

**THE DEVELOPMENT OF BIRDSTRIKE RISK ASSESSMENT PROCEDURES, THEIR USE
ON AIRPORTS, AND THE POTENTIAL BENEFITS TO THE AVIATION INDUSTRY**

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Abstract

Over the past two years CSL has been involved in the development of formal risk assessment procedures for the birdstrike hazard to aircraft. These risk assessments have now been carried out at all BAA airports in the UK and the impact of this process on the bird management at the different airports can begin to be assessed. The risk assessment process itself has also been refined over the same period, and calculations made to determine how the various target levels for birdstrike frequency, particularly those which, if not met, require further bird management to be undertaken, relate to absolute levels of risk (e.g. risk of financial loss or of a catastrophic accident).

In parallel to this, calculations have been undertaken to determine the costs of birdstrikes to world aviation. This has involved obtaining data from particular airlines and extrapolating to the world fleet. As the airlines gather more data, the cost estimates have been refined. The impact of improvements generated by the risk assessment process can now be expressed in terms of costs saved to the industry.

This paper presents the latest developments in this process, demonstrates the benefits of proper risk assessment in birdstrike prevention, and advocates the adoption of formal risk assessment in airport bird control world-wide.

1. Introduction

As the volume of air traffic continues to increase, and the populations of some hazardous bird species continue to grow, controlling the risk to aircraft from birdstrikes is becoming an increasingly important issue. This is reflected a recent publication by the UK Civil Aviation Authority (CAA 2002). Changes in certification regulations for aero-engines have also been introduced, and the International Civil Aviation Organisation is in the process of introducing new standards for airport bird control.

The world's aviation industry invests large sums of money in birdstrike prevention and in the mitigation of the effects of birdstrikes once they occur. Nevertheless, the industry suffers a conservatively estimated loss of US\$ 1.2 billion per year as a result of damage and delays following birdstrikes (ALLAN 2002).

The question that needs to be addressed is whether the effort currently expended is sufficient and whether it is effectively targeted to provide the greatest benefit in terms of both increased public safety and cost control for the airlines. MILSOM & HORTON (1995) used two key statistics, the proportion of birds under 100g in the strike sample, and the proportion of species that were regarded as controllable, to measure bird control performance at airports, but they did not set a standard that the airport was expected to achieve.

Over the past 3 years, CSL Birdstrike Avoidance Team, in conjunction with BAA, have developed a birdstrike risk assessment protocol which has now been in place at all BAA airports in the UK for the past 2 years (ALLAN 2001). The risk assessment is designed to objectively assess the risk from the different species struck at each airport. It also sets uniform standards across the company that require additional effort to be made if the risk from a particular species exceeds a specified level.

At the same time, CSL has been refining its estimates of the costs of birdstrikes to the aviation industry with the help of United Airlines (UAL). More detailed analysis of the larger dataset now available has enabled the types of strikes causing the greatest losses to airlines to be identified and the cost savings arising from the implementation of this type of risk assessment process to be estimated.

This paper seeks to bring together the experiences of the past two years, to describe the benefits, and potential costs, of formal birdstrike risk assessment to airports and to describe how this process may be used to help the aviation industry to control its operational costs.

2. Practical application of birdstrike risk assessment

A detailed protocol for the birdstrike risk assessment process developed in conjunction with BAA was presented at the previous IBSC meeting in Amsterdam (ALLAN 2000) and updated at BSC N. America in Calgary (ALLAN 2001). It concentrates on identifying bird species that have the greatest probability of causing damage to an aircraft following a birdstrike. It sets action thresholds in terms of the average number of birdstrikes with that species over a 5-year period. If the action threshold is exceeded, additional management action by the airport to reduce the risk from the species concerned must be carried out. Damage probabilities are derived from the UK birdstrike database and divided into 5 categories. Birdstrike frequency is taken from the airport's own records and again divided into 5 categories. Tables 1 to 3 show the categories into which the probability of damage and strike frequency are divided and the matrix of damage probability and frequency which governs whether additional management

action is required. For details of how partially identified birdstrikes and multiple impacts are included in the risk assessment see ALLAN (2001).

Table 1. Strike frequency categories derived from the airport's birdstrike record. Frequencies are the mean number of strikes with the species concerned averaged over the previous 5 years.

