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May 22 to May 25, 1984
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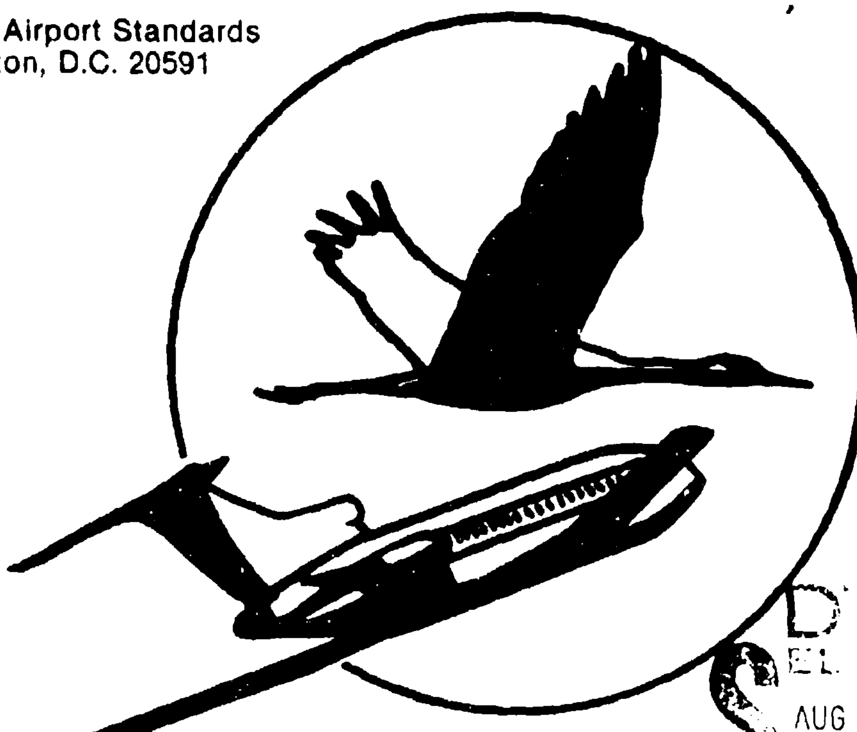

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16. Abstract

These proceedings were developed to enhance information exchange and improve understanding and control of wildlife hazards to aircraft. The 38 papers contained herein represent a wide range of views on how to control wildlife, particularly birds, which create safety hazards. Information is provided on wildlife hazards in both the United States and internationally. The Proceedings includes papers on bird strike statistics, airworthiness of aircraft and engines, identification and tracking of birds, wildlife control techniques, landscaping and airport site selection considerations, compatible land use, solid waste site bird hazards, and case studies in wildlife control.

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Wildlife Hazards to Aircraft
Conference and Training Workshop

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AD#:	TITLE:
AD-P004 177	Birds and Aviation.
AD-P004 178	Avoiding Serious Bird Strike Incidents.
AD-P004 179	Don't Fowl Out.
AD-P004 180	Accidents and Serious Incidents to Civil Aircraft due to Birdstrikes.
AD-P004 181	Analysis of Bird Strikes Reported by European Airlines 1976-1980.
AD-P004 182	Air Force Bird Strikes.
AD-P004 183	Worldwide Birdstrike Statistics of Lufthansa German Airlines.
AD-P004 184	Birds and Aircraft Engine Strike Rates.
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AD-P004 186	Aircraft Transparency Bird Impact Analysis Using the Magna Computer Program.
AD-P004 187	Microscopic Identification of Feathers in Order to Improve Birdstrike Statistics.
AD-P004 188	The Use of Small Mobile Radars to Detect, Monitor, and Quantify Bird Movements.
AD-P004 189	On the Altitudinal Distribution of Birds and Bird Strikes in the Netherlands.
AD-P004 190	Blackbirds and Starlings: Population Ecology and Habits Related to Airport Environments.
AD-P004 191	Cattle Egret Hazard Assessment.
AD-P004 192	Control of Mammals at Airports.
AD-P004 193	Airport Site Selection and Design.
AD-P004 194	Landscape Management on Airports for Reduction of Bird Populations.
AD-P004 195	Reducing Gull Use of Some Attractions Near Airports.
AD-P004 196	(Federal Aviation Administration) Policy Regarding Solid Waste Disposal Facilities.

COMPONENT PART NOTICE (CON'T)

AD#:	TITLE:
AD-P004 197	Airport Bird Hazards Associated with Solid Waste Disposal Facilities.
AD-P004 198	Successful Control of Gulls and other Birds at a Sanitary Landfill.
AD-P004 199	Effectiveness of an Overhead Wire Barrier in Deterring Gulls from Feeding at a Sanitary Landfill.
AD-P004 200	Effectiveness of an Overhead Wire Barrier System in Reducing Gull Use at the BFI Jedburg Sanitary Landfill, Berkeley and Dorchester Counties, South Carolina.
AD-P004 201	Evaluation of Effectiveness of Bird-Scaring Operations at a Sanitary Landfill Near CFB Trenton, Ontario, Canada.
AD-P004 202	Development of Bird Hazard Reduction for Airport Operational Safety.
AD-P004 203	The Bird Strike Situation and Its Ecological Background in the Copenhagen Airport, Kastrup.
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AD-P004 205	Staff Assistance to Bases for Bird Hazards.
AD-P004 206	Bird Strike Avoidance System for Dover AFB, Delaware.
AD-P004 207	Bird Strike Committee Europe.
AD-P004 208	Birds and Airport Agriculture in the Conterminous United States: A Review of Literature.
AD-P004 209	The FAA (Federal Aviation Administration) Grant-in-Aid Assurance, Far Part 139, and Airport Hazards.
AD-P004 210	The Potential of the NEXRAD (Next Generation Weather Radar) Radar System for Warning of Bird Hazards.

PREFACE

This Proceedings was prepared by PEER Consultants, Inc. Rockville, Maryland, under Contract No. DTFA01-83-R-11287. It was administered under the technical direction of the Safety and Compliance Division, Office of Airport Standards, Federal Aviation Administration.

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Publication of these Proceedings does not constitute Federal Aviation Administration approval of the findings or conclusions presented, nor does the Federal Aviation Administration endorse or recommend any products mentioned in the individual author's papers. It is published for the purpose of exchange of information.

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EXECUTIVE SUMMARY

The Proceedings for the Wildlife Hazards to Aircraft Conference and Training Workshop represents the work of 49 authors contributing 39 papers. These papers communicate to the aviation community the risks of sharing airspace with birds and problems with frequent use of airport operating areas by wildlife.

General information on wildlife hazards and statistics on bird strikes of aircraft and engines are provided. Individual papers discuss state-of-the-art techniques for identifying and monitoring hazardous wildlife and how animals can be controlled on airports.

Six papers discuss bird hazard problems created by man through conflicting land use practices, specifically addressing bird attractiveness and control at solid waste disposal facilities which are located near airports.

Bird control programs at both civil military airports are described as case studies on how airport bird control programs can be established and how airport personnel are effectively utilized in reducing wildlife hazards to aircraft.

Legal liability considerations relating to airport hazards are discussed in reference to Federal airport development grant assurances and Federal regulatory requirements.

The recurrent theme throughout these papers is aviation safety through understanding and controlling wildlife hazards. The Federal Aviation Administration's purpose in publishing the Proceedings is to make available information on wildlife hazards to the aviation community and stimulate interest and better understanding of the hazards pilots face when sharing airspace with birds and encountering wildlife on airports.

AD-P004 177

BIRDS AND AVIATION

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Bird collisions have caused serious damage to aircraft and loss of human life. Most turbine engines are more easily damaged in bird collisions than are piston engines. The extent of damage in a bird collision increases rapidly as speed increases.

Birds are attracted to airfields by open space, food, shelter and water. The attractions can be reduced by environmental management. Scaring devices can drive some birds away.

Bird movement can be studied by radar and periods of heavy concentrations of birds in the air can be observed. With experience concentrations and their movement can be predicted and avoided.

Aircraft have collided with birds almost from the beginning of aviation. The first human life lost in an accident caused by a bird occurred in 1912. From there on at intervals serious damage and loss of life have occurred in military and civil aviation. Many of the incidents were considered in isolation because they did not occur frequently. There was a tendency to forget the problem between incidents.

Canada had the same experience as other countries. The problem came to my attention first in the early 1940's when an aircraft in which I was a passenger struck a bird and suffered damage to the leading edge of the wing. In my work as a biologist, I was involved in reducing the likelihood of collisions between birds and aircraft on a few occasions in the late 1940's and early 1950's. In each case, the study related to a damaging incident.

With the introduction of turbine engines and higher aircraft speeds the concern for bird strikes became more intense. In the late 1950's and early 1960's the airline, airport and military officials came to the Canadian Wildlife Service repeatedly to ask for help in dealing with that new problem. Initially, we did not understand the problem clearly. We asked the interested agencies to collect statistics for us. The information we wanted was 'how much damage is done', 'how many birds are hit', 'what kinds of birds', 'where do strikes take place', 'what time of year is most important'. The data patterns that emerged showed that bird strikes were not very frequent - of the order of 6 to 8 per 10,000 movements of passenger aircraft and a bit more frequent in certain military roles. Strikes take place in a variety of locations, many near or on airports. A large number of kinds of birds are involved, but almost 50% of all strikes involve gulls. The strike rate increases in late summer in the northern hemisphere when both young and adult birds are flying and some are making long distance migration flights. There is a pattern of strikes on aircraft related to the cross sectional area of the aircraft.

By 1962, it was apparent that turbine engines were particularly vulnerable because they formed a large part of the frontal area of aircraft and because they could be damaged by foreign object ingestion. Because many strikes occurred near the ground, they could be very dangerous, particularly those which occurred on or just after take-off.

In Canada no single agency had enough resources to deal with the problem. The National Research Council, at the request of the Department of Transport, called together the Associate Committee on Bird Hazards to Aircraft to review the problem, suggest solutions, and work with airport and airline authorities to try the suggested solutions.

Knowing what kinds of birds were being hit and where the strikes were occurring, we looked for the things on the airport and in the airport environment that birds found attractive. Airports are large open areas. They are attractive to many birds because the birds can easily see in all directions and thereby avoid attacks by enemies. The layout of airports tends to make them attractive to birds. Other things are often extremely important. Birds require food, water and shelter. Often one or more of those things is present on or near the airport.

Water is often a problem at airports located on coasts or on islands. It may be a problem even at inland airports if they are near rivers or ponds or lakes or even if there are drainage systems in which open water is available for use by birds.

Food can be of a wide variety. The most common is that provided by a garbage dump located either on the airport or near it. Other sources can be improperly-handled food wastes at catering facilities on airports. The growth of agricultural crops attractive to birds, and insects and earthworms may all attract birds. The grass cover of the airport may support insects and small mammals that are food for birds.

Shelter can be brushy areas, some crops, overgrown ditch banks, forested areas, and improperly-designed buildings.

In all cases, we must alter the environment to reduce the number of birds that spend time on or near the airport. We need to get rid of all possible food, water and shelter from the airport itself and from the surrounding areas. Once we knew what we had to do we had to figure out how to do it, how long it took, and how much it cost. We found great differences among individual airports. Each one had to be studied as a unit. Recommendations had to be made about getting rid of specific kinds of food, water and shelter. Then the airport staff had to do the work in detail. In some cases, changes in maintenance and management procedures were necessary. In other cases, large capital expenditures had to be made to fill in low-lying wet areas, to cut down forests, and to rearrange drainage systems.

The most effective work was done where the airport staff understood clearly what the problems were and became deeply involved in designing and implementing innovative methods of solving them. In some cases, large acreages of tough thorny bushes and other difficult vegetation had to be removed to prevent birds from nesting and hiding in them. In other cases, large wet areas had to be removed to prevent birds from nesting and hiding in them. In other cases, large wet areas had to be filled with hundreds of thousands of cubic yards of earth. Sometimes fill was available from local construction sites. Occasionally, it could be secured at no cost. Labour was sometimes available through funds supplemented by special grants. Special seasonal employment programs helped at a number of airports.

