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Authorities Call for New Methods to Prevent Bird Strikes to Aircraft at Airports

Investigations of recent bird-strike accidents at airports in the United Kingdom and in the United States have resulted in several recommendations for reducing the risk of bird strikes to aircraft. The recommendations include studying the use of radar to detect bird activity near airports.

FSF Editorial Staff

Citing recent aircraft accidents in their respective countries, the U.K. Air Accidents Investigation Branch (AAIB) and the U.S. National Transportation Safety Board (NTSB) said that new technologies and new procedures should be developed to reduce the risk of bird strikes to aircraft at airports.

The AAIB and NTSB said, in separate reports, that current bird-hazard-reduction efforts have had limited effect and that new efforts should be launched. The reports made various recommendations, but both reports said that research should be conducted on the use of radar to detect bird activity near airports.

The AAIB recommendations were generated by the investigation of a Dec. 6, 1997, bird-strike accident at London (England) Heathrow Airport. The accident involved a British Airways Boeing 747-136 (B-747) that was departing from Runway 27R in daylight visual meteorological conditions for a flight to New York, New York, U.S.

The first officer was the pilot flying. Airspeed was between V_1 (then called takeoff decision speed) and V_R (rotation speed) when the commander saw a large bird flying from right to left ahead of the aircraft. The bird was on the left side of the aircraft when the commander called "rotate." The bird then appeared to turn and to fly toward the aircraft.

The aircraft was at 75 feet when the three flight crewmembers felt a "thump." Exhaust-gas temperature for the no. 2 (left inboard) engine rapidly increased above the maximum limit.

A flight crew awaiting clearance to take off on Runway 27R saw debris fall from the B-747's no. 2 engine.

The B-747 flight crew retracted the landing gear and conducted a climb straight ahead while confirming that the no. 2 engine had failed. At 400 feet, the crew conducted the "engine fire, severe damage or separation" checklist and told air traffic control (ATC) that an engine had failed.

The crew flew the aircraft south and, at 12,000 feet, jettisoned 50,000 kilograms (110,229 pounds) of fuel into the English Channel to reduce aircraft weight to the maximum landing weight.

"When the jettison drill had been completed, the flight engineer went back to the passenger cabin to conduct a visual inspection

of the no. 2 engine and noted that the intake nose cowl and the fan cowls were missing; he did not observe any related damage to the airframe," said the report.

The flight crew decided to make airspeed reductions earlier than normal while returning to Heathrow Airport, so that they could detect any handling problems as soon as possible. The report said that, although airframe vibration increased as airspeed was reduced, the crew experienced no handling problems and no difficulty reading the instruments.

The commander was the pilot flying when the crew conducted an instrument landing system approach and landed on Runway 27L at 1554 local time, after having been airborne for 68 minutes. None of the 341 occupants was injured.

The report said that the no. 2 engine was "damaged beyond economic repair." The Pratt & Whitney JT9D-7 turbofan engine fan blades were damaged severely.

"The complete intake assembly, fan cowls, jet pipe and exhaust cone had separated from the powerplant assembly; these components, together with fragments of fan blade and some feathered bird remains were retrieved from the western end of Runway 27R," said the report.

The feathers were identified as having come from a gray heron, a wading bird that typically weighs between 1.3 kilograms and 1.6 kilograms (2.9 pounds and 3.5 pounds).

Current aircraft-engine-certification standards in Joint Airworthiness Requirements (JARs) JAR-E and in U.S. Federal Aviation Regulations (FARs) Part 33 include requirements for engine performance and structural integrity after ingestion of "small" birds weighing 85 grams (three ounces), "medium" birds weighing 680 grams (1.5 pounds) and "large" birds weighing 1.8 kilograms (four pounds).

The report said that a gray heron is classified as a large bird.

The report said that the Pratt & Whitney JT9D engine was certified to earlier criteria contained in U.S. Federal Aviation Administration (FAA) Advisory Circular 33-1A; the engine's tolerance to ingestion of a large bird was demonstrated by tests using two two-pound (0.9-kilogram) birds.

"However, [the engine's] performance in this incident indicated that the basic engine would probably have met current requirements for this category of engine," said the report.

[FARs Part 33.77 requires that ingestion of one four-pound bird should not cause an engine to "catch fire, burst (release hazardous fragments through the engine case) … or lose the capability of being shut down."]

