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Reducing Bird Strikes-New Radar Networks Can Help Make Skies Safer

Tim J. Nobara, B.Eng, P.Eng, M.Eng, Ph.D

Accipiter Radar

President & CEO

Introduction

Readers of the *Journal of Air Traffic Control* hardly need to be told about the hazards of bird strikes. Even the general public is aware of them, following the downing of US Airways Flight 1549. Yet, the “Miracle on the Hudson” could have been a tragedy, had it not been for the professionalism of the aircraft’s crew and the support of rescuers.

Unfortunately, other bird strike losses have been beyond either the aircrews’ or the controllers’ help. At Boston/Logan in 1960, an Eastern Airlines Lockheed Electra hit a flock of starlings immediately after take-off, and crashed into Boston Harbor, with the loss of 62 lives. In 1995, all 24 crewmembers of a USAF E-3B AWACS died at Elmendorf AFB, AK, after the aircraft struck several geese just after rotation. Aside from the devastation of human lives lost, it’s estimated that bird strikes annually cost the aviation industry over one billion dollars worldwide.

So what is the current state of bird strike prevention? This article describes where we are today, and demonstrates how dedicated avian radar technology is starting to make a difference.

An Ideal Solution

One effective way to minimize bird strikes is to continuously track birds, both along their migratory flight paths and, especially, near airports where the threat of strikes is greatest. Think of having dedicated displays at every airport, at air traffic control facilities, with selectable presentations showing national, regional and local situations, including actual and predicted bird movements and hazards. Imagine being able to select altitude “slices” and spatial areas for closer examination.

Where are we today? Currently, airport wildlife management mainly consists of manned patrols with noise makers, pyrotechnics, falcons, dogs and traps, coupled with efforts to reduce wildlife attractants on and near the airport



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Figure 1. Planes & birds share the sky

such as vegetation management, draining standing water, zoning restrictions on garbage dumps and similar actions, in accordance with a Wildlife Hazard Management Plan usually developed and implemented with the help of USDA Wildlife Services airport wildlife biologists and specialists. These techniques are extremely valuable and have unquestionably prevented countless accidents. But they are primarily directed at keeping birds away from the immediate vicinity of the runway and the adjacent airspace of arriving or departing aircraft. At most airports visual observations are the primary source of real-time bird situational awareness and typically humans can only reliably see birds during the daylight hours at relatively short distances of up to a few hundred meters away. Visual observations are limited in time and space to when and where personnel are on patrol.

Avian radar acts as a powerful force multiplier to the wildlife manager and airport operations personnel, by bringing long-range, 360-degree, real-time situational awareness every minute of the day and night and 365 days a year. Furthermore, radar’s ability to continuously compute and store 3D position (latitude, longitude and height), speed, heading,

and radar cross section (RCS) for every tracked bird, every couple of seconds and to relay to users, process and playback massive amounts of this target information allows wildlife personnel to analyze daily and seasonal bird movements for real-time and historical uses. These capabilities can greatly enhance bird strike mitigation efforts, without increasing the associated human, monetary and environmental costs.

Steve Osmek, Senior Wildlife Biologist at Seattle-Tacoma International Airport (SeaTac) who has been using Accipiter avian radars for over two years stated *“Real-time information on birds approaching the airfield is very valuable, allowing me to intercept birds and harass them with pyrotechnics to keep them off the airport. I can also radio the tower if bird hazards to aircraft persist at a specific location. A better understanding of exactly what times of the day large flocks of European starlings approach the airport allows us to coordinate our harassment activities before these birds reach the airfield itself. Wildlife personnel using trends extracted from historical data also help us evaluate our new wildlife hazard management techniques at our storm-water ponds to determine how they are performing.”*

In the near term, it is expected that avian radars will be widely deployed at airports realizing the biggest safety

improvements for the cost, with a valuable next step being real-time target information linkages between avian radars at neighboring airports to provide a broader picture. Already, in fact, an Accipiter Radar ornithologist using an integrated display at the company’s Buffalo, NY, facility can watch real time bird movements from avian radars at Seattle-Tacoma, Chicago O’Hare and New York’s Kennedy airports along with others across North America. Simultaneously, wildlife personnel at those airports can be using their own displays to view their local information. And separately, Accipiter engineers can be checking the technical status of individual radars, without affecting these operational activities.

