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Transport Canada
Environment and Support Services
18C, Place de Ville
Ottawa, Ontario
K1A 0N8

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Our file notre référence

June 25, 1996

AKP 5158-36-20-51

All Members/Participants
Bird Strike Committee Canada

Dear Member/Participant:

Please find enclosed the minutes from Bird Strike Committee Canada meeting #24 which was held in Richmond, British Columbia on April 10 and 11, 1996. In addition, a copy of the 1995 Bird Strikes to Canadian Aircraft Summary Report has been included. If you have questions or comments on either document, please feel free to contact the undersigned.

Bird Strike Committee Canada meeting #25 will be held in Ottawa, Ontario, on Wednesday, November 6 and Thursday, November 7, 1996. The meeting will commence at 0830 on Wednesday, at the Citadel Inn, 101 Lyon Street, in downtown Ottawa. There is a block of rooms reserved under Transport Canada, Bird Strike Committee Canada, at \$81.00 per night single, and \$91.00 for a double. We recommend that you book your room soon. The toll free reservation number is 1-800-567-3600.

If you have agenda items or wish to contribute a paper for presentation, please call Bruce MacKinnon at 613-990-0515 before September 30.

We look forward to seeing you in Ottawa, and if you have any questions or comments, please contact the undersigned.

Regards,

Bruce MacKinnon
Manager, Wildlife Control

Canada

BIRD STRIKE COMMITTEE CANADA
MEETING 24, APRIL 10 & 11, 1996

CO-CHAIRS:

Mario Larose, Department of National Defence and Bruce MacKinnon, Transport Canada

MINUTES PREPARED BY: Carol Nishitoba, Kristine Sitwell

Transport Canada, Airports Group, Safety and Technical Services

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Minutes of the 24th meeting of Bird Strike Committee Canada

**April 10 and 11, 1996
Delta Pacific Resort and Conference Centre
Richmond, British Columbia, Canada**

1.0 Introduction and Welcome

Larry LeGros, Regional Director, Transport Canada Airports, gave the official welcome to all of the attendees. He stressed the importance of having a wide variety of attendees from all sectors of the aviation community because of the down-sizing of Transport Canada, the National Airports Policy, and the transfer of airports to CAA's and municipalities.

2.0 Introduction of Attendees

Terry Thompson, Alistair Pinos, and Dave Arrington were not able to attend the meeting.

3.0 Review of the Minutes/BSCC 23 Action Items

An amendment was made by Rob Certain to the BSCC 23 minutes. He stated that Benomyl did not reduce the worm problem at CFB Trenton by 85%. Rather, they were studying the effect of Benomyl to see how effective it really is.

BSCC 23 action items 1 ("Funding sources for the electrophoresis project"), 2 ("TDC projects related to Bird Hazards"), and 3 ("Waste Disposal Industry involvement with BSCC") were covered during the meeting, while item 4 ("Paper from Air Canada re: communication of bird presence") was left for reconsideration, item 5 ("Development of pilot support and guidelines for re-thinking takeoff in presence of birds") was left to airlines and pilots to discuss, and item 6 ("BSCC Logo") has been moved for discussion at BSCC 25.

4.0 Bird Strike Summary Reports

4.1 Department of National Defence (DND)

Mario Larose presented the DND strike statistics. He informed us that bird strike incidents have not increased. He also informed us that the number of bird strikes at the aerodrome have been decreasing since 1991 but increased slightly last year. The reason for this could be due to improved reporting.

4.2 Transport Canada (TC)

Transport Canada statistics were presented by Bruce MacKinnon. Bruce pointed out that the TC statistics also included DND statistics. He informed us that there was a 28% increase in the number of reported bird strikes in 1995 compared to 1994, but this could be due to better reporting and increased awareness. In 1995 Vancouver had the highest number of total strikes for the second year in a row, while Yarmouth had the highest strike rate. Bruce also pointed out that Sandspit Airport, which had a high strike rate because of its location, was not on the top 21 strike rate list.

4.3 United States Air Force (USAF)

USAF statistics were presented by Eugene LeBoeuf. He stated that the USAF bird strike totals were stable, and the statistics were relatively similar to both TC's and DND's. The USAF reported 1406 bird strike incidents last year with 36% of them occurring during daylight hours, and that there was no one dominant bird species struck. He did point out that only 0.5% of the 1995 strikes occurred in October, which was odd compared to other years. Also, greater focus needs to be placed on preventing low level strikes given that it is an area where pilots and airports have the most control. Eugene stressed the importance of everyone in the aviation community working together to make flying safer.

4.4 Canadian Airlines International

Darryl Watkins discussed recent problems with ducks at Calgary International Airport. Large flocks of ducks feed in fields north of the airport property and rest south of it on the Bow River. The ducks fly above the runway anywhere from 4 to 100 feet despite -30°C temperatures. Two ducks were hit within a two and a half week period in early 1996. He informed us that in the spring the airport will work to make the area less hospitable to waterfowl.

He also informed us that Canadian Airlines had just installed new food compactors and bins at Vancouver International Airport to reduce the number of gulls and crows.

There was no report from the International Civil Aviation Organization (ICAO) data due to the absence of Alistair Pinos.

5.0 Future Role and Activities of BSCC

The draft BSCC terms of reference that have been amended by Mario Larose were distributed for review before the next BSCC meeting in November. The role of BSCC and future initiatives may be discussed at BSCC 25.

It was also decided that the original text of the terms of reference would be distributed with the BSCC 24 minutes.

6.0 BFI Case Study - Winnipeg

Mike McKernan of TetraES Consultants presented a case study on the Integrated Waste Management Facility in Rosser, Manitoba. Mike presented the idea of a "host community" and the importance of the different siting approaches that BFI used. The five year process began in January 1991 and included a three and a half year public consultation process in search of a host community. BFI used a new approach to site selection through public consultation, keeping an "open door" policy with citizens' involvement and timelines established by the client. Communities were asked for permission, and offered technology in return. New regulations make it difficult for municipalities to finance a project like this on their own. Therefore a regional solution was needed.

Site selection criteria for this project were solely provincial, and there was minimal federal involvement. The study team was initially unaware of air safety issues related to bird hazards. Transport Canada then intervened creating an opportunity for a remedial process to take place.

Mike McKernan made a strong recommendation that BSCC increase their profile and accessibility to the public and private sectors to prevent similar occurrences from happening again.

7.0 Update - TC Wildlife Control Training Program

Dave Fairbairn stressed the importance of the Wildlife Control Training Program, for it transfers information to those who require it. The new format involves a two day course, and each participant receives a course participant's manual, as well as the Wildlife Control Procedures Manual (TP 11500). The feedback for the new program has been positive. He also informed us that the course can be tailored to any site to enhance the area's wildlife control management plan. Before the course is presented at a site, the area is studied (ecology, risk analysis, movements, etc.) so that all of the factors can be taken into account, making it a practical and site specific course.

8.0 United Airlines - Bird Strike Experience

Darrin Wong informed us that a third of foreign object damage (FOD) to their aircraft were due to bird strikes, and a large majority of these take place in the fall due to migration. FOD damage in the United States is estimated to cost approximately \$320 million a year for all FOD committee members including airports and airlines. Darrin also stressed that not all FODs are reported unless they delay or damage the aircraft. Therefore many bird strikes go unrecorded.

In addition, Darrin stated that the number of bird strikes for United Airlines for January to March 1996 is at 27, a significant increase compared to 12 strikes for the same period in 1995.

9.0 United Airlines - Bird Strike Experience - Sydney, Australia

Darrin Wong informed us that on March 31, 1995, a United Airlines Boeing 747-400 struck a bird with the #3 engine at approximately 2000 ft AGL on climb from Sydney. The pilot shut down the engine, dumped fuel and returned to Sydney. Citizens on the ground reported seeing the aircraft fly through a flock of birds and seeing a bird ingested followed by a flame out of the tail of the engine. Preliminary unconfirmed reports indicate the ingestion of 2 pelicans and damaged fan blades. Visual checks indicated no extreme damage to the core but the engine will be torn down for further inspection. Feather samples have been gathered to determine the species involved. United Airlines and Pratt & Whitney are working together to determine the number of birds ingested.

10.0 Parallel Runway Project at Vancouver International Airport

Five presentations dealt with the programs and measures instituted in order to establish the risk management process related to the Sea Island Conservation Area.

10.1 Blue Ribbon Panel Report

Bruce MacKinnon informed us that in August 1991, the Federal Environmental Assessment Review Office (FEARO) report #40 was released and contained 22 recommendations which dealt with the potential impact of the new runway development. Special attention was given to recommendation #12 which recommended that TC review the birds strike control program and guidelines for land use around airports.

Transport Canada then made a commitment to recommendation #12 and created a 4 part workplan to satisfy its commitment:

- i) Wildlife Control Program at YVR
- ii) The Avifauna Study of Sea Island
- iii) Study of the Interactions between Aviation and Avifauna at YVR
- iv) "Blue Ribbon" Panel of Wildlife and Aviation Experts - Impact Analysis

The 'Blue Ribbon Panel' report was completed in December 1995 and provided a number of recommendations and conclusions which bring to closure the recommendation 12 project.

10.2 SICA Monitoring Project

Gary Searing discussed the anticipated impact the parallel runway project would have on both raptors and Great Blue Herons in the area. The initial goal for the Sea Island Conservation Area (SICA) had been to enhance the area for birds to prevent any net loss of habitat and numbers. He then discussed the importance of enhancing the area for raptors and making the area less suitable for waterfowl which present a greater risk to aviation safety.

Gary then presented the findings of the monitoring project. He stated that the raptor population did increase with the enhancements in 1993 and 1994 but the population dropped back down to pre-construction totals in 1994/1995. He feels this is due to the influence of construction on the new runway.

The number of Great Blue Herons did not change with the enhancements. The number of shore birds did decrease as a result of habitat modification. What was once agricultural land was allowed to grow naturally and the long grass is not suitable for waterfowl.

The study has shown that the birds do not move around as much as originally thought. Gary felt this could be the result of two factors. One is that the enhancement project worked and the bird's needs are being met in the conservation area, therefore they do not have to move. The other possibility is that the disturbance of the construction area has "trapped" the birds in the Sea Island Conservation Area (SICA). Ongoing monitoring is required in order to ensure that bird activity does not affect aircraft operations on the new runway.

10.3 Avian Ecology and Air Traffic Safety at YVR

Mike Demarchi presented findings on the avian ecology study done in SICA. Surveys and radio-telemetry were used to track birds and the results were used to develop conclusions and recommendations by the Blue Ribbon Panel.

In the study he observed that there were a great number of movements of raptors between SICA and the commercial development zone. It was also found that there was no real change in flying and non-flying behaviour when the perch poles were up or down. Therefore no changes were expected in raptor behavior as a result of perch pole enhancements.

10.4 SICA Management Plan

Rick McKelvey of the Canadian Wildlife Service (CWS) discussed the FEARO recommendations which dealt with aviation safety issues and the SICA. He stated that it is important to manage both raptors and herons in SICA and discourage hazardous species. He stressed that the final management plan must maintain existing conservation values while not compromising aviation safety. Rick observed that EARP is linear, thus lacking a feed-back loop if something does not work.

10.5 On Going Management of SICA

Bob Sisler from TC informed us that Vancouver International Airport (YVR) is responsible for the runway construction itself. But YVR, TC and the CWS are working together in order to safely manage the coexistence of the airport and SICA. Two committees have been formed to aid in this process: the SICA Management Steering Committee and the SICA Working Group.

11.0 Wildlife Control Program - YVR - Systems Approach

Richard Koroscil of the Vancouver International Airport Authority presented an overview of YVR's wildlife control program. He stressed that YVR's full time wildlife control program is based on a systems approach. Habitat management and active scare techniques are the main components.

12.0 Assessment of Bird Strike Related Risk Using Event Sequence Analysis

Todd Curtis from Boeing stressed that by using event sequence analysis and determining what has occurred in past accidents you can determine possible future outcomes. He explained to us that by looking at the events leading up to the final consequence and incorporating elements such as human decisions and system failures, you can combine the probabilities of the immediate events to determine the probability of the outcome. An event sequence analysis of the risk of hull loss due to bird strikes was derived from five bird strike accident reports. He determined that 12 events have been directly involved in the outcome of past accidents and four other events that could directly be involved in future accidents. Todd concluded by stressing that the technique is very important because it looks at both dependent and independent events.

With the end of this presentation, the meeting was adjourned for day.

DAY 2

13.0 Bird Strike Damage Rates - Boeing

Todd Curtis from Boeing informed us that different aircraft models have different strike rates and resistance to damage. Bird strike rate per aircraft flight was discovered to be directly related to the frontal area of the aircraft. Approximately 75% of damaging bird strikes involved the engines and nacelle area. Engines associated with smaller aircraft had a notably higher per flight rate of damage due to bird strikes. Recommendations for future action were given.

14.0 Jet Engine Design Parameters - General Electric

Tom Aige from GE stressed that engines must be designed to deal with realistic bird strikes threats and that the most important consideration is the assessment of power loss to more than one engine due to flocking birds. He informed us of new proposed bird certification requirements for engine design. The proposed changes are that a medium flock requirement would change from 1.5 to 2.5 lbs. and that a single large bird requirement would change from 4 to 8 lbs. He also discussed fan blade design requirements to prevent damage. However, he stressed that we must address the control of large flocking birds at airports.

15.0 Wildlife Management Plan - JFK

Steven Garber from JFK presented an overview of JFK's comprehensive wildlife management plan. JFK has had 3500 - 4000 bird strikes over 17 years. In 1995 they had 23 reported bird strikes with 8 causing damage and delays. He stressed the importance of viewing the success of the plan in terms of the number of human lives saved, not in monetary terms.

16.0 Satellite Technology - Wildlife Management

William Seegar presented information on the use of miniature transmitters and the ARGOS satellite system to track birds. Small transmitters that are solar powered are placed on birds so that their location and activities can be monitored. Satellite tracking of birds is being used to look at conservation issues as well as to assess the effects on birds at US military training areas. The use of satellite tracking with other emerging technologies has been proposed to locate and forecast bird movements and migration to aid in the bird strike problem.

William Seegar has been doing extensive studies with birds of prey and has been working to develop a system with Arc/Info levels which would have the capability to look at many interactions at once. He is also working to combine satellite telemetry and real time data to look at the cause and effect relationship between military training and resources. William informed us that with the development of technology and with use of solar power, miniature transmitters that were once 200 grams when they started experimentation now only weigh 17 grams. They are working on developing that technology even further so they can monitor barometric pressure, temperature, motion, altitude, the solar array, battery voltage and humidity, as well as the heart rate and body temperature of the birds. In the future they hope to equip the birds with black and white cameras, acoustic sensors, and GPS.

17.0 Controlling Gulls at a Landfill in Albany, NY

Jim Forbes presented the preliminary findings of a gull control study done at a landfill in Albany, New York. The study started in November 1995 and will finish at the end of April 1996 on a 160 acre landfill with a 5 acre working face. The landfill is located 5 miles from the airport and is on a river which provides a roosting site for gulls.

Observations were conducted over three days in December 1995. On the first day, 5400 gulls and 6000 starlings were counted. By the third day they were able to reduce the number to 400 gulls and 300 starlings with the use of pyrotechnics and some reinforcement shooting. The starlings did not respond as well to the pyrotechnics as the gulls did. The scare techniques also had little effect on raptors.

Jim stressed that the costs of this project have tripled over estimates and advised people planning a similar experiment/study to take that into account.

18.0 Canada Goose Populations in the US

John Seubert showed slides illustrating increases in three Canada goose populations--Central and Mississippi flyways, and the Hiline population. This mid-winter survey information was provided by Dave Sharp, Central Flyway Representative of the Office of Migratory Bird Management, U.S. Fish and Wildlife Service (FWS). John also informed the meeting that the FWS is considering a modification in the system of issuing depredations permits that would authorize states and/or the Animal Plant Health Inspection Service, U.S. Dept. of Agriculture, to control urban and suburban goose populations that cause nuisance, agricultural, health, and safety problems.

19.0 Orders of Business

Missed agenda items will be discussed at the next BSCC meeting, which will take place in November in Ottawa, Ontario.

The Bird Strike Committee USA meeting is in July in Phoenix, Arizona.

At this point, the meeting was adjourned. After lunch, there was a field outing to the Vancouver International Airport to view the Sea Island Conservation Area and the new terminal.

20.0 Action Items generated from BSCC 24

1. Future roles and activities of BSCC.
2. BSCC logo.

**BIRD STRIKE COMMITTEE CANADA
MEETING 24, APRIL 10 & 11, 1996**

LIST OF APPENDICES

1. Organizational Letter
2. BSCC 24 Agenda
3. Department of National Defence Strike Data
4. Transport Canada Bird Strike Data 1995
5. Blue Ribbon Panel Report
6. Ongoing Management of the Sea Island Conservation Area (SICA)
7. Assessment of Bird Strike Accident Risk Using Event Sequence Analysis
8. Commercial Transport Engine Bird-Ingestion Design Consideration
9. John F. Kennedy International Airport Wildlife Management Plan
10. Satellite Telemetry, A Tool for Tracking and Monitoring Bird Movements from a Local to Global Scale
11. A Gull and Starling Control Program at the Colonie Landfill, Cohoes, New York
12. US Department of Agriculture Factsheet - ADC Assistance at Airports
13. Canada Geese Present Hazard to Aircraft as Reflected in the Growing Number of Bird Strikes
14. Smithsonian: What's Good for the Goose may not be good for you. January 1995
15. Superdove on 46th Street
16. December 10, 1995, Polar Air Cargo Incident
17. Canadian Study Finds Greatest Frequency of Bird Strikes to Turbofan and Turboprop Aircraft Below 100 feet in Summer
18. An Update From the BASH Team
19. The "CAPA" Anti Bird-Strike Cartridge
20. FAA Aviation News: Birds Can Be Deadly. January-February 1996
21. When Pilots Meet Birds It Can Be Deadly For Both
22. NTSB Bird Hazard Briefing
23. Argentine Spray Kills Hawks From Canada
24. Jumbo Jet Hits Birds; Engine Explodes
25. Aviation Daily: Bird Ingestion Test. February 1996
26. Air Transport World
27. Collingwood Landfill Issue
28. Addendum

LIST OF APPENDICES

SELECTED PAPERS FROM BSCE 23 MEETING. MAY 13-17, 1996

Appendices 29-35

- 29. Chairman's Report
 - 30. Serious Birdstrike-Related Accidents To Military Aircraft of Europe and Israel: List and Analysis of Circumstances
 - 31. An Aviation Insurer's View of the Situation of Bird Strike Prevention in Germany
 - 32. The Potential For Significant Financial Loss Resulting From Bird Strikes In or Around an Airport
 - 33. Evaluating the Cost of Bird-Related Damage to Civilian and Military Flights as a Vital Tool to Increase Flight Safety
 - 34. BRIS: A Computer Based Bird Remains Identification System. Further Developments
 - 35. Falconry and Bird Control of a Military Airfield and a Waste Disposal Site
-
- 36. USAF Aircraft Accident Investigation Report

APPENDIX 1

Organizational Letter



Transport
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Airports

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Environment and Support Services
18C, Place de Ville
Ottawa, Ontario
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Your file Votre référence

Our file Notre référence

March 18, 1996

AKP5158-36-20-51

Members/Participants
Bird Strike Committee Canada

Dear Member/Participant:

Please find enclosed the final agenda for Bird Strike Committee Canada # 24, which will be held in Richmond, British Columbia on Wednesday, April 10 and Thursday, April 11, 1996. Also, please find enclosed a copy of the BSCC Terms of Reference, which we will be discussing at the meeting. You may wish to review the terms of reference, and be prepared to discuss the future role of BSCC and more cost effective ways of organizing our meetings.

The meeting will commence at 0830 on April 10, and will be held at the Delta Pacific Resort and Conference Centre, 10251 St. Edwards Drive, in Richmond. The toll free reservation number is 1-800-268-1133.

If you have comments on the agenda, or any questions, please call the undersigned at 613-990-0515 or Capt. Mario Larose, at 204-833-2103.

We look forward to seeing you in Richmond.

Regards,

Original Signed by
Original signé par
BRUCE MacKINNON

Bruce MacKinnon
Manager, Wildlife Control

Canada

Made from recovered materials

Fait de papiers récupérés

51-0208 (07-90)

APPENDIX 2

BSCC 24 Agenda

AGENDA TIMETABLE

BIRD STRIKE COMMITTEE CANADA 24TH MEETING

RICHMOND, BRITISH COLUMBIA
APRIL, 1996

Wednesday, April 10, 1996

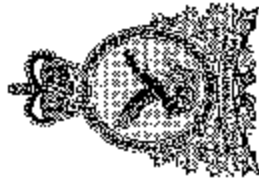
TIME	SUBJECT	SPONSOR
0830 - 0900	COFFEE AND MUFFINS	ALL
0900 - 0905	WELCOME	TRANSPORT CANADA
0905 - 0910	OPENING	MARIO LAROSE
0910 - 0920	INTRODUCTION OF ATTENDEES	MARIO LAROSE
0920 - 0930	REVIEW OF MINUTES - BSCC 23 ACTION ITEMS	MARIO LAROSE
0930 - 0945	BIRD STRIKE SUMMARY REPORTS	DND, TC, AC, CAI, FAA, USAF, ICAO
0945 - 1000	FUTURE ROLE AND ACTIVITIES OF BSCC	ALL
1000 - 1030	COFFEE	ALL
1030 - 1040	FUTURE ROLE AND ACTIVITIES OF BSCC (CONT'D)	ALL
1040 - 1055	BFI CASE STUDY - WINNIPEG	MIKE MCKERNAN
1055 - 1105	UPDATE - TC WILDLIFE CONTROL TRAINING PROGRAM	DAVE FAIRBAIRN
1105 - 1115	UNITED AIRLINES - BIRD STRIKE EXPERIENCE	DARRIN WONG
1115 - 1200	ALASKA AWACS CRASH	DAVE ARRINGTON
1200 - 1300	LUNCH	ALL
1300 - 1315	BLUE RIBBON PANEL REPORT	BRUCE MACKINNON
1315 - 1330	SICA MONITORING PROJECT	GARY SEARING
1330 - 1345	SICA MANAGEMENT PLAN	RICK MCKELVEY
1345 - 1400	ONGOING MANAGEMENT OF SICA	BOB SISLER
1400 - 1420	WILDLIFE CONTROL PROGRAM -YVR- SYSTEMS APPROACH	RICHARD KOROSCIL
1420 - 1450	NTSB INDUSTRY WORKSHOP - JANUARY 11, WASHINGTON, D.C.	DAVE ARRINGTON
1450 - 1515	COFFEE	ALL
1515 - 1535	ASSESSMENT OF BIRD STRIKE RELATED RISK USING EVENT SEQUENCE ANALYSIS	TODD CURTIS
1535 - 1550	JET ENGINE DESIGN PARAMETERS GENERAL ELECTRIC	TOM ALGE
1550 - 1600	BSCC LOGO	MARIO LAROSE BRUCE MACKINNON

Thursday, April 11, 1996

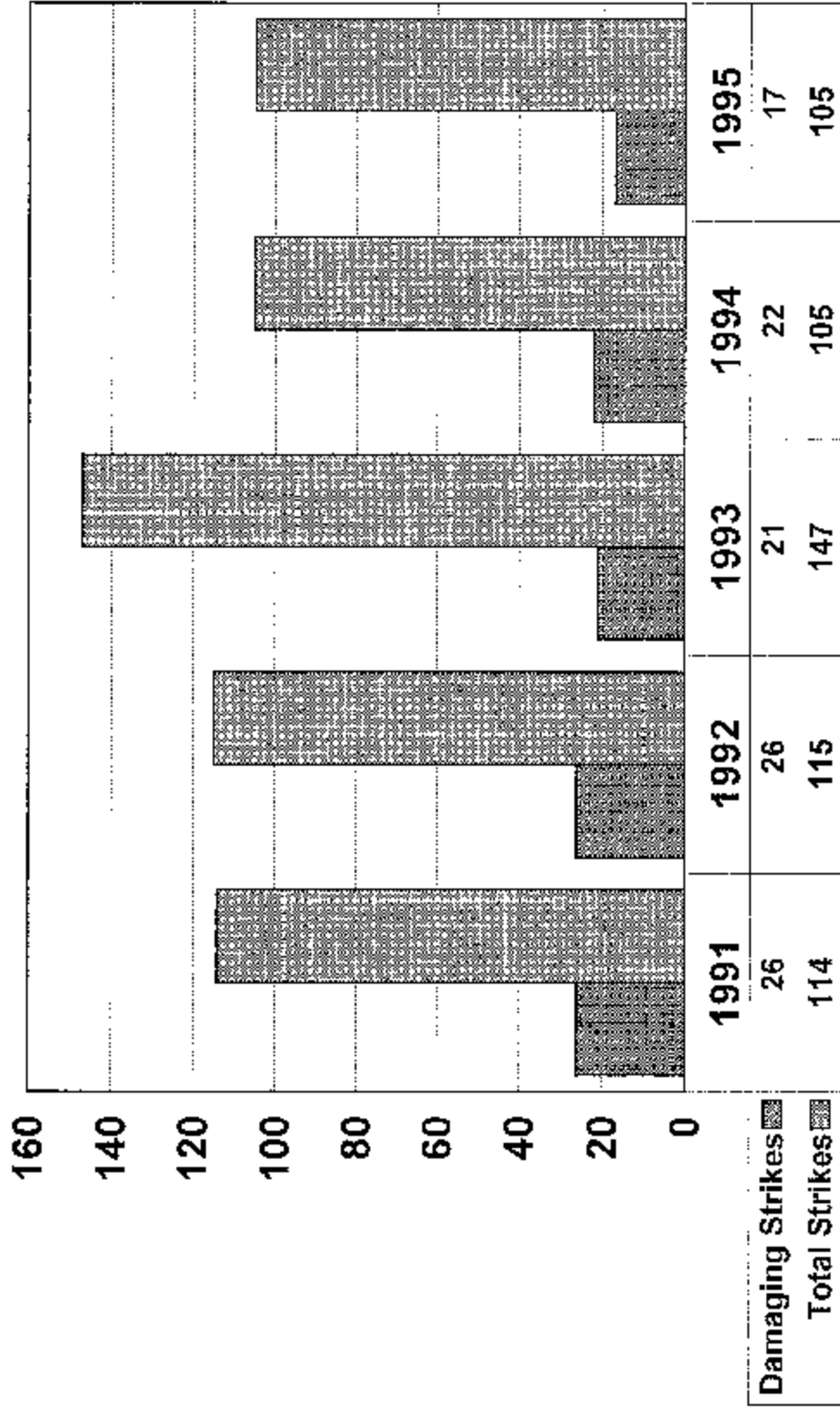
TIME	SUBJECT	SPONSOR
0830 - 0900	COFFEE AND MUFFINS	ALL
0900 - 0910	ELECTROPHORESIS UPDATE	BRUCE MACKINNON
0910 - 0940	WILDLIFE MANAGEMENT PLAN - JFK	STEVE GARBER
0940 - 1010	WILDLIFE CONTROL MANAGEMENT PLAN -CALGARY INTERNATIONAL AIRPORT	TERRY THOMPSON
1010 - 1030	COFFEE	ALL
1030 - 1100	SATELLITE TECHNOLOGY - WILDLIFE MANAGEMENT	WILLIAM SEEGAR
1100 - 1120	CONTROLLING GULLS AT A LANDFILL IN ALBANY, N.Y.	JIM FORBES
1120 - 1130	OTHER BUSINESS	ALL
1130 - 1200	CONCLUSION	MARIO LAROSE BRUCE MACKINNON
1200 - 1300	LUNCH	ALL
1300 - 1600	FIELD TRIP -SICA AND YVR WILDLIFE CONTROL PROGRAM	CRAIG RICHMOND GARY SEARING

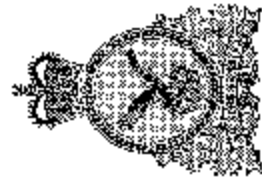
APPENDIX 3

Department of National Defence Strike Data

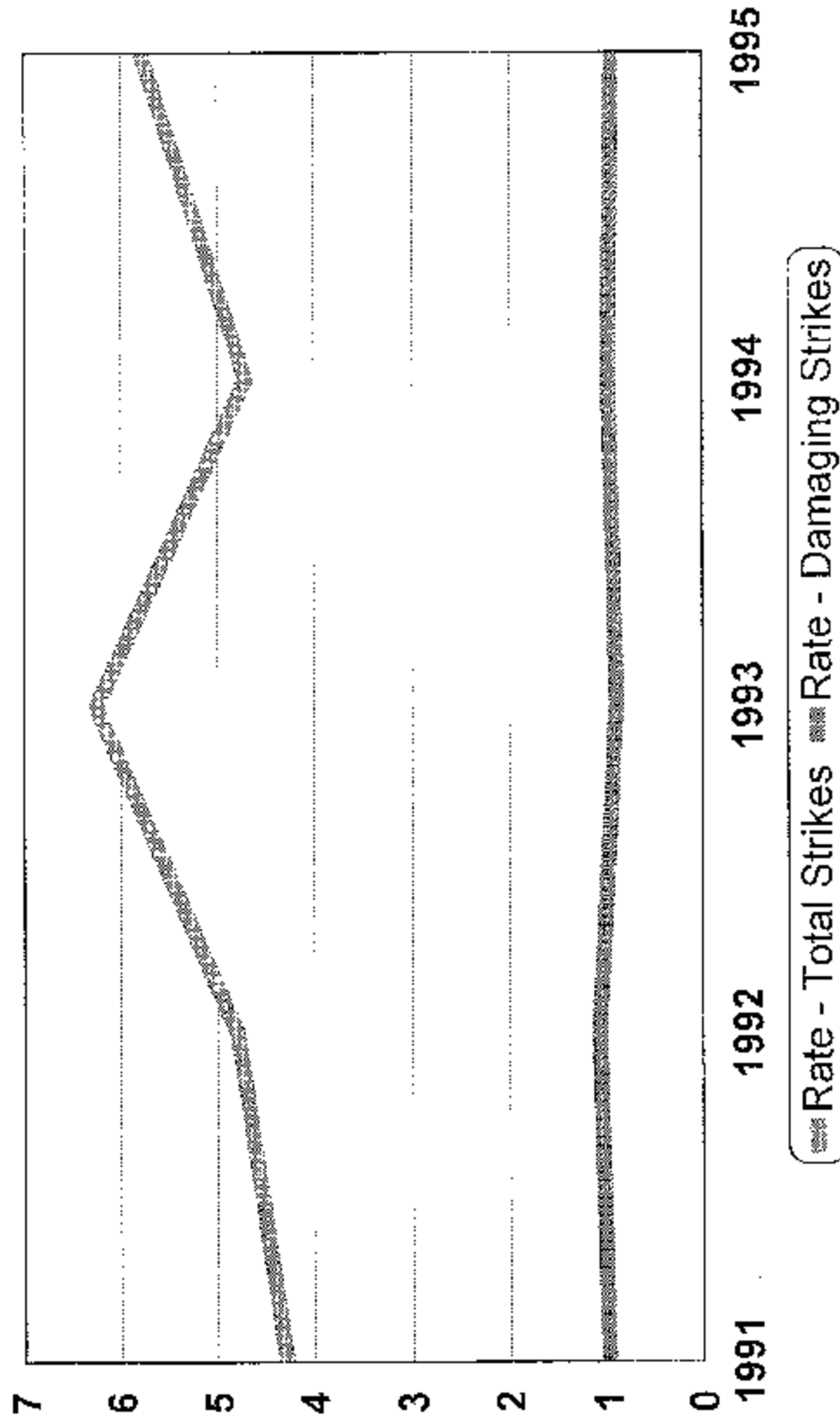


Total Strikes vs Damaging Strikes





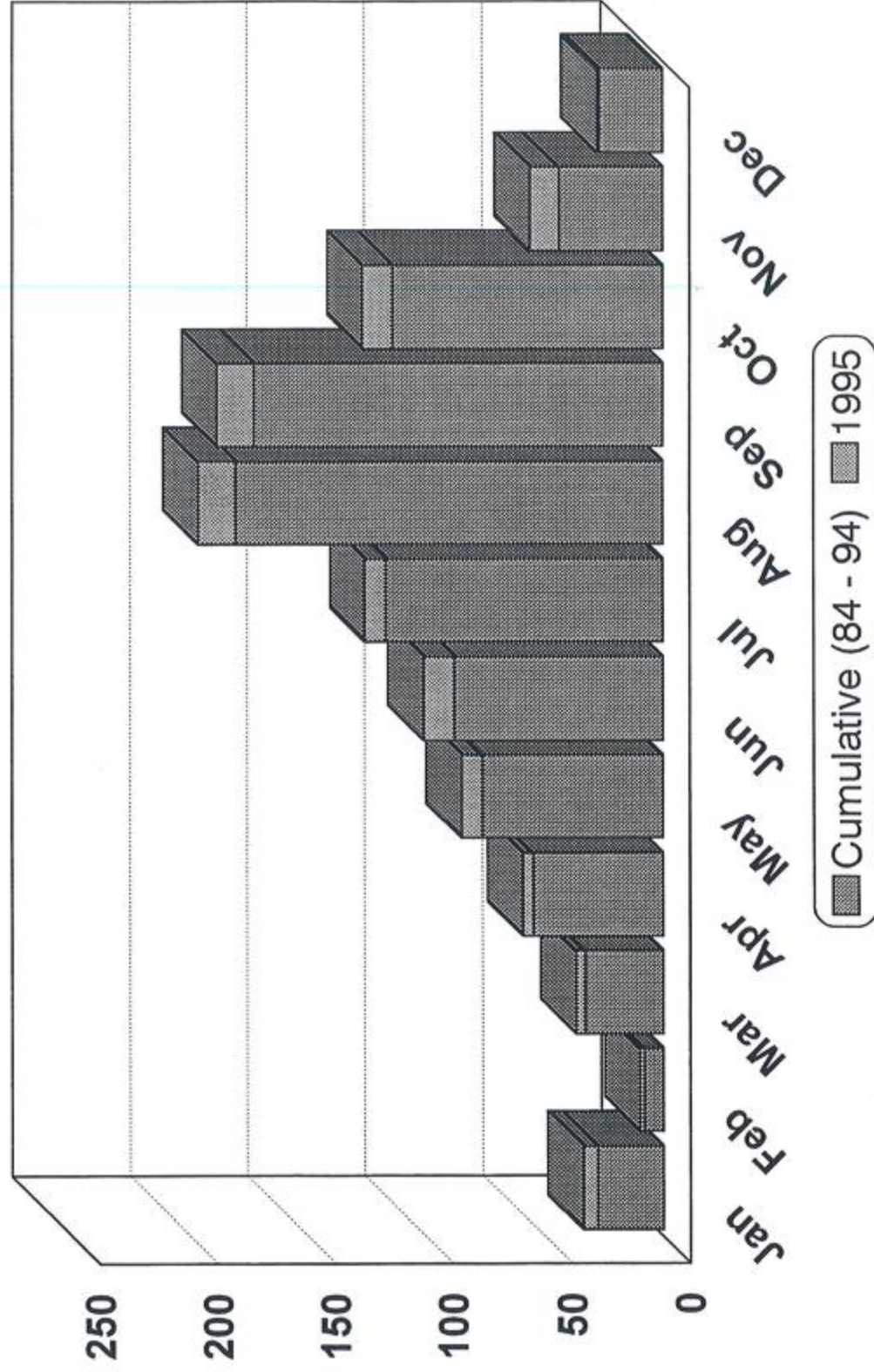
Bird Strike Rates - CF

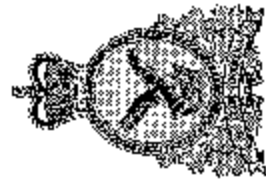


Number of strikes per 10,000 flying hours

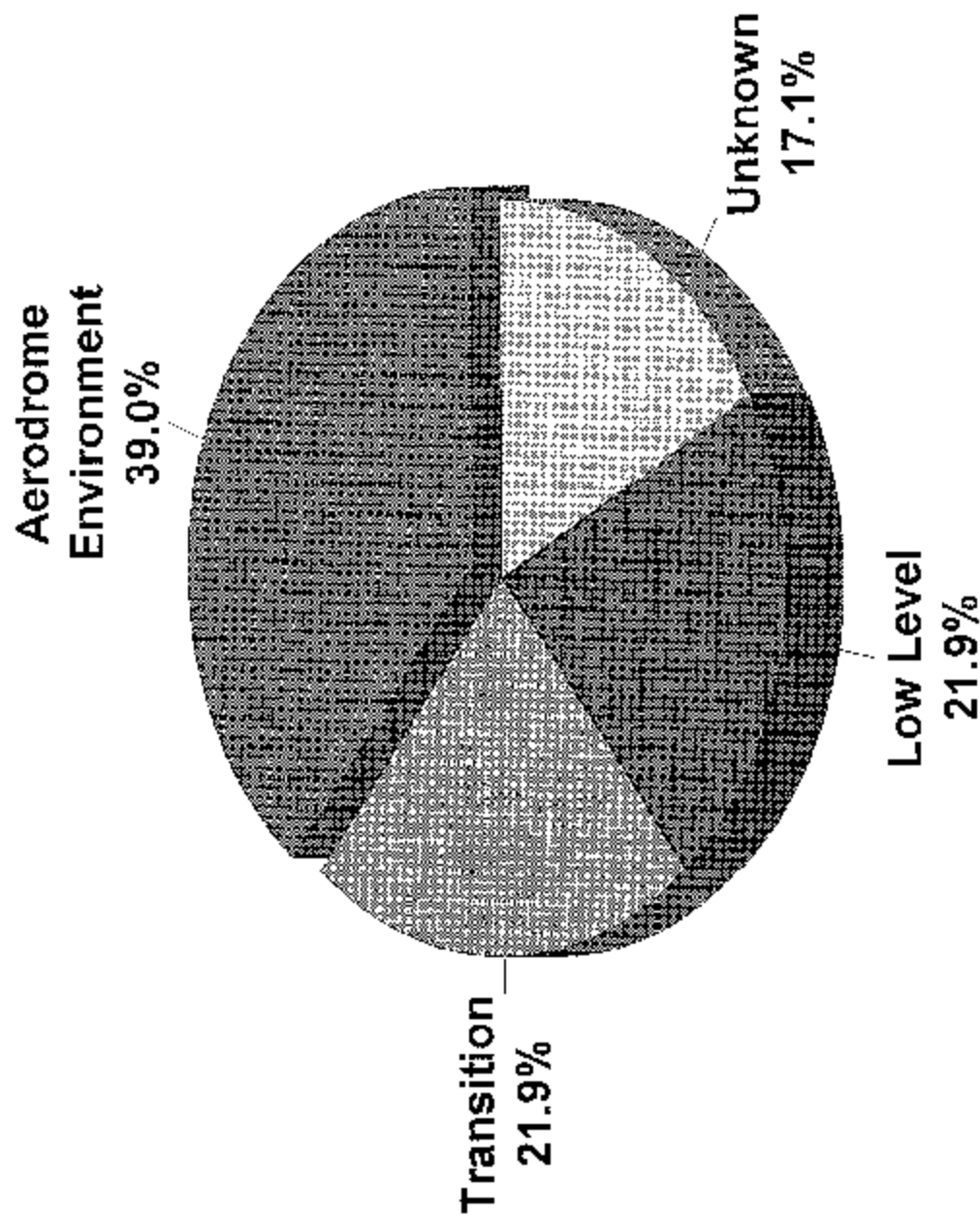


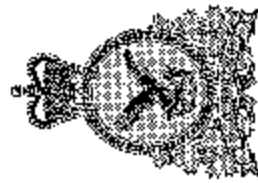
When - Cumulative



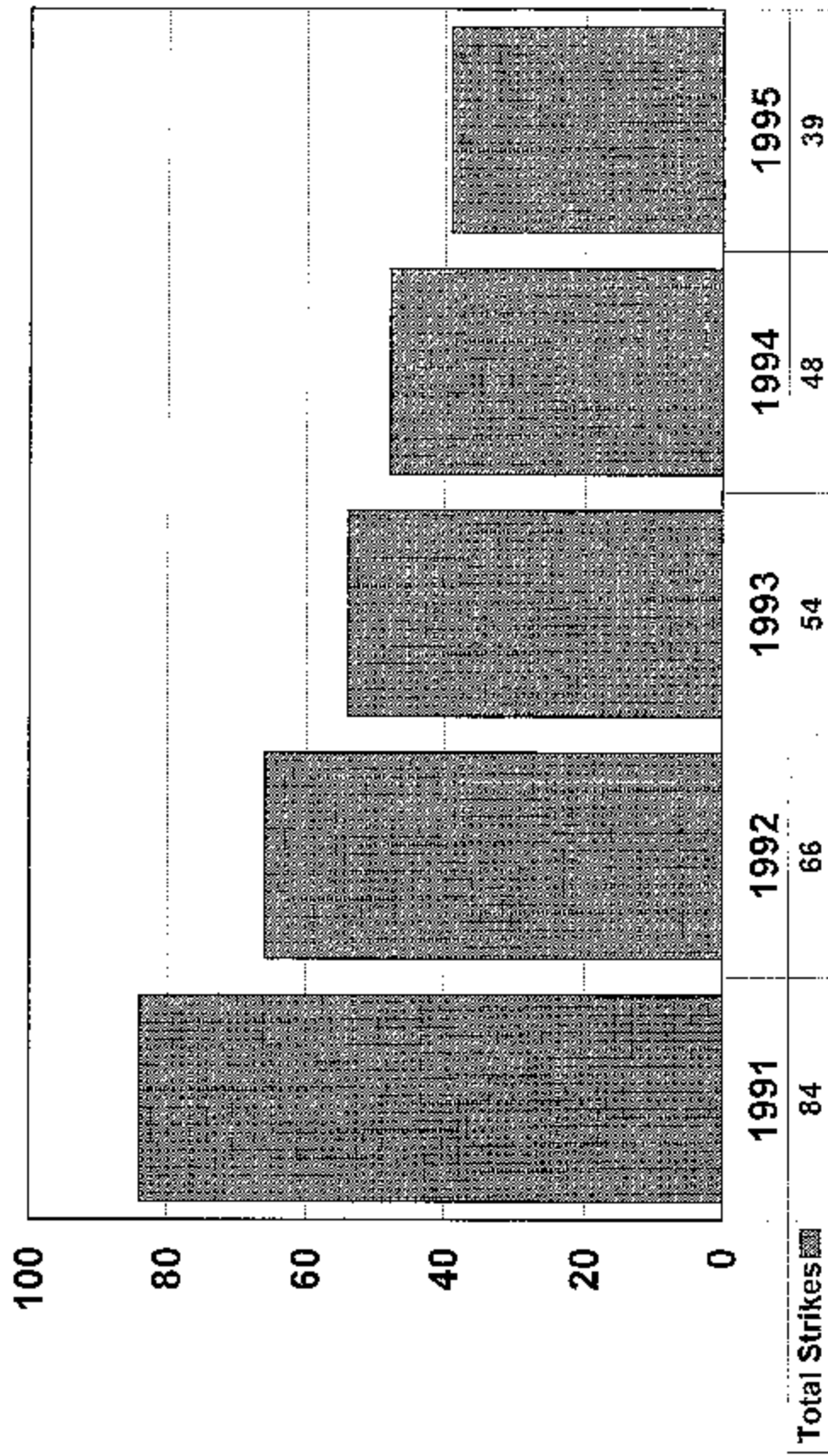


Where - 1995

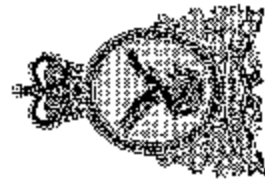




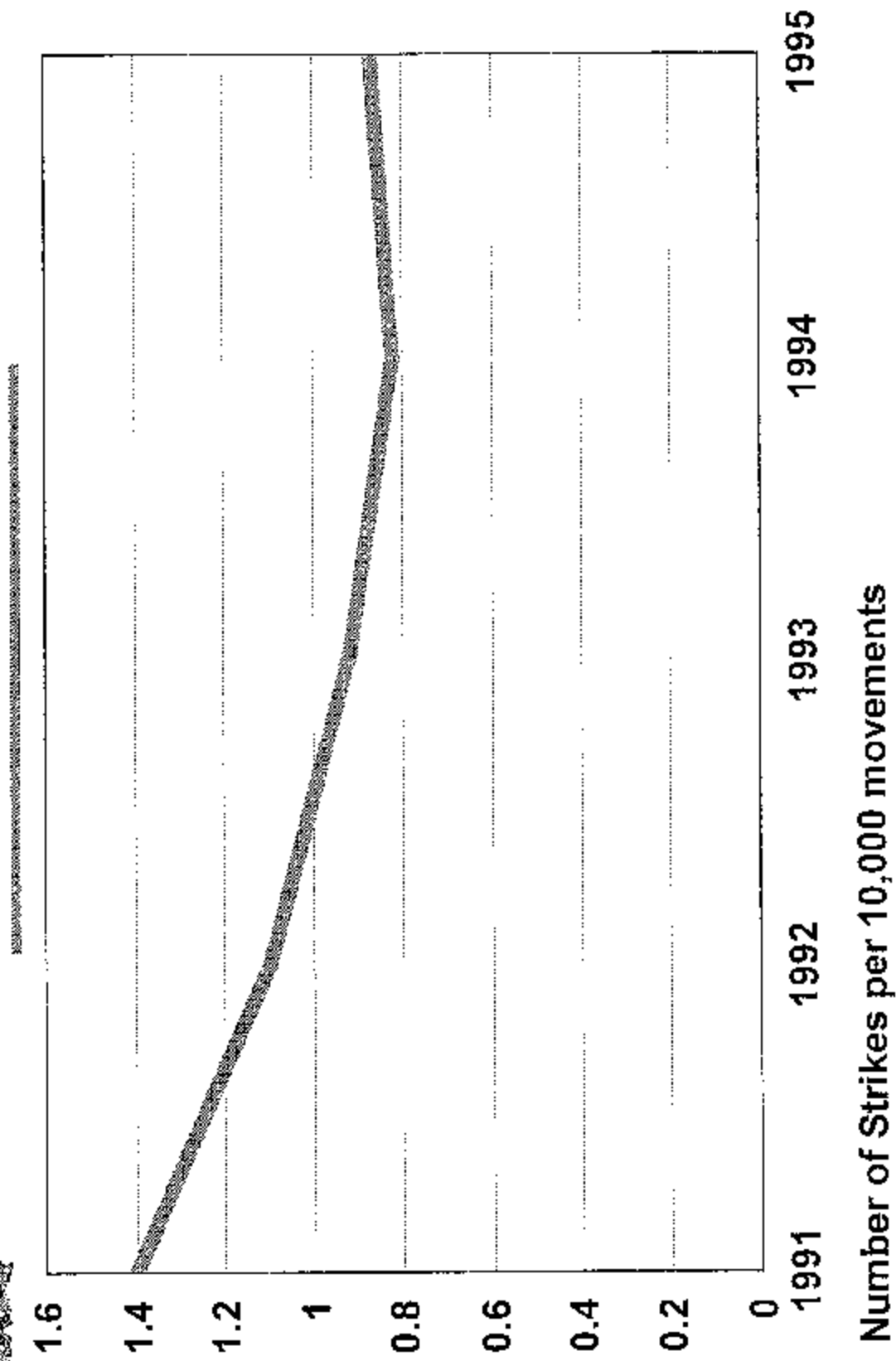
Bird Strikes - CF Aerodromes

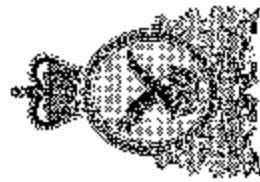


Within 5 NM of Aerodrome

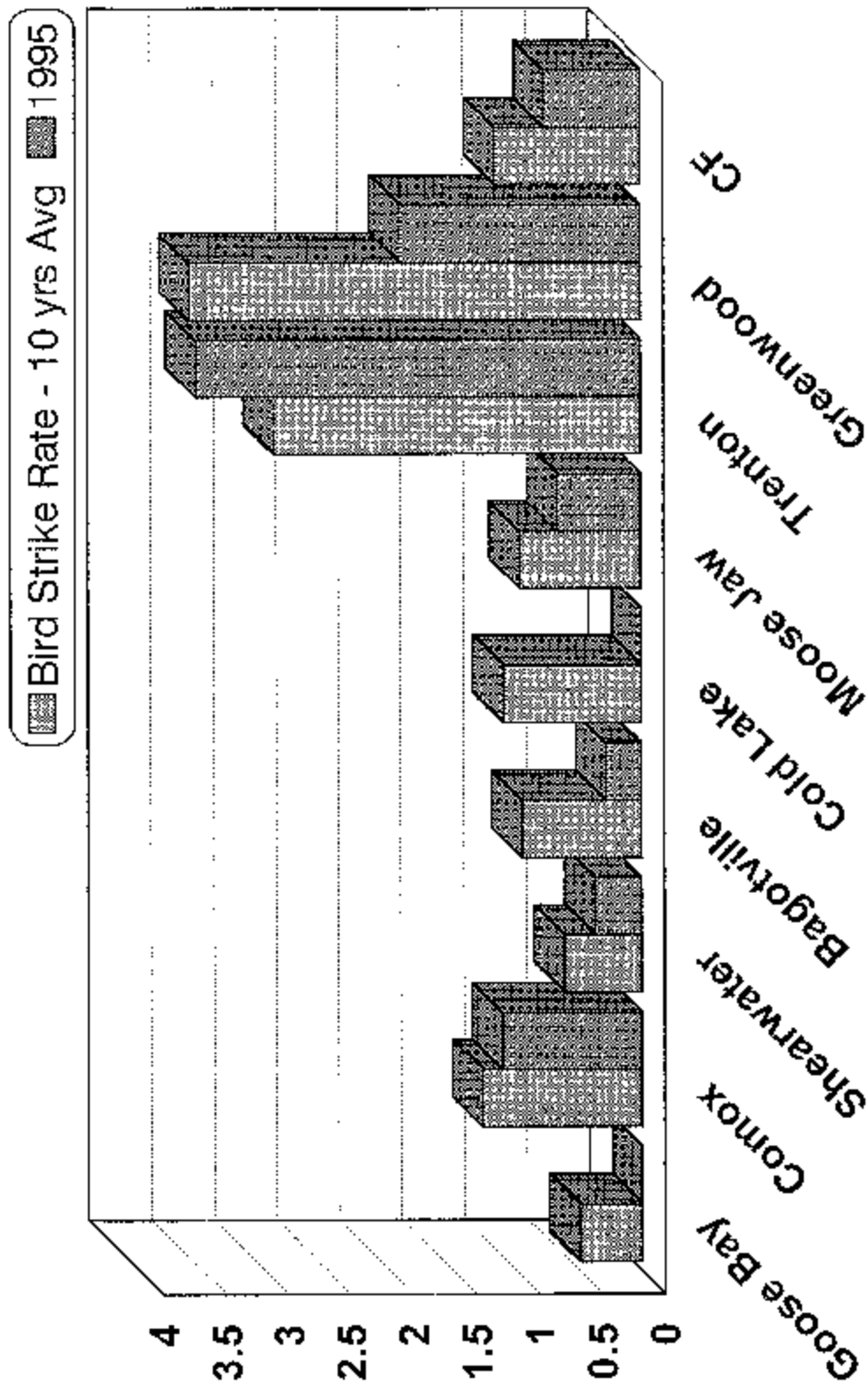


Bird Strike Rates CF Aerodromes





CF Bird Strikes Rate by Aerodromes



APPENDIX 4

Transport Canada Bird Strike Data 1995

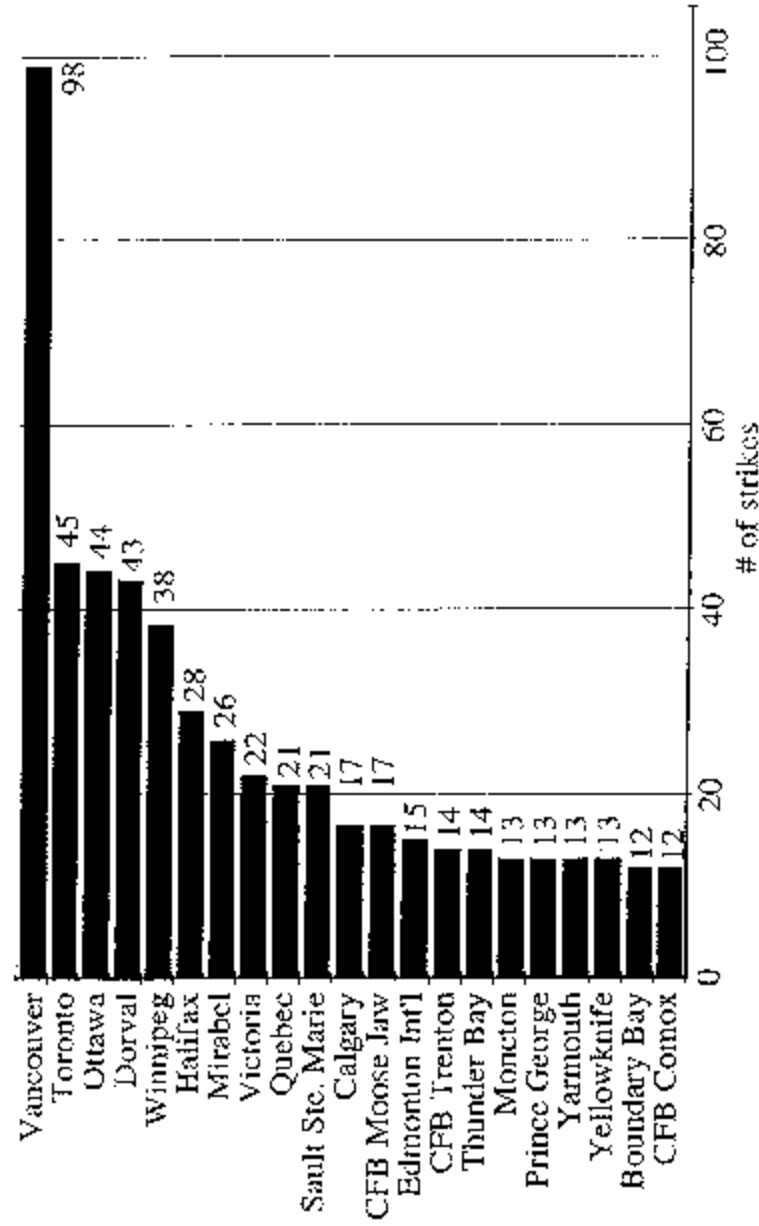
1995 Highlights

- A total of 837 bird strikes were reported to Airports Group in 1995. Of these, 795 occurred at Canadian sites, 27 occurred outside Canada, and 15 were of unknown origin.
- Of the strikes reported, 30% could not identify the bird involved. The type of bird most often hit were gulls (28%), followed by sparrows (6%), snow buntings (5%), and ducks (4%).
- The month with the highest number of strikes was August (22%); and July had the second highest number of strikes (15%). The time of day with the most incidents was between 10 A.M. and 11 A.M.
- Fifty-eight percent of the incidents where the height of the strike was recorded occurred below 100 feet AGL. Three percent of the incidents occurred at heights above 1,500 feet AGL; twenty-four percent of the incidents had no report of strike height.
- The aircraft most involved in a strike, irrespective of the number of aircraft movements, were Dash-8's (14%), DC-9's (7%), B-737's (6%) and A320's (4%).
- The parts of the aircraft most often struck were the wing, the nose, and the fuselage.
- The parts of the aircraft damaged the most were the pilot (75%), tail (57%), the lights (33%) and the engine (16%).
- The type of engine most often damaged were turboprops (6 incidents).

NOTE: This report is based on bird strike data supplied to Airports Group by the various sources listed on the following page, and therefore reflects the nature of the information furnished as well as the interpretation provided by the individuals that prepared the report.

3.1 Characteristics of Strikes at Canadian Airports

3.1b Number of Reported Strikes: Top Twenty-One Airports

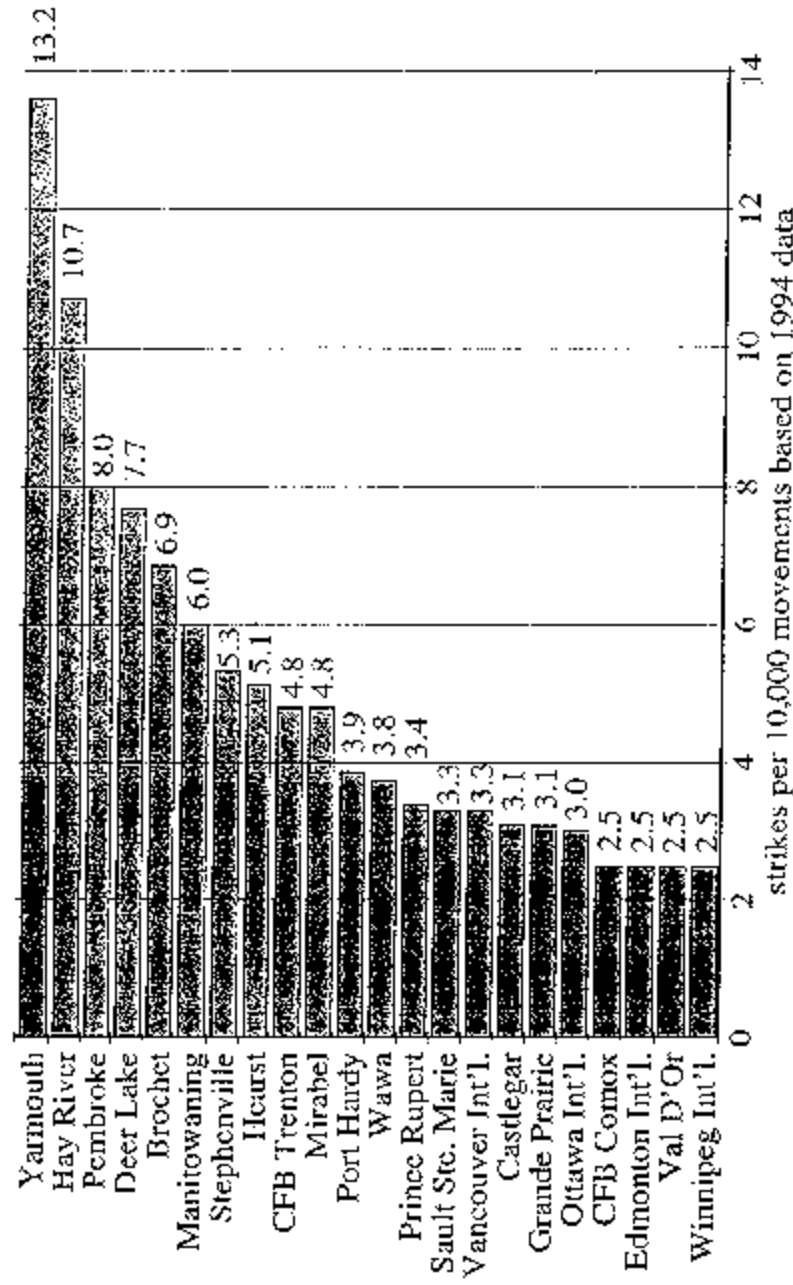


Note: The above table does not separate strikes occurring at the airport from those occurring near the airport.

Bird Strikes to Canadian Aircraft: 1994 Summary Report

3.1 Characteristics of Strikes at Canadian Airports

3.1d Strike rates: Top Twenty-two Airports



Note: The above table does not differentiate between strikes that occurred on the airport from those that occurred near the airport.

Bird Strikes to Canadian Aircraft: 1994 Summary Report

APPENDIX 5

Blue Ribbon Panel Report

Report of the Blue Ribbon Panel on Wildlife and Aviation Safety

Produced by
Transport Canada Airports
Safety and Technical Services
18C, Place de Ville
Ottawa, ON K1A 0N8

Report on Transport Canada's
Response to FEARO Panel
Report # 40-Recommendation 12 and
Flight Safety Issues
Related to Avifauna on Sea Island
and the
Sea Island Conservation Area

Parallel Runway Project
Vancouver International Airport

December, 1995

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GLOSSARY

ATAC	Air Transport Association of Canada
BSCC	Bird Strike Committee Canada
CALPA	Canadian Airline Pilots Association
COSEWIC	Committee On the Status of Endangered Wildlife In Canada
CWS	Canadian Wildlife Service
EARP	Environmental Assessment Review Process
EC	Environment Canada
EIS	Environmental Impact Statement
FEARO	Federal Environmental Assessment Review Office
GVRD	Greater Vancouver Regional District
IASC	Inter Agency Steering Committee
SICA	Sea Island Conservation Area
SRT	Safety Review Team
TC	Transport Canada
VIA	Vancouver International Airport
VIAA	Vancouver International Airport Authority (management group)
WCP	Wildlife Control Program
WHACC	Wildlife Habitat Advisory Committee on Compensation
YVR	Vancouver International Airport (international designator)
YVRAA	Vancouver International Airport Authority (management group)

EXECUTIVE SUMMARY

The addition of a parallel runway at Vancouver International Airport had been under consideration since 1946 when the Vancouver Planning Commission published plans for the facility. Due to various circumstances including the economic recession, a firm commitment was not made to construct the parallel runway until the Minister of Transport requested that the Minister of the Environment activate the Federal Environmental Assessment Review Office (FEARO) Panel in November 1989. This was done in order to conduct a public review of the environmental and socio-economic effects associated with the parallel runway project, and to consider mitigating and compensating actions which could reduce the negative impacts.

In August 1991, the FEARO Panel issued its report, #40, on the parallel runway project. This report contained 22 recommendations related to the project's impacts. In 1992, the Minister of Transport issued a response to the 22 panel recommendations, and approved the construction of the parallel runway. Recommendation #12 and the Minister of Transport's response and commitment to it has established the background and framework for the report of the 'Blue Ribbon Panel on Wildlife and Aviation Safety.'

Recommendation #12 is as follows:

"The Panel recommends that Transport Canada commission an independent, public environmental review of its Bird Strike Control Program and Guidelines for Land Use in the Vicinity of Airports to assess their effects on habitat capability in light of the proposed runway flight patterns and helicopter paths and also examine the potential effect on migratory birds of the new approach light system across Sturgeon Bank."

The following is the Minister of Transport's stated commitment in response to this recommendation:

"The bird-hazard reduction program, including land restrictions in the vicinity of the airport, is a necessary and fundamental part of aviation safety. Because the purpose of this program is to protect human lives by reducing the probability of aircraft-bird collisions, its efforts must not be compromised or undermined. In light of these circumstances, Transport Canada accepts recommendation 12, and proposes to subject the bird-hazard reduction program at YVR to a public review. This will include, among other things, the

assessment of impacts the program will have on land uses in the vicinity of airports as well as potential impacts the new aircraft flight paths will have on migratory birds.

Transport Canada proposes to conduct the public review through a committee consisting of Vancouver Airport staff, Transport Canada Headquarters representatives and other bird control specialists from the Canadian Wildlife Service (Environment Canada), the Department of National Defence and Agriculture Canada. Once the program is assessed, the committee will identify areas requiring further studies. All of these findings, as well as the committee's decisions and deliberations, will be summarized and documented in a report that will be available to the public for review and comment."

A multi-agency steering committee, chaired by Transport Canada, was established on December 10, 1993 to implement the Minister of Transport's commitment to recommendation 12. The committee approved Transport Canada's (TC) workplan designed to provide the public review of the Vancouver International Airport (YVR) Wildlife Control Program (WCP) and its impact on the wildlife of Sea Island. The four part workplan approved by the steering committee is as follows:

Section 1: Description of the Wildlife Control Program at Vancouver International Airport.

Section 2: Avifauna study of Sea Island and surrounding areas.

Section 3: Aviation study concentrating on interactions between aircraft and birds on Sea Island, and providing an evaluation of the effectiveness of the Wildlife Control Program in mitigating the associated hazards.

Section 4: Blue Ribbon Panel of Wildlife-Aviation experts to provide analysis and make recommendations dealing with Transport Canada's commitment to recommendation 12 and safety issues related to land uses in the vicinity of the Airport and the Sea Island Conservation Area (SICA), based on the findings of Sections 1-3.

The four part workplan which was developed by Transport Canada includes the examination of bird hazard issues associated with the parallel runway project; specifically

those related to the establishment of the Sea Island Conservation Area which is a parcel of land approximately 140 hectares in size on the northern portion of Sea Island. The Sea Island Conservation Area is part of the compensation program initiated in response to the FEARO Panel recommendations as compensation for wildlife habitat lost to the parallel runway project.

In November 1993, while reviewing bird strike data from the Airport, it was noted that bird strike incidents involving Barn Owls had increased significantly following the installation of Barn Owl nesting boxes in the Sea Island Conservation Area. The nesting boxes were installed as part of an enhancement initiative within the conservation area designed to increase carrying capacity. A moratorium was placed on the enhancement program, and the terms of reference for the Recommendation 12 Steering Committee were amended. This allowed the data collected for the recommendation 12 project to be used to address bird hazard and flight safety issues identified in the Minister's response to recommendation 12, and more clearly stated in the responses to recommendations 13 and 17.

Following the increase in reported Barn Owl strikes, a Transport Canada Aviation System Safety Review was conducted on the risk of bird strikes to aircraft related to the Sea Island Conservation Area. On March 28, 1994 the terms of reference for the Recommendation 12 Steering Committee was formally approved, and included references to flight safety issues.

During the period December 10, 1993 to September 19, 1995 work proceeded on the four part workplan. The Section 1 report was completed, the avifauna study produced two reports (one related to environmental issues, and one related to flight safety issues), two System Safety Reviews were conducted, and members of the Blue Ribbon Panel were selected.

The Blue Ribbon Panel convened on September 19, 1995 in Vancouver. The deliberations spanned three days, focusing on the following six subject areas contained in the panel's terms of reference, which provided the framework for the panel's activities:

1. **Transport Canada's stated commitment made in response to recommendation #12.**
2. **Determine the impact of the Wildlife Control Program on the wildlife of Sea Island.**
3. **Determine the impact of the Wildlife Control Program on land uses in the vicinity of the Airport.**
4. **Determine the potential impact new aircraft flight paths will have on migratory birds.**

5. **Provide recommendations related to issues identified in Sections 2 and 3. (Steering Committee workplan)**
6. **Provide an assessment of the compatibility of management practices in the SICA with concerns related to aviation safety identified in the Ministerial response to recommendations 13 and 17.**

Panel members reviewed a number of reports, and heard several presentations in order to have available the data necessary for them to provide conclusions and recommendations specific to the recommendation 12 issues, and also on how to achieve the balance between maintaining acceptable conservation values within the Sea Island Conservation Area while ensuring the safe operation of aircraft at Vancouver International Airport. Overall, the panel concluded that Transport Canada has addressed subject area number one in the panel's terms of reference, and completed its review of the recommendation 12 issues through a multi-agency team approach, and the results are presented in this report which will be available for public review.

In summary, the panel's response to the remaining five subject areas in the terms of reference is as follows:

- panel members agreed that the Airport Wildlife Control Program will result in a general decline in the abundance of many bird species within the Airport boundaries, but will have minimal impact on the birds resident within the Sea Island Conservation Area;
- that public concerns expressed about the possible negative impacts of Transport Canada's guidelines on 'Land Use in the Vicinity of Airports' on the wildlife of Sea Island have been addressed in the establishment of the Sea Island Conservation Area by Transport Canada;
- that increased air traffic over northern Sea Island will not likely reduce the habitat suitability of Sturgeon Bank and the foreshore of Sea Island for migratory birds;
- that the new approach lighting pier will have few, if any, negative impacts on migratory birds;
- that Barn Owl nesting sites should be eliminated from airside buildings, and that nesting structures should be removed from the Sea Island Conservation Area, and relocated to suitable areas off Sea Island;

- that Canada Geese are not a conservation issue, and should be subjected to more aggressive control measures than are currently being used on the Airport;
- that Dunlin should continue to be aggressively controlled on the Airport, utilizing techniques such as falconry on a trial basis;
- that flight safety problems associated with gulls at and near the Airport should be studied further;
- that hazards associated with Snow Geese should be addressed as soon as possible by a committee consisting of representatives from the Vancouver International Airport Authority, Transport Canada, and Environment Canada;
- that flight safety issues related to Northwestern Crows and European Starlings should be addressed;
- that Great Blue Herons are not a conservation issue on Sea Island, and enhancements for these birds within the Sea Island Conservation Area are not required;
- that Great Blue Heron movements should be carefully monitored;
- that perch pole enhancements within the Sea Island Conservation Area should be studied prior to the operation of the parallel runway, particularly those in the east and west wings, and as soon as results are available, a decision should be made whether or not to remove them;
- that raptors venturing airside from the conservation area should be dispersed or live trapped; as should raptors not associated with the conservation area that spend most of their time airside;
- that the risk management program developed to ensure the safe co-existence of the Airport and the Sea Island Conservation Area should be continued by Transport Canada, Environment Canada (EC), and the Vancouver International Airport Authority (VIRAA);
- that the Environment Canada management plan for the Sea Island Conservation Area should be focused on the maintenance of suitable habitat rather than on numeric targets for certain species;
- that aviation safety concerns related to the Sea Island Conservation Area can be mitigated through the proper management of the area, and through increased activity by the Airport Wildlife Control Program, and that the management plan based on Draft #4 and the process for revising the plan will contribute towards addressing these aviation safety concerns. Transport Canada has stated that an annual safety review shall be undertaken to ensure that the Sea Island Conservation Area management practices are attaining these safety objectives.

BACKGROUND

The background section provides a chronological summary of events related to the recommendation 12 issues leading up to the Blue Ribbon Panel deliberations. It also describes components of the process, including workshops and studies, that were deemed necessary by Transport Canada, Environment Canada, and the Vancouver International Airport Authority to effectively manage any risk associated with land use activities on Sea Island that at face value appear to be incompatible.

LOCATION

Vancouver International Airport is located on Sea Island in the Fraser River delta, the largest estuary on Canada's west coast (figure 1). The delta provides for the largest and most diverse concentration of birds in Canada — up to 1.4 million migrant and wintering waterbirds from both the Asian and the North American Arctic. Immediately surrounding the Airport are the cities of Vancouver (to the north), Richmond (to the south and east), New Westminster, Burnaby and Surrey (farther up the valley). To the west is the Strait of Georgia.

Sea Island lies between two branches of the north arm of the Fraser River. The mild year-round temperatures combined with high productivity attract large numbers of summering, migrating and wintering birds, as well as year-round residents.

Much of Sea Island has been developed for Airport operations (figure 2). There is a substantial amount of paved area, including two established runways, another one under construction, terminal facilities, and associated airside and Airport related commercial development.

Most of the vegetation on Sea Island is tall grass, closely cropped grassland near the airfields, or rough shrublands and hedgerows. These areas provide important habitat for voles, which are a major food supply for raptors and herons. Sand and mud flats, tidal and brackish marsh, and salt marsh habitat lie to the west of Sea Island on Sturgeon Bank and on Swishwash Island.

Birds are the major wildlife group on and around the Island, with 233 species identified on the foreshore and upland areas. Surveys have identified key groups such as geese, dabbling and diving ducks, gulls, Great Blue Herons,

shorebirds (mostly Dunlin and Western Sandpipers), pheasants, raptors (including eagles, hawks, falcons and owls), starlings and other passerines (perching birds). Regionally uncommon birds include the Yellow-headed Blackbird, Streaked Horned Lark, Short-eared Owl and Common Barn-Owl.

PARALLEL RUNWAY PROJECT — WILDLIFE ISSUES

The construction of an additional runway parallel to the main east-west runway, 08R-26L, had been under consideration since 1946 when the Vancouver Planning Commission published plans for the facility. (for a more complete history of the Parallel Runway Project, please see appendix A) A number of factors, including the economic recession, contributed to the project's deferral until November 1989 when a significant increase in aircraft activity at the Airport led the Minister of Transport to request that the Minister of the Environment activate a Federal Environmental Assessment Review Office Panel.

The 1984 Environmental Assessment Review Process (EARP) Guidelines Order required that federal government projects that would likely have adverse effects on the environment be subjected to an environmental review. Large scale projects with unknown impacts, such as the Parallel Runway Project, demanded extra scrutiny through the process of an Environmental Impact Statement (EIS). The EIS for the Parallel Runway Project was completed in August 1990.

The Environmental Impact Statement was used as part of the information base for the public review of the environmental and social effects of the Parallel Runway Project. This review was conducted by the FEARO Panel, which produced its report, #40, in August 1991. The FEARO Panel Report #40 contained 22 recommendations related to the impacts of the project.

One of the key concerns heard by the FEARO Panel during the public hearing process related to impacts the project might have on the wildlife of Sea Island, specifically birds. The public was concerned about habitat that would be lost to runway development, and the impact that the Airport Wildlife Control Program might have on birds. The public also expressed concern about Transport Canada's

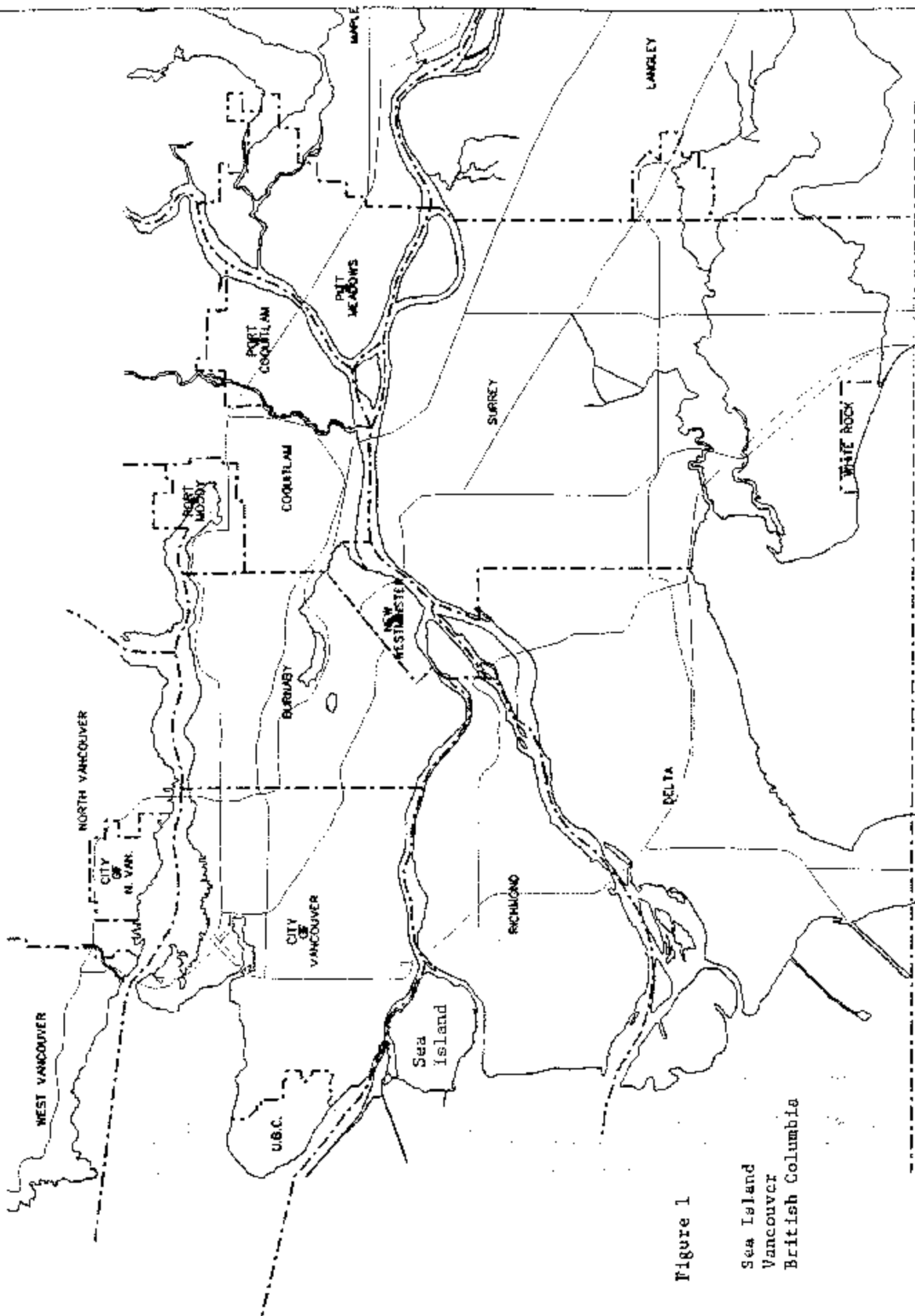


Figure 1

Sea Island
Vancouver
British Columbia

VANCOUVER INTERNATIONAL AIRPORT

SEA ISLAND CONVEYANCE AREA
 AIRPORT SERVICE ROAD
 AIRPORT SERVICE ROAD
 AIRPORT SERVICE ROAD
 AIRPORT SERVICE ROAD

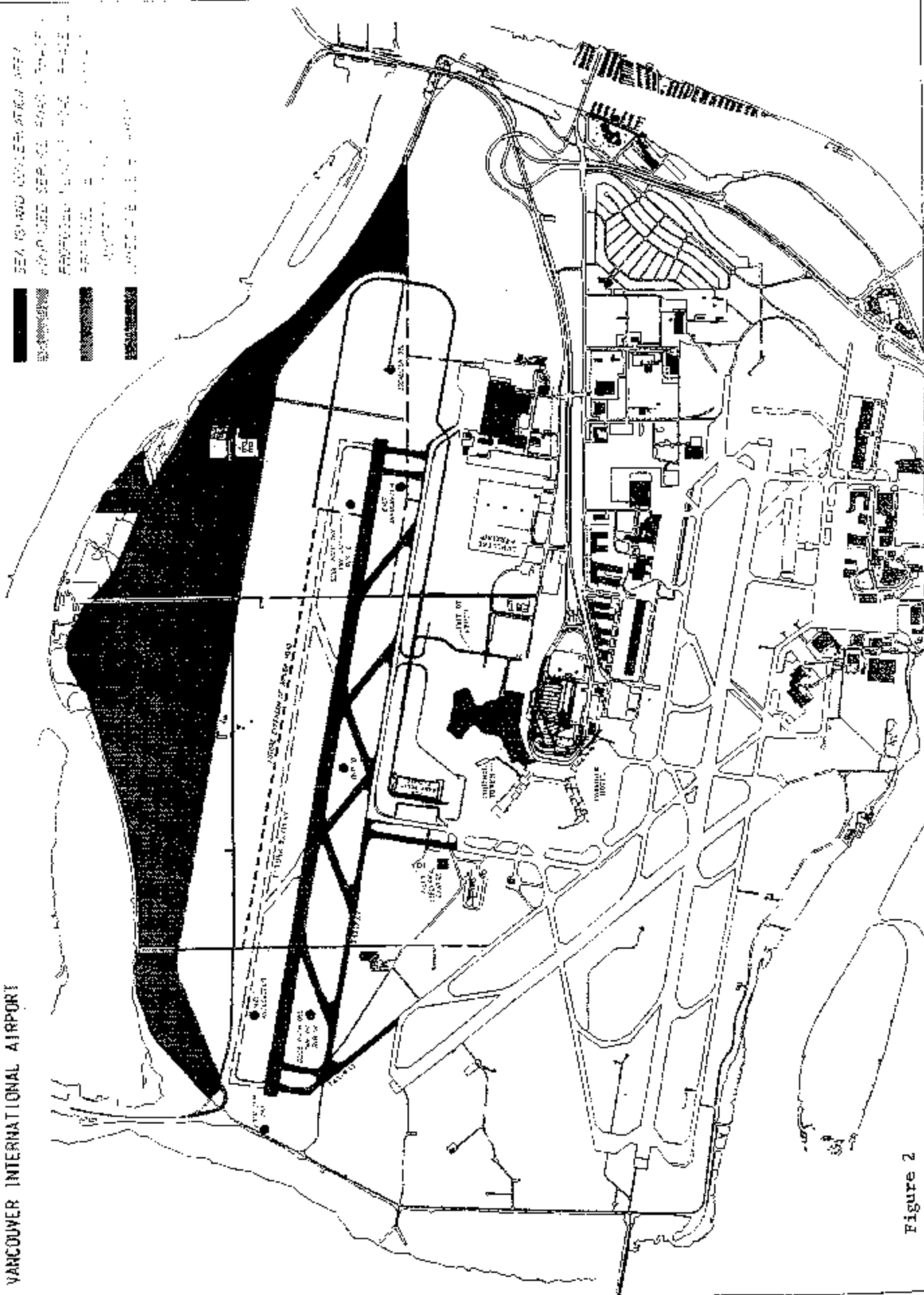


Figure 2

guidelines for 'Land Use in the Vicinity of Airports.' This is a guidance document for airport operators which recommends against certain land use activities that are attractive to birds, including wildlife refuges, with the potential to create flight safety problems. A further public concern related to the unknown effects of a new approach lighting pier on birds flying at night. (for a more complete description of the public's concerns, please see appendix B)

The concerns expressed by the public with respect to the Parallel Runway Project's potential impact on birds caused the FEARO Panel to include a number of recommendations in its report that dealt with mitigation, compensation, and analysis of impacts.

Recommendation #12 is one that reflected these concerns:

"The Panel recommends that Transport Canada commission an independent, public environmental review of its Bird Strike Control Program and Guidelines for Land Use in the Vicinity of Airports to assess their effects on habitat capability in light of the proposed runway flight patterns and helicopter paths and also examine the potential effect on migratory birds of the new approach light system across Sturgeon Bank."

Other recommendations that addressed the project's impacts on birds were numbers 13, 14, 17 and 18. (for a complete description of the recommendations related to wildlife impacts, please see appendix B) Recommendations 13 and 17 were especially pertinent to the process leading to the Blue Ribbon Panel. These are as follows:

13: "The FEARO Panel recommends that:

- a) development in the Airport North area be limited to the runway, associated taxi-ways and landscaping essential for the operation of the runway;
- b) airport-related commercial and other urban uses be permanently prohibited north of the runway;
- c) the remainder of land north of the runway be dedicated to the conservation and enhancement of wildlife values; and
- d) land uses incompatible with wildlife values in Airport North be phased out where feasible."

17: "The FEARO Panel recommends that:

- a) the whole of the area north of the runway be set aside by Transport Canada as the core of a Sea Island Conservation Area (SICA) and that this decision be reflected in the lease arrangements between Transport Canada and the VIAA;

- b) Transport Canada establish a Wildlife Management Committee with a mandate to manage the SICA area for a period of at least 50 years;
- c) the Committee consist of the Canadian Wildlife Service (acting as Chair), the Department of Fisheries and Oceans, the B.C. Ministry of Environment, the Musqueam Indian Band, the City of Richmond, the Greater Vancouver Regional District and the Fraser River Estuary Management Program;
- d) the Wildlife Management Committee have the power:
 - i) to manage SICA and associated mitigation and compensation programs;
 - ii) to coordinate habitat purchases and programs for rehabilitation, enhancement and management with other agencies; and
 - iii) to involve appropriate interest groups in joint research, planning activities, pilot projects and public education; and
- e) the administrative costs of the Wildlife Management Committee be borne by Transport Canada together with the costs of any environmental projects in the SICA area arising from the impacts of the new runway."

TRANSPORT CANADA'S COMMITMENTS TO FEARO PANEL REPORT #40

Following extensive review of the FEARO Panel Report #40, the Minister of Transport approved construction of the parallel runway in 1992, and issued a response to the 22 FEARO Panel recommendations. The response to recommendation 12 is as follows:

"The bird-hazard reduction program, including land restrictions in the vicinity of the airport, is a necessary and fundamental part of aviation safety. Because the purpose of this program is to protect human lives by reducing the probability of aircraft-bird collisions, its efforts must not be compromised or undermined. In light of these circumstances, Transport Canada accepts recommendation 12, and proposes to subject the bird-hazard reduction program at YVR to a public review. This will include, among other things, the assessment of impacts the program will have on land uses in the vicinity of airports as well as potential impacts the new aircraft flight paths will have on migratory birds.

Transport Canada proposes to conduct the public review through a committee consisting of Vancouver Airport staff, Transport Canada Headquarters representatives and other bird control specialists from the Canadian Wildlife Service (Environment Canada), the Department of National Defence and Agriculture Canada. Once the program is assessed, the committee will identify areas requiring further studies. All of these findings, as well as the committee's decisions and deliberations, will be summarized and documented in a report that will be available to the public for review and comment."

RECOMMENDATION 12 STEERING COMMITTEE

In keeping with the intent of the Minister's response to recommendation 12, Transport Canada undertook to form a committee to manage its commitment. On December 10, 1993 a multi-agency steering committee met in Vancouver to review a draft terms of reference prepared by Transport Canada, and to establish a workplan for the completion of the recommendation 12 review. (for a list of the steering committee members, please see appendix C)

The steering committee reviewed a four part workplan prepared by Transport Canada. The four parts are as follows:

Section 1: Description of the Wildlife Control Program at Vancouver International Airport

Section 2: Avifauna study of Sea Island and surrounding areas.

Section 3: Aviation study concentrating on interactions between aircraft and birds on Sea Island, and providing an evaluation of the effectiveness of the Wildlife Control Program in mitigating the associated hazards.

Section 4: Blue Ribbon Panel of Wildlife-Aviation experts to provide analysis and make recommendations dealing with Transport Canada's commitment to recommendation 12 and safety issues related to land uses in the vicinity of the Airport and the Sea Island Conservation Area, based on the findings of Sections 1-3.

The agenda for the December 10, 1993 steering committee meeting included discussions on the mandate of the group. Some members of the committee felt that their role was to deal exclusively with environmental issues related to recommendation 12, whereas others felt that the Minister's response required that flight safety issues related to birds also be examined. Similar flight safety concerns were expressed by members of Bird Strike Committee Canada (BSCC), some of whom were also steering committee members, Transport Canada officials in Ottawa, the Air Transport Association of Canada (ATAA) and the Canadian Airline Pilots Association (CALPA).

Those concerned about flight safety issues felt that the Minister's response to recommendations 13 and 17 provided the guidelines for the risk management process that would be necessary in order to deal with issues arising from the co-existence of a conservation area and a busy airport. The Minister's responses are as follows:

Recommendation 13:

- a) Transport Canada concurs with the intent of this recommendation. However, modifications will be needed to ensure that aviation safety, Transport Canada's number-one priority, is not compromised. The dedication of land immediately adjacent to the parallel runway to conservation and enhancement of wildlife values raises serious concerns over bird strikes and, therefore, aviation safety. Accordingly, a buffer or transitional zone must be established between the operational and conservation areas, to ensure that safety is not compromised by other objectives.
- b) Development north of the runway will be limited to taxiways, complementary landscaping, the area required for bird control management, and the establishment of a buffer zone in which commercial development activities would be encouraged. All development north of this area would be permanently prohibited. The undeveloped area remaining would consist of approximately 140 hectares available for conservation and for public use along the Fraser River. Commercial development activities within the buffer zone would help discourage bird activities in the airfield operations area and minimize the requirement for bird-control measures within the conservation area.
- c) Transport Canada is prepared to work with the conservation area management committee to seek ways of enhancing conservation values as long as aviation safety is not compromised.
- d) Wherever feasible, land uses in the area incompatible with conservation values would be phased out. The fuel farm would not be affected by this decision. It should be possible to orient most conservation activities away from the runway through proper placement and juxtapositioning of habitats. Physical and visual barriers will also assist in keeping wildlife away from the runway."

Recommendation 17:

"a) The Sea Island Conservation Area would consist of the estimated 140 hectares remaining north of the buffer zone. At an appropriate time, decisions will be reflected in the lease arrangements with the Vancouver International Airport Authority.

b,c,d) The SICA lands will be transferred to the Canadian Wildlife Service to be secured, as conservation habitat, in perpetuity. The CWS, as the federal agency mandated to manage wildlife habitat on federal Crown lands, would be the most efficient and practical lead agency to accomplish this task. The following conditions will apply when transferring airport lands to the CWS:

- Aviation safety will remain the top priority. Implementation of conservation and wildlife values must not compromise aviation safety.
- The subject lands in the Sea Island Conservation Area are for the maintenance of conservation and wildlife values. Habitat management must not create bird-strike hazards.
- A conservation area management committee, chaired by the Canadian Wildlife Service and including representatives of all of the organizations mentioned in c), as well as Airport and Transport Canada flight safety staff, will be responsible for advising on the management of the SICA. Its functions and responsibilities will be as outlined in recommendations 17 d-i, ii, and 18 a-b. The committee will report to Transport Canada on matters of compensation/mitigation and to the CWS with respect to management and administrative matters.
- Transport Canada will be given credit for land transferred and any productivity enhancements of specific species to offset land used for airport purposes.
- If considered necessary for aviation safety by the airport operator or Transport Canada Aviation, bird-control management practices will be implemented as part of the CWS management plan at the Sea Island Conservation Area.
- If the maintenance of aviation safety precludes continuance of conservation values, the land will revert to Transport Canada and off-site compensation will be sought on a no-net-loss basis. If land is not available, financial

compensation will be paid to the Canadian Wildlife Service for wildlife-enhancement programs in the Lower Mainland. The airport operator would apply bird-control management practices to the conservation area to ensure aviation safety.

e) The airport operator will fund the conservation area management committee for a period of three years. Thereafter, it will be incorporated into the budget program of the Canadian Wildlife Service. Any land transfer costs will be the responsibility of Transport Canada."

Prior to the December 10, 1993 meeting of the Recommendation 12 Steering Committee, an issue arose related to the Sea Island Conservation Area enhancement program that had been initiated in response to public concerns about bird habitat. Following the Minister of Transport's commitment to establish the Sea Island Conservation Area in 1992, a Raptor Heron Management Plan was prepared by Transport Canada. The objective of the plan was to maximize the habitat capability of the Sea Island Conservation Area for raptors and Great Blue Herons. The plan prescribed a number of habitat enhancements that could be used to increase the carrying capacity of the conservation area. These enhancements included Barn Owl mini-barns, Barn Owl nesting boxes, perch poles for raptors, transplanted hedgerows, American Kestrel nesting boxes, a relocated Red-tail Hawk nest, and a field mowing program designed to increase the productivity and availability of Townsend Voles, a favoured food source for raptors and herons.

Early in 1993, the enhancement plan was implemented by the Vancouver International Airport Authority. In November 1993, while reviewing bird strike data for preparation of the 1993 Transport Canada Bird Strikes to Canadian Aircraft Summary Report, Transport Canada managers in Ottawa noted that there had been a significant increase in reported bird strikes involving Barn Owls at the Airport since the implementation of the conservation area enhancement program. From 1984 to 1988 inclusive, there had been a total of six reported bird strikes involving owls at the Airport, yet during the few months following the installation of the nesting structures in the Sea Island Conservation Area, there had been five reported strikes involving Barn Owls (Transport Canada 1990-1994). In the absence of any definitive cause for this increase in reported strikes, Transport Canada managers felt that it was prudent to place a moratorium on the conservation area enhancement program.

Further to the moratorium on enhancements, Transport Canada conducted a System Safety Review on the risk of bird strikes to aircraft associated with the Sea Island

Conservation Area. This review was conducted by a Safety Review Team (SRT) from February 14 to 18, 1994. (for information on Safety Review Team composition, please see appendix D) The Safety Review Team produced a 'Report of a Preliminary Review of Risk of Bird Strikes at Vancouver International Airport Associated with the Sea Island Conservation Area' in July 1994. The report identified two issues, and provided two observations and nine recommendations. The Safety Review Team was unable to conclusively provide an assessment of risk, because the final habitat management regime for the conservation area was under development by Environment Canada, and there was insufficient avifauna data available to accurately assess the movement of birds between the conservation area and the Airport. It was decided that a second safety review would be conducted when more information was available.

As information accumulated on the nature of bird behaviour on Sea Island and in the conservation area, and as questions arose on the type of management structure needed within the Sea Island Conservation Area to effectively allow its co-existence with Vancouver International Airport, Transport Canada officials decided that a workshop should be conducted to examine the issues. A multi-agency workshop was conducted on March 28, 1994 that included representatives from Transport Canada Aviation, Transport Canada Airports, the Airport Authority, Environment Canada, and the Canadian Airline Pilots Association. (for a complete list of the workshop participants, please see appendix E)

A number of decisions were made at the workshop, serving to combine the resources that were being dedicated to the ongoing processes of the Recommendation 12 Steering Committee and the System Safety Review. The workshop also formalized the four section workplan and terms of reference established for the steering committee, and provided the basis for establishing a risk management process that would satisfy the Minister of Transport's commitments to **both** aviation safety and conservation values within the Sea Island Conservation Area. (please see appendix F for the Recommendation 12 Working Group terms of reference)

The following is a summary of the studies, plans, and management processes that developed from agreements made at the March 28, 1994 workshop, and which would provide the data examined by the Blue Ribbon Panel:

WORKPLAN-RECOMMENDATION 12 STEERING COMMITTEE

It was decided at the workshop that the Recommendation 12 Steering Committee would become a Working Group, to fall under the umbrella organization of the Inter Agency Steering Committee (IASC). The IASC was a committee chaired by Transport Canada, with membership from Environment Canada, the Airport Authority, and the Department of Fisheries and Oceans. The mandate of the IASC was to oversee the management of all the Minister of Transport's commitments to the recommendations in the FEARO Panel Report #40.

Development of the workplan proceeded as follows:

Section 1:

The section 1 report was prepared by staff from Transport Canada and the Airport, and was completed in May 1994. The report describes the activities involved in managing wildlife at the Airport, and was prepared so that the Blue Ribbon Panel would be able to assess the impacts of the Airport Wildlife Control Program on the wildlife of Sea Island.

Section 2:

The avifauna study of Sea Island and surrounding areas was carried out by staff from Transport Canada Airports, Ottawa, with assistance from Vancouver International Airport staff. The study began in April 1994, and continued until April 1995, with supplementary radio-telemetry work continuing until later in 1995. The study examined in great detail bird behaviour on Sea Island and on habitat adjacent to Sea Island that was considered important from both an air safety perspective and for the purposes of resolving the recommendation 12 issues. A decision was made later in the process to produce two avifauna study reports: one dealing exclusively with environmental issues, and the other dealing with flight safety issues.

Decisions made at the March 28, 1994 workshop included that of extending the scope of the avifauna study so that data from the study could be used by the Safety Review Team in their analysis of bird strike risk associated with the Sea Island Conservation Area. This decision effectively formalized the expanded scope of the Recommendation 12 Working Group process to include its involvement in the review of the Minister's concerns about bird strike issues identified in his response to recommendations 13 and 17.

Section 3:

In the draft terms of reference for the Recommendation 12 Working Group, the section 3 aviation study was to be carried out by an aviation consultant, who would examine the

interactions between aircraft and birds at the Airport. A decision was made at the March 28, 1994 workshop to formalize the section 3 work as the series of safety reviews to be carried out by Transport Canada Aviation.

The preliminary safety review was conducted as previously described in February 1994. Once a draft management plan for the Sea Island Conservation Area (Draft #3.7) was provided by Environment Canada, Canadian Wildlife Service (CWS), and sufficient bird behaviour data was available from the avifauna study, the Safety Review Team reconvened in order to complete the safety review. The Safety Review Team met in Vancouver from July 5 to 9, 1995. (for team composition, please see appendix G) The Safety Review Team produced its report, 'System Safety Review of Bird Hazards Related to the Sea Island Conservation Area' in July 1995. The report provided a number of observations, findings, and eight recommendations. These would all become part of the information reviewed by the Blue Ribbon Panel.

Section 4:

The draft terms of reference for the Recommendation 12 Working Group described the section 4 work as a Blue Ribbon Panel of Wildlife-Aviation experts who would provide analysis and make recommendations dealing with Transport Canada's commitment to recommendation 12, and safety issues related to land uses in the vicinity of the Airport and the Sea Island Conservation Area. The original concept described a panel composition made up mostly of experts who had not previously been involved in the parallel runway project. A decision was made following the March 28, 1994 workshop to choose participants who were more closely involved with the issues. Nominations for the Blue Ribbon Panel were requested on December 13, 1994. The Recommendation 12 Working Group and the chair of the IASC provided nominations, and panel members were selected on March 28, 1995. Plans were made for the panel to convene during the week of September 18, 1995 in Vancouver. (for a list of Blue Ribbon Panel members, please see appendix H)

SICA MANAGEMENT PLAN

The Sea Island Conservation Area is a parcel of land on the northern portion of Sea Island, approximately 140 hectares in size, which is part of the compensation package committed to by the Minister of Transport in response to the FEARO Panel recommendations, in order to compensate for habitat lost to the Parallel Runway Project. Other parts of the compensation package include the purchase of the Robertson Farm by Transport Canada for management by Environment Canada, and \$9 million transferred to Environment Canada by Transport Canada

to be used for stewardship programs developed and implemented by the Delta Farmland and Wildlife Trust. The first \$6 million has been committed towards the acquisition of conservation lands in partnership with the Province of British Columbia and the Greater Vancouver Regional District (GVRD).

Work on the management plan for the Sea Island Conservation Area was initiated by the Canadian Wildlife Service in late 1993, and a number of drafts were reviewed and developed by the Canadian Wildlife Service, Transport Canada, and the Airport Authority at a series of workshops. Draft #4 was near completion in September 1995, and a presentation on its contents was provided to the Blue Ribbon Panel for review and analysis.

The main components of Draft #4 were developed by the Canadian Wildlife Service during consultation with Transport Canada and the Airport Authority. The draft consists of a habitat management plan based on Draft #3.7. The measure of success of the Sea Island Conservation Area in terms of maintaining conservation values will be based on habitat preservation rather than on maintaining species or numbers of individual species. The draft includes a species-specific risk abatement plan which clearly describes the measures that can be taken by the Airport Authority to manage bird hazard problems. It also provides a description of the path to be taken should conservation values not be met, or should bird hazard problems develop that cannot be resolved under the species specific risk abatement plan.

ONGOING MANAGEMENT OF SICA

Decisions taken at the March 28, 1994 workshop included that of developing a long term strategy for the management of any risk that may arise from the co-existence of the Sea Island Conservation Area and the Airport. The strategy seeks to achieve and maintain a balance between the requirement to sustain a safe aviation environment while increasing habitat values. A **SICA Management Steering Committee** has been developed that consists of senior managers from the Vancouver International Airport Authority, Environment Canada, Transport Canada Aviation and Transport Canada Airports. The role of the committee is to address significant issues arising from the management of the Sea Island Conservation Area and Airport operations.

A **SICA Working Group** has also been developed, with members from Environment Canada-CWS (chair), the Airport Authority, Transport Canada Aviation and Transport Canada Airports. The role of this group is to deal in a timely manner with issues that arise during the daily operations of the conservation area and the Airport, and respond to

guidance from the Steering Committee. The ongoing inputs that provide information for the above mentioned groups consist of Safety Review Team reports, monitoring reports on birds, Wildlife Control Program reports, and proposals for SICA Management Plan revisions.(for the draft Ongoing Management of SICA process, please see appendix J)

Further to the Ongoing Management of SICA initiative, Transport Canada, Environment Canada-CWS, and the Airport Authority have been working on a memorandum of understanding which will provide the framework for the management of the Sea Island Conservation Area, including provisions for the management of wildlife within the area by the Airport Authority, and contingency measures should the conservation area not be able to meet its conservation goals.

The above mentioned plans for the risk management process under development for the Sea Island Conservation Area were presented for review by the Blue Ribbon Panel.

PROCEEDINGS OF THE BLUE RIBBON PANEL SEPTEMBER 19-21, 1995

Following the selection process for the Blue Ribbon Panel as described in Part 1 of this report, the panel met from Tuesday, September 19 until Thursday, September 21, 1995. (please see appendix H for panel members, and appendix K for the agenda)

Terms of reference for the panel had been developed and approved prior to the September meetings. (please see appendix I for the panel terms of reference) A number of background documents were sent to panel members in the months leading up to the meeting, so that panel members could become familiar with the issues. (for a list of reports reviewed by the panel members, please see appendix L) Miscellaneous reports, such as updates prepared for Bird Strike Committee Canada, but not listed in appendix L, were also reviewed by panel members.

Some reports which contained information pertinent to the panel deliberations were works in progress, or were of sufficient value and complexity that they deserved discussion with the authors. This information was provided to the panel in the form of presentations during the first day of meetings. (for a list of presentations, please see appendix L)

PART 2 FORMAT

Part 2 of the Blue Ribbon Panel report is structured in accordance with the approved terms of reference, which provided the framework for the panel's activities, and addresses the six subject areas in the following order:

- Recommendation 12 issues:
- Bird hazard issues related to the SICA and the operation of the Airport;

Each issue discussed by the panel was derived from the panel terms of reference, Safety Review Team reports, avifauna study reports, or by the panel during their deliberations. The report is organized around the identification of each issue, the panel's discussion of the issue, panel conclusions, and a summary of conclusions. The panel addressed three recommendation 12 issues, ten flight safety issues, and three miscellaneous flight safety issues that had been identified in the avifauna study reports.

ISSUES PERTAINING TO RECOMMENDATION 12

1: THE IMPACT OF THE WILDLIFE CONTROL PROGRAM ON THE WILDLIFE OF SEA ISLAND

The goal of the Wildlife Control Program at the Airport is to minimize the concentration of birds near active runways to ensure safe Airport operations. This is achieved by modifying the Airport habitat to reduce its attractiveness to wildlife, and by actively scaring birds through the use of pyrotechnics and other methods.

Habitat modifications include maintaining grass heights between 10 and 25 cm, clearing brush and shrubs, eliminating standing water near runways, and modifying buildings and other structures to prevent birds from nesting and roosting.

Dispersing birds is a major part of the daily activities performed by Wildlife Control Officers, who patrol runways and surrounding areas in small trucks equipped with spotlights, loudspeakers and sirens. Birds are actively dispersed by firing pyrotechnics from a shotgun or pistol, and distress call tapes are frequently used to group flocks of birds so that they can be dispersed by pyrotechnics. The most common scare device is a screamer shell fired from a pistol.

The panel's discussion of this issue included the following points:

- the distribution and abundance of birds is largely determined by suitable habitat.
- the expansion of Airport operations will reduce the habitat available for many birds and increase the area of operation for the Wildlife Control Program.
- Wildlife Control Program activities such as modifying habitat and dispersing birds are generally effective in reducing the number of birds in operational areas.
- it is unlikely that adjacent habitats are capable of supporting increased densities of breeding and migratory birds that will be displaced by habitat changes and Wildlife Control Program activities.

The panel concluded that:

- the Wildlife Control Program will result in a general decline in the abundance of many bird species at the Airport, but will have minimal impact on birds resident within the Sea Island Conservation Area.
- however, the panel observed that this decline is not all inclusive. Expanding Airport operations will require the maintenance of a large mowed-grass area adjacent to the new parallel runway. This will increase the habitat for bird species that are attracted to these areas, such as Canada Geese, Snow Geese, starlings, and Dunlin.

2: LAND USE GUIDELINES AND THE POTENTIAL IMPACT ON WILDLIFE

Transport Canada has published guidelines for 'Land Use in the Vicinity of Airports' (Transport Canada 1992). These guidelines are intended to provide information that can be used when zoning lands near an airport, or as general guidance for municipalities and airport operators during the decision making process when developing facilities such as waste disposal sites that may be attractive to birds.

Birds are a potential hazard to aircraft mainly at low altitudes where the greatest number of birds fly. In order to reduce the incidence of collisions between birds and aircraft, and ensure the safe operation of aircraft operating into and out of airports, natural attractants for birds are minimized as much as possible on and near airports.

Wildlife Control Program activities at airports are necessary in order to reduce bird strikes to aircraft. However, the effectiveness of these activities can be reduced by off-airport land use practices that attract birds. Examples of these land use activities include migratory waterfowl and game refuges, as well as feeding stations. Public concerns were expressed to the FEARO Panel that Transport Canada's recommendation restricting waterfowl refuges from within 3.2 km of an airport reference point might preclude the enhancement of any wildlife habitat near Vancouver International Airport.

The panel's discussion of this issue included the following point:

- the Minister of Transport's commitment to recommendation 17 set aside the Sea Island Conservation Area.

The panel concluded that:

- the original concerns of the public as expressed in FEARO Panel recommendation 12 have been

addressed in the creation of the Sea Island Conservation Area.

3: IMPACT OF NEW AIRCRAFT FLIGHT PATHS ON MIGRATORY BIRDS

The significance of this issue is described in the following statement:

"The Fraser Delta is a critical link in a series of migratory bird habitats along the Pacific Flyway between the Arctic breeding grounds of North America and northeast Asia, and wintering areas in southwestern North America, Central and South America. Sea Island and its adjacent environments are critical components of the Fraser Delta. The vast food resources of the delta provide many staging birds with the energy essential for migration. For some species that nest in the Arctic or the interior, the Fraser Delta is used as a wintering ground. The delta supports some of the highest densities of wintering waterfowl, shorebirds, and raptors in Canada" (Demarchi and Searling 1995).

During the FEARO Panel review, the public expressed concerns about the potential impact a new approach light pier might have on migratory birds. While collecting data for the avifauna study, biologists compared the number and distribution of birds using the foreshore habitats near the existing runways. Aircraft using the new runway will fly over the northwestern foreshore in the same area as those using the current crosswind runway.

The panel's discussion of this issue included the following points:

- avian communities on and around Sea Island are composed of species that currently tolerate human caused disturbances, such as aircraft flying overhead.
- more species of migratory birds and greater numbers of individual birds are present on the foreshore beneath the approach to the main runway, which is currently the most active runway, than those beneath the approach to the crosswind runway.
- birds that currently occupy the area beneath the approach-departure path of the main runway do not appear to be disturbed by aircraft activity.
- air traffic over northern Sea Island will not likely reduce the habitat suitability of Sturgeon Bank and the foreshore of Sea Island for migratory birds.
- an abundance of birds use the saltmarsh habitat formed as a result of the approach jetty for the main runway.

The panel concluded that:

- increased air traffic over northern Sea Island will not likely reduce the habitat suitability of Sturgeon Bank and the foreshore of Sea Island for migratory birds.
- the new approach lighting pier will have few, if any, negative impacts on migratory birds.

BIRD HAZARD ISSUES RELATED TO THE SEA ISLAND CONSERVATION AREA AND THE OPERATION OF VANCOUVER INTERNATIONAL AIRPORT

The safe and successful management of the Sea Island Conservation Area requires a balance to be struck between habitat enhancement values and flight safety risks. This can be achieved by careful selection of the species to be encouraged, as prescribed in the SICA Management Plan. The monitoring of flight safety concerns related to the conservation area operation will be achieved by an annual review of activity by a team of experts comprising the Safety Review Team.

The convening of the Blue Ribbon Panel provided an opportunity for a survey of the current situation as presented by the reports and witnesses made available to the panel.

The following flight safety issues were considered to be of sufficient importance for discussion by the Blue Ribbon Panel, so that the panel's knowledge and experience could be used to help develop better ways of managing bird hazards at the Airport. Although it could be argued that a number of these issues are not a direct result of the management of the conservation area or the Airport, the source of the bird hazard problem becomes irrelevant to the safe operation of the Airport if the mobility of birds causes them to have an impact on flight safety. The following issues were identified in the Minister's response to recommendations 13 and 17, the two System Safety Review reports, the avifauna study, and discussions by panel members.

1: BARN OWLS

"Barn Owls have been 'Blue-Listed' by the provincial Ministry of the Environment, i.e., considered sensitive or vulnerable. The 'Blue-List' status is attributed to habitat losses resulting from changes in agricultural practices and recent patterns of urbanization and industrialization in the Fraser Valley. The Committee on the Status of Endangered

Wildlife in Canada (COSEWIC) lists Barn Owls as 'vulnerable' in British Columbia" (Demarchi and Searing 1995).

Barn Owls have been sighted in British Columbia since 1909. The movement northward of this species from the United States has been attributed to mild winters, prime nesting and roosting sites and large vole populations.

Five Barn Owls were tracked (radio-telemetry) during the avifauna study and another 23 have been leg-banded since 1994.

The panel's discussion of this issue included the following points:

- Barn Owls roost and nest in airside buildings.
- Barn Owls hunting airside are extremely likely to become involved in collisions with aircraft, and there have been a number of serious incidents involving Barn Owls world-wide in the past few years.
- there were five reported strikes involving Barn Owls in 1993 and seven in 1994, according to Transport Canada data.
- these reported strikes represent a notable increase in the number of reported owl strikes; in that there were only five reported strikes involving Barn Owls over the previous six years, according to Transport Canada data.
- these birds are active at night after Wildlife Control Officers have ceased operations for the day, and the birds are very difficult to monitor.
- there are no proven methods of dispersing nocturnally active birds such as Barn Owls from runway areas.
- the results of the avifauna study suggest that Barn Owls in the Sea Island Conservation Area do not constitute a significant strike hazard.
- during the study none of the banded Barn Owls were known to have been struck by aircraft, although dead birds were not routinely recovered.
- Barn Owls that were trapped and radio-tagged within the Sea Island Conservation Area during the avifauna study spent little time airside.
- there is an opportunity to move the nesting boxes and mini-barns in the Sea Island Conservation Area to other locations in the Fraser Delta.

The panel concluded that:

- there is no proof that Barn Owls resident within the Sea Island Conservation Area have been involved in strike incidents at the Airport.

- prudence dictates that Barn Owl nesting structures should be moved from the Sea Island Conservation Area to other more suitable sites in the Fraser Delta area in the interests of aviation safety, and to prevent young Barn Owls from being killed as a result of collisions with aircraft. Funds should be provided to local conservation groups to enable them to manage this process.
- a vigorous attempt should be made to eliminate Barn Owl nesting and roosting sites in airside buildings.
- tests of the effectiveness of the Phoenix Wailer and other non-lethal methods of dispersing Barn Owls should be initiated.

2: CANADA GEESE

The panel's discussion of this issue included the following points:

- Canada Geese are large flocking birds that have become year-round residents of Sea Island within the last 30 years, and they have become a nuisance species and not a conservation issue.
- the existence of large patches of mowed grass on Sea Island, outside the airside zone, attract Canada Geese in large numbers.
- the current Wildlife Control Program appears to be effective in moving these birds from the airside zone.
- expansion of mowed-grass areas associated with the parallel runway will likely increase the attractiveness of the Airport to Canada Geese.
- extensive patches of mowed grass on northeastern and central Sea Island, outside the airside zone, attract many Canada Geese that are often disturbed by people and dogs.
- such disturbances adjacent to the parallel runway will likely increase the risk of strikes involving these birds.
- subsequent to the panel's deliberations, it was determined that in North America during 1995, bird strikes involving Canada Geese have caused 8 known serious incidents, resulting in approximately 200 million dollars damage, and the loss of 24 human lives.

The panel concluded that:

- Canada Geese should be subjected to more aggressive control measures than are currently being used at the Airport. These include the culling of resident birds, and trials with products that discourage geese from feeding on grass.

3: SNOW GEESE

The panel's discussion of this issue included the following points:

- Snow Geese winter on the saltmarsh and mud flat habitats of Sturgeon Bank (the Sea Island foreshore) from November to March, and are attracted to the short grass areas on western Sea Island near the main east-west runway.
- the presence of these geese under the flight path of aircraft landing from and taking off to the west may increase strike hazards to these aircraft, particularly fully loaded west-bound aircraft on takeoff.
- similar problems may occur with the parallel runway.
- the glide path configuration of the main runway and the altitudes and flight behaviour of Snow Geese combine to produce a serious bird hazard to aircraft at the Airport, and have been responsible for one serious incident in 1993.
- Snow Geese feeding or resting on the foreshore area also have the potential to create significant hazards to aircraft using the main runway if disturbed by hovercraft.
- there is a lack of information describing the response of waterfowl, and in particular Snow Geese, to the disturbance caused by Coast Guard hovercraft based on Sea Island.
- Airport Wildlife Control Officers cannot deal with Snow Geese once they are moved off Airport property onto the foreshore because this area is protected by the Canadian Wildlife Service.

The panel concluded that:

- aggressive control activities should be continued by the Airport Authority to remove Snow Geese from the airside habitats of Sea Island.
- the Airport Authority, Transport Canada, the Canadian Wildlife Service and the Coast Guard should immediately begin to work together to deal with the potential hazard posed by the presence of Snow Geese on and near the Airport.

4: EUROPEAN STARLINGS AND NORTHWESTERN CROWS

The panel's discussion of this issue included the following points:

- European Starlings are a great concern to flight safety at the Airport and have been involved in serious strike incidents at other airports.
- they are present at the Airport in large numbers.
- during the non-breeding season they frequently congregates and move in large flocks.
- they are attracted to short-grass habitats such as airports for foraging.
- they are year-round residents and nest throughout Sea Island.
- the 'grit dump' at the Iona Island sewage treatment facility is very attractive to crows.
- large numbers of Northwestern Crows and European Starlings fly over the northern part of Sea Island in the late afternoon and evening during summer, fall and early winter.
- the Sea Island Conservation Area could become an attractive night roosting site for starlings.
- these birds have the potential to create an extreme hazard to aircraft using the parallel runway, and European Starlings have been involved in the crash of at least one jet aircraft in other parts of the world.

The panel concluded that:

- action should be taken to reduce any local foraging opportunities available to Northwestern Crows and European Starlings. Examples of specific mitigating actions include closing the 'grit' landfill, not mowing fields in the Airport Commercial Development Zone, continuing an aggressive program of dispersing birds from the Airport, and removing Northwestern Crow nests or oiling their eggs.

5: GREAT BLUE HERONS

Great Blue Herons are common in the Sea Island Conservation Area, and throughout the Greater Vancouver region. They are attracted to the ditch habitats maintained in the conservation area, and most of their movements take place within that area in an east-west pattern. Most Great Blue Herons observed within the Sea Island Conservation Area rarely ventured airside during the period of the avifauna study, and their major breeding colony is in Pacific Spirit Park to the northwest of Sea Island.

The panel's discussion of this issue included the following points:

- Great Blue Herons are large, crane-like birds that are present on and around Sea Island throughout the year.
- although they normally fly alone, their large size, slow flight, and limited maneuverability make Great Blue Herons a potential hazard to aircraft.
- although the last reported Great Blue Heron strike at the Airport was in 1988, the discovery of a dead bird directly beneath the approach to the crosswind runway suggests that strikes involving this species may continue to occur.
- peak rates of Great Blue Heron movements between May and August largely involve flights between foraging areas along the foreshore and the nesting colony in Pacific Spirit Park, about four km to the north.
- the location of the parallel runway coincides with the general flight paths of Great Blue Herons flying below an altitude of 30 metres over the interior of Sea Island, on their flights to and from Pacific Spirit Park.
- aircraft on approach from and departure to the west may encounter a slightly greater risk of a strike involving this species than already exists for the other two runways.
- the implementation of habitat enhancement activities for Great Blue Herons within the Sea Island Conservation Area appears to be in conflict with the aviation safety goals for the area.

The panel concluded that:

- Great Blue Herons are not a conservation issue on Sea Island, and enhancements for these birds within the Sea Island Conservation Area are not required, and provide the perception that flight safety issues are not being fully addressed.
- the issue should be carefully monitored and if necessary, live ammunition should be used to control Great Blue Herons over the Airport.

6: RAPTOR PERCH POLES:

The 1993 implementation of the Raptor Heron Management Plan included strip mowing of grass in the open fields of the conservation area. Three metre strips of grass were mowed between 18 metre strips of unmowed long grass. The rationale for the strip mowing was to provide long

grass for Townsend Voles to proliferate, and short grass so that raptors could see the voles and capture them.

Raptors such as Red-tail Hawks and Rough-legged Hawks normally hunt from perches. The management plan included the installation of 35 artificial perch poles that could be used by raptors while hunting over the mowed grass. The intention was to enhance existing habitat, thereby increasing carrying capacity and populations, to encourage raptors to remain within the conservation area and to reduce and direct their flights. In the absence of perch opportunities, these birds will hunt from the air.

The panel's discussion of this issue included the following points:

- raptors are at the centre of the public's conservation concerns on Sea Island.
- perch poles and strip mowing are intended to encourage raptors such as Red-tail Hawks to hunt within a localized area as opposed to hunting from the air over a wider range, including airside.
- the perch poles do not attract many raptors. They do not create more habitat for raptors but the poles may help to hold the raptors in the Sea Island Conservation Area.
- the perch poles located on the east and west wings of the Sea Island Conservation Area are of most concern from a flight safety perspective because they may result in the presence of airborne hawks at critical areas in the approach-departure path of the parallel runway. However, it could be argued that the perch poles at those sites reduce the number of airborne hawks.
- because the parallel runway will not be operational until October 1996, an opportunity exists between September 1995 and October 1996 to further monitor the effect artificial perch poles have on raptor behaviour in and near the Sea Island Conservation Area, especially at the east and west wings.

The panel concluded that:

- further information should be gathered prior to parallel runway operation to determine what effect artificial perch poles have on raptor behaviour, and therefore on flight safety.
- the examination of the perch poles should be done on an experimental basis, and follow a program of removal and relocation, with ongoing monitoring.
- particular attention should be focused on the perch poles located in the eastern and western wings of

the Sea Island Conservation Area, which lie under or adjacent to the approach-departure path of the parallel runway. The decision as to whether or not to remove the perch poles should follow the results of the study.

- some panel members believe that the prudent course of action is to remove the perch poles from the conservation area, particularly those in the eastern and western wings, and locate them in an area away from Sea Island. Also, raptors that venture airside from the conservation area should be dispersed or live trapped, as should raptors not associated with the conservation area that spend most of their time airside.

7: GULLS

The panel's discussion of this issue included the following points:

- many gulls cross the approaches of all runways at the Airport on their twice daily flights between nocturnal roosts on Sturgeon Bank and inland feeding areas. Runway 26L is most affected by this behaviour in the evening.
- the general pattern of onshore westerly winds over Sea Island in the afternoon and evening requires most aircraft arriving at the Airport to use Runway 26L. This leads to conflict with gulls following the middle arm of the Fraser River near the southeastern edge of Sea Island. (It should be noted that when the parallel runway becomes operational, it will be the main arrival runway, and Runway 26L will become the main departure runway. The movement of arrival traffic northward will likely alter the current situation with respect to gulls.)
- gulls feed in the mowed-grass airside habitat, especially after heavy winter rains when soil-borne invertebrates such as earthworms are forced to the surface.
- current attempts to disperse gulls from the airside zone to areas beyond the airside boundary often result in their moving from one location to another within the airside zone, thereby increasing the hazard by forcing birds to spend more time in the air.
- there are no obvious, currently acceptable options available to prevent the daily gull movements past Sea Island.

The panel concluded that:

- the movement of gulls from nocturnal roosts on Surgeon Bank poses significant threats to flight safety.
- gull behaviour around Sea Island requires further study to identify roosting sites, feeding sites, and flight paths. In the meantime, gulls posing a threat to flight safety should be aggressively controlled over the Airport, including the use of live ammunition.
- efforts should be initiated to alter gull behaviour. The closure or relocation of feeding and roosting sites are possible options.

8: DUNLIN

The panel's discussion of this issue included the following points:

- during the day in the fall and winter, the proximity and suitability of the airside zones to the foreshore provide shorebirds, particularly Dunlin, with foraging and resting opportunities at high tides.
- these shorebirds are extremely hazardous to aircraft because of their unpredictable flocking behaviour and resistance to active dispersal techniques.
- Dunlin forage in large flocks in the airside zone, particularly after rain when soil-borne invertebrates become available.
- a number of serious bird strikes involving Dunlin have occurred at the Airport.

The panel concluded that:

- short-term aggressive measures should be continued by the Airport Wildlife Control Program in order to control shorebirds such as Dunlin.
- a falconry program similar to that used at Lester B. Pearson International Airport should be tried on an experimental basis.
- a long term systems approach to managing shorebirds should be initiated by the Airport Authority. Biocontrol agents such as the nematode *Steninerma carpocepsa* should be tried, and habitat management practices such as reducing the accumulation of surface water should be initiated. The use of pesticides to control soil-borne invertebrates is not recommended due to concerns about the toxicity of run-off into the Fraser River.

- the creation of alternative roosting sites for shorebirds away from the Airport should be explored as an option.

9: EFFECTIVENESS OF THE AIRPORT WILDLIFE CONTROL PROGRAM

The panel's discussion of this issue included the following points:

- several species of gulls, American Wigeons, Mallards, Northern Pintails, Green-winged Teals and shorebirds such as Dunlin are attracted to the feeding and loafing opportunities presented by the short-grass habitat of the Airport airside zone and northeastern part of Sea Island.
- the attraction varies among species, but is greatest during and after winter rains because local bird numbers are high, surface water flushes soil invertebrates out of the ground, tides are often high during the day, and surface water, tarmac and short-grass all combine to provide birds with ideal resting habitat.
- airside surface water accumulations result from poor drainage in many locations, and not from a rise in the water table.
- strike hazards increase when these birds cross aircraft flight paths while moving among habitat features that attract them.
- completion of the parallel runway will result in an increase of short-grass habitat.
- birds dispersed by Wildlife Control Officers are likely to move from one airside location to another as a result of increased short-grass habitat.
- many of the birds that encroach on airside zones have become habituated to present control techniques, and move from one part of the Airport to another as they are dispersed.
- the diminished response to active control techniques shown by many birds during the avifauna study suggests the need to expand, enhance and modify the Airport Wildlife Control Program.

The panel concluded that:

- a complete review of the Airport Wildlife Control Program should be commissioned by the Airport Authority, to ensure that the program is consistent with the expanding activity of Airport operations. This review should include expanding methods of control and the integration of ground maintenance

and other Airport activities in a systems approach. The review should address both habitat modifications and dispersal techniques. The review should focus on the behaviour of Barn Owls and other raptors, Canada Geese, Snow Geese, Dunlin, European Starlings, Northwestern Crows, Great Blue Herons and gulls.

- two new techniques should be added to the Airport program: a raptor trap and release program and falconry should be tried. These techniques have been successful at other airports.
- to maximize effectiveness, the Wildlife Control Program requires comprehensive management to establish program priorities and objectives, and to measure and report results.

10: SICA MANAGEMENT PLAN

Although not a flight safety issue in itself, the management prescriptions contained within the SICA Management Plan are of paramount importance in terms of the conservation area's impact on the safe operation of the Airport. Elements of the plan such as the degree and type of legislated wildlife protection, provisions for wildlife control activities by the Airport Authority within the conservation area, the extent of the enhancement program, and the dispute resolution process for the various stakeholders were all areas that required scrutiny by the panel members.

The main purpose of the panel's deliberations on the SICA Management Plan were to assess the compatibility of conservation area management practices with concerns related to aviation safety identified in the Minister's response to recommendations 13 and 17. The panel discussions were based on presentations made at the panel meeting on the two following background reports:

- Environment Canada, Canadian Wildlife Service, Sea Island Conservation Area Draft Management Plan (Draft #4), September 1995. The presentation was made by Rick McKelvey, Canadian Wildlife Service, and Gary Searing, LGL Ltd.
- Mike Demarchi and Gary Searing, Avian Ecology and Air-Traffic Safety at Vancouver International Airport, LGL Limited, September 1995. The presentation was made by Gary Searing and Mike Demarchi, from LGL Ltd.

The Minister of Transport's commitments to recommendations 14, 17 and 18 provide the direction for the development of the SICA Management Plan. Transport Canada is committed to:

- transfer to Environment Canada 140 hectares of land north of the parallel runway for management by the Canadian Wildlife Service as the Sea Island Conservation Area.
- securing, as much as possible, an overall no-net-loss of habitat capability by ensuring replacement habitat as close as possible to the habitat that is being lost to the parallel runway project, and through management programs that would increase the productivity of replacement lands.
- establishing a committee to prepare plans and oversee the management of the Sea Island Conservation Area with Environment Canada-CWS serving as chair.