The report said, "There are also airworthiness requirements which specify that the loads generated by the damage resulting from a large-bird strike will not cause failure of the engine mountings and separation of the engine from the aircraft; these [requirements] were also met.

"There do not, however, appear to be any requirements that nacelle parts should remain attached to the engine during a violent event such as this incident."

The B-747 no 2. engine nacelle components struck the ground within airport boundaries. The report said that if the bird strike had occurred five seconds later, when the aircraft was at a higher altitude [approximately 200 feet] and 0.5 kilometer (0.3 nautical mile) farther west, the nacelle components might have struck a road, and that if the bird strike had occurred 15 seconds to 17 seconds later, when the aircraft was at 500 feet and 1.5 kilometers (0.8 nautical mile) farther west, the nacelle components might have struck the M25 highway and the town of Poyle.

"Examination of the nacelle components [that] separated showed that all of the bolts attaching the [engine] intake assembly to the fan-case front flange had failed due to overload, as had those attaching the jet pipe and exhaust cone," said the report.

The report said that The Boeing Co. developed a modified, fixed-geometry intake assembly for the JT9D-7 engine soon after the B-747-100 entered commercial airline service. [The original B-747-100, of which the B-747-136 is a variant, entered commercial airline service in 1970.]

"To facilitate the interchange to this new standard intake [assembly] from the original design and to 'minimize the excessive manpower and downtime required' to replace an intake [assembly], the manufacturer issued Service Bulletin 747-71-2065, which reduced the number of fasteners attaching the intake assembly to the engine from 74 to 37," the report said. "While service experience has shown that this reduced number of attachment bolts clearly has been sufficient for normal operating conditions, it is, demonstrably, not reliably capable of retaining the intake assembly against the forces resulting from the damage resultant from a collision with a large bird. … During the time that the [B-747] has been in service, there have been several instances of major nacelle components separating after bird strikes."

Bird activity at Heathrow Airport is monitored by a bird-control patrol comprising two trained observers who use bird-dispersion techniques when significant bird activity is observed.

"At the time of this bird-strike incident, the bird-control patrol considered that there was no significant bird activity," said the report.

The report said that the gray heron is a solitary bird and that data collected by the U.K. Ministry of Agriculture Central Science Laboratory Birdstrike Avoidance Team show an increasing risk of aircraft striking large water birds at Heathrow Airport.

"This is the result of the presence, at the western end [of the airport], of Perry Oaks sewage farm, reservoirs and the river Colne valley, and, at the eastern end, of the river Crane," the report said. "In addition to herons, swans (which weigh typically between 5.5 [kilograms] and 15 kilograms [12 pounds and 33 pounds] and Canada geese (typically between 1.5 [kilograms] and 7.5 kilograms [3.3 pounds and 16.5 pounds]) transit these areas at relatively low altitudes."

These birds have roosting sites and feeding sites widely dispersed near Heathrow Airport in areas that are not within the jurisdiction of the bird-control patrol.

"The existing Heathrow Airport bird-control patrol is primarily responsible for scaring birds away from within the airport boundary [and] cannot provide a reliable means of early detection and warning of transiting large birds or formations," said the report. "An automatic system to monitor such transit activity could provide timely warnings of such incursions."

The report said that weather-radar systems can be tuned to detect large flocks of birds and that marine radar systems can be tuned to detect large birds. Adapting radar technology to reduce the risk of bird strikes to aircraft would take time, but some reduction of the risk could be achieved in the near term by more effectively managing local bird habitats and bird populations that are outside the airport's jurisdiction, the report said. This would require cooperation between airport authorities, local authorities and landowners.

The report contained the following recommendations:

- "Recommendation 98-58: In view of the apparent increased incidence of large-bird formation (e.g., Canada geese) transit flying over London Heathrow Airport, with the attendant increasing risk of multiple-bird-strike occurrence involving departing or arriving public-transport aircraft, it is recommended that Heathrow Airport and the CAA [U.K. Civil Aviation Authority] should set up a working group, in conjunction with airport operators, to review available technology to determine if a radar-based large-bird-flock-detection system or an alternative automated system could more effectively alert pilots and ATC to potential multiple-bird-strike encounters;

- "Recommendation 98-59: In order to reduce the risk of multiple-large-bird-strike encounters involving bird formations overflying London Heathrow Airport [and] conflicting with departing or arriving public-transport aircraft, Heathrow Airport should seek maximum cooperation with the relevant local-authority bodies and associated landowners to expedite effective management of the associated large-bird habitat and population around Heathrow Airport. Similar cooperative initiatives should be actively promoted by the CAA around other affected major airports in the United Kingdom;

