Data show that almost all bird strike–related hull losses of turbofan and turbojet transport aircraft worldwide occur during the departure phase of flight, when the risk of substantial engine damage is at least five times more likely than during arrival.

Analysis of the 24 bird strike–induced hull losses of turbofan and turbojet transport aircraft that were reported worldwide from 1968 to 2005[1] showed that all but one occurred during the departure phase and that at least 20 of the accidents involved ingestion of birds into aircraft engines (Table 1, p. 24). Analysis of U.S. strikes reported from 1990–2006 also showed increased risks of substantial damage during departure. These findings demonstrate the need for airports to act to minimize risks of serious bird strikes and for pilots to cooperate with airport bird strike–attenuation efforts.

The study of the 24 hull loss accidents — involving 18 turbofan aircraft and six turbojets — found that 17 of the 18 turbofan accidents and all six turbojet accidents occurred during departure, when the aircraft was no higher than 100 ft above ground level (AGL).

Birds were ingested into one or more engines in at least 14 of the 17 hull loss accidents that occurred during departure; in two other accidents, reports did not identify which part of the aircraft was struck, but engine ingestions were likely. In all six turbojet accidents, ingestion of birds into an engine was likely.

Turbofan Analysis

A separate analysis of the 40,286 bird strikes reported in turbofan civil aircraft in the United States from 1990–2006 found that 38,437, or 95 percent, occurred during either departure or arrival (Table 2, p. 24).[2] Of the strikes that occurred while the aircraft was on the ground, the number reported during the takeoff roll was 1.2 times higher than the number reported during the landing roll. However, engine ingestion was 2.3 times more likely during the takeoff roll, and substantial engine damage was 7.7 times more likely.

During the climb component of departure, 7,382 bird strikes were reported — less than half as many as the 16,408 reported during the approach component of arrival. However, the number of ingestions into an engine was similar, and substantial engine damage was reported 2.2 times more frequently during departure than during arrival.

Overall, 15,377 reported strikes were documented for the departure phase — including the takeoff roll and initial climb — about two-thirds as many as the 23,060 reported during the arrival phase — including the approach and the landing roll. However, data showed that birds struck by aircraft were more than two times as likely to be ingested into engines during departure than during arrival — 12.6 percent of departure bird strikes resulted in engine ingestion, compared with 5.7 percent of arrival bird strikes.

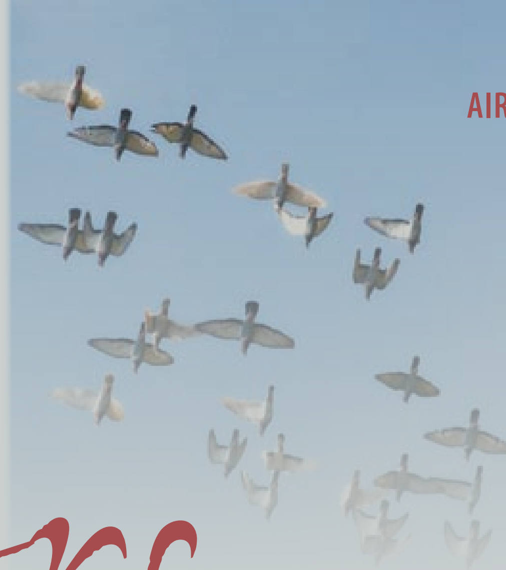
Data also showed that 3.4 times more bird strikes resulted in substantial engine damage during departure (916 strikes) than during arrival (270 strikes) and that a departure bird strike was about five times more likely than an arrival bird strike to result in substantial engine damage.

For turbofan civil aircraft in the United States from 1990–2006, only one of the 916 bird strikes reported to have caused substantial engine damage on departure actually resulted in a hull loss. At least 41 of the 916 strikes, including the hull loss, involved ingestion of birds into two engines, and damage to those engines; 13 of the 270 bird strikes reported to have caused substantial engine damage during arrival resulted in damage to two engines.

Turbojet Differences

For turbojet aircraft, differences were more pronounced in the extent of damage associated with the arrival and departure bird strikes. Of the 328 strikes reported in turbojet aircraft, 313, or 95 percent, occurred during either departure or arrival. They were almost evenly divided between the two categories; 155 occurred during departure and 159 during arrival. However, bird strikes during departure were 3.7 times more likely to involve engine ingestion and 5.8 times more likely to cause substantial engine damage than bird strikes during arrival.