We finished with a situation where many changes were made, many airports looked different, and the number of bird strikes and the damage they caused were both significantly reduced. As an example, in the first period of study from 1959 to 1963 inclusive, Air Canada's replacement costs for parts broken by bird strikes averaged a bit less than 1/4 of a million dollars per year. Our studies and recommended changes began in 1963. In the next five-year period from '64 to '69, Air Canada's hardware-replacement costs dropped to a bit more than half of what it had been in the previous five-year period. Since that time, in spite of inflation and an expanded fleet of aircraft, the hardware replacement cost has remained at a lower level. Air Canada and other airlines still have bird strikes. Things are still being done at a number of Canadian airports to reduce strikes further. Some major changes on big airports require a long time-frame before the work is completed. Sometimes, especially at military airports, it was possible to have the corrective work done rather quickly.

It is desirable to review frequently the things that originally attracted birds and to maintain a situation with the lowest level of attraction possible. Plants grow, maintenance work changes with time, and changes occur in personnel. Not everyone is enthusiastic about keeping bird numbers down and birds away from runways. It is necessary frequently to go back and to review what has been done, what changes have taken place, and what needs to be done now to keep bird attraction at a low level. Nothing is static, least of all the birds themselves. Even if you do a good job of reducing bird hazards at one time it is important to keep checking and reviewing the work at frequent intervals. Birds have all the time in the world to explore airports and find ways to make a living on them. Our job is to make sure that only the smallest possible number of birds can make a living at any time. We must continue our activities to keep that number low and decreasing.

As I mentioned earlier, the airport area itself is attractive because it is open and flat. Little birds cannot see very far if they are on the ground among grass 15 cm long and so they will move away. Bigger birds that can see over the grass feel safer from attack by enemies and will remain. If longer and longer grass is grown to make more and more birds feel unsafe on the ground, other problems may be created.

One is a build up to small mammals which may be very attractive to hawks and owls that eat small animals. If a growing season is followed by a non-growing season, tall grass may die and become a fire hazard. In our areas we cannot let the grass grow as long as we might like. We have to maintain a balance between discouraging birds of certain kinds and encouraging small mammals which attract birds of other kinds which are also struck by aircraft. We use different grass lengths on different airports, based on experience, to keep down the kinds of birds which cause most of the strike problems. The whole operation is under review continuously. The cost of mowing grass must be considered in relation to the cost of bird strikes if the grass is not mowed in a certain way. There are usually problems of money and manpower. We can never do all of the things we would like to do to reduce bird use of airports. However, we must do enough to avoid the serious incidents which have occurred in some countries when very large aircraft have sustained serious damage or have been completely destroyed as a result of bird strikes.

Even when everything possible has been done to make the airport unattractive to birds, some birds will come simply because they are passing by and need a place to land. For them a reception committee is required, which will go out quickly and drive them away with whatever method works best. Birds on an airport constitute an emergency and should be dealt with as such. Until the birds are out of the way, no aircraft landing or taking off is safe.

In addition to the birds that cause problems on and near airports, there is another whole group of problems caused by birds that may not visit airports at all.

By that, I refer to birds that travel short or long distances and pass over airports and their approaches where they can cause collisions in the air.

In Canada, the United States, and Northern Europe - where I have had much of my experience - there are spring and fall mass migrations of birds from south to north in the spring and from north to south in the autumn. In Canada those migrations involve several billion birds including up to 100 million ducks, 8 million geese, several hundred thousand cranes and swans, and hundreds of millions of birds smaller than ducks. Much of the migration occurs at night, at altitudes up to 15,000 feet. Although modern airline travel is above that altitude, each aircraft has to go up and down through the "feather curtain" on each flight.

There are also mass movements of birds between feeding and roosting areas which may involve thousands of birds. I know of one situation in an European country in which more than 15,000 gulls feed each day on a large city garbage dump and, in the morning and evening, fly to roosting areas up to 50 kilometres away. On those flights they cross through the flightways of two major airports and two smaller flying fields where they create bird hazards to aircraft and have caused damage to aircraft and death to aircrews.

All of those bird movements show up well on A.T.C. radars, civil and military. We have studied bird local movement and long distance migration by radar. We have analyzed the radar data in relation to the physiological conditions of the birds and the local weather patterns. In many cases, we can predict when bird movement will create a serious hazard to aircraft that can be avoided by changing the timing, routes, or altitudes of flights.

Our military programs have used those bird hazard forecasts to prevent losing training aircraft for the past several years. Before using that technique, they were losing one or two CF-104 aircraft per year on bird strikes. Since using the forecasts and modifying the training program on a few days and nights per year, they have not lost any. The same technique is now in use in a number of European countries with similar success.

We have also developed an electronic unit that will automatically count bird flock echoes on a radar presentation, by quadrant per minute, and express the result numerically. It can also do that by altitude band, if necessary. With that equipment, which has been well-tested but is not yet in operational use, an aircraft approaching an airfield during a heavy bird migration could be vectored to miss the heaviest bird traffic.

Another thechnique we use to reduce damage and improve safety during heavy bird migration is to reduce aircraft speed. Impact damage is related to the cube of the speed so even a small decrease in speed reduces the severity of the damage considerably.

When our airline pilots are told that bird density is high, they often request, and usually receive, permission to reduce approach speed. They may also use steeper - than normal - approach angles to reduce the time they spend in the levels where most of the birds are moving.

I hope this presentation has given you an idea of the kinds of problems we are dealing with on the airports and in the air en route. The relative importance of the two problems depends on the kind of flying. Transport aircraft usually have more problems at or near airports. Military training and combat aircraft may have more problems en route because of the altitudes and speeds at which they operate.

Whatever kind of aircraft and airports are used, there are always bird problems that can be reduced by the techniques I have discussed.

Reduction of bird hazards to aircraft depends upon human motivation. The necessary habitat control, bird dispersal, and migration hazard forecasting, involve time consuming, rather dull work that is repeated at prescribed intervals. Unless the work is always well done, bird-strikes on aircraft will continue and human lives and aircraft will be lost.

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AVOIDING SERIOUS BIRD STRIKE INCIDENTS

by

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Bird hazards to aircraft can create serious inflight emergency conditions if the pilot and crew are not prepared to handle the situation. As a pilot who has experienced two serious bird strikes that resulted in emergency landings and as a biologist who has spent the last nine years working on bird hazards to aircraft, some personal observations may assist other pilots in dealing with a midair collision with birds.

Let's examine some of the aspects of the bird-strike hazard.

Any bird, regardless of its size, should be considered a potential hazard, especially when you are flying enroute. The speed of the aircraft dictates the force of impact - the faster you are flying, the greater the impact forces. As speed doubles, the kinetic energy which must be dissipated on impact increases by a factor of four. If you must descend into an area of high bird concentrations, consider your approach speeds.

At what altitude are you safe from birds? Bird strikes have been reported as high as 33,000 ft., and ducks and geese have been observed at and above 20,000 feet Mean Sea Level (MSL). These altitudes are an exception rather than the rule. Over 90% of all civil bird strikes in the U.S. occur below 3,000 ft. above ground.

What altitude do you usually flight plan for and fly during the fall and spring bird migrations?

The greatest risk from bird hazards occurs at the lower altitudes when the aircraft is in airport environment. Most bird strikes occur during takeoff and landing - the more critical phases of flight. How many times have you observed flocks of birds on the airport, or worse, taken off through a flock of birds sitting on a runway? Some pilots have tried, only to find out too late that our feathered friends can bring down their aircraft.

TWO MAJOR RISKS

There are essentially two major risks associated with birds - windshield penetrations and engine ingestions. Pilots who have been killed, injured or crashed their aircraft have been the victims of one of these two type of strikes. Windshield penetrations generally occur on climbout or while flying at higher speeds during cruise. Commuter or air-taxi operators frequently fly at lower altitudes where birds share the same airspace.

A typical cockpit penetration results in facial lacerations, cuts on the arms and hands (pilots attempt to protect their face just prior to impact) and structural damage to the aircraft.

Because electrical panels and circuit breakers are located behind the pilot or copilot, electrical failures and electrical fires may occur. In air-taxi operations, injury to passengers is also possible.

Wind blast through the hole in the windshield can make cockpit communications impossible and radio communications unintelligible. The loss of the ability to communicate can seriously compound any emergency procedure.

It should be remembered that a spinning propeller in front of the windshield is no protection from windsheld penetrations. In high-speed situations, pilots should consider initiating a climb to reduce speed and wind blast and climb above flocks of birds.

With the windshiekd missing, changes in airflow may affect aircraft controllability at slower speeds. Don't stall out the aircraft in the traffic pattern because you failed to perform a controllability check at altitude.

ENGINE INGESTION

In an engine ingestion, damage can vary widely. On turbine and turboprop engines, the most common event is no damage or only slight damage to engine fan or compressor blades. Under more serious situations; however, blade damage can be sufficient to cause increasing engine vibrations, high exhaust gas temperatures, compressor stalls, engine fires or catastrophic failure. There was one incident in which a rear fuselage-mounted engine on an executive jet aircraft was ripped from its mounting following collison with a pelican.

Birds involved in engine ingestions frequently are flocking birds, increasing the possibility of damage to more than one powerplant. Another interesting occurrence is engines having their airflow choked off by bird remains, stopping the engine but resulting in no damage.

The most critical engine-ingestion scenario is a single or multipleengine ingestion causing power loss on takeoff. During this critical phase of flight it is essential that the pilot properly recognizes the emergency situation and performs proper engine-out or crash-landing emergency procedures.

Many military pilots (who frequently fly high-speed, low-level missions) pre-brief emergency procedures, practice bird strike emergency scenarios in simulators and study their bird hazard environment before they fly. Too few civilian pilots recognize the seriousness of such a hazard.

BIRD-HAZARD CHECKLIST

Pilots are encouraged to consider the following bird hazard checklist:

- Review information in the NOTAMS and the Airport/Facility Directory concerning your departure and destination airports.

- Flight plan at an altitude higher than 3,000 ft. above ground level - the higher the better.

- Avoid overflight of national wildlife refuges depicted on the sectional charts. Many of these refuges support large numbers of birds.

- Flight plan to avoid flying up or down rivers or along shorelines in the fall and spring. Birds frequently follow these natural terrain features during their migrations.

- Thoroughly brief emergency procedures before departure, including procedures to be followed if communications in the cockpit are lost.

- During taxiing, watch for birds on the airport. If birds are observed, request that airport management disperse them before takeoff.

- Do not take off if flocks of birds are on or adjacent to the runway.

- If an engine ingestion occurs on takeoff, abort if speed and remaining runway will allow. Inspect the engines before attempting a second takeoff. Several air carrier incidents have occurred when engine failures or high vibrations developed later in the flight becuase of undetected engine damage.

- If the takeoff must be continued, properly identify the affected engine and execute appropriate emergency procedures.

- If structural damage occurs or a windshield is penetrated, consider the need for a controllability check before attempting a landing.

- If a windshield failure occurs, climb to slow the aircraft and reduce wind blast as necessary.

- Use sunglasses or smoke goggles to reduce the effect of wind blast, precipitation or debris.

- If the windshield is only cracked or delaminates, slow the aircraft and wear sunglasses or smoke goggles to protect the eyes if the windshield should subsequently fail.

- During cruise, watch for flocks of migratory birds. Attempt to climb above observed flocks.

- During descent, use landing lights. While there is no concrete evidence that birds see and avoid aircraft using landing lights, the lights do aid the pilot in determining when he is penetrating through a flock of birds in low visibility and night conditions.