- "Recommendation 98-60: In order to reduce the likelihood of large intake assemblies suffering in-flight detachment from Pratt & Whitney JT9 powerplants on Boeing 747 aircraft as a result of bird-ingestion-damage-induced vibration effects, the aircraft manufacturer should review the reduction in the number of associated intake [assembly] attachment bolts (from 74 to 37) which was introduced by Service Bulletin 747-71-2065 to ease intake [assembly] interchange;

- "Recommendation 98-61: The current engine-certification requirements, FARs [Part] 33.77 and JAR-E 800, should be amended to require that large nacelle components remain attached to the engine up to the limit of forces on the engine and nacelle which result in the detachment of the entire nacelle from its pylon or wing attachments; [and,]

- "Recommendation 99-18: The CAA should expand the remit of its sponsored current study by the Central Science Laboratory Birdstrike Avoidance Team of the habitat, population and transit flight behavior of flocking large-bird species around Heathrow Airport to include the formulation of recommendations on the best means of managing and reducing the associated hazard of multiple-bird-strike encounters involving departing or arriving public-transport aircraft."

The CAA in December 1999 made the following responses to the AAIB recommendations:

- "[Recommendation 98-58:] The CAA will invite relevant sections of the industry to work with [the CAA] to review different technologies and determine if an early warning system would be effective and practicable in reducing the probability of bird strikes to aircraft. The current work in this area being undertaken by the FAA will form a major part of this review, which is expected to be completed by December 2000;

- "[Recommendation 98-59:] The CAA will continue to promote cooperative initiatives where it can, and within its legal remit. A facilitation role by the [U.K.] Department of the Environment, Transport and the Regions in this area would greatly assist aerodrome licensees, and the Authority is actively pursuing the Department's assistance in this matter;

- "[Recommendation 98-60:] This recommendation is not addressed to the Authority; however, the Authority will mandate Boeing Service Bulletin 747-71-2290, which increased the number of attachment bolts from 37 to 67. The bulletin has been prepared in response to three recent bird strikes and one foreign-object-ingestion event which resulted, in each case, in the liberation of the nose cowl; [and,]

- "[Recommendation 99-18:] The CAA will use its bird hazard consultant to work with the Central Science Laboratory during its current study to revisit the bird hazard control methods, in particular for the area outside aerodrome boundaries."

The CAA did not respond to Recommendation 98-61. The CAA said that this recommendation "was not addressed to the Authority."

FAA in June 1999 told the AAIB that Recommendation 98-61 was not adopted by the FAA.

"The safety issue addressed by the recommendation is the separation and departing of large nacelle components from the aircraft following engine foreign-object ingestion, and in particular, large-bird ingestion," FAA said. "Current regulations are intended to prevent such occurrences, and the regulatory requirements go beyond those [cited] in the recommendation."

FAA in November 1999 told the AAIB that FAA had published a notice of proposed rulemaking (NPRM) in response to Recommendation 98-60.

"On Sept. 30, 1999, we issued [an NPRM, Docket 99-NM-242-AD] applicable to certain Boeing Model 747-100, -200, 747SP and 747SR series airplanes," FAA said. "This proposal would require one-time detailed visual [inspections] and eddy-current inspections to detect cracking of the nose cowl mounting flange, rework of the nose cowl mounting flange, eddy-current inspection to detect cracking of the reworked nose cowl mounting flange, and corrective action if necessary."

[On Feb. 7, 2000, FAA was preparing an airworthiness directive based on the NPRM.]

The NTSB recommendations were generated by the preliminary investigations of two bird strikes to aircraft in the United States.

At 1455 on Feb. 22, 1999, a Delta Air Lines Boeing 757 (B-757) flew through a flock of birds during takeoff from Cincinnati/Northern Kentucky International Airport in Covington, Kentucky.

The aircraft was accelerating through approximately 150 knots (278 kilometers per hour), and rotation for takeoff had begun when the captain saw birds flying from left to right ahead of the aircraft.

"The captain alerted the first officer (the pilot flying) to the hazard and asked him to attempt to climb over the flock," the report said. "The first officer increased the airplane's pitch angle, but just as the main landing gear lifted off of the runway, the airplane penetrated the flock."

