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Integration and Validation of Networked Avian Radar (IVAR)

Abstract

A team of scientists and engineers from the federal government, industry, and academia is evaluating the ability of digital radar systems to identify and track biological targets and then validating these systems under realistic operational conditions. The Integration and Validation of Avian Radars (IVAR) project is funded by the Department of Defense Environmental Security Technology Certification Program. The eBirdRad radar unit utilizes off the shelf X-band marine radar coupled with advanced digital signal processing and tracking algorithms to process target information. The overall objectives of the IVAR project include: 1) the use of independent visual, thermal and other observations to validate automatic detection, tracking, and display of targets in real-time; 2) demonstrate the statistical validity of sampling protocols for bird activity; 3) validate protocols and algorithms for streaming real-time bird track data from multiple sites for immediate display and subsequent analyses; 4) demonstrate algorithms for fusing data from multiple radars; 5) capture baseline data on bird activity at the demonstration sites; 6) develop objective criteria for functional, performance, and interoperability requirements of these radars, and to guide research to extend avian radar technology. The dissemination of information through the peer review process is essential before the natural resources management community can effectively use radar to assist in the decision making process.

Introduction

Encroachment has transformed many military bases into refugia for a variety of wildlife, many of which are protected species. Birds top the list of wildlife requiring management and/or protection at military bases. Collisions between birds and aircraft are another escalating problem for military and civilian aviation worldwide, resulting in more than $1 billion dollars per year in damage to aircraft and putting passengers and air crews at risk. Despite their importance in natural resources management and air safety, birds, because of their mobility and diversity of behaviors and habitats, are notoriously difficult and expensive to sample accurately. Having a tool that can automatically detect and track birds in real-time 24/7 will provide types and amounts of data on bird activity that would not be practical to obtain any other way. These systems can alert air crews and air traffic personnel when dangerous concentrations of birds are present during air operations. They can notify natural resource managers of unusual concentrations of birds in time to send someone to investigate. And they can provide historical data for analyzing daily and seasonal activity patterns of both resident and migratory populations, for use in environmental assessments, planning operations and exercises, siting facilities to minimize their impact on bird populations, etc.

Under a growing mandate to “do more with less”, military resource managers need tools that yield a clearer understanding of where and when birds are present, what attracts them to certain locations, and how changes in the natural or manmade environments affect their distribution. Current sampling methods (e.g., visual observations) are slow and expensive, particularly for large facilities. Visual census methods, while more effective for sampling roosting birds during daylight, are unreliable from dusk to dawn, when the activity of some, particularly migratory, species is greatest, and when used to sample at the elevations and ranges of most bird strikes.

Ornithologists, scientist and radar engineers have demonstrated that inexpensive marine radars can be adapted to detect and track birds and other biological targets. However, before these systems can be applied systematically to natural resources management and bird air-strike avoidance issues, the data they generate must be scientifically validated and peer reviewed. This requires the development, validation and comparison of different sampling locations and times, bird populations, and radar configurations.

Description

The IVAR project team will employ the eBirdRad avian radar systems operating at multiple locations to validate, through independent visual, thermal and other observations that X-band radars, coupled with advanced digital signal processing and tracking algorithms, can detect and track birds and other biological targets. Previous research and deployments using small radars to monitor bird movements have relied on experienced radar ornithologists to manually interpret the radar display. Birds can sometimes be distinguished from insects and bats based on their different behaviors. Advanced automatic tracking software can distinguish among these types of target tracks based on their velocity; it can discriminate them from aircraft using the same criterion.

The original Bird Radar (BirdRad) system was designed to be an inexpensive, mobile avian radar. It included a low-cost COTS marine radar (Furuno 2155BB) outfitted with a 4º beamwidth parabolic dish antenna (for better altitude resolution) and a desktop PC for displaying and capturing the radar images in graphic files. Five BirdRad systems were built by the Clemson University Radar Ornithology Lab (CUROL) and deployed at three Navy, one Marine Corps, and one Air Force sites.

While highly effective at detecting birds in the desired 0-6 nautical mile (nmi) range, BirdRad had several limitations, principally: Radar returns from stationary objects (“ground clutter”) obscured mobile targets; extracting target tracks from screen shots was too slow and labor intensive to track many types of birds; it was difficult to relate the targets on the radar screen to the surrounding landscape. These limitations are a consequence of the fact the 2155BB is an analog radar.

