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A PROTOCOL FOR BIRD STRIKE RISK ASSESSMENT AT AIRPORTS

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Abstract

In order for airports to manage the bird strike risk effectively, a risk assessment process needs to be carried out to identify the major hazards at the airport, the levels of risk that they produce, and the most cost effective means of reducing that risk.

Despite the fact that bird controllers, managers and consultants make informal bird strike risk assessments throughout their working lives, there is no generally accepted methodology for assessing bird strike risk at airports. Other parts of the transport industry, indeed other parts of airport operations, are subject to detailed risk analysis, often with carefully calculated probabilities attached to each step of the process that leads to a particular adverse event occurring. The variability, and consequent unpredictability, of bird behaviour, combined with the lack of familiarity of the ornithologists involved in bird strike prevention consultancy with the formal risk assessment process, has led to bird strike prevention lagging behind other areas of airport safety in the development of risk assessment systems.

The aim of this paper is to produce a basic protocol for the analysis of bird strike risk on airports. The intention is that the protocol should be generally applicable to all airports, and can be modified to suit the particular circumstances at different airports around the world. I do not suggest that this is the definitive answer to the problem of bird strike risk assessment, but, hopefully, it will stimulate further thought and development of better systems that will contribute to flight safety in the future.

Key Words: Risk assessment, Analysis.

1 Introduction

Collisions between birds and aircraft (birdstrikes) are a significant hazard to aviation and cost many millions of dollars per year in damage and delays. A recent estimate from the United States Federal Aviation Administration (FAA) placed the cost of birdstrikes to the US aviation industry at US$385 million per year plus 461,000 hours of aircraft down time (Cleary et al 1999). Due to incomplete reporting of birdstrikes and poor collation of data relating to the costs of birdstrikes in terms of aircraft down time, disrupted schedules etc. these are probably conservative estimates. More rarely, catastrophic accidents have occurred following birdstrikes, some of which have resulted in significant loss of life. (Thorpe 1996). The International Civil Aviation Authority (ICAO) recommends in Annexe 14 of the Convention on International Civil Aviation that airports should take steps to both monitor and reduce the risk to aircraft by managing the hazard using a variety of techniques including habitat management to make the airport and its environs less attractive to birds. Many countries reinforce these recommendations by regulation and supply supporting guidance documents specific to local conditions (e.g. Civil Aviation Authority 1998, Cleary & Dolbeer 1999, Transport Canada 1992). ICAO is considering adopting a revised set of the recommendations in Annexe 14 as an international standard in the near future (Pinos 1999)

In order for airports to manage the birdstrike risk effectively, a risk assessment process needs to be carried out to identify the major hazards at the airport, the levels of risk that they produce, and the most cost effective means of reducing that risk. In the past, most assessments have been conducted on a ‘rule of thumb’ basis with the birdstrike risk being subjectively assessed and a standard set of risk management measures being adopted (usually habitat management and bird scaring). The risk assessment is usually based on previous experience of the airport managers and bird controllers and the risk management on the guidance documents available from regulatory authorities. Recently, more airports have employed expert consultants (usually ornithologists) to advise them on the best methods for birdstrike risk management at their site. The reports produced by such consultants are ***de facto*** informal risk assessments based on past experience and ornithological training. They are usually accompanied by a similarly informal risk management evaluation, which results in a set of recommendations on the best methods to manage the risk at the particular site concerned.

Despite the fact that bird controllers, managers and consultants make birdstrike risk assessments throughout their working lives, there is no internationally accepted methodology for assessing birdstrike risk at airports. This has arisen, in part, because of the biological element (the birds) involved in the process. Other parts of the transport industry, indeed other parts of airport operations, are subject to detailed risk analyses, often with carefully calculated probabilities attached to each step of the process that leads to a particular adverse event occurring. The variability, and consequent unpredictability, of bird behaviour, combined with the lack of familiarity of the experts involved in birdstrike prevention consultancy with the formal risk assessment process, has led to birdstrike prevention lagging behind other areas of airport safety in the development of risk assessment systems.