[NTSB factual accident report NYC99LA064 said that N_1 (low-pressure compressor speed) for the left engine decreased from 81.88 percent to 56 percent and that N_1 for the right engine decreased from 81.25 percent to 71.63 percent. The flight crew flew a left-traffic pattern and landed on Runway 18L, the runway from which they had taken off. None of the 132 occupants was injured. The aircraft was damaged substantially. Examination of the engines showed that the compressor sections in both engines were damaged; the aircraft was returned to service after the compressor sections were replaced. An FAA wildlife biologist identified the birds as starlings.]

At 2200 on March 4, 1999, a USA Jet Airlines Douglas DC-9-15F struck a flock of large birds during final approach to Kansas City (Missouri) International Airport.

"Several birds were ingested into both engines, resulting in severe engine-power loss," the report said. "The pilot regained enough power in one engine to continue the approach and land the airplane without further incident."

[NTSB preliminary accident report CHI99FA102 said that the aircraft was on a cargo flight and that the two flight crewmembers were not injured.]

The recommendation report said that the bird-strike accidents in Covington and in Kansas City showed that "despite the considerable government [attention] and industry attention that has been focused on [bird strikes to aircraft] over the last 20 years … , bird-strike hazards continue to threaten the operation of aircraft and the safety of passengers."

The report said that the U.S. Air Force is developing the avian hazard advisory system (AHAS), which uses next-generation weather radar to track bird-migration patterns and to determine if bird activity presents a risk to flight operations.

"AHAS removes radar images consistent with weather and then assumes that the residual radar images are birds," the report said. "The system correlates the new radar data with the data on the distribution of large migrant birds in the contiguous United States to estimate the migration intensity.

"The estimate is then extracted and stored in a database for selected military low-level routes, ranges and airports. The migration information is updated hourly and is available to pilots and air crews via the Internet.

"AHAS technology, if applied to civil aviation, could provide bird-strike-risk warnings to ATC and flight crews, and possibly prevent serious bird-strike incidents."

The report said that current bird-hazard reduction efforts — such as using cannon fire or gunfire to disperse birds, and maintaining vegetation to prevent birds from roosting or from feeding near airports — have had limited effect.

"A need exists for increased research and development for new bird-hazard reduction technologies, such as chemical

repellents, lasers, thermal imaging, pulsed microwaves, ultraviolet stimuli, vegetation types, and automated (bird-triggered) frightening devices," said the report.

Airports that have air carrier operations of aircraft with more than 30 passenger seats are required by FARs Part 139.337 to conduct an ecological study (also called a wildlife-hazard assessment) whenever:

- "(1) An air carrier aircraft experiences a multiple bird strike or engine ingestion;
- "(2) An air carrier aircraft experiences a damaging collision with wildlife other than birds; or,
- "(3) Wildlife of a size or in numbers capable of causing an event described in paragraph (1) or [paragraph] (2) is observed to have access to any airport flight pattern or movement area."

FAA uses the results of an ecological study to determine whether the airport must have a formal wildlife-hazard-management program.

The report said that many airports have not complied with Part 139.337.

"Because bird/wildlife reporting is voluntary, many events that would require an airport to conduct [an ecological] study are not reported to the FAA," the report said. "Therefore, many airports have been able to avoid conducting the studies."

The report said that ecological studies help to determine the levels of wildlife control that are required at airports.

"The amount of control needed at an airport varies, depending on the geographical location of the facility, local and regional wildlife, and aircraft movements," the report said. "For example, an airport located in a coastal area, with wetlands on the airport and heavy traffic … may be at a greater risk of a bird strike than a less heavily trafficked airport located in the desert."

FAA does not require reports of bird strikes to aircraft. The FAA wildlife-strike database contains information from voluntary reports of approximately 23,000 wildlife strikes between 1990 and 1998.

"FAA estimates that less than 20 percent of strikes are reported to the FAA; thus, [the wildlife-strike] database reflects only a fraction of the actual strikes and grossly underestimates the magnitude of the problem," the report said. "Bird strikes are estimated to cause in excess of 501,560 hours per year of aircraft downtime [during which the aircraft cannot be flown], [US]$237.43 million per year in direct monetary losses and $77.21 million per year in associated costs to the U.S. civil aviation industry."

The report said that the risk of bird strikes to aircraft could be increased if FAA permits airplanes to be operated at more than 250 knots (463 kilometers per hour) below 10,000 feet.

