TP 2439

STUDY OF BIRD STRIKES AT CANADIAN AIRPORTS - 1979
Summary Report

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December 1979

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transport Canada Research and Development Centre.

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17 Abstract

A two-year project undertaken to control and reduce bird strikes on aircraft at Canadian airports is summarized. Bird strike records and cost data are collected through visits to 14 Canadian airports and interviews with the personnel of Canadian carriers and various aviation organizations. The total cost of bird strikes on aircraft at Canadian airports and the individual cost at each of 14 Canadian airports are estimated. A methodology is then developed to estimate the costs and benefits of various strike reduction measures. The findings of statistical and risk analyses of bird strikes are also presented.

The report recommends more precise and comprehensive bird strike reporting procedures, the establishment of airport bird strike control committees and the appointment of full-time coordinators, periodic surveys of airports by wildlife experts, and evaluation and research and development of bird dispersal techniques and equipment.

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17 Résumé

Le rapport présente une étude de deux ans portant sur la lutte contre le péril aviaire aux aéroports canadiens. Le recensement des incidents de cet ordre s'est fait lors de visites aux 14 aéroports étudiés et par interviews chez les transporteurs canadiens et divers organismes d'aviation. Le rapport présente une estimation du coût total des collisions d'oiseaux et d'aéronefs survenues aux aéroports canadiens ainsi qu'une répartition du coût entre les aéroports étudiés. Il présente ensuite une méthodologie visant à évaluer les coûts et bénéfices de diverses mesures de prévention et donne aussi les résultats d'analyses des risques et d'études statistiques à ce sujet.

Le rapport recommande de rédiger de façon plus précise et exhaustive tout compte rendu sur les collisions aviaires et préconise l'établissement de comités de lutte contre le péril aviaire, la nomination de coordonnateurs à temps plein, l'examen périodique des aéroports par des experts en faune, l'évaluation, la recherche et le développement de techniques et de matériel de dispersion des oiseaux.

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Canada became involved in the study of bird strikes at Canadian airports in the early 1960s. Canada currently has about ten times as many geese and about five times as many ducks and swans as does northern Europe. The likelihood of bird strikes on aircraft is therefore greater in Canada and civil and military aircraft operators face higher losses due to damage caused by bird collisions.

In 1962, the National Research Council (NRC) formed a committee to work with the Department of Transport and the Department of National Defence to help make airfields less attractive as bird habitats.

In December 1976, the NRC committee disbanded, having completed the major portion of needed research. The committee recommended that, in future, emphasis in bird strike control work in Canada be placed on the implementation of the findings of its research. The committee's work was taken over by an interdepartmental committee composed of representatives from the Department of National Defence (DND), the Canadian Wildlife Service (CWS) and Transport Canada, with the Committee's secretariat being provided by the latter.

In March 1978, the Environment Division of the Airport Facilities Branch of Transport Canada's Canadian Air Transportation Administration (CATA) completed a comparative study of airport bird strike rates at major Canadian, European and United States airports. The report recommended that action be taken to control the increase of bird strike rates at a number of Canadian airports and to reduce the bird strike rate where economically feasible.

At that time, an abundance of information was available on the problem of bird strikes at airports, but no specific methodology had as yet been developed for quantifying the benefits which would justify expenditures to reduce the number of strikes. Hence, in April 1978, CATA's Airports and Construction Services, with the concurrence of the Aviation Safety Bureau also of CATA, authorized the Airport Facilities Branch to proceed with a study to develop a methodology for quantifying benefits of bird strike reduction measures, conduct site analyses at certain airports with high strike rates, and recommend plans of action to control and reduce the number of bird strikes at Canadian airports.

The airports to be included were Toronto International, Vancouver International, Calgary International, Winnipeg International, Ottawa International, Halifax International, Edmonton International, Montreal (Dorval) International,

Windsor, Thunder Bay, Regina, Hay River, Comox and Bagotville.

In June 1978, after preliminary discussions between officials of the Transport Canada Research and Development Centre (TDC) and the Airport Facilities Branch, TDC was tasked to undertake the study. A steering committee composed of representatives from the Airport Facilities Branch, TDC and CWS provided general direction for the study. The study was performed by the consulting firms of Aviation Planning Associates and Hickling-Smith Inc., and was managed by TDC.

The specific objectives of the project were:

i. To develop a methodology for quantifying the cost of bird strikes at Canadian airports and for estimating the benefits that would accrue from reducing high strike rates at these airports, and

ii. to analyze the nature, causes and severity of the bird strike problem in general and at each of 14 Canadian airports now experiencing high rates of bird strikes.

The results of the study are contained in seventeen documents: a main report (Ref. 2), site reports on each of the fourteen airports evaluated (Ref. 3-16), a report analyzing the statistics and risk of bird strikes (Ref. 1), and a compendium of visit reports of special interest (Ref. 17). These publications make up the list of references included at the end of this report.

2. STUDY APPROACH

The following outlines the steps taken and the sources from which information was obtained for carrying out this study.

a) A review was made of the relevant data files in the Airport Facilities Branch of Transport Canada.

b) Aviation Safety Bureau computer print-outs on bird strikes, obtained from reports supplied by pilots, operators and staff at various airports, were reviewed and analyzed.

c) The Aviation Safety Bureau informed Air Canada, CP Air, Eastern Provincial Airways, Nordair, Quebecair, Transair, Pacific Western Airlines and Wardair about the impending study and requested their co-operation.

d) These airlines were contacted and visited for estimates of the damages and costs of bird strikes.

e) Similar information was obtained in discussions with the Canadian Business Aircraft Owners Association and some business aircraft operators.

f) Four aviation insurance underwriters - Lloyds (U.K.), United States Aviation Underwriters Inc., Associated Aviation Underwriters (U.S.) and Skandia (Sweden) - were contacted for cost data.

g) Initial visits of twelve CATA airports with the highest strike rates were arranged by the Airports and Construction Services Directorate at Ottawa. Site visits were also arranged for two airports (Comox and Bagotville) operated by the Department of National Defence.

h) The initial visit to each of the twelve CATA airport sites consisted of four actions, namely:

   1) A briefing on the purpose and scope of the project and the role of the various participants.

   2) Discussions with the Airport Manager, the ATC Tower Chief, the Airport Emergency Services Chief, the Superintendent of Airfield Maintenance and other appropriate airport management staff on the history, nature, causes and severity of the problem at their

airport, and responsible employee for dealing with it.

3) Consultants inspected all areas of the airport, usually accompanied by a CWS representative, to observe the wildlife present, its attractants and habitat, and the topography, vegetation and other features of the airport.

4) A costing of possible changes in habitat or procedures which, on the basis of the discussions and inspection of the problem and its history, would appear to be required to reduce the bird problem at the airport.

i) Discussions were held with engine manufacturers concerning bird ingestion damage and costs.

j) Several U.S. airlines were contacted for cost data and bird strike experience at Canadian airports.

k) Visits were made to the Federal Aviation Administration, the National Transportation Safety Board, the Air Transport Association and the Flight Safety Foundation in Washington, D.C. to exchange information on bird problems.

l) Appropriate Canadian conservation organizations were contacted in order to deal with special habitat problems, including Agriculture Canada, the Fish and Wildlife Service of the B.C. Government, etc. Continuous liaison was maintained with the CWS in Ottawa for advice and supply of data, papers, reports, etc.

m) A visit was also paid to the Civil Aviation Authority in Redhill, Surrey, U.K., and to Prestwick (Scotland) International Airport, which has a high strike rate.

n) Visits were made to the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO).

o) Reports were written on each of the fourteen airports visited in 1980, containing the following topics at each site: the bird species and bird attractants at each airport; the habitat, including topography, vegetation, drainage, maintenance procedures, etc.; bird strike reporting procedures; and bird control organization. Recommendations were made for changes and improvements, and cost/benefit analyses performed

on the estimated expenditures. These reports were reviewed, amended as necessary, and verified by the airport managers concerned.

A complete list of all organizations and individuals contacted for information related to this project is listed in references 1 and 2. Notes of significant interviews are included in reference 17.

3. NATURE OF PROBLEM - BIRD STRIKE STATISTICS

The nature of the bird strike problem is described here using statistics. In this section, the incidence of strikes, causal factors and effects of bird strikes are presented.

