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RECENT PUBLICATIONS ON BIRDS AND AVIATION

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SUMMARY

The Paper contains brief details of publication on birds and aviation, which are known to the Author, produced since the previous BSCE Meeting (May 1990). Details of each publication and its availability have been included. The Paper is divided into Research, Bird Control Measures, Statistics and Engine Studies.

Issue 1 is being tabled at the Jerusalem BSCE Meeting. At the meeting it is expected that details of further publications will become available, and these will be included such that an Issue 2 can be included in the Proceedings.

1. BIRD RESEARCH

a. ***'Physiological Response of Birds to Approaching Aircraft'*** Ref: DOT/FAA/CT-91/14 Dated October 1991. The 91 page American Quarto-sized Report is available from Technical Information Service, Springfield, Virginia, 22161, USA.

SUMMARY

The laboratory study exposed birds to video scenes of aircraft during the take-off roll. Equipment to monitor the heart rate of the bird included a harness fitted with an Electrocardiogram (ECG) transmitter. The test birds were Laughing gulls *(Larus atricilla)* and Feral pigeons *(Columba livia domestica)* captured on or adjacent to Corpus Christi and San Antonio International Airports. Pigeons acclimated to airport sights and sounds were compared with pigeons not acclimated to airports. The video scenes of approaching aircraft caused heart rate increase in the unacclimated pigeons several seconds sooner than the acclimated birds, and the unacclimated pigeons were more responsive to the sound, as well as the sight, of approaching aircraft. Gulls and pigeons acclimated to airports used sight first, then sight-and-sound, and sound last as an indication of approaching aircraft during the video test.

The test birds equipped with ECG transmitters were positioned beside the active runway of San Antonio International Airport in individual cages.

The birds heart rate data were collected and stored on equipment in a mobile laboratory placed at the safety lines of a taxiway that crossed the active runway at the 4,000 ft mark. This distance from the start of the take-off roll gave the bird a view of aircraft during the rotation phases.

Aircraft tested included the 737-200, 737-300, 727-100, 727-200, DC-9, MD-80 and 767-100. The 24 test birds were exposed to over 100 aircraft departures during the test period from January through May 1990. The aircraft rotation was identified on the recorded data when the nose wheel left the ground during the take-off roll.

Statistical analysis of the recorded data was conducted and results from the analyses of variances were tested at the 5 percent level of significance. Birds exposed to the 767 wide-body aircraft experienced statistically higher maximum heart rates on the average than the other four (standard-body) aircraft. Gulls had a significantly higher average maximum heart rate than pigeons when tested at the aircraft rotation point response interval. The interval showed a higher percent change after take-off than before take-off. Gulls did not indicate by maximum heart rate response as much change as the Feral pigeons during the maximum sound response interval when the data was normalised by control tests.

Analysis of the closure rate of the aircraft to the test bird location indicated the bird response did not change significantly until the aircraft approach was within 1,000 feet of the bird. The aircraft velocity rate increase over this distance closes on the bird between 150 to 200 ft per second. The bird would have about 5 seconds to clear before impact with the aircraft. Early warning devices to alert the bird to approaching aircraft would need to be deployed prior to 10 seconds to allow the bird time to depart the runway area.

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b. ***'The Diagnostic*** Brom. The 279 p and similarities of The characteristic identification key Zoologie, Univers Netherlands.

2. BIRD CONTRO

a. ***'Les Oiseaux de*** French Aerodrom published in Fre Lecourbe, 75732

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3. STATISTICS

a. ***'Bird Strikes to*** American Quart Technical Servi Ottawa, Ontario

b. ***'Etude Statisti Annees 1988 a*** Published Sept

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b. ***'The Diagnostic and Phylogenetic Significance of Feather Structures'*** author Tim G Brom. The 279 page American Quarto-sized book is in English and describes the differences and similarities of the microscopic characteristics of bird feathers for identification purposes. The characteristics of the downy barbs of 350 mainly Palearctic birds are described and an identification key is presented. The Book is available from Instituut Voor Taxonomische Zoologie, University of Amsterdam, Mauritskade 61, Postbus 4766, 1009 AT Amsterdam, Netherlands.

2. BIRD CONTROL MEASURES

a. ***'Les Oiseaux des Aerodromes Francais, Prevantion du Peril avaiare'*** (The birds of French Aerodromes, prevention of Risk) by Jean-Luc Briot, Alain Eudot and Marc Laty published in French by Service Technique de La Navigation Aerienne, STNA/2NA 246 Rue Lecourbe, 75732 Paris CEDEX 15, France.