To fulfill its commitments, Transport Canada established the Wildlife Habitat Advisory Committee on Compensation (WHACC) to advise on the compensation program, including the management of the conservation area. The WHACC is made up of the following members:

- Environment Canada-CWS (chair)
- B.C. Ministry of Environment, Lands and Parks (Fish and Wildlife Branch)
- Musqueam Indian Band
- Transport Canada (Aviation)
- Vancouver International Airport Authority (Environment and Airside Safety)
- City of Richmond
- Vancouver Natural History Society
- Sea Island Community Association
- Corporation of Delta
- B.C. Ministry of Agriculture, Fisheries and Foods (advisor)
- Fraser River Coalition (observer)

The overall goal of the SICA Management Plan is to maintain existing conservation values while not compromising aviation safety. Specific objectives are to:

- maintain the habitat and populations of wildlife that do not contribute significantly to bird strikes at the Airport.
- maintain the primacy of aviation safety.
- provide public use that is compatible with aviation safety and wildlife management goals.

The current draft (#4) of the SICA Management Plan has undergone a number of revisions as a result of a series of

workshops attended by staff from the Canadian Wildlife Service, Transport Canada and the Airport Authority. The habitat management prescriptions in Draft #4 have been developed by the biologists who conducted the avifauna study so that the extensive data from the study could be incorporated in the plan. The main components of the plan are a habitat management plan based on the earlier Draft #3.7, a species specific risk abatement plan, and a contingency plan for dealing with air safety issues or issues related to the loss of conservation values, should they arise. The measure of the plan's success or failure will be determined by whether the conservation area is able to retain wildlife habitat rather than a predetermined number of species or individuals of a species.

Two possible approaches were identified in the avifauna study for the management of the Sea Island Conservation Area. The first option called for the management of the area in its present form, as described in Draft #4, with some enhancements, and an ongoing monitoring program to determine whether conservation and air safety objectives are being met. The second option was to allow the habitat in the conservation area to return to a mixed deciduous and coniferous forest, with no habitat manipulation such as artificial enhancement.

The panel's discussion of this issue included the following points:

- some birds will always be attracted to Sea Island habitats, regardless of management practices or land designation.
 - raptors with home ranges in the Sea Island Conservation Area were not often attracted to airside habitats during the one year avifauna study.
 - data from the avifauna study indicate that wintering raptors using the Sea Island Conservation Area do not cause significant hazards to aircraft using existing runways.
 - the number of raptors using the conservation area after the parallel runway becomes operational will not increase, and may well decrease from numbers observed during the avifauna study.
 - the current draft (Draft #4) has been under development for over a year, and agreements on many air safety and conservation issues have been reached by the stakeholders.
 - arrangements for the ongoing management of the Sea Island Conservation Area are currently being finalized; such as a contingency plan, tripartite memorandum of understanding, and a species-specific risk abatement plan.
 - data from the one year avifauna study has been incorporated in the current draft.
- The panel concluded that:
- the current approach to the management of the conservation area lands should be pursued, and a comprehensive monitoring program initiated.
 - the current SICA Management Plan needs minor revisions to meet the goal of maintaining existing conservation values while not compromising aviation safety.
 - aviation safety issues should be identified and described in the beginning of the plan, along with a clear explanation of why aviation safety issues are so important. Ongoing references to this issue in the plan should be reduced.
 - the plan should address recommendation #3 in the 1995 System Safety Review report, which identified the need to incorporate systematic prescriptions to deter species of high risk, and to include conservation targets for designated species. The panel felt that establishing numeric targets for conservation values was very problematic due to the large variation in numbers and distribution of birds from year to year, and concluded that a more useful approach would be to establish systematic prescriptions of habitat features that attract designated species. This method should provide a more reliable way to determine whether the Sea Island Conservation Area is meeting its objectives.
 - the management plan should indicate that the Sea Island Conservation Area will be managed as a special conservation area, and not a National Wildlife Area administered under the Canada Wildlife Act.
 - the SICA Management Plan should include a background section to outline the events relevant to the plan with respect to the Minister's commitments to recommendations 13 and 17.
 - aviation safety concerns related to the Sea Island Conservation Area can be mitigated through the proper management of the area, and by an active, highly motivated, and well equipped Wildlife Control Program. The current draft of the SICA Management Plan should provide the framework to address concerns related to the management of the conservation area.

11: MISCELLANEOUS ISSUES

The panel discussed several miscellaneous air safety issues that had been identified in the LGL Ltd. report 'Avian Ecology and Air Traffic Safety at Vancouver International Airport.'

The panel discussion included the following points:

- the open waste bins managed by CaterAir at the Canadian Airlines International facility on Sea Island provide a food source for gulls, and thereby create a flight safety problem.
- haying and grazing are hazardous land use practices in the vicinity of the Airport because of the short-grass habitat that the activities provide, and because of the insect activity and small mammal mortality that mowing causes. The results of mowing all contribute to create a bird attractant.
- waterfowl and shorebirds are attracted to the freshwater ponds in the Iona Island Regional Park, and to the lagoons associated with the Iona Island Sewage Treatment Facility.

The panel concluded that:

- food waste handled by CaterAir at the Canadian Airlines International hangar area should be properly contained to minimize its attractiveness to birds.
- The Airport Authority should terminate haying and grazing in the commercial development zone to reduce the area's attractiveness to birds.
- waterfowl and shorebirds attracted to the lagoons associated with the Iona Island Sewage Treatment Facility are not creating significant hazards to aircraft using the existing runways, and will not likely create hazards for aircraft using the parallel runway.
- the two freshwater ponds in the Iona Island Regional Park are not creating significant hazards to aircraft using the Airport, but should be monitored.

SUMMARY

During its deliberations from September 19 to 21, 1995 the Blue Ribbon Panel addressed the six subject areas identified in the panel terms of reference, which provided the framework for the panel's activities. Within the six subject areas, 13 main issues were discussed: three relating directly to the Minister's commitment to recommendation 12, and ten to flight safety concerns identified in the two System Safety Review reports, avifauna study reports, and from panel discussions. Finally, the panel discussed several miscellaneous flight safety issues taken from the avi-

fauna study reports. Overall, the panel concluded that Transport Canada has addressed subject area number one in the panel's terms of reference, and completed its review of the recommendation 12 issues through a multi-agency team approach, and the results are presented in this report which will be available for public review.

Following is a synthesis and summary of the panel's conclusions and recommendations related to the remaining five subject areas in the terms of reference:

- panel members agreed that the Airport Wildlife Control Program will result in a general decline in the abundance of many bird species within the Airport boundaries, but will have minimal impact on the birds resident within the Sea Island Conservation Area;
- that public concerns expressed about the possible negative impacts of Transport Canada's guidelines on 'Land Use in the Vicinity of Airports' on the wildlife of Sea Island have been addressed in the establishment of the Sea Island Conservation Area by Transport Canada;
- that increased air traffic over northern Sea Island will not likely reduce the habitat suitability of Sturgeon Bank and the foreshore of Sea Island for migratory birds;
- that the new approach lighting pier will have few, if any, negative impacts on migratory birds;
- that Barn Owl nesting sites should be eliminated from airside buildings, and that nesting structures should be removed from the Sea Island Conservation Area, and relocated to suitable areas off Sea Island;
- that Canada Geese are not a conservation issue, and should be subjected to more aggressive control measures than are currently being used on the Airport;
- that Dunlin should continue to be aggressively controlled on the Airport, utilizing techniques such as falconry on a trial basis;
- that flight safety problems associated with gulls at and near the Airport should be studied further;
- that hazards associated with Snow Geese should be addressed as soon as possible by a committee consisting of representatives from the Vancouver International Airport Authority, Transport Canada, and Environment Canada;
- that flight safety issues related to Northwestern Crows and European Starlings should be addressed;

- that Great Blue Herons are not a conservation issue on Sea Island, and enhancements for these birds within the Sea Island Conservation Area are not required;
- that Great Blue Heron movements should be carefully monitored;
- that perch pole enhancements within the Sea Island Conservation Area should be studied prior to the operation of the parallel runway, particularly those in the east and west wings, and as soon as results are available, a decision should be made whether or not to remove them;
- that raptors venturing airside from the conservation area should be dispersed or live trapped; as should raptors not associated with the conservation area that spend most of their time airside;
- that the risk management program developed to ensure the safe co-existence of the Airport and the Sea Island Conservation Area should be continued by Transport Canada, Environment Canada, and the Vancouver International Airport Authority;
- that the Environment Canada management plan for the Sea Island Conservation Area should be focused on the maintenance of suitable habitat rather than on numeric targets for certain species;
- that aviation safety concerns related to the Sea Island Conservation Area can be mitigated through the proper management of the area, and through increased activity by the Airport Wildlife Control Program, and that the management plan based on Draft #4 and the process for revising the plan will address these aviation safety concerns. Transport Canada has stated that an annual safety review shall be undertaken to ensure that the Sea Island Conservation Area management practices are attaining these safety objectives.

Vic Thom (chair)

V. Thom

Mike Matthews

Matthews

Capt. Marc Larose

M. Larose

Dr. Hans Blokpoel

H. Blokpoel

Eugene LeBeauf

Eugene A. LeBeauf

Captain Richard Sowden

R. Sowden

Dave Dunbar

D. Dunbar

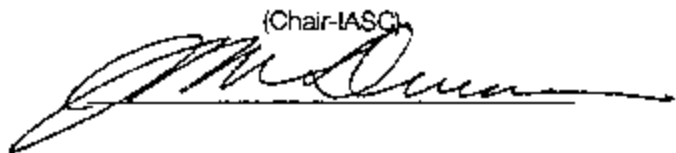
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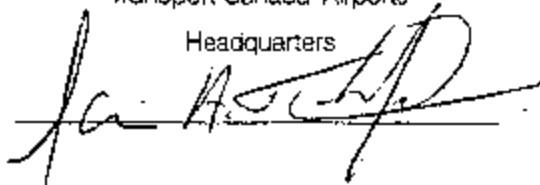
Richard Korosch

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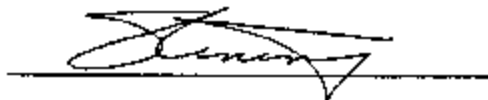
Mark Duncan
Regional Director General
Pacific Region
Transport Canada-Airports
(Chair-IASC)

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Iain Henderson
Director General
Safety and Technical Services
Transport Canada-Airports
Headquarters

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Victor Barbeau
Assistant Deputy Minister
Transport Canada
Airports

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APPENDIX 6

Ongoing Management of the Sea Island Conservation Area (SICA)

BIRD STRIKE COMMITTEE CANADA
24th MEETING
RICHMOND, B. C.
APRIL 10, 1996

ONGOING MANAGEMENT

OF THE

SEA ISLAND CONSERVATION AREA

presented by: Bob Sisler
Transport Canada - Airports Group
(604) 666-5370

BACKGROUND:

- FEDERAL ENVIRONMENTAL ASSESSMENT REVIEW PANEL FORMED IN 1989 TO REVIEW IMPACTS OF THE CONSTRUCTION OF A PARALLEL RUNWAY AT YVR.
- PANEL ISSUED REPORT IN AUGUST 1991 FOLLOWING THE COMPLETION OF THE E.I.S. RECOMMENDATIONS #13 AND 17 DEALT WITH THE SICA AREA.
- THE MINISTER'S RESPONSE TO THE PANEL RECOMMENDATIONS SET ASIDE 140 HECTARES OF LAND IN THE AIRPORT'S NORTH RESERVE AS SICA AND AGREED TO TRANSFER THESE LANDS TO CWS. AVIATION SAFETY WAS TO REMAIN THE TOP PRIORITY IN MANAGING THE LANDS FOR WILDLIFE HABITAT.

SEA ISLAND CONSERVATION AREA
PROPOSED SERVICE ROAD - PHASE 1
PROPOSED SERVICE ROAD - PHASE 2
PROPOSED SERVICE ROAD - PHASE 3
COMMERCIAL ZONE
MATERIALS DEVELOPMENT

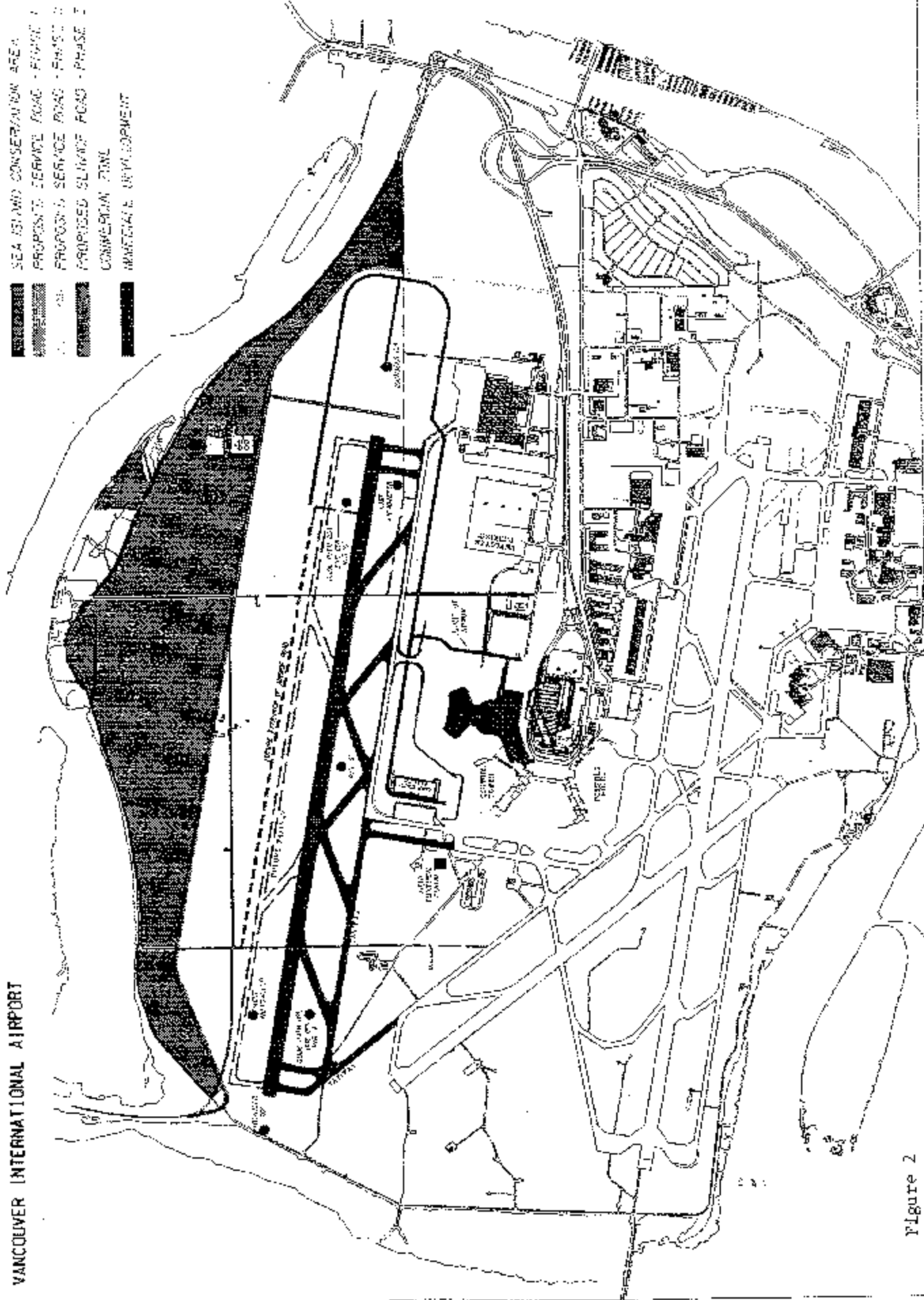


Figure 2

PROCESS:

VANCOUVER INTERNATIONAL AIRPORT

- YVRAA RESPONSIBLE FOR THE RUNWAY CONSTRUCTION
- YVRAA IMPLEMENTED ENVIRONMENTAL MITIGATION PROGRAM (2.9 M PROVIDED BY TC). SOME WORK IN SICA
- YVRAA RESPONSIBLE FOR WILDLIFE CONTROL PROGRAM
- **EMIC** FORMED TO ADVISE YVRAA ON THE IMPLEMENTATION OF THEIR PARALLEL RUNWAY ENVIRONMENTAL RESPONSIBILITIES.

TRANSPORT CANADA

- REVIEWED YVRAA'S WILDLIFE CONTROL PROGRAM, CONDUCTED AVIAFAUNA STUDY, REVIEWED INTERACTION BETWEEN AVIATION AND BIRDS AT YVR, CONDUCTED SYSTEM SAFETY REVIEW, AND CONVENED 'BLUE RIBBON PANEL' TO ANALYSE THE RESULTS OF THE ABOVE.
- TRANSPORT CANADA WORKING WITH YVRAA AND CWS TO TRANSFER THE SICA LANDS TO THE CWS.
- **Inter Agency Steering Committee** (FEDERAL AGENCIES) FORMED TO OVERSEE THE IMPLEMENTATION OF THE FEDERAL COMMITMENTS MADE FOR THE PARALLEL RUNWAY.

CANADIAN WILDLIFE SERVICES

- DEVELOP THE SICA MANAGEMENT PLAN
- WORK WITH TC AND YVRAA ON THE TRANSFER OF SICA
- **Wildlife Habitat Advisory Committee on Compensation** ADVISES CWS ON THE MANAGEMENT OF THE SICA

ONGOING MANAGEMENT OF THE SICA:

NEED:

REQUIRE LONG TERM STRATEGY FOR THE MANAGEMENT OF ANY RISK THAT MAY ARISE FROM THE CO-EXISTENCE OF THE SICA AND THE AIRPORT.

INPUTS:

SICA STEERING COMMITTEE (replaces former IASC)

- SENIOR MANAGEMENT REPRESENTATIVES OF 3 AGENCIES (YVRAA, TC, CWS) MOST DIRECTLY INVOLVED WITH ENSURING SICA MEETS ITS OBJECTIVES.
- COMMITTEE WILL BE RECEIVING ADVICE FROM THE SICA WORKING GROUP, TC's SYSTEM SAFETY REVIEW, YVRAA's EMIC, AND CWS's WHACC.
- COMMITTEE WILL ADDRESS SIGNIFICANT ISSUES ARISING FROM THE MANAGEMENT OF THE SICA AND AIRPORT OPERATIONS.

SICA WORKING GROUP

- STAFF REPRESENTATIVES OF THE 3 AGENCIES (CWS, YVRAA, TC) MOST DIRECTLY INVOLVED IN ENSURING THAT SICA MEETS ITS OBJECTIVES.
- COMMITTEE RECEIVES DIRECTION AND PROVIDES ADVICE TO THE SICA STEERING COMMITTEE. COMMITTEE IS TO DEAL WITH ISSUES THAT ARISE WITH THE DAILY OPERATIONS OF THE SICA AND THE AIRPORT. WORKING GROUP MEMBERS WILL CARRY FORTH CONCERNS FROM EMIC, WHACC, AND OTHER SICA STAKEHOLDERS.

ONGOING MANAGEMENT OF SICA

SICA STEERING COMMITTEE
YVRAA - chair CWS TC - Aviation TC - Airports



SICA WORKING GROUP
CWS - chair YVRAA TC - Aviation TC - Airports



ONGOING INPUTS
Safety Review Team Reports Bird Survey Wildlife Control Program Proposals for SICA Mgt Changes



PUBLIC INPUT
Wildlife Habitat Advisory Committee - CWS Environmental Monitoring Committee - YVRA

APPENDIX 7

Assessment of Bird Strike Accident Risk Using Event Sequence Analysis

Assessment of Bird Strike Accident Risk Using Event Sequence Analysis

Todd Curtis, P.E.

Abstract

Reports from five bird strike related hull loss accidents involving large jet transports were analyzed in order to develop an event sequence analysis based assessment of the risk of a hull loss due to bird strikes. The five accidents all had birds ingested into one or more engines during takeoff and in two of the accidents crew actions were directly involved in the sequence of events that led to the accident. From those five accidents, two groups of events were identified that should be part of a bird strike risk assessment. The first group included twelve events that were directly involved in past accidents. The second group included four events that were not directly involved in those accidents but could be directly involved in future accidents. The paper also includes a brief overview of the event sequence analysis method and a discussion of ways to expand upon the results of this study.

Introduction

This study uses event sequence analysis to develop a risk assessment of a bird strike during takeoff that leads to the hull loss of a large jet transport. An analysis of prior bird strike studies and of five previous bird related large jet transport hull losses revealed two things. First, flight crew action played a significant role in the outcome of these accidents and second, major studies of bird strike effects do not deal with the role of crew actions. Event sequence analysis is a potentially useful model for bird strike risk assessment because it can include human actions and environmental conditions that influence the outcome of an aircraft encounter with birds. This method can also accommodate common cause and dependent events.

This study will examine past bird strike related accidents to create a minimum set of circumstances, including those involving the role of decision making, that should be included in a bird strike risk assessment model. This set is not meant to be exhaustive, but rather to serve as a foundation for further development of a risk assessment model.

Past Research

Most available bird strike data and research studies focus on the effect that a bird strike has on the aircraft or on the outcome of the flight. Issues such crew coordination or the adequacy of crew training are usually not a part of these research efforts. These issues are usually discussed in detail only as part of an individual accident investigation or incident report. Typical of the major studies is the 1995 FAA study Bird Ingestion Into Large Turbofan Engines. One section described the number of events where the crew changed the planned flight of the aircraft after a bird strike event but did not discuss the flight crew's decision making process.

Information on the human element in serious bird encounters can be inferred from other studies. In 1992, a joint industry and government effort, described in FAA Advisory Circular 120-62, investigated crew performance issues in a variety of rejected takeoff scenarios. Many of the conclusions reached, such as the need to train crews to make better rejected takeoff decisions, are directly relevant to the assessment of the risk of bird strikes during takeoff.

Method

This study relied primarily on official accident investigation reports or other published accident reports to determine the sequence of events that led to five bird strike related large jet transport hull losses. These were:

1. 11/12/75, DC10, USA	- Rejected takeoff and went off the side of the runway
2. 4/4/78, 737, Belgium	- Rejected takeoff and overran the runway
3. 9/29/86, A300, India	- Rejected takeoff and overran the runway
4. 9/15/88, 737, Ethiopia	- Both engines failed and aircraft crashed during turn back
5. 9/22/95, 707 AWACS, USA	- Crashed about a mile after takeoff after one engine failed and second engine on same wing lost at least 50% of its thrust.

The sequences of events for these accidents are detailed in the Appendix. Factual data and conclusions of the accident reports were used as a guide to building the event sequence. The events include those that directly contributed to the aircraft accident and those that did not. For example, in the DC-10 event, the crew saw birds prior to impact and engine three was damaged by a bird strike. Seeing the birds did not have any bearing on the final outcome because the crew did not respond to that stimulus in a way that contributed to the accident. However, the engine damage was key because it led to an uncontained failure of the engine and the loss of other aircraft systems.

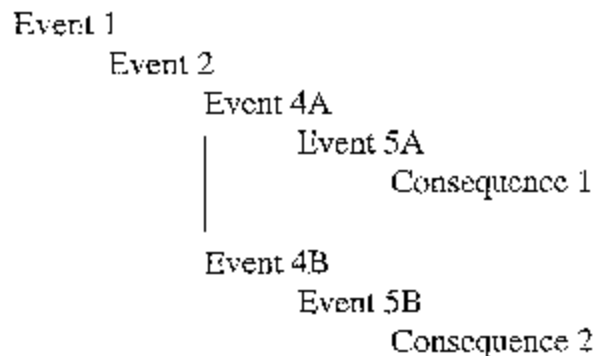
Event sequence analysis allows the analyst to use some judgment when ordering the sequence of events. For example, in that same DC-10 event, the wet runway surface was listed as the first event in the sequence, but one could argue that it should be placed before the captain's decision to reject the takeoff because that is the time when the crew may have considered the runway condition along with other aircraft and environmental factors.

Once the sequence was constructed, the task was then to choose those elements that should be included in a more general event sequence analysis based risk assessment. Part of that process was deciding which events had a direct bearing on the outcome of the five analyzed accidents and which events might have a direct bearing on future accidents.

A Brief Overview of Event Sequence Analysis

Figure 1 shows the basic structure of an event sequence map for a series of events that lead to a consequences of interest. This illustrates both the layout of a typical map and how human decisions can be incorporated into the analysis.

Figure 1: Event Sequence Map Structure



In this example, each line represents one event and the indentations are a visual reminder that the events take place in a specific sequence. The rightmost indented event represents the outcome. The probability of any one event may be dependent on the sequence of events that preceded it. For example, in a simple event sequence consisting of the flight crew spotting birds, the engine instruments indicating a substantial drop in thrust, and the crew rejecting the takeoff, the probability of the second event would be entirely independent of the first event, but the probability of the third event would be a function of the first two events.

The line connecting Events 4A and 4B in Figure 1 illustrates that the sequence branches at the point into two possible directions. The consequences at the end of these different paths can either be the same consequence arrived at through different sequences of events or they could be different consequences. In Figure 1, there is a different sequence associated with Consequence 1 and 2, but both sequences would share Events 1 and 2.

If every event in the event sequence map has a probability associated with it, then multiplying the probabilities of each event in all possible sequences from the initiating event to the final consequences will produce the probability that those consequences will occur. The combination of a consequence and the probability of that consequence constitutes the risk. Therefore to complete the risk assessment, each consequence of interest must be coupled with the product of the estimated probability of each event in the associated sequence.

Results

Construction of the event sequences of the five hull loss event made it relatively easy to compare the accidents for any similarities and differences and to select those elements that either had a direct effect on past accidents or could have an effect on future accidents. Table 1 illustrates some of those similarities and differences. Table 2 contains those events that had a direct effect on the final outcome of past accidents. Table 3 contains those elements that may have a direct effect on the outcome of future accidents involving bird strikes. Figure 2 consists of an event sequence map that is based on the information gathered from accident reports of the five hull loss accidents.

Table 1: Similarities and Difference in Accident Event Sequences

	11/12/7 5 DC10	4/4/78 737	9/29/86 A300	9/15/88 737	9/22/95 AWACS
Phase of Flight When Birds Hit	Takeoff	Takeoff	Takeoff	Takeoff	Takeoff
Birds Seen By Crew	Yes	Yes	Yes	Yes	Yes
Speed at Bird Impact	< V ₁	V _r	V _r	V _r	V _r
Captain Decided to Reject Takeoff	Yes	Yes	Yes	No	No
Human Decisions Reduced Accident Severity	Yes	No	No	Yes	No

Table 2: Events With A Direct Effect on the Outcome of Past Accidents

	11/12/75 DC10	4/4/78 737	9/29/86 A300	9/15/88 737	9/22/95 AWACS
1. Engine Ingests at Least One Bird	X	X	X	X	X
2. Uncontained Engine Failure	X		X		X
3. Partial Thrust Loss on One or More Engines		X			X
4. Full Thrust Loss on at Least One Engine	X		X	X	X
5. Full Thrust Loss on Multiple Engines				X	X
6. Aircraft Not Capable of Continued Flight and Safe Landing	X			X	X
7. Loss of Stopping Capability (tires, brakes, spoilers, or thrust reversers)	X				
8. Non- Engine System Malfunction	X				
9. Crew Coordination Problems		X	X		
10. RTO Initiated With Aircraft Beyond V ₁		X	X		
11. Airfield Management Actions					X
12. Air Traffic Control Actions					X

Table 3: Events That May Directly Effect the Outcome of Future Accidents

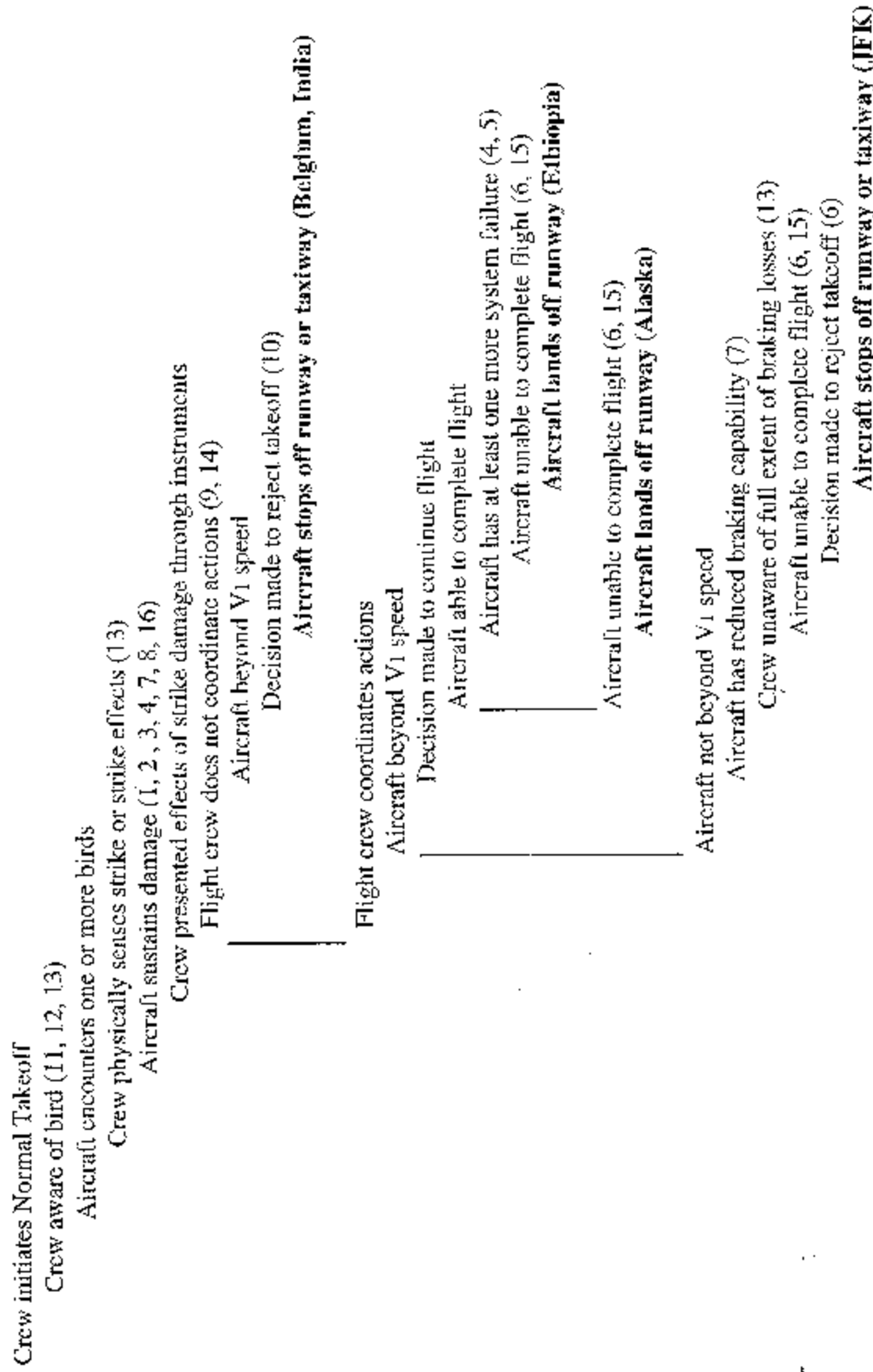
	11/12/75 DC10	4/4/78 737	9/29/86 A300	9/15/88 737	9/22/95 AWACS
13. Crew Relying on Physical Cues (visual, auditory, kinesthetic)	X	X	X	X	X
14. Procedures for Transferring Aircraft Control		X	X	X	X
15. Loss of Directional Control					X
16. Aircraft Fire Before the End of the Flight	X				

Event Sequence Map For the Five Hull Loss Accidents

Using the insights gained from the analysis of the five hull loss accidents, the event sequence map depicted in Figure 2 provides the framework for assessing the accident risk due to a bird strike during takeoff. The consequences of interest are all in bold type and are associated with at least one of the five accidents. All of the 16 events identified earlier are included in this event sequence map. For example, the multiple engine failures of the accidents in Ethiopia and Alaska are implied in the event "Aircraft unable to complete flight".

Some of the four events in Table 3 are not associated with the particular consequence of the accident it was associated with. Specifically, event 14 - "Procedures for Transferring Aircraft Control" - was associated with the AWACS hull loss, but it is not in the path in Figure 2 that leads to that accident. In that case, the transfer of control from the copilot to the pilot were not clearly coordinated, but the transfer had no effect on the outcome of the flight.

Figure 2: Event Sequence Map for Accidents Due to a Bird strike During Takeoff *



* Numbers refer to the 16 events identified in Tables 2 and 3.

Conclusions

- Analysis of past bird strike related hull loss accidents identified twelve events that were directly involved in the outcome of those accidents (listed in Table 2)
- Analysis of past bird strike related hull loss accidents identified four events that were not directly involved in the outcome of those accidents, but could become a factor in future accidents (listed in Table 3)
- These 16 events form a minimum set of events or conditions that should be included in any risk assessment of hull loss risks from bird strikes during takeoff
- An event sequence map using the 16 events from Tables 2 and 3 can be used to develop a concise summary of the sequences of events that led to the five accidents studied
- In all five accidents, decisions made by flight crews or air traffic control either directly contributed to the accident or were instrumental in reducing the severity of the mishap

Discussion

One logical step beyond this analysis would be the expansion of the event sequence map of Figure 2 to broaden the risk assessment model for hull losses due to bird strikes at takeoff. Such an expansion would allow one to illustrate how some sequences that have the possibility of leading to accidents compare with the sequences of events that led to a past accident. The biggest benefit of comparing risks in this fashion is that in a map such as that in Figure 2, is that it is easy to see how sequences of events can lead to accidents. One could take a completed event sequence map and compute the probabilities of the consequences of interest just by multiplying the probabilities of the events in that event sequence.

One could also expand the event sequence map by adding branches where appropriate. For example, a crew may see birds and hear one or more strikes on the aircraft without the aircraft performance being degraded. One consequences of interest might be injury or aircraft damage resulting from a high speed rejected takeoff when the cause of the rejected takeoff decision was based on missing or misleading readings from the cockpit instruments.

Another logical step that would be to estimate the probabilities of each of the events in the event sequence map of Figure 2 in order to estimate the likelihood of different consequences. These probabilities can be estimated through some combination of a review of accident or incident data, analysis, and engineering judgment. With this information, the risk of each consequence could be estimated. This would allow a direct comparison between the risks of the consequences that have occurred with consequences that have not occurred but have been identified through an expansion of the event sequence map.

Appendix: Event Sequences for Hull Loss Bird Strike Accidents

DC10, USA, 11/12/75
Passenger Flight
Blast fence off departure end of runway
Runway wet
Captain flying takeoff
Aircraft speed less than V1
Captain sees large rising flock of birds
Engine #3 ingests birds beyond certification limits
Severe damage to engine #3 fan blades
Engine and nacelle design unable to contain failure and prevent further significant damage and system losses
Crew hears impacts
Crew hears bangs or explosions
Aircraft able to complete flight
Captain initiates RTO below V1
Engine #3 failure indicated
Wing and pylon fire starts
Wing and pylon fire not indicated
Hydraulic system #3 lost
50 % loss of braking torque
Loss of brake system indicated
Engine #3 thrust reverser lost
2 of 10 spoilers lost
One center gear tire penetrated by foreign object and fails
Two other tires fail
Tire failures not indicated
Crew senses less effective braking
State of antiskid system not indicated
Crew aware aircraft can't stop on runway
Crew believes aircraft under control
Aircraft turns off at last taxiway at 40 kt.
Aircraft leaves pavement during runway turnoff

737, Belgium, 4/4/78
Training flight
Touch and go landing
First Officer flying
12 knot tail wind
Aircraft always above V1
Aircraft rotates
Left engine ingests bird
Crew hears strikes
Crew feels engine vibration
FO stops rotation
Aircraft able to complete flight
Captain takes control without coordinating with the FO
FO applies brakes
CPT does not get desired elevator response
CPT performs RTO
Aircraft unable to stop on available runway

A300, India, 9/29/86
Passenger flight
First Officer flying takeoff
Aircraft speed above V1
Crew sees large bird on runway centerline
FO begins rotation
Right engine ingests birds
Right engine fails
Crew hears loud noise from right side
Crew experiences severe aircraft vibration
Captain takes control of aircraft
Aircraft able to complete flight
Captain elects to reject takeoff above V1
Aircraft unable to stop on available runway

737, Ethiopia, 9/15/88
Passenger flight
First Officer flying
Aircraft at VI
Crew sees flock in motion
Captain takes control of aircraft
Aircraft rotates
Both engines ingest birds beyond certification limits
Crew hears strikes
Crew continues takeoff
Partial thrust losses in both engines
Crew aware of thrust losses
Crew firewalls engines
Aircraft gains altitude
Crew initiates return to land
Crew aware of high EGT
Engine thrust reduced
Engine 1 loses power
Engine 2 loses power
Aircraft unable to complete flight

707 AWACS, USA, 9/22/95
Military training flight
Rising terrain beyond runway
Airfield bird control and bird hazard warning process not well coordinated or managed
ATC observed large flock of geese close to runway took steps to order their dispersal
ATC did not advise the aircraft of the presence of geese near the runway
Co-pilot (First Officer) flying
Aircraft at Vr
Crew sees flock in motion
Aircraft rotates
Engines 1 and 2 ingest both ingest one or more birds beyond certification limits
Crew aware of strikes
Crew continues takeoff
Engine 2 has uncontained failure
Engine 1 stalls and loses 50-70% of thrust
Crew aware of thrust losses
Crew initiates return to land
Pilot (Captain) takes control of aircraft
Aircraft unable to maintain directional control
Aircraft unable to gain airspeed
Aircraft unable to gain altitude
Aircraft unable to clear rising terrain and complete flight

Notes:

FO = First Officer and CPT = Captain

In the AWACS event, Pilot is equivalent to Captain and Co-pilot is equivalent to First Officer
Events that had an effect on the final outcome are **bolded**

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APPENDIX 8

Commercial Transport Engine Bird-Ingestion Design Consideration

BIRD STRIKE COMMITTEE CANADA

VANCOUVER APRIL 10-11, 1996

COMMERCIAL TRANSPORT ENGINE BIRD-INGESTION DESIGN CONSIDERATIONS

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March 26, 1996

Summary

Following a brief introduction, this paper provides an overview of bird ingestion design considerations and the engine certification requirements that manufacturers must demonstrate prior to entry into service of new aircraft engine models. 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.

COMMERCIAL TRANSPORT ENGINE BIRD-INGESTION DESIGN CONSIDERATIONS

Thomas L. Alge

**GE AIRCRAFT ENGINES
Cincinnati, Ohio - USA**

March 26, 1996

1.0 INTRODUCTION

Modern aircraft turbine engines have achieved a high level of reliability while manufacturers and users continually strive to further improve the safety record. The drive for safety in single-engine aircraft has resulted in safer multiple-engine aircraft. The major safety concern today includes common-cause events which can 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. 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.

This paper provides an overview of bird ingestion design considerations and the engine certification requirements that manufacturers must demonstrate prior to entry into service of new engine models.

Engine Example for Reference

As engines have become larger, the frequency of bird ingestion has also increased. This is primarily a result of the larger forward capture areas. 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. Once a bird has been ingested, the bird can pass through the fan bypass duct and/or the primary (compressor) flowpath (Figure 2). This must be considered in the design process.

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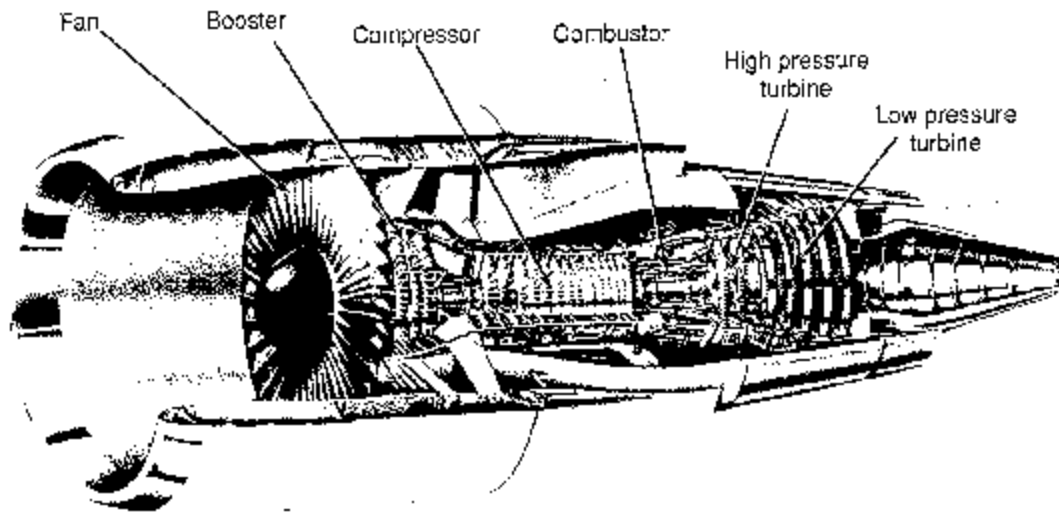


Figure 1 Propulsion System of a Modern Transport

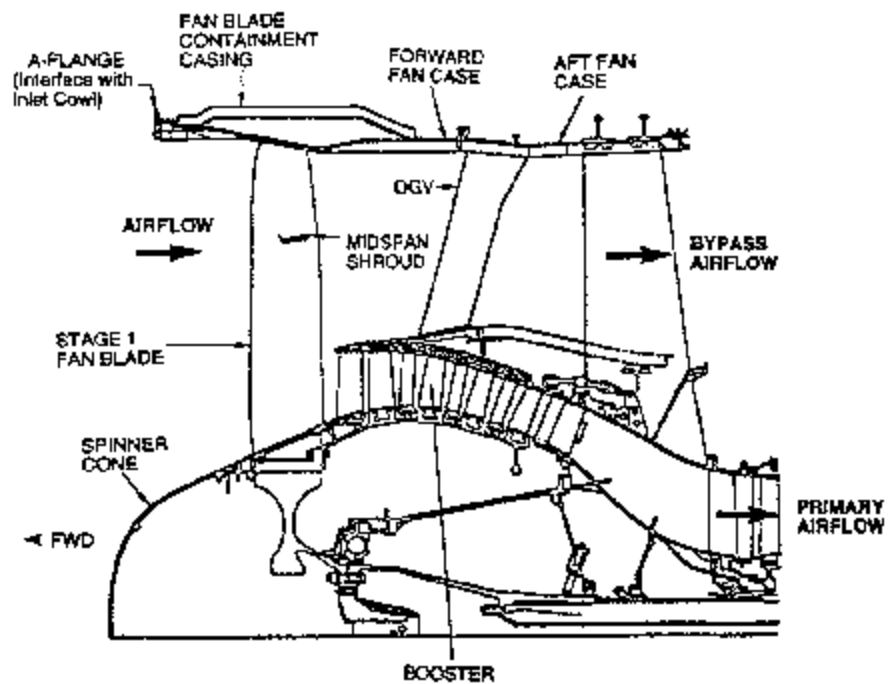


Figure 2 Typical Fan Module Components

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2.0 NEW CERTIFICATION REQUIREMENTS

Medium Bird Requirements

The existing requirements for the medium bird address only 1-1/2 pound size flocking birds. However, industry and regulatory agencies have been in agreement for several years that both multiple 1-1/2 pound and the multiple 2-1/2 pound flocking birds must be addressed as part of the medium bird certification requirements for new engines. Studies of bird ingestions into large transport engines by the FAA Technical Center and the Aerospace Industries Association (AIA) Bird Committee had identified the 2-1/2 pound Herring Gull as a flocking bird hazard which is present at most coastal airports worldwide. The Herring Gull exposure, along with the medium and large bird size certification requirements, are illustrated in Figure 3.

These new certification requirements require an engine to produce at least 75 percent of takeoff thrust and operate 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.

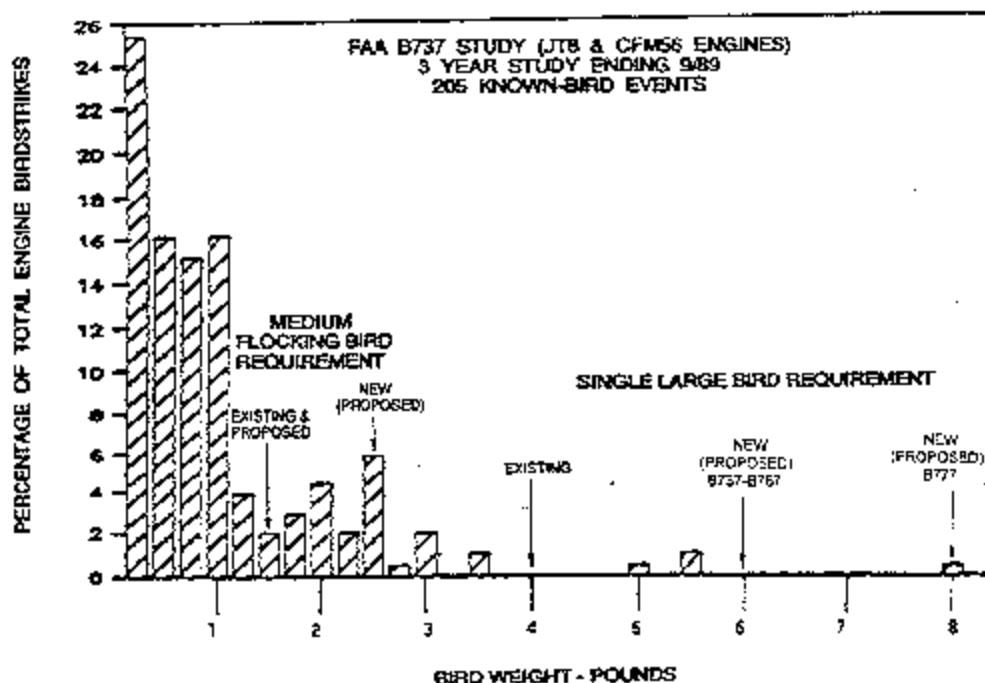


Figure 3 Worldwide Bird Exposure from FAA B737 Study

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 type of bird. 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, MD11, and A320 aircraft. For very large engines with inlet areas greater than 6000 square inches, such as on B777 aircraft, the single large bird size increases to 8 pounds. For engines with inlets smaller than 2100 square inches, the large bird requirement is the single 4 pound bird, unless a smaller bird is determined to be a more severe demonstration.

3.0 DESIGN CONSIDERATIONS

Flocking Birds

The first and most important safety assessment is the likelihood of simultaneous loss of power on more than one engine. Most modern air transport engines in service today were designed and certified to meet the ingestion of multiple birds (up to eight birds of 1-1/2 pound each, per engine) at the most critical ingestion conditions of rpm and airspeed for takeoff. This requirement was intended to represent a major flocking-bird encounter at airports. It must be recognized, however, that bird size records show that there have been flocking bird occurrences in nature that are beyond the previously certified capability of existing engine fleets.

The threat posed by flocking birds is the potential of a multiple-engine power loss caused by the ingestion of an abnormally large number of birds in more than one engine. It must be recognized that commercial transport aircraft are certified for continued departure and safe landing for the condition the equivalent of one engine out.

Large Birds

The ingestion of a single large bird during the period of takeoff and initial climb is also a certification requirement. Engines are designed and certified for safe-shutdown under these conditions, i.e., no uncontainment, no fire, separation from mounts, or loss of ability to shutdown. Such occurrences, although predominantly disabling only one engine on a transport aircraft, have resulted in runway departure accidents and off-airport landings of military fighter aircraft. Most medium-to-large turbofan engines in service to date have been certified to the single 4 pound large bird size.

A review of industry service data through 1995 on engines larger than 2100 square inches showed that ingestions of birds larger than 4 pounds virtually always resulted in safe shutdown characteristics, even for bird sizes up to 15 pounds. This was because the blade-out containment certification requirement of FAR 33.94 constitutes a more severe test relative to safe shutdown criteria for almost all engines.

4.0 FAN BLADE DESIGN - For Birdstrikes

It is possible for even a medium size bird to damage the leading edge of a blade whereas a larger bird can cause extensive deformation or fragmentation - depending on the type and size of engine. The high forces induced during a bird ingestion make it virtually impossible to design blades that will be undamaged for all impact conditions and still meet engine fuel burn and aircraft range requirements.

The aim of designers is to limit the damage to the blades and thereby minimize engine thrust loss to ensure that the engine is capable of continued operation after the ingestion of multiple medium sized birds. The designers must make sure that any blade fragments are contained by the engine casing after the ingestion of a single large bird - consistent with the blade-out requirement of FAR 33.94 as well as 33.77.

The design tradeoff becomes one of performance (reduced fuel burn) that is associated with thin airfoils as compared to thick unbreakable blades. Above all, engines must be designed for safety to meet realistic bird threats consistent with bird ingestion certification requirements for small, medium and large size birds as established by regulatory agencies.

Analytical Techniques

Two computer programs, called DYNA3D (in public domain) and DYTRAN (owned by McNeal-Schweidler Corp.), have been adapted to assist designers better analyze the bird ingestion process. Most of the theory for the DYNA3D and DYTRAN programs was initially developed at Lawrence Livermore National Laboratory and used in nuclear, automotive, and aerospace industries for crash worthiness and explosion containment engineering. The advantages of these programs include sophisticated contact-impact algorithms and the ability to model large elastic-plastic deformations and dynamic buckling. Both DYNA3D and DYTRAN program codes can deal with the complex interactions between the bird and the blades, and can model in three dimensions the large distortions and structural dynamics that are characteristic consequences of bird ingestions.

Defining the Birdstrike Problem

Bird strike is one of a class of impact problems involving soft-bodied projectiles. The projectile is considered "soft" when it is much weaker than the target material. For this reason, a soft body such as a bird "flows" upon impact and does not bounce. The significant loading on the impacted surface lasts for approximately the time it takes for the bird to travel half the blade chord length.

Smooth distortions or bending found on leading edges of fan blades after a bird ingestion in revenue service are typically classified as "soft-body" damage. This is in contrast to jagged or gouged leading edges, called "hard-body" damage, from ingested rocks or metallic objects left in an engine inlet.

Modeling the Bird

The biggest challenge in simulating a bird ingestion is analytically defining a suitable artificial or simulated bird. It had been found, as a first order approximation, that a real bird can be simulated by a cylinder (Figure 4) of 2:1 aspect ratio, made of porous gelatin equivalent to 90% water and 10% air mixture. This finding makes the problem of modeling the bird somewhat easier by allowing it to be treated as a homogenous structure. The gelatin can be represented by an hydrodynamic model (that is a model that behaves as a fluid) that could be compressed but not stretched without tearing. Calculated results with the above approximations have produced realistic results in terms of calculated airfoil distortions.

It should be noted that research sponsored by the International Birdstrike Research Group (IBRG) has been conducted by at the Central Science Laboratory in England. One of the objectives of this research is to better understand the biometrics (geometries and densities) of ingested birds, especially those used for certification testing. Another objective is to better

understand flock densities (bird spacing) to establish a model for determining quantities of birds ingested per engine, as an aircraft inadvertently passes through bird flocks. The establishment of requirements for a universally accepted artificial bird is another goal.

Mechanics of a Bird Ingestion

A bird entering a fan or compressor stage strikes several of the rotating blades and is literally sliced up. The slicing forces parallel to the chord of the blade can be ignored because of the low shear strength of the bird. The "slice" of the bird impacting on a blade is itself dependant on the developing deformations of both bird and blade, and the significant loads are developed by the forces that turn the bird slice - that is, deceleration forces - which in turn transfer momentum to the blade. In other words, it is primarily this loading normal to the blade chord that causes airfoil distortions and bending.

As an initial approximation to simulate the bird slicing and blade loading process, the effects of bird/blade deformation on the geometry of the slice are assumed to be negligible. Figure 4 shows the idealized slicing process when the bird's long axis is parallel to the engine centerline. It is the resulting angled slice cut from the bird cylinder that effectively impacts and loads the blade.

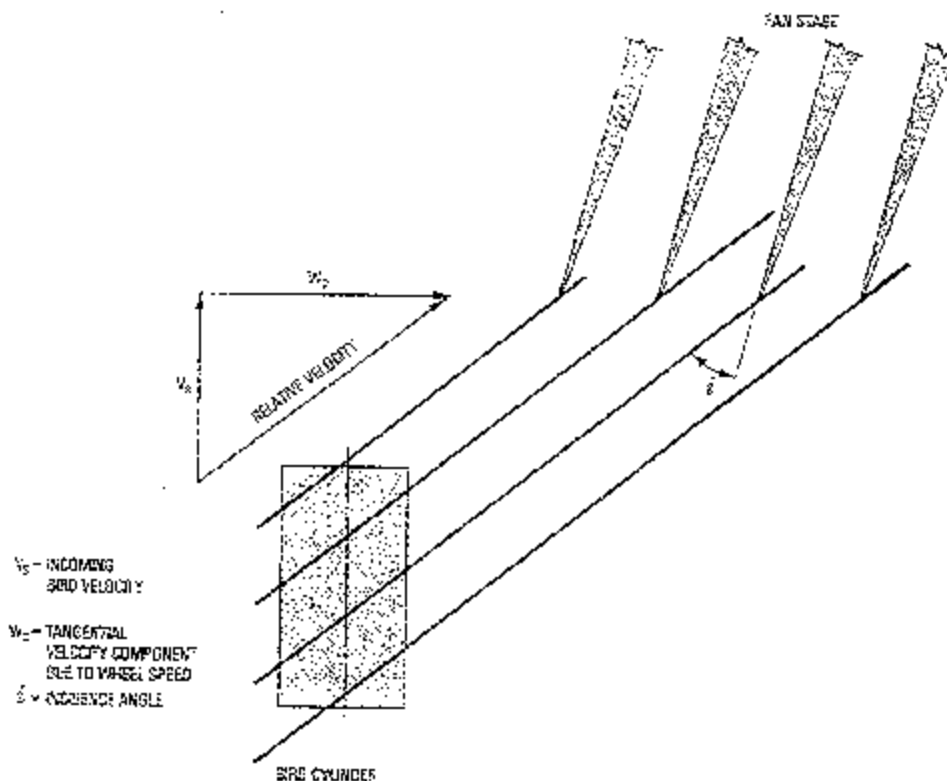


Figure 4 Blade Impact Geometry and the Slicing Process

This type of impact calculation for medium birds occurs early in the design process to determine the amounts of airfoil distortion and resultant thrust loss. Blades are then manufactured and tested as components to further calibrate and substantiate analytical models. Finally, an engine

test is conducted where dead bird(s) are shot into the inlet and aimed at the most critical locations on the blade to demonstrate that all bird ingestion certification requirements have been achieved. For the medium bird test, this typically involves the ingestion of a volley of birds targeted at the most critical fan blade location(s) at the most critical ingestion parameters (engine rpm and aircraft speed) for takeoff.

Design Improvements for Increased Capability

Lessons learned from in-service CF6-50 birdstrike experience have led to design improvements to this first generation of high bypass ratio fan blades. Where possible, these improvements have been factored into the CF6 fleets of existing and newer CF6 models for improved bird ingestion capability. For example, the design improvement for the CF6-50C fan airfoil cracking ahead of the midspan shroud (Figure 5a) following a major ingestion involved optimizing the shape of the midspan shroud as shown in Figure 5b. This resulted in an approximate 10-fold reduction in rate of fan blade transverse separations.

In the design of the CF6-80C2 fan blade released in 1986, airfoil ruggedization in the middle of the blade as shown in Figure 6 resulted in a 87% improvement over the CF6-50C2 fan blade. This produced a 2-1/2 pound bird ingestion capability in this region of the blade at initial climb speed versus the certification requirement of a 1-1/2 pound bird.

The relatively new CF6-80E1 fan blade was also thickened in the middle of the blade to achieve a 2-1/2 pound bird capability there at the most critical ingestion parameter conditions, i.e., between the takeoff decision speed (V1) and aircraft rotation speed (VR) - consistent with the proposed more stringent medium bird certification requirement.

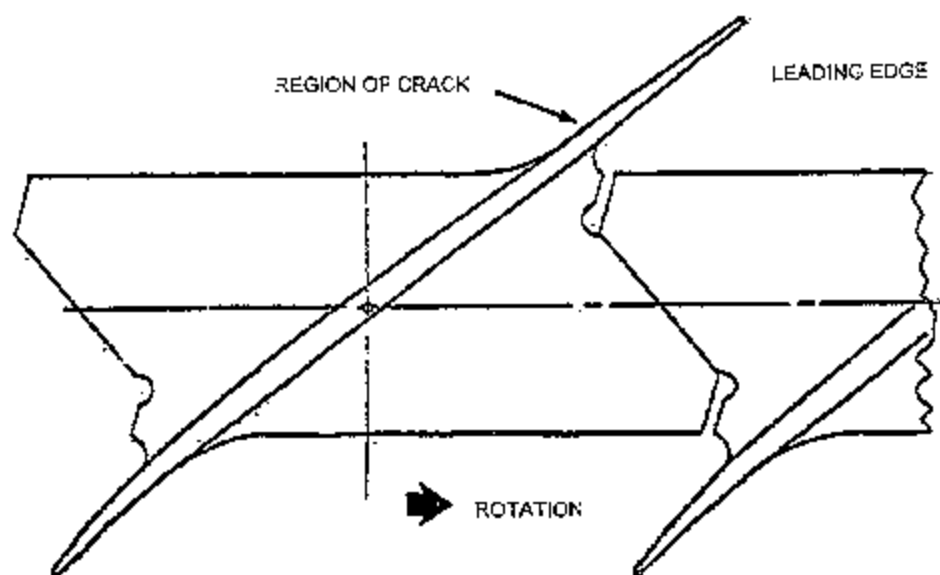


Figure 5a Typical Region of Cracking ahead of Midspan Shroud

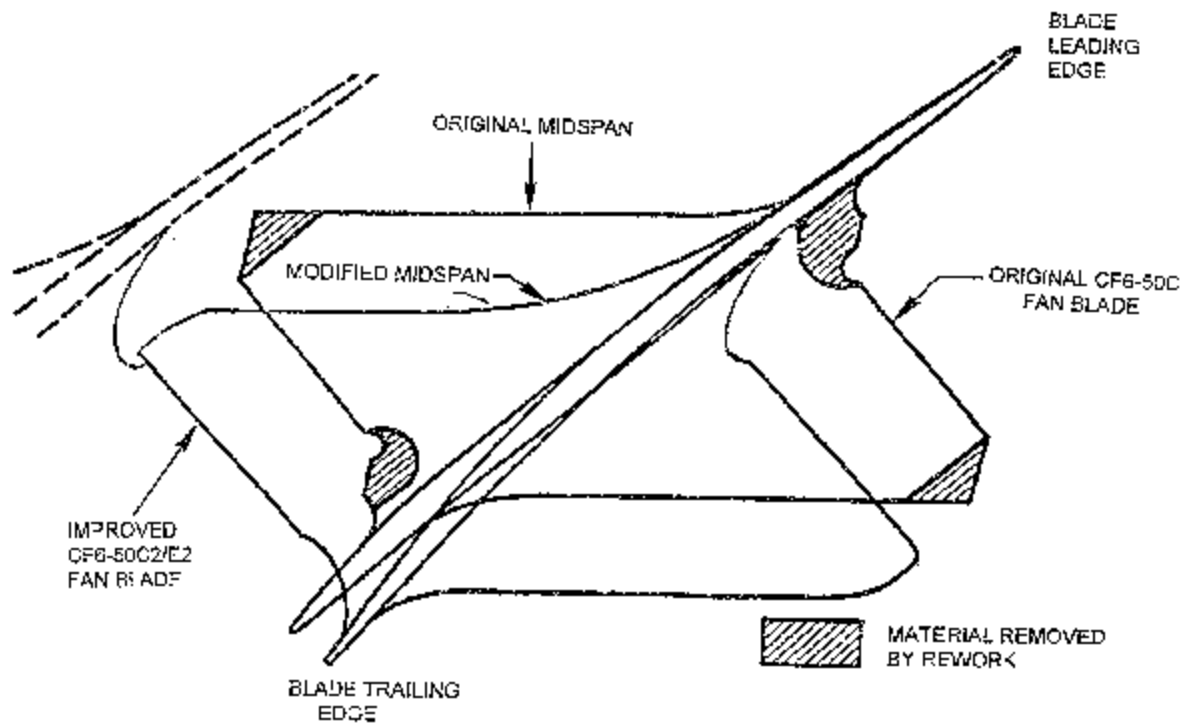


Figure 5b Modifications in Midspan Area for Improved Capability

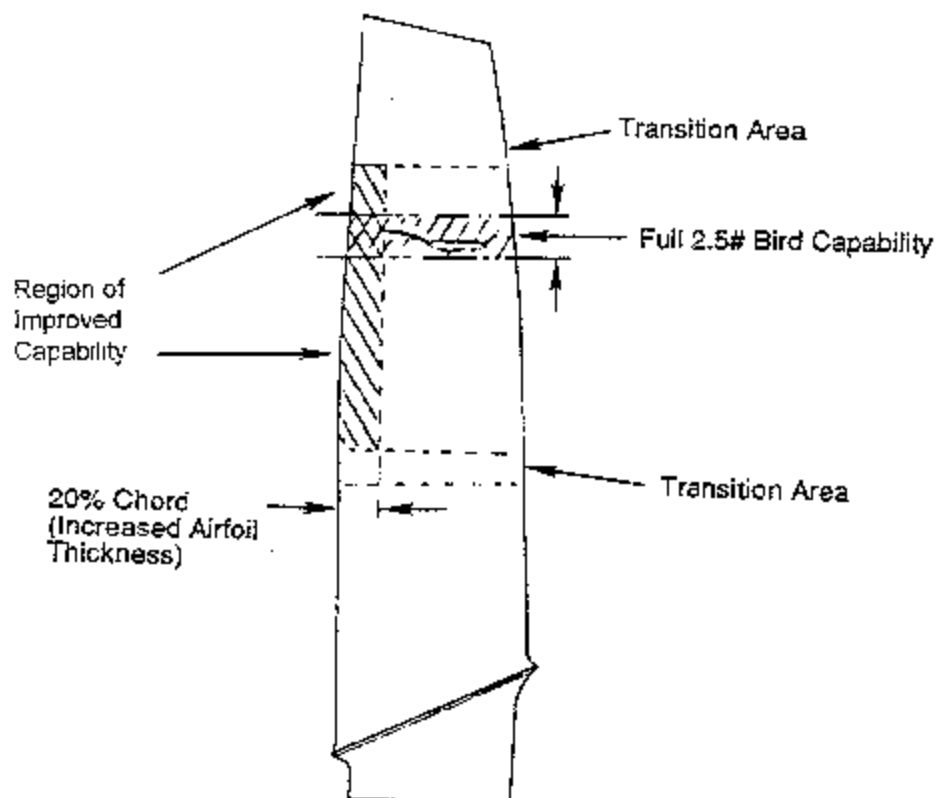


Figure 6 Airfoil Ruggedization for Increased Birdstrike Capability

The fan blade for the GE90 was designed and certified to the 2-1/2 pound medium bird requirement. The 2-1/2 pound demonstration test showed that this bird size produced virtually no fan blade damage. The GE90 engine with an inlet throat area over 6000 square inches also met the 8 pound large bird certification requirement for safe shutdown.

5.0 ROLE OF ENGINE MANUFACTURER

Engine manufacturers are required under regulatory requirements to design engines which will withstand defined ingestion criteria. These must be demonstrated during the engine certification process.

Over the years, engine manufacturers have collected details on the extent of damage from birdstrikes and other ingestion events using reports from flight crews, airline operators, and manufacturers field representatives. At GE Aircraft Engines, the consequences of each ingestion event are documented in a computerized ingestion database in order to refine the analytical design techniques and to provide engines which will meet the certification requirements. The objective is also to continuously update the GE bird threat model and to identify areas where improved airport bird hazard controls are urgently needed.

Lessons learned during revenue service experience on the first generation CF6 engines had led to fan blade design improvements, as mentioned earlier, which have resulted in a 10-fold reduction in frequency of ingestion-caused major fan damage events. Additional improvements appear in the next generation of engines. The GE90 engine was, and new CFM56 models are being, developed and certified to the proposed more stringent bird ingestion requirements.

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 adequate measures are taken to keep airports clear from potential flocking bird encounters with aircraft. Effective airport bird hazard controls are needed now and must be maintained in the future.

6.0 CONCLUSIONS

The bird ingestion threats in the flying environment can present a multiple-engine power loss hazard. Technology is advancing and can be expected to provide some degree of improved safety margin in the future. New engine designs will appear on new aircraft models. But for the present and foreseeable future, today's existing fleet of aircraft and engines will continue in operation. Operations with the current technology must be supplemented by safety measures applied through bird avoidance techniques and improved airport bird hazard control programs.

Manufacturers of aircraft engines are proceeding with physical improvements to better the odds of success. But, with the present and future flying machines, it still all comes down to this - see, measure, communicate the bird hazards and avoid! Pilots must not knowingly challenge bird flocks but must use all available means to know where they are and to avoid them.

Advances in ingestion-tolerant designs are being made in modern engines and aircraft. But these measures, on balance, are not great when compared to flocking bird exposures involving large waterfowl and gulls that are larger than that to which engines have been certified.

To avoid the occurrence of birdstrike-caused accidents and incidents, it is necessary that the government regulatory bodies and airport authorities concentrate on vigorous, cooperative and coordinated programs to control bird populations on and near airports as well as programs to monitor for the presence of migratory flocks of larger birds and then control aircraft operations.

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AUTHOR:

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APPENDIX 9

John F. Kennedy International Airport Wildlife Management Plan

Garber, S.D. 1996. Bird hazard management with integrative ecosystem planning at John F. Kennedy International Airport: Usefulness of a wildlife management plan. In: Minutes of the Twenty-fourth Meeting of Bird Strike Committee Canada. April 10-11, 1996. Richmond, British Columbia. Transport Canada. Ottawa, Ontario.

BIRD STRIKE COMMITTEE CANADA. RICHMOND, BRITISH COLUMBIA.
APRIL 10-11, 1996

At John F. Kennedy International Airport (JFK) I was hired to be the Port Authority of New York and New Jersey's first wildlife biologist where I direct the ecosystem management program designed to reduce bird hazards at JFK, La Guardia Airport, and Newark International Airport. I have used the wildlife management plan as one aspect of the job to help institute wildlife management policy while documenting past and present protocol, as well as to present analyses and future plans. I manage a staff of 30 and a budget of \$1,000,000/yr. conduct research, write and implement wildlife management plans, teach ornithology, entomology, botany, and resource management to bird control unit. Coordinate compliance with governmental agencies (U.S. Department of the Interior, U.S. Fish and Wildlife Service, U.S. National Park Service, Federal Aviation Administration, N.Y.S. Department of Environmental Conservation, N.Y.C. Department of Environmental Protection, N.Y.C. Police Department) and community relations. For years regulatory agencies involved with the management of bird-related aviation risks have strongly recommended that airport managers formulate wildlife management plans. Such admonitions were complied with through outsiders who visited the site, interviewed personnel, sometimes studied the situation, and composed a generic list of recommendations that the aviation industry relied on. This list often includes a clause suggesting future work that needs to be done. After the experts leave, it is up to the airport personnel to implement the recommendations. Sometimes this work is contracted out to the government agencies or private companies doing the contract work. Insufficient compliance can lead to disaster. At the airport in Ellendorf, Alaska U.S. Air Force recommendations may not have been adhered to and an AWACS crashed shortly after striking Canada geese on September 22, 1995. On-site management is one of the most difficult aspects of bird hazard airport consulting. On-site management is also challenging for full-time, fully-dedicated wildlife managers. I have such a challenge and have found the John F. Kennedy International Airport Wildlife Management Plan is a valuable tool in accomplishing our goals, to make the airport safer. I wish such a Wildlife Management Plan had already been written before I arrived here, but now that we have one, it is constantly being referred to, added to, and utilized. If I am to organize a falconry program, or a pigeon control program in another parking garage, or I need to know when the grass-cutting memo should go out, everything I need to know is in the Wildlife Management Plan, or will be soon. The JFK Wildlife Management Plan is over 400 pages long, and has proven invaluable in our work. It also enables us to write position papers, develop policy, and conduct research. Parts of the Wildlife Management Plan will be discussed in this talk and each of these will be included in this volume.

Garber, S.D. 1996. Use of Falconry to Reduce Risk to Safe Aviation at John F. Kennedy International Airport. In: Minutes of the Twenty-fourth Meeting of Bird Strike Committee Canada. April 10-11, 1996. Richmond, British Columbia. Transport Canada. Ottawa, Ontario, Canada.

BIRD STRIKE COMMITTEE CANADA. RICHMOND, BRITISH COLUMBIA.
APRIL 10-11, 1996

Use of Falconry to Reduce Risk to Safe Aviation at John F. Kennedy International Airport

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Introduction

John F. Kennedy International Airport (JFK) will test falconry as a method that may improve aviation safety in an environmentally sensitive manner by reducing the number of bird strikes and birds shot. The goal is to use birds of prey to deter gulls from flying over the airport. At JFK, from 1979 through 1995, gulls accounted for 72 percent of the aircraft that were delayed, or had to dump fuel and return to the airport, or lost tires, or whose engines were destroyed or damaged in bird-related incidents. During this period JFK incurred 3,943 bird strikes, of which 1,122 birds were involved in 385 incidents that were reported by the pilots (Garber 1995). JFK's response has been innovative wildlife management techniques that in the aggregate have significantly reduce the number of strikes, but in recent years the gull population has been rising. In addition to managing vegetation, fresh water, insects, solid waste, and in addition to our use of scare tactics, pyrotechnics, and firearms, to manage risks from gull strikes, we propose testing a falconry program (Garber 1995).

A falconry program might eventually enable the airport to rely less on shooting, and more on non-lethal methods of bird control. In addition, harassment by birds of prey may increase the gulls' incentive to relocate and establish another colony elsewhere in New York State. If successful, the falconry program will enhance the bird hazard management by using methods employed by nature to reduce risk to safe aviation and to reduce reliance on shooting gulls. The program, is designed to use falcons and hawks to harass gulls and kill gulls before the laughing gulls in Jamaica Bay have begun their breeding season. This way, before the shooting program begins we may be able to train the gulls to avoid flying over JFK airspace.

Falconry has been used to improve safety at airports in Canada, England, France, and Spain, and there are plans to test falconry in Taiwan. In 1979 falconry was evaluated as a potential gull control method at the Fountain Avenue Landfill, located near John F. Kennedy International Airport (JFK), however American falconers had yet to benefit from the knowledge that was accruing in other parts of the world with respect to using raptors to control gulls. Based on the best available knowledge at the time, we concluded local practitioners could not effectively manage hundreds of thousands of gulls attracted to the landfill. Instead of using falcons over the landfill to control gulls, a chemical sterilant was considered, but shortly afterward the landfill was shut down.

By 1983 gull-related problems had changed at JFK. Laughing gulls had recently recolonized the area and were posing serious safety problems: the total number of bird strikes at the airport had increased by a factor of 100%. Many possible solutions were considered, one of which was falconry. Based on advice from ornithologists we concluded not to work with falcons because it was thought falcons would not attack large groups of gulls and they would not fly at night or work in the rain. In addition it was thought that a significant number of falcons might pose a hazard to air navigation. Still, American falconers lacked experience with gull management. When a falcon was used in a demonstration at Staten Island's Fresh Kills Landfill, instead of going after the gulls, the falcon chose a pigeon; the idea was not pursued any further for approximately 15 years.

Peregrine falcons do not fly at night under normal circumstances, although they will fly at dawn, dusk, and throughout the day (Seegar, personal communication). Both Michael Givlin, (Director of Bird Control International (BCI), a Burlington, Ontario based company that specializes in bird-related problems) and Ulrich Watermann (the President of BCI, who is also with the Great Lakes Raptor Conservancy), who have flown 25,000 falcon flights spanning two decades at Canadian airports, state that falcons will attack large flocks of gulls, sometimes with as many as 15,000 birds. They also state that when trained falcons and hawks are used properly, with the aid of other bird control methods, falcons can clear large areas of gulls. Watermann also says falcons fly in the rain and he has never seen or heard of a trained falcon becoming a hazard to air navigation.

Tom Cullen, another falconer, visited JFK in 1992, studied the situation, and concluded falcons could be useful at JFK, if their use included the period months before the laughing gulls arrived so you duplicate a nesting peregrine territorial defense behavior. He also felt that it would be necessary for shooting to always remain part of JFK's bird control program. Most species nest after raptors establish their breeding territories. Beginning a falconry program early in the season would enable the falconers to set up the equivalent of a territorial or predatory boundary.

In England, at an airport where immature gyrfalcons and peregrines were used, gulls were actually attracted because the falcons were stimulating mobbing behavior. Cullen said if falcons were used at JFK inappropriately, they could cause every gull on the colony to rise, because the last one up is the first to be knocked down. When used appropriately, a gyrfalcon can harass gulls and reduce their nesting success. Proper use means falcons have to take some gulls, otherwise the gulls will not fear the falcons and will mob them. Gulls do not mob birds that can catch them.

In addition to Givlin, Watermann, and Cullen, Marc Marrone, a falconer and owner of New York's Parrots of the World, came to JFK and concluded that it would be worthwhile to experimentally test falconry as a possible method of gull control. We also sought the advice of several other falconers with airport experience, including Mark Adams of Falcon Environmental Services of Montreal who has the falcon contracts at Lester B. Pearson International Airport in Toronto and the Montreal International

Airport, as well as the Trenton Air Base which is operated by the Canadian military, and Peter Serwylo, president of Peter Serwylo Wildlife Control which is based in Dartmouth, Nova Scotia. Serwylo reportedly is having excellent results with his bird control efforts at Canada's Shearwater Air Base, however, like most of the airport falconry programs, most claims are anecdotal rather than based on unbiased scientific data.

JFK received and evaluated proposals from potential contractors and although we were impressed with the experience, accomplishments, and credentials of each of the falconers. Givlin and Watermann agreed to help establish an experimental falconry program to test falconers' claims. Together we designed a scientific test to determine if it is possible to significantly reduce bird strikes at JFK with the use of falconry. Givlin and Watermann are confident that with their program it would not be necessary to shoot thousands of laughing gulls each summer at JFK. Based on what we have seen to date, it may be that a properly designed and executed falconry program could hold some promise, so we have chosen to investigate falconry further. We evaluated falconry proposals received for the 1996 and presented our plans to go forward with a program to the Bird Hazard Task Force, which unanimously endorsed the proposal. However, due to our inability to receive a permit that covered falconry by the time the falconry program was to begin, we have chosen to get an operational permit in 1996 that we will use for a falconry program in 1997.

Falconry has been used to improve safety at the following airports: in Canada they have been used in Toronto, Montreal, and Vancouver, in France they have been used in Paris; in Spain at five military bases (including Torrejon Air Force Base, Talavera Air Force Base, San Javier Air Force Base and Air Force Academy, Moron Air Force Base, and Rota Naval Air Station) as well as at four International Airports (including Ibiza International Airport, Malaga International Airport, Sevilla International Airport, Barajas International Airport), and at Cuatro Vientos National Airport; and in England at Mildenhall, Lakenheath, Alconbury, Upper Heyford, Fairford, Lossiemouth, Yeovil, Bentwater, Woodbridge, Gatwick, Driffield, and Coltshall. In 1996 Taiwan, which has been troubled by increasing numbers of birds near its airports as well as by increasing numbers of bird strikes, has approved a one-year experiment in which 15 crested goshawks and 10 Asiatic sparrow hawks will be trained to attack lesser birds. A National Pingtung Polytechnic Institute professor, Fei Chia-Chi, believes raptor can be trained to reduce bird strikes.

In our effort to design an effective falconry project, we consulted Tom Cullen's proposal in which it was his opinion that 10 large falcons were needed to address the gull problems at JFK. Training and housing on the airport would insure full acclimation to the conditions that exist. He recommended a minimum of two falconer positions from dawn to dusk, 365 days a year. His proposal cost approximately \$500,000 for the first year. Chris von Schilgen of the New York State Department of Environmental Conservation's Division of Fish and Wildlife's Special License Unit told Marc Marrone that the Port Authority felt Cullen wanted too much money.

Cullen felt shooting would always have to be an integral part of JFK's bird control program but he and Patrick Martin of the New York State Department of Environmental Conservation thought there was a good chance that an effective falconry program could improve safety at the airport while alleviating the need to shoot as many gulls each year. They felt falcons would be useful at JFK, however, only if their use included the period months before the laughing gulls arrived so you duplicate a nesting peregrine territorial defense behavior. By bringing in falcons early in the season the falcons could set up a territorial boundary or predatory barrier. Most species nest after raptors have established their breeding territories. To use falcons effectively, some gulls need to be killed, otherwise gulls will ignore, and on occasion, even mob the falcons. Gulls will not mob a bird that can catch them. In England, at an airport where immature gyrfalcons and peregrines were used, gulls were actually attracted because the falcons were stimulating mobbing behavior. Cullen said if falcons were inappropriately used at JFK, they could cause every gull on the colony to rise, because the last one up is the first to be knocked down.

In January 1996 Givlin and Watermann came to JFK and presented a proposal for an experimental falconry program that would begin before the laughing gulls began nesting and last from May through August. They were confident with their program it would not be necessary to shoot thousands of laughing gulls each summer at JFK. Their claims were backed up with a clause that kept their program at cost if they did not deliver a guaranteed 75 percent reduction in gull strikes. They guaranteed the 75 percent reduction, even without the shooting program. If we found a method that enabled us to reduce or effectively eliminate laughing gull strikes without having to shoot them, then the number of pairs of nesting laughing gulls on the colony might increase from approximately 6,000 pairs to 3, 4, 5, or 6 times that number. Should that be the case, then we would find the nonlethal laughing gull control was just a short-term solution that contributed to our having to redeploy the shooters. Another possibility is that some day the National Park Service would agree to our using falcons to relocate the laughing gull colony, however, when we presented the falconry project at the March 1996 Bird Hazard Task Force Meeting and asked the National Park Service for permission to use the falcons on the colony, we were told that would not be possible. We will test whether a properly designed and executed falconry program can be used to modify gull behavior to improve safety at the airport.

In M.G. Wildlife Control's "Proposal to control laughing gulls (Larus atricilla) at John F. Kennedy Airport using hawks and falcons" Givlin and Watermann offered two options: 1) fly groups of 3 to 4 Harris' hawks over the colony to harass laughing gulls, collect eggs that are laid, and fly birds along the Bay from Bergen Basin to Thurston Basin. Use distress calls, dead gulls, shotguns, and pyrotechnics, or 2) if working on the colony is not feasible, then just fly birds along the Bay from Bergen Basin to Thurston Basin and use distress calls, dead gulls, shotguns, and pyrotechnics.

Operational costs for Spanish Air Force airport contracts averages out to be \$460,000 per airport per year. A partial breakdown of the costs in addition to the hourly wage of the workers, other expenses include:

a.	fully trained falcons	\$2,200 each
b.	falconry equipment	\$1,400
c.	food for falcons	\$3.50/falcon/day
d.	telemetry equipment (receiver, transmitters, etc.)	\$1,700
e.	falcon first aid kit	\$350
f.	falcon medical expenses	\$4,200

Spanish territory covers one of the two main bird migration routes between northern Europe and Africa. The Spaniards now have 27 years of experience using falconry for bird control at their airports (Chamorro and Clavero 1994). Spanish airport falconers train their falcons for four months to kill the target species in flight, as well as to hunt from "waiting on", and "from hand." During the training phase all falcons were flown daily. Expert falconers trained non-falconers during this period. Once the training phase was complete, the falcons were flown daily to maintain the level of pressure on local birds until they gave up trying to return to their nests or feeding areas.

Spanish falconers concluded for falconry to be effective at their airports (Chamorro and Clavero 1994):

- 1) The field must be wide enough around the flight line (500 meters) for the falcons to effectively perform their task, therefore, not all airports are suitable.
- 2) There cannot be woods in the immediate vicinity of the airfield where the birds can search for shelter.
- 3) Aircraft take off and landing frequency should not be more than every 3 minutes.
- 4) For successful bird control by falconry the falconer must follow and direct the operation continuously.
- 5) Before the start of the operation the falconer must demonstrate the ability to direct the kill of the birds that are the intended target of the operation on that airfield.
- 6) After a high intensity campaign of continuous and regular hunting and killing performed by the falcons on the flocks of birds for about 4 to 6 months, a good result is to be expected.

- 7) When the above results are obtained, the flying and hunting frequency of the falcons can be reduced, but should never be suspended, because without daily control, the flocks of birds will return.

Internally, the Port Authority has allocated all the necessary funds for a falconry program to commence immediately at JFK. The Bird Hazard Task Force endorsed the program and the United States Department of Fish and Wildlife and the New York State Department of Environmental Protection both promised to expedite the necessary permits. Yet, in fact they have stalled, and the result has been we may not have a program up and running until next year.

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BIRD STRIKE COMMITTEE CANADA. RICHMOND, BRITISH COLUMBIA.
APRIL 10-11, 1996

**Insect Management to Control Laughing Gulls
(Larus atricilla) at John F. Kennedy International
Airport in New York City**

**Steven D. Garber, Ph.D.
The Port Authority of New York and New Jersey
John F. Kennedy International Airport, Building 14
Jamaica, New York 11430**

4. Maintain open canopies with routine pruning
5. Conifers:
 - i) Avoid planting conifers except as widely spaced individuals
 - ii) Conifers that are currently on the airport need to be kept so branching pattern is thin.

B) Shrubs

1. Select low-growing shrubs and do not use as an understory

C) Grass

1. Minimize large expanses of lawn
2. Research the use of long grasses and alternative groundcover such as gravel in place of lawn

Landscape Architecture

JFK has been in the forefront of airport landscape architecture designed to reduce the plant-related bird attractants. We generated the Federal Aviation Administration's list of plant species that do not attract birds, which has become the industry standard. We are currently reevaluating the list, in an effort to determine which species might be dropped from, or added to, the list. Measures are being taken to guarantee our recommendations are adhered to. We avoid planting monocultures, so entire plantings are not susceptible to disease or widespread insect infestations. We also avoid planting species that stand a chance of becoming problems in the future. Plant species that might attract birds, particularly birds that roost in large numbers, such as large numbers of starlings in the fall and winter, are to be avoided, or if present, thinned, or cut down. We also avoid planting species that provide food and cover, preferring plants that are attractive to humans, but not attractants to other species. When we find that certain species are particularly susceptible to disease or insect infestations, these species are managed to the best of our ability, or culled (Garber 1995).

Vegetation Management

In a study published by the Port Authority, Burger wrote:

"Although it is always of value to investigate plant species suitable for JFK, this procedure would not affect gull numbers. Gulls do not feed on plants, don't roost or loaf in them, and generally do not come to these areas. Instead they loaf on rocky areas, access roads or runways. Substituting plant types would function only to reduce the numbers of seed-eating birds or owls (that feed on rodents). But the effect on these two groups of birds depends on the grass species and grass height" (Burger 1982).

Since her 1982 report the laughing gull situation rapidly changed, and now we have to document our vegetation management procedures as a result of the Final Environmental Impact Statement's Record of Decision as a prerequisite to airport being reissued a bird depredation permit.

Recommendations and Suggested Studies

A summary of the landscape management methods that are policy at JFK:

1. Incorporate habitat manipulation strategies in landscape plans
 - Select plant material that does not serve as an attraction for feeding or roosting by birds and is tolerant of stressful urban conditions
 - Plant vegetation in linear configurations versus circular clusters
 - A) Trees
 1. Use staggered rows of trees spaced so their canopies do not interlock
 2. Avoid rows of trees encircling parking lots if the parking lots are heavily planted
 3. Select trees with open growth forms

Garber, S.D. 1996. Vegetation Management Successfully Reduces On-Airport Bird Attractants at John F. Kennedy International Airport. In: Minutes of the Twenty-fourth Meeting of Bird Strike Committee Canada. April 10-11, 1996. Richmond, British Columbia. Transport Canada. Ottawa, Ontario, Canada.

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Nine (9) Dibrom 14 (Adulticide). 1.0 ounces of the material was mixed with 24 ounces of pre-mix solution and 6.0 to 8.0 ounces of kerosene. The above solution was mixed with water and applied to wetlands adjacent to Runway 4R-22L, to the grassy areas between 4R and 4L, as well as to adjacent areas next to the airport where insects appeared to be an attractant; these were at Howard Beach and at the Waxman Property.

Applications target mosquitoes, as well as the species known to be taken by laughing gulls, which include flying ants, green June beetles (Cotinus nitida), dogday cicadas (Tibicen chloromera), Oriental beetles (Anomala orientalis), Asiatic garden beetles (Maladera castanea), Japanese beetles (Popillia japonica), ground beetles, dung beetles, stink bugs, European chafers (Amphimallon majalis), American cockroaches (Periplaneta americana), crickets, and grasshoppers. Of the ant species reported, there are carpenter ants and field ants (Sweet 1993; Garber 1995). The smaller of the two, field ants, were in a winged phase flying over JFK from about 5:00 PM until 7:00 PM on October 2, 1995. The ants flew over JFK from the sewage treatment plant area in the direction of the bay runway. Associated with them were mostly immature laughing gulls that were insecting. When the birds got near the runway they were harassed with pyrotechnics and successfully kept away from the runway and far from the flight path of the aircraft. Four families of beetles were observed. Scarabidae, Carabidae, Tenebrionidae, and Cicindelidae. Fly species, in addition to mosquitoes, include greenhead horseflies, which are found during the summer in abundance on airside. Green darner dragonflies and amberwing dragonflies are seen at the airport, although many more species are seen in New York City (Garber 1988, 1989). To date we have yet to begin a full accounting of the insects found at JFK, but we are in the planning stage so we can establish baseline data.

On January 23, 1996 John Zuzworsky of the National Park Service came to JFK during which time we did a preliminary habitat appraisal to find some of the best localities for insects and decided to organize a field trip that would take place in the summer, when we identify Lepidopteran and Odonatan insects on JFK property.

And again on November 5, 1994

Dear Mr. Hinson:

My letter of August 16 may have gone astray, hence, the enclosed. I would appreciate the benefit of your reply.

And again on March 21, 1995

Dear Mr. Hinson:

See the enclosed. Don't you answer your mail?

Bringing in Senator Alfonse M. D'Amato, March 29, 1995

Dear Al:

I think the FAA ought to be investigated. See the enclosed correspondence. To date, no answer on the health issue.

And the Transportation Secretary responds, June 20, 1995

Dear Ed:

...I have also instructed my staff to hold face-to-face meetings with the embassies of the 12 countries in question within the next 30 days, to once again tell them of our great disapproval of the exposure of passengers to insecticide spraying and that, if they persist in such practice, we will continue to publicly name those countries so that the American people can decide whether or not to fly to those destinations.

Because researchers hired by JFK to quantify the on-airport attractants found certain species of insects that provide food for bird species that otherwise might not be attracted to the airport, JFK has made significant efforts to control these insects species. The most important arthropodan attractants on the airport and adjacent areas are now controlled through a variety of means and habitat manipulations. Most of our methods do not involve chemicals, but rather are based on: 1) plant species that are recommended and not recommended for the airport, 2) grassland management, and 3) freshwater availability.

Pesticides

It has also been determined that spraying pesticides is an important method that should be continued. For this reason, JFK hired National Helicopter to spray pesticides every other Sunday from May 21, 1995 until the insects no longer appeared to present an attractant to the birds. In 1995, National Helicopter sprayed the following 6 times: May 21, June 4, June 18, July 2, July 16, and July 30. The spray applied first was Abate 4E (Larvicide), 1.0 to 1.5 ounces of material was used. Subsequent applications involved

Insects Provide Food for Birds

Many urban birds eat insects (Garber 1987, 1989) and many bird species that migrate through urban areas eat insects, as do many bird species not usually thought of as urban tolerant species, but nevertheless are found on JFK's property, largely because airport habitats provide opportunities for these birds. Insect control is important at an airport if insects are attracting birds that increase the risk to safe operations.

Regulated Airports

Problems are compounded at international airports when insects are not controlled because this increases the risk of becoming regulated by the United States Department of Agriculture increases. At regulated airports all aircraft must be sprayed with insecticides before departing on international flights (for the precise list of nations, times of year, and types and amounts of pesticides to be used, contact the United States Department of Agriculture). In particular, because of the non-native Japanese beetle (*Popillia japonica*) (Garber 1990) at JFK, in 1982 JFK was about to become a regulated airport. Were this to happen, departing flights would have to be sprayed, which would mean it would cost the airlines down time, and would expose passengers to potentially dangerous chemicals. To avoid these possibilities, JFK investigated ways to prevent the Japanese beetles from being a problem at the airport so the aircraft would not have to be sprayed. Different insecticides were investigated, as well as milky spore. Because it takes years for milky spore to become effective, pesticides were used. In addition, neighboring communities like JFK to spray because of the mosquitoes. It was also felt that employees of the Port Authority preferred pesticides because they improve working conditions.

One of the reasons we have tried to keep JFK from being a regulated airport is because we are sensitive to the fact that people do not want to be exposed to the possible dangers of pesticides. Edward Koch, the former Mayor of New York City, is also sensitive to this, and has actively lobbied the FAA regarding pesticides that are sprayed on some aircraft (Sontag 1996), particularly in Latin America. Raising the issue with David Hinson, the Administrator of the FAA, he wrote Mr. Hinson August 16, 1994 and said:

Dear Mr. Hinson:

Are you aware of the fact that a number of countries primarily in Latin America, insist that air carriers spray the cabins for insects while passengers are still on board before allowing the plane to land? This matter was brought to public attention a number of months ago, and there was an uproar. Passengers are being subjected to insect spray which probably has carcinogenic properties.

Planting Management Plans

Landside Vegetation (vegetation on side of airport where no planes are allowed)

Tall Vegetation

Whether airside or landside, because obstructions near the approach or departure zones of runways present hazards to low flying aircraft, they need to be eliminated. Some of these locations are well-suited to trees which will seed in on their, so woody vegetation is continually cleared, and the tall trees are managed, generally by pruning, cropping, or removing them if they are too tall. Areas where large trees are felled usually do not require more maintenance for as long as ten years. The smaller species, such as the bayberries that grow in more widespread areas on the airport, are usually thinned or cleared when the maintenance crews are available during the summer months.

During 1995 the trees that had grown to a significant height at the 13R approach zone on the Lefferts Boulevard side of Bergen Basin were thinned significantly so they should not present a problem for another 10 years. They were cut on October 14, 1995; approximately 18 trees were cropped. This area has wetlands in it that JFK has agreed not to disturb, as part of a deal made when we built the long-term parking lots. However, we are allowed to clear trees as they grow.

The four tree species we culled were black cherry (Prunus serotina), white mulberry (Morus alba), the tree of heaven (Ailanthus altissima), and the eastern cottonwood (Populus deltoides). All are common weedy species in the area; two provide food for birds. The mulberries attract a wide range of species when in fruit in July, and the cherries are abundant when in fruit in August. The mulberries can be a real problem in July because laughing gulls are attracted to the tree tops and while on the wing, dip down and take the mulberries off the tree. This behavior brings gulls over the airport, and this is an additional reason that we work to control the growth of this species on the airport. Allowed to continue standing in the area were Norway maples (Acer platanoides), Sycamore maples (Acer pseudoplatanus), and a willow, probably a black (Salix fragilis) or crack willow (Salix nigra). These trees were spared because they were not in the direct flight path of the planes and because they are not considered major bird attractants at the airport.

Plants That Are Recommended

In newly constructed areas, planting are evaluated in terms of how they might enhance the overall landscaping design and beauty of the airport. Other reasons plants are appropriate in such areas is that in many cases they are needed to reduce erosion. Each species is ultimately chosen for more than just its aesthetics that are appropriate for the

particular location, it also must be physiologically well-adapted to the particular microhabitat being considered, to insure it's survival. However, at no time do we want to plant species that will attract more hazards to the airport. To minimize the bird attraction we have generated a list of species that is urban tolerant, can survive salt, wind, dust, ozone, compacted soils, and thrive on the sandy soils at the airport (Garber 1989a). To the extent that it is possible without tremendous cost, we always prefer to plant species that are both native to this region, and indigenous to this type of habitat. Our reasoning is that native species that grow in this habitat are mostly likely to thrive here without tremendous amounts of maintenance, and native species are better because there is less of a chance that they will spread in a manner that cannot be predicted, becoming weed species on the airport. We also prefer to use plants that are indigenous to this type of habitat for the same reason, and because philosophically we feel that native species, habitat-specific species, and communities of species that are found in the wild in this region are more beautiful when growing at JFK than are most non-native species growing in man-made communities. Such concepts are often difficult to explain effectively to the uninitiated, and for this reason, it is sometimes far more difficult than it should be to enforce native species preferences. But many ecosystem managers are making headway, as are we at JFK.

The species listed below are broken down according to woody vegetation (deciduous, trees, coniferous trees, and shrubs), groundcover species, and grasses. Species that are recommended are listed first, and there is a listing of species that are not recommended. Management regimens are also described, and a list of plant species found on the airport's airside is also provided.

Deciduous Trees

Trident Maple (*Acer buergerianum*)
Hedge Maple (*Acer campestre*)
Box Elder (*Acer negundo*)
Norway Maple (*Acer platanoides*)
European Hornbeam (*Carpinus betulus*)
Hackberry (*Celtis occidentalis*)
White Ash (*Fraxinus americana*)
Green Ash (*Fraxinus pennsylvanica*)
Thornless Honeylocust (*Gleditsia triacanthos*)
Golden Rain Tree (*Koelreuteria paniculata*)
Eastern Larch (*Larix laricina*)
Dawn Redwood (*Metasequoia glyptostroboides*)
Amur Corktree (*Phellodendron amurense*)
London Planetree (*Platanus acerifolia*)
Cottonwood (*Populus deltoides*)
Japanese Poplar (*Populus maximowiczii*)

Callery Pear (Pyrus calleryana)
Sawtooth Oak (Quercus acutissima)
Scarlet Oak (Quercus coccinea)
Bur Oak (Quercus macrocarpa)
Willow Oak (Quercus phellos)
English Oak (Quercus robur)
Babylon Weeping Willow (Salix babylonica)
Japanese Pagodatree (Sophora japonica)
American Linden (Tilia americana)
Littleleaf Linden (Tilia cordata)
Crimean Linden (Tilia euchlora)
Silver Linden (Tilia tomentosa)
Elm (Ulmus hollandica)
Chinese Elm (Ulmus parvifolia)
Japanese Zelkova (Zelkova serrata)

Coniferous Trees

Although we prefer to plant native species at JFK for all the reasons that native species make more sense everywhere, we have inherited many plantings from previous years that are not native, and we are not going to remove them. Pitch pine and white pine are both native to the northeast, pitch pine more commonly occurs in Long Island's sandy soils, and for this reason, this is the preferred pine for on airport plantings. However, in the past, pitch pines have not been nearly as available as Austrian and black pines, which were also recommended pine trees for sandy, coastal regions. As a result, over 95 percent of the pine trees that have been planted on the airport over the years, are Austrian and black. Of the two, black is preferable for reasons stated below in the following two species accounts.

Austrian Pine (Pinus nigra)

The Austrian pine, a native of southern and eastern Europe, has dark green, 8 to 12 cm. long needles are in pairs. The rough bark is dark brown, often with a grayish hue. Winter buds are oval, oblong, or cylindrical. Young shoots are yellowish brown. Cones solitary or in clusters, ranging from oval to conic, 5 to 8 cm. long, with scales terminating in a small prickle. This species does well in a wide range of soils, and thrives near the ocean. Of all the pines, it seems to do the best in chalky soils, and it tolerates exposed, windy areas quite well.

JFK's Austrian pines are subject to the fungal disease Diplodia pinea, which is controlled at JFK with a mixture of Bordonix and cupric sulfide, which is sprayed onto the trees. Most of the Austrian pine trees that were planted on the airport's landside property are from years ago, before this list of recommended species and those that are not to be planted on the airport was written. Many of the Austrian pines were subsequently cut down or thinned, because many evergreen trees closely planted with thick vegetation were attractants to flocks of overwintering birds, in particular, starlings. The Austrian pines still on the airport appear to suffer from Diplodia pinea, but they survive with it.

Japanese Black Pine (Pinus thunbergii)

Like the Austrian pine, the Japanese black pine, a native of Japan and Korea, has paired needles, these are 7 to 18 cm. long, slightly longer than the Austrian pine's needles. Winter buds are pointed. Young shoots are light brown, oval to conic cones are 4 to 6 cm., and occur either singly and in clusters, and its branches are stout and twisted. Often planted near the coast, and does well as a wind break. It does well in poor, sandy soils. Even though the Black pine does not suffer from Diplodia pinea like the Austrian pines, we do want to avoid a situation where they have to be cut down due to too many being planted too close together. As a matter of course, when pruning the trees on the airport, the pine trees are thinned so their otherwise dense, evergreen foliage never becomes an attractant to flocks of overwintering birds, in particular, starlings.

Shrubs

Five-fingered Aralia (Acanthopanax sieboldianus)
Glossy Abelia (Abelia grandiflora)
False Indigo (Amorpha fruticosa)
Groundsel Bush (Baccharis holmifolia)
Pea Shrub (Caragana arborescens)
Smoke Tree or Wig Tree (Cotinus coggyria)
Deutzia (Deutzia lemoinia)
Burning Bush (Euonymus alatus)
Pearlbush (Exochorda racemosa)
Goldenbell (Forsythia sp.)
Rose of Sharon (Hibiscus syriacus)
Smooth Hydrangea (Hydrangea arborescens)
Shrubby St. Johnswort (Hypericum prolificum)
Creeping Juniper (Juniperus horizontalis)
Honeysuckle (Lonicera canadensis)
Sweet Syringa (Philadelphus coronarius)
Common Ninebark (Physocarpus opulifolius)

Bush Cinquefoil (Potentilla fruticosa)
Water Ash (Ptelea trifoliata)
Roseacacia Locust (Robinia hispida)
Pussy Willow (Salix discolor or Salix tristis)
Buffalo Berry (Sherperdia argentea)
Spirea (Spirea spp.)
Lilac (Syringa vulgaris)
French Tamarisk (Tamarix gallica)
Yew (Taxus canadensis)
Weigela (Weigela spp.)

Groundcover Species

English Ivy (Hedera helix 'Baltica')
Creeping Juniper (Juniperus horizontalis)
Pachysandra (Pachysandra spp.)
Periwinkle (Vinca minor)

Plants Not Recommended As Plantings On The Airport

Largely because of a plant's **high** food value to birds, certain plant species are listed as those that should not be planted on the airport. These species include:

Deciduous Trees and Shrubs

Silky Dogwood (Cornus amomum)
Eastern Flowering Dogwood (Cornus florida)
Gray Dogwood (Cornus racemosa)
Red Osier Dogwood (Cornus stolonifera)
Hawthorn (Crataegus spp.)
Eastern Red Cedar (Juniperus virginiana)
Amur Honeysuckle (Lonicera maackii)
Tatarian Honeysuckle (Lonicera tatarica)
Crab Apple (Malus spp.)
Cherry (Prunus spp.)
Firethorn (Pyracantha spp.)

Sumac (Rhus spp.)

The sumac species at JFK are Rhus glabra, Rhus copallinum, and Rhus radicans. They are low, woody species that are attractive in their own way, especially in autumn when their leaves add beautiful color to any landscape. However, these are species we are constantly fighting at JFK. Throughout the airport each seeds in on its own, and they present a significant management challenge on airside habitats. It is primarily because of their berries that they have become staples in the diets of many birds species, including some of the overwintering species. We constantly thin and cut the sumacs, and have effectively eliminated them on landside, however airside is a more difficult area to control because it is so vast, and cutting regimens allow grasses to grow tall to keep certain bird species out. At the same time, this allows many plant species to germinate and take hold. We understand sumac species will probably remain an airside management problem that will always require a great deal of time to control, but we are proud that we have taken control of these three species on landside, and stag's-horn sumac (Rhus typhina), another common species in the area, has been entirely eliminated from both landside and airside.

Mountain Ash (Sorbus americana)

Although mountain ash foliage is beautiful in autumn, and its berries also add considerable color to the landscape, it is because of the berries that we do not plant this species here. In addition, mountain ash looks out of place in this habitat.

Bradford Callery Pear (Pyrus calleryana "Bradford")

The Bradford callery pear was not on the list of species that were not recommended at JFK until 1995, and it is not on the FAA's list either, however, we at JFK have recently recognized this to be a problem tree. Its flowers, which usually appear in spring, but some that were planted at JFK bloom in the autumn, are beautiful, and its summer and autumn foliage are also admired. Nevertheless, the small pear fruits will stay on the trees all winter, creating a ready food source for, in particular, starlings. Because we are managing attractants suitable to overwintering starlings in an effort to eliminate the threat from flocks of starlings, we have added this species to the trees not recommended list (Garber 1989b).

White Mulberry (Morus alba)

White mulberry trees on JFK property now represent plants that probably seeded in on their own. Although this species is no longer popular as an ornamental, because many horticulturists consider it a weed, we are making the point to our ground crews that mulberries are to be avoided at all costs. When in fruit, here that is in the middle of July,

they provide massive amounts of food to a range of bird species, including laughing gulls.

Red Mulberry (Morus rubra)

Even though the red mulberry is not planted very often as an ornamental, we placed it on the list because we want to stress that any mulberry species that has mulberry fruits is to be avoided. The species seed in on their own, and when in fruit, provide a significant food source to a wide range of species, including laughing gulls.

High Bush Cranberry (Viburnum trilobum)

The sandy soils at the airport are suitable to a range of attractive species that are adapted to similar environments. Many of these species have berries and vegetation are attractive. Unfortunately, the berries can attract wildlife, therefore this species is not recommended for the airport.

Vines

Bittersweet (Celastrus spp.)

This aggressive alien will climb over shrubs and trees wherever management practices allow it to stay two steps ahead of you. At an airport, that is practically everywhere. Although some people like the wild appearance of vines growing over the woody foliage, we feel it does not look clean, and because these vines bear fruit, and because the leaves stay green during much of the winter and therefore provide cover for some bird species, we do not plant this anywhere on the airport, and we remove it wherever it is growing.

Virginia Creeper (Parthenocissus quinquefolia)

Virginia creeper is a very attractive vine that is native to the area and to this specific region. It grows wild on the airside of the airport in areas where trees have grow. The berries attract birds. Due largely to the berries, we do not plant Virginia creeper anywhere on the airport. In addition, the vines can compete with the trees for water and nutrients, sometimes stressing the tree. Anything that stresses a tree can make it more susceptible to disease or insect damage. In addition to the fact that diseased trees are unattractive, and require costly maintenance, the insects on diseased trees can attract

birds. For these reasons we like to keep our trees healthy, and that is why we do not plant vines at the base of trees

Airside Vegetation

This section deals with vegetation that lives on the areas of the airport where the runways, taxiways, and aircraft are. On August 7, 1995 Dr. Robert Zaremba, a botanist with the Nature Conservancy, and I conducted a survey of the airside habitats quickly documenting as many plant species as possible. Below each of the species is listed. If there is an * after a species name, that designates that this is a New York State rare species. Any plant followed by (watch) indicates that this species is on the New York State rare plant watch list. Should anyone be interested in the exact locations of the rare or watch species, both Zaremba and Garber have marked maps in their files. Instead of presenting these in phylogenetic order, for our purposes, we have chosen to alphabetize them:

List of Airside Plant Species

Achillea millefolium
Agrostis scabra
Ailanthus altissima
Ambrosia artemisiifolia
Ammophila breviligulata
Ampelopsis sp.
Apocynum cannabinum
Aristida sp.
Artemisia caudata
Artemisia vulgaris
Asclepias syriaca
Atriplex patula
Baccaris halimifolia
Cakile edentula
Celastrus orbiculatus
Cenchrus tribuloides *
Centaurea maculosa
Cirsium canadensis
Cyperus sp.
Cyperus schweinitzii *
Dactylis glomerata
Daucus carota

Desmodium sp.
Dianthus armeria
Diodia teres
Distichlis spicata
Epilobium sp.
Epilobium hirsuta
Erigeron annuus
Eupatorium album var. subvenosum (watch)
Eupatorium hyssopifolium
Eupatorium hyssopifolium var. laciniatum
Eupatorium perfoliatum
Eupatorium fistulosum
Euphorbia sp.
Euthamia tenuifolia
Euthamia graminifolia
Festuca ovina
Gnaphalium obtusifolium
Heterotheca subaxillaris
Hibiscus palustris
Hieracium sp.
Hudsonia tomentosa
Hypericum gentianoides
Hypericum cf. boreale
Impatiens capensis
Juncus effusus
Juncus gerardi
Juncus sp.
Lactuca sp.
Lechea maritima
Lepidium virginicum
Limonium nashii
Linaria canadensis
Lonicera morrowii
Ludwigia palustris
Lycopus sp.
Lythrum salicaria
Malus sp.
Melilotus officinalis
Melilotus alba
Mikania scandens
Myrica pennsylvanica
Onoclea sensibilis
Panicum sp.
Panicum virgatum
Panicum amarum (watch)

Parthenocissus sp.
Phragmites australis
Phytolacca americana
Pityopsis falcata
Plantago lanceolata
Pluchea odorata
Polygonella articulata
Polygonum opelousanum *
Potentilla erecta
Prunus serotina
Rhus glabra
Rhus copallinum
Rhus radicans
Rosa rugosa
Rosa multiflora
Rubus flageoletti
Rumex acetosella
Rumex crispus
Salicornia europaea
Salsola kali
Saponaria officinalis
Schizachyrium scoparium
Scirpus americanus
Scirpus cyperinus
Scutellaria galericulata
Setaria sp.
Solanum dulcamara
Solanum nigrum
Solidago canadensis
Solidago juncea
Solidago sempervirens
Spartina alterniflora
Spartina patens
Sporobolus vaginiflorus
Strophostylis helvula
Suaeda linearis
Thelypteris palustris
Typha angustifolia
Verbascum thapsus
Verbena hastata

Vegetation of Airside Habitats

Based on field surveys that I conducted with Dr. Andrew Grellet of Queens College, eleven different habitat types are described. Much of this work is based on Grellet's earlier work at Dubos Point (Grellet 1992). Each of the habitats is listed: beach herbland, sand, sand shrubland, grassland, mixed shrubland, Phragmites, Phragmites thatch, saltmarsh, salt shrubland, tall mixed woodland, and short mixed woodland. Nearby JFK's airside habitat is Dubos Point, which is a wildlife preserve. The soils, weather, habitats, and species are very similar in many respects to those here. One of the primary differences between the two localities is our ecosystem management, part of an ongoing effort to maintain a safe airport. If the habitats were all allowed to grow wild, they would rapidly become similar to those at Dubos. Because JFK's habitats will become like many of those at Dubos, without constant management, it is worthwhile to describe the habitats that occur at both JFK and Dubos. This way, all the airside habitats will be described here, with a short list of associated plant species:

Sand

The similar habitats to the bare sand habitats at Dubos, that occur at JFK, are primarily found along the edge of Thurston Basin, although some also exist along Bergen Basin and Jamaica Bay. This habitat occurs along the shore, as well as landside of stands of tall cordgrass (Spartina alterniflora) that border the shoreline. At Dubos, Grellet believes the bare sand that occurs landward of tall cordgrass, is the result of erosion of peat. At JFK, the Spartina alterniflora recently colonized, and the sand is both due to vast deposits of dredge spoils used to create JFK, and some of the sand is also the result of tidal action and storm tides. many races or subspecies Associated species found at the edges of storm-piled sand, are:

Distichlis spicata

Phragmites australis

Solidago sempervirens

Spartina patens

Suaeda linearis

Sand Shrubland

Sand shrubland is dominated primarily by the following native woody species: bayberry (Myrica pennsylvanica) and sumac (Rhus copallinum). These are usually shrubby, relatively low (1 to 3 meters high), and wide-branching. In the center of the larger clumps of Myrica and Rhus is often cherry (Prunus serotina), and these sometimes are small trees. Larger concentrations of shrubs are usually those with the taller shrubs, and these usually have vines such as Toxicodendron radicans and Parthenocissus quinquefolia (Parthenocissus quinquefolia was listed as present at Dubos, however, at JFK the Parthenocissus is not definitely quinquefolia). Rubus flagellaris often grows as a mat covering the ground. Species associated with sand shrubland found in the area are:

Aronia melanocarpa
Baccharis halimifolia
Morus alba
Myrica pennsylvanica
Panicum virgatum
Parthenocissus quinquefolia
Phytolacca americana
Prunus serotina
Rosa rugosa
Rubus allegheniensis
Rubus flagellaris
Solidago sempervirens
Toxicodendron radicans

Grassland

The prairie-like vegetation of the sand grassland is dominated by native grasses and forbs. Dredge spoils here are primarily well-drained, level, sandy soils. Because JFK is built on a marsh, there is constant settling, so interspersed within these grasslands are lower areas where water collects during parts of some years. We are vigorously pursuing an ongoing effort to fill all these in. The sand was originally placed on the marsh so the airport would be built on level sand that was six feet above high tide. These grasslands are all well above the influence of normal tidal cycles. The dominant grass species is Panicum virgatum; in addition Andropogon spp. are usually present, as are a number of Compositae, especially Solidago spp. Many of the associated species found in this sand grassland are:

Agrostis perennans?
Andropogon (Schizachyrium) scoparius
Andropogon virginicus

Eragrostis spectabilis
Eupatorium verticillatum
Panicum virgatum
Phragmites australis
Rhus copallinum (seedlings)
Solidago sempervirens
Solidago (Euthamia) graminifolia
Solidago (Euthamia) tenuifolia

Mixed Shrubland

This shrubland develops on sand, it is very disturbed, and although it is dominated by the native shrubs Myrica and Rhus as well as by such exotic vines as Lonicera japonica and Celastrus orbiculatus, and this habitat includes considerable amounts of Artemisia vulgaris. Species that occur in this mixed shrubland are:

Agrostis hiemalis?
Artemisia vulgaris
Aster novae-angliae
Celastrus orbiculatus
Lonicera japonica
Myrica pennsylvanica
Phragmites australis
Prunus scrotina
Rhus copallinum

Phragmites

This tall grassland community (1 to 3 meters) is dominated by the common reed (Phragmites australis). Phragmites is usually a sign of wet soils or recent disturbance. In the reed's understory are many species. Species that occur here include:

Agalinus (Gerardia) purpureus?
Artemisia vulgaris
Bidens aristosa
Convolvulus sepium
Daucus carota
Scirpus juncoides?
Lycopus sp.
Phragmites australis
Polygonum cupidatum

Rack Thatch

This habitat is really just the rack composed of dead stems of both the common reed, Phragmites australis, and tall cordgrass, Spartina alterniflora, that are deposited by the tides along the high tide line of salt marshes, as well as next to some of the beaches along the periphery of the airport. The rack is most apparent and in the best shape during the winter.

Phragmites australis

Spartina alterniflora

Salt Marsh

The salt marsh habitats on and adjacent to JFK are a complex of grass- and forb-dominated communities that developed under the influence of daily tides. The three types of salt marsh communities present at JFK are (1) the tall cordgrass (Spartina alterniflora) type that often occurs on peat and is inundated for long periods by the tides. Some Spartina alterniflora localities at JFK were recently created with sandy dredge spoils, so the tall short grass can colonize an area much more rapidly than is required to create a deep peat salt marsh. These habitats usually occur along the edge of the land at the seaward edge. 2) The salt meadow type also occurs on peat, but is dominated by short grasses (Spartina patens and Distichlis spicata) and succulent forbs such as Limonium carolinianum, Aster tenuifolius, Salicornia europaea, and Suaeda. 3) A succulent forb community that usually develops on bare substrates such as sand or shells, and is dominated by a variable mixture of the following salt-tolerant succulent herbs:

Aster tenuifolius

Distichlis spicata

Juncus gerardi

Limonium carolinianum

Salicornia europaea

Spartina alterniflora

Spartina patens

Suaeda spp.

Salt Shrubland

A low community of widely branching, salt-tolerant, native woody plants that are inundated for short periods each day by the high tides. When this community is open there is often a dense ground layer which is dominated by the black grass (Juncus gerardi) which is a rush. Phragmites is frequently found mixed in with salt shrubland. The salt shrubland is often seen landward of the salt marshes in flat areas. Species found here include:

Baccharis halimifolia

Cyperus sp.

Juncus gerardi

Limonium carolinianum

Iva oraria var. frutescens

Phragmites australis

Solidago sempervirens

Tall Mixed Woodland

The tall mixed woodland is a community of tall woody plants with single trunks (boles) reaching heights of approximately 10 meters. The trees, which are mostly native, include Celtis occidentalis, a native species that is a dominant component of maritime forests at the southern tip of Staten Island. often have woody vines (lianas) climbing the bole and growing in the upper branches. This community's understory and fringes are dominated by shrub species, the majority of which are Myrica and. Also, this community has an important herbaceous component. Species found in the tall mixed woodland include:

Ailanthus altissima

Celtis occidentalis

Parthenocissus quinquefolia

Populus tremuloides

Prunus serotina

Short Mixed Woodland

The short mixed woodland community represents trees that reach 5 to 10 meters in height. This community has fewer species than the tall mixed woodland. Species found here include:

Celastrus orbiculatus

Parthenocissus quinquefolia

Prunus serotina

Salix fragilis?

Bayberry (Myrica pennsylvanica)

Bayberry bushes were planted along the south side of Runway 13R to control soil erosion. When bushes were large enough that when they came into fruit they became an attractant to small passerines, removal was begun in 1963 and 1964 and continued until entire removal was completed by the mid-1970s (Tommy Charles, the Chief Operations Supervisor at JFK who worked at the airport from approximated 1953 through 1988; Joanna Burger cited him in Appendix C entitled "Practices up to November 11, 1975" in her 1982 "Report on Bird Control at J. F. Kennedy International Airport"). That area has continued to have bayberry bushes growing there ever since, and periodically they are cut back

Vegetation West of Bergen Basin

January 23, 1996 John Zuzworsky of the National Park Service and I walked the grassland areas beyond the long-term parking lots and west of Bergen Basin. The soils were primarily sandy, there were some wet areas, and one hollow with standing water. Below are the plant, fungus, and lichen species we identified:

Shrubs

Blackhaw (Viburnum prunifolium)

Rhus copallinum

Trees

Eastern Red Cedar (Juniperus virginiana)

Pitch Pine (Pinus rigida)

Black Cherry (Prunus serotina)

White Mulberry (Morus alba)

Tree of Heaven (Ailanthus altissima)

Eastern Cottonwood (Populus deltoides)

Norway Maple (Acer platanoides)

Sycamore Maple (Acer pseudoplatanus)

Willow (Salix sp., either Black Willow, Salix fragilis or crack willow, Salix nigra)

North American Hackberry (Celtis occidentalis)

Tree-of-Heaven (Ailanthus altissima)

Fungus

Barometer Earthstar (Astraeus hygrometricus)

Lichen

British Soldiers

Grass

Little Bluestem (Andropogon (Schizachyrium) scoparius)

Switchgrass (Panicum virgatum)

Common Reed (Phragmites australis)

Flowers

Goldenrod (Solidago sp.)

Mugwort (Artemisia vulgaris)

Common Evening Primrose (Oenothera biennis)

Common Mullein (Verbascum thapsus)

Spotted Knapweed (Centaurea maculosa)

Grass Management

Grass Management on the Aeronautical Side

Short grass has been determined to be a gull attractant, attracting laughing gulls in particular (Blokpoe 1976; Brough and Bridgman 1980; Buckley and McCarthy 1994). The extent to which short grass at JFK was an actual gull attractant has been tested in 1985 and 1986 (Buckley and Gurien 1986), however the conclusions have never been put into

context, and the arthropodan prey species and the stages in their life history also needs to be put into the proper context. During the summers of 1985 and 1986 36 experimental plots were sampled between Runways 4L/22R and 4R/22L using two levels of grass height. Each plot was a .4 hectare square separated by a 50 meter buffer zone. Laughing gull abundance and distribution were recorded and analyzed as a response to grass height as were the abundance and distribution of both larvae and adults of potential arthropodan prey. Each summer initial mowing of plots began on May 22. Short grass plots were cut first. Upon completion of all short grass plots the grass cutters were modified for the long grass cut. Mowing of long grass was completed by June 3. To maintain treatment heights, all plots were recut between July 8-12 and again between August 14-16.

The data confirmed that the experimental plots with short grass had significantly greater abundances of laughing gulls, but lower abundances of adult insects. Grass height had no effect on numbers of beetle larvae. However the presence of laughing gulls was positively correlated with the presence of oriental beetle larvae, which were emerging in large concentrations in areas where laughing gulls were concentrated, but laughing gulls only ate oriental beetles in short. Laughing gulls were most abundant in grass during late June and July, corresponding to beetle emergence periods. Stomach analyses of airport gulls showed significant proportions of adult beetles, particularly oriental and green beetles, while bolus samples from laughing gull chicks on the Joco Marsh colony immediately adjacent to JFK revealed the almost complete absence of beetles. The primary diet of the chicks was fish and crustacea.

From this study the authors concluded that the major attractive features of JFK with regard to gulls was the existence of short grass, large concentrations of emerging oriental beetles, and the presence of freshwater ponds on the taxiways and runways. Based on these findings, recommendations for laughing gull control were to increase the length of grass in key aeronautical areas, elimination of freshwater ponding, and maintenance of current levels of the JFK bird patrol. Gurien (now McCarthy) said JFK stated making the recommended changes in grass height would not be possible because of fire safety, visibility, and aesthetics (personal communication 1995). However, since then the Port Authority has assessed the grass height situation with regard to the fire hazard potential, and determined many of the laughing gulls are gone by mid August and the grass has not dried out until then, therefore tall grass does not constitute quite as significant of a fire hazard during the summer months as was believed.

With regard to visibility, we purchased vehicles that drive higher so we can see over the grasses. Wherever the high grasses interfere with the FAA equipment, we cut the grass low. Aesthetics are sometimes the easiest, and at other times, the most difficult issues to deal with. Because aesthetics do not constitute a safety hazard, one cannot carry out habitat management policies that impinge on aesthetics without increasing any risk or danger to the flying public. It is very difficult to change people's perceptions, mores, and procedures. We at JFK work hard to create an aesthetically pleasing airport, both airside and landside. Many people feel that short grass is clean and attractive, and long grass is messy and unkempt. Therefore, regardless of a potential safety hazard, it is

difficult to change procedures to manage previously short grass areas as long grass areas. Even though Buckley and Gurien could not mobilize sufficient persuasive, diplomatic, or managerial skills to enact such changes, it has since been possible through internal mechanisms to make all of the above changes. JFK and everyone flying in and out of the airport are the direct beneficiaries.

We now manage the grassy areas where laughing gulls had proven to be a problem in a manner that is consistent with the recommendations of the Buckley and Gurien study. Airside grassy areas were found to attract laughing gulls when certain insects emerged, and for this reason we do not cut these grassy areas from May 1 through August 1, except around approach lighting, FAA equipment, propane cannons, and signs. In 1995, after ceasing grass cutting on the airside, we did not have any complaints from the Bird Control Unit that the laughing gulls were resting and feeding on insects in the grassy areas, and it may well be that the grass management had also eliminated the gulls that had once been attracted to freshwater ponding on taxiways and runways.

In 1995, although we planned to resume cutting the grass short on airside at the beginning of August, we extended this date until August 15 because there were still large numbers of laughing gulls in the area, it was warm and there were many insects available in the tall grass, and we were afraid that when we cut the grass large numbers of starlings, cowbirds, and other "blackbirds" might begin using airside habitats for feeding.

The extension to the middle of August worked well for everyone and it kept the number of birds over the airport low, perhaps in part due to this management decision. As soon as grass cutting resumed, I began surveying the cut areas and compared them to the areas that were not cut, to determine if there was a statistically significant difference in the number of birds utilizing these two habitats. We concluded, for the first month of cutting there was not much of a difference. The reason there is a first month of cutting, as opposed to say all the grass being cut in one week, is because grass cutting takes place over a very long period of time, considering how much area needs to be cut. The blades are set at the lowest rung so the cutters will not have to return before the snow arrives. The grass should be as low as possible by the time the snow arrives so the snow has somewhere to blow, otherwise we can end up with high drifts up against the high grass. This keeps snow blowing around on the runways and taxiways, creating a more dangerous airport. It is our preference to get the grass as low as possible by the time the winter sets in so the snow will blow off the runways and taxiways and disperse over the vegetated areas.

On areas of the airport where we have not had problems with laughing gulls feeding on the ground where grass grows, we have a cutting regimen that continues during the summer. At present these regimen are proving to coincide with our overall ecosystem management needs. We are monitoring the Van Wyck entrance to Federal Circle, the Van Wyck from Federal Circle to Building 269, 150th Street to North Boundary Road, the cargo areas, Central Terminal Area, areas west of Building 141, and the North

Boundary Road. Currently the cutting regimens at each of these locations are controlled, monitored, and are proving effective.

Even though 97% of the laughing gulls observed in the Buckley and Gurien study were recorded in short grass, it needs to be pointed out that in 1985 the cumulative number of laughing gulls recorded on the airport in this study area totaled 482, and during 1985 there were 2,741 pairs of laughing gulls nesting on Joco Marsh; the number of laughing gulls on their airport reflected repeat individuals and were only a small percent of the breeding population. In 1986 the cumulative number of laughing gulls observed on the airport in the study area was 548. All the laughing gulls observed in the study area were juveniles and non-breeders. Of the carcasses collected at the airport, none appeared to be current breeders, strongly suggesting that laughing gulls using the airport were non-breeders. In 1995 no juvenile laughing gulls were observed feeding at JFK. Apparently, this stage in the bird's life history is now spent elsewhere. During the summer of 1995 we observed thousands of juvenile laughing gulls in Staten Island at the Fresh Kills Landfill. Apparently the Fresh Kills site has become the dominant resting, feeding, and drinking area of choice since JFK has no juveniles resting, feeding, or drinking here any longer, and thousands inhabiting this region spend their time elsewhere. Therefore, we have succeeded in eliminating the entire problem recognized by Buckley and Gurien in their 1985 and 1986 study. It needs to be pointed out here that the Buckley and Gurien study was designed, conducted, analyzed, and written by National Park Service personnel. However it is the National Park Service which has continued for the next 10 years at harping about the grass, insects, and standing water problems at JFK with respect to all the laughing gulls they are attracting from Joco Marsh.

In 1985 and 1986 JFK was not attracting laughing gulls from Joco Marsh. The laughing gulls resting, feeding, and drinking here were juveniles, therefore they were not breeding birds, and therefore they were just spending part of their year at the airport because this habitat satisfied some of their requirements. Now that the airport is managed differently, no juvenile laughing gulls are ever observed feeding on insects or loafing on the taxiways or runways. We conclude that it is time for both the National Park Service and the United States Fish and Wildlife Service to recognize that the grass management, insect management, and freshwater management problems as identified in the Buckley and Gurien study have all been eliminated. Since these constituted the focus of Category 1 problems that needed to be eliminated before JFK could commence Category 2 procedures (see record of decision), we feel it is time to move on to Category 2. But first, in the interests of those who would like to see that JFK really has considered all the problems at the airport with a tremendous amount of care that goes far beyond the required scope of the record of decision, we recommend that you read the remaining sections of this wildlife management plan. We are doing all that is possible at JFK to continue being the Harvard of Airports, with respect to our bird hazard management, ecosystem management, and wildlife management procedures. There isn't another airport in the world that has created the years of data showing the plants and animals at the airport and how they are managed. We continue to use this data set in conjunction

with our bird strike record to find short term and long-term trends that reflect successes and areas that require additional attention.

