AVISURE
MITIGATING BIRD STRIKE RISK

Commentary

US Federal Aviation Administration

FAA-2015-2049
Bird Strike Requirements for Transport Category Airplanes

November 2015

Context

The US aviation regulatory authorities have for some time been deliberating the need to increase minimum demonstrable airframe structural ratings for wildlife collisions with transport category airplanes.

“The FAA invites interested persons to comment on the need for, and the possible scope of, changes to the bird strike requirements for transport category airplanes by submitting written data, views, or arguments as they may desire.”

Introduction

Wildlife strike has been an aviation safety issue since Orville Wright first started buzzing the corn fields of Ohio. The industry approach to managing the issue has not substantively evolved since. From an aircraft operators perspective wildlife strikes are rarely much more than a costly nuisance and given the rarity of associated major hull loss or fatal accidents, wildlife strikes are often perceived as an issue 'not worth' addressing. As a result the chain of primary responsibility for managing wildlife strike has become skewed; it has been, by default, relegated to aerodrome operators and to certain extent design engineers to bear the brunt of mitigation attempts.

Aerodromes do not collide with birds. While aerodrome operators clearly have a level of responsibility in wildlife strike mitigation, holding them primarily responsible for managing the strike issue is illogical and inequitable – aerodrome operators have no control over the flight paths of aircraft and a limited ability to control the flight paths of wildlife – and only then those wildlife movements within their boundary fence are practically amenable to diversion. Furthermore aerodrome operators and personnel have no background, experience or training in dynamic flight collision avoidance and the expectation that they attempt this function is unsound.

Aircraft, not aerodromes, collide with birds and it stands to reason that wildlife strike is an essential in-flight collision avoidance problem. Thus the expectation that engineering design will, in isolation, effectively mitigate the problem is a lot like 'placing the ambulance at the bottom of the cliff' - it is probably a good idea as a last ditch protective barrier but it is really not an approach that effectively deals with the root cause of the problem. The primary mitigation strategy for this issue should be to avoid the in-flight collision in the first instance – as it is for terrain collision avoidance; as it is with traffic and MAC avoidance and as it is for avoidance of other dynamic environmental hazards such as wind shear and thunderstorms.

Primary Observations

Our initial observations on the initiative to increase airframe structural ratings for wildlife strike are:

1. Moves to legislate for more strike resilient airframes (or engines) are essentially wasted money and effort if they are not embedded elements of coordinated, multipronged and cross-disciplinary mitigation strategy based on SMS. To date wildlife strike mitigation in civil aviation has not been coordinated in this fashion and the result is sustained global increases in incident rates to RPT aircraft over the last twenty years with a continuing over-reliance on structure to prevent catastrophe.

2. In flight collision avoidance is *the* primary function of pilot-in-command (PIC) both in the planning and execution of flight. The fundamental point of having a PIC is to conduct an aerial operation that avoids collision with terrain, collision with other aircraft and collision with thunderstorms, dust devils, wind shear, volcanic eruptions or any other defined

> environmental hazard. Collision avoidance is always the ultimate responsibility of PIC as PIC has ultimate and absolute authority over the flight path of the aircraft; i.e. only the PIC has the legally and practical ability to alter the aircraft's vector to avoid a collision. For reasons which are not clear this fundamental concept has failed incorporation into the wildlife collision avoidance paradigm currently used in civil aviation. Consequently wildlife collision mitigation in civil aviation is disjunct with little operational relevance and in almost all developed countries where reasonable records are kept wildlife collision rates are increasing. Primary responsibility for wildlife strike mitigation has devolved to the aerodrome and engineering design sectors and while their efforts to date have been diligent there is only so much that indirect or 'last line of defence' mitigation attempts can achieve. Aerodrome and engineering approaches to strike mitigation should be supplementary to a dynamic wildlife collision avoidance system based on flight path management rather than an attempts to supplant it.

Are we revisiting the airframe design stringency regulations because we can rather than because it is a measure that effectively addresses the core problem?

Primary Recommendation

Revisit the structural integrity requirements for airframes and engines but do so in the context of a comprehensive operational mitigation strategy. That strategy should be structured in a similar fashion to other existing collision avoidance strategies: i.e. it should be dynamic, responsive, airspace orientated and based on the fundamental that PIC is responsible for collision avoidance. In this regard the remainder of the industry, engineers, aerodrome operators, ornithologists and ground wildlife controllers cannot subsume that responsibility or authority; they are required to provide PIC with accurate, timely information and support so that he/she can make considered operational decisions on how to avoid or minimise the chance of collision in the first place.

