

**AN ASSESSMENT OF BIRD STRIKE RISK AT NATIONAL LEVEL**

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**Abstract**

Bird strike is widely regarded with increasing concern, for reasons including the rising populations of certain hazardous species and the replacement of turboprop fleets by jets. The risk assessment described here was commissioned by the UK CAA to provide an informed basis for regulation. The study coincided with legislation requiring aircraft commanders to report all strikes, rather than only those causing damage, and a subsidiary aim was to assess the effectiveness of this mandate in improving the completeness and accuracy of reporting.

The level of and trends in risk were assessed from historic data. Variations in reporting rate confound the picture, but the indications are that risk per movement is increasing. This is of concern, as the aviation community generally aims to reduce risks per movement over time, such that accident rates do not rise despite traffic growth. Also, while bird strike accounts for only a small fraction of the overall risk of flight, the risk is greater than that for other 'hot topics', such as runway incursions, that have been subject to recent safety campaigns. The implications are that further risk reduction measures need to be considered – an argument strengthened by an evaluation of the financial cost of strikes.

The major influences on risk were identified and corresponding measures to reduce risk suggested. One specific finding was that simple criteria for controlling land uses around aerodromes, such as the 13 km safeguarding circle used in the UK, may be insufficient. A more sophisticated, risk-based approach is proposed.

Analyses of strike data and interviews with operators indicate large fluctuations in reporting over recent years, mainly due to changes in information management within airlines. The mandate and associated publicity have however been rewarded by a notable improvement which, if sustained, will provide a more reliable basis for future decisions.

**Keywords:** risk assessment, safety, incident reporting, regulation, tolerability, safeguarding, land use

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Views expressed are those of the authors, and do not necessarily reflect those of the CAA or the operators.

## **1. Introduction**

The bird strike hazard is widely regarded with increasing concern in the civil aviation community. Reasons given for this concern include the rising population of certain large flocking species, the replacement of turboprop fleets by jets, and of three- or four-engine aircraft by twins, as well as the general increase in air traffic and public concern about safety. Furthermore, if a bird strike were to lead to an accident, it is likely that there would be demands to know why the aircraft could not have been better protected against such an apparently simple, foreseeable event – bird strike is one of the few ‘single-point failures’ with the potential to cause a catastrophic accident. While these concerns were evident at the start of this study, there was no clear picture of the level and significance of bird strike risk. Neither was it known whether the risk was actually increasing, or what factors were driving any change.

To fill this gap, and so provide a better-informed basis for regulation, the UK Civil Aviation Authority (CAA) Research Management Department commissioned RM Consultants Ltd (RMC) and Central Science Laboratory (CSL) to carry out an assessment of the bird strike risk to UK civil aviation.

The start of the study, in January 2004, coincided with new legislation [1, 2] requiring the commanders of aircraft in UK airspace to report all strikes to the CAA. Before this date, it had been mandatory to report only those in which aircraft damage had occurred. The CAA was aware that reporting levels had been declining, and the mandate aimed to reverse this trend and so provide a more robust basis for future analysis and decision-making. A subsidiary objective was therefore to assess how effective the mandate had been in achieving this aim.

Information was gathered from analyses of bird strike data collected by the CAA and, in order to capture industry experience and views, structured interviews with a sample of aircraft and aerodrome operators. The study is principally concerned with commercial air transport, but some of the findings may also be relevant to other sectors, such as business and General Aviation.

The analysis presented in this report here is preliminary, as the full 2004 bird strike and air traffic data are not yet available. The conclusions should therefore be regarded as provisional, but it is hoped that an updated results can be presented at the conference. It is anticipated that a full report of the study, including the 2004 data, will be published by the CAA during 2005.

## **2. Safety Risk**

### **2.1 The level of risk**

Risk can be evaluated using many different measures. No single measure provides a complete picture, and in this study three measures have been used to provide an indication of the size and significance of the risk: accident/ incident rates; a comparison with the overall risks of flight and a comparison with other categories of risk that are of current concern.