In looking into the future we can envisage linking local airport avian radars with bird target information derived from airport surveillance radars (ASR) and the national NEXRAD weather radar network. The high-resolution (10 m range resolution) airport avian radars can be used to provide updated ATIS advisories of bird activity within about ten nautical miles (nmi) from the airport while the medium-range ASRs provide intermediate resolution of about 150 meters out to around 60 nmi; with the long-range NEXRADs providing 1,000 meter low-resolution advisories out to about 120 nmi along air routes and at higher altitudes. (Note: While extracting bird target information from the ASRs has been demonstrated, such information is not available today.) However, aircraft TCAS-like bird avoidance systems, providing Resolution Advisories to pilots, are unlikely in the for-seeable future, because of the complexities and stringent requirements associated with aircraft control systems and the hazards of pilot avoidance actions at low altitudes or in busy airspace.

Eventually, integration of all systems could provide a complete North American Bird Strike Advisory Network, providing pilots, dispatchers and controllers with advisories of actual and predicted bird activity, from departure through en route to arrival and keyed to the expected flight plan times and altitudes in each segment, with detailed attention focused on the departure and arrival phases. Approaching their top of descent points, pilots could be provided with an accurate forecast of likely bird activity as they prepare to descend into the more hostile bird strike territory below 3,000 feet.

Current Operational Status of Avian Radar

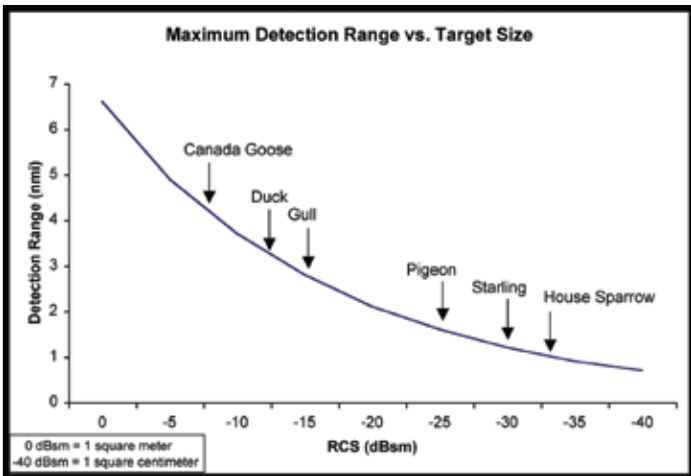
Can avian radar really track birds? Unquestionably, yes. Based on inexpensive marine radar transceivers coupled with sophisticated digital radar processors, avian radars are sensitive enough to pick up clouds of very small insects or



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Figure 2. Accipiter Radar tracks of starlings identifies new roost at SeaTac

individual larger insects such as dragonflies at short range, which are then filtered out as unwanted “clutter”. Basically, it’s a question of biomass and the distance of the bird(s) from the radar. As a particular target moves away from the radar, eventually its echo received at the radar will be too small to detect and will be lost. The radar processor is designed to automatically detect birds and then to track their positions over time so that trajectory and other target information are extracted. Depending on their radar cross-section, large individual birds can be tracked several miles out, while flocks can be tracked to 10 nmi and beyond.



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Figure 3. Bird radar cross section (related to size) determines detection range

The original developers of radar during WW II attempted unsuccessfully to remove bird returns, since they were seen as target-obscuring clutter. Today, for obvious reasons, bird returns are deliberately suppressed in the ASRs although it has been demonstrated that the data could be accessed for bird tracking. NEXRAD radars, however, do provide bird density information, a valuable capability especially during migration periods.

Yet while avian radars have been commercially developed and deployed, there are no current performance specifications, functional requirements or standards for airport use, unlike other airport radar equipment. A lack of specifications and standards brings the concern of inconsistency in performance and use and can inhibit integration with existing airport systems and wildlife management processes, potentially impairing safety.

In 2006, the FAA charged the Center of Excellence for Airport Technologies (CEAT) at the University of Illinois to conduct an assessment of the capabilities of commercially available avian radar systems with a view towards developing guidance to civil airports for their successful use.



