Flight crews can reduce the possibility and effects of a bird strike by increased awareness and by following recommended procedures.

Strategies for Prevention of Bird-Strike Events

Bird-strike events are relatively common, occur most often on the ground or at low altitude, and are usually benign. However, bird strikes can have significant economic and occasional safety consequences for flight operations. Pilots and operators should be knowledgeable about the hazard, and flight crews should use facts, data, and standard operating procedures to reduce the potential for and consequences of a bird strike.

By Roger Nicholson, Ph.D., Associate Technical Fellow, Aviation System Safety, and
William S. Reed, Safety Pilot, Boeing Flight Technical and Safety

Bird strikes are a lesser hazard to aviation than other well-known hazards such as loss of control in flight, controlled flight into terrain, and runway excursions, but they can and do present risk that needs to be addressed. The first bird strike was recorded by the Wright brothers in 1905, and the aviation wildlife hazard has been a risk to aviation ever since. The January 15, 2009, ditching of US Airways flight 1549 on the Hudson River in Weehawken, New Jersey, was the dramatic result of dual engine thrust loss arising from an airborne encounter with a flock of Canada geese. Although Boeing airplanes meet and exceed the government regulations for bird strikes, accidents and serious incidents can occur. Aviation wildlife hazards encompass birds on the ground and in flight, terrestrial animals (e.g., deer, coyotes, cattle, camels), and even airborne animals such as fruit bats; however, this article focuses on bird strikes in particular. Operators and flight crews should be aware of the risk of bird strikes, prevention strategies, and actions to take following a bird strike.

This article discusses the characteristics of bird strikes, presents practical information for flight crews, highlights the importance of reporting bird strikes, and provides resources for additional bird-strike information.

CHARACTERISTICS OF BIRD STRIKES

According to Bird Strike Committee USA, an organization that was formed in 1991 to facilitate the exchange of information and promote the collection and analysis of accurate wildlife strike data, bird and other wildlife strikes cause more than $650 million in damage to U.S. civil and military aviation annually. In addition, bird strikes put the lives of crew members and passengers at risk — more than 200 people have been killed worldwide as a result of wildlife strikes since 1988. The Bird Strike Committee takes a similar data-driven approach to the bird strike issue that organizations such

Figure 1: Example of bird-strike damage

Bird-strike damage can be quite severe and can shut down jet engines.

as the Commercial Aviation Safety Team (CAST) takes to reduce commercial aviation fatality risk. (See www.cast-safety.org.)

Experts within the U.S. Federal Aviation Administration (FAA), the U.S. Department of Agriculture, and the U.S. Navy and U.S. Air Force expect the risk, frequency, and potential severity of wildlife-aircraft collisions to grow over the next decade, based on increasing air traffic, bird populations, and the trend to twin-engine aircraft. (See http://wildlife-mitigation.tc.faa.gov/wildlife/downloads/BASH90-09.pdf.)

