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An Assessment Of The World-wide Risk To Aircraft From Large flocking Birds

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Introduction

It has long been recognised that birdstrikes with birds of medium to high weight and with flocks of birds are more likely to result in damage to aircraft and hence pose a greater risk than impacts with single birds or with birds of low weight (Milsom 1990). Current certification standards for aircraft engines and other components reflect this fact. For example, engines are required by regulation to withstand impacts with a given number of low or medium weight birds whilst retaining a specified level of performance, and to withstand an impact with a single large bird and achieve a safe shutdown of the engine. The precise number of birds of a given weight used in these tests depends upon the size of the engine, whilst the level of performance required after the birdstrike is influenced by the number of engines carried by the aircraft. Examples of the requirements for 94 and 100 inch diameter jet fans such as the Trent series manufactured by Rolls Royce are given in table 1 (J. Reed pers. comm.).

Table 1 Certification test requirements for two Rolls Royce jet engines

Engine Type	Engine Diameter	Flocking Birds	Performance Requirement	Single Bird	Performance Requirement
Trent 800	110 inches	4 x 2.5lbs	75% Thrust for 20 mins.	1x 8lb	Safe shutdown
Trent 700	94 inches	4 x 1.5lbs	75% Thrust for 20 mins.	1x4lb	Safe shutdown

These certification requirements are kept under constant review and may be amended in the light of new technological developments or changes in the birdstrike risk to which the engines are exposed in operation.

A number of recent serious birdstrike events have involved impacts with flocks of large birds (for the purposes of this study a large bird is defined as one where the average weight for that species exceeds 2kg (4.4lbs)). Some serious recent strikes have involved birds being ingested into more than one engine of the aircraft, and in some cases several birds of this weight range were ingested into a single engine. These incidents have coincided with recent substantial increases in the populations of some large flocking bird species, such as non-migratory Canada Geese (*Branta canadensis*) and migratory Snow Geese (*Anser caerulescens*) in North America (US Fish And Wildlife Service 1998.), and feral Canada Geese and Greylag Geese (*Anser anser*) in Europe (Kirby et al. 1995). This has led to calls for a reassessment of the probability of strikes with flocks of birds over 2kg in weight and for co-ordinated measures to reduce the numbers of these birds close to airports (Allan 1994, Allan et al. 1995, Seubert 1996). Other studies are in progress to establish the true probabilities of ingesting a given number of large birds into a single engine, or of ingesting birds into more than one engine during a strike with birds in this size range (Budgey & Allan in press).

The objective of this study, which was commissioned by the UK Civil Aviation Authority, was to collate and analyse the birdstrike data already available across the world in order to better understand the current risk of impacts with birds over 2kg in weight and particularly to estimate the risk of impacts with flocks of birds of this size. The study also aimed to assess whether these risks have changed over recent years, or are likely to change in the foreseeable future. These data, when combined with

information on the probability of multiple ingestions during a strike with a flock (Budgey & Allan in press), and with projections of population size changes in bird species (Bell in press), can be used to inform future decisions about certification standards.

Methods

The project has established a database of strikes with birds over 2kg in weight from around the world. Data sources used included the ICAO IBIS database, national aviation authorities, airlines, aero-engineering companies, and airports.

A total of 107 organisations have so far been approached, and 44 have responded with information.

The database was developed in Microsoft Access and details of all strike reports entered. Records were then checked to remove duplicates. Obvious errors (e.g. the bird species involved does not occur on the continent where the strike took place, or the engine involved was never installed on that airframe) were followed up and corrected where possible. Further details of those strikes where large flocks of birds were involved, or serious damage to the aircraft occurred, were obtained when available.

The data were subjected to a preliminary analysis to identify the major sources of error and bias, before a more detailed analysis was carried out where the quality of the data permitted.

Results

Data Quality

Patterns of reporting

So far, details of a total of 1902 strikes involving birds over 2kg in weight have been added to the database. The vast majority of these strikes have occurred over the period 1983-98. Flocks were involved in 908 (47.7%) of reported incidents.

A preliminary analysis of the data shows that the majority of reports (1238) come from the ICAO IBIS database. Other organisations supplied 675 additional reports that were not reported to ICAO. Eleven of these additional reports were submitted by more than one organisation and have been recorded against both reporting groups in table 2 in order to show the distribution of records unknown to ICAO. Thus, the number of strikes in Table 2 does not add up to 1902.