Other parts of the aviation industry (e.g. airlines, regulatory bodies, insurers etc.), and other people or organisations affected by it, (e.g. managers of nature reserves close to airports and local planning authorities) can also make use of birdstrike risk assessment. The precise nature of the risk assessments that these different organisations might make will vary depending upon their particular interests. For example, an aviation regulator might only be concerned with the probability of a catastrophic accident, and could safely disregard impacts with single small birds. An airline or its insurer, however, might be concerned with the probability of a birdstrike that causes damage resulting in a particular level of financial loss and may need to assess the risks associated with smaller birds that the regulator would ignore. A nature reserve manager, on the other hand, might be concerned with comparing levels of risk posed by different species that are present on his/her reserve. This might allow risk levels to be reduced by managing species of low conservation importance and protecting those of lower risk but greater interest. In all of these cases the need is for a risk assessment that employs an accepted methodology and is defensible in the event that a serious birdstrike does occur and subsequent legal action results.

The fact that airports in many countries are legally required to take steps to prevent birdstrikes means that an airport’s birdstrike risk assessment must be designed to encompass all birdstrike events, taking due regard of their probability and potential severity. The aim of this paper is to suggest a basic protocol for the analysis of birdstrike risk on airports. The intention is that the protocol should be generally applicable to all airports, and can be modified to suit the particular circumstances at different airports around the world. I do not suggest that this is the definitive answer to the problem of birdstrike risk assessment, but, hopefully, it will stimulate further thought and development of better systems that will contribute to flight safety in the future.

2 Risk Assessment

Although people undertake a simple risk assessment every time they choose when to cross the road, the formal science of risk assessment is relatively young and the techniques and terminology are still evolving. It is therefore important to define precisely the meaning of the terminology used, and to select the most appropriate risk analysis methodology for use on airports.

2.1 Terminology

In producing a risk assessment protocol, it is important that the terms used are adequately defined, as these definitions may differ in detail from those used by other workers.

In this paper I have adopted the definitions used by the British Royal Society in their publication ‘Risk: Analysis, Perception and Management’ (Royal Society 1992) with additional material from Covello & Merkhofer (1993) ‘Risk Assessment Methods’ (Plenum Press, New York).

The definitions are as follows:

<u>Hazard</u>
A situation that, in particular circumstances, could lead to harm.
(The presence of birds on or around an airfield. Hazard is frequently confused with risk e.g. ‘a severe hazard’. Hazard describes only the situation that exists not the probability of possible severity of any outcome)

<u>Risk</u>
The probability that an adverse event will occur within a specified time period or as a result of a particular event or series of events.
(The probability that a birdstrike, a damaging birdstrike or an accident will occur. This may be expressed per aircraft movement, per flight per year etc. depending upon the requirement of the risk assessment being undertaken. As with hazard, the term risk is often used in a variety of contexts. In its purest form it only describes the chance that a specified event will occur thus phrases such as severe risk should be avoided. It is the risk evaluation process that determines the acceptability of a particular risk of a particular event).

<u>Adverse event</u>
An occurrence that produces harm
(A birdstrike – even non-damaging birdstrikes may harm the reputation of an airport if they are frequent enough)

<u>Harm</u>
Loss to a person, organisation or population
(Usually damage or delays to aircraft. It is the extent of the harm combined with the probability of the adverse event that is used to determine the acceptability of the risk)

Detriment
A numerical measure of harm
(The cost of human lives, damage, delays, loss of goodwill etc. translated into a financial measure to enable cost benefit analyses to be conducted when decisions concerning risk management options are being made)

The Risk Chain
A series of events which result in a hazard causing harm. The cumulative probabilities of each link in the chain combine to give the overall risk.
(see Fig. 2).

Hazard Identification
The process of identifying hazards and the circumstances in which they could lead to harm
(Usually in the form of an ornithological or ecological survey combined with record keeping by the airport bird controllers. The hazard identification will include data on bird numbers, behaviour and location and is interpreted in relation to the probability of a birdstrike)

Risk Estimation
Identification of possible outcomes from a risk chain. Estimation of the magnitude of harm that will result from each outcome. Estimation of the probability of each outcome.
(The combination of probability and likely severity of a birdstrike incident e.g. rare events with flocks of large birds may be less acceptable than more frequent events with smaller species)

Risk Evaluation
Determination of the value of the hazards and risks in relation to possible detriment to those individuals or organisations concerned.
(Some birds, e.g. those of conservation importance, may be highly valued and would need to constitute a much higher risk than other species before management action would be considered justified.)

Risk management
The making of decisions concerning risks (usually in relation to risk reduction).
(Cost benefit analysis of the options available to reduce risks deemed unacceptable during the risk evaluation followed by decisions to implement actions and subsequent enforcement).

