Beware of the birds

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When I was asked to write this article on bird-aircraft strikes (birdstrikes) as natural disasters, it occurred to me that I had never thought of birdstrikes—an issue that I have worked on for more than thirty years—as a "natural" disaster. However, the sight of US Airways flight 1549 floating in New York's Hudson River certainly produced dismay and fears similar to those expressed during other natural disasters, and has since resulted in new found public and scientific interest in the issue. A natural disaster is defined as the consequences of a natural hazard and includes financial, environmental or human losses. Bird hazards to aircraft certainly fit the bill for a natural hazard, and the results of a birdstrike can lead to significant losses akin to a natural disaster.

Every news reporter and observer of the "Miracle on the Hudson" knew instantly that the careful ditching of the aircraft in the river had averted a much greater mishap. If the aircraft had crashed in a heavily populated part of Manhattan, it could have resulted in large scale damage and loss of life. An example of how the "Miracle on the Hudson" could have ended differently is the crash of El Al Flight 1862, a Boeing 747 cargo plane, that in October 1992 crashed into two blocks of flats in Amsterdam, The Netherlands. A total of 43 people were killed during that crash, consisting of the plane's crew of three, a non-revenue passenger in a jump seat, and 39 persons on the ground. An additional 26 people on the ground sustained injuries ranging from minor to serious.

Most major airports are located close to the population centers they service and many aircraft pass over populated areas during takeoff or landing. Some airport approach and departure corridors, like those to the Reagan National Airport in Washington, D.C., fly over major rivers, for noise abatement reasons. These rivers however, are also likely corridors for birds making local or migratory movements, placing birds and aircraft in close proximity. Placing airports on the edge of major population centers has in the past resulted in airports being located next to another city requirement: local landfills. Landfills attract many avian scavengers, including Black and Turkey Vultures, birds that can weigh in excess of five pounds, more than enough mass to cause significant damage to an aircraft. The U.S. Federal Aviation Administration (FAA) rules now prohibit landfills and other bird attractants from being located closer than five miles to an airport. But existing landfill facilities, some with the ability to operate for many more years, are currently located closer than five miles to airports. Other airports are located near wildlife refuges, farmland or other habitat features that also attract and concentrate large populations of birds.

Fowl play

The hazard birds present to aircraft is generally proportional to the mass of the individuals, or if they create a flock, the sum of the mass of the individuals that could potentially strike a critical and vulnerable part of the airframe, including being ingested into the engines. The potential impact forces exerted on an airframe in a birdstrike result from the kinetic energy of the bird impact equivalent to one-half the bird mass times the velocity squared ($(1/2)mv^2$). In practice, a glancing blow will impart less energy to the structure of an aircraft, but ultimately the larger the mass of a bird, or the denser the mass of a flock of birds, the more significant the hazard to an aircraft.

The species of bird that struck US Airways 1549 was identified as Canada Goose by the feather identification and DNA experts at the Smithsonian Institute, Division of Birds in Washington DC. An adult Canada Goose typically ranges in size from 5.8 to 10.7 lbs.; however, larger individual resident birds can exceed this value. Many cities and towns now have large resident Canada Goose populations which make frequent short distance movements that can include visiting nearby airports to feed, or passing through the airspace used by aircraft. These resident geese have adapted to exploiting the carefully cultivated lawns surrounding office buildings, in parks, or other open areas such highway medians, as a food source.

US Airways 1549 was powered by two CFM56-5B/P turbofan engines. The bird ingestion standard in effect in 1996 when this engine type was certified included the requirement that the engine must withstand the ingestion of a four-pound bird without catching fire, without releasing hazardous fragments through the engine case, without generating loads high enough to potentially compromise aircraft structural components, and without losing the capability of being shut down. The certification standard did not require that the engine be able to continue to generate thrust after ingesting a bird four pounds or larger. Therefore, the ingestion of just one Canada Goose could result in the loss of power from this engine type, as well as many other engine types currently in service with airlines.

