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THE IMPLICATIONS OF RECENT SERIOUS BIRDSTRIKE ACCIDENTS AND MULTIPLE ENGINE INGESTIONS

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ABSTRACT

The paper provides details of three recent accidents to multi-engined aircraft due to birds resulting in the death of 58 people. These were to four-engined military aircraft having implications for the airline world. The paper also examines 10 years of data from incidents where UK registered airliners suffered ingestion in more than one engine. Analysis of the 73 cases (1.7% of 4268 reported birdstrikes) shows that the rate for this type of incident varies from 3 per million flights on twin engined airlines to 8 on three-engined airliners and 5 on four-engined. In one case, on the latter, all four engines had to be changed. The strike rate is significant in safety terms. Gulls *(Larus spp)* were involved in 47% of the incidents followed by Lapwings *(Vanellus vanellus)* with 15%, i.e. 'controllable' species. These percentages are similar to those for all birdstrike incidents. Bird population data shows that the UK inland wintering population of both small and large gulls has risen steadily during the last 40 years, thus increasing the likelihood of such incidents. The threat from small birds e.g. starlings *(Sturnus vulgaris),* to turboprop aircraft, cannot be overlooked. Comparison with data from all bird strikes revealed that multi-engined strikes were more likely at dawn and dusk, but less likely during the day, possibly when flocks of birds were more easily seen by airport staff. The majority (76%) of incidents were at a height that was compatible with the aircraft being on or within the airport boundary. The paper concludes that the current level of risk can be reduced by the more rigorous application of established bird control measures on airports using proven technology supported by scientific assessment of the effectiveness of new technologies in order to reduce the likelihood of bird/aircraft encounters. With the CAA and FAA's declared intention of improving aviation safety during the next decade, bird hazards are one of the areas of risk.

Keywords: Statistics, Bird populations, Engines

(This paper is the work of an individual and may not reflect the full and final views of the UK Civil Aviation Authority)

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THE IMPLICATIONS OF RECENT SERIOUS BIRD STRIKE ACCIDENTS AND MULTIPLE ENGINE INGESTIONS

1 Introduction

a. Over 50 civil aircraft have been destroyed with the loss of 190 lives as a result of colliding with birds or attempting to avoid them. The accident resulting in the greatest number of fatalities was the Lockheed Electra here in Boston (starlings *Sturnus vulgaris, wt 80g)* on 4 October 1960 which killed 62 people. This accident was the result of bird ingestion into three engines. Multiple bird engine ingestion is still regarded as the major threat for civil aviation.

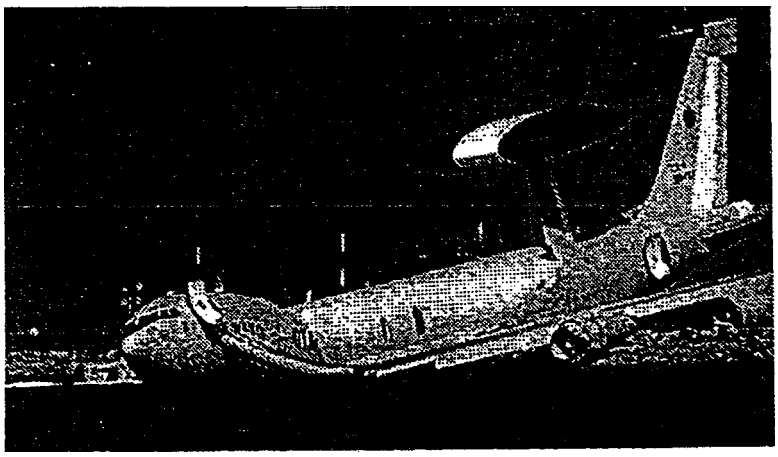
b. Up to and including 1994, over 170 military aircraft have been destroyed as a result of collision with birds with at least 34 occupants and 3 civilians on the ground killed. Most were single or twin engined fighter or attack aircraft. At least two cases were multiple engine ingestion in four-engined aircraft:
   - a Nimrod maritime reconnaissance aircraft in 1980 making an early morning take-off at Kinloss in Scotland after collision with Black-headed and Common gulls *(Larus ridibundus and Larus canes, wt 275g and 420g)* resulted in 2 deaths,
   - a non-fatal over-run as a result of a suspected gull ingestion in 1976 by a Victor flight re-fuelling tanker at Marham, Norfolk, UK,
   - although a BIB bomber was lost in 1987 in Colorado, killing 3 of the 6 crew, the cause **was a** structural penetration which ruptured fuel and hydraulic lines resulting in an intense fire. This **was** during a low level training flight and thus not associated with aerodrome problems. The bird was an American white pelican *(Pelecanus erythrorhynchos, wt 7.3kg, 161b).*

