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THE UK CIVIL AVIATION AUTHORITY'S APPROACH TO BIRD HAZARD RISK ASSESSMENT

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Abstract

The Civil Aviation Authority requires licensed aerodromes to implement safety management systems. Risk management is an essential part of safety management, in which risks are evaluated and, where necessary, strategies devised to reduce them to an acceptable level. All possible hazards are identified and their severity and probability assessed. By combining severity and probability, tolerability can be determined and the need for action to reduce the severity or probability determined. AWM and CAA have applied this methodology to the birdstrike hazard. Data from birdstrike accidents show that all aircraft types are vulnerable, and birds that alone or in flocks can cause catastrophic accidents visit virtually all aerodromes. Therefore, in the absence of mitigation, the risk level is unacceptable. Control action is necessary and the situation must be continuously kept under review to monitor the residual risk: bird hazard reduction is a 'finger in the dike' operation.

Key Words: Hazard Management, Plans, Risk assessment.

1. Introduction

Risk assessments are commonly carried out to evaluate the safety implications of changes in operations and procedures. In promoting the adoption of safety management systems by aerodrome operators, the UK Civil Aviation Authority (CAA) Safety Regulation Group (SRG) has developed an approach to safety management that differs from that applied by the UK Health and Safety Executive (HSE) to other industries. For example, in HSE terms, hazard 'means the potential to cause harm, including ill health or injury; damage to property, plant, products or the environment, production losses or increased liabilities', whereas SRG define hazard as a 'physical situation, often following some initiating event, that can lead to an accident'. The term 'Risk' may be applied to many situations, such as the loss of business or profit, but the CAA as a safety regulator is concerned with risk of injury or death arising from aircraft accidents. The following text is a late draft of a document produced by AWM for CAA that applies the Authority's risk assessment methodology to the bird hazard at aerodromes.

2. The birdstrike hazard

Birds are the cause of one of major controllable hazards to aviation (Reference 1). Up to 1995, in civil aviation worldwide, there had been at least 30 fatal accidents with 190 deaths, and 52 aircraft destroyed (Reference 2). Since then, three large aircraft, comparable with civil transports but military-operated, have been destroyed, with the loss of a further 58 lives (see Annex 1). In the UK, at least 4 aircraft have been destroyed, and 7 people killed. Set against accidents from all causes, and in the context of the large number of birdstrikes that have minor consequences, the accident rate may not appear alarming. However, most reported birdstrikes are potentially hazardous (see 4.2 below) and, in 1998 alone, UK-registered civil aircraft reported 878 birdstrikes that resulted in 28 aircraft returning, 12 aborted take-offs, 1 go-around, and 6 engine shutdowns (5 of which were on helicopters). 19 engines were damaged and at least one destroyed.

3. CAA risk assessment methodology

The procedures are well established and fully described in References 3-5. CAA SRG define hazard as a 'physical situation, often following some initiating event, that can lead to an accident'. Risk management is an essential part of safety management, and risk assessment is the process by which risks are evaluated and, where necessary, policies for their mitigation determined, as follows: -

- Identification of all possible hazards.
- Hazard review, in which the identified hazards are reviewed critically and re-defined as necessary.
- Hazard severity assignment for each of the hazards identified.
- Estimation of probability of each hazard arising.
- Risk tolerability determination in which severity and probability of hazards are combined
- Risk reduction as required by action to mitigate the severity or likelihood of occurrence.

4. Applying risk assessment methodology to bird hazards

4.1 Setting a background

One approach would be to list ***all*** the bird species that could be attracted by ***all*** the habitats and activities associated with the individual airport under consideration and then to assess, ***for each,*** the potential hazard level and likelihood of it arising. This would be a very lengthy and repetitive procedure. Therefore, it is useful to start with an assessment of the hazard presented by birds in more general terms and subsequently to apply the findings to those species likely to visit the individual aerodrome and, thus, to determine tolerability and need for mitigation action.

4.2 The bird hazard in general terms

Annex 1 is a selected list of birdstrike accidents that demonstrates a number of important factors:-

- All types of aircraft from piston-engined light aircraft, through helicopters, business jets and short and medium haul turboprop and jet airliners, to wide-bodied transports have been destroyed.
- Birds cause accidents by: causing engines to fail (including uncontained failure - disintegration and fire) or reducing power output; damaging airframes; penetrating cockpits and disabling pilots; and presenting pilots with critical situations in which they have insufficient information about the extent of damage to make good decisions.
- Nearly all birdstrike accidents to civil aircraft (except for helicopters) occur on or very close to aerodromes while the aircraft is engaged in standard aerodrome activities.
- Nearly all birdstrike accidents involve species of birds that commonly occur around and on aerodromes, or birds of similar size.
- Most birdstrike accidents are caused by birds weighing less than 1kg, and some involve single birds weighing less than 500g.

➢ Many birdstrike accidents involve single birds but, where flocks are involved, numbers are comparable with flock sizes that are common on and around aerodromes.

