

# Comment on bird strike requirement for transport category airplanes

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Blick aus dem Cockpit

Foto: BFU

B-737 cockpit windows after multiple goose strike

## **Preamble**

We would like to thank FAA Transport Airplane Directorate for offering the opportunity to comment on this hazard which, for too long, has flown under the proverbial radar. Birdstrikes to aircraft are an underreported hazard largely discounted by industry in spite of causing more catastrophes in the last 20 years to transport aircraft than other natural hazards such as volcanic ash or wind shear combined.

We hope to present information which will aid FAA Transport Airplane Directorate in its transition to Safety Management protocols, as dictated by ICAO Annex 19, by pointing out significant gaps in the aviation birdstrike area which either have not been noted or, more likely, addressed. ICAO is clear that addressing these current and emerging safety risks are vital given the growth of aviation worldwide.

FAA Transport Airplane Directorate is farsighted in its desire to amend the construction of transport aircraft. This is one of the few ways the hazard may be addressed due to the fundamentally flawed nature of hazard mitigation programs currently in place.

We also agree with industry and government safety professionals who acknowledge that simply waiting for a catastrophe to determine that action is needed is no longer an acceptable standard. Given Safety Management principles it is clear that we should act when high risk events present themselves.

We have elected to proceed by dividing the issue into a number of subareas, each of which is discussed in its own section. We then offer our conclusions. Authors' qualifications to comment are offered at the end of our submission.

## **Section A – Landing Gear**

Perhaps the least noted of threats to transport aircraft is the unexpected loss of nose wheel steering caused by bird collision with the NWS apparatus located on the nose wheel strut. As detailed in Attachment A-1, sudden and unexpected loss of steering authority caused the destruction of a KLM B-737 at Barcelona. This is not an isolated incident. Attachment A-2 details a similar event, absent the catastrophe, experienced by a United B-757 in Portland. Although this aircraft did not depart the hard surface it had to be towed to the ramp as it was unable to taxi due to loss of nose wheel steering.

It is our knowledge and belief that similar events have occurred with Airbus aircraft, particularly A-320 models, when birds struck the BSCU during approach. There were subsequently, in India, several runway excursions due to this cause.

We believe these events portray a high risk situation which FAA Airplane Directorate should study in detail. We believe either shielding for the nose wheel steering/BSCU apparatus should be required or that the vulnerable components be redesigned to place them at less vulnerable locations.

Additionally it should be pointed out that, in Attachment A-3, FAA Transport Airplane Directorate must consider multiple failures due to a flock encounter. Such a scenario

obviously increases risk dramatically. In Attachment A-3 the subject B-737 crew not only had to deal with an engine fire, but also an unsafe nose gear indication and jammed brakes on the right main gear, among other problems. As detailed by the official investigation (A-3) this incident was high risk and very close to an accident.

## **Section B – Windows and supporting structure**

The increase in large flocking birds has eclipsed the FAR 25.775 window requirement. Attachment B-1 is testament to this fact. In this high risk event at Hamburg the captain's window of the B-737 was completely shattered and opaque caused by collision with geese nominally weighing between four and seven pounds. The airspeed of the aircraft was approximately 226 KIAS at the time of collision. In fact the captain's window did spall and shower the cockpit with glass splinters. Additionally, in a seldom discussed hazard, the first officer's window was covered approximately 70% by bird remains, which dried instantly after collision, obscuring his vision. Since both pilots' vision was severely restricted the crew elected to auto land the aircraft. Both engines suffered bird ingestion but survived. It should be pointed out that, had one engine failed due to bird ingestion, a B-737-700 is unable to auto land with only one engine. Potential for catastrophe here was very high.

Other events have highlighted the interface between the window and the window frame, necessitating a review of this design. Attachment B-2 demonstrates part of the problem. A turkey has been "hydrauliced" literally into the cockpit around the window frame. This event occurred with a RJ at Washington's Dulles airport during the takeoff roll. Obviously the aircraft's speed was not high but the bird's size was great, turkeys weighing up to 20 pounds. This collision also broke several stringers in the nose of the aircraft. Likewise Attachment B-3 demonstrates a goose which entered a Fedex B-727 cockpit via the same method, around the window frame.

