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COMMERCIAL TRANSPORT ENGINE GEOGRAPHIC BIRD THREATS & TRENDS

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Summary

Following a brief introduction, this paper provides statistics on the relative bird threat for selected geographic regions compared to that in North America, using recorded "damaging" bird ingestion events on CF6 engines. Statistics on trends, as well as threat level, are provided. The data shows that certain regions and countries have achieved a marked improvement in level of bird threat since 1980, whereas other countries with a high bird threat appear to have done little or nothing to reduce the threat. Although new engines will have increased birdstrike capability, the older engines will remain in service for many years. It will always be necessary for airport operators and regulatory authorities to ensure that extreme ingestion encounters are avoided. Effective airport bird hazard controls are needed now and must be maintained in the future.

Key Words: Engineering, Engines, Statistics, Flock Density, Civil Aviation, Certification Standards, Avoidance

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1.0 INTRODUCTION

Modern aircraft engines have achieved a high level of reliability while manufacturers and users continually strive to further improve the safety record. The major safety concern today includes common-cause events which involve power loss of more than one engine. These are externally-inflicted occurrences, with the most frequent being encounters with flocks of birds.

Bird ingestion damage to aircraft turbine engines has presented a safety hazard and an economic cost problem since before the start of jet transport operations. Today costly and dangerous birdstrike incidents continue to occur in civil transport operations on and around airports. However, with the advent of high bypass turbofan engines with their larger intake capture areas and larger diameter fan rotor blades, the frequency of bird ingestions has increased - being roughly proportional to the inlet size.

To reduce bird ingestion hazards, more aggressive corrective measures are needed in international air transport to reduce the chances of serious incidents or accidents from bird ingestion encounters. Air transport authorities must continue to take preventative and avoidance actions to counter the threat of birdstrikes to aircraft.

This paper provides statistics on the relative bird threat for selected geographic regions compared to that in North America, using recorded "damaging" bird ingestion events on wide body commercial transport aircraft powered by CF6 engines. Statistics on trends, as well as threat level, are provided. The data shows that certain regions and countries have achieved a marked improvement in level of bird threat since 1980, whereas other countries with a high bird threat have done little or nothing to reduce the threat.

The historical record shows that birdstrikes to engines have caused major accidents with fatalities on two large commercial transports since 1960 and have resulted in at least 12 other events classified as accidents because of the severity of the consequences. Bird ingestions into the engines of business jets and military surveillance transport aircraft have also resulted in accidents with fatalities - most notably the September 22, 1995 crash at Elmendorf Air Force Base near Anchorage, Alaska, where two of four engines were heavily damaged after an AWACs plane flew into a flock of Canada geese during departure.

1.1 Revenue Service Bird Ingestion Data

Bird ingestion events on GE and CFMI engines are reported to the manufacturer by field service representative, operators, and regulatory authorities. Overall, reporting has been good, especially on bird ingestion events that cause engine damage. This data is used to monitor the worldwide bird threat and to evaluate how well GE and CFMI engines have met this threat. Lessons learned from factory and revenue service events are then factored into new and derivative growth engine models, as well as existing engine models, where appropriate.

Reported data is used to identify those airports with potential bird hazards and, where appropriate, we have advised the authorities of our concern. The statistics presented in this paper were based on bird ingestions on CF6 engines from 1972 through 1995.

1.2 Engine Example for Reference

High-bypass turbofan engines, as illustrated in Figure 1, power today's large commercial transports because of their high thrust capabilities and low specific fuel consumption. Such engines produce over 60,000 pounds of thrust and typically have inlet capture areas of 5000 square inches and more. A schematic of the fan section of a typical high-bypass turbofan engine is shown in Figure 2.

Although the increased frequency of bird ingestions is primarily a result of larger forward capture areas, another factor has been increased exposure to geographic regions with higher bird threats, as will be presented later in this paper.