Grass Species on the Aeronautical Side

Although the airside habitats referred to as short grass or tall grass actually have many more species beyond the grass species, which are identified in the above list of airside species

Fescue Grass

There are about a dozen *Festucas* in the eastern United States. *Festuca ovina* is common at JFK where its seeds are eaten by many bird species, including sparrows, buntings, finches, and larks. This grass species is also important to cottontail rabbits and various species of rodents.

Panic Grass

Panic grasses, commonly called switchgrass, occur in a wide variety of habitats and species. There are at least 160 species in the United States, and their identification can be difficult, therefore, most of the species we have at JFK are tentatively called *Panicum* sp., which just means they are here, but we have not identified them. One very common panic grass, *Panicum virgatum*, is very widespread on the airside. Another, *Panicum amarum*, is on the watch list of New York State. This species is uncommon throughout the state, and having a population here at the airport is significant.

The genus is an important food source to a wide range of bird species, including upland gamebirds, marsh and shore birds, and water fowl. At JFK *Panicum virgatum* is more important than any of the fescue grasses. It does very well on disturbed soils where it is an important primary species.

Common Reed

Phragmites australis is the tall grass with conspicuous seed plumes on top that flourishes along the shores and disturbed soils in low lying areas. This grass can tolerate high salinities and therefore does well both along freshwater, saltwater, and brackish habitats. This species often grows in habitats that attract waterfowl and bird species that need to be managed at an airport. We use *Phragmites* as an indicator species, one that helps us identify areas that need more habitat management. In addition, *Phragmites* is a fire

hazard and can bring ground visibility to zero where it grows high. In wet areas we have used mowing, better drainage, and fill to affect the habitats and change the species composition from being dominated by Phragmites to its being just one of many species, one that doesn't do particularly well in the altered habitat.

Bristlegrass

Setaria sp. are the bristlegrasses, of which there are about 13 in the United States, and most live in the eastern states. It is very high on the list of important grass species for wildlife, particularly birds. The bristlegrasses on JFK's airside are not as common as Panicum virgatum.

Grass Management on Landside

Grassy areas next to roadways are maintained on the airport with grasses regularly mowed to a short length. In particular, the mowed grass adjoining the roadways at the two main entrances to the airport are maintained as short grass because they do not attract significant numbers of laughing gulls. It is only long grass areas on airside that are occasionally mowed, that attract laughing gulls during the summer right after the mowing. We conducted surveys during the summer of 1995 on landside habitats and found the short grass areas do not present a laughing gull attractant.

Grass Species That Grow As Weeds

Digitaria spp.

Digitaria is the crabgrass genus, which contains a number of common weeds that grow in lawns on JFK's landside. The common Digitaria sp. at JFK is hardy and competes well with the planted grasses and other weeds. It provides excellent food for mourning doves, sparrow species, cowbirds, larks, and juncos. It is also eaten by rabbits.

Grass Species Planted

Big Blue Stem (Andropogon gerardi)
Little Blue Stem (Andropogon scoparius)
Sand Love Grass (Eriogonum trichodes)
Indian Grass (Sorghastrum avenaceum)

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BIRD STRIKE COMMITTEE CANADA. RICHMOND, BRITISH COLUMBIA.
APRIL 10-11, 1996

**Rapidly Growing Non-Migrant Canada Goose
(*Branta canadensis*) Population Presents
Hazard to Aircraft as Reflected in the Growing
Number of Bird Strikes**

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Introduction

Canada geese reached a new record in population density in North America in 1995. Non-migratory Canada geese are increasing in number exponentially, and the increase has been reflected in the number of aircraft striking geese across the continent. In North America, during the past two years Canada goose strikes have resulted in the death of 24 people and over \$200 million dollars worth of damage to aircraft. At Port Authority airports (JFK and LaGuardia) alone we had three major incidents: one at JFK when the Air France Concorde struck geese on June 3, 1995 resulting in \$6 million dollars worth of damage, September 18, 1995 at LaGuardia Airport when a Northwest Airlines Airbus A320 struck 12 Canada geese and it cost the airlines \$2.5 million. No one was hurt in either incident. On December 10, 1995 a Polar Air Cargo Boeing 747 struck a flock of migrating snow geese, which cost the carrier millions of dollars.

There have been 40 Canada goose bird strikes at JFK during the 17 years from 1979 through 1995. This is an average of 2.36 per year. Although this represents only about 1 percent of all the bird strikes at JFK, it accounts for over 2 percent of the total aircraft damaged or delayed due to bird strikes. During the first five years of record keeping at JFK (1979 through 1983) four Canada geese were struck, which is an average of .8 geese per year. During the next 11 years, from 1984 through 1995 36 geese were struck, which is an average of 3.28 per year. That is an increase of over 400 percent. We investigated other airports to find if any others have reported increased bird strike activity due to Canada geese, and although other airports rarely have the data set that JFK has, there has been a dramatic number of recent goose strikes at other North American airports.

Until recently, Canada geese did not pose a significant threat to aircraft, in fact, their numbers had decreased significantly throughout the first half of the century, so that by 1950 their numbers and range were significantly reduced from what they had been 100 years earlier. However, the Canada goose situation changed markedly in the last few decades. Over the past several years wildlife managers across North America have reported a rapid increase in numbers of Canada geese that now breed where none previously bred.

Canada geese previously flew through New York's airways during spring and fall, but never spent the summer here. Canada geese have many recognized races or subspecies, each is usually identified by biogeographic variation, that is, where they breed, and there are recognized phenotypes, usually differing according to size; some range in size from three or four pounds, while others weigh about nine pounds. Each of the subspecies nests in the northwestern United States and Canada, and winters in the United States. They occur in greatest numbers along the coasts. Migratory geese continue to breed to the north, however many geese remain further south all year round.

Canada geese have adapted to the changing environment created by humans. The geese are attracted to short grass habitats near water. Such areas were very uncommon throughout most of the United States before the forests were cut and urban and suburban habitats became a patchwork of managed lawns, grassy street sides, and the occasional thousand acre golf course. We created perfect goose habitats. These areas were kept clear of potential goose predators, and humans liked to feed the geese with the ducks. In addition, many geese were kept as exotic pets at duck ponds across the country. The Canada geese could not fly away because their wings were flipped, so they stayed around our homes and bred. The young escaped and continued to breed locally, and these local populations increased in size. As the number of Canada geese continues to increase, so does the number of goose strikes; during recent months planes have been hitting geese in record numbers.

Strike Record at JFK

The Canada goose is a dangerous bird in several respects: 1) it is one of the heaviest and densest birds regularly flying through JFK airspace, 2) Canada goose bird strikes often involve flocks, making this species an even more significant risk to aircraft at JFK, and 3) this species is rapidly increasing in numbers in our area. During the period from 1979 through 1993, 31 Canada geese hit aircraft at JFK (Garber 1995). This was less than 1 percent of the total number of bird strikes at JFK. Of these Canada goose strikes, no one was hurt, and two aircraft were either damaged or delayed, which was 2 percent of the total aircraft that were either damaged or delayed at JFK during that period. The trend in Canada goose related aircraft collisions has remained constant over this period, averaging 1.2 geese struck at JFK per year, with a range from 0 to 3.

Even before Canada geese were rapidly increasing in number, they were recognized as a hazard to aircraft at JFK; this was largely due to when an aircraft struck a Canada goose at JFK on December 14, 1965; the plane was left with an .8 inch (20.3 centimeter) diameter hole that was 10 inches (25.4 centimeters) deep in a horizontal stabilizer and there was also a 6 inch (15.2 centimeter) long indentation on the leading wing edge. At JFK, since 1979, three aircraft have been damaged or delayed due to Canada goose strikes. The total strike record for Canada geese at JFK since 1979 includes one goose struck on Runway 4R on May 1, 1979, two geese were struck Runway 13R on November 8, 1979, three on Runway 31L on May 14, 1984, two on Runway 4L on September 27, 1984, six on Runway 4L on May 9, 1985, two on Runway 13R on March 23, 1986, one on Runway 4R on October 10, 1988, three on Runway 4R on March 5, 1989, one on Runway 4R on July 28, 1989, one on Runway 4R on March 29, 1990, one on Runway 13R on May 28, 1991, four geese were struck on Runway 4L on November 9, 1991, two were struck on September 6, 1992, one on Runway 4R on November 13, 1993, one on Runway 22L on April 9, 1994, one on Runway 31R on November 10, 1994, two on Runway 22L on March 21, 1995, and the Air France Concorde incident on Runway 22L on June 3, 1995 when five geese were struck. December 10, 1995 a Polar Air Cargo Boeing 747 12 to 15 miles from JFK, on its approach, while over water at 7,500 feet,

struck a flock of Canada geese. Kent Scott, Polar Air's Vice President of Flight Operations spoke to the pilot of the aircraft who identified the birds as Canada geese. The pilot said the main landing lights were turned on at 10,000 feet, "which usually has an effect on bird activity, they'll wheel away if they can." As soon as the aircraft came out of the clouds the pilot saw a flash of white, which he thought was lightning, and then the instant before impact he saw a flock of Canada geese. When they hit the birds the airplane shuddered violently, the pilot and copilot thought they had lost the plane. You know something is terribly wrong when a 750,000 pound aircraft (when fully loaded) starts shaking violently. Kent Scott said this was the most violent incident he's heard about from any pilot during all his years as a pilot. The birds caused extensive structural damage to the aircraft. Two engines were replaced and there was major damage to the body of the plane.

Recent Strike Record at Other Airports

The growth in the Canada geese populations across the United States is reflected in the number of goose-related incidents. In June 1993 a Boeing 737 was taking off from Calgary Airport in Alberta, Canada when it struck 80 ring-billed gulls that were at the end of the runway. The plane was too close to the end of the runway so it could not abort; instead it gained enough altitude to loop around and immediately land again. Two engines were damaged; luckily no one was hurt. In the autumn of 1993 12 Canada geese were involved in a strike with a KLM Boeing 747 that was landing at the Calgary Airport in Alberta, Canada. One engine was knocked out and there was considerable damage to the fuselage. The total damage amounted to \$4-5 million. During the winter of 1994-1995 a two Canada geese were involved in a strike with a Boeing 747 which was taking off from Fort Meyers, Florida. The geese went through the plane's nose cone and the aircraft had to land in Orlando, Florida.

The Canada goose strike at JFK on June 3, 1995 occurred when an Air France Concorde was just about to land on Runway 22L and several geese hit the fuselage, and geese were sucked through two engines both of which caught fire and had to be shut off. Luckily no one was hurt, however an estimated \$6 million dollars worth of damage occurred. August 22, 1995 a Continental Airlines Boeing 757 hit a flock of Canada geese just before touching down at Seattle-Tacoma International Airport. The 9 geese that were killed damaged the aircraft's nose cone, which contains the aircraft's radar. The plane landed safely and no passengers or crew were hurt.

Airport Operations at Washington Dulles International Airport in Herndon, Virginia reported a Canada goose strike on November 6, 1992. The strike occurred during the day, the aircraft was a BA-3200 (Dewey 1995). On November 3, 1994 there was what the airport identified as a possible Canada goose strike that occurred at night to an E120; the airline reported damage to the aircraft. May 12, 1995 a dead Canada goose was found on the runway at, but the strike was never reported by a pilot. Then on September 14, 1995 a Boeing 757 landing at Dulles International Airport struck 10 Canada geese at

7:30PM. The multiple strike damaged both engines, both wings, and the radome; no one was hurt.

There was a Canada goose strike at LaGuardia Airport on September 18, 1995. A Northwest Airlines Airbus A320 was landing on a clear evening when Canada geese were seen and struck. Twelve geese were seen and struck; no one was hurt. Geese struck the radome, windshield, nose engine #2, fuselage, landing gear, and the tail. Only damage was incurred to the engine, which was shut down. The dollar estimate of the damage was been placed at \$2 million, and the estimated cost due to loss of revenue from the 48 hours during which the aircraft was out of service was \$500,000.

On September 22, 1995 a Boeing 707 United States Air Force E-3B Advanced Warning and Control System, or AWACS, jet struck Canada geese when taking off at Elmendorf Air Force Base, just north of Anchorage, Alaska. Carla Dove of the Smithsonian Institution's Division of Birds examined the feather samples (personal communication) from two engines and made the positive identification. The \$180 million four-engine aircraft lost power in two engines, which was sufficient to cause it to crash two miles from the end of the runway. All 24 people aboard were killed (22 Americans, 2 Canadians). The way \$180 million was calculated is the Boeing 707 was worth approximately \$30 million, the equipment on board and AWACS is valued at \$150 million, and although normally the 24 people's lives would be valued at \$2.5 million each, because this was the United States Air Force, no one can sue, so the additional \$60 million is not part of the calculation.

Another goose-related bird strike occurred September 25, 1995 when the jet House Speaker Newt Gingrich, the Republican from Georgia, and his wife, were flying in was taking off from a small resort island in Michigan. No one was hurt when the small jet ran off the runway on Mackinac Island, Michigan after striking four Canada geese. Their Cessna Citation aircraft hit a flock of geese that was on the runway which scattered as the plane approached. The aircraft had just begun its ascent when it hit the birds. The pilots were very shaken when at least two geese were sucked into the right engine, while two others hit the leading edge of the left wing. The collision caved in a 14 inch portion of the wing. No one was hurt when the plane aborted its take-off, skidding to a stop 30 feet off the end of the runway. Obviously, the plane should never have been cleared for take-off with geese on the runway. On October 2, 1995 a probable goose strike at LaGuardia Airport involved a U.S. Air Shuttle 727/225. It was a clear evening when the plane was taking off when one bird struck engine #2, which was damaged. The engine instantly flamed out; there was internal damage that resulted in the engine having to be rebuilt. The Estimated cost of repairs was \$150,000 and an additional \$20,000 was the other cost due to lost revenues.

Growing Risk

While certain gull species are far more numerous and account for a greater percent of the total number of bird strikes at JFK, Canada geese account for an important risk that is growing across the continent. And in light of the fact that a large percent of goose-related strikes result in significant damage to aircraft, this species' behavior needs to be monitored and managed to the best of our ability. At JFK, the possibility of a goose-related strike exists throughout the year.

During the summer months most Canada geese in the Jamaica Bay area are located near the ponds at Jamaica Bay Wildlife Refuge (Burger et al. 1983; Garber 1995 unpublished data), although some can be found in the vicinity of JFK. The habits of Canada geese continue to change rapidly, and we are on the constant lookout at JFK to be sure we keep the birds away from the runways. A particularly serious problem that increases in severity each year concerns the birds changing breeding behavior. With Canada geese breeding throughout a vast range south of where they were previously found, this species continues to increase in number throughout the area, raising issues that were never confronted before. They have become pests at the reservoirs Upstate, on golf courses throughout the region, but only at airports are the goose-related problems really life-threatening. JFK has suitable breeding locations that could sustain a large breeding population, so vigorous efforts must be sustained to continue to keep geese from becoming established on, or near our property. The Port Authority of New York and New Jersey will continue to aggressively keep geese off JFK.

Abundance

Not too long ago this abundant migrant and winter visitor along the coast was only relatively common in this area. And inland, most geese were just seen and heard during migration when flying overhead. With their changing habits over the past 30 years, Canada geese now commonly breed where they used to just spend the winter. And after breeding in areas where they used to just spend the winter, they remain through the winter. Jamaica Bay Wildlife Refuge has Canada geese present all year round.

Meanwhile, the northern breeding stocks are declining in number, perhaps due to bad weather in the north during the past several years, or in part due to the increasing competition they receive from their conspecifics when the northern breeders are on their overwintering grounds. Many people are upset with the burgeoning numbers of Canada geese; they are not appreciated by those golfers who don't like stepping in goose plop (which looks like a small dog's feces). Home owners might disapprove of geese grazing in the backyard for the same reason. But we have only ourselves to blame. Canada geese were commonly raised in captivity and many escapes never went far from the roost. Instead of migrating north, after having been penned in and bred in these southern regions, their behavior was forever altered, and now their offspring are increasing in number like rabbits.

Canada geese have bred on the airport, and we are doing everything within our power to control this behavior. When we reported the first Canada goose nest on JFK to the United States Fish and Wildlife Service, we were informed we could not destroy the nest, harass the parents, addle or oil the eggs. It was not long afterward that an Air France Concorde hit several geese when landing at JFK. No one was hurt when two engines caught fire, however, a reported \$6 million dollars worth of damage was incurred, and Port Authority has been receiving inquiries from Air France's lawyers.

Management

In the vicinity of JFK, Canada geese naturally eat cordgrass, widgeongrass, spikerush, sea-lettuce, naiad, glasswort, eelgrass, bulrush, and saltgrass (Martin et al. 1951). However, they have expanded their diet to include grazing on manmade lawns and fields, where they eat vegetation that previously were not part of their diet. Current long grass and water management aimed at reducing gull hazards is also recognized by airport personnel as a useful mechanism for controlling geese, since they graze in short grass areas. We will continue to monitor our selected grass heights and times during which we cut the grass to determine if we need to consider modifying the regimen to control any potential future goose incursions. To date, the vegetation and water management, in conjunction with our ongoing nonlethal harassment techniques, which include the use of pyrotechnics, has been successful. It needs to be added however, that because of the nest found on JFK in 1995, and the recognition that we must step up our efforts to control the potential future establishment of other geese on the airport, we interspersed nonlethal harassment techniques during the summer of 1995 with lethal techniques. When we received a federal permit to shoot 20 Canada geese, we judiciously chose the best opportunities to make the point known to the groups of geese that were resting on the airport at different intervals during the summer.

The areas at JFK where Canada geese are most likely to rest and graze have been identified and they are visited twice each day. If any geese are there they are harassed. The 20 geese that were shot this summer were shot during this harassment, which significantly affected the frequency with which these birds are found on or near the airport. But because new geese continue to find suitable habitats to rest on the airport, we continue to seek them out and harass them, significantly reducing the number of geese that fly through JFK airspace.

Future Work

Considering the risk involved from Canada geese, this is not a problem that the aviation community can afford to overlook. We need to anticipate the informational needs we will require to effectively manage this growing problem. At present, our information is limited because this problem has only appeared to be a real problem for several months

at most. It is too early to know whether this is a growing problem, or if this series of goose strikes was just an odd coincidence. Because we cannot afford to take any chances, we are working with the governmental agencies that oversee protected migratory species such as the Canada goose, to see if there is anything that can be done to manage the burgeoning populations nesting in our region, and those that fly through. In the meantime, we need to learn more about the habits of this species around our airports to determine if there are measures that can be taken to reduce the number of geese flying through the airspaces of JFK, LaGuardia, and Newark Airports.

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BIRD STRIKE COMMITTEE CANADA. RICHMOND, BRITISH COLUMBIA.
APRIL 10-11, 1996

**A 27-Yr Study of Upland Sandpipers
(Bartramia longicauda) at John F. Kennedy
International Airport in New York City**

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Introduction

Upland sandpipers (*Bartramia longicauda*) nest at John F. Kennedy International Airport (JFK) in New York City, however they did not occur on the habitat where the airport is presently located before the airport was constructed. Originally the over 5,000 acres that currently comprise JFK were a mixture of fresh and saltwater wetlands. The nearest population of upland sandpipers that historically occurred in the area were found on the Hempstead Plains of Long Island, which originally comprised approximately 60,000 acres. The Hempstead Plains was one of the best remaining habitats for upland sandpipers in the John F. Kennedy International Airport area until the first part of the century, before the region was developed and before the airport was built. Nichols estimated at least 25 pairs bred on the Hempstead Plains in the early 1920s (Bull 1975, 1985), but by the early 1940s the Hempstead Plains population only had four to six remaining pairs (Cruickshank 1942); afterward the population disappeared.

JFK is very close to where the Hempstead Plains used to extend. Much of JFK's habitat is artificially created from primarily sandy dredge spoils, which were built approximately six feet above sea level. The goal was to make a flat, dry region suitable for taxiways, runways, and buildings. In addition, upland meadow habitat was created where there used to be wetlands. To some extent, it appears these upland meadows replaced the original natural upland meadows of the Hempstead Plains. It could be that the birds breeding at JFK are descendants of the birds that used to breed at Hempstead Plains, and the birds moved to JFK when the Hempstead Plains were fragmented and reduced in size, while simultaneously, JFK was increasing in size. Today upland sandpipers only breed at a relatively small number of discrete, local sites, and these sites usually have a small number of birds.

Throughout their entire range, which includes North and South America, the total number of breeding pairs is quite small. For these reasons, and because JFK has one of the largest breeding populations, as well as one of the most significant long-term data bases on the species, we continue to monitor the species at the airport. In North America it breeds as far south as Virginia. It was formerly more common. Upland sandpipers only breed in a number of discrete, local sites. Although this species does not represent a hazard to aircraft, in light of the few that have been struck over the years, we are making every effort possible to record relevant information about the birds at the airport so others interested in this species' management might benefit from our experience.

Methods and Results

The JFK population has been utilizing air side grassland habitats for many years. Studies of the species' breeding biology have been conducted (Higgins and Kirsch 1975; Kirsch and Higgins 1976; Ailes 1980), and their home range and daily movements were studied elsewhere (Ailes and Toepfer 1977). In addition, coloniality, reproductive success, and habitat interactions have been studied in the Midwest (Bowen 1976), as have the effects of grazing on nesting upland sandpipers in southcentral North Dakota (Bowen and Kruse 1993). The upland sandpiper will not continue breeding in an area when its fragmentation reaches a certain critical threshold, therefore there is some concern that the continued divisions of the air side habitat with more taxiways and open blacktop areas, could lead to an eventual problem with this species at JFK. However, there is no indication that the numbers have decreased at all over the last several years.

From 1969 through present bird banding has been conducted at JFK under the permits held by Jay Richard Cohen, Sammy Chevalier, and Steven Garber. 410 upland sandpipers were banded at JFK from 1969 through 1987, all were banded under the permits held by Cohen and Chevalier. All banding took place between the 4s. Banding data and observations by biologists at the airport are presented in an effort to determine the history of this species at the airport during our tenures here. Two of the upland sandpipers banded here were subsequently recovered, both at the airport. Each was banded at JFK when they were too young to fly. The first was banded on July 6, 1976 and was recovered May 8, 1978. The second was banded June 12, 1981 and was recovered May 28, 1990. This latter bird may be a longevity record for the species; the hiatus between times captured was 9 years.

The total number of upland sandpipers banded at JFK each year is as follows: 1969 - 2; 1970 - 9; 1971 - 19; 1972 - 12; 1973 - 6; 1974 - 15; 1975 - 8; 1976 - 22; 1977 - 26; 1978 - 34; 1979 - 41; 1980 - 30; 1981 - 57; 1982 - 36; 1983 - 71, 1984 - 6; 1985 - 0; 1986 - 14; 1987 - 2. All were banded when they were too young to fly except for one adult in 1971, 1 adult in 1977, 2 adults in 1978, and 1 adult in 1979. The number banded appears to drop off markedly after 1983, which may be a result of the grassland management at the airport. It has been suggested that it was after 1983 that the grass was allowed to grow high during the summer, whereas during previous years it was always kept shorter during the summer months. Although the longer grass does not appear to hinder the upland sandpipers' success at JFK, it does affect the success of those trying to locate and capture them so they can be banded. None were banded in 1988, 1989, 1990, 1991, or 1992. Each of these years Chevalier was busy during the summer with other chores on the airport and was not able to devote time to banding. He retired in October 1992, and no one was here to resume his work from then until December 1994, when I began working at JFK.

Dates when upland sandpipers were either banded or recaptured (followed by an R) are listed below. The number in parentheses is the number of birds banded or recaptured:

1977

June 1, 1977
June 3, 1977 (3)
June 8, 1977 (3)
June 14, 1977
June 17, 1977
June 19, 1977 (4)
June 21, 1977 (2)
June 22, 1977
June 26, 1977
June 28, 1977 (2)
June 29, 1977
July 6, 1977 (2)

1978

May 5, 1978 R
June 1, 1978 (2)
June 6, 1978 (2)
June 14, 1978 (3)
June 15, 1978 (2)
June 16, 1978 (3)
June 19, 1978
June 20, 1978 (6)
June 21, 1978 (3)
June 24, 1978 (3)
June 28, 1978 (2)
June 29, 1978 (2)
June 30, 1978 (3)
July 5, 1978
July 8, 1978
July 24, 1978

1979

June 3, 1979 (2)
June 7, 1979 (3)
June 12, 1979
June 14, 1979 (4)
June 16, 1979 (6)
June 17, 1979
June 20, 1979 (5)
June 21, 1979

June 22, 1979 (4)
June 25, 1979 (3)
June 26, 1979
June 27, 1979 (4)
June 28, 1979
July 3, 1979 (2)
July 4, 1979

1980

June 2, 1980 (3)
June 4, 1980
June 7, 1980 (2)
June 10, 1980
June 12, 1980 (2)
June 16, 1980 (3)
June 17, 1980 (3)
June 18, 1980
June 19, 1980 (2)
June 20, 1980
June 21, 1980
June 22, 1980
June 23, 1980 (3)
June 24, 1980 (3)
June 25, 1980
June 27, 1980
July 4, 1980

1981

June 23, 1981
June 24, 1981 (2)
June 25, 1981 (2)
June 29, 1981
July 27, 1981

1982

May 31, 1982 (2)
June 1, 1982 (2)
June 2, 1982 (5)
June 6, 1982
June 8, 1982 (6)
June 9, 1982
June 10, 1982 (3)
June 11, 1982
June 14, 1982 (3)
June 16, 1982 (2)

June 19, 1982
June 20, 1982 (2)
June 23, 1982
June 25, 1982
June 26, 1982

1983

June 8, 1983 (3)
June 9, 1983 (7)
June 10, 1983 (3)
June 13, 1983 (3)
June 14, 1983 (5)
June 16, 1983 (3)
June 17, 1983 (4)
June 22, 1983
June 26, 1983
June 27, 1983 (2)
June 30, 1983 (5)
July 1, 1983 (5)
July 3, 1983 (2)
July 4, 1983
July 9, 1983
July 11, 1983
July 27, 1983

1984

June 9, 1984
June 10, 1984
June 25, 1984
July 11, 1984
July 13, 1984
July 20, 1984

1986

June 3, 1986 (1)
June 5, 1986 (3)
June 6, 1986
June 10, 1986 (2)
June 14, 1986
June 16, 1986 (3)
July 1, 1986
July 9, 1986
July 14, 1986

1987

June 20, 1987

July 23, 1987

1990

May 28, 1990 R

From the above banding dates, upland sandpipers are here during the months of June and July; one might conclude from the banding data that the earliest date the birds are back at JFK was May 8, and the latest they were here was July 27, however, most banding dates start at the end of May and beginning of June, which may be more representative of when the birds are on their nests, and when they have young in the area, because the birds being caught are primarily young that can not fly and therefore can be chased down. and during the time that there are young in the area, the adults can be caught because they are more likely to come close enough to a person with a net when the parents are protecting their young.

The hiatus reflects the time between when Chevalier worked at the airport and when Garber began. Dates during 1994 and 1995 the number of upland sandpipers observations recorded at JFK during each of the following days appears in parentheses:

1994

May 11, 1994 (1)

May 19, 1994 (1)

May 23, 1994 (2)

May 24, 1994 (1)

May 25, 1994 (1)

June 8, 1994 (2)

June 14, 1994 (6) (of which, 2 were chicks)

1995

May 22, 1995 (1)

May 25, 1995 (1)

June 1, 1995 (4)

June 5, 1995 (3)

June 7, 1995 (2)

June 10, 1995 (4 Adults, 1 Juvenile)

June 15, 1995 (1)

June 16, 1995 (4)

June 17, 1995 (3)

June 19, 1995 (1)

July 14, 1995 (4)

August 4, 1995 (2)

From the above observation data, it appears that many upland sandpipers arrive at JFK through May, but eggs do not hatch until the end of May and in June and some may hatch as late as July.

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APPENDIX 10

Satellite Telemetry, A Tool for Tracking and Monitoring Bird Movements from a Local to Global Scale

Satellite Telemetry, A Tool for Tracking and Monitoring Bird Movements from a Local to Global Scale

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Abstract

Bird strikes to aircraft can result in damage that is expensive to repair and as lost revenue due to equipment down-time. Bird strikes also poses a safety risk to commercial, private and military aviation because it has resulted in serious human injury and death. Biotelemetry has been used effectively to examine the behavior, range, and biology of avian species since the early 1960s (Samuel and Fuller 1984). Conventional biotelemetry has been used to support basic research on birds as well as the conservation of avifauna throughout the world. However, biotelemetry has limitations that do not easily allow for the continuous tracking and monitoring of bird species over long distances for long periods. In the early

1980's satellite located Platform Transmitter Terminals (PTT), compatible with the French owned Argos System, were developed to track and monitor avian species on a local to global scale (Strikwerda et al. 1985 and 1986). We report here on aspects of the development of bird-borne PTTs and some of the past and present applications of satellite tracking to study avian species. The use of satellite tracking to locate and forecast bird movements and migration to aid in the bird strike problem has been proposed (Leshem 1990). A satellite tracking system used with other emerging technologies and capabilities to address the bird strike problem is discussed.

Conventional Telemetry System Technologies

Biotelemetry has dramatically influenced the direction of wildlife research since the first application by Southern (1964) to study the wintering behavior of bald eagles (*Haliaeetus leucacephalus*). The use of conventional telemetry has allowed for a more thorough capability to perform basic research and examine ecological and management issues related to animal behavior, survival, productivity, migration and habitat use. Biotelemetry has been especially helpful in the study of avian species because birds often are widely dispersed across the landscape and use large areas through which they can move quickly. Locally birds can make diurnal or nocturnal movements between foraging areas and roosting sites while seasonally they can travel great distances between breeding, migratory and wintering habitats. Conventional telemetry is commonly employed to locate birds to observe behavior and gather information on their range and patterns of habitat use. This information can be collected by several methods, the most common by homing toward the radio signal or triangulation performed by deriving a directional bearing on the tagged animal from two or more receiver positions with a directional antenna. In nearly all applications of conventional biotelemetry, it is restricted to local use with animal positions being collected on foot, from automobiles or small fixed wing aircraft.

Applications of biotelemetry have been successful in developing management plans for the conservation of avian species. Bloom et. al (1993) determined by means of biotelemetry that red-shouldered hawks could easily be managed with human activity in areas in Southern California due to their home range of 1.2 square kilometer in selected woodland habitat. Haug and Olifant (1990) and Meretsky and Snyder (1992) conducting radio telemetry studies also were able to make conservation recommendations for burrowing owls (*Athene canicalarga*) and California condors (*Gymnogyps californianus*) in their own unique habitats. Condors posed more difficult study problems because they ranged over 200 kilometers during foraging flights from their nest or roost. In this study conventional telemetry was used to supplement observations to assist in evaluating the birds behaviors and collect injured or dead individuals. Sherrod et. al (1981) similarly used biotelemetry to examine the release of captive bred

peregrine falcons in order to re-establish the species in areas from which they were previously extirpated due to pesticide use. Small tail mounted transmitters were used to track peregrines to examine their behavior, adaptation to the wild state, and determine the causes and rate of mortality.

Biotelemetry also has been used to assess effects of land use activities on avian species. Buehler et. al (1991) and Anderson et. al (1990) used radio telemetry to evaluate raptor behavior in regard to material test and evaluation activities on military lands. Seegar and Fuller have co-managed a comprehensive program to study raptors in relation to military training in the Snake River Birds of Prey National Conservative Area (SRBOPNCA), (Marzluff et. al, 1993). Biotelemetry was used on 120 prairie falcons (*Falco mexicanus*) during four breeding seasons to examine their distribution and evaluate the effects of military training on their biology. Location estimates were collected and correlated to real-time military training, vegetation, ground cover, prey distribution and other geographically significant variables. Home range and falcon activity can be evaluated in regard to these parameters. Land use patterns of the local population of prairie falcons derived from the random telemetry sample also were examined using a splined subroutine in Arc/Info Software (Arc/Info, Environmental Systems Research Institute Inc., Redlands, California). This approach was used to produce a contour map of prairie falcon spatial use of the study area. The Geographic Information System (GIS) we developed enables us to identify areas of high and low use by falcons, and to relate them to land-use patterns and management options.

Innovations in biotelemetry systems have led to the development of sensors and special-purpose transmitters to collect an array of information. The measurements of movement and temperature are the most commonly used sensors in wildlife studies (Kenward 1987:61). Motion sensors can be modified to log activity over time thus identifying periods of prolonged activity and inactivity or mortality (Kenward 1987). Sensors have been used to detect altitude (Bogel and Burchard 1992), humidity (Howey et al. 1977), gastric motility (Kuechle et al. 1987) and heart rate (Sawby and Gessaman 1974). Sladen and Cochran developed an automatic tracking station to detect the presence of telemetry signals from transmitters attached to tundra swans, (*Cygnus columbianus columbianus*) staging for spring migration from the Chesapeake Bay, Maryland and Virginia. The system was designed to alarm biologists when signals were detected from swans moving north from their wintering areas. Results from this work provided valuable information on the harness attachment of back-pack transmitters as well as temporal and spatial information on the swans' spring migration (Sladen et al 1969, Sladen and Cochran, 1969 and Sladen 1974). Individually coded transmitters have been developed in order to increase the number of transmitters that can be monitored in the field. Coded systems also can be used effectively with a computer based remote tracking systems that can run independently in the field (Howey et. al, 1989). Seegar, Howey and

Fuller (unpublished) used an automated coded tracking system to monitor for peregrine falcons tagged along a coastal barrier island autumn migration site in the eastern United States. The configuration of the coded system indicated the general direction of the presence of each coded transmitter on the 165/MHz receiver as it was received switching among four-element antennas pointing in different directions (north, east, south and west). This system allowed for the continuous collection of presence/absence data on an endangered species as it used critical coastal migratory habitat.

Aerial tracking can be very effective for locating wide-ranging birds on their breeding grounds, wintering areas (Buehler et. al, 1991) or migration routes (Hunt and Ward, 1988). However, the use of aircraft is expensive and not practical for tracking long distance migrants that travel thousands of miles, cross dozens of geopolitical boundaries and traverse remote regions of the globe. Limiting factors associated with conventional telemetry such as restricted geographic range and human operation required to obtain information on free ranging animals prompted the development of spaced base systems to track and monitor wildlife via satellite.

Space Based Satellite Tracking Technology

Satellite transmitters called Platform Transmitter Terminals (PTTs) were designed to interface with and be tracked and monitored by the French owned Argos system (Fancy et al. 1988). The PTTs operate on an Ultra High Frequency of 401.650 MHz, transmitting an identification code and data from up to eight sensors. The signals are digitally encoded on a pulse width of 0.36 second and a pulse interval of every 50-90 seconds. The frequency of the signal must be very stable (<2 Hz drift), and the radiated power must be relatively high (0.15 to 2.0 W). The signal is received by the satellites, then transmitted to processing equipment on the ground. Locations are estimated by the Doppler principle. Location estimates vary from ± 150 m to many kilometers, depending on animal behavior, environmental variables, and data-processing options (Keating et. al, 1991). Satellites carrying the Argos system are located in 850 kilometer sun-synchronous orbits. Depending on the transmitter's latitude, it is possible to determine its location and collect information from the sensors between 6 and 20 times in a 24 hour period.

Early attempts to track wildlife by satellite involved elk that were tracked with PTTs weighing 11 kg (Craighead et. al, 1972). During the 1970's some reduction in size of the PTT was achieved and 5 kg units were used to track polar bears (*Ursus arctos*) (Kolz et. al, 1980, Schweingburg and Lee, 1982) and sea turtles (*Caretta caretta*) (Tiniko and Kolz, 1982). Toyo Communications Equipment Co., Ltd manufactured the smallest PTT available by the early 1980's, which weighed 1000 gms with the batteries included. The prototype PTT produced by the Johns Hopkins University, Applied Physics Laboratory was the

first attempt to design and miniaturize a PTT for use on a bird (Strikwerda et al. 1989). Bird borne PTTs became a reality for tracking and monitoring activities of avian species in 1984 when this solar powered PTT was successfully fielded on the back of a wild mute swan (*Cygnus olor*) captured in the Chesapeake Bay of Maryland (Strikwerda et al. 1984). Since then the technology has continued to develop and provide a unique capability to track and monitor avian species weighing as little as 800 gms. The next field test conducted with the Johns Hopkins University PTT was in 1984 on a sub-adult bald eagle. This raptor was tracked for 270 days over a 2,400 kilometer range from Maryland to Florida. The results of this experiment led to a series of field tests of the technology with other avian species (Strickwerda et. al, 1986). Additional field tests were conducted on bald eagles, golden eagles and a gyrfalcon as the PTT was reduced in size from 185 gms to a 95 gm unit produced by Microwave Telemetry Inc. (Howey, 1989).

Applications

Eagles

As the technology continued to develop and become available, others used PTTs to track and monitor the griffin vulture (Griesigner et. al, 1992), Lesser spotted eagles (Meyburg et. al, 1993) and a Steller's sea eagle (Meyburg and Lobkov, 1994). Satellite tracking is now being used to do basic research on many avian species for conservation and resource management planning. In Glacier Bay National Park, the seasonal movements of bald eagles, were examined by satellite tracking to study the eagles foraging relationship to streams and rivers that potentially could be affected by proposed copper mining activities (Kralovec 1994). In Canada, Brodeau and DeCarie (1993) studied golden eagles to evaluate the impact of a proposed hydroelectric dam to be constructed south of James Bay, Ontario. Eagles from the area to be flooded were tagged with PTTs and tracked south to their wintering grounds. The golden eagles tracked via satellite distributed themselves over the entire known eastern United States wintering range for the species, thereby establishing their natal origin south of James Bay as a critical area for the maintenance of the species in this part of North America.

In 1989 Seegar and Fuller initiated a 6-year comprehensive study on raptors for the Idaho Army National Guard (IDARNG), on the Orchard Training Area (OTA), the third largest National Guard training facility in the United States. On the OTA, centrally located within the Snake River Birds of Prey National Conservation Area, we examined the spatial relationships of military training to golden eagle movements. Satellite telemetry was used to collect location data from eagles that frequented military exclusion areas and to determine wintering ranges for adult and sub-adult eagles (Seegar et al. 1996, in press). Because golden eagles of unknown origin joined wintering eagles on the OTA, telemetry via satellite was also used to identify the breeding grounds. Initial results showed some wintering adult eagles used military areas

extensively, having much smaller wintering ranges than wide ranging sub-adult eagles (Figure 1). Unique information on the breeding areas of adult eagles was obtained within the first year of the study. In the spring of 1993 all the adult birds migrated to breeding locations in central Alaska and Western Canada (Figure 1).

Peregrine Falcons

The application of tracking birds via satellite has expanded as a result of the continued development and miniaturization of PTTs. As the size and weight of the transmitters were reduced the number of species that could carry the PTT increased. Since the early 1990s Microwave Telemetry Inc. has supplied over 900 PTT that have been applied to more than 20 avian species on a global scale. The use of radio tagging should always be based on careful consideration of the effects of the transmitters on birds' behavior and flight (e.g., Obrecht et al. 1988, Samuel and Fuller 1994).

In the autumn of 1993 PTTs (NANO 100, Microwave Telemetry Inc.) weighing about 28 grams were attached to peregrine falcons (*Falco peregrinus tundrius*), an endangered species and a Neotropical migrant that breeds in the Arctic and winters as far south as Central and South America. Fifty-four PTTs were deployed on peregrines in five locations in North America and one location in the Western Russian Arctic. Results of this effort have described the range of this Arctic falcon and identified critical breeding, migratory and wintering habitats for the conservation of the species in North and South America.

We radio tagged peregrine falcons during the autumn migration on Assateague Island, Maryland and Virginia and Padre Island, Texas. Also, adults were tagged on Padre Island in the spring as they moved north out of Latin America to their Arctic breeding grounds. Padre Island is the only known staging area for the tundra peregrine in this hemisphere and provides critical migratory habitat for the species during their northward flight. The PTTs were programmed to operate for 12 months transmitting 8 hours every three days during migration then switching to a six day cycle of transmission during breeding and wintering periods when the birds were more sedentary. During the breeding season of 1994 we placed PTTs on adult females in Ungava Bay and Rankin Inlet, Canada; Sondrestromfjord, Greenland, and on the Kola Peninsula, Russia. During the past 24 months we have collected over 6,000 positions on these peregrines. These data have provided more information on the species distribution in the Northern and Southern Hemispheres of the Americas than 25 years of conventional field studies and banding returns. Satellite tracked peregrines from this sample in the New World wintered from Delaware to Argentina and returned to breeding grounds across the Northern Arctic from Alaska to Greenland.

The following peregrines were all captured in the spring on Padre Island

and tracked to their wintering and breeding grounds (Figure 2: 5709, 5695 & 5707). The track of 5709 shows a bird that bred in the Eastern Canadian Arctic then moved south to a wintering area on the Yucatan Peninsula in the autumn. The track of 5695 shows a western migrant that bred in Alaska north of the Yukon river and wintered in Northern Argentina. Falcon 5707 shows the unique track of a wandering non-breeding adult (Seegar et al. in press) (Figure 3). This falcon flew to the Rankin Inlet study area where non-breeding peregrines commonly are seen by biologists. She then left the western shore of Hudson Bay, traveled to southern Baffin Island and went north to the Arctic Ocean. From northern Baffin Island she traveled south by way of the Eastern Coastal flyway to a wintering area along the Northern Coast of Venezuela. Satellite based tracking data demonstrate the importance of Padre Island as critical habitat for the tundra peregrine falcon. During the spring migration birds staging on Padre Island migrated to breeding areas representing the entire range of the species on the North American continent. This information was collected and mapped with minimal field time and expense. The space based tracking system provided regular data from birds flying through remote areas that could not be accessed or effectively covered by conventional wildlife tracking methods.

During the past 15 years the electronics in the PTTs have been miniaturized and have provided new capabilities through the integration of microprocessors. The transmitters can interface with a variety of sensors to index activity and collect data from the environment surrounding the organism. An experimental bird borne transmitter produced by Microwave Telemetry Inc. weighs 20 grams which includes only 3.5 grams of electronics is being field tested on the Texas Gulf Coast to track the migration of the adult male peregrine falcon (600 gms.). This further reduction in size and weight of the PTT will allow for the application of satellite tracking to a wider variety of smaller avian species. Generally, tracking via satellite is being used to gather data addressing issues that were previously too costly or impossible to consider with conventional methods. We are combining satellite tracking with other technology and with proven procedures for innovative approaches to research and management of natural resources (Fuller et al. 1995b). Furthermore, we are continuing the development of more advanced PTTs and new sensors which will expand the present capabilities.

Advanced Bird Borne Satellite Telemetry Development

The present configuration of the bird borne PTT allows for the interface of a variety of sensors. The most commonly used on the satellite transmitters are temperature, motion, altitude and battery voltage. Absolute vapor pressure sensors are available for limited use with a temperature thermistor to monitor for humidity (Howey et al. 1977). Howey (pers. comm.) is currently developing a bird borne transmitter design that will incorporate a Global Positioning System

(GPS) receiver and will interface with an acoustical sensor to monitor animal behavior and a miniature camera (Seegar et al. 1996)

Global Positioning System Qualified ARGOS PTT

The Argos system maximum accuracy is location estimate of $\pm 150\text{m}$ but locations obtained from low power (100mW) bird borne PTTs often are in the range of $\pm 2\text{ km}$ of the bird's true locations. To achieve the highest grade ARGOS location at least 4 messages have to be received by the satellite over a period exceeding 420 seconds. A single Argos message can relay up to 256 bits of information from sensors on the transmitter to the user via the satellite.

The availability of small commercial GPS receivers make it possible to combine such a receiver with an Argos transmitter and field a package small enough to be carried by a goose size bird. By scheduling the collection of GPS locations throughout the day and storing these positions for later transmission via Argos as many as 20 more accurate GPS positions ($\pm 20\text{ m}$) can be transmitted to the user in a single Argos message. The present Argos/GPS package under development by Microwave Telemetry Inc. incorporates a commercially available GPS receiver, a microcontroller based data logger and a Microwave Telemetry NANO PTT. The data logger controls the GPS receiver and the collection of GPS data, which is dependent on power availability from the solar charged power source. The data logger then sequences data transfer to the NANO PTT at times favorable to satellite availability. The prototype unit (200 gms) is undergoing laboratory testing.

Digital Audio Capture Sensor System

The digital audio capture sensor is being developed at the Johns Hopkins University, Applied Physics Laboratory (JHU/APL) for interface with an Argos compatible PTT (Seegar et al. 1996). It is anticipated that the entire digital portion of the audio capture system including the microphone could be built on a 2 cm by 2 cm circuit board weighing about 16 grams. All components used in the design are available in surface mount packages. The software for the system was all written in 6800 series assembly language. Acoustical information stored in the microprocessor will be processed to determine the specific nature of the animal vocalization. The information will be processed and evaluated by means of pattern recognition. This information along with the time and location will be stored for transmission.

Camera Qualified Satellite PTT

The camera packaged chip measures .66 cm square x 0.105 cm high and weighs less than 2 grams. The camera can be mounted on a circular circuit board with diameter 1.25 cm and requires a regulated 5 volt, 20 mA power supply. The

camera's exposure can be set to either automatic or manual mode. The camera's frame rate (i.e., exposure time) is variable between 0.5 and 24 frames per second. The camera's image format can be configured to one of 160 x 160, 160 x 120, 120 x 160 or 120 x 120 pixels. This allows the user to trade coarser image detail for greater image storage. Twice as many 120 x 120 pixel images can be stored in a given amount of memory as 160 x 160 pixel images. For the satellite transmitter application the camera will be operated remotely from its central control, using the camera in its digital mode. In this mode the image data can be stored indefinitely aboard the sensor package, and transmitted at a pre-arranged time (Seegar et al. in press).

Discussion

The use of PTTs for repeatedly sampling the movements of birds continentally and locally has been well demonstrated. With the integration of GPS and new sensors with the PTT, more accurate locations of free ranging birds, as well as environmental and behavioral data, can be collected on a regular basis. We have collected and evaluated geographic, demographic, and ecological information. Our capabilities are being expanded to include information pertinent to bird flight, such as weather, migration, and avian biology on a global scale. One of our goals is to provide information for maintaining and conserving biodiversity.

One of our objectives is to monitor and forecast bird migration on a continental to transcontinental scale. The system to accomplish this will incorporate emerging technologies in remote sensing, tracking via satellite, radar, and advanced data processing to support a model to provide near-real time forecast function of bird movements.

The system we are developing includes a GIS, remote sensing, GPS and Argos satellites. We are using the system for natural resource management data for U.S. military installations, research of endangered species and transcontinental tracking including monitoring of Neotropical migrants. This basic research supports multiple land use management for the conservation of biodiversity. The system is Unix-based ARC/INFO running on a SPARC station 10 Model 41. Grass 4.1 is being used on the SPARC station for image processing and Arc View is being used for desktop mapping and data exchange among collaborators.

In Idaho we used remote sensing and GIS to develop spatial databases on vegetation, landscape characteristics, and animal distribution in the Snake River Birds of Prey National Conservation Area. The system includes a ground truthed vegetation map from Landsat Thematic Mapper satellite imagery. Temporal sequences of Landsat Multi-spectral Scanner imagery are used to detect changes in land cover related to wildfire, military training, and climate change. Data from field research including conventional and satellite telemetry

are incorporated into a spatially-explicit model of habitats, prey and raptors to project outcomes of different disturbance and climate scenarios and to generate management alternatives for the Bureau of Land Management, Idaho Army National Guard and Department of the Army.

The application of bird tracking via satellites to bird strike to aircraft has been proposed (Leshem 1991). In Israel a bird strike program has been successfully developed for the Israel Air Force (IAF), which integrates the use of gliders, drones, ground observations and ground based radar. This program has contributed significantly to the reduction of bird strikes by military aircraft and was adopted by civil aviation in Israel in 1990. The program in Israel has saved the IAF 300 million dollars in damage as well as the lives of pilots during the past ten years. Geographic information on satellite monitored sentinel birds moving in migratory flocks that pose a threat to aircraft can be integrated with the other elements of Israel's system and enhance the forecast and monitoring of birds there.

Aircraft movements are projected to go up substantially in the near future (Garber 1995) and bird populations that increase the risk of bird strikes (e.g. non-migratory Canada geese, seasonal gull flocks near airports) are increasing in North America (Rusch et al. 1995, Hestbeck 1995). Information from world-wide sources show a marked increase in strike rates during the migratory months in spring and fall when the numbers of birds in proximity to airports increase dramatically (Dolbeer et al. 1995). Factors influencing the timing and routes of migration are little understood but new technologies can enhance our ability to follow migrating birds and track their locations relative to airports and aircraft flight paths. Much effort has been expended to understand bird strike on a local level. Studies include: local bird movements; nesting and feeding habits; crop management practices that attract or deter wildlife species; relocation of landfills that attract gulls to the proximity of aircraft; and, different techniques for scaring birds from runways. The implementation of airport wildlife management plans and the development of active bird strike teams have had a positive effect on bird strike rates but important research is yet to be done (Garber, 1995).

Reduction of the probability of bird strike to aircraft in the U.S. is a cost effective approach to human safety and the financial problem. Regulations stipulate the development of aircraft and aircraft engines capable of withstanding the impact of birds that weigh .7 kg.. This is expensive and adds additional weight to aircraft. These new modifications will be incorporated in future generations of aircraft but not in older equipment currently in use. Over the past decade Israel developed a program designed to reduce the probability of bird strikes that resulted in reduced damage and loss of life. This was done through the organized education and training of personnel within the aircraft community. The system also provided information on the presence of migratory birds within aircraft operating areas. The addition of a space based system to track avian species of concern to the aircraft industry using Geographic

Information Systems and ground based radar as well as other bird tracking techniques can provide critical information to assist in reducing the probability of bird strikes with aircraft.

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Figure 1

Wintering and Breeding Areas
And
Migration Tracks Of

Two Adults and One Sub-Adult Golden Eagles
Radio Marked At The Orchard Training Area, Idaho

Adults
Sub-Adults - - - - -

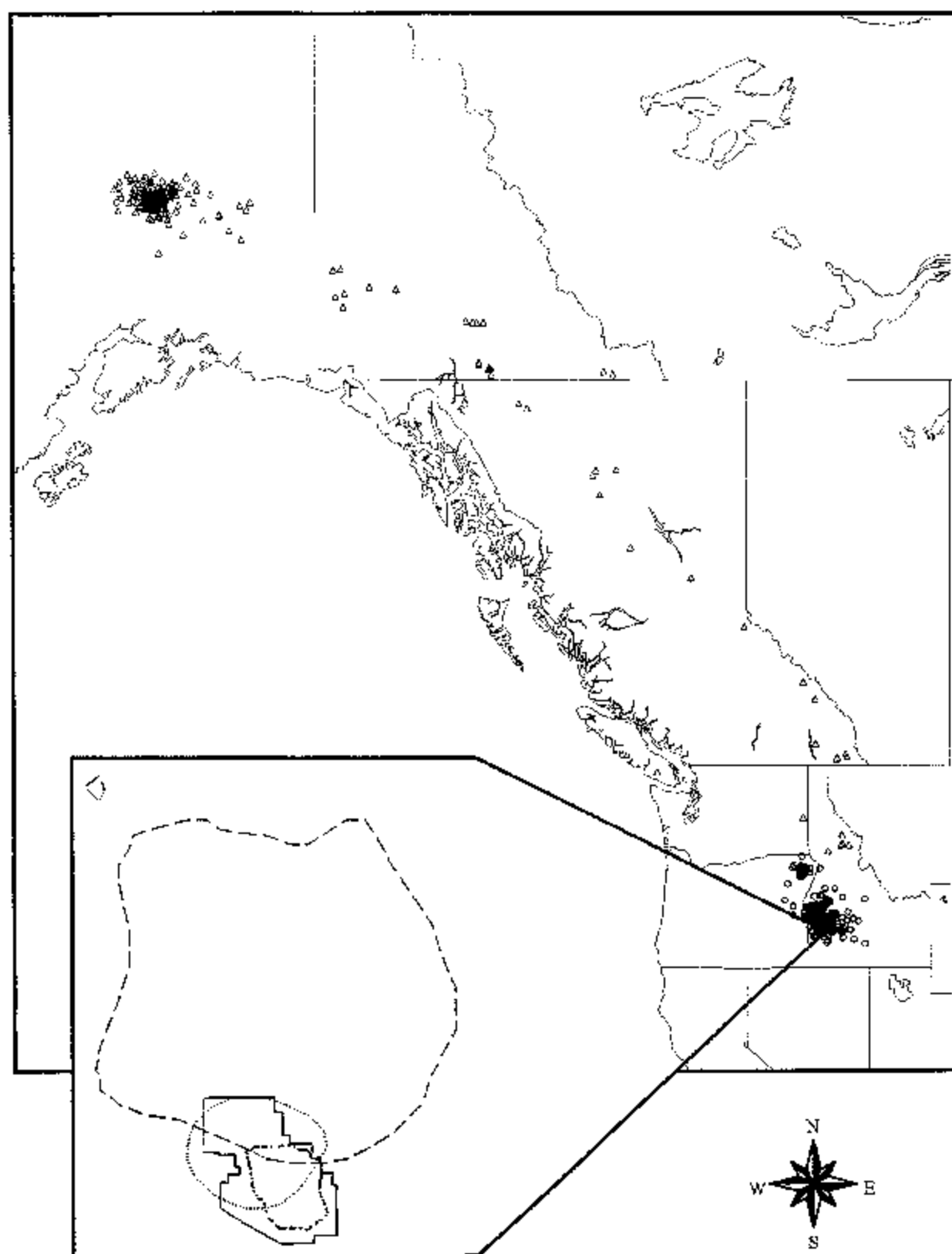


Figure 2

Breeding, Wintering, and Migration Tracks
of
Three Peregrine Falcons

5709	▲
5795	☆
5707	■

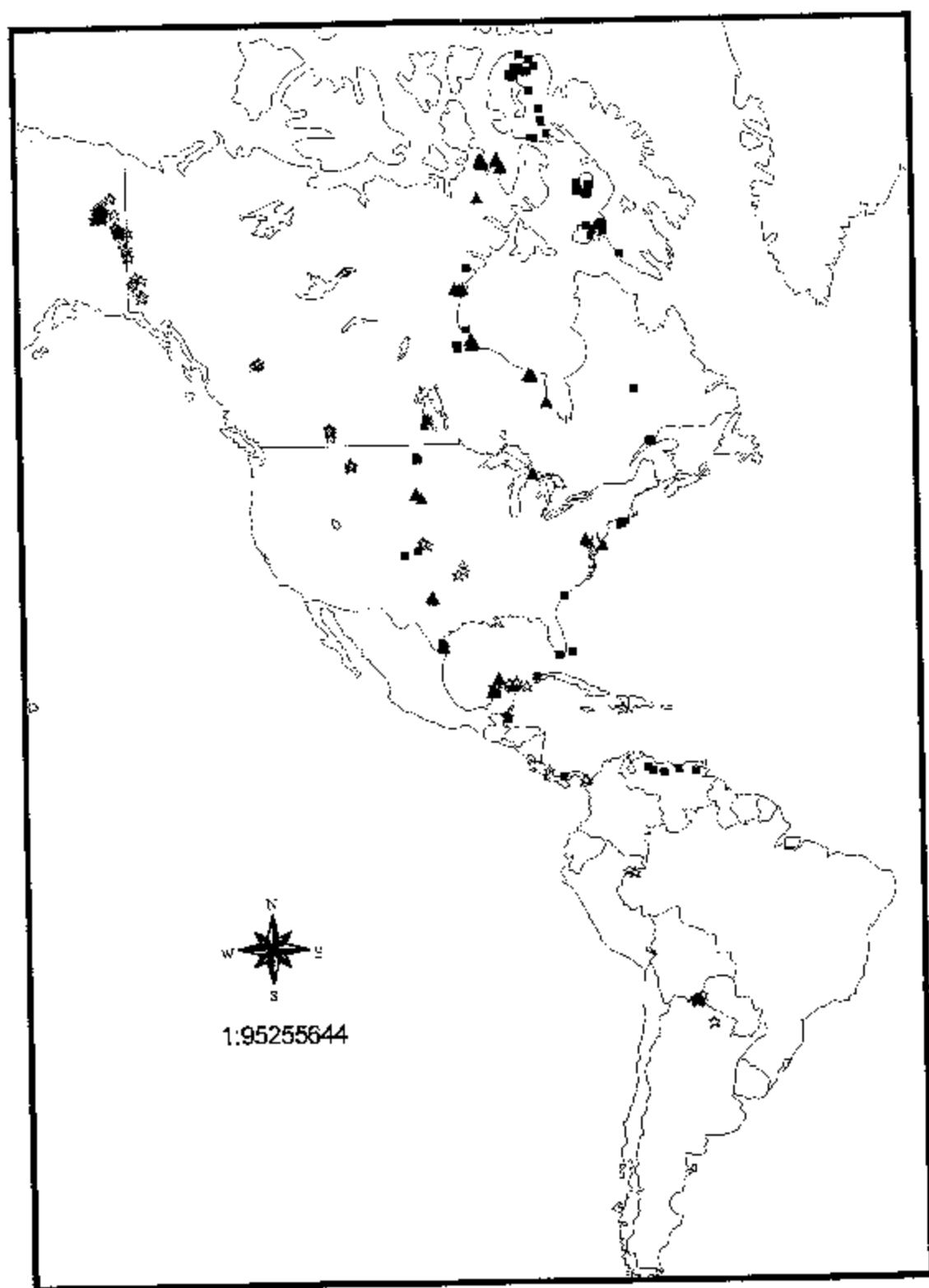
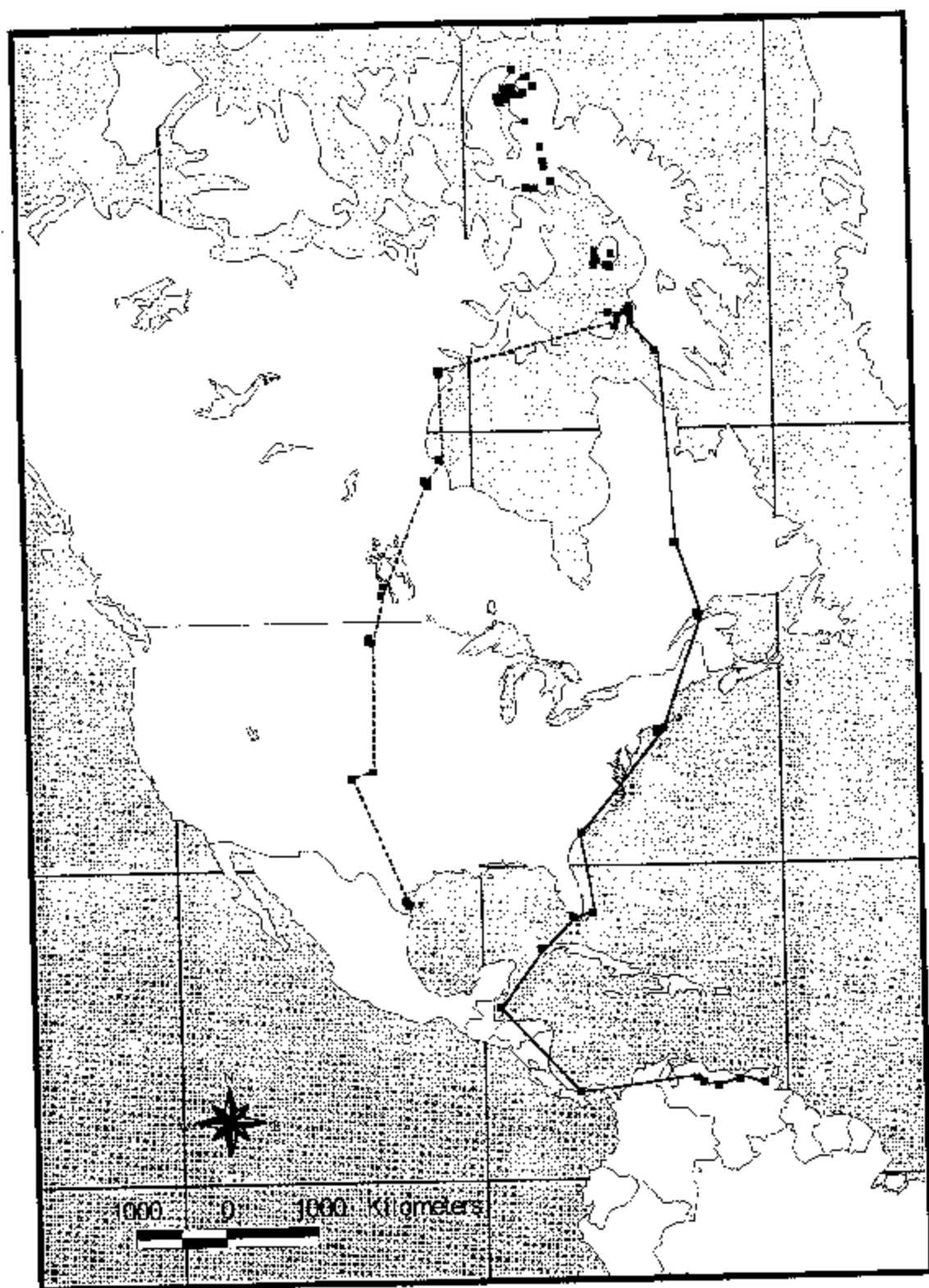


Figure 3

The Wintering, Summering, and Migration Track
of a Non-Breeding Peregrine Falcon
5707

Spring Migration North - - - - -
Autumn Migration South - - - - -



APPENDIX 11

A Gull and Starling Control Program at the Colonie Landfill, Cohoes, New York

A GULL AND STARLING CONTROL PROGRAM AT THE COLONIE LANDFILL, COHOES, NEW YORK

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ABSTRACT: A program to control three species of gulls and starlings was conducted on a five acre working face at a 160 acre landfill adjacent to the Mohawk River and approximately five miles from the Albany County Airport, New York. The program was requested by the landfill operator in order to meet standards of the New York State Department of Environmental Conservation for permit compliance. A bird management plan was developed that included nine (9) proposed bird control techniques. Three (3) of those were actually implemented and two (2) were found to be useful. Bird numbers were reduced from the original population of 5,400 gulls and 6,000 starlings to 400 gulls and 300 starlings. Gulls were found to be more difficult to control in the current study than in other studies reported in the literature. The reason will be discussed. A certain amount of innovation was required to achieve success and some of the tricks of the trade will be discussed.

APPENDIX 12

US Department of Agriculture Factsheet - ADC Assistance at Airports

FACTSHEET

Animal Damage Control

United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

March 1995

ADC Assistance at Airports

Protecting agriculture, property, natural resources, and health and human safety from wildlife damage is the mission of the U.S. Department of Agriculture's Animal Damage Control (ADC) program. ADC also addresses wildlife threats to public health and safety. Birds and other wildlife can pose significant threats to both human safety and property when they occur near airports. Through a balanced effort involving research and wildlife management, ADC biologists are reducing the incidence of wildlife-caused damage to U.S. aviation.

Wildlife Problems at Airports

The wings of planes and the wings of nature often compete for the same airspace at the same time. When that happens, collisions may occur, sometimes resulting in injuries or death to passengers and crew and damage to aircraft. To help prevent these potentially dangerous interactions, ADC biologists provide airport officials across the Nation with advice and recommendations on how to keep runways and flightpaths clear of wildlife. Problem species include deer, moose, antelope, coyotes, dogs, gulls, blackbirds, pigeons, waterfowl, ducks, hawks, starlings, vultures, and others.

Airports in the Eastern and Southeastern United States experience the greatest number of wildlife-aircraft collisions, but the problem exists nationwide. The Federal Aviation Administration (FAA) estimates that birds and animals threaten human safety and cause \$35 million in damage each year to aircraft in this country. Indirect costs, such as flight delays, aircraft changes, and loss of revenues, add an additional \$5 million annually.

In 1992, 70 bird-aircraft strikes at Chicago's O'Hare International Airport, the world's busiest, resulted in \$8 million in damage to aircraft, while 101 bird-aircraft strikes at John F. Kennedy International Airport (JFKIA) in New York caused millions of dollars worth of damage. Since 1979, bird-aircraft collisions at JFKIA have resulted in 42 aborted takeoffs and 37 damaged or destroyed engines.

The History of Wildlife Strikes

The first reported wildlife-aircraft strike occurred on April 12, 1912, when a Model EX Wright Pusher collided with a gull and crashed into the ocean, killing the pilot. FAA reports that more than 100 people have died and 40 planes

have been destroyed in wildlife-related aviation accidents since the early 1900's.

- In 1960, a plane taking off from Boston's Logan Airport struck a large flock of starlings and guilts and went down, resulting in 62 human deaths.
- In 1973, a jet crashed shortly after takeoff from the DeKalb-Peachtree Airport in Georgia after colliding with birds, killing seven persons onboard and injuring one person on the ground.
- In 1975, a plane sucked herring gulls into its engine at JFKIA. The engine exploded and separated from the aircraft, the takeoff was aborted, and the plane caught fire and was destroyed. Fortunately, no fatalities occurred, largely because all 139 passengers were airline employees trained in evacuation procedures.
- In 1987, a jet hit a deer at O'Hare International Airport, resulting in an aborted takeoff and \$100,000 in damage to the aircraft.



White-tailed deer

- In 1988, an aircraft sucked birds into its engine upon takeoff in Denver, CO, resulting in two deaths, one injury, and extensive damage to the airport. That same year, a jet hit a red fox on the runway at Standiford Field in Louisville, KY, and a jet fighter struck a mallard duck on takeoff at Cannon International Airport in Reno, NV. Damage to the aircraft was estimated at more than \$5,000.
- In 1991, a plane carrying 350 passengers aborted takeoff at JFKIA after gulls were drawn into 1 of its engines. Although no one was seriously injured, the aircraft lost its brakes and 10 tires in the accident.
- In 1992, a twin-engine, turbo-prop commercial aircraft struck a white-tailed deer while landing at Laredo International Airport in Texas, resulting in extensive damage to the propeller and fuselage.
- In 1993, just 1 herring gull in the left engine of a plane carrying 158 passengers out of O'Hare shut the engine down, necessitating an emergency landing. Damage to the plane was estimated at \$1.5 million.
- On two separate occasions in 1994, a commercial aircraft struck a coyote during takeoff at O'Hare.

How ADC Helps

When airports experience wildlife conflicts, FAA encourages airport officials to contact ADC. Programs to control wildlife hazards at airports are often complex and require much coordination. ADC wildlife biologists offer technical and direct operational assistance to airport managers and are available to conduct onsite evaluations of wildlife problems at the airport. All ADC programs are conducted pursuant to Federal and State laws, regulations, and policies.

ADC biologists recommend the use of noise-making devices, such as cracker shells, propane cannons, and bird distress tapes. In addition, ADC provides guidance on how to modify habitat to make the airport unattractive to wildlife. These recommendations include reducing water and garbage sources at the airport; installing wildlife-resistant fences; modifying or removing overgrown vegetation, trees, and roosting sites; and trapping and relocating wildlife. If these techniques fail, the Department of the Interior's U.S. Fish and Wildlife Service or the State's wildlife



Ring-billed gull

department may issue a permit to remove a limited number of the problem species from the airport.

ADC's Denver Wildlife Research Center conducts research on new harassment methods, wildlife behavior, habitat management, and how landfills near airports affect bird-aircraft strikes. This research will help ADC develop new ways to minimize wildlife hazards at airports. Additionally, ADC wildlife biologists are active in a number of professional groups, such as The Wildlife Society and Birdstrike Committee USA. The latter organization facilitates the exchange of information, supports research and develops new technologies, provides training, and acts as a liaison to Canadian and European counterparts. ADC biologists are also members of special task forces at airports, including JFKIA and O'Hare, that are monitoring hazards to the airports and developing control strategies to protect human safety and to conserve wildlife resources.

Additional Information

You may obtain more information about the wildlife services of ADC from any State APHIS, ADC office. For the address and telephone number in your area, call the ADC Operational Support staff at (301) 734-6281.

APPENDIX 13

Canada Geese Present Hazard to Aircraft as Reflected in the Growing Number of Bird Strikes

**Canada Geese (Branta canadensis) Present Hazard to Aircraft
as Reflected in the Growing Number of Bird Strikes**

**Steven D. Garber, Ph.D.
Wildlife Biologist**

**The Port Authority of New York and New Jersey
New York, New York**

December 22, 1995

During 1995 Canada geese have been responsible for the deaths of 24 people and for over \$200 million dollars worth of damage to aircraft in North America. At Port Authority airports (JFK and LaGuardia) alone we had three major incidents: one at JFK when the Air France Concorde struck geese on June 3, 1995 resulting in \$6 million dollars worth of damage, on September 18, 1995 at LaGuardia Airport a Northwest Airlines Airbus A320 struck 12 Canada geese; no one was hurt but it cost the airlines \$2.5 million. On December 10, 1995 a Polar Air Cargo Boeing 747 struck a flock of geese, which also caused millions of dollars worth of damage.

There have been 40 Canada goose bird strikes at JFK during the 17 years from 1979 through 1995. This is an average of 2.36 per year. Although this represents only about 1 percent of all the bird strikes at JFK, it accounts for over 2 percent of the total aircraft damaged or delayed due to bird strikes. During the first five years of record keeping at JFK (1979 through 1983) four Canada geese were struck, which is an average of .8 geese per year. During the next 11 years, from 1984 through 1995 36 geese were struck, which is an average of 3.28 per year. That is an increase of over 400 percent. We investigated other airports to find if any others have reported increased bird strike activity due to Canada geese, and although other airports rarely have the data set that JFK has, there has been a dramatic number of recent goose strikes at other North American airports.

Until recently, Canada geese did not pose a significant threat to aircraft, in fact, their numbers had decreased significantly throughout the first half of the century, so that by 1950 their numbers and range were significantly reduced from what they had been 100 years earlier. However, the Canada goose situation changed markedly in the last few decades. Over the past several years wildlife managers across North America have reported a rapid increase in numbers of Canada geese that now breed where none previously bred.

Canada geese previously flew through New York's airways during spring and fall, but never spent the summer here. Canada geese have many recognized races or subspecies, each is usually identified by biogeographic variation, that is, where they breed, and there are recognized phenotypes, usually differing according to size; some range in size from three or four pounds, while others weigh about nine pounds. Each of the subspecies nests in the northwestern United States and Canada, and winters in the United States. They occur in greatest numbers along the coasts. Migratory geese continue to breed to the north, however many geese remain further south all year round.

Canada geese have adapted to the changing environment created by humans. The geese are attracted to short grass habitats near water. Such areas were very uncommon throughout most of the United States before the forests were cut and urban and suburban habitats became a patchwork of managed lawns, grassy street sides, and the occasional thousand acre golf course. We created perfect goose habitats. These areas were kept

clear of potential goose predators, and humans liked to feed the geese with the ducks. In addition, many geese were kept as exotic pets at duck ponds across the country. The Canada geese could not fly away because their wings were flipped, so they stayed around our homes and bred. The young escaped and continued to breed locally, and these local populations increased in size. As the number of Canada geese continues to increase, so does the number of goose strikes; during recent months planes have been hitting geese in record numbers.

Strike Record at JFK

The Canada goose is a dangerous bird in several respects: 1) it is one of the heaviest and densest birds regularly flying through JFK airspace, 2) Canada goose bird strikes often involve flocks, making this species an even more significant risk to aircraft at JFK, and 3) this species is rapidly increasing in numbers in our area. During the period from 1979 through 1993, 31 Canada geese hit aircraft at JFK (Garber 1995h). This was less than 1 percent of the total number of bird strikes at JFK. Of these Canada goose strikes, no one was hurt, and two aircraft were either damaged or delayed, which was 2 percent of the total aircraft that were either damaged or delayed at JFK during that period. The trend in Canada goose related aircraft collisions has remained constant over this period, averaging 1.2 geese struck at JFK per year, with a range from 0 to 3.

Even before Canada geese were rapidly increasing in number, they were recognized as a hazard to aircraft at JFK; this was largely due to when an aircraft struck a Canada goose at JFK on December 14, 1965; the plane was left with an 8 inch (20.3 centimeter) diameter hole that was 10 inches (25.4 centimeters) deep in a horizontal stabilizer and there was also a 6 inch (15.2 centimeter) long indentation on the leading wing edge. At JFK, since 1979, three aircraft have been damaged or delayed due to Canada goose strikes. The total strike record for Canada geese at JFK since 1979 includes one goose struck on Runway 4R on May 1, 1979, two geese were struck Runway 13R on November 8, 1979, three on Runway 31L on May 14, 1984, two on Runway 4L on September 27, 1984, six on Runway 4L on May 9, 1985, two on Runway 13R on March 23, 1986, one on Runway 4R on October 10, 1988, three on Runway 4R on March 5, 1989, one on Runway 4R on July 28, 1989, one on Runway 4R on March 29, 1990, one on Runway 13R on May 28, 1991, four geese were struck on Runway 4L on November 9, 1991, two were struck on September 6, 1992, one on Runway 4R on November 13, 1993, one on Runway 22L on April 9, 1994, one on Runway 31R on November 10, 1994, two on Runway 22L on March 21, 1995, and the Air France Concorde incident on Runway 22L on June 3, 1995 when five geese were struck. December 10, 1995 a Polar Air Cargo Boeing 747 12 to 15 miles from JFK, on its approach, while over water at 7,500 feet, struck a flock of Canada geese. Kent Scott, Polar Air's Vice President of Flight Operations spoke to the pilot of the aircraft who identified the birds as Canada geese. The pilot said the main landing lights were turned on at 10,000 feet, "which usually has an effect on bird activity, they'll wheel away if they can." As soon as the aircraft came out of the clouds the pilot saw a flash of white, which he thought was lightning, and then

the instant before impact he saw a flock of Canada geese. When they hit the birds the airplane shuddered violently, the pilot and copilot thought they had lost the plane. You know something is terribly wrong when a 750,000 pound aircraft (when fully loaded) starts shaking violently. Kent Scott said this was the most violent incident he's heard about from any pilot during all his years as a pilot. The birds caused extensive structural damage to the aircraft. Two engines were replaced and there was major damage to the body of the plane.

Recent Strike Record at Other Airports

The growth in the Canada goose populations across the United States is reflected in the number of goose-related incidents. In June 1993 a Boeing 737 was taking off from Calgary Airport in Alberta, Canada when it struck 80 ring-billed gulls that were at the end of the runway. The plane was too close to the end of the runway so it could not abort; instead it gained enough altitude to loop around and immediately land again. Two engines were damaged; luckily no one was hurt. In the autumn of 1993 12 Canada geese were involved in a strike with a KLM Boeing 747 that was landing at the Calgary Airport in Alberta, Canada. One engine was knocked out and there was considerable damage to the fuselage. The total damage amounted to \$4-5 million. During the winter of 1994-1995 a two Canada geese were involved in a strike with a Boeing 747 which was taking off from Fort Meyers, Florida. The geese went through the plane's nose cone and the aircraft had to land in Orlando, Florida.

The Canada goose strike at JFK on June 3, 1995 occurred when an Air France Concorde was just about to land on Runway 22L and several geese hit the fuselage, and geese were sucked through two engines both of which caught fire and had to be shut off. Luckily no one was hurt, however an estimated \$6 million dollars worth of damage occurred. August 22, 1995 a Continental Airlines Boeing 757 hit a flock of Canada geese just before touching down at Seattle-Tacoma International Airport. The 9 geese that were killed damaged the aircraft's nose cone, which contains the aircraft's radar. The plane landed safely and no passengers or crew were hurt.

Airport Operations at Washington Dulles International Airport in Herndon, Virginia reported a Canada goose strike on November 6, 1992. The strike occurred during the day, the aircraft was a BA-3200 (Dewey 1995). On November 3, 1994 there was what the airport identified as a possible Canada goose strike that occurred at night to an E120; the airline reported damage to the aircraft. May 12, 1995 a dead Canada goose was found on the runway at, but the strike was never reported by a pilot. Then on September 14, 1995 a Boeing 757 landing at Dulles International Airport struck 10 Canada geese at 7:30PM. The multiple strike damaged both engines, both wings, and the radome; no one was hurt.

There was a Canada goose strike at LaGuardia Airport on September 18, 1995. A Northwest Airlines Airbus A320 was landing on a clear evening when Canada geese

were seen and struck. Twelve geese were seen and struck; no one was hurt. Geese struck the radome, windshield, nose engine #2, fuselage, landing gear, and the tail. Only damage was incurred to the engine, which was shut down. The dollar estimate of the damage was been placed at \$2 million, and the estimated cost due to loss of revenue from the 48 hours during which the aircraft was out of service was \$500,000.

On September 22, 1995 a Boeing 707 United States Air Force E-3B Advanced Warning and Control System, or AWACS, jet struck Canada geese when taking off at Elmendorf Air Force Base, just north of Anchorage, Alaska. Carla Dove of the Smithsonian Institution's Division of Birds examined the feather samples (personal communication) from two engines and made the positive identification. The \$180 million four-engine aircraft lost power in two engines, which was sufficient to cause it to crash two miles from the end of the runway. All 24 people aboard were killed (22 Americans, 2 Canadians). The way \$180 million was calculated is the Boeing 707 was worth approximately \$30 million, the equipment on board and AWACS is valued at \$150 million, and although normally the 24 people's lives would be valued at \$2.5 million each, because this was the United States Air Force, no one can sue, so the additional \$60 million is not part of the calculation.

Another goose-related bird strike occurred September 25, 1995 when the jet House Speaker Newt Gingrich, the Republican from Georgia, and his wife, were flying in was taking off from a small resort island in Michigan. No one was hurt when the small jet ran off the runway on Mackinac Island, Michigan after striking four Canada geese. Their Cessna Citation aircraft hit a flock of geese that was on the runway which scattered as the plane approached. The aircraft had just begun its ascent when it hit the birds. The pilots were very shaken when at least two geese were sucked into the right engine, while two others hit the leading edge of the left wing. The collision caved in a 14 inch portion of the wing. No one was hurt when the plane aborted its take-off, skidding to a stop 30 feet off the end of the runway. Obviously, the plane should never have been cleared for take-off with geese on the runway. On October 2, 1995 a probable goose strike at LaGuardia Airport involved a U.S. Air Shuttle 727/225. It was a clear evening when the plane was taking off when one bird struck engine #2, which was damaged. The engine instantly flamed out; there was internal damage that resulted in the engine having to be rebuilt. The Estimated cost of repairs was \$150,000 and an additional \$20,000 was the other cost due to lost revenues.

Growing Risk

While certain gull species are far more numerous and account for a greater percent of the total number of bird strikes at JFK, Canada geese account for an important risk that is growing across the continent. And in light of the fact that a large percent of goose-related strikes result in significant damage to aircraft, this species' behavior needs to be monitored and managed to the best of our ability. At JFK, the possibility of a goose-related strike exists throughout the year.

During the summer months most Canada geese in the Jamaica Bay area are located near the ponds at Jamaica Bay Wildlife Refuge (Burger et al. 1983; Garber 1995 unpublished data), although some can be found in the vicinity of JFK. The habits of Canada geese continue to change rapidly, and we are on the constant lookout at JFK to be sure we keep the birds away from the runways. A particularly serious problem that increases in severity each year concerns the birds changing breeding behavior. With Canada geese breeding throughout a vast range south of where they were previously found, this species continues to increase in number throughout the area, raising issues that were never confronted before. They have become pests at the reservoirs Upstate, on golf courses throughout the region, but only at airports are the goose-related problems really life-threatening. JFK has suitable breeding locations that could sustain a large breeding population, so vigorous efforts must be sustained to continue to keep geese from becoming established on, or near our property. The Port Authority of New York and New Jersey will continue to aggressively keep geese off JFK.

Abundance

Not too long ago this abundant migrant and winter visitor along the coast was only relatively common in this area. And inland, most geese were just seen and heard during migration when flying overhead. With their changing habits over the past 30 years, Canada geese now commonly breed where they used to just spend the winter. And after breeding in areas where they used to just spend the winter, they remain through the winter. Jamaica Bay Wildlife Refuge has Canada geese present all year round.

Meanwhile, the northern breeding stocks are declining in number, perhaps due to bad weather in the north during the past several years, or in part due to the increasing competition they receive from their conspecifics when the northern breeders are on their overwintering grounds. Many people are upset with the burgeoning numbers of Canada geese; they are not appreciated by those golfers who don't like stepping in goose plop (which looks like a small dog's feces). Home owners might disapprove of geese grazing in the backyard for the same reason. But we have only ourselves to blame. Canada geese were commonly raised in captivity and many escapes never went far from the roost. Instead of migrating north, after having been penned in and bred in these southern regions, their behavior was forever altered, and now their offspring are increasing in number like rabbits.

Canada geese have bred on the airport, and we are doing everything within our power to control this behavior. When we reported the first Canada goose nest on JFK to the United States Fish and Wildlife Service, we were informed we could not destroy the nest, harass the parents, addle or oil the eggs. It was not long afterward that an Air France Concorde hit several geese when landing at JFK. No one was hurt when two engines caught fire, however, a reported \$6 million dollars worth of damage was incurred, and Port Authority has been receiving inquiries from Air France's lawyers.

Management

In the vicinity of JFK, Canada geese naturally eat cordgrass, widgeongrass, spikerush, sea-lettuce, naiad, glasswort, eelgrass, bulrush, and saltgrass (Martin et al. 1951). However, they have expanded their diet to include grazing on manmade lawns and fields, where they eat vegetation that previously were not part of their diet. Current long grass and water management aimed at reducing gull hazards is also recognized by airport personnel as a useful mechanism for controlling geese, since they graze in short grass areas. We will continue to monitor our selected grass heights and times during which we cut the grass to determine if we need to consider modifying the regimen to control any potential future goose incursions. To date, the vegetation and water management, in conjunction with our ongoing nonlethal harassment techniques, which include the use of pyrotechnics, has been successful. It needs to be added however, that because of the nest found on JFK in 1995, and the recognition that we must step up our efforts to control the potential future establishment of other geese on the airport, we interspersed nonlethal harassment techniques during the summer of 1995 with lethal techniques. When we received a federal permit to shoot 20 Canada geese, we judiciously chose the best opportunities to make the point known to the groups of geese that were resting on the airport at different intervals during the summer.

The areas at JFK where Canada geese are most likely to rest and graze have been identified and they are visited twice each day. If any geese are there they are harassed. The 20 geese that were shot this summer were shot during this harassment, which significantly affected the frequency with which these birds are found on or near the airport. But because new geese continue to find suitable habitats to rest on the airport, we continue to seek them out and harass them, significantly reducing the number of geese that fly through JFK airspace.

Future Work

Considering the risk involved from Canada geese, this is not a problem that the aviation community can afford to overlook. We need to anticipate the informational needs we will require to effectively manage this growing problem. At present, our information is limited because this problem has only appeared to be a real problem for several months at most. It is too early to know whether this is a growing problem, or if this series of goose strikes was just an odd coincidence. Because we cannot afford to take any chances, we are working with the governmental agencies that oversee protected migratory species such as the Canada goose, to see if there is anything that can be done to manage the burgeoning populations nesting in our region, and those that fly through. In the meantime, we need to learn more about the habits of this species around our airports to determine if there are measures that can be taken to reduce the number of geese flying through the airspaces of JFK, LaGuardia, and Newark Airports.

APPENDIX 14

**Smithsonian: What's good for the Goose may not be good for you.
January 1995**

By Steve Kemper

What's good for the goose may not be good for you

Honk if you've had it up to here with geese on the golf course, in your yard, all over parks and beaches. You are not the only one

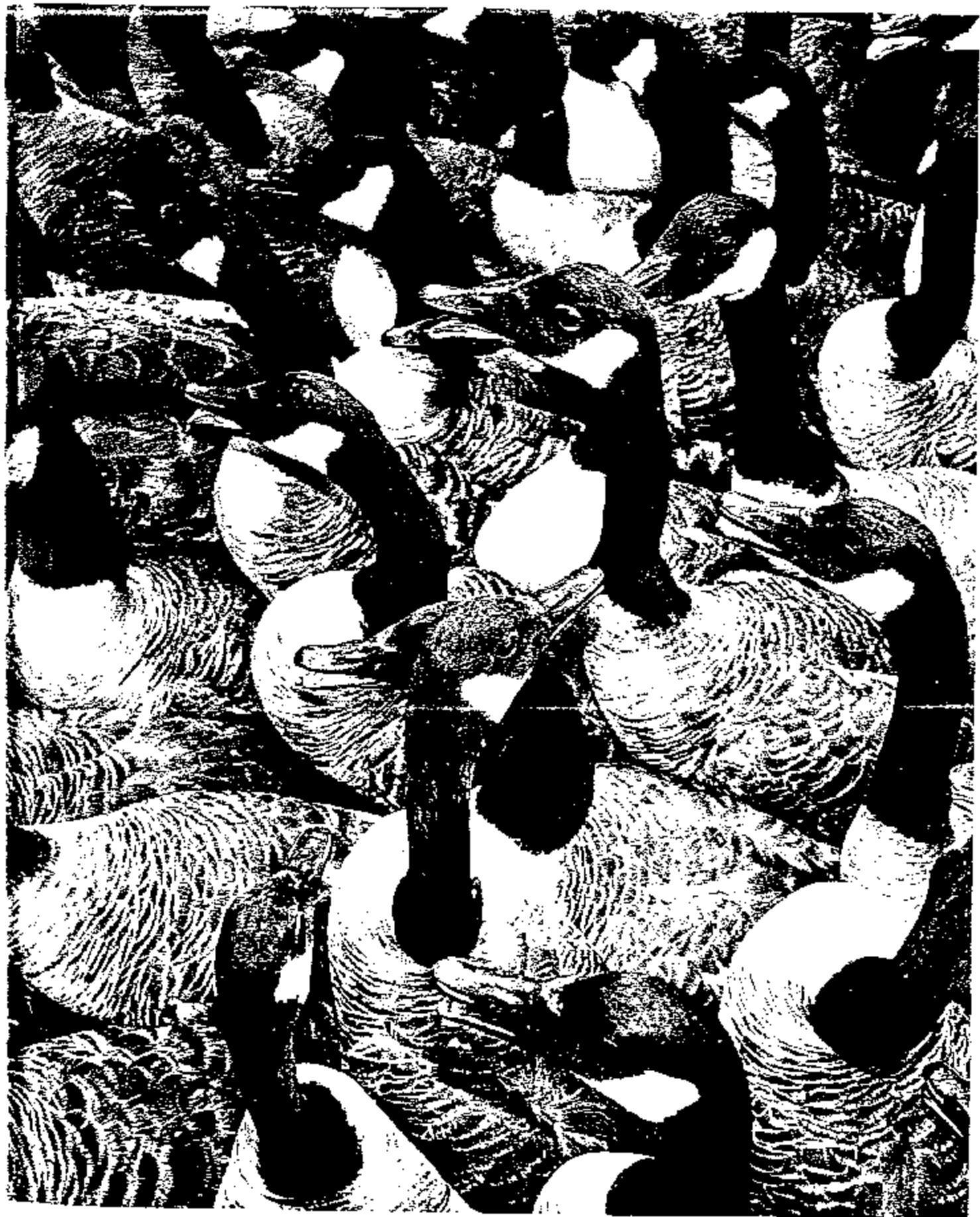
Saul and Robin Asken were thrilled when Canada geese encamped every spring on an island in their pond. "We thought, what a miracle of nature," says Robin. "We videotaped them. We didn't even mind all the noise they made because they were so beautiful." Then one morning the geese would be gone, in the gypsy way of migratory waterfowl.

But that was before some neighbors began feeding the birds. Lured by the prospect of easy living, a dozen of the geese decided to cease their wanderings and retire permanently to the pond in bucolic Weston, Connecticut. "It turned into a miserable experience," says Robin, who manages her husband's cosmetic-surgery practice and often works at home. "You had to scrape your shoes when you got to the door. It was such a hot summer, and the smell outside was so bad. And they were extremely aggressive. We felt like prisoners in our house. They chased me and my children up and down the driveway. Even the dog was frightened. He chased the geese, but then the geese chased him."

Last spring she decided to fight back. "I put my heart and soul into it. I felt like a raging maniac, because every time I saw the geese I would run outside and stream and chase them. I tried everything. There's a man in a store in Westport who laughed at me because I

Penned geese await relocation during summer roundup in Virginia. Because they're molting, the birds can't fly.





Photographs by Cameron Davidson



Out for a stroll, goose family trespasses on a putting green in Alexandria, Virginia. Short grass and plenty of

it, together with an ample water supply, makes golf courses ideal and increasingly popular goose habitat.

would come in to buy balloons to line my driveway and other things to scare the geese. He got this wind-activated penguin and called me and said I should try it. It worked for a while. Everything worked for three or four days, and then you'd look out and see them sitting right next to whatever you were using to scare them. We spent a lot of money on balloons and plastic ornaments. My yard really looked ridiculous."

The Askens have plenty of exasperated company all over the country—farmers, wildlife officers, town officials, airport administrators, golfers. They grumble about property damage, threats to human health and safety, and just plain aggravation. The number of "nuisance goose" complaints jumps every year. And yet most people, starved for contact with wildlife and sentimental about it, are delighted to see these handsome birds thrive amid urbanization. They take their children to the park to feed the geese, unaware that they are contributing to the problem.

Nor all that long ago, people thought of Canada geese as symbols of wildness and long-distance flight, high-flying heralds carrying news of the seasons along the flyways. But today there is a burgeoning population of sedentary geese that, as one wildlife official puts it, "couldn't find Canada on the best day of their lives." Nor do they want to. These resident pests find landscaped suburban lawns much more pleasant than subarctic tundra. Tastier, too.

We are reaping the consequences of success. The renaissance of *Branta canadensis* is one of wildlife management's great triumphs. Due to more favorable weather conditions, changing agricultural practices and restrictions on hunting, Canada goose populations doubled between 1955 and 1974, and kept on rising. In 1948 there were 200,000 geese in the Atlantic flyway; by 1981 they numbered 955,000.

Of the 11 races of Canada geese, none has rebounded as spectacularly as *Branta canadensis maxima*. Considered extinct in the mid-1930s, this large (12 pounds, on average) creature now makes up most of the resident goose colonies around the country. Because of hunting pressure and bad weather up north, the overall number of Canada geese has been declining in the Atlantic flyway over the past ten years: it was down to 600,000 last year. The population of year-round residents, however, has exploded. Many states on the Eastern Seaboard have adopted special hunting seasons aimed specifically at these resident flocks, but no one really expects this to have much effect. The birds usually live near people, and towns are reluctant to let hunters blast away in parks or on corporate campuses.

From the goose's perspective, the reasons for sticking

Steve Kemper lives in Connecticut, where he sees plenty of geese. He wrote about the entrepreneur and inventor Dean Kamen in the November 1994 issue.

around are obvious. First, there's its temperament. Biologist Harold C. Hanson, who rediscovered the "extinct" race *B. c. maxima* in 1965, noted that the "placid disposition of the giant Canada goose sets it apart from all others."

The second reason is that we have created more and more attractive habitat. If a Canada goose were to design paradise, there would be lots of short, tender grass for grazing, a pond of fresh water for drinking and security, and no predators. It would look almost exactly like a park, golf course, waterfront estate, cemetery or manicured corporate complex (sometimes referred to by wildlife officers as "corporate goose farms").

Perhaps because their situation is relatively plush and safe, giant geese among us tend to live longer than their migratory cousins. They also have more goslings, which are far more likely to survive than those hatched amid predators on an inhospitable piece of tundra and then required to fly 1,500 miles through inclement weather and hunters' guns. Result: exponential leaps in the population of resident geese.

Wildlife biologists are just beginning to confirm the numbers. New Jersey now believes that 50,000 geese are parked in the state. (At a recent workshop on geese, held by the Wayne, New Jersey, Department of Parks and Recreation, a man suggested killing two birds with one stone by feeding resident Canada geese to the homeless.) Seattle has counted a year-round population of 5,000 on Lake Washington. Biologists were amazed to discover that the giant Canadas in the Mississippi flyway number about one million—three or four times the previous estimates, and as many as all the other races of Canada geese in the flyway combined.

When does a thing of beauty cease to be a joy and become a nuisance? When it chews your grass down to the dirt. When it besmears beaches and picnic areas, sometimes forcing them to close. When it eats your budding crop of rye and befouls your farm pond. When you can't use the swimming pool because the geese already have. When your children can't play outside without getting stained green or nipped by a hissing mother goose. Goose lovers tend to dismiss such complaints and goose-free people tend to chuckle at them. Even the birds' victims, most of them, admit the humorous side of their travails. But their laughter is fleeting. They want relief.

In the Seattle area, 96 public parks and golf courses decided recently to reclaim their land. "People were fed up," said Mike Pizler, an animal-damage control officer with the U.S. Department of Agriculture (USDA) who was stationed in the area at the time. "We just had a woman call who had chased two geese right out of her house after they'd chased her in from the porch."

Under Pizler's guidance, the group worked its way through the traditional arsenal of antigoose weapons. They tried frightening the birds with explosive shells and noisemakers. They tethered dogs on lines along the



A gander flies at photographer who approached his nest. Such behavior is defensive, but geese can inflict injury.



Carefree flock grazes on lush lawn at one of the many corporate headquarters in Hartford, Connecticut.



On a summer day, geese who should be in their northern breeding grounds waddle up a Virginia road instead.

beaches. They put up flags and low fences and helium balloons and shiny Mylar tape on poles. They even deployed small, remote-controlled boats and airplanes to chase the birds. Nothing worked for long. (Other popular and futile nostrums include dried blood, mothballs, salt, stuffed owls, stuffed foxes, plastic swans, live swans, mechanical clappers, ultra-high-frequency sounds, propane cannon, electric fences, slingshots, monofilament line and brooms.) Frustrated, the Seattle group decided to try goose relocation.

During the next two years, 3,500 geese migrated involuntarily from the area, most of them in an 18-foot trailer bound for waterfowl habitats built by the Army Corps of Engineers along the Lower Snake River in Washington and Idaho. The Corps expected to need a steady supply of relocated geese for replacements as the earlier arrivals either strayed from the reserve or were shot by hunters. But the geese just sat there, and soon the place was jammed.

Last year, with a permit from the U.S. Fish and Wildlife Service, which has jurisdiction over migratory waterfowl, Pitzler's group started to spray the eggs around Lake Washington with a mineral oil solution that suffocates the embryos. Pitzler estimates that the combination of relocation and egg spraying has cut the resident population to about 3,000. "But it won't take long for those birds to repopulate the area," he says. "If we don't have a continual waterfowl management program, it's going to get out of control again."

On the other side of the country, Mitchell Posin worries that the geese living on Martha's Vineyard are going to eat his spring clover again. He prefers to move his 150 sheep to new pasturage every two days so the clover's root system stays charged and healthy. "But the geese just blow it," he says. "They eat it right down to nothing." It annoys him that he has to use extra fuel and fertilizer, and that he has to buy concentrated sheep feed instead of relying entirely on his own forage.

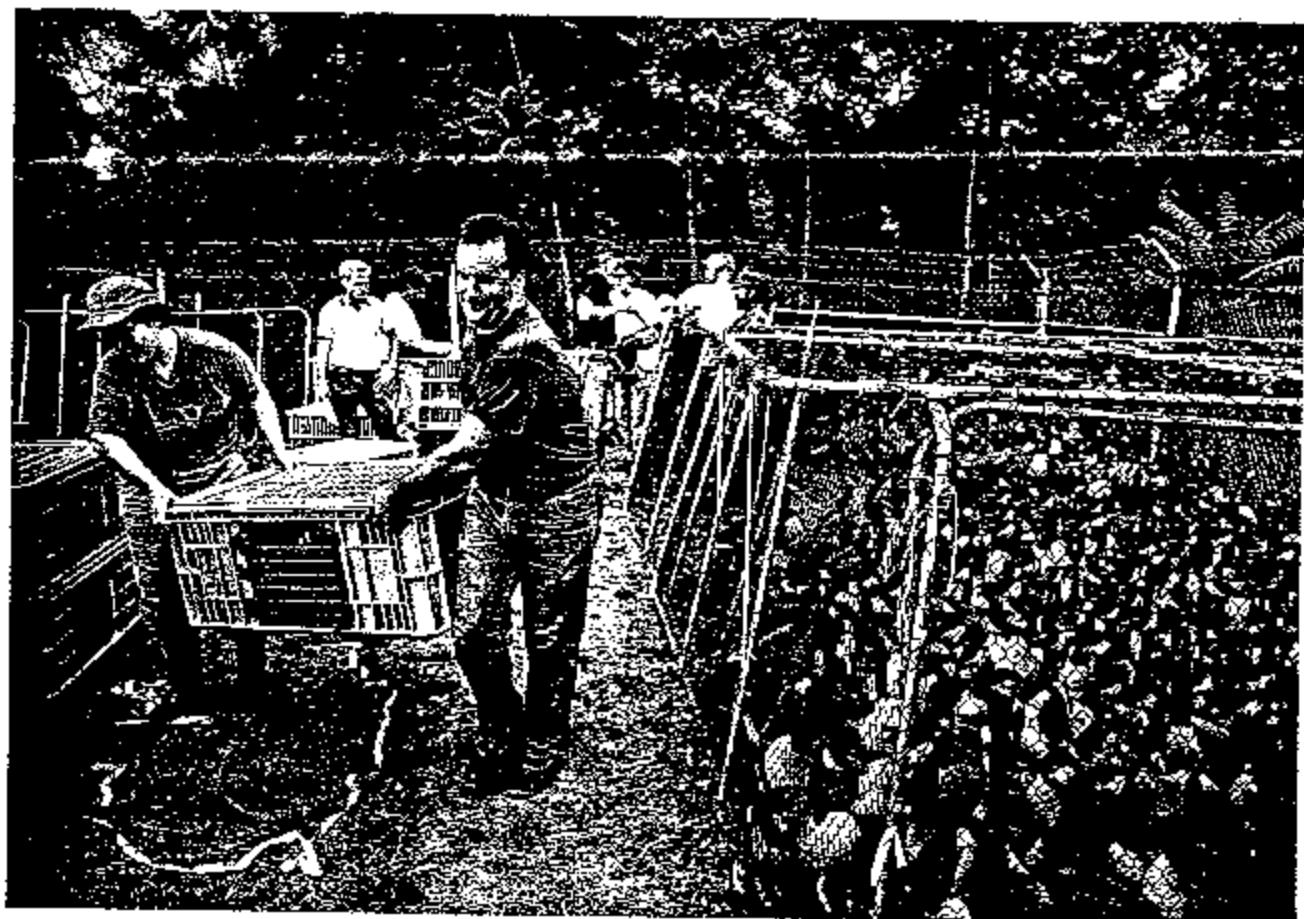
Laura E. Henze, the USDA's director for animal-damage control in Connecticut, Massachusetts and Rhode Island, asks him what kinds of deterrents he has tried. Posin ticks off many of the usual weapons, failures all. He doesn't hunt but intends to start because of the geese, and has requested a special permit to kill some of the birds out of season. "For me to farm," he says, "I have to get out there and get on 'em."

Posin hasn't yet tried to scare away the geese with pyrotechnic "shell-crackers," so he, Henze and William L. Searle, a Massachusetts environmental police sergeant, walk out into his fields with a shotgun. Posin points out places where geese have browsed clover to the nub. Several geese grazing nearby look up in mild curiosity. Posin points the shotgun and fires. A shell-cracker explodes over the birds, and they skim down to the freshwater pond at the bottom of the field. Posin shoots another round. The birds flutter their wings briefly, then settle right back. Posin fires again. The geese don't even flinch. Posin raises an eyebrow. "Believe me," he says, "you gotta kill 'em."

If Posin shoots some of the 300 or so geese that regularly dine on his clover, that flock will abandon the area, but a new batch of the Vineyard's 4,000 resident geese surely will move in. "More people are encroaching on wildlife, and vice versa," notes Henze. "Attitudes are changing, too. We're turning into a society that's more preservationist than conservationist, but basically these geese have turned into livestock. They are not wild animals anymore."

That was Howard Steinberg's argument two years ago when he persuaded the town council of Morristown, New Jersey, to petition the Interior Department—unsuccessfully, as it turned out—to remove resident Canada geese from the protection of the Migratory Bird Treaty Act so he could get rid of them. "They're not

Goose about to be banded (right) complains, but to no avail. Birds captured and banded in the Alexandria area, near Washington, D.C., are penned (below) and relocated to central Virginia.



Canada geese anymore, they're tri-state geese," says Steinberg, Morristown's health officer and director of human services. "We have a situation where a treaty ratified in 1918 protects Canada geese because they were almost hunted into extinction. But in 1994 are they becoming extinct? Or are they a nuisance?"

He worries about the threat to public health. "The geese most definitely have contaminated lakes, beaches and water supplies," Steinberg says. Groton, Connecticut, recently spent more than \$250,000 to reseed and reloom the embankments of its reservoirs after a flock of 300 geese reduced the grass to dirt, which led to erosion and pollution. Geese are hazards at airports, too, where they congregate to munch the acres of short grass. They have forced planes to land with goose-ruined engines and goose-damaged wings.

The USDA's Henze gets more complaints about Canada geese than about any other animal. The most goose-prone area on her beat is Fairfield County, in southeastern Connecticut, and the gooseiest spot in that county is the wealthy town of Greenwich. The place teems with ponds, parks, country clubs and sweeping lawns. "I've been dealing with geese for more than 15 years, and it gets worse every year," says Frank Keegan, the town's director of parks and recreation. "Each one of those buggers is just a lawn-mowing-and-fertilizing machine—in one end and out the other. We've tried everything, but there's no real solution. They're resilient, and they get used to anything. So we've concen-

trated on two areas, Byram Shore Beach and the golf course, and given the rest to the geese."

The town has conceded its biggest beach, Greenwich Point, to the birds. That infuriates Harry Catanzaro, who feels that Greenwich's hefty taxes entitle him and his family to a clean space to unroll a beach towel. Last year he and other disgusted citizens circulated a petition at the beach calling for the town to do something. "I want my kids to be able to walk barefoot on the beach again," he says. "I don't believe in shooting everything, but there has to be a balance."

Combatants in the goose wars are upset that the birds won't be reasonable. They don't know their place. They refuse to accept people as a higher authority. They don't pay taxes or country club dues but act like those who do are the intruders.

Every summer Sunday, for instance, a few miles up the coast from Greenwich, nearly 20,000 humans pile into Sherwood Island State Park and mingle with hundreds of geese. There is often a traffic jam at the park's entrance, caused by a slow parade of crossing geese or by a fender bender caused by someone slamming on the brakes to avoid the parade. Over on the volleyball and baseball fields, someone is probably slipping into an involuntary goose glissade, which occasionally ends in a sprained ankle or separated shoulder. In the picnic areas people flick tables clean, while on the beaches sunbathers look for an unsoiled patch of sand.

When the park's supervisor, Glenn A. Dochtermann, moved there five years ago, geese were in the habit of sitting, and so forth, on the front steps of his house. He has pushed them out about 40 yards and is working hard on the rest of the park—letting grass grow tall in back areas (tall grass makes geese nervous because it provides cover for predators), filling in dozens of parking-lot potholes that geese use as watering holes and squawking at them through the PA system in his truck.

Whoopie-ti-yi-yo, get along little dogies

One afternoon in early July, a crew from Connecticut's Department of Environmental Protection fans out over several acres in Sherwood Island and slowly herds about 150 grazing geese off of a baseball field, away from a dripping water pipe, between some picnic tables and toward the mouth of a wide, V-shaped chute that ends in a mesh corral. The birds can't fly away because they are molting and have lost their flight feathers.

The goose-punchers' mission is to make sure all of the adult birds are outfitted with white neck collars prominently emblazoned with large, black identification numbers. Before a goose can be properly ID'd, its sex must be determined, which involves folding its neck under its wing, flipping the bird over and prying into its tail feathers—a process accompanied by a lot of nipping and



Superintendent Glenn Dochtermann scares geese with blanks at Sherwood Island State Park in Connecticut.

After eating bread spiked with a drug, tranquilized geese congregate around a pond in western Virginia. They will be captured and taken east to state's coast.



squinting by the birds and an equal amount of yelping and swearing by the handlers. Later in the year, spotters throughout the state will record neck-collar numbers as part of a six-year study of the movements and survival rates of both resident and migrant Canada geese in the Atlantic flyway.

Golf courses make perfect goose habitat. Consequently there are more birds than birdies at many clubs, and many foul fairways. Disgusted golfers have been known to swing at geese with their mashies. Ten years ago, a golfer in Maryland was arrested for clubbing one to death. Along with the usual complaints about droppings, wildlife officers occasionally hear about nesting geese that attack golfers or won't let them near a green. Some courses have gotten permits to shoot the birds; a country club in Maryland held a goose hunt, followed by a goose feast.

Pat Lucas took over as superintendent of the Innis Arden Golf Club in Old Greenwich, Connecticut, in the late 1970s. "There were hundreds of geese here then," he says, bouncing along a fair way in a cart. "Now we don't have a problem." But as he crests a hill, he sees a flock of Canada geese grazing at the edge of a serpentine pond. "They must not know Innis Arden," says Lucas calmly.

His strategy for goosing the geese is two-pronged. First weapon: large plastic swans accompanied by small plastic cygnets. "We have three fake swan families on our pond," he explains. "If geese fly over and see the swans, nine times out of ten they go somewhere else because they know that swans with cygnets are vicious. But you can't just put out swans and live happily ever after. If the geese do land, and you don't do anything, pretty soon the bravest one will go in the water, and then more of them. Pretty soon they're swimming around the swans, and the jig is up."

Which brings Lucas to his second prong. "We've named it the hunter-ambush approach. If they land on the grass, you have to make them feel hunted. I'll have a guy with a shotgun creep up on them from the woods for 10 or 15 minutes early in the morning or late in the evening. The gander will give out a signal: 'Something's wrong!' They stop eating. All their heads point in one direction, toward the stalker. They start to flap their wings a little. That means they're primed to go. Then the guy comes out of the woods blasting blanks. They take off and won't come back because they get the message."

Sometimes, though, Lucas runs into geese that won't leave, the ones he calls "rogue geese—hard cases." To give these toughs the willies, the ambusher carries a boombox, and just before he jumps out shooting, he cranks up a tape of Canada goose distress calls. "You're speaking in their own language," he says. "It gets rid of them." Golf course superintendents from all over the country call Lucas for advice. He scoffs at the usual array of antigoose techniques. "The key is, you've got to stop thinking like a human and start thinking like a goose."

The goose-brained approach also has paid off for Dow Jones and Company Inc. Three years ago the corporation's headquarters, on 175 acres in South Brunswick, New Jersey, was overrun with hundreds of geese. Today the pond is goose-free, and the expensive brogues alighting from the corporate helicopter no longer skid in foreign matter. The reason: Bert and Bessie, the company's tireless Border collies. The dogs herd the geese into the pond and then keep circling it. The geese get frustrated because they can't waddle out and eat the grass, so they leave. Geese periodically test Bert and Bessie, which keeps the dogs alert and happy. The company is getting inquiries about them from other corporations and from golf courses.

What to do about nuisance geese?

A Canadian named Bill Lishman is trying to teach geese to migrate. For the past two autumns, he has used an ultralight aircraft to lead small flocks from Canada to Virginia. The first "class" made it back to Canada on its own. Science is on the case as well. Biologists at the USDA's Denver Wildlife Research Center are looking for ways to nauseate geese. Two compounds, tested on corporate lawns and golf courses throughout the country, show great promise. The first is methyl anthranilate, which occurs naturally in grapes and citrus fruits, and is enjoyed by humans as an additive in grape juice, grape soda and bubble gum. Geese detest it.

"We've encapsulated the material so it's not released until the geese begin feeding," says John Cummings, the wildlife biologist in charge of the project. "It's the same as scratch-and-sniff technology. As geese feed, they pop these capsules and get a mouthful, and they shake their heads and go someplace else." The other compound has the code name DRC-156. "It's a taste compound, and it also irritates the stomach, like if you were to eat a bad taco," explains Cummings. "The bird remembers that, and when he tastes it again, he avoids it." Though both compounds are food products, they must go through the laborious federal approval process for pesticides, since they will be used to fight pests.

Cummings' research center sits on 600 acres with lots of short grass. "It's kind of ironic," he says, "but we have our own goose problem here." The birds nest around planters and entryways, and—especially during breeding season—harass employees trying to get into the buildings. "We have a pair nesting in our quad right now," says Cummings. "The male will chase people and give defense postures to passing cars."

In Ohio, another USDA research biologist, Richard Dolbeer, is excited about alpha-chloralose, a compound once used as an anesthetic for humans because of its narcotic effect. Dolbeer has tested it all over the coun-

try and used it two years ago to remove 25 geese that were causing a hazard at Florida's Daytona International Airport. The compound looks like powdered sugar. Dolbeer mixes it with vegetable oil, then injects it into bread. He slips this Mickey to the geese and waits. "About half an hour later," he says, "a goose looks like somebody who's had too much to drink. It starts wobbling around, and then sits down and passes out." The stupefied geese can easily be collected and put into pens for relocation. They recover within 12 hours.

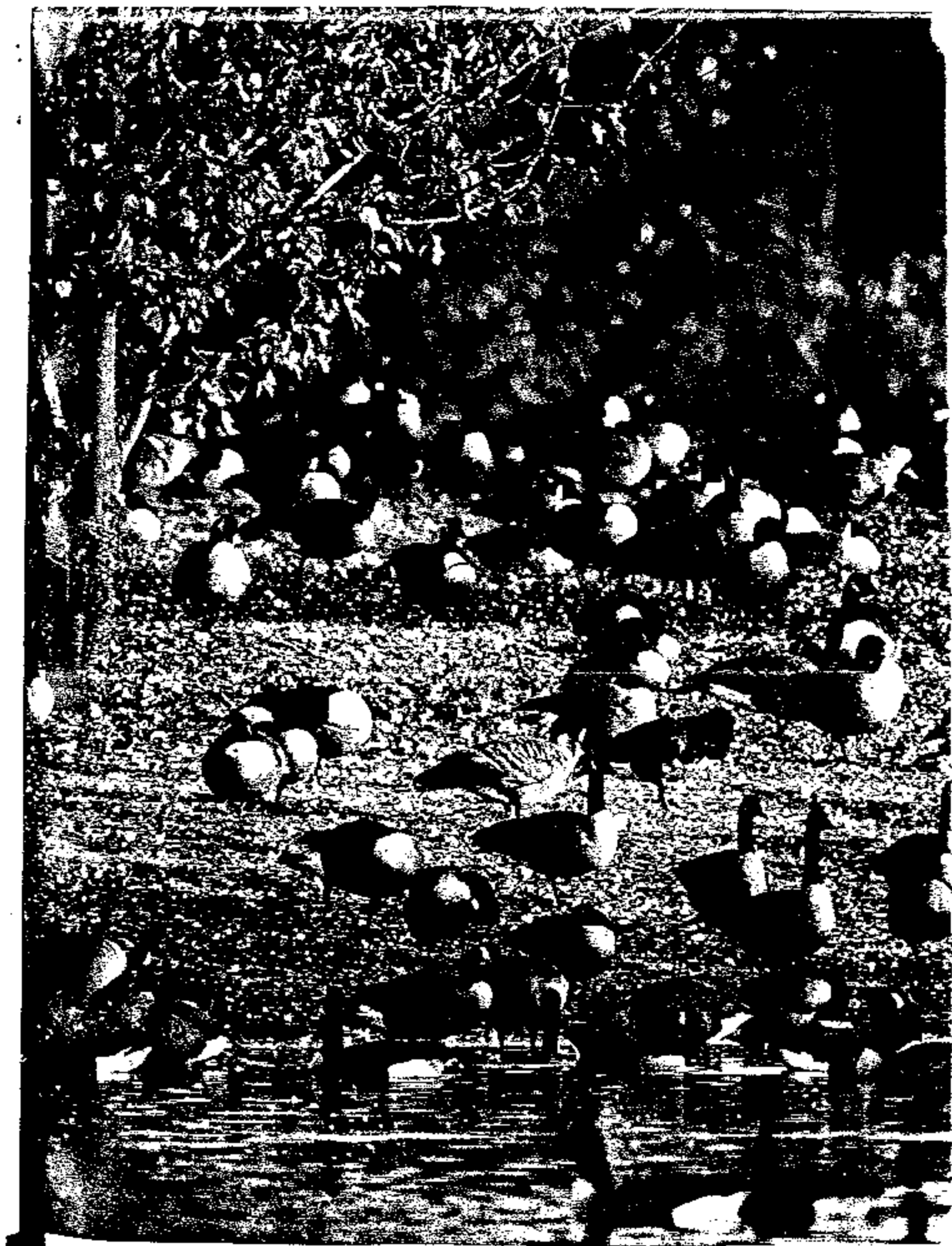
Such talk doesn't please Leslie Gerstenfield-Press, a biologist in the research and investigations department of People for the Ethical Treatment of Animals (PETA), in Rockville, Maryland. She calls trapping and relocation inhumane and traumatic for the birds, who may get separated from their families and be transported in uncomfortably crowded cages. PETA recently filed a large-scale lawsuit in Minnesota to prohibit the trapping and moving of geese. The group's opinion of hunting and euthanasia is, of course, far worse.

"We prefer habitat modification," says Gerstenfield-Press. "It's somewhat inconvenient but worth it in the long term. It's more ethical. Excuse me if I don't think it's warranted to trap and remove geese because they're hindering play on a golf course. I don't consider the play is all that important."

What does she recommend doing when geese take over public places, such as a park or beach? "When you say geese are 'taking over a park,' I would never use those words. I don't view Canada geese at a park as a problem. We took that place and changed it from a meadow and put in a park and picnic benches, so we have stolen their home, and they have a right to be there."

If Canada geese have proven themselves masters at adapting to the changes we've made in their habitat, it's less clear whether we can adapt to the changes they are making in ours. Shortly after Robin and Saul Asken moved into their house in Connecticut, they hired a biologist to relocate 15 raccoons, at \$150 per raccoon. They regularly see herds of 10 to 15 deer. And then there are the geese. "I chose to live here," says Robin Asken. "I have this beautiful area, and living here is what I want. But it comes with problems—ticks on the deer that carry Lyme disease, rabies in the raccoons, and now we have this goose problem." She pauses. "You learn to deal with these things." Recently the Askens spent \$3,000 on a 600-foot fence between their yard and the pond; now they have another fence bordering the pond. "Sometimes I wonder," Robin jokes, "if we'd feel safer living in Manhattan."

Downy carpet, close-cropped grass, show how intensively geese use one stretch of Maryland's Eastern Shore.



APPENDIX 15

Superdove on 46th Street

BY DAVID QUAMMEN

Superdove on 46th Street

Avifauna for a postmodern world

AS I STEP OUT THE DOOR OF THE HOTEL AND TURN east along the canyon of 46th Street, toward the shadowy heart of Manhattan, I see a pigeon. Needless to say, this would not usually constitute a noteworthy ornithological observation. But today isn't usual.

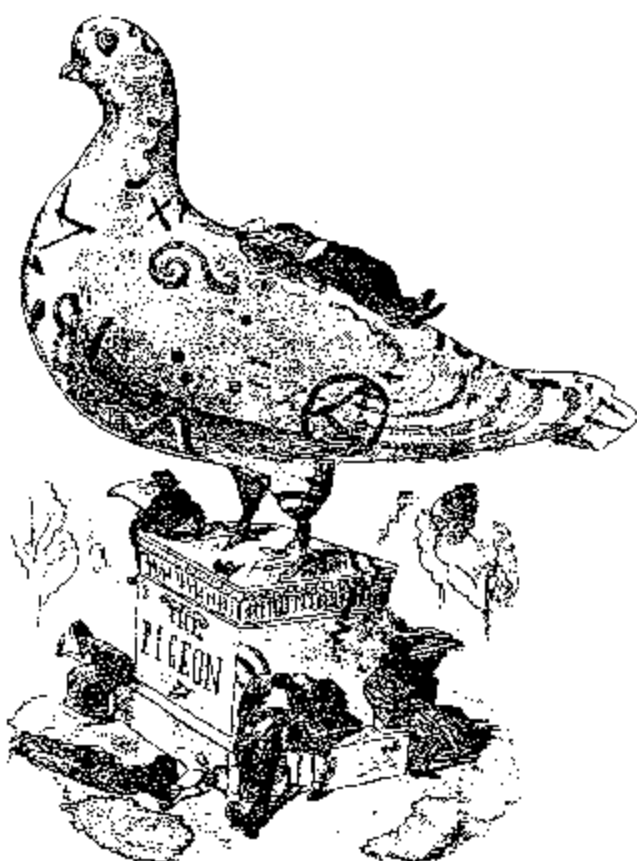
The bird is ordinary enough in appearance, and it's behaving as city pigeons do. It shuffles sideways with no sign of nervousness, letting me pass. It knows the rhythms and protocols of New York street traffic better than I do, and it's less of a stranger in a strange land. Its head ticks forward and back as it moves, counterbalancing the motion of its legs. By any unprejudiced standard it's a handsome animal, feathered plushly in Confederate gray with a pair of blue bands across each wing and a sheen of green iridescence on the nape of its neck—the archetypal pigeon color scheme. Still, I see something different in this creature from what I saw the last time I looked at a New York City pigeon. The bird itself isn't aberrant, but my perspective has changed.

"There it is," I think. "The superdove."

I feel a mild sense of awe and a tinge of eschatological concern. It doesn't look like a creature of such menacing superiority; it doesn't look like a conqueror of worlds. But lately I have cause to wonder.

THE "SUPERDOVE" BUSINESS COMES FROM A NEW BOOK I've been reading, by two biologists named Richard F. Johnston and Marián Janiga. The title is *Feral Pigeons*, that being Johnston and Janiga's careful label for the avian pests that waddle through parks and piazzas on five continents, that nest in attics and rain gutters and clock towers, that stir without rancor or partisanship on equestrian statues of the martial heroes of virtually every nation. "Superdoves" is an alternative label, offered half-whimsically by the authors because it's less precise and more freighted with comment. The word hints at a tangle of evolutionary and ecological factors, tracing backward in time more than 5,000 years and lurching forward toward a dreary postmodern future. At the core of that tangle stands one basic truth: Feral pigeons aren't like other birds.

They aren't even like other pigeons. They fly faster. They eat a more diverse diet. They breed earlier in life, more abundantly throughout it, and repeatedly during nearly all months of the year. They travel long distances, transplanting themselves into new terrain with the robust impertinence of weeds. They have invaded, in particular, the concrete environments that the human species constructs for itself. They succeed in living at high population densities in close proximity to people who despise them. They can hear high-frequency sound; they can see



ultraviolet light. They possess an extraordinary degree of genetic variability and an amazingly reliable sense of orientation. Laboratory experiments suggest that they are capable of symbolic reasoning. If those traits don't qualify them as "super," what could?

They aren't wild animals and they aren't domestics. They hover around humanity like a guilty memory, flighty but ineluctable. They are genetically designed for survival in the severe urban landscapes of the late twentieth century and beyond, and it's a fact worth noting that we ourselves helped design them. Feral pigeons reflect a potent amalgam of two evolutionary forces—artificial selection as practiced by human breeders and natural selection as effected by all other forms of circumstance—that may be unique in the history of animals.

A dour person would say that they're precisely the birds we deserve. Myself, I'm not quite that dour.

THE LONG HISTORY OF FERAL PIGEONS BEGINS WITH A single species of wild bird, *Columba livia*, commonly known as the rock dove. This was one of five closely related species of ground-frequenting and cliff-nesting pigeons native across large portions of Europe and Asia. Probably it had originated in southern Asia and gradually spread west; fossil remains show that by 300,000 years ago it had reached the eastern Mediterranean. That seems to

NATURAL ACTS

he where, between five and ten thousand years ago, the rock dove was first domesticated.

Johnston and Janiga suggest that the domestication occurred in two ways, complementary processes with a combined result. First, hunters prowling through rocky terrain must have captured squabs (unfledged nestlings) and taken them into captivity to be reared and fattened as food. That practice would have given way to rearing the captured squabs into breeders and keeping them as a steady, convenient source of meat. The second track to domestication was that some wild rock doves "found the mud and stone walls of human settlements suitable for nest sites and the wheat and barley these people grew suitable for nutrition." So the doves voluntarily took up residence in the settlements, working the market squares and the granaries for what food they could snatch. These birds were "synanthropes," in Johnston and Janiga's terminology—that is, born wild but inherently predisposed toward associating themselves with humans.

Populations of feral pigeons were presumably founded in early settlements

and cities not long after domestication began. Those ferals most likely carried mixed ancestry—some blood from escaped domestics and some from synanthropic colonizers. Seven or eight thousand years later, the phenomenon continues, with one difference: Nowadays there are few remaining source populations of wild *C. livia* providing synanthropic colonizers. The wild rock dove survives only on certain northwestern European islands (the Shetlands, the Orkneys, the Hebrides), in patches along the Mediterranean coast, in some mountainous areas of the Near East, and in scattered remnants elsewhere. Even those few populations are presently being compromised by the further geographical spread and genetic intrusion of feral pigeons. That's a whole other side to the feral pigeon story—but a significant one, and we'll come back to it.

With the wild populations so scarce and marginal, new recruits to feral populations come nowadays from just two sources: reproduction by the ferals themselves and a continuing trickle of escapees from captivity. Reproduction by the ferals yields young birds reflecting a strange, mean-streets version of

natural selection. And the escapees bring their own genetic baggage, some of which is pretty weird too.

BESIDES ITS ADAPTABILITY TO ROCKLIKE structures and its willingness to eat grain, one other trait made *C. livia* a prime candidate for domestication: its prolificness. A pair of rock doves would produce at least two or three clutches a year, maybe five or six clutches a year in ideal conditions. No wonder that by about 4,000 a.c. pigeon images were appearing in the fertility art of Mesopotamian cultures.

Later the birds came to be valued for more than just food and religious imagery. The practice of breeding them selectively into specialized lineages—for beauty, for whimsy, for show, for sport—probably dates at least to the Romans, and it was well established in the Near East by the time of the Crusades. Artificial selection practiced on pigeon stock by fussy and imaginative breeders is what stretched the genetic potential of *C. livia* in various directions. And thanks to the isolation of captive pigeon stocks one from another, that fabulous diversity was maintained over time within the countless individually managed populations.

"The Arab civilization was the first culture we have record of that kept recognizable breeds of pigeon," according to Stephen Bodio, a writer and naturalist whose own lifelong affection for domestic pigeons and their history is recorded in a wonderful book titled *Aloft*. By 1327, Bodio writes, the city of Modena in Italy had codified guidelines about competitive pigeon-flying. Another place where the mania for pigeons took hold was England. In 1676, an ornithological compendium by Francis Willughby described 17 domestic breeds of pigeon, notable among which were the tumbler, the carrier, the narrow-tailed shaker, the Barbary, and the Jacobin. The tumbler was a breed that actually turned somersaults in the air as it flew. The Jacobin of Willughby's era, if it resembled the Jacobins of today, was a bizarre thing whose entire head was buried inside a mane of overgrown feathers, so that it could hardly see well enough to feed itself. Francis Willughby's book signals the fact that already by three centuries ago, the breeding of fancy pigeons had been taken a very long way.

During the late 1850s, Charles Darwin used the selective breeding practiced by

pigeon fanciers as an important paradigm for his notion of natural selection and included a section on domestic pigeons in the first chapter of *The Origin of Species*. By that time he had joined two of the London pigeon clubs and done a fair bit of pigeon breeding himself. "The diversity of breeds is something astonishing," Darwin wrote.