While FAA Transport Directorate is considering whether the nose area of aircraft should be reinforced to prevent bird penetration through the radome area, we must also consider the equally undesirable effect of bird penetration around the window frames. The obvious hazards of pilot incapacitation, depressurization and structural failure must all be evaluated. Attachment B-4 details such a case. Climbing through 12,000' the MD-90 struck a flock of approximately 3 pound birds, causing a two foot square tear in the fuselage adjacent to the first officer's eyebrow window. Obviously the aircraft was accelerating to its climb speed when the collision occurred, demonstrating once more that the speed of the aircraft is more important than the size of the bird.

In the same light window integrity must be reconsidered. Birds are not penetrating the window per se, as noted above, in large transport aircraft but a number of cases clearly indicate the spalling of the inner pane, showering the crew with glass shards. Likewise, in smaller transport aircraft the requirements are not as stringent leading to greater risk. Attachment B-5 demonstrates the risk run by the smaller aircraft, as the bird has penetrated the pilot's window through and through and injured the pilot. Considering that

some the smaller transport aircraft are approved for single pilot operations, as in this case, pilot incapacitation leading to catastrophe is neither unforeseeable nor extremely improbable. We believe there are enough of these incidents of record to rate this hazard as high risk.

## **Section C – Engine mount integrity**

The damage caused by bird ingestion into a jet engine is well documented, particularly when the bird exceeds the engine design standards or more than one bird is ingested. While FAA Transport Directorate has studied the integrity of the engine mounts, to prevent vibration caused by bird ingestion from tearing the engine from the wing, this work needs to be revisited. The last 20 years or so has revealed a surprising gap in our safety standards. Stress on the engine mounts, due to engine vibration from bird ingestion, is neither extremely improbable nor is it limited to short duration. Attachment C-1 details a B-767 dual engine ingestion event at Rome. Both engines can be seen to be registering the maximum recordable vibration, one engine at maximum vibration during the entire, short, flight. In this event the captain would report to the authors that “...the airplane was shaking so bad I didn’t think we were going to make it back”. Attachment C-2, regarding a P&W JT9D-7 on a B-747, the ingestion of an approximate 3 pound bird caused such damage that “...six of the eight bolts attaching the main gearbox to the diffuser case had sheared”.

Unfortunately, worldwide, flight crews have no training regarding bird collisions and have proven to engage in risky business. One crew, operating a B-767, noted bird strikes on takeoff but elected to continue their 600 mile flight from Melbourne to Sydney. One engine was throttled back until the vibration level was acceptable and the other operated normally. Upon arrival inspection revealed both engines were damaged. Likewise an Air Cyprus A-330 crew struck birds on departure at Lanarca but continued their 2,000 mile journey to London. Their birdstrike report was refused by UK CAA which had pulled flamingo remains from the aircraft. There are no flamingos in the wild in Britain. There is a large salt lagoon next to the Lanarca airport which attracts thousands of flamingos. Attachment C-3, part of a presentation to the U.K. Flight Safety Committee, lists several similar events worldwide, the most egregious being a PAL B-777 operated from Manila to Vancouver, where the damaged engine was inspected and replaced.

Engines are obviously not only being operated at a vibration level not contemplated by manufacturers but are also being operated for a significant period of time in this damaged condition. As there is no restriction either by manufacturers or regulators to this action, FAA Airplane Directorate should ensure that the engine mount attachments are sufficient both in number and in strength to withstand the fatigue stress of prolonged, many hours, operation. One does not need to be a safety professional to grasp the high risk nature of an engine dropping off mid-ocean.

## **Section D - Airframe**

For large transport aircraft, particularly those with wing leading edge slats, bird collision with the leading edge of the wing does not appear to be high risk. While holes in the wing are undesirable, they have not proven to compromise the safety of the aircraft. However, the same collision between birds and smaller transport aircraft, such as regional jets and turboprops, is another matter.

Unshielded by a slat, wing leading edges on these smaller aircraft have proven vulnerable to high risk degradation in an insidious manner. Attachment D-1 is illustrative. The Cessna 500 struck mute swans on climb out, damaging the wing leading edge leading to rupture of the fuel tank and fuel leakage. Similarly a DHC-8 stuck a large bird in descent in 2010 and penetrated the wing leading edge and fuel tank, leading to a fuel leak.