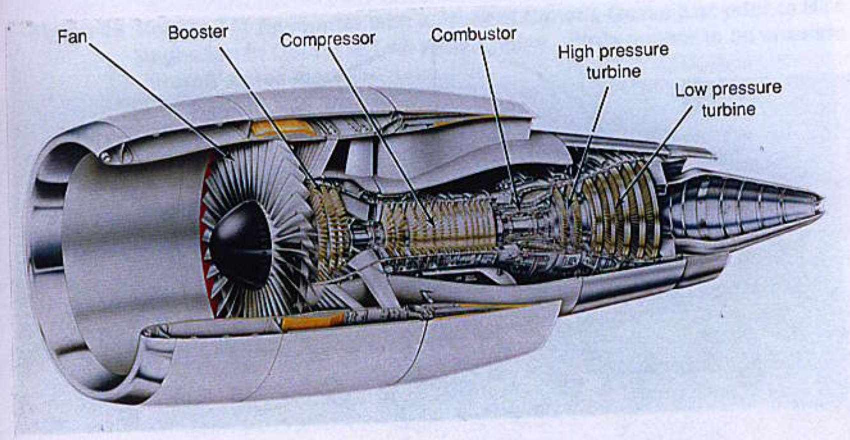

Figure 1 Propulsion System of a Modern Transport

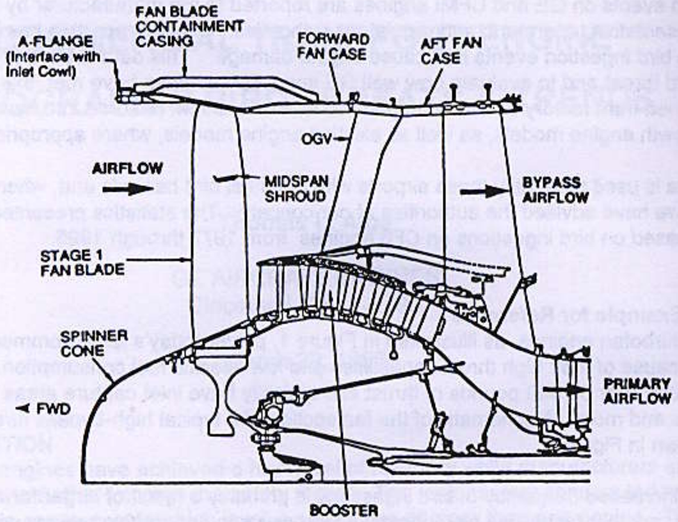

Figure 2 Typical Fan Module Components

Over 98 percent of approximately 6000 commercial CF6 and CFM bird ingestion events have occurred at or near airports during the takeoff, initial climb, final approach, and landing flight phases as shown in Figure 3. Thus, bird control efforts and bird avoidance techniques must be focused at airports and nearby environs.

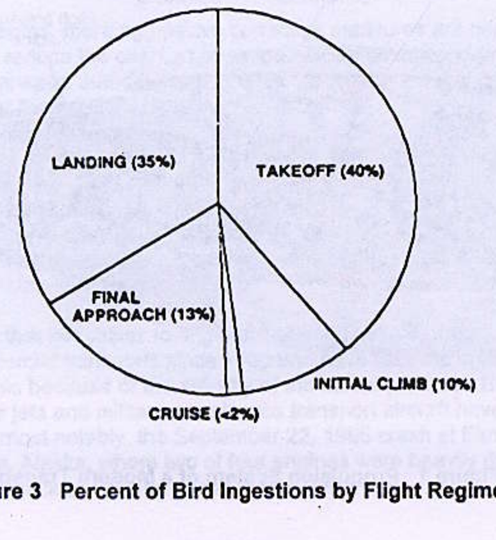

Figure 3 Percent of Bird Ingestions by Flight Regime

2.0 THREAT POSED BY LARGE FLOCKING BIRDS

The frequency of ingesting large birds in migratory or intermediate flocks has been very low. An illustration however of a Boeing 747 encounter with a flock of Greater Canada Geese on approach to Calgary in 1992 is shown in Figures 4a and 4b. This event resulted in one goose being ingested in the left outboard engine. Damage to the engine was heavy but there was no significant power loss. However, encounters with flocks of geese which weigh an average of about 8 pounds each can be severe, e.g., the 1995 AWACs accident at Elmendorf near Anchorage.

Figure 4a Boeing 747 Encounter with a Flock of Canada Geese just prior to Bird Ingestion in Outboard Left Wing Engine. Birds appear to be unaware of aircraft's presence.

Figure 4b Same Event a short time later. Birds are now aware of aircraft and have initiated evasive actions.

4.3 Bird Threat in North America

Progress in North America, as shown by country in Figure 6, was attributed primarily to efforts in Canada since 1980. This was a direct result of the dedication of Transport Canada, the airport managers in Canada, and airport bird patrol teams. The active bird-control patrols using their whistles and poppers and the use of trained predator birds at some locations have been effective. The high traffic at selected airports in the United States has a tendency to keep birds flushed from the active airport runways and may, along with active bird hazard control programs, be contributing factors to the relatively low damaging rates in North America.