Constructing an aircraft that is robust enough to resist impact forces and generate sufficient power to sustain flight after ingesting or being struck by birds is a significant engineering challenge given the competing interests of reducing fuel consumption, reducing emissions, and optimizing passenger/cargo loads. An aircraft could be built like a tank to resist any bird or wildlife collision, but will likely never fly due to engineering, operational and financial constraints. The U.S. National Transportation Safety Board (NTSB) is investigating whether current materials technology will allow airframe and engine impact resistance standards to be set to achieve better strike resistance in the future. The problem is that standards set now will take many years to permeate throughout the civilian aircraft fleet and many at risk aircraft will still be in service. It is also unlikely that these new standards will be able to accommodate the ingestion of multiple geese. One has to remember that in North America the Tundra Swan is a long distance migrant weighing in excess of 20 pounds—a body mass that will almost always cause significant damage in any collision.

Clearly the combination of where airports are located, the presence of large birds in the vicinity, increased bird populations and more aircraft in service suggest we have a large potential for significant and potentially catastrophic bird-aircraft strikes. Like other natural disasters, future birdstrikes have the potential to be much worse. Imagine if US Airways flight 1549 had been a fully loaded Airbus 380—which can carry between 525 (three passenger classes) and 853 passengers (all economy)—and had failed to clear New York City. Although an Airbus A380 has four engines, the loss of two of those engines on the same wing while in a similar phase of flight as US Airways 1549 was, would make the aircraft extremely difficult to fly. Losing engines on both wings on either side of the fuselage was always considered a more unlikely scenario than the loss of two engines on the same wing. Although statistically less probable, the US Airways 1549 birdstrike has shown that the potential to lose all engines on both wings when encountering large flocks of waterfowl exists.

Control and mitigation

The reason I had never associated birdstrikes with other natural disasters in my mind is because I recognized that the risk of a birdstrike can be managed and mitigated in ways not possible with other natural hazards. We can't stop lava from being ejected from a volcano, predict earthquakes with precision, or turn away a tornado bearing down on a town in Kansas. But a lot can be done to prevent birdstrikes from occurring and we have an ability to control and mitigate birdstrikes in ways not possible with other natural disasters.

For the first 12 years of my professional life I worked for the bird control program for the U.S. Air Force (USAF) in the United Kingdom. Using a combination of habitat management and active bird harassment we could take an airfield with the birdlife typically found on a wildlife refuge and make it effectively bird free. Birdstrikes would occasionally occur, but were limited to smaller birds that posed little risk for collision damage.

One tool employed for habitat management was cutting grass at a height high enough to deter birds from foraging in it, but short enough to prevent the stands of grass from folding over and laying down in strong winds, rain or snow. Managing water on airfields was another habitat management tool; it is important to get effective drainage and to eliminate pools, puddles or other standing water on airfields that could attract birds. A simple rule of thumb for airfield bird control is to do the opposite of what you would do on a refuge to encourage wildlife, including having a monoculture of vegetation that provides the least possible base of food resources, shelter and places to reproduce. For the last thirty years the science of habitat management on airfields has been well known and understood, but not always fully applied. What is often lacking are firstly a realization of the level of effort and resources that are truly required to correctly manage the habitat, and secondly apathy towards the birdstrike issue when strike rates decline.

After an airfield has been rendered as unattractive as possible to birds (and other wildlife such as deer or feral pigs) the residual bird populations must be "taught" to stay away using active harassment. When birds do attempt to prospect on the airfield they must be met with a swift and effective response. Lethal control should be a method of last resort on airfields and applied generally only when habituation has occurred. The tools of active management are many and varied. As I like to point out to trainees, you can scare away a bird by putting an umbrella up and down rapidly. The question is not *what* will scare a bird, but what will scare it and *keep* it away. Unfortunately, birds learn and habituate to any stimulus that does not pose a real threat of eminent harm. Birds readily recognize that aircraft have no hostile intent towards them and will accept an airfield as a safe place to live. Many hunters have also observed that migrant waterfowl learn the effective range of a shotgun and how to fly over an area out of harms reach.