- If flocks of birds are encountered on descent or on an instrument approach, execute a missed approach, climb and go around to execute a second approach. Since most flocks of birds are distributed downward in the airspace, climbing will avoid the greatest number of birds. Birds also will migrate in waves across a wide front. A delay in the approach may result in clear airspace.

- If high bird concentrations are encountered, slow the aircraft to minimize impact forces.

- Upon landing, check the aircraft for any bird-strike damage.

- Report all bird strikes on FAA Form 5200-7 (Bird Strike/Incident Report) available through the local General Aviation District Office, Flight Service Station or Airport District Office.

- Recognize that a bird is a ballistic object, much like a bullet. Many pilots never experience a bird strike, and only a third of all bird strikes cause damage. However, awareness of the problem can aid in the proper handling of an emergency situation.

These 20 tips are designed to prepare the pilot and crew for a bird strike. Improved pilot awareness of potential hazards will result in a reduction in the number of serious bird strikes. I encourage you to practice engine-out procedures, especially prior to the beginning of bird migrations.

AD-P004 179

DON'T FOWL OUT

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(This paper is the second of a three part series prepared for the Naval Aviation Safety Review.) Bird Strike Hazard Reports prepared after collisions en birds and Naval aircraft indicate that there are many measures ble to pilots which can reduce the risk of future collisions. These : scheduling flights around peaks of bird activity, avoiding bird itats, restricting speed at low altitudes, lookout vigilence, visor discipline, aircraft to aircraft and aircraft to control tower communication, preflight briefings, bird strike avoidance training, development of a Bird Aircraft Strike Reduction Plan for each air facility, and good reporting.

Last month we left poor Cal Rodgers pinned under his Wright aeroplane - the world's first bird-aircraft strike fatality. Calbraith Perry Rodgers was not your basic run-of-the mill pilot. He was a great great grandson of Commodore Perry. Socially prominent, he was a member of the NY Yacht Club and was a former Columbia University football player. At 6' 4" he was also one of the world's tallest aviators. In 1911 this dashing figure captured the imagination of the entire nation, when he became the first ever to fly coast to coast. Leaving Sheepshead Bay, NY on September 17th at an average air speed of 50 mph, his goal was to complete the trip in 30 days and win a $50,000 prize offered by William Hearst. He became lost the first day, however, when he followed the wrong railroad tracks (the navigation system of the day). On the second day he crashed into a tree ensuring that he wouldn't get to California in a month. After extensive repairs he continued the trip anyway. A subsequent landing site, which he thought was a field, turned out to be a swamp. On another occassion he shredded a prop on a barbed wire fence and later crashed trying to fly <u>under</u> some wires. When he landed in Pasadena, CA on November 5th to the cheers of 20,000 admirerers, all that remained of his original aircraft was the vertical rudder and the dripping pan!

On April 3 1912, a gull became entangled in his external controls while he executed an acrobatic manuever 100 ft over Long Beach, CA. Seven thousand people watched in horror as he plunged to the edge of the surf.

It seems ironic that this well bred, well educated national hero who had survived so many crashes would meet his end due to a bird strike.

Cal Rodgers had no way of learning about bird strikes from others - he was the pioneer when it came to fatal bird strikes, but we can try to learn something from his probable mistakes which may have included:

inadequate bird avoidance training
inadequate bird lookout vigilence
failure to consider habits of local birds

Cal Rodgers not only had inadequate bird avoidance training, he didn't have much training of any kind. In fact, he had only been flying for three months when he departed on his cross country trip!

Furthermore, it is difficult to imagine that anybody attempting a "Texas Tommy" in a primative airplane at low altitude over a beach had any spare time to look for birds. Rodger's lookout vigilence probably was nil.

Unfortunately, these sorts of errors are still being made. In additional to lives, the stakes involved in Naval bird aircraft strikes also include aircraft costing millions of dollars, and important defense missions. But there are positive steps each pilot can and should take to minimize the risk of colliding with a bird and that's what this article is about.

The pilots report and the Commanding Officers comments found in General Use Naval Aviation Bird Strike Hazard Reports, Limited Use Naval Aircraft Mishap Investigation Reports speak eloquently on the subject of how not to hit a bird. So lets allow their thoughts to reinforce the main points. (All quotations below are extracted from recent reports.)

Almost everyone has heard the world's biggest lie - the check is in the mail. The world's second biggest lie (known only to a few Naval aviators and found only on Bird Strike Hazard Reports) is "corrective action is beyond the originator's capability." Sadly this defeatist attitude can become a self-fulfilling prophecy. And what could the author have meant by, "Due to infrequency of reported bird strikes...corrective action is not deemed necessary at this time?" Of course corrective action is possible and necessary. At risk are missions, lives and aircraft. The hazard keeps increasing too, as larger, faster aircraft (and more of them) fill the skies. It is foolhardy to be lulled into complacency because strikes at a particular location have been infrequent or minor. The stakes are too great. Prevention of bird-aircraft collisions, like baseball, is a "game of inches." A six inch difference in the point of impact may be the difference between a dead bird and a dead pilot. And keep in mind that one-third of all military strikes involve engines. (Any time a bird enters an engine a catastrophe can occur.) Said one hazard reporter, "had the bird impacted some other portion of the aircraft and not caused injury to the PAC, the incident would not have been a mishap." That's like saying - if my Great Aunt Edna had had wheels she would have been a Chevrolet. And if that loon had been a few inches to the left maybe it wouldn't have killed the co-pilot of a private jet near Cincinatti in 1983. And if that goose had been a few inches lower maybe the pilot of that Republic Airlines flight wouldn't have lost an eye. And if those gulls were a few inches higher in September 1981 in Cleveland maybe the Commander of the Thunderbird Demonstration Team would be alive today. Lets keep the word "if" out of our bird-aircraft strike hazard vocabulary. Corrective action not deemed necessary indeed!

There are many, many positive steps that air crews and air traffic controllers can take to minimize the risk of a bird strike. There are no magic wands or ray guns available and the problem will never be eliminated. But the odds of incurring a mishap can be reduced by following a few general guidelines.

For years researchers have been looking for aircraft-mounted devices that will repell birds, but the pickings have been slim.

The use of wingtip-mounted strobelights reduced bird strikes marginally in a study done at the Swiss Ornithological Station. In theory the more unnatural an aircraft looks, the more likely birds will notice it early and try to get out of the way. If one believes that lights can't hurt anything, then the idea is to play the odds and have them on night and day when operating under 10,000 feet. The most successful, proven bird strike reduction methods do not rely on technology, however, but rather on command emphasis, training, good airmanship, and resolve.

Since most birds are found at low altitude, pilots have the law of averages on their side by doing two things (when the mission permits)

1. Minimize flying below 6,000 feet AGL

2. Avoid bird habitats such as marshes and farms when low altitude flying is necessary

But strikes occur at higher altitudes also. In the words of one OINC after an A-6E cruising to NAS, Cubi Point, RP struck a bird on 15 Dec '83, "Bird strikes continue to plague naval aviation even at altitudes where one might not expect them. Constant vigilance combined with professional airmanship is the only sure way to minimize the mishap potential."

Nobody ever said it was easy to fly an airplane and watch for birds at the same time. In between the mission, the piloting and the office work (reading maps, checking instruments, keeping records), there isn't a lot of time left for bird-watching. Military missions which require night flying, bad weather flying, wing flying and high speed flying and combinations thereof don't make it any easier. Compounding the problem is the fact that most strikes happen during take-off and landing when there is least opportunity for bird watching.

The Commanding Officer's comments after a CH-53D hit a bird during a 9 January 1984 troop lift near Camp Pendleton, CA sums this thinking up very succinctly. "Birds will continue to be a hazard to the helicopter pilot. All aircrew members must be constantly aware of this problem and keep a good lookout doctrine. Nothing can replace the value of several sets of eyes constantly looking for hazards."

Stated another way after an A-4M experienced a strike on 5 December 1983 enroute to MCAS Cherry Point, NC, "Our best and only defense against the constant potential of bird strikes is awareness of the possibility, professional preflight briefs of hazards and emergency procedures, and good heads up flying."

Now let's talk about some avoidance and evasion techniques that can save your life. An obvious step to consider when flying near concentrations of birds is to slow down. At speeds below 250 KIAS, chances of seeing and avoiding birds increase. So when speed is not mission essential, throttle down, and give yourself and the birds some extra time to react. (The birds don't want to be involved in a strike either.) And remember, the force of impact is proportional to the square of the speed of the aircraft. At supersonic speeds a duck may do as much damage as a cannon round. By slowing down, the impact force is reduced if a strike does occur. This thinking applies also to taxi speeds.

Another prudent avoidance strategy is to limit formation flying when bird activity is greatest. Wing and interval takeoffs sometimes lead to wingmen hitting birds scared up by the lead. This is a dangerous time for the wingman to encounter birds since he is concentrating on the lead aircraft and little else. When birds make a sudden appearance during a takeoff roll it is up to the leader to warn the wing. When bird activity is heaviest it may be safer to depart in trail.

Another important technique is to keep sighted birds in sight. To allow birds to slip into a blind spot is to court disaster. For example, on a UH-1N, the co-pilot's doorpost, the door and window frames, the windscreen and greenhouse frame, and the windshield wiper motor join together in the upper left quadrant of the copilot's field of view to create a 113 sq. inch trapezoidal blind spot. This blind spot located twelve to seventeen inches from the copilot hides an area (given a 125 knot closure rate with an object three seconds from the aircraft) larger than six football fields. Very large birds could easily "hide" in such an area.

If there are a few seconds to attempt an avoidance manuever, and you're not sure which way to turn, just remember that old song, "Clear the Loon" and climb. Why? Because most birds are "programmed" to dive when they are trying to avoid collisions.

Some bird avoidance strategies seem so obvious they may not seem worth discussing. But some of the most obvious never seem to show up on hazard or mishap reports. For example, what should a pilot do if he spots a bird 1000' dead ahead while cruising at 250 KIAS and no safe avoidance measure is possible with the aircraft being flown? If control can be maintained, the answer is duck! This scenario provides 3 whole seconds to do something. Ducking under the windscreen may not seem too macho, but it sure beats decapitation (or loss of eyesight).

Visor discipline won't decrease the rate of bird stikes but it will minimize the consequences. According to one study 20% of all strikes involve canopies. (Seven percent are shattered.)

If you think the hazard is exaggerated, ask Idaho Air National Guard pilot, Greg Engelbreit. In April 1982, while flying his RF-4C Phantom II fighter at low altitude slightly below the speed of sound, he smashed into 25 lb. whistling swan. The left panel of the windshield desintegrated. Plexiglass ricochetted around the cockpit like shrapnel, carving up everything in sight including parachutes. Engelbreit was knocked unconscious, his left arm shattered. The navigator (a non pilot) somehow landed the aircraft after Engelbreit revived just long enough to lower the landing gear, flaps and tail hook. Several hours of surgery and transfusions were required to pull him through. He may never have full use of his arm, but his life was saved by his visor.

These kinds of occurences are by no means rare in Naval aviation. On 20 March '82, while transitioning to a landing configuration into MCAS Beaufort, SC, a T-2C struck one of twenty birds crossing its flight path. The bird penetrated the canopy above the pilots head and continued to the bulkhead behind the rear cockpit ejection seat. The pilot in command declared an emergency and made an immediate uneventfull landing. Said the Commanding Officer, "A proper down and locked visor precluded serious, facial/eye injury to the student in the rear seat."

On 30 November '82 a UH-1N enroute to MCAS Cherry Point, NC took an 8 lb loon through the left windscreen. The pilot in command stabilized the aircraft at 400 feet and declared an emergency and landed safely. Uncle Sam had to dish out only $529 for repairs, but the pilot was injured and and an additional cost of $25,000 in lost workdays was incurred.

