FLIGHT SAFETY FOUNDATION
Airport Operations
Vol. 18 No. 4 *For Everyone Concerned with the Safety of Flight* July/August 1992

Airports — Breeding Grounds for Birdstrikes

Report predicts hundreds of ingestion events each year and many of them are likely to cause engine failures, engine damage, aborted takeoffs, turnbacks and diversions. And a just-released safety recommendation by the U.S. National Transportation Safety Board suggests that current certification requirements for engine foreign object ingestion may not be adequate because they do not consider effects of normal service "wear and tear."

—

Editorial Staff Report

Engine birdstrikes are most likely to occur in the airport environment at midday during the summer months, a study sponsored by the U.S. Federal Aviation Administration (FAA) concludes.

The three-year study, conducted by the Structural Integrity Division of the University of Dayton Research Institute, focused on engine bird ingestion rates for Boeing 737 twin turbofan aircraft.

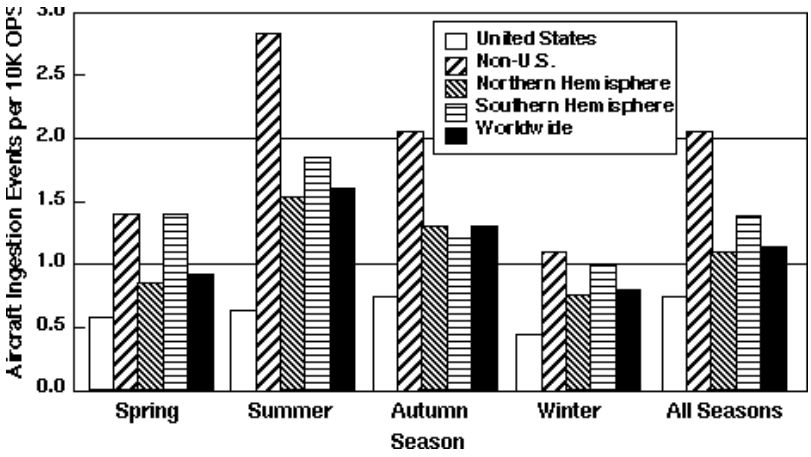
The majority of aircraft ingestion events involved a single bird and a single engine on the aircraft, the FAA report said. Engine damage occurred in 45 percent of all engine ingestion events and 175 engine ingestions resulted in damage classified as moderately severe or worse.

"Of the 89 multiple bird engine ingestions, 58 percent resulted in some engine damage. Engine damage was reported in 43 percent of single bird ingestions."

The majority of aircraft ingestion events for which the phase of flight was known (578 of 718) occurred within the airport environment during takeoff and landing. The report said the probability of engine damage is greater when the ingestion occurs during the takeoff and climb phases of flight than during approach and landings. It said damage also increases at airspeeds of 140 knots or higher.

"Of the ... known phase of flight engine ingestion events, 64 percent occurred on takeoff and climb and 33 percent occurred during approach and landing. Fifty-two percent of the engine ingestion events that occurred during takeoff and climb resulted in engine damage, with only 29 percent resulting in damage on approach and landing. This suggests a relationship between engine speed (thrust) and bird ingestion engine damage. ... However, engine speed or power was rarely reported during the study. In all, 35 engine failures occurred during takeoff and climb and only two engine failures during approach and landing."

The findings that nearly all birdstrikes occurred near airports in a non-cruise configuration, the report said, are "understandable because these phases of flight naturally occur closer to the ground where bird concentrations are higher. ..."



Source: *Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft.*

The report [*Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft* (October 1986-September 1989), Final Report, October 1991] was designed to determine the number, weight and species of birds ingested into medium and large inlet area turbofan engines. Data were collected from Boeing 737 model aircraft that are equipped with either Pratt & Whitney JT8D medium inlet area turbofan engines or CFM International CFM56 large inlet turbofan engines.

Data collected during the 1986-89 study period yielded a total of 1,107 engine birdstrikes in one or both engines (from a total of 8.91 million Boeing 737 commercial aircraft operations), which included 31 instances where one or more birds were ingested into both engines.