Table 2: Sources of information on birdstrikes with birds over 2kg in weight.

SOURCE OF DATA	**NUMBER OF STRIKES REPORTED**
ICAO	1238
ADDITIONAL DATA SOURCES	**NUMBER OF STRIKES REPORTED**
National Aviation Authorities	603
Engine Manufacturers	59
Airlines	5
Others	8

Despite the large number of strikes recorded, a relatively small minority of countries report birdstrike data to ICAO. For example, a total of 38 countries from the 228 listed in the ICAO IBIS handbook (ICAO 1997) reported in 1996, and even fewer do so consistently each year.

It is also well known that even in countries with good reporting systems, not all birdstrikes are necessarily reported to the central authority. For example, Cleary *et al.* (1998) estimate that only 20% of birdstrikes occurring in the USA are reported to the Federal Aviation Administration (FAA). It is, however, likely that strikes with large birds have a greater chance of being noticed and reported than those with small birds which may be considered inconsequential and therefore ignored. Even so, the data available probably represent considerable underestimates of the number of strikes with birds over 2kg in those countries that have sent data to ICAO.

There are very obvious patterns in the data caused by changes in reporting frequency within countries and by changes in whether the central authority in each country sends data to ICAO each year. Table 3 shows the number of strikes with birds over 2kg reported per year by the 20 countries reporting the highest total number of these strikes in the period 1983-1998. The effect of the sudden rise in reporting from 1991 onwards which resulted from the FAA's drive to ensure that birdstrikes are reported in the USA is clear. The opposite trend has occurred in India following the cessation of reports from 1991 onwards (the smaller number of strikes noted for these two countries outside the periods when reporting occurred derive from other sources such as airlines or aero-engineering companies).

It is clear that an attempt to determine trends in strikes with large birds using the data reported to ICAO is likely to produce spurious results unless the information is interpreted very carefully. Figures 1 and 2 show the annual totals of birdstrikes reported for geese and old world vultures respectively. The changes in numbers of strikes mirror the changes in reporting practices described above and mask any true changes in risk that may arise from changes in population size for the two groups.

Table 3 Number of strikes with birds over 2kg reported by different countries each year from 1983 to 1998

COUNTRY	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	TOTAL
UNITED STATES		2	11	17	11	8	42	40	84	102	93	124	127	130	107	175	1073
INDIA	23	20	23	23	17	20	17	17	12	2	4	2	1				181
CANADA	4	5	4	6	18	11	1	1		10	15	15	12	17		7	126
AUSTRALIA	5	8	13	8	13	13	10	12			1	1		2		2	88
UK	1	3	4		2	1	2	3	4	1		3	2	3		1	30
SOUTH AFRICA	1	1	1	2	1	2	2	1		3			3	7	1		25
PAKISTAN		6	4	1	1	1	2	3	1				1	1			21
UNKNOWN							1	4		3	1	1	5	4			19
WEST GERMANY		1		2	1	2	1	3	2	1	1	2		1	1		18
USSR					2	4	5	3									14
KENYA	1	1				2		1	5							1	11
FRANCE		1	1	1				1	1		1			1		1	8
MALAYSIA	1	2		1								2	1			1	8
GREECE			1					1	2		2			1	1		8
NORWAY												1	3		3		7
MOROCCO				1			1		2			1		1			6
SPAIN								2	1				1	2			6
UGANDA						1		1		1	1	1		1			6
BRAZIL									2		1			1	1		5

Data accuracy

Significant problems also occur with the accuracy of the data submitted. Numerous instances were found of the bird species involved in a strike not actually occurring on the continent where the strike took place. Similarly, strikes were recorded with engines which are never fitted to the aircraft involved. Where

possible, these errors have been corrected, but in those cases where it was not possible to determine the correct information the record has been discarded. It is impossible to determine how many further reporting errors remain undetected.