On 12 October '83, the IP of a T-34C entering a landing pattern at NAS Whiting Field, Milton, FL was struck in the neck by a chicken hawk. A similar strike there six weeks earlier resulted in both pilots being temporarily knocked out. Fortunately, both of these dangerous incidents had happy endings.

Visor discipline is important; it saves lives, eyes and aircraft. If ever tempted to leave a visor up just remember these words: a bird in your face is a major disgrace.

Another method of reducing bird stikes is to emphasize the subject during pre-flight briefings. When blood and feathers were found inside a main wheel well of an A-7E at NAS Cecil Field, FL during a preflight inspection on 5 Dec '83, the Commanding Officer was motivated to comment as follows:

"Episodes of this nature serve as a constant reminder that bird strikes are a possibility in every phase of flight. Pilots/aircrew need to continually brief their actions should a bird strike occur. Bird strike emergency procedures always receive attention during low level flight briefing while...often neglected during briefings on take offs and landings. Ironically, the majority of reported bird strike incidents have occured in airport traffic areas. Although it is impossible to eliminate these incidents we can take precautions to minimize their effects; i.e., know your procedures, be prepared, anticipate it happening in any phase of flight."

Heed this good advise. Bird strike hazards should be treated like weather during briefings. Just as missions have to be adjusted for weather conditions, they may have to be modified to avoid bird migrations and other concentrations of birds.

If bird density is too high, pilots should be briefed to change runways or even fields. The checklist should always include potential problems, evasive actions, engine failure procedures and visor discipline.

On 16 January '84, a CH-53D collided with a gull while landing at MCAS New River, NC. The crew was fortunate. The gull remains only got as far as the port nose, gearbox oil cooler and the port engine air particle separator. Undoubtably the crew will continue to take seriously the bird strike awareness training provided during the OPEVAL period.

Said one Commanding Officer, after an A-4M hit some birds during a 6 January '84 air to ground bombing run at MCAS Cherry Point, NC, "Bird strike frequency continues to be high even though the intense migration period has ended. Smaller non-migrating birds have continued to be a bird strike problem... This hazard should be included in all preflight briefs."

Just as preflight briefings prepare pilots for the "big picture" on bird activity, on-going communication on the subject provides constant update on local conditions. Pilots must talk to each other and to the control tower. The control tower must provide immediate information regarding the movements of birds.

On the night of 11 February '81, a flock of gulls flew into the path of Otis 10, a KC-130F making a visual approach landing at MCAS New River, Jacksonville, NC. Multiple strikes were taken on all four propellers, on the lower left portion of the windscreen, on the vertical stabilizer approximately mid way up, on the leading edge of both wings; and on the starboard refueling pod. The remains of 87 birds were found on or about the runway! The corrective action in the hazard report read as follows: "It is recommended that pilots request a report on bird activity when operating in areas where a high degree of bird activity might be expected, for example, coastal regions. It is recommended that the reporting of observed bird activity by pilots be vigorously pursued. Otis 10 was not cautioned of any bird activty. There had been noticed bird activity approximately one hour prior to the arrival of Otis 10."

One-thousand birds took to the air as four TA-4's landed at NAF El Centro, CA on 15 Nov '83. The next aircraft to land, an F/A-18A struck six birds. Could increased awareness and/or in-flight communication have prevented this strike?

Another potentially avoidable strike occurred on 23 September '82 when an F-4S flying a full maintenance check at MCAS Beaufort, SC, hit a bird during takeoff climb. The reporter remarked that "At the time of the strike multiple aircrafts were in the touch and go pattern with no reported bird activity."

Transient crews have a special need for local knowledge. When an SH-3D hit a bird during a touch and go at NAS Jacksonville on 8 December '83, the Commanding Officer said, "The hazards of bird strikes will remain with us. Communication flow between pilots and controllers concerning local bird activity continues to be the best method of transmitting knowledge of a known hazard and avoiding active bird concentrations."

Crews should not be shy either. By requesting information on bird activity they remind air traffic controllers to look for birds. On 21 November '83 an OV-10D aborted a takeoff after rolling through 15 gulls at MCAS New River, NC (two dead gulls were found). The Commanding Officer emphasized"...the necessity to query air traffic controllers about bird activity in the local operating area."

The role of the tower in alerting aircraft of hazards cannot be over-emphasized. In many cases published warnings are necessary. On 1 October '82 a P-3B killed at least 21 birds 10-15 seconds after liftoff from MAF Misawa, Japan. A three engine landing at 114,000 lbs was made after an emergency declaration, fuel dump and burndown. A NOTAM warning was issued.

On 18 January '84 an A-4F hit one of 30-40 black ibises at 600 ft. AGL, and 230 KIAS during practice bombing. A six inch hole in the radome and 12-14 nicked compressor blades resulted. The recommended corrective action included,"...NAS Fallon include the following in remarks section of IFR supplement: "Caution - light to heavy bird activity vicinity airfield. All aircraft use landing or taxi lights while in the airport traffic area."

The key is teamwork; on-going two way multi-media communication flow will reduce bird-aircraft strikes. Silence is deadly, not golden, when it comes to communications on bird activity.

A classic principle of war is to know your enemy. This is not to say that Navy pilots should become ornithologists, but rather that a basic knowledge of bird behavior - especially migrations, roosting tendencies, and daily feeding patterns can help in reducing strikes. This knowledge can be acquired by sharing information and by observation. Seasonal bird migrations are a well studied phenomenon. Altitudes, flighways, speeds, rates and densities are known. Consult the P.I.F. for VR/IR routes with high densities of bird migration.

On 24 January '84 an E-2C hit a bird during a multiple touch and go at NAS Norfolk, VA. Feathers and remains were removed from the starboard oil cooler duct, the engine air inlet and the forward prop spinner assembley, which luckily were replaced at a cost of only $45.30 and a half a manhour.

In his comments the Commanding Officer noted that, "as long as birds and Naval aviators continue to vie for the same airspace the chances of collision are ever present..." The suggested corrective action was as follows:

"Awareness of nesting communities and large concentrations of migratory birds should allow a Naval aviator to avoid the area if possible."

Sometimes the critter whose habits must be understood isn't even a bird. At NAS, Cubi Point, Republic of the Phillipines, an A-7E roaring through the night on 5 May '82 during night bombing practice encountered an all too common problem at that location. It was only upon postflight download of an unexpended MK76 that the remains of a large bat (28 inch wingspan) were discovered. The MK76 was on the centerline aft of an MER located on station 2. The explosive charge was not actuated despite a direct hit of the bat's body with its wings extending aft, enveloping the entire bomb. The aircraft suffered no damage. The bat strike probably occured during a GCA approach or during aircraft climbout after takeoff.

In his comments the Commanding Officer stated, "Command has taken measures to avoid flight during the hours of peak bat flying." That is almost an understatement because Cubi Point provides almost a textbook review of many of the points presented thus far. Lets let the Bat Strike Hazard Report dated Jan '84 [prepared after a momentary torch and 3 engine landing by a P-3B (MOB)] do the talking:

"Postflight inspection revealed remains of a fruit bat in the number four engine air intake against the inlet guide vanes. Subsequent required maintenance on engine revealed no damage...Heavy fruit bat migration occurs in the immediate vicinity of Cubi Point just prior to the rainy season. Bat activity is heaviest at dusk when large groups fly through the airport traffic area to their nighttime feeding grounds. Cubi tower routinely advises aircraft of any known bat activity taking place in the area. Additionally aircrews are warned of the hazard by a sign conspicuously posted in the flight planning room and a warning in the enroute supplement. This squadron has educated all pilots on the hazard and terminated all avoidable field work at Cubi Point between the hours of 1800 and 1900 local until the bats have departed the area."

If the object of our attention was limited to just one bird we would pick the gull. (There are actually forty-four species, each with its own peculiarities.) The Air Force notes that 80% of all engine ingestions by large birds involve gulls.

When a gull was ingested into a TA-7C engine at NAS Miramar, CA on 13 June '83, tentative identification of the debris was made as follows: "fishy odor and grey and white feathers indicated the ingested bird was a seagull."

Be aware, as the pilot of an A-4M was at MCAS Cherry Point, NC on 15 December '83 when he noted that, "During low ceiling and foul rainy weather, large amounts of seagulls are noticed inhabiting the many open fields and grassy areas nearby the airfield. Due to vicinity of the station near many bodies of water, seagulls are a constant threat."

Discretion is the better part of valor after colliding with a bird. The pilot of an F-14A who hit a flock of English sparrows at NAS Miramar, CA on 3 January '84 on his take off roll with 10,000 feet of runway remaining did the correct thing - the only thing to do - he aborted. "A timely abort prevented this incident from becoming a mishap." Even if everything seemed fine and the instrument readings were normal, he took the prudent course of action.

There have been well documented cases of seemingly innocous bird strikes causing serious problems later on. A minor dent in a wing may later lead to fuel line or hydraulic failure. A minor bird strike on at least one occassion caused a P-3 radome to disintegrate....hours later.

Sometimes the need to abort is obvious - like when a P-3C II rolled through 100 gulls on 30 December 1983 at NAS, Moffett Field, CA. The take-off was aborted when birds struck the windscreen and damaged the radome and antennas.

The crew of an HH-46A witnessed an "explosion of feathers" upon takeoff from OLF Imperial Beach, CA on 4 November 1983. Feathers were found in the particle collector box of the number 2 engine after a precautionary landing.

Another obvious abort situation developed when a pilot in a F-4S over NAS Oceana, VA heard and felt a loud thump while decending through 600 feet and 150 knots. An immediate climb with both engines in afterburner was initiated with the port engine at 70%. An emergancy was declared. After a safe landing, part of a mallard duck was removed from the first hinge section of the forward camp assembly.

Sometimes the need to abort is more subtle such as when the crew of an A-6E heard and felt a thud during a low level navigation/practice bombing syllabus training sortie. Flying at 400 kts in night IMC conditions over the Boardman Target in Pendleton, OR they commensed an immediate climb. With all instrument indications normal they aborted the mission and made an uneventful landing. Post-flight inspection indicated that a strike on the star-board intake had FODed the engine.

The final step is for each pilot to integrate and internalize bird strike training and briefings...to prepare mentally for any eventuality. After a TA-4J taking off from NAS Lemoore, CA struck a bird on 25 January '84, the Commanding Officer stated that "a bird strike during the take off evolution is one of those events over which the pilot has very little control; the options for evasive manuevers/alternative procedures are extremely limited. However, the procedures to be followed after the bird strike occurs can be well thought out in advance. Bird migration and nesting in the vicinity of NAS Lemoore is a fact of life. Each pilot must establish and review a "what if" scenario in order to prepare himself to face the problem."

On 2 December '83 an AV-8A ingested a bird passing 800' on climbout one mile from MCAS Cherry Point, NC. The reporter noted that, "all air crews...must formulate a plan of action, both to avoid bird activity and also what to do in case. Don't wait for an emergency; think about bird strikes now."

Another way to look at the cerebral aspect of bird strike prevention was expressed after an A7E collided with either a large turkey buzzard or a black vulture on 11 January '84. It was during landing, on a drizzly night at NAS Cecil Field, FL that a loud thud followed by a bright flash was observed. The engine was rejected to the the tune of $31,536 due to compressor damage.

The investigating board noted that, "Mishaps of this type can never be totally eliminated, however, their effects can be minimized through proper briefings, bird strike awareness, and expecting the unexpected in every phase of flight."

There are times when all of the bird strike avoidance techniques described are inadequate. Thats the time to ask for help. When a P-3B hit a bird on 25 October '82 at NAS Barbers Point, HI, that marked the fourth such incident in less than a week. A local ornithologist was consulted and tentatively identified the problem as migratory golden plover feeding in grass areas next to the runway.

The services of the USAF Bird Aircraft Strike Hazard (BASH) team have, on occassion, been requested by Naval activities. BASH has been very helpful on several occassions, but neither their mission, staffing, nor funding permits routine support for the Navy.