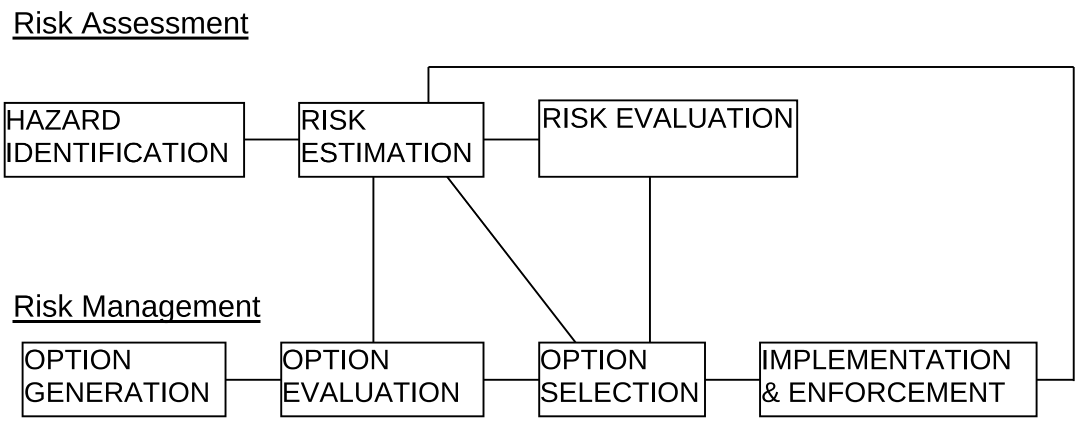

Figure 1. Risk Assessment and Risk Management flow chart

These processes combine to form the overall process of risk assessment, which integrates risk analysis and risk management as a means of both identifying and controlling levels of risk in any activity (see figure 1).

2.2 Risk Assessment Techniques

The development of risk assessment techniques has usually involved the production of a methodology appropriate to a particular industry or process. For example, many engineering processes, where the probability of failure of a component can be accurately measured and the consequences definitively determined, lend themselves to a mathematical probabilistic approach. Those processes involving human factors, where responses to a particular set of circumstances may be more variable, lend themselves to a more subjective assessment of the probability of a particular event, usually in the form of a numerical scale or a ‘high, medium, low’ ranking.

Risk assessment is also frequently supported by reference to large databases of information relating to previous occasions where a particular hazard resulted in a particular outcome. Such data can be used to estimate the probability of a particular outcome, providing that the conditions that were current when the data were gathered remain the same at the time the risk assessment is made. Care is thus always needed when interpreting historical data, such as birdstrike databases, as part of risk assessment processes. For example, at many airports in the UK the Lapwing, (***Vanellus vanellus***) has become relatively rarely struck in recent years probably due to declines in populations across the UK. Reference to the UK CAA’s historical database shows the annual total of Lapwing strikes to be fairly constant at between 50 and 80 per year, but once the national increase in air traffic movements has

been taken into account, the risk per flight from Lapwings has fallen to 0.18 per 10,000 movements compared to an average of 0.33 for the preceding 17 years. Lapwings constituted only 10.8% of the UK birdstrike total in 1995, compared to an average 19.9% for the period 1976-1995 (see table 1). Although consolidated data are not available, this downward trend is known to have continued in the past 5 years.
Because of the variation in bird populations and behaviour over time and the inevitable inaccuracies involved with birdstrike reporting and bird remains identification, it is unwise to rely solely on an airport's birdstrike rate (usually expressed as strikes per 10,000 aircraft movements) as a measure of risk. This is particularly so when assessing the risks posed by very rare events that may have highly damaging outcomes (e.g. strikes with very large but uncommon birds). A subtle change in bird behaviour that increases the risk of a strike with such a species may take some years to become apparent from

Table 1.
The total number, rate per 10,000 aircraft movements and proportion of the total number of birdstrikes caused by Lapwings (Vanellus vanellus) in the UK over the past 15 years.