Bodio, in *Aloft*, also remarks on that astonishing diversity. "Only three domestic animals show a comparable range of physical types to the pigeon: the dog, the chicken, and (maybe) the goldfish." In addition to its variability, the pigeon embodies other characteristics that make it appealing to avocational breeders—its early maturity, its fast-hatching eggs, its year-round reproductive activity—because they help shrink the time in which a breeder can see results. Besides these, Bodio cites one further attraction: "Pigeons can do various things, unlike a goldfish or (unless you are a cockfighter) a chicken." One of the things they can do is fly home fast.

Racing homers, originating around 1800, were quite different from the Jacobins and fantails and frillbacks and pouters and all other fancy breeds. Rac-

ing homers were bred for performance, not for show. Their inherited compulsion and talent was to fly fast and return home reliably, each to its own familiar loft. One formidable strain of racing homers came out of Belgium, a second strain out of England. In the early nineteenth century, before telegraph and telephone, homers brought stock-exchange information to Antwerp from brokers in Brussels, Paris, and London. In the later wars of the century and on through World War I and even World War II, they carried tactical messages. And among passionate racing enthusiasts like Stephen Bodio's father, on the outskirts of Boston in the 1950s, they were bred strong, sleek, and fast enough to make 600-mile homing sprints in a day.

Occasionally, though, a homer failed to return home. Maybe it had been killed by a bullet or a hawk; maybe it had lost its way; maybe it had simply gotten distracted or seduced into another path of life and ended up on the streets of a nearby city, like a runaway teenager, scuffling out its sustenance among a flock of tough and enterprising companions. To the pigeon breeder, that sort of errancy was the unavoidable cost of doing business. To the

NATURAL ACTS

pigeon, it was a challenging reentry into the realities of natural selection.

SO PIGEONS HAVE GOTTEN AROUND, AND not just by wing power. The appeal that they carry among fanciers has been their ticket to worldwide distribution. They're in Australia, they're in Hawaii, they're in the Arctic, they're in Tierra del Fuego. They have even arrived in Montana.

On a brisk afternoon with snow on the ground, 2,000 miles west of the west end of 46th Street, I help Steve Bodio carry water out to the pigeons in his loft. It's a modest plywood shed divided into three rooms, each room furnished with nest alcoves and perches. At full capacity, as it is now, it holds 40-some pigeons. Although his pigeon-fancying tastes are broad, time and space impose limitations, and in this loft Steve is keeping just three breeds: Spanish pouters, English carriers, and racing homers.

The pouters are elegant birds, each of them capable of inflating its crop and hoisting itself into a proud, chesty posture, like a bodybuilder at flex in an overly tight truss. The carriers, despite their name, are also a show breed, with decorative wattles across the top of the bill and around the eyes. "I like breeds," Steve says. "I'm not one of these animal rights people who thinks breeding things for characteristics is wrong." From all around us, as he speaks, come the sounds of cooling adults, peeping juveniles, wings flapping skittishly. "On the other hand, I'm more interested in the whole gestalt of the breed—how they act, everything—than just in breeding a perfectly round wattle."

My attention gravitates to the racing homers. I comment that they look like rock doves, with their pale gray wings, their dark bands, their highlights of shimmering green. Yes, but only superficially, Steve says. His breeder's eye sees nuances that I don't. Wild rock doves have a steeper forehead and a thinner bill, he explains. Also, these homers are longer legged, more deeply muscled, more streamlined than rock doves, and half again as big. "They've evolved toward—or been humanly caused to evolve toward—a fairly efficient so-called wild type," he says. "But with actually a little more efficiency for pure flying than even the rock dove." Besides greater speed, there's another thing. "They're a little more enduring as a long-distance flier. I mean, what reason would a rock dove have to fly 600 miles?"

The racing homers, superdoves in their own right, are the breed from which feral pigeons are mainly derived, at least in America. They have probably been a major source of European feral populations too. Those AWOL homers have brought their speed, their endurance, and their directional savvy to the gene pools of feral populations, no small contribution toward making the urban superdoves what they are.

I ask Steve Bodio, breeder of elite pigeons, historian of the fancy, what he thinks when he sees feral pigeons on a city street. "I think they're survivors. I think they're great," he says generously. He appreciates any form of wildlife, he adds, that "treats human edifices as just another part of the environment. They're just living in the human canyon."

THE HUMAN CANYON, NOT BEING descended from cliff-dwelling ancestors, I can only tolerate it for short periods myself. After a few days of pigeon-watching and other New York business, I catch a cab for the airport.

It's early Saturday morning, and as the taxi heads east along 46th Street, I find midtown Manhattan blessedly deserted. The sidewalks are empty, except for pigeons. On the corner of 46th and Park Avenue, one bird pecks its way sedulously across the concrete, as though expecting at any moment to find a kernel of wheat. At 59th Street, where we turn east again, I notice two dozen pigeons perched along the horizontal bar of a streetlight, like a rank of cadets calmly awaiting the next war. I think of Johnston and Janiga's book, so thorough, so authoritative, so new that even Steve Bodio hasn't yet seen it, and of its comment about superdoves.

The two authors refer passingly to the beleaguered status of *Columba livia* in the wild. They warn that genetic dissolution threatens those few remnant populations (which in Johnston and Janiga's preferred terminology are rock pigeons, not rock doves) and that it's a situation attributable to habitat destruction and urban encroachment throughout Europe and Asia. Then they end their book with a statement that in light of the situation sounds peculiarly cheery. "Whether or not we have a conservation program for Rock Pigeons, if there is no reduction of the absolute numbers of humans we think the disappearance of ancestral Rock Pigeons could occur as early as in the last half of the twenty-

NATURAL ACTS

first century. But," write Johnston and Janiga, "we would have superdoves in their places."

I find that cold consolation. Like Steve Bodio, I'm glad that at least some forms of avifauna are willing and able to grace the world's cities, and I'm not aghast that feral pigeons don't happen to carry the same array of genes as *C. livia* in the wild. But the feral pigeon is not, repeat not, a satisfactory substitute for the wild rock dove.

And this relentless replacement of wild populations by feral ones, rare species by weedy ones, inconvenient beasts by convenient ones, isn't limited to pigeons. It's a lamentably broad trend. Humanity is changing the world's flora and fauna—not just extinguishing many species but also transforming those that remain. We're doing it by the force of our ecological sovereignty and by the evolutionary selection (call it natural, call it artificial) that we exercise.

To say so is to open a large topic—too large for the closing paragraphs of a small essay. But since this is my last Natural Acts column, after 15 years, I want to leave you, good and valued readers, with something to chew on. So I ask you to consider a troubling but real possibility: that the heavy presence of *Homo sapiens* across all the world's landscapes, our irrepressible self-interest and our well-meaning management decisions, may yield a global menagerie of diminished, tractable creatures. Think of "supergrizzlies" in Yellowstone that are too sensible to eat hikers, "superwolves" in Minnesota that are too prudent to mess with cows, "supertigers" in Nepal that feed dutifully on tethered goats for the edification of ecotourists in blinds, "supergorillas" on the Virunga Volcanoes that carry acquired resistance to whooping cough and prefer a PowerBar to a mouthful of nettle leaves, "superdeer" strolling imperturbably through the suburbs, "superjinkgo" trees growing from holes in city sidewalks on a diet of carbon monoxide and dog piss, "supermosquitoes" that drink only from hummingbird feeders.

We're headed toward that, and to me it's a dreary prospect. If we come to such a point, with the surviving species (few as they may be) merely cultivated reflections of human dominance, human suffering, human fancy, we'll have selected away something precious. When the last bears and the last plants left alive are all just as super as we are, the world will be a crowded and lonely place. **Q**

APPENDIX 16

December 10, 1995 Polar Air Cargo Incident

March 1, 1996

Mr. Bruce MacKinnon
Manager, Wildlife Control
Safety and Technical Services
18C Place de Ville
Ottawa, Ontario K1A 0N8

Reference: Birdstrike Information Request

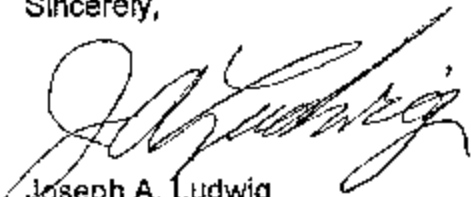
Dear Mr. MacKinnon,

Enclosed are pictures of the birdstrike damage incurred by aircraft N859FT while on approach to JFK on December 10, 1995.

Also included is the preliminary teardown report for the #3 engine that was changed because of bird ingestion.

Further details on the costs involved will be forwarded to you when available.

Sincerely,


Joseph A. Ludwig
Director of Quality Assurance

G.O.M.
FORMS

POLAR AIR CARGO

APPENDIX E

PAGE: 3

POLAR AIR CARGO
FLIGHT CREW REPORT

ATTN.

BRUCE LEONARD
BRUCE MCKENON

Originator enters the following items:

STATION		DATE		TIME	
[] [] [] [] [] []		21095		6000	
A/C NUMBER		DEPART DATE/UTC		TRIP NUMBER	
FOR N859FT		121695		P0188	
DEP STA		OFF TIME/UTC		CAPTAIN'S NAME	
LCA		2248		MOORE	
CLEARED TO		LANDED AT		ON TIME/UTC	
JFK		JFK		0007	
LOCATION AT TIME OF IRREGULARITY		TIME OF IRREGULARITY		FLT LEVEL	
JFK		2355		075	
GROSS WT. AT LANDING		FUEL QTY./LBS. AT REG.		FUEL DUMPED (LBS)	
505000		30000		[] [] [] [] [] []	

* MANDATORY TELETYPE REPORT

Send immediately after landing. Check all items applicable.

EQUIPMENT FAILURE OR AIRPLANE DAMAGE	OPERATIONAL	PAX OR CREW
☐ 1 ENGINE FAILURE OR SHUTDOWN	☐ 10 LANDED OVER MAX	☐ 25 ILLNESS
☐ 2 TURBINE ROTOR FAILURE	☐ 11 BOMB WARNING	☐ 26 INJURY
☐ 3 FIRE OR FIRE WARNING	☐ 12 HIJACKING	☐ 27 UNCONSCIOUS
☐ 4 SMOKE OR FUMES	☐ 13 OFF PAVEMENT	☐ 28 DEATH
☐ 5 LEAKING OR DAMAGED DANGEROUS GOODS	☒ 14 STRUCK OBJECT	☐ 29 MISCONDUCT
☐ 6 FLIGHT CONTROLS	☐ 15 HARD LANDING	☐ 30 INTOXICATION
☐ 7 PRESSURIZATION	☐ 16 DAMAGE TO OTHER PROPERTY OR A/C	☐ 31 OTHER
☐ 8 LOOSE CARGO	☐ 17 TURBULENCE	
☐ 9 OTHER	☐ 18 CROSS NAVIGATION ERROR	
	☐ 19 ABORTED TAKEOFF	
	☐ 20 UNKED LANDING	
	☐ 21 EMERG. EQUIPMENT REQUESTED	
	☐ 22 EVACUATION	
	☐ 23 EXERCISED EMERG. AUTHORITY	
	☐ 24 OTHER	

NARRATIVE REPORT (Please Print)

(For items to be included, see Written Report Content and Disposition in Chapter 6 of the Flight Operations Manual.)

14. AT 7,500 FT WHILE BEING VECTORED FOR YOR/DME 22L APPROACH
AT NIGHT ENCOUNTERED FLOCK OF BIRDS AND HAD MULTIPLE
BIRD STRIKES. WEATHER CONDITIONS AT TIME OF INCIDENT WERE
SCATTERED BROKEN LAYERS. NO ABNORMAL ENGINE OR FLIGHT INSTRUMENT
INDICATIONS NOTED. NORMAL APPROACH & LANDING FOLLOWING BIRD
STRIKE.

NAME	CAPACITY	SIGNATURE	☐ Check if you wish an acknowledgement of receipt of your comments.
MOORE	CAPT	<i>Robert M. Moore</i>	
Robert M. Moore 1315 WOODWARD AVE. JACKSONVILLE, FL 32207 904 396-6129		EMPLOYEE NUMBER	325
		CREW MAIL BOX NUMBER	



USA GE Aircraft Engine Services Ltd.

TO: BEN KRENK
Polar Air Cargo

FROM: ROSS CHILCOTT
Snr. Development Engineer (JT9D).

COMPANY: GE Capital Aviation Services

FAX NO: 00 353 61360070

SUBJECT: ENGINE NO. 695755
BIRDSTRIKE INVESTIGATION

GE Aircraft Engines Wales,
Nantgarw, Cardiff, CF4 7YJ.
Tel. 44 (0) 1443 847369
Fax 44 (0) 1443 847363
23rd February 1996.
Ref.
Page 1 of 2.

cc. Bill Kerrigan
Steve Shamsai

Engine Serial no. 695755 has undergone strip inspection at our facility in the presence of the Air Claims insurance assessor Mr Chris Shepherd. The following are the preliminary findings that were highlighted :-

The presence of bird debris in the area of the Fan, Fan exit vanes and LP Compressor inlet confirmed that a bird ingestion had indeed taken place as reported.

FAN

Bird debris present on many of the fan blades primarily concentrated on the inner span area however there did not appear to be evidence of impact damage when viewed in this dirty condition. The fan blades were dismantled for complete overhaul inspection in accordance with the engine manual.

FAN CASE

No damage evident upon inspection however a lot of bird debris present on Fan exit vanes and acoustic panels. All panels were removed for thorough cleaning which included the 3.0 bleed v/v area.

LP COMPRESSOR

The stage 1 stator had suffered the main damage from the bird impact with 8 off vanes plus the outer shroud badly distorted. Had the shroud damage not occurred then the stator would have been repairable through vane replacement however its condition resulted in scrappage. The stator is a fixed 1 deg open i.e. to SB 4816 std.
Tip rub was evident throughout all the rotor paths.
The remainder of the module was in reasonable condition considering the ingestion.

INTERMEDIATE CASE

Bird debris was present throughout the gaspath areas. The rear of the variable inlet guide vanes exhibited damage on a number of the airfoils which was typical of that which occurs as a result of a 'clash' with the stage 5 HPC blades during a surge condition. This was confirmed by inspection of the leading edge of the stage 5 blades (see HPC report).

HP COMPRESSOR

Module was in a dirty condition throughout as expected following an ingestion. The leading edge of a number of the stage 5 blades were damaged as a result of a 'clash' with the variable inlet guide vanes which occurs during an engine surge event. This surge event was obviously a result of the bird ingestion. Tip rub was evident throughout all the rotor paths.

HIP TURBINE

Apart from the evidence of T1 & T2 blade tip rub the module was visually in reasonable condition. As there was evidence that the engine had surged during the ingestion event (see HPC report) two of T2 & T1 blades were submitted for metallurgical examination & overtemp confirmation. Subsequently the T2 blades were found to have operated at above max permissible limit and were hence scrap while the T1 blades had operated at the max limit which meant they were OK for continued service however when measured for length they were found to be below the min length limit.

COMBUSTOR

Some minor cracking and burning evident on both liners. T1 NGV's in good condition.

L.P TURBINE

Module was disassembled for precautionary inspection as a result of the HPC ingestion event.

A final report will be issued when full scrappage details are known.

Regards,

TO: Mike Arnold

From: T.C.

REF: A/C N859FT @ TOWER AIR HANGAR 17

TOTAL PAGES=4

MAINTENANCE SCORECARD AS OF 2230Z 12/12/95

1. Right wing LE dent - 36" o/b of fuselage.
2. 1-2-3 pack inlet has feathers
3. Lower beacon damaged-replaced ops check good - needs to be sealed.
4. #3 engine bird strike- engine down-mounts ok on pylon-engine at hangar 17-will use same nose cowl due no damage.
5. #4 engine bird strike-replaced nose cowl - damaged nose cowl sitting on pallet waiting for disposition.
6. #7 t/e canoe
7. #8 t/e canoe
8. BS 1060 frame damaged
9. L/E lwr fuselage panels damaged
10. lwr panel damage aft center of E/E compt.
11. extend flaps
12. 1,2,3 heat exchangers
13. radome
14. mid anti ice duct
15. BS 360 dent
16. #1 plenum check
17. #2 plenum check

18. #3 plenum check
19. #7 tire change
20. #3 engine 1st stage stator vanes bent
21. #8 canoe loose
22. #13 L/E panel
23. #2 main tank
24. #13 L/E panel delamination
25. #3 hot boro
26. #4 engine requires 2 set of fan blades due bent
27. DMI RH logo light
28. DMI f/o vor
29. DMI light captains radio ins panel
30. DMI pack zone temp controller
31. #14 L/E disconnected
32. LOG- Runway turnoff light Inop
33. LOG- APU battery charger Inop
34. LOG-#4 engine slow to accelerate
35. Section 41 internal stringer L32 damaged dented -sta 350-370
36. section 41 stringer L33 sta 350-370
37. Section 41 stringer L32 & L33 sta 360
38. Section 41 (Inspection) Internal /sta 360 stand off bracket broken
39. Section 41 Internal "cat walk" not secure r/h side
40. #3 engine Horizontal firewall hyd. press. line outlet leaking
41. #3 eng l/h side cowl #5 latch is damaged.

42. sheetmetal request insp. right wing L/E area below L/light damaged.

43. Birdstrike damage @ BS300-BS320 at 539R

44. Perform video borescope of eng 695742

maintenance turnover from dayshift to nights for 12/12/85

A. 1730Z Need #13 L/E panel- P/N 65B02450-3. Need engine change bolt kit for #3 engine. Notified stores @ 1740z jfk. Also notified maintenance control "MIKE" about above. Above part verified @ 1928Z and maintenance control notified.

B. New engine arrived removing from truck @ 1745Z. #3 engine already removed from A/C upon my arrival(Polar Rep). Engine change bolt kit supplied by Polar.

NOTE: Tower air has #13 L/E panel in stock

Notified JFK stores received four eng chip kits @ 1916Z.

C. Made log item M5 for robbing #1 hydraulic qty ind. P/N 200-007-005 part on order(Expediting out of vendor) Above robbed part used for N850FT.

D. Log item M5 Hyd leak R/H body w/w- c/w Tightened "B" nut on R/H body gear steering module.

E. R/H L/E inbd of landing light-sheetmetal working.

Parts missing from engine change kit

1ea 9155-18 retainer

2ea bacw10bp18acu washer

1ea 65b91342-6 filler

1ea safety bolt

Above parts purchase from tower if needed.

chip detector kit on hi-boy

eng change kit on hi-boy

F. 2 polar mechanics to check 2 spare tires in bulk compt. Need to check inner and outer wheel bearing p/n's.

parts we need

LTD	p/n	findings
9403	65B07656-581	stringer no record of part
9404	65B07656-527	stringer nis
9402	65B11651-2	rib nis
9409	65B10541-25	chord nis
9410	65B0541-9	chord nis
9407	65B08060-16	L/E skin nis
9406	65B12203-88	Rib nis
9408	65B12204-6	Rib nis

Above parts not on order- Lou verdone JFK stores given list @ 1830Z
12/12/95

APPENDIX 17

**Canadian Study Finds Greatest Frequency of Bird Strikes to
Turbofan and Turboprop Aircraft Below 100 feet in Summer**

Canadian Study Finds Greatest Frequency of Bird Strikes to Turbofan and Turboprop Aircraft Below 100 Feet in Summer

Only 12 percent of bird strikes caused problems, which included obscured cockpit vision, an engine fire and a forced landing.

Robert L. Koenig
Aviation Writer

Most reported bird strikes involving Canadian aircraft in 1994 occurred at altitudes below 100 feet (30.5 meters) above ground level, often during either the takeoff run or the landing roll (Figure 1 and Figure 2, page 2), according to a Transport Canada study. The survey found that gulls were hit by aircraft far more than any other type of bird.

Bird Strikes to Canadian Aircraft: 1994 Summary Report was issued by Transport Canada's environmental services office and the agency's safety and technical services section in December 1995.

Turbofan and turboprop aircraft were the types most likely to report striking birds, the survey found. The majority of damage from strikes involved aircraft wings, radomes, noses and engines.

Canadian experts analyzed 655 bird strikes that were reported to Transport Canada's airports group in 1994. Of those, 623 strikes occurred in Canada, 23 took place outside Canada (involving Canadian aircraft) and in nine strikes the location was not reported.

In addition to bird strikes, the study mentioned 15 cases in which aircraft struck mammals at airports in 1994. Rabbits were the most common animals, accounting for a third of mammal strikes. Other animals included gophers (two), coyotes (two) and skunks (two).

Although most aircraft that struck birds reported no adverse effects, the bird strikes did cause problems in 12 percent of the reports. Effects ranged from obscured cockpit vision to an engine fire and a forced landing.

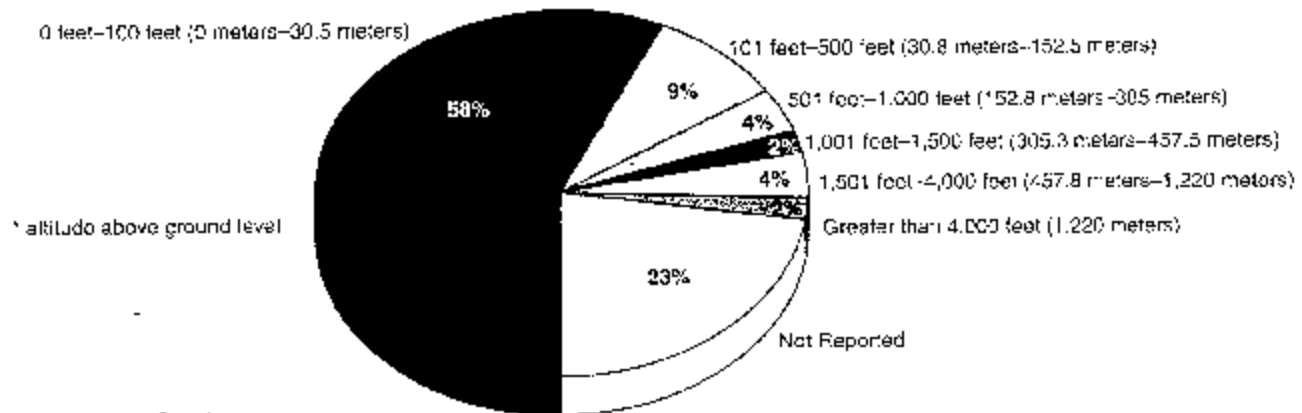
The analysis focused on bird strikes that were reported by Canadian airports, airlines, pilots and Transport Canada. Analysts took steps to avoid duplication in analyzing the results. At most of Canada's civilian airports in 1994, the rate of bird strikes ranged from one strike to five strikes per 10,000 aircraft movements. The data are intended to help airports improve their bird-control and mammal-control programs, as well as for employee training and public awareness programs.

According to the data, a typical bird strike in Canada occurred during takeoff or landing in the late morning of a summer's day, and involved a gull hitting the wing, nose or fuselage of either a turbofan or a turboprop aircraft.

The consequences of bird strikes can range from engine fires to obscured vision from the cockpit windows, sometimes forcing aborted takeoffs or precautionary landings.

In most of the reports analyzed — 382 of the 655 reported bird strikes (about 55 percent) — the flights were not affected by the incidents. In 197 other cases, the effects, if any, on the flight or the aircraft were not reported.

Altitude* of Reported Canadian Bird Strikes, 1994



Source: Transport Canada

Figure 1

Effects reported in 76 cases included:

- 47 reports in which the aircraft made a "precautionary landing" after the bird strike;
- A dozen reports in which the aircraft aborted takeoff;
- Six bird strikes that resulted in "engine ingestion";
- Six reports in which the strike obscured cockpit vision;
- One report that led to a forced landing; and,
- One report in which the bird strike resulted in a fire.

Three reports cited "other effects" (unspecified in the reports) from bird strikes.

The majority of aircraft affected by bird strikes were either turbofan or turboprop aircraft, with far fewer incidents involving turbojet, turboshaft or piston-powered aircraft. Those

statistics partly reflect the proportions of types of aircraft that typically use Canadian airports.

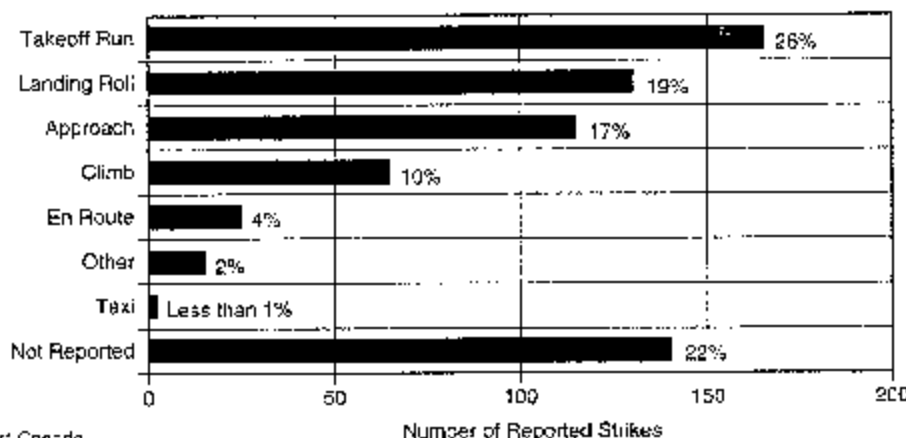
- **Turbofan.** Thirty-five percent of reported bird strikes, in which the type of aircraft was identified, involved turbofan aircraft. Of the various types of aircraft, turbofans also reported the highest percentage of engine damage when birds struck the engines.

Of the approximately 230 bird strikes to turbofans, 10 percent were strikes to the engines. And 26 percent of those strikes resulted in engine damage, the report said.

- **Turboprop.** After turbofans, the type of aircraft struck most often by birds were turboprops. One-quarter of all reported bird strikes involved turboprop aircraft.

Of those approximately 160 reports, 15 percent involved strikes to the engine/propeller. But only 12 percent of those strikes to turboprops resulted in engine damage.

Phase of Flight of Reported Canadian Bird Strikes, 1994



Source: Transport Canada

Figure 2

Aircraft Most Frequently Involved in Reported Canadian Bird Strikes, 1994

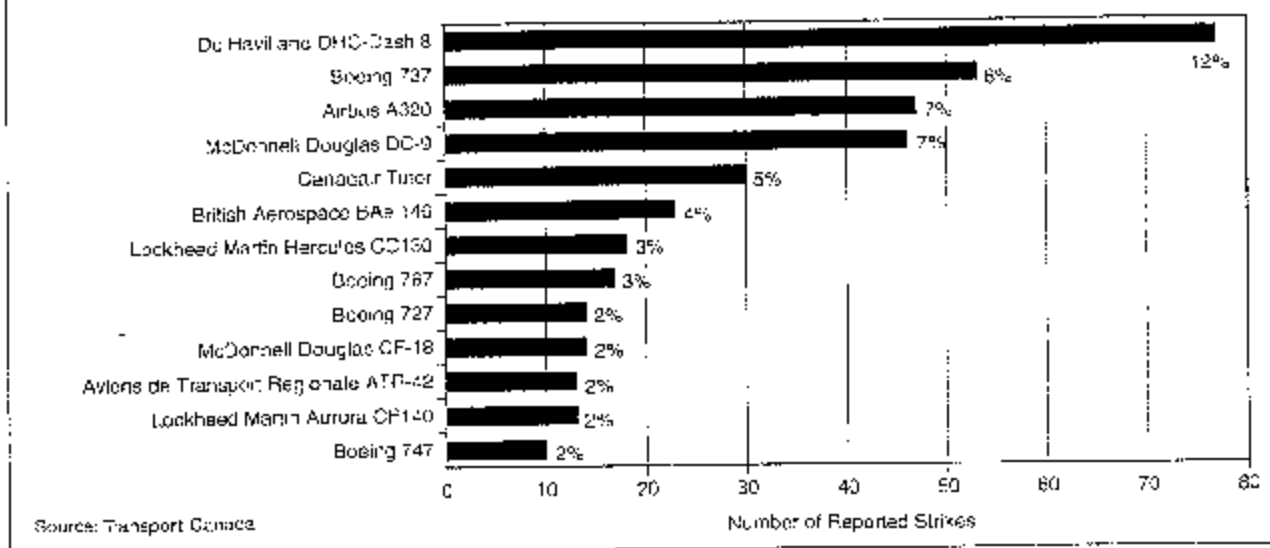


Figure 3

Other types of aircraft were involved in fewer bird strikes:

- **Turbojet.** Seven percent of reported strikes involved turbojet aircraft. Ten percent of those strikes were to the engine. And one-quarter of those strikes to the engine resulted in damage.
- **Piston-powered aircraft.** Five percent of strikes involved piston aircraft. Only 1 percent of those strikes hit the engine/propeller, and none of those strikes resulted in damage.
- **Turboshaft.** Less than 1 percent of the Canadian bird strikes involved turboshaft aircraft. None of the birds struck the engine/propeller of those planes.

The aircraft model most often involved in bird strikes, regardless of the number of aircraft flights, was the de Havilland DHC-Dash 8 (Figure 3). Dash 8s were in 77 reports (about 12 percent of the total bird strikes).

Other aircraft involved in a relatively large number of bird strikes were the Boeing 737 (53 strikes, or 8 percent of the total); the Airbus A320 (47 strikes, or 7 percent) and the McDonnell Douglas DC-9 (46 strikes, or 7 percent).

Bird strikes most often resulted in damage to the:

- Engine (in 24 percent of the 49 strikes to that aircraft component);
- Radome (in 17 percent of the 35 strikes);
- Wings/rotor (in 16 percent of the 90 strikes);
- Canopy/nose (in 14 percent of the 57 strikes); and,
- Windshield (in 10 percent of the 39 strikes).

Late summer — July, August and September — was the most common period for bird strikes to occur in Canada, and between 8 a.m. and noon was the most likely time of day.

The survey found the most bird strikes in the following months:

- August (20 percent);
- September (15 percent);
- July (13 percent);
- October and May (both 9 percent);
- November (8 percent); and,
- June, March and December (each 6 percent).

The fewest bird strikes occurred in January and February (each month with 2 percent of the total strikes), and April (4 percent).

The most bird strikes were reported between 9 a.m. and 10 a.m. (62 strikes). Strikes also occurred relatively often in other late-morning hours:

- From 8 a.m. to 9 a.m., there were 50 strikes;
- From 11 a.m. to noon, there were 47 strikes; and,
- From 2 p.m. to 3 p.m., there were 42 strikes.

The fewest strikes occurred between midnight and 6 a.m., when relatively few aircraft were landing or taking off. In general, the number of bird strikes per hour slowly decreased after 3 p.m.

Most of the reported bird strikes — where such details were reported — took place during the day when there was no precipitation, the report found. There was rain during 9 percent

of the moments; there was fog during 4 percent; and there was snow during fewer than 1 percent.

When reported, the sky conditions during bird strikes were about evenly divided among clear, partially cloudy and overcast days. The light conditions were not reported in more than half of the reports, but most of the bird strikes occurred during the day. Only 7 percent occurred at night, 3 percent at dusk and 1 percent at dawn.

As part of Canadian airports' wildlife control programs, Transport Canada requires airport personnel to submit an "Airport Staff Bird Strike Report" after observing or being told of a strike.

"The emphasis is on identifying the kinds of birds involved," said the report. One reason to gather more information about the types of birds is to help improve the airports' bird-control programs.

About 35 percent of the strike reports did not identify the kinds of birds involved. But, of the identified species, the survey found that the kinds of birds struck most often were:

- Gulls (26 percent);
- Sparrows (6 percent);
- Swallows (5 percent);
- Snow buntings (4 percent);
- Hawks, owls and starlings (each 3 percent); and,
- Geese, ducks and kestrels (each 2 percent).

Other kinds of birds in reported strikes were doves, crows, egrets, a pelican and a number of shorebird species, such as killdeer and plovers.

Although Transport Canada's study was as comprehensive as possible from the reports, the authors — staff members of Transport Canada — cautioned that some strikes go unreported.

The report said that the data presented provide "a reasonably clear description of the 1994 bird-strike situation." The report added, however, that "there is no way of knowing precisely how many strikes go unreported, or how they may or may not affect" the report's data. ♦

Editorial Note: This article was adapted from *Bird Strikes to Canadian Aircraft: 1994 Summary Report*, Transport Canada, Airports Group, Report no. TP10573E, December 1995. The 26-page document includes an index, a summary of bird-strike highlights, an introduction and numerous charts and graphs.

About the Author

Robert L. Koenig is a Berlin, Germany-based correspondent who specializes in transportation and science issues. He has written on aviation matters for Science magazine and the Journal of Commerce. Before his move to Germany, he was a Washington, D.C., newspaper correspondent for the St. Louis Post-Dispatch, for which he covered transportation issues. He won the National Press Club's top award for Washington correspondents in 1994. Koenig has master's degrees from the University of Missouri School of Journalism and from Tulane University in New Orleans, Louisiana.

AIRPORT OPERATIONS

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Wine & Beer Import

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APPENDIX 18

An Update From the BASH Team

AN UPDATE FROM THE

BASH

TEAM

MAJ DAVE ARRINGTON
HQ Air Force Safety Agency

■ The USAF Bird Aircraft Strike Hazard (BASH) Team — what the heck is that? And what does it have to do with you? For those of you who have had close encounters with our feathered friends, you may have some idea. For everyone else, well, laugh it off and read on for enlightenment. But I think you might be surprised.

How serious is the bird strike problem?

The numbers speak for themselves. Each year, over 3,000 bird strikes are reported with damage averaging over \$50 million. Since 1987, the USAF has lost 14 aircraft to this problem. Eleven crewmembers were killed, and there were

know where to concentrate our research and program management efforts. Second, we can give you do's and don'ts during your mission to reduce your risk of a catastrophic strike. Let's start with the team.

What is the USAF BASH Program mission, and what are we doing for you? Our mission is the preservation of war-fighting capability through risk management of wildlife hazards to aircraft operations. We do this through three distinct programs: intervention, avoidance, and tolerance.

Intervention

Intervention is just what it implies — taking direct action to manipulate the birds themselves. This takes place at the airfield and involves habitat manipulation, bioacoustics, and pyrotechnic techniques for bird control. Remember that 70 percent of the strikes occur around the airfield, so much of our time is concentrated in reducing that risk. We provide staff assistant visits to evaluate the base and surrounding habitat and provide information on bioacoustics and pyrotechnic (frightening) techniques.

In most cases, if the base manages habitat properly and has a bird control team for frightening, bird and mammal (BASH deals with all wildlife problems) strikes can be reduced to a minimum. The important thing to remember is that we are managing to reduce flocking and the numbers of large birds — it's impossible to discourage all species.

Although only 30 percent of bird strikes occur during low-level flight, 70 percent of all damage is done in this flight regime. The energy equation says it all: $E = 1/2 \text{ mass} \times \text{velocity squared}$. For example, an aircraft traveling at 500 KIAS, striking a turkey vul-

Keep three things in mind:

1. Wildlife can/has ruined many a flier's day.
2. The BASH Team exists solely to help make your flying safer.
3. There are ways to reduce the risks you face.

several permanent injuries.

We know almost all bird strikes occur at 2,000 feet AGL or less. (See figure 1.) We also know that nearly 70 percent of bird strikes occur in the airfield environment, with a little less than 30 percent during low-level flight. (See figure 2.) By identifying strike remains, we can determine what species of birds we hit by time of day and year.

At this point, you are probably thinking, "So what! This is nice info, but how does it help me in the cockpit?"

It helps you in two basic ways. First, we



Original USAF Photos

ture (the most commonly struck bird), equals 1.5 million foot pounds of energy. That equates to one nice piece of antiaircraft artillery. There isn't an aircraft made that won't suffer damage from such an encounter. Obviously, we cannot manipulate the bird habitat in our military operating areas (MOA) and low-level training routes. Thus, avoidance becomes the only solution, and that's where we have our biggest challenge.

Currently, we have developed a Bird Avoidance Model (BAM) which predicts or gives a relative risk for any visual or instrument route. We can also give a general analysis of ranges and MOAs. The problem with this current model is that it requires each unit to call us with requests for analysis by our low-level expert. In other words, there is a time delay between request and delivery. Plus, it's rather restrictive since it analyzes the entire route as a single entity, rather than by leg segment.

Thus, we are developing a user-friendly, WINDOWS-based system that has incorporated updated bird migration data and will include many new species. This new model will be loaded on CD ROM to be sent to every unit for time-effective route/range/MOA analysis. The model will allow crews to call up a map showing bird hazard locations with route overlay and intensity based on time of day, year, and desired flight altitude. The crew can then select a leg-by-leg analysis to determine appropriate actions to minimize the risk.

But it doesn't stop there. Routes can be built (MOAs/ranges) by simply activating the crosshair (mouse) and selecting the desired route points over the risk map that avoid high concentrations of birds. The model will then complete a leg analysis for comparison. You can also enter preplanned routes for MOAs or ranges by lat/long and modify points that fall in high-risk areas. We hope to have this model available in early 1997.

Avoidance

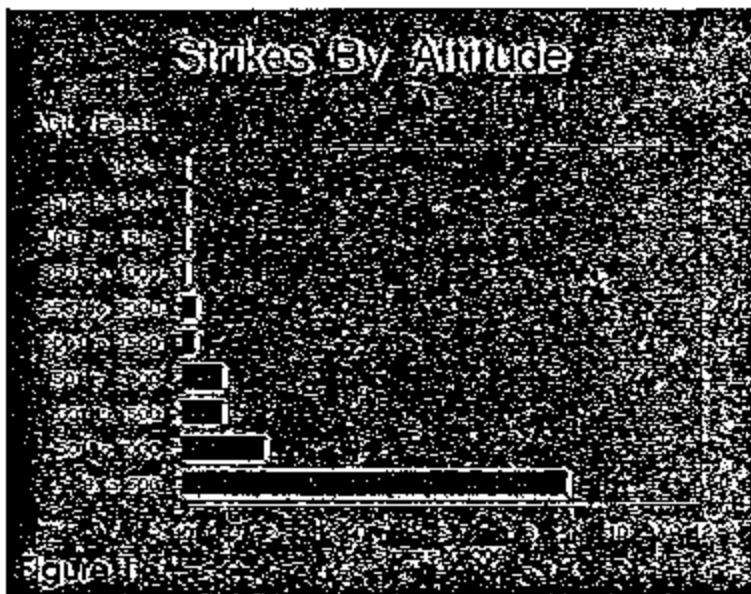
Avoidance in the traffic pattern is an important issue. Although it is fairly simple to control birds directly on the airfield, it is entirely different for those passing over or near the runway. Bird conditions in the area are passed to aircrews via Bird Watch Conditions code. There are three levels. Light — bird activity is at normal low intensity, and flying activity is not impacted. Moderate — birds are in the immediate vicinity, and transition should be limited to minimum requirements for training. Severe — extreme bird activity which should cancel all transition training and limit landings to straight-in, full stops.

Launches should only be mission-essential sorties.

I know what you're thinking at this point. "What determines the bird intensity levels?" This becomes somewhat difficult since each location is unique. But there are a few general guides.

First, if the bird activity is just a few scattered small species around the perimeter of the field, Light would be a good call. If there are soaring birds of prey (which includes vultures) near the field or pattern, or small flocks passing over the field, Moderate is in order. Large congregations of any bird in the vicinity, especially flocks of large birds, Severe is the call. However, here is an extremely important note: Moderate and Severe should be in effect only while birds are physically present. Once they depart the area, allow approximately 20 minutes, then return the bird-watch condition to Light. Maintaining a bird-watch condition of Moderate for the entire migration season does nothing to warn aircrews of current feathered activity and can lull them into thinking moderate intensity is normal.

Photo by TSgt Perry J. Keiman



The Judgment Call

Who should be making the judgment call? That's a good question — the answer varies at each base. Here are some general guidelines to go by when establishing procedures.

Tower has the capability to relay information to an aircrew quickly. Thus, tower personnel should always have the authority to change bird-watch condition codes. It's their job to observe airfield activity at all times, and they can inform crews immediately if there's a hazard.

ATIS should be used to broadcast infor-

continued

Avoidance in the traffic pattern is an important issue. Although it is fairly simple to control birds directly on the airfield, it is entirely different for those passing over or near the runway. Bird conditions in the area are passed to aircrews via Bird Watch Condition codes.

BASH TEAM

continued

mation on current activity. This will give an aircrew a heads-up on what to expect. Aircrews should advise tower of any bird or animal activity observed while flying or taxiing and advise tower that an upgrade of the bird-watch condition code is warranted. Base ops, primary supervisory officers, and flight safety officers who observe bird activity should have the authority to call tower and change the code. Crews transitioning in the area should advise tower of any potential hazards for relay to other crews. Bottom line — time delay is the enemy.

Preventing Catastrophic Damage

Even with the best BASH program imaginable, some bird strikes will occur. With this in mind, aircraft components are, and will continue to be, designed to withstand impacts. That doesn't mean the strike won't inflict damage, but catastrophic damage will, hopefully, be prevented or, in extreme cases of engine ingestion, contain the damage to allow safe egress.

As an example, B-1 windscreens are de-

signed to take a 4-pound bird at 550 KIAS and not fail. F-16 windscreens have been upgraded to withstand strikes above 500 KIAS. The T-38 community now has a 4-pound,

400-KIAS windscreen available. These new windscreens have saved more than just a few lives.

The folks in Aircrew Protection at Wright-Patterson AFB, Ohio, are responsible for this technology. They work closely with the BASH Team to obtain strike statistical data. This data is used to determine strength criteria based on the type of birds likely to be encountered. This is a dynamic field. For example, we know heavy weight specie populations are on the increase and will likely result in component criteria changes. We regularly discuss these issues with Wright-Patterson AFB to ensure the most accurate data is available for design engineers.

What You Can Do

The above info is nice and dandy, but you're thinking, "What can I do in the cockpit right now to help myself?" There is quite a bit you can do to help protect yourself and your aircraft. Let me start by saying this: There is method to the madness related to birds' feeding and migration patterns.

First, if you're going low level, use our BAM to get an idea of the relative risk. Your wing flight safety shop should have BAM information for your use.

The next step is knowing a few basic rules of times and locations to avoid if possible. Generally 1/2 hour before until 1 hour after sunrise and 1 hour before until 1/2 hour after sunset are peak activity periods. During migration season, you can also include the hours of darkness. The vast majority of birds, including waterfowl, migrate at night. The sunrise and sunset rule is probably a little easier for schedulers to live with for times to avoid, but excluding night flying during spring and fall just isn't going to happen.

However, keep this in mind: Peak migration activity is likely to occur just before and after a major weather frontal passage, especially during the fall. Also, migrating birds tend to fly at higher altitudes. Thus, being 1,000 feet AGL during night low level is probably no better than 500 feet AGL.

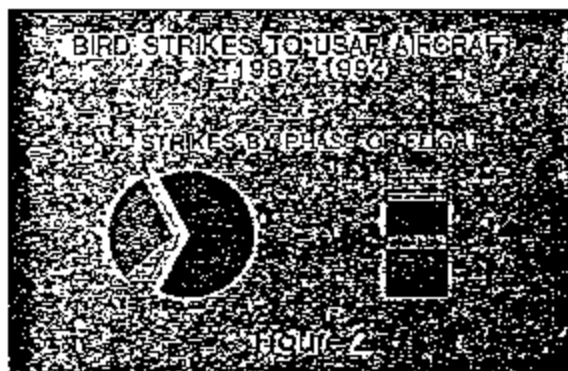
For those with NVGs or FLIR capability, abort the route when activity is observed. If a handful is on the move, very likely there are many thousands right behind them. Again, the best bet is to avoid the area if the BAM indicates the risk is high.

During midday, raptors or birds of prey are a risk to you. These birds like to ride thermals or hang on the windward side of cliffs or hills. Keep a close eye when approaching ridgelines or in areas where thermals are likely. Raptors have taken more lives and destroyed more aircraft than any other group of birds.

Avoid water, or at least overfly at the highest altitude possible. Where there is water, large birds will be nearby.

Last, if birds are observed in the pattern, LAND!

By now you have a very general idea about BASH hazards and the team dedicated to you. This article just scratches the surface of what we are doing and what you should know to reduce your exposure. In future writings, we will take single subjects and explain each in detail to make you familiar with every aspect of the potential wildlife hazards you face. ■



The vast majority of birds, including waterfowl, migrate at night. The sunrise and sunset rule is probably a little easier for schedulers to live with for times to avoid, but excluding night flying during spring and fall just isn't going to happen.

APPENDIX 19

The "CAPA" Anti Bird-Strike Cartridge

THE "CAPA" ANTI BIRD-STRIKE CARTRIDGE

Leaders in civilian and military pyrotechnics
since 1739

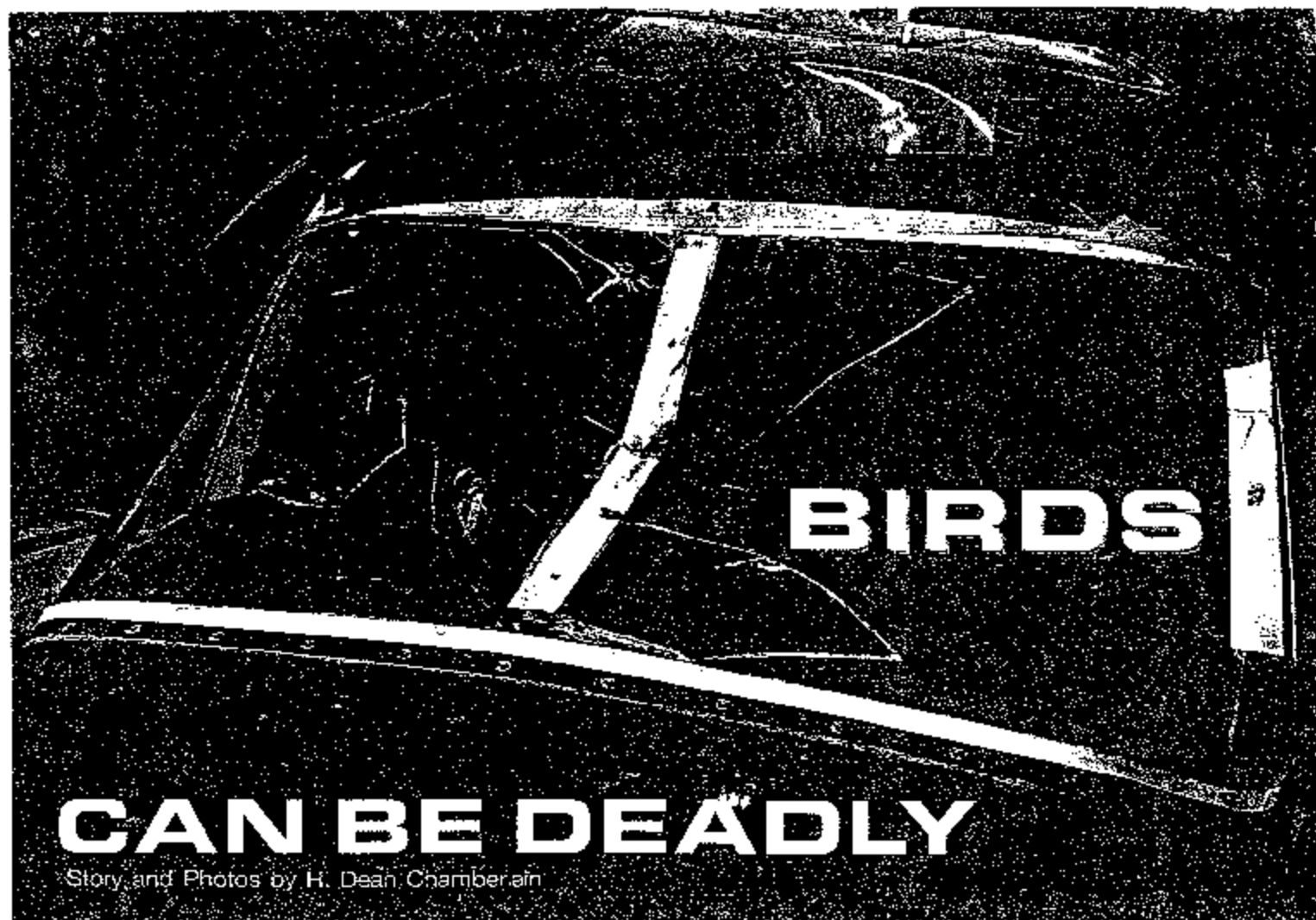
The CAPA self-propelled scare charge provides highly
efficient deterrence against bird strikes



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APPENDIX 20

FAA Aviation News: Birds Can Be Deadly. January-February 1996



Some might say flying is for the birds. Others might even say that birds invented flying. But regardless of what you think about birds and flying, we think birds have been flying relatively safely for millions of years. We don't know for sure, since the FAA has no Neolithic bird accident statistics on file. Apparently, the government's data systems weren't on-line then.

A quick review of history lists only one reported flight accident involving some type of bird-like experimental aircraft made of feathers and wax. Apparently the reported midair breakup was caused by the sun's heat. According to early, unconfirmed reports, important flight feathers fell off the pilot because the heat melted the wax attaching the feathers to the man when he busted his assigned altitude and flew too close to the sun. But it must have been a myth because we all know a little bit of sun could never melt FAA-

approved, TSO'd, human-feather-attachment wax. Plus, we all know that no FAA inspector would ever sign off on an experimental "aircraft" made of wax and feathers. Mylar maybe, but not feathers.

Today, we have a different problem involving feathers and birds. Humans have mostly gone beyond trying to imitate birds flying, but we still have a problem with our fine feathered friends. Ever since humans started to fly, birds and bird(persons/men/women, your choice) have managed to collide with each other with increasing frequency and with increasing damage. It seems that birds and flying humans just can't stay out of each other's way.

Although birds and some pilots (such as glider pilots who often share the same thermal with soaring birds) can operate near each other with relative safety, birds can and do occasionally strike great fear in the hearts of the most intrepid aviators because a bird

strike through the cockpit can ruin any pilot's day, especially if the bird is a big, fat goose.

The problem is easy to understand. It is harder to fix. In today's world of ever expanding urban areas, increased air operations, and decreasing amounts of unused airspace, it is inevitable that birds and aircraft are going to conflict with each other both in the air and on the ground. Bird strikes and jet engine bird ingestion have caused aircraft to crash. Birds have also caused millions of dollars of aircraft damage. The birds lose too; few birds escape a midair collision or engine ingestion unharmed.

Jet aircraft are even more vulnerable to birds than prop aircraft. Although the larger jet engines are designed to be able to ingest an occasional small bird with minor damage to the engine, a large bird or large numbers of smaller birds sucked into a jet aircraft's engines have caused more than one aircraft to crash. In other



cases, cockpit strikes have disabled pilots. In some of those strikes, the pilot or a copilot was able to safely land the aircraft. In a few cases, the aircraft crashed.

Military aircraft are especially vulnerable to cockpit bird strikes when the aircraft is flying low and fast on nap of the earth training missions at 500 feet and 500 knots. The U.S. Air Force has spent considerable money and effort to develop safer canopies for its low flying aircraft. One large bomber reportedly crashed because of birds. According to a 1993 Air Force study titled "Determination of Body Density For Twelve Bird Species,"—a project designed to develop test data for bird strike research—Air Force aircraft average 3,000 to 3,500 bird collisions each year at an annual cost of more than \$65 million. The report also noted a 1992 report which said seven Air Force personnel had died from bird strikes between 1987 and 1992.

Regardless of the type of aircraft involved, military or civilian, bird strikes are a classic case of "lose/lose" for both the bird and the aircraft.

We printed a tongue in cheek article called "The Kamikaze Kanaries of Operation Revenge" in our March-April 1992 issue. The article discussed the dangers of bird strikes from the bird's perspective and told of actions birds can take to eliminate the metal pollution of aircraft from the bird's natural flight environment. It was a humorous way to point out some important flight safety issues for pilots when dealing with birds. In this article, we want to discuss the issue seriously from a pilot's perspective.

Two items brought the importance of bird strikes to mind. One was seeing a flock of about 50 large Canada geese flying in their classic "V" formation about two miles south of Washington National Airport. Fortunately, the geese were flying relatively low, and they were westbound on the west side of Alexandria, VA. They were not on the east side of the town which is along the Potomac River just south of the airport and down river from Washington, DC. The scary thought is they could have already flown low across the river.

Birds flying over or across the Potomac River near National Airport are always a threat because jet aircraft arriving and departing the airport have to fly over the river both inbound and outbound to avoid the prohibited airspace over Washington and for noise abatement. In addition to migratory birds such as the geese (which today seem to migrate less and less in the Washington area), National Airport has a year-round problem with gulls on and near the airport. Other airports have similar problems with local bird populations such as JFK International Airport in New York which is located near a protected bird breeding area. In other cases, landfills or dumps near airports attract large numbers of birds which then threaten the safety of flight operations.

BIRD STRIKE PREVENTION TECHNIQUES

The other important item, which resulted in this story was seeing an article in the Orlando, FL, FSDO-16 Aviation Safety Program Newsletter on how to avoid bird strikes. Written by the Florida Association of Flight Instructors, the article said about eight aircraft are lost each year because of bird strikes. In paraphrasing the article, it said if you hit a two-pound seagull while you are flying at 120 mph, the resulting impact would have a force equal to 4,800 pounds. If you are flying in a jet at 600 mph the same impact would have a force of 72,000 pounds. The newsletter noted, "Some anti-aircraft rounds exert less force than that."

The article listed several suggestions to help pilots avoid bird strikes:

- Don't fly beneath a flock of birds because birds tend to dive to avoid danger. Pilots should pitch up to try to avoid a bird collision because the bird will probably dive.

- Turn on your landing lights when flying near areas with birds. The lights might help the birds see you in time to get out of your way. [Editor's Note: Don't expect the birds to turn on their landing lights for you. They were not type certificated with electrical systems

or landing lights. They also don't have transponders for the same reason.]

- The final suggestion is to avoid flying near areas where birds concentrate such as marshlands, dumps, and landfills.

PRIME MIGRATION PERIODS

The FAA *Aeronautical Information Manual* (AIM) has a complete section on bird hazards—Section 4, Chapter 7, on page 7-4-1. According to the AIM, 90 percent of the reported bird strikes occur at or below 3,000 feet. Strikes at higher altitudes are common during migration. Ducks and geese are frequently observed up to 7,000 feet. March through April and August through November are listed as the prime migration periods.

The AIM notes there are four major migration routes across the U.S. with numerous other smaller flyways. The major routes are the Atlantic Flyway which parallels the Atlantic Coast, the Mississippi Flyway which includes the Great Lakes and Mississippi River areas, the Central Flyway located east of the Rocky Mountains, and the Pacific Flyway which parallels the West Coast. These routes are flown by birds traveling from Canada and the northern U.S. to the southern U.S., Mexico, and Central and South America.

When flying in and near one of the flyways, pilots should avoid flying low. If operationally possible, another suggestion you might want to consider is to fly as slowly as possible consistent with safety when flying near birds to minimize the force of a bird strike. The impact forces are both a function of the closing velocities and the weight of the bird and aircraft.

Pilots should also avoid charted wildlife refuge areas. If overflight is necessary, please comply with the minimum overflight altitude listed on the chart. If possible, you should fly at a higher altitude both to minimize disturbing the protected wildlife and to minimize the chance of a bird strike. The higher altitude also provides extra time in case of an engine failure, bird strike, etc.

DEALING WITH THE INEVITABLE

No one wants to hurt or kill a bird, but sometimes bird strikes are unavoidable. Although airport operators, aircraft operators, the military, and the FAA have spent millions of dollars and years of effort trying to solve the bird strike problem, the problem will continue as long as birds and pilots share the same airspace. But as we start a new year and as the birds wintering in the south start their annual trek north to their spring nesting areas, pilots need to be especially watchful and avoid birds and their flyways whenever possible. In the case of operating in and out of airports with known bird problems, pilots need to be very careful. In such cases, pilots should develop an emergency plan of action in case of a bird strike or engine ingestion.

In the case of an engine or engines sucking in birds during takeoff, like any takeoff emergency, the question becomes one of do you have enough power to go-around, or do you have to abort on the runway? This is the classic go-no-go decision.

A bird strike or engine ingestion while you are en route becomes a question of can you continue to an airport for a landing or must you make an off-field landing? In some reported bird strike accidents, there was control damage, but the pilots were able to continue flying. In others, especially those involving helicopters, the pilots had to make precautionary landings.

If in-flight, what are your plans if a bird strikes your windshield and penetrates your cockpit? Assuming you are uninjured, are you prepared for the noise, confusion, increased drag, and bird parts and blood in the cockpit? If the bird is not killed by the impact, what are you going to do with an injured, terrified, wild bird in the cockpit? What are you going to do if that bird is the size of a duck or goose and it lands in your lap? Or, for that matter, what are you going to do with an injured, terrified, wild passenger in the cockpit? These are only some of the questions a pilot must be prepared to answer when operating near birds.

NTSB BIRD STRIKE ACCIDENT REPORT REVIEW

A review of 67 accidents covering the period from January 1983 through April 1995 revealed some interesting data. For one thing, bird strikes or birds being ingested into jet engines can happen to any type aircraft from small, single-engine aircraft to helicopters to big aircraft to Boeing 747's. There were 12 fatalities listed from all causes and 11 serious injuries listed in the 67 reports. The good news is the number of bird strikes that resulted in substantial aircraft damage resulted in minor or no injuries to those on the aircraft.

The key point here is how few bird-related accidents are fatal to the aircraft occupants or pilots. Of the 12 fatalities listed in the reports, one fatality was only indirectly related to the bird strike. Apparently because of a misunderstanding between the pilot and his passenger, the passenger jumped to his death after he misjudged his height above the water as the helicopter was making an emergency water landing after a bird strike.

MAINTAIN CONTROL OF YOUR AIRCRAFT

In reading the 67 accident reports, some of the pilots apparently forgot to remember the first and most basic rule of flying: Always fly your aircraft.

Even when involved in the confusion and shock of a midair cockpit bird strike, pilots must continue to fly their aircraft. The NTSB data told of accidents in which a few of the pilots took evasive action to avoid birds and either lost control of their aircraft or flew the aircraft into the ground or low wires. In some cases, the pilots lost control while taxiing, taking off, landing, or while trying to go around. In others they lost control in flight. As previously stated, one defensive technique to avoid birds is to pitch up or climb because birds normally dive to avoid danger, but if you pitch up to avoid a bird strike, you can't pitch up so high you stall. A stall/spin accident can be just as damaging as a bird strike.

Another surprising discovery was the number of fatal and serious injury accidents reported that were the result of what could best be described unofficially as pilot error. After the bird strike or while maneuvering to avoid birds, the aircraft crashed. In a surprising number of cases, the pilot ran off the runway or taxiway or failed to execute a successful go-around or collided with an object after trying to avoid a bird or a flock of birds. In a few cases, the pilot simply lost control of the aircraft after a bird strike or while trying to avoid a flock of birds and crashed. These reported accidents show that a pilot must always fly the aircraft no matter what happens.

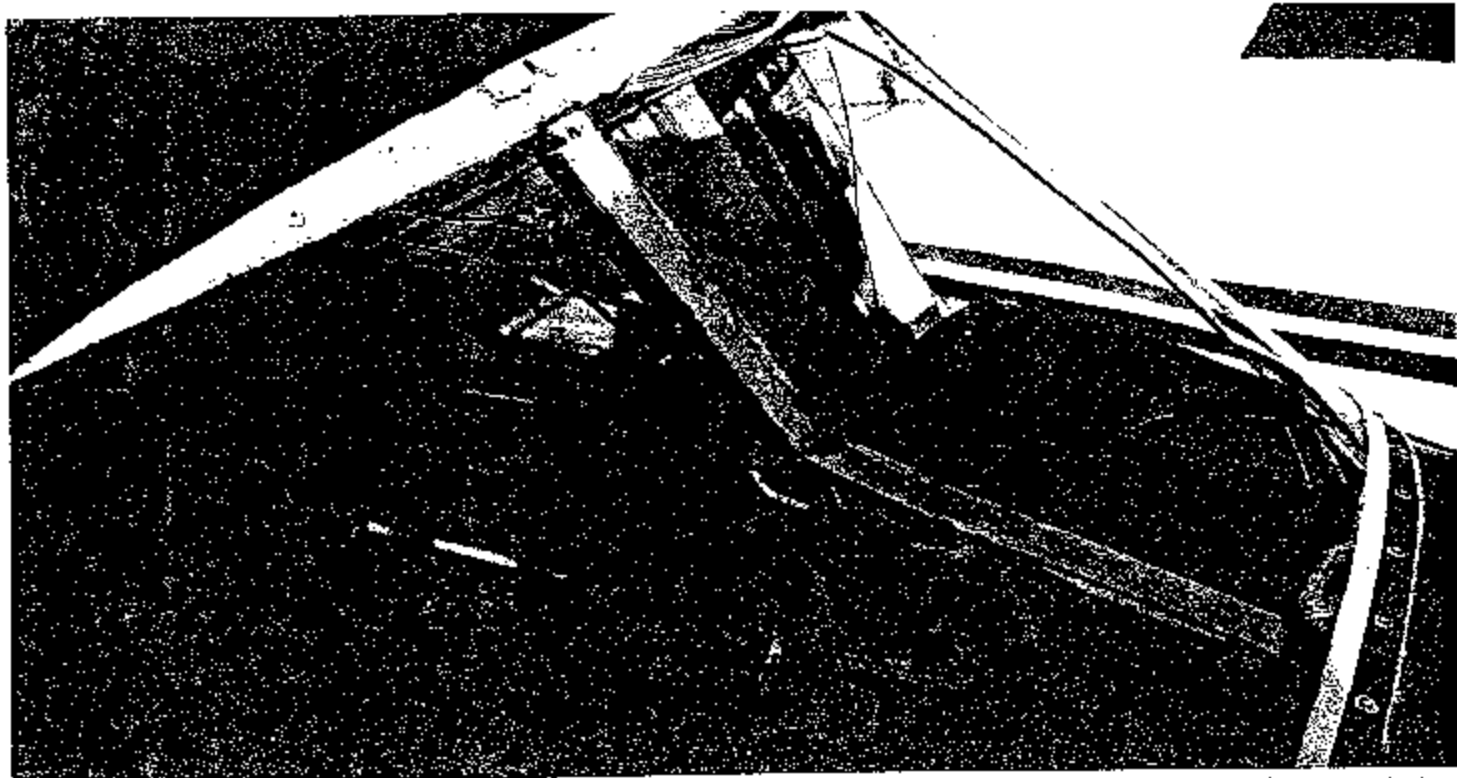
And fly their aircraft is exactly what the majority of the pilots did in the 67 NTSB accident briefs. Most of the pilots were able to regain or retain control and execute a successful landing at an airport or an off-airport site. In some cases, this was done while injured. In one case, the pilot suffered facial injuries and his glasses impacted his head when he was hit in the face by a bird, but the pilot was able to land in spite of his injuries wearing a spare pair of glasses. In some cases, a copilot was able to land the aircraft. In a few cases, the pilot heard a thump while flying but did not discover that the aircraft had been hit by a bird or birds until after landing when damage was discovered.

STRIKES CAN HAPPEN ANY TIME OF DAY

The NTSB reports also highlighted another important observation. Bird strikes can happen any time day or night and at various altitudes. In many cases, the strikes occurred during darkness. In other cases, the strikes occurred during daylight. In one case, an IFR pilot hit birds upon breaking out of a low overcast. In some cases, it was known that large numbers of birds were on the ground when the pilot attempted to takeoff or land.

In the case of a night bird strike while in cruise, there is little a pilot can do to avoid such a collision. But when the pilot is aware of





Graphic proof that birds and planes don't mix. The pilot of this light twin struck a Canada goose at night. Luckily he was in radar contact and communication with a military air base, where he was able to make an emergency landing. No injuries to the pilot, but fatal for the goose and a big dent in the pilot's wallet as well as windshield centerpost.

the possibility of birds on an airport or birds have been reported on the airport, a pilot must be prepared for a collision if a takeoff is attempted or a landing made while the birds are near or on the runway.

In such cases, it would appear to be wiser to delay the takeoff or landing until the birds clear the area.

If the birds are just loafing (a termed used in one government report to describe bird actions) on the runway and are not moving off, the pilot has to use good judgement in determining what to do. Contacting the tower, airport manager, or the local FBO is one solution.

The airport may have noise devices to scare the birds away or someone could drive a vehicle through the area to make the birds move, etc.

Regardless of what the airport does, it may be safer for someone on the ground to make the birds move than to try to move them in an aircraft and risk a bird strike.

If possible, the pilot might divert to another airport. Regardless, the pilot in command is responsible for the safe operation of his or her aircraft.

BIRD/WILDLIFE INFORMATION AND INCIDENT REPORTING

The appropriate FAA *Airport/Facility Directory* (A/FD) can warn pilots of potentially dangerous bird populations. Pilots flying into non-familiar airports can check the A/FD for any listings about birds/wildlife hazards. For example, the entry for New York's JFK International states, "Flocks of birds on and in/of [in the vicinity of] arpt." The Washington National Airport entry says, "Flocks of birds on and in/of arpt. Frequent seagull and goose and duck populations airborne over adjacent river areas." The Philadelphia International Airport entry also lists birds on and in/of arpt. (Its entry also lists another common problem for many airports: deer—but that's another story.)

In its ongoing effort to compile and track operational hazards, the FAA's Office of Airport Safety and Standards has FAA Form 5200-7, Bird Strike Incident/Investigation Report, that aircraft operators and pilots can use to report such incidents. The form asks for such information as extent of damage, estimated repair costs, incident location,

effect on flight, phase of flight, and information about the number and type of birds involved. It also asks if the pilot was warned of birds. The report can also be used to report other wildlife species incidents or damages. The form is included in the AIM, as Appendix 1, Bird Strike Incident/Ingestion Report. It is also available from local FAA offices and airports. According to FAA data, 2,200 civil bird strikes were reported in the U.S. in 1994.

Hopefully, no one will have to fill out a Bird Strike Incident/Ingestion report as we approach the beginning of another migratory season. Let's all keep a sharp lookout for our feathered friends.

After all, we are sharing their airspace. ➔

Editor's Note: We want to thank Mr. Chris P. Dwyer, formerly a Wildlife Biologist for the U.S. Department of Agriculture, for his suggestion that another article was needed on bird strikes and for the research material he provided for the article. Dwyer is now working with the Missouri Department of Conservation. We also want to thank the NTSB for the accident data, and the Andrews AFB Aero Club for its assistance.

APPENDIX 21

When Pilots Meet Birds It Can Be Deadly For Both

HOBBIES

When pilots meet birds it can be deadly for both

There's a war going in the Middle East, but it's not between people seeking a homeland and those defending one. It's between birds and planes.

In the periods of September-October and March-May about 500 million birds congregate more than 100 species fly over Israel. This tiny country, which is host to 65 per cent of the world's short population at one time or another, has a high number in the middle of the north-south routes of birds migrating between Europe and Africa.

Israel, Lebanon and Turkey are particularly important land masses to large soaring birds like eagles, hawks, vultures and storks because they produce rising columns of warm air called thermals. To conserve valuable energy, the birds circle upward on the thermals until they disperse and then glide downward to catch the next rising column of air.

The birds have used this airspace for millions of years. They are no longer alone. Between 1972 and 1994 there were 1,200 collisions between birds and military aircraft in Israel. None of the

for enthusiasts and long-time friend of mine. His PhD study on migratory movements of birds through Israel became invaluable to the air force and, as a result, bird strikes were reduced by 30 per cent.

Leishem is not satisfied, though. He had just returned to Israel from a fundraising trip in North America to help construct a network of migrating bird radar tracking stations not just for Israel but throughout the Middle East. He never did think small. Nor does he take no for an answer.

Already the first station is being built at Lefrion. Called the International Institute for Research on Bird Migration, it is costing \$12 to \$15 million U.S. to build, with an additional \$13 million raised to cover operating costs. It is scheduled to open in 1997 and will feature a research centre, museum of bird migration and an auditorium with a big screen to project the movements of the migrating birds. It will also house a Russian-made radar system. It normally costs \$700,000 U.S. but Leishem bought it "garage-sale".

But Leishem bought it "garage-sale".

style for a mere \$20,000 because of the devaluation of the Russian ruble.

Knowing Leishem as a "do-it-yourself" guy, I expect he will indeed realize his dream even if it means that he has to negotiate a comprehensive defence package for the entire Middle East.

Another Israeli ornithologist is making the news these days. Ofer Bahat, a doctoral candidate at Tel Aviv University, is studying the physiology of free-flying eagles using a sophisticated thermal camera and matching diagnostic software.

Bahat tracked the movements of several eagles with miniature transmitters and discovered that they often fast for a week to 10 days before finding food, usually in the form of carrion. When an eagle does find a good-sized dead animal, it increases its body weight by a third with just one huge feast. For example, a 7-kilogram bird can scarf down 2 kilograms of meat at one sitting. Normally the bird will loaf around for a day before resuming its regular activity.

But during those times of food short-

age, Bahat figures that the eagles have to take it easy to save energy, despite the fact that they must spend about 10 hours a day flying in search of their next meal.

Now, Israel isn't noted for its cool weather, so Bahat wondered how the gliding eagles were regulating their body temperature and managing their energy balance. To find the answer, an Israeli imaging technology firm, Elbit Industries, provided Bahat with an infrared camera and the Israeli Electric Company donated funds for the use of a special airborne platform for in-flight filming.

On his maiden flight, Bahat took the world's first infrared photo of a flying eagle. Analyses of the film showed that when the weather is hot, the long bare neck of the bird dissipates heat like a radiator. When it is cold, the blood vessels in the neck contract and instead conserve any heat loss.

To my mind, the lesson in all of the above is that co-operation and collaboration can lead to remarkable achievements. Enough said.



DAVID R. LEISHEM
BIRD'S EYE VIEW

birds survived, of course, and in a few cases, air force personnel were killed. Millions of dollars worth of damage has been done. One of the latest fatalities included a pilot and his co-pilot killed on Aug. 10, 1993, when a stork was sucked into one of their plane's two engines. The jet erupted in flames and crashed into the Negev Desert.

The key here is the date. August is not a time for migrating birds and the pilots had been caught off guard by the bird strike.

Earlier Yossi Leishem, an Israeli rap-

APPENDIX 22

NTSB Bird Hazard Briefing

NTSB Bird Hazard Briefing

Hazards of Bird Ingestion Into Aircraft Turbine Engines



January 11, 1996
Washington DC

Todd Curtis, Boeing, (206)294-1682

Significant Bird Strikes 1994-Present

- Over 175 Events in Boeing Safety Database
- All Are Large Jet Transports
- At Least 100 Causing Damage
- At Least 11 RTOs of 100 Knots or More
- One Hull Loss With Fatalities

Selected Recent Events

- 737-400 6/12/95 Turkey
- 737-300 11/2/95 Portland, ME
- 737-200 11/21/95 Hannover, Germany
- 747-200 1/1/96 Cairns, Australia

737-400, Turkey

- Dual Engine Ingestion Leading to RTO
- Seven Blade Pairs Replaced On Engine One
- All Blades Damaged on Engine Two

737-300, Portland ME

- Air Turn Back After Engine Two Ingestion
- Blade Fragments Penetrated Inlet Case

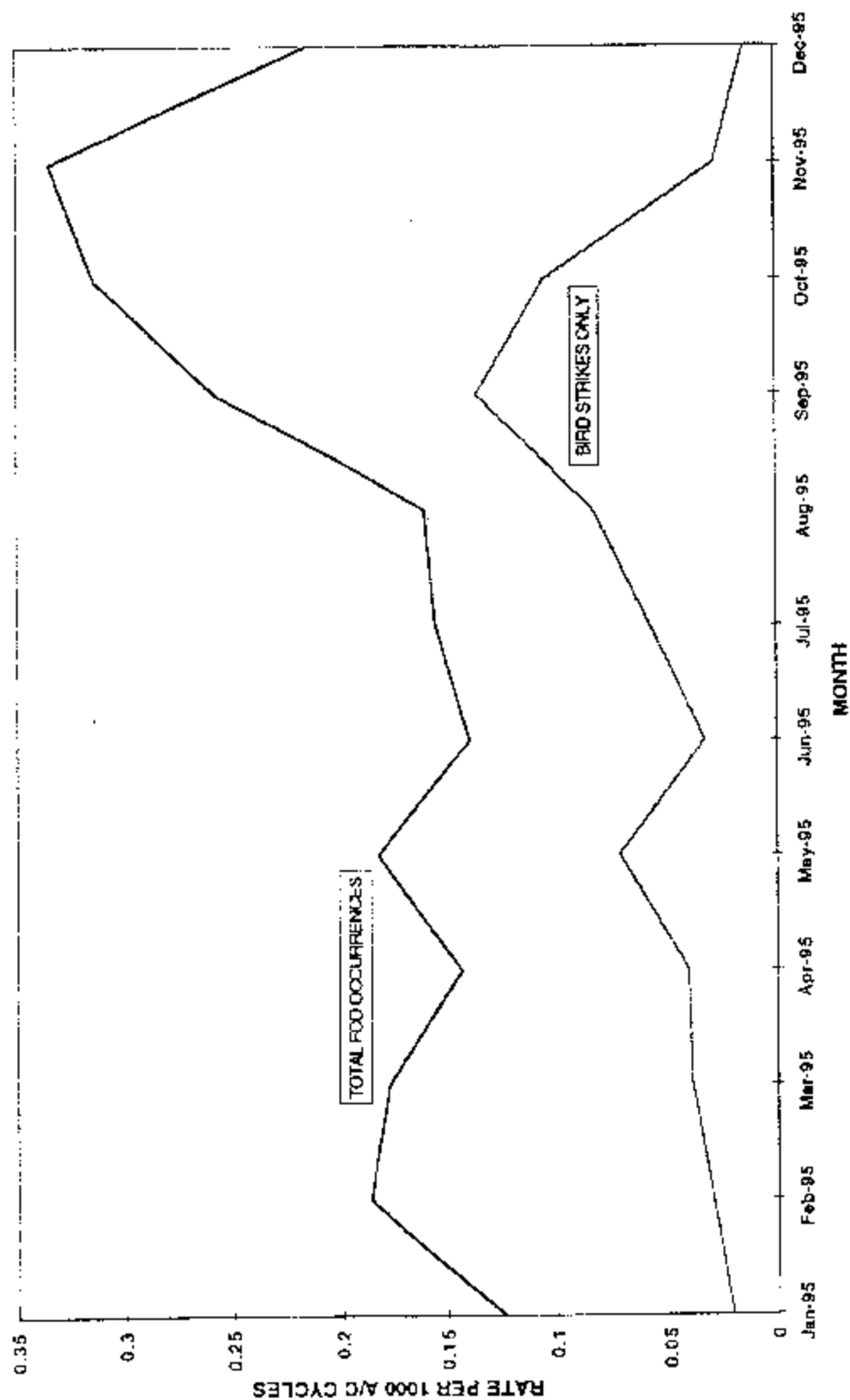
737-200, Germany

- Multiple Duck Strike at Night
- Both Engines Had All Fan Blades Damaged
- Air Flow Sensor Missing

747-200, Australia

- Multiple Goose Strike During Takeoff, ATB
- Twelve Sets of Fan Blades Replaced Engine One, Six Sets in Engine Two Plus Other Engine Two Damage
- Both Engines Replaced

UA FOD OCCURRENCES FOR 1995



DISCUSSION ITEMS (LARGE BIRD THREATS)

MANUFACTURER PERSPECTIVE

Data suggests that it is mostly a large transport threat at the engine level

- large intakes increase probability of ingesting whole large birds into multiple engines during flock encounters
- The current regulations (representing most of what is flying today) provide for "safe-power" up to 1-1/2 lb flocking birds
- The aircraft structure is not a problem at low encounter speeds associated with low altitude airport bird threats.

Concern: There continue to be multiple engine ingestions of large flocking birds, examples of which are:

DISCUSSION ITEMS (LARGE BIRD THREATS)

Examples of Concern

- 1) ORD B757 7/23/91
- 2) LGA A320 9/21/95
- 3) ORD MD80 12/10/95
- 4) JFK Concorde
- 5) Cairns Australia, B747 1/2/96
- 6) Elmendorf 9/23/95

DISCUSSION ITEMS (LARGE BIRD THREATS)

Airport Issues

- FAA oversight and R&D programs
- State oversight
- Airport operations
- Foreign programs and research

DISCUSSION ITEMS (LARGE BIRD THREATS)

Panel Discussion

What factors can reasonably be considered at airport level?

- identification of hazard
- Control of hazard

What is missing?

- Airport issues
- research needs
- Aircraft/engine design issues?

BIRD STRIKE COMMITTEE EUROPE



SOME BSCE COMMENTS ON PANEL DISCUSSION ITEMS

- a. Several years ago in a sample of 7500 European strikes only 1% were thought to be over 4 lb, however 1.9% of strikes by birds of any size affect more than one engine. Air transport operations are on the increase and so is the Canada goose population, by about 8% per annum. Hopefully, this meeting will help to focus attention on the problem. Other European countries are experiencing problems, including Scandinavia. It was a Special Subject at the 1994 BSCE meeting in Vienna, with several papers presented.
- b. Flocks of birds must not be allowed on or near airports. Airport management must, by now, be aware of the hazard and their responsibilities in minimising bird hazards. Pilots must NOT accept take-off clearance if they can see a potential hazard on the airport. Air Traffic Control would not clear an aircraft for take-off with a vehicle on the runway, equally they must not give clearance if there are hazardous birds around. Better a late departure than a long delay caused by a rejected take-off or fuel jettison and return. Good management can reduce the threat.
- c. Most research covers agriculture and amenity damage as well as public health aspects. The general public has to be convinced of the need to kill Canada geese on a wider scale. It is possible to obtain a licence for air safety reasons in Europe to kill outside the shooting season.
- d. The move from original 4 lb only, through medium multiple to mixed medium plus 8 lb is intended, in the long term, to reduce the risk but it remains an airport area problem. The methods of control exist, it is motivation and commitment to their use that is lacking.
- e. The airport control aspects are covered by BSCE Working Paper No 3 from BSCE meeting in Vienna 1994 'Feral Canada Geese as a Hazard to Aircraft in Europe: Options for Management and Control' by D Allan and C J Feare. The general control of non-migratory Canada geese is covered in Wildlife Biology Vol p129 to 143 'The Biology of Canada Geese in Relation to the Management of Feral Populations' by A Kirby and C Feare.
- f. These comments are not intended to address the question of resistance of aircraft and engines to large flocking bird strikes. The threat needs to be evaluated in the light of up-to-date statistics and the significance of new technology engine fans in this respect needs to be better understood.

General:

This subject is also likely to be discussed at the 1996 BSCE meeting in London 13-17 May. All are welcome, contact BSCE Chairman. A new version of the BSCE Green Booklet 'Some Measures Used by Different Countries to Reduce Bird Hazards' will probably be introduced.

J Thorpe
Chairman, BSCE
6 January 1996

Chairman: John Thorpe
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Safety Promotion Section
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NATIONAL TRANSPORTATION SAFETY BOARD
490 L'ENFANT PLAZA, EAST, S.W.
WASHINGTON, D.C. 20594

BIRD HAZARD BRIEFING

JANUARY 11, 1996

Proposed Agenda

Introduction and welcome-Mr. Goglia

Review of the recent ingestion problem-Mr. Weaver

Briefing on recent large bird encounters-Major Arrington

Correlation of engine ingestion data base
with recent large bird encounters- Messers. Weaver, Curtis,
Lewis

Airport Bird Control Programs-Mr. Southilier

Foreign Programs-Mr. Thorpe

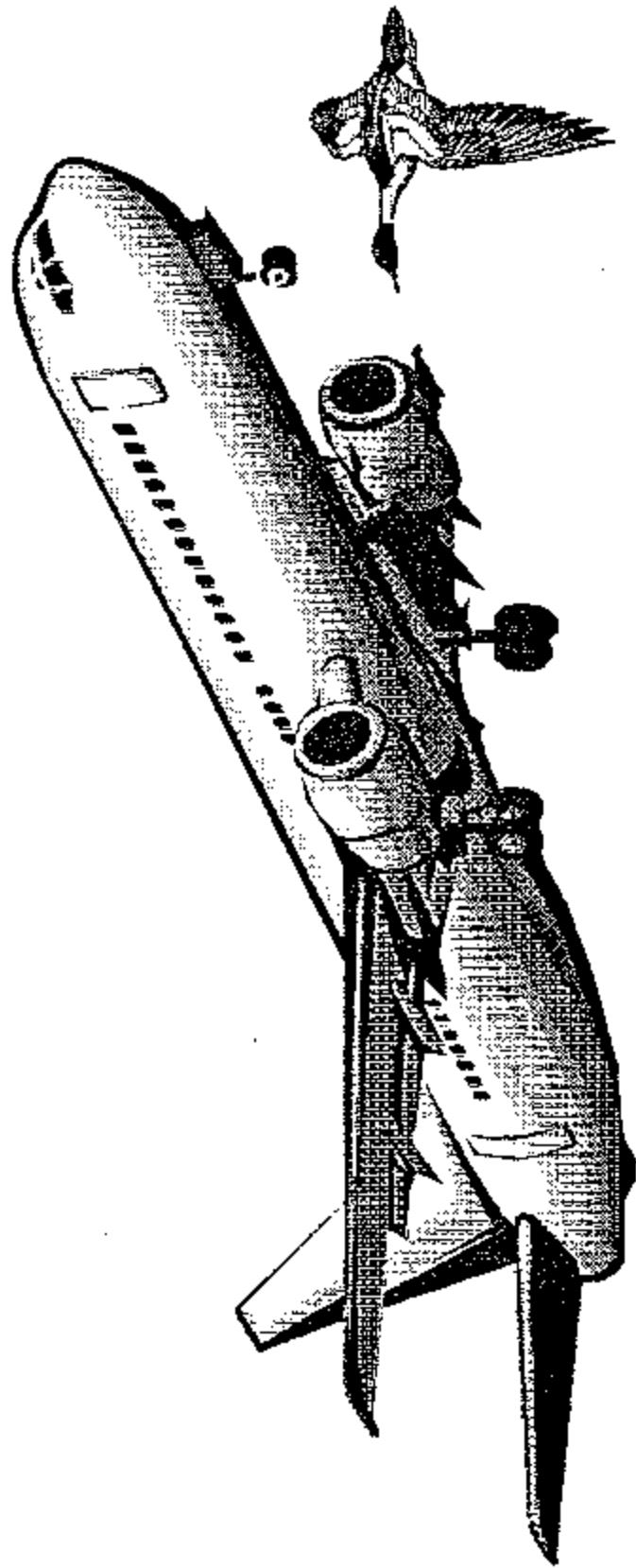
Countermeasure programs and devices

Group discussion.

Closing Remarks

Note: We will attempt to take periodic brakes and anticipate
taking our lunch brake from about 11:45 to 12:45.

Safety Recommendations Addressing Bird Strikes



November 22, 1995

National Transportation Safety Board
Recommendations addressing Bird Strikes
Report Date: 11/22/1995

Report : AAR-73-12
Accident Date : February 26, 1973
Accident City : ATLANTA
Accident State: GA

Recommendation Numbers

A-73-037 A-73-038

Abstract

A GATES LEARJET MODEL 24, N454RN, OPERATED BY THE MACHINERY BUYERS CORP., CRASHED AT 1012 P.S.T. ON FEBRUARY 26, 1973, AFTER TAKEOFF FROM DEKALB-PEACHTREE AIRPORT, ATLANTA, GEORGIA. THE TWO CREWMEMBERS AND FIVE PASSENGERS WERE FATAALLY INJURED, ONE PERSON ON THE GROUND SUSTAINED BURNS. THE AIRPLANE DEPARTED FROM RUNWAY 20L ON A FLIGHT PLAN TO MIAMI, FLORIDA. WITNESSES OBSERVED SMOKE TRAILING FROM THE AIRPLANE AS IT CROSSED THE FIELD BOUNDARY. THE TOWER CONTROLLER ADVISED THE CREW OF N454RN THAT THE AIRPLANE'S LEFT ENGINE APPEARED TO BE EMITTING SMOKE; THE CREW OF N454RN RESPONDED THAT THEY HAD "HIT SOME BIRDS." THE TOWER CONTROLLER INQUIRED WHETHER N454RN WAS RETURNING TO LAND, AND N454RN RESPONDED "DON'T BELIEVE WE'RE GONNA MAKE IT." AFTER THE CRASH, THE REMAINS OF 15 COMBUSTIBLES WERE FOUND WITHIN 150 FEET OF THE RUNWAY 2R THRESHOLD. A MUNICIPAL SMOKE IS LOCATED ADJACENT TO THE AIRPORT JUST EAST OF RUNWAY 2R/20L. THE NATIONAL TRANSPORTATION SAFETY BOARD DETERMINES THAT THE PROBABLE CAUSE OF THIS ACCIDENT WAS THE LOSS OF ENGINE THRUST DURING TAKEOFF DUE TO INGESTION OF BIRDS BY THE ENGINES, RESULTING IN LOSS OF CONTROL OF THE AIRPLANE. THE FEDERAL AVIATION ADMINISTRATION AND THE AIRPORT AUTHORITY WERE AWARE OF THE BIRD HAZARD AT THE AIRPORT; HOWEVER, CONTRARY TO PREVIOUS COMMITMENTS, THE AIRPORT MANAGEMENT DID NOT TAKE POSITIVE ACTION TO REMOVE THE BIRD HAZARD FROM THE AIRPORT ENVIRONMENT.

Log Number : 0469
Recommendation Number : A-73-037
Date of Issue : June 29, 1973
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : September 14, 1974

Recommendation Subject

DISSEMINATE BY THE WIDEST POSSIBLE DISTRIBUTION OF FAA ADVISORY CIRCULAR 150/5200-3A DATED MARCH 2, 1972, SUBJECT "BIRD HAZARDS TO AIRCRAFT." TO ENSURE THAT ALL AIRPORT OPERATORS, AIR CARRIERS, AIR TAXI OPERATORS, FLYING SCHOOLS, FIXED-BASE OPERATORS, AND AIRLINE TRANSPORT, COMMERCIAL, AND PRIVATE PILOTS, AND FLIGHT INSTRUCTORS ARE FULLY AWARE OF THE HAZARDS TO AVIATION ASSOCIATED WITH BIRD STRIKES.

Addressee : FAA

Date Of Response: 07/16/1973

ACTION HAS BEEN TAKEN TO INSURE THE WIDEST POSSIBLE DISTRIBUTION OF AC 150/5200-3A, BIRD HAZARDS TO AIRCRAFT. IN ADDITION TO THE NORMAL DISTRIBUTION OF 19,000 COPIES, THIS CIRCULAR HAS BEEN MADE PART OF INSPECTORS HANDBOOK FOR GENERAL AVIATION, SCHEDULED AIR CARRIER OPERATIONS, AIR TAXI OPERATIONS, AND ACCIDENT PRESENTATION SPECIALISTS.

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Date of NTSB Followup Ltr:

Log Number : 0469
Recommendation Number : A-73-033
Date of Issue : June 29, 1973
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : November 27, 1974

Recommendation Subject

DISSEMINATE THE CONTENTS OF THIS REPORT IN THEIR TRADE PUBLICATIONS TO THEIR MEMBERS TO ENSURE THAT THE POSSIBLE CONSEQUENCES OF BIRD HAZARDS TO AIRCRAFT ARE FULLY KNOWN TO ALL WHO MAY BE IN A POSITION TO CONTROL THIS HAZARD: NATIONAL ASSOCIATION OF STATE AVIATION OFFICIALS, AMERICAN ASSOCIATION OF AIRPORT EXECUTIVES, AIRPORT OPERATORS COUNCIL INTERNATIONAL, AIRCRAFT OWNERS & PILOTS ASSOCIATION, AIR TRANSPORT ASSOCIATION OF AMERICA, AIR LINE PILOTS ASSOCIATION, ALLIED PILOTS ASSOCIATION, NATIONAL AIR CARRIER ASSOCIATION, NATIONAL AIR TRANSPORTATION CONFERENCES, NATIONAL BUSINESS AIRCRAFT ASSOCIATION, AND NATIONAL PILOTS ASSOCIATION.

Addressee : FAA

Date of Response: 07/16/1973

LETTER FROM THE ORGANIZATION OF ACCREDITED AIRPORT EXECUTIVES TO SAY THAT THEY WILL DO ALL POSSIBLE THROUGH THEIR AIRPORT MANAGER MEMBERS TO CONTROL SUCH HAZARDS "ON AIRPORT" WHERE AIRPORT MANAGEMENT HAS THE NECESSARY AUTHORITY, OR REQUEST THE COOPERATION OF THOSE WITH AUTHORITY TO CONTROL SUCH HAZARDS IN PROXIMATE "OFF AIRPORT" LOCATIONS. MULTIPLE RESPONSES, SEE FILE

Date of NTSB Followup Ltr:

National Transportation Safety Board
Recommendations addressing Bird Strikes
Report Date: 11/22/1995

Report :
Accident Date : March 25, 1975
Accident City :
Accident State :

Recommendation Numbers

A-75-024

Abstract

ON DECEMBER 4, 1974, THE NATIONAL TRANSPORTATION SAFETY BOARD FORWARDED TO THE FAA SAFETY RECOMMENDATIONS A-74-115 AND 116, WHICH DEALT WITH OUR INVESTIGATION OF THE DURABILITY OF DRILLED FAN BLADES ON CF6 ENGINES. NOW THAT OUR INVESTIGATION IS COMPLETED, THERE ARE THREE OTHER AREAS WHICH WE BELIEVE WARRANT CORRECTIVE ACTION. THESE AREAS ARE: (1) ENGINE ICING CERTIFICATION TESTS; (2) EXTENDED OPERATION OF CF6-50 POWERED AIRCRAFT IN MODERATE ICING CONDITIONS; AND (3) PERFORMANCE DEGRADATION OF LARGE TURBOFAN ENGINES CAUSED BY BIRD INGESTION.

Log Number : 0610
Recommendation Number : A-75-024
Date of Issue : March 25, 1975
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : December 03, 1975

Recommendation Subject

GATHER ACCURATE ENGINE PERFORMANCE INFORMATION FROM SELECTED IN-SERVICE CASES OF BIRD INGESTION BY LARGE TURBOFAN ENGINES WHICH RESULTED IN ENGINE SHUTDOWN, SERIOUS THRUST LOSS, OR EXCESSIVE VIBRATION. THIS INFORMATION, IN COMBINATION WITH THE MOST RECENT ORNITHOLOGICAL DATA AND ADVANCES IN ENGINE TECHNOLOGY, SHOULD BE USED TO EVALUATE THE ADEQUACY OF BIRD INGESTION CRITERIA FOR LARGE TURBOFAN ENGINES.

Addressee : FAA

Date Of Response: 05/02/1975

FAA LTR: THE FAA WILL ANALYZE THE REPORTS OF INCIDENTS OF SHUTDOWN OF LARGE TURBOFAN ENGINES AFTER BIRD INGESTION. THE PURPOSE OF THIS ANALYSIS WILL BE TO EVALUATE THE ADEQUACY OF PRESENT BIRD INGESTION REQUIREMENTS FOR ENGINE CERTIFICATION. THE BOARD WILL BE ADVISED OF FAA'S ACTIONS BY JUNE 30, 1975. 7/18/75 - FAA LTR: FAA OBTAINED AVAILABLE DATA OF BIRD INGESTION BY JT9D AND CF6 ENGINES. ANALYSIS SHOWED 214 TOTAL BIRD INGESTIONS ON HIGH-BYPASS ENGINES OVER A FIVE-YEAR PERIOD ENCOMPASSING OVER 15 MILLION ENGINE HOURS AND OVER ONE MILLION FLIGHTS. THE AVERAGE IN-FLIGHT SHUTDOWN RATE IS APPROXIMATELY .003 FOR 1,000 ENGINE HOURS. THERE WAS NO CASE OF MULTIPLE ENGINE SHUTDOWNS ON HIGH-BYPASS ENGINES. FAA BELIEVES BIRD INGESTION CRITERIA ARE ADEQUATE. THE ACCEPTANCE CRITERIA WHICH WERE FORMERLY OF AN ADVISORY NATURE IN THE CERTIFICATION PROCESS HAVE NOW BEEN INCORPORATED AS REQUIREMENT BY THE ADOPTION OF AMENDMENT 33-6 TO PART 33 OF THE FAR'S. A JOINT FAA/NASA PROJECT IS PLANNED TO REVIEW ADVANCES IN MATERIALS AND NEW ENGINE DESIGN FEATURES.

Date of NTSB Followup Ltr:

National Transportation Safety Board
Recommendations addressing Bird Strikes
Report Date: 11/22/1995

Report : AAR-76-19
Accident Date : November 12, 1975
Accident City : JAMAICA
Accident State : NY

Recommendation Numbers

A-76-008 A-76-009 A-76-010 A-76-011 A-76-012 A-76-013

Abstract

ON NOVEMBER 12, 1975, OVERSEAS NATIONAL AIRWAYS FLIGHT 032, A McDONNELL DOUGLAS DC-10-30, CAUGHT FIRE DURING THE TAKEOFF ROLL ON RUNWAY 13R AT JOHN F. KENNEDY INTERNATIONAL AIRPORT (JFK), JAMAICA, NEW YORK. THE FIRE ERUPTED IN THE AREA OF THE RIGHT ENGINE AFTER THE AIRCRAFT ENCOUNTERED A FLOCK OF SEA GULLS WHICH HAD BEEN ON THE RUNWAY.

Log Number : 0699
Recommendation Number : A-76-008
Date of Issue : March 08, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : August 15, 1978

Recommendation Subject

IN COORDINATION AND COOPERATION WITH THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY, EXPEDITE THE FOLLOWING ACTIONS: (A) DETERMINE THE WEATHER CONDITIONS, OCEAN TIDE CONDITIONS, SEASONAL FACTORS, MIGRATORY PATTERNS, AND DAILY MOVEMENT PATTERNS WHICH COULD BE USED TO FORECAST PERIODS OF GREATEST BIRD HAZARDS AT THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY AIRPORTS AND TAKE EFFECTIVE ACTIONS TO DISPERSE THE BIRDS BEFORE USE OF THE AFFECTED RUNWAYS IS PERMITTED. (B) REMOVE THE ABANDONED RUNWAY 7-25 PIER AT JFK. (C) REMOVE THE BIRD ATTRACTION TO THE BEACH ADJACENT TO THE SOUTH AND EAST BOUNDARIES OF THE AIRPORT BY ELIMINATING THE BEACH THROUGH GRAVEL FILL, DREDGING, A SEAWALL OR OTHER APPROPRIATE MEANS. (D) DRAIN THE CHAPEL POND AT JFK.

Addressee : FAA

Date Of Response: 06/16/1976

FAA LTR: FAA IS PROCESSING RECOMMENDATIONS WITH PORT AUTHORITY AND U.S. FISH AND WILDLIFE SERVICE. (A) ADDITIONAL WORK NEEDS TO BE ACCOMPLISHED; (B) FAA CONCURS WITH PORT AUTHORITY THAT REMOVAL OF PIER IS NOT NECESSARY PROVIDED OTHER ACTION TAKEN TO PREVENT ROOSTING OR RESTING OF BIRDS; (C) FAA CONCURS WITH PORT AUTHORITY THAT BEACHES ADJACENT TO THE AIRPORT DO NOT CAUSE A BIRD PROBLEM; AND (D) FAA AGREES THAT POOL SHOULD BE DRAINED.

Date of NTSB Followup Ltr:

National Transportation Safety Board
Recommendations addressing Bird Strikes
Report Date: 11/22/1995

Date Of Response: 04/14/1978

FAA LTR: AS TO PART (A), FORECASTING IS AN ONGOING PROBLEM AND ONLY TIME AND EXPERIENCE WILL PROVIDE THE EXPERTISE TO FORECAST PATTERNS OF BIRDS IN THE VICINITY OF JFK. PATROLS ARE IN CONSTANT OPERATION TO DISPERSE BIRDS AT PORT AUTHORITY AIRPORTS. IN RESPONSE TO PART (D), THE CHAPEL POND AT JFK WAS DRAINED AND MONITORED FOR THREE MONTHS. AFTER THAT TIME IT WAS FILLED AND MONITORED FOR BIRD ACTIVITY; IT WAS DETERMINED THAT THE POND ATTRACTED A SUBSTANTIAL NUMBER OF BIRDS. IT WAS DRAINED AGAIN AND HAS REMAINED SO.

Date of NTSB Followup Ltr:

Log Number : 0699
Recommendation Number : A-76-009
Date of Issue : March 08, 1976
NTSB Status : CLOSED - ACCEPTABLE ALTERNATE ACTION
Closeout Date : August 15, 1978

Recommendation Subject

REQUIRE A PHYSICAL INSPECTION OF A RUNWAY AND ADJACENT AREAS AT EACH CONTROLLED AIRPORT CERTIFICATED UNDER 14 CFR 139, WHICH HAS A RECOGNIZED BIRD-HAZARD PROBLEM ON EACH OCCASION BEFORE: (A) DESIGNATING THAT RUNWAY AS THE ACTIVE RUNWAY, OR (B) ALLOWING TAKEOFFS FROM OTHER THAN THE ACTIVE RUNWAY

Addressee : FAA

Date Of Response: 06/16/1976

FAA LTR: DETERMINATION OF WHAT CONSTITUTES A "RECOGNIZED BIRD HAZARD" IS COMPLEX. WE HAVE INITIATED A STUDY TO IDENTIFY THOSE AIRPORTS WHICH HAVE LARGE CONCENTRATIONS OF BIRDS WHICH COULD BE A HAZARD. STUDY TO BE COMPLETED WITHIN NINE MONTHS.

Date of NTSB Followup Ltr:

Date Of Response: 04/14/1978

FAA LTR: THE STUDY WAS CONDUCTED. THE FINDINGS OF THE UNPUBLISHED STUDY WERE INCORPORATED INTO FAA ORDER 5200.6 "GUIDELINES FOR THE NATIONAL PLAN ON BIRD HAZARD DETECTION AND CONTROL" DATED 11/15/76 WHICH IS BEING IMPLEMENTED BY ALL REGIONS.

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Date of NTSB Followup Ltr:

Log Number : 0609
Recommendation Number : A-76-010
Date of Issue : March 08, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : August 15, 1978

Recommendation Subject

FREQUENTLY REVIEW THE OPERATIONS MANUAL FOR EACH AIRPORT CERTIFICATED UNDER 14 CFR 139 WHICH HAS A RECOGNIZED BIRD HAZARD PROBLEM TO ASSURE THAT THE PROVISIONS OF THEIR BIRD-HAZARD REDUCTION PROGRAM ARE ADEQUATE.

Addressee : FAA

Date of Response: 06/16/1976

FAA LTR: AIRPORT OPERATIONS MANUAL REVIEWED EACH ANNUAL INSPECTION. CONSIDERING REVISIONS. COMPLETION EXPECTED WITHIN ONE YEAR.

Date of NTSB Followup Ltr:

Date of Response: 04/14/1978

FAA LTR: A SPECIAL PROGRAM WAS ESTABLISHED TO REVIEW THE AIRPORT OPS MANUAL ON A SEMI-ANNUAL BASIS TO ENSURE THAT THEY WERE BEING MAINTAINED IN AN UP-TO-DATE STATUS AND TO ASSURE THAT THE PROVISIONS OF THE BIRD HAZARD REDUCTION PROGRAMS ARE ADEQUATE. OUR CERTIFICATION STAFF CONTINUED THIS PROGRAM THROUGH SEVERAL CYCLES. WE NOW FIND THAT THE OPS MANUALS AND THE BIRD HAZARD REDUCTION PROGRAMS ARE ADEQUATE.

Date of NTSB Followup Ltr:

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Log Number : 0699
Recommendation Number : A-76-011
Date of Issue : March 08, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : August 15, 1978

Recommendation Subject

REQUIRE THAT A SPECIALLY TRAINED, STAFFED, AND EQUIPPED BIRD- DISPERSAL ORGANIZATION BE ESTABLISHED AT EACH CONTROLLED
CERTIFICATED AIRPORT WITH A RECOGNIZED BIRD- HAZARD PROBLEM.

Addressee : FAA

Date Of Response: 06/16/1976

FAA LTR: WHEN THE STUDY IDENTIFIED IN A-76-009 IS COMPLETED, WE WILL DETERMINE THE TYPE OF SPECIALIZED EXPERTISE NEEDED
WITHIN EACH JURISDICTIONAL AREA.

Date of NTSB Followup Ltr:

Date Of Response: 04/14/1978

FAA LTR: ORDER 5200.6, PARAGRAPH 6.C.(2), PROVIDES FOR APPROPRIATE ACTION.

Date of NTSB Followup Ltr:

Log Number : 0699
Recommendation Number : A-76-012
Date of Issue : March 08, 1976
NTSB Status : CLOSED - ACCEPTABLE ALTERNATE ACTION
Closeout Date : June 16, 1977

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Recommendation Subject:

AMEND 14 CFR 139.67 TO REQUIRE THAT, WHERE THE ADMINISTRATOR FINDS THAT A BIRD HAZARD EXISTS, AN ECOLOGICAL STUDY BE CONDUCTED TO DETERMINE THE MEASURES NECESSARY FOR AN EFFECTIVE BIRD-HAZARD REDUCTION PROGRAM.

Addressee : FAA

Date Of Response: 05/16/1976

FAA LTR: THE STUDY AND SUBSEQUENT ANALYSES DESCRIBED IN A-76-009 MAY INDICATE A NECESSITY FOR FORMAL ECOLOGICAL STUDIES TO DETERMINE THE FACT OF ANY EXISTING HAZARDOUS CONDITIONS AND METHODS FOR HAZARD REDUCTION. ANY EXPANSION OF OUR CURRENT UNDERTAKING OR EFFORTS TO REGULATE ARE LIMITED BY ECONOMIC IMPACT, FEDERAL FINANCIAL ASSISTANCE CAPABILITY, AND AVAILABLE FAA RESOURCES.

Date of NTSB Followup Ltr:

Log Number : C699
Recommendation Number : A-76-013
Date of Issue : March 08, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : May 20, 1981

Recommendation Subject:

REVISE FAA FORM 5280-3, AIRPORT CERTIFICATION SAFETY INSPECTION, TO INCLUDE MORE DETAILED CRITERIA FOR USE BY AIRPORT CERTIFICATION SPECIALISTS TO EVALUATE THE BIRD HAZARD POTENTIAL AT AN AIRPORT. THESE CRITERIA SHOULD INCLUDE, BUT NOT BE LIMITED TO, MIGRATORY PATTERNS, LOCAL ATTRACTANTS, AND AIRPORT FEATURES LIKELY TO ATTRACT BIRDS.

Addressee : FAA

Date Of Response: 06/16/1976

FAA LTR: CONCURRENTLY WITH STUDIES INITIATED ON BIRD HAZARDS, WE WILL REVISE FAA FORM 5280.3, AIRPORT CERTIFICATION SAFETY INSPECTION, TO PROVIDE GUIDANCE TO CERTIFICATION INSPECTORS ON BIRD HAZARDS. WE EXPECT TO COMPLETE THE REVISION CONCURRENT WITH THE STUDY IDENTIFIED IN A-76-009.

Date of NTSB Followup Ltr:

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Date Of Response: 04/14/1978

FAA LTR: THE EXPANSION OF FAA FORM 5280.3 TO INCLUDE MORE DETAILED CRITERIA FOR USE BY AIRPORT CERTIFICATION SPECIALISTS IN EVALUATING THE BIRD HAZARD POTENTIAL AT AN AIRPORT, SHOULD BE COMPLETED WITHIN THE NEXT 60 DAYS. A COPY OF THE REVISED FORM WILL BE FURNISHED TO THE BOARD WHEN AVAILABLE.

Date of NTSB Followup Ltr: 03/20/1981

Date Of Response: 05/01/1981

FEDERAL AVIATION ADMINISTRATION LTR: THE FAA HAS NOW COMPLETED ITS WORK ON THE EXPANDED FAA FORM 5280-3, AIRPORT CERTIFICATION SAFETY INSPECTION. THIS REVISED VERSION INCLUDES MORE DETAILED CRITERIA FOR USE BY AIRPORT CERTIFICATION SPECIALISTS IN EVALUATING THE BIRD HAZARD POTENTIAL AT AN AIRPORT.

Date of NTSB Followup Ltr: 05/20/1981

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Addressee : FAA

Date Of Response: 04/02/1976

(76/07/26) CE IS PLANNING TO CONTINUE TESTING OF THE CF6 ENGINE TO VALIDATE THE USE OF AN ALUMINUM HONEYCOMB FAN BOOSTER COMPRESSOR SHROUD RUB STRIP. ONE OR MORE TESTS ARE PLANNED. THE FIRST TEST, USING A CF6 ENGINE, IS SCHEDULED FOR THE END OF APRIL. FURTHER TESTING MAY BE SCHEDULED DEPENDING ON THE RESULTS OF THIS TEST. ANY DECISION BY THE FAA WITH RESPECT TO ACTUAL BIRD INGESTION TESTS WILL BE MADE ONLY AFTER ANALYSIS OF ALL TEST RESULTS. FAA RESPONSE OF 2/7/78 STATING FIVE ENGINES LEFT TO BE MODIFIED

Date of NTSB Followup Ltr:

Log Number : 0727
Recommendation Number : A-76-062
Date of Issue : April 01, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : September 29, 1978

Recommendation Subject

UNTIL THE CF6 ENGINE IS MODIFIED, REQUIRE THAT A BIRD PATROL SWEEP RUNWAYS AT ALL AIRPORTS WHICH HAVE RECOGNIZED BIRD PROBLEMS AND ARE SERVED BY CF6-POWERED AIRCRAFT. THE SWEEP SHOULD BE MADE BEFORE A RUNWAY IS PUT INTO OPERATION FOR CF6-POWERED AIRCRAFT AND AT SUFFICIENT INTERVALS THEREAFTER TO ASSURE THAT A BIRD HAZARD DOES NOT EXIST.

Addressee : FAA

Date Of Response: 04/02/1976

(76/07/26) A SPECIAL FAA TASK FORCE VISITED SEVERAL AIRPORTS TO REVIEW AND EXAMINE THE BIRD PROBLEM. A GRANT WAS TRANSMITTED TO ALL REGIONS TO IDENTIFY AIRPORTS WHERE A BIRD HAZARD PROBLEM EXISTS AND TO IMPLEMENT ACTION TO ALLEVIATE THE HAZARD. A SERIES OF MEETINGS HAVE BEEN PLANNED WITH ATA, AIRLINES, AND AIRPORT OPERATORS COUNCIL INTERNATIONAL. THE FAA WILL DEVELOP A NATIONAL PLAN OF IMPLEMENTATION. SUPPLEMENT DATED 7/24/78: FAA FEELS THAT IMPLEMENTATION OF FAA ORDER 5200.6... WHEN COMBINED WITH OUR ACTIONS PERTINENT TO THE CF-6 ENGINE MEETS THE REQUIREMENTS OF RECOMMENDATION A-76-62... WE PLAN NO FURTHER ACTION AT THIS TIME

Date of NTSB Followup Ltr:

National Transportation Safety Board
Recommendations addressing Bird Strikes
Report Date: 11/22/1995

Report : AAR-76-19
Accident Date : November 12, 1975
Accident City : ORMAICA
Accident State: NY

Recommendation Numbers

A-76-059 A-76-060 A-76-061 A-76-062 A-76-064

Abstract

ON MARCH 11, 1976, THE NATIONAL TRANSPORTATION SAFETY BOARD COMPLETED ITS PUBLIC HEARING INTO THE OVERSEAS NATIONAL AIRWAYS, INC., ACCIDENT OF NOVEMBER 12, 1975. DURING THAT ACCIDENT, THE CREW OF A MCDONNELL DOUGLAS DC-10-30F REJECTED TAKEOFF FROM JOHN F. KENNEDY INTERNATIONAL AIRPORT AFTER A NUMBER OF LARGE BIRDS WERE INGESTED INTO THE NO. 3 ENGINE. ONE OF THE BASIC ISSUES IN THE ACCIDENT WAS THE CATASTROPHIC DISINTEGRATION OF THE ENGINE.

Log Number : 0727
Recommendation Number : A-76-059
Date of Issue : April 01, 1976
NTSB Status : CLOSED - ACCEPTABLE ALTERNATE ACTION
Closeout Date : February 02, 1979

Recommendation Subject

REQUIRE IMMEDIATE RETEST OF THE GENERAL ELECTRIC CF6 ENGINE TO DEMONSTRATE ITS COMPLIANCE WITH THE COMPLETE BIRD INGESTION CRITERIA OF AC 33-1A.

Addressee : FAA

Date Of Response: 04/02/1976

(76/07/26) THE FAA'S RESPONSE DOES NOT SPECIFICALLY ADDRESS ITSELF TO THE RECOMMENDATION. HOWEVER, THE FAA BELIEVES THAT ON THE BASIS OF OPERATIONAL AS WELL AS CERTIFICATION TESTS WHERE BIRD INGESTION DAMAGE WAS ENCOUNTERED, IT APPEARED HIGHLY IMPROBABLE THAT THE BIRD INGESTION WOULD PRODUCE ENOUGH UNBALANCE AND SUBSEQUENT DAMAGE TO CREATE THE SERVICE FAILURE MODE. IT WAS THEREFORE, CONSIDERED MOST APPROPRIATE TO SIMULATE A BIRD STRIKE BY CONTROLLED FAN BLADE FAILURE TO A DEGREE EXCEEDING THE MOST SEVERE UNBALANCE CONDITIONS ENCOUNTERED TO DATE. IT WAS ALSO CONSIDERED IMPORTANT TO UNBALANCE CONDITIONS WITH THE ABRADABLE EPOXY REMOVED AND REPLACE WITH ALUMINUM HONEYCOMB MATERIAL. THE FAA PARTICIPATED IN THE TESTS OF BOTH THE CF6-50 AND CF6-50 ENGINES. FAA LTR 2/7/78: THE EXTENSION TO THE COMPLIANCE DATE FOR AD 76-21-04 (CF6-60 ABRADABLE ROOSTER SHROUD STRIP REPLACEMENT) WAS GRANTED AT THE REQUEST OF TWO AIRLINE OPERATORS BECAUSE THE REQUIREMENT OF FULL COMPLIANCE BY 12/31/77 WOULD PROVIDE A SERIOUS IMPACT ON THEIR FLIGHT SCHEDULES...IT WAS NOT CONSIDERED A COMPROMISE IN SAFETY TO DEFER COMPLIANCE COMPLETION UNTIL 6/30/78 SINCE THE CF6-50 MODEL ENGINE CONTAINS ONLY ONE-THIRD THE AMOUNT OF EPOXY MATERIAL AS THE CF6-50 MODEL. THE CF6-50 ENGINES WERE MODIFIED BY 6/1/77.

Date of NTSB Followup Ltr: 01/06/1978

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Log Number : 0727
Recommendation Number : A-76-060
Date of Issue : April 01, 1976
NTSB Status : CLOSED - ACCEPTABLE ALTERNATE ACTION
Closeout Date : February 02, 1979

Recommendation Subject

REQUIRE THAT ANY ENGINE MODIFICATIONS NECESSARY TO COMPLY WITH THE BIRD INGESTION CRITERIA OF AC 33-1A BE INCORPORATED INTO ALL NEWLY MANUFACTURED CF6 ENGINES.

Addressee : FAA

Date of Response: 04/02/1976

(76/07/26) 60. CE IS PLANNING TO CONTINUE TESTING OF THE CF6 ENGINE TO VALIDATE THE USE OF AN ALUMINUM HONEYCOMB FAN BOOSTER COMPRESSOR SHROUD RUB STRIP. ONE OR MORE TESTS ARE PLANNED. THE FIRST TEST, USING A CF6 ENGINE, IS SCHEDULED FOR THE END OF APRIL. FURTHER TESTING MAY BE SCHEDULED DEPENDING ON THE RESULTS OF THIS TEST. ANY DECISION BY THE FAA WITH RESPECT TO ACTUAL BIRD INGESTION TESTS WILL BE MADE ONLY AFTER ANALYSIS OF ALL TEST RESULTS. FAA LTR 2/7/78: THE EXTENSION TO THE COMPLIANCE DATE FOR AD 76-21-04 (CF6-6D ABRASABLE BOOSTER SHROUD STRIP REPLACEMENT) WAS GRANTED AT THE REQUEST OF TWO AIRLINE OPERATORS BECAUSE THE REQUIREMENT OF FULL COMPLIANCE BY 12/31/77 WOULD PROVIDE A SERIOUS IMPACT ON THEIR FLIGHT SCHEDULES. IT WAS NOT CONSIDERED A COMPROMISE IN SAFETY TO DEFER COMPLIANCE COMPLETION UNTIL 6/30/78 SINCE THE CF6-6 MODEL ENGINE CONTAINS ONLY ONE-THIRD THE AMOUNT OF EPOXY MATERIAL AS THE CF6-50 MODEL. THE CF6-50 ENGINES WERE MODIFIED BY 6/1/77.

Date of NTSB Followup Ltr: 01/06/1978

Log Number : 0727
Recommendation Number : A-76-061
Date of Issue : April 01, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : June 08, 1978

Recommendation Subject

REQUIRE THAT ANY ENGINE MODIFICATIONS NECESSARY TO COMPLY WITH THE BIRD INGESTION CRITERIA OF AC 33-1A BE INCORPORATED INTO ALL CF6 ENGINES IN SERVICE.

National Transportation Safety Board
Recommendations addressing Bird Strikes
Report Date: 11/22/1995

Log Number : 0727
Recommendation Number : A-76-064
Date of Issue : April 01, 1976
NTSB Status : CLOSED - ACCEPTABLE ACTION
Closeout Date : July 30, 1986

Recommendation Subject

AMEND 14 CFR 33.77 TO INCREASE THE MAXIMUM NUMBER OF BIRDS IN THE VARIOUS SIZE CATEGORIES REQUIRED TO BE INGESTED INTO TURBINE ENGINES WITH LARGE INLETS. THESE INCREASED NUMBERS AND SIZES SHOULD BE CONSISTENT WITH THE BIRDS INGESTED DURING SERVICE EXPERIENCE OF THESE ENGINES.

Addressee : FAA
Address Status CAA as of 05/09/1986 - CLOSED - ACCEPTABLE ACTION

Date Of Response:

Date of NTSB Followup Ltr: 05/23/1984

Date Of Response: 04/02/1976

(76/07/26) CONSISTENT WITH YOUR RECOMMENDATION, THE AGENCY IS IN THE PROCESS OF SCHEDULING A REGULATORY REVIEW WITH ALL INTERESTED PARTIES TO IDENTIFY AREAS NEEDING POSSIBLE REVISION IN FAR 33. SPECIAL ATTENTION TO FAR 33.77 WILL BE GIVEN.

Date of NTSB Followup Ltr: 07/30/1980

Date Of Response: 10/30/1980

FEDERAL AVIATION ADMINISTRATION LTR: THE FAA ACKNOWLEDGES THE NEED FOR BETTER DATA RELATING TO THE NUMBER AND SIZES OF BIRDS BEING INGESTED. BECAUSE THE NORMAL REPORTING ACTIVITY OF THESE EVENTS DOES NOT USUALLY PROVIDE INFORMATION OF THIS KIND, THE FAA HAS TAKEN THE INITIAL STEPS TO ESTABLISH A SPECIAL PROJECT TO OBTAIN THE NEEDED DATA. THE FAA WILL TAKE APPROPRIATE ACTION IF STATISTICALLY MEANINGFUL DATA ARE OBTAINED WHICH JUSTIFY THE AMENDMENT OF EXISTING STANDARDS.

Date of NTSB Followup Ltr: 12/03/1980

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Date of Response: 12/10/1981

FAA LTR: THE FAA IS IN THE PROCESS OF COLLECTING STANDARD USE DATA TO ALLOW PROPER ANALYSIS OF BIRD INGESTION INTO LARGE HIGH BYPASS RATIO TURBOFAN ENGINES. CONTRACTS HAVE BEEN AWARDED TO THE GENERAL ELECTRIC COMPANY, PRATT & WHITNEY AIRCRAFT GROUP, AND ROLLS-ROYCE, INC., TO OBTAIN INFORMATION REQUIRED TO EVALUATE THIS HTSB RECOMMENDATION. EACH COMPANY HAS IDENTIFIED AN ENGINEERING TEAM TO INVESTIGATE SIGNIFICANT BIRD INGESTION INCIDENTS. WHEN AN INCIDENT OCCURS, THE TEAM WILL BE DISPATCHED TO THE SCENE TO OBTAIN INFORMATION ON KINDS OF BIRDS, NUMBER OF BIRDS, THROUST LOSS, DEGREE OF ENGINE AND AIRPLANE DAMAGE, ETC. EACH COMPANY WILL CONDUCT ITS OWN ENGINE INVESTIGATIONS OVER A PERIOD WHICH MAY BE EXTENDED TO TWO YEARS IN AN ATTEMPT TO GATHER SUFFICIENT DATA FOR A STATISTICALLY VALID SAMPLE. A FINAL REPORT WILL BE PREPARED AND A COPY WILL BE FORWARDED TO THE BOARD. THE FAA WILL TAKE APPROPRIATE REGULATORY ACTION IF MEANINGFUL DATA ARE OBTAINED WHICH JUSTIFY THE AMENDMENT OF EXISTING STANDARDS.

Date of NTSB Followup Ltr: 03/22/1982

Date of Response: 05/10/1985

FAA LTR: ENCLOSED FOR THE BOARD'S INFORMATION IS A COPY OF "A STUDY OF BIRD INGESTIONS INTO LARGE HIGH BYPASS RATIO TURBINE AIRCRAFT ENGINES." THE FAA'S TECHNICAL CENTER CONDUCTED A WORLDWIDE STUDY OF BIRD INVESTIGATIONS BY LARGE, HIGH BYPASS-RATIO TURBOFAN ENGINES. THE STUDY INCLUDED ALL KNOWN INGESTIONS OF THIS TYPE IN SERVICE, AND COVERED THE PERIOD FROM MAY 1, 1981, THROUGH JUNE 3, 1983. THE TECHNICAL CENTER HAS ANALYZED THIS DATA (IN ORDER TO CHARACTERIZE THE BIRD STRIKE ENVIRONMENT) AND PREPARED THIS REPORT. WE ARE IN THE FINAL PLANNING STAGES FOR THE FAA'S COURSE OF ACTION RELATIVE TO THIS ISSUE. WE WILL ADVISE THE BOARD IN ABOUT 60 DAYS OF OUR PROGRESS OR FURTHER ACTIONS.

Date of NTSB Followup Ltr: 06/07/1985

Date of Response: 10/29/1985

THE FAA HAS DECIDED TO GATHER ADDITIONAL BIRD INGESTION SERVICE DATA TO IMPROVE OUR STATISTICAL DATA BASE ON THE LATEST CLASS OF ENGINES (I.E., THOSE CERTIFICATED TO THE CURRENT REGULATIONS AND METHODS). THE STUDY ADDRESSED ABOVE CONTAINS ONLY A RELATIVELY SMALL AMOUNT OF DATA ON THE LATEST CLASS OF ENGINES BECAUSE THEY WERE ONLY BEGINNING TO ENTER SERVICE AT THE TIME THE DATA WAS BEING GATHERED. THERE DOES EXIST, HOWEVER, SUFFICIENT DATA ON THESE ENGINES TO CONCLUDE THAT THEY REPRESENT A SIGNIFICANT IMPROVEMENT OVER PREVIOUS ENGINES IN THEIR TOLERANCE TO BIRD INGESTION. THE ADDITIONAL DATA GATHERING MENTIONED ABOVE WILL ALLOW THE FAA TO QUANTIFY THIS IMPROVEMENT. DETAILS OF THESE FUTURE STUDIES ARE BEING DEVELOPED. I WILL KEEP THE BOARD ADVISED OF PROGRESS AND ACTIONS.

Date of NTSB Followup Ltr: 12/10/1985

National Transportation Safety Board
Recommendations Addressing Bird Strikes
Report Date: 11/22/1995

Date of Response: 05/09/1986

"...THE ENGINE INVOLVED IN THE SUBJECT ACCIDENT, THE CR6-50A HIGH BYPASS-RATIO TURBOFAN ENGINE WAS CERTIFIED BASED UPON BIRD INGESTION TESTING WITH SIX 1-1/4 POUND BIRDS. AMENDMENT 6 TO 14 CFR PART 33, WHICH BECAME EFFECTIVE OCTOBER 31, 1974, REQUIRES LARGE ENGINES TO BE TESTED WITH FIGHT 1-1/2 POUND BIRDS; HOWEVER, NO LARGE ENGINES HAD BEEN CERTIFIED UNDER THESE STANDARDS WHEN RECOMMENDATION A-76-64 WAS ISSUED. SINCE LATE 1977, LARGE TURBOFAN ENGINES HAVE MET AMENDMENT 6 OR LATER BIRD INGESTION REQUIREMENTS, AND A RECENT BIRD INGESTION STUDY HAS SHOWN THAT THESE ENGINES ARE SIGNIFICANTLY IMPROVED IN THEIR ABILITY TO SAFELY INGEST THE SIZE AND NUMBER OF BIRDS ENCOUNTERED IN ACTUAL SERVICE OPERATION. THEREFORE, I BELIEVE THE FEDERAL AVIATION ADMINISTRATION (FAA) HAS, IN FACT, COMPLIED WITH THE INTENT AND SPIRIT OF SAFETY RECOMMENDATION A-76-64."

Date of NTSB Followup Ltr: 07/30/1986

CANADA GEESE AND GREAT CORMORANTS AS A THREAT FOR AVIATION IN THE EASTERN BALTIC AREA

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ABSTRACT

There are not yet fortunately strikes with Canada geese (*Branta canadensis*) and Great Cormorants (*Phalacrocorax carbo*) in the Eastern Baltic area as far as we know. But increasing populations of this species will become a real threat in 5-10 years near coastal aerodromes, because breeding range of these species has expanded very quickly to the East.

As far as we know, there are not yet registered collisions between Canada Geese (*Branta canadensis*), Great Cormorants (*Phalacrocorax carbo*) and aircraft in the Eastern Baltic area, but the fast expansion of these species to the East will provoke possible incidents in the nearest future, because their breeding numbers is increased very quickly.

Canada Goose increases frequency of own sightings everywhere: in Lithuania (Svazas, Vaitkus, Vinskas, 1992; Svazas, 1993), in Latvia (Celmins, 1992; Celmins, Baumanis, Mednis, 1993), in Estonia (Peterson, 1992; Lilleleht, Leibak, 1993). In Latvia in 1992 this species was considered as a sporadic visitor (mainly in winter and spring). One breeding record in 1991. This species has not previously been mentioned on the Latvian List in general (Celmins, 1992). In Estonia this species is irregular passage migrant and irregular winterer (Peterson, 1992; Lilleleht, Leibak, 1993). In Leningrad Region of Russia one decade ago this species was as rare vagrant (Mal'chevskiy, Pukinskiy, 1983). Presently there, as well as in Finland, this species is a common vagrant bird.

Great Cormorant is a common already breeding water bird in Lithuania - there are about 750-800 nesting pairs (Svazas, 1993). In Latvia quite common on passage in the coastal zone and rare breeder. Inland increasing in last decades. Biggest breeding colony more than 30 pairs on the Lake Lubana in eastern Latvia. Sometimes found wintering (Celmins, 1992). In the next year this colony, appeared since 1989, was in 2 times bigger - already ca 60 pairs (Celmins, Baumanis, Mednis, 1993). In Estonia Cormorants began to nest during last decade and their numbers is constantly increasing. In 1990 about 200 pairs were registered on islands of the Moonsund archipelago (T.Kastepold, oral comm., by Peterson, 1992). Single pairs are nested aperiodically on islands of the Gulf of Finland. In general Cormorants are migratory birds, but some birds are wintering on western Islands and northern coast (Peterson, 1992). Total their numbers in Estonia - 250-300 breeding pairs (Lilleleht, Leibak, 1993). Perhaps, Great Cormorants breeds in the eastern part of the Gulf of Finland too (Noskov, Fedorov, Gaginskaya, Sagitov, Buzun, 1993).