For the 12 years I worked on airfields in the United Kingdom (UK) for the USAF we had perhaps the ultimate tool for hazing wild birds: trained falcons which would be released to pursue any bird foolish enough to attempt to make an airfield its home. A falcon is a natural predator of the target bird species which have had their instinct refined through many generations of natural selection to not habituate to a falcon's presence, because the next attack may be lethal. The other advantage to using falcons is that it motivates bird control staff on an airfield to do what can be a boring job, with many hours watching and waiting for birds to arrive.

Birds of a different feather

Great Britain is a relatively small island land mass with a large coastline relative to the inland area. Therefore, gulls from the coast can sweep inland within hours of adverse weather at the coast to simply exploit food sources from agricultural activity or landfills. Many bird species in addition to gulls create a large dynamic bird hazard, and all airfields, military or civilian, employ bird control staff to keep the airfields free of birds during all operating hours. In contrast, bird control teams are not found on every airfield in the United States, and where employed, they often work only seasonally or are part-time staff with other duties. The result is that airport bird control is not as uniformly effective at all airports in the U.S. as it is in the UK. The difference is the emphasis placed upon passive and active management of bird hazards by the U.K. Civil Aviation Authority through regulation, requirements and inspection. The FAA has yet to match these standards, but flight 1589 may propel the agency down the relatively simple road of requiring airports to follow best practices and allocate the resources necessary for more effective birdstrike risk management.

It is outside the perimeter of an airfield that birdstrike risk management becomes much more difficult. Flight 1589 encountered geese away from the airfield where the height of the airfield grass or the number of staff harassing birds on the ground would make no difference. Birds have wings to make use of widely dispersed resources, and make both daily and seasonal movements in response to changing availability of resources on the landscape or climatic events. The best long range pyrotechnic rounds for bird hazing are limited in range to about 1000 feet above the ground. It would be difficult to use *any* tool to reach out 5 miles from an airfield, the zone within which aircraft are typically sharing the airspace with birds, and scare them away.

One of the newer devices we have been utilizing for bird hazing is the LRAD (Long Range Acoustic Device, manufactured by the American Technology Corporation) loud speaker system, the same type of device used to successfully deter pirates from ships with an intense blast of focused sound at up to 140 decibels. This has proven a powerful tool for bird control, not just because of the sound pressure level which in and of itself can be shocking, but the sound type that can be used, including bird alarm or distress calls which can convey information of present danger to wild birds. The use of bioacoustic playbacks as a bird hazing method has been a technique used for years to scare birds. The LRAD however enhances performance to unprecedented sound levels. But for all this power it is still almost impossible to have an effect on birds beyond a kilometer or so from the airfield.

Radar love

When I came to the United States 15 years ago it was to continue my masters degree research into methods of managing birdstrike risk beyond the range of direct human influence. Much of that work has involved the use of radar to detect and track birds to provide improved situational awareness for aircraft birdstrike risk management. Initially the aim was to populate bird avoidance models (BAMs) for the United States Air Force whereby the risk of a birdstrike could be determined from the past history of bird activity in an area by time of day and time of the year. The demands of digitizing radar data to integrate into bird avoidance models motivated the search for better methods than the video recorders and manual entry we were using in the mid-1990's. Signal processing technology available in workstation computers has advanced so rapidly in the past decade that it is now possible to reliably track and quantify bird activity in real-time using modified marine radars similar to those used on high seas vessels.

Having left the United Kingdom to pursue the development of technology for mitigating birdstrikes with radar it was not a little ironic to see the first user of real-time radar detection of birds to be a Royal Air Force (RAF) base in the United Kingdom. Again the United Kingdom was leading the way in setting the standard for airfield bird control. RAF Kinloss had suffered a fatal birdstrike to a Nimrod Maritime surveillance aircraft on November 18, 1981. The Nimrod suffered a major birdstrike immediately after takeoff and crashed into a wooded area to the east of the air base. Tragically, both pilots were killed, but due to their skill in controlling the crash, the remainder of the crew escaped. The subsequent mishap investigation required the RAF to pursue radar to mitigate strikes when the technology was available.