Chances of substantial engine damage from a bird strike are far greater during departure than any other phase of flight.



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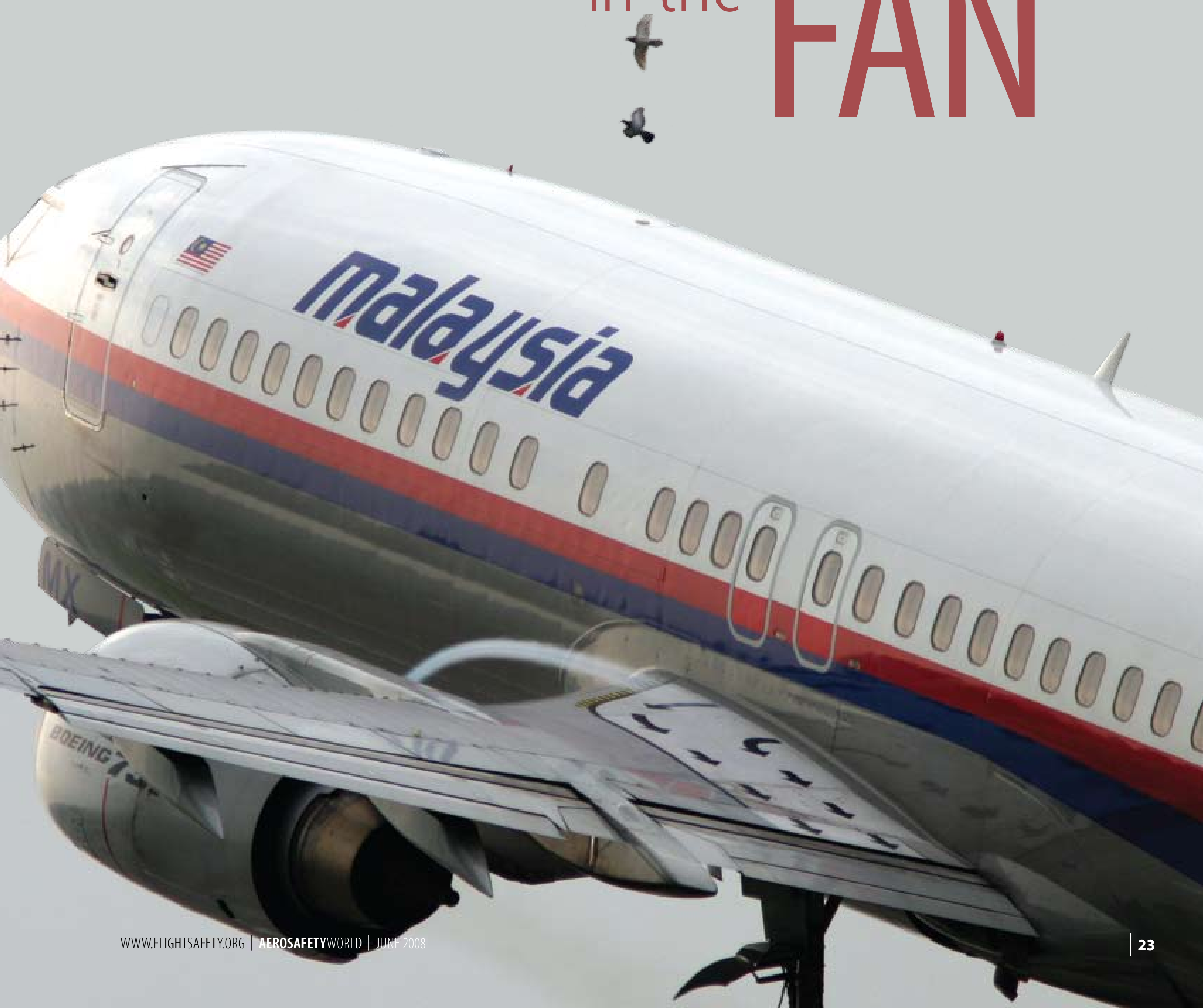
Feathers in the FAN

BY RICHARD A. DOLBEER



Phase of Flight in Hull Loss Bird Strikes, 1968–2005[1]