All above-mentioned information allows to suggest, that in 5-10 years near coastal aerodromes these species will be a real threat for aviation in Eastern Baltic Area, as it is already in Western Europe.

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FERAL CANADA GEESE (*BRANTA CANADENSIS*) AS A HAZARD TO AIRCRAFT IN EUROPE: OPTIONS FOR MANAGEMENT AND CONTROL

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ABSTRACT

- The British Canada Goose population is around 60,000 birds and is increasing at 2% per year. Similar increases are being seen in a number of European countries.
- There have been only two recorded birdstrikes with Canada Geese in Britain. Both were with birds overflying an airfield situated close to reservoirs and gravel pits. Both resulted in damage to the aircraft.
- Canada Geese cause localised damage to agriculture and amenity grassland. They may also cause hazards to public health and affect water quality.
- Canada Geese respond well to standard aerodrome bird scaring techniques and are unlikely to constitute a significant 'on airfield' problem at sites with good bird control and habitat management, unless the airfield is immediately adjacent to a lake or river. Hazards from birds transiting airfields to and from nearby water bodies are likely to be more significant.
- Because Canada Geese are an introduced species, pressure to conserve them is less than for indigenous birds. There may therefore be scope for population control and management of this species away from the airfield to reduce the hazard from overflying birds.
- Available control techniques fall into two categories: behaviour modification and population reduction.
- Few data are available on the effectiveness of population reduction techniques such as control of reproduction or the culling of adults. The likely effects of such programmes on the behaviour and biology of Canada Geese are also poorly understood. Research into both is currently in progress at CSL.
- The development of Integrated Management Strategies (IMS) to control bird numbers at the local level must be the first objective. Local populations have differing biology which will profoundly influence the choice of strategies that make up the IMS.
- Expert advice should be sought by landowners/airport operators to ensure that the most cost effective IMS is developed for a particular situation.

1. Introduction

The threat posed by birds to aircraft is not a static one. The nature and severity of the hazard can change on a daily or seasonal basis, or in response to short term changes in factors such as weather conditions. More difficult to evaluate, however, are changes in birdstrike hazards which may occur in response to longer term changes in the overall abundance or distribution of bird populations. Such processes occur relatively slowly (e.g. the Collared Dove (*Streptopelia decaocto*) which has spread across the whole of Western Europe since the 1930's (Gibbons et al. 1993)). These changes in range or abundance may be driven by natural processes or assisted by man. Some, such as the Collared Dove, may have little impact on the aviation community, but others have the potential to cause serious hazards. One such species is the Canada Goose (*Branta canadensis*).

The Canada Goose is a native of North America where between eight and twelve distinct races are recognised (Delacour 1959, Palmer 1976, Madge & Burn 1988). There is considerable overlap between the races, but in general birds are darker towards the west of their breeding range and larger towards the south. Most of the races are highly migratory, and some, particularly the larger races, show a pronounced northward migration before the summer moult (Sterling & Dzubin 1967, Salomonsen 1968, Wege 1980, Zicus 1981, Davis et al. 1985).

1.1 The growth of Canada Goose populations in Europe

Canada Geese were first introduced to Great Britain as an ornamental waterfowl in the collection of King Charles II (St. James's Park, London) in 1665. A number of other introductions to wildfowl collections around the country followed (Owen 1983). The morphology and colouration of the current British and European populations suggest that the original introductions were from the larger, less migratory, eastern races: the nominate (*B.c.canadensis*) and the Giant Canada Goose (*B.c.maxima*) (included in *B.c.moffitti* by some authorities (Palmer 1976)). Most introduced Canada Geese therefore show little migratory behaviour, the exception being the Scandinavian populations which migrate south in winter in response to harsh weather conditions (Fabricius 1983).

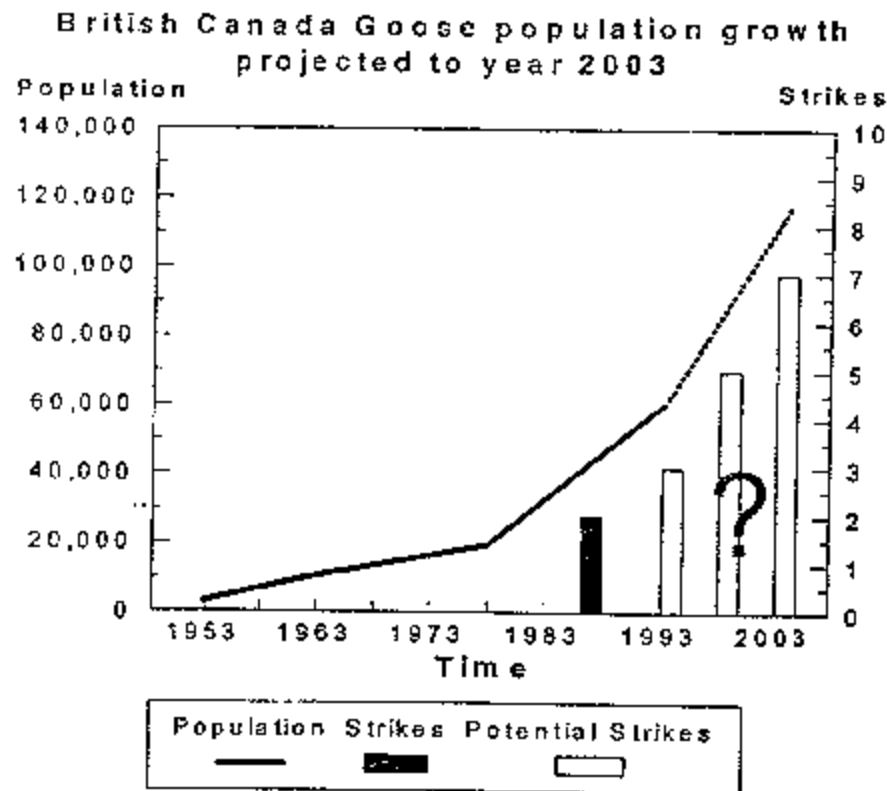
The population in Britain remained relatively small until the 1950's when the first deliberate relocation of birds occurred. At least 700 birds were moved by the Wildfowl Trust (now The Wildfowl & Wetlands Trust - WWT) to relieve local agricultural problems, and many hundreds of birds were translocated by the Wildfowlers Association of Great Britain and Ireland (WAGBI, now the British Association for Shooting and Conservation - BASC) to provide shooting of wild geese in southern Britain. These movements, together with the creation of gravel pits and other artificial habitats along river valleys, resulted in the spread of the species and the first calls for control (by the Wildfowl Trust) were made in the 1960's.

Elsewhere in Europe, a similar pattern occurred with population growth following deliberate introductions or relocations of geese either as ornamental waterfowl or as a shooting quarry. This has led to the establishment of a number of expanding

populations (e.g. 60,000 birds in Scandinavia (Vikberg & Moilanen 1985, Udo 1979, Masden & Andersson 1990, Heggberget 1991), and smaller populations in many other countries including the Netherlands, Belgium and the Republic of Ireland). There are still plans to introduce the species to Russia for sport shooting (Masden & Andersson 1990, Gabuzov 1990).

The first organised summer census of Canada Geese in Britain was carried out in 1953, when between 2,200 and 4,000 birds were recorded. At that time, the birds formed discrete, localised, sub-populations, each with a rather restricted range, and little or no movement between them. Surveys in 1967-1969 indicated that the population had increased to 10,500 and many new localities had been colonised. A census in 1976 indicated an estimated 19,400 birds. These survey results suggest a five-fold increase in the population over the 24 years from 1953 to 1976, whilst the 1991 survey produced 220% more birds than in 1976 (see fig. 1). Over the whole period, the population appears to have been growing at a progressively faster rate, from 6.8% to 8.0% per year; the average growth rate since 1976 was 8% per year (Delany 1992).

Fig. 1



As the size of the British population of Canada Geese has increased, conflicts between the birds and human interests have become more frequent. Requests for licences to control agricultural and amenity damage by Canada geese have increased in number (UK government data) and calls for a national strategy to reduce the population size and/or prevent further spread have been made by landowners, municipal authorities and some biologists. Although complaints about Canada Geese damaging agricultural crops, fouling amenity grassland or harassing native waterfowl species are common, the extent of the present or likely future problem posed to aviation interests has been little studied.

1.2 The birdstrike hazard posed by Canada Geese

Only two birdstrikes with Canada Goose have been recorded in Britain (UK Civil Aviation Authority data). On 5th. August 1989 a Boeing 747 struck two Canada Geese on take off from London Heathrow at a height of 200 feet. Damage to the nose-wheel door was sustained but the flight continued. On 20th. August 1990 a Boeing 747, also at Heathrow, struck three Canada Geese on the take-off run. The aircraft scraped its tail on the runway during take off and returned for an overweight landing. The aircraft was removed from service for repair.

London Heathrow, although not immediately adjacent to large water bodies, is close to a number of reservoirs and gravel pit complexes which carry large and growing populations of Canada Geese. As numbers continue to increase in the rest of Britain and Europe, the potential for more such incidents at other airports also increases. Because of their highly social nature, flocking habit and high weight (birds in the British population weigh between 3 and 4 kg (pers. obs.)) there is clearly the possibility of that a very serious incident could occur if birdstrikes with this species become more frequent.

In their native North America, Canada Geese are a migratory species, but in recent years a large population of non-migratory birds has built up in a number of US cities. Laycock (1984) estimated the total population of urban Canada Geese to number 'hundreds of thousands' in North America as a whole, mostly of the race *B.c.maxima*. The increasing numbers of Canada Geese in the urban environment has coincided with a rise in the number of incidents of collisions with aircraft in recent years. For example, between 1986 and 1989 Canada Geese were involved in 11 birdstrikes costing \$250,000 at Reno-Sparks airport, Nevada USA which resulted in the US Federal Aviation Administration threatening to close the airport if control measures were not instituted (Fairaizil 1992). Similar problems occurred at Minneapolis St. Paul airport, where four strikes with Canada Geese occurred between 1980 and 1984 (J. Cooper pers. comm.) In both cases the problems were exacerbated by the arrival of large numbers of migrant geese, but the rising population of feral birds in Britain, often on urban fringe sites close to airports, clearly has the potential to cause serious hazards to aircraft.

Both of the birdstrikes involving Canada Geese in Britain were with birds overflying the airfield. Canada Geese breed and roost on or around bodies of water. They feed mostly by grazing short turf or agricultural crops, and may fly considerable distances to find suitable feeding areas. Canada Geese are therefore unlikely to frequent

airfields with an effective long grass policy and, since they may be hunted in the open season, respond well to scaring with pyrotechnic devices. The hazard posed by Canada Geese on the airfield itself is therefore easily manageable at most sites. Exceptions to this situation are airfields which are immediately adjacent to lakes or rivers, e.g. Burke Lakefront Airport, Cleveland USA is flanked by Lake Erie and, despite a long grass regime, is frequented by large numbers of Canada Geese which breed nearby (pers. obs.). Airfields with large bodies of water such as balancing ponds on the site may also attract Canada Geese from time to time. For example, Chicago O'Hare Airport has a large lake on the property which attracts Canada Geese to the airfield and a number of strikes with this species have occurred (R. Sliwinski pers. comm.) Nevertheless, it is overflying Canada Geese that constitute the greatest hazard at most airfields. If these problems are to be controlled, management of bird numbers or behaviour away from the airfield needs to be considered.

Because Canada Geese are an introduced species in Britain and Europe, there is less pressure to conserve them than for native species. They are, however, protected under the Birds Directive of the European Union, and have varying degrees of protection under the national laws of the member countries. It is possible, in Britain at least, to obtain special licenses to control bird populations if a clear hazard to aviation can be demonstrated and if other control methods not requiring licenses have failed. Because most Canada Goose hazards to aircraft are likely to result from birds flying over airfields, any effective management programme will require work to be conducted off the airfield and could involve the licensed destruction of birds. Such control methods can be extremely controversial and should not be undertaken lightly or without a reasonable prospect of success. This paper reviews the available management techniques, both lethal and non-lethal, for controlling Canada Geese away from an airfield, and describes a number of integrated management strategies that could be employed to reduce the hazard to aircraft posed by Canada Geese by reducing their numbers at a particular site or sites. The techniques described are legal in Great Britain providing the appropriate licenses are obtained where necessary. Workers in other countries should ensure that their national laws permit the use of the methods described.

2. MANAGEMENT OPTIONS CURRENTLY AVAILABLE TO CONTROL CANADA GEESE

Feare (1991) reviewed the options for the control of Canada Geese in Britain, but research into agricultural and amenity damage prevention has concentrated on only one option, involving reducing reproductive output (Giles & Street 1990, Baker et al. 1993). Other work has taken the form of *ad hoc* population management, usually without proper experimental design and with little or no follow up or publication of the data. Research (funded by the UK Ministry of Agriculture Countryside Division) into the effectiveness of a number of population control techniques is currently in progress at CSL (Watola unpubl). Assessment of the likely effectiveness of the various management techniques available therefore leans heavily on American research, and on experience with other waterfowl species in Europe.

The control methods currently available fall into two categories: behaviour modification (by scaring (including shooting), habitat management, exclusion and chemical repellents); and population control (by relocation, shooting in or out of season, egg control, culling at moult, and culling with other capture techniques (e.g. narcotised baits or traps)).

The main objective of managing Canada Geese for flight safety would be to remove or deter the Geese from a water body or feeding ground which involved them making flights across an airfield. Detering birds from using a temporary food source e.g. sprouting winter wheat is analogous to a farmer protecting a temporarily vulnerable crop, and may involve the short term deployment of behaviour modification tactics such as scarers. Preventing birds from making long term use of a water body or feeding site may require management of the population to reduce numbers or to eradicate the birds altogether because they will eventually habituate to scaring techniques.

2.1 Behaviour modification techniques:

2.1.1 Scaring with acoustic stimuli

The pyrotechnic 'shell-cracker' commonly used in airfield bird control may be used to deter Canada Geese from a site. This method has the advantage that the human operator can respond to the behaviour of the birds and thus reduce habituation to the stimulus. The presence of the operator also adds a visual stimulus to the technique. If supported by occasional shooting (see below) this is a most effective scaring method, but its use in public areas may not be possible for safety reasons.

The most commonly used agricultural bird scarer is the gas cannon, a device designed to emit one or more explosive reports, usually at set intervals. Although not recommended for long term scaring on airfields, such devices can be effective in the short term scaring of most birds, particularly those subject to hunting pressure, as the sound of the cannon simulates that of a shotgun. Other acoustic scarers produce a variety of loud shrieks, distress calls, infrasound and ultrasound. These systems were developed mainly to protect agricultural crops, many of which are vulnerable to bird damage for a relatively short period. Heinrich & Craven (1990) detected no habituation of migrant Canada Geese to a sonic scarer over a seven week trial period. If acoustic scarers are to be deployed for longer periods, they should be regularly moved (ADAS 1987) or combined with other techniques to reduce the rate at which the birds become habituated to the scaring stimulus. Urban Canada Geese, which are not hunted and are accustomed to the kinds of unusual stimuli associated with living in close proximity to man, may very quickly learn to ignore gas cannons and other noise-producing devices.

Many species habituate less rapidly to scarers incorporating their own distress or alarm calls and the structure of these calls is being examined to increase their effectiveness further through the synthesis of superstimuli by enhancing certain particular segments of the calls (Aubin 1990). The distress calls of birds are

extensively used to deter them from airfields (Bridgman 1980). Mott & Timbrook (1988) successfully used the alarm calls of Canada Geese to deter birds from damage sensitive areas for 2-3 week periods, but the birds moved only a short distance and returned immediately after scaring stopped. Canada Geese do not produce distress calls.

2.1.2 Scaring with visual stimuli

Visual scarers can take a variety of forms, from the familiar scarecrow, through plastic strips attached to poles, to kites or balloons representing birds of prey, and even inflatable human figures which rise from a box in the ground carrying an imitation firearm! Kites and balloons may not be suitable for use on airfields, but could be deployed effectively at other sites. As with acoustic scarers, these devices are effective in deterring birds from areas for as long as the birds' natural neophobia persists. Heinrich & Craven (1990) found that Canada Geese were deterred from fields where brightly coloured strips of mylar tape 1.5m long and 15cm wide attached to poles 1.7m high. Poles were set out at densities of 1.5 per hectare. The geese were not deterred, however, if they landed in an adjoining field and walked into the protected area. In the same study, human effigies (scarecrows) were also found to deter migrant Canada Geese particularly from small fields with tall boundary features such as woods. As with the mylar flags the deterrent effect only occurred if the birds saw the scarecrow from the air. Birds that landed nearby and walked into the field were not deterred. The trials described above were conducted on migratory Canada Geese subject to hunting pressure. Urban geese may be far less easy to scare using passive acoustic or visual stimuli.

2.1.3 Scaring by shooting

Although shooting is more usually regarded as a means of population control, it can also be used to reinforce scaring programmes. Shooting to scare geese combines visual (the presence of the shooter) with acoustic (the sound of the gun) stimuli and is reinforced by the occasional killing of a bird. An increase in the shooting pressure on geese at a particular site is likely to make them generally more wary and more responsive to other scaring techniques, particularly gas cannons and scarecrows. In Britain, Canada Geese can be legally shot in season (1 September to 31 January, or to 20 February below high water mark of average spring tides) and licences to shoot a limited number of birds to aid scaring during the close season can be obtained in order to reduce risks to flight safety.

2.1.4 Chemical repellents

Attempts have been made for many years to develop a harmless chemical repellent with which to treat crops in order to prevent wildlife damage. So far none have proved wholly successful, either due to lack of repellency, toxicity to plants or to the birds themselves or lack of persistence of the effect. Methyl anthranilate has been successfully employed against Canada Geese in the United States (Cummins et al. 1992). In Britain, cinnamamide has proved effective in preventing many bird species from feeding on treated foods (Crocker et al 1993, Crocker & Reid 1993) and experiments with Canada Geese are needed. Research is continuing in this area.

(Cummings et al. 1992) but at present there are no fully effective chemical repellents licensed for use in Britain.

2.1.5 Physical exclusion

Canada Geese can be excluded from an area either by fencing to prevent birds from walking in, or by the use of wires or tapes strung across the area to prevent them from landing. Such techniques are frequently and successfully employed to restrict access of a variety of bird species to small areas such as ponds or ditches (Rochard & Irving 1987). It is probably impractical to attempt to exclude geese from large water bodies or fields, and this would also restrict access to the public, farm machinery and other bird species.

2.1.6 Habitat modification

In some cases, it may be possible to modify an area used by Canada Geese to make it less attractive. Planting of dense scrub on the banks of lakes could deter geese from walking out of the water to feed, but such scrub would require adequate protection from the geese during establishment. To prevent breeding, nesting cover could be removed or, where birds breed on islands, the islands could be removed or water levels raised in order to flood them: this would have clear implications for other island-nesting species!

Conover & Kania (1991) have shown that feeding sites are chosen on the basis of their proximity to water and their openness in terms of both detection of approaching threat and the angle of climb needed to fly out of the site. Separating grassed areas from water bodies with a belt of trees high enough to require a climb out angle of over 13 degrees is suggested as a way of reducing the use of foraging sites near water. Replanting grass areas with plant species unpalatable to Canada Geese could deter birds (Conover 1991) and modification of cropping patterns, so that vulnerable crops are not available to Canada Geese, could be included in hazard alleviation programmes (Feare 1994, Trump et al. 1994).

All of the above solutions present problems in terms of the impact of habitat modification on other bird species, restriction of public access, or loss of recreational or landscape value in public areas.

2.2 Population management techniques

All of the behavioural modification techniques described above have the disadvantage that they simply move the problem elsewhere and, possibly, encourage the further spread of Canada Geese. Many behaviour modification techniques lose their effectiveness over time, and some are expensive, requiring substantial investment in equipment or staff costs over a long period. Population reduction, on the other hand, can offer permanent solutions to local problems without risk of moving geese elsewhere, and with at least some of the techniques, the effects can be immediate. Unfortunately, the techniques are often difficult to apply

and those involving the destruction of birds can be controversial. In Britain, apart from shooting in season, all population control techniques require special licences.

2.2.1 Shooting

Canada Geese can be legally shot in Britain between 1 September and 31 January (20 February on the foreshore) but they are not highly regarded by as a quarry species by wildfowlers (Harradine 1991). Nevertheless, data from the British Association For Shooting And Conservation suggest that Canada Geese accounted for 36% of the geese shot in Britain in 1987-88, compared to 11% in 1980, and that most Canada Geese are shot early in the season when other species are not present (Harradine 1991).

In terms of direct population control, increased shooting pressure has a number of difficulties, however. It would be extremely difficult to shoot enough birds at a site to achieve a rapid population reduction, as the birds would quickly become wary and increasingly difficult to shoot. Intensive shooting pressure may also stimulate birds to move to other sites, thus moving the problem elsewhere and possibly increasing the rate of spread of the species. Both migratory and sedentary populations of Canada Geese in North America have been shown to withstand heavy hunting pressure, with annual harvests of up to 40% of the population (Sheaffer et al. 1987, Chapman et al. 1969).

2.1.2 Reproductive control

Production of young can be inhibited by preventing adults from breeding, or by preventing eggs from hatching.

While chemical contraception for Canada Geese is conceptually attractive, there are so many practical difficulties that this technique is not yet available. Nor is there a mechanism for delivering any such chemical selectively to adult Canada Geese, thereby avoiding risk to other bird species; these problems are common to all species for which chemosterilisation is considered (Feare 1990).

Adult geese may be prevented from producing young by shooting them at the nest, a technique that has dual advantages in both reducing breeding output and at the same time reducing the number of breeding birds in the adult population. The shooting of adults at close range while they are defending their nest would be emotive but, in that a quick, clean kill could be achieved, this would be a humane way of killing adults.

One of the commonest ways of attempting to control Canada Goose numbers has been the destruction of eggs or their treatment to prevent hatching. Such treatment usually takes the form of pricking the eggs with a small nail and destroying the embryo. Treated eggs are left in the nest and the female allowed to sit as normal (if eggs are removed or destroyed the female may lay a new clutch). Other techniques that achieve the same objective include replacing the eggs with wooden dummies or hard boiling the eggs to prevent hatching. Hatching can also be effectively and

humanely prevented by coating the eggs with liquid paraffin (Baker et al. 1993), although approval of this chemical for this use in Britain is still awaited.

Canada Geese are long-lived birds with relatively low annual mortality at many urban sites, with the result that it may take many years for the size of a population to fall if reproduction is prevented. Also, if a small number of broods is missed, the limited recruitment that results may be sufficient to replenish the annual losses through mortality. Wright & Phillips (1991) reported no significant population reduction following a programme of egg replacement and suggested that a programme to increase adult mortality by shooting would also be required.

Reproductive control might thus be an effective technique in preventing further population growth at sites with large breeding colonies, but cannot alone reduce a flight safety hazard within an acceptable time scale without some additional means of increasing adult mortality.

2.2.3 Relocation

One of the most frequently used means of reducing problems with non-migratory Canada Geese in North America is to relocate large numbers of birds to rural areas, either to form new colonies or to increase the size of migratory populations (Addison & Amernic 1983, Laycock 1984, Converse 1985, Cooper 1986, Conover 1992). Early relocation experiments in Britain were largely unsuccessful, with some birds returning to the original capture site. This does not appear to be a problem in North America, where birds are shipped over large distances (Converse 1985, Cooper 1986). Canada Geese can be easily captured by rounding up during the moult or by the use of traps (Nastase 1982) or stupeficient baits (Woronecki et al. 1990) at other times of the year. These operations require the appropriate licences and should only be carried out by trained professionals. Mass relocation of birds is therefore an extremely expensive operation and it is unlikely, given the problems currently being encountered with Canada Geese, that many landowners would be willing to take more birds. Even in the United States, where the birds are valued as a hunting resource, it is becoming increasingly difficult to find landowners willing to take relocated geese (J Cooper pers. com.). Further redistribution in Europe is likely to encourage the spread of this species and possibly increase the rate of population growth. For these reasons relocation of birds should be discounted as a control option.

3.2.4 Culling of adult birds

a) At the moult

Canada Geese become flightless for a three to four week period in late June and early July while they moult their wing feathers. During this period the birds are vulnerable to predators and remain on or close to water. Here, large numbers can be easily captured by rounding them up using canoes or small boats and herding them into a pen on the bank. Birds must be humanely dispatched, e.g. by cervical dislocation, lethal injection or shooting at close range with a small bore

firearm. The presence of a veterinary surgeon at such an operation may help to allay public fears about humaneness.

There is clearly the potential to effect a dramatic reduction in the numbers of geese at any site where a round-up can be carried out and this technique would achieve an immediate reduction in any flight safety hazard. A number of such culls have been conducted in the past with varying degrees of success but none has been followed up to determine the number and frequency of culls needed to reduce the population to a predetermined level. MAFF is currently researching the effectiveness of culling as a control strategy in order to determine where culls should be undertaken, what proportion of birds needs to be killed and how culling should be combined with other techniques to achieve specific population reduction goals.

b) At other times

The killing of adults at the nest is discussed above. In addition, traps or stupeficient baits can be used to capture small numbers of geese at sites where round-ups of moulting birds are not possible. Small scale culls using these techniques may be employed at sites where killing needs to be carried out discreetly, but both techniques require that the target birds are attracted to bait. This may be relatively easy in public parks where Canada Geese are used to receiving food from people, but may be more difficult in rural areas where geese have less contact with the public and less experience of novel foods. All culling should be undertaken by trained personnel and must be conducted under appropriate licences.

3. INTEGRATED MANAGEMENT STRATEGIES (IMS) FOR THE CONTROL OF CANADA GEESE

3.1 The choice of control techniques

The choice of which techniques to employ will depend on the precise circumstances at the airfield concerned. The management techniques which could be used to control birds originating from a nearby farm or country estate (e.g. concerted shooting, physical exclusion or large scale culls) may be very different to those which may be employed in a city centre park where access to the public cannot be easily restricted.

If population control forms part of the IMS, the bird controller needs to have some knowledge of the behaviour patterns and biology of the geese in the area. Different populations may have profoundly differing population biology (e.g. levels of recruitment, mortality and movement patterns) which will influence the best choice of control measure.

An excellent example of the need to understand the population biology of the birds concerned is the Canada Goose control programme instituted around Minneapolis St. Paul Airport. In the USA (J. Cooper pers. com.). Here, problems were being encountered with Canada Geese from surrounding populations frequenting the airfield and surrounding wetland areas to feed. Biologists captured and marked most

of the geese in the surrounding populations. They discovered that birds from each site had traditional feeding areas which they always used, and that only those birds originating from certain lakes (not necessarily the lakes closest to the airport) were causing the problems. Eighty to ninety percent of the birds in the populations that were causing the hazard were relocated out of the state. The numbers of birds in the vicinity of the airport was reduced by between forty and ninety percent. This reduction persisted despite the fact that the uncontrolled populations continued to increase in size. If the control had not been preceded by a study of the movements of the birds, extra resources would have been unnecessarily expended controlling populations that were not causing a flight safety hazard.

3.2 Examples of possible management strategies:

a) An airfield close to a public park where geese breed and roost. The geese fly out to feed on nearby fields crossing the airfield. Shooting is not possible in the park and public pressure may prevent culling.

The mortality of Canada Geese in such situations is likely to be very low so egg control may take many years to reduce the population size. If the park suffers problems with damage to grassland etc. staff may be made available to assist in a long term egg control operation. In this case, any small influx of birds from surrounding populations may be enough to maintain numbers. If the park is not important as a nature reserve, habitat modification to exclude geese from breeding sites may be an acceptable alternative. In order to achieve a rapid reduction in the hazard, scaring, shooting or exclusion at the feeding site may be the only option. If transiting flights are at predictable times (e.g. dawn and dusk) flying operations may be able to be modified to reduce the hazard.

b) An airfield close to country estate where shooting is practiced and culling is possible. The geese fly out to feed and cross the airfield.

Culling during the moult can be carried out to effect an immediate reduction in the hazard. If the estate wishes to keep some geese, then egg control combined with shooting in season can be used to keep the total population down to an acceptable level. If birds from surrounding areas move in, further smaller culls could be employed to manage the hazard.

c) A farm with winter cereals near the airport is attracting geese from a nearby water.

Since the food source, and hence the hazard, is short term, scaring and exclusion (e.g. gas cannon and tape streamers) reinforced by shooting at the feeding site can effectively eliminate the hazard and protect the crop in this situation. Assistance from the farmer may therefore be a way of reducing costs.

d) There is a complex of lakes and gravel pits close to the airfield. Geese move from one area to another throughout the year and cross the airfield at unpredictable times.

If the movements of the geese are not predictable and they have a number of alternative feeding or roosting sites then scaring at a given site is unlikely to be effective. A concerted population reduction programme, targeted at the birds which actually cause the problems, and coordinated across a number of the sites is the only way to effectively reduce the hazard in this situation.

In conclusion, the control of Canada Geese depends upon the development of IMS which are appropriate for the location, nature and scale of the problems encountered. The one feature that all situations have in common is that the population biology of the birds at that site will profoundly affect the effectiveness of the IMS employed. A thorough understanding of the processes involved in the population biology of Canada Geese is therefore required if successful IMS are to be developed. Expert advice should be sought before expensive and potentially controversial control programmes are implemented.

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Bird Strikes Underreported; NTSB Wants 'Better Handle' On Data

Only about 15% of bird strikes against aircraft are being reported, according to preliminary information from a bird ingestion conference sponsored Jan. 11 by the National Transportation Safety Board. "We need better reporting to really understand the problem," NTSB member John Goglia told *The DAILY*. The session established that bird ingestion could represent up to one-third of in-service damages to the fleet, he said. "The predominant airplane in the fleet today is two-engined. These engines were certified with [ingestion tests using] 1 1/2-pound birds. Biologists say Canada geese can be in the 12-pound range."

The session was backed by NTSB Chairman Jim Hall, who noted that while FAA engine certification sets minimum bird strike standards for large turbojet engines, there is no requirement that an engine continue to operate after ingesting multiple objects, such as Canada geese. Citing a Canadian study, Goglia said concerns about ecology have resulted in a "bird population that is exploding by a factor of a couple thousand percent. We have a Canada goose problem that has doubled over the last decade. The problem also is changing somewhat, in that we have both a migratory Canada goose and a resident Canada goose." Populations of the non-migratory bird are "growing tremendously" in New England, he said. He cited an Air Force determination that a flock of geese was responsible for the crash of an E-3 AWACS airplane last Sept. 22 near Anchorage that killed all 24 people aboard. The Air Force report faulted Elmendorf Air Force Base airfield managers and a controller for not keeping the geese off the field and not warning the crew about the geese.

Canadian studies have shown that 90% of bird impacts are at altitudes below 500 feet and "right at the airport," making it "pretty dicey" for high gross weight aircraft, Goglia said. NTSB's bird strike session, attended widely by industry, military and foreign aviation officials, "found some things we can quickly do," such as updating airman's information manuals, he said. "We will ask FAA to do that. We are also going to look at some better communications. It was obvious from all the different groups that they understand some issues the same way. Those areas are quick and easy."

"We need to get a better handle on the data. There is a process in place where bird strikes are supposed to be reported, but we are getting maybe 15% of the reports. American and United, in particular, are doing interesting work in tracking damage to their fleets, but they are just now trying to find ways to correlate between airlines through the Air Transport Association. United has done some comparisons between bird strike damage and other damage, and bird ingestion represents about one-third of total aircraft damage."

Goglia said conference participants discussed cost-sharing by FAA, the military services, Canada and possibly NTSB to produce a video on the problems of bird strikes. "We are going to explore that also," he said. For a transcript of the Jan. 11 proceeding, send a request to Goglia at the National Transportation Safety Board, Washington, D.C. 20594.

America West Flies New Livery Today

America West debuts a new look today, putting into scheduled service the first 737-300 painted in its new livery of pearl white and turquoise, with an oversized red signature and logo. The carrier says that the new look is just an outward sign of significant changes in its product, and that it complements its new image — "unique, bold and impossible to ignore." America West plans to repaint the fleet in two years as aircraft are taken out of service for regular maintenance. It also is refurbishing aircraft interiors. John Garel, senior VP-marketing and sales, said the new look signals the beginning of "a major growth plan that will transform America West over the next two years, increasing our capacity by nearly 30% and adding at least eight new cities to our route system."

American and American Eagle are bringing back weekend BreakAway fares for nonstops from Dallas/Fort Worth, Chicago, Los Angeles, New York, Nashville and Miami. The mileage-based specials, ranging from \$79 to \$299 roundtrip, require a one-day advance purchase for travel Jan. 19 through May 21. Most passengers must depart on a Saturday and return on Monday or Tuesday. Transcontinental and Hawaii trips require a Friday departure.

General Electric yesterday reported record results for 1995 including revenues of \$70 billion and net earnings of \$6.6 billion, up from \$60.1 billion and \$4.7 billion in 1994. In the fourth quarter, GE had revenues of \$19.8 billion, up from \$17.8 billion, and net earnings of \$1.9 billion, up from \$768 million. GE said its Aircraft Engines unit realized "double-digit increases in operating profit."

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INTELLIGENCE

Delta plans to respond rapidly and aggressively to Southwest's expansion into Florida. Executive VP Harry Alger said Delta will not concede Florida markets to any competitor, but "we must mount a competitive response, and do it quickly." The preferred approach is to get the low-cost operation being negotiated with its Air Line Pilots Association up and running, but this requires an agreement with the union in the next few weeks, Alger said. It is time "to post bids, grow our airline and compete, compete, compete."

Danger of ingesting birds in aircraft engines is growing due to exploding populations of wild fowl. NTSB member John Coggia said following a meeting in Washington on the subject (DAILY, Jan. 11). Authorities plan a campaign to make aviators more aware of the bird strike problem, he said. Canada geese are being blamed for last year's crash of a \$170 million E-3 AWACS aircraft that killed all 24 people aboard.

U.S. and Thailand are expected to reach an agreement in aviation talks scheduled to begin today in Bangkok. The accord is likely to include a "decent route description" and permit third-country code-share service to Thailand, according to an industry official. Some restrictions on local Thai traffic are expected to remain, however.

The Raptors, Toronto's new professional basketball team, have cut short an agreement to fly to games on Air Canada charters for the rest of the season and will travel with another charter carrier instead. Air Canada said the decision was mutual and that the team had special needs that it could not meet. Air Canada continues to fly an aircraft painted in Raptors colors, and to sponsor the Air Canada Center, which, when built, will be the team's home.

Canadian Refurbishes 737s To Step Up Competition With Air Canada

Canadian Airlines will refurbish its fleet of 737s, adding a forward business-class cabin with new, larger business-class seats. The upgrade is Canadian's latest effort to improve its domestic service and draw passengers away from rival Air Canada, particularly in the eastern part of the country, where Air Canada has provided better service. "This is traditionally a market where our friends at Air Canada have been dominant," a spokesman for Canadian told The DAILY. "Now we're more actively going after it."

Currently, Canadian's 37 all-passenger 737-200s are configured in a single-cabin layout with 112 seats in six abreast seating. A movable divider separates business travelers from those in coach, and middle seats are not filled. The new configuration will provide 12 wider seats in the forward cabin in a four-abreast configuration and 88 seats in coach. There will be 39 inches of pitch between business-class seats and 34 inches of pitch in coach, an improvement over the 33 inches currently offered to passengers in coach. Air Canada offers 34 inches of seat pitch in coach on most of its domestic jets and 38 inches in the forward cabin. One exception is its Canadair regional jets, with 31 inches of seat pitch in a one-class configuration.

Canadian will begin the reconfiguration Jan. 28, upgrading one jet per day until March 4. The 737 is the backbone of Canadian's short-haul fleet, but the airline also operates more than a dozen A320s that already have a separate business-class cabin. In addition to the 37 all-passenger 737s, Canadian operates six 737-200 Combs in northern Canadian markets. Those aircraft will remain in their one-class configuration.

In other efforts to compete better against Air Canada, Canadian launched an international business-class product in October and started a shuttle service between popular Canadian cities in November. (Continued)

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NTSB Holding Briefing On Bird Ingestion Hazard

National Transportation Safety Board Member John Goglia is moderating a briefing today on the hazards of bird ingestion into aircraft turbine engines. The safety board said it is coordinating the briefing because of its "longstanding interest in the issue of the hazards birds present to aircraft." A notice to industry from NTSB Chairman Jim Hall said that despite progress during the past 20 years, "there does not appear to be a viable solution that will adequately protect an aircraft from all bird ingestion scenarios."

Hall said that while the FAA engine certification process mandates minimum bird strike standards for large turbojet engines, there is no requirement that an engine continue to operate after ingesting multiple large objects, such as Canada Geese. "Nevertheless, efforts to address and solve this problem continue, and the briefing will provide an ideal opportunity to update the aviation community on the status of bird control programs, engine design countermeasures and what future developments are envisioned." Representatives of federal, state and foreign governments, trade associations, airframe and engine manufacturers and air carriers were expected to attend the briefing, conducted at NTSB headquarters in Washington.

The board said it "persuaded" FAA in 1973 to disseminate widely an advisory circular on bird strike hazards. In 1976, the board recommended retest of an engine model to demonstrate compliance with bird ingestion criteria and improvements in rules governing testing of engines to withstand bird ingestion. It said FAA established a special program in 1978, at its urging, to review the airport operations manual on a regular basis to ensure, among other things, that provisions of the bird hazard reduction program were adequate.

Delta Takes Delivery Of Four Wide Area Ice Detection Units

Robotic Vision Systems Inc. (RVSI) said its Aircraft Safety Division has received its first airline order for ID-1 wide area aircraft ice detection systems, from Delta. The order is for four units and includes spares and technical support. They will be installed this winter at East Coast airports to inspect aircraft in adverse weather conditions. "This is the first deployment of wide area ice detection systems in the world," said RVSI.

The units can "quickly and accurately" scan an entire aircraft wing or other critical surface for ice, frost and other frozen contaminants. The system can "see through" water or deicing fluid that may mask contamination and works in darkness and during storms, the company said. The unit integrates a color video display in a handheld sensor head. Ice is displayed to the operator as white and uncontaminated surfaces as green, providing what RVSI called a "simple go, no-go" indication.

Computer/Telephone Technology Enables Delta Customers To Book Own Flights

Delta's customers will be able to book their own flights this year on a system called VoiceView TalkShop that connects to customers' computers and telephones. Delta in February will begin using VoiceView technology that makes computer and telephone use possible together on a standard telephone line. VoiceView will be used by Delta to give customers flight information and direct dialing to reservations offices. The system was developed by Radish Communications Systems, Boulder, Colo.

BA Discovers Way To Make Cappuccino, Good Toast Inflight

A decent piece of toast will soon be available on British Airways flights, the carrier says. BA engineers have finally figured out how to brown bread properly inflight and brew a superior cup of cappuccino. The improved toast is possible with an inflight safety device that retains smoke if the bread starts to burn. BA said it is testing several prototypes. Toast and cappuccino will be available to passengers on all 90 of the carrier's long-haul aircraft by next year, the airline says, starting in first class. The airline pours 40 million cups of coffee and currently serves 15 million pieces of mediocre toast per year to its passengers.

Tower To Fly Eight 747s In Hadj Wet-Lease Contract

Tower Air will again operate charter flights this spring, carrying pilgrims to Mecca for the 1996 Hadj. The carrier said yesterday it has signed a wet-lease agreement to provide eight 747s for the event which runs from the middle of March through the end of May. Tower has operated Hadj flights under contract since 1992. Last year it provided seven aircraft for pilgrimages.

Air Canada yesterday started scheduled service between Toronto and Philadelphia. The carrier is operating four daily nonstop flights in the market using 50-passenger Canadair jets.

AIR TRANSPORT

BIRD-STRIKE THREAT DRAWS NEW WARNING

EDWARD H. PHILLIPS/WASHINGTON

Escalating bird populations are an increasingly serious hazard to airline operations and merit aggressive efforts to combat their presence near airports, according to the U.S. National Transportation Safety Board.

"We need to get a better handle on data related to bird strikes and better reporting to really understand the problem," NTSB member John J. Goglia said. He is spearheading safety board efforts to learn more about the threat birds pose to modern jet transports. Although the FAA requires airlines to report bird strikes, only 15% of encounters are actually reported, according to Goglia.

"The chief problem is that nobody's talking about bird strikes within the airline industry," he said. No single source exists

to collect and correlate data on birds around airports. In 1991, the FAA produced a report on the bird threat, but no action was taken, Goglia said. He intends

'Nobody's talking about bird strikes within the U.S. airline industry'

to urge the FAA to resume its study of bird habitats around airports.

Much of the safety board's concern centers on ingestion of birds into jet engines.

The majority of jet-powered transports in service are powered by two turbofan engines certified to withstand the impact of a 1.5-lb. bird, but not larger birds such as the Canada goose, which can weigh up to 12 lb.

Older turbofan engines, such as the Pratt & Whitney JT-8-series that powers Boeing 727, 737-200 and McDonnell Douglas DC-9 series transports, were certified before the FAA adopted standards for bird ingestion tests, according to a Pratt & Whitney official. The company conducted its own tests, however, and did make design changes to the powerplant before production began. FAA certification of the upgraded JT8D-200 installed on the McDonnell Douglas MD-80 required bird tests. The FAA has, how-

AIR TRANSPORT

ever, changed its certification requirements for new technology, large-diameter fan engines in an attempt to address ingestion of larger, heavier birds such as Canada geese.

The GE90, Pratt & Whitney PW4084 and Rolls-Royce Trent 800 engines that power the Boeing 777 are examples of powerplants that meet more stringent standards.

To certify the PW4084, for example, Pratt & Whitney had to demonstrate in separate tests that the engine could ingest four 2.5-lb. birds and one 8-lb. bird and continue operating for at least 20 min.

Birds are a problem in Canada as well as the U.S. About 90% of bird strikes reported in Canada occur near airports and at altitudes below 500 ft., according to a recent Canadian study. Increased protection of birds and their habitats won by environmental and animal rights groups in both countries has fostered explosive growth in bird populations, Goglia said.

The number of Canada geese, for example, has nearly doubled in the past 10

years, the Canadian study said. In addition, "we have both migratory and resident Canada geese in the U.S.," exemplified by an escalating population of resident geese in New England, he said.

Awareness of how serious the threat of these larger birds can be was tragically demonstrated in September, 1994,

when a U.S. Air Force E-3 Airborne Warning and Control System aircraft crashed as it departed Elmendorf AFB, Alaska. All 24 occupants on board were killed [AW&ST Jan. 15, p. 19].

Shortly after takeoff, the aircraft's left two Pratt & Whitney TF33 engines ingested several Canada geese. One engine lost all power and the other was severely damaged, according to the Air Force accident report. A tower controller saw the flock of geese near the runway shortly before the E-3 took off, but failed to warn the flight crew. The report also said Elmendorf's Bird Aircraft Strike Hazard (BASH) program is inadequate. The program is intended to minimize bird-related hazards through flight line patrols, environmental controls and alerts.

Of 177 bird strikes at American Airlines in 1995, 31 caused flight cancellations or delays

United Airlines and American Airlines are among U.S. carriers that record and track bird strikes. Safety officials and engineers from both airlines are trying to determine how best to correlate their data with information gleaned by other carriers through the Air Transport Assn., which represents most major U.S. carriers.

In 1995, United experienced one bird strike per 18,000 aircraft cycles, said Darin Wong, senior engineer at United's San Francisco base. The majority of those impacts, however, involved small birds and resulted in little or no damage to the engines or airframe components, he said.

Wong estimates that about 33% of total damage to UAL aircraft stems from bird strikes or ingestion. The "bird problem is one that merits more attention" within the aviation industry, and UAL fully supports the NTSB's efforts, he said.

American Airlines suffered 177 bird strikes last year, of which 31 caused either delays or cancellations due to engine ingestion or airframe damage, an official said. It cost more than \$500,000 to repair the aircraft and engines.

In addition to bird ingestion, Goglia also plans to call for studies aimed at determining what type of data collection is necessary to help the airline industry pinpoint maintenance problems that could lead to accidents.

APPENDIX 23

Argentine Spray Kills Hawks From Canada

Argentine spray kills hawks from Canada

Race on for answer before next winter

BY PETER WHELAN
Special to The Globe and Mail

Pesticides sprayed on fields in Argentina are killing tens of thousands of wintering Swainson's hawks that nest on the Canadian Prairies and the adjacent U.S. Great Plains.

A researcher from the U.S. Forest Service counted 3,909 dead hawks in a 50-kilometre square last week and estimated that they represented between 20,000 and 40,000 dead. The count was incomplete, partly because scavenging vultures and raptorial birds were eating the bodies quickly.

The insecticide monocrotophos and other pesticides are being sprayed from aircraft and tractors to control grasshoppers in fields of alfalfa and other new crops. Hawks flying behind the tractors to seize flushed grasshoppers get sprayed directly, then eat more pesticide in the grasshoppers.

Scientists from Canadian and U.S. governments and universities are working with the Argentine environmental agency, INTA, to

propose a change to less severe pesticides.

Research scientist Geoff Holroyd of the Canadian Wildlife Service in Edmonton said the situation needs urgent action, especially since Swainson's hawks have been in decline for a decade in their main Canadian breeding grounds in Saskatchewan and Alberta. Nesting failures have explained part of the problem, but researchers have been puzzled and alarmed by a further downward drift.

"I think this is comparable to what happened to the peregrine falcon in the 1960s and 1970s. Hopefully, we have caught it in time," Mr. Holroyd said. "This went to the Environment Minister's desk, and he approved action within 24 hours."

The autumn race of peregrines was all but wiped out by pesticides in eastern North America three decades ago and is just coming back now with the help of planning programs. Mr. Holroyd is chairman of the Canadian com-

Hawks in Argentina die from pesticides

From Page A1

The Swainson's hawks will leave Argentina at the end of February and spend two months migrating north.

The big, dark-plumaged hawk is a familiar sight soaring over the Canadian Prairies on upturned wings, like a vulture. It raises its young largely on Richardson's ground squirrels but eats many insects after migrating in large flocks to the wintering grounds on the South American pampas.

The Canadian population is estimated at 40,000 to 100,000 in a world population of 350,000 to 400,000. Canadian birds were inordinately represented in the Argentine deaths. Of 13 leg bands recovered, nine were from Alberta and Saskatchewan hawks. Two Alberta hawks lagged with satellite transmitters are both in the danger area.

The study area is at the junction of the states of Cordoba, Buenos Aires and La Pampa. Cattle ranching used to dominate, but irrigation recently opened the area to a variety of crops. This is only a small part of the winter range of the hawks and a small part of the cultivated farmland. "We don't

know how far this problem extends," Mr. Holroyd said. Ninety per cent of the killed hawks were adults. The separate winter range of immature birds is not known.

Monocrotophos is an organic phosphate insecticide that is fast-acting and highly toxic to birds and animals. It kills insects either on contact or when taken in with eaten crops. It is no longer sold in the United States and was never registered for use in Canada.

"At worst, the Argentine toll would represent 5 per cent of the world population and half the Canadian population," Mr. Holroyd said.

"This appears to explain decline in this hawk. We also speculate that secondary effects of the pesticides could be reducing nesting success of the birds when they return to Canada."

Concern that Argentine pesticides were hurting migrant North American hawks appeared in birding literature as long ago as 1968, but there were no specifics. The first solid evidence came last year when 300 Swainson's hawks were found dead in the same area, apparently from pesticide poisoning.



Insect spraying in Argentina is killing Swainson's hawks.

(W. Earl Gieddes, Birds of Canada)

inittee working to rebuild the peregrine population.

Environment Canada is funding field work by INTA, and Canadian farm experts are to offer expert advice about pesticides. "It is too late to do anything this year, but we hope for a solution by next winter," Mr. Holroyd said.

Please see Hawks / A2

APPENDIX 24

Jumbo Jet Hits Birds; Engine Explodes

APPENDIX 25

Aviation Daily: Bird Ingestion Test. February 1996

ANA in 1996: Service Growth, Belt-Tightening

All Nippon Airways (ANA) plans to add service this year to Frankfurt, Vienna, Yangon and Ho Chi Minh City, the carrier said in its 1996 business plan. The new service is subject to government approval, and ANA applied for Ho Chi Minh City route authority 18 months ago but was turned down. ANA plans to boost capacity 7% — 2% in the domestic market and 18% in international service — by increasing aircraft utilization 2% and adding four 777-200s and two 767-300s to its fleet. The carrier currently operates two 777s and will take a third in a month. By March 31, when its fiscal year ends, ANA will operate a fleet of 131 aircraft.

The carrier said it is well on its way to meeting the goals of a four-year plan, launched April 1, 1994, that calls for increasing revenues 15% and aircraft utilization 10%, and a 20% reduction in manpower costs per available seat kilometer by March 1998. "The coming year will be a year of great promise for ANA, but not without effort," said Seiji Fukatsu, president and chief executive. "We will continue our belt-tightening and productivity measures to increase our competitiveness."

Already announced plans include service from Narita to Los Angeles through a code share with Delta and the addition of an ANA aircraft to the three-times-a-week Vienna service the carrier provides with Austrian Airlines. The aircraft would continue to Paris, giving ANA daily service in the market. The Los Angeles service requires government approval. From Kansai, the carrier plans to add flights or start service to Frankfurt, Milan, Rome, Vienna, Yangon, Honolulu, Ho Chi Minh City, Hong Kong and Bangkok. Domestically, ANA hopes to increase its passenger volume 4%, load factor 1% and available seat miles 2%.

Chase Working With Philippines On 747 Purchases

Chase Manhattan said it completed a \$103.6 million financing of a 747-400 aircraft for Philippine Airlines. Chase said it acted as an adviser and arranger for the 12-year financing, which was priced at 6.03% fixed interest. The financing, guaranteed by the U.S. Export-Import Bank, was placed with WestLB, which had earlier taken out bridge financing from Chase. Chase, which also advised on and arranged the financing of two 747-400s the carrier acquired in 1993, said it is working now with PAL on the financing of a fourth, for delivery this quarter.

BR710 Loses Fan Blade Tip During Bird-Ingestion Test

The new BMW Rolls-Royce BR710 turbofan that powers the Gulfstream V and Global Express business jets failed a bird ingestion test, but program officials said engine certification seven months from now is not in jeopardy. Gulfstream President and Chief Executive Fred Breidenbach confirmed to DAILY affiliate *Show News* at the Singapore Air Show that a fan blade tip came off a few seconds short of the engine's required 10-minute post-ingestion run after being fed four 1.5-pound birds. But he emphasized that the blades were not production-standard solid blades, which would have withstood the test. The BR710's full-authority digital engine control sensed an imbalance after the blade tip came loose, and it shut the engine down immediately. Although the failure is disappointing, it is "no big deal" and the test will be rerun soon with production-configuration blades, Breidenbach said. The engine remains on schedule for an August certification by Europe's Joint Airworthiness Authorities.

DOT has renewed DHL Airways' exemption authority to operate scheduled all-cargo service between Cincinnati and Houston, on the one hand, and Monterrey and Guadalajara, Mexico, on the other. The carrier also received permission to integrate this service with its existing flights in the Cincinnati/Houston-Mexico City market. DHL operates Cincinnati/Houston-Guadalajara service five times a week, using 727 aircraft, and uses small aircraft in the Monterrey market (DAILY, Jan. 23). (Docket OST-95-145)

DOT renewed America West's exemption to operate scheduled combination service between Phoenix, Ariz., and San Jose del Cabo, Mexico. The carrier offers 17 weekly nonstops on the route, using 737-300 aircraft (DAILY, Dec. 11). (Docket OST-95-736)

Aeromexpress has applied for renewal of its authority to operate scheduled all-cargo service between Mexico City and Atlanta, Dallas and Dayton. (Dockets OST-95-135 & OST-95-219)

DOT has revoked the certificate authorizing Patriot Airlines to operate all-cargo charter service. (Docket 48131)

APPENDIX 26

Air Transport World

Top Gun

Bird strikes are one thing. Deer strikes are a whole different ball game.

Not to diminish the danger of bird strikes but Philadelphia International had a much, shall we say larger, problem. The airport grounds were overrun with deer.

In contrast, European airports have the problem of excess rabbits. Sitting on a Galwick taxiway and counting rabbits and rabbit holes by the hundreds in the infield area, one begins to get the distinct idea that the little rodents have undermined the entire area. One wonders what would happen if a taxiing airliner suddenly dropped 5 ft. straight down?

Deer don't dig warrens but they present other problems. Imagine—briefly, because otherwise, it is too disgusting—the outcome of sucking a 10-point buck into a modern turboban. See what we mean?

Wait until authorities start requiring engine manufacturers to pass a higher standard of foreign-object damage during certification testing. ("OK, load the deer launcher.")

And hitting a deer with an airplane at any speed will have consequences.

The deer population on the U.S. East Coast is exploding. There are a number of reasons for this: No predators, lots of protected green space and curbs on hunting. All have combined to assist the deer population in growing beyond its natural habitat. Many show up in suburban neighborhoods; sometimes, even in cities.

At Philadelphia Airport last year, at least 50 deer were count-

ed inside the fence. Holes in the fence were fixed but deer jump really well. Cutting down trees that the deer find savory didn't help. Even explosives were tried—to no avail.

But with three airplane/deer collisions this year—and four others at North Philadelphia Airport—something had to be done. Frustrated airport authorities went with a typically American solution, one that had been used at Chicago, New York, Denver and Orlando airports: Shoot 'em.

Orlando hired a "consultant" to eliminate its problems at \$100 a rack. He got 43.

"Yo, I'm da consultant. You got some sorta problem wid da deer?"

Late last year at Philadelphia, two gentlemen toting rifles fitted with night-vision scopes and silencers, shooting from special 16-ft. towers, launched an onslaught against the indigenous Bambi population, using soft-tipped bullets that mushroom on contact to "cut down on the ricochets."

They identified themselves as "biologists" from the U.S. Dept. of Agriculture.

Sure, why not? USDA has a good stockpile of silencers and dum-dum bullets.

"They're going to stop where we want them to stop," said a "biologist."

But these biologists have hearts of gold. They delivered their "harvest" to the local food bank, to be distributed to the disadvantaged as Bambi-burgers and Bambi-steaks.

But keep an eye on the catering from PHL vendors. If the mystery "beef" on your next outbound from PHL is a little tough or tastes a bit different, well... consider that wild venison is lean and quite good for you.

Is that a Pan Am pallet in your pocket?

They can be seen all over the place, clustered in quiet spots on airport ramps, trading stories about cargo holds and forwarders they have seen. They are theULD containers and pallets, those freight cars of the sky, knocking around from one corner of the globe to the other, hauling the freight and picking up dents.

Some of these, the Pan Am ULDs and pallets, are wanted.

Airline Container Leasing Inc., of Elmont, N.Y., says the courts have declared that it is the rightful owner of the Pan Am units and ACL wants them back.

When the airline went belly up, it had some 6,000 of these things on lease from ACL, floating around the system.

If you cooperate and turn in a pallet, it's worth \$200 in



STEVE WOLF!!!!!!

UAL's Gerry Greenwald, having passed up the chance to capture USAir, now sees the situation in a different light with the entrance of Stephen M. Wolf on the scene.

reward money, or \$100 for a ULD. If you don't have possession of such but feel no problem about eating on someone else, ACL will pay a \$25 "finder's fee" to individuals that prefer to remain anonymous," ACL said. Those keeping the devices will risk dire consequences and demerage charges.

"Pss! Hey, fella. Come here. Interested in a ULD? Go on, take a look."

APPENDIX 27

Collingwood Landfill Issue

STUDIES OF NUMBERS AND MOVEMENTS OF GULLS WITH RESPECT TO
POTENTIAL BIRD HAZARDS TO AIRCRAFT SAFETY ASSOCIATED WITH A
PROPOSED LANDFILL NEAR THE COLLINGWOOD MUNICIPAL AIRPORT

BY

LGL LIMITED

environmental research associates

for

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Public Works Department
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P.O.Box 157
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LGL Report No. TA2102

21 November 1995

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EXECUTIVE SUMMARY

Introduction

The Towns of Collingwood and Wasaga Beach and the Township of Clearview (formerly Stayner, Creemore and Nottawasaga Township) are preparing the Georgian Triangle Waste Management Master Plan (GTWMMP). Included in the plan is a new landfill. A preferred site (known as Site I-1) has been identified; it is located about 2 km from the end of the main runway at the Collingwood Municipal Airport.

Landfills in the Great Lakes region attract large numbers of birds, particularly gulls. Birds and aircraft occasionally collide in the air. In most cases the bird is killed but the aircraft suffers no damage. However, in rare instances the bird(s) can cause damage to the aircraft, even threatening the aircraft's safety. Therefore, there is concern whenever a landfill that attracts birds is placed near an airport.

LGL Limited was retained by the Town of Collingwood to provide an independent evaluation of potential bird hazards to aircraft safety associated with the proposed siting of a landfill at Site I-1.

Field Research

Field studies were conducted between 9 August and 3 November 1995. Gulls and other landfill-related birds in the Collingwood-Wasaga Beach-Stayner area were censused at two existing Simcoe County landfills (Nottawasaga and Wasaga Beach), in the communities of Wasaga Beach and Stayner, along the shore of Nottawasaga Bay, in the regional countryside, and at the Collingwood Municipal Airport. At the Nottawasaga and Wasaga Beach landfills, "towering" behaviour (circling high into the air on thermals) by gulls was documented. Observations also were made of the movements of gulls with respect to the existing landfills, the Collingwood Municipal Airport, and the gulls' night roost. Based on the results of this field work, and numerous other studies in the Great Lakes region, predictions were made of the numbers and movements of gulls that are likely to occur as a result of the construction of a new landfill at Site I-1. These predictions assume that there is no bird control in place at the proposed landfill.

Predicted Numbers and Movements of Gulls

The numbers of gulls at the proposed landfill are likely to be highest in the late summer (late July and August; approximately 2,000 to 3,000 gulls), and to remain relatively high through September (1,000-2,000) with a gradual decline beginning in October and continuing to freeze-up. Few if any gulls are expected to be present during the winter. Large numbers of gulls return to the area in late March and April, frequenting fields and landfills. Gulls nest on an island off Collingwood Harbour from April to July. In general, most gulls in the Great Lakes region feed along the lakeshore rather than at landfills when nesting, although undoubtedly would visit the landfill.

Gulls at the landfill will not create a hazard to aircraft while they remain feeding or loafing on the site. A potential hazard will be created only if the gulls fly into airspace being used by aircraft. Thus, it is the flight movements and towering behaviour of the gulls that determines whether they will pose a hazard to aircraft. During the non-nesting period of the year (late July through late March/early April, except winter), gulls feeding at a landfill at Site 1-1 will probably fly a north-south route between the landfill and the night roost on Nottawasaga Bay. These flights would occur primarily at dawn and dusk. If gulls from the Collingwood nesting colony were to feed at a landfill at Site 1-1, then they would probably fly on a more or less straight line (NW-SE) route between the landfill and the colony. These gulls would fly parallel to the main runway at the airport but they would not overfly it. It is not known how many gulls would be involved in flights from the colony. In the appropriate weather conditions, towering was found to be a frequent event at the existing landfills.

Predicted Bird Hazards to Aircraft Safety

Based on information about aircraft types and movements and predictions of bird numbers and movements, it is possible to summarize the main findings with regard to potential for birds attracted to the proposed Site I-1 Landfill to pose hazards to the safety of aircraft using the Collingwood Municipal Airport.

Gulls that feed at the landfill will roost at night on Nottawasaga Bay to the north. These gulls will be flying away from the aircraft Approach/Departure path to Runway 13/31, the main runway at the airport. In the afternoons, some of these gulls enter airspace used by

aircraft on the circuit pattern from runway 13. Therefore, the gull movements between the landfill and the night roost may pose a threat to aircraft safety on some occasions.

Gulls will frequently tower over the new landfill, sometimes to altitudes up to 500-1,000 ft (agl), or more. The weather conditions that lead to formation of thermals usually involve westerly or northerly winds that can drift the thermals into the aircraft Approach path to Runway 31. Under these weather conditions, aircraft will be landing into the wind on Runway 31. In these situations, towering gulls could create a hazard to these aircraft. It should be pointed out that thermals and towering occur primarily on clear days that provide the gulls with unlimited visibility allowing them to see and react to approaching aircraft. This acts to minimize but not eliminate the risk.

Mitigation Measures

While it is possible to control gulls at landfills, an effective gull control program requires management commitment, personnel dedicated to full-time control, and the involvement of biologists or professional controllers. For a small landfill such as a Site 1-1, the cost of such a program may be prohibitive. Partial control while less costly, can increase, rather than decrease, the hazards to aircraft. This is because gulls very often tower over or near a landfill after they are scared into the air. Full-time control means preventing gulls from landing at the landfill in the first place.

Recommendations

The following recommendations, in order of more preferred to least preferred, are made. These refer only to potential bird hazards to aircraft associated with the siting of a landfill at Site 1-1. They do not address any other factors that influence the selection of a preferred landfill site.

1. Select a landfill site other than Site 1-1 or 1-2. If this cannot be done, then the following options should be considered.
2. Operate the landfill site with a full, professionally-operated gull control program in place for the 40-year life of the landfill.

3. Operate the landfill with a control program conducted by landfill staff with the assistance of, and training by, experienced biologists or controllers. In our experience, this is not an optimal solution because of the potential to increase bird hazards to aircraft, rather than decrease them, if the control program is incorrectly operated.
4. Operate the landfill with no gull control program. This would create a hazard to aircraft over the 40-year life of the landfill.

INTRODUCTION

The Towns of Collingwood and Wasaga Beach and the Township of Clearview (formerly Stayner, Creemore and Nottawasaga Township) are preparing the Georgian Triangle Waste Management Master Plan (GTWMMP). Included in the plan is a new landfill. A landfill siting process was begun in 1989 and has reached the Stage 2B phase whereby a preferred landfill site has been identified. The preferred site (known as Site I-1) is located about 2 km from the end of the main runway at the Collingwood Municipal Airport (Figure 1).

Landfills in the Great Lakes region attract large numbers of birds, particularly gulls. Birds and aircraft occasionally collide in the air. In most cases the bird is killed but the aircraft suffers no damage. However, in rare instances the bird(s) can cause damage to the aircraft, even threatening the aircraft's safety. Therefore, there is concern whenever a landfill that attracts birds is placed near an airport.

In response to this concern, LGL Limited was retained by the Town of Collingwood to conduct some basic field work and to provide an independent evaluation of the potential safety risks associated with siting the proposed landfill near the Collingwood Municipal Airport. This report presents the results of the field studies and our evaluation of potential bird hazards to aircraft safety that might be created by birds attracted to the landfill.

METHODS

Field studies were conducted on 10 days during 7 visits to the area between 9 August and 3 November 1995. The studies were designed to investigate the existing numbers and movements of gulls and other birds that are likely to be attracted to a future landfill at Preferred Site I-1. The study emphasized those species that could pose hazards to the safety of aircraft using the nearby Collingwood Municipal Airport. Gulls were the primary focus of the field observations. The field studies are described below. A summary of the field activities and the dates on which they were conducted is presented in Table 1.

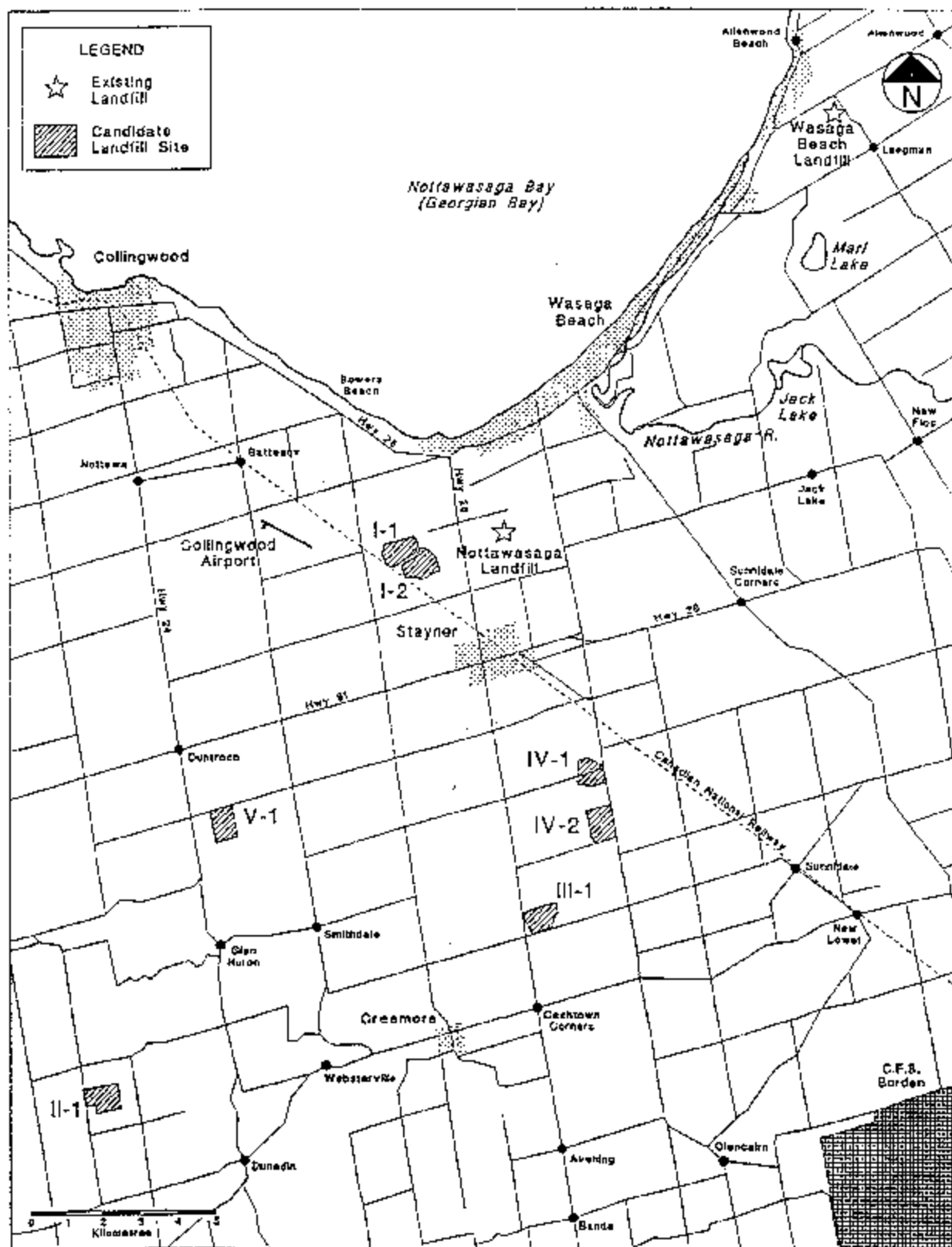


Figure 1. Map of the study area showing the two existing landfill sites - the Nottawasaga Landfill and Wasaga Beach Landfill - and Candidate Landfill Sites (as identified in the Stage 2B report).

Table 1. Outline of the field observation program, August–November 1995.

[illegible]

Numbers of Gulls

Gulls and other landfill-related birds in the Collingwood-Wasaga Beach-Stayner area were censused at two existing Simcoe County landfills (Nottawasaga and Wasaga Beach), in the communities of Wasaga Beach and Stayner, along the shore of Nottawasaga Bay, in the regional countryside, and at the Collingwood Municipal Airport (see Figure 1). The species and ages of gulls were determined using 10X binoculars and a 25X telescope. Two species of gulls comprised more than 99% of the gulls recorded during the study — herring gull and ring-billed gull. Herring gulls were classified on the basis of plumage into <1 year, 1-2 year, and ≥ 2 years age categories. Ring-billed gulls were classified into <1 year and ≥ 1 year age categories.

Nottawasaga and Wasaga Beach Landfills

The Nottawasaga Landfill (County of Simcoe Landfill Site No. 10) and Wasaga Beach Landfill (County of Simcoe Landfill Site No. 15) each were censused during the midday period (approximately 10:00-15:00) on 10 weekday dates. These counts included gulls that were feeding at the active face and gulls that were loafing elsewhere on the site. The numbers of gulls were either counted exactly or estimated. The species and age composition of the flock of gulls at the landfill were determined by either identifying all the gulls present, if few enough gulls were present to permit this, or identifying a sample of the gulls present (usually at least 20%) and extrapolating the species-age proportions of the sample to the entire flock.

Wasaga Beach and Stayner Day-Use Areas

Gulls forage at a variety of sites other than landfills. These include, for example, day-use areas such as schoolyards, parks, and shopping mall parking lots. (Gulls also forage along lakeshores and in agricultural fields; surveys of these areas are described below.) Censuses of the numbers, species, and ages of gulls were made at several locations in Wasaga Beach and Stayner. Seven locations were censused in Wasaga Beach: Zehrs Plaza, Oakview Community Centre/Kinsmen playing field, the Schooner Town Parkette, Birchview Dunes Elementary School, Waterworld, the Georgian Bay Driving Range, and the Wasaga 500 Go-Karts facility. Four sites were censused in Stayner: the elementary school and secondary school, the Stayner

Granite Club, and the Stayner arena/Legion Park. Two other day-use areas away from Wasaga Beach and Stayner also were censused: Blue Mountain Go-Karts, and the Great Northern Exhibition grounds.

Shoreline Areas

The numbers, species, and ages of gulls were counted at selected locations in Wasaga Beach Provincial Park along the shoreline of Nottawasaga Bay on 10 and 31 August and 28 September. Counts were made at New Wasaga Beach, Beach #1, #3, and #6. An accurate count was not possible on 10 August because of the number of people and gulls on the beaches. Opportunistic observations also were made at the foot of several streets along the shoreline southeast of Collingwood, between Collingwood and Wasaga Beach Provincial Park Beach #6.

Agricultural Fields

Gulls were counted along a roadside survey route in the regional countryside of the Collingwood-Wasaga Beach-Stayner area. This survey was conducted on eight dates (see Table 1). The survey route varied somewhat during the study as new areas were added. The routes that were followed and the locations of gull flocks on fields are illustrated in Appendix 1. The distance of each roadside census varied between 23 km (9 August) and 99 km (29 September to 3 November); the lengths of each survey are listed in Table 6.

Collingwood Municipal Airport

Observations of the numbers of gulls and other birds on and over the Collingwood Municipal Airport were made from the northwest end of the airfield on eight dates (see Table 1).

Movements of Gulls

Gulls roost at night in dense flocks on large bodies of water where they are safe from terrestrial predators. The movements of gulls between night roosts and daytime feeding areas

usually follow repetitive, traditional routes. Thus, gulls are likely to establish, and then continue to use, new flight routes between a new landfill at Site I-1 and their night roost. Consequently, it is important to determine the location of the night roost so that the probable flight lines associated with the new landfill can be determined. During this study, observations were made of the movements of gulls with respect to the existing landfills, the Collingwood Municipal Airport, and the night roost.

Landfills: Flightline Observations

Observations were made of the numbers and flight paths of gulls arriving at, or flying over or past, the Nottawasaga and Wasaga Beach landfills during the early morning, and of gulls departing from and flying over/by the Nottawasaga Landfill in the late afternoon. At the Nottawasaga Landfill, early morning observations were made on 31 August and 29 September, and late afternoon observations on 30 August. At the Wasaga Beach Landfill, an early morning watch was conducted on 10 August.

Collingwood Municipal Airport

The numbers, directions, and altitudes of gulls and other birds observed flying over the northwest end of the Collingwood Municipal Airport were recorded on six dates (Table 1). Observations were made during the mid day and afternoon periods (approximately 11:00 to 17:00), and during the late afternoon when gulls were flying to roost.

Flightlines and Night Roost

En route to the night roost, gulls often gather in flocks on water or land at pre-roost gathering areas. Pre-roost gathering areas on water tend to be re-used regularly whereas terrestrial pre-roost areas may vary over the years as land-uses change. Field work was conducted to discover the location(s) of the major gull roost(s) and pre-roost congregation(s) that were used by gulls from the study area, and the flight paths flown by gulls departing or enroute to the roost(s) or pre-roost congregation area(s). These were determined by observing gulls flying from the roost at daybreak, and returning to roost in the evening. Observations were made from the landfills in the early morning and near sunset, from inland agricultural

areas in the late afternoon, and at several locations along the shore of Nottawasaga Bay around sunset. Notes on locations, times, flight directions, flock movements, notable congregations on the water or land or in flight, and approximate numbers were recorded. Observations were made on 9, 10, 30, and 31 August, 8, 28, and 29 September and 10 and 20 October.

Observations of Towering Behaviour

Certain birds are well known to circle or "tower" high into the air on thermals or rising columns of warm air. Although this behaviour does occur at altitudes as low as 100-200 ft, towering often occurs up to 500 to 1,000 ft and occasionally higher. Consequently, towering can bring birds to heights where they are more likely to encounter aircraft and become hazards to aircraft safety. Of the birds that occur regularly at landfill sites, gulls are of greatest concern because they often tower, usually in flocks.

Towering behaviour by gulls was documented at the Nottawasaga Landfill and Wasaga Beach Landfills during the midday censuses. The numbers and altitudes of towering gulls and the circumstances on the landfill site at the time, were recorded.

Other Birds

Counts were made of other non-gull bird species that are attracted to landfills and that could pose hazards to aircraft because of their size and/or flocking tendencies. These species included European starlings, American crows, and turkey vultures. Counts of these species were made at the Nottawasaga and Wasaga Beach Landfills, and at the Collingwood Municipal Airport. Only records of significant concentrations were made during the surveys of agricultural fields and day-use areas.

RESULTS AND DISCUSSION

Numbers of Gulls

Ring-billed and herring gulls are the two most abundant gulls in southern Ontario, and together they accounted for over 99% of the gulls recorded during this study. The field

surveys were conducted during the late summer dispersal of gulls from their nesting colonies and the fall migration period of the annual cycle for these two gulls. It is during these times of year when gull numbers in southern Ontario are at their peak. By 9 August when the field observations began, ring-billed and herring gulls have completed their nesting activities, and the young-of-the-year have fledged and left the nest. During August, adult and young-of-the-year gulls disperse throughout the Great Lakes region. Gulls from north of the study area move south into the study area gradually through August and September. By late October and early November most of the ring-billed gulls have moved out of the study area.

Nottawasaga Landfill

The numbers, species, and ages of gulls at the Nottawasaga Landfill were recorded during each of the 10 surveys. The data are presented in Table 2 (numbers and species) and Table 3 (age categories).

The numbers of gulls observed at the Nottawasaga Landfill ranged between 192 (November 3) and 982 (August 10) but showed few consistent patterns or trends, although there seemed to be a general decline in numbers in October and early November (Table 2). The Nottawasaga Landfill is a small site that receives little putrescible waste (e.g. about 40 mt per day in July 1995). Relatively small numbers of gulls are attracted to the site. Such low numbers could easily double or triple with the addition of a flock of gulls flying in from a nearby field, and could decrease in similar fashion. This could account for the marked but inconsistent variation in the counts.

Ring-billed and herring gulls predominated at the Nottawasaga Landfill; only 3 great black-backed gulls were observed (Table 2). On most surveys, there were more herring gulls than ring-bills or numbers were similar. However, there were markedly more ring-billed gulls on 28 September (92%), and during the two October censuses (73%, 72%). A decrease in ring-billed gull numbers at the landfill was evident on 3 November, coincident with their usual time of departure for migration. On all censuses, most gulls were adults or near adults (Table 3).

Table 2. Numbers and species of gulls during mid-day counts at the Nottawasaga Landfill, August-November 1995.

Survey Date	Total No. of Gulls	Gulls Sampled for Species ID		Ring-billed Gull		Herring Gull		Great Black-backed Gull	
		Number	%	Total	%	Total	%	Total	%
Aug 9	220	220	100%	118	54%	102	46%	0	0.0%
Aug 10	982	522	53%	384	39%	598	61%	0	0.0%
Aug 30	405	405	100%	154	38%	251	62%	0	0.0%
Aug 31	238	237	99%	41	17%	196	82%	1	0.4%
Sep 8	200	164	82%	82	41%	118	59%	0	0.0%
Sep 28	892	411	46%	823	92%	69	8%	0	0.0%
Sep 29	520	273	53%	281	54%	239	46%	0	0.0%
Oct 10	350	194	55%	254	73%	96	27%	0	0.0%
Oct 20	465	247	53%	337	72%	128	28%	0	0.0%
Nov 3	192	119	63%	41	21%	149	78%	2	1.0%

Table 3. Ages of ring-billed and herring gulls recorded at the Nottawasaga Landfill, August-November 1995.

Survey Date	Total No. of Gulls	Extrapolated Numbers					
		R-b & H Gulls Sampled for Species & Age		Ring-billed Gull			
		Number	%	<1 yr		≥1 yr	
				Number	% ^b	Number	% ^c
Aug 9	220	220	100%	3	3%	115	97%
Aug 10	982	522	53%	9	2%	375	98%
Aug 30	405	405	100%	7	5%	147	95%
Aug 31	238	237	100%	10	24%	31	76%
Sep 8	200	164	82%	9	11%	73	89%
Sep 28	892	411	46%	31	4%	792	96%
Sep 29	520	273	53%	4	1%	277	99%
Oct 10	350	194	55%	8	3%	246	97%
Oct 20	465	247	53%	30	9%	307	91%
Nov 3	192	119	63%	12	29%	29	71%
						41	21%

^a Sample size as a percentage of the total number of ring-billed and herring gulls, not all gulls. All individuals of other gull species were identified and aged.

^b Percentage of all ring-billed gulls in this age category.

^c Percentage of total number of gulls.

Continued...

Table 3. Concluded.

Extrapolated Numbers									
Herring Gull									
Survey Date	<1 yr		1 yr		≥2 yr		Total		% ^c
	Number	% ^d	Number	% ^d	Number	% ^d	Number	% ^d	
Aug 9	6	6%	4	4%	92	90%	102	46%	
Aug 10	43	7%	12	2%	543	91%	598	61%	
Aug 30	22	9%	10	4%	219	87%	251	62%	
Aug 31	14	7%	14	7%	168	86%	196	82%	
Sep 8	24	20%	5	4%	89	75%	118	59%	
Sep 28	26	38%	4	6%	39	57%	69	8%	
Sep 29	16	7%	10	4%	213	89%	239	46%	
Oct 10	10	10%	4	4%	82	85%	96	27%	
Oct 20	9	7%	11	9%	108	84%	128	28%	
Nov 3	35	23%	20	13%	94	63%	149	78%	

^c Percentage of total number of gulls.^d Percentage of all herring gulls in this age category.

Over the past two years, the Nottawasaga Landfill has been the subject of periodic efforts to control the numbers of gulls at the site. At the onset of this study, an overhead barrier of five lines was present over the active area during the 9-10 August survey. This gull control program had been initiated approximately two weeks previously and had been successful in reducing gull numbers from approximately 1,000-2,000 to several hundred according to Mr. Doug Thoratton (County of Simcoe, pers. comm.). The overhead barrier appeared to be effective on 9 August (220 gulls), but not on 10 August (982 gulls). On 10 August, gulls were gaining access to the active disposal area by walking and flying under the lines through the open eastern side where vehicles backed up to unload. By the time of the next survey on 30 August, all lines but one were down and the active area had moved away from this area. This arrangement existed for the remainder of the field work. A starter pistol and pyrotechnic shells also were available at the Nottawasaga Landfill but were not used during the study period.

Wasaga Beach Landfill

The numbers, species, and ages of gulls at the Wasaga Beach Landfill were recorded on each of the 10 field days. Data summarizing the numbers and species of gulls recorded are presented in Table 4; Table 5 summarizes the age composition of ring-billed and herring gulls at the site. The Wasaga Beach Landfill accepted more waste than did the Nottawasaga Landfill. In July 1995, the Wasaga Beach Landfill received about 150 mt of waste per day (Russ Nicholson, Waste Reduction Officer, County of Simcoe, pers. comm.).

Numbers of gulls recorded at the Wasaga Beach Landfill ranged between 315 (November 3) and 1,119 (August 9) (Table 4), averaging higher than counts at the Nottawasaga Landfill. Most counts recorded fewer than 800 gulls. The general trend was a gradual decrease in numbers during the study period, although numbers did increase in late August-early September and again in mid October.

As at the Nottawasaga Landfill, ring-billed and herring gulls were by far the most abundant gull species recorded. On most censuses they were the only gulls present (Table 4). Herring gulls were more common on most censuses, with the exception of 30 August, and 10 and 20 October. There was a very noticeable reduction in the numbers and percentage of ring-

Table 4. Numbers and species of gulls during mid-day counts at Wasaga Beach Landfill, August-November 1995.

Survey Date	Total No. of Gulls	R-b & H Gulls Sampled for Species ID		Ring-billed Gull		Herring Gull		Great Black-backed Gull	
		Number	%	Total	%	Total	%	Total	%
Aug 9	1,119	379	34%	285	25%	834	75%	0	0.0%
Aug 10	690	350	51%	248	36%	442	64%	0	0.0%
Aug 30	585	491	84%	370	63%	215	37%	0	0.0%
Aug 31	895	400	45%	114	13%	777	87%	4	0.4%
Sep 8	913	430	47%	395	43%	515	56%	3	0.3%
Sep 28	423	189	45%	63	15%	360	85%	0	0.0%
Sep 29	405	262	65%	127	31%	277	68%	1	0.2%
Oct 10	750	266	35%	648	86%	102	14%	0	0.0%
Oct 20	360	193	54%	265	74%	95	26%	0	0.0%
Nov 3	315	150	48%	38	12%	277	88%	0	0.0%

Table 5. Concluded.

Extrapolated Numbers									
Herring Gull									
Survey Date	<1 yr		1 yr		≥2 yr		Total		% ^c
	Number	% ^d	Number	% ^d	Number	% ^d	Number	% ^d	
Aug 9	43	5%	57	7%	734	88%	834	75%	75%
Aug 10	54	12%	27	6%	361	82%	442	64%	64%
Aug 30	38	18%	23	11%	154	72%	215	37%	37%
Aug 31	113	15%	58	7%	606	78%	777	87%	87%
Sep 8	77	15%	54	10%	384	75%	515	56%	56%
Sep 28	35	10%	39	11%	286	79%	360	85%	85%
Sep 29	34	12%	22	8%	221	80%	277	68%	68%
Oct 10	23	23%	6	6%	73	72%	102	14%	14%
Oct 20	20	21%	3	3%	72	76%	95	26%	26%
Nov 3	25	9%	44	16%	208	75%	277	88%	88%

^c Percentage of total number of gulls.^d Percentage of all herring gulls in this age category.

billed gulls at the landfill from 20 October (265 ring-bills, 74%) to 3 November (38 ring-bills, 12%). This is the time of year when many ring-billed gulls migrate out of southern Ontario. On all censuses, a significant majority of gulls were adults or near-adults (Table 5). Great Black-backed gulls were observed on three dates, with a total of 8 individuals recorded (Table 4).

A gull control program was in place at the Wasaga Beach Landfill during this study. The program consisted of overhead lines, a propane cannon, and pyrotechnic shells fired from a starter pistol. Not all components were employed at the same time. Overhead lines had been installed about two weeks before this study began, and were in place for the 9 and 10 August censuses. By 30 August, however, the active area was no longer under the lines, and no lines were in place on censuses on and after 28 September. The propane cannon was in use during the 9 and 10 August censuses but not during any other visits. Pyrotechnic shells had been fired on the days of all censuses from 28 September to 3 November, but no shells were fired while we were at the site.

Substantial numbers of gulls were present at the Wasaga Beach Landfill in spite of the bird control efforts. It is not known how many gulls would have been present in the absence of the control measures. Some of the day-to-day variability in gull numbers at the site was undoubtedly related to the amount of time between the census and the most recent firing of pyrotechnic shells. Clearly, the numbers of gulls present at the Wasaga Beach Landfill as determined by this study underestimate the numbers that would have been present in the absence of gull control efforts.

Wasaga Beach and Stayner Day-Use Areas

A total of 11 day-use areas were censused for gulls and other landfill-related birds: seven were located in Wasaga Beach and four in Stayner. The results of these counts are presented in Table 6.

Usually no gulls were observed at these day-use areas. When gulls were present, typically it was only one or two individuals. On 10 and 30 August respectively, 50 and 35 gulls were observed at the Waterworld facility in Wasaga Beach. During the summer tourist

Table 6. Numbers of gulls recorded on the Day-Use Areas, Airport, Shoreline, and Agricultural Fields Surveys.

Survey and Locality	Aug 9	Aug 10	Aug 30	Aug 31	Sep 8	Sep 28	Sep 29	Oct 10	Oct 20	Nov 3
Wasaga Beach Day-Use Areas										
Zehrs Plaza	-	1	0	-	0	0	0	0	0	0
Oakview Community Ctr/Kinsmen Field	-	1	1	0	0	0	0	0	0	0
Schooner Town Parkette	0	0	0	-	0	0	0	0	0	0
Birchview Dunes Elementary School	-	0	0	-	0	0	0	7	0	0
WaterWorld	-	50	35	-	0	0	0	0	0	0
Georgian Bay Driving Range	0	0	0	0	0	0	0	0	0	0
Wasaga 500 Go-Karts	0	0	1	-	0	0	0	0	0	0
Subtotals	0	52	37	0	0	0	0	7	0	0
Stayner Day-Use Areas										
Stayner elementary school	-	-	0	-	0	-	2	9	0	2
Stayner Granite Club	-	-	0	-	0	-	0	0	0	0
Stayner arena/Legion Park	-	-	-	0	0	-	0	1	0	0
Stayner high school	-	-	-	-	0	-	0	0	0	0
Subtotals	-	-	0	0	0	-	2	10	0	2
Other Day-Use Areas										
Blue Mountain Go-Karts	0	-	0	-	0	-	0	0	0	0
Great Northern Exhibition grounds	0	-	0	-	0	-	0	0	0	0

Continued...

Table 6. Concluded.

Survey and Locality	Aug 9	Aug 10	Aug 30	Aug 31	Sep 8	Sep 28	Sep 29	Oct 10	Oct 20	Nov 3
Collingwood Municipal Airport										
On the airfield	0	-	1	-	0	1	0	0	0	0
Flying Over	6	-	0	-	0	0	0	0	-	-
Shoreline Survey										
New Wasaga Beach	-	107	-	26	-	89	-	-	-	-
Beach #1	-	*	-	109	-	124	-	-	-	-
Beach #3	-	*	-	16	-	63	-	-	-	-
Beach #6	-	45	-	15	-	1,600	-	-	-	-
Subtotals	-	>1,000*	-	166	-	1,876	-	-	-	-
Agricultural Fields										
Site I-1	-	-	0	-	0	-	0	0	0	0
Site I-2	-	-	0	-	0	-	0	0	0	0
Site III-1	-	-	-	-	-	-	0	0	0	0
Site IV-1	-	-	-	-	-	-	0	0	0	0
Site IV-2	-	-	-	-	-	-	0	0	80	0
Site V-1	-	-	-	-	-	-	0	0	0	0
Other Fields	24	0	1,727	-	180	-	220	3,219	2,038	940
Subtotals	24	0	1,727	-	180	-	220	3,219	2,118	940
No. Agricultural km surveyed	23	27	56	-	56	-	99	99	99	99
No. Gulls per 10 km	10	0	308	-	32	-	22	325	214	95

"-" indicates not surveyed

* See text.

season, this is a popular attraction with many people and the associated food items that attract gulls. After the end of August, and the closing of the facility for the season, no gulls were recorded at Waterworld.

Two other day-use areas outside of Wasaga Beach and Stayner were censused also — Blue Mountain Go-Karts, and the Great Northern Exhibition grounds. No gulls were recorded at these locations.

Of the 110 gulls recorded at day-use areas, all but two were ring-billed gulls. The other two were herring gulls.

Shoreline Areas

Wasaga Beach attracts large numbers of gulls, especially ring-billed gulls, during the summer tourist season. The gulls are attracted by discarded food scraps and handouts provided by the many people there. Flocks of gulls also use areas of the beach to loaf during the day, and to gather in pre-roost congregations as sunset approaches. Once the tourist season is over, after Labour Day, gull numbers decrease markedly. Some gulls still forage along the beach, but it is used primarily by gulls for loafing and pre-roost flocking. The data from the shoreline surveys are presented in Table 6.

On 10 August, an estimated 1,000 to 2,000 gulls were present along Wasaga Beach, although a precise count was not conducted. Only 166 gulls were counted during the next census on 31 August. This was a cool and windy day and few people were on the beach. A total of 1,876 gulls were counted during the next census on 28 September. Of these, 1600 were at Beach #6 and were probably a pre-roost congregation rather than a mid-day loafing flock. The 276 gulls at the other beach sites that were censused are more expected mid-day numbers.

Agricultural Fields

At certain times of the year, primarily spring and autumn, substantial numbers of gulls forage on agricultural fields. Gulls on fields typically occur in several large flocks on a few

fields rather than being widespread in small numbers on many fields. Fields that are being ploughed or otherwise worked are particularly attractive. Surveys for gulls in roadside fields in the study area were conducted on eight dates. The results of these surveys are presented in Table 6, and include the numbers of gulls observed on six short-listed Candidate Landfill Sites. The locations of the survey routes, and gull flocks, for each survey are mapped in Appendix 1.

The numbers of gulls recorded on agricultural fields ranged from 0 (10 August, short survey) to 3,219 (10 October). Many gulls also were observed on 20 October (2,118), 30 August (1,727) and 3 November (940). On 20 October, approximately 80 gulls were foraging on a field beside Site IV-2 as the field was being ploughed. This was the only occasion when gulls were recorded on any of the short-listed Candidate Landfill Sites. On fields across the road from Site IV-2, there were approximately 2,000 gulls loafing on 10 October and 48 gulls loafing on 20 October. Almost all of the gulls observed on fields were ring-billed gulls.

Collingwood Municipal Airport

Gulls were rarely recorded using the Collingwood Municipal Airport (Table 6). Single gulls (ring-bills >1 year old) were observed on the airfield on two dates: 30 August and 28 September.

These observations do not reflect overall gull use of the airfield, however. Our observations were made during middays and afternoons. In discussions with Mr. Alex Stroud, Airport Manager, on 3 November 1995, he indicated that during the spring through autumn period, gulls frequently use the airfield in the early morning to forage and loaf. On occasion, he said, hundreds and sometimes 1,000-2,000 gulls (very approximately) are present. The gulls subsequently leave the airfield either on their own, or by being flushed by an aircraft or airport personnel attempting to clear the gulls from the runway. It is often necessary to shoot gulls in order to clear the runway.

Movements of Gulls

Studies of existing gull movement patterns provided indications of the likely movement patterns that would occur if the landfill was established at Site I-1. Knowledge of the likely movement patterns allows for an assessment of the potential bird hazards to the safety of aircraft using the Collingwood Municipal Airport.

Nottawasaga Landfill: Flightline Observations

Observations of gull movement patterns at and near the Nottawasaga Landfill were made during the early mornings of 31 August and 29 September, and the late afternoon of 30 August. During the early morning periods when the gulls were leaving the roost and flying inland to forage, most gulls were moving in a north-to-south direction. During the late afternoon period, when gulls were returning to the roost, most gulls were moving in a south-to-north direction.

Observations of flying gulls were made from 06:38 to 07:30 (52 minutes) on the morning of 31 August; observations were ended early because of an approaching thunderstorm. A total of 399 gulls were observed either flying over, flying by, or arriving at the Nottawasaga Landfill. Almost all (99.5% — 397 of the 399) gulls were flying over or by the site, rather than approaching and landing at the landfill. Of the 399 gulls, 76% (303) were flying from the N and 24% (95) from the NW.

Two hours (07:15 to 09:15) of observations of gull movements were made during the early morning of 29 September. Of the total of 1,059 gulls observed, 69% (726) were fly-overs and fly-by's. Again, the majority of gulls came from the N (81%) and NW (16%).

Gulls observed departing, flying over, and flying by the Nottawasaga Landfill during the late afternoon of 30 August were all headed to the N or NNW.

The principal directions of arrival, departure, fly-overs and fly-by's correspond well with the points of Nottawasaga Bay closest to the Nottawasaga Landfill, i.e., to the north. The gulls generally were taking the most direct route to and from the bay.

Wasaga Beach Landfill: Morning Flightline Observations

Gull movements were observed from the Wasaga Beach Landfill between 06:45 and 08:45 on the morning of 10 August. A total of 650 gulls were recorded arriving at, flying over, or flying by the landfill. Unlike the behaviour observed at the Nottawasaga Landfill, almost all gulls approached and landed at the Wasaga Beach Landfill rather than flying further inland. The principal directions of arrival were from the NW (38% of gulls), W (29%), and N (14%). These principal directions of arrival correspond well with the points of Nottawasaga Bay closest to the Wasaga Beach Landfill, i.e., to the west through north. The gulls generally were taking the most direct routes to and from the bay.

Collingwood Municipal Airport

Observations of gulls flying over and by the airport were made during late morning, mid afternoon, and late afternoon near sunset. Only six gulls were seen flying over the airfield during these observations, all during the late afternoon of 9 August. Nevertheless, these data describe only part of the movements of gulls around the airport. During the middle of the day, relatively few gulls fly over or by the airport, as indicated by these data. Other data suggest, however, that many gulls do, on occasion at least, fly over and by the airport. The airport manager, Mr. Alex Stroud, indicated (pers. comm.) that gulls often are on the airfield in the early morning when he arrives. No observations were made here at this time of day during our study. Also, although very few gulls were observed flying over or by the airport, flightlines of gulls flying towards Nottawasaga Bay were seen in the general vicinity of the airport near sunset (see next section).

Together these observations suggest that gulls fly over and by the Collingwood Municipal Airport principally during the early morning and late afternoon. On occasion, it is likely that these flights involve substantial numbers of gulls, perhaps a few thousand.

Flightlines and the Night Roost

Observations near sunset of gull flocks and gull movements indicated that, during the study period, local gulls roosted overnight far out in Nottawasaga Bay (Figure 2). The precise

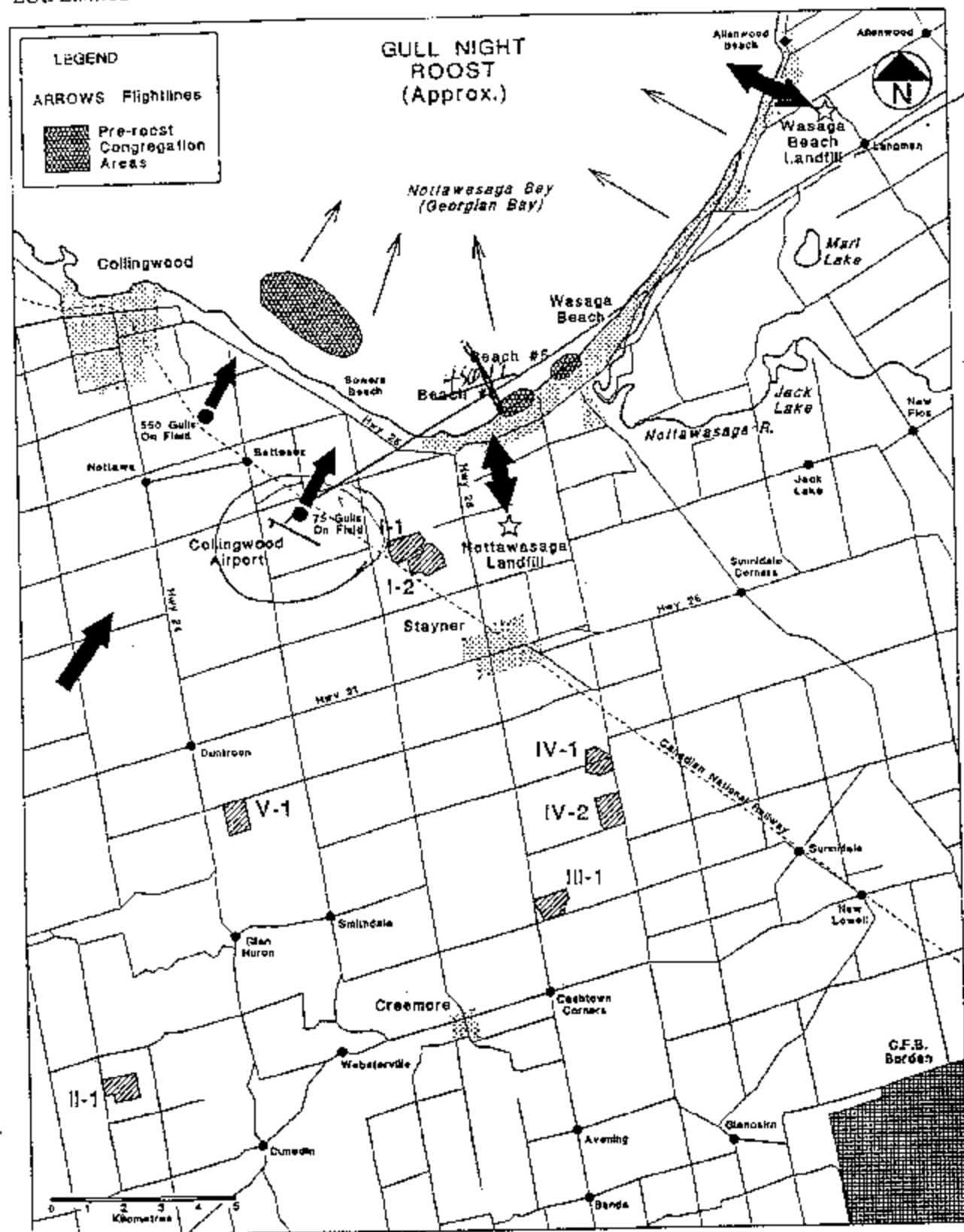


Figure 2. Observed major flightlines, pre-roost congregation areas, and the approximate location of the night roost used by gulls in the study area, 9 August to 3 November 1995.

location of the roost was not determined, but could be approximated by extrapolating the gulls' flightlines. The roost was beyond sight of land well out in the middle of the bay. Flocks of gulls flying to the roost in the late afternoon and evening approached the roost from many inland locations. Consequently, their flightlines appeared as spokes converging on the hub of a wheel. The locations of several pre-roost congregating areas were determined also. The largest, involving several thousand birds at its peak during the study, was located just offshore along the stretch of Nottawasaga Bay southeast of Collingwood (Figure 2). Other pre-roost flocks gathered along the beach of Wasaga Beach Provincial Park at Beach #6 (e.g., 1600 gulls on 28 September) and Beach #5.

The data from this study identify several important facets of gull numbers and behaviour in the southern Georgian Bay area. There are far more gulls in the region than feed at the Nottawasaga and Wasaga Beach Landfills. These birds seem well dispersed inland during the day and then fly to Nottawasaga Bay on a fairly broad front. Thus, substantial numbers of gulls already pass over the Collingwood Airport and through its Approach/Departure paths on the twice daily flights to and from the night roost. If there was a landfill at Site I-1, and if there was no bird control at the landfill, then a significant gull flightline between the site and Nottawasaga Bay would be established. This flight would undoubtedly take the shortest route to the bay for most of the year. However, during the nesting season from April through mid July, it is possible that a flightline between the landfill and the gull nesting colony off Collingwood Harbour might be used. Such a NE/SW flightline would bring gulls closer to the Collingwood Municipal Airport.

Gull Towering Behaviour

Towering by gulls occurs most frequently during the warmer months when thermals of warm air are most frequent. Because towering takes gulls to higher altitudes, it brings them to heights where they are potential hazards to aircraft safety. Towering behaviour was investigated at the Nottawasaga Landfill and Wasaga Beach Landfill during the midday censuses, where it often but not always followed a disturbance that caused gulls to flush into the air.

Towering was observed infrequently at the Nottawasaga Landfill. Gulls observed at this site tended to be either loafing near the active face or foraging in the active area. The only towering that was observed at the Nottawasaga Landfill was on 28 September when nearly 900 gulls were present. The gulls on the site flushed several times, in response to the observer and to passing hawks. As a result, about 120 gulls towered over the site at 200-300 ft above ground level (agl). Eventually, a few (<20) of these gulls reached approximately 1,000 ft in altitude and subsequently dispersed away from the landfill. Many of the other towering gulls resettled.

At the Wasaga Beach Landfill, towering gulls were observed on five of the 10 midday censuses. On 9 August, 300-400 of the approximately 1,100 gulls present were towering over the entrance to the site when the observer arrived. All of the gulls were at altitudes of less than 500 ft.

On 10 August, 690 gulls were present at the Wasaga Beach Landfill. About 200-300 of these gulls flushed and began to tower apparently in response to the noise from a propane cannon. Many of these gulls subsequently resettled, but about 50 continued to tower 200-300 ft over the site, 40 minutes later.

All of the approximately 900 gulls at the Wasaga Beach Landfill flushed en masse on 8 September. Initially, about 100 of these gulls formed a flock that towered at about 300-400 ft. Five minutes later, about 50 of the gulls were towering at between 500 and 1,000 ft (agl).

On 28 September, a turkey vulture flew in low over the Wasaga Beach Landfill and flushed the 415 gulls that were present. Some of the gulls resettled almost immediately, but about 100-120 gulls began towering and rose to about 200-400 ft (agl). Some of these towering gulls then left the area, while others resettled on the landfill.

Most of the approximately 400 gulls at the Wasaga Beach Landfill flushed in response to disturbances by a bulldozer and trucks at the active disposal area. Eventually most of these gulls resettled, but about 150 began towering and formed a flock that extended from 200 ft to 500 ft, top to bottom, above the landfill.

Turkey vultures also regularly soared over and near the landfills; particularly the Wasaga Beach Landfill which was frequented by more vultures than was the Nottawasaga Landfill. On occasion, the vultures were observed at altitudes of approximately 1,000 ft to 1,500 ft (agl). The numbers of vultures involved were always fewer than 15 individuals, however, and typically fewer than 10.

Other Birds

The numbers of other bird species at landfills, besides gulls, that could pose a hazard to aircraft safety were recorded. These species were the European starling, American crow, and turkey vulture. Table 7 presents the numbers of these species recorded at the Nottawasaga Landfill and the Wasaga Beach Landfill.

The numbers of these species were low during the study period. The maximum numbers of each species at the Nottawasaga Landfill were 45 starlings, 43 crows, and 3 turkey vultures. Numbers averaged higher at the Wasaga Beach Landfill; peak numbers were 100 starlings, 60 crows and 42 vultures. The 42 vultures on 8 September was far higher than recorded on any other day (Table 7). There was no equipment activity at this particular time allowing some of the vultures to feed at the active area. Most were loafing away from the active area. It is likely that at least some of these birds were migrants that were passing through the area.

ASSESSMENT OF POTENTIAL BIRD HAZARDS TO AIRCRAFT

In this section, we evaluate the potential for a landfill at Site I-1 to create bird hazards to the safety of aircraft using the Collingwood Airport. The assessment begins with a brief overview of the bird hazard issue. This is followed by a description of the Collingwood Airport and an analysis of the location of the proposed landfill in relation to the airport. Bird populations and movements at the new landfill and their relationship to the airport are then discussed. The potential interactions between these bird movements and aircraft movements are evaluated to determine whether a hazard would be created. Potential mitigation measures are then discussed.

Table 7. Numbers of European starlings, American crows, and turkey vultures recorded during mid-day counts at the Nottawasaga Landfill and the Wasaga Beach Landfill.

Survey Date	NOTTAWASAGA LANDFILL			WASAGA BEACH LANDFILL		
	Starlings	Crows	Vultures	Starlings	Crows	Vultures
Aug 9	0	0	0	0	3	2
Aug 10	0	5	3	<10	0	0
Aug 30	<10	0	1	50	17	5
Aug 31	<10	0	0	<10	10	1
Sep 8	10	<10	0	<10	36	42
Sep 28	20	1	1	10	0	3
Sep 29	30	15	0	10	0	1
Oct 10	40	43	0	<10	60	3
Oct 20	45	3	0	40	30	0
Nov 3	40	0	0	100	3	0

Review of Bird Hazards To Aircraft

It has been well documented that collisions between birds and aircraft can damage the aircraft, occasionally severely. There are numerous instances where commercial, private and military aircraft have crashed as a result of bird strikes (Blokpoel 1976; Thorpe 1982, 1984). Turbine (including jet) powered aircraft are most vulnerable to serious bird strikes through ingestion of birds into the engines. Also, the high speeds attained by turbine aircraft lead to increased numbers of strikes, since birds have less time to avoid the fast-approaching aircraft (Busnel and Giban 1965), and increased damage when strikes do occur.

Small piston-powered aircraft are much less susceptible to damage by birds than are turbine-powered aircraft. Concerning the engines themselves, Blokpoel (1976:43) states that

"The propellers on piston-engined aircraft are strong and, although often struck, they are rarely damaged by birds; further, the rotating propeller blades tend to protect the strong piston engines by chopping up the birds, and strikes causing severe damage to piston engines have not been reported. Turbine engines, however, are a different matter altogether. They are usually exposed and are quite vulnerable to bird impact. The rotor and stator blades of the engine's compressor may bend or break on heavy impact ... and, in the worst case are completely destroyed."

Summaries of the circumstances of collisions between light aircraft and birds are rarely published. One such list published by the British Civil Aviation Authority (CAA 1973) shows that light piston aircraft (single engine and light twins) often collide with birds, most commonly gulls, but that the damage is usually nil or minor.

Birds occasionally do, however, cause serious damage to or even crashes of light aircraft. The first recorded human fatality caused by a bird/aircraft collision occurred in California in 1912 when a gull became entangled in the control cables of a light aircraft (Blokpoel 1976). In 1964, a Turbulent (an extremely small, one-seat piston-engined aircraft) struck a gull during final approach to an airport in Northern Ireland; despite the fact that the windscreen where the gull struck was not broken, the aircraft apparently stalled and the pilot was killed (Stables and New 1968). In 1977, an Aero Commander (twin engines), while taking off at Chicago, struck gulls and crashed (Thorpe 1984). A number of light aircraft and gliders, including one in

Canada, have crashed after striking eagles or hawks (e.g., Blokpoel 1976; Nemergut *et al.* 1976). In some cases these raptors appear to attack rather than to avoid the aircraft. Another fatal crash occurred when a light aircraft, shortly after take-off, struck three geese (Seubert 1976). Two more recent incidents include a Piper Super Cub that crashed in Maine on 21 July 1984 when a bird penetrated the windshield and a Cessna 172 that crashed into the ocean one mile from shore off East Hampton, New York, on 11 February 1988 due to a bird strike; the pilot was killed in the latter accident (Plunkett and Gibson 1990). This incomplete list illustrates the fact that collisions between light aircraft and birds do occasionally occur and can cause crashes and human fatalities.

Aircraft are most vulnerable to the effects of bird strikes during the take-off and landing phases near airports. During the take-off climb the aircraft needs to generate full power and damage caused by a bird strike can jeopardize safety. In addition, the nose of the aircraft is high during take-off; this reduces the pilot's ability to see and avoid birds in the air. During landing, the aircraft is at reduced power and has much less capability and room for manoeuvring to avoid collisions. It is for these reasons that bird attractants, such as landfills, close to airport runways are of concern.

Transport Canada is responsible for air safety in Canada. Transport Canada guidelines state that food waste disposal sites should not be located within 8 km of an airport runway (Transport Canada 1992). The guidelines envision exceptions based on the "expert advice of a bird hazard specialist".

Collingwood Municipal Airport

Facilities

The Collingwood Municipal Airport has two runways. The main runway (13/31) is oriented NW/SE. This asphalt runway is 4,983 ft (1,519 m) long X 100 ft (30.5 m) wide. The runway is capable of handling some jet aircraft. A secondary grass runway (01/19) is oriented N/S. It is 2,450 ft (747 m) long X 75 ft (23 m) wide. The grass runway is not maintained in winter. The main runway at the airport was recently extended from 3,000 to 4,983 ft. The

airport is considered to be an important community amenity that will help to attract industry to the Georgian Triangle region.

Air Traffic

The Collingwood Airport has a fairly small amount of traffic at present, but there are hopes to increase traffic in the future, particularly business aircraft. There are two sources of data on the amount of traffic at the airport. The airport keeps its own records and it sends information to Transport Canada. Transport Canada publishes an annual volume entitled Aircraft Movement Statistics that provides information on the amount of air traffic at airports in Canada.

According to the records maintained at the airport, there were 4,932 aircraft movements in 1994, a substantial decrease from earlier years (Mr. Alex Stroud, Manager, Collingwood Municipal Airport, pers. comm.). The corresponding data from Transport Canada indicate that there were 2,664 movements, based on only 270 days of the year. A movement is a take-off or landing at the airport. The Transport Canada sample of 2,664 movements consisted of 76 by jet aircraft, 105 by turboprops, 2,397 by piston-engined aircraft, 64 by helicopters and 22 by gliders. Thus, a very low proportion (7%) of the movements at Collingwood Municipal Airport were by the jet and turboprop aircraft that are most vulnerable to bird strikes.

Location in Relation to Site I-1

The proposed Landfill Site I-1 is located ESE of the Collingwood Airport. The closest (western) boundary of the landfill property is approximately 1,970 m from the SE end of Runway 13/31. Aircraft taking-off to the SE on Runway 13 and following runway heading will pass about 500 m south of Site I-1.

The prevailing winds in the area are from the west and northwest. Therefore, most take-offs and landings on the main runway will be on Runway 31. In this case aircraft are taking-off to the NW, away from the direction of the proposed landfill. On the other hand, aircraft landing on Runway 31 will pass about 500 m south of the landfill. Assuming a 3° glide slope on the IFR (Instrument Flight Rules) Approach, then an aircraft would be at about 350 ft above

ground level (agl) when it passed the southwest corner of the landfill property. The IFR approach is most likely to be used by jet and turboprop aircraft. In the following analyses, aircraft are assumed to be between 300 and 500 ft agl when they pass the landfill on final approach. On take-off, aircraft would be between 500 ft and 1,000 ft when they pass the landfill.

According to Mr. Alex Stroud, Airport Manager, aircraft on IFR approach to Collingwood Airport pass over Site I-1 before turning onto final runway heading southwest of the landfill site. As noted, the IFR approach is most likely to be used by the more vulnerable jet and turboprop aircraft and it is more likely to be used in poor weather conditions.

Each airport has circuit patterns that govern flight patterns in air space near airports without Air Traffic Control Towers. Standard left hand circuit patterns are used at the Collingwood Airport. For example, after take-off, aircraft climb on the runway heading to approximately 500 ft (152 m) agl, at which point a left hand turn is executed to the reverse or downwind direction while continuing to climb to 1,000 ft (305 m) agl. At an appropriate point on the downwind leg of the circuit, a descending left hand turn is started to place the aircraft at approximately 500 ft above ground and lined up with the runway for landing. Itinerant VFR (Visual Flight Rules) aircraft approaching the airport for landing from outside the local traffic patterns would either join the circuit pattern or would land using a straight in approach to the runway.

A typical circuit pattern would be conducted within about 3 km of the centre point of the runway. Therefore, aircraft joining the left hand circuit from Runway 13 would pass directly over the proposed landfill at Site I-1 at an altitude of slightly over 500 ft agl. According to the Airport Manager, this circuit pattern is used on about 25-30% of the movements at the airport (A. Stroud, pers. comm.). He noted that the estimated use of Runway 13 was higher than predicted based on wind conditions because in light wind conditions aircraft used this runway rather than taxiing from the tarmac/hangar area to the SE end of the runway in order to use Runway 31.

Predicted Gull Numbers and Movements

The proposed landfill at Site I-1 will have a 40-year life with a total capacity of about 908,000 mt of waste. This provides an average 22,700 mt of waste per year or about 91 mt per day. There will be seasonal patterns in the amount of waste accepted at the landfill; highest amounts are expected in the summer months of June-September. This is also the period when large numbers of gulls are expected to be present at the landfill. It should be noted that both the Nottawasaga Landfill and the Wasaga Beach Landfill will be closed when the new landfill opens.

Based on the results of the present studies and numerous other studies in the Great Lakes region, it is possible to predict the numbers and movements of gulls that are likely to occur as a result of construction of a new landfill at Site I-1. The following evaluations assume that there is no bird control in place at the proposed landfill.

The numbers of gulls at the new landfill are likely to be highest in the late summer period of late July and August. Combining the numbers from the two existing landfills indicates that the numbers of gulls at the replacement landfill could peak at between 2,000 and 3,000 gulls per day during the late summer. Numbers in the fall are likely to remain high with a decline beginning in October and continuing to freeze-up. The overall average numbers in the fall might range from 1,000 to 2,000 gulls.

It is unlikely that any gulls remain in the area in winter. Only in a very mild winter in which Nottawasaga Bay did not freeze is it likely that a few gulls might remain in the area. In this unusual situation a small number of gulls might frequent the landfill in winter. Large numbers of spring-migrating gulls are present in the Collingwood area in late March and April. These birds are distributed in many fields and presumably are also found at the landfills during this season. However, no data on the numbers involved are available.

It is not known whether the gulls that nest in the colony off Collingwood Harbour use landfills for feeding. In the Great Lakes region, our experience has been that most gulls feed along the lakeshore rather than at landfills. However, some gulls do feed at landfills at this time. If gulls from the Collingwood colony were to feed at the landfill at Site I-1, then they

would probably fly on a more or less straightline (NW/SE) route between the landfill and the colony. These gulls would fly parallel to the main runway at the airport but they would not overfly it. It is not known how many gulls would be involved in these flights.

Gulls feeding at the landfill will not create a hazard to aircraft while they remain feeding there. A potential hazard will only be created if the gulls fly into airspace being used by aircraft. Thus, it is the movement and towering behaviour of the gulls that determines whether they will pose a hazard to aircraft.

During the non-nesting season, gulls feeding at a landfill at Site I-1, will probably fly a north/south route between the landfill and the night roost on Nottawasaga Bay. These flights will take the gulls away from the Approach/Departure paths for Runway 13/31. Thus, these birds will not pose a threat to aircraft on runway headings. However, a substantial number of aircraft will pass over the landfill at a little over 500 ft agl on the left hand circuit from Runway 13. Most gull flights over such short distances are usually conducted at altitudes below 500 ft, particularly on the morning flights. Thus, most birds will be below aircraft on the circuit pattern and aircraft approaching the airport using the IFR approach from the ENE. In the afternoon in good weather conditions, some gulls will likely use thermals and be at higher altitudes when they leave the landfill area and cross the IFR approach. In these conditions, therefore, there is the likelihood of interactions between aircraft and gulls.

An additional concern is that gulls from the landfill will tower up into airspace used by aircraft on the left hand circuit from Runway 13 and aircraft approaching or departing the airport on runway heading. Observations during this study demonstrated that towering is a frequent event at landfills. Flocks of gulls were observed towering over or near the existing landfills on 30% (6 of 20) midday landfill visits from 9 August to 3 November 1995. A similar situation is expected at the proposed landfill for Site I-1. Gulls tower on thermals of rising warm air. These thermals often break loose from the ground and drift downwind which in most cases will drift the thermal and the gulls into the airspace used by aircraft approaching the airport to the northwest. In southern Ontario, thermals form mostly in the clear, fairly dry conditions that are associated with westerly and northerly winds. Thus, towering gulls can drift into aircraft approach paths and, as noted earlier, enter airspace used by aircraft on IFR approach over the landfill.

Based on observations in this study, it is possible that a small number of turkey vultures may be associated with the landfill site during the June-September period. The constant towering by vultures presents a hazard to aircraft. If the landfill is operated properly with full daily cover, then the numbers of vultures attracted to the new landfill site will be minimized.

Predicted Bird Hazards to Aircraft

Based on the previous discussions of aircraft types and movements and the predictions of bird numbers and movements in the preceding section, it is possible to summarize the main findings with regard to potential for birds attracted to the proposed Site I-1 Landfill to pose hazards to the safety of aircraft using the Collingwood Municipal Airport.

Gulls that feed at the landfill will roost at night on Nottawasaga Bay to the north. These gulls will be flying away from the aircraft Approach/Departure path to Runway 13/31, the main runway at the airport. In the afternoons, some of these gulls enter airspace used by aircraft on the circuit pattern from runway 13. Therefore, the gull movements between the landfill and the night roost may pose a threat to aircraft safety on some occasions.

Gulls will frequently tower over the new landfill, sometimes to altitudes up to 500-1,000 ft (agl), or more. The weather conditions that lead to formation of thermals usually involve westerly or northerly winds that can drift the thermals into the aircraft Approach path to Runway 31. Under these weather conditions, aircraft will be landing into the wind on Runway 31. In these situations, towering gulls could create a hazard to these aircraft. It should be pointed out that thermals and towering occur primarily on clear days that provide the gulls with unlimited visibility allowing them to see and react to approaching aircraft. This acts to minimize but not eliminate the risk.

MITIGATION MEASURES

It is possible to control gulls at landfills. However, attaining and maintaining control of gulls at a landfill is not a trivial operation and it carries substantial financial costs. Many landfills, including some in Simcoe County, have attempted to control gulls. Very often the control efforts are unsuccessful or are successful only for a short period of time. An effective

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APPENDIX 1
RESULTS OF SURVEYS OF AGRICULTURAL FIELDS

control program must insure that gulls are never allowed to feed or loaf on the landfill property. If this is done, then gulls stop making regular visits to the landfill.

Effective landfill gull control programs require management commitment, dedicated personnel, and the involvement of biologists or professional controllers. Because the landfill will take relatively small amounts of waste, it is possible that the cost of a full scale control program will be prohibitive. Recent tenders for a full-year gull control program at another small landfill in southern Ontario ranged from \$90,000 to \$125,000 per year. A similar price at Site I-1 would be equivalent to a cost of \$4-\$5 per mt of waste. It is possible to reduce this amount somewhat since control is not likely to be needed for the 3 month winter period. It is beyond the scope of this report to scope out the details and the costs of a bird control program for the site.

There will be a temptation to operate a gull control program with existing landfill staff using standard control techniques such as pyrotechnics, distress calls, propane cannons, shotguns, etc. The location of the landfill in relation to the main runway of the airport makes this a potentially risky approach. Gull control is effective when there is full-time control that prevents gulls from landing at a landfill. Partial control, which is far more common, means that gulls are often present at the landfill but are scared away when someone has time to do so. Overall, numbers present are reduced but the hazard to aircraft is greatly increased. This is because gulls very often tower over or near a landfill after they are scared into the air. Thus, unless control is continuous, every time gulls are flushed from the landfill, they may tower into airspace used by aircraft and thereby create a potential hazard to aircraft.

RECOMMENDATIONS

The following recommendations refer only to potential bird hazards to aircraft associated with the siting of a landfill at Site I-1. They do not address any other factors that influence the selection of a preferred landfill site. The following options are listed in the order of most preferred to least preferred.

1. Select a landfill site other than Site I-1 or I-2. If this cannot be done, then the following options should be considered.

2. Operate the landfill with a full, professionally-operated gull control program in place for the 40-year life of the landfill. The cost of a full scale control program would have to be determined to see if it was economically feasible.
3. Operate the landfill with a control program operated by landfill staff with the assistance of, and training by, experienced professional biologists or controllers. As discussed above, an incorrectly operated control program could increase bird hazards to aircraft rather decreasing them. In our experience, this is not an optimal solution.
4. Operate the landfill with no gull control program. This would create a hazard to aircraft over the 40-year life of the landfill. It could also diminish future growth in the use of the airport, if potential users are concerned about the close proximity of the landfill to the end of the main runway.

ACKNOWLEDGEMENTS

We would like to thank the following individuals for help and assistance with this study. Mr. Ken Astill, Town Engineer for the Town of Collingwood administered the project. Mr. Alex Stroud, Manager of the Collingwood Municipal Airport kindly provided information about the airport and the concerns of the airport users. Mr. Doug Thornton and Mr. Russ Nicholson, County of Simcoe, provided information about the existing landfills and amounts of waste accepted. Ms. Caroline Kirkpatrick, Study Coordinator, Solid Waste Management Department, County of Simcoe helpfully facilitated this study.

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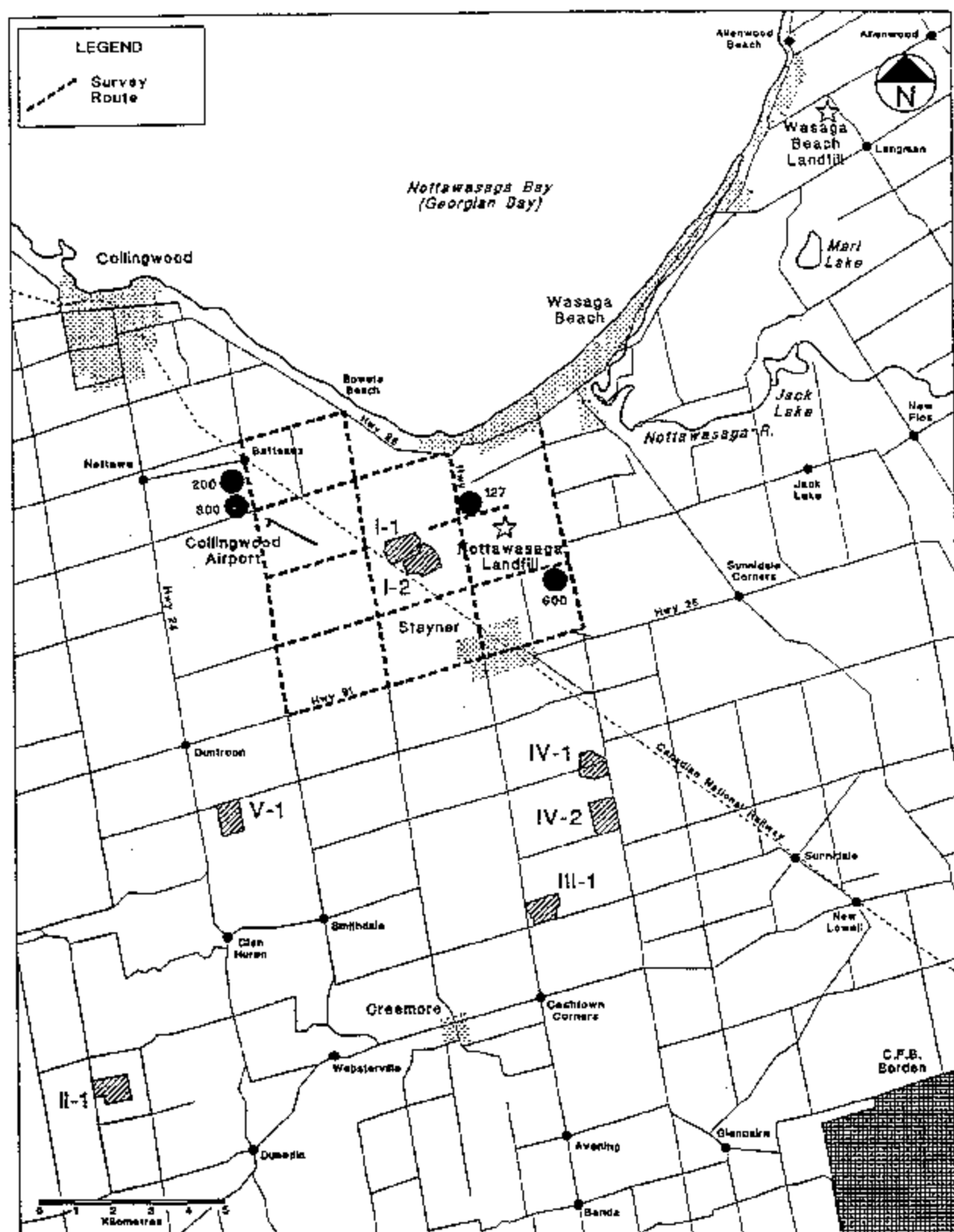


Figure 5. Survey route and the locations and numbers of gulls observed on agricultural fields: 30 August 1995.