Year	Total strikes with Lapwings	Rate per 10,000 movements	% of UK total
1976	75	0.39557	20.10724
1977	54	0.282427	16.71827
1978	64	0.315426	24.06015
1979	62	0.282075	20.46205
1980	71	0.325539	23.43234
1981	77	0.366144	21.56863
1982	93	0.440133	23.48485
1983	91	0.406613	19.7397
1984	136	0.57554	29.24731
1985	84	0.356839	18.66667
1986	80	0.328003	21.2766
1987	56	0.214231	15.46961
1988	51	0.177824	16.29393
1989	56	0.178515	15.34247
1990	74	0.227343	18.04878
1991	87	0.295215	19.41964
1992	90	0.312392	18.03607
1993	57	0.182751	12.89593
1994	70	0.209143	14.52282
1995	52	0.146561	10.85595

examination of birdstrike statistics alone. Other evidence, in the form of records of bird numbers on and around the airfield, frequency with which birds cross the path of aircraft, typical flock sizes and the mass of individual species can all be used to inform the risk assessment process. Some of these data may be gathered routinely by the airport bird control staff in a systematic way that will allow probabilities to be generated (e.g. the total numbers of birds crossing a runway each day could be used as a crude numerical measure of risk), other data may need to be gathered or estimated as part of the risk assessment process. It is unusual, however, for data on bird numbers and behaviour to be gathered in such a way as to allow accurate probabilities of birdstrike risk to be calculated. It is therefore suggested that a simple interval based measures of risk and likely detriment arising from a particular hazard is the best compromise approach. A suggested protocol is described below.

3 Suggested Risk Assessment Protocol

The risk assessment protocol suggested below follows the process outlined in figure 1 above. It suggests an outline methodology for each step of the risk assessment process, particularly in terms of how the data needed to produce a defensible risk assessment can be gathered and how probabilities can be estimated when conducting a risk estimation. Risk evaluation and risk management are dealt with only briefly, as the decisions relating to these processes will depend greatly on local factors such as environmental legislation, conservation pressure, available budgets etc.

3.1 Identification And Description Of The Hazard

This part of the risk assessment process is probably best conducted by ornithologists familiar with the birdstrike problem and its alleviation. The need to accurately identify and count birds in what may be very large flocks in a systematic way means that, unless an airport employs a wildlife management specialist, the data gathered may be unreliable or subject to challenge in the event of a legal dispute.

3.1.1 Bird species

Because the size and behaviour of bird species differs, and hence the probability that they will be struck and that a strike will cause damage differs also, it is clearly necessary to identify the bird species on and around an airfield if an accurate risk assessment is to be made. This may seem self evident, but many airport bird control units record birds only to the genus or family level and on many airports around the world there is no systematic recording of the birds present at all. A similar problem occurs when recording details of birdstrike incidents after they have happened. Many airports fail to report birdstrikes or assume that the fragmentary remains that are left after the event cannot be identified at all. Proper training of airport staff in bird identification will help both the risk assessment process and the day to day bird control on the airport, whilst thorough recording of all birdstrikes and the use of expert assistance in remains identification (DNA based analysis is now available for this purpose) is essential if the risk at the airport is to be fully understood.

3.1.2 Bird numbers

It may seem obvious that an increase in bird numbers on or around an airfield should lead to an increased birdstrike risk. This is not necessarily true, however, as it is only when the location and behaviour of the birds cause them to come into conflict with an aircraft that a birdstrike can occur. It is certainly true that an increase in the population size of birds that are already causing a birdstrike risk (e.g. gulls roosting on a runway) will increase the probability of one being struck, but some bird species have behaviour patterns or habitat preferences that mean they are rarely if ever hit by aircraft. Corvids, particularly Rooks (***Corvus frugilegus***) and Crows (***Corvus corone***) can be abundant on an airfield but are rarely struck compared to gulls or waders. The reasons for this are not entirely clear, but corvids seem to have behavioural mechanisms that allow them to avoid aircraft more successfully than other types of birds. Accurate data on bird numbers are, therefore, required as part of the risk assessment process, but they can only be properly interpreted in conjunction with information on location and behaviour if a proper risk analysis is to be carried out.

3.1.3 Bird location

On the airfield itself, the closer that birds are to the active runways and taxiways the greater the probability of a birdstrike. Of particular concern is the presence of birds close to the rotation point at the end of the take off runway. An aircraft experiencing a birdstrike on or after the rotation point will be unable to safely abort its take off, the engines will be at their most vulnerable to damage, the aircraft load will be at maximum and manouvering ability will be low due to low airspeed and low altitude. As with bird numbers, bird location needs to be interpreted in conjunction with information on bird behaviour. This is especially true for bird populations off the airfield where large concentrations of birds many kilometers from the airfield can have a profound effect on the probability of a birdstrike. Gulls, for example, may fly up to 50km to and from feeding and roosting sites. A large gull roost 5 km to the west of an airport and a landfill 25km to the east could thus cause thousands of gulls to cross the airfield or its approaches twice daily causing a considerable increase in the probability of a birdstrike. Determination of the likely impact of bird behaviour and location is especially important in risk assessments associated with new developments close to airports that may attract birds. Airports need to have a detailed knowledge of the location and behaviour of existing bird populations in their local area if they are to be able to successfully oppose new developments on the grounds of increased birdstrike risk.

