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BASH

BIRD / WILDLIFE AIRCRAFT STRIKE HAZARDS

Bird Detection Radar Development ...From Dare County To The Cape!

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Photo Illustration by Dan Harman

Only 14 percent of bird strikes to our aircraft occur during low-level and range operations. That number isn't really that small when one considers this 14 percent accounts for 62 percent of total damage costs! In the spirit of mishap prevention, developing technology to increase aircrew safety and reduce damage is one of the USAF BASH Team's primary missions. Correctly identifying hazards allows us to properly target the correct species with an appropriate tool while prudently spending diminishing government funds.

The United States Air Force made its first steps into using small mobile radar to detect and count birds at Dare County Bombing Range, NC, in the summer of 1993. Dare County Bombing Range is operated by the 4th Fighter Wing at Seymour Johnson AFB. The range is a large expanse of Pocosin Wetlands, bounded on the north by the Albemarle Sound, on the east by the Croatan and Pamlico Sounds, and on the west by the Alligator River. The peninsula is separated from the Atlantic Ocean by the Outer Banks, a string of narrow barrier islands. A section of mainland Dare County near the range was donated to the U.S. Fish and Wildlife Service in the 1970s to protect unique regional peat lands, establishing the Alligator River National Wildlife Refuge. By 1993, the Alligator River Refuge started to wrap around the Dare County Bombing Range, and the USAF BASH Team needed a way to quantify and manage year-round the risk that vultures and wintering/migrating waterfowl presented to aircraft using range airspace.

A decision was made to use modified marine radars to detect and quantify bird activity at Dare County Range, and to use the data to populate a Bird Avoidance Model (BAM). In 1994, antennas were changed, scan patterns modified, and a video recording system was added to the radar. These adjustments saved countless man-hours of video ground truthing (verification) counts, size approximation, altitude, and flight direction of airborne targets.

Many lessons were learned during this pilot project. For example, bird detection with a 3 cm X-band in the horizontal plane was significantly less than a 10 cm radar. In addition, birds could not be easily detected when it rained and the display became saturated. However, we did learn that birds do frequently fly in the rain. Birds were observed flying directly into and disappearing inside a region of rain using a conical scanning radar. Perhaps the biggest find was detecting a large movement of 30,000-40,000 20-pound-plus Tundra Swans as they passed directly over the range each fall at altitudes from 500-3,500 feet! This migration primarily occurred at night, unseen by range staff or pilots flying on the range. The project proved that commercial off-the-shelf radar equipment could be used to detect and quantify bird strike hazards to aircraft and find previously undetected bird hazards that existed before we lost an aircraft.

With completion of the Dare County BAM in 1995, the radar equipment was relocated to Moody AFB in south central Georgia. Instead of manually typing records of bird activity to the computer database, the system had evolved to a more automated bar code entry process. Hundreds of hours of video review were still required but unique insights into bird biology were gained daily.

Photo Courtesy of Authors

While the equipment was being reassembled at Moody AFB, the project staff developed a plan over lunch to spin a marine radar in the vertical plane like a windmill instead of the more typical horizontal plane used on a boat. Biology researchers at the University of California also had the same idea. Vertical scanning is now the mainstay of bird radar studies in recent years. Vertical scanning offers the ability to look at both the approach and departure corridors, and above a single runway to see all the birds moving in that area. This is a key piece of small mobile radar technology. Data derived from Dare County and Moody AFB became the foundation of what is now the Avian Hazard Advisory System.

A problem still hindered researchers: Marine radar could see thousands of bird targets an hour, far beyond human limits to record all that activity manually. Several attempts were made to create an interface between the radar and a computer, starting with video feed and image processing to capture target information. Later, a radar computer interface card was used to take raw radar signals and bypass the radars' electronics, completing more sophisticated signal processing inside a high-end computer workstation. Success! Days of counting targets were finally over, and bird detectability on radar was significantly enhanced. Further breakthroughs revealed that applying the correct signal processing algorithms to horizontal S-band radar data would detect birds in both rain and snow. Applying clutter mapping techniques allowed birds to be seen over areas with moderate ground clutter. Unmodified off-the-shelf marine radars cannot detect birds within ground clutter or rain.

The advent of automated software to track, quantify, and display bird and aircraft activity opened up another opportunity…a radar could be used to see and avoid birds in real time rather than taking all the data to produce a model for forecasts. The first airfield to employ this technology for real-time air traffic control was RAF Kinloss, Scotland, in 2002. Large flocks of geese transit that airfield twice daily during winter months, creating a severe flight hazard, particularly after sunset as the geese return to their roosts. A British Aerospace Nimrod MR1 maritime surveillance aircraft crashed at RAF Kinloss in November 1980, killing two crewmembers as a result of such a collision to combat the bird strike danger. A bird detection radar was installed at RAF Kinloss.

Within a year of radar employment at RAF Kinloss, the first USAF bird detection radar was installed at Dare County Range. The vertical scanning radar informs range controllers of bird altitudes, enabling aircrews to decide what delivery routines can be performed while maintaining vertical separation from bird activity. Range officers and 4th FW aircrew members developed procedures to pass bird activity information and blend risk management decisions into range operations.

Range officers were quick to see an additional benefit. It was very accurate at depicting bird activity relative to aircraft, but it could also detect civil aircraft taking unannounced shortcuts through range airspace. DeTect designers wondered how else their radar could be used to improve flight safety.

