAA *Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures* (AIM), Section 7-4-6, *Flights Over Charted U.S. Wildlife Refuges, Parks, and Forest Service Areas*, details current FAA procedures regarding wildlife hazards. Current instructions to pilots focus on general awareness of possible wildlife hazards and protocols for dealing with wildlife encounters that threaten the aircraft. AIM directs pilots to reduce bird strike risks through (1) avoidance, through the implementation of strategies such as minimizing en-route flight at lower elevations during migratory months, avoiding over flight of known areas of bird concentration, and climbing to avoid collision with birds encountered en route, and (2) review of emergency procedures for wildlife encounters that threaten aircraft, including engine ingestion, engine-out, and windshield strike. AIM also notes that pilots may be advised of bird activity at specific airports through the Airport/Facility Directory and the NOTAM system.

c. International regulations also discuss the issue of wildlife hazard management in airports. ICAO Annex 14, Aerodrome Design and Operations, Section 9.4 (Wildlife Strike Hazard Reduction), states that "Action shall be taken to decrease the risk to aircraft operations by adopting measures to minimize the likelihood of collisions between wildlife and aircraft" (9.4.3). Additionally, in the ICAO Airport Services Manual (Doc 9137), Part 3, guidance is provided on the effective measures for establishing whether or not wildlife, on or near an aerodrome, constitute a potential hazard to aircraft operations, and on methods for discouraging their presence.

2.4. Avian Threats to Aircraft.

a. In 2009, the ditching of U. S. Airways 1549 and a series of other serious bird/aircraft collisions created greater awareness of the hazards that bird strikes present to aircraft safety. Those public incidents, however, represent only a fraction of the total wildlife strikes to aircraft. Under the current voluntary reporting system, more than 7,000 strikes across the United States are reported annually to the Federal Aviation Administration (FAA). Compared to aircraft or other moving objects, the rapid changes in the altitude, speed and direction of birds and migratory flocks present challenges to the development of sensors and operational procedures aimed at enhancing safety in the United States National Airspace System (NAS).

b. Beyond the threat posed to human life by aircraft collisions with birds and other wildlife, the cost of direct and incidental damages is high. Estimates vary, but the US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) has placed costs at approximately $500 million annually. [2] Reporting on bird strikes alone, the Naval Safety Center Bird Aircraft Strike Hazard (BASH) Prevention Program estimates more than $310 million in direct damage to aircraft since 1980. [3]

c. The risk of wildlife strikes to aircraft has been trending upward for the past three decades, driven by:

(1) Growing populations of many large bird species.

(2) Adaptation of hazardous bird species to urban environments, including airports.

(3) Increased commercial air traffic consisting of aircraft with two, rather than four, engines.

(4) Increases in the number of potentially more vulnerable regional jets, which transit a greater proportion of their time in the lower altitudes than long-haul aircraft.

d. Public awareness of the threat that birds can pose to aircraft is now high, and there have been recommendations by the National Transportation Safety Board and calls to action by the public related to wildlife management. However, the FAA, aviation industry professionals and others have, for decades, been addressing the complex problem of bird and other wildlife hazards in the airport environment through the development, testing and implementation of management techniques including harassment and habitat modification.

2.5. Avian Radar Fundamentals.

a. Functional Principles. Avian radar operates on a relatively simple concept. An energy wave, or radio signal, is generated and transmitted through an antenna. A portion of the radiated signal is then reflected from surrounding objects and returns to the system. That returned signal (also called an echo) is in an analog form, so it is then processed several times, first into a digital signal, then refined to remove clutter (such as noise and other interference), and finally to identify, process, and plot a target.

b. Basic System Components.

(1) The major components of any avian radar system are a radar unit, a scanning unit / antenna, a digital radar signal processor (DRSP), and a visual display. Figure 2-1 shows how each of these units are positioned in a functional diagram.

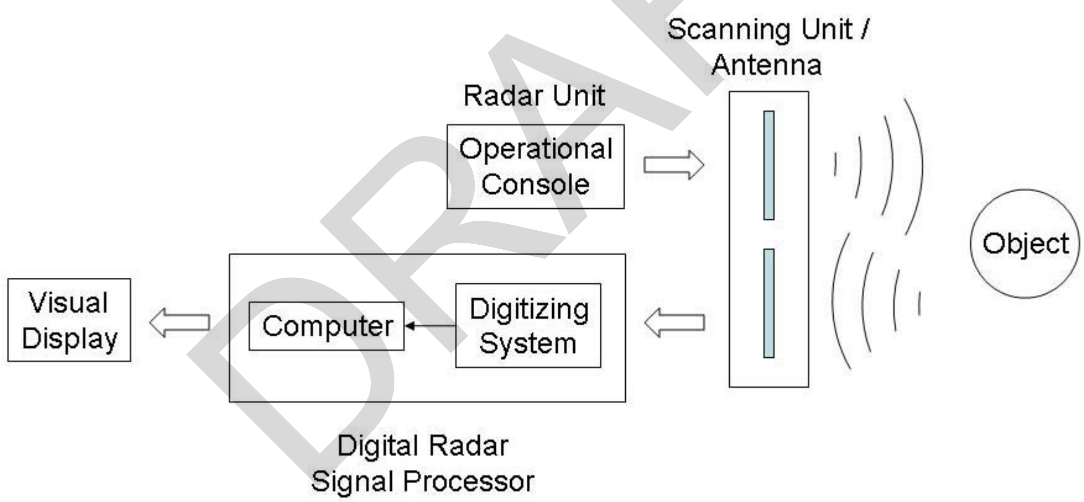


Figure 2-1. Basic Radar System Components

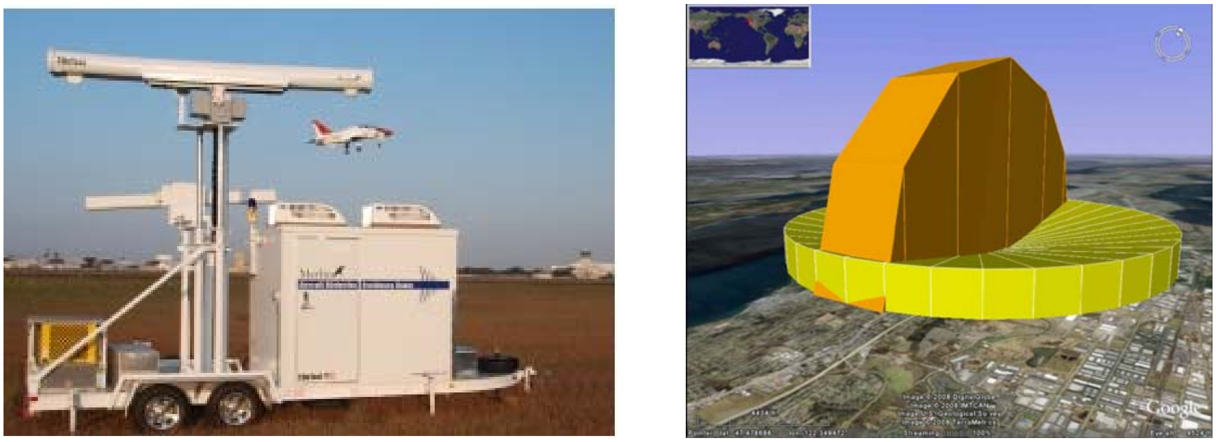
(2) Radar Unit. The radar unit consists of an operational console containing a plan position indicator (PPI) screen. As shown in figure 2-2, the console is used to adjust power/range settings, antenna rotation speed, and PPI display characteristics.

Figure 2-2. A Radar Operational Console

(3) Scanning Unit / Antenna.

(a) The scanning unit contains, and controls, the system's transmitting and/or receiving antennas. The antenna is designed to spatially form a directive beam to scan the surrounding area. Depending on the operational objectives, the antenna can be rotated mechanically or electronically in the vertical or horizontal directions to obtain the desired data. For avian radars, there are two general types of antennas – the slotted array antenna and the parabolic dish antenna.

(b) **Slotted Array Antenna.** The detection volume of an array antenna spinning in a horizontal plane is defined by the antenna design, usually 1-2 degrees wide and 10 or more degrees up and down from horizontal. Because the lower part of the beam contacts the ground at short ranges as a function of antenna height above ground, the detection volume will depend on the upper part of the beam. At 3 miles, a 2- by 10-degree beam produces a volume of detection of approximately one-tenth of a mile wide and one-half a mile high. Any target in that volume, whether close to the ground or at altitude, will be shown on the PPI in the 3-mile range band. For this reason, slotted array antennae provide range and bearing, but no altitude information, when spinning in the horizontal plane. Alternately, when oriented to spin (about the horizontal axis) in the vertical plane, azimuth and range can be converted to altitude and ground range. Figure 2-3 shows an example of a slotted array antenna, and the representative coverage of the array antennae spinning in both the vertical and horizontal rotation modes.



(a) A slotted array antenna

(b) Coverage of the Array Antennae in Vertical and Horizontal Alignment

Figure 2-3. Slotted Array Antenna

(c) **Parabolic Dish Antenna.** Parabolic dish antennae project a defined conical beam so simple geometric calculations, using beam characteristics and antenna orientation, can be used to provide both range and altitude information. The detection volume of the parabolic dish is a function of the conical beam width, which is typically 2 to 5 degrees. The parabolic dish can be set to rotate at any angle between 0 and 90 degrees above the horizon. Therefore, by adjusting the antenna at prescribed angles one can determine the known height of the beam at a given range, yielding an estimate of target altitude. Figure 2-4 shows an example of parabolic dish antennae, and a coverage volume produced with a beam width of 4 degrees.

(a) A parabolic dish antenna

(b) Representations of Dish Antenna Coverage as a Single Cone (Left) and the Full Volume Covered as the Dish Rotates (Right)

Figure 2-4. Parabolic Dish Antenna

(4) Digital Radar Signal Processor (DRSP).

(a) The Digital Radar Signal Processor (DRSP) is the core of the modern avian radar system. Components include a digitizing system to transform the analog signal data into digital data, and a computer that uses the digitized data to reject clutter, process target detections, and plot target tracks. The flexible presentation of radar data achieved by the DRSP eases the workload of operators in the analysis and interpretation of radar information.

(5) Visual Display.

(a) In avian radar systems, the user is provided with a computer screen displaying a map with various overlays, as selected by the user, containing radar-tracking data from the DRSP. Used in conjunction with the PPI display of "raw" sensor data, one can easily compare the processed and raw images to verify that accuracy of information provided. Figure 2-5 shows a sample display containing DRSP-processed track information.

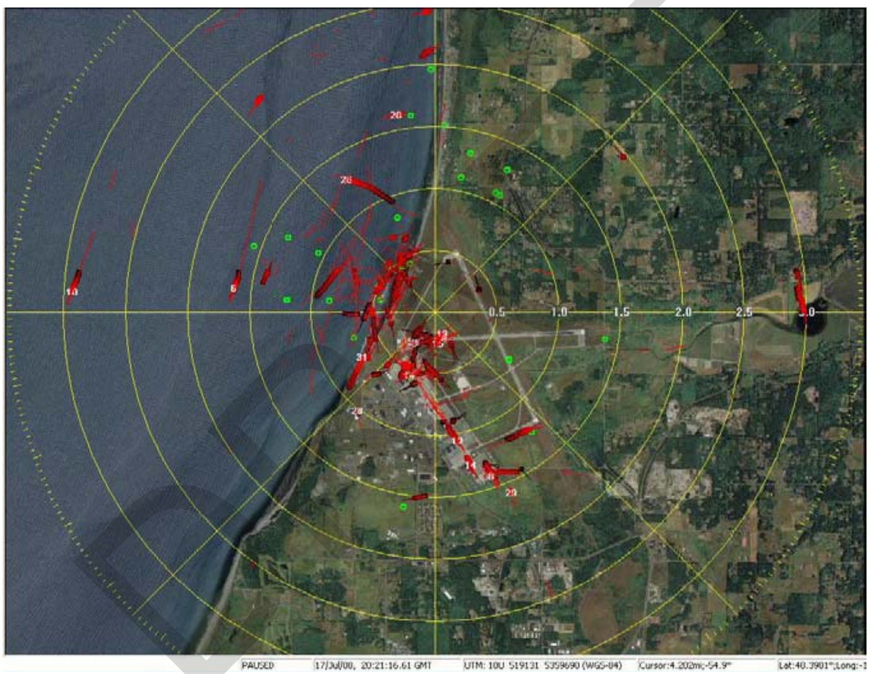


Figure 2-5. Radar DRSP Showing Detected Movements on a Geographically Referenced Screen

2.6. System Implementation Overview.

a. The successful implementation of avian radar at an airport requires significant effort in several different stages within a wildlife hazard management program. The following chapters in this AC correspond to the principal implementation stages, and contain information designed to help airports make the best decisions possible at each stage. A robust implementation plan typically consists of the following stages:

(1) Selection (Chapter 3): Consists of a needs assessment and objective setting to develop system performance requirements. These activities will require careful consideration and involve airport personnel, agency involvement, and possibly manufacturer participation to define technological capabilities and equipment selection.