### **Accident and incident rates**

Historic rates were derived from strike records contained in the Mandatory Occurrence Reporting Scheme (MORS) database and the CAA bird strike database. The MORS database [3] is intended to record all types of safety-related aviation incident, the criterion for inclusion being that the aircraft was endangered or potentially endangered. For bird strikes, this criterion is generally interpreted to include any strike that causes significant damage or other safety-significant effects such as a rejected take-off (RTO). The CAA bird strike database complements MORS, by recording all strike incidents, whatever the level of damage or safety consequence. The CAA database therefore contains many more records than there are bird strikes in the MORS database.

On average over the period 1990-2003, for events occurring in the UK or to UK-registered aircraft abroad, there have been:

850	Strike records per year in CAA database
47	MOR bird strikes per year
0.29	Injury accidents per year
0.05	Fatal accidents per year (as there have been no UK fatal accidents since 1975, this average is based on the period 1975-2004)

The estimates above span a range of severities of event. The more serious the event, the more immediate is the picture given of the significance of the risk, but the less it can be relied upon as a statistically representative, since serious events are rare. Less serious events are not so directly related to real safety concerns. In principle, less serious events should be better statistical indicators, being more frequent, although they are more likely to suffer from under-reporting and reporting rate fluctuations.

### **Comparison with the overall risk of flight**

For commercial flights, bird strike accounts for between about 0.6% and 2% of accidents or MORS reports. While this is, numerically, only a small proportion of the total, it does not mean that bird strike can be dismissed. Since the total risk can be divided up into any number of categories, at any level of detail, the proportion of overall risk is an indicator of the proportion of effort that should be devoted to that category, not an indicator of tolerability.

The significance of bird strike can also be illustrated by looking at how much it contributes to particular types of incident. Historic data show that bird strikes are a cause of about 1.4% of engine failures and 3.4% of rejected take offs (RTOs). Again, these are small percentages, but not negligible. In the interviews with air operators, several mentioned that bird strikes are usually in the top two or three most frequent categories of internal Air Safety Reports (ASRs) filed by their crews. From this, too, it may be concluded that bird strike does merit attention as a significant class of incidents.

### **Comparison against other specific 'hot topic' risks**

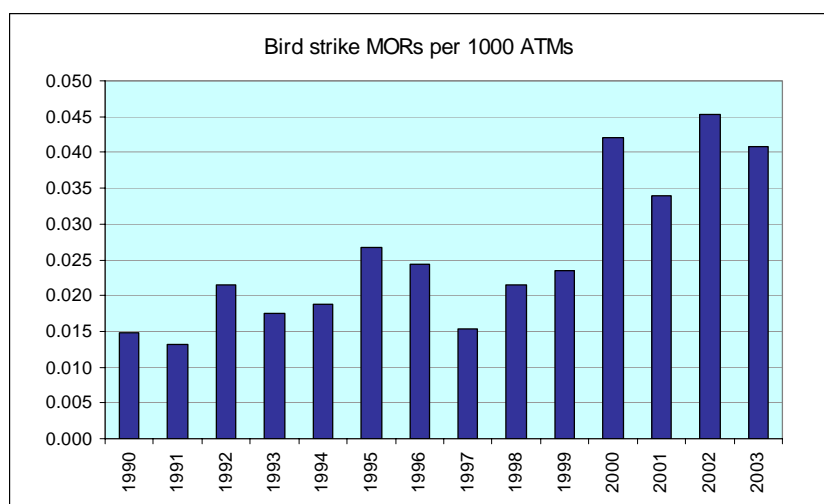
Comparison with other categories of aviation risk can help in understanding the size and significance of a risk, although caution is needed in drawing conclusions from such comparisons, since categories can be arbitrarily defined, at any level of detail. In this study it was decided to compare the rate of bird strike MORs against that of other types of incident which industry and regulators have recently focussed upon as requiring action. Bird strike MORs were found to be less frequent than level busts or airspace infringements, but more common than runway incursions or risk-bearing airproxes. In all cases the bird strike MOR rate was within an order of magnitude of that of the other incidents. The level of bird strike MORs is thus comparable to that of other types of incident that the aviation community has deemed important. This lends support to the conclusion of the comparison with overall risk - that bird strike merits further attention as a significant risk.