"FAA is considering allowing new high-speed, low-level airplane operations to facilitate air-traffic flow … , including air carrier turbojet-airplane operations," the report said. "Because the majority of bird strikes occur at altitudes lower than 10,000 feet, increasing the exposure times of air carrier turbojet airplanes to that altitude range at higher speeds may markedly increase the risk of bird strikes to those airplanes."

The report made the following safety recommendations to FAA:

- "Evaluate the potential for using [AHAS] technology for bird-strike-risk reduction in civil aviation and, if found feasible, implement such a system in high-risk areas, such as major hub airports and along migratory-bird routes, nationwide. (A-99-86);
- "In coordination with the U.S. Department of Agriculture, conduct research to determine the effectiveness and limitations of existing and potential bird-hazard-reduction technologies. (A-99-87);
- "In consultation with the U.S. Department of Agriculture, require that wildlife assessments be conducted at all [FARs] Part 139 airports where such assessments have not already been conducted. (A-99-88);
- "Require the development of a wildlife-hazard-management program for all airports determined to need one as a result of the wildlife-hazard assessment proposed in Safety Recommendation A-99-88. (A-99-89);
- "Ensure that the wildlife-hazard-management programs are incorporated into the airport certification manuals and periodically inspect the programs' progress. (A-99-90);
- "Require all airplane operators to report bird strikes to [FAA]. (A-99-91);
- "Contract with an appropriate agency to provide proper identification of bird remains, establish timely procedures for proper bird-species identification and ensure that airport and aircraft maintenance employees are familiar with the procedures. (A-99-92);
- "Before allowing high-speed, low-level airplane operations, evaluate the potential risk of increased bird-strike hazards to air carrier turbojet airplanes. (A-99-93); [and,]
- "With representatives from the U.S. Department of Agriculture, the [U.S.] Department of the Interior, the

[U.S.] Department of Defense and the U.S. Army Corps of Engineers, convene a task force to establish a permanent bird strike working group to facilitate conflict resolution and improve communication between aviation safety agencies and wildlife-conservation interests. (A-99-94)."♦

[FAA responses to the safety recommendations were not available as of Feb. 7, 2000.]

[Editorial note: This article, except where specifically noted, is based on the U.K. Air Accidents Investigation Branch *AAIB Bulletin 9/99*, Ref: EW/C97/12/2/025, September 1999; the U.K. Civil Aviation Authority *Follow-up Action on Occurrence Report, Accident to B747-100, G-AWNJ, at London LHR on 6 December 1997*, Dec. 10, 1999; and U.S. National Transportation Safety Board *Safety Recommendation A-99-86 through –94*, Nov. 19, 1999.]

Further Reading from FSF Publications

Cleary, Edward C.; Wright, Sandra E.; Dolbeer, Richard A. "Wildlife Strikes Are an Increasing Hazard to U.S. Civil-aircraft Operations." *Airport Operations* Volume 25 (January–April 1999): 1–27.

FSF Editorial Staff. "Bird Strike during de Havilland Dash 8's Approach Disables Left-engine Instruments, Brakes and Nose-wheel Steering." *Accident Prevention* Volume 55 (August 1998): 1–5.

FSF Editorial Staff. "Airport Land Uses Require Planning to Prevent Wildlife-Aircraft Strikes." *Airport Operations* Volume 23 (July–August 1997): 1–6.

Alge, Thomas L.; Moehring, John T. "The Worldwide Bird Problem — Effects on Aircraft, Status of the Problem and Control of the Hazard." In *Best Practices and Processes for Safety: Proceedings of the 49th Annual International Air Safety Seminar*. Alexandria, Virginia, United States: Flight Safety Foundation, 1996.

Thorpe, John. "The Effects of Birds on Aircraft and Some Remedial Measures." In *Aviation Safety: Challenges and Solutions: Proceedings of the 8th Annual European Aviation Safety Seminar*. Alexandria, Virginia, United States: Flight Safety Foundation, 1996.

FSF Editorial Staff. "Military Boeing 707 Strikes Birds after Liftoff; Damage to Engines No. 1 and No. 2 Results in Loss of Power and Impact with Terrain." *Accident Prevention* Volume 53 (November 1996): 1–8.

Koenig, Robert L. "Canadian Study Finds Greatest Frequency of Bird Strikes to Turbofan and Turboprop Aircraft Below 100 Feet in Summer." *Airport Operations* Volume 22 (January–February 1996): 1–4.

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