(2) Procurement (Chapter 4): Specific equipment performance standards are provided. Since the current avian radar market does not support off-the-shelf solutions, avian radars are often purpose-built with sensors and associated systems configured specifically for an airport. Identifying the critical performance requirements for a given airport situation is therefore fundamentally important to future success.

(3) Deployment (Chapter 5): Consists of two primary elements, site selection and installation.

(a) Site Selection. The site selection process is a critical element of eventual avian radar performance. A possible conflict arises because it is necessary to conduct preliminary testing of radar at an airport before a site is selected and FAA installation forms (i.e. Form 7460) can be submitted.

(b) Installation. Following site selection, the avian radar must be installed. Although physical placement of the radar system may take only a few days, a complete installation will require set-up procedures adopted by the manufacturer and then acceptance testing by the airport. Once operational, performance criteria may require test and validation under a variety of weather conditions.

(4) Operation and Data Analysis (Chapter 6): Contains information typical applications of avian radar systems in the airport environment, an overview of data usage and analysis, including the risk assessment process, and suggestions for continuous program improvement.

CHAPTER 3. SYSTEM SELECTION

3.1. AIRPORT NEEDS ASSESSMENT.

a. Conducting a needs assessment is the first step in defining the performance requirements for the selection of an avian radar system. Given the diversity of potential expectations for avian radar, a careful review of needs should be conducted by the airport as an essential step in the planning process. Identifying needs provides the foundation for seamless integration of avian radar technology into an airports wildlife hazard mitigation program. Typical needs that might be identified include:

- Developing a continuous surveillance program for aircraft approach and departure corridors.
- Improving a general understanding of bird movement and dynamics in relation to aircraft movement.
- Improving assessment of wildlife hazards considering issues such as potential altitudes of collisions or velocity and damage potential.
- Identifying bird movement periods and locations that can be used in planning departure times or departure paths.
- Developing an improved wildlife management program based on around-the-clock observations.
- Identifying management problem areas considering bird utilization of airport buildings or structures.
- Identifying management problem areas considering the origin, destination, and timing of transient birds.
- Providing real-time access of radar information to operations staff on the airport to improve response times to identified wildlife hazards.

b. The typical needs assessment will place a higher priority on the threat assessment, but currently available avian radars are more appropriately used to address the needs of wildlife management. As a component of the threat management system for aircraft operations, avian radars at civil airports cannot be expected, at this time, to contribute to improved safety by providing a sense-and-alert system that will warn of imminent bird/aircraft collision threats. However, avian radars can provide valuable real-time information to improve airport safety. For example, a real-time indication of the concentration of birds at a location can guide wildlife managers to the site to disperse these birds.

c. The deployment of an avian radar system at a civil airport is a complex undertaking that includes preliminary site selection decisions, actual deployment, operations, maintenance, data analysis, management, and information dissemination. Although this document provides a general protocol for avian radar deployment and addresses a wide range of issues associated with radar use in the complex environment of a typical civil airport, the actual activities that must be completed for avian radar deployment will be site- and situation-specific.

3.2. SETTING OBJECTIVES.

a. After a needs assessment has been conducted, setting objectives is the logical next step in the development of system performance requirements. A clear statement of objectives refines the needs assessment, identifies the requirements for avian radar selection, defines operational characteristics and procedures, and identifies specific information products.

b. The following is an example of a general objective and more specific sub-objectives for the use of avian radar in wildlife management.

(1) Objective. Operate an avian radar system to support the management of wildlife at the airport. The avian radar system will be used to collect and process data to provide information that will support the accomplishment of the following sub-objectives.

(2) Sub-objectives:

(a) Identify the dynamics, timing, and trends of bird presence, movements, abundance, and behavior on and around the airport.

(b) Identify wildlife activity and use patterns on and around the airfield (i.e., loafing/roosting sites, location of source populations, movement patterns) with an emphasis on night hours.

(c) Identify the origin and destination of birds tracked by the radar outside the airfield.

(d) Identify target by bird category (e.g., single versus flock, small versus large).

(e) Determine relationships between habitat characteristics and bird activity at problematic locations.

(f) Reinforce wildlife hazard management recommendations made to airport officials by the wildlife biologists.

(g) Provide a foundation for a long-term regional analysis of avian presence on and near the airport.

(h) Provide information needed to develop management options for hazardous conditions that exist beyond the influence of common airport management techniques.

(i) Compare radar data and existing wildlife observational programs to identify hazards potentially undetected by traditional wildlife hazard management. Identify new wildlife hazards on the airport.

(j) Conduct frequent calibrations of the radar system.

(k) Validate and verify radar performance considering both range and altitude of targets.

3.3. BIRD MOVEMENT PATTERNS AND RADAR COVERAGE REQUIREMENTS.

a. As uncooperative targets, birds present hazards to aircraft that can be related to mass, behavior, and life history. Further complicating the ability to mitigate bird hazards is the fact that the movement patterns displayed by a given species will vary based on season and flock origin. Subsequently, the radar coverage area requirements for studying an individual or group of birds may be tremendous, and cannot be met with a single system. Indeed, true regional coverage requires an integrated network of avian radars. To focus on the actual area that can be studied with equipment operated directly by airports, the following bird patterns and corresponding coverage areas are provided as a general guide. In the future, technological innovations and information coordination among various stakeholders may someday allow the ability to capture and use data from all three categories.

(1) Migrating Birds / Regional Radar Coverage.

(a) Migrating birds move seasonally over long distances. Typically migrations occur below 5000 ft, but migrating birds may be present at altitudes in excess of 10,000 ft.

(b) Regional Coverage - Regional radar coverage is needed to detect migrating birds, which will alert ATC personnel and pilots to expected flight altitudes and relative density of birds at those altitudes and provide warnings for airport controllers of possible future conflicts with airport operations. At present, weather radars can provide this coverage, and research is continuing on the interpretation of bird migrations using these radars. It may be possible to adapt Terminal Doppler Weather Radars for bird-target identification and tracking. Advisory Circular guidance is needed to integrate radar information into air traffic control altitude assignments and generally improve situational awareness of birdstrike hazards for in-transit aircraft.

(c) The detection of migrating birds will require a radar that scans a hundred or more miles to altitudes in excess of 10,000 ft. The radar for migrant detection need not be on the airport, and multiple radars may be needed for good regional coverage. Possible candidates include NEXRAD and TDWR radar systems.

(2) Commuting Birds / Local Coverage.

(a) Local commuting birds show daily movement patterns in local (airport) to regional scales (5 – 20 miles from an airport). Commuters will move from roosting and loafing sites to feeding locations at altitudes from ground level to several thousand feet.

(b) Local Coverage - In the local area, out to approximately 20 miles from an airport, it is important to provide detection and tracking of migrating and commuting birds that may conflict with airport operations. A regional radar can provide needed information for in-transit aircraft and warnings about potential conflicts with aircraft. The radar capabilities required include good altitude discrimination and systems support to identify and track threats to an airport's defined approach and departure paths. AC guidance is needed to improve local radar coverage to support rapid and reliable predictions used to advise ATC personnel about hazards in approach and departure paths.

(c) To detect commuting birds, a radar should be located at or near the airport and must effectively scan altitudes up to several thousand feet to a range of 10 to 20 miles. Possible candidates include TDWR, modification of existing airport surveillance radars, or development of a dedicated bird radar.

(3) Resident Birds / Airport Coverage.

(a) Resident birds remain local to a site and may nest or roost on or near airports. Resident birds forage locally and typically fly under 1000 ft., although soaring birds may reach high altitudes.

(b) Airport Coverage – Airport coverage is needed because bird strike data indicate that 90% or more of bird strikes occur below 3000 ft agl, 80% occur on or near the airport surface (citation). Aircraft taking off and landing are the most vulnerable to bird strikes. Avian radars at airports must serve two purposes. The avian radar installation should support an effective and sustained wildlife hazard management program and contribute to the improvement of airport operations (including air traffic control). Real-time information on the status of bird activity can direct wildlife managers to locations where dispersal will eliminate hazards. The same real-time information, supported by well-developed operational procedures, provides ATC personnel with defined options for safety management on and around the airport. Just as real-time information is critical, the use of radar data to identify trends is critical to the development and implementation of airport safety management systems that consider seasonal to daily patterns of bird movement. Wildlife managers can use information on movement dynamics to identify areas as well as times for mitigation. ATC personnel can use trend information to provide accurate and timely alerts to pilots about wildlife hazards on and around the airport. Because basic airport radar data, when effectively processed and archived, can provide real-time and historical information, it is possible to operate avian radars in a way that provides critical information at all levels of airport operations.

(c) For resident birds, the radar should be located on the airport, scanning from the ground to several thousand feet to a range of 5 miles. Possible candidates include several commercially available avian radar systems.

3.4. ADDITIONAL SYSTEM CONSIDERATIONS.

a. Major advances in avian radar technologies provide airports with a wide range of pricing and performance options. An airport operator can identify any specific performance standards based on a number of factors to meet their unique needs and requirements. Some of the factors that may be considered are the:

(1) Local and regional geography (such as the proximity to bodies of water, where wave action can produce clutter),

(2) Number, types, and movement patterns of bird species,

(3) Number and type of aircraft operating,

(4) Number and size of surveillance areas,

(5) Location of surveillance areas (and their horizontal/vertical distance from the sensor),

(6) Radar precision/sensitivity (generally, an increase in detection precision/sensitivity will also increase the rate of false positives/negatives),

(7) Radar maintenance requirements,

(8) Airport climate (sensors generally operate most effectively under clear and dry conditions - heavy rainfall or snow can degrade sensor effectiveness), and

(9) Ability of personnel to respond to alerts.

3.5. EQUIPMENT CONSIDERATIONS.

a. Adaptation of Marine Radar Technology.

(1) Radar systems designed specifically for the detection and tracking of bird targets are a relatively new product. The most common avian radar systems use readily available marine band radar technology (S-band and X-band) with scan configurations and digital processing of sensor data optimized for wildlife target detection and tracking. Although marine radar technology was originally designed to detect and track large, slow-moving targets on a flat surface, it has benefited from advances in electronics and the availability of low-cost digital processing.

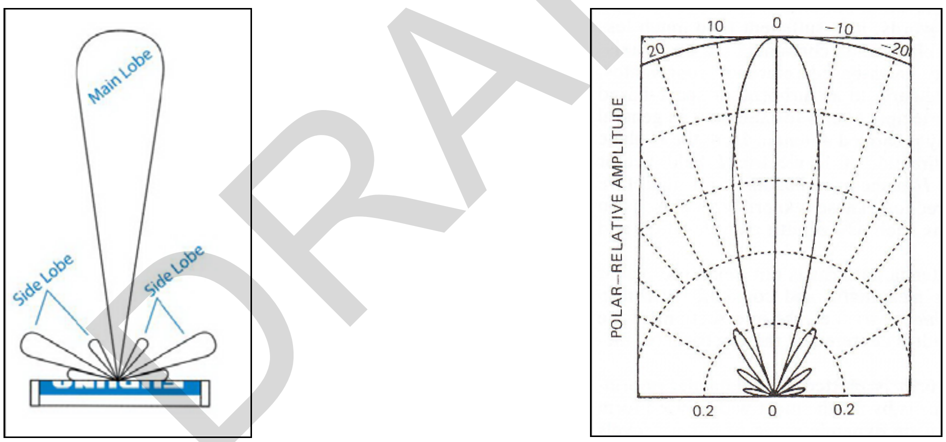
(2) The use of marine radars as the basis for avian radar systems brings compromises in technological capabilities based on the cost and availability of off-the-shelf sensors. Radars featuring improved resolution, tracking, Doppler measurement, or other advanced detection and capabilities exist, but these radars are only now being introduced to the commercial marketplace. Airports selecting more common and economical marine radars for their avian radar systems must be prepared to accommodate certain limitations in range, target size resolution, altitude determination, and sophistication in clutter management.

b. Radar Unit. A component of this selection includes choices of radar transmission power, control sophistication, and potential conflicts of radar RF emissions at the airport. Avian radar manufacturers can accommodate specific needs, but additional planning and cost may be associated with meeting such needs.

c. Scanning Unit / Antenna.

(1) Antenna selection is one of the most important decisions that can be made in implementing an avian radar system. The antenna type (array or parabolic dish) determines the operational characteristics of the radar (e.g., volume coverage) as well as the response of the system to clutter interference. The type of antenna should be selected by considering coverage needs and volumes of detection as constrained by clutter based on radar location. The importance of the availability of coarse altitude information for targets should also be considered.

(2) An issue for both antenna types is extraneous energy that is emitted from the radar when the beam is generated. This extraneous side-lobe energy, as shown in figure 3-1, is inherent in all antennae, although some designs will minimize this problem. Side-lobe energies, as well as main lobes that strike the ground, enable spurious reflections from both stationary and moving reflectors. This produces echoes called “ground clutter” that clutter the screen and interfere with target detection.