Fig. 1 Annual total of strikes with geese world-wide and the annual total of strikes with birds over 2kg reported in the USA

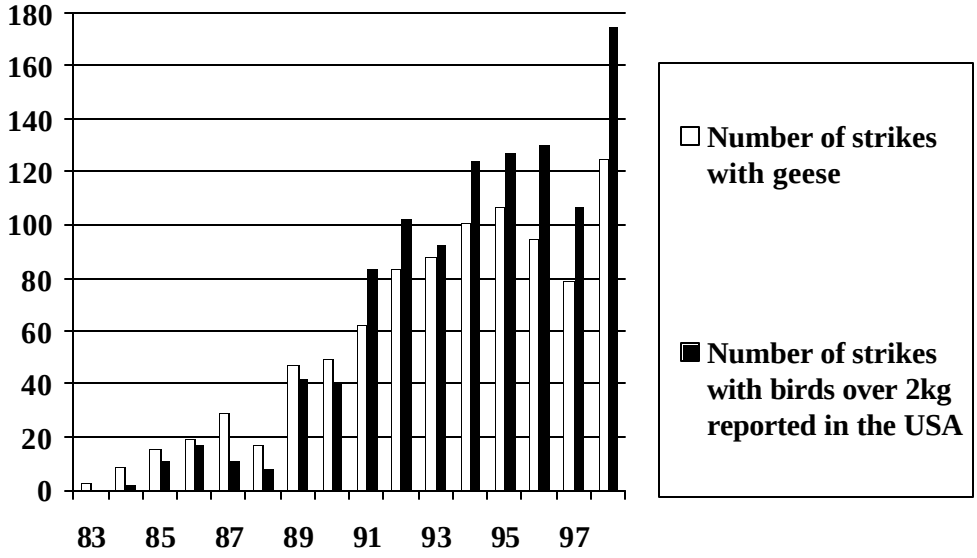
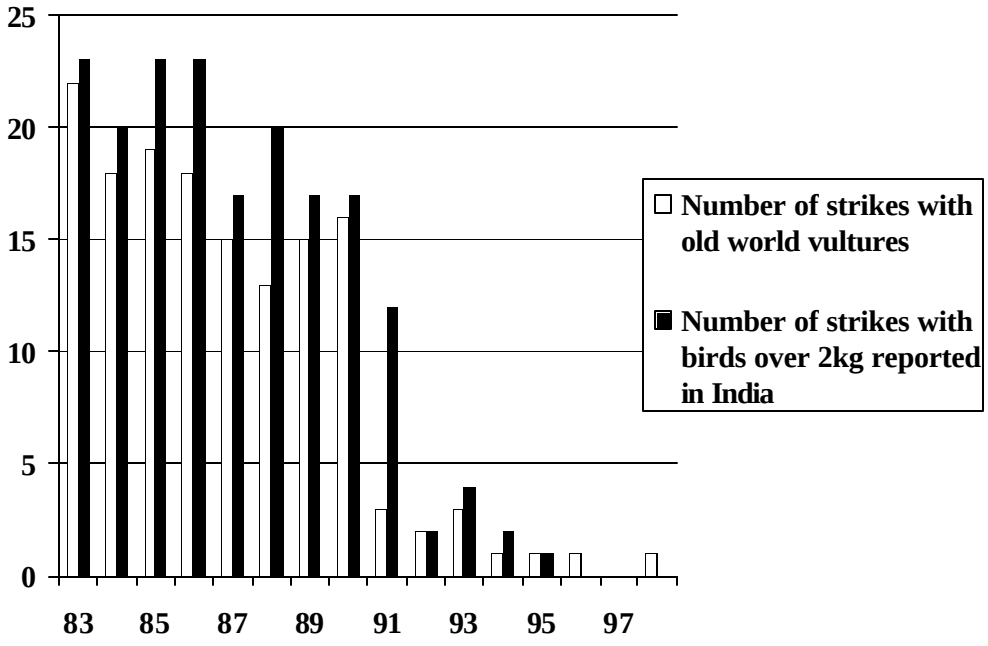


Fig. 2 Annual total of strikes with old world vultures world-wide and the annual total of strikes reported in the India



Species involved

The species breakdown of the strike sample is shown in table 4. A total of 59 species or groups of birds that could reliably be recorded as over 2kg in weight were reported. The majority of the strikes involved large waterfowl, which reflects the species present in North America which has the largest number of air traffic movements and also, since 1991, a more efficient recording and reporting system for birdstrikes. Other species groups, such as old world vultures, have shown variations in numbers of strikes over the study period, but these are largely due to changes in reporting practices by countries where they occur (e.g. India).

