

## **The Use Of Risk Assessment In Airport Bird Control**

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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 propose 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. An example of how this process has been implemented by one major UK airport is given.

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.

**Keywords:** Risk assessment, analysis, airport, birdstrike

### 1 Introduction

Collisions between birds and aircraft (birdstrikes) are a significant hazard to aviation and are estimated to cost commercial airlines world-wide between US\$1.2 and 1.4 billion per year in damage and delays (Allan in press). 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 Annex 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 Annex 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 the 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.

As well as the airports themselves, 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 high risk and protecting those of lower risk but greater ecological 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

### 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:

#### **Hazard**

**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 or possible severity of any outcome)

#### **Risk**

**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).

#### **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.)

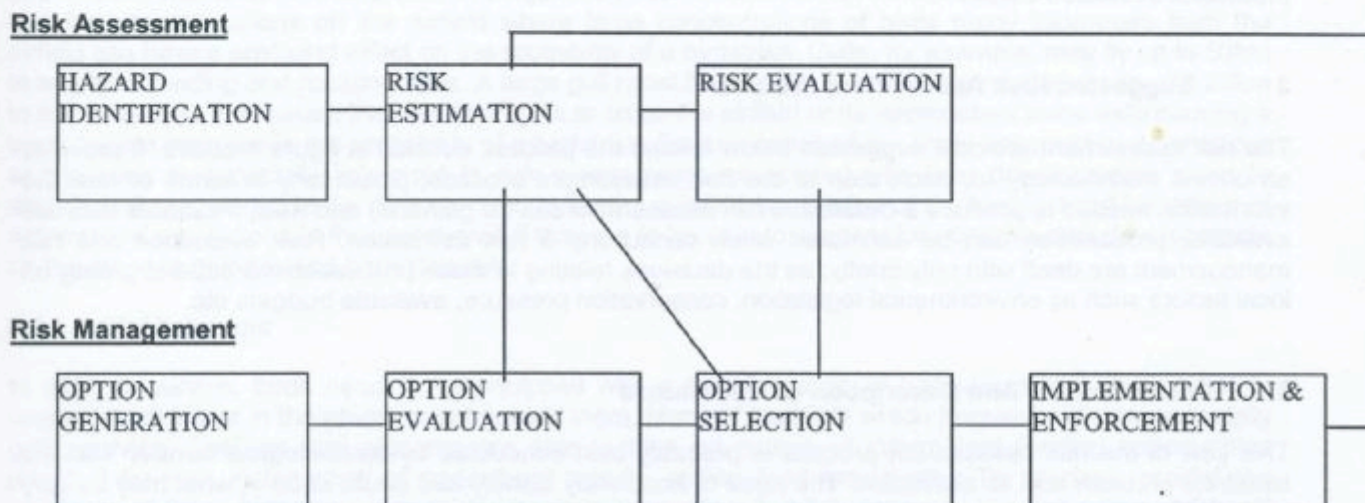
#### **Risk management**

**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).

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).

Figure 1. Risk Assessment and Risk Management flow chart



### 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.

Because of the variation in bird populations and behaviour over time and the inevitable inaccuracies involved with birdstrike reporting and bird remains identification, it may be 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 examination of birdstrike statistics alone. Other evidence, in the form of records of bird numbers on and around the airfield, seasonal differences in strike rates, frequency with which birds cross the path of aircraft, typical flock sizes, frequency of strikes involving flocks 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

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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. At those airports with good data gathering and birdstrike reporting it may be possible to use numerical measures of probability and severity in the risk assessment process. At others, it may be necessary to use simple interval based measures of risk and likely detriment on a 'low medium high' scale. In either case the basic risk assessment method is the same, and 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 provides an outline methodology for each step of the risk assessment process, particularly in terms of how the information needed to produce a defensible risk assessment can be gathered and how, if suitable data are available, 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 airfields in Western Europe, 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 manoeuvring 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 that 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 birdstrike occurring is not fully understood, and it is not possible to assign a precise level of risk to a group of birds on or near an airport. The alternative approaches are, therefore, to use a scale of risk based on an arbitrary division such as low medium high, or to rely on historical data from the recent past to determine a probability of an incident occurring (e.g. the number of strikes per year with a particular bird species over the past 5 years). Tracking trends in these measures year on year can indicate changes in risk levels arising from different species or groups of birds. The latter technique requires that an acceptable standard of birdstrike reporting and bird remains identification has been in place at the airport for a suitable length of time.

## 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.

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### 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.

## 3.4 Example

An example of how this has been achieved on one UK airport is shown below. Here the airport has had reliable reporting and identification of birdstrikes over many years. It therefore felt able to use actual data to calculate the probability of a birdstrike rather than estimating the probability on a 'low-medium-high' arbitrary scale. It used its birdstrike data to determine the number of strikes per year averaged over the past 5 years for each of the species identified in the hazard description process. No account was taken of increasing air traffic rates over that period because the airport managers are interested in the probability of a strike occurring on their airport rather than on the risk per flight in this instance. The strike frequencies were divided into 5 probability categories.

<b>No. Strikes per year (airport data)</b>	>10	3-10	1-2.9	0.2-2.9	0-0.1
<b>Probability category</b>	Very High	High	Moderate	Low	Very Low

The measure of harm used was the proportion of strikes with each particular species that resulted in damage to the aircraft. In this case the UK Civil Aviation Authority database was used to give an increased sample size of strikes for each species and thus ensure that the proportion of strikes causing damage was as reliable as possible. The percentage of damaging strikes was divided into 5 levels of severity.

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

The airport then produced the probability X severity matrix shown below and assigned acceptability levels to each of the cells.

SEVERITY	PROBABILITY				
	Very High	High	Moderate	Low	Very Low
Very High	Reject	Reject	Reject	Reject	Review
High	Reject	Reject	Reject	Review	Review
Moderate	Reject	Reject	Review	Accept	Accept
Low	Review	Review	Accept	Accept	Accept
Very Low	Accept	Accept	Accept	Accept	Accept

Each species that was identified in the hazard description as a potential risk was subjected to this process and assigned to the appropriate category. Other factors, such as the occurrence of strikes with flocks of birds (automatically unacceptable except for species with a 'very low' rating for severity), or species with a rapidly increasing trend in strike frequency over the past 5 years were also taken into account and some species reassigned to new categories on the basis of this information. This process was only allowed to move a species into a more severe category and could not be used to move a species to a more acceptable level of risk. Any species that fell into the review or unacceptable categories at the end of this exercise was subjected to the risk management process described below.

### 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

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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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