Phase of Flight	Turbofan-Powered Aircraft		Turbojet-Powered Aircraft		All Turbine-Powered Aircraft	
	Number of Incidents	Percent of Total	Number of Incidents	Percent of Total	Number of Incidents	Percent of Total
Departure (takeoff roll and initial climb)	17	94	6	100	23[2]	96
En route	1	6	0	0	1[3]	4
Arrival (approach and landing roll)	0	0	0	0	0	0
Total	18	100	6	100	24	100

1. Data include all known bird strike–related hull loss accidents worldwide involving turbofan and turbojet transport aircraft greater than 12,500 lb/5,700 kg maximum takeoff weight.
2. In 20 of the 23 departure accidents, one or more engines were damaged by bird ingestions. In two accidents, it was undetermined if birds were ingested into engines, and in one accident, the landing gear was struck.
3. A bird struck the radome.

Source: Richard A. Dolbeer

Table 1

U.S. Bird Strikes Involving Turbofan Civil Aircraft, 1990-2006

Phase of Flight	Total Reported Strikes	Strikes With Bird Ingested Into Engine	Percent of All Strikes With Engine Ingestion	Strikes With Substantial Engine Damage	Percent of All Strikes With Substantial Engine Damage
Departure	15,377	1,938	12.6	916	6.0
Takeoff roll	7,995	980	12.3	449	5.6
Initial climb	7,382	958	13.0	467	6.3
En route	383	37	9.7	7	1.8
Descent	1,466	78	5.3	18	1.2
Arrival	23,060	1,327	5.8	270	1.2
Approach	16,408	905	5.5	212	1.3
Landing roll	6,652	422	6.3	58	0.9
Total	**40,286**	**3,380**	**8.4**	**1,211**	**3.0**

Source: Richard A. Dolbeer

Table 2

Only one of the 29 departure bird strikes — and none of the arrival bird strikes — that were reported to have caused substantial damage resulted in a hull loss. At least three of the departure strikes, including the hull loss, involved ingestion of birds into two engines and damage to the engines. Damage to two engines was reported in one of the five arrival strikes that involved substantial engine damage.

Synergistic Factors

The primary reason that bird strikes are more likely during arrival than departure is that aircraft typically spend more time below 3,500 ft AGL during the arrival phase of flight. Previous studies have found that 95 percent of bird strikes occur below 3,500 ft AGL.[3]

However, although some studies have produced conflicting findings,[4,5] birds appear to be more likely to be ingested into aircraft engines during strikes that occur on departure.

Three synergistic factors may explain why bird strikes are most likely to have serious consequences when they occur during the departure phase.

First, fan and compressor rotor speeds are higher during departure, a factor that may increase the possibility that birds near an engine will be ingested. Second, the increase in kinetic energy of fan blades and compressor blades during departure increases the likelihood of substantial damage after bird ingestion. And third, flight crews typically face more challenges — and must make more decisions — in dealing with failed or compromised engines during departure than during approach.

The data, and especially the finding that only two hull losses resulted from the combined 945 turbofan and turbojet bird strikes during departure, are indicative of the robust qualities of turbine engines, the ability of modern aircraft to be operated with less than full power and the skill of today's flight crews.

Nevertheless, the aviation industry cannot afford to be complacent, especially because populations of many large, flocking birds are increasing and the birds are adapting to airport environments.[6] Efforts to eliminate bird strikes must focus on detecting hazardous birds in the airport environment and dispersing them, especially keeping them out of the paths of departing aircraft (see "Wildlife Hazards at Smaller Airports").

The increase in bird populations is a primary reason for the worldwide increase in bird strikes. In addition, however, the population growth has coincided with the increasing use of relatively quiet turbofan aircraft, which

Wildlife Hazards at Smaller Airports

General aviation airports in the United States experience wildlife problems similar to those affecting major airports, but they also face unique challenges — often including a shortage of resources for coping with bird strikes.[1]

In a presentation prepared for delivery in May at Flight Safety Foundation's 53rd annual Corporate Aviation Safety Seminar (CASS), three wildlife services officials said that the U.S. Federal Aviation Administration (FAA) database of wildlife strikes involving civil aircraft does not fully reflect the extent of the problem at smaller, general aviation airports.