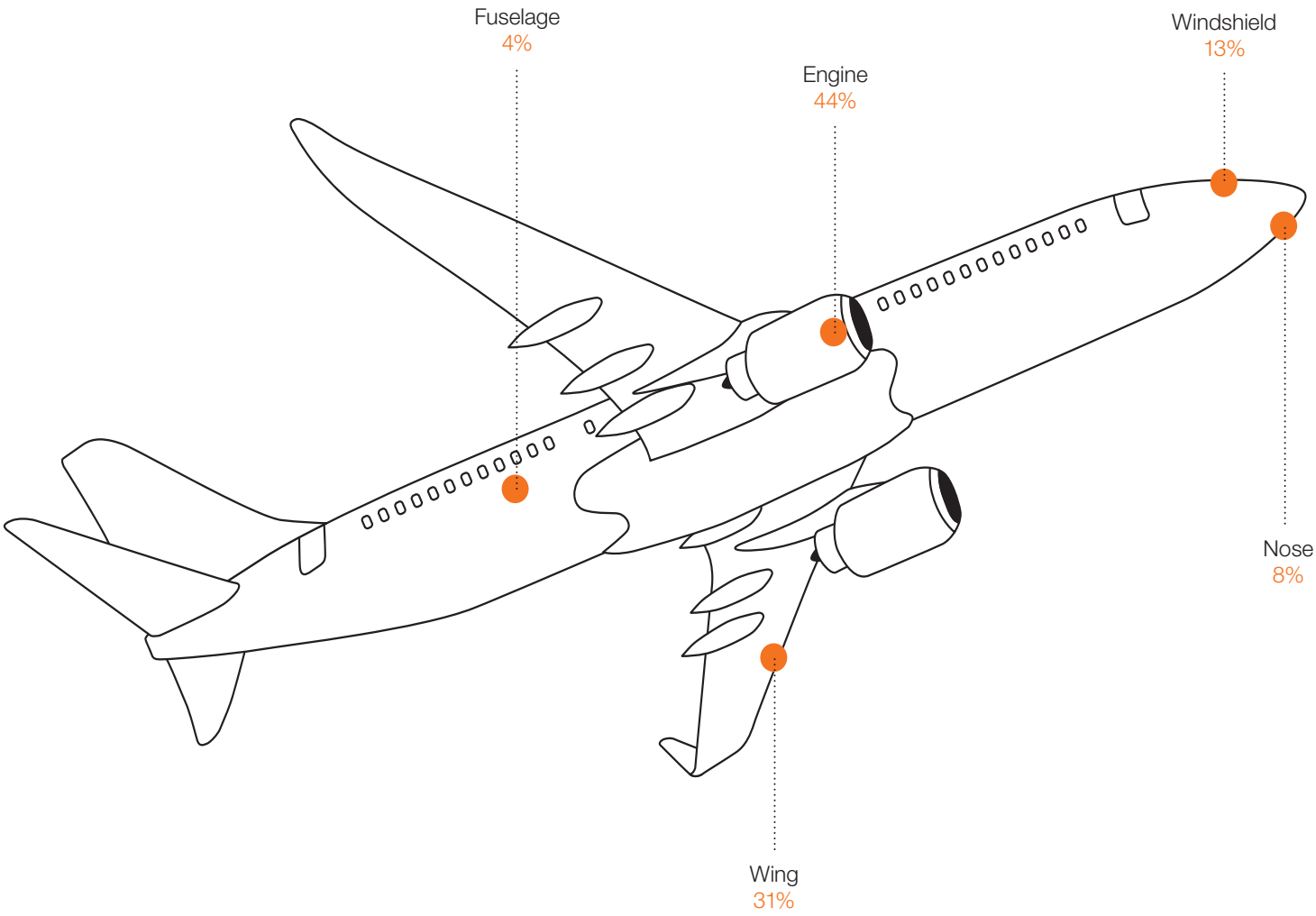
While bird strikes usually inflict most damage on the engines, all areas of an airplane can be damaged (see figs. 1 and 2). Airplane damage and effect on flight from bird strikes are closely correlated to kinetic energy, derived from the mass (determined by bird species) and the square of the speed of the collision. (A 20 percent increase in speed raises the kinetic energy by 44 percent.)

Single or multiple large birds, relatively small numbers of medium-size birds, and large flocks of relatively small birds are all problematic and have resulted in accidents. In the United States, a list of birds most hazardous to flight has been identified: large flocking waterfowl (Canada goose); gulls; pigeons and doves; blackbirds, starlings, and sparrows; and raptors (hawks and kestrels). Most bird strikes occur on or near the ground, highlighting the need for wildlife management on airport grounds and in the vicinity. (See http://wildlife-mitigation.tc.faa.gov/wildlife/downloads/BASH90-09.pdf.)

The aviation bird-strike hazard is a global and industrywide issue affecting all aviation stakeholders, including pilots, mechanics, airlines, airport operators, air traffic controllers, wildlife personnel, aviation safety analysts, airplane and engine manufacturers, flight training organizations, and the traveling public. Boeing participates in national and international groups dedicated to exploring and addressing the problem of

Figure 2: Locations of bird-strike damage

Three-quarters of bird strikes involve the wing or engines, but they can damage almost any part of an airplane.



bird strikes, and Boeing airplanes meet and exceed regulatory bird-strike requirements. Boeing has many design features, including system separation, system redundancy, and structural attributes, to protect against bird strikes beyond the four-pound regulatory general bird-strike FAA requirement (eight pounds for empennage).

COMMON MISCONCEPTIONS ABOUT BIRD STRIKES

A number of widespread misconceptions about bird strikes may give pilots a false sense of security and prevent them from reacting appropriately to the threat of a bird strike or an actual event. These misconceptions include:

- Birds don't fly at night.
- Birds don't fly in poor visibility, such as in clouds, fog, rain, or snow.
- Birds can detect airplane landing lights and weather radar and avoid the airplane.
- Airplane colors and jet engine spinner markings help to repel birds.
- Birds seek to avoid airplanes because of aerodynamic and engine noise.
- Birds dive to avoid an approaching airplane.