3.1 Incidence of Bird Strikes

The overall strike rate in Canada between 1972 and 1977 was 3.3 per 10,000 movements (two movements per flight: take-off and landing). In Figure 1, this strike rate is compared to strike rates in various other countries. The large differences in strike rates between countries are a result of the various reporting standards used by each country as well as the specific nature of the bird strike problem in each country (e.g., climate, migration routes, proximity to water, bird types). Another reason is the definition of aircraft movements; in some cases, the count includes all civil aviation, while in others only scheduled commercial aviation was analyzed.

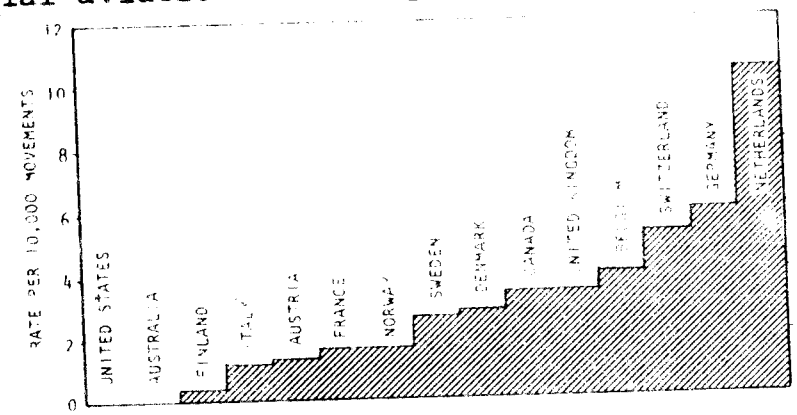

Figure 1 Bird Strike Rates for Various Countries

The variation in strike rates at Canadian airports is probably a result of the differing nature of the bird strike problem at each airport; reporting standards are fairly uniform. The bird strike rates at Canadian airports are shown in Figure 2. In this figure, the movement statistics are based on the total civil aviation aircraft movements at each airport.

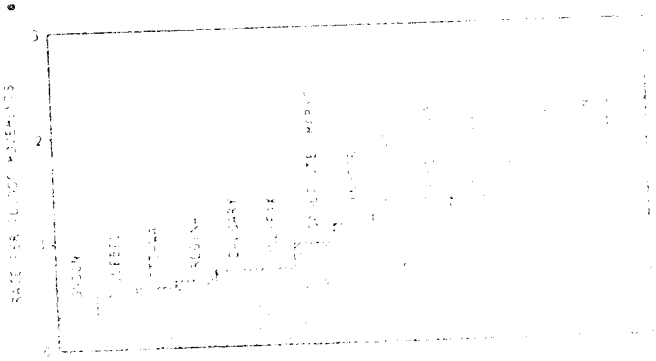

Figure 2 Bird Strike

3.2 Causal Factors of Bird Strikes

The variation in the bird strike rate from airport to airport in Canada is dependent upon many operational and environmental factors as illustrated in Figure 3.

Operational characteristics include the flight phase, airspeed and altitude, as well as the frontal area, colour, etc., of the aircraft. Environmental characteristics include the location of the airport (proximity to feeding grounds, migratory paths, nesting areas), the environment of the airport, the time of year and time of day, as well as the characteristics of the birds themselves.

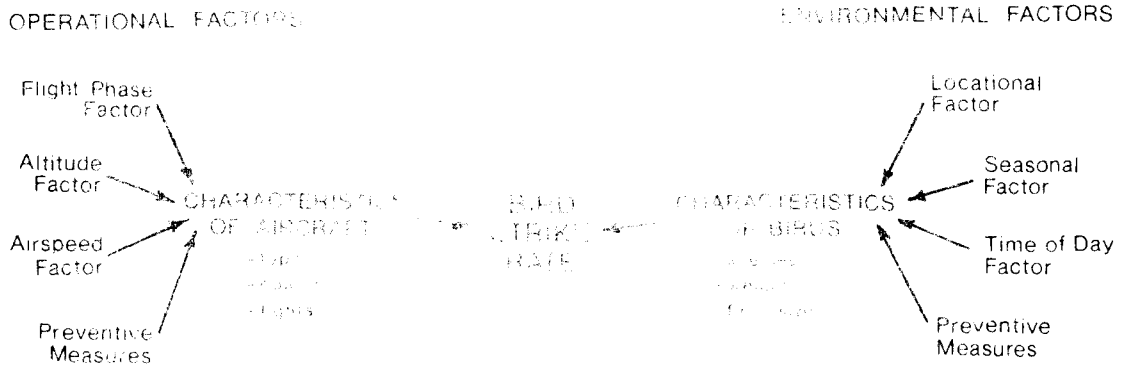

Figure 3 Causal Factors of Bird Strikes

3.2.1 Operational Factors

Bird strike records of Australia, Canada, the United Kingdom and the United States were a useful means of correlating the strike rate to various factors:

Flight Phase Factor Figure 4 clearly indicates that the flight phases during which the most bird strikes occur are take-off and landing. The majority of bird strikes occur in these phases because most birds fly at low altitudes.

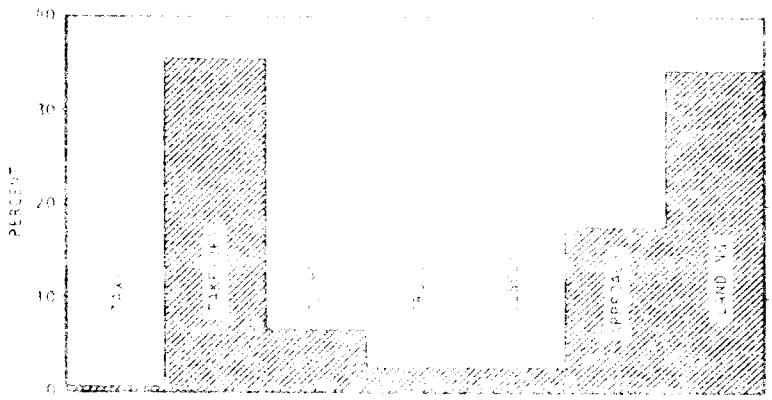

Figure 4 Bird Strikes by Flight Phase

Altitude Factor From the preceding, it seems reasonable to expect that a high proportion of bird strikes would take place at ground level or at least at low altitudes. Figure 5 shows that by far the highest proportion of bird strikes occurs below 200 feet.

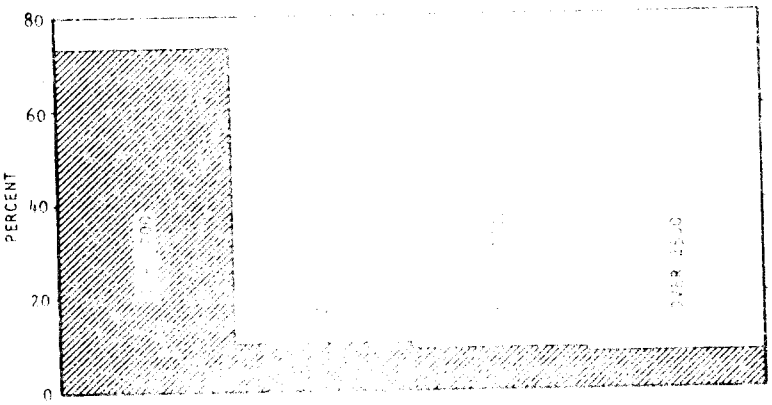

Figure 5 [illegible] by Altitude

Airspeed Factor Figure 6 indicates that most bird strikes occur at low airspeeds. This is in keeping with the fact that a large proportion of bird strikes takes place on take-off and landing and, therefore, at airspeeds commonly used during these flight phases.