c. The first and only fatal accident to a jet turbine powered airliner was in 1988 at Bahar Dar in Ethiopia when 35 people were killed following ingestion of Speckled pigeons *(Columba guinea, wt 320g)* in both JT8D engines of a Boeing 737. This is the only fatal accident in over 500 million flying hours by jet turbine airliners. Statistically this might be considered a satisfactory record. However, a number of fatal accidents have occurred to turboprop powered airliners and to executive jet aircraft.

2 Recent Accidents

a. On 22 September 1995, a JT3D engined Boeing E3 AWACS, based on the B707 4 engined airliner, was making an early morning departure from Elmdorf USAF base Anchorage, Alaska, USA. Just after the heavily loaded aircraft lifted off a large flock of Eastern Canada geese *(Branta canadensis canadensis, wt 7kg, 15* 16) were encountered. Birds were ingested in engines 3 and 4, rendering the aircraft unflyable. It crashed on rising ground approximately 40 seconds later killing the 24 crew. The flock of geese were known to frequent the aerodrome and *had probably been alarmed by a C130 which departed shortly before the AWACS.*

b. At Aktion Air Force Base in Greece, another Boeing AWACS was taking off on 14 July 1996. Just beyond the point of rotation a large black bird was seen close to the aircraft moving from left to right. The crew heard a noise on the right-hand side of the aircraft and the aircraft continued to accelerate for another 2-3 seconds at which point the commander initiated a rejected take-off, at a speed beyond that calculated and briefed. The aircraft over-ran the runway into a lake, resulting in the aircraft being severely damaged, the fuselage fractured etc. Of the 14 crew all escaped, one suffering back injuries. Subsequently, it was found that engine 3 had been struck (bird species unknown) but not damaged. The commander's decision to abandon take-off was influenced by his belief the aircraft had suffered a strike in spite of a bird control programme at Aktion and by his knowledge of the Alaskan accident.



c. On 15 July 1996, a Belgian Air Force C130 Hercules was approaching Eindhoven, Netherlands. Shortly -before landing, a go-around was initiated because of a large number of birds near the end of the runway. Many birds impacted the left wing area and cockpit and engines 1 and 2 lost power, but the crew feathered engine 3. With engine 4 at full power the aircraft turned left, lost altitude and impacted on the airfield close to the runway. A severe fire broke out but owing to lack of coordination of the fire and rescue efforts and jammed exits 34 of the 41 on board died because it had been thought that the only occupants were the four crew. Shortly before the Hercules landed a flock of birds was observed from the control tower, on and around the runway close to the tower. They were then driven away by several bird scaring rounds being fired from the tower. The flock subsequently moved away and were not observed again. Just before the aircraft landed, the bird scarer and Air Traffic Control checked the end of the runway for presence of birds, none were seen. Subsequent investigation showed that there were *between 500 and 600 starlings (Sturnus vulgaris), together with a few lapwings (Vanellus vanellus, wt 215g),* most of which were presumably in the grass around the runway. The grass had been mown several days before with the cuttings still lying on the ground. If the birds were in that area, they would have been very difficult to see. It is believed the birds were scared by the approaching aircraft.