3.1.4 Bird behaviour

In order to survive, birds need to be equipped with a flexible range of behaviours which allow them to respond to changes in the environment around them. Many of the birds which frequent airfields, especially gulls, corvids, Starlings and pigeons, are able to take advantage of intermittent feeding opportunities provided by man in the form of agricultural activity, spilled food waste etc.. To precisely predict the behaviour of these birds on a day to day basis is impossible, but it is precisely this behaviour which will determine the likelihood of a birdstrike at any given time. The best that can be hoped for is to integrate general ornithological knowledge about the feeding, roosting and breeding preferences of the bird species found on and around the airport, with observations of their behaviour made by bird controllers or wildlife management specialists. As with bird numbers and location this emphasises the need for accurate and detailed monitoring of the birds both on and around the airport by suitably qualified personnel and the expert interpretation of the data gathered by birdstrike prevention specialists if the resulting risk assessment is to stand up to critical scrutiny.

3.2 Risk Estimation

Once the hazard has been adequately described in terms of the species, numbers, location and behaviour of the birds on and around the airport, the risk assessment can proceed to estimate the probability that particular species, populations or groups of birds frequenting a particular site will cause a birdstrike which will result in a specified level of harm (e.g. catastrophic accident, aborted take off, delay to flight etc). The chain of events that leads to a damaging birdstrike is summarised in figure 2. The cumulative probabilities of each step in the chain heading to a particular event can, in theory, be calculated to produce an overall probability of that event occurring in a particular set of circumstances. In reality, however, a number of the links in the chain, especially those associated with bird behaviour can, at best, have a probability estimate of ‘low, medium, high’ assigned to them and thus the overall risk estimation will be similarly limited in accuracy. Nevertheless, it is useful to consider how the risk estimation for the different steps in the event chain can be arrived at so that the final risk estimation is derived as accurately as possible.

3.2.1 Presence of birds on or near the airfield

The frequency with which birds are present on the airfield or in its environs needs to be assessed. Keeping of systematic records by bird control staff

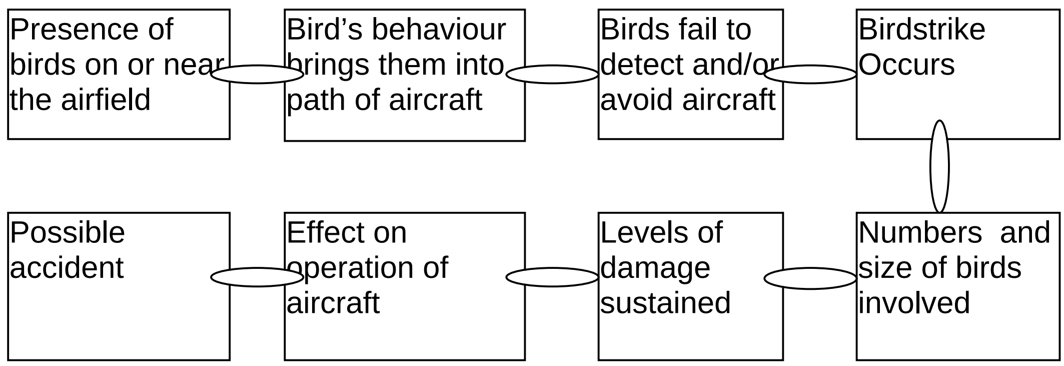

Figure 2
Flow chart showing risk chain for a birdstrike event

and/or commissioning an expert ornithological survey will provide the information necessary. Seasonal changes in bird abundance and preferred feeding or roosting locations should be investigated when planning a field survey protocol. Risk estimation should allow for the effect of airport bird control programmes and habitat management measures on bird numbers and location so that an evaluation of the impact of control measures on risk can be made. In general, more birds on or close to the operational areas or the approaches will increase the probability of a birdstrike.