The bird species involved in the fatal strike at RAF Kinloss was the relatively small Lapwing, a 12 ounce member of the plover family. During the 1990's a much larger bird problem emerged, both in numbers and body size. Flocks of Graylag geese, a 5-1/2 pound bird started to roost in Findhorn Bay at one end of the airfield runways and feed in fields at the other end of the airfield. This would set up a twice daily movement of geese down the runway and through the approach and departure corridors, often in the hours of darkness and rarely during the same time day to day. This large, unpredictable hazard needed a real-time warning system. Today a radar system I helped develop is used tactically by air traffic controllers to observe when the geese are moving and avoid conflict between the movements of birds and aircraft. This established Avian Radar Systems as a real-time tool for managing birdstrike risk. The United States Air Force then started to deploy Avian Radar Systems in 2002 for real-time data collection and risk assessment for mission planning rather than capturing historic data into bird avoidance models.

The next major milestone for radar technology came with a Turkey Vulture strike to the U.S. Space Shuttle *Discovery* on July 26, 2005. The vulture caused no damage to the external tank it impacted, but if the bird had been a few hundred feet higher when the shuttle would have been moving much faster, or if the impact had occurred in a different and less robust area of the shuttle the result could have been much different. The strike to STS-114 was also the first "Return to Flight" Space Shuttle mission following the Space Shuttle *Columbia* disaster. The Space Shuttle *Discovery* launched at 10:39 am in daylight, with more cameras trained on the launch than any previous mission, primarily looking for foam shedding. NASA engineers quickly realized that the impact with a five pound bird could have had a greater effect than the foam impact that resulted in the loss of Columbia.

NASA did not stage a second "Return to Flight" mission until a year later. In the intervening time they looked for optical and radar systems that could monitor bird activity in the airspace around the launch pad and in the ascent flight. Located in the heart of the Merritt Island National Wildlife Refuge, the Kennedy Space Center is home to a robust population of wildlife. The more than 12,000 personnel driving to work on the expansive facility often run over animals which supported a population of about 350 vultures in the area. Many of these vultures would soar over the launch pad to while away time between meals of road kill.

I become involved in this program with 45 days left before the second "Return to Flight" Mission planned for July 1st, 2006. The optical solution NASA came up with could place vultures in three dimensions around the launch pad using video cameras, but the small field of view and limited depth of field could not effectively scan the ascent trajectory of the shuttle. The other radar system they had evaluated in an attempt to fill this gap had not performed well in the high ground clutter environment created by the huge steel structure that is the shuttle launch pad. My team and I were given 45 days to not only show NASA we could detect vultures above the intense ground clutter of the shuttle launch pad, but to also do it with a radar having a low enough power output so that it would not damage sensitive electronics on the vehicle or potentially trigger pyrotechnics at the launch pad.

We assembled a radar system in under thirty days and even added additional safeguards to protect sensitive equipment at the site. On the July 4th, 2006, the Space Shuttle *Discovery* on the STS-121 became the first space launch to use an Avian Radar System to establish that the ascent path was free from birds. In practice, the avian radar system is treating the vertical flight path as it would the horizontal flight path of an aircraft down the runway. But an important precedent was set by NASA in which a launch would be delayed *if* vultures or other large and potentially damaging birds occupied the shuttles flight path. When launching to the space station the launch window is ten minutes long. The launch attempt is always for the middle of the launch window, after the first five minutes have passed. As a computer launches the space shuttle, a decision to launch has to be made approximately one minute before launch. If birds occupy the flight path of the shuttle, then four minutes remains within which to launch the shuttle or scrub the mission and fly another day.

After thirteen launches with an avian radar system in place NASA has yet to delay the launch of a Space Shuttle as no birds have been present during a launch window. Part of this success can be attributed to a "Road Kill Roundup" that quickly responds to dead animals on the nearby roads, which has removed thousands of pounds of food, both reducing the vulture population by 30-40% and forcing the remaining vultures to more actively look for food rather than loiter around the launch pads. But NASA steadfastly does what parents encourage children to do before crossing the road. They look both ways to make sure all is clear before launching! This is a simple step that makes all the difference to the potential for a birdstrike.