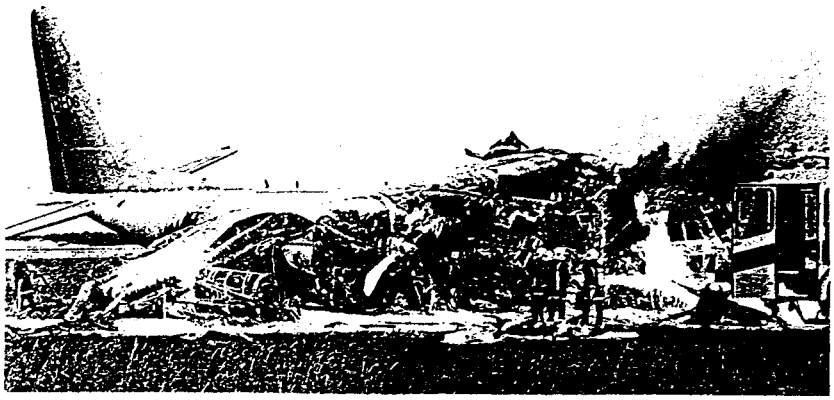


Photo: Regionale Politic Brabant Zuid-Oost

d. All three of these recent accidents were to military aircraft of a type similar to civil aircraft, at airfields with a bird control programme. Birds are unlikely to be influenced by aircraft colour schemes, logos etc, so these accidents could easily have involved civil aircraft.

3 UK Airline Multiple Engine Ingestions

a. Number of Cases

During the period 1986 to 1995 UK registered aircraft over 5700kg (12,500 1b), experienced 73 cases of more than one engine being struck by birds. During the period UK airliners reported 4268 bird strike incidents, thus the 73 events constitute 1.7% of the total.

b. Number of Engines Installed in Aircraft - see Table 1

- 52 of the events were to twin-engined aircraft where birds were ingested by BOTH engines (an incident rate of 3 per million flights)
- 5 incidents involved aircraft with three engines (a rate of 8 per million flights, based on a small sample size)
- 16 were to four-engined aircraft (a rate of 5 per million flights).

c. Damage

Once a flock of birds has been encountered, the damage that results is a matter of the airworthiness standard (i.e. age) that the engine was designed to withstand, together with a degree of luck in that the bird remains may exit via the fan by-pass without damage. Although full details of the resulting damage are sometimes not provided by the reporter, only those cases where repairs or replacement are necessary, have been counted as damage. It appears that out of the 73 events there were 6 cases of both engines being damaged on twin engine aircraft. This is a rate of 1.4 per million flights. When aircraft with three engines are considered, there was one case of two engines being damaged in 0.3 million movements. Information on four-engined aircraft shows two cases of two engines being damaged and one serious incident where all four engines were damaged and had to be changed. Those occurred in 1.6 million aircraft movements.

- The extent of damage may in future years show a reduction as engines tested with the

recent more stringent requirements, come into service. However, some older engines which pre-date the requirements for testing against multiple medium birds, will remain in service for many years. Thus, the only real solution is to reduce encounters with flocks of such a size that they can affect more than one engine.

d. Which Engine Positions were Struck

On four-engined aircraft, where known, the two engines on the same side were struck in 75% of cases, leaving only 25% for the other combinations.

e. Phase of Flight – Table 2

Similar percentage of strikes occurred during the take-off run and climb (the critical phases of flight when the aircraft is heavy and engines are at a high power setting), compared with during approach and landing. In some cases, the bird impacts were prior to decision speed VI with enough runway remaining for the aircraft to stop. During the approach and landing phase when the power settings are lower, damage is less severe and not as hazardous.

f. Bird Species – see Table 3

Much as before, gulls were involved in 47% of the events, similar to their percentage involvement in all bird strike incidents. The same applies to lapwings (Vanellus vanellus) (15%). Nearly all (90%) of the events where the species was known involved birds for which there are known and well tried control procedures.

g. Bird Populations

Figure 1 shows the steady increase in UK inland wintering gull populations during the last 40 years (Ref 1). This sort of population expansion has occurred in other species, e.g. Canada geese *(Branta canadensis)* Figure 2 and Cormorants *(Phalacrocorax* sp) (Ref 2, 3, 4, 5). Steps may need to be taken as soon as possible to deal with these rising populations before further accidents occur. A public relations exercise may have to target the environmental protection lobby to persuade them of the need for firm action, which will also assist the survival of other bird species, which are also threatened by these population explosions.