Nothing could be more illustrative of the benefit of improved structures than the American Airlines B-767 incident departing Paris. The aircraft was in climb at 14,000' and encountered a flock of Northern Shovelers, a two pound bird. Although the cockpit was penetrated via the nose, and the fuselage and wing leading edge had holes in them from the encounter, the empennage was unharmed even though it also stuck multiple birds. As the empennage is designed to resist an eight pound bird and the requirement for rest of the aircraft is only four pounds, the benefit of the strengthened structure is clearly evident. One can raise the same argument for reinforcing the wing leading edges of the smaller transport aircraft, particularly considering that their operational environment is much more up and down through bird rich altitudes than larger transport aircraft. Uncontrollable fuel leaks can readily lead to uncontrollable inflight fire, a catastrophic situation.

## **Section E – Flocking or not flocking**

FAA Transport Directorate has suggested that “...single bird strike approach is an adequate approach for airframe structure as long as the single bird strike criteria are robust.” We disagree for several reasons. Safety management principles require observing a system, the airplane, as a whole. In the past the engineering approach used by the FAA has excluded the ability to do so. For example, a B-727 departing IAH encountered a flock of snow geese and suffered damage to all three engines. The left engine failed due to bird ingestion. The center engine suffered damage due to ingestion of radome parts, knocked loose by bird strike. The right engine’s pylon, through which fuel lines and control cables run, was penetrated by multiple birds. In discussions of the Engine Working Group this event was not classified as a multiple engine ingestion event as the center engine did not ingest birds, per se, and the right engine, although damaged, did not suffer a direct ingestion.

There is no doubt that this was a very significant event but it faded from our records of “high risk” not because it wasn’t high risk, but because the engineering view was too narrow. We need to take the view of the risk level of the system, not individual components.

When examining the record of catastrophic accidents we find that the system is being overwhelmed not by single birds but by flocking encounters. Attachment E-1 demonstrates a Falcon 20 freight aircraft destroyed by striking multiple flocks of doves. Attachment E-2 illustrates the Ryanair B-737 accident at Ciampino. The multiple blood smears completely across the front of the aircraft support the pilot’s statement that “...a black cloud suddenly rose up from underneath and enveloped the aircraft”. His black cloud was a flock of over 1,000 starlings. The aircraft crash landed on the runway and was damaged beyond repair. The Hudson River crash resulted from striking a flock of Canada geese only three months after the Ryanair accident.

While these catastrophes can be dismissed by naysayers as engine events, we should recall that one of our design objectives is to produce an aircraft that is flyable, even after a failure, without “exceptional piloting skill”. Attachment A-3 details a crew which was clearly task saturated by a flock encounter and the failure of multiple components on our system, the aircraft. We are fortunate that this event did not mimic the Hudson River accident where the crew was also task saturated but greatly aided by engineering design, i.e., control laws.

The question really for both designers and regulators is how to determine the greatest threat to the system and how to mitigate the threat. Single bird encounters, while sometimes spectacular, have generally not proven as hazardous as the flock encounters, particularly large flocking bird encounters. As the number of large flocking birds has significantly increased since the last evaluation of the threat we recommend that FAA Transport Directorate consider an increase in the size of the bird used to establish standards.

## **Section F – Ambiguous Data**

Perhaps the most difficult task for those engaged in hazard mitigation is determining the extent of this hazard due to incomplete and ambiguous data worldwide. As U.S. designed and built aircraft fly U.S. citizens throughout the world, the threat worldwide needs to be evaluated. FAA Transport Directorate, in its Request for Comments, has inspected U.S. data only. Obviously the wide variety of environments worldwide and varying species and number of birds must be surveyed for potential threats.

FAA Transport Directorate is not alone in puzzling how to properly collect this data. Attachment F-1, from members of the Engine Working Group, adequately discusses their frustrations in collecting data. Due to the many differing data sources the Engine Working Group was compelled to hire the Boeing Co. to compile a creditable database. The Engine Working Group has moved further by now maintaining a database in conjunction with AIA.