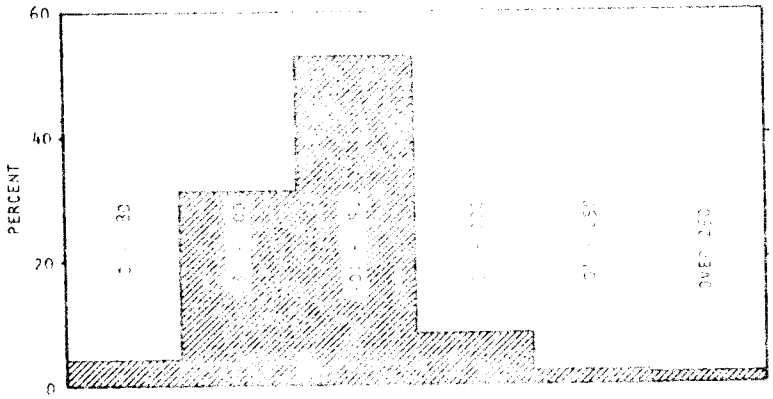

Figure 6 [illegible] by Airspeed (knots)

Characteristics of Aircraft A comparison of the bird strike rates for various groupings of aircraft is shown in Figure 7. This figure shows that the rate for jet aircraft is higher than that for either turbo-props or propeller aircraft. The reason for this is not all that clear, although it

does seem reasonable to expect that aircraft speed, size, noise patterns, use of lights, colour, etc. would affect the strike rate.

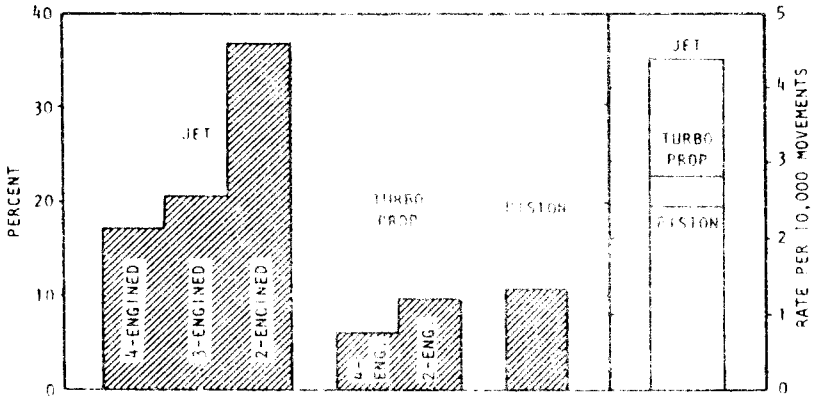

Figure 7 Bird Strikes by Type of Aircraft

3.2.2 Environmental Factors

Environmental factors relate directly to the numbers and types of birds near airports.

Locational Factors This is one of the most important factors and is defined as the proximity of the airport to bird migration routes, bird nesting areas, feeding grounds, water, and so forth. There is no statistical information available, however, to correlate the strike rate to the location of the strike.

Seasonal Factor The frequency of bird strikes is related to the seasonal variation in bird population, as shown in Figure 8. The seasonal factor takes into account the spring and fall migrations, the fall harvesting activity, the spring breeding periods and the increase in the number of young, inexperienced birds during this season.

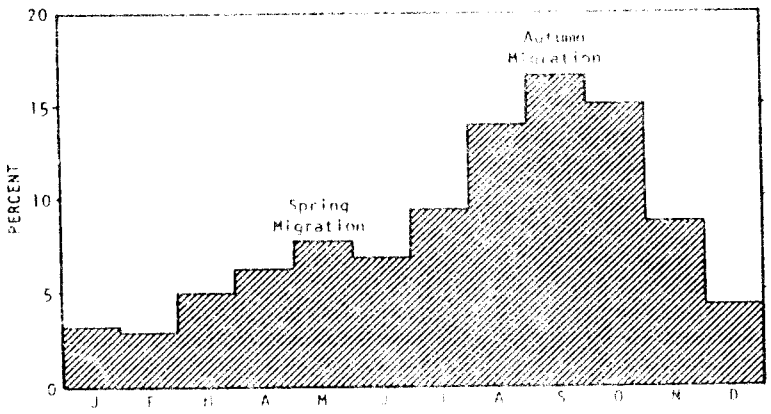

Figure 8 Bird Strikes by Month

Time of Day Factor The feeding and sleeping habits of birds result in increased bird activity at certain times of the day. The early morning seems to offer the highest risk of a bird strike. The distribution of bird strikes by time of day appears in Figure 9.

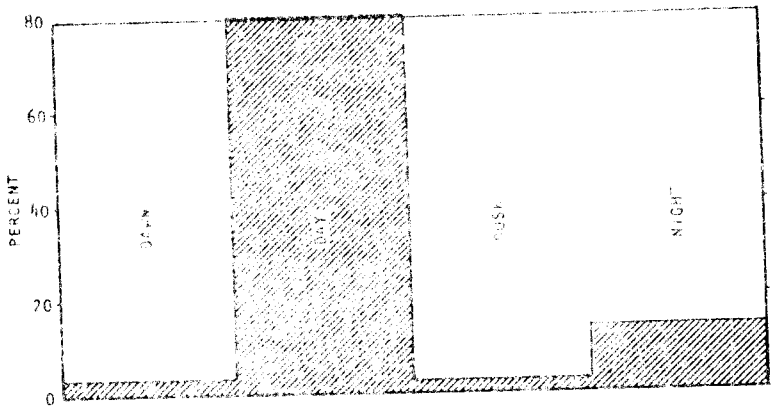

Figure 9 Bird Strikes by Time of Day

Characteristics of Birds The presence and characteristics of particular birds also affect the strike rate. Gulls, for example, account for 53 per cent of strikes reported in Europe. In the United States, the number of strikes by birds of prey is quite significant. In Canada, different birds pose problems at different airports: sandpipers (or dunlins) in Vancouver, gulls, crows, and pigeons in Toronto and the black-headed gull in Halifax. The worldwide distribution of bird strikes by bird species is shown in Figure 10.

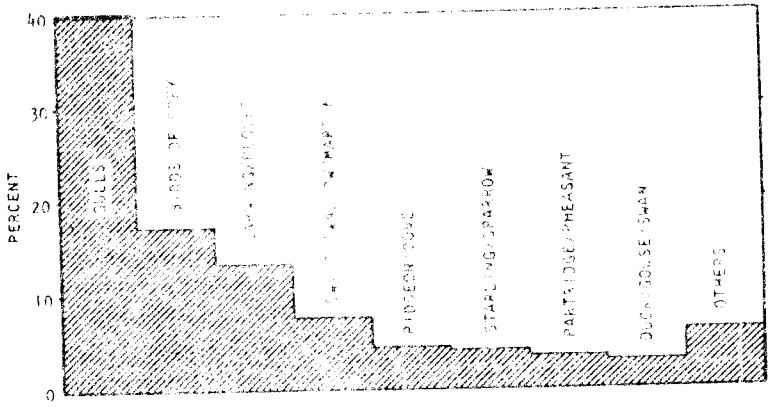

Figure 10 Bird Strikes by Bird Species

3.3 Effects of Bird Strikes

In worldwide civil aviation since 1960, at least 12 major crashes with almost 100 lives lost have been due to bird strikes. On the military side, some 65 crashes and 35 deaths were reported as resulting from bird strikes. In Canada, since 1969, seven significant incidents have been reported as being due to bird strikes, including the death of three people in a small plane over British Columbia in 1971 (see 4.1).

Most strikes occur on the forward-facing parts of aircraft. A bird strike may result in a barely noticeable smear on the aircraft surface, some torn metal, a shattered windshield, or considerable damage to an engine. A serious strike may startle the pilot, impair his judgment, or distract his attention. It may also aggravate an existing aircraft malfunction.

The effect of a bird strike partly depends on the section of the aircraft struck. The part of the aircraft most frequently reported as being struck is the nose and radome, followed by the windshield and engines. The distribution of the bird strikes by the part of the aircraft struck is shown in Figure 11.

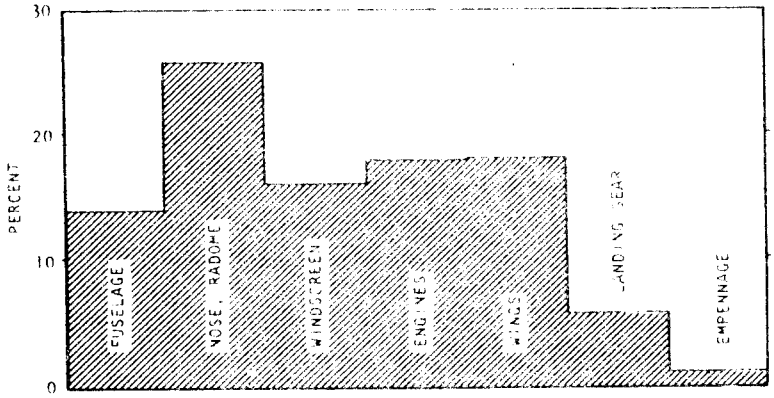

Figure 11 Bird Strikes by Part of Aircraft Struck

Loss of life/aircraft or injury to the flight crew occurs in about 1 per cent of reported bird strikes. Over 80 per cent of the strikes result in negligible damage, as shown in Figure 12.