Figure 1 UK Wintering Gull Population

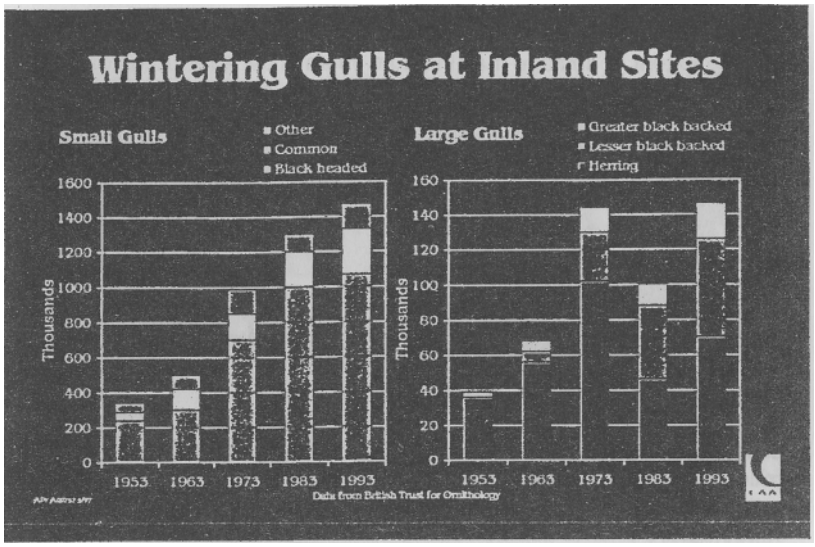
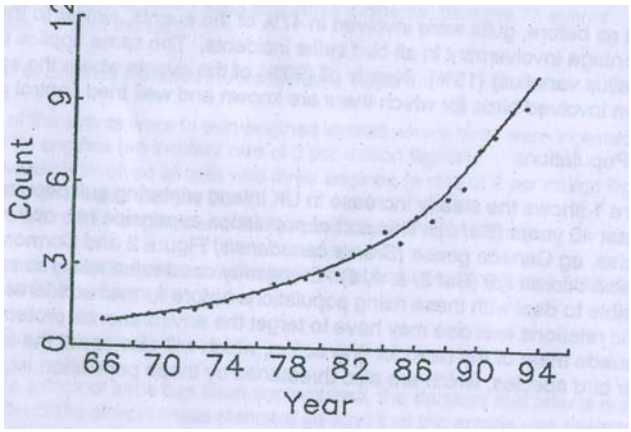


Figure 2 North American Canada Goose Population



h. Airports – see Table 4

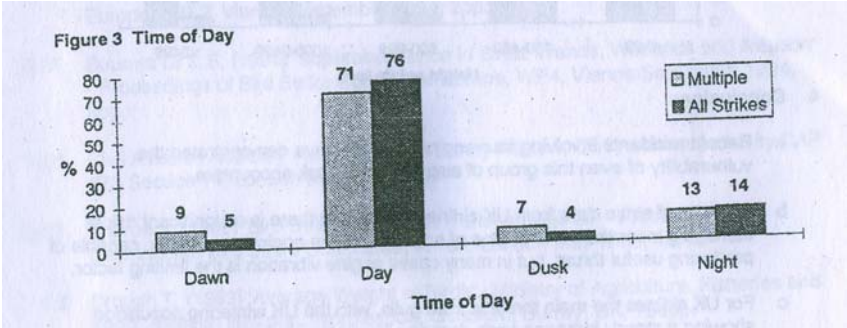
It appears that 60% of the multiple engine incidents suffered by UK airlines occurred at UK airports but it is not know whether this simply reflects the proportion of movements. The UK's busiest airport is Heathrow and it is not surprising that a significant number of events have occurred there. In a similar vein, Palma, Spain is heavily used by most, if not all, UK charter airlines.