The first place to look for help is from the cognizent field division of the Naval Facilities Engineering Command. Your Public Works Officer has at his disposal, Navy civilian applied biologists working out of NAVFAC Engineering Field Divisions (EFD's) located at Honolulu, HI; San Bruno, CA.; Charleston, SC.; Norfolk, VA.; and Philadelphia, PA.

When 8 collisions between P-3's and gulls occured at NAS Brunswick, ME during an 8 week period in 1982, an Engineering Service Request (ESR) was sent to Northern Division, Naval Facilities Engineering Command.

An applied biologist met on-site with air operations personnel and the local U.S. Fish and Wildlife Service specialist. They developed measures to be included in a new bird-aircraft strike reduction plan. The primary purpose of the plan was to identify methods of making flightlines, taxiways, runways, and surrounding areas unattractive to birds, and to establish responsibilities and coordination

Northern Division, Naval Facilities Engineering Command is currently on the distribution list for Bird Strike Hazard Reports. Information is entered there into a computerized bird strike data base. Cognizent EFD's are notified when serious strikes or developing patterns are noted. Coordination has also been established with the Federal Aviation Authority (FAA) and with Navy natural resources personnel who are responsible for land management planning.

Don't play, "I've got a secret" with bird strikes. The first step in getting help when it is needed to report bird strikes faithfully, completely and accurately. And don't follow the recommended procedures just because OPNAV says so. Because if you don't, the next thing that goes bump in the night could be fatal.

Remember that old song, "Too close for comfort?" Well, there is no such thing as a routine bird strike. Implied in each seemingly trivial occurrence is the realization that the difference between a minor strike and a disaster might have been the width of this page. It helps to be lucky, but you've got to be good to be lucky. Luck occurs most often when preparation meets opportunity. So prepare now to prevent bird strikes and to react properly when they occur.

ACCIDENTS AND SERIOUS INCIDENTS TO CIVIL AIRCRAFT DUE TO BIRDSTRIKES

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ABSTRACT

The Paper contains detailed histories of accidents and serious incidents e.g. double engine ingestion, holed airframe, for the years 1981 to 1983. An attachment contains a summary of all fatal accidents due to bird strikes between 1912 and 1980. The paper is divided into three groups;

- (1) transport aeroplanes over 5700kg (12,500lb) and executive jets,
- (2) aeroplanes below 5700kg, and
- (3) helicopters.

No attempt has been made to analyse the information although it is apparent that for transport aeroplanes the critical area is engines and for light aeroplanes and helicopters the windshield may be critical.

INTRODUCTION

Surprisingly the first fatal accident caused by a birdstrike was when a Wright Flyer crashed after striking gulls in 1912. Since then there are known to have been 18 fatal accidents to civil registered aircraft and at least 34 aircraft destroyed. It is likely there are more, as information is only accurate for about the last 20 years. Of these fatal accidents, 5 involved public transport aircraft and 13 involved general aviation aircraft.

The number of fatal accidents to transport sized aircraft is thus quite modest, and there have been no fatal accidents involving jet airliners. The increased awareness of the problem, implementation of proper measures at a growing number of airports around the world, and tougher airworthiness criteria for aircraft and engines may account for this. However, there have been some very near misses in recent years such as the Kennedy Airport DC 10 and Belgian Boeing 737 write-offs when the occupants all escaped from the burning aircraft. There have also been many cases of multiple engine damage, fortunately with just sufficient power to return, or runway length in which to stop.

The author would welcome any new or additional information.

Serious Incidents to Aeroplanes over 5700kg together with Executive Jets

Date	Aircraft	Regn	Operator	Location	Total Aboard	Injury to Occupants
15.2.81	Fokker F28	VH-	-	Derby Australia	-	Nil

During take-off run struck a Nankeen night-heron (Nycticorax caledonicus weight 750gm). Take-off was abandoned after an uncontained failure of engine 1. Compressor case holed by 2 blades, but cowling not penetrated.

25.2.81	DC10	N-	-	New York JFK	-	Nil

During climb a flock of gulls was ingested in engine 2 & 3. There was medium damage to engine 2 and major damage to engine 3.

25.3.81	B707(JT3D)	-	-	Kanombe, Rwanda	-	Nil

During landing birds of prey were ingested in engine 1 and 2. Aircraft was imobilized by engine damage.

29.3.81	B727	N-	-	Nr New York JFK	-	1 Minor

During climb at 3,500ft geese were struck, inner and outer panes of first officers windshield shattered, but bird did not penetrate. First officer received facial cuts from glass fragments. Left wing holed.

7.4.81	Lear 23	N400PG	Private	Lunken Executive Cincinnati, USA	2	1 Killed 1 Minor

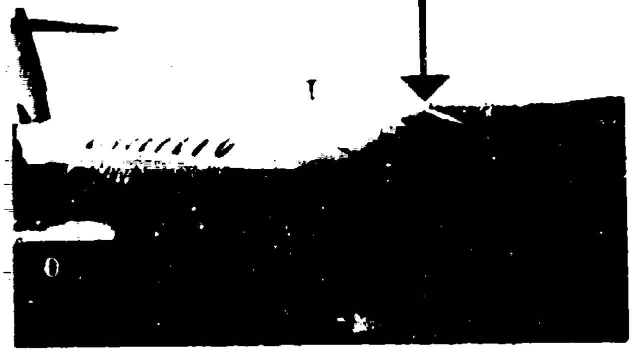
The aircraft was in a climbing turn at about 4000ft when the aircraft struck a Common Loon (Gavia immer weight 3.7kg). The bird penetrated the right windscreen and killed the co-pilot. Windscreen debris damaged No 2 engine which had to be shutdown. The pilot's arm was badly cut but a safe landing was made using the emergency brake chute and with no flaps. The weather was good, the flight being at 11.35 local time. The pilot did not see the bird. The Lear 23 is of an age such that the windscreen was not required to withstand a bird of even 4lbs.

18.4.81	NAMC YS11A	N173RV	Sced Pax	Sand Point, Alaska	39	Nil

The aircraft was on short finals when a gull struck the windshield centre post, the remains seriously reducing the pilots vision. The pilot misjudged distance and altitude, the main gear impacted an embankment on the approach, both main gear wheels were knocked off and the aircraft came to rest 1500ft beyond the threshold. The damage was substantial.

6.5.81	A300B	F-BGEB	Air France	Paris Orly	-	Nil
	During the take-off roll at 110kts struck flock of wood pigeons (Columba palumbus weight 460gm). Birds ingested in both engines damaging four fan blades on each one. Take-off abandoned and stopped on the runway. Birds also struck wings, landing gear, fuselage and empennage.					
24.5.81	B737	-	-	Johor Bahru, Malaysia	-	Nil
	Both engines were damaged during the take-off run.					
21.6.81	B737	G-BMHG	Air Europe	Naples, Italy	-	Nil
	During the take-off run a flock of birds was seen to land on the runway about 100 yds ahead of the aircraft. The birds, pigeons (Columba sp) took off just before the aircraft reached them at about 120 kts (V_1 125). Several impacts were felt so the take-off was successfully abandoned using reverre thrust and brakes. Later some fusible plugs blew. There was birdstrike damage to the nacelles, nosewheel steering cables and to both engines. Six LP compressor blades were damaged in No 1 engine and 5 in No 2 engine. Both engines were changed.					
4.7.81	DA01 Mercure	F-BTTG	Air Inter	Ajaccio Corsica	-	Nil
	During the climb at 3000ft 250kts the outer windshield was shattered after a violent bird impact.					
6.7.81	DC10-30	N112WA	World Airways	Gatwick UK	-	Nil
	At rotation on take-off flames and smoke were seen from engine 3 and the aircraft returned with the engine shutdown. The runway was inspected and 80 or more pieces of engine were found, together with some bird remnants. The bird remains were identified as either Feral or Wood Pigeon. (Columba sp of weight 400 to 500gms). The engine was seriously damaged with holed casing.					
20.7.81	DC8-62	-	-	Thesalonika, Greece	-	Nil
	Take-off was abandoned after striking pheasants (Phasianus colchicus weight 1.2 kg) on take-off. There was severe damage to engines 2 and 3. Repair cost was 145,000 US dollars.					
8.8.81	L1011	G-BEAK	British Airways	Larnaca Cyprus	347	Nil
	On take-off there was a loud bang at 90 kts, so the take-off was abandoned. Evidence of bird ingestion in engines 1 and 3. Ground run revealed power loss on engine 3. Aircraft ferried to base.					
19.8.81	DC3	ET-ABY	Ethiopian Airlines	Jimma	-	-
	Aircraft suffered a birdstrike causing wing leading edge skin damage and five broken or cracked ribs.					
29.8.81	B747SP	-	-	Wellington NZ	-	Nil
	During take-off struck flock of gulls. Uncontained failure on engine 1. Aircraft diverted to Auckland.					
1.9.81	Fokker F28	SE-DGC	Linjeflyg	Near Ornskoldsvik Sweden	-	Nil

While flying at 8000ft and slightly above 300 kts the aircraft struck an Osprey (Pandion haliaetus, weight 1.5 kg). The bird penetrated the skin above the windshield damaging frames, looms etc and entered the flight deck causing considerable mess.



12.9.81	B747	-	-	Delhi, India	-	Nil

During approach struck vultures (Cathartidae). Engine 2 suffered uncontained failure holing No 2 fuel tank as a result of flying debris.

24.9.81	B737	-	-	Nagaya, Japan	-	Nil

Abandoned take-off after gulls were ingested in both engines. Blade damage was found in both engines.

16.10.81	A300B	F-	Air Inter	Paris, Orly	-	Nil

During approach at 150ft and 130kts struck a flock of Stock Doves (Columba Oenas weight 350gm). Birds ingested in both engines.

19.10.81	DC8-50	-	-	Makurdi, Nigeria	-	Nil

Engines 1, 2 and 4 ingested birds when the aircraft struck a flock during the take-off run. Landing gear and lights also struck. Two engines repaired at base, once changed.

19.10.81	A300B	F-	Air France	Tunis	-	Nil

Struck flock of birds at 150 kts during take-off run. Both Engines, Fuselage and wing struck. Three fan blades were damaged.

23.3.82	B747 (JT9D-7)	VT-EFJ	Air India	Jeddah, Saudi Arabia	-	-

During the approach the aircraft passed through a flock of birds causing the pilot to shutdown No 1 engine and bring No 2 back to idle. After touchdown No 2 was shutdown due to vibration. Both engine nose domes and all fan blades were damaged. There were holes in the nose cowl of No 2 engine and the tail cone was missing.

19.6.82	DC8-63	-	-	Yesilkoey, Turkey	-	Nil

Gulls ingested in engines 3 and 4 during landing run. Both engines changed.

11.7.82	B747 (JT9D)	G-AWNA	British Airways	Melbourne, Australia	91	Nil

At about 75ft on take-off the aircraft struck a flock of birds, loud bang from engine 3 which ran down and was shutdown with high JPT. Engine 4 vibration warning came on so was throttled to idle. Made immediate return, engine 4 shutdown after landing. Birds were racing pigeons (Columbia livia, wt 250 gm) released 100 miles away and returning to Melbourne. Believed 3-4 birds in engine 3 and 2-3 in No 4. The aircraft was at a very light weight. Both engines changed.

1.9.82 B737 G-BGDF British Airways Turin, Italy - Nil

During the take-off 07.20 hrs the aircraft passed through a flock of gulls at 50ft. Engine 2 indicated a vibration warning. Air traffic reported flames from No 2 engine. This was shutdown and the aircraft returned. Engine 2 was changed as it was severely damaged.