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Figure 4. Accipiter Radars at SeaTac provide 360 degree, 3D information on birds

CEAT’s avian radar activity is led by Professor Edwin Herricks, its Coordinator of Airport Safety Programs and the 2008 recipient of the agency’s prestigious Excellence in Aviation Research award. CEAT’s Performance Assessment Program is a cooperative, CEAT-directed effort among the FAA, other federal agencies, airports, and vendors. It employs methodical, science-based procedures to determine technical characteristics, detection capability for avian targets, and the operational performance of avian radars in a commercial airport environment. The goal of the program is to gather the information necessary to assure that large scale deployment and operational use of avian radar technologies at civil airports is justified based on proven performance, does not compromise safety, and is compatible with all aspects of airport operations.

Under the program so far, Accipiter avian radar systems have been installed at Seattle’s SeaTac, Chicago’s O’Hare and New York’s JFK. This plan puts the radars into the hands of host airport end users so that they can provide necessary feedback to determine how these tools can best be integrated into existing wildlife control practices to improve safety.

In addition, the FAA's Avian Radar Assessment Program has joined up with DoD's Environmental Security Technology Certification Program to leverage their avian radar validation efforts under the Integration & Validation of Avian Radars (IVAR) project. This project began in early 2007 with Accipiter radars deployed at Elmendorf Air Force Base, AK, Patuxent River Naval Air Station, MD, Naval Air Station Whidbey Island, WA, Marine Corps Air Station Cherry Point, NC, and Edisto Island, SC.

In one to two years, the information needed for a formal FAA Advisory Circular (AC) should be in hand, that will include minimum requirements, specifications and standards relating to the successful acquisition, deployment, commissioning, operation, training and maintenance of avian radar systems at civil airports, consistent with uses that have been demonstrated to integrate well with existing wildlife control practices, in accordance with regulations. The AC is also expected to address avian radar funding under the FAA's Airport Improvement Program (AIP).

Avian radar – Inexpensive and Versatile

Military radar systems and mission-critical civil systems such as ASRs are very expensive to develop, acquire and operate due to their hardware complexity and relatively small production quantities. For affordability, all avian radars use commercial-off-the-shelf (COTS) marine radar transceivers, the same kind used on ships and fishing boats. Marine radars are used all over the world and sales number in the hundreds of thousands; hence, they are very inexpensive, costing only 1/10th to 1/100th of their high-end counterparts. At the same time, they are rugged, highly reliable and built to withstand severe environmental conditions.

How are avian radars used? In many different ways, with more applications coming to light as experience with their use grows. For example, a wildlife biologist could begin the day over coffee by rapidly replaying night-time bird movements to see where birds flew in overnight and plan dispersal activities for the morning. While en route, the biologist can view current bird movements around the airfield in real-time on a display in his or her truck. While away from the truck, a Blackberry could receive a text message warning of an incoming flock approaching the airport. Particular alerts indicative of birds in specific hazardous airspaces could also go directly to the tower or other air operations personnel, and could be accompanied by specialized ATC bird alert displays. In the office, wildlife staff can be reviewing historical movement patterns to identify the onset of migration and patterns that may be indicative of new roosting sites, or to

monitor the effectiveness of new habitat alterations intended to reduce bird attractants.

A pilot planning to fly to a particular airport could access a web site over the Internet and examine various bird activity levels today, the past week, or the past month, for example.

Airport managers could retrieve daily, monthly and seasonal count and movement detail and compare year-over-year data to assess long-term trends resulting from the implementation of their individual wildlife hazard management plans.

Following a bird strike, air operations personnel could playback tracks shortly before the strike occurred to try to determine where the birds came from. Accident investigators could do the same.

And importantly, like access to NextGen's future System Wide Information Management (SWIM) system, all these individuals could access the avian radar network simultaneously for their specialized data needs.