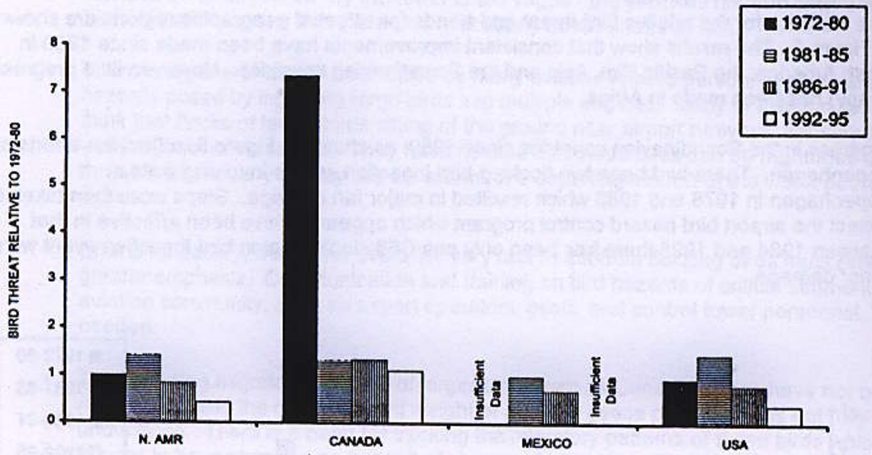

Figure 6 Bird Threat and Trends in North America

4.4 Bird Threat in Europe

In Europe, there has been some progress overall in reducing damaging bird ingestion events, although the rate of damaging bird ingestions is over twice that of North America - based on these statistics. Most European countries have made progress as shown in Figure 7. Yet, there are high traffic locations in Europe, as well as elsewhere, with high bird activity, such as Amsterdam, Frankfurt, and Paris. It will remain a challenge to the airport authorities to control birds at these airports. There also appears to be a growing herring gull threat at coastal airports in the eastern Mediterranean countries based on CFM56 engine data, which is not fully reflected in the CF6 statistics presented here.

In the United Kingdom, the recent increase in the rate of damaging bird ingestions is consistent with reports of a 35 percent increase in birdstrike activity at their airports in 1995. This may reflect growing bird populations or reduced government funding in support of airport bird hazard control studies, which may have led to a reduced focus on controlling birds at airports.

In France, major efforts have been taken by the DGAC to establish bird control programs at all French airports. These efforts include monitoring and tracking the birdstrikes at airports in France and implementing improvements in airport bird controls where needed. At the end of 1991, one hundred French airports had bird hazard control programs in place, in accordance with French regulations. Now the world watches to see if the bird control programs there will be effective.

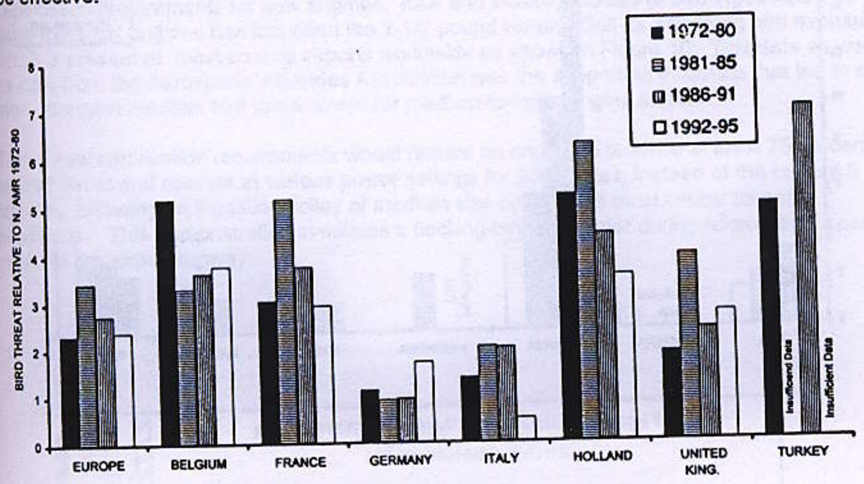

Figure 7 Bird Threat and Trends in Europe

4.5 Bird Threat in Asia

The reduced bird threat in Asia has been attributed primarily to efforts initiated in Japan and India as shown in Figures 8 and 9. The benefits in India since 1980 reflect the dedication of the government and the excellent ongoing work being conducted there by their field scientists to reduce the presence near airports of kites, scavenger vultures, and white-backed vultures.