The 64 page A5 sized booklet describes each bird species with excellent colour illustrations. It includes the migration, behaviour on aerodromes, distribution across Europe at each time of year and most effective control method.

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b. ***'Bird Control on Aerodromes'***, CAP384 Published by UK Civil Aviation Authority, 37 Gratton Road, Cheltenham, Glos, England, GL50 2BN.

The 66 page A5 sized booklet published July 1990 covers bird identification and behaviour, habitat management, detection and dispersal methods and equipment. It contains colour illustrations and is intended to provide guidance to aerodrome operators on the measures which can be taken to produce effectlve bird control at an aerodrome.

3. STATISTICS

a. ***'Bird Strikes to Canadian Aircraft'*** 1984-88 Summary Report, Ref TP10574E. The 27 page American Quarto-sized data summary published during 1990 is available from Safety & Technical Services, Environmental Review Services Airports Group, Transport Canada, Ottawa, Ontario K1A 0N8, Canada.

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b. ***'Etude Statistique des Collisions Oiseaux - aeronefs survenues en France durant Les Annees 1988 and 1989'*** Ref 007/STNA/2S, by Monsieur J L Briot and Monsieur A Eudot. Published September 1990.

The 47 page A4 sized paper in French summarises and analyses the data for the two year period. There had been a 20% increase in number of bird strikes compared with the previous two year period, the strike rate was similar. There were 66 cases of damage. A Summary in English is included. The address is given in paragraph 2a.

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c. ***'Analysis of Bird strikes Reported by European Airlines 1981-1985'***, CAA Paper 92004 by J Thorpe. Available from Civil Aviation Authority, 37 Gratton Road, Cheltenham, Glos, England, GL50 2BN. The price is £3.55 inclusive of post and packing or £4.45 for overseas surface mail. The Paper was included in the proceedings of BSCE 20, Helsinki May 1990 as WP 28. The 31 page A4 sized paper summarises and analyses almost 7,500 strikes from 14 countries.

4. ENGINE STUDIES

a. ***'Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft (October 1986-September 1989)'***. Ref DOT/FAA/CT-90/28 dated October 1991. The 179 page American Quarto-sized publication is available from National Technical Information Service, Springfield, Virginia 22161, USA.

SUMMARY

An investigation was initiated by the Federal Aviation Administration Technical Center in September 1986 to determine the number, weight, and species of birds which are ingested into medium and large inlet area turbofan engines during world-wide service operation and to determine what damage, if any, results. This report summarises the three years of Boeing 737 (B737) data that were collected to support this effort. The first year of data is published under report number DOT/FAA/CT-89/16 (1). The first and second years of data are summarised together and published under report number DOT/FAA/CT-89/29 (2).

A total of 8.91 million aircraft operations were flown by B737 commercial aircraft during the three year period of which Pratt and Whitney JT8D medium inlet area turbofan engines accounted for 71.8% and 28.2% were with CFM International CFM56 large inlet area turbofan engines.

During the three years of data collection, birds were ingested by one or both engines during 1,076 aircraft operation which yields a probability of aircraft ingestion of 1.21×10^{-4}. One or more birds were ingested into both engines of the aircraft during 31 of the 1,076 aircraft ingestion events. Thus, a total of 1,107 engine ingestion events were reported during the data collection period. There were 17.82 million engine operations during this period which yields a probability of engine ingestion of 6.21×10^{-5}. A conclusion of these data is that bird ingestion events are rare, but probable events.

When the species of the ingested bird was reliably identified, the most commonly ingested birds were from the order charadriiformes (shorebirds) - primarily gulls, lapwings, and plovers. The majority of ingested birds (155 of 167) weighed 1.13 kg or less. The bird weight distribution of ingested birds in the United States (284 gm) was smaller than the distribution of birds (397 gm) in foreign countries. Four birds larger than 1.86 kg were ingested abroad; whereas, only one bird larger than 1.86 kg was ingested in the United States. The bird ingestion rate within the United States was significantly lower than the foreign bird ingestion rate.

The majority of aircraft ingestion events (972 of 1,076) involved a single bird and a single engine on the aircraft. The remaining 104 aircraft ingestion events involved multiple birds and/or multiple engines.

Engine damage occurred in 45% of all engine ingestion events and there were 175 engine ingestions that resulted in engine damage classified as moderately severe or worse.

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SUMMARY

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The majority (578 of 718) of aircraft ingestion events, for which the phase of flight was known, occurred within the airport environment during take-off and landing. The probability of engine damage is greater when the bird ingestion occurs during the take-off and climb phases of flight than when it occurs during approach and landing. Aircraft airspeed at or above 140 kts also increases the probability of engine damage.