(a) Example of Primary Beam (Main Lobe) and Secondary Beam (Side Lobe) Radiation Patterns for a Slotted Array Antenna (Source: Furuno® Product Documentation)

(b) Plot of Beam Generated by a Parabolic Dish Antenna Showing Main Beam and Side Lobes [reference 3]

Figure 3-1. Radiation Patterns

(3) The slotted array antenna generates a beam of approximately 20 degrees vertical (10 degrees both above and below the horizon) by 1-2 degrees horizontal. Since much of the lower portion of the beam reaches the ground a short distance from the antenna, the effective coverage of the antenna is limited to the top half of the beam. The coverage produced by the array antenna can be described as a triangular volume of revolution, reaching the altitude at a given range, as shown in Table 3-1.

Table 3-1. Coverage of a 22-Degree Slotted Array Antenna and a 4-Degree Parabolic Dish with Dish Tilts of 0, 5, and 10 Degrees

	Distance From Antenna (mi)	0	0.5	1	2	3	4	5	6
Beam Height Array (ft)	Top of beam	0.0	513	1026	2053	3079	4105	5132	6158
	Bottom of beam	0.0	0	0	0	0	0	0	0
Beam Height Dish 0° (ft)	Top of beam	0.0	92	184	369	553	738	922	1106
	Bottom of beam	0.0	0	0	0	0	0	0	0
Beam Height Dish 5° (ft)	Top of beam	0.0	324	648	1297	1945	2593	3242	3890
	Bottom of beam	0.0	138	277	553	830	1107	1384	1660
Beam Height Dish 10° (ft)	Top of beam	0.0	561	1122	2245	3367	4489	5611	6734
	Bottom of beam	0.0	371	742	1484	2226	2968	3710	4452

(4) The beam generated by the parabolic dish is a cone with the diameter based on the number of degrees of a circle, usually 4 to 5 degrees. As shown in table 1, the distance between the top and bottom of the beam (diameter of the area in the beam) varies with range. Further, the up-tilt of the antenna (as indicated by 0°, 5°, and 10°) produces a minimum and a maximum altitude covered by the beam at any range. The slotted array antenna is limited to providing only the range and azimuth of a target, while the parabolic dish antenna can use simple geometry to also define the elevation (height) of a target (assumed to be at mid-beam). Dish antennae may offer improved detection in high clutter situations because the energy in the beam is pointed into the air, avoiding ground clutter.

d. DRSP.

(1) Avian radars generally provide only limited information beyond range, direction of movement, and velocity. It is the interpretation and application of that information to specific operational objectives that gives radar its value. Unfortunately (though understandably), manufacturers each have their own proprietary processing equipment, software, and algorithms to process raw signal data to obtain optimum results. Airports must be aware of the capabilities and limitations provided by each proprietary system.

e. Visual Displays. The availability of DRSP processing allows the development of specialized displays that can meet a range of user expectations. A wide range of options exists for the display of radar data. Typical display options provide target tracking with system capabilities to count tracks, summarize data, and then display results in either real time or as historical summaries. In terms of the actual display equipment, there are a variety of display sizes and colors to consider depending on the intended applications.

3.6. DATA ACQUISITION AND MANAGEMENT CONSIDERATIONS.

a. A critical factor in maximizing the potential of avian radars is developing a clear set of requirements for data availability. In some settings, a radar sensor with minimal digital processing can be operated using a trained observer to provide an assessment of bird activity. The most powerful use of the radar is supported by avian radar systems where digital processing supports automated operation and connections to an operational center where the flow of data is real-time. To achieve this level of connectivity to radar systems, a high-speed connection is required. This high-speed connection may only reach the operations center but, if external connectivity can be provided, then remote operation, maintenance, and additional supporting systems (including centralized data processing or a centralized alert system) for multiple airports are possible.

b. The major focus of data acquisition and management for any application must be on data quality, considering both precision and accuracy. After quality, factors such as data geographic references, the time interval between data generation, analysis, and reporting are important. In addition, a radar system's data management program should reflect the results of an airport's needs analysis and quality assurance program. Data specifications for wildlife management are likely to be different than the specifications for real-time applications or for future sense-and-avoid applications.

(1) Data management for wildlife management may require specifications for acquisition, processing, and archival storage.

(2) Data management for real-time data use may require methods for data distribution to users.

(3) Data management specifications for future sense-and-avoid warnings should include all the data quality specifications plus well developed procedures for providing alerts, including some definition of relative hazard that is developed based on criteria established by airport and regulatory personnel.

c. Because data storage and retrieval is essential for the comparative analysis of movement dynamics, the characteristics of the data archive are critical. Data from specified time periods, such as hourly or daily summaries of tracks, must be readily connected to provide comprehensive database searches. It should be noted that radars generate very large data sets and the data management tools (e.g., database management systems, or DBMS) that accommodate these large data sets must be available as a part of the data management system to facilitate data post-processing. Moreover, different post-processing applications (see below) may require different views of the same data. The data management system should readily support these, and future, views of the data with minimal computer programming. During post-processing, other software, such as Geographic Information System (GIS) or statistical analysis programs, may be used to fully explore the information content of the radar data. Usually, the radar system manufacturer will have developed unique analytical methods for this level of analysis, which should be considered in relation to the specific needs of the airport.

d. Different users require different data products, so a continuing challenge in data visualization is producing products that are useful to users. Unfortunately, users may have a sense of what they want or need, but may have little understanding of the data types needed. Thus, they are often unable to develop specifications for their desired products. Therefore, an effort was undertaken to develop pilot products, share these products with users, and then modify the products based on user comments. The CEAT web page at the University of Illinois (http://ceatasmp.cee.illinois.edu) provides examples of products developed by CEAT. The web page also provides examples of preliminary products that are intended to solicit user feedback.

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CHAPTER 4. PERFORMANCE SPECIFICATIONS

4.1. FUNDAMENTAL STANDARDS.

a. Basic Functions. Avian radar systems must perform the following functions:

(1) Detect the movement of standard bird targets at ranges and altitudes appropriate for the sensor and as specified by the airport.

(2) Plot detected targets in a coordinate system and assemble sequential plots into tracks.

(3) Operate in conjunction with, and not interfere with, airport and aircraft communication, navigation, and surveillance systems.

(4) Operate in conjunction with, and without interference from, normal airport and aircraft operations (e.g., aircraft and vehicle movements).

(5) Provide a data record of wildlife movements, allowing for equipment calibration and the analysis of wildlife events (including daily, seasonal, and annual activities).

(6) Support maintenance programs and periodic calibration and tuning.

b. Standard Avian Target (SAT). A theoretical object used as a standard for evaluating the performance of avian radar systems. The SAT has the following characteristics, which approximate the physical features of an average crow:

(1) Radar Cross Section (RCS): -16 dBm^2

(2) Mass: 1.1 lb (.50 kg)

NOTE: *When multiples of the SAT are referenced in this AC, the RCS and mass quantities are increased or decreased accordingly. For example, a 2 SAT (or 2 times the Standard Avian Target) object has a mass of 2.2 lb and an RCS of -13 dBm^2 (since doubling the intensity on a logarithmic scale equates to an increase of 3 dB). A 2 SAT object would therefore approximate the physical features of another common bird, the Mallard duck.*

4.2. DETECTION PERFORMANCE.

a. Standard Object Detection. Avian radar systems must be able to detect the following targets at each of the ranges (from the sensor) specified:

(1) Range: 0.3 to 1 nmi (.6 to 2 km). Target: 1 SAT up to an altitude of 1000 ft (300 m)

(2) Range: 0.3 to 3 nmi (.6 to 6 km). Target: at least 2 SAT up to an altitude of 3000 ft (900 m).

b. Multiple Objects. Avian radar systems must be capable of tracking at least 1000 targets, simultaneously.

c. Object Resolution. Avian radar systems must be capable of differentiating two standard avian targets located at most 100 ft (30 m) apart, at a range of up to 1 nmi (2 km).

d. Surveillance Area. At a minimum, avian radar systems must be able to provide coverage of the airspace defined by the flight path of the airport's primary runway (for both landing and takeoff), up to 3 nmi (6 km) from the sensor location and up to 3000 ft (900 m) in elevation (at 5 nm / 9 km). The surveillance "range bin," or specific areas/volumes of detection, must be defined by the manufacturer for each location. Additional surveillance areas (based on the airport's wildlife hazard management plan) may be specified by the airport operator.

e. Location Accuracy. Avian radar systems must provide location information for a detected target that is within 100 ft (30 m) of the actual target location.

f. Detection Precision. Avian radar systems must be capable of detecting an SAT up to 3 nmi (6 km) from the sensor with a confidence level of 90%

g. Inspection Frequency. Avian radar systems must be capable of continuous operation to allow for the continuous inspection of the surveillance areas airspace during flight operations. Updates for the position of an SAT position must occur at a rate of at least 0.5 s and at most 5 s. The duration of flight operations is dependent on the airport and specified by the user.

h. Detection Response Time. Avian radar systems must have the capability to acquire an SAT located in the surveillance area within 5 seconds of the area being scanned.

i. Weather. Avian radar systems must demonstrate the detection performance under both clear and inclement weather conditions.

(1) Demonstrate detection capabilities under rainfall or snow conditions (e.g. having a specific intensity, duration, and frequency) for a two-year category of storm in the local region (as specified in *CLIM 20, Climatology of the United States No. 20*). Specific requirements may be specified by the user.

(2) Avian radar systems must have site-specific performance specifications that include validated:

(a) performance during clear weather conditions;

(b) performance during inclement weather conditions; and

(c) provide the airport operator with the amount of time required for the system to recover after a rain or snow storm, that is, to return the performance capabilities of clear weather conditions after adverse weather conditions subside. In this case, the end of adverse weather conditions will be defined as when precipitation of rain or snow ends.

(3) Lighting conditions. All systems must demonstrate detection performance during daylight, nighttime, and dawn/dusk operations.

4.3. SIGNAL STANDARDS.

a. Signal Generation. Both magnetron or solid state systems are acceptable.

b. Antenna configuration. Multiple antenna configurations are possible meeting site requirements (including either phased array or dish antennae).

4.4. DATA STANDARDS.

a. Data Digitization (Analog to Digital Data Conversion).

(1) Fidelity. Analog radar echo signals must be converted to digital data with the fidelity of the digitized data to the analog signal known.

(2) Format. Digitized radar data converted in the B-scan or scan-converted format systems are acceptable.

(3) Multi-tasking. The system must be able to record B-scan or scan-converted data while not interfering with data processing (detection and tracking) or data recording (of the detections/plots and tracks). Thus, these processes must be able to occur simultaneously to allow constant observation of the displays.

b. Clutter Management.

(1) System processors must be able to provide the capability to identify clutter, map clutter locations, and address clutter influences on the detection of a target.

(2) The system must be able to detect, and correct, false positive and false negative target detections. In addition, the processors must be able to detect, and correct multipath interference and side lobe detections as a class of false positive detections.

c. Data Storage and Archiving.

(1) Avian radar systems must be capable of recording at least one hour of raw digital data (in a B-scan and/or scan-converted format) to support reprocessing. Reprocessing may facilitate event forensics, training, calibration and sensitivity testing, and wildlife management inquiries. In addition, the hardware and software tools required for reprocessing must be provided by the manufacturer.

(2) Avian radar systems must be capable of recording at least one hour of plot and track data, or regenerating plot and track data from the raw digital data. The ability to store and view any screen captures of plot and track displays is also required.

(3) In the reprocessing of plot and track data, avian radar systems must be capable of supporting analyses that change criteria for track display, that provide alternatives for track history displays, and that provide easy comparison of track histories over different time scales.

(4) Avian radar systems must allow the easy retrieval of archived plot and track data based on a given date and time.

(5) All stored data must contain the scan update rate used by the system.

(6) Any type of plot and track data able to be retrieved and displayed must be provided in a standard, non-proprietary format, such as video (e.g. .avi, mpeg, etc.), image format (e.g. .jpg, gif, etc.) and Google Earth utility (.kml).

4.5. DATA PRESENTATION / DISPLAY STANDARDS.

a. Plot and Track Parameters.

(1) The system must provide a display of detected avian targets as plotted bird detections or processor identified bird tracks;

(2) Plotted bird detections and identified bird tracks must display the following data in a user-accessible format that include parameters in Table 4-1.

Table 4-1. Parameters recorded for each update (scan) of each tracked target.