4.6 Bird Threat in Africa

Africa has the highest relative bird threat today in terms of damaging bird ingestions, as shown in Figure 5. The statistics show that overall little, if any, progress has been achieved since 1972. Yet, the bird threats in Egypt and Senegal are relatively low and have been improving. Kenya has also shown improvement since 1991. It appears that the airports in Africa need to take steps to review and improve their airport bird hazard control programs.

4.7 Overview of Results

The results of this analysis of damaging birdstrikes show that where aggressive bird control efforts were undertaken, measurable reductions of damaging rates have been achieved. In other words, the methodology exists and damaging birds can be controlled when the commitment is made.

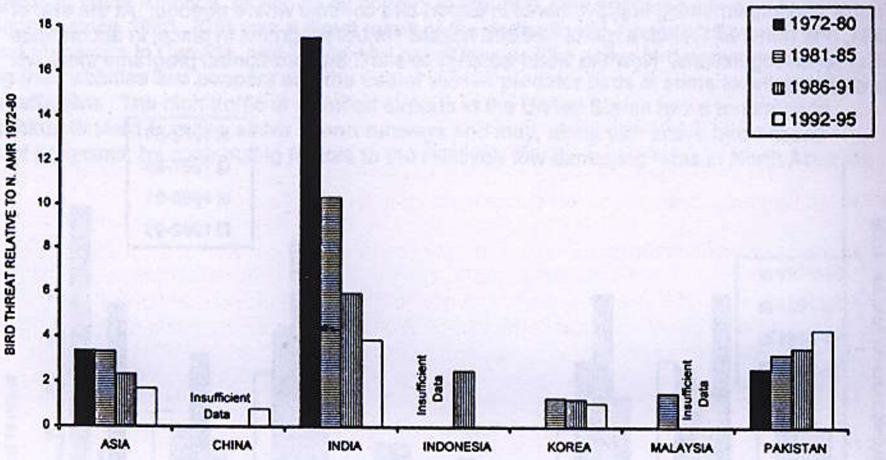

Figure 8 Bird Threat and Trends in Asia

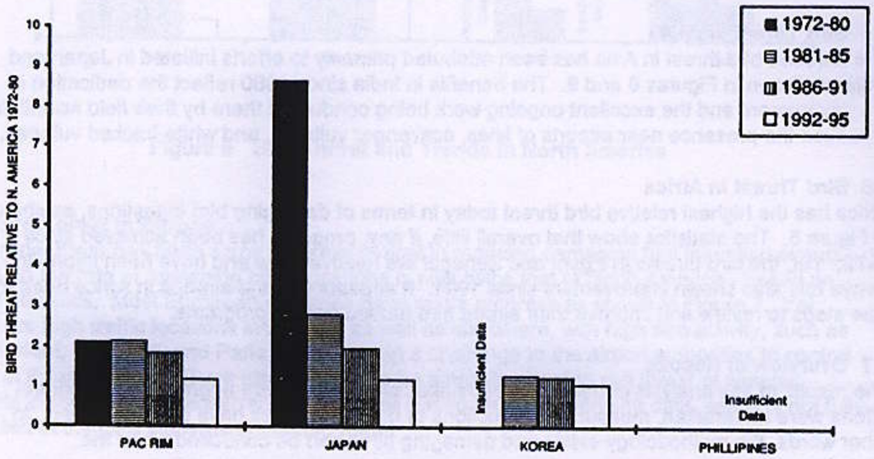

Figure 9 Bird Threat and Trends in Pacific Rim

5.0 NEW CERTIFICATION REQUIREMENTS

5.1 Medium Bird Requirements

The existing requirements for the medium bird address only 1-1/2 pound flocking birds. However, industry and regulatory agencies have been in agreement that both multiple 1-1/2 pound and multiple 2-1/2 pound flocking birds must be addressed as part of the medium bird certification requirements for new engines. FAA and industry studies of bird ingestions into large transport engines had identified the 2-1/2 pound Herring Gull as a flocking bird exposure which is present at most coastal airports worldwide as shown in Figure 10. This data as well as data from the Aerospace Industries Association was the supporting evidence that led to a more stringent medium bird requirement for medium-to-large engine sizes.

These new certification requirements would require an engine to produce at least 75 percent of takeoff thrust and operate at various power settings for 20 minutes, instead of the current 5 minutes, following an ingestion volley of medium size birds at the most critical takeoff conditions. This demonstration simulates a flocking-bird encounter during takeoff and a safe return to the airport runway.