Most birdstrikes cause little or no damage but, otherwise, are very similar to those listed in Annex 1 (common aircraft types striking on take-off or landing modest numbers of birds of species that typically congregate on airfields). Although birdstrikes are controllable, when they are permitted to occur their consequences are not. Catastrophic birdstrike accidents occur when ***chance*** factors intervene during and immediately after the event: birds are ingested into one or more engines and cause uncontained failure or sufficient loss of power for the aircraft to crash; or the pilot loses control or must make an immediate decision without adequate information.

Although even single relatively small birds cause accidents, there are relationships between bird weight and numbers, and the risk that the aircraft will be damaged (Reference 6): -

BIRD WEIGHT	% DAMAGING STRIKES (% DAMAGING ENGINES)
<100g (small)	2.7 (0.7)
101-1000g (medium)	12.0 (3.96)
>1000g (large)	22.7 (4.97)

No OF BIRDS STRUCK	% DAMAGING STRIKES (% DAMAGING ENGINES)
1	8.12 (2.1)
2-10	14.6 (4.6)
11-100	40.32 (22.6)

Thus, species that are larger than 100g, or occur in flocks (***e.g.*** gulls, lapwings, corvids, pigeons, starlings, etc), are most likely to cause damage to aircraft, and have the potential to cause accidents. Also, as numbers increase (independent of weight), the risk of ingestion and engine damage increases markedly for larger flocks. All these factors have led to the defining of a "priority group" of bird species that (i) fit either or both these categories; (ii) are attracted to the airfield environment; and (iii) are susceptible to the available standard techniques for removing birds from aerodromes. These then become the main targets for mitigation action (see 5 below).

4.3 Hazard severity

There is no fixed formula for degrees of hazard. However, References 3-5 use a common four level classification defined as follows: -

CLASSIFICATION	RESULTS: ONE OR MORE OF THE FOLLOWING
Catastrophic	Loss of aircraft; Multiple fatalities
Hazardous	Large reduction in safety margins; Physical distress or workload such that flight crew cannot be relied upon to perform their tasks accurately or completely; Serious injury or death of a relatively small proportion of occupants
Major	Significant reduction in safety margins; reduction in ability of flight crew to cope with adverse operating condition as a result of increase in workload or as a result of conditions impairing their efficiency; Injury to occupants
Minor	Nuisance; operating limitations; emergency procedures

Applying these criteria to the potential results of birdstrikes with flocks of small birds and individuals or flocks of medium-sized and large birds (4.2 above), it is apparent that the hazard severity for birdstrikes includes all levels up to and including ‘catastrophic’.

4.4 Hazard probability

The following definitions are derived from References 4 and 5, but originate from Joint Airworthiness Requirement 25, which quantifies probability in terms of flight hours. However, CAA SRG consider that the definitions are equally valid for aircraft movements and birdstrikes at an aerodrome.

CLASSIFICATION	QUALITATIVE & QUANTITATIVE DEFINITIONS
Extremely improbable	Should virtually never occur. $<10^{-9}$ per movement
Extremely remote	Unlikely to occur when considering several systems of the same type but, nevertheless, has to be considered as being possible. 10^{-7} to 10^{-9} per movement.

Remote	Unlikely to occur during total operational life of each system but may occur several times when considering several systems of the same type. 10^{-5} to 10^{-7} per movement
Reasonably probable	May occur once during total operational life of a single system. 10^{-3} to 10^{-5} per movement
Frequent	May occur once or several times during operational life. 1 to 10^{-3} per movement.

Accidents from all causes should occur at a frequency of 1×10^{-7}, or lower. Thus, individual hazards should pose a considerably lower risk, perhaps in the order of 1×10^{-9}. Given the low frequency of accidents, it is not possible to quantify accurately risks from individual causes, such as birdstrikes. For example, aircraft movements at individual UK airports are commonly in the order of tens of thousand ***per annum*** and the indications are that the risk of a major birdstrike accident is probably below 1 in 10^{-7} for UK civil aerodromes ***as a whole.*** However, it is impossible to determine the situation at individual aerodromes (all of which have different local conditions and hazard levels), because insufficient aircraft movements have been accrued. On the other hand, because most aerodromes have several tens of thousands of movements ***per annum*** and because they have not suffered major accidents caused by birds in the past 25 years, we can infer that the probability of an accident is lower than the 1×10^{-5} or 1×10^{-6}. All categories of aircraft have suffered catastrophic accidents following strikes with common birds and strikes with the ***potential*** for catastrophic results occur relatively frequently. Therefore, the probability is, at best, 'extremely remote' and may even be as high as 'remote'. Also, serious incidents such as loss of an engine on takeoff, (severity classification 'hazardous' and 'Major') occur sufficiently frequently to fall into the 'reasonably probable' category.