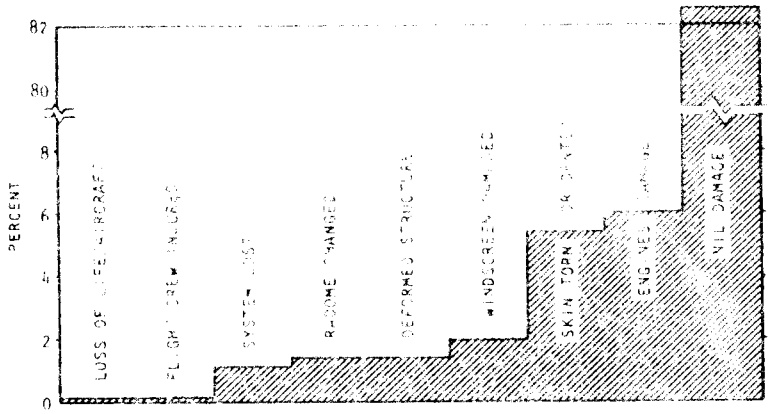

Figure 12 Effects of Bird Strikes on Aircraft

3.4 Summary Comments

The statistical information indicates that the probability of a bird strike at Canadian airports is approximately one in every 10,000 movements. The probability of serious damage as a result of a bird strike is one in every 50,000 movements. Injuries from bird strikes may occur once in every 2 million movements, while the probability of a fatality is one in every 5-7 million movements. The actual fatality rate in Canada, however, is well below this figure, which is based on worldwide incidents. In Canada, three people have been killed in civil aviation accidents resulting from bird strikes since 1971, and two military pilots were killed in a bird strike accident in 1976.

4. COST OF BIRD STRIKES TO AIRCRAFT

This section discusses the severity of the bird strike problem in Canada, the U.S. and Western Europe, and the cost of strikes to operators at Canadian airports. Operational and incidental costs resulting from strikes, as well as damage costs, are considered and profiles are furnished of each of the Canadian trunk and regional carriers affected by strikes.

4.1 The Bird Strike Problem in Canada and the United States

Since 1960, four commercial aircraft have been destroyed as a result of bird strikes in the United States. On October 4, 1960, a Lockheed Electra struck starlings and crashed on take-off from Boston-Logan International Airport; 62 people were killed. On November 23, 1962, a Viscount was flying over Maryland (Washington/Baltimore) when it hit whistling swans. The aircraft crashed, killing all 17 people on board. On November 12, 1975, gulls struck an Overseas National DC-10 on take-off from JFK International Airport and was destroyed. Fortunately, there was no loss of life in the accident. On July 25, 1978, a North Central Airlines Convair 580 ingested a sparrow hawk at Kalamazoo, Michigan, and crashed. Only three people of the 43 on board were injured.

In addition to these loss of aircraft accidents, there have been many other accidents of a less serious nature to air carrier aircraft.

Executive jets are particularly susceptible to bird strikes, as the effect of a strike is proportionately greater on their smaller engines. Also, executive jets operate into small airports where, generally speaking, not as much attention is given to bird control measures.

The first loss of life in Canada as a result of a bird strike involved a general aviation aircraft: in 1971 a Cessna 180 hit a bald eagle at Gibson's Landing, B.C., and crashed, killing the three people on board. Two National Defence Tutor aircraft were also destroyed in separate accidents in June 1976; in one of these accidents, two National Defence pilots lost their lives when their aircraft hit a duck near Regina.

Other serious bird strikes have occurred in Canada in which an aircraft disaster was narrowly avoided. Numerous bird strikes have occurred since the introduction of large jets, but two recent bird strikes highlight the situation. Both strikes occurred on take-off, usually the most critical phase of flight for a bird strike. On March 13, 1978, a

Wardair Boeing 747 sustained bird strikes on Number 1 and Number 2 engines on take-off from Toronto International Airport. Number 1 engine sustained heavy damage. Nobody was injured in the incident. A B-747 can carry up to 440 passengers.

On September 9, 1978, a flock of gulls struck a Pacific Western Airlines B-707 on take-off from Vancouver. Number 3 engine was damaged and failed. Number 4 engine sustained heavy damage and had to be shut down. The aircraft dumped 29,000 pounds of fuel and returned to the airport. Both damaged engines had to be replaced. Once again, nobody was injured. A B-707 can accommodate 189 passengers.

It should be noted that general aviation (G.A.) aircraft have been involved in 16 of the 41 serious bird strikes in Canada and U.S. from 1960 to 1978. Of the 16 G.A. incidents, five involved the loss of executive jets.

4.2 The Bird Strike Problem in Western Europe

In Western Europe, there have also been several serious bird strikes to carrier aircraft, including the loss of a Boeing 737 at Charleroi, Belgium, on April 4, 1978, which was destroyed by fire after it struck wood pigeons.

Three executive jets have also been destroyed in recent years.

Several Canadian National Defence CF-104 aircraft have been destroyed in Europe as a result of bird strikes.

Details of serious aircraft incidents caused by bird strikes in Canada, the United States and Western Europe are presented in references 1 and 2.

4.3 Sources of Cost Data on Bird Strikes at Canadian Airports

The cost of bird strikes affects several parties, each of whom has an interest in the problem, varying according to their involvement in it, or exposure to it. But, in the end, it is the travelling public that is affected most of all, since it has ultimately to bear all the costs of damage due to strikes or their prevention. The parties concerned and the kinds of costs that may affect them individually are listed in Table 1.

Costs to Airlines
- additional inspections
- additional maintenance, repair and overhaul
- delays and effect on schedules and crews
- substitution of equipment, aircraft and crews; ferry costs
- cancellations and loss of revenue
- cost of accommodating passengers
- diversions and unproductive flying, including fuel dumping
- additional insurance premiums
- leasing of other operators' equipment, e.g. aircraft or engines
- injuries to personnel.

Costs to Other Operators (private aircraft, general aviation, charter operators)
- same items as for Airlines.

Costs to Airports
- prevention (counter measures) and cure actions - manpower and techniques/equipment (habitat improvements, scare patrols)
- possible rearrangement or addition of facilities, e.g. runways
- loss of revenue due to diversions
- maintenance.

Costs to Municipalities
- possible relocation of municipal facilities, e.g. garbage dumps
- possible expropriation of farms and other agricultural land.

Costs to Public
- inconvenience (delays and nuisance)
- loss of life or injury
- locating and planning new airports
- higher fares.

Costs to Insurers
- adverse judgments re public liability of clients, i.e. airlines, airport operators
- cost of claims in excess of deductible amounts for damage stated in operator's policy

Costs to Manufacturers
- design, test and development
- modification to existing aircraft and engines
- weight penalty re payload capability and economic effect
- aerodynamic penalty.

Costs to Aviation Administrations
- service re notification (migratory patterns) and warning of bird strike problem
- collection, analysis and dissemination of data
- training and familiarization of ATC personnel, radar operators, etc.

Table 1 Costing of Bird Strikes - Parties Concerned with the Problem

The scope of this study did not permit an evaluation of all the items listed in Table 1. Canadian air carriers were concentrated upon as the primary source of information on costs. The amount of information available and the period of time over which it has been compiled vary considerably from carrier to carrier. A key information source was executive jet operators.

Each Canadian airline was asked to provide all available information on company costs resulting from bird strikes. These costs were to include operational and incidental costs associated with bird strikes, as well as the cost of engine and airframe repair, and maintenance costs, as outlined in Table 1. These "indirect" or "other" costs can sometimes exceed the "direct" damage costs.

4.2 Profile of Canadian Air Carriers

In 1977, the eight major Canadian airlines carried 19,523,381 passengers on 772,786 system movements; during that same period, 322 bird strikes were reported to the Aviation Safety Forum by pilots. The number of passengers carried by each airline and the number of aircraft movements by each airline are shown in Table 2.