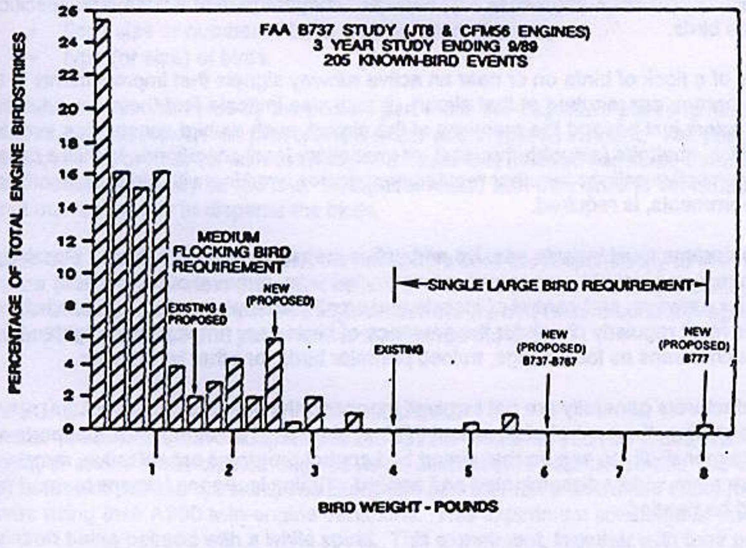

Figure 10 Worldwide Bird Exposure from FAA B737 Study

5.2 Large Bird Requirements

The demonstration of a single large bird ingestion at climb conditions represents a typical inflight encounter of a larger vulture or waterfowl. For this ingestion, the engine must be capable of being safely shut down within 15 seconds and not result in a condition potentially hazardous to the aircraft. The current certification requirement through 1995 for medium to large high bypass ratio engines has been the 4 pound bird.

A more stringent single large bird certification requirement has been proposed that increases the size of the large bird to 6 pounds for engine inlet sizes of 2100 to 6000 square inches, i.e. for B737, A340, MD11 and B767 aircraft. For very large engines with inlet areas greater than 6000 square inches, such as on B777 aircraft, the single large bird size would increase to 8 pounds.

6.0 CONTROLLING BIRDS AT AIRPORTS

The behavior of birds, like humans, reflects their need and search for food, water, shelter, and companionship. Unfortunately, many airports with uncontrolled vegetation and insects, water drainage problems, and geographic location near oceans and lakes are attractive to birds. These bird attractions in the proximity of airports must be identified in order to deter birds in their daily travels from nesting or roosting areas in their search for food from crossing airport runways and flight paths as well as resting on or near runways. Airport bird hazard control programs must include knowledge of bird types, when they frequent the area, and specific needs of these birds.

The presence of a flock of birds on or near an active runway signals that improvements in the bird control program are required at that airport. It may also indicate that there are adverse contributing factors just beyond the premises of the airport, such as bird sanctuaries, crops, garbage landfills, abattoirs (slaughterhouses), or unsanitary local conditions. In these cases, the need for corrective actions by other regulatory agencies, working with airport authorities and local governments, is required.

Bird control programs must include passive and active measures that deter birds. Passive airport terrain features include proper surface water drainage, removal of undesirable vegetation near runways, and control of insects and small mammals. Active bird hazard control patrols must regularly check for the presence of birds near runways and frighten them away using such means as loud bangs, trained predator birds, or other techniques.

Engine manufacturers generally are not involved in, nor do they have directly useful experience regarding, the control of birds and FOD at airports. The authorities at airports must assume this responsibility to assure that airport bird control programs are effective, remain active, and are more widely disseminated and applied. Timing is urgent: lessons learned from history should be heeded:

- In 1987, the authorities in Ethiopia had been advised of a safety threat from flocking birds due to a lack of adequate airport bird hazard controls in that country. In 1988, during a revenue service departure from Bahar Dar, Ethiopia, a Boeing 737-200 ingested birds in both engines and lost power. While attempting an off-airport landing, the aircraft struck a river bank and burned which resulted in fatalities. Today, substantially improved airport bird hazard controls are in place in Ethiopia.

- On 22 September 1995, a US Air Force AWACs aircraft encountered a flock of Canada Geese during takeoff rotation from Elmendorf Air Force Base near Anchorage, Alaska. Canada Geese had been roosting near the departure runway. Investigation determined that both left wing engines ingested geese and lost power. The aircraft crashed and all crew members were fatally injured. In July of 1995, the USAF Bird Aircraft Strike Hazard (BASH) Team had visited Elmendorf and identified habitat problem relative to the presence of flocks of Canada geese. Not all of the BASH Team recommendations had been implemented on the date of the accident.