Of the 73,500 wildlife strikes in the database for the period 1990–2006, about 4,000 occurred at general aviation airports, which typically are located in more rural areas than major airports, lack fencing to exclude deer and other large animals and have limited funding — or no funding — for the implementation of wildlife hazard mitigation programs, according to the presentation. However, the wildlife officials estimate that less than 5 percent of strikes at general aviation airports are reported.

For occurrences that were reported for the period 1990–2006, data show that two-thirds of all 36 wildlife-induced hull losses of civil aircraft in the United States involved general aviation aircraft with maximum takeoff weights of up to 59,500 lb/27,000 kg[2] and occurred at general aviation airports, the presentation said.

In addition, 15 percent of the 1,378 strikes that resulted in aircraft damage and 18 percent of the 449 strikes that caused substantial damage occurred at general aviation airports, and 59 percent of the 729 wildlife strikes involving deer were reported at general aviation airports, the presentation said.

"These higher damage rates at [general aviation] airports are likely related, at least in part, to the fact that the [general aviation] aircraft typically using these airports have less stringent airworthiness standards related to wildlife strikes, compared to commercial transport aircraft," the wildlife officials said.

They said that the specific issues that must be addressed at general aviation airports include "methods of funding wildlife hazard mitigation programs, economical deer-proof fencing, training of airport personnel in mitigation techniques and improved reporting of wildlife strikes. These safety issues will be of increasing importance in the coming decades, given the interest in air taxi services provided by very light jets (VLJs)."

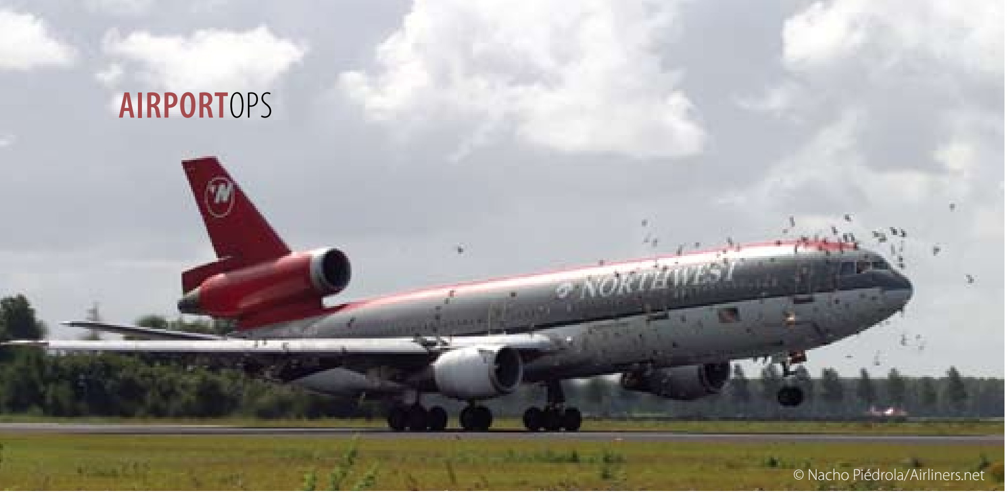
VLJs used in air taxi service are expected to make extensive use of general aviation airports that are not certificated and regulated for passenger service in accordance with U.S. Federal Aviation Regulations Part 139, which applies to about 570 airports that routinely serve air carrier aircraft. Among other things, Part 139 certification requires airports that experience wildlife hazards to develop wildlife hazard management plans; the estimated 14,377 general aviation airports typically are not required to address wildlife issues.

The presentation recommended several actions to minimize wildlife strikes at general aviation airports, including reporting all observed wildlife hazards to airport management; delaying takeoffs until birds in runway areas have been dispersed by airport operations personnel; prohibiting the feeding of birds on airport property and ensuring that food waste is inaccessible to birds; reporting all wildlife strikes; and providing education and guidance on these matters for pilots and maintenance personnel.

— Linda Werfelman

Notes

1. Dolbeer, Richard A.; Begier, Michael J.; Wright, Sandra E. "Animal Ambush: The Challenge of Managing Wildlife Hazards at General Aviation Airports." In *Proceedings of the 53rd annual Corporate Aviation Safety Seminar*. Alexandria, Virginia, U.S.: Flight Safety Foundation, 2008.
2. Of the 24 aircraft destroyed in wildlife strikes at general aviation airports, two had maximum takeoff weights from 5,701–27,000 kg/12,500–59,500 lb, eight had maximum takeoff weights of 2,551–5,700 kg/5,600–12,500 lb, and 14 had maximum takeoff weights of less than 2,551 kg/5,600 lb.