The engineering approach to wildlife strike management

Approaches to wildlife strike mitigation that require minimum structural standards for airframes or engines to minimise strike impact damage have a long and well documented history. Some of the advantages and limitations to this approach are listed below.

Advantages

- Reduces the probability of catastrophic failure as a result of collision with wildlife
- Relatively simple to apply
- Can be either included in the primary design or, within limitations, retrofitted to aircraft.
- Discrete and static, i.e. once an element is designed/fitted it does not require dynamic or constant operational input to work.
- Has secondary effect of helping advance structural and materials design toward lighter, stronger components.

Limitations

- To date almost always applied reactively, i.e. after a major accident or series of incidents.
- The approach quickly asymptotes against strength to weight ratio and knock-on structural or design compromises
- Operational control of air speed is simpler to apply and can have a significantly greater effect on post-collision structural failure.
- The approach does not significantly affect the primary probability of collision and therefore does not significantly reduce the:
    - incident rate
    - industry costs of strike - as most of the costs per strike are incurred as a result of downstream flight delays, cancellations and LAME examinations rather than actual damage costs.
    - wildlife attrition rate

This strategy is an adjunctive rather than a first line mitigation and should be considered a part of an integrated collision risk management program. Using the ‘Reason Model’ it should be final barrier against catastrophe and it should follow a long line of human factors, air operational, behavioural and ecological barriers designed to anticipate and avoid collision. Probably the most significant disadvantage of the engineering approach in civil aviation to date is that is has been misapplied as a first line approach to wildlife strike management and thus has tended to defer serious attempts at dynamic or procedural mitigation.

Low level high speed flight in the strike zone (B030AGL)

Some of the limitations of the design-engineering approach to strike mitigation are highlighted in the transcript of the following accident in the USA in 1987.

> *Rockwell B1B Lancer, wildlife strike, fatal hull loss, USA 1987. (Excerpt from Global Security.org, Weapons of Mass Destruction, B1-B losses)*
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> *The first B-1B [84-0052] crash after the aircraft became operational in 1986 was on 28 September 1987 at La Junta, near Pueblo, Colorado. Two of those killed were instructors who were not in ejection seats and did not have time to bail out manually. A third crewman, the co-pilot, died because his ejection seat malfunctioned. Three surviving crew members bailed out successfully. The bomber from Dyess AFB was flying a low level training mission about 600 feet above the ground at a speed of 560 knots [about 645 mph] when the plane struck a 15 to 20 pound (6.7-9.0 kg) North American white pelican. The bird tore through a wing, ripping apart critical hydraulic, electrical and fuel lines. This started a fire which made it impossible for the pilot to control the plane. The Air Force subsequently hardened the vulnerable area on the remaining B-1s. Individual B-1Bs were restricted from high-speed, low-altitude flight below 5,000 ft. above ground level until bird strike protection kits were installed, with all modifications completed by December 1988. The modifications are designed to withstand the impact of a 10-lb.(4.5kg) bird at 590 kt. The B-1B was originally designed to withstand strikes by birds weighing up to six pounds.(2.7kg)*

American White Pelican body weights reportedly have a broad range between 3.5 and 13.6 kg, although more typically these birds average between 5.0 and 9.1 kg. One study reported a mean body mass of 7.0 kg and another study found mean weights to be lower, with eleven males averaging 6.34 kg and six females averaging 4.97 kg. Thus the response to the Lancer accident resulted in a leading edge upgrade rating less than estimated impact force incurred by the initiating incident; and correspondingly the upgrade would be unlikely to mitigate structural failure in the event of any future impact by the same species under the similar operational circumstances. This anecdote highlights the limitations of trying to engineer a structural solution to an in-flight collision problem, particularly if it is a retrofit. It doesn't suggest that the leading edge upgrade was useless and shouldn't have been carried out but rather it graphically underscores the requirement for multiple cross-disciplinary approaches to mitigate a complex dynamic problem.

To our knowledge this leading edge upgrade was in fact the only mitigation response to this incident. No attempt was made to define the ambient, climatic, biological or behavioral circumstances that led to the pelican conflicting the aircraft at that time, altitude and position. No attempt was made to understand the flight path requirements of the operation in the context of local wildlife airspace usage and thus provide some foundation to deconflict future operations. No attempt was made to adapt ground based or airborne sensor platforms to the detection and early warning of airborne avian threats or to the strategic modelling of avian threats that might allow for avoidance during mission planning. At least, if these things were explored in the wake of this accident they were not published or used to advance and develop a more comprehensive strike mitigation paradigm. Ironically if this incident had been a midair collision with another aircraft, an enemy missile or controlled flight into terrain these types of investigations would have been carried out in great detail and the lessons learnt would have been applied operationally to prevent recurrence. In these circumstances any recommended structural changes would have been supplementary not primary provisions of the response.