No. Strikes per year (airport data)	>10	3-10	1-2.9	0.3-0.9	0.2-0
Probability category	Very High	High	Moderate	Low	Very Low

Table 2. Strike severity categories derived from the UK birdstrike database. Categories are based on the percentage of strikes between 1975 and 1995 that were recorded as damaging to the aircraft

Percentage of strikes causing damage (national data)	>20%	10-20%	6-9.9%	2-5.9%	0-1.9%
Severity category	Very High	High	Moderate	Low	Very Low

Table 3. Risk assessment matrix showing combinations of severity and frequency that require immediate action, review or no action

SEVERITY	PROBABILITY				
	Very High	High	Moderate	Low	Very Low
Very High	3	3	3	3	2
High	3	3	3	2	2
Moderate	3	3	2	1	1
Low	2	2	1	1	1
Very Low	1	1	1	1	1

Key

3 Immediate additional action required to reduce the current risk

2 Review of current management practices and options for additional action required

1 No further action beyond current management is required

2.1 Potential problems with the species based approach

Evaluation of the UK's birdstrike database (reported elsewhere at this meeting) show that there remain significant problems with the full and accurate reporting of birdstrikes in the UK. A bias towards non reporting of non damaging birdstrikes may lead to an overestimation of the levels of damage caused by some species, whilst the failure to fully identify the remains left following birdstrikes may result in an underestimation of the true frequency of strikes with particular species. Whilst both of these factors are important if an absolute numerical level of risk needs to be calculated (e.g. the exact probability of a damaging strike or of a catastrophic accident) it is not critical in this risk assessment process. Because the action thresholds have been set at an arbitrary level which is not precisely related to an absolute level of risk, the only requirement for this system to function is that the level of identification accuracy and reporting is consistent from year to year. If the reporting was inconsistent then changes in reporting standards could be interpreted as changes in risk levels and actions taken, or not taken, in error. BAA airports have a policy of reporting all birdstrikes and of submitting all birdstrike remains to be expertly identified. The standard of reporting should,

therefore, have remained reasonably constant over the risk assessment period and any changes in risk, either for better or worse, should be real. Any airport that contemplates setting up a similar risk assessment protocol will need to take steps to ensure that its reporting of birdstrikes and identification of birdstrike remains are as complete and consistent as possible.

2.2 Benefits of formal risk assessment to the airport

The experience of BAA managers and staff in operating the risk assessment protocols has been generally positive. The process allows the identification of the sources of greatest risk and helps managers and staff to focus their efforts on those species that will provide the greatest safety benefit if controlled further. This process has proved particularly useful at those airports where the nature of the hazard has changed in recent years. Much of the bird control effort in the UK has focused on grassland bird species such as Lapwings (*Vanellus vanellus*) Gulls (*Larus sp.*) and Starlings (*Sturnus vulgaris*). Recent large scale population declines in the Lapwing, combined with the development of effective deterrents, such as bird repellent grass swards, has resulted in the risk from this species being largely under control at most UK airports. In contrast, the development of colonies of rooftop nesting gulls adjacent to some airports and the increase of populations of Woodpigeons (*Columba palumbus*) and Canada Geese (*Branta canadensis*) has changed the species giving rise to the greatest risk and hence to the techniques that need to be deployed to manage that risk. In the past it has sometimes proved difficult to persuade airport bird controllers, especially those that have been doing the job for many years, that they need to adopt different strategies to those that have proved successful in the past. This risk assessment process pinpoints the sources of greatest risk in a way that makes it impossible to avoid dealing with the issue, even if it requires a change in approach to bird control or the adoption of new control techniques that were not necessary in the past.

Bird control services inevitably compete for resources with other airport safety and security areas, and all civil airports are under pressure to minimise operating costs in order to maximise profit margins. Whilst all airports give safety the highest priority, the presence of a formal risk assessment has proved helpful in some cases in securing resources to carry out bird management projects that may not previously have been regarded as warranting further expenditure. This is especially true of capital works such as drainage, bird exclusion from large water-bodies etc. that require large short term investment to achieve longer term risk reduction. The fact that the airport has, on record, an assessment that requires further action can greatly assist bird control managers in securing resources to enhance the birds control effort.

2.3 Potential costs of formal risk assessment to the airport

The risk management actions that are identified by the risk assessment process are normally in addition to those already in place at the airport. The fact that the risk from a species has fallen to an acceptable level does not mean that risk management measures can be abandoned, rather that they are clearly effective and should be maintained. This means that any additional risk management will usually incur additional costs. For example, if the risk from large gull species is identified as requiring further action and the detailed analysis of the timing of strikes shows that the peak risk is in June, it is likely that there is a breeding colony, perhaps on a rooftop, nearby. This will require an off airfield survey to identify where the colony is, and management of the birds to disperse the colony. All of this will require additional manpower, equipment and possibly the employment of specialist contractors. Airports that embark on a formal risk assessment process need to be aware of the possible financial implications of the outcome.