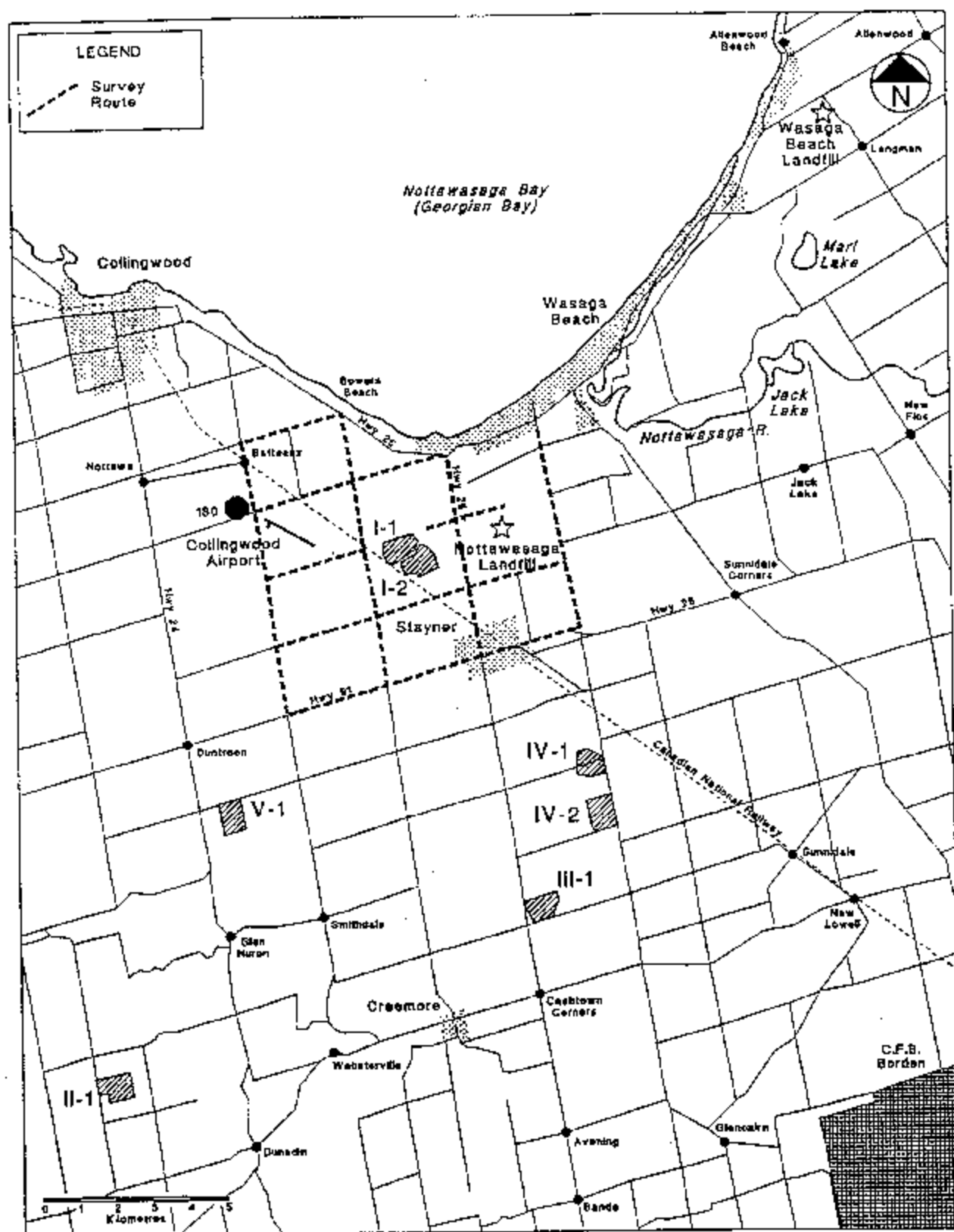


Figure 6. Survey route and the locations and numbers of gulls observed on agricultural fields: 8 September 1995.

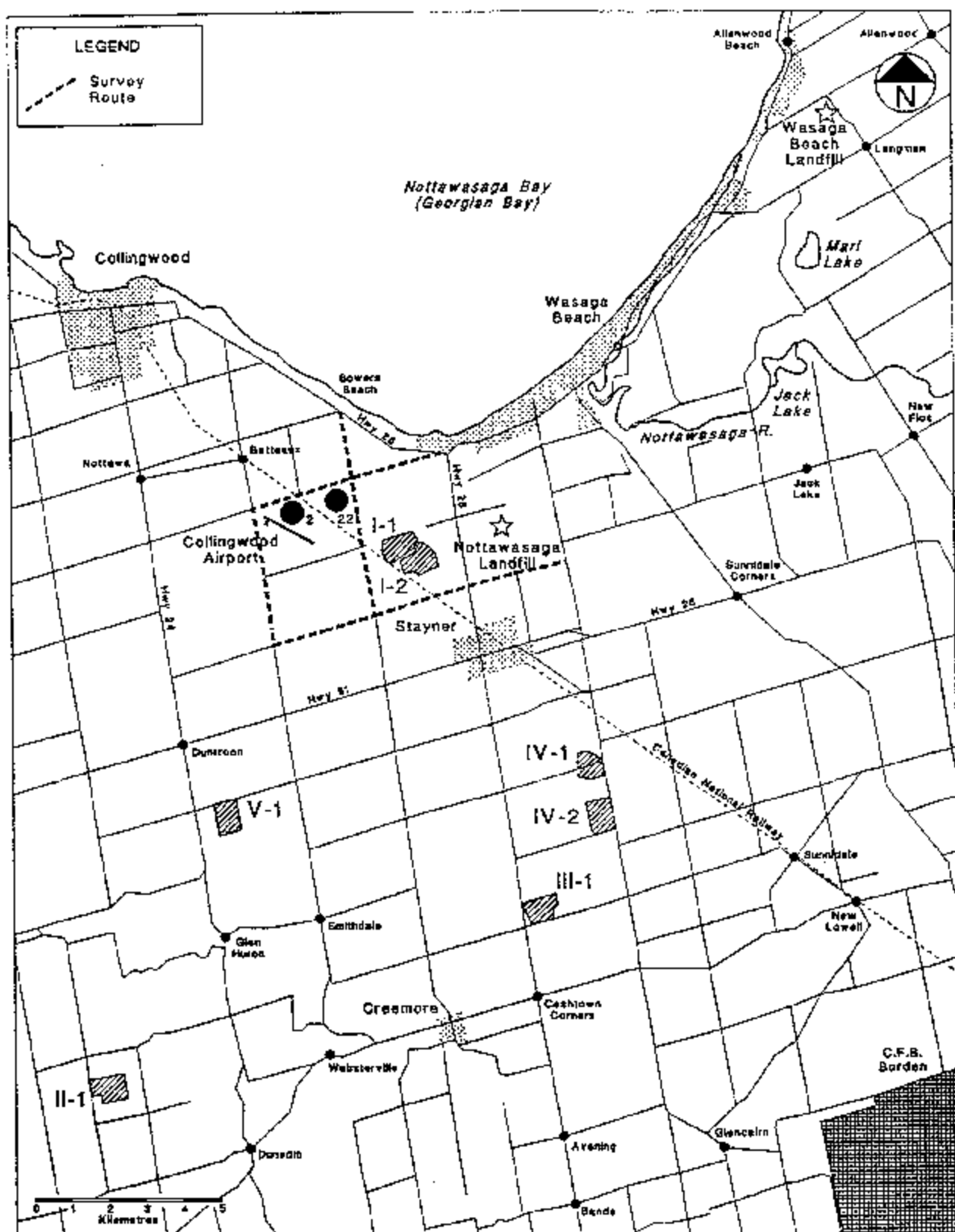


Figure 3. Survey route and the locations and numbers of gulls observed on agricultural fields: 9 August 1995.

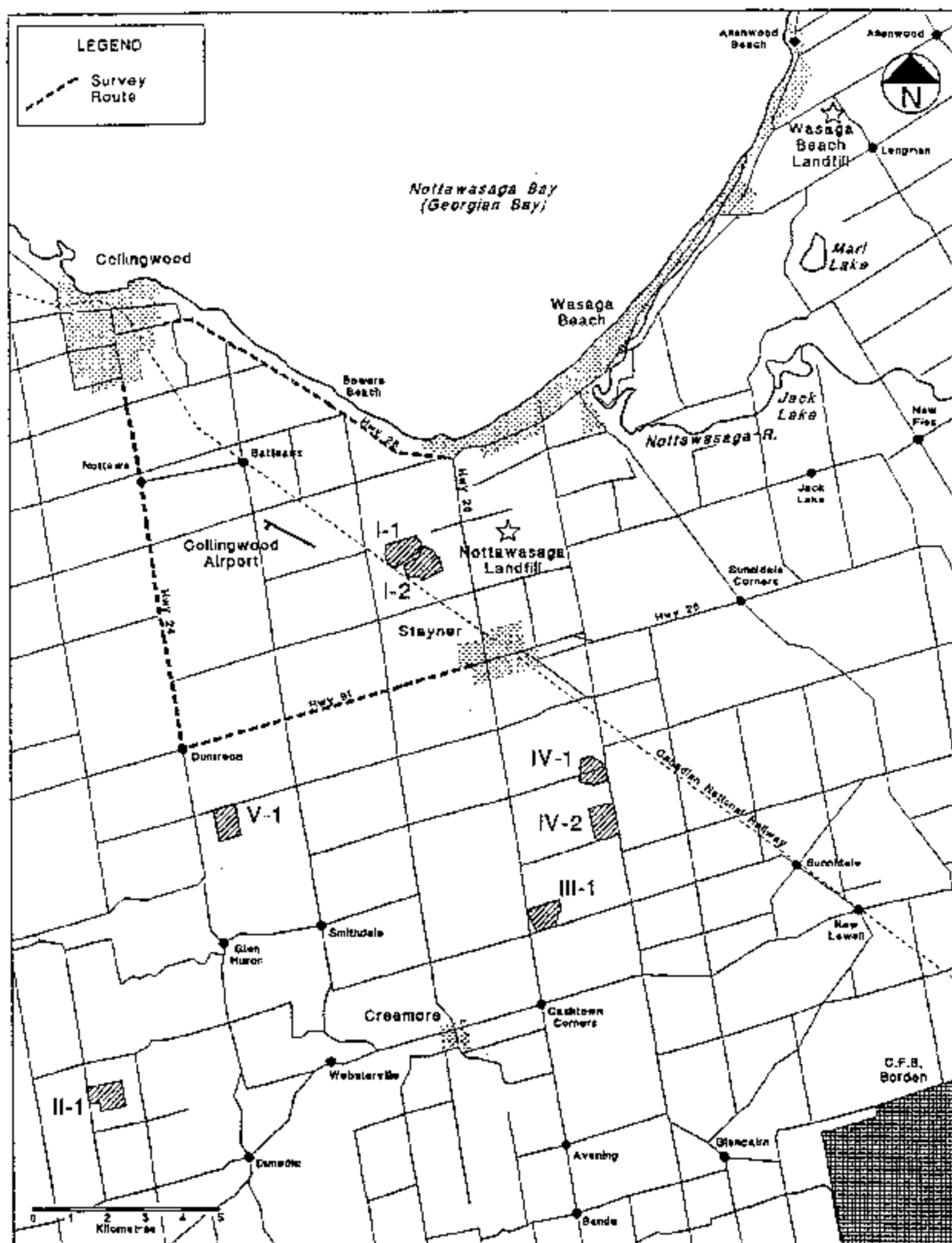


Figure 4. Survey route and the locations and numbers of gulls observed on agricultural fields: 10 August 1995. (No gulls were observed).

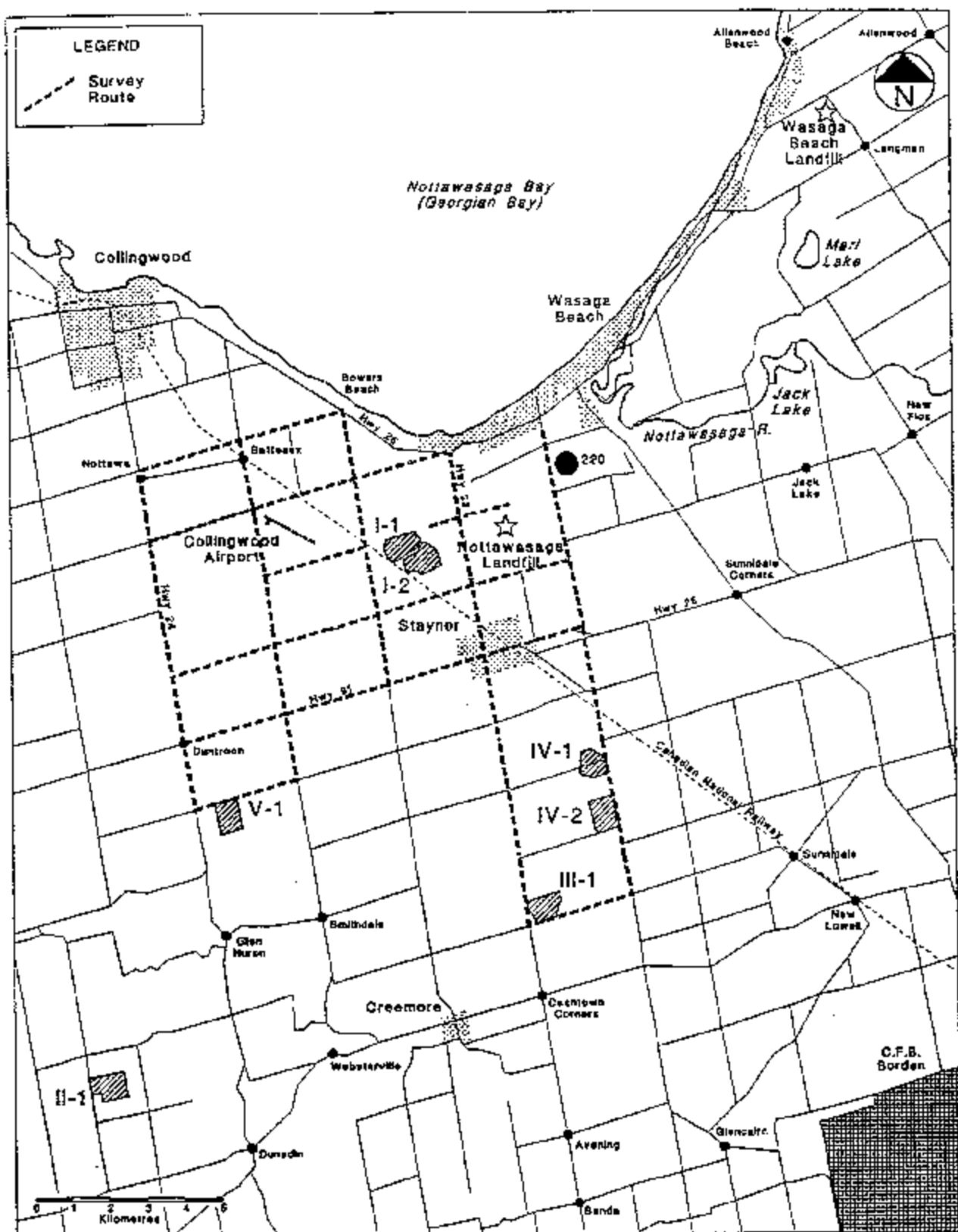


Figure 7. Survey route and locations and numbers of gulls observed on agricultural fields: 29 September 1995.

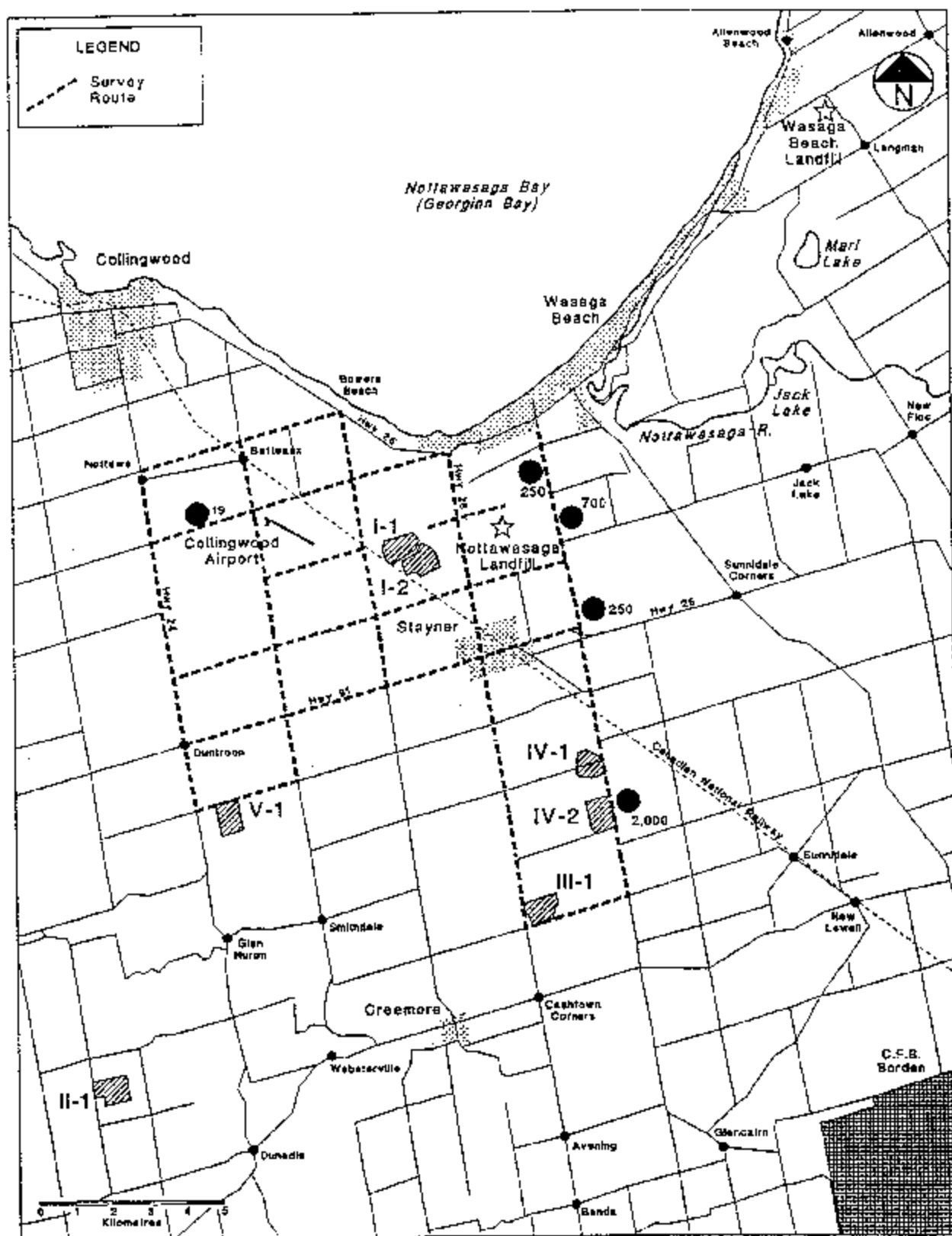


Figure 8. Survey route and the locations and numbers of gulls observed on agricultural fields: 10 October 1995.

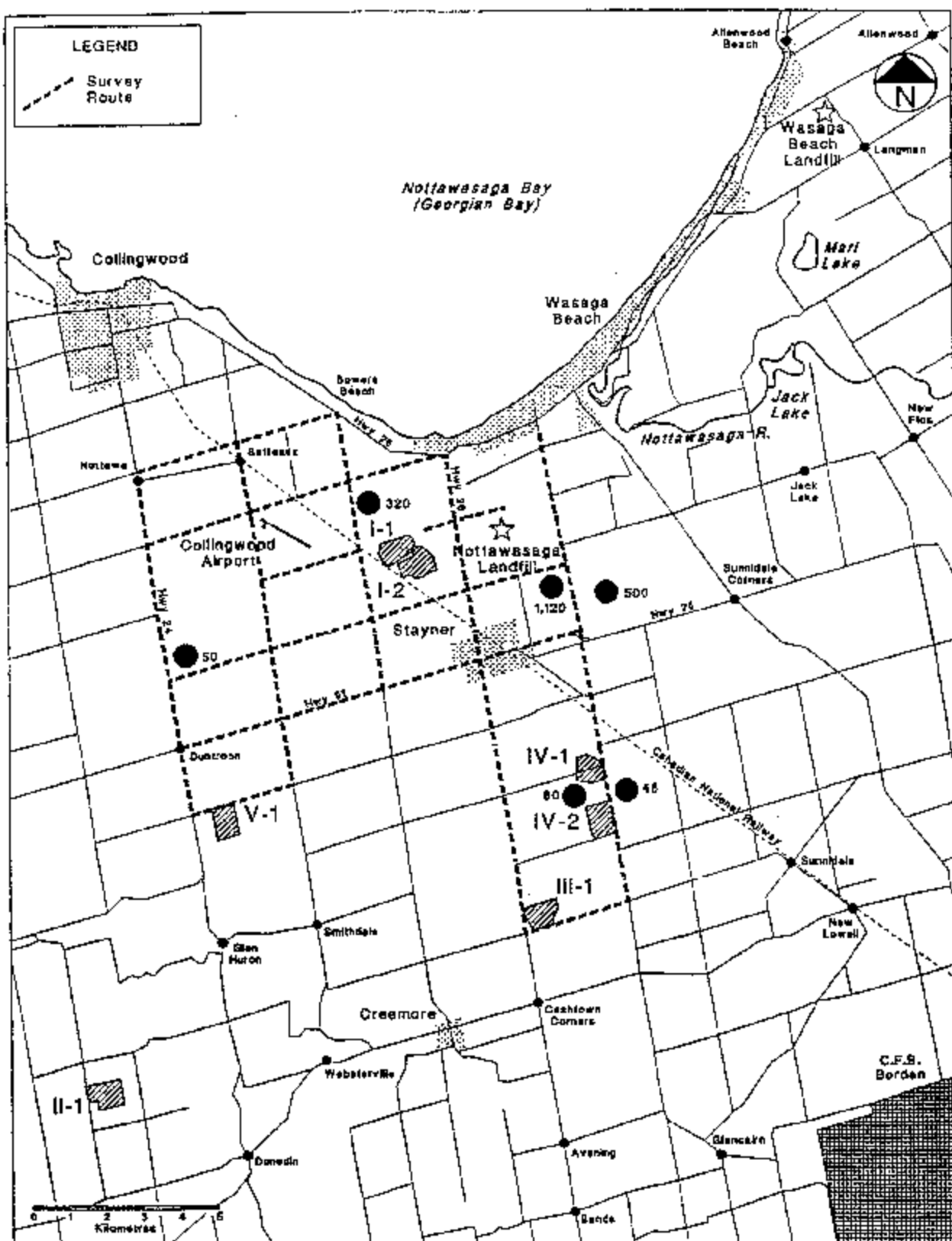


Figure 9. Survey route and the locations and numbers of gulls observed on agricultural fields: 20 October 1995.

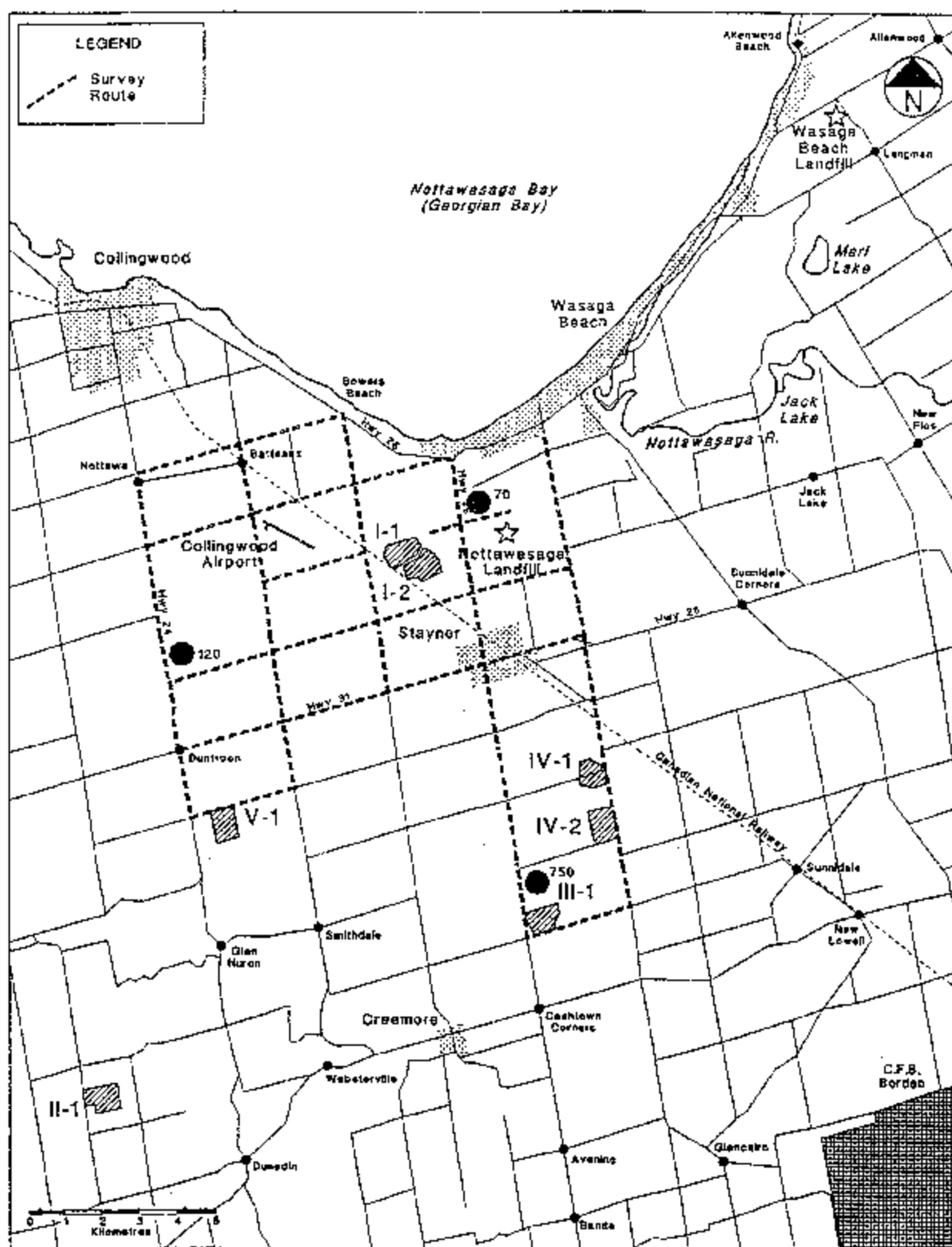


Figure 10. Survey route and the locations and numbers of gulls observed on agricultural fields; 3 November 1995.

Councillors defend landfill site I-1 selection

□ But chair of airport commission 'baffled' by support for site

By Laurel Lane-Moore
THE ENTERPRISE-BULLETIN

When it comes to picking a new landfill site, Site 1-1 is still the number one choice in the eyes of Cullman's voters.

Selection of the site, located about 2 kilometers southeast of the Cullman airport, has been members of the Airport Commission and airport users who fear birds attracted to the nearby landfill will pose a hazard to

aircraft.

But Mayor Doug Girdles remained convinced the site is the best of the bunch and won't present a danger to the airport if a full-time golf course program is implemented, Tennessee Department of Transportation officials said.

At a meeting Feb. 10 of the Georgian Triangle Waste Management Authority (GTWMA), airport commission did nothing to change its mind, he said. Councilman Bob 12.

"Basically, my interpretation of the meeting at Site 1-1 is that the site," said Girdles. "What would happen is there will be a full-time golf course program for the site. I didn't hear anything new."

Top Canadian biologist Robert Davis was invited to the Feb. 9 meeting to

speak about the "Call Report," a study he prepared last November for the Town of Cullman. He was also asked to suggest the best ways of discouraging birds from gathering at the proposed site.

Councillor Paul Russell, who also attended the GTWMA meeting, said the information he heard "discouraged the development of Site 1-1."

"With full golf course, there will be better golf control (on the airport) than there is today," he said.

Councillor Ed Christie agreed, adding that the town could join the bird control program in a "positive plus."

"It was where we're going here with a touch of benefit. We've got to stop in the showing the benefits to the people."

Councillor Sonny Faley had mixed feelings about the proposed location of the landfill.

"I'm really not comfortable with a dump so close to the airport, but we may end up with more aerial control over it."

CAG Captain Morrison also gave his take on the legal advice he had heard on the selection process.

"If we were to change now, we would have to have a very good reason, or we could be in trouble if the reason is the birds, they're saying that's not accepting the opinions of the two reports."

Councillor Rick Lloyd cautioned against acting on the commission's choice and "changing the rules now."

"I-1 is the best site with the appropriate golf control body recommended. I feel it will work and I don't think we should change the rules now. Through money's been spent."

But Councillor Tony Girdles said he came away from the meeting with a very different interpretation of what was presented. He pointed out that Davis had released his last recommendation, advising the commission to "select a landfill site other than Site 1-1."

"If this cannot be done," Davis added, his second recommendation was to "operate the landfill site with a full, professionally-operated, golf course program in place for the 40-year life of the landfill."

"The first recommendation is to look for another site," Girdles told the Enterprise-Bulletin. "That's still where I'm coming from. You look at the first recommendation first."

Councillor Tim McRabb said several airport users have talked to him about their objections to the proposed location of the landfill. McRabb said he believes the criteria used in selecting the preferred site don't adequately consider "the negative impact on our airport."

Airport Commission Chair Doug Murray agrees.

"I'm absolutely baffled why their

minds are so set on going to Site 1-1," said Murray in an interview. "This is the only one that affects the business of the airport as strongly, and where there is a risk to human lives."

While he acknowledges that birds can be a problem at any site, Murray points out that this bird would not have to be controlled to such an extent as the other sites on the commission's short list.

"At the others, birds are a nuisance. Here, they're a danger."

Even if a full-time control program is implemented, says Murray, the existence of a nearby landfill site would pose a risk in the minds of pilots.

"A lot of it is perception and safety. It's not reality," he said. "There is always a danger with a bird strike — it's a potential fatality and all pilots know that. When you put a landfill site

at the end of a runway, it makes them very worried."

Part of the commission's job is to expand business at the airport, when there is a perception of risk, it makes the job of selling the airport very difficult," said Murray.

Murray said he didn't hear anything at last week's GTWMA meeting that changed his position on Site 1-1.

"The commission has been given any reason to suggest that putting a landfill site at the end of the runway would do no harm."

If the committee plans to pursue Site 1-1, Murray says he fears a "great counter proposal" for them.

"They can save a lot of money if they use the airport as a dump because they may have to close it anyway."

THE ENTERPRISE-BULLETIN, Wednesday, February 21, 1996 - A3

The Enterprise-Bulletin

Wednesday, January 10, 1989

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For the birds!

□ Airport commission chair asks council to find another location for landfill site

By Laurel Lane-Moore
The Enterprise-Bulletin

Collingwood Council should heed the warning of a bird expert and toss out a plan to build a landfill site near the Collingwood airport.

That is the recommendation from Doug Murray, chair of the Collingwood Airport Commission. In a strongly-worded statement presented at a general committee meeting Monday night, the Collingwood pilot urged council to accept the advice of biologist Ralph Davis of L.G.L. Ltd. Environmental Research Associates.

Collingwood council must decide "whether to take the advice of Ralph Davis and avoid a potentially disastrous situation in the first place or create a situation and hope you can control it afterwards," said Murray.

In a study presented last month to the steering committee of the Georgian Triangle Waste Management Master Plan (GTWMP), Davis recommended the committee select a landfill site other than Site 1-1 or 1-2. The committee has spent more than \$2 million and eight years studying potential sites for a new landfill in the Collingwood area. The committee finally narrowed its choice to Site 1-1, located in Clearview Township about 2 km. from the end of the main runway at the Collingwood airport.

Davis' study, dubbed the "Gull Report," showed birds, especially gulls, would be attracted to the landfill site, and could pose a hazard to pilots and

passengers using the Collingwood airport.

Murray said Davis made it clear choosing another site is "the only reliable option."

A less desirable option, according to Davis' report, would be to operate the landfill site with a "full-time, professionally operated gull control program in place for the 40-year life of the landfill."

"Who the heck's going to fly into the airport if they're risking their lives?"

Councillor Tim McNabb

Such a program could cost up to \$200,000 a year, said Murray, and has rarely been effective.

"For a small landfill such as Site 1-1, the cost of such a program may be prohibitive," Davis writes in his report. "Partial control, while less costly, can increase, rather than decrease, the hazards to aircraft. This is because gulls very often tower over or near a landfill after they are scared into the air. Full-time control means preventing gulls from landing at the landfill in the first place."

Even if a control program is put into place, said Murray, the airport commission would have a tough time settling prices on the idea of using an airport located so close to a landfill.

If an accident resulted from a bird hitting an aircraft, the town could face a costly lawsuit, Murray warned.

"One bird strike could cost \$6 million."

CONTINUED ON PAGE A3

Feathers fly in latest landfill battle

FROM FRONT PAGE

Councillor Ed Christie, a member of the GTWMP, said he believed the airport and the landfill site can coexist if a full bird control program is put in place at the landfill site.

"There is an alternative. We can have a viable airport and we can have a well-managed landfill site."

Councillor Tim McNabb expressed concern about the "serious threat" to airport safety.

"I'm not willing to gamble over 40 years that some aircraft is not going to be brought down by a bird. I think that's ludicrous."

Asking airport users to take that gamble is not reasonable, he said. The potential risk to safety would have a "considerable impact" on use of the airport, he added.

"Who the heck's going to fly into the airport if they're risking their lives?"

Mayor Doug Garbutt, also a member of the waste management steering committee, pointed out the information contained in the study was "a totally different version of what we heard" from Davis during the site selection process.

Garbutt said the committee needs to meet with Davis to clarify the issue.

The airport is important not just to the town of Collingwood but to other communities taking part in the selection of the landfill site. Garbutt

stressed.

He added, however, that the estimated cost of maintaining a full bird control program did not seem prohibitive.

"That is only \$5 a tonne. Four million dollars over 40 years is not a big cost to maintaining a landfill site."

In any case, said Garbutt, the users of the landfill site would bear the cost of such a program.

Members of council will recommend that a full bird control program be implemented if the county goes ahead with plans to build a landfill at Site 1-1.

Garbutt said the site, when raised against other properties, stood "head and shoulders" above the others.

"We've got to find a place for our garbage," he said.

Dr. Murray said the Enterprise-Bulletin, in finding it difficult to believe Site 1-1 is the "only possible site" for a dump. The risk to airport safety should put it out of the running, he contends.

The odds of an aircraft being hit by a bird may be as low as one in 4,000-5,000, he said, but "any bird strike has the potential to be fatal."

"The stakes are awfully high. Why increase the risk?"

The Gull Report was commissioned by the Town of Collingwood, but the \$15,000 tab for the study will be picked up by the County of Simcoe.

Council delays landfill motion

FRONT PAGE - JAN 20/96

□ Councilors worry site selection didn't consider true impact on airport

By Laurel Lane-Moore
THE ENTERPRISE-BULLETIN

Members of Collingwood Council are concerned about the possible dangers of locating a landfill site near the Collingwood airport. But there's no need to get into a flap about it, says Mayor Doug Garbutt.

"Nobody's putting a shovel in the ground tomorrow," Garbutt told council Monday night. "There's lots of time to get the information we need."

Garbutt said town officials plan to meet with Ralph Davis, the biologist who sounded the alarm about the proposed location of the Simcoe County landfill just two kilometers from the airport. In a recent study dubbed "The Gull Report," Davis said birds attracted to the nearby landfill could pose a hazard to aircraft and recommended that another site be selected.

But Garbutt said comments in the Gull Report contradict what Davis told Georgian Triangle Waste Management Master Plan (GTWMMP) steering committee. Before the preferred site was selected, the committee was told an effective bird control program could be put in place at the landfill site, said Garbutt, a member of the committee for the past eight years.

"He was there when we selected the

mation about the site selection. The process is a long one, and is not likely to be completed soon, he added.

"If a decision was made tomorrow, it would probably be another five years"

before construction began, he said. A meeting of the GTWMMP, Airport Commission representatives and Davis is planned for Feb. 1, 7 p.m., in the council chambers of the Clearview municipal offices, in Stayner.

"I think there's a flaw here and it needs to be addressed."

Councillor Tim McNabb

site?" Garbutt asked the Enterprise-Bulletin. "He told us the birds could be managed."

On Monday night, Collingwood Council put off a motion calling for a full gull control program to be implemented for the life of the landfill site, if the GTWMMP stuck with Site 1-1 as the preferred site for a new landfill for the Georgian Triangle.

Councillor Tim McNabb, who drafted the motion last week, withdrew his support, cautioning that approval of the motion could be interpreted as support for Site 1-1. After reviewing a GTWMMP report detailing how the sites were ranked, McNabb said he was concerned that the airport didn't figure more prominently in the criteria for selection. He said the report does not address the "three-dimensional" nature of the airport's operation in its consideration of impact on nearby businesses and employment.

"Obviously, aircraft are going to be impacted by a dump," he said. "That needs to be punched into the criteria of selection."

"I think there's a flaw here and it needs to be addressed."

Garbutt said there is still plenty of time for council to obtain more infor-

APPENDIX 28

Addendum



HE THOUGHT HE COULD....

The following is taken from the September Issue of USAviator. The Bozo of the Month is the fellow (or what was left of him...) whom the Arizona

Highway Patrol came upon some time ago. It seems that they spotted a pile of smoldering metal embedded into the side of a cliff rising above the road, on the outside of a curve. The wreckage resembled the site of an airplane crash, but it was a car. The type of car was unidentifiable at the scene. The boys in the lab finally figured out what it was, and what had happened. It seems that a guy had somehow gotten hold of a JATO unit (Jet Assisted Take-Off, actually a solid fuel rocket) that is normally used to give heavy military transport planes an extra "push" for taking off from short airfields. He had driven his Chevy Impala out into the desert and found a long, straight stretch of road. Then he attached the JATO unit to his car, jumped in, got up some speed, and fired off the JATO!! Best as they could determine, he was doing somewhere between 250 and 300 mph when he came to the curve... The brakes were completely burned away, apparently from trying to slow the car. It seems that our wayward JATO-jockey was not concerned that solid-fuel rockets don't have an "off" switch...

**SELECTED PAPERS FROM BSCE 23 MEETING.
MAY 13-17, 1996**

APPENDIX 29

Chairman's Report

BIRD STRIKE COMMITTEE EUROPE

CHAIRMAN'S REPORT

- a Good morning ladies and gentlemen. Thank you Captain Sharples for formally opening the meeting, it has been useful to hear something of your airline's experience of bird strikes incurred by your airline, it gives an idea of the global cost, let alone hazard. It is with great pleasure that I welcome you all to the historic city of London, its 20 years since Bird Strike Committee Europe last met here. It is interesting to reflect on some of the changes that have taken place since the 1976 meeting. As a result of Europeanisation, the pubs can now stay open all day and we are steadily moving toward metric system of measurement, but we will never drive on the right-hand side of the road. The Channel Tunnel now links us with France and I have had the pleasure of doing 300kph about 5 feet above the ground, even military pilots can't get that low. Thanks to the efficiency of modern airliners, you can now fly round the world for less than a month's pay, so not surprisingly air travel has increased by 80%. Our major topic of conversation used to be the weather, now it is the weekly National Lottery with a £10 million jackpot. We will be happy to look after anyone's ticket for this week's draw, if you win we'll phone you - from the Bahamas!
- b 1996 is the 30th anniversary of the first meeting of Bird Strike Committee Europe in Frankfurt, Germany. I am very pleased to say that Dr Jochen Hild, who incidentally signed the minutes of the first meeting, is still working with us today. To mark his 30 years of loyal service to Bird Strike Committee Europe.
- c What has the Committee achieved in its 30 years? **Safety is a negative subject, if you have done the job properly there is nothing to show for it, a zero is your measure of success.** Then of course someone will say 'why do we need all those staff when there hasn't been an accident!' Over the years, some of the major tasks which BSCE has been responsible for are:
- ♦ better data and case histories in order to improve awareness of the hazard,
 - ♦ establishment of systems to track and warn pilots of bird movement and migration,
 - ♦ design guidance on structural criteria to withstand bird strikes and use of new technology and materials,
 - ♦ collation of several editions of a booklet on the 'Use and effectiveness of difference methods of discouraging birds from airports', known as 'The Green Booklet',
 - ♦ significant progress in the accurate identification of bird remains collected from inside engines etc,
 - ♦ provision of assistance to ICAO at workshops on bird hazards in various Regions.
- d My own first meeting was in 1972 here in London, only Baron Rochard from the UK, Dr Bruno Bruderer from Switzerland and Dr Vladimir Yacobi from Russia were at that meeting. In the 24 years I have been associated with the Committee we have made small, steady steps to improve the bird strike situation. **It is unlikely that we will ever make giant leaps, the real world is not like that, no one is going to be able to wave a magic wand and solve the bird strike problem over-night**
- e As many of you know, the UK is unusual in that the Civil Aviation Authority is not part of Government, we are funded through charges on the industry that we regulate via Certificates of Airworthiness, licences, aerodrome inspections, air traffic service etc. There are moves for the rest of Europe to adopt a similar approach. To host this meeting, I obtained sponsorship from industry. I am most grateful for the help that has been provided by British Airports Authority, Britannia Airways and the Airport Operators Association, without their help we would not be in these spacious surroundings. The comprehensive audio/visual equipment is thanks to help from the Royal Air Force and the printing of the proceedings will be the result

of assistance from the Willis Corroon Aerospace Insurance Group. This meeting will achieve a notable first, in all its years BSCE has never been able to visit an aircraft or engine factory. I am, therefore, very pleased that Rolls-Royce have agreed to host a group of us on Friday where we hope, amongst other things, to see a bird gun firing against an engine test specimen. Its rumoured that they are also providing a chicken lunch! As the size of the party has to be limited, there may not be a place for everyone who wants to go, we will try to arrange at least one representative from each country. Those interested in ornithological matters will be able to visit the world famous Wildlife and Wetlands Trust at Slimbridge, which may also include a discussion on the problems that wetlands might pose for us.

- f At the Jerusalem meeting in 1992 where I took over as Chairman, we enjoyed excellent hospitality that will never be equalled. Thanks to the Great Western Royal Hotel and the exhibitors, there will be a reception from 18.30 to 20.30 hours on Tuesday evening in the room next to this one. Everyone, together with any accompanying persons, is cordially invited. I think it will be very welcome after what will be a very long day tomorrow as there are 23 aerodrome papers.
- g At the Vienna meeting, there was some comment about the lack of participation from ICAO, from airlines etc. As a result of this comment, I made a special approach to ICAO and I am very pleased to report that we have a representative from Montreal headquarters with us. I also sent invitations to the meeting to:
 - ♦ all participants in Vienna and Jerusalem,
 - ♦ both the Civil Aviation Administration and military representative in any country not represented via previous participation,
 - ♦ UK and major European airlines, via the flight safety officer
 - ♦ all organisations such as IATA, Flight Safety Foundation, IFALPA etc.

In addition, the UK Flight Safety Committee has been particularly supportive by publishing, in their internationally distributed magazine "Flight Safety Focus", last year, my comprehensive illustrated article on bird hazards called "Conflict of Wings". There have been two follow-up 'advertisements'. In February I gave a presentation to the Flight Safety Foundation 8th Annual European Seminar in Amsterdam. An item advertising the meeting was submitted for the list of Forthcoming Events in both Aviation Week and Flight International and the meeting details were sent to IATA for dissemination via their Safety Committee Information Exchange. As you can see, there has been very wide publicity. Thus it is very encouraging to find that we have 115 participants and 25 countries represented, including, for the first time, I believe, Bulgaria and Hungary.

- h Birds have been a threat since the very beginning of aviation with over 190 people killed and 52 aircraft destroyed. Surprisingly, there has only been one fatal accident to a jet airliner in many hundreds of millions of flying hours. However, there have been many near misses in which sheer good luck or pilot skill averted a fatal accident. It might be argued that one of the reasons for the low number of accidents has been the effectiveness in the field of the various measures that we discuss at these meetings. At a public enquiry the then Lord Chief Justice stated 'complacency is the enemy of safety'. We must never relax our vigilance, at times it will up to us to press for what we know needs to be done in our area of responsibility. Bird strikes are only a small part of the safety picture, but it is by making small improvements in a lot of areas, that aviation safety is improved even beyond its current high standards.
- i On the international scene I have already mentioned the Flight Safety Foundation presentation but ICAO are going to run a second workshop in Nairobi for the Region. This will be held between 11 and 16 September 1996. The Steering Committee have discussed assistance. Bird Strike Committee USA still meets at annual intervals and their next meetings

will be in Phoenix, Arizona between July 14-17. Also the Canadian Committee is very active and meets every 6 months. The latter produce excellent reports containing papers, discussion etc and I try to incorporate some of the main points for periodic distribution through a Chairman's Newsletter. There is also a Nordic Advisory Bird Strike Group that has been meeting for a year. Bird hazard is a subject that doesn't stand still and there are always things happening that people need to know about more frequently than our 2 yearly meetings.

- j You will notice here today a number of exhibitors, this is something that was tried for the first time at the last meeting in Vienna. For those participating at BSCE for the first time, there is little point in finding the knowledge if its not possible to examine some of the equipment needed. We are very pleased to see the exhibitors but it should be pointed out that BSCE does not endorse any of the equipment that you see on display. The only Latin I can remember from my school days is 'caveat emptor' - buyer beware. It should perhaps also be pointed out at this stage that BSCE does not necessarily endorse everything in presenters papers, we merely provide the forum for the information to be presented.

- k Sadly, since we last met three notable accidents have taken place:

- ♦ the fatal accident to a Falcon 20 Executive Jet at Paris Le Bourget following ingestion of Lapwings into an engine, resulting in the death of the ten occupants,
- ♦ the loss of an F15 fighter at low level in Israel killing the two crew,
- ♦ destruction of the United States Airforce AWACs airborne reconnaissance aircraft in Alaska following Canada goose ingestion in engines 1 and 2. All 24 on board were killed, and
- ♦ loss of a Royal Norwegian Air Force F16 due to a Great black-backed gull, the pilots ejected safely.

I am sure that we will hear more about some of the events and the background at this meeting. However, Major Dave Arrington, Head of the United States Airforce Bird Team, informs me that he is unable to attend this year's meetings because they have been very busy since the AWACs accident. They have made dramatic changes to the Airforce programme and while interest is high much has to be accomplished before the peak of interest subsides, he says he thinks that we will find their new programme quite enlightening.

In the UK it also seems that 1995 was a very bad year from the point of view of bird strikes, we experienced a 25% increase in reported strikes compared with 1994, with over 1000 reported. I will be interested to hear during this meeting whether there has been anything similar in other European countries, possibly as a result of our excellent summer affecting the number of juvenile birds that survived. Even the public are at risk from birds, in March this year, a fisherman on a lake in the North of England was hit on the head by a gull, knocking him off balance. As he fell he hit his head on the side of the boat and was knocked unconscious. A passing jogger spotted him floating in the water and he was rescued suffering from hypothermia. Thanks to local rules his lifejacket had kept him afloat for 45 minutes.

- l I would like briefly to report on progress since the last meeting. We have not held a Steering Committee meeting, as we have managed everything by correspondence, including selection of special subjects of concern for this meeting. In Vienna we did not have a chairman for the Bird Remains Identification Specialist Group and I was very grateful that Dr Henri Ouellet from Canada stepped in at the last minute and chaired the working group. I am very pleased to report that Dr Jan Wattel from the Netherlands has now agreed to take over chairmanship of this specialist group and I wish him every success in what is clearly a fast developing activity.

m The Aerodrome Working Group were left with three recommendations from the Vienna meeting:

- ♦ *'That participants of BSCE should assist the editors of the 5th edition of 'The Green Booklet Some measures used in European countries to reduce bird strikes on airfields' by providing the requested information via their national representatives.' The working group has been very active in collecting the information from all participants and other countries. The Chairman, Olavi Stenman, held a meeting in York with his two Vice Chairmen, Jean-Luc Briot from France and John Allan from the UK, to review the material they had collected. A draft of the new edition will be given to different countries in order to receive comments on that draft. This change in the schedule will enable the group to be sure that all countries are satisfied with what is in the book about their activity and to include any new information from this meeting. The working group hope that everyone will have enough time to review the final draft before the printing is done during the summer. A draft will be distributed to one member of each of the countries based on registration at the meeting.*

n The Impact Engineering Specialist Group were left with several recommendations:

- ♦ *'The attention of the appropriate authorities should be drawn to the cost to civil and military aviation resulting from low bird strike resistance.' The specialist group chairman informs me that the cost of bird strikes continues to be an easily definable problem that can be articulated as a rationale for investment in both tolerance and prevention. Efforts and increasing tolerance have resulted in a windshield 4 lb bird strike capability being increased to 500 plus knots for the F15 and F16 at no weight penalty. Mission compatible capabilities have also been incorporated into the T38 and F18. Efforts at prevention have demonstrated feasibility of some amazing possibilities that Jeff Short will cover. The ability to use the operational statistics has created some enlightening insights at preventing bird strikes. It is clear that birds are not suicidal and they are not oblivious to the threat, we just need to exploit the clues they are giving us. Adaptation of technology for aircraft collision avoidance and missile collision enhancement appears very promising. You will notice in the invitation one of the special subjects is the cost of bird strikes here at the London meeting. Sadly, we have had very little information from airlines etc. Maybe further information will become available during this meeting.*
- ♦ *'Work should be encouraged which will result in realistic definition of lateral and longitudinal spacing of birds in flight.' This information is needed by the airframe and engine design community and for use in establishing airworthiness criteria. Outside in the exhibits area you will see the equipment being used by Dr John Allan and his team for 3-dimensional photography and video of bird flock density and spacing, this is the sort of information that this recommendation addresses and it is good to see tangible evidence. The CAA is one of the sponsors of this research.*
- ♦ *'Discussion and analyses on the need for bird strike requirements for light aircraft helicopters should be supported.' As yet there has been little progress in this area although the Joint Aviation Authorities (JAA) has looked into this and found the case as yet unsupported.*
- ♦ *'Emergence and application of new criteria for airframe and engine certification should be monitored to encourage standardisation.' There have been some moves in this area mainly as a result of industry pressure to see a more realistic bird requirement which includes a mix of 675g and 1.1kg (1½ and 2½ lb) birds, together with moves towards an 3.6kg (8 lb) bird in place of the 1.8kg (4 lb) bird. In WP65 by Jeff Short which will cover work to utilise hospital equipment (MRI & CATSCAN) to develop a density map of intact birds. The information is being developed to enable the impact analysis computer codes*

Military Bird Strike database EURBASE is now being used to evaluate the effect of BIRDTAMs. A big step forward was the start in October 1995 in The Netherlands of the building of two new ROBIN systems aft six years of research. When finished at the end of 1997 two air defence radars will be able to monitor large scale bird movements all over the country. ROBIN2 is set up to be adapted to other types of radar and to work in a network. In addition the RNLAf signed contracts with the national bird census organisation to develop a low level bird migration database based on visual data for inclusion in the warning system. In Israel the efforts to set up a radar network in the Middle East intensified. As will be detailed during this meeting an international centre for the study of bird migration and flight safety is being created. Their satellite tracking of Storks in close co-operation with German ornithologists has already revealed exciting results and will be intensified.

q **Military Low Flying Working Group**

- ◆ 'The BSCE participants should urge the appropriate national authorities to investigate the possibility of contributing to a dedicated multi-national system for the detection and reporting of actual data concerning medium and high intensities of bird migration.'
- ◆ 'The BSCE participants should urge appropriate national authorities to provide warnings (BIRDTAM) as well as bird movement forecasts for civil transport and general aviation in accordance with ICAO regulations.'
- ◆ 'The BSCE participants would urge national air staffs and Air Traffic Services to consider/reconsider how the warnings and forecasts can be obtained by pilots without delay and loss of information according to national necessities. With respect to civil aviation the procedures must be in accordance with ICAO regulation.'

Experts from seven countries attended the 10th meeting of the Bird Hazard at Low Level Group in March 1995 in Traben-Trarbach, Germany. The main purpose was the progress of radar observations in Belgium, Germany and The Netherlands. The recommendations of previous meeting were reviewed. Nearly all the above recommendations are covered by papers which will be presented at the working group meeting on Wednesday.

r **And finally we come to the Statistics Working Group. The recommendations were as follows:**

- ◆ 'Consider implementation of a bird strike awareness programme for pilots, engineers, ATC, airport personnel etc.'
- ◆ 'Send their bird strike data to ICAO for incorporation in the IBIS system.'
- ◆ 'Persuade military authorities to assist Dr W J Richardson, Canada in obtaining information from open sources on destroyed military aircraft and deaths due to bird strikes.'
- ◆ 'Send any information on serious bird strikes to the Working Group Chairman.'
- ◆ 'Ensure that BSCE style civil analyses, including aircraft and airport rates, be sent as one document for the years 1986-1990. (The French PICA computer programme would be able to assist.)'
- ◆ 'Quantify and communicate the effectiveness of their bird control programmes to the Working Group.'

Again these recommendations are addressed by a number of papers that will be presented later today at the Statistics Working Group meeting. Regrettably there has been no progress

to better predict the structural response of engine fan blades during a bird strike. The information will also be of value in developing the artificial bird, (BSCE22, Recom 8, 2, d, vi).

- ◆ 'Work should be encouraged which will result in realistic artificial birds for use in testing of bird impact tolerance.' *It is possible that at the meeting we will hear more of progress in this area. Why use artificial birds when chickens are cheap? Would you like to work in an environment of decaying chicken flesh?*
- ◆ 'Work should be encouraged which will result in better understanding of the criteria which would result in removal from service of components which have a reduction in bird strike resistance.' *The statistics do not, as yet, show whether deterioration takes place although there are rumours of problems with composites. This meeting may provide further information.*
- ◆ 'Encourage preparation of reports which show use of bird strike statistics in the design and development of aircraft components.' *This recommendation will, hopefully, be addressed at this meeting.*

o Bird Remains Identification Working Group

The routines for identification of bird remains have now been set firmly - macroscopic comparison with conserved bird skins when entire feathers are present, microscopic study of downy barbules when only small fragments remain. Combination of both methods offers the best possibilities to come down to species level. The production of a CD-ROM with a detailed key for microscopic work will be a major step forward to be set in early autumn. This will help airfield personnel to deal with easier cases on the spot. For difficult and critical cases consultation of a specialised identification centre will remain vital. A pilot study has shown that identification of remains without any recognisable feather fragments is possible with DNA technology.

p Remote Sensing Working Group

- ◆ 'BSCE participants should urge national authorities to encourage the appropriate military and civil personnel to evaluate the capability of radar and other remote sensors to monitor bird presence and bird movements.'
- ◆ 'BSCE participants should join attempts to further develop the electronic assessment and calibration of remote sensor output with respect to the bird hazard.'
- ◆ 'BSCE participants should intensify the contacts with industry in the development of small, dedicated, commercially available bird observation radars in accordance with the principles described in the BSCE Radar Booklet.'
- ◆ 'BSCE participants should co-operate with respect to the highly recommended use of Geographical Information Systems (GIS) when quantifying the density, identity and potential hazard of bird movements, particularly at the lowest flight levels.'
- ◆ 'BSCE participants should verify and evaluate their spatial and temporal bird density assessments with improved bird strike statistics, with special reference to large soaring birds.'

Slowly but surely all air forces start to consider to develop or achieve electronic devices to evaluate bird echoes at radar screens. The progress was discussed during a joint meeting of the Remote Sensing and the Low Level WG in Traben Trarbach, March 1995. The European

in compiling new statistics covering the period 1986 to 1990 and we ought by now to be in a position to cover the period 1991-1994. This may be because of problems in obtaining airport and aircraft movement data in order to show rates because it is the strike rate that is an important feature. The number of strikes is obviously dependent on aircraft movements.

Thank you for your attention, and finally I wish you all a pleasant stay and an enjoyable and useful meeting.

**FATALITIES AND DESTROYED CIVIL AIRCRAFT DUE TO BIRD STRIKES
1912-1995**

**by John Thorpe
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Summary

Following a short introduction, the paper contains brief details of all known accidents involving either fatality or the destruction of civil aircraft as a result of bird strikes. The paper is divided into three sections, transport aircraft, general aviation aircraft and helicopters. There have been over 50 aircraft written off and 190 people killed due to bird strikes.

WORLD-WIDE BIRD STRIKE ACCIDENTS INVOLVING DESTRUCTION OF AIRCRAFT OR FATALITY, 1912-1995

1 INTRODUCTION

The first known bird strike to a powered aircraft was on 7 September 1908 when Orville Wright was flying several complete circles near Dayton, Ohio during which he chased a flock of birds and killed one. The first fatal accident due to birds was in 1912 at Long Beach in California, when a gull lodged in the flying controls of a Wright Flyer, killing Cal Rodgers, the first person to fly across the USA. In the November 1925 issue of the Royal Aeronautical Society Journal the then Director of Civil Aviation Sir Sefton Brancker wrote in an article 'The Lessons of Six Years Experience in Air Transport' the following *"There is one form of collision which must not be altogether forgotten; the possibility of colliding with birds in flight. We have had one mysterious incident in which the pilot lost control of his aircraft flying over the sea at a low height, the pilot's opinion was that he had been struck on the head by a sea bird, several were flying nearby, but nothing was ever clearly proved. In the East, propellers of aircraft taking off have been broken by kites flying over the aerodrome. I have never heard of an aeroplane encountering a flock of ducks at night; such an eventuality might lead to danger of injury to the pilot, the propeller or wing structure. The best precaution to meet such a danger will be good screening for the pilot and robust metal construction."* These were prophetic words 70 years ago. Since then birds are known to have caused:

- 30 fatal accidents
- the destruction of at least 52 civil aircraft
- 190 deaths.

It is quite likely there are more, as information is only accurate for the last 25 to 30 years. The author would welcome any new or additional information.

The paper contains brief details of each case of loss of life or destruction of the aircraft divided into three sections:

- transport aeroplanes over 5700 kg and business jets
- aeroplanes of 5700 kg and below
- helicopters.

2 DISCUSSION

In general the sample size is too small for any in-depth analysis, however, a number of points are noteworthy:

- the seven fatal accidents to transport sized aeroplanes is quite modest, and surprisingly there has only been one fatal accident to a jet airliner, in over 500 million hours flying. This may, in part, be due to a growing awareness of the problem, implementation of better airport measures around the world and improved airworthiness criteria for aircraft and engines.
- however, there have been many cases of multiple engine damage, fortunately with enough runway length to abandon take-off or sufficient power to return. European airlines continue to experience about 20 cases per year where more than one engine ingests birds.
- business jets often operating from aerodromes with little or nothing in the way of bird control measures, also appear to be vulnerable as in many cases their engines are of an age which pre-dates bird ingestion testing.
- twenty of the fatal accidents involve general aviation aircraft, and one helicopter. These classes of aircraft are **not** required to be designed to withstand bird strikes and they are therefore more vulnerable, particularly the windshield which can be holed by a bird as small as a Swift (*Apus apus*, 40gm).
- a number of fatal general aviation accidents were the result of pilots attempting to avoid birds.

3 OTHER SIMILAR PAPERS

Similar papers covering 'serious' incidents have been published as follows:

- 1912 to 1982	WP16 and 16A BSCE16, Moscow August 1982
- 1981 to 1984	WP27 BSCE17, Rome October 1984
- 1984 to 1985	WP4 BSCE18, Copenhagen May 1986
- 1985 to 1987	WP22 BSCE19, Madrid May 1988
- 1987 to 1989	WP29 BSCE20, Helsinki May 1990
- 1989 to 1991	WP31 BSCE21, Jerusalem May 1992
- 1992 to 1993	WP26 BSCE22, Vienna August 1994

In the papers above 'serious' has been defined as:

- loss of life
- injury to occupants
- destruction of aircraft
- loss of, or damage to, more than one engine
- damage to one engine, together with ingestion in another engine
- uncontained engine failure
- fire
- Significant sized holes, eg windshield, nose, radome
- major structural damage
- particularly unusual or dangerous features, eg complete obscuring of vision, multiple or significant system loss, propeller damage, helicopter rotor or transmission damage.

4 CONCLUSION

Aircraft continue to be destroyed and occupants killed or injured in accidents due to:

- striking birds
- attempting to avoid birds
- birds being the start of a chain of events.

Although NOT a major cause of accidents bird strikes are nevertheless a serious safety and economic hazard which remedial measures and tougher aircraft engines appear to be having little effect. This may be due to expanding populations of 'problem' birds.

5 TRANSPORT AIRCRAFT

DATE	AIRCRAFT	LOCATION	PART STRUCK	BIRDS/WEIGHT	OCCUPANTS/ INJURY
4.10.60	Lockheed L188 Electra (Allison 501)	Boston, USA	Engines	Starlings - 80gm (<i>Sturnus vulgaris</i>)	72/ 62 fatal 9 injured

A few seconds after becoming airborne a starling flock was ingested into 3 engines. Engine 1 had to be shut down and 2 and 4 lost power. Speed decayed and aircraft stalled and spun into harbour. Worst bird strike accident.

15.07.62	Douglas DC3 (P&W R1830)	Lahore, Pakistan	Windshield	Vulture - up to 10kg (<i>Accipitriformes</i>)	3/ 1 fatal

Co-pilot killed when vulture attacked aircraft and penetrated windshield during cruise.

23.11.62	Vickers Viscount (Dart)	Maryland, USA	Tailplane	Whistling Swan - 6kg (<i>Cygnus columbianus</i>)	17/ 17 fatal

At night at 6000ft, aircraft struck a flock of Whistling swans. One penetrated the tailplane leading edge weakening the structure, causing detachment and the aircraft to crash.



Remains of
tailplane

28.07.68	Falcon 20 (CF700)	Lake Erie, USA	Engines	Gulls - 280gm to 1.7kg (<i>Larus sp</i>)	3/

Gulls ingested into both engines on take-off causing severe damage, ditching in lake, 315 dead birds on runway.

28.07.69	Douglas DC3 (P&W R1830)	Khar, Ambadu, India	Engines	Cranes - up to 6kg (<i>Grus sp</i>)	4/

While flying at 300ft the aircraft struck a flock of Cranes blocking both carburettor intakes, ditched in sea.

Notes:

- 1 The part struck relates to the part which was the primary cause of the accident.
- 2 Cases included where aircraft in flight suffered total loss of engine power resulting in a crash.

26.03.73	Lear 24 (CJ610)	Atlanta, USA	Engines	Cowbirds - 44gm (Molothrus ater)	7/ 7 fatal 1 third party injured

Just after take-off severe power loss on both engines. Aircraft crashed into buildings and burned. Left engine had 14 strikes, right at least 5.

12.12.73	Falcon 20 (CF700)	Norwich, UK	Engines	Gulls* (see below)	9/ 1 minor injury

Just after it became airborne Gulls [Common gulls (Larus canus 420g) and Black-headed gulls (Larus ridibundus 275g)] caused severe damage to both engines, crash landed in fields.

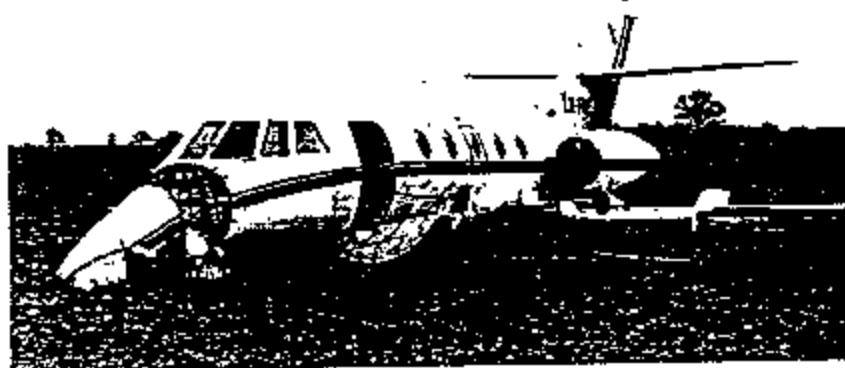


Photo - Eastern Courier Newspaper, Norwich

14.06.75	NA265 Sabreliner (JT12A)	Watertown, USA	Engines	Franklin's gull - 260gm (Larus pipixcan)	6/ 3 injured

Ingestion in both engines at rotation on take-off. Crash landed tearing off wings causing severe fire.

12.11.75	DC10 (CF6)	Kennedy NY, USA	Engine	Gulls+ (see below)	139/ 11 minor injuries

At about V1 speed Gulls [Great black-backed gulls (Larus marinus 1.7kg), Ring-billed gulls (Larus delawarensis 485g) and Herring gulls (Larus argentatus 1.1kg)] ingested in engine 3 which exploded, causing severe wing fire. Abandoned take-off, aircraft burnt out. All occupants were airline employees who knew emergency procedures.



20.11.75	HS125 (Viper)	Dunsfold, UK	Engines	Lapwing - 215gm (Vanellus vanellus)	9/ 6 third party fatalities

At about 75ft, during initial climb, Lapwings ingested in both engines, power loss, crash landed destroying car using road at end of airfield. Fire broke out but occupants escaped. Flight was at dusk.

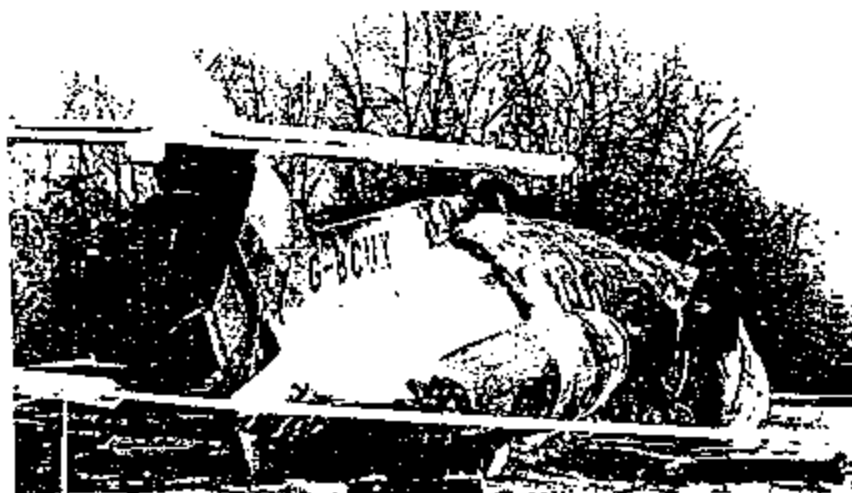


Photo - Southern West Service, Guildford

06.02.76	Lear 24 (CJ810)	Bari, Italy	Engines	Gulls - 280gm to 1.7kg (Larus sp)	3/

Gulls ingested in both engines at about 450ft, power lost and crashed in field.

12.11.76	Falcon 20 (CF700)	Naples Florida, USA	Engines	Ring-billed gulls - 485gm (Larus delawarensis)	11/ 11 injured

Both engines failed just after lift-off, causing aircraft to crash.

04.04.78	B737 (JT8D)	Gosselies, Belgium	Engine	Wood pigeon - 465gm (Columba palumbus)	3/

Wood pigeon ingested during training touch and go, abandoned take-off beyond V1 and over-ran into industrial area. Burnt out. Left engine found with bird damage.



25.07.78	Convair 580 (Allison 501)	Kalamazoo, USA	Engine	Sparrowhawk - 105gm (Falco sparverius)	43/ 3 injured

Just above V1 speed, Sparrowhawk ingested in one engine on take-off, auto feathered, crashed in field.



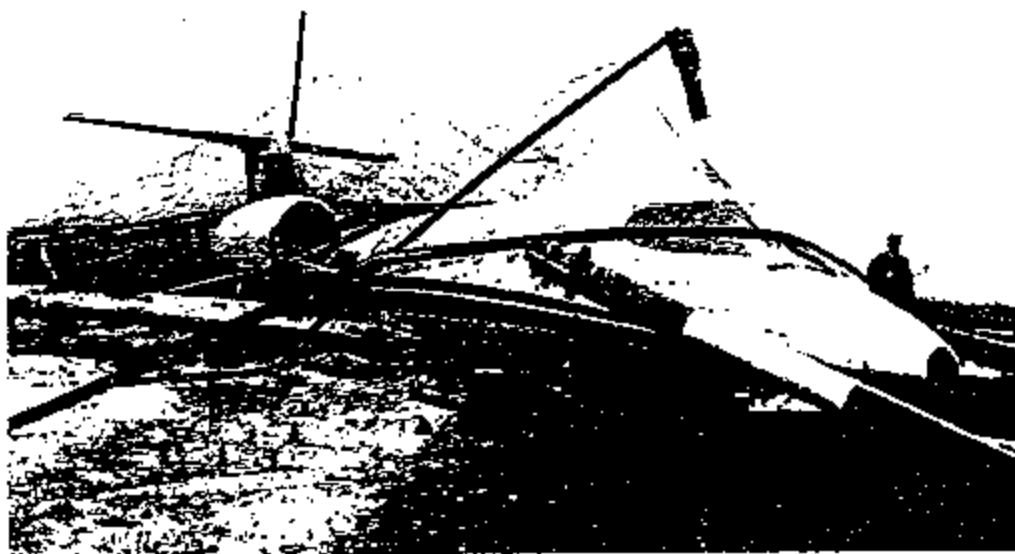
07.04.81	Lear 23 (CJ610)	Lunken, Cincinnati, USA	Windshield	Loon - 3.7kg (Gavia immer)	2/ 1 fatal 1 injured

At 4000ft Loon penetrated right windshield killing co-pilot and injuring pilot. Windscreen debris damaged Engine 2 and was shutdown. Hydraulic and brake systems lost.



06.12.82	Lear 35 (TFE731)	Le Bourget, Paris	Nil	Black-headed gulls - 275gm (Larus ridibundus)	-/ 1 injured

Abandoned take-off above V1 after striking gulls. Over-ran, ILS installation which penetrated cockpit, injuring co-pilot. Engines were not damaged.



17.08.83	Lear 25 (CJ610)	Wilmington, USA	Engines	Starlings - 80gm (Sturnus vulgaris)	2/

At 500ft passed through starling flock. Both engines failed. Force landed after striking trees in industrial area.

29.09.86	A300	Madras, India	Engine	Black Kite - 780gm (Milvus migrans)	196/ 11 minor

At about 150 kts a large bird was seen on the runway centreline, handling pilot rotated aircraft, at 5 to 8 degrees loud noise heard from right-hand side followed by severe vibration. Commander took control and initiated abort action. Reverse thrust and brakes applied, aircraft over-ran and sustained damage beyond repair. There was no fire and there were minor injuries during the evacuation. Cause has been attributed to wrong decision to reject take-off after rotation, when bird strike had caused engine vibration.

15.09.88	Boeing 737 (JT8D)	Bahar Dar, Ethiopia	Engines	Speckled pigeon - 320gm (Columba guinea)	104/ 35 fatal 21 injured

Ingestion in both engines at lift off, surging, loss of power. Attempted circuit for return, both engines failed. Crashed 10Km from airport during attempted landing in open country but struck river bank and burned. Airport is 5800ft amsl.



25.07.90	B707	Addis Ababa, Ethiopia	-	Pigeon (Columba sp)	2 serious injury

Take-off abandoned after V1, overrun and damaged beyond economic repair.

20.08.93	Antonov An-12	Slavgorod, RU	Engines	-	6/

As the aircraft climbed through about 150ft, its No 2 and 4 engines failed. The crew attempted to return, however, a forced landing was made beyond the end of the runway. The aircraft touched down with its undercarriage retracted and slid for about 460m before it caught fire and was destroyed. At the time of the take-off a large flock of birds was reported in the vicinity of the runway and it is believed the engine failures may have resulted from multiple bird strikes.

20.01.95	Dassault Falcon 20	Le Bourget, France	Engine	Lapwing - 215gm (Vanellus vanellus)	10/ 10 fatal

On take-off from Paris Le Bourget Airport, just after rotation, it encountered a flock of Lapwings and a number were ingested into the left engine. The aircraft climbed away but the pilot immediately reported that he was returning due to an engine fire. A tight left-hand circuit was flown at a height of about 500ft agl to land back on Runway 25. The aircraft impacted the ground just to the right of Runway 25, close to the threshold of Runway 21, was not lined up with the runway but on a heading diverging to the right by about 30°. The aircraft was destroyed by impact and post impact fire. During the circuit a number of witnesses saw the rear of the aircraft engulfed in flame. The initial investigation discovered 15 dead birds on the runway close to the point where the aircraft had become airborne. The rear cowl, exit guide vane and a number of fan blades from the left engine were found further along the runway, while the fan disk, with all its blades sheared off flush with their attachment points, was found some 500m to the side of the runway. It has apparently been determined that, following the bird ingestion, the fan had separated and exited the engine with shrapnel penetrating the rear fuselage, puncturing the feeder tanks and a fire had then immediately broken out in this area. The accident is still under investigation.

6 AEROPLANES OF 5700KG AND BELOW

DATE	AIRCRAFT	LOCATION	PART STRUCK	BIRDS/WEIGHT	OCCUPANTS/ INJURY

03.04.12	Wright Flyer	Long Beach, Calif, USA	-	Gull (<i>Larus sp</i>)	1/ 1 fatal

Struck gull while flying along the beach. Control jammed and aircraft crashed, killing pilot, Cal Rogers, the first man to fly across America.



10.02.29	Arado	Madras, India	-	-	1/ 1 fatal

Shortly after take-off struck large bird, aircraft crashed.

11.55	Cessna	Aberdare Mtns, Kenya	Wing tip	Vulture (<i>Accipitriformes</i>)	1/ 1 fatal

En-route struck vulture, pilot attempted to avoid but bird hit wing tip, jamming ailerons.

10.01.59	-	Serengeti, Tanganyika	-	Griffin vulture - 5.4kg (<i>Gyps fulvus</i>)	1/ 1 fatal

Struck Griffin vulture and crashed.

11.03.63	Beech 35	Bakersfield, Calif, USA	Tailplane	Common loon - 3.7kg (<i>Gavia immer</i>)	1/ 1 fatal

Struck Common loon which removed right-hand tailplane.

01.02.64	Turbulent	Nr Belfast, UK	-	Gull (<i>Larus sp</i>)	1/ 1 fatal

Spun in from low altitude after striking or avoiding gull. Dead gull found 60 yards away and avian blood on windscreen of open single seater aircraft.

18.08.70	Stampe biplane	Nr Wicklow, Ireland	Cockpit	Jackdaw - 234gm (Corvus monedula)	1 serious

While filming aerial sequences the aircraft was flying low over a lake when a Jackdaw passed through the propeller disc. Because of a camera fitted to the aircraft, there was no windshield. The pilot was struck in the face and almost knocked unconscious. In order to avoid hitting the water the pilot pulled the nose up, straight into power lines. There was a flash and the aircraft struck the water. Both occupants were able to escape, the pilot suffered severe cuts to his face needing 50 stitches.

02.07.71	Cessna 180	British Columbia, Canada	-	Bald eagle - 5kg (Haliaeetus leucocephalus)	3/ 2 fatal

En-route struck a Bald eagle.

16.04.72	Mitsubishi MU2	Atlantic City, USA	Windshield	Geese (Anser sp)	3/ 3 fatal

While in climb struck flock of geese, windshield destroyed incapacitating one or both pilots. Uncontrolled descent into the sea.

29.12.75	Single engined	Stockton, California	-	Goose (Anser sp)	5 fatal

Crashed shortly after take-off after collision with three geese.

30.08.76	Saab MFJ15	Nr Awassa, Ethiopia	-	Vulture (Accipitriformes)	2/ 2 fatal

Climbing through 200ft struck Vulture. Aircraft went out of control and crashed vertically.

23.04.77	Aero Commander 690	Meigs Field, Chicago, USA	Engine	Gull (Larus sp)	4/ 4 fatal

Gull ingested in one engine, causing loss of power, emergency procedures improperly executed and aircraft spun into the water.

19.10.79	Swearingen Merlin	Palo Alto, Calif, USA	Engine	Gulls (Larus sp)	4/ 2 fatal 1 injured

During approach, a flock of gulls clogged an engine intake (engine not damaged). Pilot attempted go-around but lost control crashing inverted into parking area destroying or damaging 7 other aircraft.

06.08.81	Cessna 402	Near Muslars, Kenya	Windshield	Ruppell's griffon vulture - 7.5kg (Gyps rueppellii)	1/ 1 fatal

Suffered bird strike with a Ruppell's griffon vulture which penetrated the windshield, killing the pilot instantly, the aircraft was destroyed.

..-81	Callair A9	Australia	Strut/top surface wing	Black kite - 780gm (Milvus migrans)	1/ 1 minor injury

While towing a glider, a Black kite became lodged between the strut and the top surface of the left wing causing loss of aileron control. The aircraft was forced into a turn descending into woodland where it struck trees. The aircraft was destroyed by fire.

11.07.83	Boeing Stearman	Webb, Texas, USA	-	-	1 Serious

Just before flying under wires during a dusk agricultural spray run, a bird struck and broke a plastic fuel gauge located under the centre section of the upper wing. Fuel sprayed on to the windshield and pilot's face, restricting his forward visibility. In an effort to miss the power lines, the aircraft struck trees. The pilot suffered serious injuries and the aircraft was destroyed. (Source NTSB)

21.07.84	Piper PA18	Seboomook Lake, USA	Windshied	Cormorant - up to 2.4kg (Phalacrocorax sp)	1 Minor

On final approach for a water landing a bird, believed Cormorant holed the windshield causing cuts to the pilot's face as a result of his glasses impacting his eyebrows. The stunned pilot came to in the water and after releasing himself he escaped from the inverted, submerged aircraft. A nearby boat rescued the pilot (Source NTSB)

30.08.84	Boeing Stearman	Kalispell, Minnesota, USA	Canopy	Red tailed hawk - 1.1kg (Buteo jamaicensis)	1 Fatal

The pilot was completing a turn on to an agricultural spray run when at 15 ft and 65 mph he struck a bird, believed Red tailed hawk. The force of impact broke the canopy and distracted the pilot. The aircraft struck the ground and overturned killing the pilot. (Source NTSB)

25.11.84	Ercoupe 415	Wixom, Minnesota, USA	-	-	1 Fatal 1 Serious

Flying into a low sun as the aircraft turned finals a large flock of birds flew in front of the aircraft, the pilot dived to avoid them and collided with power lines. The aircraft crashed killing the pilot whose blood alcohol level was 0.11%. (Source NTSB)

29.01.87	Cessna 150	Vancouver, Washington, USA	-	-	2 Fatal

While returning from an instructional flight the aircraft passed through an area of heavy bird activity and the student made a nose down avoidance manoeuvre. The instructor took control with a rolling pull-up which over-stressed the right wing. (Source NTSB)

-08.87	Hanglider	Flinders Ranges, Australia	Wing tip	Wedge tailed eagle - 3.5kg (Aquila audax)	1 serious injury

While thermalling at 2700 ft agl an eagle attacked the glider. On its third attack it dislodged the wing tip tensioner, thus releasing all tension to one wing. The hang glider spiralled down and was wrecked, the pilot was hospitalised. There had been previous attacks in the area by eagles.

17.09.87	Schweizer 164	Weiner, Arizona, USA			1 Fatal 1 Serious

During an agricultural flight to chase birds from a rice field, the aircraft struck a large flock of birds. The pilot allowed the wheels to contact the crop and the aircraft overturned. Both occupants were unrestrained, the passenger, of the single seat aircraft, was found dead outside the cockpit. Several dead birds were found at the accident site. (Source NTSB)

24.11.87 Osprey Homebuild Cape Liptrap, Windshield - 1/
Australia

At 70 kts just after take-off struck a bird, shattering windshield, pilot vision impaired by wind blast. After landing and shutting down found back of aircraft on fire, vacated before aircraft was destroyed. Believe bird damaged fuel line allowing fuel to spray on hot exhaust.

11.02.88 Cessna 172P East Hampton, NY, 1 Fatal
USA

Shortly after departure the pilot radioed that he had struck some birds and couldn't maintain control. The aircraft crashed in the sea about 1 mile off shore, killing the pilot. (Source NTSB)

26.12.91 Piper PA31 Navajo Musiara Windshield White headed 9/
(5Y-SRV) Aerodrome, vulture - about 9 fatal
Maasi-Mara, 5.4kg
Kenya (Gyps africanus)

A DC3 had suffered a collapsed landing gear and over-ran the runway. The PA31 flew over the site (not its destination) probably to show the passengers, at about 250ft at fairly high cruise speed. The aircraft struck a bird, oscillated, banked and pitched down uncontrollably, crashed and burned just beyond the end of the runway, killing all the occupants. Witnesses had seen a black object fall from the aircraft and the remains were found of a White headed vulture, together with shattered parts of the windscreen. The autopsy revealed pre-impact spinal injuries.



Burnt out
wreckage

25.01.92 Cessna 401 Maasi-Mara, Wing tip believed Marabou 7/
(5Y-BGW) Kenya stork - 5.9kg 7 fatal
(Leptoptilos crumeniferus)

While in the cruise another aircraft heard a radio transmission 'I have been hit by a large bird and I'm having difficulty flying it, I can hardly control the aircraft'. The aircraft crashed killing all occupants. Witnesses had seen objects falling from the aircraft. The wing tip fuel tank and aileron were found about one mile from the main wreckage. Avian blood was found on the wing leading edge.



10.08.92	Cessna 441 Conquest	Nr Lee Gilmer Memorial Ap, Georgia, USA	Engine	-	1/ 1 serious injury

On take-off, as the aircraft climbed through about 50ft, it encountered a flock of birds. Power was lost on the right engine, however, the pilot reportedly then failed to feather the right propeller or retract the aircraft's undercarriage or flaps. The Cessna lost height and crashed about 1.5 miles beyond the end of the runway. The NTSB determined the cause to be: The poor in-flight decision by the pilot in that after a partial loss of power, he shut down the wrong engine, did not follow the emergency checklist, did not raise the flaps and did not retract the undercarriage. A factor in the accident was the in-flight collision with birds during the take-off climb.

24.02.94	Piper PA28-160	Lake Ontario, Canada	Windshield	-	1/ 1 fatal

The pilot was on a flight to Hamilton Airport, Ontario, he told ATC that something had come through his windshield, that he could hardly see, could not see the instruments and was disoriented. Six minutes later he made his last radio call and the aircraft was observed on radar to fly an 'S' pattern east-bound over Lake Ontario before it disappeared from radar at 13.45 hours 14 miles NE of Hamilton airport. The pilot, who had over 17,000 hours, much of it on low level pipeline patrols and the aircraft are still missing. An aviation witness on the ground saw the aircraft and reported the weather as sunny, visibility unlimited, cloud base approximately 5000ft.

18.06.94	Cessna 441 Conquest	Fort Frances, Canada	Engine	Gull (Larus sp)	6/

On take-off from Fort Frances, just after rotation, a bird struck the aircraft and was ingested into the No 1 engine. Power was lost on the engine but the pilot elected to continue with the take-off. However, he was then apparently unable to maintain control. The aircraft veered to the left, off the side of the runway, the left wing tip struck the ground and the aircraft crashed. The aircraft sustained substantial damage but the six occupants escaped with only minor injuries.

22.10.95	DHC-6 Twin Otter 300	Bole Intl Airport, Ethiopia	Windshield	White backed vulture - 8.0kg (Gyps afracanus)	20/ 4 serious injuries

When about 20 miles from Addis Ababa airport, the aircraft collided with a large bird, a White backed vulture. The bird struck the aircraft's windshield causing the support structure and both windshields to fail and collapse into the cockpit. The crew, although injured, were able to maintain some control and continued towards Bole International Airport. However, on arrival, they were unable to correctly position the aircraft for landing and, rather than carry out a go-around, elected to make a forced landing some 300m south of the runway. The aircraft touched down safely but during the ground run it fell into a depression and ground looped to the left sustaining substantial damage. The accident happened in daylight (ETA 0950L).

6 HELICOPTERS

DATE	AIRCRAFT	LOCATION	PART STRUCK	BIRDS/WEIGHT	OCCUPANTS/ INJURY

02.03.81	Bell 206	Vancouver State, Canada	Windshield	Raven - 1.2kg (Corvus corax)	4/ 4 killed

The helicopter went missing on a low altitude sheep count and was not found until 3 months later. When found, at least one raven had struck the plexiglass front windshield and probably entered the cockpit area. The helicopter crashed as a result, killing all 4 on board.

29.01.83	Bell 47	Riverview, Florida, USA	Door area	-	1 Minor

The helicopter was flying at about 50 mph, 15ft above the water, when a bird came through the door opening, striking the pilot on the right temple. The pilot lost control and it crashed into the ocean, the pilot was uninjured, the passenger suffered minor injuries. The helicopter was written off. (Source NTSB)

21.01.85	Hughes 369	Honolulu, USA	Rotor system	-	Nil

While flying over the water at about 400 ft, 1/2 mile from the shore, the pilot saw a large flock of birds, but was unable to avoid them. An extreme vibration developed, the pilot ditched the helicopter whereupon it rolled over and sank. The pilot was able to swim ashore. (Source NTSB)

30.05.90	Schweizer 269C	Tallulah, Louisiana, USA	Tail boom	-	Nil

While en-route at 800 ft a flock of birds was struck. There was severe vertical vibration and the pilot made a precautionary landing. During the flare the main rotor blade flexed and struck the tail boom causing the helicopter to become uncontrollable. The helicopter rolled on to its side. (Source NTSB)

APPENDIX 30

Serious Birdstrike-Related Accidents To Military Aircraft of Europe and Israel: List and Analysis of Circumstances

**SERIOUS BIRDSTRIKE-RELATED ACCIDENTS
TO MILITARY AIRCRAFT OF EUROPE AND ISRAEL:
LIST AND ANALYSIS OF CIRCUMSTANCES**

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ABSTRACT

This paper lists and summarizes the circumstances of 168 accidents in which military aircraft were destroyed or damaged beyond repair as a result of encounters with birds. At least 34 aircrew and 3 civilians on the ground were killed in these accidents. The analysis includes data from 21 countries: 14 in western and central Europe, 4 in eastern Europe, Israel, and Canadian and U.S. forces in Europe. Data were available for 15-46 years within the 1950-95 period, depending on the country. This paper excludes additional known accidents and fatalities in countries for which only fragmentary data were available. Of the 168 accidents considered, 45 were in the U.K. and Ireland, 18 in Scandinavia, 57 in western and central Europe, 11 in southern Europe (no data for Spanish forces), 21 in eastern Europe (data very incomplete), and 7 in Israel. At least nine European military aircraft were lost to birdstrikes outside Europe and Israel. Most aircraft lost were jet fighter and attack aircraft (88 before 1980; 55 from 1980 to date), single-engined trainers (12), or twin-engined bombers (7). Two 4-engine aircraft, a Victor tanker and Nimrod patrol aircraft, were lost in the U.K. The largest numbers of accidents (45 before 1980; 33 more recent) were during low-level (≤ 1000 feet AGL) cruise flight, mainly at high speeds. The second most common category involved aircraft at or near aerodromes (34 before 1980; 24 more recent), mainly at low altitude and low speed. Most losses involved engine ingestions and/or windscreen penetrations. Gulls, followed distantly by buzzards (hawks), ducks, pigeons and corvids, were the birds most commonly identified as being responsible for the accidents, with some notable regional differences. Additional accident data from other years and other countries are sought to provide a basis for a more comprehensive and representative list and analysis at a future date.

Key Words: Europe, Israel, military accident list, fatalities, location, month, aircraft type, phase of flight, altitude, speed, windscreen penetration, engine ingestion, engine type, species.

1. INTRODUCTION

Many military aircraft have crashed because of birdstrikes, and many aircrew have been killed. Buurma (1984) estimated that, in the early 1980s, West European military forces may have lost up to 10 jet fighters per year due to birdstrikes. Until recently there had been little attempt to report compiled multinational information about total numbers and circumstances of these accidents. At the 1994 BSCE meeting, I presented a preliminary list of 131 accidents in which military aircraft of 10 countries were destroyed and/or aircrew were killed (Richardson 1994). That list included at least partial data from seven European countries. It listed 69 serious bird-related accidents in Europe, plus 32 in the U.S.A., 9 in Canada, 5 elsewhere, and 16 at unknown locations.

Many more data on European birdstrike accidents have been compiled since 1994. Most of this information was provided by persons who attended the 1994 BSCE meeting, by various military flight safety offices, and (for the U.K.) by other compilers of military accident data. I thank all the individuals and agencies listed below under ACKNOWLEDGEMENTS and APPENDIX 1—Data Sources, without whose help this paper would have been impossible.

This paper includes 15-46 years' data from all major western and central European air forces except Spain. For some countries, data are also available from the navy and army air arms. In addition, some accident data are now available from four eastern European air forces: Hungary and the former East Germany, Czechoslovakia, and USSR (USSR data very incomplete). Also included are recently-released accident data from Israel plus Canadian and U.S. losses in Europe. Overall, these data include 152 military aircraft lost in Europe, 7 in Israel, 9 European aircraft lost outside the region, and at least 37 fatalities (see APPENDIX 2).

An analysis of the circumstances of serious accidents caused by birds is relevant in identifying the most hazardous situations. Analyses of serious accidents should use data from as many years and countries as possible to provide an adequate statistical basis. However, many factors vary among countries, and operations and equipment change across years. "Pooled" data must, therefore, be interpreted cautiously.

It is hoped that this paper will stimulate release of information about other bird-related accidents in Europe and elsewhere, and about the circumstances of incompletely-documented cases listed in APPENDIX 2.

2. DATA SOURCES AND PROCEDURES

This paper considers accidents from 1950 to date. It is based largely on accident data received from or corroborated by the flight safety offices of the countries concerned (APPENDIX 1). However, for most countries data are lacking or incomplete up to 1955-80, depending on the country (Table 1). In all cases, one must allow for the inevitable incompleteness of records, and for large differences in investigation and reporting standards among countries and years. For some countries with large air forces, the only known bird-related accidents are recent, suggesting that earlier records may be incomplete. For the former USSR, 10 known accidents are included, but these undoubtedly are only a small minority of the actual number.

"Serious accidents" are defined as those in which a military aircraft was destroyed or damaged beyond economical repair as a result of colliding with birds (164 accidents) or while attempting

to avoid birds (4 accidents), or there were human fatalities. In Europe and Israel, all known fatalities from birdstrikes also involved loss of the aircraft.

This paper includes known cases of aircraft "damaged beyond repair" (dbr) but not totally destroyed. For most countries, most or all listed accidents involved unequivocal destruction of the aircraft. However, for the U.K., especially before 1980, there are many known "dbr" cases (see APPENDIX 2). These aircraft were retired from military flying after being damaged by birdstrikes. Nowadays, aircraft with similar damage would often be repaired, given the higher costs and longer lifetimes of modern military aircraft. The "aircraft losses to birdstrike" data in Tables 1-10 do not distinguish "dbr" aircraft from aircraft totally destroyed. There probably were additional "dbr" birdstrikes in countries for which records of such occurrences are less readily traceable than in the U.K.

APPENDIX 1 documents, by country of aircraft ownership, the sources used to compile the accident data that are listed in APPENDIX 2 and analyzed below.

3. FREQUENCY OF SERIOUS ACCIDENTS

3.1 Aircraft Losses

At least partial data were available from 6 countries in the 1950s and 16 in the 1960s. Well over 19 military aircraft were lost to birdstrikes in Europe in the 1950s, and well over 33 in the 1960s (Table 1). For the 1970s and thereafter, data were available from 20-21 countries. Military aircraft losses for Europe and Israel were 49+ in the 1970s, 48+ in the 1980s, and 18+ in the 1990s to date (Table 1). It is emphasized that data are incomplete for some countries, especially for the earlier years. Also, official data on losses of aircraft from Spain are lacking, and data are lacking or incomplete for most eastern European countries.

Loss rates (aircraft/year) seem to have declined in recent years for some countries: Germany, Sweden, U.K. and Canadian Forces in Europe. Factors responsible are outside the scope of this review, but include changes in fleet sizes, flying hours, and aircraft types (e.g. retirement of F-104 in Germany and Canada). These apparent patterns must be treated cautiously because of differences among years and countries in investigation and reporting practices.

3.2 Fatalities

Subject to the same data limitations, there were at least 37 fatalities: at least 2 in the 1950s, 6+ in the 1960s, 12+ in the 1970s, 12+ in the 1980s (including three civilians on the ground), 4+ in the 1990s to date, and 1 in an unknown decade (Table 2). The worst known bird-related accidents for Europe and Israel since 1950 involved a Belgian F-104 lost in Germany in 1980, probably due to a birdstrike, with 3 civilian fatalities; and an East German Mi-8 helicopter lost to a bird ingestion in 1975 (3F). This excludes the Royal Navy Sea King helicopter lost on 19 May 1982 near the Falklands (21 or 22F), for which the cause is officially listed as "not positively determined" (Cdr R.P. Seymour, RN FSAIC, pers. comm., Jan 1996). There were at least 6 European and Israeli accidents with two aircrew fatalities and 19+ with one fatality. Overall, there were at least 27 accidents with 1-3 fatalities and 126 accidents with no fatalities. In the other 15 cases (14 pre-1980) I do not know whether there were fatalities.

TABLE 1. Minimum numbers of military aircraft of Europe and Israel lost to birds, 1950 to date^a. Includes 9 European aircraft lost outside Europe and Israel (see ^c, ^g, ^m), plus 8 Canadian and 7 U.S. aircraft lost in Europe. Includes aircraft destroyed and damaged beyond economical repair.

Country of Origin	Service(s)	Years with Data	Number of Aircraft Lost by Decade					Minimum Totals
			1950s	1960s	1970s	1980s	1990s	
Western European Forces								
Austria	AF	57 ^b -95	0	0	0	0	0	0
Belgium	AF	60-95	?	0	1	3	0	4
Denmark	all	50-95	0	0	0	0	0	0
Finland	AF	61-95	?	?	?	0	0	0
France	AF	75-Jan96	?	?	0+	0	5 ^c	5
	Navy	60-Jan96	?	0	0	0	2	2
Germany (W)	AF	62-95	?	4+	6	4	0	14
	Navy	62-95	?	1+	6	2	0	9
Greece	AF	65-94	?	0+	1	0	1	2
Italy	AF	61-94	?	0+	0	2	1	3
Netherlands	all	56-95	2+	3	2	2	1	10
Norway	AF	56-95	0+	0	1	1 ^d	1	3
Portugal	AF	75-95	?	?	0+	1	1	2
Sweden	AF	65-95	?	2+ ^e	7	0	0	9
Switzerland	AF	≤74-95	?	?	1+	0	1	2
United Kingdom	RAF ^f	50-94	14 ^g	10 ^g	11	13 ^g	2	50 ^f
	RNavy	58-95	2+ ^g	1	0	3+ ^h	0	6
	Army	64-95	?	?	0	1	1	2
Subtotal			18	21	36	32	16	123
Eastern European Forces								
Czech.+Slov. Rep.	AF	Incomplete ⁱ	?	1+	0+	1+	0+	2+
East Germany	AF	67-88	?	2+ ^k	5	3	1	10
Hungary	AF	60-95	?	0	0	1	0	1
former USSR	AF	Incomplete ⁱ	1	3	1	3	1	10+ ^m
Subtotal ^f			1	6	6	8	1	23+ ^m
Other Forces								
Israel	AF	72-95	?	?	4+	2	1	7
Canada (in Eur.)	all	64-95	?	6+	1	1	0	8
U.S.A. (in Eur.)	all	73 ^f -95	?	?	2+	5 ^o	0	7
Totals			19	33	49	48	18	168 ⁿ

^a Includes 2 RAF and 2 British Army aircraft lost while avoiding birds or (one case) simulated birds.

^b There was no Austrian military flying in 1950-56.

^c Two of these accidents were outside Europe and Israel.

^d Excludes RNorAF F-16 loss on 5 Jul 1988 (fatal; possible birdstrike).

^e Some further SwedAF crashes before 1967 were probably due to birds (T. Alerstam pers. comm.).

^f Of the early RAF losses, many were "damaged beyond repair", not totally destroyed (see APPENDIX 2).

^g One of these accidents was outside Europe and Israel.

^h Excludes RN Sea King helicopter loss on 19 May 1982 (fatal; circumstances not positively determined) and RN Hunter birdstrike on 19 Aug 1982 (possibly damaged beyond repair).

ⁱ Excludes British Army Sluox helicopter lost on 6 Dec 1966 (fatal; reports of cause differ).

^j Data from former Czechoslovakia and especially USSR are incomplete.

^k One East German loss listed for 1960s may have been in early 1970s.

^l East Germany combined with Germany (W) after 1990s.

^m Row totals include one USSR accident (outside Europe, in Soviet Asia) during an unknown decade.

ⁿ Not known whether any of fifteen 1966-72 USAF accidents listed in Richardson (1994) were in Europe.

^o One U.S. Army writeoff in Europe in 1984 is included; no other U.S. Army records available.

TABLE 2. Minimum numbers of human fatalities attributable to birdstrikes and bird avoidance during military aircraft operations of Europe and Israel, 1950 to date^{a,b}. Includes 1 Soviet fatality in Asia and 3 U.S. fatalities in Europe. No known bird-related fatalities for aircraft of Austria, Denmark, Finland, France, Germany (W), Greece, Italy, Switzerland, or Canadian forces in Europe.

Country of Origin	Service(s)	Years with Data	Number of Fatalities by Decade					Minimum Totals
			1950s	1960s	1970s	1980s	1990s	
Western European Forces								
Belgium	AF	60-95	?	0	0	3 ^a	0	3 ^a
Netherlands	all	56-95	0+	0	1	1	0	2
Norway	AF	56-95	0+	0	1	0 ^c	0	1
Portugal	AF	75-95	?	?	0+	0	1	1
Sweden	AF	65-95	?	0+	5	0	0	5
United Kingdom ^e	RAF	50-94	2+	2+	0	3	0	7+
	Army	64-95	?	7 ^c	0	0	1 ^b	1
Subtotal			2+	2+	7+	7+	2+	20+
Eastern European Forces								
Czech.+Slov. Rep.	AF	Incomplete ^d	?	1+	?	0+	?	1+
Germany (E)	AF	67-88	?	1+ ^a	4	1	-	6
Hungary	AF	60-95	?	0	0	1	0	1
former USSR	AF	Incomplete ^d	?	2+	?	?	?	3+ ^f
Subtotal ^d			?	4	4	2	0	11+ ^f
Other Forces								
Israel	AF	72-95	?	?	1+	0	2	3
U.S.A. (in Eur.)	all	73 ^g -95	?	?	0+	3	0	3
Totals			2	6	12	12	4	37 ^f

^a Includes 3 civilian ground fatalities during a BelgAF crash probably caused by birds.

^b Includes 1 British Army fatality attributable to a bird avoidance manoeuvre.

^c Excludes RNorAF (1F), U.K. Navy (21-22F), U.K. Army (2F) accidents mentioned footnotes to Table 1.

^d Data from former Czechoslovakia and especially USSR are incomplete.

^e One East German fatality listed for 1960s may have been in early 1970s.

^f Row totals include one USSR fatality (outside Europe, in Soviet Asia) during an unknown decade.

^g Not known whether any of the 1962-1972 USAF accidents listed in Richardson (1994) were in Europe.

The crew ejected in a high proportion of the serious accidents, and most ejections were successful (APPENDIX 2). Unsuccessful ejections were often at low altitude. An increasing proportion of in-service military aircraft are capable of successful ejections down to low or zero altitude and airspeed, so the success of ejections might be expected to increase. However, some pilots continue to be killed by birds penetrating windscreens. Also, a significant proportion of the fatalities involved aircraft without ejection seats, e.g. the Mi-8 helicopter in 1975 (3F), RAF Nimrod patrol aircraft in 1980 (2F), and British Army Lynx helicopter that hit terrain while avoiding birds in 1991 (1F). The worst confirmed losses to birds for non-European military aircraft have also involved aircraft with no ejection seats (USAF E-3 in 1995, 24F, Gresch 1996) or an insufficient number of ejection seats (B-1B in 1987, 3F, Greeley 1988).

This paper does not tabulate injuries, as explained in Richardson (1994). Some birdstrikes to European military aircraft have caused serious injuries, with or without loss of aircraft. In one case three ground personnel were injured by detonating ordnance (SwedAF, 1 Sep 1977).

4. CIRCUMSTANCES OF SERIOUS ACCIDENTS

4.1 Geographic Distribution

Some birdstrike-related accidents have occurred outside the borders of the operating country. Losses outside the home country included 2 Belgian, 2 French, 7 West German, 4 Netherlands, and 18 British aircraft (Table 3, APPENDIX 2). Eight of 17 known Canadian losses to birdstrikes since 1964 were in Europe, and at least seven U.S. aircraft have been lost to birdstrikes in Europe since 1973. Four of 10 known losses of former USSR aircraft were outside the European part of the USSR, in France (1), East Germany (2), and Asia (1). Nine of the 168 known losses tabulated were outside Europe and Israel, including two French aircraft in Chad; British losses in Aden (2), Hong Kong (2), Nigeria (1) and the Falklands (1+); and the Soviet aircraft in Asia.

European countries where the most known birdstrike accidents have occurred are Germany and the U.K.: 34 losses in West Germany since 1962 plus 11-12 in East Germany since 1967; 43 losses in the U.K. since 1950. Military aircraft from at least six countries have been lost to birdstrikes in West Germany (Table 3). Other countries with numerous losses include France (12+ aircraft from five countries), Sweden (9+ aircraft), Netherlands (7) and Israel (7). Although the Danish armed forces do not know of any losses of their aircraft to birdstrikes, at least six foreign military aircraft have crashed after birdstrikes in or near Denmark (Table 3).

Changes in the distribution of accidents are presumably occurring because of recent changes in the deployment of military forces. Also, the apparent distribution of bird-related accidents obviously depends on the completeness of records. Losses are no doubt more seriously underestimated in some countries than in others. Losses in Spain are underestimated because official Spanish data have not been obtained. Data on losses in eastern Europe (including the USSR) are very incomplete. Unofficial reports of birdstrike accidents in Albania, Poland and Romania are excluded from this paper pending corroboration.

4.2 Monthly Distribution

Serious bird-related accidents have occurred at all times of year, but numbers of accidents have been notably lower in winter—December, January and February—than in other months (Table 4). Both for Europe as a whole and for most regions within Europe, there has been no strong tendency for more accidents in spring and/or fall than in summer. However, in the U.K., birdstrike accidents have been especially common in November.

4.3 Types of Aircraft

Most military aircraft involved in serious bird-related accidents have been single-engine fighter or attack aircraft (121 of 167 known types, or 72.5%), most being flown by one pilot (Table 5). In addition, 12 of the losses (7%) were single-engine trainers. Twin-engine fighter and attack aircraft accounted for 21 accidents (13%). Other twin-engine fixed-wing aircraft, mainly Canberra and Il-28 light bombers, accounted for 8 losses (5%). Other losses consisted of three helicopters, two 4-engine aircraft, and one Soviet fighter of unstated type.

The circumstances of the helicopter and 4-engine losses are of special interest, in part because of their infrequency. ▶ An East German Mi-8 helicopter was lost in 1975 after ingesting a bird into a turboshaft engine. ▶ Two British Army helicopters were reportedly lost upon striking wires or

TABLE 3. Geographic distribution of serious accidents (writeoffs and/or fatalities) attributed to birds, considering military aircraft of Europe and Israel plus 8 Canadian and 7 U.S. aircraft lost in Europe, 1950 to date. Tables 1 and 2 show the specific years when data for each country were available. No known losses of aircraft from Austria, Denmark or Finland. "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

Number of Aircraft Lost in Various Countries																			
Country of Origin	Service(s)	Belgium	Denmark	France	West Germany	Greece	Ireland	Netherlands		Portugal	Spain	Sweden	Switzerland	Total		Israel	Elsewhere	Minimum	
								Italy	Other lands					UK	Other				
Western European Forces																			
Belgium	AF	0+2	-	-	1+1	-	-	-	-	-	-	-	-	-	1+3	-	-	1+3	
France	AF,N	-	-	0+5	-	-	-	-	-	-	-	-	-	-	0+5	-	0+2	0+7	
Germany (W)	AF,N	-	2+2	1+1	14+2	-	-	0+1	-	-	-	-	-	-	17+6	-	-	17+6	
Greece	AF	-	-	-	-	1+1	-	-	-	-	-	-	-	-	1+1	-	-	1+1	
Italy	AF	-	-	-	-	-	-	0+3	-	-	-	-	-	-	0+3	-	-	0+3	
Netherlands	all	-	-	-	3+1	-	-	-	4+2	-	-	-	-	-	7+3	-	-	7+3	
Norway	AF	-	-	-	-	-	-	-	-	1+2	-	-	-	-	1+2	-	-	1+2	
Portugal	AF	-	-	-	-	-	-	-	-	-	0+2	-	-	-	0+2	-	-	0+2	
Sweden	AF	-	-	-	-	-	-	-	-	-	-	9+0	-	-	9+0	-	-	9+0	
Switzerland	AF	-	-	-	-	-	-	-	-	-	-	-	1+1	-	1+1	-	-	1+1	
United Kingdom	AF,N,Ar	-	1+0	1+0	7+0	-	0+2	-	1+0	-	-	-	-	23+17	33+19	-	-	5+1	
Subtotal		0+2	3+2	2+6	25+4	1+1	0+2	0+4	5+2	1+2	0+2	9+0	1+23	1+17	70+45	-	-	75+48	
Other Forces																			
Czech+Slov., E. Germ.,																			
Hung., USSR	AF	-	-	0+1	-	-	-	-	-	-	-	-	-	-	0+1	13+8 ^b	-	1+0	14+9
Israel	AF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4+3	-	4+3
Canada	all	-	1+0	3+0	3+1	-	-	-	-	-	-	-	-	-	7+1	-	-	7+1 ^c	
U.S.A. ^a	all	-	-	-	0+1	-	-	-	-	-	0+3	-	-	2+1	2+5	-	-	2+5 ^c	
Totals ^a		0+2	4+2	5+7	28+6	1+1	0+2	0+4	5+2	1+2	0+2	9+0	1+25	1+18	79+52	13+8	4+3	6+3	102+66

^a Biased by lack of Spanish Air Force data and unknown locations of many pre-1973 USAF accidents.

^b These E. European accidents were in E. Germany (7+4), Hungary (0+1), former USSR (4+2), and unknown (2+1); data are incomplete.

^c Canadian and U.S. military losses outside Europe and Israel are excluded; see Richardson (1994) for those data.

TABLE 4. Monthly distribution of serious accidents (writeoffs and/or fatalities) attributed to birds, by geographic region, considering military aircraft of Europe and Israel plus 8 Canadian and 7 U.S. aircraft lost in Europe, 1950 to date.

Months	Number of Aircraft Lost by Geographic Region of Accident							Minimum Totals
	UK + Ireland	Scandinavia	West+Cent. Europe ^a	Southern Europe ^b	Eastern Europe ^c	Israel	Other ^d	
January	2	-	2	-	-	1	-	5
February	2	1	3	-	-	1	1	8
March	2	2	7	1	2	-	1	15
April	4	2	4	2	5	-	-	17
May	2	3	5	1	2	1	-	14
June	4	2	3	3	1	-	1	14
July	3	1	8	-	1	-	1	14
August	2	3	8	-	3	1	1	18
September	7	2	6	-	-	-	-	15
October	5	2	6	2	3	2	1	21
November	11	-	3	2	1	-	2	19
December	1	-	2	-	-	1	-	4
Unknown	-	-	-	-	3	-	1	4
Totals	45	18	57	11	21	7	9	168

^a West & Central Europe: accidents in France, Belgium, Netherlands, W. Germany, and Switzerland.

^b Southern Europe: accidents in Portugal, Spain, Italy, and Greece.

^c Eastern Europe: accidents in Czech & Slovak Rep., Hungary, E. Germany, former USSR west of Urals.

^d Other: Russian Asia (1), Aden (2), Chad (2), Nigeria (1), Falklands (1), Hong Kong (2).

TABLE 5. Types of aircraft involved in serious accidents (writeoffs and/or fatalities) attributed to birds, considering military aircraft of Europe and Israel plus 8 Canadian and 7 U.S. aircraft lost in Europe, 1950 to date. Includes 9 European aircraft lost outside Europe (see footnotes). "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

Type of Aircraft	Number of Aircraft Lost				Minimum Totals
	1-engine	2-engine	4-engine	Unknown	
Turbine-powered Fixed-wing					
Fighter & Attack ^d Crew 1	68 ^a +32 ^b	3+5 ^c	-	1+0	72+37
Crew 2	7+9	4 ^c +8	-	-	11+17
Crew ?	4+1	1+0	-	-	5+1
Subtotal	79+42	8+13	-	1+0	88+55
Trainer ^e	5+6	-	-	-	5+6
Bomber, Patrol, Tanker	-	7 ^c +0	1+1	-	8+1
Other (RV-1D)	-	0+1	-	-	0+1
Piston-engined Fixed-wing	0+1 ^f	-	-	-	0+1
Helicopter	0 ^g +1	1+1 ^h	-	-	1+2
Totals	84+50	16+15	1+1	1+0	102+66

^{a,b,c} Four (^a), two (^b) or one (^c) of these accidents were outside Europe and Israel.

^d Includes 2-seat training variants of high-performance aircraft.

^e A few of these were 2-seat trainer aircraft flown by a crew of one.

^f RAF Bulldog went out of control and crashed when avoiding "simulated" birds, 29 Sep 1986.

^g Excludes British helicopter lost in uncertain circumstances (see footnotes ^{h,j} to Table 1).

the ground while avoiding birds. ▶ An RAF Victor 4-engine tanker was lost in 1976 after multiple gull strikes when takeoff was aborted above decision speed; in retrospect, it was concluded that the birdstrike caused little damage and the aircraft could have taken off. ▶ A Nimrod 4-engine patrol aircraft was lost in 1980 because of multiple gull strikes immediately after takeoff, with effective failure of three engines (Oliver 1990:68-70). (Another 4-engine aircraft was lost in the U.K. before 1950: In 1944, an RCAF Halifax bomber was destroyed in a crash landing after the only fully-qualified pilot was disabled by a bird penetrating the windscreen.) The rarity of serious bird-related accidents to helicopters and 4-engine aircraft is noteworthy. However, when major damage occurs, the risk is high: ejection seats are often absent, and the number of personnel aboard is often large.

All except five of the 167 losses of known aircraft types involved turbojet- or turbofan-powered fixed-wing aircraft (APPENDIX 2). The exceptions were the three turboshaft-powered helicopters, a small turboprop, and a piston-engine trainer. ▶ The one turboprop, a U.S. Army RV-1D Mohawk, was lost in Germany when a multiple birdstrike just after takeoff caused both engines to lose power. No turboprop military aircraft are known to have been lost to birdstrikes in Australia, Canada or the U.S.A. (Richardson 1994), but several civil turboprops, mainly 2- and 4-engine, have crashed (Thorpe, this volume). ▶ The one piston-engine aircraft loss in APPENDIX 2 was a special case: an RAF Bulldog trainer crashed when the student pilot lost control at low altitude after being told to manoeuvre around simulated birds (McD 1988).

4.4 Phases of Flight

Of the 148 accidents for which phase of flight is known, 90 or 61% happened during cruise or weapons range flight, i.e. not closely associated with an airport. Most of these serious en-route birdstrikes (78 of 90) were at low-level (≤ 1000 ft AGL; Table 6). En-route birdstrikes accounted for similar proportions of the losses of single and twin-engine aircraft (63 vs. 57%).

Conversely, 58 (39%) of the 148 bird-related accidents during known phases of flight were on or near airfields during takeoff, climb, approach, touch and go landings, overshoots, or flight demonstrations. Of these serious accidents near aerodromes, the majority were during takeoff and climbout (Table 6). The two known accidents to European 4-engine aircraft since 1950 were during or immediately after takeoff. In this paper, aircraft are considered to be on climbout from the moment they leave the ground, and on approach until they reach the runway.

4.5 Altitudes and Speeds

Consistent with the above, 103 (72%) of 143 bird-related accidents at known altitudes involved encounters at ≤ 500 ft AGL (150 m), and 27 more (19%) were at 501-1000 ft (Table 7A). Of these low-altitude strikes, 50 were near aerodromes and 72 were during low-altitude cruise or weapons-range flights. The highest confirmed-altitude strikes resulting in aircraft loss were eight strikes at 2500-3500 ft (760-1065 m).

Reported speeds during bird encounters that caused aircraft loss ranged from 0 knots for a hovering Mi-8 to 595 knots (1100 km/h); seven of these strikes were at 500-595 kt (APPENDIX 2). Cases at high speeds (>400 knots) were almost all during cruise or weapons-range flights, mainly at low altitude (Table 7B). Cases at medium speeds (201-400 kt) occurred in many circumstances. Most accidents involving strikes at speeds ≤ 200 knots happened during the takeoff roll or early stages of climb, and most involved either aborted takeoffs with runway overruns or

TABLE 6. Phase of flight for serious accidents attributed to birds, as in Table 5. "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

Phase of Flight	Number of Aircraft Lost				Minimum Totals
	1-engine	2-engine	4-engine	Unknown	
Aerodrome					
Takeoff	7+2	3 ^a +0	1+0	-	11+2
Climb	11+7	1+3 ^a	0+1	-	12+11
Approach	4+8	0+1	-	1+0	5+7
Other/Unknown	<u>4^a+2</u>	<u>2+2</u>	<u>-</u>	<u>-</u>	<u>6+4</u>
Subtotal	26+17	6+6	1+1	1+0	34+24
Cruise					
Cruise—Low ^d	38 ^a +26 ^b	7 ^a +7	-	-	45+33
Cruise—High ^d	<u>5+5</u>	<u>0+2</u>	<u>-</u>	<u>-</u>	<u>5+7</u>
Subtotal	43+31	7+9	-	-	50+40
Unknown	15 ^b +2	3+0	-	-	18+2
Totals	84+50	16+15	1+1	1+0	102+66

^{a,b} One (^a) or two (^b) of these accidents were outside Europe and Israel.

^c "Other" includes touch and go, overshoot, and flight demonstration. No losses during landing rollout.

^d "Low" is ≤1000 ft AGL or described as "low-level". "High" is >1000 ft AGL or described as "high".

"Cruise" includes flights on weapons ranges.

TABLE 7. Aircraft altitude and speed for serious accidents attributed to birds, by phase of flight, as in Table 5. "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

	Number of Aircraft Lost by Phase of Flight ^c				Minimum Totals
	At or Near Aerodrome	Low-alt. Cruise	High-alt. Cruise	Unknown	
A. Altitude (feet AGL)					
0-500	24 ^a +20 ^a	29 ^b +24 ^b	--	4 ^a +2	57+46
501-1000	4+2	16+3	-	2+0	22+5
1001-2000	1+1	-	2+3	-	3+4
2001-4000	1+0	-	1+3	1+0	3+3
Unknown—Low	-	0+4	-	4+0	4+4
Unknown—High	-	-	2+1	-	2+1
Unknown	4 ^a +1	0+2	-	7 ^a +0	11+3
Totals	34+24	45+33	5+7	18+2	102+66
B. Speed (knots)					
up to 200	23 ^a +17 ^a	3+1	1+0	0+2	27+20
201 - 400	6+5	13 ^a +8	0+2	2+0	21+13
401 - 600	0+1	26 ^a +21 ^b	0+3	-	26+25
Unknown	5 ^a +1	3+5	4+2	16 ^b +0	28+8
Totals	34+24	45+33	5+7	18+2	102+66

^{a,b} One (^a) or two (^b) of these accidents were outside Europe and Israel.

^c Phases of flight categorized as in Table 6.

ejections soon after takeoff. A few cases at ≤ 200 kt involved helicopters or other low-speed aircraft in cruise flight.

Birdstrikes during high-speed low-level cruise caused similar proportions of the bird-related accidents before 1980 (36%) and subsequently (37.5%, unknown altitude and unknown speed cases excluded; Table 7B). Strikes during medium- and high-speed low-level cruise caused 54% of the accidents before 1980 and 48% subsequently.

4.6 Parts of Aircraft Hit

The engine(s) were the most commonly-reported part(s) struck. Of 144 serious accidents in which the part struck was reported, 102 or 71% involved the engine(s), 24 (17%) the windscreen or canopy, and a further 11 (8%) both the engine(s) and windscreen (Table 8). There were only seven serious accidents in which the parts struck were reported not to include either the engines or windscreen. These cases involved strikes on the wing plus air intake (3 cases), intake only (2), wing only (1), and wing+nose+fuselage (1). Four of these seven accidents not involving the engine(s) and windscreen were cases where the aircraft was "damaged beyond repair", not totally destroyed. Some reports of engine ingestions or windscreen strikes mentioned that one or more additional parts were also struck (APPENDIX 2). The actual frequency of multiple-strike cases is undoubtedly higher than reported.

Centrifugal flow turbojets, as used in many early jet aircraft, have been considered more resistant to birdstrikes than axial flow engines. At least 15 aircraft powered by centrifugal flow turbojets were lost to birdstrikes (British Meteor, Vampires, Venom, Sea Hawk; Soviet Il-28, MiG-17; Czechoslovak MiG-15). Parts struck are known for 7 cases. The engine(s) were known to be involved (along with other parts) in only 2 of 7 cases, and one of those aircraft, an RN Sea Hawk, landed safely before being declared "damaged beyond repair".

Windscreen/canopy strikes (and especially penetrations) were much more common during cruise flight than during operations at or near aerodromes. During cruise, windscreen strikes were reported in 28 of 83 cases for which the part struck was reported (Table 8). At least 18 of these involved windscreen penetration, and in at least 4 more cases windscreen shattering or obscuring was a major contributing factor. In contrast, for accidents at and near aerodromes, a windscreen strike was reported in only 3 of 50 cases, and it was a major factor in no more than 1 of 50 cases. Engine ingestions were reported for 61 of 83 losses during cruise (73.5%) but for almost all losses near aerodromes (47 of 50 or 94%).

4.7 Types of Birds

Considering all 168 accidents, the birds responsible for the most accidents were gulls (35 cases), buzzards and hawks (11), ducks (8), pigeons (8), and corvids (6). These totals can be considered relative to the 98 accidents caused by collisions with known types of birds or 168 accidents caused by collisions with (or attempts to avoid) known and unknown types of birds (Table 9). Other groups that each accounted for at least 3-4 accidents were seabirds (Gannet and 2 others), pelicans, herons/egrets/storks, cranes, geese, waders (Lapwings or "plovers" in each case), and vultures. All values are minima because of the many accidents for which bird type is unknown.

4.7.1 Types Struck by Phase of Flight: Gulls were the worst problem both near aerodromes and during low-level cruise, but caused only one known accident during cruise above 1000 ft AGL.

TABLE 8. Parts of aircraft struck during serious accidents attributed to birds, by phase of flight, as in Table 5. "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

Part of Aircraft	Number of Aircraft Lost by Phase of Flight ^c				Minimum Totals
	At or Near Aerodrome	Low-alt. Cruise	High-alt. Cruise	Unknown	
Windscreen ^d	1+0	10+4 ^a	1+4	4+0	16+8
Engine(s) ^d	25 ^a +20 ^a	26 ^a +19 ^a	4+3	4+1	59+43
Both of Above ^d	1+1	3+6	-	-	4+7
Other Parts Only	1+1	0+3	-	2+0	3+4
Unknown, Multiple	-	1+0	-	-	1+0
Unknown	6 ^a +0	5 ^a +0	-	8 ^b +0	19+0
None (avoided)	0+2	0+1	-	0+1	0+4
Totals	34+24	45+33	5+7	18+2	102+66

^{a,b} One (^a) or two (^b) of these accidents were outside Europe and Israel. ^c Phases of flight as in Table 6.

^d Some cases involved multiple strikes including parts additional to windscreen and/or engines.

TABLE 9. Types of birds struck during serious accidents attributed to birds, by phase of flight, as in Table 5. "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

Type of Bird	Number of Aircraft Lost by Phase of Flight ^b				Minimum Totals
	At or Near Aerodrome	Low-alt. Cruise	High-alt. Cruise	Unknown	
Seabird	-	0+3 ^a	-	-	0+3
Pelican	1+0	2+0	-	-	3+0
Heron+Stork	0+2 ^a	0+1	-	1+0	1+3
Crane	-	-	0+1	2+0	2+1
Bustard	-	-	-	1+0	1+0
Swan	-	-	-	1 ^a +0	1+0
Goose	0+2	1+0	-	-	1+2
Duck	0+1	5+1	0+1	-	5+3
Wader/Shorebird	1 ^c +2	-	-	-	1 ^c +2
Gull	7+6	11 ^a +8	1+0	2+0	21+14
Kite	1 ^a +0	-	-	-	1+0
Hawk/Buzzard	-	4+5	1+1	-	5+6
Falcon	1+0	-	-	-	1+0
Eagle	-	0+1	-	-	0+1
Vulture	-	1 ^a +1	0+1	-	1+2
Pigeon/Dove	1+4	3+0	-	-	4+4
Corvid	-	3+0	1+1	0+1	4+2
Starling	1+0	-	-	-	1+0
Other landbird (small)	0+1	-	0+1	-	0+2
Unknown	21 ^a +4	15+12 ^a	2+1	11 ^a +0	49+17
None (avoided)	0+2	0+1	-	0+1	0+4
Totals	34+24	45+33	5+7	18+2	102+66

^a One of these accidents was outside Europe and Israel. ^b Phases of flight categorized as in Table 6.

^c One case involving gulls plus plovers is counted only under gulls.

(Table 9). Similarly pigeons caused accidents both near aerodromes and during low-level cruise. In contrast, there were no known losses to buzzards or corvids near aerodromes; they were struck during both low- and high-altitude cruise. Losses to ducks were mainly during low-level cruise, as were all losses to seabirds and 2 of 3 losses to pelicans.

4.7.2 Types Struck by Region: Gulls were the dominant problem in Scandinavia (50% of all birds struck and 82% of identified birds) and in the U.K.+Ireland (34-70%; Table 10). Gulls were less dominant in the loss statistics from west and central parts of continental Europe (16-26%). Elsewhere, samples were small but gulls were not dominant: southern Europe, 9-14%; eastern Europe, 5-8%; Israel, none; European aircraft lost outside Europe, 11-17%. Likewise, gulls are not dominant for military aircraft losses in North America (5-7%, Richardson 1994).

Other types of birds commonly responsible for aircraft losses were plovers and pigeons in the U.K., and buzzards, pigeons, ducks and corvids in west and central Europe. Elsewhere samples were very small. However, notable groups included pelicans and buzzards in Israel, and vultures

TABLE 10. Types of birds struck during serious accidents attributed to birds, by geographic region, as in Table 5. "x+y" shows numbers of accidents before 1980 (x) and from 1980 to date (y).