7.0 BIRD AVOIDANCE GUIDELINES

Recognizing that the bird threat appears to be growing worldwide, the following guidelines are proposed to aid in pilot training and awareness of bird threats in the skies we fly.

Pilot educational training, both initial and recurrent training, must include an awareness of what constitutes a bird hazard threat and the possible consequences. It must be recognized that the worst threat is from flocking birds, especially gulls, kites, pigeons, and waterfowl (geese/ducks) - due to the potential for a multiple engine power loss. Encounters with birds must be avoided. Pilots must not challenge the birds.

Effective Pilot Communication with the control tower in response to reports of "bird activity in the airport vicinity" is needed to determine key facts on the severity of the bird threat, such as:

- the locations of the birds with respect to the active runway and flight plan,
- flock size or number of birds and direction of travel,
- type (or size) of birds.

Bird avoidance procedures by the pilot as part of his pre-departure planning may be the best method of, and last resort for, preventing a major bird ingestion incident. The presence of flocking birds on or near an active runway is a threat that must be corrected before an aircraft departs - afterwards may be too late. Bird patrol teams with their ground vehicles may need to be sent out repeatedly to disperse the birds.

Effective bird avoidance requires that control towers take the responsibility to alert crews to the presence of birds on or near the active runways. Pilots must take the responsibility to avoid the birds where possible. Airport managers must assure bird hazard control programs are in place and include active bird patrol teams to disperse the birds.

8.0 VISUAL ALERTING PATTERNS ON SPINNERS

A number of operators have adopted painted spinner patterns, such as swirls, marquees, commas, or snake eyes, on their engines as an attempt to reduce birdstrikes. To evaluate the effectiveness of painted spinners, one European operator ran a controlled experiment on their spinners using their A300 twin-engine transports. This experiment consisted of one spinner per aircraft being painted with a white spiral. This experiment, together with their prior unpainted spinner experience, is summarized below:

Painted Spinner	No. of Engines	No. of Ingestions	Accumulated Engine Cycles	Ingestion Rate per 1000 Cycles
Yes	13	14	16,819	0.832
No	17	44	52,342	0.840

The message from this experiment was that the white spiral on the blade spinner had no appreciable benefit in terms of a reduced bird ingestion rate.

From a ground safety perspective, however, painted patterns on spinners serve as good visual alerts for ground maintenance crews to indicate when the engine is windmilling or rotating at low speeds. This should reduce the risk of injuries from contact with the turning spinners and blades.

This author is unaware of any conclusive scientific information or significant statistical data that has shown a proven long-term benefit in terms of reducing bird ingestions from painted spinners or the use of landing lights or strobe lights.

9.0 SUMMARY

Birds are one of our world's most precious resources and need to be protected. However, their presence at and around airports poses a safety threat to aircraft operations. Birds in flocks must be avoided or diverted.

Airport bird hazard control programs should be reviewed with particular emphasis on the control of flocking birds, such as gulls, pigeons, waterfowl (geese/ducks), etc.

Pilot initial and recurrent educational training must emphasize an awareness of what constitutes a bird hazard threat and the possible consequences. Pilots must not challenge the birds!

The worldwide air transport industry must address bird ingestion threats. It must begin now to take those corrective measures that would be carried out in the aftermath of a major accident resulting from an ingestion-caused multiple-engine power loss.

The following on-going activities need to be addressed to reduce the bird threat to aviation:

- Airport managers must make sure that effective bird control programs are being implemented on a regular basis. It needs to be recognized that existing fleets of engines will remain in service for many years.
- Flight Crews, recognizing that bird control programs will never be 100 percent effective, must avoid flocking encounters. Threats must be corrected before an aircraft departs or lands; afterwards may be too late.
- Regulatory agencies must issue the more stringent bird ingestion certification requirements now being proposed for new engines.

Two recent major transport accidents with multiple fatalities (the 1988 B737-200 accident at Bahar Dar and the 1995 accident at Elmendorf), other events classified as accidents because of the severity of the consequences, and a number of near misses emphasize the high degree of importance attached to effective monitoring and control of birds at and near airports.

The data presented in this paper on the experience with damaging bird encounters on aircraft engines clearly shows that the methodology exists and damaging birds can be controlled when the commitment is made.

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