The other potential cost to the airport arises from a failure to act, or to document actions, following a risk assessment. If a species is identified as requiring further management and the airport does nothing, it is potentially extremely vulnerable, either to action from its regulator or to private legal action from an airline in the event of a serious incident. Similarly, if actions have been taken, but not properly documented, difficulties may result in proving that the airport has acted on the risk assessment. The production of a full action plan is, therefore, most important, especially if the airport decides not to take action to control a particular risk, in which case a reasoned argument needs to be put forward.

3. Updated estimates of birdstrike costs

ALLAN (2002) produced a revised estimate of the costs associated with birdstrike damage and delays to the world aviation fleet. Initially this was based on only one years data from UAL which is one of the few airlines to track its spend on birdstrike incidents in a way that permits analysis of both damage costs and delays and cancellations. Since then, more data have become available, and the estimate appears to be robust year on year, varying between US\$ 0.90 and 1.16 billion per year. The lower figure represents the total birdstrike costs in 2002 and may reflect the financial difficulties and consequent reductions in flight numbers suffered by some of the world's larger airlines in that period. This emphasises one of the major weaknesses of this cost estimation process, i.e. that it is based on data from only one airline and extrapolated to the world fleet. Until other airlines begin to track birdstrike costs in a way that can be analysed in detail, it will not be possible to increase the sample size or geographical range of the data further. The larger sample size, covering 4 years of operation, now available from UAL has, however, permitted some more detailed analysis to be undertaken.

3.1 Total annual costs

The data available up to the end of 2002 show that the estimated cost of birdstrikes for the world fleet remains around one billion US\$ per year [*table 4*]. The proportion of costs arising from direct damage to aircraft is only 12% of the total. The rest is made up of delays and cancellations to the aircraft struck and of secondary delays, cancellations and costs that result from the aircraft being out of position or passengers missing connecting flights.

Table 4 *Estimated birdstrike frequency and costs to world aviation 1999-2002. See Allan (2002) for a detailed description of the calculation methods*

YEAR	No. Of Strikes	Total Cost (billion US\$)
2002	34851	0.89
2001	37684	1.08
2000	39616	1.32
1999	31578	1.35

3.2 The source of costs

The birdstrike risk assessment process described above was developed from the point of view of the airport operator and concentrates on improving public safety by reducing or eliminating birdstrikes that are likely to cause accidents or severe damage to aircraft. It also reduces the exposure of the airport to possible legal action following such an incident. The risk assessment matrix in table 3 is, therefore, weighted towards those species that result in a high probability of damage following a strike (usually species of high mass). For example,

even if the number of strikes with a species with a 'very low' rating for damage probability reaches the 'very high' level, the risk assessment requires only a review of current practices because the probability of a severe birdstrike incident with species such as Swallows (*Hirundo sp.*) or sparrows (*Passer sp.*) remains very low. We have examined the UAL birdstrike costs to determine whether, as well as reducing risk to passengers and possible liability to the airport, the risk assessment process also helps to reduce birdstrike costs to the airline.

The birdstrikes suffered by UAL over the period 1999-2002 were separated into damaging and non-damaging strikes. This was achieved by examining the costs associated with the incidents and assuming that any incident that cost under US\$1000 was non-damaging. This was based upon the fact that there would be some costs associated with having an aircraft checked following a birdstrike but that any repair to a modern aircraft would cost more than US\$ 1000 no matter how small. There may, therefore, be some non-damaging birdstrikes included in the damaging category if the cost of a return to the airport and/or safety checks amounted to more than US\$1000, but there should be no damaging strikes included in the non-damaging category if the assumption about the cost of even the smallest repair is correct. The cost of repairs, delays and cancellations were then split between the damaging and non-damaging strikes [Table 5].