Months	Number of Aircraft Lost by Geographic Region of Accident ^a							Minimum Totals
	UK + Ireland	Scandinavia	West+Cent. Europe	Southern Europe	Eastern Europe	Israel	Other	
Seabird	-	-	0+1	0+1	-	-	0+1	0+3
Pelican	-	-	-	1+0	-	2+0	-	3+0
Heron+Stork	-	-	0+1	-	1+0	0+1	0+1	1+3
Crane	-	0+1	-	-	2+0	-	-	2+1
Bustard	-	-	-	-	1+0	-	-	1+0
Swan	-	-	-	-	-	-	1+0	1+0
Goose	-	-	1+0	-	0+2	-	-	1+2
Duck	1+0	-	4+1	-	0+2	-	-	5+3
Wader/Shoreb.	0 ^b +2	-	-	-	1+0	-	-	1 ^b +2
Gull	8+6	6+3	6+3	0+1	0+1	-	1+0	21+14
Kite	-	-	-	-	-	-	1+0	1+0
Hawk/Buzzard	0+1	-	4+3	0+1	-	1+1	-	5+6
Falcon	-	-	1+0	-	-	-	-	1+0
Eagle	-	-	-	-	-	0+1	-	0+1
Vulture	-	-	-	0+2	-	-	1+0	1+2
Pigeon/Dove	1+1	-	3+3	-	-	-	-	4+4
Corvid	-	-	4+0	-	0+2	-	-	4+2
Starling	-	1+0	-	-	-	-	-	1+0
Other landbird (small)	-	-	-	0+1	0+1	-	-	0+2
Unknown	15+6	7+0	16+6	0+4	8+0	1+0	2+1	49+17
None (avoided)	0+4	-	-	-	-	-	-	0+4
Totals	25+20	14+4	39+18	1+10	13+8	4+3	6+3	102+66

^a Geographic regions defined as in Table 4.

^b One case involving gulls plus plovers is counted only under gulls.

in southern Europe (2 USAF losses in Spain). The vulture problem in southern Europe would probably have been more prominent if official Spanish data were available. Vultures are more widely distributed in the U.S.A. than in Europe, and are the dominant cause of military aircraft losses in the U.S.A. (28-36%, Richardson 1994).

4.8 Special Cases

4.8.1 Crashes While Manoeuvring to Avoid Birds: Of the 168 accidents listed, four British accidents involved aircraft that crashed during low-altitude manoeuvres to avoid colliding with birds ($n=3$) or simulated birds ($n=1$). These accidents may not be officially listed as being directly caused by birds. Two British Army accidents involved helicopters that hit wires (29 Apr 1986) or the ground (14 Nov 1991) while manoeuvring to avoid birds. Two RAF accidents (and two similar USAF accidents) were described in Richardson (1994).

4.8.2 Fatality or Ejection but Aircraft Not Destroyed: I am not aware of any European military accidents in which an aircraft was landed successfully after one crewman was killed by a birdstrike. There have been at least three such cases in the U.S.A. (Richardson 1994).

At least two dual-seat military aircraft have landed successfully in the U.K. after a birdstrike and successful ejection of the rear-seat crewman. These ejections, both during high-speed low-level cruise flight, have not been included as serious accidents elsewhere in this paper. One involved a British Buccaneer that collided with geese on 9 Nov 1970 (Bourne 1991 and pers. comm.; T. West pers. comm.). The other involved a USAF F-15E whose canopy was penetrated by a duck on 16 Sep 1994 (*Air Forces Monthly* Nov. 1994:58; USAF BASH database).

5. CONCLUSIONS

Military services in many countries have been very helpful in releasing, for this analysis, detailed data on serious bird-related accidents to their aircraft. For military aviation, the birdstrike problem has been serious at least since 1950. Actual numbers of serious accidents and fatalities are even higher than shown in this paper, given the incomplete data, especially prior to 1980. If data from more years and countries can be compiled, including Spain and additional parts of eastern Europe and the Mideast, a more comprehensive analysis subject to fewer biases will be possible. **Agencies and individuals who can fill gaps or make corrections in APPENDIX 2, or expand it to other countries and years, are encouraged to contact the author or to publish the data.**

6. ACKNOWLEDGEMENTS

This compilation and analysis would have been impossible without help from many flight safety offices, birdstrike specialists, and aviation historians. These cooperators are mentioned in APPENDIX 1—DATA SOURCES. I also thank those acknowledged in my 1994 paper; many of those data are used again here. All contributions were important, but the following individuals were especially helpful in responding positively to a series of requests for follow-up data: C.K. Aas, Dr. T. Alerstam, Dr. J. Becker, W.B. Brown, Dr. L.S. Buurma, S/L J.G. Chapman, W/C D.R. Collier Webb, Cdt. R. Degriek, R.J. Dunn, Dr. Y. Leshem, Cdr R.P. Seymour, R.C. Sturivant, and M.M. Thompson. I thank Tim West for making available the results of his exhaustive search for RAF birdstrike accidents. For help in making contact with various flight safety offices and/or encouraging them to release data, I thank Dr. L. Buurma (RNethAF), Maj. W. Stone (Canadian Armed Forces/DFS), and J. Thorpe (U.K. CAA/BSCE).

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APPENDIX 1: Data Sources

Countries Not Listed in Richardson (1994)

Austria: There have been no known serious birdstrike accidents to Austrian military aircraft since military flying resumed in 1957 (Col. H. Marchard, Austrian AF, pers. comm., Jan 1996).

Belgium: Air Force records extending back to 1960 show four aircraft losses to birdstrikes (Table 1 and APPENDIX 2); details were provided by the Belgian AF (Cdt. R. Degrieck and Maj. G. Transon, pers. comm., Dec 1994, Mar 1996).

Czech and Slovak Republics: Murár (1994a,b) reports no recent serious birdstrike accidents. There was a fatal windscreen penetration in the early 1960s, and one aircraft was lost in 1985 (details from LCol. R. Peca, Flying Safety, Slovak AF, pers. comm., Feb 1995).

East Germany: Dr. J. Becker, German Military Geophysics Office, provided details concerning 10 aircraft of the former National Peoples Army (NVA) lost to birdstrikes, 1967-88, plus information on two Soviet Air Force losses in East Germany (pers. comm., Jan-Feb 1996).

Finland: There were no serious bird-related accidents to Air Force aircraft in 1981-89 (Finnish AF 1990) or in 1990-95 (Col. M. Ahola, LCol. J. Hipeli and M. Tavinen, Flight Safety, Finnish AF, pers. comm., Dec 1994, May 1996).

France: Air Force records for 1975 to early 1996 show five aircraft lost to birdstrikes, all in the 1990s; details were provided by the French AF (Col. Louvion and LCol. Bouvet, pers. comm., Nov 1994, Apr 1996). Navy records for 1960 to early 1996 show the loss of two Aéronavale aircraft to birdstrikes; details were provided by CV de Lesquen, Flight Safety, French Navy (pers. comm., Feb 1996).

Greece: Air Force records for 1965-94 show two serious bird-related accidents; details were provided by LCol. K. Kalamatas, Flight Safety, Hellenic AF (pers. comm., Dec 1994).

Hungary: Records for 1960 to early 1996 show one known serious accident caused by a birdstrike; details were provided by LCol. A. Papp, Flight Safety, Hungarian Home Defence Forces (pers. comm., Mar 1996).

Israel: Dr. Y. Leshem, Tel Aviv Univ. (pers. comm., Oct 1989, Sep 1994, Jan 1996) sent details for 7 known Israeli AF losses to birdstrikes in 1972-95, supplementing limited published data on some of the accidents (Petreanu and Abbady 1988; Leshem 1994).

Italy: Air Force records for 1961-94 show two confirmed and one probable birdstrike losses; details were provided by Col. F. Draghi and LCol. Pani, Flight Safety, Italian AF, pers. comm., Dec 1994, June 1995).

Portugal: Air Force records for 1975-95 show two aircraft lost to birdstrikes; details were provided by Col. L.F. Palma de Figueiredo, Flight Safety, PortAF, pers. comm., Feb 1996).

Former USSR: Dr. V.E. Jacobi (pers. comm., Dec. 1994) provided details for seven definite losses of USSR military aircraft to birdstrikes during 1953-82. Dr. J. Becker sent data on two additional USSR losses in East Germany. The loss of a MiG-29 to a birdstrike at Paris in 1989 was widely reported (e.g. *Flight Intern.*, 22 July 1989:11).

Updated Data from Other Countries

Richardson (1994) listed sources of data for 7 European countries considered in the earlier compilation, and for Canadian and U.S. forces operating in Europe. The following additional or updated data have been obtained subsequently.

For four countries, no additional accidents have been attributed to birds beyond those listed in Richardson (1994): **Canada**, updated data from Maj. T.L. Manderson, Flight Safety, CAF (pers. comm., Jan 1996). **Denmark**, Maj. E.G. Nielsen, Flight Safety, Tactical Air Comm. Denmark (pers. comm., Jan 1996). **Netherlands**, Dr. L.S. Buurma, NethAF (pers. comm., Jan and Mar 1996). **Sweden**, Dr. T. Alerstam, Lund Univ. (pers. comm., Jan 1996).

Germany: Dr. J. Becker (pers. comm., Feb 1995, Jan 1996) provided > more details on the 22 West German Air Force and Navy losses listed in Richardson (1994), > details on a previously unlisted accident on 30 Oct 1970, and > confirmation that there had been no recent bird-related losses of military aircraft in Germany.

Norway: Air Force records back to 1956 confirm three losses to birdstrikes (LCol. K. Tunesvik, Flight Safety, NorwAF, pers. comm., Feb 1996). More details about two accidents listed in Richardson (1994) and another in 1995 were provided by LCol. Tunesvik and C.K. Aas, Zoological Museum Aviation Bird Office (pers. comm., Aug 1994, Feb 1996). A fatal F-16 loss on 5 July 1988, not confirmed as due to a birdstrike, is excluded.

Switzerland: Swiss AF records show no total loss of an aircraft other than a previously-listed 1974 accident, but a Hunter was damaged beyond repair in 1991. Details were provided by Col. W. Schafroth, Flight Safety, Swiss AF (pers. comm., Jan and Mar 1996). See also *Air Forces Monthly*, Mar 1996:58.

United Kingdom: Much additional information about U.K. losses to birdstrikes has become available to me since 1994, when I listed 15 losses of RAF aircraft since 1980 to birdstrikes or bird avoidance. Official data on these and other RAF losses since 1970 were supplied by the RAF Inspectorate of Flight Safety, IFS (S/L S.P. Bridger, pers. comm., Oct 1994; S/L J.G. Chapman, pers. comm., Feb-Mar 1996). Data on other RAF losses back to 1950 were compiled from many sources. Unofficial published accounts, including Mason (1986:219ff), Jackson (1989: 144ff), Oliver (1990) and most notably Dunn (1996), provided a provisional list. Most of that information was checked > against accident information cards held by the Air Historical Branch (*vide* Tim West, Lakenheath, U.K.) and/or > by correspondence with IFS. W/C D.R. Collier Webb, Directorate of Flying, Boscombe Down, supplied details for aircraft lost during test flying on 23 Oct 1953 and 24 July 1981 (pers. comm., Mar 1996).

The Royal Navy Flight Safety & Accident Investigation Centre (FSAIC) sent details for most RN losses to birdstrikes back to 1958 (Cdr R.P. Seymour, pers. comm., Jan-Feb 1996). The fatal RN Sea King accident off the Falklands on 19 May 1982 is excluded; the cause was "not positively determined". Other data came from Langley (1970), Oliver (1990), Dunn (1996), naval aviation historian R.C. Sturtivant (pers. comm., Mar 1996) for most RN losses, and W/C Collier Webb for the accident on 28 Oct 1958.

For the British Army, data on bird-related damage to several aircraft for years back to 1964 (Maj. N.D. Gibson, HQ Director Army Aviation, pers. comm., Mar 1996) were supplemented by R.J. Dunn (pers. comm.) and E. Myall (pers. comm.). Two helicopters lost to "bird avoidance" are included here, but there may have been other bird-related losses.

United States: The USAF BASH database and Naval Safety Center database show no recent USAF, USN or USMC losses to birdstrikes in Europe (W.B. Brown, NSC, pers. comm., Jan 1996; Lt. C. Atkins, BASH Team, pers. comm., Mar 1996). Other USAF and USMC losses in 1995 are outside the scope of this paper. The locations of two F-111E birdstrike accidents in 1975, listed in Richardson (1994) as "Europe?", are confirmed as England (T. West, pers. comm.). Locations of 15 USAF losses in 1966-72 remain unknown to me; some may have been in Europe. The one U.S. Army aircraft lost to a birdstrike during 1983-87 (GAO 1989:8) was presumably an RV-1D Mohawk lost in Germany (*Flight Intern.*, 6 Oct 1984:848). No other U.S. Army data have been obtained.

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere.
See Table 1 for services and years covered. Blanks denote "unknown". For explanatory notes, see last page of Appendix 2.

Date Y M D	Location Where Struck	Ser- vice	Aircraft		Acc. # Persons		Flight		Type of Bird(s) Struck	Altitude AGL (feet)	Speed (knots)		Parts Hit W E		Aircraft Regis- tration
			Type	Sub- type	Cate- gory	Cate- gory	A	E			Kil- led	Time			
Belgian AF															
770926	W. Germ. Rheinbach	AF	Mirage 5	BA	FA 1	wo	1	1	0	CrL D	Pigeons, Wood	600	420	P	BA-34
800512	W. Germ. Neunkirchen	AF	TF-104	G	FA 1	wo	2	2	3gm	CrL D	prob. birdstrike	500	450	F	
881117	Belgium Kleine Brogel	AF	F-16	A	FA 1	wo	1	1	0	Cl D	Pigeons, Wood	400	200	F	FA-62?
890718	Belgium Liege/Bierset	AF	Mirage 5	BA	FA 1	wo	1	0	0	Ap D	Pigeons, Wood	300	195	F	BA-45
Canadian Forces (Europe only)															
641027	France Troyes	AF	CF-104		FA 1	wo	1	1	0	CrH D	corvid?	2000	200	- F	12849
650916	W. Germ. Zweibrucken	AF	CF-104		FA 1	wo	1	1	0	Ap D	unkn.	3000	300	- F	12853
650916	France near Boan	AF	CF-104	D.2	FA 1	wo	2	2	0	CrL D	unkn.	7-1000	410	- F	12659
660321	W. Germ. Eschau	AF	CF-104		FA 1	wo	1	1	0	CrL D	unkn.	1000	410	- F	12820
670718	Denmark Kertagat	AF	CF-104		FA 1	wo	1	1	0	CrL D	gull?	300	420	- F N	12734
690425	France Niefern	AF	CF-104		FA 1	wo	1	1	0	CrL D	large	800	420	P -	12854
780818	W. Germ. Oberthal	AF	CF-104		FA 1	wo	1	1	0	CrL D	unkn.	800	420	- F	829
810316	W. Germ. near Leipheim	AF	CF-104	D.2	FA 1	wo	2	2	0	CrL D	buzzard	500	510	- F	665
Czech & Slovak AF															
6_	Czechoslovakia?	AF	MiG-15		FA 1	wo?	1?	1			unkn.			P -	
850510	Czechoslovakia	AF	MiG-21	MF	FA 1	wo	1	0	0	TO D	gulls	5	135	- F	4306
French AF & Navy															
900517	France Fonties d'Aude	AF	Mir. 2000	N	FA 1	wo	2	2	0	CrL D	gull	500	400	S F	321
900726	Chad Doun-Doum	AF	Mir. F1	CR	FA 1	wo	1	1	0	CrL D	unkn.	300	475	- F A	633
910314	France Alincourt	AF	Jaguar	E	FA 2	wo	1	1	0	CrL D	>1	500	400	S I	E17
920613	Chad N'Djamena	AF	Jaguar	A	FA 2	wo	1	1	0	Cl D	Egrets, White	50	185	F	
960119	France Istres AFB	AF	Mir. 2000	N	FA 1	dbt?	2	2	0	Ap D	Gull, Yel.-leg.	110	135	I	
920204	France off Penmarch	Na	S.Etendard		FA 1	wo	1	1	0	CrL D	Gannet, North.	100	480	S F	
960126	France off Casals	Na	S.Etendard		FA 1	wo	1	1	0	CrL D	Gull, Yel.-leg.	500	450	P -	
Germany (East) AF															
670807	-E. Germ. Neuhaardenberg	AF	MiG-21	SPS	FA 1	wo	1	1	0	CrH D	unkn.	>3300	>324	- F	
67-74	E. Germ.?	AF	MiG-21		FA 1	wo	1	1	0		unkn.				
720320	E. Germ. Neubrandenburg	AF	MiG-21	PFM	FA 1	wo	1	0	0	De D	>1	1000	324	F F	

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere (cont'd)
See Table 1 for services and years covered. Blanks denote "unknown". For explanatory notes, see last page of Appendix 2.

Date Y-M-D	Location Where Struck	Ser- vice	Aircraft		Acc. # Persons			Flight Phase/	Time	Bird(s) Struck	Altitude AGL (feet)	Parts Hit			Aircraft Regis- tration
			Type	Sub- type	Cate- gory	Date- gory	A E Kil b. i. led					W E	s n	Other	
740417	E. Germ. Drewitz-Cottbus	AF	MiG-21	US	FA 1	wo	2 2 0	Cl	D	unkn.	<3300	<324	-	F	
750428	E. Germ. Neuhausen	AF	Mi-8		H 2	wo	3 na	Hov	T	unkn.	660	0	-	F	
761002	E. Germ. Neubrandenburg	AF	MiG-21	PFM	FA 1	wo	1 0 1	Cl	D	unkn.	165	216	-	F	
770817	E. Germ. Neubrandenburg	AF	MiG-21	MF	FA 1	wo	1 1 0	Ap	D	unkn.	330	190	-	F	
820622	E. Germ. Drewitz-Cottbus	AF	MiG-23	BN	FA 1	obr	1 0 0	CrH	D	ducks	2000	485	I	F	
880506	E. Germ. Neubrandenburg	AF	MiG-21	PFM	FA 1	wo	1 1 1	Cl	T	ducks	65	216	F		
880805	E. Germ. Gorliz	AF	MiG-21	US	FA 1	wo	2 2 0	CrH	D	crows	1640	270	F		
Germany (West) AF & Navy															
620411	W. Germ. Augsburg	AF	F-84		FA 1	wo	1 1 0	CrL	D	buzzard	500	<450	P	-	
640805	W. Germ. Furstentfeldbruck	AF	G-91	R/3	FA 1	wo	1 1 0	Cl	D	pigeons	100	160	F		
670516	W. Germ. Elbe estuary	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	gulls	500	450	P		
691130	W. Germ. Schwabish Hall	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	duck?	800	450	-	F	
701030	W. Germ. Holzkirchen	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	crow	800	450	-	F	
710907	W. Germ. Eiderstedt Pen.	AF	G-91	R/3	FA 1	wo	1 1 0	CrH	D	gulls	1200	<450	P		
720801	W. Germ. Bremen-N	AF	G-91	R/3	FA 1	wo	1 1 0	CrL	D	buzzard	500	360	-	F	
760809	W. Germ. Drake/Weer	AF	G-91	R/3	FA 1	wo	1 1 0	CrL	D	buzzard	500	360	-	F	
771007	W. Germ. Bad Schwalbach	AF	TF-104	G	FA 1	wo	2 2 0	CrL	D	pigeons	800	450	F		
781010	France Nancy-W	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	crows	800	420	F		
810706	W. Germ. Niederstetten	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	buzzard	600	450	-	F	
810817	France Ollieres	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	buzzard?	500	450	-	F	
820421	Italy Fraeca Ran.	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	unkn.	450	450	-	F	
820804	W. Germ. Hohenfels Ran.	AF	F-104	G	FA 1	wo	1 1 0	CrL	D	unkn.	400	400	-	F	
670428	W. Germ. Bad Neinberg	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	duck?	1000	200	-	F	
760315	W. Germ. Eiderstedt Pen.	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	Goose, Barnacle	900	420	-	F	
770419	Denmark Moen	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	gulls	300	450	P	F	
780816	W. Germ. Heiligoland	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	gulls	500	400	F		
780919	Denmark Anholt	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	gull	200	450	-	F	
781207	W. Germ. Schleswig	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	ducks	800	480	F		
790417	W. Germ. Eiderstedt Pen.	Na	F-104	G	FA 1	wo	1 1 0	CrL	D	Sheilduck	800	440	-	F	

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere (cont'd)
See Table 1 for services and years covered. Blanks denote 'unknown'. For explanatory notes, see last page of Appendix 2.

Date Y M D	Location Where Struck	Ser- vice	Aircraft		Acc. # Persons			Flight		Type of Bird(s) Struck	Altitude (feet)	Parts Hit			Aircraft Regis- tration
			Type	Sub- type	Cate- gory	A	E	Kil- led	Phase/ Time			WE	s	n	
810826	Denmark Oksebol Ran.	Na	F-104	G	FA 1	wo	1	1	0	CrL D	150	500	F		
850208	Denmark Bornholm	Na	F-104	G	FA 1	wo	1	1	0	CrL D	350	450	- F		
<u>Hellenic (Greek) AF</u>															
750627	Greece central	AF	F-84	F	FA 1	wo	1	1	0	CrL D	1000	320	P I		52-6443
921007	Greece Tenagra	AF	Mir. 2000		FA 1	wo	1	1	0	Cl D	100	240	F I		
<u>Hungarian Defence Forces</u>															
841016	Hungary Tasszar	AF	MG-21	U	FA 1	wo	2	2	1	Ap D	850	205	- F		
<u>Israel AF</u>															
730219	Israel Judean Des.	AF	Nesher		FA 1	wo	1	1	0	CrL D	300	360	- F		
741028	Israel Hulah Valley	AF	A-4		FA 1	wo	1	0	1	CrL D	400	420	P -		
790115	Israel N. Sinai	AF	A-4		FA 1	wo	1	1	0	CrL D	500	500	- F		
791007	Israel Izrael Val.	AF	Kfir		FA 1	wo	1	1	0	Ap D	900	220	- F		
830504	Israel Judean Des.	AF	A-4		FA 1	wo	1	1	0	CrL D	300	420	P -		
881218	Israel Judean Des.	AF	F-16		FA 1	wo	1	1	0	CrL D	300	420	- F		016
950810	Israel Negav	AF	F-15	B/D	FA 2	wo	2	0	2	CrL D	300	550	- F F		
<u>Italian AF</u>															
890620	Italy near Ghedi	AF	Tornado	IDS	FA 2	wo	2	2	0	CrL D	800	225	F		7077
891107	Italy near Lecce	AF	G-91	Y	FA 2	wo	1	1	0	CrL D	900	400	- F		6464
940801	Italy Poggioraini	AF	MB339	A	T 1	wo	2	2	0	CrH D	2500	250	- F I		54464
<u>Netherlands AF</u>															
550220	Netherl. Soesterberg	AF	Hunter	Mk.6	FA 1	wo	1	1	0	CrI?	<8000		- F		
550915	W. Germ. Gronau	AF	Hunter	Mk.6	FA 1	wo	1	1	0	CrH N	2500		- F		
600707	Netherl. Leeuwarden	AF	Hunter	Mk.4	FA 1	wo	1	0	0	TO N	0	[low]	F		
610620	Netherl. Eindhoven	AF	F-84	F	FA 1	wo	1	0	0	TO	0	[low]			
640729	Netherl. Soesterberg	AF	Hunter	Mk.6	FA 1	wo	1	0	0	CrI	low		- I		
750711	W. Germ. Wiesbaden	AF	NF-5		FA 2	wo	1	1	1	TO	0	[low]	- F		
790301	W. Germ. Steinfeld	AF	F-104		FA 1	wo	1	1	0	CrH	>2500		- F		D-8280
811201	W. Germ. Jever	AF	F-104	G	FA 1	wo	1	0	0	CrL	4-500		- -	WI	D-81337

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere (cont'd)
 See Table 1 for services and years covered. Blanks denote 'unknown'. For explanatory notes, see last page of Appendix 2.

Date Y M D	Location Where Struck	Service	Aircraft		Acc. # Persons			Flight		Type of Bird(s) Struck	Altitude		Parts Hit		Aircraft Regis- tration
			Type	Sub- type	Cate- gory	A	E	Kil- led	Time		AGL (feet)	Speed (knots)	W	E	
531004	Nether.	AF	F-16	A	FA 1	wo	1	0	1	TO	0		-	F	J-252
900504	Nether.	AF	NF-5	A	FA 2	dbr	1	1	0	T&G	low		-	I	K-3044
Norwegian AF															
710809	Norway	AF	F-5	A	FA 2	wo	1	0	1	CrL D	500	3-400	P	-	67-14894
810802	Norway	AF	F-16	A	FA 1	wo	1	1	0	CrH D	2500	450	P	-	78-0280
950504	Norway	AF	F-16	B	FA 1	wo	2	2	0	Cl D	1100	320	-	F	78-0307
Portuguese AF															
980309	Portug.	AF	A-7	P	FA 1	wo	1	1	0	CrL D	350	360	-	F	5516
920429	Portug.	AF	A-7	P	FA 1	wo	1	0	1	CrH D	2-4.5k	3-450	S	-	5523
Swedish AF															
670627	Sweden	AF	Lansen	A	FA 1	wo	2	0	0	Cl	20	TO	-	F	
690313	Sweden	AF	Lansen	A	FA 1	wo	2	2	0	CrL	100	430	-	F	
700531	Sweden	AF	Lansen	A	FA 1	wo	2	2	2	Cl	35	175	F		
730416	Sweden	AF	Dreken	S	FA 1	wo	1	1	0	CrL	165	595			35933 ?
731017	Sweden	AF	Dreken	J	FA 1	wo	1	0	0	TO	0	165	S		35379 ?
741005	Sweden	AF	Lansen	A	FA 1	wo	1	1	1	CrL	165	430	-	F	
760830	Sweden	AF	Lansen	S	FA 1	wo	2	2	0	Cl	TO	160	-	F	
770321	Sweden	AF	Viggen	AJ	FA 1	wo	1	0	1	CrL	~85	595	S	-	37032 ?
770901	Sweden	AF	Lansen	A	FA 1	wo	1	0	0	TO	0	110			
Swiss AF															
741023	Switzerl.	AF	Mirage III	S	FA 1	wo	1	1	0	Cl D	50	190	S	F	
910812	Switzerl.	AF	Hunter	F.58	FA 1	dbr	1	0	0	De D	<1650	405	-	- W I	J4028
United Kingdom (AF, Navy, Army)															
530730	France	AF	Vampire		FA 1	wo?		0?	0?	CrL?	low		I	W F	
531023	UK/En.	AF	Canberra	B.2	B 2	wo	2	0?	2	Cl	v. low	[low]	F	U	WF892
550226	UK/En.	AF	Metac		FA 2	wo				CrL?	low				VZ286
560127	UK/Sc.	AF	Vampire	FB.5	FA 1	dbr	1	0	0	CrL?	low				WG850
560202	HongKo.	AF	Vampire	FB.9	FA 1	dbr	1	0	0	cl.					
561003	UK/Sc.	AF	Hunter	F.4	FA 1	wo	1			TO?	TO?	[low]	-	I	XE705

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere (cont'd)
See Table 1 for services and years covered. Blanks denote "unknown". For explanatory notes, see last page of Appendix 2.

Date Y M D	Location	Where Struck	Ser- vice	Aircraft			Acc. # Persons			Flight Phase/	Type of Bird(s) Struck	Altitude AGL Speed (feet) (knots)	Parts Hit		Aircraft Regis- tration
				Type	Sub- type	Date- gory	Cate- gory	A	E	Kil- led			W	E	
561101	UK/En.	Norfolk?	AF	Hunter	F.1	FA 1	dbr	1	0	0	CrL?	low			WW600
570410	UK/Wa.	Anglesey?	AF	Vampire	T.11	FA 1	dbr	2?	0?	0?	CrL?	500	-	W	XH319
570522	UK/En.	Devon?	AF	Hunter	F.1	FA 1	dbr	1	0	0	unkn.				WT681
570628	UK/Sc.	Leuchars	AF	Hunter	F.4	FA 1	wo	1	0	0	dir.				XF997
571114	UK/Sc.	Kinloss	AF	Hunter	F.4	FA 1	dbr	1	0	0	CrL	1800	-		WT719
580212	UK/En.	Linton on Ouse	AF	Vampire	FB.5	FA 1	dbr	1	0	0	"TO"	"TO"			WA257
591110	UK/En.	Lincs.?	AF	Hunter	F.4	FA 1	dbr	1	0	0	CrL?	300			XF953
591118	Aden	Khotmekar	AF	Venom	FB.5	FA 1	wo	1			unkn.				WR531
600329	Aden		AF	Hunter	FGA.9	FA 1	dbr	1	0	0	CrL	250	400		XF424
600507	UK/En.	Somerset	AF	Vampire	FB.5	FA 1	wo	1			CrL?	100			WA445
601109	W. Germ.	near Jever?	AF	Hunter	F.6	FA 1	dbr	1	0	0	CrL	250	390		XE590
610316	W. Germ.	near Jever?	AF	Swift	FR.5	FA 1	dbr	1	0	0	unkn.		-	-	WK295
620904	UK/En.	Swindon	AF	Vampire	T.11	FA 1	wo	2?	0?	0?	TO	0	100		XD448
640817	HongKo.	Kai Tak	AF	Canberra B.15	B.15	B.2	wo	2?	2?	0	TO D	TO			WH958
640930	UK/En.	Jedburgh	AF	Jet Prov.	T.4	T.1	wo	2?	2?	0	CrL D	300	190		XF684
650714	Neither.	Roermond	AF	Canberra B.16	B.16	B.2	wo	2?	2?	0?	OvSh	300	130	-	WT324
660727	UK/En.	N. Frodingham	AF	Jet Prov.	T.4	T.1	wo	2?	2?	0?	CrL D	250	180		XP625
681120	UK/En.	Watton	AF	Canberra T.17	T.17	B.2	dbr				TO D	TO	105	-	WJ988
710225	W. Germ.	Dieforth	AF	Canberra PR.7	PR.7	B.2	dbr				CrL	100	300	S - N	WT523
710629	UK/En.	Dieforth	AF	Jet Prov.	T.3	T.1	wo	2	2	0	Ap D	300	110	-	XN558
720426	UK/En.	The Wash	AF	Harrier	GR.1	FA 1	wo	1	1	0	CrL D	500		F	XV749
720504	Denmark?		AF	Harrier	GR.1	FA 1	wo	1	1	0	CrL D	400	360	-	XV794
720627	W. Germ.	Wesel	AF	Harrier	GR.1A	FA 1	wo	1	1	0	CrL D	700	420	-	XV780
730709	W. Germ.	Wildenrath	AF	Harrier	GR.3	FA 1	wo	1	1	0	CrL D	20	135	F	XV791
731012	UK/En.	Leeming	AF	Gnat	T.1	T.1	"dbr"	2	0	0	CrL D	250	360	I N I	XP637
740107	UK/En.	near Mansfield	AF	Jet Prov.	T.4	T.1	dbr	1+	0?	0	CrL D	300	230	S - N	XP548
740516	W. Germ.	Wildenrath	AF	Harrier	GR.3	FA 1	wo	1	1	0	CrL	20	20	-	XV800
760928	UK/En.	Marham	AF	Victor	K.2	K.4	wo	0	0	0	TO D	0	145	-	NWF
790325	W. Germ.	near Sudbourn	AF	Jaguar	T.2	FA 2	wo	2	2	0	CrL D	250	240	P F	XX147
800312	UK/Wa.	Lampeter	AF	Harrier	GR.3	FA 1	wo	1	1	0	CrL D	200	420	S F	XW765
800731	UK/En.	Elvington	AF	Jet Prov.	T.3A	T.1	wo	1	1	0	CrL D	400	140	F	XN590

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere (cont'd)

See Table 1 for services and years covered. Blanks denote "unknown". For explanatory notes, see last page of Appendix 2.

See Table 1 for services and years covered. Blanks indicate unknown. For explanatory notes, see page 2.

Date Y M D	Location Where Struck	Ser- vice	Aircraft		Sub- type	Cate- gory	Acco. Cate- gory	# Persons			Flight Phase/	Time	Type of Bird(s) Struck	Altitude AGL (feet)	Speed (knots)	Parts Hit		Aircraft Regis- tration
			Type	A				E	Kil-	W						Other		
201117	UK/Sc. Kinloss	AF	Nimrod	MR.2	P 4	wo	20	na	2	Cl	T	20	138	S	F	NWTF	XV256	
810601	UK/Sc. Forfar	AF	Jaguar	T.2	FA 2	wo	2	2	0	CrL	D	300	450	P	F		XX828	
810724	UK/En. Bristol Channel	AF	Jaguar	T.2	FA 2	wo	2	2	1	CrL	D	500	450	P	F		XX916	
821020	UK/En. Chivenor	AF	Hawk	T.1	T 1	wo	1	1	0	Ap	N	350	130	-	F		XX300	
830919	UK/Sc. Lossiemouth	AF	Jaguar	GR.1	FA 2	wo	1	1	0	Ap	D	100	[low]	F	U		XX114	
831121	UK/En. Settle	AF	Jet Prov.	T.3A	T 1	wo	2	2	0	CrL	D	low		F	U		XM453	
840815	UK/En. Cranwall	AF	Jet Prov.	T.3A	T 1	dbr	2	0	0	Cl		25	low	-	-		XM473	
841107	UK/Wa. Mona	AF	Hawk	T.1	T 1	wo	2	2	0	T&G	D	100	140	-	F	F	XX180	
841129	S. Allen, Stanley, Falkl	AF	Harrier	GR.3	FA 1	wo	1	1	0	CrL	D	250	480	S	-	N	XZ992	
860929	UK/En. near Thirsk	AF	Bulldog	T.1	pT 1	wo	2	na	0	Cl		~250	[low]	-	-		XX514	
890814	UK/En. Abingdon	AF	Tomado	GR.1	FA 2	wo	2	2	0	Cl	T	150	170	F	-	U	ZD710	
910925	UK/En. Great Driffield	AF	Harrier	T.4A	FA 1	wo	2	2	0	CrL	D	250		P	-	U	XZ147	
930628	UK/En. Coningsby	AF	Harrier	GR.7	FA 1	wo	1	1	0	CrL	D	low		-	-	W	ZD430	
580428	UK/Sc. Morayshire?	Na	SeaHawk	FB.3	FA 1	dbr	1	0	0		unkn.			-	-	I	WM981	
581028	Nigeria ENE of Kano	Na	SeaVixen	FAW.1	FA 2	wo	2	2	0	CrL	D	100	450	-	-	I	XJ479	
621115	UK/Sc. Firth of Tay	Na	Scimitar	F.1	FA 2	wo	1	1	0	CrL		400	420	-	-	I	XD265	
841201	UK/Sc. Ft. William	Na	SeaHarl.	FRS.1	FA 1	wo	1	1	0	CrL	D	500	420	-	F		XZ458	
851129*	UK/En. English Channel	Na	Hunter	GA.11	FA 1	dbr	1	0	0	CrL		250	450	-	-	I	VW267	
871015	N.Ireland off NW Ireland	Na	SeaHarl.	FRS.1	FA 1	wo	1	1	0	CrL	D	250	480	-	F		ZA190	
860429	UK/En. Catterick	Ar	Gezelle	AH.1	H 1	dbr	4	na	0		D	125	[low]	-	-	-	XZ336	
911114	N.Ireland Gortin Gap	Ar	Lynx	AH.7	H 2	wo	11	na	1	CrL	D	low	[low]	-	-	-	XZ186	
United States (Europe only)																		
750305	UK/En. Shapell	AF	F-111	E	FA 2	wo	2	2	0	CrL		1000		?	?	M	68-0081	
751105	UK/En. Boston	AF	F-111	E	FA 2	wo	2	2	0	CrL	D	400	480	S	-		68-0060	
801113	Spain Bardenas Ran.	AF	F-4	E	FA 2	wo	2	1+	1	CrH	D	3500	450	P	-		68-0475?	
840809	UK/Sc. Tain Ran.	AF	F-111	E	FA 2	wo	2	2	0	CrL	D	200	530	-	-	I	N	68-0019
861008	Spain Bardenas Ran.	AF	F-16	A	FA 1	wo	1	1	0	CrL	D	low	hi	-	-	F	I	82-0999?
870520	Spain Bardenas-Reales	AF	F-4	E	FA 2	wo	2	0	2	CrH	D	2000		P	-		72-0160?	
840908*	W. Germ. Wiesbaden	Ar	RV-1	D	O 2	wo	2	2	0	Cl		[low]	[low]	F	U			64-14238?

APPENDIX 2: Serious military aircraft accidents attributable to birds in Europe and Israel, and for European aircraft elsewhere (cont'd)
See Table 1 for services and years covered. Blank denotes 'unknown'. For explanatory notes, see last page of Appendix 2.

Date Y M D	Location Where Struck	Ser- vice	Aircraft		Acc. # Persons		Flight Phase/ Time	Type of Bird(s) Struck	Altitude AGL (feet)	Parts Hit			Aircraft Regis- tration	
			Type	Sub- type	Cate- gory	Cate- gory				A	E	Kil- led		Speed (knots)
Former USSR (very incomplete)														
?	Asia	Lake Chany	AF	MiG-17	FA 1	wo	1	0?	1	CrL?				
5304	Ukraine	Charnovtsy	AF	Il-28	B 2	wo				swan			low	
60summer	Ukraine	Odessa (Arciz)	AF	Il-28	B 2	wo		1+		cranes			650	
6604	Estonia	Tallinn	AF	MiG-17	FA 1	wo	1	0?	1	buftard				
6804	USSR?	Baltic region	AF	MiG-21	FA 1	wo	1	1	0?	Crano, Eur.			2600	
701007	E. Germ.	Alleedt	AF	?	FA	wo	1	1	0	stork			985	
8003	Ukraine	Kchar'kov Oblast	AF	MiG-21	FA 1	wo				Lapwings			1000	
820710	Russia	Borisoglebsk	AF	MiG-21	FA 1	wo	1	1	0	Ap			330	
890608	France	Paris LeBourget	'AF'	MiG-29	FA 2	wo	1	1	0	D			395	
911119	E. Germ.	Juterbog	AF	MiG-23	FA 1	wo	2	2	0	unkn.			525	
					UM	wo				Ap			500	
										goose			215	

* Unofficial report of uncertain accuracy.

Aircraft Categories: B=Bomber; FA=Fighter/Attack; H=Helicopter; K=Tanker; O=Other; P=Patrol; PT=piston-engined Trainer; T=Trainer.

Following digit shows number of engines.

Accident Categories: wo = aircraft written off (destroyed); dbr = damaged beyond (economical) repair.

Persons: Ab. = Number of aircraft aboard; Ej. = # who ejected; Killed = # aircraft killed or (in one Belgian AF case) # killed on ground.

Flight Phase: TO = takeoff; Cl = Climb; CrL = Cruise at low-level (up to 1000 ft AGL); CrH = Cruise at high altitude (above 1000 ft AGL)

Ap = Approach; La = Land; T&G = Touch and Go landing; OvSh = Overshoot; Dam = Demonstration flight; cir. = in circuit; Hov = Hover.

Time: D = Day; N = Night; T = Twilight.

Parts Hit: Wa = Windscreen; - = not struck; S = struck, not reported as penetrated; P = penetrated.

En = Engine(s); - = no ingestion; I = ingestion, damage limited or uncertain; F = engine failure after ingestion.

Other parts reported struck: A = Probe; F = Fuelage; I = Intake; L = Landing gear; M = Multiple parts; N = Nose or radome; T = Tail;

U = Unknown other parts; W = Wing(s).

APPENDIX 31

An Aviation Insurer's View of the Situation of Bird Strike Prevention in Germany

**AN AVIATION INSURER'S VIEW
OF THE SITUATION OF BIRD STRIKE PREVENTION IN GERMANY**

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Summary

Following an introduction regarding the background of the author, the paper contains brief details regarding German aviation law applicable to the bird strike problem and possible consequences arising from civil law. The next chapter deals with the Lufthansa reporting and statistical system to comply with legal requirements regarding bird strikes. Developments of the bird strike situation in Germany - also taking into account the cost of damages - are explained by extracts from statistics. Description of changes that were achieved by a major German airport by changing its bird strike prevention activities. Conclusions and recommendations based on our experience.

(This paper is the work of an individual author and may not reflect the full and final views of Delvag Luftfahrtversicherungs AG)

Key words: airlines, aviation law, civil statistics, cost of damages, German law, insurers

An Aviation Insurer's View
of the Situation of Bird Strike Prevention in Germany

1. Background Information regarding Delvag and Lufthansa

Delvag is an insurance company owned by Lufthansa German Airlines. Due to this special situation we are not only acting as an insurer of the different airlines belonging to the Lufthansa Group - like Condor, Lufthansa Cargo, Lufthansa CityLine - but are, when necessary, also acting as the insurance department of Lufthansa.

Due to this role we not only focus on major damages - hull deductibles start at US \$ 500.000 for a Boeing 737-200 and go up to US \$ 1.000.000 for large aircraft like the Boeing 747.

We also must keep an eye on smaller incidents either as hull-deductible insurer or as the insurance department for those damages which are still too small to be covered by hull deductible insurance.

The role of the insurance department also implies the need to watch the development of costs that are not covered by any insurance (cost of rerouting or schedule changes following occurrence of damage, cost for passenger accommodation, etc.).

The watchdog function is not limited to cost monitoring. It also includes surveillance of the conditions which lead to the noticed facts.

We therefore have installed a detailed reporting system and gather facts concerning changes occurring at and in the vicinity of airports. We are also keeping an eye on legal developments.

Since Lufthansa's home base is located in Germany and aircraft of Lufthansa and its subsidiaries perform more than fifty percent of the commercial aircraft movements in this country, this article focuses on the situation in Germany. We think that our knowledge regarding the legal system in Germany and developments which can be proven by our statistical system might be of interest to others.

2. Bird Strike Prevention and the Law

2.1. International Law

International law which results from the ICAO convention, a multilateral contract signed by nearly all countries, stipulates either to follow „the standards and recommended practices“ or to announce any deviations resulting from national law.

Regarding our topic here, the relevant information is laid down in Annex 14, paragraph 9.5, in the "Airport Services Manual" (Doc 9137) Part 3, and in the "Manual on the ICAO Bird Strike Information System (IBIS)" (Doc 9332).

Although these documents contain important information and are also applicable to the situation in Germany, because Germany acceded to the convention, I do not intend to comment on these as I think most of us know these facts and it would only waste our time to recapitulate them again.

2.2. German Law

2.2.1. The law regarding aviation

According to article 73 paragraph 6 of the German Basic Law - the so called Grundgesetz (GG) - aviation is governed by federal law.

The individual states have no legislative authority of their own in this respect unless they were empowered by federal act pursuant to article 71 GG.

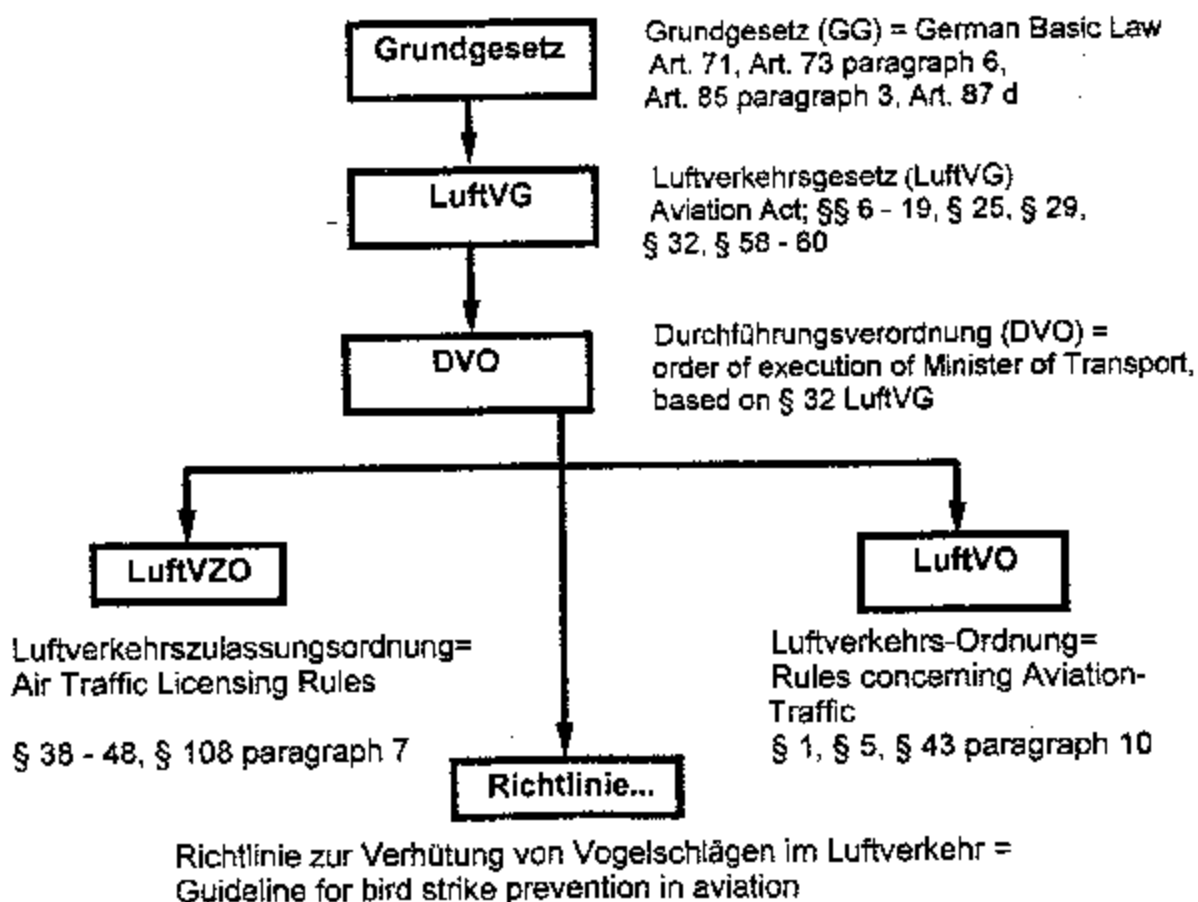
Up to now this has not been done.

According to article 87 d of the Basic Law aviation administration is performed as federal administration. It is possible to transfer administrative tasks to the states by using the construction of federal-mandatory-administration.

The basis for German aviation law is the aviation act - Luftverkehrsgesetz (LuftVG). It contains the most important regulations and powers for the Federal Minister of Transport (Bundesminister für Verkehr) to issue orders, after having obtained the consent of the Bundesrat (the second chamber of parliament where delegates are representatives of the different German states).

Table 1 shows the structure of the different acts and regulations in this field

Table 1: Sketch regarding system of German Aviation Law



2.2.2. German law concerning airports

Airports are one of the basic elements of a modern traffic infrastructure. Due to their importance the legal system in Germany has set up regulations regarding planning requirements, size and sites where an airport is permitted to be erected, as well as security aspects in view of location and operation of an airport.

The basic regulations are laid down in §§ 6 to 19 of the Luftverkehrsgesetz (LuftVG).

For safety reasons § 25 LuftVG stipulates that any take-off or landing outside an approved airport - except in emergencies - is only allowed in case of consent of the owner of the ground and the appropriate aviation authority has granted permission.

Any landings outside the designated areas of an airport or outside the regular operating times of the airport are only allowed upon consent of the airport operator and the authorities gave a permit.

In fact these regulations force nearly everyone to make use of an appropriate airport.

On the other hand, the law (§ 29 LuftVG) defines a clear responsibility of the authorities for safety of aviation. Authorities are allowed to transfer these duties to third parties.

The Luftverkehrszulassungsordnung (LuftVZO) defines in §§ 40 to 44 the procedures and requirements that are necessary to obtain permission to operate an airport. Operation of an airport requires prior consent of the authority which has to carry out a licensing check process.

LuftVZO defines in §§ 45 and 46 the duties of the airport operator.

The most important obligation is to keep the airport in safe condition and to report events that have considerable influence on airport operations without undue delay to the authorities.

To make it clear to all responsible people in the German aviation industry, the German Minister of Transport issued a guideline regarding procedures in respect of the bird strike hazard.

This guideline - issued on 13 February 1974 - is binding for airport operators as well as for aviation authorities. The original wording and a translation are attached.

According § 47 LuftVZO, the authority has the right to check the conditions of the airport and - in case the requirements for an operation permit are not fulfilled, and not only temporarily - theoretically has the right to revoke the operation permit (§ 48 LuftVZO). More practicable are the contents of § 108, paragraph 7 a) of the LuftVZO. It makes clear that non-compliance with § 45 LuftVZO may be fined pursuant to § 58 LuftVG.

The most powerful tools to force people to comply with the rules are laid down in §§ 58 and 59 of the LuftVG, where different penalties are listed in respect of several offences.

2.2.3. The law concerning airlines and aircraft operators

The regulations applicable to aircraft operations cover a wide area as the legal system deals with nearly every possible situation and sets up respective rules.

As it seems impossible to cover all aspects in this article I would like to concentrate on the main aspects regarding bird strikes.

The LuftVO - the law containing „traffic rules of aviation“ - stipulates in § 2.1 that any aircraft must be operated by a pilot.

The pilot has to ensure compliance with any rule of the relevant orders, which is laid down in § 3.2 LuftVO.

Due to this the pilot is responsible for reporting any disturbance or abnormality that occurs during operation of the aircraft (§ 5.1 LuftVO). The reporting of a bird strike is based on this rule.

To enforce compliance of this reporting obligation, § 43, 10 LuftVO stipulates that non-compliance with this obligation shall be subject to sanctions pursuant to § 58 paragraph 1 no. 10 of the LuftVG.

2.2.4. The law of torts

Any individual who suffers a loss or damages looks for third parties to either share the monetary damage or providing compensation for it.

The same reaction pattern applies to airlines or aviation insurers.

When a bird strike occurs and results in damage to an aircraft, we are talking about a case of hull damage. To avoid dealing with minor claims the insurance industry has set up a system of deductibles. Thus a lot of damages are not transferred to the insurers but are kept in the books of the aircraft owner.

The German Civil Code (Bürgerliches Gesetzbuch, BGB) contains in § 823 rules which cause a tort-feasor to indemnify a third party for damage suffered by the tort-feasor's negligent or wilful wrongdoing.

In general - pursuant to § 823.1 BGB - the claimant has to prove the cause of damage, the responsibility of the party he is claiming from, and that the damages he is claiming are related to or were solely caused by the alleged wrongdoing.

In respect of § 823.2 BGB the claimant has to prove the violation of a so called "obligation to protect" and that his damages were caused by circumstances which, had the protectionlaw been obeyed, would not have happened.

The proven violation of a protectionlaw changes - contrary to the general rules in German jurisdiction - the burden of proof to the advantage of the claimant (prima-facie evidence). To avoid being liable for claimed damages, the accused party has to prove that the violation of the protectionlaw had no influence on the occurrence of the damage.

The contents of §§ 29, 45 and 46 LuftVZO and the "Guideline Concerning Bird Strike Prevention" of the German Minister of Transport must be considered to be "protectionlaw" in the meaning of § 823.2 BGB.

3. Bird strike statistics

3.1. Reporting and statistical system in Germany

Due to the requirement of § 5 LuftVO, written reports regarding bird strike incidents have to be submitted to the Federal Aviation Office (Luftfahrtbundesamt - abbreviation = LBA).

Based on these reports and on traffic reports stemming from the airports, the LBA is able to prepare bird strike statistics.

As the different airlines belonging to the Lufthansa Group represent the majority of reporting companies in Germany (in respect of incidents reported) Lufthansa and the LBA have agreed on some changes - as is permitted by § 5 paragraph 1, last sentence of the LuftVO - in the reporting system.

Instead of directly submitting the individual reports prepared by pilots to the LBA, Lufthansa set up an organisation which collects the data and submits the collected data by copy of a data file to the LBA.

LBA adds data concerning bird strikes received from other airlines or private aircraft operators to the data received from Lufthansa and by doing this receives the complete statistical information concerning bird strikes occurring in Germany.

Due to the fact that the bird strike statistics of the Lufthansa Group are based on more than fifty percent of the total aircraft movements at the major German airports, the findings regarding the rate of bird strikes and the rate of bird strike related damages seem to be realistic for the situation at these airports. To give feedback to the airport personnel in charge of bird strike prevention regarding the effective value of their activities, our statistics are not only kept a company secret or given to government authorities but are also distributed to the airports and the German Bird Strike Prevention Committee.

Reports to international database systems (like IBIS) concerning the bird strike situation in Germany are released by the LBA.

3.2. Lufthansa's reporting and statistical system

During the last years the Lufthansa statistical system has been subject to continuous improvement. The present situation is depicted in Table 2.

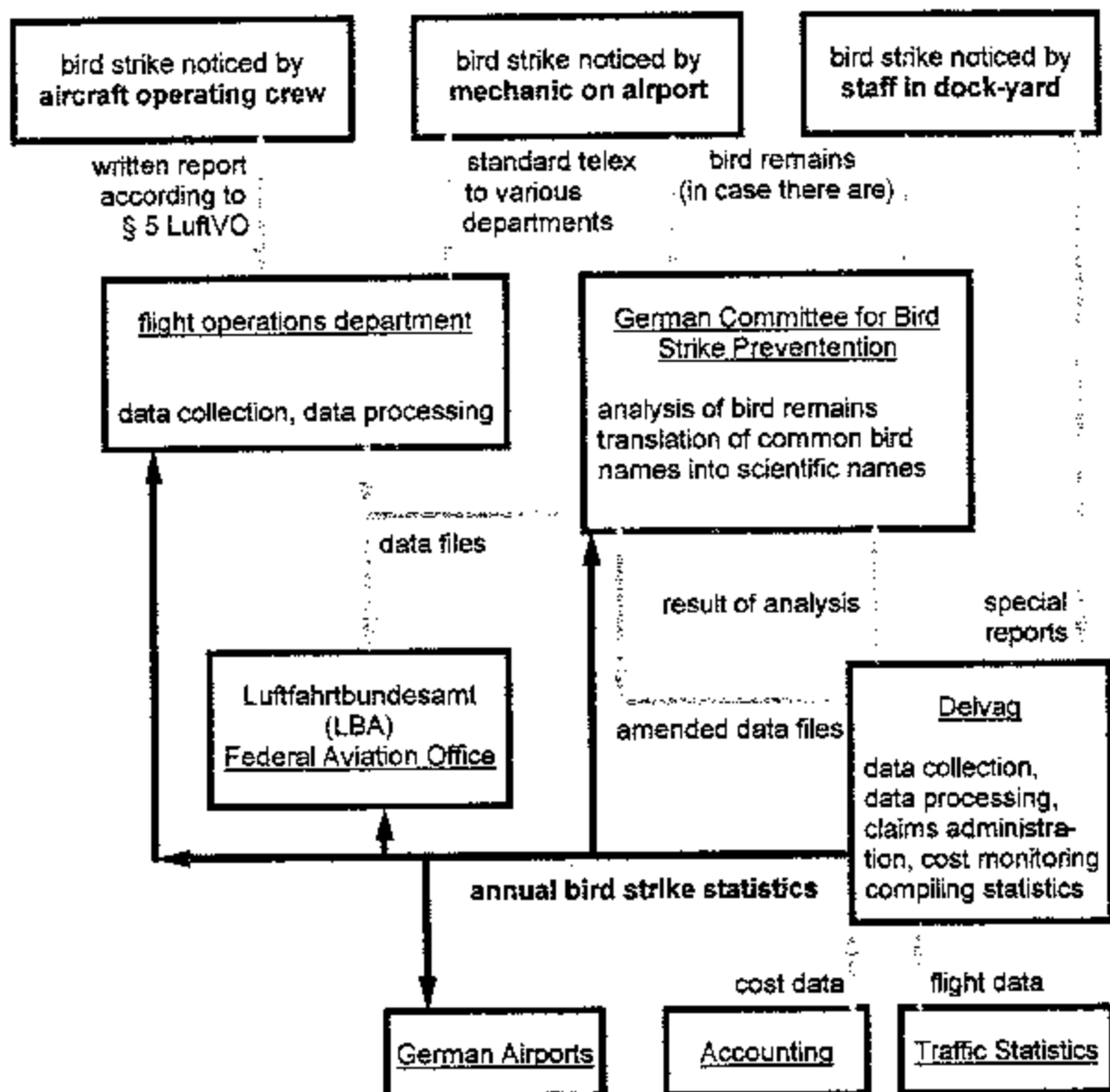
The old system was designed to comply with the law, so the reporting side done by flight crews was well developed but cost documentation took only those cases into account where the amount of hull damage exceeded the amount of DEM 5.000,00. Under the new system all damages are incorporated into the statistics as well.

Since in the past bird remains only occasionally were secured and forwarded for analysis, the German Committee for Bird Strike Prevention asked for improvement of the situation in order to obtain more detailed knowledge of the bird species causing the damages.

The technical staff of Lufthansa was informed about this problem and the importance of getting analysis results and as a consequence the number of secured bird remains is increasing. Details regarding this development are shown on Table 3.

Table 2:

Bird strike reporting system of Lufthansa

**Table 3:**

Number of analysis on bird remains found in or at aircraft of Lufthansa

year	1993 and years before	1994	1995
number of analysis on bird remains	10 to 20 per year	33	75

3.3. Extracts from our bird strike statistics

Our statistics are based on bird strikes which affected Lufthansa aircraft. The breakdown into regions where the incidents occurred is given in the following Table 4.

Table 4:

Distribution of bird strikes by region

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Germany	185	205	239	207	190	274	306	253	356	422
Other Europe	81	73	100	112	108	110	124	124	135	178
Europe total	266	278	339	319	298	384	430	377	491	600
Africa	13	12	22	14	23	16	13	9	23	17
America	5	13	5	10	13	12	3	11	6	11
Asia	18	12	17	10	16	18	13	9	16	19
Australia	2	0	0	1	0	2	0	1	2	0
Intercont (ttl)	38	37	44	35	52	48	29	30	47	47
Worldwide	324	323	385	368	351	432	459	407	540	655

Concentrating on bird strikes which occurred within Germany the sorting according to the criteria of flight phase results in Table 5.

Table 5:

Distribution of bird strikes in Germany according to flight phase

Part a: number of events

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Rolling	0	0	2	0	2	0	1	0	0	1
Start	63	56	83	43	60	76	81	106	98	102
Climb	14	19	16	13	17	24	24	46	0	13
En route	2	2	3	4	10	0	0	0	58	65
Descent	47	41	57	70	43	69	83	30	54	74
Landing	41	57	53	61	53	74	69	44	101	118
Unknown	18	30	25	16	5	31	48	27	45	49
Total	185	205	239	207	190	274	306	253	356	422

Part b: shares of flight phases in percent of total number of events

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Rolling	0,00	0,00	0,84	0,00	1,05	0,00	0,33	0,00	0,00	0,24
Start	34,05	27,32	34,73	20,77	31,58	27,74	26,47	41,90	27,53	24,17
Climb	7,57	9,27	6,69	6,28	8,95	8,76	7,84	18,18	0,00	3,08
En route	1,08	0,98	1,26	1,93	5,26	0,00	0,00	0,00	16,29	15,40
Descent	25,41	20,00	23,85	33,82	22,63	25,16	27,12	11,86	15,17	17,54
Landing	22,16	27,80	22,18	29,47	27,89	27,01	22,55	17,39	28,37	27,96
Unknown	9,73	14,63	10,46	7,73	2,63	11,31	15,69	10,67	12,64	11,61
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Taking into account the areas in which the different entities are responsible for bird strike prevention activities, we can divide the above mentioned figures into the following groups:

- **Group A** = within the airport area
- **Group B** = in the vicinity of the airport (up to 12 km)
- **Group C** = outside the airport (more than 12 km away from the airport) or unknown

The result of this sorting is shown in Table 6.

Table 6:

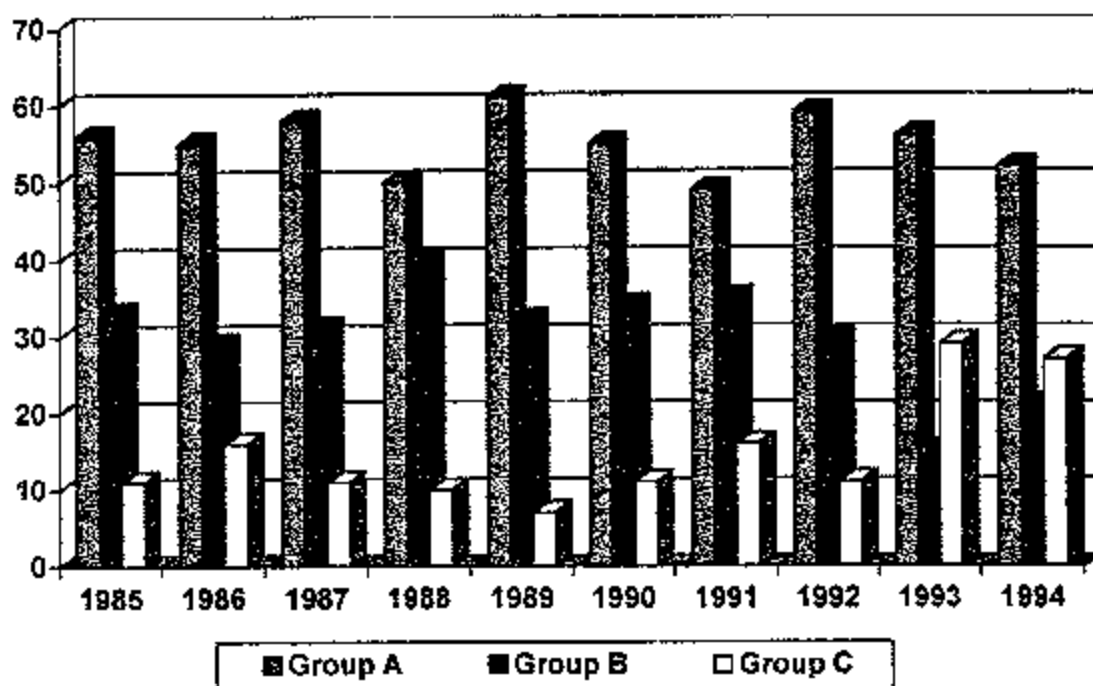
Number of bird strikes in relation to the distance between the airport and the place of incident

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Group A	104	113	138	104	115	150	151	150	199	221
Group B	61	60	73	83	60	93	107	76	54	87
Group C	20	32	28	20	15	31	48	27	103	114
Total	185	205	239	207	190	274	306	253	356	422

The following **Chart 1** illustrates the change in the individual shares of the groups.

Chart 1:

Share of distance groups in total bird strike events in Germany



Correlating the observed number of bird strike events with the total number of flight movements performed we get the more significant bird strike rate. The same can be done with the number of events resulting in damages to get the bird strike damage rate. These rates are based on 10,000 movements.

Development of the bird strike rate and the bird strike damage rate are shown in the following Table 7.

Table 7:

Bird strike rates and bird strike damage rates 1985 to 1994

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Bird Strikes	185	205	239	207	190	274	306	253	356	422
Damages	25	39	55	52	66	49	74	113	183	162
Bird strike rate	6,12	5,81	6,08	4,65	4,11	6,08	4,80	4,32	5,40	7,11
Damage rate	0,73	1,07	1,40	1,17	1,19	1,09	1,11	1,93	2,76	2,73

As the Lufthansa statistics does not only provide details regarding development of bird strike events and the respective rates I would like to show some details regarding cost of bird strikes.

The following Table 8 contains information regarding costs of hull damages which resulted from bird strikes.

Table 8:

Hull damage cost of bird strikes in Germany

	Total of Cost	average cost per event	average cost per 10,000 movements
1990	867.908	17.712	19.259
1991	4.944.410	66.816	74.328
1992	2.481.074	21.956	42.365
1993	19.561.972	106.896	296.727
1994	2.525.561	15.590	42.552
amounts are given in DEM			

As some events were very expensive and these might have an inadequate influence on the statistics we eliminated the most expensive events of the year 1991 and 1993 and received Table 9.

Table 9:

Hull damage cost of bird strikes in Germany (without extrema)

	Total of Cost	average cost per event	average cost per 10,000 movements
1990	867.908	17.712	19.259
1991	3.421.660	46.241	51.440
1992	2.481.074	21.956	42.365
1993	2.852.658	15.588	43.271
1994	2.525.561	15.590	42.552
amounts are given in DEM			

To get better knowledge in respect of the structure of the damages it seems to be helpful to assign the different events to groups using the individual amount of damage as the sorting criteria.

The result of this transaction can be seen in Tables 10 and 11 and Charts 2 and 3 on the following page.

Table 10:

Number of events grouping by amount of individual cost of damage

<u>amounts are in DEM</u>	1990	1991	1992	1993	1994
less than 10.000,00	41	49	90	155	138
10.000 to 49.999,99	4	12	13	8	12
50.000,00 to 499.999,99	4	11	9	19	10
500.000,00 to 999.999,99	0	0	1	0	1
1.000.000,00 or more	0	2	0	1	0

Chart 2:

Share of groups in number of events per year

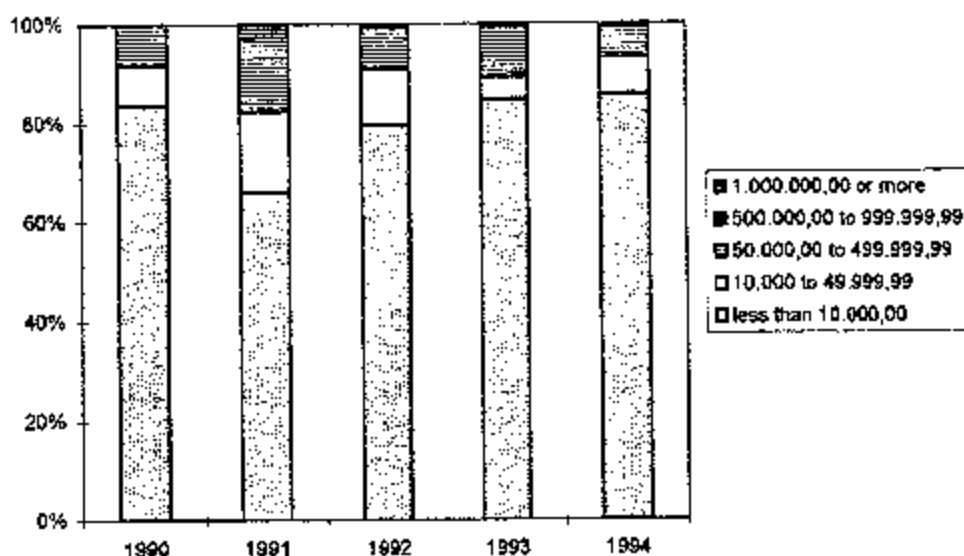


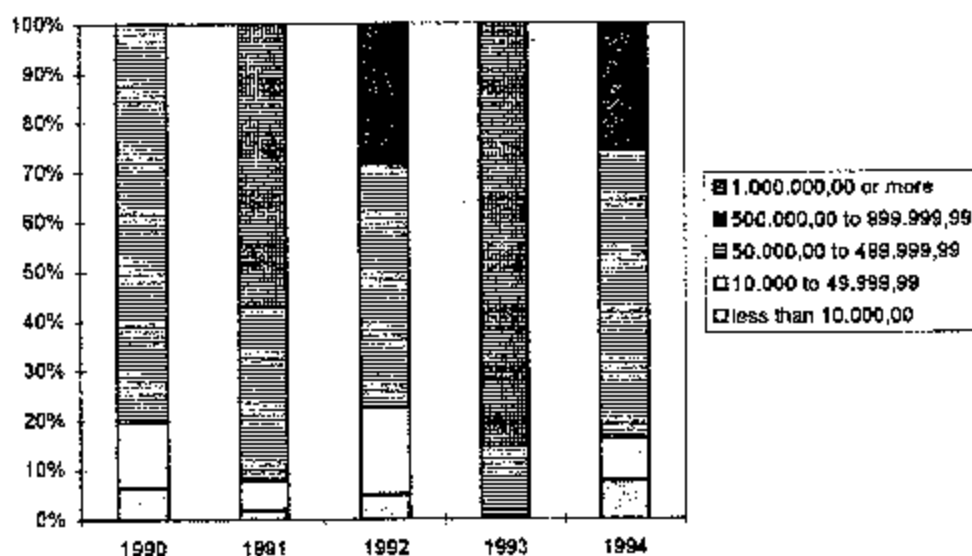
Table 11:

Total of costs of defined group of events

<u>amounts are in DEM</u>	1990	1991	1992	1993	1994
less than 10.000,00	56.060	97.407	123.882	168.850	195.570
10.000 to 49.999,99	114.500	288.600	435.870	193.975	214.300
50.000,00 to 499.999,99	697.348	1.734.638	1.216.812	2.489.833	1.465.250
500.000,00 to 999.999,99	0	0	704.510	0	650.441
1.000.000,00 or more	0	2.823.765	0	16.709.314	0

Chart 3:

Share of defined groups in damage costs per year



In addition to the costs of hull damages the costs of consequential damage have also an important influence on the cost situation of airlines. Although it is possible to buy insurance protection for these costs I do not know any airline having done so. The reason for this is that such contract is not a standard and therefore expensive.

As airlines have (in general) no coverage for such cost and are only in exceptional cases able to take recourse against third parties for damages suffered by bird strikes, no permanent data collection is done in respect of such costs.

Consequential damage depends on several factors:

- extent of damage to the aircraft
- distance between place of occurrence and home base / major base of the airline
- size of the fleet of the airline
- kind of business (cargo or passenger transportation)

In case the damage to the aircraft is only a minor one, any repair may be deferred to regular stop at the repair facilities of the airline.

Severe damage that requires immediate repair of the aircraft to enable safe operation will cause problems to organise repair and have severe influence on the network operation of the airline.

Such problems are for example: time and transportation capacity needed to get the repair team and spare parts to outside airports, to cover flights to be performed by the defective aircraft by use of other (suitable) aircraft, availability of other aircraft, crew and aircraft rotation schedules, passenger accommodation, protection of cargo.

Regarding cost volume the following figures are to be mentioned:

- cost per block-hour of an aircraft ranges from DEM 10,000 to 25,000
- hotel accommodation of passengers costs up to DEM 200 per person/per night, sometimes even more
- spare engines needed as a replacement, at least during time needed for repair of the damaged engine, come up to DEM 8,000,000 and capital used for such investment is subject to interest

Although no permanent statistics are prepared it seems realistic to say that in many cases consequential damage caused by bird strike is considerably higher than the hull damage.

After this general description of the bird strike situation in Germany I want to focus the development and situation of a major German airport which, according my judgement, may be a good example to measure effectiveness of so called environment management recommended by the German Bird Strike Committee.

3.4. Changes in bird strike prevention done by a major German airport

As I do not intend to blame this particular airport for activities or decisions that are already part of the history I ask for your understanding that I do not name this airport.

This airport had been chosen as in the past the situation regarding bird strike prevention has not been as effective as desired by airlines or their insurers but now the situation has changed - which can be verified by the following data.

3.4.1. The History

This airport's management knew that it had some problems in respect of bird strikes. The rate per 10.000 movements was not within the line with that of other German airports, there was an area within the airport used for agriculture by outside farmers, the function of the bird strike prevention officer was said to be one of the tasks of the CEO of that airport.

Long and not always friendly discussions between airport management, German Committee for Bird Strike Prevention, airport insurers and Lufthansa caused the airport management to change its attitude towards the handling of its bird strike problem.

3.4.2. The Changes on the airport

The airport management asked (and paid) for an expertise regarding the environmental situation at and around the airport and also for advice regarding changes to be done. The expertise and adherence to the respective advice had, among others, the following results:

- agricultural area changed to long-grass-area
- trees and bushes attractive to birds were removed
- wet areas were drained
- a full-time bird strike prevention officer had been hired
- a constant bird monitoring and reporting system had been installed

3.4.3. The Changes to be seen in statistics

The following Table 12 shows the changes to be noticed by comparing the development of figures of this particular airport and those of all airports of Germany. To eliminate statistical clutter we also show the average rate of three years, the shown year and the two years before.

Table 12:

	annual bird strike rate		3 years average bird strike rate		annual bird strike damage rate		annual bird strike rate index (base = 1985)	
	Germany	X	Germany	X	Germany	X	Germany	X
1985	6,12	9,51	6,82	10,71	0,73	1,19	100,00	100,00
1986	5,61	6,81	6,29	8,74	1,07	0,94	91,67	71,61
1987	6,08	6,49	5,94	7,60	1,40	1,47	99,35	68,24
1988	4,65	7,61	5,45	6,97	1,17	1,37	75,98	80,02
1989	4,11	5,62	4,95	6,57	1,19	1,38	67,16	59,10
1990	6,08	5,83	4,95	6,35	1,09	1,70	99,35	61,30
1991	4,60	4,79	4,93	5,41	1,11	1,54	75,16	50,37
1992	4,32	4,67	5,00	5,10	1,93	0,90	70,59	49,11
1993	5,40	5,34	4,77	4,93	2,76	2,67	88,24	56,15
1994	7,11	6,37	5,61	5,48	2,73	2,07	116,18	66,98

4. Conclusions and Recommendations

4.1. Conclusions

As explained before the monetary damage resulting from bird strikes is, especially in times of hard competition between airlines and decreasing profit margins, a permanent hazard to profitability of an airline.

This is due to high deductibles in respect of hull damages, which leave a large piece of the cake at the airlines, and the consequential damage, for which most of the airlines have no insurance coverage at all.

The aviation insurers are not often faced with claims resulting from bird strike events. But, as also shown before, bird strikes can have an enormous loss potential.

Therefore airlines and their insurers are required all and any prevention activity that is possible and reasonable.

The methods used by German airports have proven to be effective in reducing the bird strike risk. Especially strict adherence to the advice given by the German Committee for Prevention of Bird Strike in Aviation seems to have best results as shown by deviating figures for the average of all German airports and the figure of one single airport which followed strictly such recommendations.

The increasing bird strike rate of the last years could have several reasons. This trend must be changed and investigations to explain the reason to enable corrective actions have been initiated.

The airport operators on the other hand have a variety of opportunities to reduce the risk of occurrence of a bird strike. Such activities will cost their money and increase their cost situation and consequently the fees to be paid by airlines using the airport.

In an open market airlines sometimes have the opportunity to choose between airports which are not too far away from each other.

Although landing fees are not the only factor to decide to operate from airport A or the neighbour airport B, fees can be the "the last drop" to fill the barrel.

Knowing about this airport managers might, contrary to their common sense which says "only a safe airport is a good airport", feel to be forced to save cost at the wrong spot in aiming to improve the chance of their airport to get additional traffic (and money).

To enable airport management to reach a justified decision regarding activities in respect of bird strike prevention it seems to be necessary to let them have all the information available in respect of bird strike situation at their airport.

To be able to find a fair compromise between the - sometimes - deviating interests of the parties in this area of business it seems to be necessary, or at least helpful, to have clear rules given by legislation.

4.2. Recommendations

Airlines and airports should support each other to reduce the hazard of bird strike events to a minimum.

Airlines should collect and submit data regarding bird strike events of their aircraft and the resulting costs to the airports to give them a feed-back regarding the effectiveness of their prevention activities.

Prevention activities should be checked regularly by use of statistical data.

Experts of the different countries should exchange their knowledge of the legal aspects as this might help to convince all the different parties to work at those standards necessary to perform aviation at best possible safety standards.

Keeping in mind the words I heard from John Thorpe some time ago:

"If You think that loss prevention does not pay off, try a loss !"

I want to add: **"Don't even think about such trial !"**

The original text of the "Guideline" is given on the following pages. The translation had been done by the author and therefore, the only legally binding text is the German one.

**Richtlinien zur Verhütung von Vogel-
schlägen im Luftverkehr**
vom 13. Februar 1974

**Guidelines for the prevention of bird
strikes in aviation**

I. Vorbemerkungen

I. Preliminary Remarks

1. Die Richtlinien sind auf die Erfordernisse für Verkehrsflughäfen, die dem Fluglinienverkehr dienen, abgestellt. Für Maßnahmen bei anderen Flugplätzen können sie zweck- und sinnentsprechend angewendet werden.
2. Die Richtlinien erfassen nicht flugsicherungs-technische Maßnahmen wie die Radarbeobachtung von Vogelbewegungen und die diesbezügliche Warnung an die Flugzeugführer.
3. Die Richtlinien beinhalten zusätzlich zu dem Vogelschlagproblem auch Maßnahmen hinsichtlich anderer den Flugbetrieb auf Flugplätzen gefährdende Tiere.

1. These guidelines are tailored to the requirements of airports that are serving scheduled air traffic. For measures at other airfields they may be applied accordingly.
2. The guidelines do not cover air traffic control measures like monitoring of bird movements by radar and corresponding warnings to pilots.
3. In addition to the bird strike problem the guidelines contain also measures in respect of other animals endangering air traffic operations on airfields.

II. Allgemeines

II. General

Die Abwehr von Gefahren für die Sicherheit des Luftverkehrs sowie für die öffentliche Sicherheit oder Ordnung durch die Luftfahrt gem. § 29 LuftVG und die sichere und ordnungsgemäße Durchführung des Flughafenbetriebes gemäß § 45 Abs. 1 LuftVZO müssen auch auf die Verhütung von Schäden im Luftverkehr durch Vogelschläge (Zusammenstöße von Luftfahrzeugen mit Vögeln) ausgerichtet sein. Zu diesem Zweck sind im Rahmen der jeweils gegebenen rechtlichen und sachlichen Möglichkeiten die in diesen Richtlinien genannten Maßnahmen durchzuführen. Hierbei sind auch Bundes- und Landesgesetze über Naturschutz, Tierschutz, Jagdrecht und Abfallbeseitigung in Betracht zu ziehen.

The protection measures against hazards for safety of aviation as well as for public safety and order pursuant to § 29 LuftVG and safe and orderly operation of the airport pursuant to § 45 para 1 LuftVZO must also be directed towards prevention of damages in aviation caused by bird strike (collision between aircrafts and birds). To achieve this goal the measures named in this guideline have to be applied within the legal and factual capability.

The federal law and the law of the individual states concerning environment protection, animal protection, game-law and law concerning disposal of waste have to be taken into consideration in this respect.

III. Biotopgutachten

III. Biotop expertise

Der Flughafenunternehmer soll ein mit Beteiligung der zuständigen Naturschutzbehörde und des Deutschen Ausschusses

The airport operator shall obtain an expertise concerning the ecological situation (biotope expertise) regarding the airport

zur Verhütung von Vogelschlägen im Luftverkehr (DAVVL) zu erstellendes Gutachten über die ökologischen Verhältnisse (Biotopgutachten) des Flughafengeländes und seiner für Maßnahmen nach diesen Richtlinien in Betracht kommenden Umgebung einholen. Das Gutachten soll Vorschläge für die nach den örtlichen Gegebenheiten zweckmäßig erscheinenden Maßnahmen beinhalten. Es ist der Flughafengenehmigungsbehörde zur Kenntnis zu bringen.

IV. Maßnahmen auf dem Flughafengelände

1. Das Flughafengelände soll nicht ackerbaulich, gartenbaulich oder weidewirtschaftlich genutzt werden. Auf ihm sollen kein Nutzvieh (z.B. Rinder, Schafe, Schweine, Federvieh u.ä.) sowie keine Tauben gehalten werden. Unkontrollierter Bewuchs soll auf dem Flughafengelände nicht bestehen. Erforderlichenfalls sind Maßnahmen zur Vogelvergrämung und zur Niederhaltung des Besatzes von Tieren, die den Vögeln als Nahrung dienen, zu treffen.
2. Auf dem Flughafengelände sollen keine Gehölze vorhanden sein, die von Vögeln bevorzugte Früchte tragen. Gegebenenfalls ist durch pflegerische oder planerische Maßnahmen darauf hinzuwirken, daß Wind-, Schnee- und Schallschutzpflanzungen, Baumgruppen, einzeln stehende Bäume sowie Neupflanzungen wenig anziehend für Vögel sind.
3. Die Flughafenumzäunung soll gegen Haarwild dicht sein. Gegen die den Flugbetrieb gefährdenden Tiere sind ggf. besondere Maßnahmen erforderlich (z.B. Abschuß von Wild, Beseitigung von Nistplätzen, in Sonderfällen Fang und Aussiedlung von Vögeln). Um den Vogel- und übrigen Tierbestand wirksam unter Kontrolle halten zu können, sollte der Flughafenunter-

area and the area in the vicinity of the airport, which may be subject to measures according these guidelines. The expertise shall be prepared with the co-operation of the relevant authority for conservation and nature and the German Bird Strike Prevention Committee. The expertise must contain proposals for measures best adopted to the local situation. The expertise has to be given to the knowledge of the airport licensing authority.

IV. Measures on the airport area

1. The area of the airport shall not be used for agricultural, horticultural or pasture use. No domestic animals (for example cattle, sheep, pigs, poultry or similar) nor pigeons shall be kept there. Uncontrolled growth shall not exist on the airport. If necessary measures to scare birds and to diminish animals serving as feed for birds have to be performed.
2. On the airport area there shall not be any bushes carrying fruit preferred by birds. If necessary cultivating or planning activities have to strive for less attractivity of wind, snow or noise protection plantations, single trees and new plantations.
3. The fence around the airport must be safe in respect of furred game. Against animals endangering the aviation operations special measures are necessary (for example shooting of games, removal of breeding locations, in special cases catch and evacuation of birds). To keep an effective control on number of birds and other animals the airport operator

nehmer grundsätzlich mit den zuständigen Jagdbehörden eine besondere, den Sicherheitserfordernissen der Luftfahrt Rechnung tragende Regelung über die Jagdausübung treffen.

4. Auf dem Flughafen sollen keine Plätze, die Vögel und andere Tiere anziehen, wie Müll- oder Komposthaufen o.ä., vorhanden sein. Naß- und Sumpfflächen sollen beseitigt werden. Offene Gewässer, wie Gräben und Teiche, sollen möglichst vermieden werden, an vorhandenen im Rahmen der gegebenen Möglichkeiten vogelvergrämende Maßnahmen vorgenommen werden.

Nistplätze an Gebäuden sollen entfernt werden. Neue Gebäude sollen so geplant werden, daß sie Vögeln möglichst wenig Nist- und Aufsitzmöglichkeiten bieten. Soweit am Rand von Betriebsflächen, insbesondere der Start- und Landebahnen, Wasserablaufgräben vorgesehen werden, soll gegen das Aufkriechen von Regenwürmern und Schnecken den durchgehenden, parallel zum Rand verlaufenden Schlitzrinnen der Vorzug gegeben werden. Im Nahbereich der Start- und Landebahnen und der Rollbahnen sollen Einrichtungen der Flugsicherung, des Flugwetterdienstes sowie der Flughafenbefeuerung und Rollbeschilderung, soweit erforderlich und möglich, mit Vorrichtungen versehen sein, die das Aufsitzen von Vögeln verhindern.

V. Maßnahmen in der Umgebung von Flughäfen

1. Bei Maßnahmen in der Umgebung von Flughäfen ist ggf. die Unterstützung von Stellen außerhalb der Luftfahrtverwaltung zu suchen, die hierfür aufgrund ihrer Befugnisse und Zuständigkeiten in Betracht kommen.
2. Auf landwirtschaftlichem Gelände unterhalb der inneren Hindernisbegren-

zung sollte in principle agree with the hunting authority in charge on rules regarding hunting which is adjusted to the security requirements of aviation.

4. On the airport there shall not be areas like garbage dumps, compost places or similar which are attractive to birds or other animals. Wet areas or bog have to be removed. Open waters like trenches or ponds should be avoided if possible, at existing possible bird scaring measures be taken.

Nesting sites on buildings should be removed. New buildings should be designed that they offer birds less possible breeding and resting opportunities. In case gutters are intended at the end of operation areas, especially at runways, slit-gutters parallel to the edges should be preferred to prevent earth-worms and snails from crawling.

In the vicinity of runways and taxiways the installations of air traffic control, meteorological services, runway lighting and taxi signs should, if necessary and possible, be equipped with appliances avoiding birds to rest.

V. Measures in the vicinity of airports

1. For measures in the vicinity of an airport the support of authorities outside the aviation administration must be requested, if these have to be considered competent or their powers are affected.
2. On agricultural ground within the inner obstruction prevention area it should

zungsfläche soll nach Möglichkeit durch Maßnahmen der Nutzung eine Niederhaltung des Vogelbesatzes erreicht werden. Bei ackerbaulicher und weidewirtschaftlicher Nutzung sollen ggf. vogelvergrämende Maßnahmen angestrebt werden. Bei forstwirtschaftlicher Nutzung ist Nadelgehölzen möglichst der Vorzug gegenüber Laubgehölzen zu geben.

3. Es ist anzustreben, daß im Bereich unterhalb der inneren Hindernisbegrenzungsfläche keine freifliegenden Tauben gehalten werden.
4. Auf dem Gelände unterhalb der inneren und der äußeren Hindernisbegrenzungsfläche sollten die jagdrechtlichen Belange mit den zur Verringerung des Vogelbesatzes erforderlichen Maßnahmen abgestimmt werden. Gegebenenfalls ist anzustreben, daß eine elektroakustische Vogelvergrämung durchgeführt wird und die als besonders gefährdend anzusehenden Vogelarten in erhöhtem Maß bejagt, gefangen, ausgesiedelt oder ihrer Nistplätze beraubt werden.
5. Im Bereich unterhalb der inneren und der äußeren Hindernisbegrenzungsfläche sollten großflächige Gewässer, wie Bagger- und Stauseen, möglichst vermieden, und unvermeidbare Neuanlagen nur im Benehmen mit der Luftfahrtbehörde vorgenommen werden. Erforderlichenfalls ist anzustreben, daß an bereits vorhandenen Gewässern im Rahmen der gegebenen Möglichkeiten vogelvergrämende Maßnahmen vorgenommen werden.
6. Es ist anzustreben, daß auf dem Gelände unterhalb der inneren und der äußeren Hindernisbegrenzungsfläche und der um 5 km verlängerten An- und Abflugflächen vorhandene Müllplätze beseitigt und Neuanlagen nicht genehmigt werden.

be tried to keep the number of birds low by adequate use of the land.

In case of agricultural and pasture use bird scaring measures should be used if necessary.

In case of forestry the use of coniferous trees has to be preferred instead of foliage trees.

3. It has to be striven for that within the area of the inner obstruction prevention area no free-flying pigeons are kept.

4. On the area within the inner and outer obstruction prevention surface the requirements of game-law and the measures to reduce the bird population should be correlated.

If necessary electro-acoustic bird scaring should be performed and the bird species considered to be especially endangering should, at a forced level, be shot, caught, evacuated or their breeding places taken away.

5. Within the area below the inner and outer obstruction prevention surface large water-surfaces like excavation or storage lakes should as far as possible be avoided and unavoidable new implementations only be done in consent with aviation authorities. If necessary it must be achieved that bird scaring measures are carried out at existing lakes.
6. It has to be striven for that on the ground within the inner and outer obstruction prevention surface and the by 5 km enlarged approach and climb-areas existing garbage dumps are removed and new ones are not to be licensed.

VI. Verschiedenes

1. Die aufgrund Nr. IV und V angewendeten Maßnahmen zur Verringerung der Vogelschlaggefahr sollen möglichst dem letzten Stand der Erkenntnisse entsprechen und mit den im Biotopgutachten enthaltenen Vorschlägen verträglich sein. Fachgerechte Versuche, die dem weiteren Fortschritt auf diesem Gebiet dienen, sind im Sinne dieser Richtlinien zulässig.
2. Bei ausgedehnten Änderungen der Betriebsflächengröße, der Art des Bewuchses auf dem übrigen Flughafengelände o.ä. sind die eventuellen Auswirkungen auf den Biotop, ggf. aufgrund einer fachlichen Stellungnahme, zu berücksichtigen. In der Umgebung von Flughäfen ist anzustreben, daß wesentliche biotopverändernde Maßnahmen nur im Benehmen mit der Luftfahrtbehörde vorgenommen werden.
3. Der Flughafenunternehmer soll einen Beauftragten zur Überwachung der nach Nr. III und IV erforderlichen Maßnahmen bestellen und dessen Ausbildung und Fortbildung insbesondere durch Entsendung zu geeigneten Fachveranstaltungen sicherstellen.
4. Für den mit der Erstellung des Biotopgutachtens Beauftragten soll nach Möglichkeit eine Berechtigung zum Betreten des zu begutachtenden Geländes erwirkt werden.
5. Die Start- und Landebahnen und die Rollbahnen sollten täglich auf getötete Vögel und sonstige Tiere überprüft werden. Dabei sollen die Kadaver so beseitigt werden, daß sie anderen Tieren nicht zum Fraß dienen können. Über Art und Anzahl der gefundenen Tiere sowie über den Fundort (z.B. "erstes Drittel Landebahn 27")

VI. Miscellaneous

1. The measures to reduce hazard of bird strike applied pursuant to Nr. IV and V should be according best standard of knowledge and be in line with the proposals contained in the biotop expertise.

Competent tests which are helpful for progress on this field are permitted within the sense of this guideline.

2. In case of extreme alterations of the operation area, the kind of growth on the other airport area or similar the influence on the biotop, if necessary based on an expertise, has to be obeyed.
In the vicinity of airports it must be achieved that measures significant to the biotop are only carried out in consent with the aviation authority.
3. The airport operator shall appoint a delegate for monitoring the measures pursuant Nr. III and IV and to ensure the education and advance training especially by sending to suitable professional events.
4. For the delegate to prepare the biotop expertise a permit to access the area to be reported on should be arranged.
5. Runways and taxiways have to be checked daily for killed birds and other animals. Corps should be deposited in such a way that they are not serving as feed for other animals. Regarding species and number of found animals and location where found (first third on runway 27) and date notes should be made on a uniform sheet which, after a

und Datum sollen Aufzeichnungen auf einheitlichem Vordruck geführt und nach Ablauf eines Kalenderjahres über die Flughafengenehmigungsbehörde dem Bundesverkehrsministerium zu Auswertungszwecken vorgelegt werden.

period of one calendar year has to be presented for analysing purpos to the Ministry of Transport via the airport licensing authority.

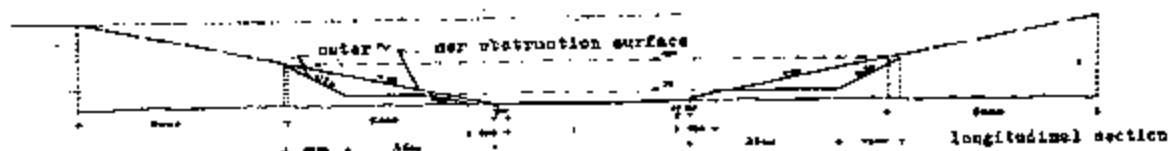
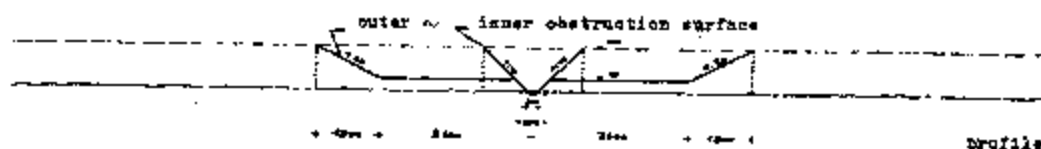
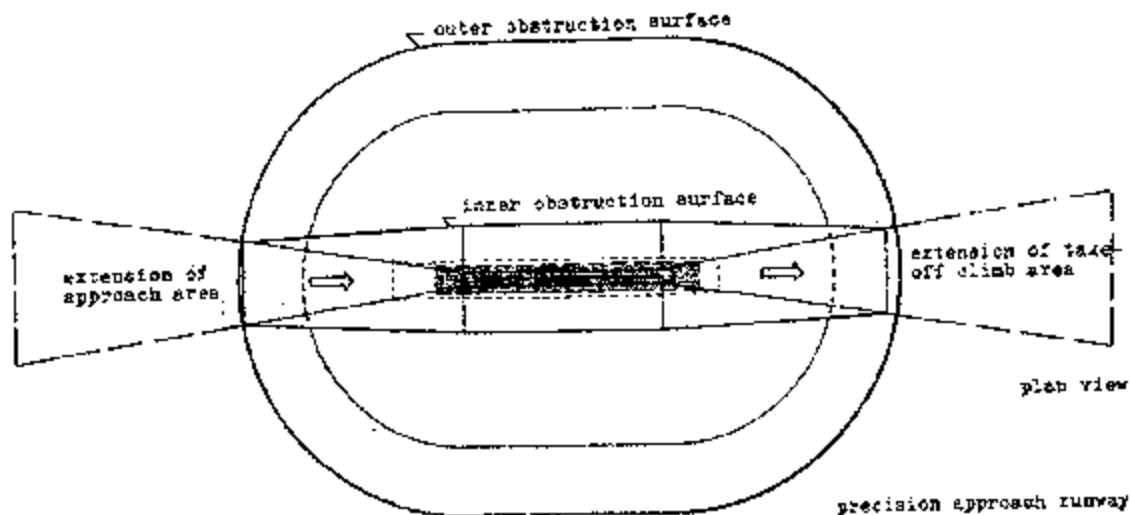
VII. Beginn der Anwendung

Nach diesen Richtlinien soll ab ihrer Veröffentlichung in den Nachrichten für Luftfahrer verfahren werden.

VII. Start of application

As soon as these guidelines have been published in "News to airmen" they have to be applied.

Following sketches may help to explain the meaning of different zones in respect of the guideline.



APPENDIX 32

The Potential For Significant Financial Loss Resulting From Bird Strikes In or Around an Airport

THE POTENTIAL FOR SIGNIFICANT FINANCIAL LOSS RESULTING FROM BIRD STRIKES IN OR AROUND AN AIRPORT

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Summary

Following a brief introduction, this paper contains a brief study outlining some arguments concerning the perceived need for maintaining an adequate "airport and/or air traffic control legal liability" insurance programme. It includes reference to known losses caused by bird strikes and an analysis suggesting that in an increasingly litigious world, bird dispersal measures must be vigilantly maintained.

(Key words: legal liability, insurance)

INTRODUCTION

This brief study offers a simple review outlining our strong belief as to why there is a need, indeed an increasing need, for airport and air traffic control authorities to arrange the appropriate legal liability insurance covers.

We commence our study by considering the potential for loss i.e. may an airport and/or air traffic control authority be found legally liable in the event of:

- (i) loss of, or damage to an aircraft
- (ii) injury or death of passengers and damage to their property, or
- (iii) third party injury, death or property damage

resulting from a bird strike - we review some known losses;

a brief review of potential exposures i.e. fleet composition, traffic development etc.- both current and forecast, and general aviation;

Having considered the potential for loss we identify some specific matters of concern, including potential loss scenarios, proposed changes to International protocols affecting passenger legal liability awards etc.

In summary, we hope our study will offer "food for thought"; airport and/or air traffic control legal liability insurance is necessary. In general terms, airport legal liability insurance is not expensive and considerable insurance capacity is available; limits of circa US\$ 1,000 million and above are fairly simply arranged (subject always to satisfactory individual risk profiles).

Mr. J. Goglia of the United States NTSB recently hosted a review on the subject of bird strikes; may we perhaps take this opportunity of quoting his comment that "...escalating bird populations are an increasingly serious hazard to airline operations and merit aggressive efforts to combat their presence near airports..." An accident involving a Boeing 747 aircraft could result in over 500 passenger fatalities - is this so impossible? We must always remember that the only difference between the possible and the impossible is that the impossible is merely likely to happen less often! Subsequent insurance claims for the aircraft hull, passenger fatalities and any third party injuries and/or damage could result in a massive overall claim.

We suggest the arguments for buying adequate airport and/or air traffic control legal liability insurance will be found compelling; will any further persuasion be required?

prepared by Business Information and Management Systems ("BIMS")

March, 1996

[birdconf-presentn and bird96 in freelance]

THE POTENTIAL FOR AN AIRPORT AND/OR AIR TRAFFIC CONTROL LEGAL LIABILITY LOSS RESULTING FROM A BIRD STRIKE

We open our study by asking three simple questions, namely:

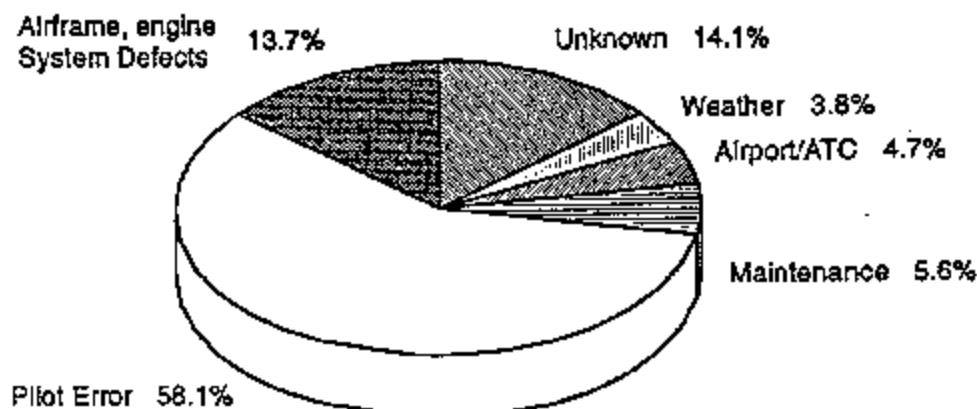
- Is the potential for loss real?
- do losses occur?
- can an airport and/or air traffic control authority be found legally liable following an accident?

We answer in the simplest of terms, yes! The potential for loss is real, losses have occurred and an airport or air traffic control authority can be found legally liable following an accident. It is not just the daily regimen of slips and falls, collisions with glass doors etc. within an airport terminal that require an authority to purchase adequate airport legal liability insurance cover. The ever present possibility of debris on the runway, birds etc. with consequent threat to air traffic will always be a constant cause for concern and require vigilance in maintaining avoidance measures.

Ever increasing legal liability damages awards must be borne in mind; we note the recent damages award to a passenger involved in the 1989 British Midland Airways crash at Kegworth (involving 47 passenger fatalities) who became disabled as a result of the crash; the court awarded damages of £1,425,000 (or excess of US\$ 2 million). Whilst this action does not appear to involve an airport or air traffic control authority it quite clearly demonstrates award trends. International protocols regarding passenger legal liability award levels are currently under review; could any such review impact adversely on an authority? I understand that according to Japanese philosophy, recourse to litigation represents a fundamental failure in human relations; we in the United Kingdom are currently witnessing an explosion in the desire to seek legal remedies - everything now seems to have a monetary price as we seek the new Holy Grail, compensation. It has been observed that once the law starts talking, there is no stopping them. Oddly enough, even in these troubled times, some airports, including some of the larger ones, do not appear to purchase any cover; surely a false economy?

By way of opening our study in very general terms, it is interesting to note that a recent Boeing Company report identified primary loss causes for 234 jet airline accidents, occurring during 1984 to 1995 inclusive; the primary cause of loss was identified as per Figure 1.

FIGURE 1. - Jet airliner accidents - 1984 to 1995 inclusive - by cause:



It will thus be noted that 4.7% of the accidents resulted from what may be considered airport and air traffic control related causes - split currently unknown.

It must be stressed that the foregoing applies in respect of airline losses only; it must also be borne in mind that airline traffic forms only a part of overall traffic levels; general aviation activities are significant. Whilst the active commercial aircraft fleet stands at circa 24,000 aircraft, the active "general aviation" fleet (excluding China and the former Soviet Union) approaches 300,000 aircraft. We consider some fleet distributions later in this study.

Can bird strikes really be held responsible for aircraft accident/loss? Surely the chances of the total loss of an aircraft resulting from a bird strike are almost non-existent? Minor damage may perhaps be caused, but the total destruction of an aircraft with resultant passenger fatalities is surely something of a long shot? Nevertheless, it is a possibility, if perhaps distant possibility. If I might take an individual example, United Airlines reported that during 1995, they experienced a bird strike every 18,000 aircraft cycles; we understand that whilst in the majority of instances these involved small birds with little, if any, resultant aircraft damage, the airline's senior engineer at their San Francisco base, estimates that annually, circa 33% of all damage to United Airlines aircraft is caused by bird strikes.

I am sure that a myriad of examples will be cited during the course of this week; may I perhaps mention one instance, which had the fates been less than kind, could have resulted in significant financial loss with the airport and/or air traffic control authority perhaps being included in any subsequent legal actions.

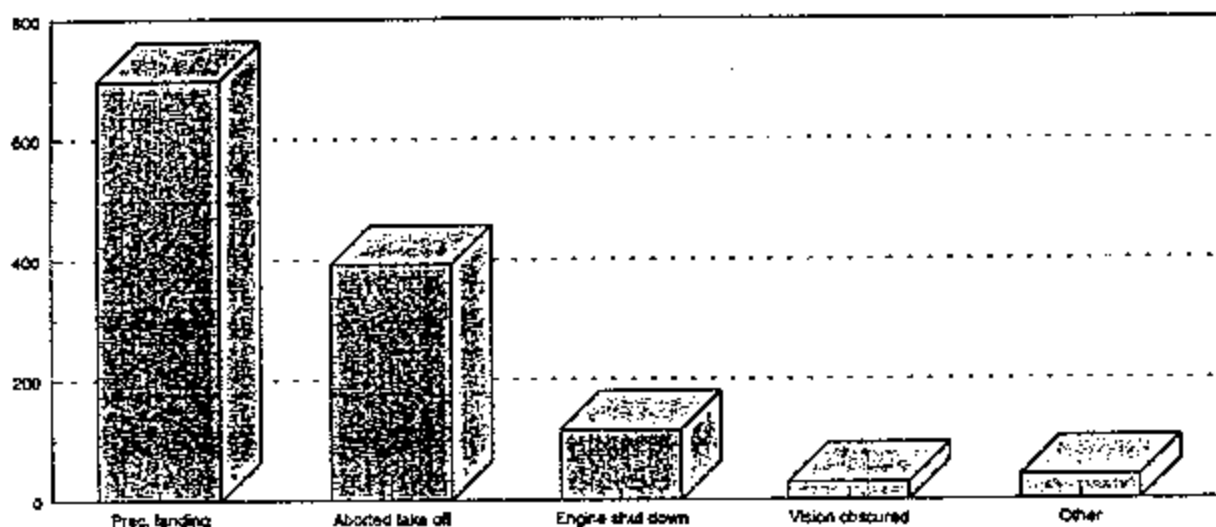
About a couple of years ago, a Boeing 737 aircraft was involved in an incident in North America; in this instance, it is important to note that the topography of the airport involved is such, that a vertical curve on the runway involved meant that the flight crew could not see the far end of the runway until they were approximately half way down the runway. The aircraft performed the standard take off run; however, as it was being rotated, the first officer sighted a large flock of birds (gulls) on the runway, apparently attracted by earthworms which had come to the surface at the end of the runway, following heavy rainfall the previous day. Estimates as to the number of birds varied although the general consensus suggests the flock numbered more than one hundred. The flight crew had no alternative but to continue the take off and with the aircraft approaching, the birds rose. It appears that approximately sixty birds either hit the nose, wings and landing gear or were ingested in the engines. The Captain immediately declared an emergency; control of the aircraft was maintained and a successful emergency landing was carried out; no one on board the aircraft was injured, nor was the aircraft substantially damaged.

We understand that the possibility of taking action against various parties, including the airport authority, was considered but for various reasons, essentially economic (repair costs were apparently relatively light), not pursued. We understand that there were slightly more than 100 passengers on board. Had disaster struck, the resultant financial loss could therefore have been very significant! As to whether the aircraft operator and/or their insurers would have been able to succeed in any action against the airport will of course, remain unknown; however, the monetary sums involved would have been significant and warranted serious consideration for pursuing action against the airport authority if it was felt said authority was responsible, either wholly or partially. Even had the authority successfully resisted any action they would be faced at the very least, with a significant legal bill and perhaps more damaging, adverse publicity.

In response to the question can an airport and or air traffic control authority be found legally liable following a bird strike accident, the successful action taken against Norwich Airport following the December, 1973 loss, caused by a bird strike, of a Falcon 20 aircraft highlights the possibility that an authority may be found legally liable. The Judge, in his summing up, noted that "...the Defendants owed the Plaintiffs (the aircraft operator) the common duty of care, that is, a duty to take such care when carrying on their activities at the airport as was reasonable in the circumstances...". After weighing up all the considerable amount of evidence, the Judge decided that the Defendants failed in their duty and that "...there must be judgement for the Plaintiffs for damages...".

Are bird strikes a rare occurrence? We have already commented on United Airlines' experience. Figure 2., based on ICAO supplied information and covering the period 1989 to 1993 inclusive, identifies the consequences of bird strikes by individual effect, quite clearly demonstrating that an airport and/or air traffic control authority must constantly monitor bird populations and take the appropriate measures to disperse flocks:

FIGURE 2. - The consequences of bird strikes by Individual effect:



We have already mentioned the December, 1973 Falcon 20 aircraft loss. Was this really an isolated incident? Certainly not! Table 1. identifies some individual instances of aircraft total loss, including, where applicable, the aircraft hull insured loss amount, resulting from bird strike(s):

TABLE 1. - Some individual aircraft accidents resulting from bird strikes:

Date of loss:	Location:	Aircraft type:	Insured hull loss:
November, 1975	JFK, New York	DC-10	circa US\$ 25 million
April, 1978	Gosselies, Belgium	Boeing 737	circa US\$ 7.9 million
July, 1978	Kalamazoo, USA	Convair 580	circa US\$ 600,000
September, 1988	Bahar Dar, Ethiopia	Boeing 737	circa US\$ 20 million *
January, 1995	Le Bourget, France	Falcon 20	circa US\$ 2.3 million
September, 1994	Elmendorf AFB, Alaska	"AWACS" (of U.S. Airforce)	not insured **

* there were 35 resultant fatalities and 21 serious injuries reported

** there were 24 resultant fatalities

In overall terms, we are aware of at least 15 individual aircraft (12,500 lbs. or over and executive jet aircraft) crashes during the last 25 years which were attributed to bird strikes. Of general interest, an October 1995 accident attributable to a bird strike (a white backed vulture weighing 6 kg.) involved an Ethiopian Airlines, DHC-6 Twin Otter aircraft; 2 of the 17 passengers and 2 of the 3 crew members were injured.

What of the culprits? Is the threat increasing or diminishing? In very broad terms, we suggest the threat must be perceived as increasing. Airline fleet development forecasts suggest some significant increases in aircraft numbers as we move into the next millennium; please refer to the comments included later in this study. Whilst it is difficult to provide an accurate measure of bird populations, it would appear that in general terms, numbers of gulls, geese, (mute) swans and other wildfowl are either stable or showing increases. An important and contributing factor to both increasing and newly resident populations, particularly here in the United Kingdom (and doubtless, elsewhere), is the growth in mineral extraction sites, an increase in the number of rubbish tips and established nature reserves. It is interesting to note that such sites may be situated in close proximity to an airport (the New York, JFK airport, adjacent to the Jamaica Bay Wildlife Refuge being such an example) and must therefore be a source of constant concern. Bird dispersal methods must be ever monitored and reviewed. I am sure most of you will have read recently of a rather charming (attempted and apparently successful) solution to the problem of bird strikes which has been developed at the Lake Hood seaplane base near Anchorage, Alaska. Pigs (namely Curly, Larry and Moe) take up residence during the gull breeding season and feast on the gulls' eggs. This relatively humane response to the bird strike problem appears, so far at least, to have been successful; one of the base users is reported as saying "...those pigs are the first thing that's ever worked...".

Should consideration of global warming play a part in our calculations? There appears to be a general consensus that temperatures world-wide are rising. Could rising temperatures affect some long established migratory patterns? It is, as yet, too early to comment; however, in the long term this must be a distinct possibility, perhaps some normally migratory birds might not feel the need to take their annual holidays? One change that has already been noted, here in the United Kingdom and doubtless elsewhere, is that birds are now nesting earlier.

In summary, bird dispersal methods must be ever monitored. Even the most carefully considered risk management programmes cannot be guaranteed to be 100% effective all the time!

A BRIEF REVIEW OF EXPOSURE LEVELS - BOTH CURRENT AND FORECAST::

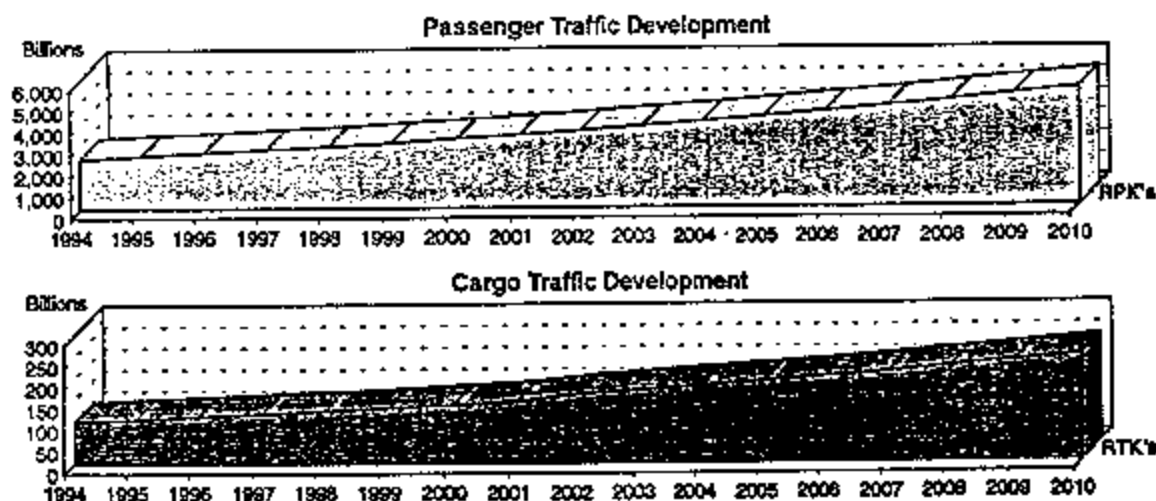
It is of course commercial air traffic and the carriage of passengers that presents the greatest potential for major legal liability loss; passenger traffic levels are ever increasing. Based on preliminary 1995 estimates, ICAO confirm a continued annual rise in both scheduled passengers and freight tonnes carried (and the international content), as is shown in Table 2. (the breakdown between domestic and international traffic showing constant annual increases in international traffic levels):

TABLE 2. - Traffic level development:

Year:	Passengers (millions):	Split domestic and international as %:	Freight tonnes (millions):	Split domestic and international as %:
1989	1,109	76% dom. and 24% int'l.	18.2	53% dom. and 47% int'l.
1990	1,165	76% dom. and 24% int'l.	18.4	53% dom. and 47% int'l.
1991	1,135	76% dom. and 24% int'l.	17.4	51% dom. and 49% int'l.
1992	1,145	74% dom. and 26% int'l.	17.6	47% dom. and 53% int'l.
1993	1,139	72% dom. and 28% int'l.	17.9	42% dom. and 58% int'l.
1994	1,227	72% dom. and 28% int'l.	20.0	41% dom. and 59% int'l.
1995 est.	1,288	72% dom. and 28% int'l.	21.6	41% dom. and 59% int'l.

These growth levels are compatible with general industry estimates which forecast continued levels of growth well into the next millennium; our interpretation of published forecasts is demonstrated in Figure 3.

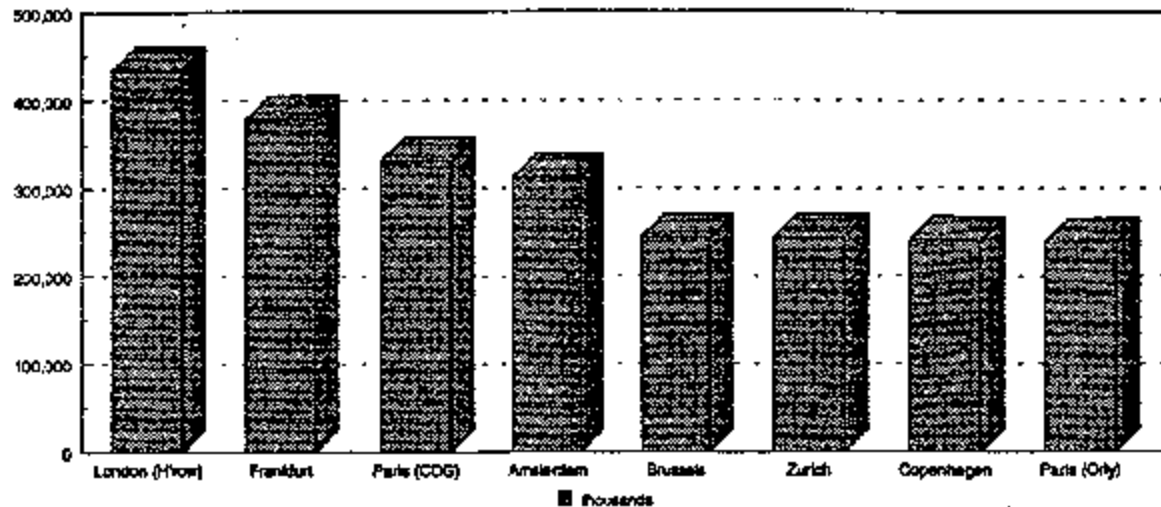
FIGURE 3. - Passenger and cargo traffic development:



Interestingly, a White Paper, entitled "Air traffic management - freeing Europe's airspace" was recently presented by the European Commission against the backdrop of ever increasing air space congestion in Europe, the volume of air traffic being noted as constantly on the rise.

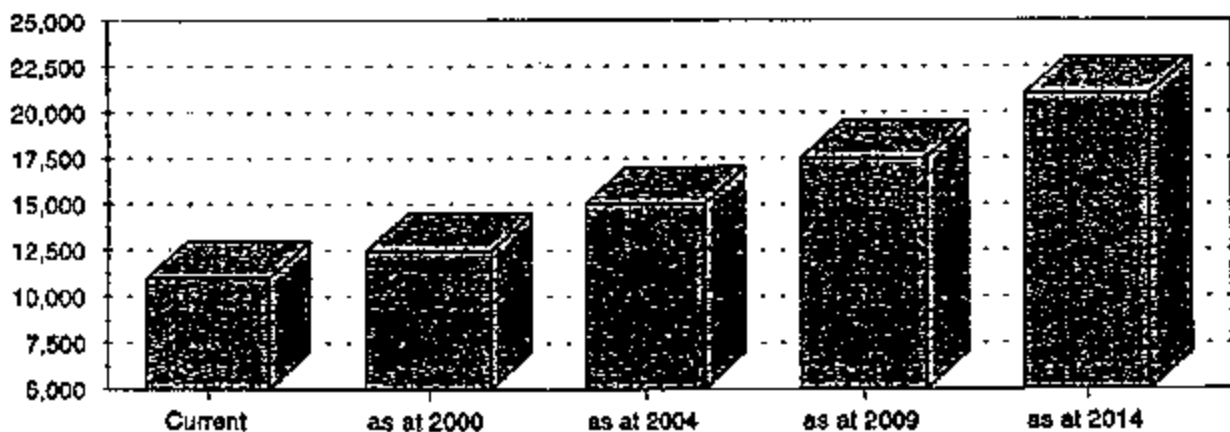
Additional evidence that traffic movements are moving ever upwards is demonstrated by some preliminary 1995 traffic figures provided by the Airports Council International (ACI). As a brief aside, affiliations to bodies such as the ACI and the International Federation of Air Traffic Control Associations (IFACTA) demonstrate our interest in airport and air traffic control matters and ensure we enjoy continual access to a wide range of statistical data. Figure 4. identifies reported 1995 aircraft movements at some of the major European airports; all results show increases over 1994 levels.

FIGURE 4. - Aircraft movements - some preliminary 1995 results:



To accommodate the forecast increases in traffic levels, some significant fleet development programmes are anticipated; current industry based indications suggest that the world jet aircraft fleet (excluding eastern built aircraft) will probably more than double within the next twenty years. Figure 5., based on published estimates, outlines our interpretation. To bring these forecasts to fruition will however require some considerable financial investment: according to Boeing, this will amount annually to excess of circa US\$ 50 billion by the year 2004 and beyond.

FIGURE 5. - The active world jet aircraft fleet - current and projected:



Similarly, some significant turbo prop fleet development is anticipated. Table 3. identifies our understanding of the make up of the world airline fleet as at January, 1996 (based on Airclaim's CASE database):

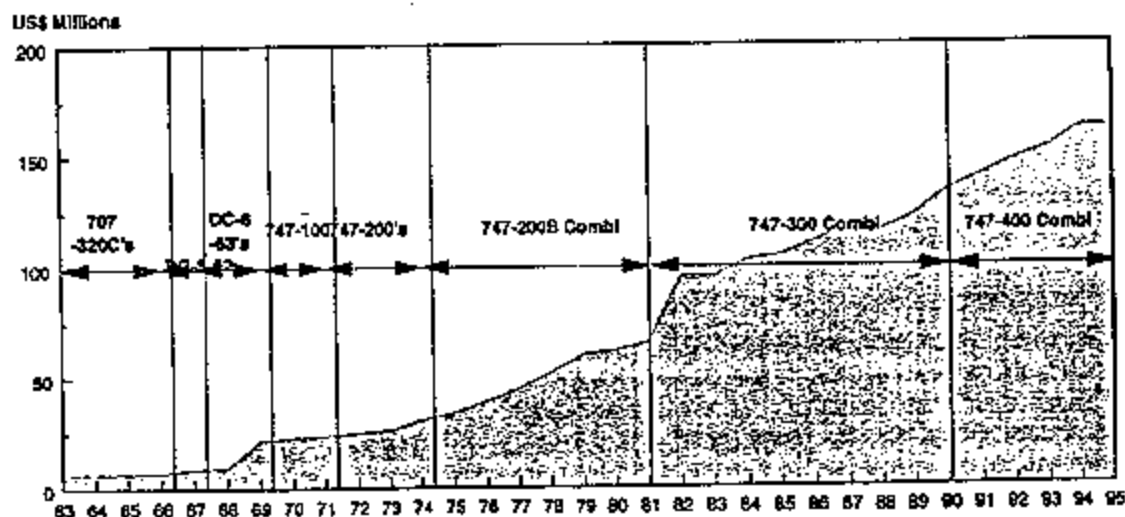
TABLE 3. - The current world airline fleet:

	Aircraft in service	Aircraft stored
Jet aircraft (excluding former USSR built aircraft)	11,044	360
Former USSR built jet aircraft	3,018	85
Turbo prop aircraft (excluding former USSR built aircraft)	4,862	265
Former USSR built turbo prop aircraft	3,650	37
Executive jet aircraft (non USSR built)	858	14
Totals	23,432	761

It is of course, the airline fleet composition that is of particular importance when considering airport and/or air traffic control legal liability insurance and the possibility of a major loss. We specifically identify two significant factors, namely (i) aircraft values and (ii) individual aircraft seating capacities.

Firstly, let us consider individual aircraft values. Figure 6, showing highest basic list prices, reflects the inexorable rise in aircraft values since 1963 (actual insured values are often considerably in excess of list prices once lease considerations etc. are taken into account - aircraft valued at US\$ 250 million plus are currently being operated by the world's airlines!):

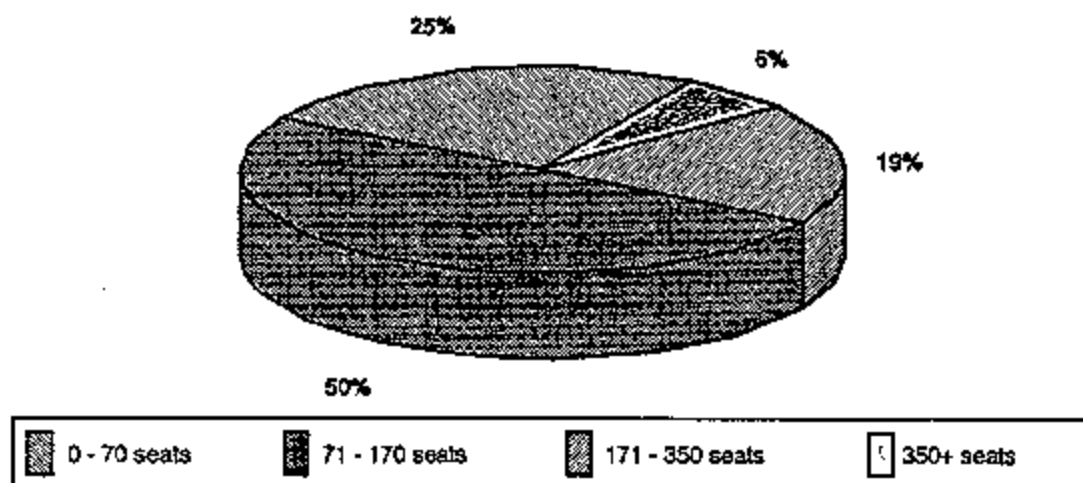
FIGURE 6. - Highest aircraft basic list prices:



These increasing values are reflected within the overall airline fleet insured value. Since 1986 the overall fleet value has increased by an extraordinary 200% (plus)! Our researches indicate that there are currently excess of 350 aircraft valued at US\$ 100 million and over in operational service and slightly excess of 500 aircraft with a basic list price of over US\$ 100 million each, on order to airlines.

However, whilst aircraft insured values are an important subject for consideration, it is of course, the potential for resultant legal liability loss in the event of airline passenger injury and/or fatality which provides the major cause for concern. What of individual aircraft passenger seating capacities? Figure 7. demonstrates our understanding of the individual airline aircraft seating capacity breakdown of the current world jet/turbo prop fleet (excluding former Soviet Union built aircraft). It will be noted that approximately 6% of the world fleet of 16,000 plus aircraft are fitted with 350 (plus) seats, representing 9% of the airline jet fleet. Industry forecasts expect this figure will be considerably increased by the years 2014/15; perhaps to 20% or upwards i.e. circa 4,000 plus aircraft.

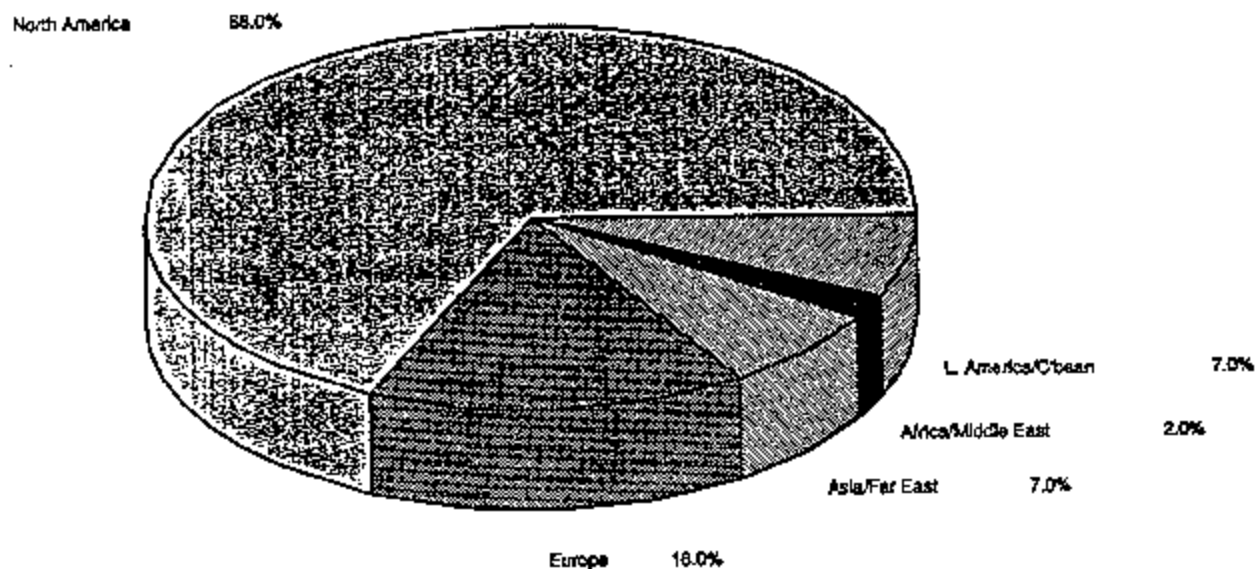
FIGURE 7. - The world jet and turbo prop airliner aircraft fleet - seat distribution:



Another factor by which we may determine potential for loss is to consider individual aircraft cycles. It is particularly interesting to note that the world airline fleet (excluding former Soviet Union built aircraft) is now flying excess of 31 million hours per annum, compared to around 22 million five years ago (an increase of 40% plus). Average annual cycles per aircraft are currently running at approximately 1,500 cycles per passenger aircraft and almost 1,100 cycles per freighter aircraft (overall average 1,405 cycles) with average daily utilisation standing at approximately 6.5 hours per passenger aircraft and 3 hours per freighter aircraft (overall average slightly less than 6 hours).