The system's powerful processing capabilities support real-time displays, automated alerts, and a variety of information products that derive from recorded target information. Accipiter avian radars include a patented, multi-mission, multi-user, target information system that supports real-time integration and fusion from multiple avian radars (larger

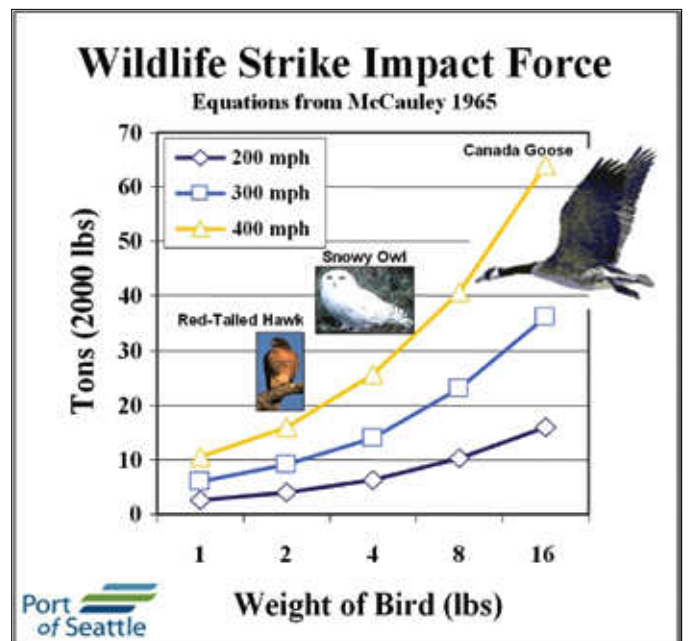


Figure 5. Current jet engines are designed against single bird ingestions up to four pounds

airports will need more than one for adequate coverage), provides open interfaces to third party airport management systems and facilitates multi-airport, continental integration as described earlier. Furthermore, by providing access to the target information through an open radar data server, users anywhere can simultaneously run any number of different applications appropriate to their specific mission; and new information products can be easily added at will.

X-band, S-band, Antennas and Coverage

Marine radars come in two frequency bands, X-band and S-band, and are fitted with array antennas (sometimes called T-bar or slotted-waveguide antennas) that rotate in the horizontal plane to provide 360-degree coverage. Array antennas produce a narrow beam (approximately 1 degree wide at X-band) with good angular resolution in the horizontal plane and a wide beam (approximately 20 degree high) with poor angular resolution in the vertical plane. Since marine radars are intended for navigation and show required shorelines and reasonably large vessels on the water, the narrow horizontal array beam ensures maximum fidelity where it's needed.

Avian radars can be fitted using X-band or S-band transceivers and antennas. The choice is based on end-use requirements. X-band is typically preferred because for the same size antenna, it gives three times the fidelity in angular resolution for isolating individual birds, for minimizing ground clutter which inhibits detection and for providing more accurate bird location estimates. X-band has also been tested at the FAA's Oklahoma City Test Center and shown not to interfere with ASDE-X surface detection radars or other radar equipment. However, the ASRs are typically at S-band; therefore using S-band avian radars will require similar testing to ensure that interference is not an issue. One advantage with earlier magnetron-based, S-band radar signals over their X-band equivalents is they generate less clutter from rain, providing the antenna resolution is the same (which is not typically the case). However, newer solid-state X-band and S-band marine radar transceivers are being introduced by manufacturers that help reduce clutter of all types, and which will equalize X-band and S-band performance in rain. Magnetron or solid-state transceivers can both be used successfully, with the choice depending on particular airport requirements.



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Array antennas rotating in the usual horizontal plane (H-array), or turned sideways to rotate in the vertical plane (V-array) can be provided by all avian radar vendors. In addition, Accipiter offers custom-built, horizontally rotating, X-band dish antennas. The selection and orientation (horizontally or vertically rotating) of an antenna should also be based on end-use requirements. Antennas that rotate horizontally provide 360-degree coverage, which is highly desirable as birds fly from any direction into and across the airspace around airports. Tracking birds from their roosts to their feeding grounds and back and receiving warning of birds moving from any direction is important for maximizing the benefits of avian radar. V-arrays, rotating like a bicycle wheel, can only provide coverage within a restricted, 20-degree wide vertical trough-like area rising up from the ground and out from the radar and are therefore typically aligned with a particular runway. Birds are only seen by the V-array when they fly down or through the trough. Regardless of their orientation, radars with H- or V- arrays are only capable of providing 2D position information (latitude and longitude for an H-array or range and height for a V-array) which lies in the plane scanned by the array's narrow beam dimension. Furthermore, the H- and V-arrays scan different, largely non-overlapping regions of space so their respective 2D information cannot be combined to give 3D position information.