i. Time of Date – see Figure 3 below

Particularly in summer, the majority of flights are in daylight and the periods of time categorised as dawn and dusk are short compared with lengthy day and night. Comparison between the time of day when multiple ingestions occur and when all strikes occur (using data from 1976-1995 for UK airlines) (Ref 6) shows that multiple engine strikes were a greater proportion of the total at dawn and dusk, and a smaller

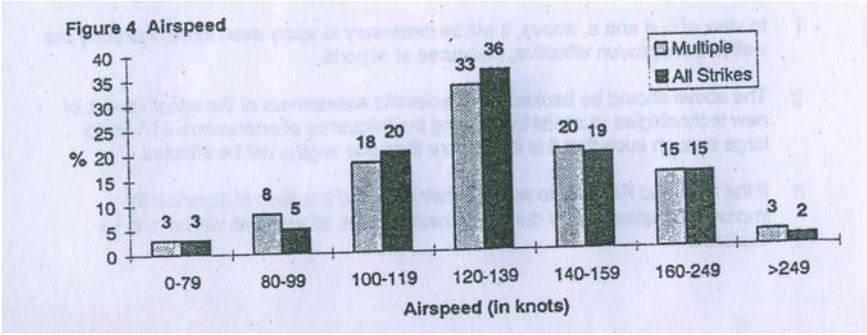
proportion in daylight, perhaps because bird control staff are better able to see flocks of birds. The percentages at night comparing all strikes and multiple strikes are almost identical. It might be thought that this emphasises the need for enhanced measures to detect flocks of birds on the airfield when detection is difficult due to poor light. The comparatively high percentage of all strikes which are during the night should not be overlooked as tile number of night aircraft movements are generally restricted for noise reasons.

Figure 3 Time of Day



j. Airspeed – see Figure 4 below

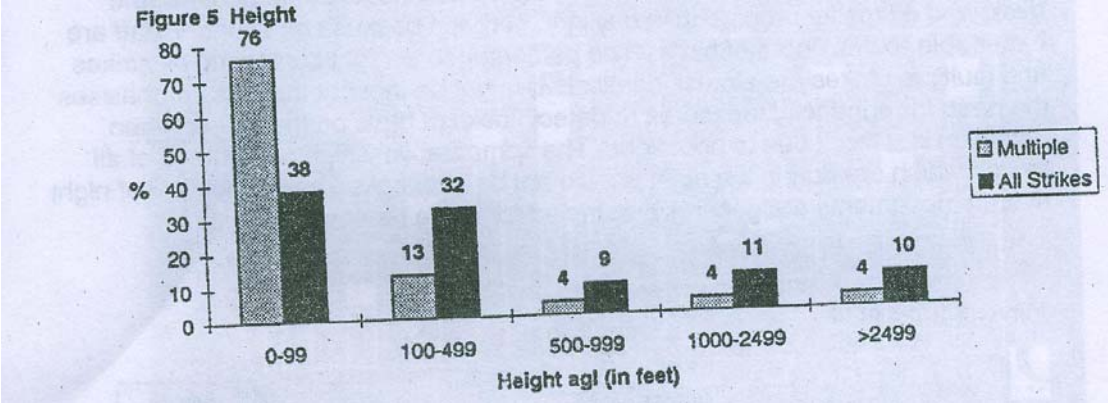
Examination of the aircraft's airspeed when the multiple events occurred shows that there is almost no difference from the percentages in each speed band when ail strikes are examined.



k. Height – see Figure 5 below

When the height bands, i.e. above ground level, of the strikes is examined it is clear that in the multiple strike events, a much greater percentage, 76%, compared with 38% of all strikes, are between 0 and 99ft. The percentages in the other height bands is corresponding much less. This shows that the vast majority of multiple engine encounters occur either on the runway or within the airport boundary.