Airline	Passengers	Movements
Air Canada	10,346,466	363,894
CP Air	2,644,203	75,754
Eastern Provincial Airways	398,523	50,902
Nordair	596,744	38,102
Pacific Western	4,533,862	121,210
Quebecair	654,886	85,396
Transair	521,923	31,528
Wardair	627,674	6,000 (approx.)
Total	19,523,381	772,786

Table 2 Number of Passengers Carried and Number of Movements for Eight Canadian Airlines - System Operations, 1977

4.5 Cost of Bird Strikes to Canadian Carriers

Damage costs and other indirect costs associated with bird strikes to Canadian carriers have run as high as $312,500 for a single incident:

> On September 9, 1976, gulls struck a Pacific Western Boeing 707 on take-off from Vancouver, destined for Honolulu. Number 3 engine was damaged and failed. Number 4 sustained damage and had to be shut down. The aircraft dumped 29,000 pounds of fuel and returned to the airport. The two damaged engines required changing, thereby using up all available spare engines. Almost immediately afterwards another engine had to be changed for mechanical reasons. As no further spares were available, an engine had to be leased from another airline. The cost of the lease was therefore attributable to the strike. The aircraft was out of service for seven days.
>
> The overall costs incurred by PWA as a result of this strike were estimated as follows:

Cost of parts - engine repairs	$159,865
Cost of labour - engine repairs	34,819
Cost of fuel and oil - engine repairs	790
Passenger accommodation costs	15,612
Carriage of passengers by other carriers	26,046
Substitution of other PWA equipment	1,800
PWA labour cost - engine changes	1,118
Leased engine costs	72,525
Total	$312,575.

In some cases, the strike itself causes little or no damage, but the corrective action taken by the flight crew after the strike results in considerable damage to the aircraft: an aborted take-off can blow tires, burn out brakes and even result in an overrun, possibly damaging the landing gear, etc.

For the period January 1976 to December 1978, the eight airlines reported $1,241,285 in costs due to bird strikes, as indicated in the following table. It should be noted that not all airlines provided data for the three year period, so the cost figures could be somewhat higher.

Airline	Period	Length of Period (years)	Costs ($)
Air Canada	[illegible]	[illegible].0	[illegible]51,1[illegible]
CP Air	[illegible]	[illegible].0	[illegible]3,33[illegible]
Eastern Provincial	Jan. [illegible] 78	1.0	10,75[illegible]
Nordair	Jan. [illegible] 76	3.0	[illegible]5,00[illegible]
Pacific Western	Jan. [illegible] 76	3.0	3[illegible]2,5[illegible]
Quebecair	Jan. [illegible] 76	3.0	[illegible],000
Transair	Jan. [illegible] 76	[illegible].0	270
Wardair	[illegible]	[illegible].0	[illegible]9,[illegible]98
			[illegible],388

Table [illegible] Summary of Carrier Bird Strike Costs at Canadian Airports – 1976-1978

4.6 Cost of Bird Strikes to Canadian Executive Jet Operators

Officers at the Canadian Business Aircraft Association (CBAA) in Toronto and several executive jet operators were contacted for bird strike data. They are concerned about the bird strike problem, especially in view of several fatal accidents which have occurred in other parts of the world since 1968. No data on costs of bird strikes were available; however, they agreed to provide as comprehensive costs as possible on any strikes they might experience in 1979, so as to provide representative input for this segment of the industry. Information on three bird strikes in 1979 resulting in costly damage to executive jet aircraft was furnished and is presented in Table 4.

Date	Operator	Strike Details	Labour & Material ($)	Other ($)	Total ($)
July 7/79	Simpsons-Sears	HS125 on climb at Toronto	109,500	2,800	112,300
July 26/79	Colibri Aviation	Citation 1 on take-off at Dorval	32,000	2,000	34,000
Aug. 17/79	Brooker-Wheaton Aviation	Learjet 36 on take-off at Toronto	23,000	1,200	24,200
	Total				170,500

Table 4 Bird Strike Costs Incurred by Canadian Executive Jet Operators (Selected Incidents)

tal ($)
2,300
4,000
4,200

0,500

5. METHODOLOGY FOR ESTIMATING BIRD STRIKE COSTS

The approach used in this study to estimate the costs of bird strikes at Canadian airports was to obtain bird strike costs for a base period and to allocate costs for any particular airport on the basis of its average number of annual recorded strikes.

5.1 Calculation of Cost to Air Carriers of Bird Strikes at Canadian Airports

The procedure used to determine this cost was to add together a calculated figure for total damage and related costs, and an estimate for the cost of disastrous accidents to air carrier aircraft.

5.1.1 Damage and Related Costs for Air Carrier Operations in Canada

Three methods were used to determine bird strike cost per movement of air carrier operations at Canadian airports.

Method 1

Information compiled by regional air carriers from 1976 to 1978 was used in conjunction with corresponding Air Canada, CP Air and Wardair data.

The bird strike cost per movement was calculated as follows:

$$\frac{\text{average annual bird strike total cost (\$)}}{\text{average annual movements}}$$

$$= \frac{\$492,729}{693,313}$$

$$= \$0.69/\text{movement.}$$

Method 2

A second method was to analyze CP Air data, available for 1971-1978, together with Air Canada data for the same period, obtain an average bird strike cost per movement, and adjust for inflation. The bird strike cost per movement using this method is $0.50.

Method 3

A third method was to analyze Air Canada data compiled over the period 1962-1978, obtain an average bird strike cost per movement, and adjust for inflation. The resultant bird strike cost per movement is $0.87.

Details of these three methods are presented in reference 2.

The costs of bird strikes per air carrier movement resulting from the foregoing analyses are as follows:

Method 1	$0.65 per air carrier movement
Method 2	$0.50 " " " "
Method 3	$0.87 " " " "

Method 1 considers the operation of all Canadian carriers in all parts of Canada, in the most recent time period (1976-1978). Bird strike cost per movement as calculated using this method is therefore the most representative of the three calculations. The 1976-1978 period was chosen as the base period for calculating the total damage and related costs for Canadian air carrier operations in Canada.

The average annual number of aircraft movements by Canadian air carriers for the 1976-1978 period was 693,313. The average number of movements at Canadian airports by aircraft of gross weight over 39,000 lbs., i.e. carrier aircraft, was 882,560 for the base period. The difference of 190,000 movements was generated primarily by U.S. and foreign carriers operating into Canada. To arrive at an annual national bird strike cost for air carriers for the three-year base period, it is assumed that, on average, an equal cost per movement can also be assigned to these foreign carriers for which bird strike costs are not available - since they share the same risks. The annual national cost for air carriers therefore becomes:

$$882,560 \times \$0.65 = \$573,664.$$

5.1.2 Cost of Disastrous World Air Carrier Accidents Due to Bird Strikes

Although no catastrophic bird-caused accidents have occurred to carrier aircraft in Canada, the potential does exist. Therefore, the estimated world cost per movement for a disastrous air carrier accident must be added to the damage and related costs per movement for air carrier operations in Canada if a realistic assessment of the bird strike problem, in dollar terms, is to be made.

Four disastrous air carrier accidents due to bird strikes have occurred at or near airports in the world since 1960:

Electra aircraft	1960	Boston
DC-10 aircraft	1975	New York
B-737 aircraft	1978	Charleroi, Belgium
Convair 580 aircraft	1978	Kalamazoo, Michigan

In the first case, some 62 lives were lost. While the latter three involved no loss of life, the aircraft were completely destroyed. By good fortune, the DC-10 and B-737 were not carrying revenue passengers, the 737 crashed on a training flight, the DC-10 on a [illegible] flight. The 580 was carrying 42 revenue passengers, two of whom were seriously injured.

The U.S. National Transportation Board stated that the DC-10 accident would have been catastrophic had the flight been a routine one with passengers untrained in emergency evacuation. It is believed the same could have been said of the 737 accident.

It seems reasonable, therefore, to assume that the 737, DC-10 and the [illegible] accidents had the potential of being catastrophic [illegible] loss of life, in addition to [illegible].