The study concluded that although birdstrikes are rare, they remain probable events. Based on 17.8 million engine operations during the three-year period, the study concluded there was a .006-percent probability for engine ingestion. It said that the majority of engine bird ingestion events result in "either minor or no damage."

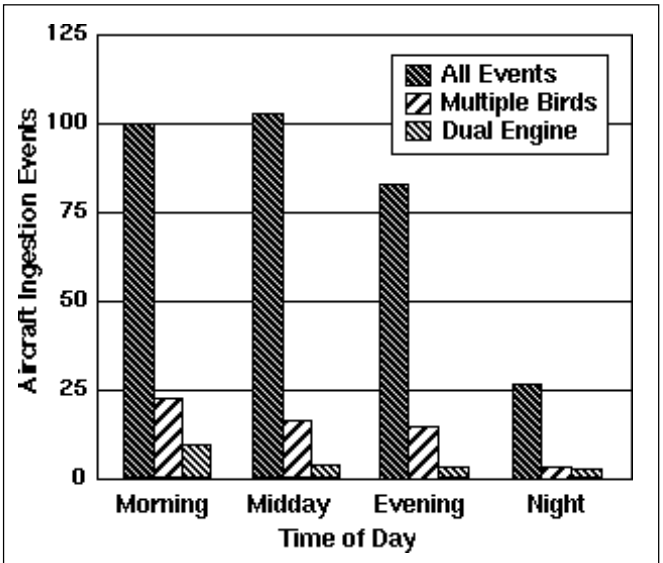
"The probability of a birdstrike during any given flight is extremely low," the study said. "But when the number of flights is considered, the number of birdstrikes becomes significant."

The FAA study said that of the birds that could be reliably identified, the most commonly ingested birds in the United States were pigeons/doves and gulls; with gulls, lapwings and hawks/vultures the most frequent ingested birds in non-U.S. locations. It said the majority of those birds weighed 40 ounces or less. (The median bird weight worldwide was 10 ounces.) The report lamented the low identification rate for ingested birds and added that "species-related descriptions of ingested birds ... probably provide a conservative view in that the birds that caused damage are better represented in the sample than birds that did not cause damage."

The report added: "The bird features that influence damage cannot be discerned, however, because of the possible bias in the identifications. The differences between the birds that cause damage and birds that do not cannot be readily identified because there is less information about the birds that did not cause damage."

However, the study did establish a correlation between bird weight and size, and engine damage. "The probability of damage occurring rises very steeply (reaching 50 percent) at 6.0 ounces and the curve levels off at 90 percent at about 70 ounces. The relationship between bird weight and the probability of any damage is very strong. ..."

Bird avoidance, the report said, is largely a matter of keeping aircraft away from large bird concentrations or removing birds from such high traffic areas. "The bird avoidance approach is subject to various degrees of success (or failure) ... because flight schedules place airplanes in specific areas at specific times and the effectiveness of airport bird control programs (if any) varies from airport to airport and country to country."



Source: *Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft.*

There are two reasons to account for a drop in bird ingestions at night, the report said. It noted that both bird and aircraft flight activity are reduced at night.

The report concluded that 3.8 percent of all engine ingestion events resulted in an engine failure. It said five engine failures were caused by birds weighing one pound or less. Multiple bird ingestions also increase the likelihood of engine failures, the report said.

The FAA study concluded that the overall engine failure rate for 737 aircraft due to bird ingestion was .005 failures per 10,000 aircraft operations.

In all, there were 42 reported engine failures. In 27 of the 42 engine failures, a transverse fan blade fracture appeared to be the cause. Engine damage occurred in a total of 494 events.

Data indicated that 31 of the engine failures were caused by the ingestion of a single bird and nine were caused by the ingestion of multiple birds. In five of the 23 engine failures where the bird weight was known, the bird (or birds) weighed more than two pounds.