Even more ironically, in the 10-20 years preceding this accident, the Israeli Air Force (IAF) had in fact instigated all the bio-operational investigations listed above and incorporated them into a successful and sustained wildlife strike mitigation program for high-speed low-level operations. To our knowledge increasing airframe structural impact rating to reduce hull loss rates *after* mid-air collisions with wildlife was not a prominent feature of their program. No to our knowledge has this strategy ever been a first line response for managing mid-air collision between aircraft or controlled flight into terrain.

Recommendation 2

Refocus resources and expedite investigations into defining, anticipating and forecasting flight path conflicts between wildlife and aircraft at different spatial and temporal scales. Use this information to draft conflict avoidance procedures.

Wildlife population trends, recent high impact incidents, and strike data.

As noted in the FAA document preamble it is possible that the US strike risk profile is changing in response to increasing aircraft movements and an apparent increase in the mass flux of high risk wildlife through critical airspace. This is consistent with observations abroad; similar wildlife-biomass increases or redistributions have been documented in Europe and Australasia. In addition, first principle bio-energetics suggests that as global urbanisation progresses, wildlife contamination of terminal airspace will continue to increase.

In this instance it would have been useful to examine the list of high impact strikes in the context of the overall trend in civil strike rates, damaging strike rates, the trend in strikes with an adverse effect on planned flight and in particular with an analysis of the rate of debilitating airframe or engine strikes that result from sub-maximal impacts; that is, how effective are the current airframe/engine design requirements at meeting the required continuation of flight standards?

Unfortunately, however, this statement simply serves to highlight another fundamental limitation of the current aviation wildlife management approach. It is extremely difficult to derive this information or get a good appreciation of real or confounded strike safety trends. In all but a handful of developed countries wildlife strike reporting is not mandatory. Even in countries where most strikes are reported the quality of the incident data is often questionable and the attitudes of those collecting it are often perfunctory. Even more frustrating is the almost total lack of investigation into strike incidents. Occasionally a serious strike related accident will be investigated – but do we really want to be investigating serious strike accidents? No - we should be preventing serious strike accidents by investigating and learning appropriate lessons from the myriad of strike incidents – every year in this country around 2000 aircraft-wildlife strikes are reported to ATSB – with very rare exception none of these are ever investigated and so the invaluable information contained in those incidents is never extracted and applied to critical, evidence based prevention. In the rare (usually serious or fatal accidents) where wildlife strikes are investigated, the investigation normally centres on the airframe, engine and procedural responses to the accident – never yet in recent civil aviation have we seen the absolutely central investigative question addressed; *"Why was that aircraft and that animal trying to occupy the same space at the same time?"* is admittedly a difficult question but as long as we keep ignoring it we will never learn how to correctly answer it and we will be relegated to assessing whether the floatation devices and evacuation procedures are adequate to minimise loss life when the aircraft ditches.

In this respect wildlife strike as an aviation safety issue is somewhat orphaned – it is still primarily a reactive and siloed management approach and with a nebulous data collection base it is likely to remain so. As Richard Dolbeer recently said, "if you can't measure it, you can't manage it". Without good information we can't effectively define the problem and consequently the extent of the problem and its projected impact on aviation safety remain ambiguous and open to question. Likewise innovative management approaches also remain ambiguous and open to debate ensuring the reluctance of competitive sub-sectors of the industry to embrace management beyond the ineffective minimalist procedures that already exist.

Recommendation 3

Prioritise resource and efforts into collecting accurate wildlife strike data, analysing it and deriving robust information that will support evidence based management. In particular investigate strike incidents in the same way we would investigate loss of separation, infringement of Controlled Airspace or Mid-air collision incidents; that is asking the question “why did this collision/near miss occur in the first place?”

Some of the data and information requirements are:

1. Complete strike records at least for all operations with A/C >7000kg MTOW
2. Accurate breakdown of strike rates by aircraft weight category.
3. Accurate reporting of strike consequences including real costs
4. Aero-ecological modelling of airspace usage by wildlife by locations against approach and departures procedures in use at those locations
5. Engineering models which address the susceptibility of different airframes to the *probability* of strike. That is, how do frontal area, sound signature, MTOW(V speeds) engine placement and engine diameter, wake profile and disturbed air in front of the aircraft contribute to the probability of a strike or ingestion occurring?
6. Forecasting and Nowcasting wildlife airspace usage as per what is currently in use with the European ESA Flysafe initiative.