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are more difficult for birds to detect and avoid than older aircraft with noisier engines.[7,8]

At some airports, wildlife hazard management plans (WHMPs) have been implemented to minimize the risk of bird strikes and other wildlife strikes. WHMPs typically call for removing habitat and food that appeal to wildlife; using techniques to disperse hazardous wildlife; and establishing an airport wildlife hazard working group to educate the airport community about the risks of wildlife strikes and to monitor and coordinate wildlife control activities. WHMPs should include provisions for inspecting runways that have been idle and dispersing birds before aircraft departures.

These plans should be developed and overseen by professional biologists with training in wildlife damage management and knowledge of the state and federal laws that protect some species.

The International Birdstrike Committee has adopted recommended standards titled "Best Practices for Aerodrome Bird/Wildlife Control" to address this issue.[9] One standard says that a "properly trained and equipped bird/wildlife controller should be present on the airfield for at least 15 minutes prior to any aircraft departure or arrival. … The controller should not be required to undertake any duties other than bird control during this time."

Pilots who see birds on the runway should notify air traffic control (ATC) and delay departure until the birds have been dispersed. When ATC personnel see birds on or near a runway, they should notify the pilots of departing aircraft, who should delay takeoff until the birds have been dispersed, and airport operations personnel, who should see that dispersal activities are performed.

In the United States, air traffic controllers are required to issue advisory information on bird activity that is reported by pilots, observed by controllers, or detected by radar and verified by pilots.[10] These and other related issues should be discussed by an airport's wildlife hazard working group to ensure that ATC, commercial air carriers and others within the aviation community understand the risks of bird strikes and that procedures can be developed to limit the possibility of takeoffs while flocks of hazardous birds are on or near runways. Bird-detecting radar also may be useful in these efforts.[11]

In addition, flight crew training should include response scenarios to the single- and multi-engine ingestions of birds during departure. ●

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Notes

1. Information about bird strike–induced hull losses was gathered from presentations to International Birdstrike Committee meetings by Thorpe, J. in 2003 and 2005, by Richardson, W.J., and West, T., in 2000; and from Cleary, E.C.; Dolbeer, R.A.; Wright, S.E. *Wildlife Strikes to Civil Aircraft in the United States, 1990–2006*. U.S. Federal Aviation Administration (FAA), Serial Report No. 13 DOT/FAA/AS/00-6 (AAS-310). 2007.
2. Information about reported bird strikes in the United States from 1990–2006 was gathered from the FAA National Wildlife Strike Database.
3. Dolbeer, R.A. "Height Distribution of Birds Recorded by Collisions With Aircraft." *Journal of Wildlife Management* Volume 70 (December 2006): 1345–1350.
4. Banilower, H.; Goodall, C. *Bird Ingestion Into Large Turbofan Engines*. DOT/FAA/CT–93/14. Atlantic City, New Jersey, U.S.: FAA Technical Center. 1995.
5. Martino, J.P.; Skinn, D.A.; Wilson, J.J. *Study of Bird Ingestions Into Small Inlet Area, Aircraft Turbine Engines*. DOT/FAA/CT–90/13. Atlantic City, New Jersey, U.S.: FAA Technical Center. 1990.
6. Dolbeer, R.A.; Eschenfelder, P. "Amplified Bird Strike Risks Related to Population Increases of Large Birds in North America." In *Proceedings of the 26th International Bird Strike Committee Meeting (Volume 1).* Warsaw, Poland, 2003.
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8. Kelly, T.C.; O'Callaghan, M.J.A.; Bolger, R. "The Avoidance Behavior Shown by the Rook (*Corvus frugilegus*) to Commercial Aircraft." In *Advances in Vertebrate Pest Management II*, H.J. Pelz, D.P. Cowan and C.J. Feare, editors. Filander Verlag. 2001.
9. International Birdstrike Committee. *Standards of Aerodrome Bird/Wildlife Control*, Recommended Practices No. 1. October 2006.
10. FAA. Order 7110.65R. *Air Traffic Control*. Feb. 16, 2006. Chapter 2, Section 1, Paragraph 22.
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