In fact, none of these statements is scientifically proven.

PREVENTIVE STRATEGIES

Airports are responsible for bird control and should provide adequate wildlife control measures. If large birds or flocks of birds are reported or observed near the runway, the flight crew should consider:

- Delaying the takeoff or landing when fuel permits. Advise the tower and wait for airport action before continuing.
- Take off or land on another runway that is free of bird activity, if available.

Wildlife strike facts

- More than 219 people traveling by airplane have been killed worldwide as a result of bird strikes since 1988.
- Between 1990 and 2009, bird and other wildlife strikes cost U.S. civil aviation more than $650 million per year.
- About 5,000 bird strikes were reported by the U.S. Air Force in 2010.
- More than 9,000 bird and other wildlife strikes were reported for U.S. civil aircraft in 2010.
- Between 1990 and 2004, U.S. airlines reported 31 incidents in which pilots had to dump fuel to lighten load during a precautionary or emergency landing after striking birds on takeoff or climb. An average of 11,600 gallons of jet fuel was released in each of these dumps.
- Waterfowl (31 percent), gulls (25 percent), raptors (18 percent), and pigeons/doves (7 percent) represented 81 percent of the reported bird strikes causing damage to U.S. civil aircraft between 1990 and 2009.
- More than 950 civil aircraft collisions with deer and 320 collisions with coyotes were reported in the United States between 1990 and 2009.
- About 90 percent of all bird strikes in the United States are by species federally protected under the Migratory Bird Treaty Act.
- Between 1990 and 2009, 415 different species of birds and 35 species of terrestrial mammals were involved in strikes with civil aircraft in the United States that were reported to the Federal Aviation Administration.

Source: Bird Strike Committee USA

To prevent or reduce the consequences of a bird strike, the flight crew should:

- Discuss bird strikes during takeoff and approach briefings when operating at airports with known or suspected bird activity.
- Be extremely vigilant if birds are reported on final approach. If birds are expected on final approach, plan additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

ADDITIONAL RESOURCES

Additional information is available online through a number of industry groups. Information includes significant strike events, key issues to reduce strikes, risk assessment, system information, papers and newsletters, and discussion forums.

- Bird Strike Committee USA (www.birdstrike.org).
- International Bird Strike Committee (www.int-birdstrike.org).
- International Civil Aviation Organization (ICAO) (www.icao.int/icao/en/ro/nacc/acilac/index.html).
- Embry-Riddle Aeronautical University (http://wildlifecenter.pr.erau.edu).
- National Bird Strike Committees or Aviation Wildlife Hazard Groups.

THE IMPORTANCE OF REPORTING BIRD STRIKES

Flight crews and maintenance and line personnel are encouraged to report all bird strikes because data are essential to quantify and manage the hazard. Reporting bird strikes enables aviation authorities to monitor the risk to aviation and the effectiveness of wildlife hazard mitigation measures. Bird-strike data, together with

Factors contributing to the increase in wildlife strikes

- The Great Lakes cormorant population increased from only about 200 nesting adults in 1970 to more than 260,000 nesting adults in 2006.
- In 1890, about 60 European starlings were released in New York City's Central Park. Starlings are now the second-most abundant bird in North America with a late-summer population of more than 150 million birds. Starlings are considered "feathered bullets," having a body density 27 percent higher than herring gulls.
- The North American nonmigratory Canada goose population increased about fourfold from 1 million birds in 1990 to more than 3.9 million in 2009. About 1,500 Canada geese strikes with civil aircraft were reported in the United States between 1990 and 2009. About 42 percent of these strike events involved multiple birds.
- A 12-pound Canada goose struck by a 150-mph airplane at liftoff generates the kinetic energy of a 1,000-pound weight dropped from a height of 10 feet.
- The North American population of greater snow geese increased from about 50,000 birds in 1966 to more than 1 million birds in 2009.
- The nesting population of bald eagles in the contiguous United States increased from fewer than 400 pairs in 1970 (two years before DDT and similar chlorinated-hydrocarbon insecticides were banned) to more than 13,000 pairs in 2010. Between 1990 and 2009, 125 bald eagle strikes with civil aircraft were reported in the United States. The mean body mass of bald eagles is 9.1 pounds for males and 11.8 pounds for females.