We should perhaps touch on "general aviation" (there are many definitions of "general aviation" - our very simple interpretation is ... *aerial observation, agricultural, air taxi [this seems to cheerfully hover between both the commercial and "general aviation" camps dependant on whose definition is under review], corporate/executive, private/recreation and instructional activity* ... Whilst the potential for major legal liability loss is of course much less than for commercial activity, it is sensible to offer our understanding of "general aviation" activity. "General aviation" is dominated by the United States; we suggest that circa 63% of the active world fleet (excluding China and the former Soviet Union for which we understand aircraft numbers are fairly low) are based in the United States; our geographical viewpoint, Figure 8., identifies our understanding of the world-wide distribution (the 68% figure for North America includes 5% for Canada):

FIGURE 8. - The current active world general aviation fleet (based on an estimated circa 280,000 aircraft):



Of the foregoing, we suggest that slightly excess of 80% are piston engine aircraft, circa 4% turbo prop aircraft, circa 3% jet aircraft, circa 5% rotor wing aircraft with the balance relating to various other types. Our data base further suggests that the world-wide "general aviation" fleet (excluding China and the former Soviet Union for which activity is, we understand, minimal) currently operates for circa 40 million hours annually, perhaps slightly more, involving circa 120 million annual movements.

Increases in aircraft values, increases in aircraft numbers and particularly the number of operational wide body aircraft, increases in traffic levels are met head on by increases in certain bird population levels - could this combination of circumstances result in an increase in accidents?

WHAT IS THE POTENTIAL FOR LOSS - IS THE SKY THE LIMIT?

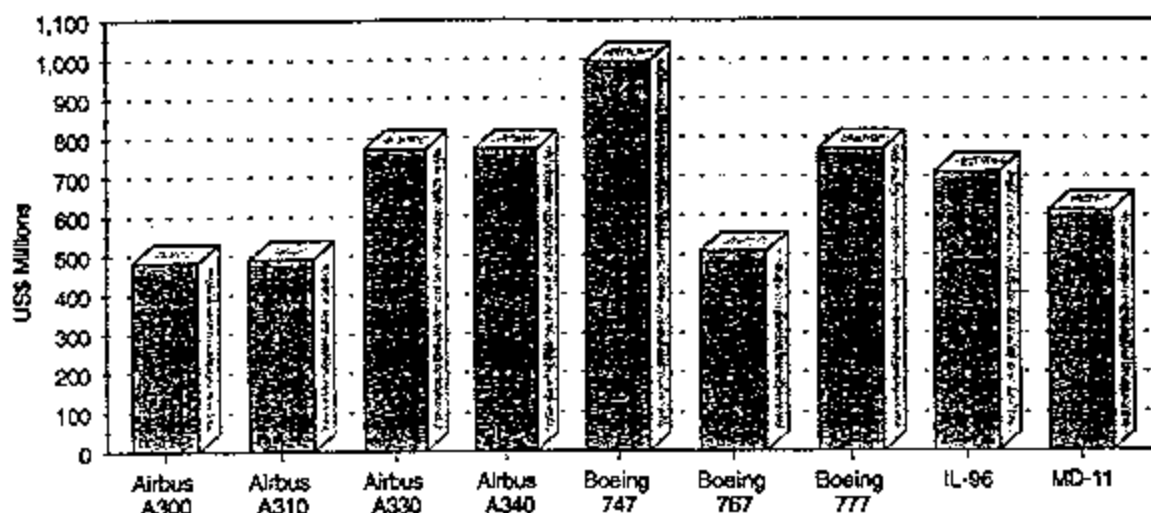
1994 calendar year airline loss levels were the highest on record and the single major contributing factor relates to passenger liability settlements and/or reserves, with potential liability losses arising from just the China Airlines and USAir accidents (26th April, 1994 and 8th September, 1994 respectively) approaching US\$ 600 million. Liability exposures are of considerable concern to airline insurers; United States passenger legal liability awards are edging ever upwards with US\$ 2.5 million (perhaps higher?) per person now considered by some the average (initial) reserve (with similar levels for Japan?). With regard to the (above mentioned) China Airlines loss we understand that relatives of some 121 passengers who died have filed a suit against both the airline and aircraft manufacturer claiming slightly more than US\$ 2 million a passenger (the airline earlier offered up to US\$ 154,000 a person). We have already mentioned the recent award arising from the 1989 British Midland Airways crash at Kegworth. Whilst none of these actions appear to involve an airport and/or air traffic control authority they quite clearly demonstrate award trends.

Ah well, you will say. These comments apply to the United States and the Far East - why should they affect us? It is well known that damage awards in the United States can involve fairytale figures; surely, we in the Old World adopt a more mature attitude to the question of damage awards? I suggest this is a questionable assertion; here in the United Kingdom, it would seem increasingly so. Sadly, it seems there is now a tendency for us to feel that we are all victims - nothing is our fault; someone must pay compensation (and lots of it) if something goes wrong and that someone is going to be the insurer (at least, while they have some money!). The well publicised case here of unhappy parents suing the management of a theatre for "trauma" suffered by a three year old child taken to see a production of Peter Pan, despite a warning issued by the theatre that the play was unsuitable for children below the age of 7 (a fact of which the parents were apparently aware) highlights an increasing insanity and inability to accept personal responsibility.

It is perhaps appropriate that we consider the important proposed changes to the international protocols affecting passenger legal liability awards i.e. the "IATA Inter-carrier Agreement". It is not necessary to reproduce the proposed agreement in full; merely to note that in essence, the purpose of the Agreement is to waive any existing passenger liability limitations [Warsaw etc. Conventions] so that *...recoverable compensatory damages may be determined and awarded by reference to the law of the domicile of the passenger...* By this simple device, the world finally becomes the oyster of the United States legal system. It is intended that the new agreement become effective either by 1st November, 1996 or the date of signing by the respective governments. A number of airlines have already signed their agreement. As to how this proposal will affect liability exposures under airport and/or air traffic control legal liability covers remains to be seen although it seems likely there could be some impact at least, particularly in the event of an accident involving United States domiciled passengers outside the United States. There will doubtless be many complications to resolve if this proposal becomes effective (i.e. initial indications suggest that defining domicile will provide hours of fees for the lawyers); as with all things, will the legal profession be the ultimate beneficiaries? It could be argued perhaps that the waiver of liability limits could dissuade plaintiffs from attacking other parties including airport etc. authority's in a move to circumvent Warsaw etc. limitations; conversely however, might such a development result in increased pressure on airline insurers to subrogate against an airport? An airline itself, following loss, might wish its insurers to take the appropriate legal measures to ensure that their (the airline) claims record reflects their own fortunes and is not blackened by the perceived failures of others.

If we make the assumption that the average passenger liability award in the United States now stands at circa US\$ 2.5 million a person, even a limit of US\$ 1,000 million any one loss appears potentially inadequate. Figure 9., presented perhaps as a scare tactic as much as anything else, identifies the major current production aircraft, showing potential cumulative losses following a total loss based on a 70% passenger load factor (with 100% passenger fatalities) and a settlement of US\$ 2.5 million a passenger.

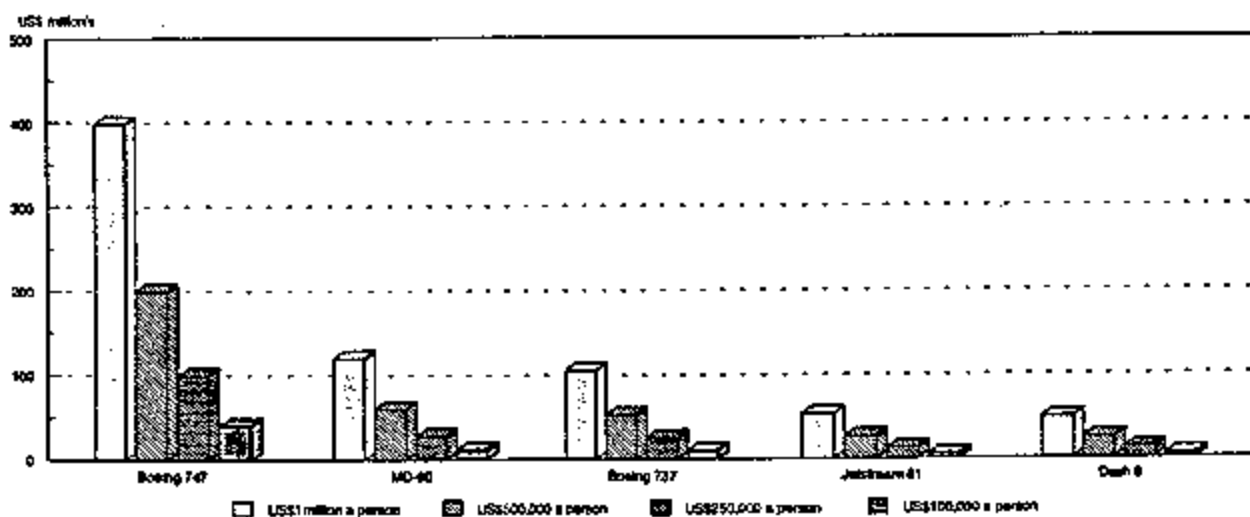
FIGURE 9. - Some projected passenger legal liability loss scenarios:



It must always be remembered that the above is based on a 70% passenger load factor; what would happen in the event of a 100% load factor? Also, our projections make no provision for the aircraft hull (insured hull values can touch US\$ 250 million) and any third party liability losses; in this regard we note the recent An-32 accident in Kinshasa, resulting in considerable loss of life on the ground. Similarly, there were 43 ground fatalities and a further 11 persons injured following the 1992 El Al Israel Airlines, Amsterdam accident. Additionally, we must always bear in mind that the foregoing illustration reflects claims assuming United States related exposures; awards elsewhere are not necessarily so high (yet!).

To enable us to view an overall picture, Figure 10. shows potential cumulative losses for some of the popular aircraft currently in service based on a number of average award levels, once again assuming a 70% passenger load factor (it must be borne in mind that it is essentially the loss of a high passenger capacity jet aircraft that provides the greatest exposure for the airport and/or air traffic control authority);

FIGURE 10. - Some selected passenger legal liability loss projections:



It is important to note that whilst we make reference to aircraft passenger load factors of 70% this must be viewed as a general average; in many cases, current passenger load factors are significantly in excess of this figure. Also, it is important to note that figures included in both the above illustrations do not include any provision for any aircraft hull loss content.

To close, we suggest that whilst the selected limit may be based, in some measure at least, on local legal systems and the level of domestic awards, international initiatives such as the "IATA Inter-carrier Agreement" will surely bring about a narrowing of national distinctions and must be fully considered when selecting the appropriate liability limits. We in Europe seem to daily witness the many tentacles of the European Commission merrily tickling away; like it or not, will we see a general standardisation of legal systems within the Union?

CONCLUSION

To summarise my earlier observations, I note that:

- airport legal liability insurance is relatively inexpensive and current insurers capacity levels are generally adequate to meet required levels of liability;
- individual insured aircraft values now touch US\$ 250 million;
- the wide body aircraft content of the world airline fleet is ever increasing;
- in general terms, bird populations, gulls, geese, (mute) swans (and legal eagles?) are increasing;
- might changing weather patterns result in changes to migratory patterns - bird dispersal strategies must be constantly reviewed;
- there is an increasing trend to seek legal remedies to compensate any and all misfortunes - international passenger legal liability protocols are under review - passenger legal liability awards are generally increasing - will courts be increasingly sympathetic to the plaintiff?

The best laid plans of mice and men do sometimes go astray; our vision, particularly these days, is sometimes obscured by detail and we miss the obvious! Is the sky the limit? New developments in engine manufacture (i.e. the GE 90 and Rolls Royce Trent engines) should help alleviate the problem, at least in part; even so, the bird strike problem will surely remain with us for as long as aircraft are flying.

Let us now offer a possible future loss scenario, set in the United Kingdom. The "IATA Inter-carrier Agreement" is in force and a Boeing 767 aircraft (insured value at circa US\$ 75 million) carrying 200 passengers crashes on take off as a result of a bird strike, 150 passengers are killed, 30 suffer serious disabling injuries and 20 walk away uninjured. Taking the recent Kegworth award as our bench mark let us assume a slightly more modest award of US\$ 1.5 million a person for passengers who became disabled; an average award of perhaps US\$ 1 million to the dependants of each fatality (this allowing for a few United States domiciled passengers); excluding any third party exposure, our proposed scenario results in an overall loss approaching US\$ 300 million.

On the evidence presented, I am sure that you will agree that the case for the maintenance of adequate airport bird dispersal techniques and airport and/or air traffic control legal liability insurance is compelling; I very much hope that my arguments have been persuasive. Whilst the possibility of a major loss may be slight, it is nevertheless real and must be kept in mind. Henry Kissinger suggested that "...the real distinction is between those who adapt their purposes to reality and those who seek to mould reality to their purposes...". There is always a need to both accept and adapt to, the current reality!

Thank you

APPENDIX 33

Evaluating the Cost of Bird-Related Damage to Civilian and Military Flights as a Vital Tool to Increase Flight Safety

EVALUATING THE COST OF BIRD RELATED DAMAGE TO CIVILIAN AND MILITARY FLIGHTS AS A VITAL TOOL TO INCREASE FLIGHT SAFETY

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ABSTRACT

In the last two decades numerous papers were presented at BSCE meetings, summarizing the data on damage from birds to civilian and military flight in various differing profiles. As far as we know no attempt has been made to try and evaluate the yearly economic damage from birds in the global scale. The reability of effecting the systematically data is improving as fast as the usage of computers has become so easy, and more and more air forces and flight companies publicize the data. In our opinion presenting the summing up of the financial data of the rate of damage to flight from birds is of vital importance to promoting the subject to decision makers so they will invest funds improving flight safety on subjects of manpower, research etc...By comparing the level of damage and treatment of the problem in each country will encourage the decision makers to treat flight safety more seriously on a local level and regional level (like the European market, or the cartels of insurance companies). In this paper we will try to present the first attempts to define the minimul and maximal estimates of damage in civilian and military flight based on published data. Unfortunately the information sources are limited in many countries and even in the western world the data bases of all air collisions with birds are partly reported . A few parameters which are the case for calculations will be presented:-1) the directory cost of the air collision 2) estimated of cost of power hours of repairing the damage 3) estimates of flight hours lost because of the collision 4) in fatalities of aircrew the cost of flight training assessment of the total cost. 5) other indirect costs.

As a few examples we bring Dobleer at all (1995) who estimates the damage from birds in 1994 in the U.S.A was 225 million \$. Thorpe (1994)summed losses of 1310 reported damage to engines between 1986-1990, average of 262 engines per year. Some of the occasions are especially high like the B-1B which collided with a pelican at U.S.A, 3 crew man were killed and the damage was 282 million \$, or the C-3 which collided with 12 birds - 24 crew were killed and damage of 190 million \$ incurred.

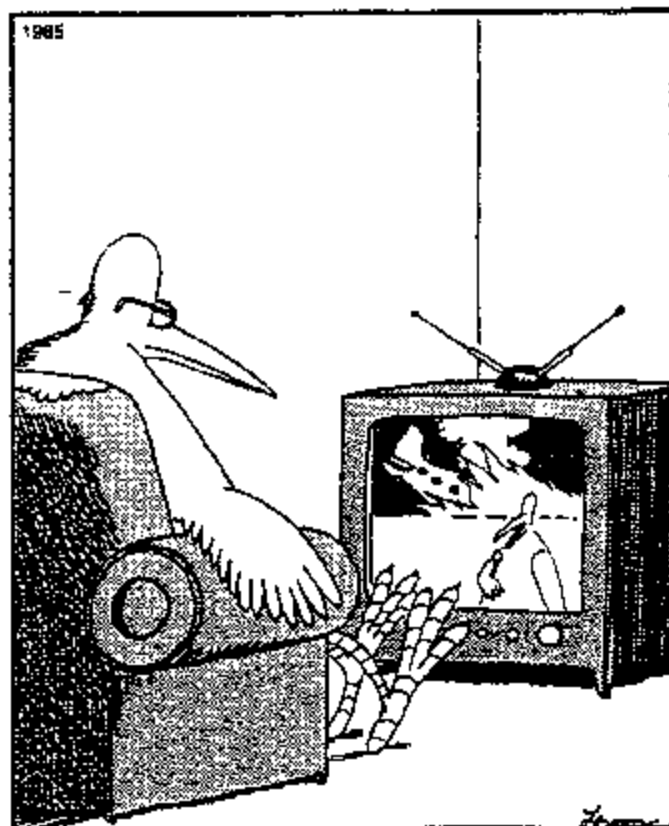
EVALUATING THE COST OF BIRD-RELATED DAMAGE TO CIVILIAN AND MILITARY FLIGHTS AS A VITAL TOOL TO INCREASE FLIGHT SAFETY

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SUMMARY

This paper attempts to evaluate the global cost of bird-related damage to civilian and military flights. We believe that the global yearly direct and indirect damage reaches several billion dollars. We suggest that the BSCE initiate the establishment of a global database for bird strikes as a tool for decision makers to invest money to increase flight safety.



"Details are still sketchy, but we think the name of the bird
sucked into the jet's engines was Harold Mecker."

INTRODUCTION

In the last two decades, numerous papers were presented at BSCE meeting summarizing the data on damage from birds to civilian and military flight in various differing profiles. As far as we know, no attempt has been made to try and evaluate the yearly economic damage from birds in the global scale. The ability to effect the data systematically is improving as fast as the usage of computers; additionally, a greater number of airforces, airlines, and airport authorities publicize the data.

A European database of military bird strikes has been established in the RNAF (Decker 1994, W.P. 20). By March 1994, the database contained information on 25,569 bird strikes from 9 airforces covering a period of 3 to 17 years. Richardson (1994, W.P. 21) summarized the circumstances of 131 accidents in which military aircraft crashed and 40 crew members were killed in 10 airforces. 14 fighter jets and one helicopter crashed between 1980-1994 in the Indian Airforce (averaging 1 per year). All aircraft crashed due to one species of bird: the Indian whitebacked vulture, *Pseudogyps bengalensis* (Satheesan, 1994, W.P. 23).

In many airforces, the data is still not collected and analyzed systematically, and many others are withholding publication of the data because of security regulations. For these reasons, it is almost impossible to get an accurate global picture of the rate and number of air collisions in military flights.

A quick scan through the literature reveals that the situation in civilian flight is almost the same as that in military flight. Thorpe (1994, W.P. 28) summarized the number of civilian air collisions between 1986-1990 based on the ICAO IBIS System: a total of 22,331 incidents occurred in 5 years, in which 3 aircraft were destroyed and 1310 engines were damaged. Dolbeer, Wright & Cleary (1995) summarized the damage caused by bird and other wildlife strikes to civilian aircraft in the United States in 1994: based on FAA data 2,150 bird strikes were reported, and 22% indicated some type of damage or other cost. An independent analysis of strike records for a major US airport estimated that fewer than 20% of all strikes were included in the FAA Wildlife Strike Database. They also estimate that the yearly damage probably exceeds the \$112 million estimated for military aircraft in the USA.

According to preliminary information presented in the Bird Ingestion Conference held on 11 January 1996 by the National Transportation Safety Board (NTSB), John Goglia, member of NTSB, claimed that only 15% of air collisions with birds are reported, and that bird ingestion represents about one-third of total aircraft damage.

In this paper we will try to estimate the damage of birds to military and civilian flights as a vital tool to present to decision makers, in order to convince them to invest more money, manpower, and research to increase flight safety.

MILITARY FLIGHTS

There is a large discrepancy in the character of air collisions between countries depending on their location on the globe: a country like Israel at the junction of 3 continents will face more air collisions in the migration season, despite its small size (74% of severe air collisions in Israel occurred in the migration month). The location of Israel on the Eastern part of the Mediterranean Sea attracts vast numbers of soaring birds over the limited air space. The soaring birds avoid crossing the sea, instead hugging the coastline, and thus the potential risk of colliding with these heavy birds, many weighing over 2 kilograms are much higher than in a country like The Netherlands, which will have a higher proportion of waders and a lower potential of risk. The Northern countries will have a higher risk during the summer when the birds are back in their nesting areas and the countries closer to the equator will have a higher risk in the winter, when the population of birds winter there.

The level of monetary damage to different airforces also depends on the type of aircraft used: F-15/1 costs \$100 million each, as compared to the Mig 21 or Skyhawk which costs only a few million dollars. A single pelican which collided with the strategic bomber B-1B in the USA caused \$282 million in damage and killed 3 crew members. The same level of damage occurred with 12 Canadian Geese which destroyed last year the EWACS in Alaska and killed 24 people.

There is currently no standardization of the prices of each aircraft; for example, the loss of an F-16 is calculated in the U.S.A.F. at \$16-17 million, but in the I.A.F. it is calculated as \$27 million. Also, the reporting of damages is not comprehensive: most airforces calculate only the direct damage to the aircraft and its parts, and do not deal with the much higher cost of manpower to obtain and repairs the parts, and to investigate the accident. If the pilot is injured or killed, the hospital costs and money required to psychologically treat the family, and the lost cost of training the pilot should also be included. Unfortunately, we tried but could not obtain this data from the IAF, since it is considered classified information. We believe that the true, comprehensive cost is at least two times (if not more) as high as the direct cost of the damage to the aircraft.

Sqn. Ldr. Bob McCloud, FS2b, published in 1992 a paper with statistics of air collisions with birds in the UK. McCloud found that "the Maintenance Analysis and Computing Division (MACD) carried out a most valuable study during 1991 to determine the cost of birdstrikes both in terms of hard cash and operational capability.... During the period of the study (Oct 89 to Sep 90), nearly 61,000 man-hours were expended on birdstrike repair or, in other words, a permanent work force of 40 men at a cost of 1 million pounds. The cost of spares accounted for a further 13 million pounds and the total downtime was equivalent to 14.4 aircraft being permanently grounded.... If you have a birdstrike, there is a 20% chance that you will not have achieved all of the aims of the sortie and when you land, it is likely that your aircraft will be off-line for the rest of the day."

In table 1, we published data of 6 airforces which are incomplete and difficult to compare, but can give an idea of the scope of the problem. In the IAF, the total cost of direct damage

2) It is estimated that the data provided on birdstrikes is only 15-30% of the real picture. The Statistic Working Group of the BSCE suggests that the BSCE urge governments, airforces, airlines, airport authorities, and other organizations like the European Market and insurance companies to cooperate and coordinate a more efficient data collection system.

3) The BSCE should push for greater publicity of the problem at different levels by producing explanatory material, videos, and publishing data.

4) We suggest that the BSCE be the leading organization to initiate a global database for civilian and military birdstrike data to be established and funded by airlines and governments who are suffering from the problem. The database will be initiated by urging 2 representatives from each country (one for civilian and one for military aviation) to collect and analyze their own data on one global system, making overall analysis easier and more efficient, as currently done in the 13 airforces of the European Military BirdStrike Database in the RAAF.

ACKNOWLEDGMENTS

This paper and vision are an outgrowth of discussion with many of my colleagues: Prof. Sidney Gauthreaux, Prof. Yoram Yom-Tov, Drs. Luit Buurma, Dr. William S. Seegar, and Dr. W.J. Richardson. I wish to thank the Israeli Air Force officers who gave me the opportunity to get involved in radar research, and especially to Col. B., head of radar units in the IAF, and Col. E., head of the flight safety unit. Thanks also to the Airport Authority in Israel and especially to Mr. Yair Ganot, Mr. Uri Orlev, and Mr. Jerry Yashon, from El Al captain Ilan Hyatt and Yoav Regev, and Mr. Richard King, flight insurance expert from the U.K. Additional thanks to all of my colleagues at the Society for the Protection of Nature in Israel and at Tel-Aviv University, and especially to Prof. Terkel, Dan Alon, Judy Shamoun, Sacha Litman, and Betty Key. Finally, thanks to my friends at the Armoured Corps Memorial at Latrun, Maj. Gen. (Res.) Arie Keren, and Lt. Col. (Res.) David Gal'am.

**If you think safety
is too costly,
try an accident!**

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Table 1: Evaluating the cost of Damage of 6 Air Forces

A) Country/ Air Force	B) No. of air- collisions (no. of years)	C) % with damage	D) Estimation of damage	E) Average of air collision with damage	F) No. of aircrafts lost
1) U.S.A.F (Arlington 1994) U.S.A	1989-1993(5) 13,427 (2685 per year)	15% (402 per year)	\$85 million = (\$17 million per year)	\$42,288	8 (1.6 per year) 6 F-16, 3 T-38
2) R.N.A.F (Decker, 1994) The Netherlands	1978-1993(16) 2709 (168 per year)	30% (55 per year)	?	?	4 (0.25 per year) (Richardson, 1994)
3) G.A.F (Decker, 1994) Germany	1979-1992(14) 7328 (523 per year)	20% (105 per year)	?	?	7 (0.50 per year) (Richardson, 1994)
4) R.A.F (Decker, 1994) U.K	1980-1993(14) 9534 (681 per year)	40% (272 per year)	15-20 million per year (Thorpe, 1994 W P1)	64,338 (\$96,507)	15 (1.07 per year) (Richardson, 1994)
5) F.A.F (Decker, 1994) France	1977-1992(16) 2526 (157 per year)	90% (142 per year)	?	?	4 (0.25 per year) (Col. Dudret, P3R. COM.)
6) I.A.F (Leshem, 1994) Israel	1972-1994 (22.5) 2639 (117 per year)	29% (34 per year)	\$109 million 1983- 1995) \$8.3 million per year	\$247,117	7 (0.29 per year) (Leshem, 1996)

between 1983-1995 was \$109 million, an average of \$8.3 million per year. Most of these data come after we succeeded in dramatically reducing collisions in the migration season by 88% since 1984. If the research and the regulation of Bird Plagued Zones (B.P.Z.) had not been undertaken, the damage would have been an order of magnitude higher.

The IAF's fighter planes are mainly F-16s and F-15s, and soon will get the F-15/I, which will raise the potential cost of damage **two orders of magnitude higher** than only two decades ago, when the airforce was composed of Mirages, Skyhawks, and Phantoms.

CIVILIAN FLIGHT

Thorpe (1994) showed that between 1986-1990, 4,466 accidents were reported per year, and 262 engines were damaged or lost per year. As indicated by different sources, it seems that only about 15-20% of the real cost of damage is reported, bringing the numbers to around 20,000 air collisions per year and damage or loss of 1300 engines per year.

Richard King (Per. Com.), an expert in flight insurance for different leading insurance companies, reports that in most airlines have a \$800,000-\$1,200,000 deductible for accidents. This might be one of the reasons that the reporting rate and knowledge of accidents is less than the true numbers. It is likely that airlines only report major damages.

Boeing engines are expensive and cost between \$1-5 million. The price for aircraft that can hold more passengers is rising rapidly, as is the daily rate of take-offs and landings at airports, thus raising the potential for air collisions with birds. Dolbeer et al. (1995) revealed that the total reported down-time to aircraft in the USA in 1994 was 40,280 hours. Richard King (Per. Com.) claims that **the comprehensive cost of each collision is about 4 to 5 times higher than the direct cost of the damage**. For example, an engine of an El Al Boeing 737 ingested a hooded crow on take-off from Ben-Gurion Airport for New York in April 1996. The pilot was forced to land the plane in London because the engine lost power. It was discovered that several blades of the engine had been destroyed in the impact. All of the passengers had to be taken to a hotel, and El Al flew in a replacement engine from Amsterdam. Three other scheduled flights for that aircraft had to be canceled, and this domino effect cost El-Al 5 times more than the direct cost of the damage to the engine. Also in the USA, the comprehensive cost of damage is 4 to 5 times higher than the direct cost of damage (Seegar, Per. Com.). Seegar claims that the yearly comprehensive cost of damage from birds in the USA only reaches \$1-1.25 billion.

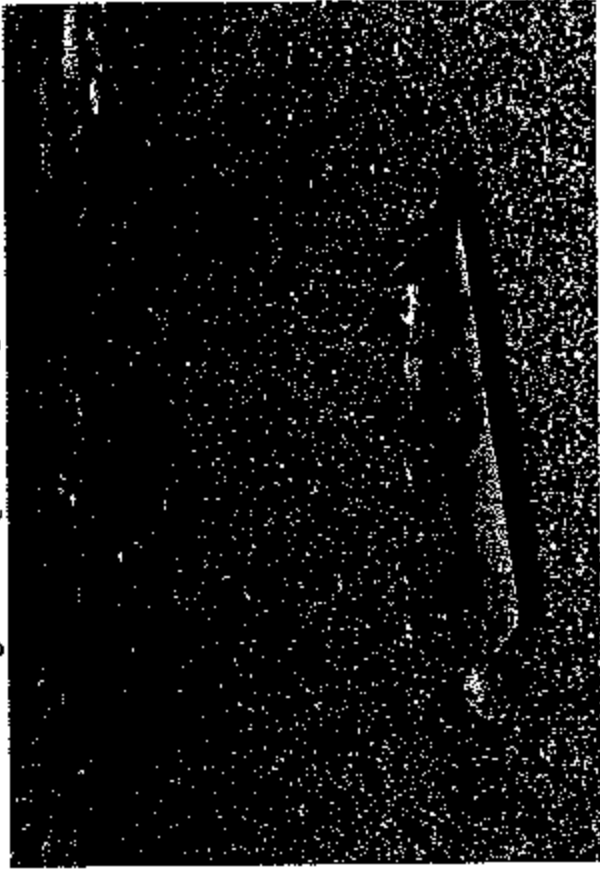
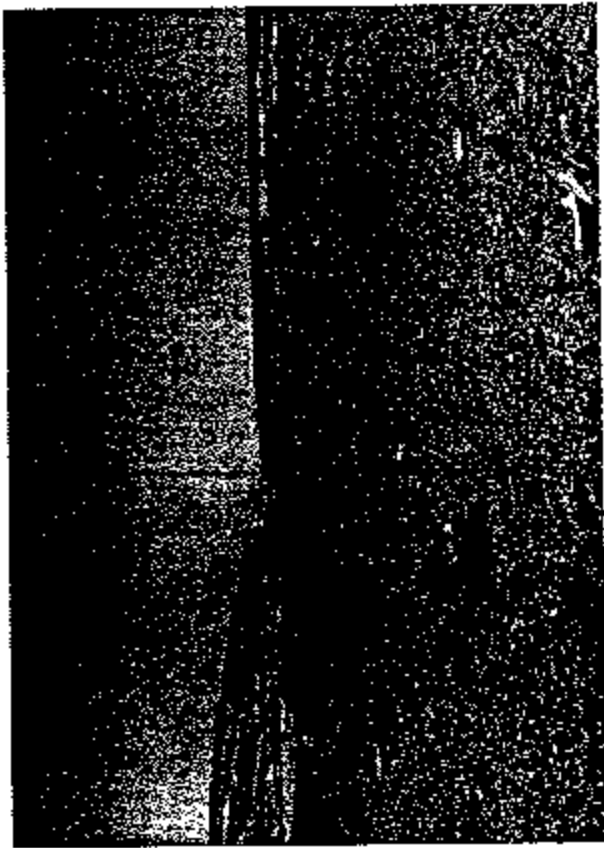
As previously stated, there is an urgent need for a reliable global database. It seems that the yearly damage to civilian and military aviation from birds exceeds several billion dollars per year.

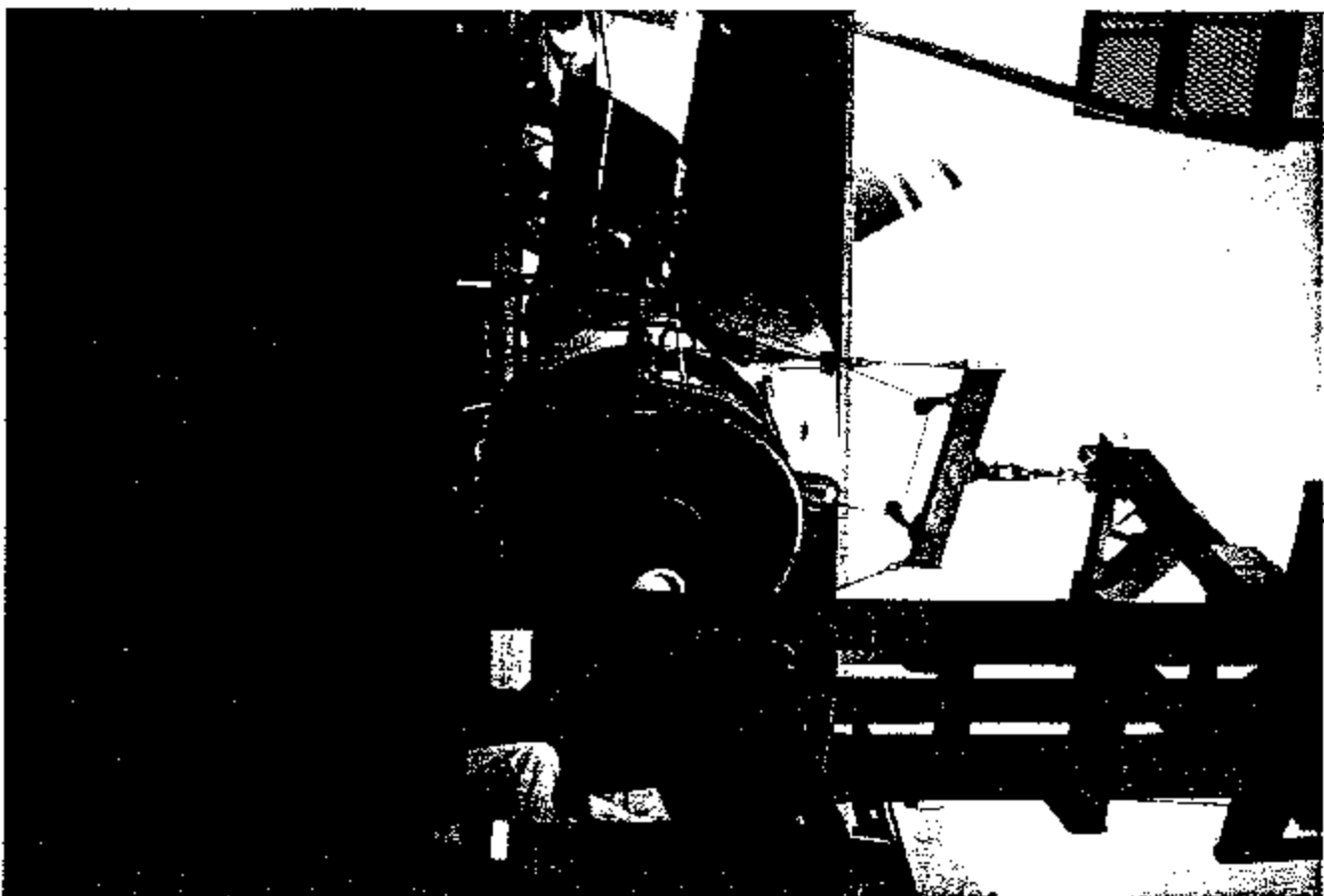
CONCLUSIONS

- 1) Evaluating the cost of bird-related damage to civilian and military aviation can be a vital tool for decision makers to take action to increase flight safety.

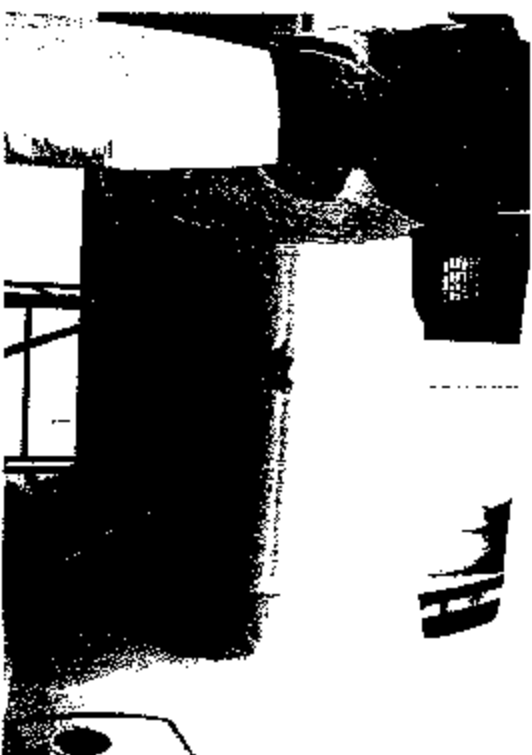


On 10 August 1995, 5 days before we started regulating the Bird Plagued Zone (B.P.Z.), preventing low level flights, an F-15 flying 550 knots, 1000 feet AGL over the Negev Desert, Israel, collided with 3 migrating white storks. Both the pilot Capt. Levy and navigator Capt. Vivente were killed. The aircraft crashed 5 seconds after 2 storks hit the body and the third bird penetrated the engine. **Above left:** Remains of 2 of the storks. **Below left:** Remains of the F-15 scattered in an area 400x400 meters. **Above right:** The engine **Below right:** Remains of the tail.





Left: 27 September, 1994: EL AL flight 001, a Boeing 747, while taking off from Ben-Gurion Airport collided with six chockbars. Four penetrated engine number 3 (82.8 million damage), and two hit the side of engine number 4. Above: 28 December, 1988: A golden eagle penetrated the engine of an F-16 over the Judean Desert, Israel, while flying 420 knots, 300 feet AGL. The F-16 crashed but the pilot ejected at the last second. Below: December, 1995: Remains of a buzzard collision with a Hercules (C-130) over the Northern Negev.



APPENDIX 34

**BRIS: A Computer Based Bird Remains Identification System.
Further Developments**

**BRIS: A COMPUTER BASED BIRD REMAINS IDENTIFICATION SYSTEM.
FURTHER DEVELOPMENTS.**

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Summary

A user-friendly computer information and identification system for bird remains (BRIS) is being developed by the European Centre for the Identification of bird Remains (Zoological Museum; University of Amsterdam), the Expert Centre for Taxonomic Identification (ETI) and the Tel Aviv University. The BRIS, based on ETI's Linnaeus II software, consists of various parts. A multimedia database stores detailed textual and pictorial information on feather structures. An innovative computer-guided identification system assists the user to recognise the identification characters and to identify the taxa. An interactive geographic information system allows for quick geographic searches through the data. Also general information on bird species, such as descriptions, diagnostics, colour pictures, distribution maps etc is included. BRIS now covers 200 European species and will be released on CD-ROM in 1996. International cooperation is sought to expand the system with more species and further information. We actively solicit comments, suggestions and input from ornithologists and others who are working on the identification of bird remains. We propose an international network of specialists to expand the BRIS. In this paper the methods of identification and the implementation of the geographic information system are discussed.

BRIS: a computer based Bird Remains Identification System. Further developments.

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Abstract. A user-friendly computer information and identification system for bird remains (BRIS) is being developed by the European Centre for the Identification of Bird Remains (Zoological Museum; University of Amsterdam), the Expert Center for Taxonomic Identification (ETI) and the Tel Aviv University. The BRIS, based on ETI's *Linnaeus II* software, consists of various parts. A multimedia database stores detailed textual and pictorial information on feather structures. An innovative computer-guided identification system assists the user to recognize the identification characters and to identify the taxa. An interactive geographic information system allows for quick geographic searches through the data. Also general information on bird species, such as descriptions, diagnostics, colour pictures, distribution maps etc. is included. BRIS now covers 200 European species and will be released on CD-ROM in 1996. International cooperation is sought to expand the system with more species and further information. We actively solicit comments, suggestions and input from ornithologists and others who are working on the identification of bird remains. We propose an international network of specialists to expand the BRIS. In this paper the methods of identification and the implementation of the geographic information system are discussed.

Introduction

Reliable identification of bird remains is of vital importance for flight safety statistics. Bird collisions are hazardous, costing many millions of dollars world-wide. Also in other fields like archaeology, criminology, studies on food consumption of carnivores, and in enforcement of nature protection laws, identification of bird remains is conditional. In all these cases remains of birds, sometimes very small, need to be identified. Identification of pieces of feather, skin, and blood requires special expertise. Once the species name is known, information on migration routes, cruising height, flocking, foodweb relation etc. can be obtained from the literature, compulsory to avoid further collisions.

Presently identification of feather remains depends on skilled and experienced scientists with access to a large collection of microscopic slides for comparison, since this information is not readily available in the literature. Feather characters need visual recognition, which is extremely difficult to describe in text. The complicated process of identification based on feather microstructures is not very well suited for dichotomous keys. New approaches with the help of computer technology are supportive to document the experts view. Also reproduction of thousands of photographs of microscopic details of various feather structures in a traditional way is not feasible, while publication in digital form reduces publishing costs considerably. ETI's multimedia *Linnaeus II* software (fig. 1) offers new opportunities to taxonomists to produce completely illustrated keys based on feather characteristics supported by an extensive image library, a database with descriptions and references, and a geographic information system for distribution information.

Developments

The European Centre for the Identification of Bird Remains at the Zoological Museum in Amsterdam offers for many years expertise for various parties. A long standing cooperation with the and Royal Netherlands Airforce (RNLAF) was mutually beneficial, both for improving identifications as for devising measures to prevent damage.

In 1994, this centre and ETI started a project to build a computer based Bird Remains Identification System

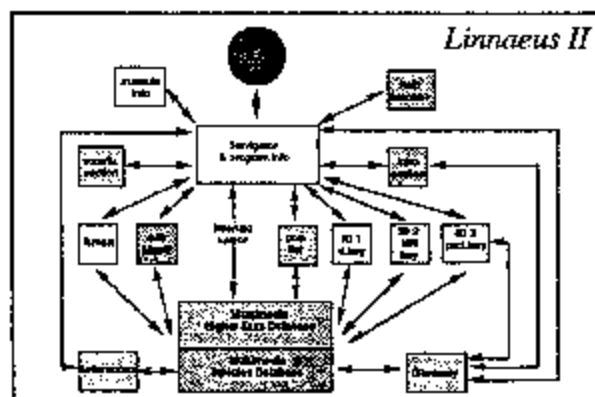


Fig. 1. The modules and structure of the interactive *Linnaeus II* program. Via the "navigator" the user obtains access to the various hyperlinked sections. 1. The multimedia (text, pictures, sound, video) database for higher taxon and species, which can be accessed directly via the taxon list or via the identification module. 2. The three identification modules (dichotomous key, multiple entry key, or pictorial key) support the user in identifying a species (ID1, ID2, ID3). 3. A geographic information system (MapIt) allows searching via distributional data. 4. The Timex module makes selecting a particular time stream possible. In addition there are several hyperlinked supporting modules. 5. The Glossary provides explanations and illustrations of terms used. 6. The reference section contains all literature cited. 7. The Introduction section provides general information on the group treated or on methodology. 8. The contributors section contains information on the authors and their institutions. 9. A special info section on the institute or data provider can be added if required.

On-line helpfunctions for all parts of the program can be switched on and off in the navigator section.

(BRIS) based on ETI's Linnaeus II software (Schalk and Los 1994). The system (fig. 2) comprises a multimedia species database storing detailed textual and pictorial information on downy barboles of body feathers and general information on the bird itself. Equally important to the extensive image library is the interactive identification system, based on a species/character/state matrix, allowing the user to quickly identify feather remains. The computer-assisted identification key follows a multi-entry approach with the possibility to select any character state in any order thus providing free (combinations of) choices depending primarily on observations. Moreover, the key provides a measure of probability on the identified species.

The system is supported by an "on-line" interactive illustrated glossary of terms, a reference database, and a feather preparation (methods) section. A progress report of this project was published in the BSCE 22 proceedings (Prast et al. 1994). Since 1995, Tel Aviv University, the Israeli Airforce (ILAF) and the Society for the Protection of Nature Israel (SPNI) joined the project. In Israel, at the Tel Aviv University, feather remains collected by the ILAF were studied macro- and microscopically since 1992. The identification was also based on characters of downy barboles (Brom 1986; Laybourne and Dove 1994). This allowed to improve and extend the system up to 200 species from the western palearctic and to well over 1000 photographs made with light- and scanning electron microscope (SEM).

The interactive geographic information system in ETI's Linnaeus II software, was applied for storing distributional data of the species, thus supporting geographic searches. A CD-ROM with the system will be published in 1996. Here we present an account of approaches used to combine the bird feather data sets from different researchers and institutions. We actively solicit comments, suggestions, and input from anyone working on the identification of bird remains and propose to create an international network of specialists to expand the system further.

Standardising methodology

Data, measurements, and terminology of the various structures were standardised resulting in extended expertise in downy structures. Microscopic preparations for the study of these structures can be made using different techniques, each with its specific advantages and drawbacks. In Amsterdam dry slides for light microscope (LM) were used (Brom 1986). In Tel Aviv, washed feathers were examined with the SEM (Laybourne et al. 1992) and the light

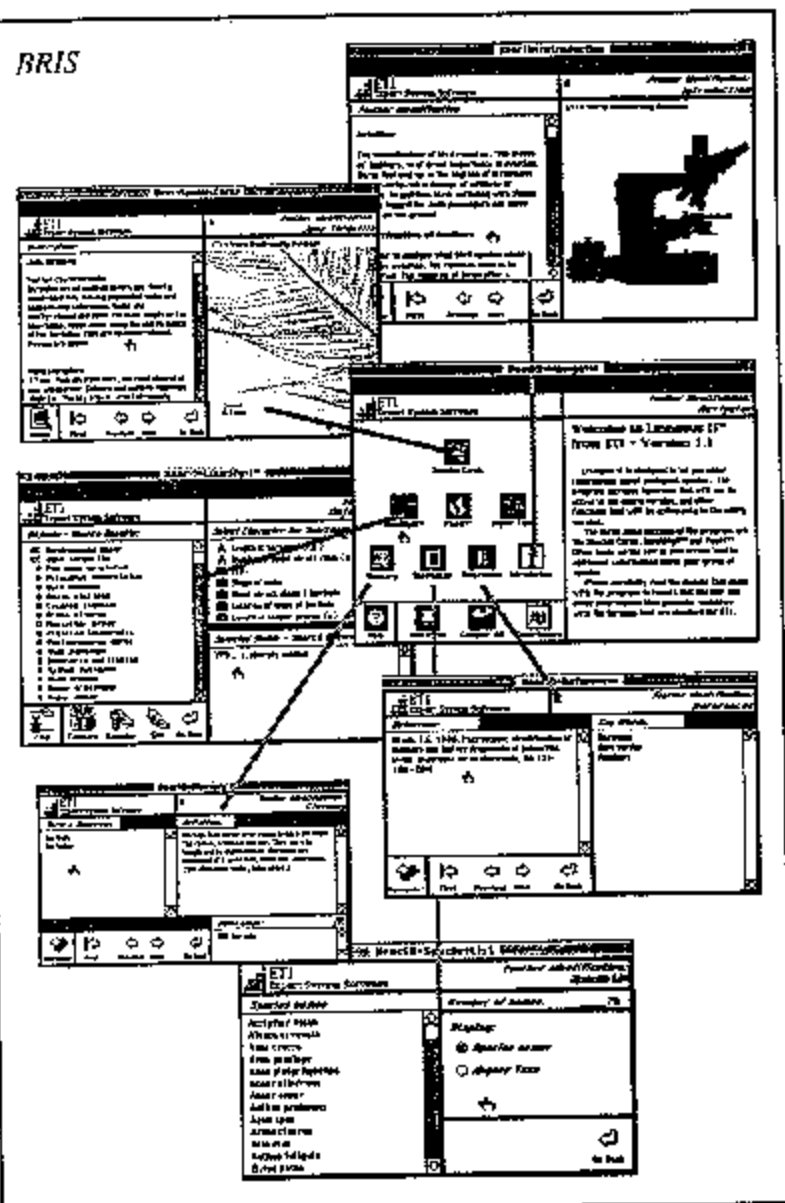
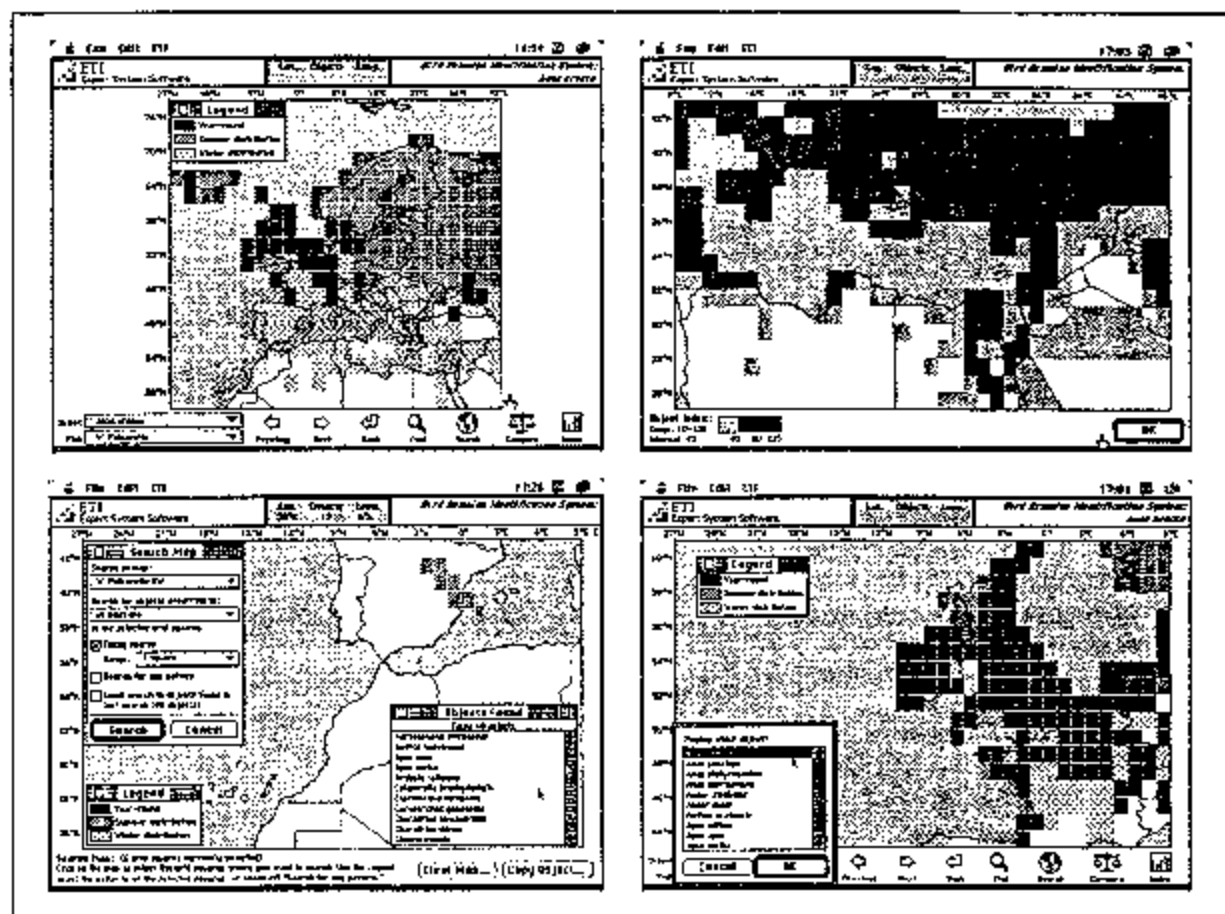


Fig. 2. BRIS based upon the Linnaeus II software consists out of various modules that can be accessed from a central point: the so-called Navigator. The Introduction section contains general information about features and methodology. The Species Database contains detailed information on the feather characteristics (text and pictures) and general information about the species. The Identify module is the expert system that assists the user in identifying the feather remains. An illustrated glossary is hyperlinked with the database and identification module and allows the user to quickly look up a specialized term. It can also be accessed directly from the navigation. A Reference section contains all relevant literature on the subject. The Species list allows the user to directly access the species database via the list of species or higher taxa. The geographic information system (Map) that forms part of BRIS is detailed in figure 3.

bedded in Flo-Text (Laybourne and Dove 1994) (recently renamed Shandon Mount, Shandon inc.). Although we both have worked independently before starting this co-operation, both our methods were an extension of earlier studies on microstructures of the downy parts of feathers (e.g. Chandler 1916; Day 1966; Lucas and Stettenheim 1972). Comparison of both methods supported its compatibility.

Distribution and concentration of pigment is best visualised in the embedded preparations. Some enlarged nodal structures, such as in Anatidae may appear pigmented in dry slides, turned out to be unpigmented in the embedded slides. Also stippled pigmentation observed in embedded slides could not be observed in dry slides. Different nodal



it is easy to separate the bell-shaped nodes of passerines from the vase-shaped nodes of waders, which characters are hard to observe in dry slides. On the other hand, preparation of dry slides is less complicated under field conditions and unpigmented structures like villi and short prongs are easier to discern. In the methods section of the BRIS CD-ROM, special attention is given to these methods and their application.

The standardised identification system in BRIS is based on a matrix, including all the characters examined. The character states define as many states as possible to improve the 'resolution' of the identification process. The matrix includes both descriptive information and measurements. The quantitative characters are approached by subdivision of character states into intervals. A species is placed into its specific interval by selecting at random from five test samples. Measurements are from the basal parts of barbs. The descriptive characters define node and internode shape, node and prong distribution, and pigmentation. Standardising the two datasets induced clarification of the feather descriptions for all species examined. Though characters may overlap between different character groups, the unique combination of the characters will lead to identification; the more characters are defined, the lower the taxonomic group that can be identified. The expansion to 57 families with 200 species required the establishment of new characters and character states. Finally, a single identification key was created for all 200 species. Now in total 47 character states spread over 11 characters are used for identification (table 1)

Fig. 3. The geographical information system MapIt is created from the Navigator. MapIt shows distribution maps of 200 bird species. For each species the user can choose between the general distribution map of the western Palearctic region (a) or one of the six underlying maps (b), showing the different parts of the western Palearctic region in more detail. Furthermore it can be used as a tool in the identification process by providing a list of bird species found on a particular urn (c). Finally MapIt offers the possibility to compare areas by estimating for each area a biodiversity index. Ranges and intervals are user defined (d).

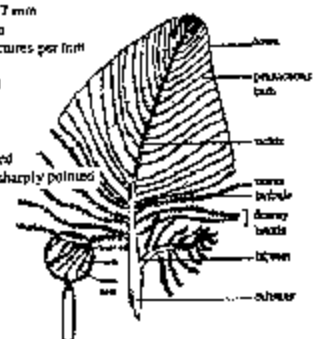
Interactive geographic information

Apart from microscopic identification, an important tool in the identification process is the geographical position where the actual strike occurred. A known location may reduce the number of bird species theoretically involved. ETI developed an interactive geographic information system for the Linnaeus II software named MapIt, for storing distribution data of each species (Fig.3). MapIt displays distribution patterns of the 200 species, with for each species the general distribution in the western Palearctic region, or one of the six underlying maps, showing different parts of the western Palearctic region in detail. MapIt can support the process of bird identification by providing a list of species in a particular bird strike area selected by the user. This way the number of possible suspects may be reduced. Another option is to compare areas by estimating for each area the number of species occurring in that area. We intend, in a later phase, to further improve the bird distribution data with details per season or even per month, including, for migratory birds, migration routes and cruising height.

An international network of specialists

One of the first steps in solving the problem of collisions between birds and aircraft is establishing which bird spe-

Table 1. List of characters and states in the identification system. Most characters are qualitative. The characters 1, 2, and 7 have quantitative values in discrete intervals (character states). Measurements are from basal parts of barbs.

1. Length of barbs shorter than 1.0 mm between 1.0 and 1.7 mm longer than 1.7 mm		7. Length of longer prongs absent longer than adjacent internode between lengths of 1 and 1/2 adjacent internode between length of 0.01 mm and 1/2 adjacent internode shorter than 0.01 mm (rare)
2. Number of nodal structures per unit fewer than 20 between 20 and 30 more than 30		8. Distribution of prongs at barbs prongs absent mostly at proximal part mostly at distal part even length and equally distributed even length and unequally distributed
3. Vili absent roundish or knobbed recurved and (or) sharply pointed		9. Location of prongs at nodal structures absent mostly at one side at both sides
4. Shape of nodes absent slightly thickened ring-shaped triangular vase-shaped bell-shaped diamond-shaped quadrilobed		10. Distribution of pigment pigmentation slight or absent concentrated in nodes stippled pigmentation concentrated in nodes and filling less than 50% of internodes uniformly in nodes and filling more than 50% of internodes even and translucent concentrated only in internodes
5. Comparison of nodal structures along one barbs all nodal structures about the same size, or a general increase in size abrupt increase / decrease in size		11. Shape of internodes all are straight some are kinked
6. Location of nodes nodes absent regularly distributed along entire length of barbs at proximal part of barbs detached (multiple nodes) present along less than 30% distal part present along 30 - 70% of distal part present along more than 70% distal part		

cies are the most accident prone' (Brom 1986). Using both microscopic and macroscopic methods to identify feather remains, a majority of the material can be assigned to species (Shamoun and Yom-Tov 1994), thus affecting bird strike statistics (Buurma and Brom 1979) and considerably increasing the quality and value of bird strike reports (Buurma 1984; Buurma and Dekker 1990). Reliable birdstrike statistics can only be integrated and evaluated when all feather remains are identified with standardised methods (Brom 1991). These data will lead to a better insight in bird behaviour, including flight tracks and periods of bird activity. This all will promote better preventive measures. Standardisation of methods will also improve proper identification of bird remains (Brom and Wattel 1990). BRIS will offer an excellent opportunity to distribute standardised identification keys, as well as a feather image library. Also, it offers the possibility to combine available expertise in one single system, and to distribute it to users world-wide at reasonable costs. The European Centre for the Identification of Bird Remains together with the Tel Aviv University and ETI will release the BRIS CD-ROM in a package which includes an option for users to enter a contract with the centre for further expertise and support.

BRIS is constructed in an "open" way, it may be expanded with more species and to other types of information, like other feather parts, macroscopical feather characters, skeletons skulls, geographical or ecological information and migration routes. Expanding the list of identification characters or states is not restricted. The combination of different data sets will further enhance the system and its usefulness. Building such a highly specialised system is a job of specialists and should be based upon international cooperation and data exchange. We solicit other experts to join an international network for collaboration to cover more taxa and areas.

Acknowledgements

The authors express their thanks to RNLA, ZMA, ETI, University of Tel Aviv, ILAF and SPNI for their support and assistance in this project. Special thanks are directed to Mohammed Zandvakili for his help in digitising hundreds of slides and photo's.

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APPENDIX 35

Falconry and Bird Control of a Military Airfield and a Waste Disposal Site

Falconry and bird control of a military airfield and a waste disposal site.

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Germany

Summary

The paper reports results of a study about the effect of falconry on bird control at a military airfield and a waste disposal site over a period of one month with four peregrine falcons, two gerfalcons and one hybrid falcon near Cuxhaven, Germany. The main target species were gulls during 130 flights. For analysing the effects on flocks different parameters like weather condition, number of present species, distance between falcon and prey, hunting success, time of flight and scaring etc. were ascertained. By the use of correlation we tested the coherence between flight-time and scaring-time or number of the present birds respectively species with the scaring-time. There was no significant correlation found. By comparing the scaring-time between the military airfield and the waste disposal site, the period between take wing and return of the flocks at the airfield was longer.

On the basis of this results we cannot recommend falconry because the success by using falconry for bird control is correlated to a lot of different factors and the effort is not proportional to the success.

(Key words: falconry, bird control)

1. Introduction

There is a long tradition to use birds of prey for scaring birds from airfields. But unfortunately you can find only a few current information about the circumstances of the operation respectively you find scarcely a detailed analysis of the efficiency of this method (CHAMORRO, 1994). The Birdstrike Committee Germany does not recommend the use of birds of prey on civil airfields for different reasons (KEIL, 1984), for example: high personnel and financial costs, limitation to daylight hours, purchase of falcons in accordance to the natural conservation laws, flight safety hazard by the hunting falcons etc. Now some of these aspects changed and there is a need of a new assessment. With the objectives to collect data during the flights falcons were launched against birds at the naval airfield Nordholz and the neighbouring waste disposal site of the City of Cuxhaven.

2. Methods

The trial is carried out by an experienced falconer and his assistant who recorded all the flights. Every flight was documented on special multiple choice minutes which recorded all important parameters like: place, date, time, weather conditions, present bird species, flock size etc. In these minutes we tried to document all parameters useful for the final analysis. In table 1 you find a drawing up of the falcons (sex and age) respectively their number of flights and successful predation. The falconer launched peregrine- and gyrfalcons and in some cases birds from crossbreeding of gyr- and peregrinefalcons. Most of these individuals were juveniles. When the trial started all birds were well trained, and already 64 herring gulls were caught.

Tab. 1 Falcons at the trial

species/name	sex	age	number of the flights	successful flights (number)	(%)
Peregrine W1	female	juv.	21	23	74
Peregrine W2	female	juv.	17	9	53
Peregrine W3	female	juv.	19	10	53
Peregrine W	male	adult	1	0	0
Gyrfalcon G1	female	juv.	12	8	67
Gyrfalcon Fritz	male	juv.	36	30	83
Hybrid					
Gyrfalcon/ Peregrine	female	juv.	9	5	56
Gyrfalcon/ Peregrine Mike	male	adult	4	1	25
Gyrfalcon/ Peregrine Jumbo	female	adult	1	0	0
total			130	86	

The area of the naval airfield Nordholz covers 585 ha mostly meadows (60%), forestry (16%) and traffic area (17%). The surrounding is used mostly for agricultural purposes. The military airfield is 8 km far from the coast. The occurrence of birds on the airfield is highly influenced by the low distance to the sea. There is a waste disposal site 3 km north of the airfield. All over the year you find the following species: black-headed gull, herring gull, common gull, starling, lapwing and rook.

For analysing the dates we used the statistic package of SPSS.

3. Results

Between the 9th of October and the 17th of November 1995 130 flights were recorded, only at 5 days no falcons were launched. On average 4 flights per day took place. Most of the flights (99) were carried out at the waste disposal site, and only 28 at the airfield because of the frequent absence of birds.

At 130 attacks 86 successful flights were recorded. Mostly herring gulls were captured on the waste disposal site where 72% of the flights were successful but only 28% on the airfield with just 3 gulls captured. In some cases the attacks started at the airfield and the falcon flew after a lack of success straight away to the waste disposal site. Table 1 summarises the number and the course of the flights of the single falcons.

3.1. Comparison of flight time and scaring time

There are differences between the recorded flight time at the airfield and the waste disposal site. On the waste disposal site the flight time is on average only the half ($\bar{x} = 2,44 \pm 3,60$; $n = 95$) of the time where falcons on the wings on the airfield ($\bar{x} = 6,85 \pm 6,83$; $n = 26$). In parallel run the scaring time: at the waste disposal site birds return on average of 16 minutes ($\bar{x} = 15,87 \pm 10,97$; $n = 76$) in contrast on the airfield it takes twice as much ($\bar{x} = 27,95 \pm 31,75$; $n = 22$). The reason for this may be caused in higher rate of successful flights at the waste disposal site. Flights with prey take only a little time. After this the situation is becoming more stable. This is documented too by the shorter scaring times of successful flights in contrast to unsuccessful attacks on the waste disposal site. On average successful flights scared flocks for 18 minutes ($\bar{x} = 18 \pm 10$; $n = 71$) in contrast to unsuccessful flights with 22 minutes ($\bar{x} = 22 \pm 23$; $n = 28$) scaring time.

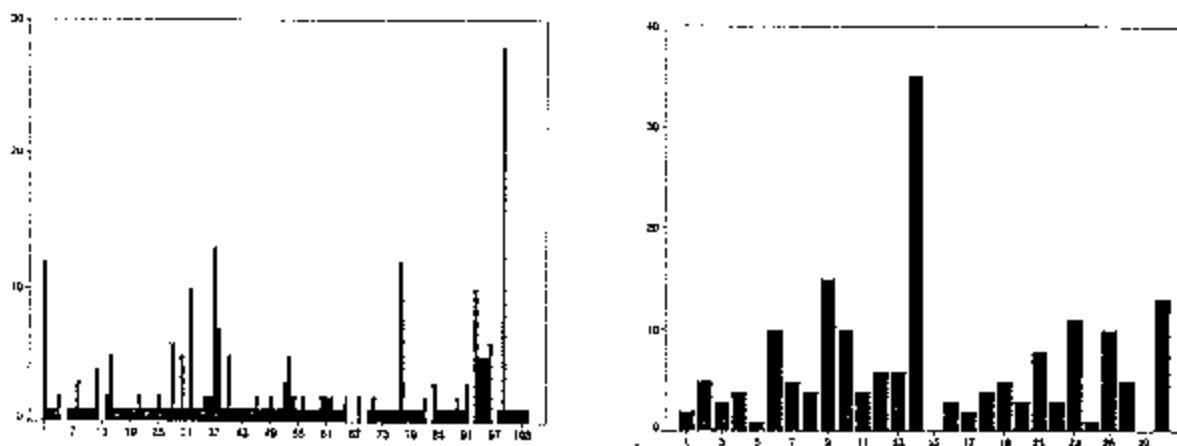


Figure 1: Recorded flight time at the waste disposal site (left) and at the military airfield (right). Y-axis: the recorded flight time in minutes.

3.2. Trends of flight time and scaring time during the trial

Apart from the comparison of the mean values we asked if there are any effects of habituation or any increase. Therefore we analysed the recorded flight time and scaring time during the period of study. There was no general result. At the waste disposal site the scaring time during the trial was equal. In contrast to this the scaring time at the military airfield increased but not the flight time.

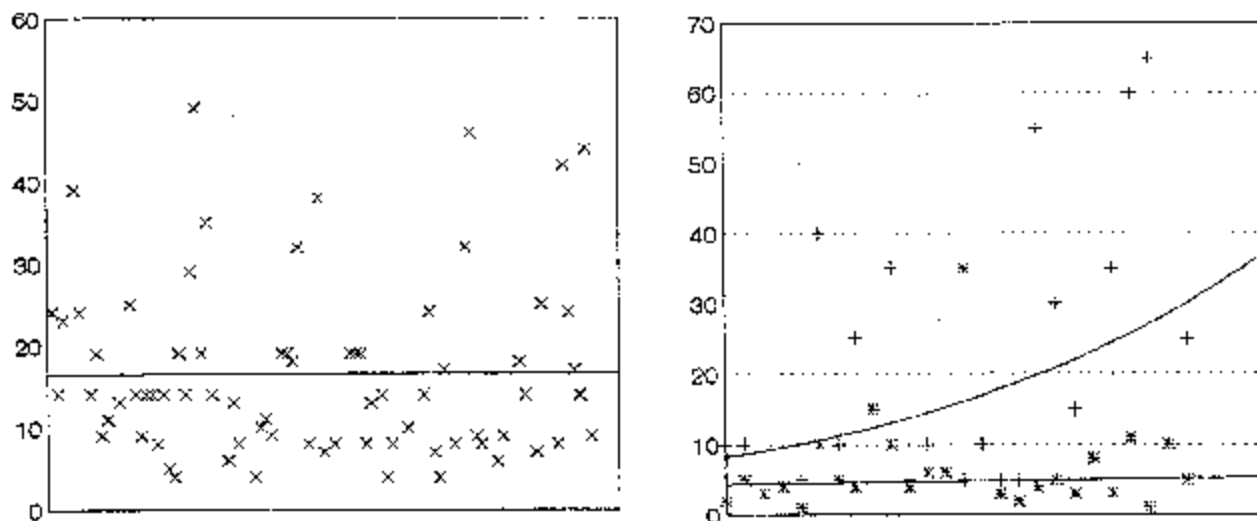


Figure 2: Recorded scaring time at the waste disposal site (left) and the military airfield (right) in minutes. At the waste disposal site (left) there was no increase in the scaring time recorded. At the military airfield the scaring time (+) increased and the flight time (*) stayed constant.

3.3. Trends of flock size over the period of study.

The trends of flock size at the airfield and waste disposal site were unequal. During the study the flock size at the waste disposal site increased in contrast to the military airfield where the flock size decreased. But it can be excluded that there was a change from the airfield to the waste disposal site because the frequent birds at the airfield were starlings and lapwings which does not occur at the waste disposal site, where gulls dominated.

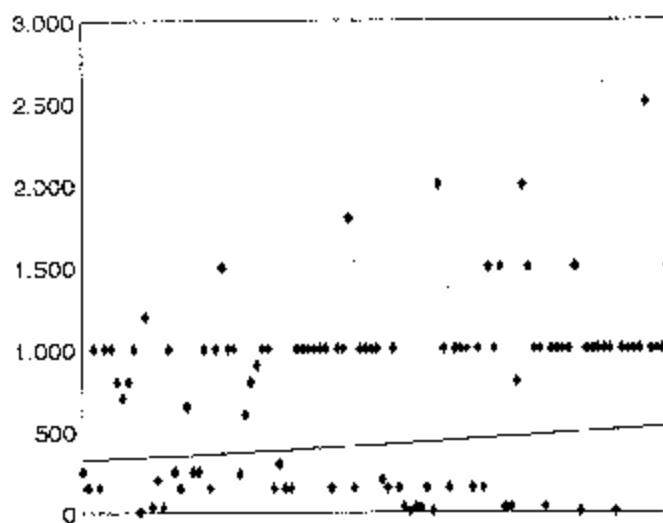


Figure 3: Flock size during the study at the waste disposal site with a calculated trendline

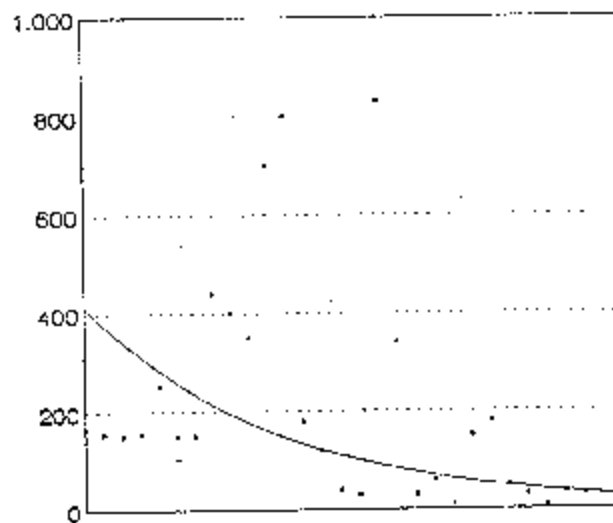


Figure 4: Flock size during the study at the military airfield with calculated trendcurve.

3.4. Correlation between flight time and scaring time

The relation between the parameters flight time and following scaring time we also checked. For both locations we found no statistic correlation between these parameters.

4. Discussion

The difference in the function of the airfield and waste disposal site influenced straightly the result of the trial. On the waste disposal site the immense food supply attracts great flocks of gulls every day. On the military airfield the function of a roosting place is prominent.

Due to the lack of great flocks on the airfield 80% of the flights took place at the waste disposal. Mostly herring gulls were captured there. Nevertheless no decrease of flock size was recorded and the scaring time after the flights was equal during all the study. The reason for this may be caused by the great attraction of this area for gulls and in a kind of habituation after the short attack the falcon caught the prey and the situation become stable after a short time. On the basis of this trial we suppose that it is not the predation itself which decisively frightens the birds.

Increasing scare time and decreasing flock size at the military airfield may jump to the conclusion that these effects are caused by the action of the falcons but the reason in the decrease of the recorded flock size may be meteorological or induced by bird movements because smaller flock sizes were recorded on the airfield at the end of the trial after a period with no predatory flights of falcons on this area.

The increase of the scaring time at the airfield may be caused by the longer period of the falconer's activity at this area and this may effect a certain disturbance of the roosting birds. The fact that we could not find a positive correlation between the two factors flight time and following scaring time shows the low influence of the use of falcons on scaring birds.

5. Conclusions

The use of falcons for birdstrike prevention needs the precise knowledge about the interaction between prey and predator (CURIO, 1993), but there are a lot of factors we do not know today and we suppose it is not only a question of falconry skill.

On the basis of this study on a military airfield we cannot recommend falconry as a routine method for bird control on civil airfields. A successful use is correlated to a lot of different factors, which we yet cannot manage.

6. Acknowledgements

The author likes to thank M. Holscher, R. Henning, Marinefliegergeschwader Graf Zeppelin, the City of Cuxhaven and the German Military Geophysical Office.

7. References

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APPENDIX 36

USAF Aircraft Accident Investigation Report



AFI 51-503

USAF AIRCRAFT ACCIDENT INVESTIGATION REPORT

**E-3B
AIRCRAFT
#77-0354**

**ASSIGNED TO:
3rd WING
ELMENDORF AFB, ALASKA
22 SEPTEMBER 1995**

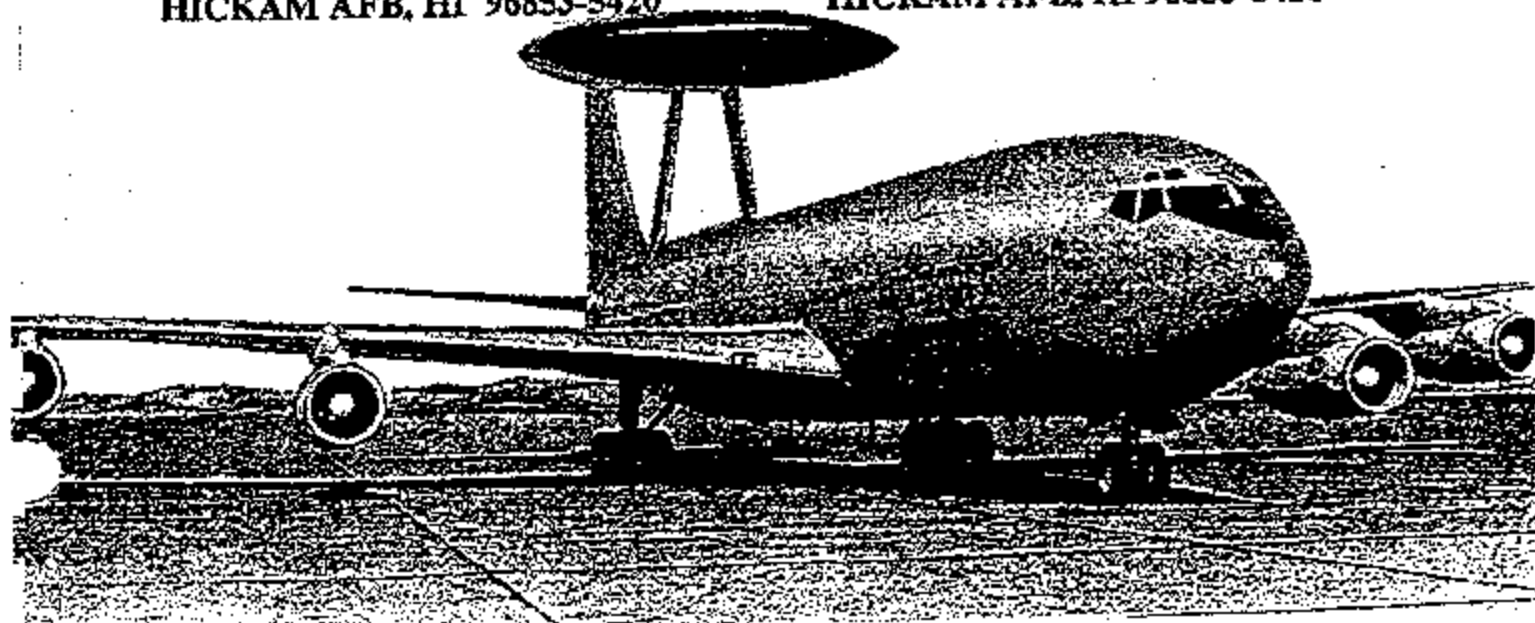
CONDUCTED IN ACCORDANCE WITH AFI 51-503

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EXECUTIVE SUMMARY

Accident Investigation
E-3B, SN 77-0354
Elmendorf AFB, Alaska
22 September 1995

While departing Elmendorf AFB on a routine training mission the morning of 22 Sept 95, an E-3B aircraft struck a flock of Canada Geese, several of which were ingested by the number one and number two engines. The result was an immediate, unconfined catastrophic failure of the number two engine as well as compressor stalls in the number one engine. The mishap aircraft began a slow left-hand climbing turn, struck a hilly wooded area less than 1 mile off the departure end of the runway and broke apart. The mishap aircraft was destroyed and all 24 crew members were fatalities.

The aircrew did everything humanly possible to fly this aircraft out of an unflyable situation. All flight deck aircrew members were fully qualified to perform in their assigned crew positions. Aircrew training and qualifications were not a factor in this accident. Material and maintenance factors did not contribute to this accident.

The flock of Canada Geese that the mishap aircraft struck after rotation originated in the infield area adjacent to runway 05. The senior controller in the tower told two witnesses that he observed the geese lift off and turn to the right, directly into the path of the mishap aircraft. Two minutes before the E-3 began takeoff roll, a C-130 taking off on the same runway flushed a flock of geese. The tower controller observed this flock, but did not notify the mishap aircraft or Airfield Management.

The geese had been roosting in the infield adjacent to runway 05 and 33. AFR 127-15 describes this condition as "an immediate safety hazard." The reason why the geese went undetected was the result of systemic failure. A Headquarters Air Force Safety Agency team conducted a staff assistance visit at Elmendorf AFB in July 1995. Their endorsement of the Wing's written plan (OPLAN 127-15) convinced the Wing that nothing else was required to prepare for migration season. Also, Elmendorf had experienced only one aircraft goose strike in the past five years.

The 3rd Wing had a well-written plan, but there were inadequate preventive measures to handle the growing number of geese on the airfield. Specifically, there was no augmentation of airfield patrols, no static deterrents, such as sound cannons, and no spotlighting of infield areas during hours of darkness. The primary action of the program at 3rd Wing was to maintain the infield grass at a recommended height of 7-14 inches. Airfield Management reacted effectively when geese were seen. In the 17 days prior to the accident they dispersed geese on seven occasions, and two days prior they killed geese that would not disperse. However, procedures to detect and deter geese were inadequate and lacked perseverance.

In summary, the accident was directly caused by the ingestion of Canada geese into engines one and two. Furthermore, two factors substantially contributed to the accident. First, the Wing lacked an aggressive program to detect and deter geese; specifically, the Bird Hazard Reduction Working Group did not adequately prepare for the migration season, Airfield Management's efforts to detect and deter geese were inadequate, and an earlier Safety Agency staff assistance visit had mislead the Wing to believe it was prepared. Second, the tower controller failed to notify the mishap aircraft or Airfield Management that geese were present in the infield.

I. STATEMENT OF AUTHORITY AND PURPOSE

A. Authority: On 18 October 1995, General John G. Lorber, Commander, Pacific Air Forces, appointed Colonel Thomas J. Gresch as Accident Investigator (AI), under authority of AFI 51-503 (formerly AFR 110-14) to investigate an aircraft accident involving E-3B, 77-0354, assigned to the 962nd AACS, 3rd Wing, Elmendorf Air Force Base, Alaska (Tab Y).

B. Investigation Period: The investigation officially began 20 October 1995, when the AFI 91-204 Safety Board President released Part I of the Safety Mishap Report to the Accident Investigator.

C. Purpose: According to AFI-503, the purpose of this investigation is to obtain and preserve all available evidence for use in claims, litigation, disciplinary action, adverse administrative proceedings, and for all other purposes deemed appropriate by competent authority. This accident report is not privileged, and is releasable LAW AFI 51-503 and AFI 37-131, Air Force Freedom of Information Act.

D. Time Reference: The times addressed in this report are Alaska local times, unless otherwise noted. Furthermore, unless otherwise specified, times are stated in a 2400 hour clock format.

E. Aircrew: Twenty four personnel were aboard the mishap aircraft on 22 September 1995:

Captain Glenn J. Rogers, Jr., Aircraft Commander;
Captain Bradley W. Paakola, Co-Pilot;
Lieutenant Colonel Richard G. Leary, Navigator;
Technical Sergeant Bart L. Holmes, Instructor Flight Engineer;
Technical Sergeant Mark A. Branner, Instructor Flight Engineer;
Major Marlon R. Thomas, Mission Crew Commander;
Major Steven A. Tuttle, Air Surveillance Officer;
Major Richard P. Stewart, Mission Crew Commander;
Captain Robert J. Long, Senior Director;
First Lieutenant Carlos Arriaga, Weapons Director;
Master Sergeant Stephen C. O'Connell, Instructor Advanced Air Surveillance Technician;
Technical Sergeant Charles D. Sweet, Jr., Instructor Airborne Radar Technician;
Technical Sergeant Ernest R. Parrish, Airborne Area Specialist, 381st Intelligence Squadron;
Technical Sergeant Timothy B. Thomas, Instructor Computer Display Maintenance Technician;
Technical Sergeant Brian K. Van Leer, Instructor Advanced Air Surveillance Technician;
Technical Sergeant Mark A. Collins, Instructor Communications Systems Operator;
Staff Sergeant Scott A. Bresson, Instructor Airborne Radar Technician;
Senior Airman Joshua N. Weter, Computer Display Maintenance Technician;
Staff Sergeant Raymond O. Spencer, Jr., Instructor Air Surveillance Technician;
Senior Airman Lawrence E. DeFrancesco, Instructor Communications Systems Operator;
Airman Derien F. Watson, Air Surveillance Technician;

Airman Jeshua C. Smith, Air Surveillance Technician;
Master Corporal Joseph Jean-Pierre Legault, Canadian Air Forces, Communications Technician;
Sergeant David L. Pitcher, Canadian Air Forces, Battle Director Technician.

This is the normal crew complement for this aircraft and type of mission.

F. Matters Investigated: This Class A aircraft accident investigation involved an E-3B, AWACS. The aircraft was assigned to the 962nd Airborne Air Control Squadron, 3rd Wing, Elmendorf Air Force Base, Alaska. During a routine training mission, the mishap aircraft struck a flock of Canada geese, several of which were ingested by the number one and number two engines. The result was an immediate, unconfined catastrophic failure of the number two engine as well as compressor stalls in the number one engine. The mishap aircraft began a slow left-hand climbing turn, struck a hilly wooded area .9nm off the departure end of the runway and broke apart. The mishap aircraft was destroyed and all crew members were fatalities.

II. SUMMARY OF FACTS

A. History of Flight: On 22 September, 1995, aircraft 77-0354, an E-3B (call sign YUKLA 27) was scheduled for an 0800 take-off on a 6.2 hour routine training mission. The aircraft was assigned to the 962nd Airborne Air Control Squadron, 3rd Wing at Elmendorf Air Force Base, Alaska. The mishap aircraft initiated take-off roll at 0745 from runway 05. Approximately 45 seconds later, after beginning the rotation for lift-off, the aircraft experienced numerous bird strikes in engines number one and two causing significant loss of thrust to both engines (Tab J). 39 seconds (Tab N) later, the mishap aircraft impacted a wooded area approximately .9nm (Tab R) Northeast of runway 05, fatally injuring all 24 crew members. The mishap aircraft was completely destroyed upon impact. This incident was the first loss of an E-3, so local, and national media attention was high.

B. Mission: Mishap aircraft was departing on a routine training mission. Scheduled sortie duration was 6.2 hours.

C. Briefing and Preflight:

1. Crew Rest: The crew was scheduled to enter crew rest at 1800 on Thursday, 21 September, 1995. This provided 12 hours of non-duty time prior to a 0600 show time on Friday, 22 September. All evidence indicates the flight crew received adequate non-duty time and crew rest was not a contributing factor in this mishap.

2. Flight Planning: Flight planning for this mission was accomplished in accordance with all applicable guidance and regulations. Flight planning was not a contributing factor in this mishap.

3. Mission Briefing: Mission planning and the pre-mission briefing were conducted in accordance with all applicable guidance and regulations. This briefing included a safety and emergency procedures briefing. The mission briefing was not a contributing factor in this mishap.

D. Impact: At 0747:12, the mishap aircraft impacted at coordinates 149 degrees, 45 minutes West and 61 degrees, 16 minutes North, approximately .9 nm Northeast of Elmendorf Air Force Base runway 05. The impact area is on Elmendorf Air Force Base property.

E. Egress Systems: Egress systems were not a factor in this accident.

F. Personal and Survival Equipment: The impact was not survivable (Tab J); therefore, personal and survival equipment were not a factor.

G. Rescue:

1. Aircraft 77-0354 crashed at 0747:12 immediately after take-off from Elmendorf Air Force Base, Alaska, on 22 September 1995. Base fire and rescue vehicles were alerted at 0746:44 when the tower controller activated the Primary Crash Alarm System (PCAS). Crash 10 was the first unit responding at 0747:49 (Tab N). The wreckage was located and the first firefighter was on scene at 0758. The first crew member was located at 0832 and the last body was found at 1938.

H. Crash Response:

1. There were many difficulties experienced in the crash response. The weather was not a factor and the sun was up and lighting conditions were good. The topography presented difficulties. Although the crash location was on base, there were no access roads leading to the site. Crash response firefighters initially proceeded to the scene on foot until a bulldozer created better access. The fire burned for several hours. Fire crew were able to get water hoses to the scene at 0901. Units from nearby Ft. Richardson also assisted in the crash response.

2. Overall, given the terrain and lack of access roads, crash response was very effective and people were on scene relatively soon after the crash. Due to the severity of the impact, however, crash response and rescue efforts were not a factor in this mishap.

I. Environmental Response:

1. The following environmental response was received from Capt. Jim Liddle, 3rd SPTG/CEVC. (Phone: DSN 317-552-8057/7021):

a. A preliminary environmental site assessment was conducted 28-29 Sep 95 for the site of the AWACS crash. The objective was to determine the location and extent of contamination. Per Alaska Department of Environmental Conservation (ADEC) regulation, 18 AAC 75, the area is considered a "spill" site requires a report to be filed with the state. This

happened immediately after the incident. Closure of the spill report will come when the ADEC is satisfied that the level of contamination is not compromising the environment.

b. 20 samples were taken for laboratory analysis. An effort was made to include areas known to be high in hydrocarbons, as well as future drainage zones and background samples. Sample locations were marked with large wooden stakes for future reference. Samples were analyzed for diesel range organics (DRO) and metals. Analytical results indicated that the only contaminant of concern was DRO from jet fuel. Drainage areas were free of contamination (as expected) and the land prior to the initial impact zone was also free of fuel.

c. A follow-up sampling occurred 01 Nov 95. The purpose of this task was to prove that the DRO had not migrated into the subsurface and that the higher levels were actually vaporizing and naturally attenuating. Although our marking stakes had been removed and much of the ground had been modified (including the addition of a gravel road through the site), we attempted to sample in areas that had been high in DRO initially. Samples were taken at the surface, where a comparison would indicate the level of dissipation, as migration was thought not to be an issue by the ADEC because there are no sources of potable water at the crash site.

d. Analytical results for the follow-up effort are expected 13-14 Nov 95. Once these are assessed, a final spill closure report will be filed with the ADEC. We expect that they will support our efforts to close this issue as quickly as possible. If that is the case, no future remediation projects will be required for the site.

e. Asbestos sampling was conducted for the site and pieces of wreckage thought to be asbestos containing material (ACM). A portion of the Rotodome was found to contain 1 to 2 percent ACM in a non-friable state. Non-friable asbestos does not pose a health hazard as long as it is not mechanically abraded or burned. It is intended that this material will be disposed per the applicable regulations, in an approved asbestos landfill.

J. Maintenance Documentation:

1. AFTO form 781 aircraft records and Computer Automated Maintenance System (CAMS) records for aircraft 77-0354 were reviewed (TAB U-A-1 through TAB U-A-40). My maintenance technical advisor visited the maintenance facility and reviewed all maintenance log books.

2. Operating time on number one engine was 10,369.0 hours (TAB U-E-1).

3. Operating time on number two engine was 25,803.5 hours (TAB U-E-1).

4. Operating time on number three engine was 23,743.9 hours (TAB U-E-1).

5. Operating time on number four engine was 12,813.3 hours (TAB U-E-1).

6. Engines were physically examined, and engine records and log books were reviewed. All engines were operating normally before the ingestion of birds.

7. AFTO 781 and CAMS reflect that all scheduled inspections were accomplished on time or scheduled for future inspections (TAB U-A-16).

8. Two TCIO's were discovered awaiting action; both have parts on back order (TAB U-A-21, U-A-22). Neither TCIO was a contributing factor to the accident.

9. BPO through flight conducted on 20 Sept 95 reflected no abnormal discrepancies (U-D-1, U-D-2).

10. Examination of maintenance documentation revealed no discrepancies that contributed to the accident.

K. Maintenance Personnel and Supervision

1. Inspection of personnel training records reflect that the Dedicated Crew Chief and Assistant Dedicated Crew Chief were thoroughly trained and current on all assigned maintenance tasks.

2. No Maintenance practice or procedures were related to the mishap.

L. Engine, Fuel, Hydraulic and Oil Inspection Analysis

1. The number one engine (S/N PW00707003) was installed on aircraft 77-0354 on 20 Mar 91 (TAB U-E-1).

2. The number two engine (S/N PW00660090) was installed on aircraft 77-0354 on 29 Jan 93 (TAB U-E-1).

3. The number three engine (S/N PW00659708) was installed on aircraft 77-0354 on 5 Apr 95 (TAB U-E-1).

4. The number four engine (S/N PW00696822) was installed on aircraft 77-0354 on 11 May 94 (TAB U-E-1).

5. Fuel samples were collected from tank farm tanks 49, 50 and pump houses 88 and 89 (TAB U-B-1). Additional fuel samples were gathered from MA fuel truck # 89600973 and fuel hose cart #76W00175 (TAB U-B-1). The base fuel lab conducted particle assessment and fuel weight tests. No tests showed evidence of contaminated fuel. No fuel sample was recovered from the crash site, due to the post impact fire.

6. Hydraulic fluid was removed from hydraulic carts ACH1 and ACH2. Test results met specification limits (TAB U-C-1).

7. Oil was taken from oil carts ACO1 and ACO2. Test results met specification limits (TAB U-C-2).

8. Examination of the engine records and the fluid test results do not indicate any abnormalities that were factors in the mishap.

M. Airframe and Aircraft Systems

1. Aircraft 77-0354 arrived at Elmendorf AFB, AK on 16 Dec 93, with 14057.8 total operating hours. This aircraft had a good statistical record while assigned to the 962 AACCS (TAB U-F-1). Over the past year, aircraft 77-0354 had an 83 percent mission capable rate and an 81.5 percent maintenance fix rate. Additionally this aircraft had only three ground aborts and six air aborts for FY 95 (TAB U-F-2).

2. The last Phase Inspection took place on 17-21 Jul 95. This scheduled inspection was complied with without any difficulty.

N. Operations Personnel and Supervision:

1. This mission was authorized for flight by Major Guy Wills, the 962nd AACCS Assistant Operations Officer, Air (TAB K-6).

2. The briefing guide used for mission planning at the 962nd AACCS is the 3rd Wing FORM 0-105, DEC 94 (TAB K-8). This briefing sheet was accomplished and it was not a factor in this mishap. Operations supervision was not a factor in this mishap.

O. Crew Qualifications:

1. Overall Unit Training and Documentation Deficiencies

a. The governing training regulation during the mishap was ACC/PACAFR 51-60 Vol 2, dated 2 Jun 92. This document covered currency requirements for the aircrew. PACAFR 51-60 Vol 2, has since been superseded by MCI 11-E3, which officially went into effect on 5 Oct 95. Currency requirements are different in this new instruction, but it did not apply to the E-3 mishap on 22 Sep 95. All currencies discussed are the ones in effect 22 Sep 95 from PACAFR 51-60, Vol 2. The unit documentation was excellent and no discrepancies were found. All flight deck aircrew were current and qualified in every required event and ready to fly.

2. Capt Glenn J. Rogers Jr., Aircraft Commander

a. Qualification Training: Capt Rogers completed his initial E-3 Co-pilot training in Mar 92 and upgraded to Aircraft Commander in Dec 94. The 962nd Squadron Commander certified him as a mission ready aircraft commander on 27 Feb 95. Capt Rogers had a solid flying background with no breaks in flying operational assignments since pilot training.

b. Continuation Training:

1. Ground Training: Capt Rogers' ground training history was reviewed. He was current and up to date in all aspects of 962nd AACS required ground training.

2. Flying Training: Capt Rogers was partially complete with his semi-annual flying training requirements. He was current in every event. Capt Rogers briefly lost mission ready status on 27 Jul 95 for failing to maintain air refueling currency. He regained mission ready status on 17 Aug 95 (TAB T-A-24). Capt Rogers met the Air Force requirements for his job and his flying training was not a factor in this mishap.

c. Experience Level

1. Total Flying Experience: Capt Rogers had accumulated 1,922 hours of flying time, excluding student pilot training (TAB G). All of this flying was accomplished in the E-3B, E-3C, TC-18, and the SE003 simulator. Capt Rogers was a mission ready, Experienced, GCC Level A, Aircraft Commander.

2. Recency of Flying: Capt Rogers had flown one 10.0 hour sortie on 25 Aug 95. This was his only sortie in the last 30 days. He flew three additional sorties logging a total of 26.9 hours in the last 90 days (TAB G).

d. Performance and Overall Qualification: There were no documented recurring problems in Capt Glenn Rogers' training records (TAB T). He had flown four sorties in the last 90 days. He was current by all Air Force standards. Capt Rogers had a strong flying record and was a very capable Aircraft Commander.

3. Capt Bradley W. Paakola, Co-pilot

a. Qualification Training: Capt Paakola completed his initial E-3 Co-pilot training in Nov 92. The 962nd Squadron Commander certified him as a mission ready Co-pilot on 29 Dec 93. Capt Paakola had a strong flying background with no breaks in operational flying assignments since pilot training. No discrepancies were noted in Capt Paakola's qualification or mission ready status.

b. Continuation Training:

1. Ground Training: Capt Paakola's ground training history was reviewed. He was current and up to date in all aspects of 962nd AACS required ground training.

2. **Flying Training:** Capt Paakola had completed the majority of his semi-annual flying training requirements and had not lost currency in any event. He met the Air Force requirements for his crew position and his flying training was not a factor in this mishap.

c. Experience Level

1. **Total Flying Experience:** Capt Paakola had accumulated 1,258.9 hours of flying time, excluding student pilot training (TAB G). All of this flying was accomplished in the E-3B, E-3C, TC-18, and the SE003 simulator. He was an Experienced, mission ready, GCC Level B, Co-pilot.

2. **Recency of Flying:** Capt Paakola had flown three sorties in the last 30 days. He flew a 9.9 hour mission on 14 Sep 95 and a 6.5 hour sortie on 7 Sep 95. In addition, he flew four sorties in August and three in late July logging a total of 79.2 flying hours in the 90 days prior to the mishap (TAB G).

d. **Performance and Overall Qualification:** There were no documented recurring problems in Capt Bradley Paakola's training records (TAB T). He was a strong Co-pilot who was being actively prepared for Aircraft Commander duties. His training records were thorough and gave a very clear picture of a responsible and competent aviator.

4. LtCol Richard G Leary, Navigator

a. **Qualification Training:** LtCol Leary completed his initial E-3 Navigator qualification in Jan 95 and became mission ready in Mar 95. LtCol Leary began his flying career in the RF4C. He returned to flying in the E-3 and was assigned to the 962nd AACS.

b. Continuation Training:

1. **Ground Training:** LtCol Leary's ground training history was reviewed. He was current and up to date in all aspects of 962nd AACS ground training requirements.

2. **Flying Training:** LtCol Leary had completed approximately half of his semi-annual flying requirements. He was current in every event.

c. Experience Level:

1. **Total Flying Experience:** LtCol Leary had accumulated 1,150.3 hours of flying time, excluding student time (TAB G). All of his flying was accomplished in the RF4C or the E-3. LtCol Leary was an Experienced, GCC Level A Navigator.

2. Recency of Flying: LtCol Leary had flown a 9.9 hour sortie on 14 Sep 95 and two additional missions in the last 30 days. He flew seven more sorties for a total flying time of 79.2 hours in the last 90 days.

d. Performance and Overall Qualification: There were no documented recurring problems in LtCol Leary's training records (TAB T). He was mission ready, current and qualified in the E-3.

5. TSgt Mark A Bramer, Instructor/Evaluator Flight Engineer

a. Qualification Training: TSgt Bramer completed his initial E-3 Flight Engineer training in Nov 85 and upgraded to Instructor Flight Engineer in Jul 92. The 962nd Squadron Commander certified TSgt Bramer as mission ready in Aug 92. TSgt Bramer had accumulated 4,562.6 hours of flying time (TAB G). He was an Experienced, GCC Level A, Evaluator Flight Engineer.

b. Continuation Training:

1. Ground Training: TSgt Bramer's ground training history was reviewed. He was current and qualified in all aspects of required 962nd AACCS ground training.

2. Flying Training: TSgt Bramer had completed the majority of his semi-annual requirements. He was current and up to date and met all aspects of 962nd AACCS required flying training.

c. Performance and Overall Evaluation: There were no documented training deficiencies in TSgt Bramer's records (TAB T). TSgt Bramer had flown seven sorties in the last 30 days for a total of 41.7 hours. He flew four additional missions in the last 90 days for a total of 70.2 hours. He was a well respected and experienced Instructor/Evaluator Flight Engineer with a very high level of experience.

6. TSgt Bart L Holmes, Instructor Flight Engineer

a. Qualification Training: TSgt Holmes completed his initial E-3 Flight Engineer training in Mar 89. After a tour at Tinker AFB, OK, he transferred to the 962nd AACCS where the Squadron Commander certified him as mission ready in Apr 93. TSgt Holmes had accumulated 3,510.3 flying hours (TAB G). He was an Experienced, GCC Level A, Instructor Flight Engineer.

b. Continuation Training:

1. Ground Training: TSgt Holmes' ground training history was reviewed. He was current and up to date in all aspects of 962nd required ground training requirements.

2. **Flying Training:** TSgt Holmes was about half-way complete with his semi-annual flying training requirements. He was current and qualified.

c. **Performance and Overall Qualification:** There were no documented recurring problems in TSgt Holmes' training records (TAB T). He had flown one 2.3 hour mission two days prior to the mishap and logged a total of 50.6 flying hours in the last 90 days. TSgt Holmes was a well respected and experienced Instructor Flight Engineer with a great deal of flying time in the E-3.

P. Medical:

1. Medical records, toxicology reports and postmortem examinations of the 24 crew members associated with the mishap flight of 22 Sep 95 were reviewed. Their medical records were current and they were medically and psychologically qualified for flying duties. None of the crew members had any disqualifying medical conditions (Tab BB).

2. Postmortem toxicological reports were negative or consistent with tissue decomposition. Review of postmortem examinations revealed injuries that were consistent with damage to the aircraft and the crew members' duties on the mishap flight. Due to the nature of the accident and resultant injuries, the crew members died instantaneously and did not suffer (TAB AA).

Q. **Nav aids and Facilities:** Local NOTAMS were reviewed (TAB K-4). The Elmendorf AFB bird condition was listed as "moderate". Other airfield data did not apply and was not a factor in this mishap.

R. Weather:

1. Various weather forecast documents were reviewed including satellite depictions and prognostic charts (TAB W). In addition, the DD 175-1 was reviewed (TAB K-3).

2. The mishap crew received a flight weather briefing on a DD Form 175-1. The briefing was conducted by a forecaster at 0605. The Aircraft Commander, Capt Rogers, received the weather briefing. It included the forecast takeoff and landing weather and any significant hazards expected for the planned flight.

3. Sunrise on 22 Sep 95 occurred at 0742. The lighting at the time of the mishap was twilight. The sun had yet to rise above the mountains to the East of the field but there was sufficient light to see objects without the aid of artificial illumination. Weather was overcast at about six to nine thousand feet and the temperature was approximately 55 degrees; visibility was greater than five miles. The winds for the takeoff were from the Northwest at 11 knots. The runway was dry and tire friction was normal. Weather was not a factor in this mishap.

S. Governing Directives and Publications:

1. The applicable instructions and regulations that apply to the mishap Aircrew are:

- a. T.O. 1-1C-1
- b. T.O. 1-1C-1-27
- c. T.O. 1-1C-1-27CL-1
- d. T.O. 1E-3A-1
- e. T.O. 1E-3A-1CL-1
- f. T.O. 1E-3A-1-1
- g. AFI 11-206
- h. MCR 55-33
- i. 3rd Wing Instruction 13-203
- j. ACC/PACAFR 51-60 Vol II



THOMAS J. GRESCH, Col, USAF
Accident Investigator

III. STATEMENT OF OPINION

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause or causes of, or the factors contributing to the accident set forth in the accident investigation report may not be considered as evidence in any civil or criminal proceeding arising from an aircraft accident, nor may such information be considered an admission of liability by the United States or by any person referred to in those conclusions or statements.

Based on eye witness testimony, technical analysis of the accident site, technical analysis of the aircraft engines, and simulator flight profiles, I believe the accident was directly caused by the ingestion of Canada Geese into the #1 and #2 engines (Tab V-B, V-C, V-D, V-F, V-G, V-H, V-J, V-K, V-M, V-U, V-V). The resultant loss of thrust rendered this aircraft incapable of controlled flight. It subsequently crashed into a hill less than a mile from the departure end of the runway (Tab R-3, S-2, V-F, V-G).

Based on a thorough review of the training records and Standardization/Evaluation records, it is my opinion that all flight deck aircrew members were fully qualified to perform in their assigned crew positions (Tab T). Aircrew training and qualifications were not a factor in this accident.

Based on technical analysis and a thorough review of maintenance documentation, procedures, personnel and supervision, I believe that material and maintenance factors did not contribute to this accident (Tab U, V-O, V-P).

Using the exact flight and atmospheric data that existed at Elmendorf AFB, AK, on the morning of 22 September 1995, I flew the mishap aircraft simulator profile at Tinker AFB, OK. I am convinced that a total power loss on #2 engine and a 50 to 70 percent power loss on the #1 engine immediately after rotation renders the E-3 incapable of controlled flight. I am convinced that the flight deck aircrew accomplished their emergency procedures flawlessly in an attempt to fly this aircraft out of an unflyable scenario.

I am convinced that the mishap aircraft struck a flock of Canada Geese that originated from an infield area adjacent to runway 05. The mishap Co-pilot and Flight Engineer saw "all the birds" simultaneous with the "Rotate" call (Tab N-40). Two eyewitnesses stated that they saw a disorganized flock of approximately 100 geese above, below and behind the mishap aircraft just after rotate (Tab V-U, V-V). The two personnel in the control tower had an excellent view of the runway area, but invoked their rights to remain silent; therefore, I was unable to obtain their testimony (Tab V-X, V-Z). Immediately after the accident, however, MSgt Leis told two witnesses that he observed geese lift off and turn right, directly into the path of the mishap aircraft (Tab V-LL, V-VV).

A number of geese were roosting in the infield areas near runways 05 and 33 (Tab V-E, V-T, V-II). AFR 127-15 describes this condition as "an immediate safety hazard." Why these geese went undetected was the result of systemic failure. The Bird Hazard Reduction Working Group (BHRWG), required by AFR 127-15 and the supplemental 3rd Wing OPLAN 127-15, were

responsible for the overall implementation and supervision of 3rd Wing's Bird Aircraft Strike Hazard (BASH) program. I examined the Bird Strike Information for Elmendorf for the last five years (Tab GG). The only recorded incident of geese striking an aircraft occurred in September 1993 when a C-130 aircraft struck several geese on the runway after a blacked out landing. It was common knowledge that migratory geese typically arrived in large numbers on Elmendorf during September and October (Tab V-E, V-AA, V-MM), but the BHRWG formulated no special plan to handle these increasing numbers (Tab V-AA, V-CC). There was no augmentation of airfield patrols. Additionally, static deterrents, such as sound cannons, were not utilized until after the accident (Tab CC, V-AA, V-I, V-T). I believe Airfield Management operated with little supervision or input from the BHRWG. Action depended on personalities rather than established process. Airfield Management reacted effectively when geese were seen, but procedures to detect and deter geese were inadequate. AFR 127-15 advises that perseverance is the key to bird dispersal. This lack of perseverance, especially in the infield areas, was a contributing factor to this accident.

Several witnesses emphasized the lack of Air Force training in BASH issues (Tab V-GG, V-HH, V-JJ, V-KK). The deficiencies I noted in bird detection and deterrence did not result from insufficient Air Force training. Airfield Management could have been instructed by the BHRWG to perform more frequent airfield checks, to go into infields, to use spotlights, or to install sound cannons. These tasks require little expertise and could have been performed easily. I believe the BHRWG and the Wing's Safety office had sufficient training and knowledge to formulate and implement an effective bird detection and deterrence program.

HQ AFSA/SEFW personnel (BASH Team) conducted a Staff Assistance Visit (SAV) at Elmendorf AFB in July 1995, before the fall migration had begun. This team emphasized habitat management but did not discuss the particulars of 3rd Wing's plan for migration season. The team did advise Airfield Management personnel to prevent geese from establishing themselves in the airfield. They reviewed OPLAN 127-15 and noted its sufficiency, but did not discover that BHRWG meeting minutes were not being kept (Tab DD, V-II).

Finally, MSgt Leis, the senior tower controller on 22 September 1995, should have warned the mishap aircraft that geese might be near the runway. Just moments before the E-3 began takeoff roll, a C-130 taking off on runway 05 flushed a flock of geese (Tab V-LL, V-VV). MSgt Leis observed this flock, but did not notify the mishap aircraft (Tab V-LL, V-VV). While it would not have been standard operating procedure for a tower controller to raise the bird watch condition to severe, he certainly could have warned the aircraft of the potential hazard.

A. Background Information

1. Controlling regulations require a thorough plan to reduce the potential for bird strikes to aircraft.

Air Force Regulation 127-15, The Bird Aircraft Strike Hazard (BASH) Reduction Program, gives policy and guidance for implementing an effective bird aircraft strike hazard reduction program. It designates the Air Force agencies that are responsible for carrying out the program

and evaluating its effectiveness. It outlines procedures for developing a wing-level BASH program and establishes requirements for its operation. This regulation further states:

The key to a successful BASH reduction program is an active concern by well trained individuals assigned specific tasks. Birds on runways, taxiways, or infields create an immediate safety hazard and must be dispersed before flying operations can safely continue. The key to active bird dispersal is perseverance. When birds are strongly attracted to an airfield, several teams may be required to provide continual harassment. A well-written, workable BASH plan is the key to reducing bird strike hazards and ensures continuity of knowledge with personnel turnover. Local expertise and assistance is available through the USDA Animal Damage Control.

3 WG OPLAN 127-15, based on AFR 127-15, establishes and defines the BASH Program at Elmendorf Air Force Base. Its purpose is to provide a base program to minimize aircraft exposure to potentially hazardous bird strikes in areas where 3 WG conducts flying operations. This plan is designed to establish a Bird Hazard Reduction Working Group (BHRWG), establish procedures to identify and to communicate hazardous situations to aircrews and supervisors to determine if altering / discontinuing flying operations is required, and to decrease the attractiveness of Elmendorf AFB to birds by eliminating, controlling, or reducing environmental factors which attract birds. The OPR (office of primary responsibility) for implementation of this plan is the 3 WG Safety Office. Members of the BHRWG include 3 WG Vice Commander as chairman, as well as a representative from Operations, Flight Safety, Airfield Management, Civil Engineering, the flying organizations and representatives from other interested agencies. Meetings are to be held semi-annually in conjunction with changing bird activity with meetings called by 3 WG/SE. 3 WG SOF (Supervisor of Flying) will declare bird watch conditions (BWC) based on personal observations, Airfield manager observations, pilot reports, radar observations, etc.; and coordinate bird dispersal through the Airfield Manager. The 3 OSS/DOFJ (Airfield Manager) will coordinate BWC with the 3 WG SOF during duty hours, declare appropriate BWC through the tower supervisor when 3 WG SOFs are not on duty and coordinate dispersal of birds through the Base Wildlife Management Office under all BWC Severe conditions or 3 WG SOF requests.

2. On 22 September 1995, the geese population on Elmendorf Air Force Base was high and many geese were frequenting the airfield.

Mr. Corey Rossi, U.S. Department of Agriculture Animal Damage Control Specialist, stated that there were entirely too many geese on Elmendorf Air Force base (Tab V-T). Mr. Allen Richmond, Chief of Conservation and Environmental Planning, 3rd Civil Engineering Squadron, stated that he had counted the goose population on Elmendorf since 1990 (Tab V-E). He estimated that there were about 1,000 geese on site in 1990, with yearly increases until the population peaked this year at 2700. On the day of the accident, he estimated that there were around 900 geese on the base (Tab V-EE). Other witnesses have seen many geese on the base and airfield (Tab V-I, V-S, V-FF, V-MM). Three witnesses, who were at Elmendorf as part of a HQ PACAF Air Traffic Systems Analysis Visit (ATSAV) during a several day period just prior

to the accident remarked that the base, compared to other Air Force bases, had an unusually high number of birds (Tab V-LL, V-TT, V-UU). One witness stated, "But I've never really been at a location, except for, of course, Elmendorf now, that's had so many birds. I mean, not only on the flightline, of course, but all over the place. I mean they're everywhere" (Tab V-LL). Clearly, there was a large number of geese on Elmendorf the day of the accident.

It appears that an extremely dangerous condition was developing at Elmendorf: geese were becoming strongly attracted to the airfield area. Two members of the ATSAV team had occasion to view the airfield and commented on the number of geese there. One remarked that "it wasn't uncommon to see geese out there;" the other stated, "I had never seen that number of geese in an airfield before" (Tab V-TT, V-UU). Evidence suggests that geese were, in fact, roosting in the areas near runway 05 and 33 (Tab V-E, V-I, V-T, V-II). Between 6 September and 20 September 1995, Base Operations and Wildlife personnel dispersed geese from the airfield on several occasions (Tab CC, V-E, V-I). These efforts included actions to disperse geese from infield areas (Tab V-TT). Clearly, 3rd Wing was on notice that geese were indeed locating in infields as well as on hard surfaces such as runways and taxiways. On two occasions, Allen Richmond's office had to kill geese with shotguns in order to disperse the flock. The geese were beginning to establish themselves and occasional dispersal was not deterring them from returning. As the Wing's Safety officer explained, "they were not reacting as normal" (Tab V-GG).

These infield geese were extremely hazardous, as AFR 127-15 makes clear. The presence of these geese warrants a Severe Bird Condition even if they are not directly on or above the runway. The movements of these geese can be sudden and unpredictable. Within moments, a large flock can fly from an airfield area to a location and altitude dangerous to aircraft (Tab V-T, V-II). Furthermore, geese tend to leave their roost in the early morning hours (TAB V-E, V-II, V-T). Clearly, this situation called for a plan of increased vigilance to detect and deter these geese.

B. 3rd Wing Had No Aggressive Plan or Methodology to Detect and Deter Geese

1. The Bird Hazard Reduction Working Group did not adequately prepare for migration season.

A basic tenet of AFR 127-15 is the requirement for semi-annual Bird Hazard Reduction Working Group (BHRWG) meetings. After talking with several witnesses who would have been members of this group, I could not establish when the meetings were held or what topics were covered. Colonel Heskew, 3rd Wing Vice Commander and Chairman of the BHRWG, stated that the BHRWG was not part of the Foreign Object Damage (FOD) Board meetings, but typically met immediately after the FOD Board and did so on a monthly basis (Tab V-AA). Colonel Wall, the Operations Group Commander could recall one occasion when the BHRWG met after the FOD Board (Tab V-CC). Lieutenant Colonel Donisi, Commander of the Operations Support Squadron, which included Airfield Management, never attended a BHRWG and had no idea who did (Tab V-DD). MSgt Fuentes, who was the Flight Safety NCO and had much responsibility for the BASH plan and program, stated that the BHRWG was sometimes separate from the FOD

Board and other times bird issues were addressed during the FOD Board (Tab V-SS). TSgt Tackett, who assumed MSgt Fuentes' duties during September 1995 when MSgt Fuentes was reassigned to the 509th Bomb Wing, testified that MSgt Fuentes told him during a brief turnover of BASH information that the BHRWG was part of the FOD board (Tab V-HH). MSgt Sweeney, who was present at nearly every FOD board during 1995 could recall no occasion when the BHRWG met after the FOD Board (Tab V-QQ). His belief was that there were no separate BHRWG meetings because the Safety office had erroneously assumed that BASH issues were addressed during the FOD board (Tab V-QQ). He related that TSgt Tackett called him several weeks after the accident and told him to be sure to mention "BASH" during the FOD board so the term would be reflected in the minutes of those meetings (TAB V-QQ). Colonel Heskew and Colonel Wall refer to BASH (historical data) slides (Tab V-AA, V-CC), but these slides were shown during FOD Board meetings (Tab V-QQ). It is possible that the BHRWG also showed these slides. It is equally possible that Colonel Heskew and Colonel Wall are confusing the showing of BASH slides at the FOD Board with a separate BHRWG meeting.

What topics were addressed by the BHRWG was also difficult to ascertain. As stated, several witnesses refer to the BASH slides, but these slides simply contain historical data (Tab FF). Colonel Heskew stated that the March 1995 BHRWG meeting was intensive, but it is not clear what was discussed. He stated that migration season was discussed during the May 1995 meeting, but went on to say that the main emphasis was preparation for the SAV (Tab V-AA). Colonel Wall could recall no specific discussions, only the slides (Tab V-CC). MSgt Fuentes stated that bird hazard strategies and awareness was occasionally discussed during the FOD Board. Who attended the BHRWG and what was discussed was further complicated by the fact that no minutes of BHRWG meetings were kept. Although Lieutenant Colonel Renelt, Chief of 3rd Wing Safety, opined that minutes are not necessary (Tab V-R), AFR 127-15 clearly establishes this requirement. I also examined the minutes of the last ten FOD Board meetings and could find no mention of the BHRWG or associated meetings.

The BHRWG did not formulate a concrete plan to deal with changing bird activity levels or the presence of geese in the airfield. 3rd Wing had an effective OPLAN, but the BHRWG was responsible for ensuring that the implementation of this plan resulted in effective geese detection and deterrence at all times of the year. Colonel Heskew and Colonel Wall stated that the only specific tasks assigned to individuals was to prepare for the SAV (Tab V-AA, V-CC). MSgt Fuentes claimed there was no special preparation for the SAV because the Wing's OPLAN was already prepared and operating (Tab V-NN). Colonel Heskew explained that, because the migration meeting was in May 1995 before the season began, there was no frame of reference for assigning specific tasks (Tab V-AA). I am unsure why there was no follow up meeting after the geese began arriving and frequenting the airfield. Colonel Heskew stated that it appeared everyone was prepared for the migration season and that MSgt Fuentes had told him that geese were not a problem in the airfield (Tab V-AA). Reports submitted after the May 1995 meeting, however, indicated that geese were arriving on base and becoming a problem in the airfield (Tab EE).

Wildlife experts were not included in the FOD Board or BHRWG meetings during 1995, but Allen Richmond submitted information concerning goose counts in reports that Colonel Heskew

received (Tab EE, V-AA). The 21-25 August and 4-8 September 1995 reports state "Canadian goose counts continue to be high, with the birds showing up regularly along the flight line. Conservation agents have twice assisted Base OPS in dispersing the birds from the runway medians during the past week." The 11-18 September 1995 report states "Canada goose counts continue to be high, with the birds showing up regularly along the flightline. Due to the number of cracker shells being expended in driving geese from the flightline, conservation agents have been instructed to shoot a few geese, if they have to fire more than five cracker shells to disperse them" (Tab EE). As stated, Lieutenant Colonel Renelt was also aware that the geese were not reacting as normal to dispersal efforts (Tab V-GG). As OPR of the OPLAN he could have called a special meeting of the BHRWG. It is not clear whether the BHRWG ever discussed the fact that geese were becoming a problem on the airfield. Perhaps it was assumed that Airfield Management would meet the increased challenge. Regardless, the lack of a strategy to handle migration season left Airfield Management to exercise their own judgment, which resulted in poor detection and deterrence of geese.

2. Airfield Management's efforts to detect and deter geese were inadequate.

AFR 127-15 states that perseverance is the key to controlling airfield areas and warns that single trips around the runway perimeter are not effective. The regulation advises that several teams may be required to deter geese who are strongly attracted to an airfield. Roosting infield geese went undetected because Airfield Management had no controlling plan to locate them. Technical Sergeant Kossover, one of the key personnel conducting airfield patrols, stated that there was no formal strategy or instruction, only word of mouth transfer of information from one person to the next (Tab V-I). It is evident that personnel knew geese posed a danger to aircraft and they acted to disperse them on several occasions, but their efforts to detect or deter infield geese were inadequate. Few, if any, of the suggested patrol and deterrent methods suggested by AFR 127-15 were in place.

The several team approach recommended by AFR 127-15 was not implemented. TSgt Kossover described solo patrols during which he used his truck to scare geese from one airfield area to another (Tab V-I). Moreover, it appears that these patrols occurred infrequently. While regulations require only two checks per day (Tab V-UU), the high number of geese in Elmendorf's airfield warranted increased patrols. The last runway check on 22 September 1995 occurred nearly 3.5 hours before the mishap aircraft began takeoff roll (Tab CC). Several geese could have arrived in the infields after the last check and prior to the takeoff of the E-3.

Airfield Management did not sufficiently check these infield areas for the presence of geese. Base Operations personnel and Supervisors of Flying were engaged in little other than vehicle sweeps of runways and taxiways (Tab V-I, V-K, V-Q). A cursory glance at the infield would not result in the detection of geese (Tab V-E, V-II). These patrols were effective, if at all, during daylight hours only. Prior to the accident there was no illumination of infield areas before first light. Furthermore, there were no static deterrents, such as cannons, to make the airfield habitat unattractive to geese (Tab V-T). Airfield cannons are not an absolute necessity, but, without them, superior detection methods would be needed. The worst possible combination existed: there were infrequent patrols of the airfield, nearly no checking of infields, and no placement of

static deterrents. This combination of factors resulted in geese roosting in the infields without being detected. Those aircraft that began takeoff roll at or before dawn were at risk that those geese would move into their flight path, as it happened in this accident.

I could not determine why Airfield Management did not aggressively patrol infields. I agree with Colonel Heskew that, if anyone had known geese were roosting in the infield, the birds would have been dispersed (Tab V-AA). Given the several witnesses who had, at one time or another, seen geese in nearly every airfield location, it is difficult to believe that no one considered the possibility that geese could be roosting there. It seems there would have been a greater interest in those median areas. There was a general assumption, however, that geese would not roost in the infields. This assumption may explain why there were limited detection and deterrent measures. Whether Airfield Management should have taken a more active role in detection and dispersal without being told to do so by the BHRWG is difficult to say. MSgt Freniere was the Airfield Manager. She was well aware of the BASH plan and had been personally briefed by the BASH Team during the July 1995 SAV. I attempted to establish her understanding of Airfield Management's specific responsibilities in the OPLAN, but she invoked her right to remain silent (Tab V-Y).

3. The Staff Assistance Visit (SAV) conducted by HQ AFSA/SEFW during July 1995 may have contributed to the BHRWG belief that 3rd Wing was prepared for migratory season and to the assumption that geese would not roost in infields.

The SAV concluded that Elmendorf Air Force Base was in "fine shape" (Tab DD). The visit occurred during the month of July, when the goose population was quite low (Tab V-E). The team spent the majority of their time surveying the airfield and other outdoor areas (Tab V-S, V-II). The team did not attempt to locate minutes from BHRWG meetings or to evaluate participation in or content of these meetings. Major Arrington stated the BASH Team does not "get into digging into the specifics in a lot of cases" (Tab V-II). During the debrief, the BASH Team emphasized that geese should not be allowed to establish themselves in the airfield. It is not clear whether the team believed static deterrents in the airfield were unnecessary, assumed there would be active patrols by Airfield Management personnel, or simply did not realize that migrating geese would be highly attracted to the airfield. I believe the BASH Team's endorsement of the Wing's OPLAN convinced the BHRWG that nothing else was required to prepare for migration season (Tab V-AA).

The SAV may have generated a false assumption that geese would not remain in tall grass. The SAV team echoed the recommendation in AFR 127-15 that infield grass be kept at seven to fourteen inches in height. The logic is that birds do not feed in long grass and do not roost there because they cannot see predators (Tab V-E, V-T). Several witnesses believed that habitat management was the key to deterring geese, and that geese would not frequent infields when grass was kept at that height (Tab V-AA, V-BB, V-FF, V-OO). The problem was that the infield grass at Elmendorf was bent by heavy rains and became low enough for the geese to roost but remained long enough to conceal them from a cursory view (Tab V-E, V-II). It is possible that Airfield Management personnel did not routinely check infields because, based on the SAV, they

assumed there would be no geese there. Regardless, these geese remained and originated from one of those areas before striking Yukla 27 on 22 September 1995 (Tab V-E, V-K, V-T, V-U, V-V, V-LL, V-VV).

C. MSgt Leis Should Have Warned The Mishap Aircraft

Moments before the mishap aircraft's departure, MSgt Leis witnessed a C-130 takeoff and flush a flock of geese from the infield adjacent to runway 05 (Tab V-LL, V-VV). Fortunately for that aircraft, this flock turned away from its flight path. MSgt Leis was on notice that geese were concealed from view in the infield area near runway 05. While he could have assumed that every infield goose joined the flock that the C-130 flushed and that this flock had left the area, sound judgment dictates that he should have contacted the E-3 and warned the crew. The aircraft could have held takeoff until the squadron SOF or Base Operations could ensure that these geese had not returned and that no more geese were in the area. I cannot imagine why MSgt Leis did nothing. He had more than two minutes to advise the mishap aircraft that a flock of geese had taken wing and nearly struck the C-130 (Tab N).

The witnesses whom I queried regarding MSgt Leis' actions did not believe it was clear that he should have warned the aircraft or changed BWC to severe (Tab V-LL, V-TT). CMSgt Marshall, an expert in tower control procedures, stated that no regulation authorized MSgt Leis to raise the bird watch condition to severe (Tab V-UU). It is true that 3rd Wing's OPLAN envisioned the SOF or Base Operations changing bird watch conditions, but MSgt Leis did not have a SOF in the tower, and Base Operations had already completed an airfield check without spotting these geese, who may have flown in after the last patrol. CMSgt Marshall stated that 3rd Wing altered its OPLAN after the accident to allow tower controllers to change the bird watch condition. I do not view the change in the OPLAN as an indicator that it was poorly conceived. Whether MSgt Leis changed the bird watch condition is irrelevant. As an experienced SOF stated, many geese were dispersed from the airfield in the past without a change in bird watch condition to severe (Tab V-MM). The goal is not changing bird watch condition; it is ensuring the safety of aircraft. The relevant question is whether MSgt Leis should have warned the aircraft. He could safely assume that no one outside the tower had seen a flock of geese leave the infield area. I believe he had a duty to warn the mishap aircraft and that his failure to do so was a contributing factor to this accident.



THOMAS J. GRESCH, Col, USAF
Accident Investigator

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