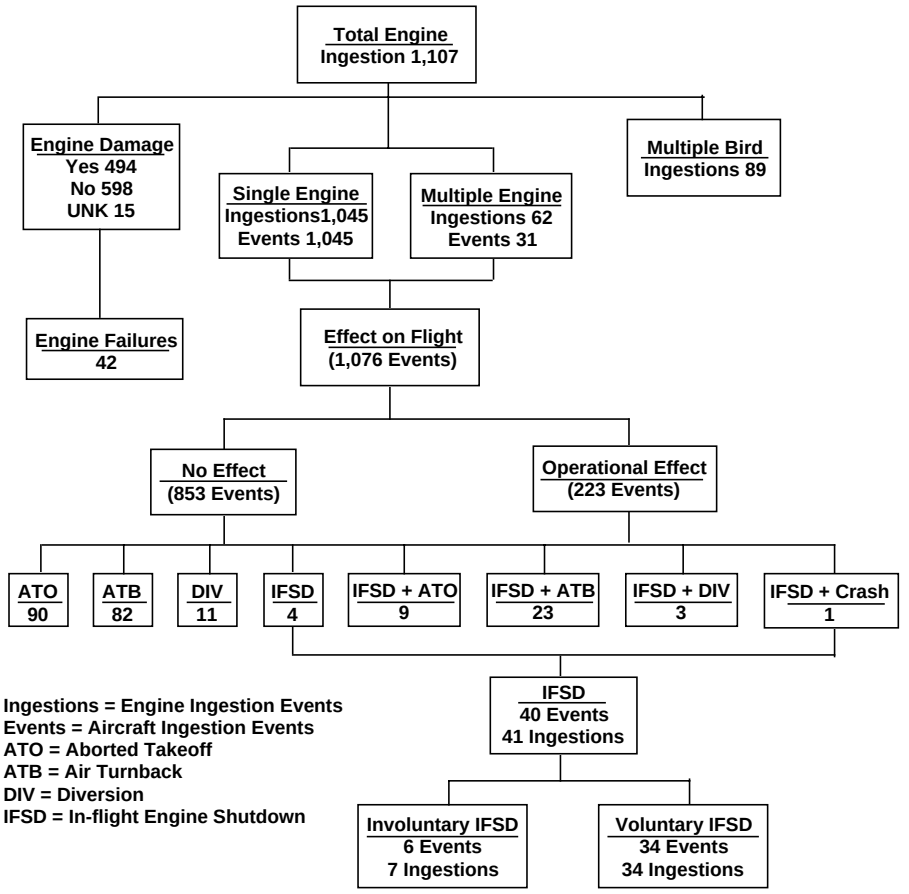
There were 99 aborted takeoffs reported, along with 105 turnbacks and 14 diversions.

Based on data provided by the engine manufacturers and the FAA, the study computed ingestion rates per 10,000 scheduled airport operations. According to the study, there were about 17.8 million Boeing 737 airport operations at 1,143 airports worldwide during the period. Bird ingestion events were reported at only 296 of these airports, which had about 12.18 million airport operations. There were also bird ingestion events reported by unscheduled 737 flights at 27 additional airports.

The data showed bird ingestion events at 84 airports in the United States, with a total of 284 events reported. There were 790 ingestion events reported at 239 non-U.S. airports.

Data suggest that the greatest threat of an ingestion event is posed by birds that live near the airport or whose migratory paths cross over or near airport property. In addition, the rate of reported bird ingestions per airport operation is 3.3 times higher at non-U.S. airports than at U.S. airports. The study suggested that the difference could be due, in part, to "more conscientious and cooperative reporting" by non-U.S. airport operators or that simply fewer birds were located at U.S. airports.

According to the study, 31 aircraft experienced single bird ingestions into both engines during the same event, with eight events resulting in damage to both engines. There were five events where multiple birds were ingested into both engines, the most hazardous bird ingestion situation that a jet aircraft can encounter.