The following analysis is made of the potential cost of the four accidents:

a) Aircraft cost (1978 dollars)

Electra	[illegible] million
737	[illegible] million
DC-10	[illegible] million
Convair	[illegible] million.

b) Aircraft capacity (including crew)

Electra	100
737	120
DC-10	260
Convair	56.

c) Revenue load factor = 55%

d) Number of persons aboard aircraft @ 55% load factor

Electra	[illegible] (actual)
737	80
DC-10	[illegible]
Convair	23 (actual).

e) Dollar value, if all lives lost @ $350,000*

Electra	$21.7 million
737	$28.0 million
DC-10	$60.2 million
Convair	[illegible] million.

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* Associated Aviation Underwriters' estimate of current amount, based upon a continuous record of loss of life claims and awards due to aircraft accidents over several years.

f) Total cost of accidents Electra $ 31.7 million 737 $ 42.0 million DC-10 $100.2 million Convair $ 16.5 million

Grand Total $190.4 million.

g) Estimated number of air carrier turbine aircraft movements, worldwide, excluding U.S.S.R.

Period 1959-1978 - 250 million.

h) Estimated world cost of disastrous air carrier accidents, per movement, 1959-1978

$$\frac{\text{Total Cost}}{\text{No. of Movements}} = \frac{\$190.4 \text{ million}}{250 \text{ million}} = \$0.76$$

5.1.3 Total Cost to Air Carriers of Bird Strikes in Canada

This estimate is the sum of:

a) The cost per movement for damage and related costs: $0.65

b) The estimated world cost per movement for disastrous accidents: $0.76

Total bird strike cost per air carrier movement $1.41

Total bird strike cost estimate for damage, related costs and disastrous accidents to air carriers:

882,560 movements x $1.41 = $1,244,500 annually.

5.2 Cost of Bird Strikes at Canadian Airports to Canadian Executive Jet Operators

The procedure used to determine this cost was to add together a value for total damage and related costs and an estimate for the cost of disastrous accidents to executive jet aircraft.

Details are contained in reference 2 and the results are:

a) Damage and related costs: $134,000

b) Estimated cost of disastrous accidents: 202,100

Total annual [illegible]
damage, related [illegible]
accidents [illegible] $336,100

5.3 Total National [illegible] Air Carriers and Executive [illegible] Base Period

The total national [illegible] for the base period, 1976-[illegible] costs:

a) $1,249,900 [illegible] for air carriers [illegible]

b) $336,100 [illegible] executive jet [illegible]

The annual [illegible] ($1,586,000).

5.4 [illegible] in Canada

This is calculated [illegible] amount by the average annual [illegible] recorded by the Airport Facility [illegible]

5.5 Alternative [illegible] Analysis

The above analysis of [illegible]-caused accidents may be open to criticism [illegible] safety; hence, an alternative method was used [illegible] the "catastrophic factor" (details of [illegible] outlined in reference 1).

Cost-benefit [illegible] the problem of measuring social benefit [illegible], where matters of life and [illegible] the problem is compounded by [illegible] overtones.

An evaluation [illegible] General Motors Research Laboratories [illegible] background for the proposed risk [illegible] evaluation framework focused [illegible] on the simple effectiveness [illegible] amount of risk logic that [illegible] the benefit reduction [illegible] is therefore or effectiveness [illegible] not the whole measured [illegible] population.

An evaluation [illegible] First, it provides [illegible] from risk-reduction [illegible] estimates,

it provides one measure of the cost-effectiveness of these programs.

The framework can be used to derive a desirable budget increase for a specific safety program. All that is required is an estimate of the number of fatalities that could be reduced by the proposed program. Once this is known, the maximum possible longevity gain can be calculated and a rough estimate of the desirable budget increase can be derived. The desirable budget increase would be limited by the point where the program would no longer be socially as cost-effective as other programs.

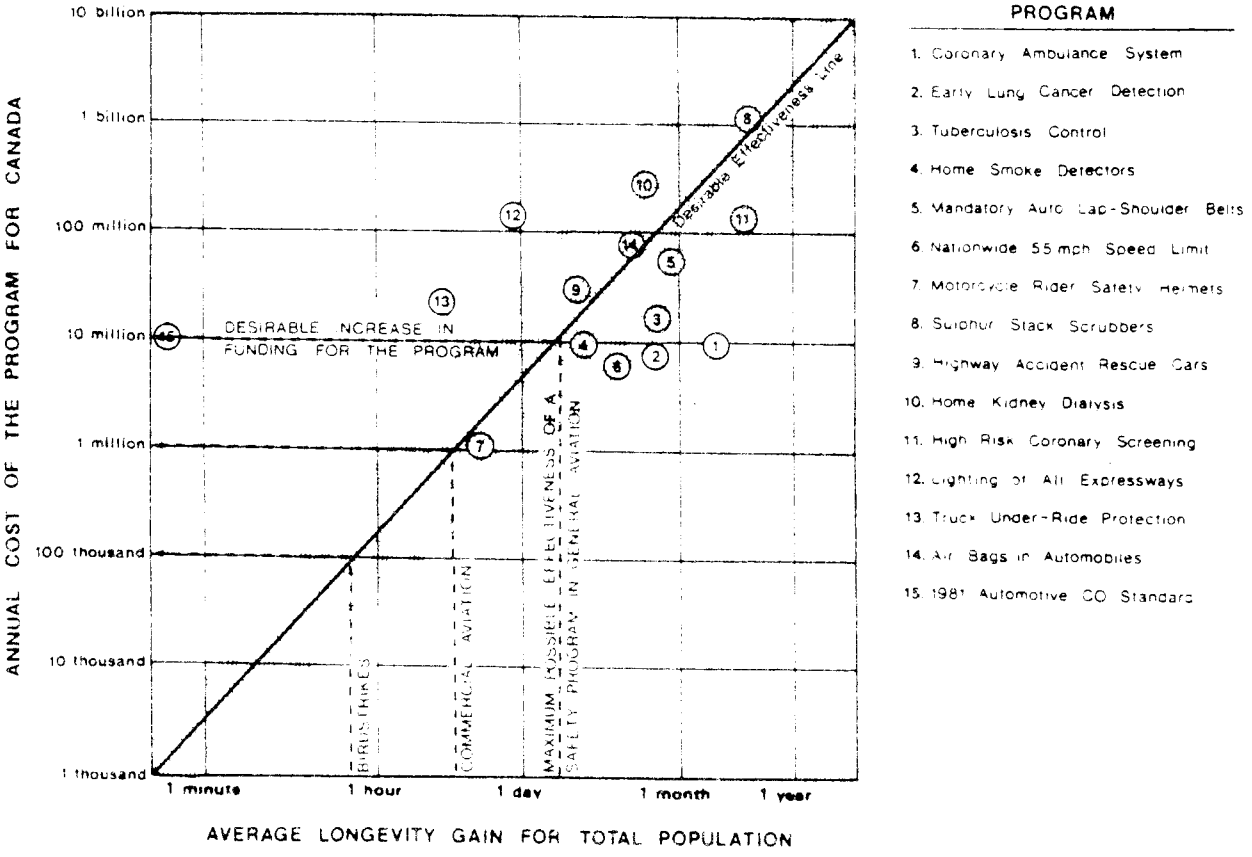

Figure 13 Desirable Budget Increases for Various Safety Programs

As shown in Figure 11, the largest gain in benefits is to be achieved by improvements in general aviation safety as about 80 people are killed in general aviation accidents every year in Canada. [illegible] number of fatal accidents, it is desirable to increase the safety budget by about $10 million per year. This would probably be a fairly significant increase over existing funding for general aviation safety programs.

It should be noted that serious bird strikes occur more often with small aircraft and increment in general aviation safety could to a degree also serve to alleviate part of the bird strike problem. It is not necessary to know the amount of existing funding [illegible] funding in terms of existing [illegible] safety programs. The framework [illegible] difficulty in obtaining facilities [illegible] framework considers marginal [illegible] cost-effectiveness.

Increased spending on [illegible] general aviation safety is not likely as [illegible] $1 million - probably an insignificant amount [illegible] relation to existing funding since the majority of [illegible] operations is quite low compared to that for general aviation. Increased spending would result in few additional benefits.

Finally, investments to reduce the number of bird strikes, with relatively few benefits to be gained, warrants an annual budget increase in the order of $200,000. This comparatively low figure is derived from the estimate that there is a risk of only one person being killed each year in an airplane accident caused by a bird strike in Canada.