However, 3D bird and aircraft movement information (latitude, longitude and height) is critically important in realizing avian radar's full potential. Accordingly, leading ornithologists such as Dr. Sidney Gauthreaux (Clemson University Radar Ornithology Laboratory) and Dr. Bob Beason (formerly with USDA's National Wildlife Research Center) have long used dish antennas when 360-degree coverage and 3D location estimates are needed. The typical 4-degree spotlight beam associated with Accipiter X-band dish antennas provide reasonable angular resolution in all dimensions without giving up 360-degree coverage. In fact, side-by-side deployments at a number of military and civil airports have shown that dish antennas typically see as many birds as the wide-beamed array antennas because of the reduction in ground clutter associated with dish antennas. Dish antennas are usually inclined in elevation a few degrees above horizontal, coincident with typical landing and departure paths. This inclination ensures that coverage is oriented to where the risk of bird strikes is the greatest. Additional dishes can be used for additional vertical coverage as is done at SeaTac.

The avian radar's digital radar processor (DRP) couples with the radar transceiver, digitizes the received signals, filters target returns, and implements automated detection and tracking in order to produce target information. While coverage



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Figure 6. A Navy EA-6B Prowler aircraft (moving right to left) approaches a large flock of black-bellied plovers 1.5 nmi away



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Figure 7. Toronto Island controllers use Accipiter radars to alert them of vessels near runways.

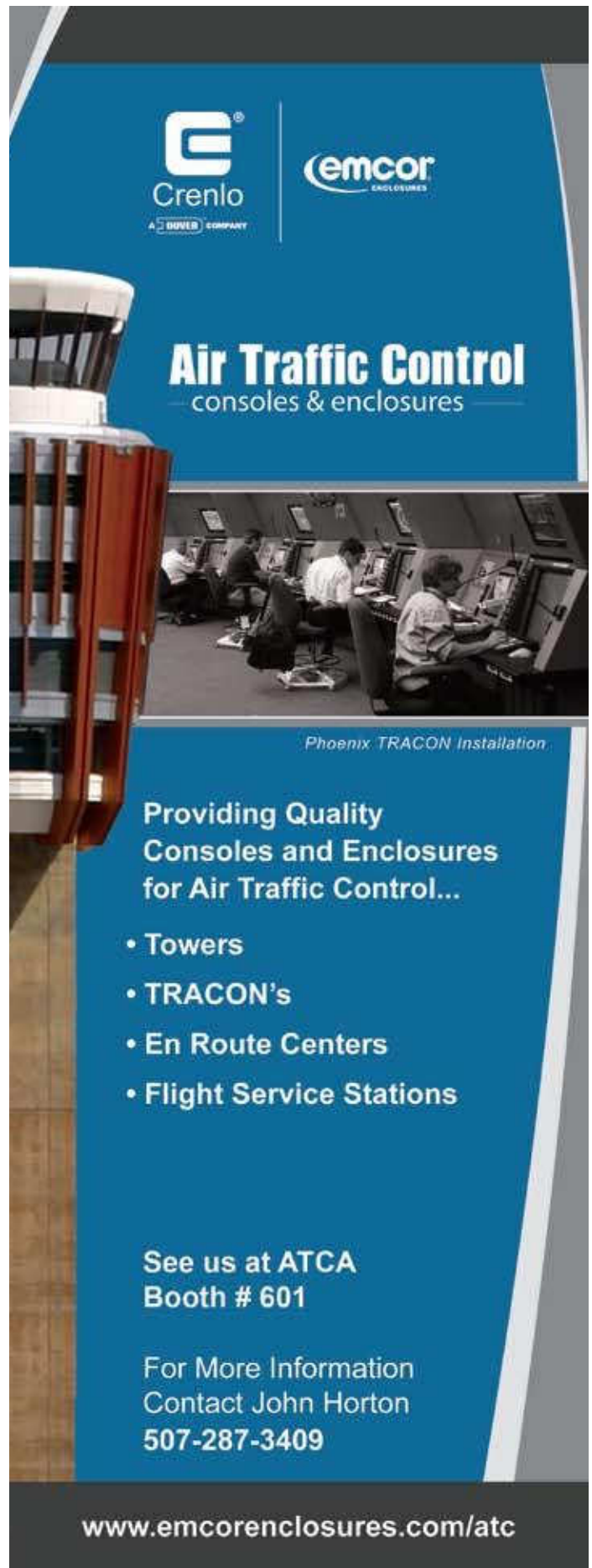
and the theoretical limit on target detection performance are driven by the radar's transceiver and antenna, the signal processing algorithms in the DRP determine how close the radar system gets to this performance limit. The field of radar signal processing is well established for extracting target information from virtually any type of target, including birds. Accipiter avian radars include sophisticated tracking methods based on the military Gold Standard for tough tracking problems involving maneuvering targets and dense environments such as bird migration.