Parameter	Units	Datum	Precision (plus/minus)	Comments
Track ID				Unique identification up to maximum tracks allowed
Latitude	Decimal Degrees	WGS84	150 ft, 50 m	For all plotted detections making up a track
Longitude	Decimal Degrees	WGS84	150 ft, 50 m	For all plotted detections making up a track
Altitude	Meters	ARL	150 ft, 50 m	For all plotted detections making up a track; elevation of radar antenna = 0 m ARL
Speed	Meters/Second		5 m/s	
Range	Feet/Meters	From Radar	150 ft, 50 m	1% of range value
Heading	Degrees	True North	1°	
Date	(yyyymmdd)	UTC	1 d	e.g. (19471014) = October 14, 1947
Time	24-hour clock (00:00:00.0)	UTC	0.1 s	e.g. (00:00:00.0) = Midnight
Azimuth	Degrees	True North	1°	
Intensity (RCS)	Relative			
Number of detections in track				
Spatial Covariance				Uncertainty in target spatial coordinates.

b. Plotting and Tracking.

(1) Target data can be displayed in plotting and tracking displays in a coordinate scheme or on electronic maps of the airport. The specific display options will be specified by the airport, consistent with airport systems operations.

(2) Plot generation. Displays must be capable of providing a geographic reference to target location (in the form of range rings and bearing, or on a latitude/longitude grid). In addition, the ability to import or overlay electronic maps or aerial imagery must be provided.

(3) The system must provide information on the maximum number of tracks, track handling capacity, track storage procedures, and system saturation that limits track identification or storage.

(4) Multiple Sensor Integration. The system must have the ability to provide spatial and temporal alignment, in near real-time, for the fusion of tracks from multiple sensors with overlapping coverage.

(5) The system must have the capability to record and compare radar sensor PPI display and the display produced by the radar digital processor.

(6) The plot and track archive in any avian radar system must support easy access to historical data, support access by location, date, and time, and allow assembly of data sets for multiple locations, dates, or times.

(7) Remote Use. Avian radar systems must provide the capability for the remote operation, display, and recording of data when specified by the user.

(8) Options. The system must be able to provide the following options for target tracks:

(a) Target position coordinate system

(b) Track history display

(c) Maximum number of targets tracked per time interval

c. Display Standards.

(1) The following tools and reference items must be provided on the user display, at a minimum:

(a) Distance measures and heading

(b) Electronic range markers

(c) Units for on-screen measurements

(2) The following notification features must be provided by the system:

(a) User-controlled parameters for setting alarms.

(b) Media (cell phone, email, etc.) for notifying personnel of an alarm.

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CHAPTER 5. DEPLOYMENT

5.1 GENERAL.

a. The deployment phase of the avian radar implementation effort consists of:

(1) Site Selection:

(a) Clutter Management / Mapping

(b) Bird Habitat / Critical Area Considerations

(c) Airspace Considerations

(d) Airport Installation Consideration

(2) Equipment Setup and Initial Operation

(3) Integration into Airport Operations

5.1. SITE SELECTION.

a. Determining the site for the avian radar on an airport is a complicated and time-consuming activity. Although the primary objective for radar deployment is effective detection and tracking of targets, issues such as safety zones, power availability, network connectivity, and general access take precedence over optimal placement of radar. Placement of the radar on the airport invariably requires compromise in location.

b. Finding an acceptable site for the radar requires prioritizing identified needs and then carefully analyzing competing issues. From a radar operations perspective, the most critical criterion is minimizing clutter interference for critical areas. From a wildlife detection perspective, the most important criteria for site selection are providing good detection capabilities for known critical areas on the airport. Critical areas are those locations where observational data suggests a high hazard potential due to site attractants or the actual use of the area known from observations. These two factors can generally be accommodated by several locations. The final location is then determined by considering infrastructure needs, such as the enclosures needed for the radar system (including towers or other structures required for the radar antenna), power supply, and the availability of high-speed connectivity.

c. Clutter Management / Mapping.

(1) The beam patterns of both slotted array and parabolic dish antenna types produce reflections from ground surfaces, buildings, and other fixed targets that interfere with target detection and tracking. This “clutter environment” decreases the radar’s ability to detect and track avian targets. Thus, assessing the clutter environment when selecting a radar system is an important strategy for optimizing a radar’s effectiveness. Although experienced individuals can suggest locations based on “eyeball” surveys, the only way clutter is fully revealed is by operating the radar. This produces a difficult situation in the radar implementation process. Using the radar on the airport requires the completion and approval of an FAA Form 7460 for the exact locations of the radar unit(s). Unfortunately, it is not possible to select exact locations without using the radar on the airport to map the clutter environment.

(2) A number of solutions have been found to this quandary. In some instances, temporary permission is granted for radar use during limited time periods. This facilitates the movement of the radar to multiple sites on the airport to provide actual data for possible alternative locations. After the temporary deployment of the radar, clutter mapping results can be reviewed and radar locations selected. If temporary permission is not available, airport personnel should use their judgment to select a small number of locations and submit FAA Form 7460 applications for each location. Deployment will be delayed if these initial locations are unacceptable, requiring testing of other locations. However, it is likely that one of the selected locations will meet minimal needs and full implementation can occur immediately after clutter mapping has been completed.

d. Bird Habitat / Critical Area Considerations.

(1) The location of possible sites can be determined using the records of wildlife managers to analyze the airport's landscape and features to identify locations that may be attractive to birds. Such understanding of critical areas attractive to wildlife can be the basis for assessing needs and locating the radar to meet those needs. Several examples are described below.

(2) Wildlife managers can develop a grid for their airport. Personnel involved with wildlife management could be tasked with coding activity types to grids to provide better location information for later analysis. The reports of patrol activities could then be mapped on the airport grid map using a GIS. Figure 5-1 illustrates an example of the areas of higher and lower levels of wildlife management activity by month. This geo-referenced data could then provide the basis for analysis of wildlife activities by location and over time, providing an improved assessment of wildlife threats to aircraft safety.

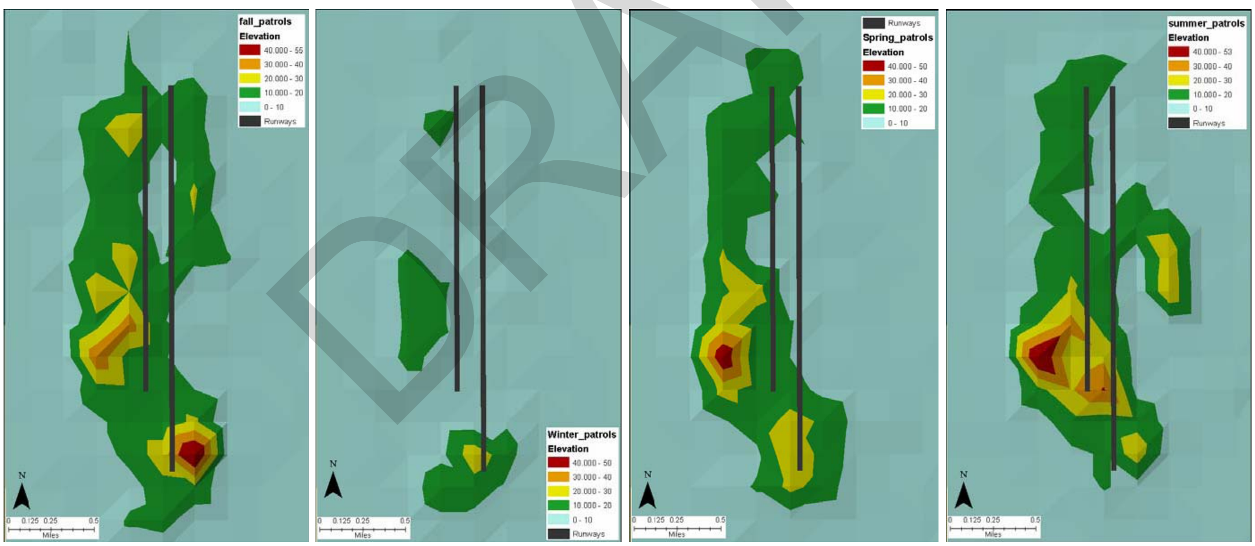


Figure 5-1. Areas of Higher and Lower Levels of Wildlife Management Activity by Month

(3) Wildlife personnel could also conduct point counts of birds. A point count is simply observing and counting birds sited from a known location using a standard observational procedure. The point count could provide coordinates that could be used in a GIS, enabling analysis of observational data in a geographic context. The changing numbers of birds observed could be tallied for a given period of time. Figure 5-2 provides another example of an assessment product, in this case, the seasonal changes in wildlife numbers.

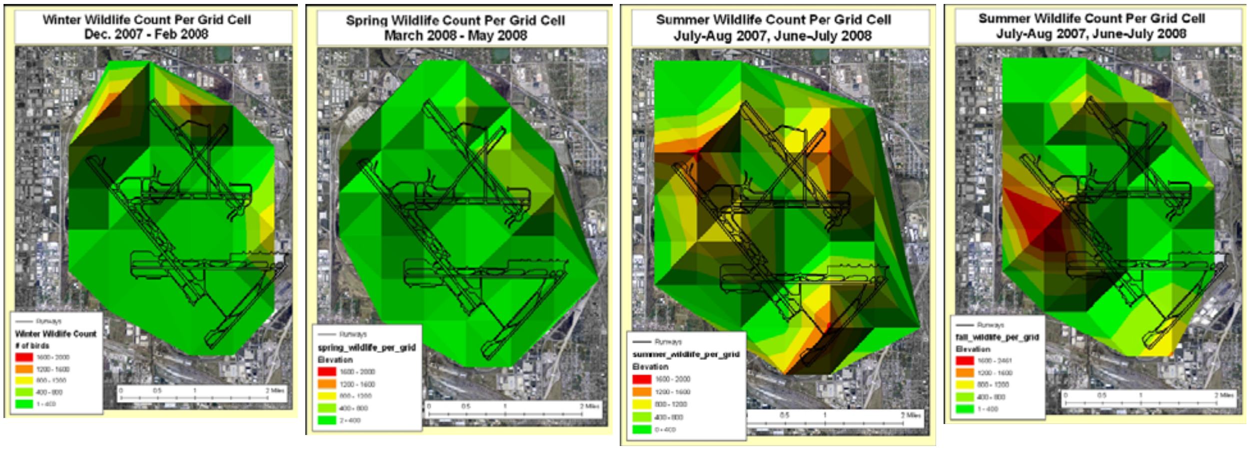
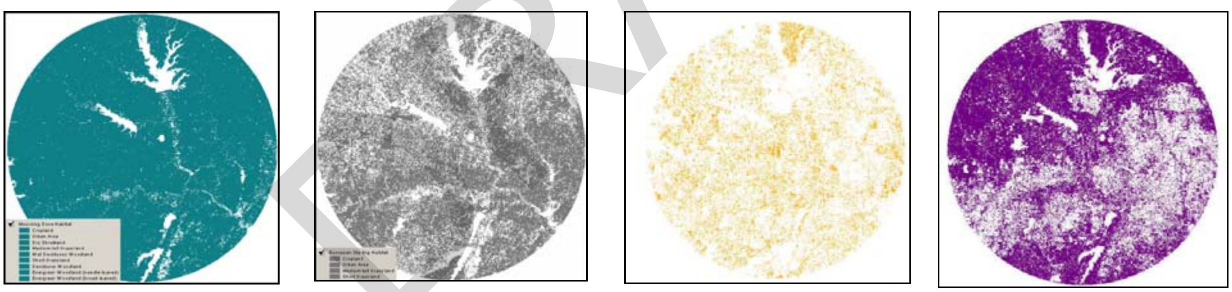


Figure 5-2. Seasonal Changes in Wildlife Numbers

(4) To analyze the threat surrounding an airport on a larger regional scale, a GIS can be a helpful tool. Land cover data from the United States Geological Survey Gap Analysis Program can be used to identify habitat conditions that could attract birds. Figure 5-3 shows the product that can be obtained by relating bird habitat preferences to the location of attractive habitat at a sample airport. Using this approach, it is possible to identify areas of attractive habitat relative to the corridors typically used by airport traffic. Assessing issues such as expected altitude of aircraft and known characteristics of species flight behaviors, it is possible to develop a comprehensive assessment of avian hazards in the airport operational environment. In this hazard assessment, the hazard potential produced by both numbers of birds and the mass of individual birds can be determined.