12.9.82 B707 G-BFEO Tradewinds Khartoum, Sudan - Nil

At 400ft on take-off the aircraft struck a large stork (Ciconiidae up to 3 kg). The left-hand windscreen was obscured by blood. The aircraft returned where it was found the radome had been severely holed, with large radial crack. The ILS glideslope aerial was broken.

13.9.82 B747CF - - Luxemburg - Nil

During the take-off engine 4 ingested birds resulting in fan and nose cowling damage after it had been pierced by part of a fan blade. The aircraft returned.

3.11.82 DC10 - - Entebbe, Uganda - Nil

During the climb the aircraft encountered between 11 and 100 herons (Ardea sp, up to 1.8 kg), which were ingested in engines 1 and 3. Engine 1 was shutdown.

4.12.82 B747(CF6-50) PH-BUN KLM Amsterdam, Netherlands 132 Nil

During the take-off run at 14.00 hrs GMT on runway 19L at about 1/3 of the runway at 135 kts the aircraft struck a flock of 100 Lapwings (Venellus vanellus, weight 250 gm) suffering multiple engine damage. The take-off was abandoned stopping with 800 metres left. The passengers desembarked via stairs at the end of the runway. Engine 1 beyond economic repair and changed, engine 2 had nine fan blades and some fan exit vanes changed, engine 3 had little damage and engine 4 had one fan blade changed. Wing trailing edge flaps also damaged. About 75 dead birds were found on the runway. Bird patrols were in continuous use.

6.12.82 Lear 35 HB-VFO Private Paris LBG - 1 Serious

At about 8.30 local the aircraft abandoned take-off after V_1 as a result of striking a flock of black headed gulls (Larus ridibundus). The aircraft failed to stop and over-ran striking the ILS installation, seriously injuring the co-pilot. The aircraft was destroyed. The engines were not in fact damaged and there was one birdstrike on the wing.

12.12.82 B737 G-AVRN Britannia Manchester, UK - Nil

During the take-off at about 140 kts the aircraft struck a flock of lapwings, which were ingested in both engines. The aircraft returned. Engine 1 was changed, there was no damage to engine 2.

23.1.83 DHC-7 LX-AHA Arika Dov Airport Tel Aviv - Nil

During a night take-off the aircraft struck flock of gulls, which rose off the runway at rotation (85kts). Vision completely lost through left windscreen and partially lost through the right. No power was lost. After climbing to 1500ft, gear and flaps left down, the aircraft returned. Over 60 strikes were counted on the aircraft and 500 to 1000 dead birds were found. The prop spinner was damaged beyond repair, two others damaged. No 2 de-icer boot damaged. Bird remains found in all engine intakes, but no engines were damaged. Wing de-icer boots damaged. One VOR & one ADF aerial damged. Birds ingested in air conditioning system. Nose gear taxy light smashed. One over-centre spring cable on main gear was knocked off it's pulley. Crew praised aircraft's ability to cope with such a large flock with so little degradation of performance.

24.3.83 DC10 (CF6-50) LN-RKA SAS Copenhagen, Denmark 160 7 Minor

During the take-off run a flock of gulls was struck as the aircraft rotated at 165 kts. An immediate return was made because of vibration and severe damage to engine 3. Overweight landing by 44 tons, necessitated 10 wheels changed. Emergency evacuation caused minor injuries to seven people. Engine 3 fan, nose cowl and pylon internal structure damaged. On bird passed through engine 1 fan. Runway was wet, fuel jettison and reverse thrust not used due to fire risk as ATC reported engine on fire.

-.6.83 A300B F- Air France Bordeaux, France - Nil

At rotation speed on take-off the aircraft passed through a flock of birds, which were ingested in both engines. Take-off was abandoned at a speed almost equal to V_2. The aircraft was successfully stopped on the runway. Both engines were changed. At least one bird had entered each engine.

17.7.83 B737 G-BHVG Orion Bristol, Lulsgate, UK - Nil

At 50ft and 130 kts during approach struck flock of pigeons and gulls. Teleflex cable from landing gear was damaged resulting in loss of ground/air sensor and associated systems.

2.10.83 B747 JT9D-7Q - China Airlines Anchorage, Alaska - Nil

During a down take-off ducks (Anas sp, weight up to 1.5 kg) were ingested in engines 1 and 2. The take-off was abandoned at 80 kts. Two fan blades on engine 2 exited the front engine cowl causing damage to the wing leading edge devices. Engine 1 overtemperatured during reverse thrust due to core damage, but no fan damage. Birds were flying low across the runway, probably on migration.

8.10.83 TU134 - Aeroflot Krasnodar, USSR - Nil

Struck flock of crows (Corvus sp weight up to 550g) on take-off, right-hand engine failed and fuel pump knocked off. Climb rate reduced to 200 ft/min and aircraft made immediate return.

9.10.83 B707 CS-TBA Air Portugal Birmingham, UK - Nil

Take-off was abandoned at 100 kts because of multiple bird strkes and small loss of power on engine 2. No damage found but birds struck engines 1, 2, 3.

31.10.83 DC10 OO- - Ostend, Belgium - Nil

During training touch and go large flock of birds were seen on the runway after take-off power had been selected. Aircraft returned to Brussels. Inspection revealed damage to engine fan with one blade separated, cowling holed and cabin window damaged. Engine 3 had signs of ingestion but no damage.

3.11.83 B737 G-BGYK Britannia Glagow, UK - Nil

At 50ft, 133 kts during landing round-out large flock of lapwings rose from the runway. Both engines, the wing, fuselage and landing gear were struck. Engine 2 was changed due to blade damage.

4.12.83 B747 (JT9D) G-AWNE BA Muscat, Oman 327 Nil

At about 150 kts on the take-off run a small thump was felt and engine 2 N1 rpm started to fluctuate, with vibration felt and indicated. The engine was shutdown. After fuel was jetisoned the aircraft diverted to a convenient maintenance facility. Engine 2 fan blades damaged, nose cowl torn and accoustic lining holed. Engine changed.

Serious Incidents to Aeroplanes of 5700kg and Below

Date	Aircraft	Regn	Location	Total Aboard	Injury	Damage
25.4.81	C182	C-FTKQ	Near Cooking Lake Alberta, Canada	-	Minor	Substantial
	Aircraft struck a duck (Anas sp) which jammed in carburettor intake causing loss of power. Aircraft forced landed into trees.					
18.7.81	C152	G-BIOM	Near Lerwick, UK	1	Minor	-
	While descending through 1000 ft at about 90 kts the aircraft struck a gull breaking the windscreen. The pilot suffered a cut nose.					
6.8.81	Cessna 402	5Y-ATU	Near Musiars, Kenya	1	1 killed	Destroyed
	Suffered birdstrike with a Ruppell's Griffon (Gyps rueppellii weight 7.5 kg) which penetrated the windscreen killing the pilot instantly. The pilot, the sole occupant was killed and the aircraft destroyed.					
-.1.82	Microlight	G-	Nr Bolton, England	-	Nil	-
	A flock of gulls were encountered and the engine exhaust was knocked off (falling near a house and going 3" deep into the frozen ground). The pilot glided to a safe landing.					
2.2.82	Beech 200	EI-	Nr Nairobi, Kenya	-	-	Substantial
	While on final approach the pilot attempted to avoid a large flock of birds, but shortly afterwards the pilot felt a large thump at the back end of the aircraft and it pitched up. After recovering a normal landing was made. The bird, a Marabou Stork (Leptoptilos Crumeniferus weight up to 7 kg) struck the fin leading edge, crushing the whole fin leading edge back to the front spar. The fin attachment was not damaged.					
10.2.82	C404		Maya Maya, Congo	-	1 minor	-
	During approach the aircraft struck bats (Chiroptera) smashing the windscreen and slightly injuring the pilots face.					
3..4.82	Cessna 172	F-	Sarre Union, France	-	Nil	-
	Just before touchdown the pilot noticed two buzzards (Buteo sp) on the beginning of the runway so the pilot overshot and made a circuit. On his second approach both birds were in the air and the pilot took evasive action to miss one of them. The aircraft landed too fast, bounced and the landing gear and propeller were damaged. The bird damaged the left-hand wing leading edge.					

30.7.82 Piper PA23 G-AYWF Amsterdam, Netherlands Nil -

While making a night landing a thump was felt as the aircraft descended through 150ft. A Grey heron (Ardea cinerea, weight 1.8kg) had damaged struck the wing leading edge damaging ribs, stringers and holing the skin.

26.7.82 Piper PA23 VH- · En route Australia - Minor -

An eagle penetrated the windshield, causing a deep cut to the pilots head and cuts to his hand. The aircraft was landed satisfactorily.

9.9.82 Wasmer Guepard F-BXCA Limoge, France 1 1 Serious -

While descending through 1800ft at 140kts the aircraft struck an Osprey (Pandion haliaetus - weight 1.5 kg). The windscreen was shattered and the pilot's head and face badly cut.

31.10.82 Piper PA24 - Bensbach, Papua New Guinea - Nil -

The right-hand windshield was broken by a cockatoo (weight up to 900gm).

16.1.83 Cessna 152 G-BFKG Middle Wallop, UK 1 Nil Substantial

Loud bang at lift-off as the aircraft struck a bird. The pilot decided to re-land during which the nose wheel collapsed. Dead bird, probably lapwing found on the grass runway.

6.5.83 Piper PA23 Aztec G-ASMN White Waltham, UK - Nil -

Just after lift-off the aircraft struck a pigeon. The wing leading edge was badly damaged and full rudder was required during landing.

24.5.83 Partenavia P68 SY-BDC Keekorok, Kenya - Nil -

During climbing turn at 400ft after take-off a Bataleur Eagle (Terathopius - weight 2.[illegible] kg) struck the left-hand stabilator. There was severe leading edge damage but no adverse control effects.

Serious Incidents to Helicopters

Date	Aircraft	Regn	Location	Total Aboard	Injury	Damage
2.3.81	Bell 206	CF-	Vancouver State Canada	4	Four Killed	Destroyed
	The helicopter went missing on a low altitude sheep count and was not found till Jun 8. When found at least one raven (Corvus corax, weight 1.2 kg) had struck the plexiglass front windscreen and probably entered the cockpit area. The helicopter crashed as a result, killing all 4 on board.					
3.6.81	Bell 47	G-	Redhill, UK	-	-	Minor
	While in the hover the rot[illegible] damaged when a crow (Corvus sp weight 550 gm) flew into it.					
2.1.82	Bell 206	G-P	[illegible]les from Kelso S[illegible]land	-	-	Minor
	While cruising at 600 ft at 90 kts the pilot felt a slight yaw and simultaneous severe vibration. He shut down the engine and made an autorotative landing in a field. The tail rotor had been struck by a bird (leaving three small feathers) bending the leading edge of a blade out of alignment, and resulting in tail rotor drive shaft damage.					
24.2.82	SA341 Gazelle	F-GAMK	Marseilles, France	-	Minor	-
	While flying at 200 ft and 100 kts the aircraft struck a gull smashing the window in the door causing minor injury to the passengers.					
13.4.82	SA 341 Gazelle	G-	New Seaton, UK	-	-	Minor
	At 1800 ft, 125 kts a gull was seen to pass over the rotor, no impact was heard or felt. On landing the stabilizer "fibreglass" fin skin was found to be cracked and had to be renewed.					
15.7.82	AS 332 Tiger	G-TIGG	Nr Montelimar, France	-	Nil	Minor
	While en-route at 145 kts, 2000 ft the aircraft struck an eagle, holing the radome and jamming the radar scanner.					
16.7.82	SA319 Allouette	F-	France	-	Minor	-
	While flying at 1500ft and 200 kts a martin (Riparia weight 14 gm) penetrated the windshield injuring the pilot.					
21.7.82	SA318 Allouette	F-	Lyon Satolas, France	-	Nil	-
	While approaching to land at 500 ft and 6 kts the windshield was penetrated by a starling (sturnus vulgaris weight 80 gm).					
-.-.82	Bell 206	N-	Detroit, U.S.A.	-	Minor	-
	A Mallard Duck weighing 5lbs broke the windscreen knocking the pilot unconscious and breaking his nose. The helicopter was on autopilot (fitted at pilot's request) and the pilot came to at 700 ft and 110 kts over Detroit.					
1.9.83	SA316 Alouette	F-BYCS	Montpelier, France	-	1 Minor	-
	Approaching the aircraft at 150 ft and 85 kts the helicopter collided with a gull weighing 1.2 kg and 4 ft wingspan. The windscreen was shattered, the remains striking the pilot, who retained control and landed safely, in spite of cuts on his hands.					
-.11.83	Bell 206	-	Sandakan, Borneo	-	Nil	Minor
	Large bird of prey attached the helicopter, the pilot managed to dodge the birds first attempt but when the pilot looked up the eagle was again diving with wings folded. At the last second the bird must have realised there was something odd about its "prey", as it spread its wings and attempted to torn away. The wing smashed the nose bubble and the body holed the honeycombe belly structure. Bird was Brahming Kite (Haliastur indus, weight 570 gm)					