Table 4. The number of birdstrikes recorded for the 20 most commonly struck species or species groups over 2kg in weight.

SPECIES OR GROUP	NUMBER OF STRIKES
GOOSE SP	605
CANADA GOOSE	305
EAGLE SP.	184
OLD WORLD VULTURE	179
NEW WORLD VULTURES	88
GREAT BLUE HERON	70
CRANE SP	61
NEW WORLD VULTURE	49
SANDHILL CRANE	38
SNOW GOOSE	35
AUSTRALIAN BUSTARD	33
PELICAN SP	30
BALD EAGLE	29
STORK SP	26
SWAN SP	24
TURKEY SP	15
MAGPIE GOOSE	12
WHITE STORK	12
WEDGE-TAILED EAGLE	11

Multiple impacts

Of the 1902 reported strikes, 1012 resulted in some damage to the aircraft and 272 in substantial damage. The strike sample contained 908 incidents involving impacts with more than one bird, and 27 involved birds impacting more than one engine of a multi-engined aircraft. There were 31 incidents where every engine on an aircraft was hit by a bird over 2kg in weight. Table 5 shows the number of engine ingestions in relation to the number of engines present for each incident.

Table 5 Number of engines struck in relation to number of engines on the aircraft for impacts with birds over 2kg in weight.

	NUMBER OF ENGINES STRUCK			
No. OF ENGINES ON THE AIRCRAFT	**1**	**2**	**3**	**4**
1	12			

2	290	17		
3	24	5	1	
4	38	2	1	1

Discussion

Limitations imposed by poor data quality

Inconsistent reporting by countries, incomplete reporting of birdstrikes within countries and errors in bird identification all combine to make the interpretation of these data extremely difficult. Compiling trends in the number of strikes with large birds using the entire dataset is impossible. It may be possible to discern trends in a limited range of countries, where reporting standards are thought to be good and which have reported consistently over a significant period are selected (Bell in press). However, if this is done, the number of strikes in the sample becomes very small. The unknown level of inaccuracies involving bird identification mean that a small number of errors could significantly influence such a sample to the extent where calculated trends become unreliable. For example in the UK, where a comprehensive reporting regime has been in place for many years, an average of less than 2 strikes with birds over 2kg have been reported each year between 1983 and 1998. One or two inaccurate identifications would profoundly influence how such a dataset is interpreted.

If trends in birdstrike frequency are to be accurately monitored, it is advisable to select a representative sub-set of the countries that report to ICAO and which have good internal reporting mechanisms. If these countries can be encouraged to report each year then the data submitted can be used to monitor changes in strike frequency and these can be accurately corrected for changes in aircraft movements and bird populations in the countries concerned (Bell, in press).

The likely total of incidents with large birds world wide

Despite the concerns about data quality described above, it is possible to use the data obtained so far to make some crude estimates of the true frequency of strikes with birds over 2kg in weight world wide. In order to achieve this estimates are needed of a number of parameters:

- The proportion of strikes with birds over 2kg that are reported within those countries submitting data to ICAO.
- The impact of undetected inaccuracies within the data on the analysis
- The numbers and behaviour of birds over 2kg in those countries which do not report compared to those that do.
- The number of air transport movements in those countries that report and those that do not.

At present some of this information is available, but much either does not exist, or requires extensive interpretation to produce the estimates required. Further development of the database, combined with studies to determine the other information needed, will allow a more reliable estimate of the risk to aircraft from collisions with large flocking bird species to be made in the future.

Conclusion

The difficulties encountered in interpreting the available data, which arise from incomplete or inaccurate information being submitted, or from inconsistent reporting by national organisations, illustrate the importance of recording and reporting birdstrike incidents. Even allowing for the fact that birdstrikes with large birds, and especially those with flocks, are more likely to be reported, it is probable that the database established for this project contains only a fraction of the incidents that have actually occurred. Nevertheless, some broad conclusions can be drawn from the data available, and as more data are collected, predictions and estimates can be refined and the true level of risk from large flocking birds determined. Hopefully, these data can be used to inform future decisions on aircraft certification standards.

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