The enhanced BirdRad (eBirdRad) system employs Sicom Systems’ Accipiter® Digital Radar Processor (DRP) to digitize the analog signal of the 2155BB radar. The system includes a digital radar interface board mounted in a COTS PC to digitize the raw analog data from each sweep of the radar and provide the data to the DRP. The Processor performs the signal processing, display, detection, tracking, data archiving and distribution in real-time. Processor functions include scan-conversion, adaptive clutter-map processing to remove ground and weather clutter, detection, and numerous operator displays, including a built-in GIS. The Processor uses high-performance MHT/IMM automatic tracking algorithms, the gold standard for military applications. Its design is highly modular and includes an integrated client application suited for avian radar applications. All Processor functions are implemented in software and are user-configurable in real-time.

The superior performance of eBirdRad derives from the Accipiter® DRP being the only affordable desktop implementation of the MHT/IMM algorithms – the recognized standard for difficult tracking of maneuvering targets in three dimensions. The efficiency of these algorithms allows eBirdRad to be operated at lower detection thresholds, and

thus to detect and track dim targets. And because eBirdRad was designed to be Web Services-compliant, it is the only avian radar that meets DOD's emerging network-centric architectures (e.g., FORCEnet, GIG, etc.).

Technical Approach

eBirdRad has demonstrated that detecting and tracking birds in three dimensions over a 0-6 nmi range is feasible and affordable. During the IVAR project, there will be seven Accipiter®-based avian radar systems deployed at the locations listed in Table 1 (see Table 2 for the sites and the sponsors of each site). ESTCP funds will be used to lease Accipiter® processors for two more sites. The objectives of this project require avian radar systems to be evaluated under a range of real-world conditions: Environmental, seasonal, operating, terrain, clutter, different sizes, types, and numbers of birds or other biological targets such as bats and insects. No one site has all the requisite range of conditions. While some of the units in Table 1 are mobile and could (and will) be deployed to other sites for specific studies (e.g., data fusion), permanently assigned radars will generate longer term re-cords at multiple sites for better between-site comparisons and replicate within-site studies.

Table 1. List of Performers and their organizations.

Role	Organization	POC
Lead	SPAWAR Systems Center	Marissa Brand
Partnering	Sicom Systems Ltd	Dr. Timothy J. Nohara
	Clemson University	Dr. Sidney Gauthreaux, Jr
	USDA/Wildlife Services	Dr. Robert C. Beason
		Michael Begier
	Computer Sciences Corp.	Gerald S. Key
	NAS Patuxent River	James Swift
Demonstration Sites	NAS Whidbey Island	Matt Klope
	Washington County OLF	William D. Nobel
	MCAS Cherry Point	William H. Rogers
	Elmendorf AFB	Herman Griese
	FAA (SEATAC & JFK)	Ryan King
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Table 2. Accipiter®-Based Avian Radars at Performer Site.

Site	Model	Sponsor	As Of
NAS Patuxent River	eBirdRad	Navy	Present
MCAS Cherry Point	eBirdRad	Navy	Present
Sicom Systems Ltd	AR-1 Mobile Unit	Navy	Present
SEATAC Int'l Airport	AR-2	FAA-CEAT	October 2006
Sicom Systems Ltd	eBirdRad t	Navy	October 2006
NAS Whidbey Island	eBirdRad	Navy/FAA-CEAT	June 2007
Washington County OLF	eBirdRad	Navy	March 2007
JFK Int'l Airport	AR-1 Mobile Unit	FAA-CEAT	March 2007
Clemson University	eBirdRad	Navy/ESTCP	June 2007
Elmendorf AFB	eBirdRad	Navy/ESTCP	January 2008

Validating avian radar systems will be the focus of the project during the first year, using existing sites to validate the radar physics and biological sampling capabilities of these systems. Thermal imagery will be used to provide additional "ground truth" of biological

targets. The data will be managed and retained to use later in additional validation studies. Similarly, data collected to meet an early project objective (e.g., validation) will be stored so they can be replayed later to develop and test data streaming algorithms under different conditions. And throughout the project, protocols developed to configure and operate the radars and to collect, process and transmit data will be used to adapt and extend the functional requirements and performance specifications for avian radars.