(a) Land Cover Types that are Good Habitats for Mourning Doves (Teal)

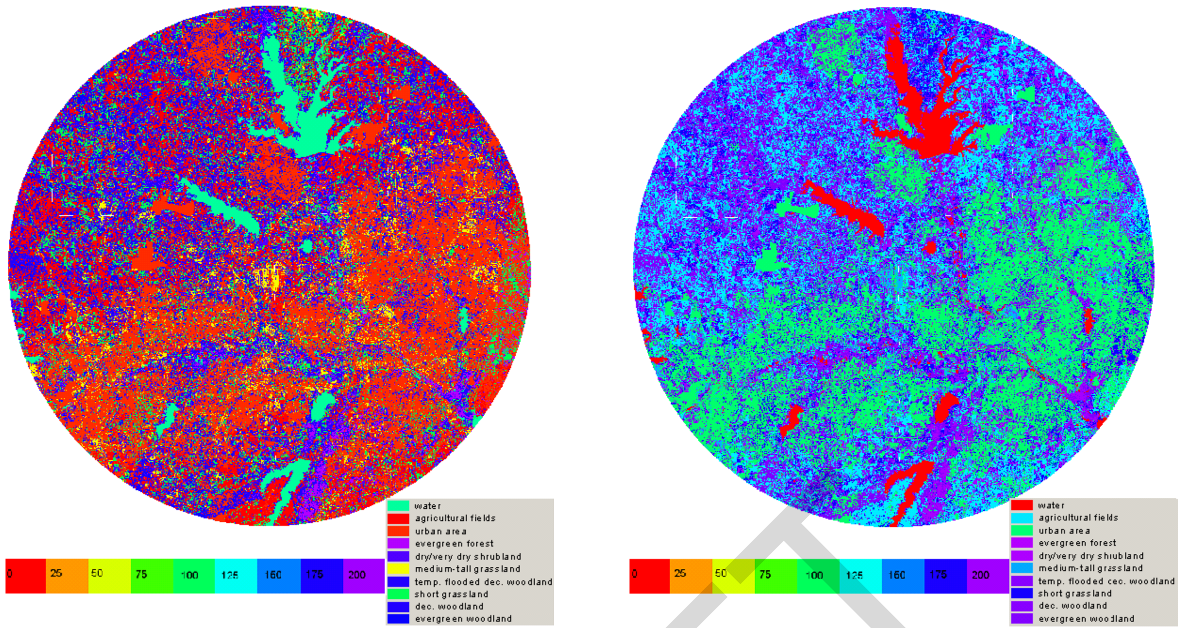
(b) Land Cover Types that are Good Habitats for European Starlings (Grey)

(c) Land Cover Types That are Good Habitats for European Meadowlarks (Yellow)

(d) Land Cover Types That are Good Habitats for Grackles (Purple)

Figure 5-3. Land Cover Types

(5) Figure 5-4 below shows the relationship between attractive habitats and the threat posed by the quantity and mass of avian species. The red areas identify the highest threat; the blue and purple areas identify the lowest threat. The figure also illustrates the dispersed threat of birds on the landscape. A general assessment would find that the species include small birds that are dispersed across the landscape to feed or find shelter. As shown in the figure, when mass is taken into account, the water features on the landscape—particularly large reservoirs—present the highest threat because waterfowl tend to be bigger birds. These large-bird species move in flocks that present a particularly high hazard to aircraft.



(a) Attractive Habitats Showing Threats Associated With Numbers of Birds

(b) Attractive Habitats Showing Threats Associated With the Mass of Birds

Figure 5-4. Attractive Habitats Showing Threats

(6) Of course, references can also be made to an existing airport management plan, including reference to regional analyses and any wildlife data available for the airport, if available. A careful review of historical wildlife data, assisted by GIS to ease the visualization of the relationship of critical areas, can provide a wealth of bird habitat information to assist in this review.

(7) These types of analyses demonstrate that understanding the landscape, its features, and how attractive landscape features are to birds provide a basis for identifying where to "point" the radar, defining its coverage area by antenna characteristics and the existing clutter environment. Understanding the regional context for airport wildlife management should be a critical need of any airport wildlife management program.

e. Airspace Considerations. The selection of the location is also dependent on the ability for the radar to cover critical aircraft flight corridors. This process can be relatively simple. References can be made to instrument landing system documentation for approach and departure procedures. Empirical data is often available from radar track summaries, as shown in figure 5-5.

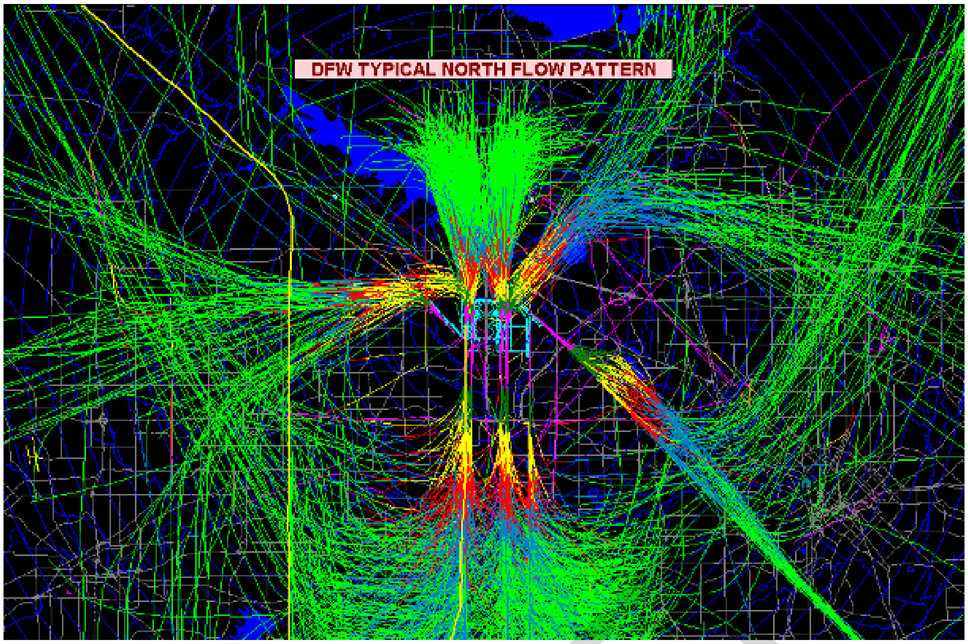


Figure 5-5. Radar Tracks Showing Expected Arrival and Departure Paths of Aircraft (Colors Indicate Altitude)

f. Airport Installation Considerations.

(1) Physical Enclosures. Avian radar systems have components that must be protected from the weather and temperature extremes. Although the radar base and antenna are designed for permanent exposure to the elements, the remainder of the radar unit, the DRSP, and all other hardware supporting the radar must be protected. Options include housing these elements in a mobile trailer, a permanent purpose-built structure, a temporary structure, or in an airport building. When determining enclosure type, consideration must be given to the length of cable necessary to meet the manufacturer's requirements for connecting the radar controller with the rotating head and antenna. That distance, with the location that will provide the best coverage of critical areas, will ultimately determine the enclosure type.

(2) Power.

(a) Power considerations are critical for any long-term deployment of the radar. It is possible to provide generator power, but maintaining fuel for the generator is usually the most critical operational parameter. The most essential technical parameter is conditioning the power (via an uninterruptible power supply, or UPS) to provide an acceptable source for the radar and communications systems. Power supply voltage and amperage must be considered if heating or cooling is needed in the enclosure to maintain temperatures within a required range.

(b) Although sometimes overlooked by non-electricians, the grounding of the system is particularly important in field applications. Typical mobile trailers have a floating ground that may not provide the needed protection for people and critical electrical equipment during situations such as lightning strikes. Particular attention should be paid to grounding the trailer and assuring that all equipment in the trailer is properly grounded.

(c) An important protection for the electronics in a radar system is a UPS. A high-quality UPS will not only maintain operation on battery power for short-term power interruptions, but will also condition power so that sensitive electronics are provided with reliable power, particularly if short-term operations require generator power.

(3) Network Connectivity.

(a) All avian radars provide the highest level of service when high-speed connectivity is provided among multiple units at an airport and a central router provides access to a local-area (LAN) or wide-area network (WAN), such as the Internet. Connectivity can range from physical transfer of archived data on portable storage media to connectivity using high-speed optical cable. Wireless connectivity can provide sufficient connection speeds to support remote radar operations.

(b) Varying levels of connectivity can produce differing results. Wireless broadband is available in many areas. This access allows remote administration of the machines, limited live viewing, and very poor data transfer rates when compared to the bandwidth required for radar data transfer. The maximum bandwidth that currently can be obtained with this technology is 2 Mbit/s download with significantly less upload (500-700 kb/s). However, it is important to note that typical electronic equipment containing a wireless LAN / wireless backhaul communications system (based on the IEEE 802.11 std, or unlicensed, Part 15 rules) will need to have those capabilities removed prior to final installation and operation in the airport environment. The FAA is currently involved in efforts to develop a protected wireless communications system for use in the airport environment, based on the IEEE 802.16 standard.

(4) Security Issues.

(a) All radars connected to the Internet through a router are by default located behind firewalls blocking all external access requests. For access to the radars, ports must be designated and open, based on the service needed. All services that run on ports exposed to the Internet should be password protected.

(b) Data transfer is an important security issue. This security is associated with both the data channel and the security or limited access requirements developed, based on airport policies. In a sample system setup, radar data is transferred using secure protocols and then is resident at a secure server in a remote location. Data is encrypted via secure sockets layer (SSL) when sent over the Internet. The data resides on this server until it can be accessed. Online access is limited to accounts with varying levels of access privileges; physical access to the secure server must also be restricted.

(5) Bandwidth Issues.

(a) Data can be remotely retrieved in a number of ways, but the most efficient is to directly download the data from the radar system. The method employed depends on the availability of an Internet connection as well as the bandwidth of that connection. Data can also be locally retrieved by attaching an external hard drive to the radar system and manually downloading the data, although this procedure is not recommended. Depending on the source (cable, fiber, etc.), bandwidth will not be a limiting factor to radar utility. Modern networks are capable of transferring several gigabytes of data over the course of a few hours.

(b) Fiber-optical cable networks typically provide the highest speed connectivity currently available. Optical cable-based networks provide an ideal base for data transfer and management. Data accumulated during a day of operation can be transferred overnight, allowing the data to be available the next day. With this type of connection, the screen can also be viewed in near real time. Remote access is also improved with high-speed connectivity.

5.2 EQUIPMENT SETUP AND INITIAL OPERATION.

a. Setup. Delivery to final deployment locations may require the preparation of pads or buildings and the availability of power and connectivity. Temporary power and connectivity may need to be provided, depending on testing or other operational requirements.

b. Initial Operation. The initial operational period may last from weeks to as much as a year. This potentially long timeframe is required to determine optimal configuration of radar settings to accommodate different weather conditions and seasonal patterns of bird movements that may improve detection of transient species. In the initial operational period, the radar can be operated and settings adjusted to accommodate site-specific conditions not identified in clutter mapping.

(1) Alternative Configurations:

(a) The radar unit and the DRSP in the radar system are closely coupled, and configurations of both must be optimized to provide the best site-specific radar operational performance. A range of settings is possible in both the radar and the DRSP. Most of these settings are established as part of the manufacturer's development of the avian radar system, but other settings can produce site-specific configurations or configurations that address different conditions (e.g., rainfall). Alternative configurations include the antenna selected and operational settings of the radar unit (e.g., pulse length or rotational speed). If using a parabolic dish antenna, fields to specify the different angles are available in the configuration step. Additionally, it is possible to minimize clutter by placing the antenna close to the ground. Radar technologists also advise that clutter fences can be developed for some installations, but no clutter fencing has been attempted in the performance assessment program to date.

(b) Aside from these physical configuration elements, the available options on the radar unit electronics (e.g., for internal clutter management systems) and the DRSP allows a vast number of settings for the radar system. The radar manufacturer limits the options for configuration changes based on an intimate understanding of the system and a desire to meet airport needs when the availability of trained staff may be limited. Manufacturers will typically provide a tuning service as part of the radar set-up and select a limited number of configurations that are most suitable to addressing identified objectives and meeting airport needs.

(2) Selecting Optimal Configurations:

(a) The radar unit and the radar system present the user with many possible adjustments to adapt performance to a site. Manufacturers of avian radars have experience in the use of their systems and usually have established radar unit and radar system configurations that have achieved advertised performance. Even though general configurations will produce adequate performance levels, there is usually a period of adjustment where the radar experts adjust the radar to site-specific conditions.

(b) Airport operators should carefully review configurations with the radar manufacturer and expect the identification of alternative configurations to meet different needs and uses. For example, there may be a different configuration that will work more effectively during different seasonal weather patterns or for resident or migratory birds. The process of selecting alternative configurations is based, in part, on needs and objectives as well as experiences gained as the radar is used, developed, and analyzed for both validity and utility.

(c) A second group of configuration issues are associated with detection volumes and displays. After determining critical areas for radar coverage, data should be reviewed to ensure that the radar beam actually covers critical areas. Such areas may shift, and adjusting the radar may be required as needs change. In addition, as actual radar data is assessed, it is essential to make sure that data is not contaminated by aircraft traffic or by traffic from nearby roads or highways on or off the airport property. Displays (color selection, trail length, speed values, distance values, screen extent, alarm zones, and useful maps) should also be configured to ease operations and enhance the radar's usefulness. Such settings will typically be developed by the radar manufacturer in consultation with the airport client.

(3) Periodic Review of Configurations:

(a) To ensure quality assurance, an avian radar implementation program should include a regular review of radar operations and operational performance. A basic requirement is the periodic review of performance associated with the proper settings of the radar unit. As discussed above, the actual settings used for operation may change with season or target presence, thus a review of operational configurations may be scheduled based on seasonal or other time frames.