Attachment A

BIRDSTRIKES 1912 to 1980

Fatal Accidents and Destroyed Aircraft over 5700kg (12500lb) together with Executive Jets

Date	Aircraft	Location	Occupants	Deaths	Other
4.10.60	L188 Electra	Boston, USA	72	62	9 serious injuries
	Starling (Sternus vulgaris weight 85 gm) flock ingested into 3 engines, aircraft stalled and crashed.				
15.7.62	DC3	Lahore, W Pakistan	2	1	-
	Co pilot killed when vulture (Falconiformes) penetrated windscreen during cruise.				
23.11.62	Viscount	Maryland, USA	17	17	-
	At 6000ft whistling swan (Cygnus columbianus weight 8 kg) struck and removed left tailplane, aircraft crashed.				
28.7.68	Jet Falcon	Lake Erie, USA	3	Nil	Aircraft ditched
	Gulls (Larus spp) ingested into both engines on take-off causing severe damage, ditched in lake.				
23.7.69	DC3	Nr Djibouti, E Africa	4	Nil	Aircraft destroyed
	Cranes (Grus sp weight up to 5 kg) blocked carb intakes on both engines, ditched in sea.				
26.3.73	Lear 24	Atlanta, USA	7	7	1 third party serious injury
	Cowbirds (Molothrus ater weight 45 gm) caused damage on take-off and severe power loss on both engines. Aircraft crashed into buildings.				
12.12.73	Falcon 20	Norwich, UK	9	Nil	
	Gulls* caused severe damage to both engines on take-off, crash landed.				
14.6.75	NA265 Sabreliner	Watertown, USA	6	Nil	3 serious injuries
	Franklin's gulls (Larus pipixcan weight 260 gm) ingested in both engines on take-off, crash landed.				
12.11.75	DC10	Kennedy NY, USA	139	Nil	2 serious injuries
	Gulls+ ingested in Eng 3 which exploded, causing severe wing fire, abandoned take-off, aircraft burnt out.				
20.11.75	HS125	Dunsfold, UK	8	-	6 third party deaths
	Lapwings (Vannellus vanellus weight 300 gm) ingested in both engines on take-off, power loss, crash landed destroying car.				
6.2.76	Lear 24	Bari, Italy	2	Nil	Aircraft Destroyed
	Gulls ingested in both engines, power lost and crashed in field.				
12.11.76	Falcon 20	Naples, Florida USA	11	Nil	11 serious injuries
	Ring-billed gulls (Larus delawarensis weight 485 gm) caused both engines to fail just after lift-off, causing aircraft to crash.				
4.4.78	Boeing 737	Gosselies, Belgium	3	Nil	Aircraft Destroyed
	Wood pigeon (Columba palumbus weight 450 gm) ingested during touch and go, abandoned take-off and over-ran. Burnt out.				
25.7.78	Convair 580	Kalamazoo, USA	43	Nil	3 serious injuries
	Sparrow hawk (Falco sparverius weight 120 gm) ingested in one engine on take-off, auto feathered, crashed in field.				

* Common (Larus canus weight 400 gm) and Black-headed (Larus ridibundus weight 300 gm)

\+ Great black-backed (Larus marinus weight 1.8 kg) Ring-billed (Larus delawarensis weight 585 gm) and Herring (Larus argentatus weight 1.1 kg)

Fatal Accidents to Aeroplanes of 5700 kg and Below

Date	Aircraft	Location	Occupants	Deaths	Damage
3.4.12	Wright Flyer	Long Beach, Calif USA	1	1	Destroyed
	Struck gull while flying along the beach. Controls jammed and aircraft crashed drowning pilot.				
10.2.29	Arado	Madras, India	2	2	Destroyed
	Shortly after take-off struck large bird, aircraft crashed.				
-.-.55	Cessna	Aberdare Mtns, Kenya	1	1	Destroyed
	En-route struck vulture, pilot attempted to avoid but bird hit wing tip jamming ailerons.				
10.1.59	-	Serengeti, Tanganyika	1	1	Destroyed
	Struck a Griffon vulture (Gyps fulvus, 5.4 kg) ano crashed.				
-.3.63	Beech 35	Bakersfield, Calif USA	1	1	Destroyed
	Common loon (Gavia immer wt 3.7 kg) which removed right hand tailplane.				
1.2.64	Turbulent	Nr Belfast UK	1	1	Destroyed
	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.				
2.7.71	Cessna 180	British Columbia, Canada	3	2	Destroyed
	En-route struck a Bald eagle (Haliaetus leucocephalus wt 5 kg).				
16.4.72	Mitsubishi MU2	Altantic City, USA	3	3	Destroyed
	While in climb struck flock of geese, windshield destroyed incapacitating one or both pilots. Uncontrolled descent into the sea.				
30.8.76	Saab MFJ15	Nr Awassa, Ethiopia	2	2	Destroyed
	Climbing through 200 ft struck Vulture. Aircraft went out of control and crashed vertically.				
23.4.77	Aero Commander 690	Chicago, USA	4	4	Destroyed
	Gull ingested in one engine, emergency procedures improperly executed and aircraft spun into the water.				
19.10.79	Swearingen Merlin	Palo Alto, Calif USA	-	2 killed 1 serious	Destroyed
	During approach a flock of birds clogged au engine intake (engine not damaged). Pilot attempted overshoot but lost control crashing inverted into parking area destroying or damaging 7 other aircraft.				

Fatal Accidents to Helicopters

Nil

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ANALYSIS OF BIRD STRIKES REPORTED BY EUROPEAN AIRLINES 1976-1980

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ABSTRACT

Birdstrikes reported world-wide between 1976 and 1980 by European Airlines from 14 countries have been analysed. The analysis of over 7500 strikes includes the annual strike rate for each country, for aircraft types and airports, all based on aircraft movements. It also covers bird species and weights, part of aircraft struck, effect of strike, and cost.

The paper shows that gulls were involved in over 40% of the incidents where the type of bird was known, and that only 1% of bird strikes involves birds of over 4 lbs. The major effects have been damage to over 330 engines and the loss of a Boeing 737 aircraft (value $4.5 million). Engineering costs are estimated to be about 16 million US dollars excluding the Boeing 737.

INTRODUCTION

This paper contains a summary of birdstrike data reported by European Countries for the years 1976 to 1980. It is similar to a paper using data from 1972 to 1975 which was presented at the Third World Conference on Bird Hazards in Paris, October 1977.

For the following reasons, the detailed analysis only includes civil aircraft of over 5700 kg (12500 lb) maximum weight, except that all executive jets including those of weight less than 5700 kg have been included:

(a) the airworthiness requirements relating to bird strikes are different for the smaller class of aeroplanes,

(b) much more is known about the reporting standard, and movement data of operators of transport types, and the movement data is more readily available than that from air taxi or private owner aircraft,

(c) the 5700 kg and less classification is, in general, a much slower aircraft with a different mode of operation, requiring less airspace, and a noticeably different strike rate would be expected.

Information has been obtained from a total of 13 European Countries, of which eight have been able to provide full information every year.

The strike rate for each country is dependent upon two major factors:-

- reporting standard.
- bird strike problem within that country.

DISCUSSION

Annual Rate / Country

The overall strike rate for the 7608 (and 15 million aircraft movements) incidents contained in the analysis is 5.1 per 10,000 movements (two movements per flight). This is somewhat higher than the rate of 3.5 recorded between 1972 and 1975.

Fig. 1 Annual Strike Rate

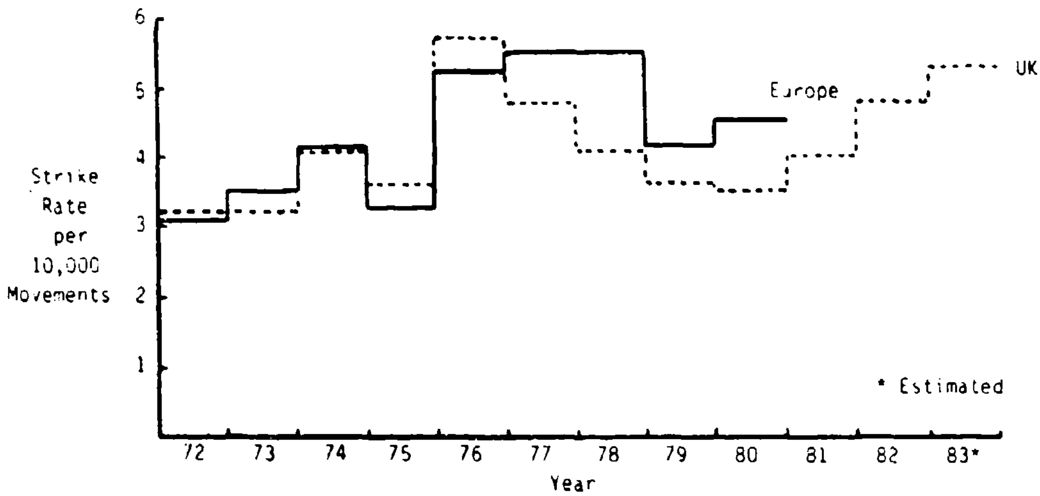


FIGURE 1 shows the annual strike rate for each year for the past nine years. The UK data (which comprises about 25% of the European Data) is shown for comparative purposes. There does not appear to be a clear trend, which in any case could be influenced by variation in reporting standards.

Fig. 2 Strike Rate by Country

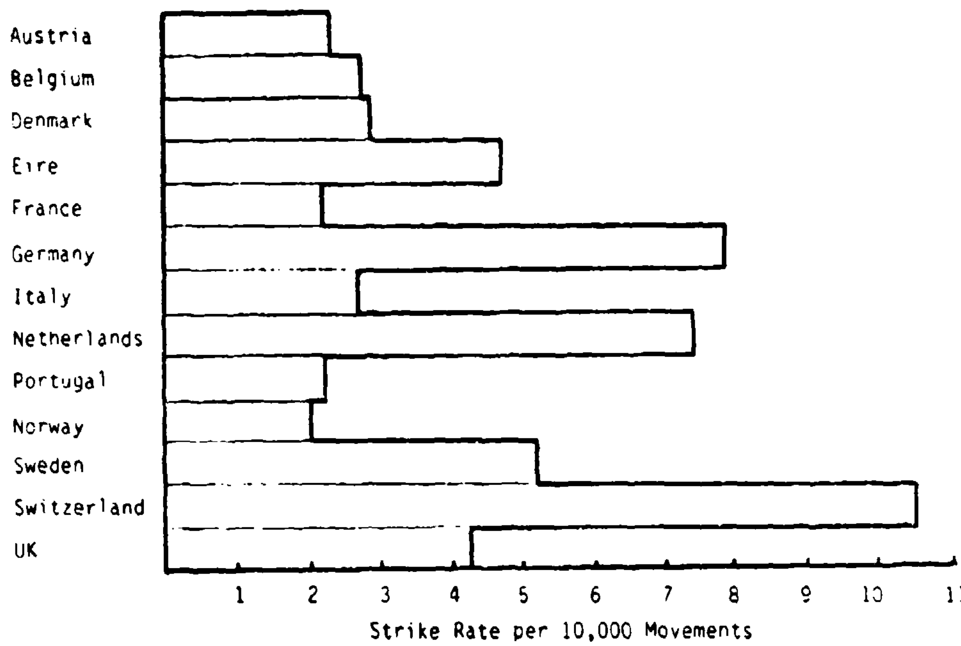


FIGURE 2 shows the rate for each country, Switzerland being the highest and Norway the lowest. Although each country is reporting strikes world-wide, a high proportion of its aircraft movements are within its own country and its record will thus be affected by its own birdstrike problem.