Property damage [illegible] are not considered in this method [illegible] potential for increasing lifespan per capita [illegible].

The results of this [illegible] support the expenditures recommended in Table [illegible].

6. METHODOLOGY FOR ESTIMATING BENEFITS OF BIRD STRIKE REDUCTION MEASURES

6.1 Introduction

The literature search revealed that no methodology exists for estimating quantitatively the benefits which accrue from aircraft bird strike reduction measures. Hence, a methodology has been developed from logic, recognizing the limitations of bird strike data generally and of data for each of the airport sites studied.

6.2 Benefits of Bird Strike Reduction Measures

The benefits of reducing the number of bird strikes at Canadian airports may be realized in two ways:

i) savings to operators through reducing damages and associated costs of bird strikes;

ii) savings to operators through a reduced likelihood of catastrophic accidents and claims and settlements associated therewith. Since such crashes could also involve liabilities on the part of CATA, it behooves CATA to attempt to reduce strike rates to a minimum.

6.3 Reduction Factor

No statistics are available to indicate, in a precise quantifiable way, what reduction in strike costs can be expected by undertaking certain measures to reduce aircraft bird strikes, and the dynamics and diversity of the problem would appear to preclude any meaningful construction of such data.

Hence, the procedure used here is to calculate what would result from an arbitrary selection of a reduction factor of 25%, 33.3%, 50% or some other percentage.

6.4 Costs if No Measures Undertaken

Air carriers and executive jets account for a high percentage of the movements of turbine aircraft at the airports under study. No bird strike cost information is available from operators to indicate clearly what costs can be considered representative of individual airports. Hence, it is necessary to estimate the cost incurred at individual airports by obtaining a total bird strike cost to operators at all airports in Canada and allocating a portion of this total cost to individual airports on the basis of their bird strike rates.

6.5 Costs of Bird Strike Peduction Measures

The overall cost of a bird strike reductiсn program at a particular airport is the sum of the costs of measures recommended to reduce the number of strikes (such as the costs of additional operations and maintenance staff and equipment), the costs of additional airport construction, and the costs of outside contract labour and equipment.

The recommended measures were assembled through site visits and discussions with, among others, airport personnel, regional and headquarters staff, and the Canadian Wildlife Service (Ref. 3-17).

The costs of the measures were estimated by CATA airport staff, regional staff, contractors and others with a knowledge of the costs involved and are summarized in Table 5.

Airport	Cost of Single Action ($)	Annual Cost of Continuing Actions ($)	Cumulative Cost 1981-1995 ($)
Bagotville	0	0	0
Calgary International	0	3,062	45,900
Comox	0	0	0
Edmonton International	0	0	0
Halifax International	40,000	33,600	544,000
Hay River	0	0	0
Montreal (Dorval)	10,000	31,000	475,000
Ottawa International	0	1,365	20,475
Regina	29,500	0	29,500
Thunder Bay	0	1,848	27,720
Toronto International	47,000	62,000	977,000
Vancouver International	0	0	0
Windsor	120,000	0	120,000
Winnipeg International	320,000	0	320,000
Total	566,500	132,875	2,559,595

Table 5 Estimated Cost of Measures to Reduce Bird Strikes at Canadian Airports

7. FINDINGS AND RECOMMENDATIONS

7.1 Introduction

A comprehensive description of current bird strike reporting procedures in Canada and bird control organizations at CATA airports as well as the means of improving the former and increasing the effectiveness of the latter is provided in the main report (Ref. 2). Findings and recommendations other than those specific to the fourteen sites studied can be summarized under the following categories:

a) measurement of the bird strike problem;

b) types and numbers of birds involved and environmental factors associated therewith;

c) measures to reduce the bird strike rate and their resulting benefits;

d) exposure and vulnerability of aircraft and engines to bird strikes.

7.2 Measurement of the Problem

Findings:

Comprehensive bird strike reporting is an essential element in achieving continued reduction of the bird strike rate. It is therefore incumbent upon all contributors to furnish information which will assist in identifying the problems and the appropriate remedial measures.

Much more inclusive and precise reporting is required to enable a better assessment of the nature of the problem in Canada. An in-depth assessment of current reporting procedures is needed to identify and eliminate the inadequacies in the system.

The costs of bird strikes to aircraft operators are another indispensable requisite, as they afford the only means available for measuring the severity of the problem. Operators therefore have an obligation to record and supply such costs on a continuing basis.

Recommendations:

1. It is recommended that the bird strike reporting procedure in Canada be reviewed and improved to ensure that all strikes are reported by all parties concerned - pilots, operators, airport managements, air traffic services - whatever the type of aircraft involved, or the degree of damage, in order that total costs may be estimated, and bird control measures justified.

2. It is recommended that all operators be required to send bird strike data and costs periodically to CATA headquarters in the format employed by CP Air, which has the following headings: date, location, flight regime, aircraft type, type of bird, details of damage, costs (labour and material), other, total.

3. It is recommended that the methodology described in section 6 be used to determine the cost of strikes at individual airports.

7.3 Types and Numbers of Bird Involved and Associated Environmental Factors

Findings:

The most common bird species endangering aircraft in Canada and the environment favoured by these species, as indicated by visits to 14 Canadian airports during the course of this study, are as follows:

Species	Environment
Gulls	Nesting and loafing area, proximity of natural food source (shoreline), food source on airport (earthworms and insects such as grasshoppers, crane flies, etc.).
Waterfowl (Ducks)	Ponding, nesting in ditches (especially where vegetation uncontrolled), food source on the airport such as cereal crops, earthworms.
Waders/ Shorebirds	Nesting, food source on the airport, proximity of shoreline.
Raptors (Hawks)	Mice, small mammals (baby mares and rabbits, ground squirrels, gophers).
Owls	Mice, small mammals (baby mares and rabbits, ground squirrels, gophers).

Pigeons/ Doves	Weed seeds, roosting and nesting in airport buildings.
Corvids (Crows/Ravens)	Carrion, insects, weed seeds.
Starlings	Insects and larvae (crane fly).
Blackbirds	Nesting.
Snow Buntings	Weed seeds, attraction of expansive area provided by airport similar to nothern tundra.

Gulls represent the species of bird involved in the greatest percentage of damaging strikes. Of those strikes reported by the airlines as causing damage, for those years where detailed information was collected for this study (1976-1978), the bird species involved was identified and reported in 16 of the 44 strikes. Gulls were involved in 11 of the 16 strikes.

Recommendation:

It is recommended that CWS or other wildlife experts make periodic surveys of airports to determine the number and species of birds creating a problem and the attractants to these species.

7.4 Measures for Reducing the Bird Strike Rate and their Potential Benefits

Findings:

Once the problem bird species is identified and the severity of the problem assessed, bird control requirements may be formulated. The usual initial approach is to try and manage the habitat in such a way as to make it unattractive to birds by removing or altering as many of the conditions favourable to them as possible. One or more of the following courses of action may be appropriate:

Attractants	Remedial Measures
Agricultural Practices	Control agricultural utilization of airports carefully, e.g. no cereal crops, hay crops permissible depending upon local conditions.
Earthworms	Improve drainage; apply Benomyl along runway edges; minimize farming operations involving cultivation.
Small Mammals	Reduce rough areas; eliminate long grass cuttings and improve hay

	Operations on airports; mow grass on infield areas regularly.
Insects (Grasshoppers, Crane Flies, etc.)	Apply appropriate chemicals for control.
Shelter and Cover	Clean ditches, eliminate rough areas containing bushes, tall weeds, etc.; mow grass regularly and screen buildings.
Perching Sites	Remove lone trees, fences, posts, powerlines, etc., whenever possible.
Water Ponding	Improve drainage, fill low areas.
Weed Seeds	Convert weed-growing areas to grass, or mow to prevent formation of seeds; prevent grass-kill due to snowplow operations along runway edges and reseed with grass, if necessary.
Garbage	Ensure cleanliness within airport boundaries; relocate or control dumps outside the airport.

Because of the diversity of species and other considerations (such as the impracticability or cost of altering certain physical features at an airport), it is unlikely in many cases that habitat manipulation alone will completely eliminate the bird problem, and additional measures will be necessary.

These measures may take the form of frightening the birds away by using various dispersal techniques and equipment, by trapping the birds and then releasing them far from the airport, or, as a last resort, by killing the birds.