Figure 5 Height



4 Conclusions

a. Recent accidents involving four-engined aircraft have demonstrated the vulnerability of even this group of aircraft to bird flock encounters.
b. 10 years of strike data from UK airlines shows that there is a significant risk of damaging more than one engine of an airliner. The engine may still be capable of producing useful thrust, but in many cases engine vibration is the limiting factor.
c. For UK airlines the main threat is from gulls, with the UK wintering population showing a steady increase each decade. There are similar population increases in different species, e.g. Canada geese, in other parts of the world. Steps should be taken to persuade environmentalists of the need for action to curb this expansions before it is too late.
d. The threat from small birds which flock densely, e.g. starlings, must not be overlooked, particularly with turboprop aircraft.
e. The majority of muitiple engine strikes occurs on the runway or within the airport boundary.
f. In view of c, d and e, above, it will be necessary to apply even more rigorously the well known, proven effective, measures at airports.
g. The above should be backed up by scientific assessment of the effectiveness of new technologies to assist in reducing the frequency of encounters with flocks large enough such that it is likely more than one engine will be affected.
h. If the CAA and FAA are to achieve their declared intention of significantly improving aviation safety during the next decade, all avenues will have to be explored.

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UK AIRLINES 1986 TO 1995

Table 1 - Number of Installed Engines/Damage

Number of Installed Engines	Multiple Strike Events	Estimated aircraft Movements* (Ref 7)	Number of Engines Damaged				
			1	2	3	4	Nil
2	52	8.32 million	9	6	-	-	37
3	5	0.29 million	1	1	0	-	3
4	16	1.64 million	2	2	0	1	12
	73	10.26	12	9	0	1	52

* 2 Movements per flight

Table 2 – Phase of Flight

Phase	Number of Events	%
Take-off run	19	26
Climb	18	25
Descent	1	1
Approach	21	29
Landing Roll	13	18
Unknown	1	-
TOTAL	73	

Note: In Tables 1 to 3 the percentage quoted **excludes** unknown.

Table 3 – Bird Species

Species	Mean weight (Ref 8)	Multiple Engine Strikes		All Strikes (Ref 9)
		Number	%	%
'Gull' (*Larus sp)*	up to 1.8kg	16	27	25
Black-headed gull (*Larus ridibundus)*	275g	9	15	8
Herring gull (*Larus argentatus)*	1.1kg	2	3	2.5
Lesser black back (*Larus fuscus)*	820g	1	2	0.5
Total gulls		28	47	39.5
Lapwing (*Vanellus vanellus)*	215g	12	20	13.6
Swift/swallow/martin	up to 80g	5	8	10.9
Golden plover (*Pluvialis apricaria)*	185g	4	7	0.4
Starling (*Sturnus vulgaris)*	80g	3	5	1.7
Oyster catcher (*Haematopus ostralegus)*	500g	2	3	0.3
Partridge (*Perdix perdix)*	400g	2	3	0.9
Pigeon (*Columba sp)*	up to 456g	2	3	6.6
Skua (Stercorarius sp)	up to 1.6kg	1	2	0
Duck (*Anas sp)*		1	2	0.5
(Unknown)		(15)		

Table 4 - Airport

UK		Foreign	
Heathrow	7	Palma - Spain	4
Belfast Int	6	Venice - Italy	2
Newcastle	3	Preve - Greece	2
Manchester	3	Genoa - Italy	2
Belfast City	3	Melbourne - Australia	2
Teesside	2	Dalaman - Turkey	2
Edinburgh	2	Airports with one event	15
Birmingham	2		
Southend	2		
Blackpool	2		
Gatwick	2		
Sumburgh	2		
Airports with one event	8		
Total	45	Total	29