This year, DeTect, Inc. will provide a mobile radar not just for bird strike prevention, but also

to maintain safe separation between UAVs and manned aircraft. UAV operators have data links with GPS coordinates informing them where other aircraft are located. This new radar will have multiple roles. The first signal processor will be set to minimize weather, enabling greater aircraft detection and providing safe separation. A second parallel signal processor will do the exact opposite and be optimized for hazardous weather detection. The weather radar display will also include real-time lightning strike monitoring.

But of all the aviation safety-related bird radar projects to date, the most ambitious is potential strike detection and notification during a space shuttle launch. A Turkey Vulture, estimated at nearly five pounds, struck the STS-114 mission shuttle on takeoff from Kennedy Space Center on Jul. 26, 2005. Two other vultures were noted extremely close to the shuttle as it climbed away from the launch pad. They succumbed to the eventual flame plume from the rocket boosters.

Turkey Vultures frequently strike USAF aircraft, causing serious damage. They are the only species to have the dubious distinction of appearing on both "Top 10 Strike Lists" compiled by the USAF BASH Team using over 20 years of strike data forwarded from the field. Turkey Vultures rank eighth for strikes by count, with 519, and second for strikes by cost, with over $98 million in damage.

The STS-114 strike was the first known bird strike to a space vehicle. With a Turkey Vulture's average weight on the East Coast being around five pounds, a strike at a critical point on the shuttle could be catastrophic. The foam chunk that fatefully struck Columbia's wing in 2003 was estimated to weigh only 1.7 pounds. This bird strike event was taken very seriously by NASA following the damage to and subsequent loss of Columbia.

A couple of challenges to operating radars around rockets had to be overcome. Rocket fuel requires careful management of exposure to radiofrequency (RF) energy. 30-60 Kw marine radars typically used for bird detection was out of the question…too powerful. The other challenge was the ground clutter generated by the shuttle itself and the large steel gantry from which it was launched.

DeTect staff were given the opportunity to show NASA what they could do with just weeks left to the launch of mission STS-115. Selecting a lower power radar and using the vertical scanning technique perfected over years of development, DeTect staffers successfully detected vultures over a power station building that offered a similar radar cross-section to that of the shuttle launch pad.

With vulture detection successfully demonstrated at the range, as required by NASA, the last challenge was to build additional safeguards into the radar system. One such safeguard prevented accidental RF radiation of facilities where shuttles are assembled and rocket fuel stored. NASA required electronic redundancy to ensure the radar emitted only in approved directions. DeTect also built a second passive system using radar-absorbing material to provide redundancy. The system was tested on the empty 39A pad with two weeks to launch. When RF levels were acceptable, the radar was pointed toward the shuttle Discovery parked on launch pad 39B. The vulture population enormity sank in. More than 300 vultures call Kennedy Space Center home, and they were spending hours at a time soaring directly over the launch pad.

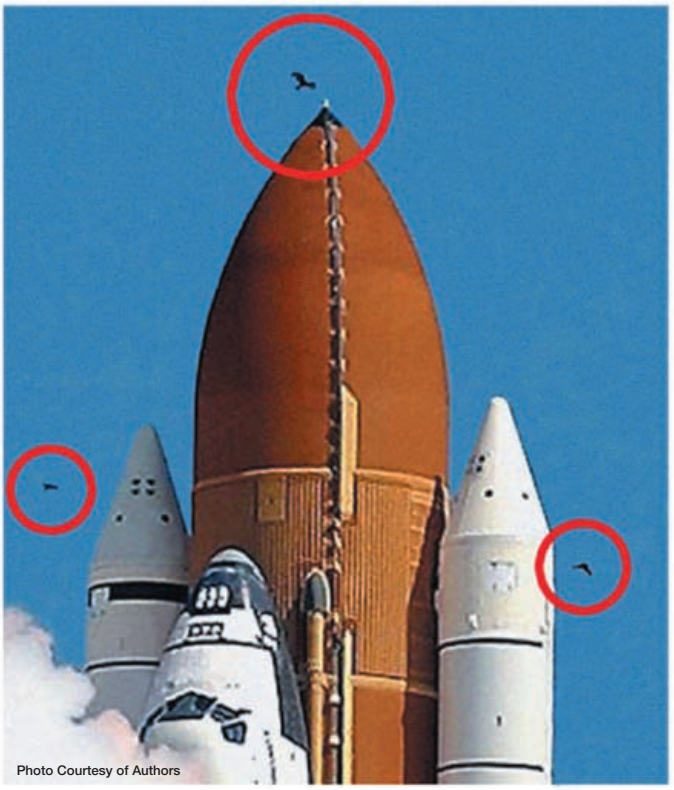
Photo Courtesy of Authors

On 4 Jul 06, after two scrubbed attempts for weather, DeTect staffers watched radar displays from the Launch Control Center. NASA personnel watched similar displays in the Fire Control Room. Three Turkey Vultures briefly soared over the launch pad just five minutes before launch but moved away from the area leaving a clear path for an uneventful and successful Discovery launch sequence. NASA ensured a strike-free shuttle launch.

Launching a shuttle is very similar to launching an aircraft. The only difference is the shuttle climbs straight up rather than gradually down a runway. The same tools can be used to see if the path is clear or obstructed by birds.

Today, bird detection radars are operating at Dallas-Fort Worth International Airport and Louisville International Airport. Bird detection radars will be operating at several Air Force bases by the end of this year. This technology has proven viable for military, civil, UAV, and space operations.