Experimental phase

For the past ten years the FAA has been researching radar to manage the birdstrike risk at civil airports. So did the FAA look both ways before launching Flight 1549? No! The program has remained experimental and is trying to overcome many issues, including the issue with ground clutter that NASA has already solved. My team has not been involved in this program but the public statements by those involved appear to indicate they are focused on using the data in a historical sense, looking at the previous day's activity rather than real-time as is done by the United States Air Force and NASA for the Space Shuttle Program.

NASA Avian Awareness Radars at Kennedy Space Center, FL pointed towards Pad 39-A. For full redundancy during a launch a second duplicate radar system is available to the NASA Test Director for making launch decisions. The radars scan in both vertical and horizontal planes.

Airfield Avian Radar System with satellite data link allows operation at remote locations without network infrastructure. Typical Airfield systems use much larger and more powerful radars than can be employed by NASA for shuttle launch operations.

Mobile Avian Radar Systems are also used for environmental studies, monitoring bird activity at wind turbine sites and for other research needs. This particular system has a scissor lift to raise both the horizontal and vertical scan radars above the tree line or other obstacles on the ground allowing data collection in areas that would otherwise be impossible to use.

An Avian Radar System would not be used to vector aircraft around birds—this would be an almost impossible task for a commercial airliner loaded with passengers. The aircraft would not have the maneuverability and the certain knowledge of an impact is not possible with a long enough lead time. However the concept of looking both ways before taking off or leaving a holding pattern to land is one that could have prevented US Airways 1549 landing in the Hudson River. The pilot and co-pilot both report seeing many large flocks of geese around their flight path … would they or should they have taken off if a radar had noted their presence before they were cleared for take off ... we may never know.

After nearly thirty years in this business I find it to be very disappointing that the FAA should lag a decade behind the United States Air Force and NASA in their thinking. Those involved with the FAA's Avian Radar Program appear to think that doing as NASA does and looking both ways before a launch is not appropriate for civil aviation. This is a debate that is unfolding at the time I write this and will play out in the coming months. The NTSB is likely to weigh in on the issue after public hearings on flight 1549 to be held in June 2009. But why should birds be treated any differently than a truck straying onto the runway? The end result of a collision with large birds such as geese is the same! We delay landings for wind sheer and bad weather, why not high risks for birdstrikes?

The question is simple, are we willing to continuing flying in the presence of large hazardous birds without an attempt to detect and avoid them? If the answer is no, then we must decide how much risk is unacceptable and determine how we will manage the risk by delaying landings and departures. If NASA can determine when the risk of launching the shuttle is unacceptable to astronauts, even after recognizing the huge costs associated with scrubbing a mission, then we can do the same for the flying public. The recent population growth of species of geese, cormorants and other large birds worldwide means that civil aviation cannot continue to fly oblivious to the hazards around them. The flying public would be outraged if pilots did not use weather forecasts and real-time weather observations before flying. Why is it different with respect to birds?

On airfields we have the tools and techniques to manage the hazards created by birds. Outside the perimeter fence the first line of defense is to look both ways before flying, and radar is the best available tool to do this. The systems to manage the risk currently exist; we just need the will to deploy them in civil aviation.

About the author

T. Adam Kelly (bashbam@aol.com) was born and grew up in the United Kingdom. He managed to turn his childhood practice of the art of Falconry into a full time job as a contractor to the United States Air Force controlling birds to prevent birdstrikes on Military Airfields in England. After receiving a masters Degree in Conservation Biology from The University of Kent, Canterbury England he moved to the United States in 1994. Adam is currently a Vice President and Chief Technology Officer at DeTect-Inc and has been Detects Program Manager for NASA's Avian Radar System on the most recent thirteen launches of the Space Shuttle.