## 2.2 Assessment against tolerability criteria

There are no specific regulatory criteria for judging the tolerability of bird strike risk. The criteria adopted for this study are based on generic principles of safety management in aviation and more generally. They require firstly that risk must not increase over time, and secondly that risk must be kept As Low As Reasonably Practicable (ALARP).

### Is bird strike risk increasing?

This criterion reflects the widely held principle amongst both industry and regulators that accident rates (per year) should not be allowed to increase, and should where possible be reduced, despite the growth in traffic. This implies that the risk per movement should be reducing at least as fast as the rate of growth in traffic. In this study, the trend in the rate of bird strike MORs per movement was used as the measure for assessment against this criterion (Figure 1). MORs, unlike fatal and injury accidents, are numerous enough to allow trend analysis over a number of years, but not so much affected by variations in reporting rate variations as the 'all strikes' measure.



**Figure 1:** Trend in rate of bird strike MORs, 1990-2003

From Figure 1 it appears that the rate of MORs per movement has increased markedly over the period. As traffic has also been growing, this would appear to violate the tolerability criterion. While it is possible that the increase reflects, wholly or in part, an improvement in reporting rates rather than a real increase in risk, the study of completeness and accuracy (Section 3) tends to suggest that reporting rates have declined over the same period. The balance of evidence is therefore that there has been some real increase in strike rates. It would therefore be prudent to take a precautionary approach, giving further attention to bird strike as part of the overall objective of driving down accident rates.

### Is bird strike risk ALARP?

The ALARP principle (as interpreted in the UK) requires that further measures to reduce risk must be taken until the cost becomes grossly disproportionate to the safety benefit obtained. Cost-benefit studies were beyond the scope of the present work, but potential measures that may be reasonably practicable were identified in this study. Their feasibility, effectiveness and cost will require further discussion by regulators and industry in the context of overall aviation safety – i.e. taking into consideration what resources and effort should be devoted to bird strike as compared to other risks.

## 2.3 Economic consequences

In addition to the safety consequences of bird strikes, there is a direct financial cost to operators. While this cost has no direct bearing on safety arguments, it is of interest to assess the extent to which cost, as well as safety, might be a significant factor in decisions about the management of bird strike risk.

The cost was estimated principally on the basis of the work reported in [4]. The cost elements for which quantified data were available were those to air operators and aerodromes resulting from damage to aircraft and flight delays and cancellations. These give a lower bound estimate of the overall cost, as there are additional, less readily quantifiable, costs such as impact on reputation, and costs to other stakeholders.

To assess how this estimated financial cost compares with the safety detriment, we used the concept of the Value of Preventing a Fatality (VPF). The VPF is a notional value used in some hazardous industries as a guide to how much it is reasonable to spend on safety. It is in no sense an actual 'value of life' (a meaningless or even offensive concept) - VPFs are most often derived by considering how much people are prepared to pay for relatively small improvements in safety and are usually applied to assist decisions about whether or not to implement measures which, in most cases, lead to similarly small reductions in risk, rather than 'definitely' saving certain lives.

Typical VPFs used in transport industries in the UK are between 1.5 and 5 million Euros. The expected number of fatalities per year from bird strike (derived from the risk assessment in Section 2.1) was multiplied by the VPF to give an equivalent, 'monetarised' annual cost of the safety detriment.

The estimated financial cost was several times greater than the monetarised safety detriment. While there are major uncertainties in this comparison, due to the scarcity of reliable data and the various fundamental assumptions that have to be made in this type of analysis, the implication is that cost is a significant additional factor which operators should take into account in decision-making, especially as the cost elements evaluated represent only part of the total.