It was determined that 3.8% of all engine bird ingestion events resulted in an engine failure. Five engine failures were caused by birds that weighed less than or equal to 450 gm. Engine failures are also more likely to occur when multiple birds are ingested into an engine.

The following summary shows the most pertinent statistics extracted from the three yeas of data for the B737 aircraft:

Probability of Ingestion Per Aircraft Operation	
World-wide	1.21×10^{-4}
United States	0.59×10^{-4}
Foreign	1.94×10^{-4}
Engines Experiencing Moderate/Severe Damage	175
Multiple Bird, Engine Ingestion Events	89
Dual Engine Aircraft Ingestion Events	31
Dual Engine, Multiple Bird Aircraft Ingestion Events	11
Single Engine, Multiple Bird Aircraft Ingestion Events	73
Aircraft ingestion Events By Phase-of-Flight	
Take-off and Climb Phase-of-Flight	63.8%
Approach and Landing	33.4%

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1. ***'Study of Bird Ingestions into Small Inlet Area Aircraft Turbine Engines (May 1987 to April 1989)'***. Ref DOT/FAA/CT-90/13 dated December 1990. The 78 page report is available from address in paragraph 4a.

SUMMARY

An investigation was initiated by the Federal Aviation Administration (FAA) Technical Center in May 1987 to determine the numbers, weight, and species of birds which are ingested into small inlet area turbofan and turboprop engines during world-wide service operation and to determine what damage, if any, results. Small inlet area engines are defined as those engines having an inlet area up to approximately 1,400 square inches. This report presents an analysis of the two years of data. The purpose of the analysis is to assist the FAA in evaluating certification test requirements for such engines. In particular, this report presents information concerning ingestion events as related to time of day, phase of flight, month, location and bird species and weight.

Throughout the world during that time there were approximately 16 million operations by the engines included in the data (ALF502, TFE731, TPE331 and JT15D). This figure includes 24 months of operations for the first 3 engines and 12 months of operation for the fourth. A total of 210 engine ingestion events were reported during this period. The probability of an engine ingestion event occurring is 1.3×10^{-5} per operation. Thus, the ingestion of a bird is a rare but not impossible occurrence.

Within the United States, the most frequently ingested bird weight is 113 gm, while outside the United States, the most frequently ingested bird weight is 223 gm.

It was found that ingestions occurred more frequently in the daytime than at night. More than likely this is the result of 2 factors: fewer aircraft flight at night and more birds flying In the daytime.

It was determined that the engine ingestions could be described adequately by a Poisson distribution. This made is possible to test hypotheses about the relationship between engine size and ingestion rate. The data are consistent with the hypothesis that ingestion rates are directly related to engine cross section area. It was determined that the ingestion experience of the turboprop engine was different from that of the turbofan engines, but the reasons for this difference could not be determined.

It was observed that the same number of engine ingestion events occurred in the combined take-off/climb phases of flight as in the combined approach/landing phases of flight. The ration of landing events to approach was close to one (55:45), whereas the ratio of take-off events to climb events exceeded 10 (91:9). Less than 5% of all ingestion events occurred during taxi or at cruise altitude.

Engine damage occurred in 50% of all engine ingestion events, and it was not the case that there was a threshold bird weight such that smaller birds did no damage and larger birds always caused damage. Instead, the probability of damage increased with bird weight. However, in some events small birds caused damage, while in other events larger birds caused no damage at all. Probability of damage versus bird weight curves were computed from the data. Also, the probability of engine damage is greater when the bird ingestion occurs during the take-off and climb phases of flight than when it occurs during approach and landing. Aircraft airspeed at or above 140 knots also increases the probability of engine damage.

It was determined that 5% of all engine bird ingestion events resulted in an engine failure. Four engine failures were caused by birds that weighed more than 1.86 kg and 2 were caused by birds that weighed less than 225 gm. Engine failures are also more likely to occur when multiple birds are ingested into an engine.

Probability of Ingestion per Engine Operation	
World-wide (all engine types)	1.3×10^{-5}
United States (JT15D engine excluded)	1.04×10^{-5}
Foreign (JT15D engine excluded)	1.922×10^{-5}
Most Commonly Ingested Bird	
United States	Dove
Foreign	Lapwing
Engines Experiencing Moderate/Severe Damage	
Turbofans	41
Turboprops	2

5. GENERAL

'Vogel und Luftverkehr' All aspects of bird strike problem. Two Journals per year. In German with English Summary. Approximately 60 pages A5 size. 15 DM per annum from Bird Strike Committee Germany, Fröschenpuhl 6, D-5580 Traben-Trarbach, Germany.

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