<u>3.2.2 Bird's behaviour brings them into path of aircraft</u>
As part of bird control procedures or a risk assessment survey bird behaviour in the area around the airport should be documented. This will allow the impact of particular behavioural patterns on the risk of a birdstrike to be assessed and will assist in the identification of any remedial measures that may be considered as part of the risk management process. The risk assessment should also include an estimation of the effect on the probability of a strike of any change in behaviour that may occur as a result of changes in the habitat surrounding the airport; e.g. if a new feeding area was established where none exists at present, would flightlines to and from it increase or reduce the probability of a strike.

A further element to be considered here is the frequency of air traffic and air traffic patterns at the airport. Even if birds regularly move across the runway of an airport with few air traffic movements, the probability of birds and aircraft coming into conflict are substantially reduced compared to that at a busy international airport. The risk per flight of a birdstrike may be far higher at the quiet airport, but the total number of strikes in a year will be far lower and, assuming that all other risk factors are equal, the probability that a disasterous event will occur will also be reduced. These risk estimations become particularly important when cost benefit decisions are made about investments in risk management programmes.

3.2.3 Birds fail to detect and/or avoid aircraft

The reasons why birds fail to avoid such large and noisy machines as aircraft are still poorly understood. Recent studies by Kelly (1999) have shown that birds exhibit a range of avoidance behaviours when encountering aircraft and for the majority of the time are successful in doing so. Birdstrike data suggest that inexperienced juvenile birds may be worse at avoiding aircraft than adults, and certain species groups (e.g. corvids) seem less prone to birdstrike than others. It may thus be possible to make some allowance for time of year or bird species involved when assessing the probability of birds failing to avoid aircraft once their behaviour has brought them into the same air space, but it is probably better to assume that there is a fixed, but unknown probability that the birds will fail to avoid the aircraft.

3.2.4 Birdstrike Occurs

The combined probabilities of the first three links in the event chain determine the chance that a birdstrike will occur. The following steps determine the probability that a particular level of harm will arise from the incident.

3.2.5 Numbers and size of birds involved

It is well established that birdstrikes with larger birds have a greater tendency to cause damage to aircraft, and that strikes with flocks of birds are also more likely to result in damage being sustained (presumably because of the greater chance of a bird hitting a vulnerable part of the aircraft during a flock encounter) (Milsom & Horton (1995). It is generally assumed that the larger the number of birds present on or around an airfield the greater the probability of a strike with a flock, but there is little evidence to support this contention and it is more likely that the general behaviour of the species involved (e.g. their tendency to flock when evading a predator) combined with local conditions that might cause concentrations of birds to accumulate close to the active areas of the airfield or in the approaches (e.g. ploughing of a nearby field, sudden heavy rainfall or a breakdown of bird control measures on the airfield) that will have the greatest effect. Such incidents are difficult to predict, but are almost certain to occur from time to time at any airfield. Risk estimation should therefore take account of the possible frequency of such occurrences in relation to the measures in place to mitigate their effects. For example, an airfield on a known migration route for large waterfowl when sudden arrivals of large flocks of hazardous birds might be expected could counter the resulting risk of a strike with a flock of large birds by having a contingency plan for additional bird control resources to be deployed at short notice. The absence of such a plan would indicate an increased risk of such a strike.

3.2.6 Levels of damage sustained

As stated above, strikes with flocks of birds and with larger birds are statistically more likely to cause damage to aircraft. However, the relationships between bird weight, bird number and damage levels are complicated by engineering factors (the resistance of the part struck to damage) and other circumstances surrounding the strike such as the speed of impact, the orientation of the bird at impact, etc. Analyses of birdstrike databases show that there are broad relationships between factors such as impact speed, speed of rotation of a jet engine fan etc. and damage, but the levels of uncertainty remain high. It is likely that birdstrike databases document those incidents where damage levels were high quite accurately, but the proportion of strikes where there was no damage or minor damage that was not reported is unknown. It is probably safest to avoid attempting to assign probabilities to levels of damage and simply to assume that, in general, slower aircraft are less likely to sustain damage than faster moving ones (military jet fighters operating at low level are probably at the greatest risk from birdstrike), that turboprop engines are less vulnerable than jets, and that large flocks of large birds are more likely to cause serious damage. The uncertainty that surrounds the occasionally surprising outcome of a birdstrike incident (either substantially more or less damage than expected) suggests that this link in the event chain is one where probability of a particular level of damage is difficult to attach to a particular set of circumstances surrounding a possible birdstrike incident.