This analysis says nothing about how much *should* be spent to reduce bird strike risk – that would require an analysis of the costs and benefits of the potential risk reduction measures. Nevertheless it indicates that the financial cost of bird strikes is a significant additional factor in favour of considering additional measures to reduce bird strike risk, over and above the safety arguments.

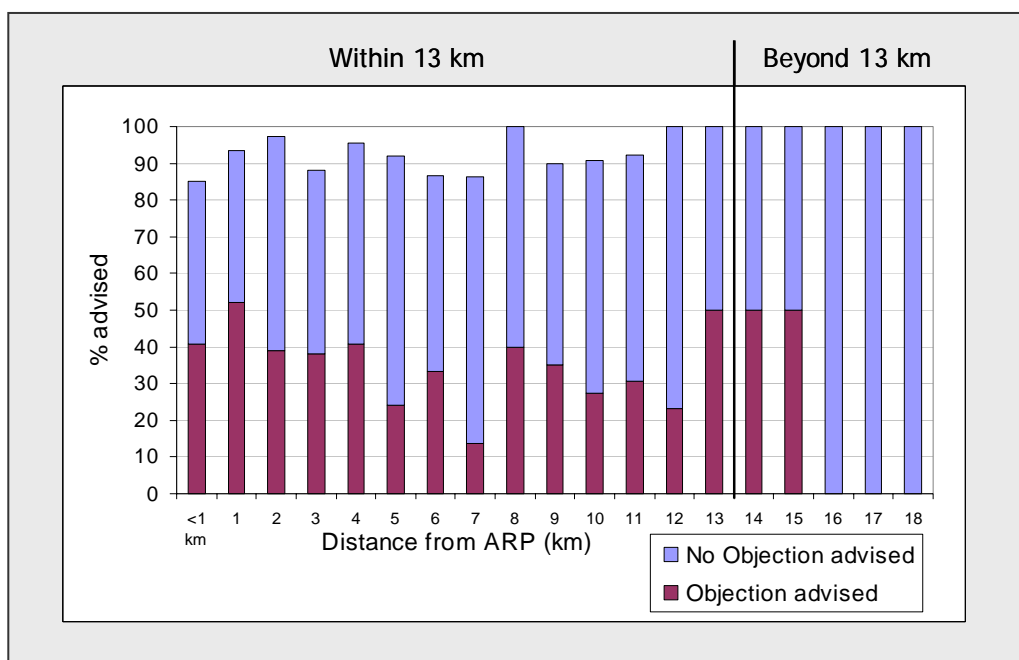
## 2.4 Specific risk factors and areas for improvement

Because the present study was concerned with the overall risk to UK aviation, the emphasis in analysing the data and interview findings was on looking for aspects that could inform regulatory policy or complement existing guidance to operators. Those of greatest potential interest internationally are summarised below.

### Safeguarding – the control of land use around aerodromes

Most States impose some control on land uses around aerodromes in order to prevent (*inter alia*) developments that would attract more birds. In the UK, for example, planning authorities have a duty to consult aerodrome operators on all planning applications within a 13 km radius of the aerodrome [5,6] that may attract birds. The aerodrome operator reviews the application for its potential effect on bird hazard, and may object to or comment upon the application as they see fit.

The choice of this 13 km circle dates back to the 1970s and, like many historic standards and rules-of-thumb, is based largely on subjective judgement (see [7] for an explanation and critique of the rationale). Its validity was reviewed using an analysis of expert advice on over 200 planning applications that CSL have provided to a range of airports over recent years. Figure 2 shows the relationship between the proportion of applications for which the operator was advised to object and the distance of the application site from the Aerodrome Reference Point (ARP).



**Figure 2:** Variation with distance from ARP of expert advice on planning applications

There was no evidence of diminishing risk with distance, and even beyond the 13 km limit, a substantial fraction of applications were considered to pose an unacceptable risk. This suggests that changes to, or additional guidance on, safeguarding would be advisable.