(b) The review of configurations requires a baseline setting that is also associated with a baseline performance level. An element of the clutter mapping procedure is to identify specific baseline settings and performance expectations for the radar. The results from the clutter mapping and from each review of configuration should be documented and archived.

5.3 INTEGRATION INTO AIRPORT OPERATIONS.

a. The deployment of avian radars at civil airports is a complex process. Successful deployment and use of avian radars requires a clear understanding of the system's capabilities and limitations as well as its physical, technological, and personnel requirements.

b. Coordination plans.

(1) Airport Integration. A critical part of initial deployment considerations is developing a coordination plan for the effective use of the avian radar technology. The actual coordination plan will be specific to each airport, reflecting the organizational structure and the operational methods in place. Although operational integration with air traffic and with wildlife management requires similar information from the radar, objectives will vary in the areas of airspace coverage, data validation, and speed of information transfer.

(2) Air Traffic Integration. The integration of avian radar information into air traffic control is a complex undertaking that must consider radar technology issues, air traffic, and methods to ensure information utility in the air traffic environment. Although not optimized for air traffic use, avian radars can provide valuable information to air traffic control activities. The FAA is currently assessing these integration issues, taking into account the many benefits available from understanding the movement dynamics of birds in and around airports.

(3) Wildlife Management Integration:

(a) The operational integration of avian radars into wildlife management at airports can take advantage of the new information resources provided by radar systems. Although avian radar systems are bound by physical and technical limitations, the requirements of wildlife management can accommodate those limitations while still providing major benefits to airport safety. The primary benefit of avian radars is that they provide a means to continuously monitor the movement of targets, including birds, in the scan volume of the radar. This capability adds a new dimension to wildlife management by providing night-time surveillance of the airport, a permanent record of targets detected and tracked, and new options for the long-term monitoring of bird movement dynamics.

(b) The wildlife management operations at an airport can benefit from radar data in many ways. For example, in a typical situation where radar imagery can be transmitted to field vehicles, managers could to determine where their management activities are needed, which can contribute to the improved effectiveness of management options, such as harassment. For the near term, improved local and regional management can be achieved using daily or weekly summaries of bird movement activity with information on paths of movement supporting identification of the origin and destination of transitory birds. Further, this near-term information can be consolidated to provide a better picture of the threats of bird movement to aircraft, supporting the integration of updated information in airport Automatic Terminal Information Service (ATIS) announcements, or even Notice to Airmen, when unusual activity is observed. Finally, over the long term, the avian radar contributes to an archive of information, collected in a uniform manner, which can support detailed analysis of patterns and trends in bird movement.

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CHAPTER 6. OPERATIONS AND MANAGEMENT

6.1. GENERAL.

An operational scheme focusing on supporting the wildlife hazard management plan and bird strike prevention programs can be developed once the many phases of the avian radar implementation program have been completed. It is at this stage where the optimum radar system application, as defined by the benefits and limitations from the equipment configuration and installed location in the airport environment, can be developed. This chapter outlines the potential applications of avian radar systems, as well as the significant data management issues involved in those operations.

6.2. APPLICATIONS.

a. Potential applications of avian radar run the gamut from straightforward to highly complex. For instance, using radar to track seasonal patterns of bird movements around an airport can generally be implemented quickly and easily. Other applications, such as integration into aircraft operational activities, would most likely require more time and effort to implement.

b. Wildlife management applications. The enhanced capabilities made possible by avian radar add a new dimension to airport wildlife management. The ability to check for birds at distances beyond the capability of human sight or to determine that a new concentration of activity requires management attention can make wildlife management much more effective and efficient. Avian radars expand wildlife management personnel's observational capabilities to night and to distances exceeding the normal 500- to 1000-ft limits where visual capabilities, even with good binoculars, degrade. The radar system provides an observer with a dynamic view of bird activity that is updated every few seconds, which can be carried into the field using readily available communications and computer technology, allowing wildlife officers a detailed view of bird activity on and around the airport. These new capabilities can change the perceived value, and effectiveness, of wildlife management programs to provide improved safety at an airport.

c. Bird strike prevention programs / hazard warning applications. An improved understanding of bird movements on and around the airport can lead to significant safety improvements. Some of these improvements include:

(1) A better understanding of movement dynamics, particularly regular patterns of flight over areas of the airport;

(2) A directed management effort to reduce or eliminate observed hazards, including the guidance of focused harassment activities to areas of threatening bird concentrations;

(3) An improved observational effort to provide visual confirmation of threats that can be relayed to airport users; and

(4) The development of a data set that can be analyzed to update conditions based on known history, particularly when trends in activity have been identified. For example, ATIS announcements can be made that are timely and accurate and change according to the presence and abundance of birds. This can avoid the habituation problem with pilots when the same warning is provided in ATIS summaries for weeks or months on end. The improvement of hazard warnings will make controllers and pilots more aware of potential threats.

6.3. DATA ACQUISITION AND USE.

a. The current and potential applications of avian radar identified above clearly show the importance of data collection and analysis in the operation and management of the systems. Radars produce extremely large data sets that must be processed and analyzed, then interpreted and archived. Although the DRSP provides a reduction in the magnitude of the sensor data stream by converting the raw digital data signals to plots and track data for targets, retaining detection and plot data and generating moving target tracks still has the potential for producing large data sets that must be organized and archived.

b. The management problem for radar data grows with the number of radar systems in operation and the processing needs of airport users. Systems integration capabilities provided by a manufacturer can be used to post-process daily radar plot-and-track data and produce several data visualization products. Although this process is currently manual, improvements are underway to complete basic post-processing on a radar data server and complete initial steps for visualization of data resources automatically.

c. Types of Data. The first step in developing data-handling procedures, appropriate to a given application, is to understand the types of data produced by avian radar systems. Avian radar systems produce three main types of data:

(1) Raw Data. The signals generated and received by the marine radars used in commercial avian radar systems are analog waveforms (i.e., radio waves). The first step in processing the received signals is to convert them from analog to digital form. This digitized, but unprocessed, data is referred to as "raw data." Although raw data sets are extremely large, their retention allows maximum flexibility in post-processing.

(2) Processed Plot Data. This data usually consists of detections that have met processor criteria and are then aggregated into a plot of the position of each target in the current scan of the radar and the association of a plot with previous plots of that target to form a track of that target. At a minimum, the "plots-and-tracks" data include the spatial (e.g., longitude, latitude, and in some configurations, altitude) and temporal (i.e., date and time) coordinates of the targets of interest. Further processing of this data may use parameters such as speed and heading to refine identification leading to the identification of avian targets, which are then tracked on the display. Retaining plot data allows the development of tracks during post-processing using different selection criteria. Plots-and-tracks data sets are still large, but size reduction from raw data is significant.

(3) Track Data. This data is most conveniently used when displayed in relation to geographic references. The analysis of individual tracks can lead to further refinement of target type and characteristics. The display of track data is the first product of the performance assessment. As figure 6-1 shows, tracks can be displayed for given time periods, such as hourly track summaries. Using track summaries, it is possible to identify daily timing and dynamics and to conduct analyses that relate bird activity to environmental conditions. Track data is also useful in identifying migratory events.

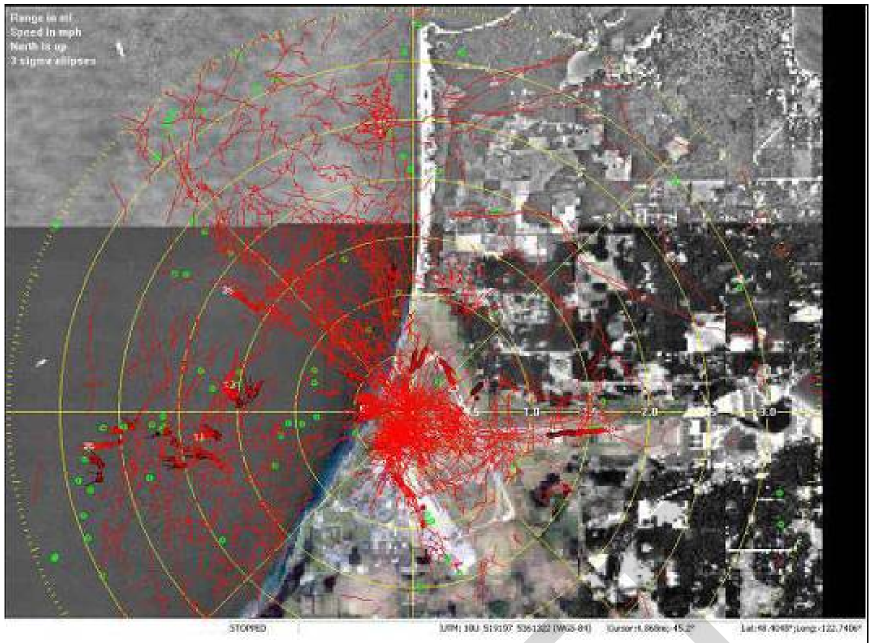


Figure 6-1. Example of an Hourly Track Summary

d. Data Processing. Avian radar data processing generally includes two steps. As described above, the first step produces digital data by sampling the analog data stream from the radar sensor and then processing the digitized data to remove clutter and detect and track targets. The second step takes the digitized data, which are now in a form that can be processed by a computer, to display the tracks over maps of the area on the computer screen. This step can be done by different commercially available software. In addition to raw data, processed data in the form of plots, tracks, and radar detection data should be archived in a form that allows ready retrieval and supports post-processing. The archival data can be used in post-processing that may use statistical, GIS, or other methods for data analysis. The general data processing process is illustrated in figure 6-2.

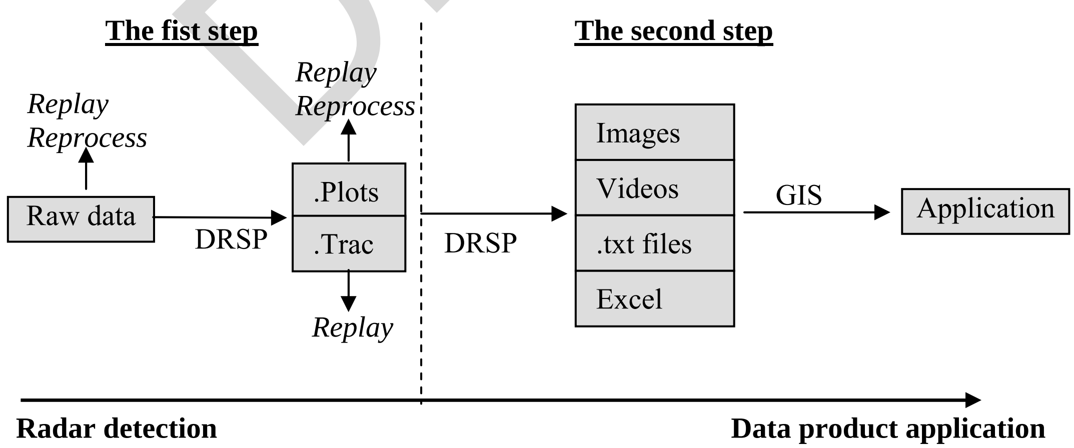


Figure 6-2. Flowchart of Radar Data Processing

e. Data Usage.

(1) Immediate Use.

(a) Although avian radar systems support post-processing by providing opportunities for data storage and management, the basic design of the radar supports immediate use of the data if experienced operators are available to observe the displays. The analog PPI provides an unaltered view of radar returns, typically showing clutter and targets. Most radar systems are capable of providing image history, which can be used as a simple tracking tool for targets. Some experience is needed to interpret PPI displays because the display has a radial context and the orientation of the screen may not match the preferred orientation of the observer. The PPI screen is an important adjunct to system utilization because it is free of extensive data processing and establishes a baseline for interpretation of any processed data.

(b) On the computer monitor, the PPI displays processed data, usually over a map, or other geo-referenced display. The processed data is updated continuously and the data processor can show plots of targets that overlay geographic features, as well as tracks of targets over time. This display provides the operator with information that can be used immediately in support of wildlife management.

(c) The general options for immediate use are illustrated in Figure 6-3. The digitized data is processed by the computer. Depending on the manufacturer system, it is possible to specify display characteristics by adjusting parameters such as color, track history, and track length. It is also possible in some systems to immediately replay just observed conditions. Finally, data is recorded and transferred to archives for later review or post-processing.