3.2.7 Effect on operation of aircraft

It is likely that the severity of damage sustained will be directly related to the probability of a particular effect on operation. A non damaging birdstrike may go undetected or a pilot may decide to continue with a flight if all indicators are normal, alternatively it may result in a precautionary return to the airfield for an engineering inspection. A strike causing minor damage to an engine with resulting detectable vibration might require substantial and expensive aircraft down time to allow repairs to be carried out. It is probably safe to assume that the severity of the effect on the flight is directly proportional to the damage severity, but we have already seen that this is especially difficult to predict. Birdstrike databases may help to determine the proportion of birdstrikes that have a direct effect on flight operations, but as with damage levels the number of strikes where there is no effect on the flight that go unreported is unclear.

3.2.8 Possible accident

The probability that a damaging birdstrike will result in an accident is similarly difficult to quantify. The human factors involved in pilot decision making immediately following a birdstrike mean that two identical incidents may have radically different outcomes. It is also the case that accidents following birdstrike incidents are so rare that there are few data from which to draw conclusions based on historical events. Catastrophic accidents following birdstrikes have happened to light aircraft and large transports, to turboprops and jets and to civil and military craft. The probability that an accident will occur is extremely small. There have been 50 civilian aircraft and 190 lives lost in civilian aviation since 1912 following birdstrike incidents despite the fact that many thousands of birdstrikes occur around the world each year.

3.3 Risk Evaluation

The process of risk evaluation involves the combining of the probability of an outcome and the associated harm that may arise from the presence of a particular hazard. This information is used to decide if the risk is acceptable or if it requires risk management action to reduce it.

3.3.1 Whose Risk?

The process of evaluating risk depends upon the perception of the individual or organisation making the evaluation. To the airline passenger, for example, the crucial measure of risk is the probability that the flight he or she is on will be affected by a birdstrike, to the airport manager it is the number of birdstrikes per year or the rate per 10,000 movements that is of interest, to the airline it is the number of strikes on its own flights around the world that is important, and to the national regulator it may be the total number at all airports in its own country.

3.3.2 Risk of What?

All of those mentioned above would regard a catastrophic accident as unacceptable, but different organisations or individuals may be interested in determining the probability of different outcomes from a birdstrike incident. The individual traveler, for example, would regard any delay to his or her flight as unacceptable, an airport manager would be concerned with the probability of strikes which might cause damage or delays thus inconveniencing either the flying passengers or the airlines that use the airport. Airlines will be concerned only with birdstrikes that cause damage or delays to their operations, whilst national regulators might be concerned with the probability of catastrophic accidents or particularly severe damage.

3.3.3 Risks versus hazards

Once a risk has been deemed unacceptable, some evaluation of the value of the hazard needs to be made in order to inform the risk management process that follows. For example, if an airport is constructed in the middle of an internationally important wetland the conservation value of the bird life present there may be judged to be so high that any management action to reduce what could be a severe hazard to aircraft is deemed unacceptable.

3.3.4 Acceptable and unacceptable risks

The final result of the risk evaluation process is a decision on the levels of risk that are acceptable to the organisation or individual concerned. This risk is essentially a combination of harm multiplied by probability of occurrence. Since it is not possible to do more than assign probabilities of occurrence to more than a subjective scale, one is left with a risk matrix similar to the one shown in figure 3 below.

The levels of probability associated with the classifications here described as Rare, Very Rare etc. are clearly open to debate if, indeed they can be assigned at all, and the decision about acceptability or unacceptability for the different cells of the matrix will inevitably vary depending upon the organisation conducting the risk evaluation. Matrices of this type can be constructed for the overall birdstrike risk at an airport, for a particular bird species or for all birds at a particular site. If the outcome of the risk estimation and the risk evaluation falls into the review or unacceptable categories then risk management action needs to be considered.

LEVEL OF HARM PROBABILITY OF OCCURRENCE

	Very rare	Rare	Occasional	Common	Frequent
Catastrophic accident, hull loss, possible loss of life	Unac-ceptable	Unac-ceptable	Unac-ceptable	Unac-ceptable	Unac-ceptable
Significant damage possible risk to aircraft	Review	Review	Unac-ceptable	Unac-ceptable	Unac-ceptable
Minor damage no risk to flight	Acceptable	Acceptable	Review	Unac-ceptable	Unac-ceptable
Precautionary return or delayed take off	Acceptable	Acceptable	Review	Unac-ceptable	Unac-ceptable
No damage or delay	Acceptable	Acceptable	Acceptable	Review	Review

Figure 3 Example of a risk matrix for birdstrike risk evaluation.