Aerodrome operators should be encouraged to take (as some already do) a more risk-based approach to monitoring and responding to land use changes in their vicinity, rather than relying on the current safeguarding circle alone. The assessment should extend outside the current circle, at least for initial screening of areas to be monitored. As part of this risk-based approach, active monitoring of planning applications and the potential for change is to be encouraged, rather than reliance on notification from planning authorities.

Also, some land use changes outside the scope of planning control can have a significant effect on bird hazard. They include, in the UK for example, agricultural activities such as ploughing, changes in cropping or livestock, changes in wetland management at nature reserves, temporary soil stripping during construction and changes in coastal and water-based activities such as recreation and fisheries. Aerodrome operators should be encouraged to monitor environmental change and to develop links with local farmers and other landowners and managers.

In the longer term, regulators might consider amending the shape/ size of the safeguarding circle to reflect the actual variation of risk with location more accurately.

#### **Active bird control in low visibility**

An analysis of the number of reported strikes by visibility suggests that a disproportionately high number occur during low visibility conditions, relative to the proportion of time in which such conditions occur and the reduced aircraft movement rates. In addition, operator interviews revealed significant variations in control practices during low visibility. There are also variations in the attitude of ATC to allowing bird control vehicles onto movement areas in low visibility. While recognising that aerodrome-specific differences may justify such variations, it is suggested that regulators should consider issuing guidance on best practice control in low visibility.

### Pilot training and procedures

Amongst the air operators interviewed, pilots receive no specific training in handling bird strikes or responding to bird warnings, and no SOPs exist. Flight Safety departments and flight operations regulators should consider whether these issues merit further action.

### 2.5 Future trends

There are many factors that may affect bird strike risk in the future. Figure 3 shows these influences at a high level, and how they interact. Note the feedbacks from 'Risk' – if an accident were to occur as a result of a strike it would be a driver for reactive change.

This diagram provided a structure for identification of specific potential trends in the UK, some of which may also affect other States. Changes that may increase risk include the greater importance being given to biodiversity aims, both in terms of land use and habitat management and via the deliberate re-introduction of certain bird species, such as Red Kite in the UK. There are also behavioural changes – an increase in roof-nesting by Oystercatchers has been noted, for example. Some likely changes can have both positive and negative effects on risk. Urbanisation around airports, for example, is expected to provide more nesting opportunities for gulls and feral pigeons, and could increase the attractiveness of the aerodrome itself to some open ground species if the area around it is greatly urbanised, while reducing the populations of other species in the surroundings.

Change that may reduce risk include the intention that the current ICAO Annex 14 Recommendation for control of existing attractions (as well as restrictions on new development) should become a Standard, although it is unclear how this might be implemented within national planning law.