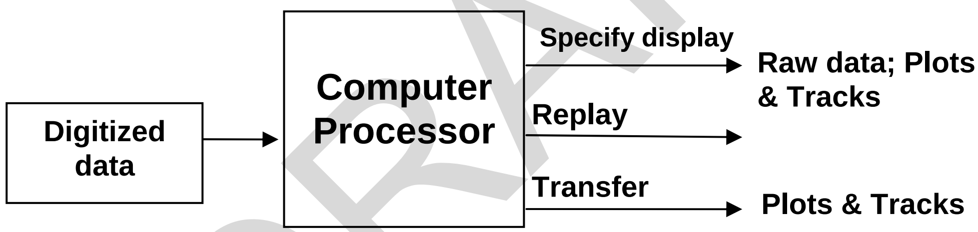


Figure 6-3. Flowchart of Radar Raw Data Processing With DRSP

(2) Intermediate Use. The intermediate use of radar data involves taking recorded plots, track, or radar performance data and developing hourly, daily, or other activity summaries. Intermediate use of the data is dependent on the manufacturer's system that defines the characteristics of the stored data and the post-processing tools available to analyze the data. Some manufacturers provide specialized software to view tracks and analyze those tracks. For example, simple time-based histories of tracks can provide a sense of movement dynamics. Designating areas and counting tracks in those areas is the foundation for developing alerts to potential hazards. Intermediate use takes advantage of images, videos, and files for text generation or spreadsheet analysis, as shown in Figure 6-4. The actual data files that, at a minimum, contain data such as time, ground velocity, heading, and target location (latitude and longitude) can be accessed for further analysis using data display or geographic information software.

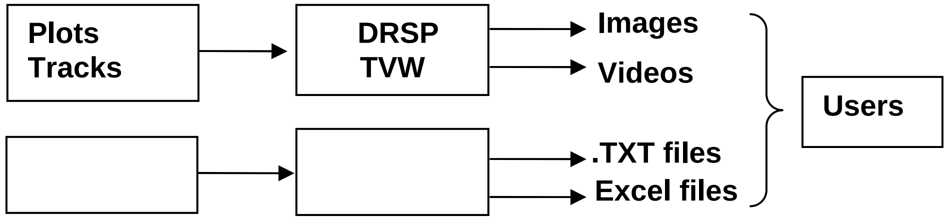


Figure 6-4. Flowchart of Data Product Generation

f. Archival System.

(1) The data archiving system provided by the radar manufacturer is an important consideration of radar system acquisition and deployment. Archival systems have benefits and limits. For example, the use of common database systems provides convenience and readily available training. However, the database engine can be limited in terms of the number of records it can store, and it may be difficult to assemble sequential data sets for historical analysis. Full-function relational database management systems (RDBMS) that do not have these limitations are available as both proprietary and open-source products. Likewise, analysis software packages (e.g., GIS) are also available as proprietary and open-source products. Regardless of which products are chosen they should support open standard interfaces and languages (e.g., SQL for an RDBMS; DWG/DXF, DGN, SHP, GML or KML for GIS) to avoid being locked into a single manufacturer's products.

(2) An important point to evaluate when considering avian radars is the efficiency with which the data is stored and the capabilities that exist for post-processing. To provide maximum utility, raw data storage is needed. Raw data may originate from the radar unit, but often have large file sizes that limit the length of time data can be recorded. This raw data is valuable because it provides a data set that can be processed as part of a quality assurance program, assesses changes and improvements in the processing software, or enables the review of incidents of interest with full reprocessing capability. The raw data resource may also be an intermediate product of the digitization process. This data is often subject to compression algorithms, and it is possible to archive raw data for reprocessing for long time periods.

(3) Post-processing. The radar's tracking capabilities enable a day's worth of tracks to be visualized in different ways. Depending on the manufacturer solution, tracks may be stored as plot and track files or may be added to a database that contains additional data derived from the radar. Manufacturer solutions vary from a program that assembles and replays tracks from recorded data to external analytical engines, such as GIS programs, which assemble and process radar data.

(4) Reprocessing. Airport operators will find that there will be situations where it is important to reprocess data. Full reprocessing is only available if the raw data from the radar unit is recorded. This record is seldom available because of the massive size of the data sets generated by the radar. Alternatives exist in various approaches provided by different manufacturers. Raw data compression schemes reduce storage requirements, but storage of all radar data is still limited by size requirements. It is possible to develop storage systems that only retain data from a limited time and continuously roll over data sets. This approach would be suitable for event analysis. Reprocessing can also take a form in which a processed data set is used by a program that allows a review of plot-and-track data, such as using different criteria for track generation or the analysis of track density in relation to areas defined on a radar screen/area map overlay.

(5) Metadata.

(a) Metadata is data about data. It provides information that is not recorded with the primary measurement data, but which may be necessary to use and interpret the measurements. Metadata provides the context in which the measurements were made. For example, the track data output from an avian target (i.e., the primary measurement data) would typically include the spatial and temporal coordinates of the targets; it may not include the horizontal and vertical coordinates of the radar, the time zone of the date/time values (e.g., GMT versus local), the configuration of the radar (e.g., antenna type and angle, range setting), or how and when the radar was last calibrated. Depending on the avian radar system, some of this metadata may be recorded in a “configuration file” that is generated and used by the DRSP.

(b) Another common type of metadata is found in a data dictionary. A data dictionary is a human-readable document that names and describes the records and fields in the output data stream. A data dictionary provides details such as the type and length of each data element and the minimum and maximum values of numeric fields. If the output data is simply streamed into ASCII “flat” files, a single data dictionary may suffice. However, if the data is streamed into an RDBMS, a second data dictionary is also required that describes the tables, records, and fields in the database; the type and length of data elements; minimum and maximum values; and similar information. A document that maps the elements in the output data stream into the tables and elements of the database is also desirable.

(c) The importance of metadata, including a data dictionary, cannot be overemphasized. Without it, the avian radar becomes, in a sense, a black-box that limits the users’ ability to understand and interpret the data and to use the data for other, perhaps unforeseen, applications. As an example, avian radars can only directly measure the range and azimuth of a target. If the DRSP computes the altitude of a target, the description of the altitude field in the data dictionary should detail how (including the formula) altitude is computed, the assumptions that go into that computation (e.g., a narrow-beam dish antenna was used), whether the altitude values are reported as integer or decimal numbers, the precision of the computed altitudes as a function of range (e.g., ±4 m at 1 km), and the units and datum in which the altitude values are recorded (e.g., meters above radar level). From this information and other metadata, the users can, for example, compute the height of a target above ground level.

(d) Metadata needs to be tightly coupled with the primary measurement data. Both the data and metadata should be contained in the same data storage mechanism. When users retrieve measurement data, they should be able to easily find the accompanying metadata, and vice versa. Equally important, when the measurements data are moved from one RDBMS to another, the metadata should be moved.

6.4. DATA ANALYSIS AND THE RISK ASSESSMENT PROCESS.

a. Once avian radar data can be reliably obtained and used, the process of analyzing the data can begin. Involves the identification of potential threats through the use of fundamental risk management processes. A risk assessment is a systematic, explicit, and comprehensive approach for managing wildlife risks impacting the airport. The guidance in this chapter concerning the performance of a risk assessment will help an airport to accurately assess wildlife hazards.

b. A risk assessment enables an airport to determine where unsafe wildlife conditions exist. Planning for and mitigating such conditions creates multiple layers of safety within the airport environment. An incident or accident will most likely occur when gaps in the safety layers present themselves, such as staff being unaware of a potentially hazardous situation. The risk assessment process helps to focus staff attention and streamline efforts expended in managing wildlife hazards.

c. There are five phases in the wildlife hazard risk assessment process:

- Phase 1. Describe the system
- Phase 2. Identify the hazards
- Phase 3. Determine the risk
- Phase 4. Assess and analyze the risk
- Phase 5. Treat the risk
- Phase 6. Supervise and review the assessment.

d. These phases are described below:

(1) Phase 1: Describe the system. When considering the environment of the airport system, consider all of the wildlife risks already outlined in the ACM, wildlife hazard assessment, and/or wildlife hazard management plan. The existing risks and conditions should steer the focus of the risk management analysis and will assist in determining potential mitigation strategies.

(2) Phase 2: Identify Hazards.

(a) In this phase, wildlife hazard sources are identified in a systematic, disciplined way. There are many ways to do this, but all require the identifier to have at least four skills:

(i) Operational expertise

(ii) Training in wildlife hazard risk management, and if possible, hazard analysis techniques

(iii) A simple, but well-defined, hazard analysis tool

(iv) Adequate documentation of the process

(b) The hazard identification effort should mirror the management structure and complexity of the airport in question. The airport manager at a small airport could conduct it alone, while it may be conducted by a committee or group at a larger airport. Regardless, the person or the group will require sufficient operations expertise, safety experience, and training to adequately conduct the assessment.

(c) The hazard identification stage considers all the possible sources and contributing factors of wildlife hazards.

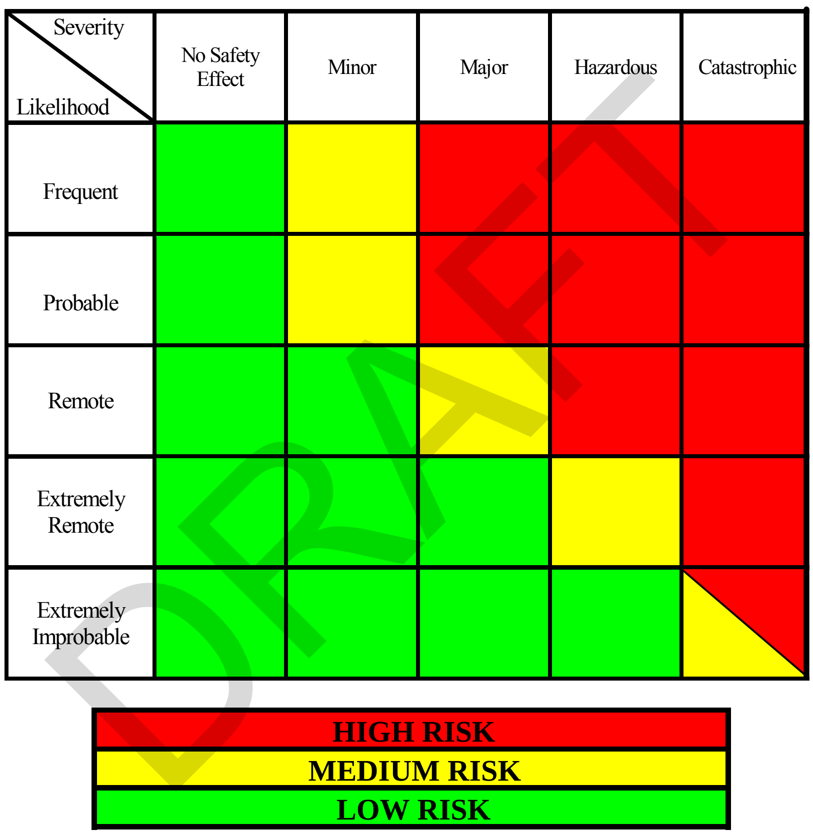
(3) Phase 3. Determine the risk

(a) In this phase, each wildlife hazard in its system context is identified to determine what risks exist, if any, that may be related to the hazard. In this phase, there is no determination of the severity or potential of the risk occurring. First, all potential hazards are identified and documented. Next, the hazards are subjected to an assessment of the possible severity and potential risk as described in Phase 4.

(b) For example, an airport may have identified a wildlife hazard at a busy runway approach area, with the associated risk of resident birds being ingested into the engines of landing aircraft. That hazard and the identified risk would be documented before moving to Phase 4, a determination of the probability of that risk occurring, and the severity if such an event were to occur.

(4) Phase 4: Assess and Analyze the Risk. In this Phase, the airport operator estimates the level of risk such as by using the predictive risk matrix in Table 6-1. *Note: Airports may choose to reduce or expand the size of this table based on their physical configuration and operational characteristics. In addition, since no formal FAA requirements exist for a "predictive risk matrix," airports may choose to define each category differently.*

Table 6-1. Predictive Risk Matrix



(a) Risk is the composite of the predicted severity and likelihood of the outcome or effect (harm) of the hazard in the worst credible system state. In order to assess the risk of an accident or incident occurring, severity and likelihood are first determined.

(b) Severity is determined by the worst credible potential outcome. Less severe effects may be considered in addition to this, but at a minimum, the most severe effects are considered. Determination of severity is independent of likelihood, and likelihood should not be considered when determining severity. Over time, quantitative data may support or alter the determinations of severity and probability, but the initial risk determinations will most likely be qualitative in nature, based on experience and judgment more than data.

(c) The risk levels used in the matrix can be defined as:

(i) High risk – Unacceptable level of risk: The proposal cannot be implemented or the activity continued unless hazards are further mitigated so that risk is reduced to medium or low level. Tracking and management involvement are required, and management must approve any proposed mitigating controls. Catastrophic hazards that are caused by:

- single-point events or failures
- common-cause events or failures
- undetectable latent events in combination with single point or common cause events are considered high risk, even if extremely remote

(ii) Medium risk – Acceptable level of risk: Minimum acceptable safety objective; the proposal may be implemented or the activity can continue, but tracking and management are required.

(iii) Low risk – Target level of risk: Acceptable without restriction or limitation; the identified hazards are not required to be actively managed, but are documented.

(d) Hazards are ranked according to the severity and the likelihood of their risk, which is illustrated by where they fall on the risk matrix. Hazards with high risk receive higher priority for treatment and mitigation.