4.5 Risk assessment

Risk level is determined by combining the severity and probability of the hazard. The purpose of assessing risk is to determine its tolerability and whether it must be reduced. Numerical values may be assigned for the severity and probabilities as defined above, and added or multiplied together to arrive at a numerical value that can be compared with pre-determined and agreed values for safety in general. However, for some types of occurrence, such as serious birdstrikes, the data are insufficient to determine quantitative risk assessments for specific examples such as an individual aerodrome. This is not a serious problem because the next stage, assessing tolerability (4.6 below), tends to 'smooth out' the numerical boundaries between hazard and probability levels.

4.6 Risk tolerability

When the risk has been determined, The score can be used to determine whether the risk is acceptable, at a level that requires on-going review, or is unacceptable and must be reduced to a lower category. This method of looking at hazard, probability and tolerability can be expressed as a matrix: -

	EXTREMELY IMPROBABLE	EXTREMELY REMOTE	REMOTE	REASONABLY PROBABLE	FREQUENT
CATASTROPHIC	Review	**Unacceptable**	**Unacceptable**	**Unacceptable**	**Unacceptable**
HAZARDOUS	Review	Review	**Unacceptable**	**Unacceptable**	**Unacceptable**
MAJOR	Acceptable	Review	Review	Review	Review
MINOR	Acceptable	Acceptable	Acceptable	Acceptable	Review

When the birdstrike hazard is considered in the above terms, it can be seen that, in principle, effective mitigation measures are ***always*** required to reduce it to a lower category because of the possibility of a catastrophic accident, and the situation must be kept under review.

4.7 Risk reduction

An ‘unacceptable’ risk level must be reduced, and, where it falls between ‘acceptable’ and unacceptable, it should be reduced to a level As Low As Reasonably Possible (ALARP principle). Mitigating action may be aimed at reducing the severity of the hazard, its probability, or both. A further risk assessment, taking into account the effect of the risk reduction measure or measures, should be made to ensure that mitigation action reduces the risk to an acceptable level. If not, further measures are necessary until the aim is achieved. To reduce the hazard of birds on aerodromes, the usual approach is to reduce the probability of birdstrikes by removing birds from the vicinity of aircraft.

4.8 Conclusion on the bird hazard in general terms

All aircraft are vulnerable and all aerodromes are visited by birds that alone or in flocks can cause catastrophic accidents. It is never acceptable to permit ‘priority group’ (4.2 above), or birds of comparable size or with flocking habits, to occupy an aerodrome and its airspace while aircraft are operating. This principle over-rides the need to determine whether individual bird species are hazardous from their past record. However, categorizing birds in this way assists in determining priorities and methods for mitigation action.

5. Hazard mitigation and review

5.1 Hazard identification

As indicated in 4.1 above, it would have been possible (but time-consuming) to consider all bird species and attractants when assessing the overall risk. However, by adopting a more general approach at the earlier stage, all factors that bring birds to the aerodrome and into conflict with aircraft must be considered next to produce a coherent policy to reduce the hazard to an acceptable level. Different aerodromes may have hazards caused by different species, but the principles in terms of what attracts the birds to the aerodrome and how they can be removed are generally applicable. From this, it is possible to construct a framework as indicated in the Table at Annex 2 in very general terms. The Table should be refined for each aerodrome to record site-specific risks and targeted mitigation action. In all cases, the starting point is that hazardous birds will occur in locations on and around the aerodrome where they can cause birdstrikes and, therefore, the initial risk level is generally ‘unacceptable’.

5.2 Mitigation

A further review taking into account the effect of mitigation action is necessary to assess the residual risk. Generally, it is unlikely that this can be reduced to a level below that requiring continuous review: bird hazard reduction is a ‘finger in the dike’ operation. The hazardous birds that are numerous on aerodromes are also common in the surrounding countryside and urban areas. The best bird control systems reduce strike rates with hazardous species from typically 4-6 per 10,000 movements to around 1 per 10,000 movements. In 4.4 and the matrix in 4.6 above, it would be necessary to reduce the probability of a birdstrike accident to the level of ‘should virtually never occur’ to lower the residual risk to ‘review’ level. Therefore, in most cases, the ‘As Low As Reasonably Possible’ (ALARP) principle should be used.

5.3 Hazard review

‘Review’, in the case of bird hazards, refers to the changing bird hazard on and around the aerodrome and, especially, to the mitigation measures, very few of which are permanent or constant in their effect. In special circumstances, it may be possible to remove a hazard completely and permanently: for example, draining and infilling a duck pond on the airfield will remove the specific hazard it generated, and no further action will be necessary. However, this is not typical. Airfield long grass deters birds without

continuous attention but it can slowly (or, sometimes, rapidly) becomes less effective over several years as thatch accumulates. Unless the maintenance regime constantly monitors the sward condition and includes corrective action to maintain it in a healthy, bird deterrent condition the sward becomes sparser and weeds invade. Experience has shown that there is a tendency for the performance of bird hazard control teams to deteriorate with time if they are not continuously monitored and managed. Where the hazard has been acknowledged by the provision of habitat management, manpower and equipment to mitigate it, failure to ensure that these resources are fully utilized is as much neglect of safety as ignoring the hazard in the first place.

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