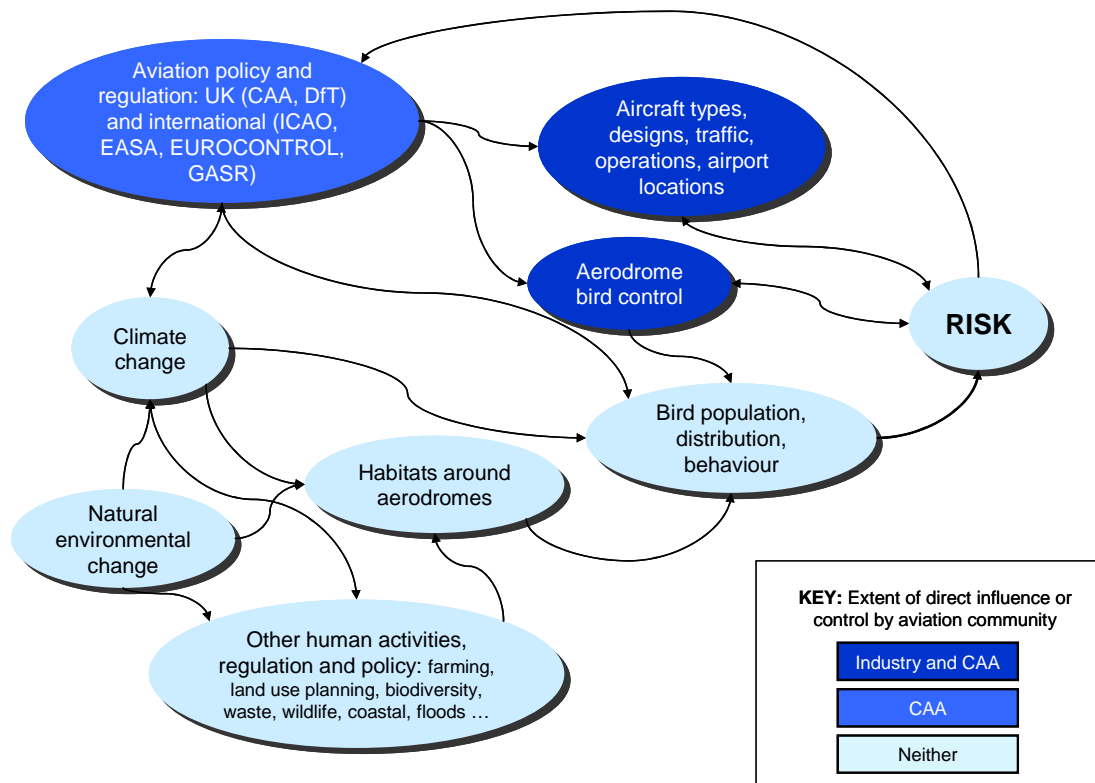


Figure 3: Influences on bird strike risk

### 3. Completeness and Accuracy of Bird Strike Reporting

This section assesses the completeness and accuracy of bird strike reporting by air operators and aerodromes, and identifies opportunities for improvement. It also provides the baseline for establishing, in Section 4, whether the recent mandate has been effective.

The reporting process was reviewed to identify actual or potential areas of weakness and opportunities for improvement. The intended process for the capture and flow of strike information, as set out in the relevant regulations and guidance, was represented as a flowchart. This was compared with current practice, as revealed by analyses of data and in the operator interviews, in which actual procedures, reasons for non-reporting, and obstacles to good information flow were discussed.

It was apparent that the intended lines of communication are quite long and complex. In general, the chain can be broken by the failure of any one link, and regulatory auditing is therefore an essential safeguard, to identify such failures and enable operators to improve their processes.

Analysis of whether a report was submitted by the aerodrome operator, the air operator or both these fields showed that the rate of reporting by air operators has declined, both as a proportion and in absolute terms, over the past decade. The most likely reasons for this appear to be related to issues in the management of strike report information within airline safety departments rather than a decline in primary reporting by pilots. In this regard the mandate was a timely and appropriate measure.

There are major variations in the extent to which strike reports are shared between the various stakeholders. There are also variations in the extent to which warnings about current bird activity are passed between bird control staff, pilots and ATC. This variability suggests that there are opportunities to improve (while recognising that genuine site-specific differences may justify some variation). There is an ongoing need to remind operators of their responsibilities and encourage best practice in sharing information.

A number of other recommendations were made with regard to the detailed content and design of report forms, and the practicalities of the reporting process. A key principle behind all of these was to make the precise reporting requirements clearly evident to the actual reporters, making report forms as self-explanatory as possible, whilst not overloading them with notes and guidance.

A move to electronic reporting could reduce errors and improve the efficiency of the process, but a number of IT and other issues will have to be resolved first. In particular there are legal issues concerning the balance of freedom of information requirements [8] and reporter confidentiality, and a need to consider compatibility with harmonised European aviation incident reporting requirements. These issues apply to many types of incident report, not just bird strike, and so will have to be addressed at a wider level.

### 4. Effectiveness of the Mandate

The effectiveness of the mandate was evaluated principally by comparing the frequency of strike reports before and after implementation. To complement this analysis, the interviews with aircraft and aerodrome operators included discussion of industry awareness of the mandate, perceptions of its value, and effects on reporting processes.