As data is the heart of any mitigation effort we recommend that FAA Transport Directorate initiate a data collection effort similar to the Engine Working Group's effort. Safety management uses data collection as its source to point out gaps in our safety programs. Unfortunately, in this aviation birdstrike hazard, some parties abuse the data collection effort in an effort to prove the efficacy of their actions, not to identify gaps. A database in the hands of an uninvolved third party would both improve the integrity of our collection efforts and ease the task of safety professionals in observing and correcting gaps in the safety program.

One aspect of data collection which should be revisited by FAA Transport Directorate is the mandatory reporting of birdstrikes. The National Transportation Safety Board (NTSB) first recommended this action to FAA in 1999, and then again after the Hudson River event in 2005. The Department of Transportation Inspector General's report of 2012, which reviewed airport wildlife control efforts, also recommended FAA initiate mandatory data collection. Despite these recommendations FAA's point group for birdstrikes, FAA Airports, has consistently refused to consider such action and left us with our currently ambiguous state.

## **Section G – Industry mitigation**

It is clear that transport category aircraft cannot be designed or built which will withstand all encounters with large flocking birds. Neither can such aircraft be designed or built which will withstand all encounters with volcanic ash. Or severe icing. Or wind shear. However, for other environmental hazards we have established defense in depth. Manufacturer's design is supplemented by manufacturer's recommended procedures for the hazards and operational policies which avoid or lessen the effects of the hazards. That is not happening in the birdstrike hazard arena.

Attachment G-1 is an example of this deficiency. This power point slide, presented to the UK Flight Safety Committee, contrasts two distinct hazards: post maintenance test and ferry flight accidents on the left, birdstrike accidents on the right. The information on the left is gathered from Flight Safety Foundation's magazine *Aerosafety World*. The information on the right was gathered by the authors from various accident reports. The number of catastrophes or high risk events is almost identical in each column. The types of aircraft involved are almost identical. Upon observation of the serious nature of losses during post maintenance/ferry flights FSF's members rapidly initiated a working group to close the gaps observed and recommend best practices for post maintenance/ferry flights.

Unfortunately Flight Safety Foundation has repeatedly refused to work in birdstrike mitigation even though the losses are almost identical. When pressed to contribute to mitigation in this area, FSF leadership said they were interested only in working "...on the big killers". Shortly thereafter they initiated a Ground Accident Prevention program. Ground accidents cost carriers \$10 billion a year in losses but rarely result in fatalities. Authors are not attempting to vilify Flight Safety Foundation, rather to use this experience as a case study of the lack of defense in depth and lack of industry involvement.

While we have recently increased the robustness of new jet engines in some categories, it must be remembered that the current fleet engines will continue to fly for the next 20 years or so. Increased engine safety will be incremental over a period of years. Likewise, we may have increased safety at U.S. airports by engaging in airport wildlife control. Unfortunately Attachment G-2 calls these efforts into question. This attachment, the 2012 DOT Inspector General's Report on airport wildlife control, makes it clear that airport wildlife control efforts across the country vary widely and are inconsistent.

There is no doubt, however, that the airport operator's mitigation efforts stop at the airport fence. There is a huge, unaddressed, gap from the time the transport aircraft crosses the fence line until it climbs through 10,000'. About 95% of birdstrikes occur below this altitude. Since the airport operator cannot control this space and since manufacturers cannot build a "bird proof" airplane, why have we not developed operational procedures to close this gap? We have those operational procedures to address volcanic ash *avoidance*, but not bird avoidance. We have operational procedures for the mitigation of a volcanic ash *encounter*, but not a bird strike encounter.

The authors believe this gap exists because industry does not understand the problem or the solutions. Unfortunately industry has been poorly served by experts who only understand biology and not aviation or safety management. As a result there are few official guidelines in the U.S. Attachment G-3 lists operational steps which aircraft owners/operators can take to close this gap. Unfortunately this type of information is an orphan in the U.S. and has no play, despite its advocacy in the U.K. and elsewhere.