NOTE: *At U.S. airports, many of the airport operators' actions are governed by standards issued by the FAA. The FAA would not expect an airport operator to conduct an independent risk analysis of an action or condition directed by a mandatory FAA standard or specification. Any discretionary action or decision by the airport operator in the application of the standards should still be analyzed.*

(5) Phase 5: Treat the risk. In this phase, the airport operator develops options to mitigate the risk and alternative strategies for managing a hazard's risk(s). These strategies can be used to reduce the hazard's effects on the system. It should be noted that the majority of risk management strategies address medium and high-risk hazards. Low-risk hazards may be accepted after considering risk.

(a) The risk management activity should identify feasible options to control or mitigate risk. Some options could include:

- Avoidance: selecting a different approach or not participating in, or allowing, the operation or procedure
- Assumption: accepting the likelihood, probability, and consequences associated with the risk
- Control: development of options and alternatives that minimize or eliminate the risk
- Transfer: shifting the risk to another area

(b) Prior to operational use, a mitigation strategy is validated and verified (as operational experience or data may support). Once validated, verified, and accepted, it then becomes an existing element of the system or operation.

(c) Next, the effect of the proposed mitigation measure on the overall risk is assessed. If necessary, the process is repeated until a measure or combination of measures is found that reduces the risk to an acceptable level.

(d) When risk is determined to be unacceptable, it is necessary to identify and evaluate risk mitigation measures by which the probability of occurrence and/or the severity of the hazard could be reduced. When risk mitigation strategies cross organizations, risk acceptance and approval from stakeholder organizations is necessary.

(e) Risk mitigation may require a management decision to approve, fund, schedule, and implement one or more risk mitigation strategies. Appropriate risk mitigation strategies are developed, documented, selected, and implemented. Hazard tracking is the core of this risk management phase. Each medium and high-risk hazard is tracked until its risk is mitigated to an acceptable level and the effectiveness of the controls mitigating the risk is verified.

(f) When assessing risk using a group or committee, remember that interactions between safety-group participants with varying experience and knowledge tend to lead to broader, more comprehensive, and more balanced consideration of safety issues than if an individual conducts the assessment. Thus, if possible, group analysis by appropriate subject matter experts, is recommended.

(6) Supervise and review the assessment. This step provides a continuous monitoring function in the risk assessment process and triggers—on the basis of new or changing incident data, a return to Step 1 of the assessment process.

6.5. CONTINUOUS PROGRAM IMPROVEMENT.

a. Safety performance monitoring validates the wildlife hazard management program, confirming the organization’s safety objectives. Through regular review and evaluation, management can pursue continuous improvements in wildlife management and may revise safety objectives, policies, procedures, and training programs to ensure that the wildlife management program remains effective and relevant to the organization’s operation.

b. The wildlife Manager, in assessing the effectiveness of the wildlife management program, should work with the persons that have direct responsibility for analyzing hazards, identifying control measures derived from that analysis, and ensuring those measures are effective.

c. Program Audits. Similar to financial audits, these audits provide a means for systematically assessing how well the organization is meeting its wildlife management objectives. The audit provides a review of existing conditions and results in recommendations for enhanced wildlife control. Management may choose to have an external agency audit the system (e.g., by a consultant or another airport operator), or choose to perform the audit using airport/airline staff. In addition to supporting the airport operator’s existing responsibilities for self-inspection and correction of discrepancies under 14 CFR Part 139, an effective airport wildlife management program audit should:

(1) Systematically review the effectiveness of existing wildlife-management procedures used by airport and airline personnel, including all available feedback from daily self-inspections, assessments, reports, and other safety audits;

(2) Develop identified performance indicators and targets;

(3) Solicit input through a non-punitive safety reporting system;

(4) Communicate findings to staff and implement agreed-upon corrective procedures, mitigation strategies, and enhanced training programs; and

(5) Promote safety in the overall operation of the airport by improving coordination between airport staff, airline personnel, and airport tenants.

d. Wildlife Committee.

(1) A number of airports of varying sizes and complexities have found it helpful to establish a wildlife committee.

(2) The composition of the committee is under the airport's discretion, but typical committee members include those stakeholders with a direct relationship to wildlife hazards, including: tenant representatives, airlines, airport operations and public safety staff, and contractor representatives, etc. The airport's wildlife manager would typically chair the committee.

(3) One of the most important functions of the wildlife committee is to serve as a resource for the wildlife manager. In addition, the determination of potentially hazardous wildlife situations can be performed by the wildlife committee, as well as performing an evaluation of collected wildlife hazard data.

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APPENDIX A. ADDITIONAL SYSTEM STANDARDS.

a. Design Standards.

(1) Total Life. Avian radar systems must be designed to perform its intended function for its "total life" period when maintained according to the manufacturer's instructions. The "total life" for which the equipment is designed, assuming it is used and maintained in accordance with the manufacturer's recommendations, must be a minimum of 10 years.

(a) Avian radar equipment reliability. The mean time between failure for a magnetron component must be at least 3 years.

(2) Environment. Avian radar systems, including all associated outdoor mounted equipment, must be designed to withstand the following extreme climatic conditions and operate without damage or failure:

(a) Weather:

(i) Ambient temperature range: -25 degrees F (-32 degrees C) to +123 degrees F (+52 degrees C) ambient outdoor air temperature (may be modified by the purchaser if the device is to be used in extreme climates).

(ii) Relative Humidity: 5% to 90% (may be modified by the purchaser if the device is to be used in extreme climates).

(iii) General Environment: Dust and airborne hydrocarbons resulting from jet fuel fumes.

(b) Components must be protected from mechanical, electrical, and corrosion damage causing impairment of operation due to rain, snow, ice, sand, grit, and deicing fluids.

(c) All electric motors, controls, and electrical wiring / equipment placed outdoors must be weatherproof in order to protect the equipment and connections from the elements.

(d) All non-moving structural components and materials must be individually and collectively designed and selected to serve the total life requirement under such conditions. Moving or working components, such as tires, motors, brakes, etc. are exempt from this provision.

(3) Power Supply. In the event of a power failure, the system must have the capability to automatically power-up and operate in the condition and settings that were available just prior to the power failure.

b. Construction Standards.

(1) General Requirements:

(a) All equipment and material must be new, undamaged, and of the best grade; decisions concerning quality, fitness of materials, or workmanship are determined by the purchaser.

(b) Where items exceed one in number, the manufacturer must provide products from the same component manufacturer with identical construction, model numbers, and appearance.

(c) Insofar as possible, products must be the standard and proven design of the manufacturer.

(d) The manufacturer must install electrical connections for power, controls, and devices in accordance with NEMA and NEC recommendations and requirements. Transmitting equipment must be installed and adjusted in accordance with manufacturer's published instructions and the requirements specified herein.

(2) Workmanship. The manufacturer must install all equipment, materials, specialties, etc., in accordance with the best engineering practice and standards for this type of work.

(3) Materials:

(a) Equipment exposed to the weather must be weatherproof type.

(b) All external components must be constructed and finished in a manner to inhibit corrosion based on the purchaser's specific environment.

(c) All machined surfaces must be coated with a suitable rust preventative.

(4) Parts:

(a) Standard and Commercial Parts. Insofar as practicable, commercially available standard parts complying with commercial and/or military standards must be used throughout.

(b) Interchangeability and Replaceability.

(i) All parts having the same manufacturer's part number must be directly and completely interchangeable with each other with respect to installation and performance.

(ii) All components and assemblies incorporated in the equipment must be designed and manufactured to dimensional tolerances which permit future interchangeability and facilitate the replacement of parts.

(c) Spare / Replacement of Parts. The manufacturer must develop and provide to the purchaser a parts list, including associated replacement/repair costs.

(d) Substitutions. The purchaser must approve any material or equipment designated as an "or equal" product, but these items must be clearly distinguished and noted in the technical manuals as substitutions.

(5) Codes, Standards, Regulations, and References. The manufacturer must recognize and comply with all codes and standards applicable to the design and construction of this type of equipment which are generally accepted and used as good practice in the industry.

c. Installation and Acceptance Standards.

(1) Installation:

(a) Obstructions and other standards. Avian radar systems must conform to applicable airport obstruction criteria, marking and lighting, and equipment design and installation standards.

(b) Prior to installation, the manufacturer must obtain all site construction, environmental, and coordination requirements for installation of the detection system at the airport.

(c) Unless otherwise specified by the purchaser, installers of mechanical and electrical work must participate in any pre-installation meetings at the project site to review conditions of other related project work.

(d) The manufacturer must provide trained personnel at the time of delivery to place the device into operation.

(e) Equipment located outside of paved surfaces should be designed and built with ease of maintenance in mind.

(2) Quality Assurance. The manufacturer must test all of the equipment installed under this specification and demonstrate its proper operation to the purchaser. The manufacturer must furnish all required labor, testing, instruments and devices required for the conduct of such tests.

(a) The manufacturer must install all electrical, instrumentation, and mechanical works to the satisfaction of the purchaser, with inspecting authorities having jurisdiction.

(b) The manufacturer must notify the purchaser in writing of any instances in the specifications that are in conflict with applicable codes. The manufacturer must perform all work in accordance with applicable laws, rules, or regulations.

(c) Deviations from the specifications required for conformance with the applicable codes and/or laws must be corrected immediately, but not until such deviations have been brought to the attention of the purchaser.

(d) For applicable codes and/or laws that govern the minimum design requirements: where this AC calls for materials, vents, sizes, design details, etc., in excess of the code requirements, the AC takes precedence.

(3) Inspection. The manufacturer will establish a formalized final inspection regimen to ensure each system is adjusted as designed, all systems are operating properly, and the finish in complete and undamaged. The user may choose to participate in the final inspection of designated systems.

(4) Testing. After the equipment has been installed and the various units have been inspected, adjusted/calibrated, and placed in correct operating condition, the equipment must be field tested in accordance with the purchaser's testing procedures and requirements. The field tests must demonstrate that the equipment functions are in compliance with the specifications over the entire range of operation. The manufacturer must report any unusual conditions and correct deficiencies of any of the units.

(a) Preliminary Qualification Tests. Preliminary qualification tests may be specified by the purchaser.

(b) Formal Qualification Tests. Formal qualification tests may be specified by the purchaser.

(5) Manuals and Publications. The following operation and maintenance manuals must accompany the delivered equipment. The quantity of items is specified by the purchaser. No special format is required.

(a) Operator's handbook.

(b) Illustrated parts breakdown and list.

(c) Preventive maintenance schedule.

d. Equipment Training and Maintenance Standards.

(1) Training:

(a) The manufacturer must provide trained personnel at the time of delivery to adequately train airport/airline staff in the operation and maintenance of the detection equipment.

(b) Training must include written operating instructions that depict the step by step operational use of the detection system. Written instructions must include, or be supplemented by, materials which can be used to train subsequent new operators.

(c) Training topics must include trouble shooting and problem solving, in the form of theory and hands-on training, for personnel designated by the purchaser.

(d) At least four hours of training for airport/airline personnel must be provided by the manufacturer. Training selected personnel as part of a "Train the Trainer" program will also satisfy this requirement.

(e) Upon the completion of training, the manufacturer must issue to each participant a certificate of competency.

(2) Maintenance:

(a) Preventive. The manufacturer must develop and provide to the purchaser written documentation on recommended preventive maintenance actions.

(b) Cleaning. The manufacturer must develop and provide to the purchaser written documentation on recommended cleaning procedures, including solvent types and tools.

(c) Inspection. The manufacturer must develop and provide to the purchaser written documentation on regularly scheduled maintenance inspection procedures. A focus on sensitive equipment and schedule timelines must be included in the documentation.

(d) Recalibration. The manufacturer must develop and provide to the purchaser a recalibration plan and recalibration procedures. Recalibration should ensure wildlife management program performance specifications are maintained for the life of the sensor.

e. Procurement Guidance:

(1) All options should be explored in the procurement of avian radar technologies. If airport personnel are confident that requirements and specifications can be developed for bidding or other procurement procedures, then they can proceed directly to procurement. If there is uncertainty about the actual requirements of specifications, then a demonstration of the technology at the airport should be considered. In the demonstration, the manufacturer will provide an operational radar system and work with airport personnel to establish how needs and objectives can be translated into tangible specifications for radar acquisition. In this situation, manufacturers can supply much needed technical information to airport personal who, in turn, will be able to assess how their needs can be met by a manufacturer's product. **NOTE:** *The costs for such a demonstration must be borne by the airport, and are not eligible for reimbursement with federal funds.*

(2) It is essential for airports to determine the level of support they need from a manufacturer and to develop specifications for operation and maintenance services consistent with the availability and responsibility of airport personnel. Manufacturer involvement can range from generally independent management of the radar system by the airport to a turn-key operation with regular assistance provided by the manufacturer.

(3) Buy America. Equipment described in this AC purchased with federal funds (AIP or PFC) are subject to the Buy America Act codified in 49 USC 50101. Further information, including waiver qualifications, can be found in the legislative text located at: http://uscode.house.gov/

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