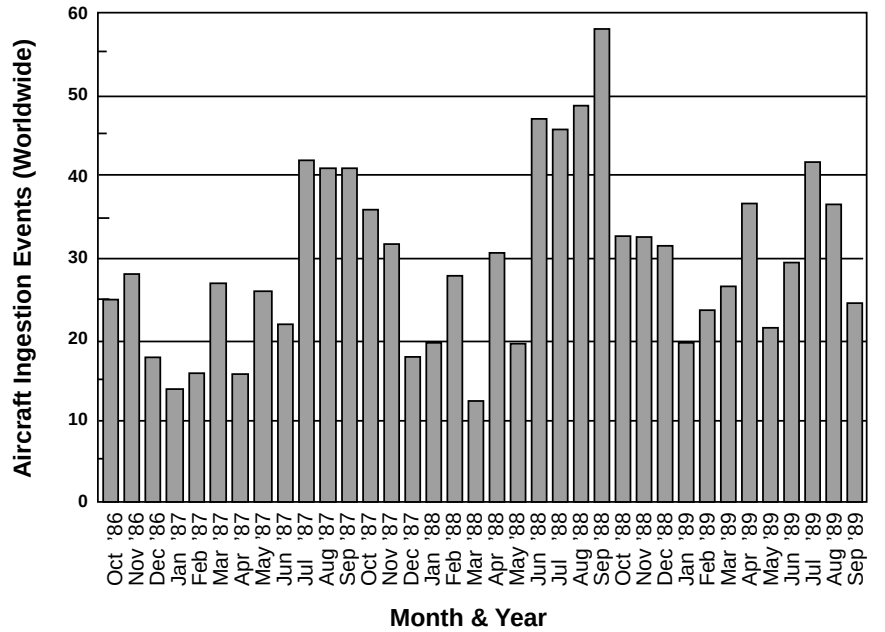


Source: *Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft.*

Moderate or severe engine damage occurred in 175 (49 U.S., 125 non-U.S. and one unknown) of the 1,107 engine ingestion events reported in the data collection period.

Data also suggested that engine size played a role in ingestion events, but it was not clear whether this correlation was a result of inlet area or diameter. "The discrepancy could be due to differences in collection rates between geographic regions," the report said.

Based on its findings, the FAA study said: "The overall



Source: *Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft.*

likelihood of an aircraft ingestion event in a single operation is slightly more than one in 10,000. But although the odds of having a bird ingestion on any one operation are very small, there are millions of Boeing 737 operations each year and thus hundreds of ingestions can be expected each year."

The U.S. National Transportation Safety Board (NTSB), in a safety recommendation released in June 1992, called for modification of certification requirements for turbine engines following analysis of a bird-induced Boeing 767 aborted takeoff in Ireland in 1991. The NTSB recommended that certification requirements be amended to take into account the potentially adverse effects of "pre-existing service-acceptable blade damage, such as nicks, scrapes and gouges, that can occur during normal operation."

The NTSB said an investigation revealed that the bird ingested in the 767's engine caused more damage to the fan blade than expected under current certification criteria. (The bird weighed 18 ounces. U.S. federal regulations require that a four-pound bird not cause an engine to "burst, catch fire, generate loads greater than the ultimate of the mounting installation or lose the ability to shut down.")

The 767's No. 2 engine was severely damaged by a birdstrike that occurred as the aircraft reached V_1, but the aircraft was brought to a full stop 2,000 feet short of the end of the runway. The NTSB concluded that the incident "clearly demonstrates that current certification requirements do not address the environment found in normal operations.

"Nicks or imperfections in the leading edge of turbine engine fan blades are accepted in daily operations and ... tolerances are provided for acceptable damage. The NTSB is concerned that the current engine foreign object ingestion certification requirements do not take into account blade imperfections that are normally found in service. By not considering normal service damage, the certification criteria do not provide the level of flight safety that is assumed when foreign object ingestion tests are conducted on a new engine." ♦

—G.C.S.

What's Your Input?

Flight Safety Foundation welcomes articles and papers for publication. If you have an article proposal, a completed manuscript or a technical paper that may be appropriate for *Airport Operations* please contact the editor. Submitted materials are evaluated for suitability and a cash stipend is paid upon publication. Request a copy of "Editorial Guidelines for Flight Safety Foundation Writers."

AIRPORT OPERATIONS

 • Subscriptions : $55 U.S. (U.S. - Canada - Mexico), $60 Air Mail (all other countries), six issues yearly. • Staff: Roger Rozelle, director of publications; Girard Steichen, assistant director of publications; Ashton Alvis, production coordinator; Sandra Mitchell, editorial assistant • Request address changes by mail and include old and new addresses. • Flight Safety Foundation, 2200 Wilson Boulevard, Suite 500, Arlington, VA 22201-3306 U.S. • telephone: (703) 522-8300 • telex: 901176 FSF INC AGTN • fax: (703) 525-6047