Looking to the future, next generation, multi-beam 3D antenna systems are being developed by Accipiter to further improve coverage and target location accuracy, simultaneously. New, patent-pending, MULTI-BEAM antennas that integrate with COTS marine radar transceivers have recently been successfully field-tested using remote controlled aircraft designed to mimic birds in terms of RCS and movement. The field trial results demonstrate that production units will provide 360-degree coverage similar to an H-array, with latitude, longitude, and height estimates for all tracked targets consistent with a 1 degree angular accuracy in both H- and V- dimensions. This dramatically improved effective angular accuracy will be particularly valuable for discriminating flocks at long ranges from the airport.

The Future is Already Beginning

While the FAA has taken the lead in assessing these radars for their use in bird strike prevention, Transport Canada, who regulates Canadian airports, has made its own contribution to the advancement of this technology in a different, but surprisingly similar, marine exclusion zone (MEZ) application.

In early June 2009, Toronto City Centre Airport, an island airport in downtown Toronto, became the first civil airport control tower to be equipped with a radar alerting system commissioned for operations and driven by the very same components used in Accipiter's avian radars. With Lake Ontario on the west and the Port of Toronto on the east, a dedicated, hands-off, dual-radar, dual-camera visual display integrated in the tower cab alerts controllers to the presence of unauthorized vessels in MEZs off the ends of its runways so they can direct aircraft departures and approaches accordingly. The tower display screens are overlaid with the outlines of exclusion zones similar to the No Transgression Zones on the screens of Precision Runway Monitors (PRM) used to ensure safe separation between aircraft flying approaches to closely spaced parallel runways.



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For avian radar, similar bird hazard zones could be defined, with alerts issued when the estimated number, size or dynamics of the birds in a particular zone reach an appropriate threshold.

Listening to the Users

While Accipiter's scientists and engineers are leading specialists in their fields, input from the user community, including controllers, wildlife experts, pilots, regulators and others, continues to provide key information about their respective requirements, and their first-hand experience with avian radar. This information will enable system developers to continue to deliver improvements to better meet safety objectives for years to come.

Unquestionably, US Airways Flight 1549 has become a catalyst in spurring stakeholder interest in avian radar development. This perfectly matches Accipiter Radar's strategy of following a spiral development model, working with stakeholders to implement and deploy existing proven systems technology now, and then progressively innovating, testing, and adding new, safety driven features to further enhance user capabilities. It's a user driven, vendor delivered model of development, testing and system deployment at airports. The continuing assessment of new advances will allow new capabilities to be efficiently integrated into civil

airport environments in a responsible and timely manner, leading to the ideal system. While the bird strike hazard will never disappear, the eventual continent-wide introduction of avian radars and their multitude of applications and integration can be expected to lessen its threat significantly, allowing birds and man to safely share the skies. ✈️

About the Author

Dr. Tim J. Nohara is the founding President and CEO of Accipiter Radar, the industry leader in the development of avian radars for use at civil airports. He left Raytheon (developers of airport surveillance radars) in 1994 to assemble a world-class team of radar professionals to pioneer affordable avian and security radars designed for small, uncooperative targets. Tim received the B.Eng, M.Eng and PhD degrees from McMaster University where he specialized in radar. He is a licensed professional engineer, and a member of the IEEE and the PEO. He has contributed to textbooks and authored numerous peer-reviewed technical publications, reports and patents in radar.

tnohara@accipiterradar.com
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