Attachment G-4 clearly indicates an operational policy which can directly determine the seriousness of a bird encounter. This attachment documents the rationale used by Transport Canada to resist high speed flight at low altitude. Worldwide there are many FIRs with no speed restrictions at low altitude or air traffic facilities which routinely waive speed restrictions, particularly in Europe. Aircraft speed is absolutely a determinate of the seriousness of collision and also completely under the control of the aircraft owner/operator. Reducing speed at low altitude would seem an easy fix in mitigation but is rarely discussed in industry. Therefore we believe that FAA Transport Directorate would be prudent to set design standards based upon the maximum speed at which a transport aircraft can operate, particularly in bird rich altitudes below 10,000' and especially below 3,000'.

Industry groups working in the birdstrike area are either limited in scope, such as the Engine Working Group, or unsuccessful as safety advocates such as birdstrike committees. Although ICAO encourages states to form birdstrike committees to address the birdstrike hazard the birdstrike committee groups have produced virtually no policy, procedures or best practices despite meeting for decades.

As there is no advocacy for closing the gap described above the authors would invite the FAA Transport Directorate to initiate, as part of its work program, some nature of industry group which can supplement aircraft design with operational procedures to close gaps which design cannot address. We are hoping the pilot of the Hudson River aircraft is incorrect when he recently stated that his accident "...could happen again today". As his

collision was four miles from the airport and as we still have not addressed this gap, he may be correct.

## **Section H – Conclusions**

The authors are aware that this is a lengthy submission and have refrained from including too many examples to illustrate their point. Further information regarding each section is available from the authors. We regret that we are unable to furnish financial data regarding our illustrations or recommendations but it is unavailable to the authors. We will point to the IBSC conclusion that birdstrikes cost the worldwide aviation industry around \$3 billion per year in direct damage repair and time out of service.

In conclusion we recommend:

A. Review of the landing gear, particularly the nose wheel steering components, to better shield critical components from bird strike.

B. Increased robustness of the nose of the aircraft, particularly around the window frames. A revisit of the window standards given the number of large flocking birds in the environment. A revisit of window standards for smaller transport aircraft, particularly those which are authorized to be operated by a single pilot.

C. Given the propensity of flight crews to continue operating damaged engines, the engine mount robustness must be revisited.

D. Fuel tanks in smaller transport aircraft must be redesigned to ensure integrity when striking large flocking birds on the leading edge of the wing.

E. FAA must consider multiple bird strikes and their effect upon the entire system to ensure safety of the entire system. The ‘one component failure’ idea of the past has been subsumed by the reality of the number of large flocking birds.

F. A creditable database with which to monitor the birdstrike problem must be established.

G. Industry and government must work together to use readily available techniques to reduce risk in those areas of the hazard where engineering solutions are either impractical or not available.

## **The Authors**

Dr. Valter Battistoni is a graduate in law from the University of Rome. He joined the ENAC where he had a 31 year career in airport management. While an airport manager he authored over a dozen papers and professional articles on the aviation birdstrike hazard and was the chairman of the Birdstrike Committee – Italy for five years. He served as

technical consultant for ENAC to the Italian courts in litigation resulting from birdstrikes on airports. He has subsequently taught seminars to airport personnel on wildlife hazards on airports and consulted on other birdstrike caused accidents. He originated and manages the website [www.birdstrike.it](http://www.birdstrike.it)

Captain Paul Eschenfelder received his safety management training at the Naval Postgraduate School in Monterey, Cal. He managed aviation safety management programs for a variety of naval commands. In a concomitant civil career he spent 20 years working in a variety of safety programs: he was a member of the FAA/JAA Engine Harmonization Working Group which amended engine standards for bird ingestion for large engines; he participated in the FAA REDAC for Airports when funding for airport wildlife program research was being initiated; he served two terms on the Secretary of Agriculture's Advisory Panel when Wildlife Services was attempting to establish airport wildlife work as a line of business; he was a member of the steering committees of Birdstrike Committee USA and International Birdstrike Committee. As an adjunct professor at Embry Riddle Aeronautical University he originated and led the first training program for airport wildlife control personnel in the U. S. which was acceptable to the FAA Administrator. He has written or presented over two dozen papers or presentations on aviation birdstrike hazards and mitigation. In a 32 year civil flying career he has flown a variety of large transport category aircraft ranging from the DC-9 to the A-330 in worldwide operations.

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