Source: Bird Strike Committee USA

knowledge of the operational environment, are utilized by Boeing as a basis of many airplane design features beyond regulatory requirements. Bird-strike data also help researchers understand the nature of strikes and develop a scientific approach to reduce the cost and safety consequences of bird strikes.

Aviation stakeholders should report all known or suspected bird strikes to their national or recognized wildlife strike data repository (e.g., the FAA National Wildlife Strike Database in the United States) and share the strike information with the airport operator, the airline safety department, and the aircraft and engine manufacturers. Each of these individual reports will be combined into a single composite data record. Reporters should provide as much information as possible, including:

- Airplane model and series designation (e.g., 777-300).
- Airplane serial number or registration.
- Phase of flight.
- Speed and altitude of the airplane.
- Geographical location of the airplane.
- Date and time of day.
- Origin and destination airport.
- Number and species of bird observed and struck.
- Impact locations of strikes and damage on airplane.
- Effect on flight (e.g., rejected takeoff, air turnback, diversion).

If bird remains are available, trained personnel should identify the species involved, or the bird remains should be collected using the correct procedure (as outlined at http://wildlife-mitigation.tc.faa.gov/wildlife/speciesid.aspx) and bird-strike collection kit and shipped to a qualified laboratory. It is crucial to determine the species of the bird or birds involved in a bird strike and the location of the strike, so that wildlife management can take appropriate actions. Effective wildlife management involves controlling attractants, often species-specific, including food, foraging, roosting, and nesting opportunities. Managing the environment may be necessary, even to the extent of grass

The bird strike should be reported by the flight crew in the pilot's log or by the maintenance crew in the maintenance log. After a bird strike, the airplane should be inspected for possible damage to airplane structure and airplane systems.

type and height, insects, rodents, and invertebrates, along with water sources and land use, such as agriculture.

In the event of a bird strike, maintenance personnel should follow the appropriate maintenance procedures for bird strike inspection in the Airplane Maintenance Manual. Maintenance personnel must be cognizant of the possibility that the bird remains can contain infectious material. The bird strike should be reported by the flight crew in the pilot's log or by the maintenance crew in the maintenance log. After a bird strike, the airplane should be inspected for possible damage to airplane structure and airplane systems.

In the United States and Canada, bird-strike information can be reported online at http://wildlife-mitigation.tc.faa.gov/wildlife/strikenew.aspx or via FAA form 5200-7 Bird/Other Wildlife Strike Report.

HOW AIRLINES CAN GET INVOLVED

Airlines and other stakeholders can help address the ongoing problem of bird strikes by participating in local, regional, national, or international aviation wildlife hazard activities, such as bird-strike committees or equivalent groups.

Airlines can also form their own internal aviation wildlife hazard group and designate a single point of contact for coordinating all aviation wildlife hazard activity, both internally and externally.

SUMMARY

Bird strikes have always been a part of aviation. While they usually cause no more than minor damage, they can pose a threat to air safety. By being aware of the ongoing possibility of bird strikes and by following recommended procedures, flight crews can reduce the possibility and effects of a bird strike.

For more information, please contact Roger Nicholson at roger.nicholson@boeing.com.

Practical bird-strike information for flight crews

Although it is not possible to avoid all bird strikes, flight crews can take steps to reduce the chance of a bird-strike event. If a bird strike does occur, the appropriate action can improve the flight crew's ability to maintain control of the airplane and land safely.

This information from the Boeing Flight Crew Training Manual provides flight crews and flight operations personnel with practical information about preventing and managing bird-strike events.

PREVENTION STRATEGIES

- Pilots should not rely on onboard weather radar, landing lights, airplane markings, time of day, or visibility to prevent bird strikes.
- Flight operations may need to be modified in the presence of known or anticipated bird activity.
- Delay takeoff or landing in the presence of bird activity.
- Below 10,000 feet, keep speed below 250 knots if operationally possible.
- Below 2,000 feet, climb at the maximum rate to reduce the flight time exposure to a strike hazard.
- Descend with idle power and avoid extended low-altitude level flight, particularly over water courses, nature reserves, or other areas of known or expected bird activity.
- When landing is assured, consider landing through birds versus a missed approach to avoid birds. This reduces the energy of the collision, the potential for increased damage associated with engines at a high power level, and the potential for multiple engine ingestions at low airplane energy states and low altitude.
- Avoid or minimize maneuvering at low altitude to avoid birds.