3.4 Risk Management

The process of risk management involves identification and evaluation of options for managing the hazard or changing an operation to reduce the resulting risk to an acceptable level. In the aviation context this has usually involved taking action to deter birds from the airport or its environs by habitat management to remove attractive features or by scaring actions to change the behaviour of the birds. Less commonly, it can involve changes in the operational patterns of aircraft to avoid concentrations of birds thus reducing the risk without modifying the hazard. The latter is normally only possible for military aircraft when flying can be suspended in particular high risk areas without interrupting passenger schedules.

3.4.1 Costs and benefits

It is clearly necessary to eliminate unacceptable risks in any industry, but the process by which this is achieved, and especially any risk management options identified for intermediate levels of risk (the ‘Review’ category in the matrix), will be subject to cost benefit analysis. A full description of the cost benefit approach to risk management is beyond the scope of this paper, but, put simply, it requires the full costs of the detriment to an individual or organisation to be compared with the costs of reducing the risk to an acceptable level. One of the historic difficulties in birdstrike prevention is that the majority of the costs of birdstrikes (repairs and delays to aircraft) are not carried by the organisations which have the requirement to control the problem (the airports). A cost benefit analysis of hazard management options for birdstrike control at airports may thus conclude that providing the worst hazards are kept to a reasonably low frequency (so that airlines do not take their business elsewhere or regulators remove an airport’s license to operate) then there is little to be gained from investing in more birdstrike risk management. It is not coincidental that in many countries birdstrike prevention has been led by military aviation where the financial benefits of risk management accrue to the same organisation as the costs and a ‘spend to save’ culture can be developed.

4 Use Of The Risk Assessment In Bird Control

As the control of birdstrikes is essentially a process of risk analysis and management, the potential uses for a more formal form of risk assessment than those used at present are numerous. The risk analysis process can be adapted to any of the situations detailed below as well as many other areas.

4.1 Targeting And Evaluation Of Bird Management Effort

A full airport birdstrike risk analysis will allow managers to target resources at those areas that pose the most unacceptable levels of risk. Regular reviews of the risk assessment will assist in tracking changing risk and reallocating resources to provide the greatest benefit in relation to money spent.

4.2 Justification For Spending Resources On Hazard Management

In the commercial sector a formal risk assessment may help managers to bid for, and justify retention of, resources needed to conduct bird control or other hazard management on the airfield. An objective assessment of the acceptability of the risk levels that would arise if, for example, budgets for habitat management measures were cut are more likely to find favour with budget managers than a ‘worry that things could get worse’ based on past experience. This is especially true if birdstrike risk management is competing with other areas of safety promotion which have established risk analysis methods in place.

4.3 Possible Litigation

There is an increasing tendency for airlines, and their insurers, to seek to retrieve costs arising from serious birdstrike incidents through the courts. There would also certainly be huge amounts of litigation in the event of a birdstrike related accident involving loss of life. In either case, the presence of a properly conducted risk assessment with the necessary documentation relating to the process itself and the risk management measures taken to reduce any unacceptable hazards will greatly assist in defending the position of an airport in a court of law. It should be noted, however, that the same risk assessment, if not acted upon, would prove of similar advantage to the other side of any legal argument

4.4 Controlling developments near airports

The possible risks associated with the increasing pressure to develop land near airfields for uses such as nature conservation mean that formal risk assessment will have an increasing role to play not only in protecting airfields against unsuitable developments, but also in evaluating which parts of a development might produce an acceptable risk in situations where compromise solutions are considered possible. For example, a detailed species by species risk assessment might allow developers to design a reserve to provide habitat for a non hazardous species whilst including a reserve management plan that controls birds that would produce an unacceptable hazard.

5 Conclusion

As the science of risk analysis develops and becomes more sophisticated it is likely to become standard practice to conduct relatively complex risk analyses for almost every industrial or transportation process. The control of birdstrike risks has been slow to take up proper risk assessment procedures, largely due to the uncertainties involved in the interpretation of bird behaviour. The benefits of proper risk assessment are clear, however, and birdstrike specialists should seek to develop an agreed protocol for carrying out this process. Hopefully this paper will provide a starting point for this to be carried out.

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