Specific Questions

FAA noted some specific areas for comment:

1. **Should the bird weight requirement be applied consistently across the airplane?**

   - No, because the effect is not specifically mass dependent. It is dependent on impact force (mass X speed) as applied to functionally critical components.

2. **Should the bird weight requirement be increased, to eight pounds or some other value?**

   - A difficult thing to answer. Consider this, imagine if pigs flew and the average pig weighed 80kg. Then the average pig strike would reap the consequence of 80kg mass intersecting the airframe/engine at speed. In the absence of any other effective mitigation measures and in order to prevent catastrophe then airframes and engines clearly would have to be designed to withstand an 80kg mass impact at a set TAS - as this would be the only line of defence. If however we could reliably detect and avoid pigs in flight and we significantly reduced speed while flying in the pig strike zone then you could with some degree of confidence reduce the stringency of the airframe and engine impact ratings. Thus the "weight" rating you refer to is dependent on the efficacy of all other mitigation measures used as well as the mass-speed combination likely to be operationally encountered. In today's civil aviation regime it is apparent from global statistics that current strike mitigation measures are relatively ineffective. This suggest that airframe rating maybe the only barrier guarding against frequent strike related hull loss incidents. Hence, in the current biological milieu the exposed and critical components of airframes (including LEDs, undercarriage, windscreens, propellers and engine intakes) need to be rated to withstand at least 5kg impact at 250kts IAS below 3000 AGL. We suggest 5kg (11lbs) here because it's a reasonably good midpoint of the recorded individual weights of pelicans/various species of geese/swans /raptors which represent the major risk species. Then again, many of these are flocking species and occasionally result in multiple strikes – so maybe the rating should be 6X5=30kg estimating that the average multiple strike involves around 6 individuals? The engineering response will always be a compromise and may never be able to mitigate the horrid realty of a multiple pelican strike.

3. **Should a ‘‘no-penetration’’ requirement be applied to the entire fuselage, not just the windshields?**

    - Penetration by what under what conditions? No, because the consequence of penetration is dependent on impact force (mass X speed) as applied to functionally critical components and varies significantly over the whole fuselage. Can we build a airframe that will guarantee no fuselage penetration after strike a flock of 10 pelicans at 400kts TAS? I doubt it.

4. **Should the bird strike criteria be expanded to 10,000 feet?**

    - 10000 feet above what? And for the application of what criteria? When assessed on strike probability alone then it is generally accepted that the strike zone or the height block where the majority of bird operations occur is up to 3000’AGL. However we probably need to consider the height block zone where most strike related hull loses/fatalities occur. If this includes the airspace up to and including 10000(AMSL or AGL) then the answer is yes.

5. **Should the 0.85 speed reduction factor at 8000 feet, currently specified in § 25.571, be removed?**

    - No not in the short term.

6. **Should the speed criterion for bird strikes be based on VMO rather than VC?**

    - Yes. Although consideration should be given to amending Title 14, Code of Federal Regulations 91.117 to state, *“unless otherwise authorized by the Administrator, no person may operate an aircraft below 10,000 feet MSL at an indicated airspeed of more than 200 knots*. Given the apparent trend in high risk flocking wildlife and increase in serious high impact wildlife strikes this approach is much easier and less costly to implement and more likely produce a greater safety margin than increasing airframe structural ratings.

Recommendation 4

With respect to the specific questions above surrounding mass limitations, structural ratings and speed limitations: There is a dearth of accurate data, analysis and investigative result in the wildlife strike arena that makes projection ambiguous. However, even so, the current indications are that high-impact off-airport strikes are increasing with a concomitant increased probability of fatal hull loss accident. At the same time there is evidence that airport centric wildlife management approaches lack operational relevance and are at best only partially effective. In the short term we recommend striving for the highest mass-impact rating and lowest speed restriction that are possible to achieve in order to offset the risk of hull loss. In the medium term we recommend expediting the prescription for better data collection and analysis, a reassignment of primary collision avoidance responsibility to PIC and further significant investigations into procedural detection and avoidance systems. The structural ratings and speed restrictions could be relaxed as more integrated and operationally relevant approaches prove effective.

Some relevant literature

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