The key finding from the results available to date is that the frequency of reports to the CAA database doubled in the year following the mandate. As significant advance publicity had been given, and the CAA had in practice been encouraging the reporting of all strikes for over a year before the mandate took formal effect, this increase is all the more notable. More detailed analyses will be performed when the full 2004 data are available.



Statistical analysis of other indicators suggests that the observed increase is most likely to have been a result of the mandate, rather than any increase in the actual strike rate or other factors affecting reporting. The mandate therefore does appear to have been effective.

There was generally good awareness of the mandate amongst both air operators and aerodromes, but continued reminders will be needed to ensure that the improvement in reporting is sustained. Awareness of the importance of reporting bird strikes will otherwise tend to be overtaken by other, albeit important, issues.

## **5. Conclusions**

### **5.1 Findings**

The assessment indicates that bird strike risk per movement to UK aviation is increasing as a proportion of total aviation risk, and possibly also in absolute terms. While bird strike risk accounts for only a small percentage of the overall risk of commercial flight, it does merit attention as a significant class of incidents – the level of risk is comparable to that for other issues, such as runway incursion and level busts, on which the aviation community has recently focussed a campaign of risk reduction. It would therefore be prudent for regulators and industry to seek to reduce the risk, both in order to take a precautionary approach to bird strike itself, and as part of the wider objective of driving down aviation accident rates overall.

Interviews with operators and analyses of strike data showed that there have been large fluctuations in reporting over the past decade, and these appear to have been mainly due to changes in information management within airlines. The mandate, together with efforts to publicise the importance of reporting, has however been rewarded by a notable improvement – a doubling of the reporting rate - which, if sustained, will provide a more reliable basis for future decisions.

### **5.2 Potential risk reduction measures**

A number of measures have been suggested by which bird strike risk could be reduced and reporting improved further and sustained. Their feasibility, cost and effectiveness will require further consideration by regulators and industry, to determine what is required to meet the ALARP requirement.

Although this study has been specifically concerned with the risk to UK aviation, a number of the potential risk reduction measures may also be of interest to other States, and these are summarised below.

- Aerodrome operators should be encouraged to take a more pro-active, risk-based approach to monitoring and responding to potential land use changes in their vicinity, rather than relying on current safeguarded areas and notification processes. In the longer term, regulators might consider amending the shape or size of safeguarded areas to reflect the actual variation of risk with location more accurately.
- Guidance should be provided to aerodrome operators on best practice control methods in low visibility conditions.
- Flight Safety departments and flight operations regulators should consider whether pilots should receive specific training in handling bird strikes or responding to bird warnings, and whether SOPs are required.
- There is an ongoing need to remind operators of their responsibilities and encourage best practice in sharing information.
- Report forms should be as self-explanatory as possible, whilst not overloading them with notes and guidance.
- A move to electronic reporting could reduce errors and improve the efficiency of the reporting process, but a number of legal, institutional and IT issues will have to be resolved first. As these issues apply to incident reporting in general, not just bird strike, they will have to be addressed at a wider level.

### References

1. Air Navigation (General) (Amendment) (No. 2) Regulations 2003. Statutory Instrument 2003 No 3286. HMSO, London.
2. Air Navigation (Amendment) (No. 2) Order 2003. Statutory Instrument 2003 No. 2905. HMSO, London.
3. CAP 382. Mandatory Occurrence Reporting Scheme. UK CAA.
4. JR Allan. The Costs of Birdstrikes and Birdstrike Prevention. IBSC Meeting 2002.
5. The Town And Country Planning (Safeguarded Aerodromes, Technical Sites And Military Explosives Storage Areas) Direction 2002. HMSO, London.
6. Scottish Executive Planning Circular 2 2003. Annex 2: Arrangements for Safeguarding Aerodromes, Technical Sites And Military Explosives Storage Areas. HMSO, London.
7. CAP 680. Aerodrome Bird Control. UK CAA, 2002.
8. Freedom of Information Act 2000/ Freedom of Information (Scotland) Act 2002. HMSO London.