Table 5. Direct costs, delays and cancellations resulting from damaging and non damaging birdstrikes to UAL aircraft 1999-2002

Type Of Strike	Total Cost Of Damage (million US\$)	Total Cost Of Delays And Cancellations (million US\$)	Total Cost (million US\$)	Number of strikes	Average Cost Per Strike
Damaging	23	37.43	60.43	267	226,329
Non Damaging	0.53	110.7	111.23	4938	22,417

The data show that the total cost of non-damaging strikes (111.23 million US\$) is almost double that of damaging strikes (60.43 million US\$) over the 4-year period. However, there were 267 damaging strikes compared to 5205 non-damaging events. Each damaging strike therefore costs an average of US\$ 226,329 compared to US\$ 21,300 for a non-damaging event. Preventing one damaging strike will, on average, save the airline over ten times more in operating costs than preventing a non damaging incident. It is therefore reasonable to concentrate bird control efforts on the species that are most likely to cause damage both from the point of view of public safety and to control operating costs of the airlines involved.

Where the effectiveness of this risk assessment process differs for the airline compared to the airport is in the emphasis placed on the control of species with a low damage probability. Such species are highly unlikely to cause an accident or serious incident but, because of their greater frequency, they result in almost double the total operating cost to the airline, largely as a result of delays caused by precautionary returns to the departure airport for aircraft inspections following strikes. There is little cost benefit to the airport in attempting to control these strikes, especially as many result from species such as Swallows which are known to be difficult or impossible to control effectively. However, if an airport can prevent reasonably large number of these strikes they can reduce the operating costs of the airlines significantly. This could cause airlines to press for a reassessment of the current risk assessment process to give more emphasis to species causing a high frequency of non-damaging strikes.

3.3 Damage costs around the world

As well as determining whether concentrating on preventing damaging birdstrikes gives the best cost saving to an airline, the larger dataset enabled an evaluation to be made of where in the world it would be most profitable to concentrate additional bird management effort. Strikes were split into the different continents into which UAL operate and the cost calculations repeated for each region. It should be noted that the number of UAL flights into some areas is small and the results of the cost calculations may be subject to large biases. There is also the possibility that standards of birdstrike reporting within UAL vary from continent to continent. UAL does not fly at all into Africa.

Table 6. *The number of birdstrikes per 10,000 movements suffered by UAL aircraft in different world regions 1999-2002*

	North America	S. America	Asia/Australasia	Europe
Damaging	0.44	0.81	0.88	1.14
Non Damaging	8.06	18.07	7.06	13.6

Table 7. *The cost per strike (US\$) of birdstrikes suffered by UAL in different world regions 1999-2002*

	North America	S. America	Asia/Australasia	Europe
Damaging	229,330	306,943	141,082	197,635
Non Damaging	23,306	10,914	12,048	12,036

The data show some interesting differences in the numbers and costs of birdstrikes encountered in different parts of the world. UAL suffers 2.6 times as many damaging birdstrikes in Europe compared to N. America and 1.7 times as many non-damaging strikes. However the cost of a damaging strike in Europe is 0.86 of the cost in N. America and non-damaging strikes cost half as much. This may reflect the relative costs involved in aircraft inspection in Europe compared to elsewhere in the world. If a routine inspection in Europe costs over US\$ 1000 then the strike would be categorised as damaging in the current analysis. This may explain the larger number of strikes but the lower overall cost in Europe compared to elsewhere. Alternatively, it may show that the birdstrike risk is greater in Europe than elsewhere in the world. Further analysis of the data, including a sensitivity analysis relating to the sum of money used to identify non-damaging strikes is needed to clarify this issue.

4. Conclusion

The risk assessment process developed jointly by CSL and BAA has proved robust in operation and has been welcomed by the airports involved. Management actions initiated over the past two years have begun to bear fruit and the strike frequency with those species identified as requiring further management action have begun to fall in many cases. Providing that the airport involved understands the possible cost implications of embarking on this process and the possible legal consequences of failing to act on its own risk assessment, then the process can be recommended as a means of focussing effort on those

species that will give the greatest safety benefit if controlled. Airlines will also benefit from this process in that damaging strikes, which cost around ten times as much as non-damaging incidents, are likely to be reduced in frequency as are non-damaging strikes with the most hazardous species. Where airlines may see less benefit will be in the lack of emphasis that the risk assessment places on strikes with a very low probability of damage. These strikes result in the vast majority of an airline's birdstrike costs and the risk assessment process may actually reduce the airport's commitment to preventing these strikes whilst it concentrates on the more risky incidents. In summary, the formal risk assessment offers benefits to the passenger, the airport operator and the airline, but care will need to be taken to ensure that control of strikes with very low damage probability is not neglected in the push to reduce strike frequency with more hazardous species.

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