BIRD STRIKES DURING TAKEOFF ROLL

If a bird strike occurs during takeoff, the decision to continue or reject the takeoff is made using the criteria found in the Rejected Takeoff maneuver of the QRH. If a bird strike occurs above 80 knots and prior to V1, and there is no immediate evidence of engine failure (e.g., failure, fire, power loss, or surge/stall), the preferred option is to continue with the takeoff followed by an immediate return, if required.

DETECTING A BIRD STRIKE WHILE IN FLIGHT

- Visual: Birds seen in close proximity to the airplane or colliding with the airplane, bird remains on windshield, cracked windshield.
- Tactile: Vibration of airframe or engine, thrust loss, asymmetric thrust, increased drag, abnormal airplane handling characteristics.
- Auditory: Noise of strike or noise attributed to resulting damage: engine surging, compressor stalls, aerodynamic noise from damaged radome, loss of pressurization from pressure vessel penetration.
- Olfactory: Smoke, odor, or cooked bird smell.
- Engine indications: Reduction or fluctuation in primary power parameter (e.g., engine pressure ratio, fan speed, or equivalent), abnormal fuel flow, abnormal engine vibration monitoring (e.g., error vector magnitude or equivalent), engine failure, engine exceedances.
- Flight instruments: Loss of data or erroneous indications arising from damage to air data sensors or angle-of-attack sensors.
- Other airplane systems or structure affected directly by a strike: Damaged communications or navigation antennas, damage to exposed electrical wiring or hydraulic lines, damaged radome or weather radar, broken landing lights, or cascading and multiple effects from sensor damage or engine damage.

RESPONSES TO A KNOWN OR SUSPECTED BIRD STRIKE

Immediate action

- Fly the airplane and maintain flight path control.
- Monitor flight and engine instruments.

Multiple engine failure or thrust loss

- Attempt to restart engine(s).

Severe engine damage

- Shut down engine according to procedure.

Strong engine vibration

- Reduce thrust, which will often reduce vibration.
- Shut down engine per flight crew operations manuals guidance.

Multiple engine ingestion and abnormal engine indications

- Air turnback or diversion to nearest suitable airport.

Known or suspected multiple engine ingestion, with normal engine indications

- Consider air turnback or diversion to nearest suitable airport.
- Reevaluate decision to continue with extended-range twin-engine operational performance standards, extended range operations, or overwater flight because engine damage or performance degradation may manifest later in the flight.

Known or suspected strikes with large flocking birds, such as Canada geese

- Consider air turnback or diversion to nearest suitable airport, because damage may affect aerodynamic lift and drag, subsequent fuel burn, and ability to complete the flight safely.

Known or suspected airframe damage or engine damage

- Maintain or reduce speed — do not accelerate unless necessary for safety of flight or to maintain flight path control.

Damaged windshield or depressurization

- Below 10,000 feet, discontinue climb and level off.
- Above 10,000 feet, descend to 10,000 feet or the minimum safe altitude.

Known or suspected strike with landing gear extended or in takeoff or landing configuration with high lift deployed

- Use available system information to assess possible damage to flight controls and high lift devices, and make minimal and prudent changes in airplane configuration in accordance with the flight phase.
- Use available system information to assess possible damage to landing gear and associated systems, including exposed electrical, pneumatic, and hydraulic systems, and potential effects on the ability to steer and stop on the runway.

Known or suspected strikes to air data and angle-of-attack sensors

- Be aware that this may affect other airplane systems and have cascading effects.
- Be aware of the potential for loss or erroneous air data and degraded flight control modes, including loss of envelope protection or limiting, unreliable airspeed, propulsion systems in alternate mode.

Bird strikes during approach or landing

- If the landing is assured, continuing the approach to landing is the preferred option. If more birds are encountered, fly through the bird flock and land.
- Maintain as low a thrust setting as possible.
- If engine ingestion is suspected, limit reverse thrust on landing to the amount needed to stop on the runway. Reverse thrust may increase engine damage, especially when engine vibration or high exhaust gas temperature is indicated.

Postflight actions following a known or suspected bird strike

- Report all known or suspected bird strikes or bird activity on or in the vicinity of the airport via established procedures. Ideally this information reaches all stakeholders, including air traffic control, the airport operator, the airline, airplane and engine manufacturers (particularly the local representative), the national regulatory authority, and the appropriate national bird-strike committee or aviation wildlife hazard group.