There are two categories of scaring techniques:

- static scaring devices, such as visual devices (windmills and bird mock-ups), or sound devices (audio-visual alarms and gas cannons),
- a mobile unit using flashing or search lights, broadcasting of recorded distress calls chosen for the type of birds involved, and pyrotechnics (shell crackers and live ammunition).

The latter technique has been found to be more effective at the Canadian airports studied, and is facilitated by staffing a patrol group furnished with a vehicle equipped

with radio and the above devices. Such a patrol has the advantage of mobility and choice of the most effective scaring technique for the problem at hand. The patrol, however, is dependent on the air traffic control tower which alerts the patrol when spotting birds that may present a problem to aircraft preparing for take off or landing. As well as performing the dispersal function, the patrol unit, in conjunction with field maintenance personnel, can often determine what is attracting birds (such as earthworms after heavy rains or grasshoppers in dry weather) and then implement corrective habitat measures.

Individual airport organizations are needed to deal with the bird strike problem and select the appropriate combination of bird control techniques. The nature of the problem varies from airport to airport and changes in the environment around individual airports or variations in the weather may alter the problem.

In the course of this study, it has become apparent that the success of a bird strike control and reduction program at any airport depends to a large degree upon the awareness of the problem by the various parties concerned and the cooperation between them. Experience has shown that the most effective means of achieving such awareness and cooperation is by appointing one person to coordinate all bird control work, assisted by airport security personnel, wildlife organizations and a local committee consisting of those affected by the problem (operators and pilots) and those responsible for its control (airport management, air traffic control, emergency services).

It has been generally found that the cost of corrective measures is more than offset by savings to aircraft operators, even if only a relatively small reduction in the bird strike rate is achieved.

Recommendations:

1. It is recommended that an Airport Bird Strike Control Committee be established at each CATA airport. The purpose of the committee would be to ensure a coordinated approach to dealing with the control of bird strikes at CATA airports.

2. It is recommended that a full-time Bird Strike Control Coordinator be appointed by the Airport Manager at all major CATA airports, so that the problem of bird strikes may be given continuous attention.

3. It is recommended that consideration be given to expanding CATA Document AK 91-10 "Airport Operations and Control of Bird Strikes" in the following respects:

a) the need for a Bird Control Organization, consisting of a Coordinator with specifically defined duties, and a Bird Strike Control Committee at all CATA airports;

b) formal inspections of CATA airports by the Environment Division of CATA's Airport Facilities Branch and/or by the Aviation Safety Bureau (or appropriate offices) to check on the efficacy of bird control operations;

c) inclusion of specific guidance material on bird dispersing procedures, equipment and techniques which are proving successful in practice;

d) inclusion of a section on bird species commonly found at CATA airports and their behaviour patterns.

4. It is recommended that CATA Headquarters provide training courses for bird control coordinators, possibly in conjunction with the CWS.

5. It is recommended that the importance of alerting airfield personnel concerned, as well as pilots, of bird concentrations, observed by Air Traffic Services (ATS) visually or on radar especially during migrations, be included in the Air Traffic Manual of Operations and other relevant ATS instructional and procedural material.

6. It is recommended that the methodology presented in section 6 be used to estimate the cost-benefits of bird strike reduction measures at individual airports.

7. It is recommended that a program of technical evaluation, research and development be instituted to provide the most economical and effective technology to eliminate bird (and other wildlife) problems at Canadian airports, as most equipment and techniques now employed were designed for agricultural use.

7.5 Exposure and Vulnerability of Aircraft and Engines to Bird Strikes

Findings:

While all forward-facing areas of an aircraft may be struck by birds, the nose (i.e. radar housing radome and windscreen) seems to be struck most frequently, followed by wings and engines. The majority of strikes cause little or no damage. Windscreens or radomes sometimes have to be changed. However, in one of those areas where jet engines are struck, they are damaged to such an extent that repair

or replacement is necessary. Engines are therefore the most vulnerable part of a jet aircraft to strikes, and when one or more engines fail, particularly on take-off, the result can be serious and even catastrophic.

Some jet engine designs have considerably less resistance to bird strikes than do other designs - e.g. the very large jet engines fitted to wide-bodied aircraft suffer less damage from smaller birds than do the smaller jet engines fitted to executive jet aircraft.

Discussions with experts indicate that the newer jet engine designs now coming on the market will all be optimized for fuel efficiency and noise considerations, which will inevitably make the engines less rigid and more vulnerable to bird strikes than are earlier engine models. Fan blades will be lighter for weight saving and thinner (optimized cross-sectional design) for aerodynamic reasons. Struts supporting the cowling around the fan will be angled and shaped to reduce noise levels. Fan blade snubbers (which add rigidity) will be eliminated to increase fuel efficiency.

Unless the strike prevention program at airports is improved, it seems likely that the number of damaging strikes and the resulting costs will increase once the newer jet aircraft - both air carrier and executive - fitted with these engines are introduced into service, notwithstanding present airworthiness bird strike requirements.

Recommendation:

It is recommended that air transport administrations be apprised of trends in jet engine design to decide whether any specific or general action is needed to avoid undue problems to aircraft.

7.6 Need for Continual Updating of Bird Strike Data

Findings:

One of the reasons for the increase in the number of strikes at certain airports in 1979 may be the appearance of new bird attractants, such as a new or different type of insect.

In the first ten months of 1979, Victoria Airport experienced 11 strikes. If this rate were to continue, Victoria would become the airport with the sixth highest bird strike rate in Canada; Bay River Airport, on the other hand, with only 4 strikes in the same time frame, would be dropped from the list if its lower rate were to prevail.

This points out the need for continual appraisal of the problem, so that priority can be given to those airports which are in most need of attention.

Recommendation:

It is recommended that bird strike data be continually recorded and updated so as to ensure that timely attention is given to airports which suddenly experience a significant increase in bird strikes.

7.7 Postscript

In the course of this study, a serious situation became apparent: many experts (from CATA, CWS and the carriers) familiar with the bird strike problem at airports have disappeared from the scene (through death, retirement or transfer); and the current attitude is one of complacency. These two elements could combine to create a situation worse than that during the period of high strike rates which occurred with the advent of jet aircraft. The costs at that time were high, and could now become catastrophic if the wildlife situation at Canadian airports is not controlled continuously.

References

(Transport Canada reports forming the Study of Bird Strikes at Canadian Airports - 1979)

(1) TP 2440 - Study of bird strikes at Canadian airports - 1979, Risk and Statistical Analysis

(2) TP 2441 - Study of bird strikes at Canadian airports - 1979, Main Report

(3) TP 2442 - Study of bird strikes at Canadian airports - 1979, Site Report: Toronto International Airport

(4) TP 2443 - Study of bird strikes at Canadian airports - 1979, Site Report: Vancouver International Airport

(5) TP 2444 - Study of bird strikes at Canadian airports - 1979, Site Report: Calgary International Airport

(6) TP 2445 - Study of bird strikes at Canadian airports - 1979, Site Report: Winnipeg International Airport

(7) TP 2446 - Study of bird strikes at Canadian airports - 1979, Site Report: Ottawa International Airport

(8) TP 2447 - Study of bird strikes at Canadian airports - 1979, Site Report: Halifax International Airport

(9) TP 2448 - Study of bird strikes at Canadian airports - 1979, Site Report: Edmonton International Airport

(10) TP 2449 - Study of bird strikes at Canadian airports - 1979, Site Report: Montreal (Dorval) International Airport

(11) TP 2450 - Study of bird strikes at Canadian airports - 1979, Site Report: Windsor Airport

(12) TP 2451 - Study of bird strikes at Canadian Airports - 1979, Site Report: Thunder Bay Airport

(13) TP 2452 - Study of bird strikes at Canadian Airports - 1979, Site Report: Regina Airport

(14) TP 2453 - Study of bird strikes at Canadian airports - 1979, Site Report: Hay River Airport

(15) TP 2454 - Study of bird strikes at Canadian airports - 1979, Site Report: CFB Comox

(16) TP 2455 - Study of bird strikes at Canadian airports - 1979, Site Report: CFB Bagotville

(17) TP 2456 - Study of bird strikes at Canadian airports - 1979, Compendium of Visit Reports of Special Interest - A Working Paper