Aircraft Type

Fig. 3 Strike Rate, Jet Aeroplanes

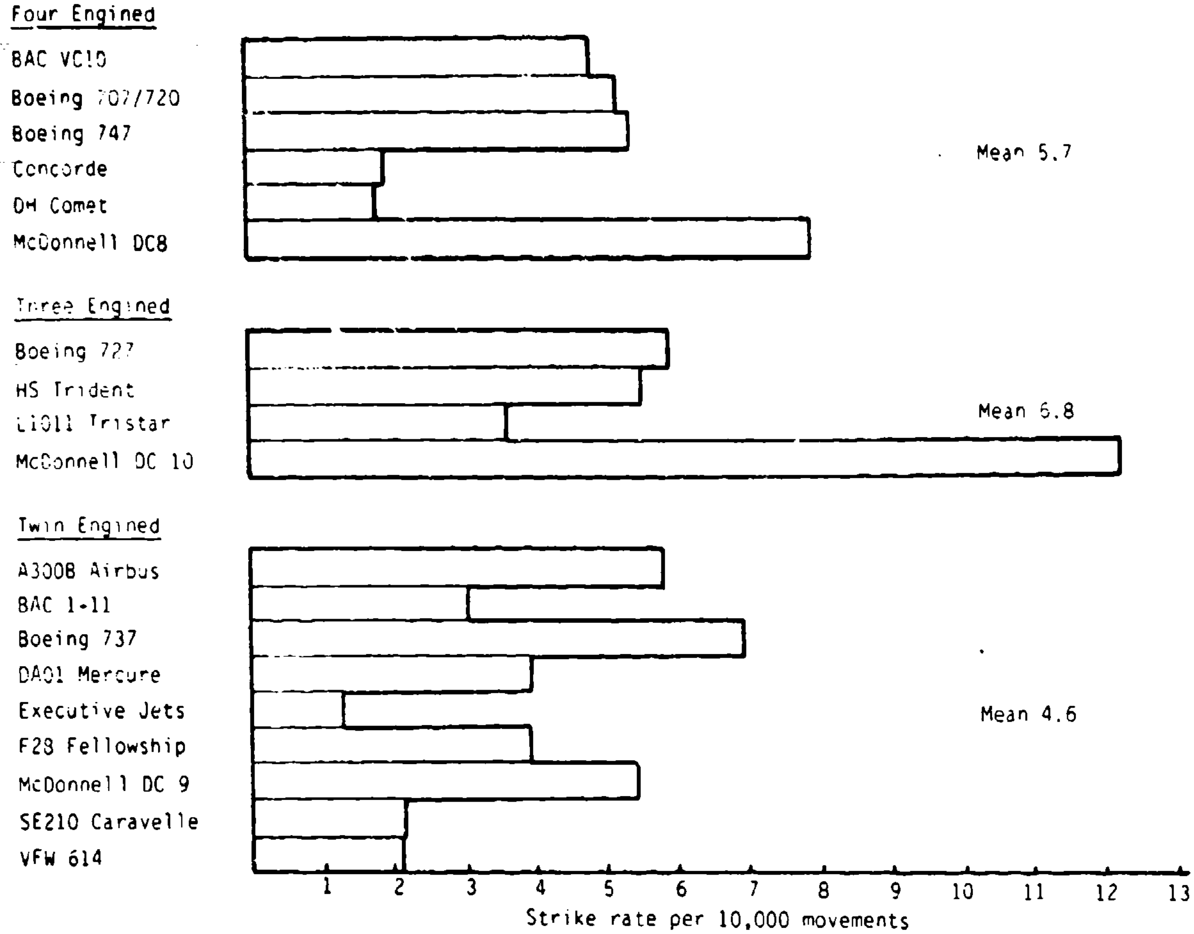


FIGURE 3 shows that aircraft which appear similar can have very different rates for example the DC8 (used by eight countries) has a rate of 7.9 compared with the B707 (used by 9 countries) which has a rate of 5.2. Similarly the DC10 (used by 11 countries) rate is 12.2, much higher than the L1011 (used by only two countries) rate of 3.6. Furthermore, the B737 has a rate of 6.9, which is higher than the wide-bodied A300B Airbus rate of 5.8. It therefore appears that there is little meaningful correlation between aircraft type and strike rate.

On average jet aircraft with three engines have a higher strike rate than those with two or four engines, mainly due to the high DC10 rate. The group of aircraft which are wide bodied have a strike rate of 7.5, which is above the rate for all jets of 5.5. The rate for executive jets is 1.2, thus it appears that frontal area does influence the strike rate. Concorde has a low bird strike rate.

Turboprop and Piston Aeroplanes

About 16% of movements are by turboprop aeroplanes, which have an overall strike rate of 2.7. The rate for piston engined aeroplanes is similar at 2.8, but this class only accounts for 1% of the movements.

Helicopters

Because helicopters mainly fly at low altitude where birds are most frequently found, they are continuously exposed to the risk of a strike thus rates have been based on flying hours. The rate for the 300,000 hours is 1.05 per 10,000 hours. This low rate may be due to the comparatively low speed and high forwards noise levels.

Aerodromes

Aerodrome data is of particular importance as it may indicate where bird control measures need to be taken. Some countries provided aerodrome movement data for their nationally registered aircraft, so that a national rate can be qu.ted. For others only the total number of strikes at each aerodrome, reported by all European sources is available in the absence of movement data.

Aerodromes which have a high number of strikes or a high strike rate may be influenced by some of the following:

- a very good standard of reporting.
- a large bird population (perhaps due to the aerodrome's geographic location
- a large number of aircraft movements.
- incorrect or no bird control measures.
- a difficult problem in spite of use of correct bird scaring methods.
- an influence which is beyond the control of the aerodrome (eg a garbage dump).

Fig. 4 European Airports, European Operators
Total Strikes, (Rate in brackets)

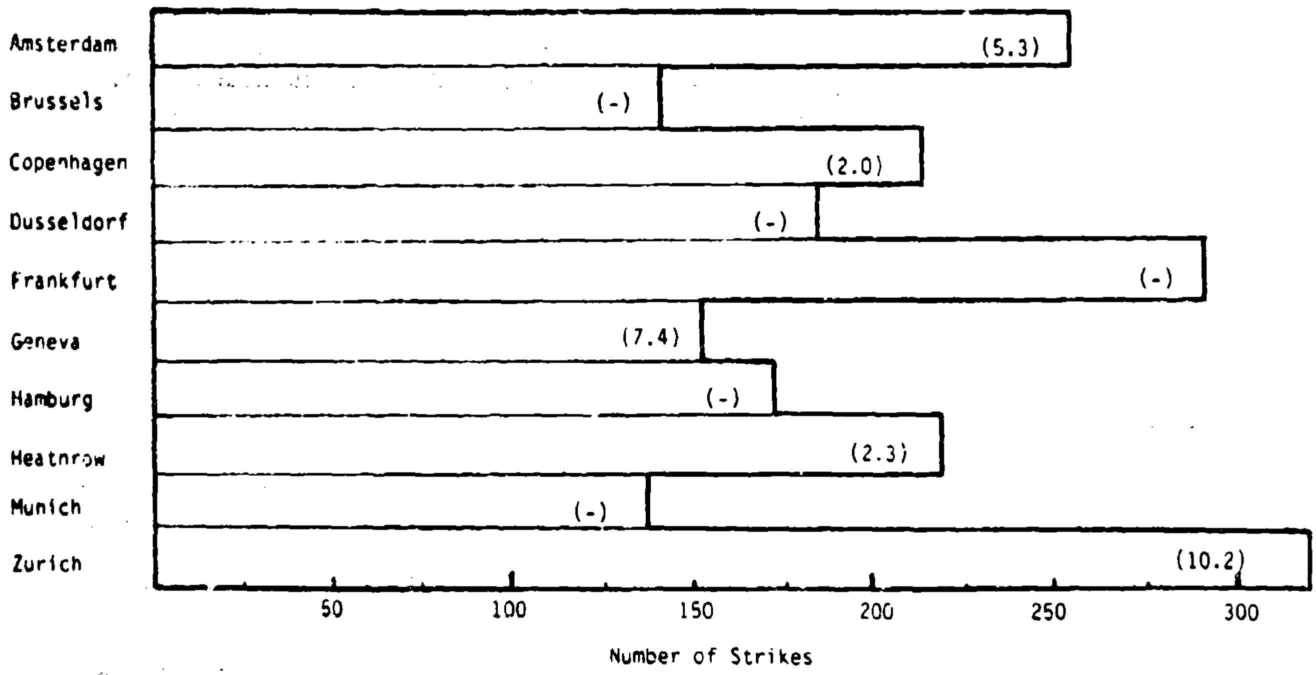


FIGURE 4 shows the ten European airports which have the highest total birdstrikes. It should be noted that many of these airports have a high number of movements and thus a very low rate. (See FIGURE 5)

Fig. 5 Strike Rate (National Airlines) at Selected Major European Airports

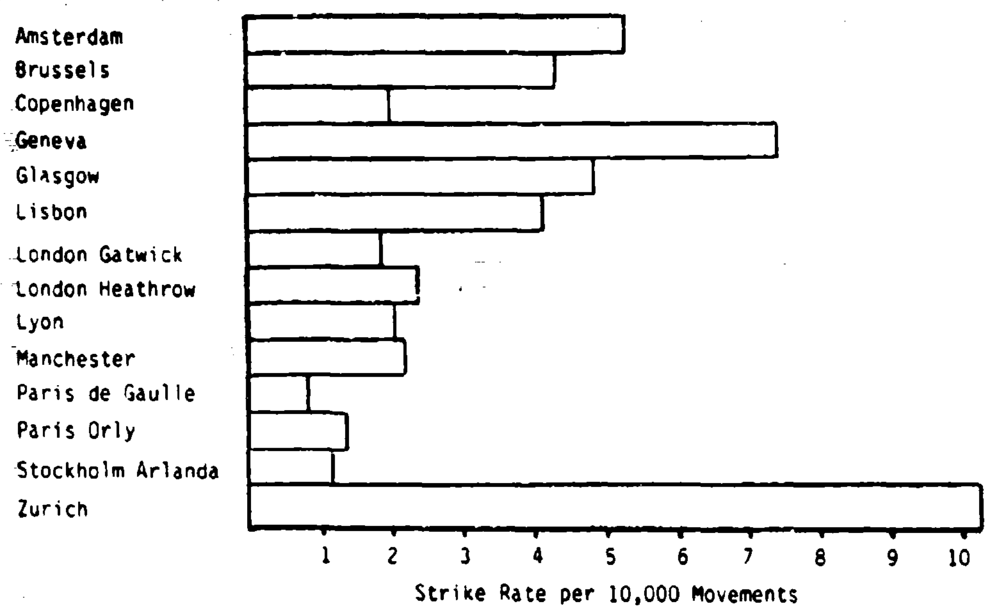
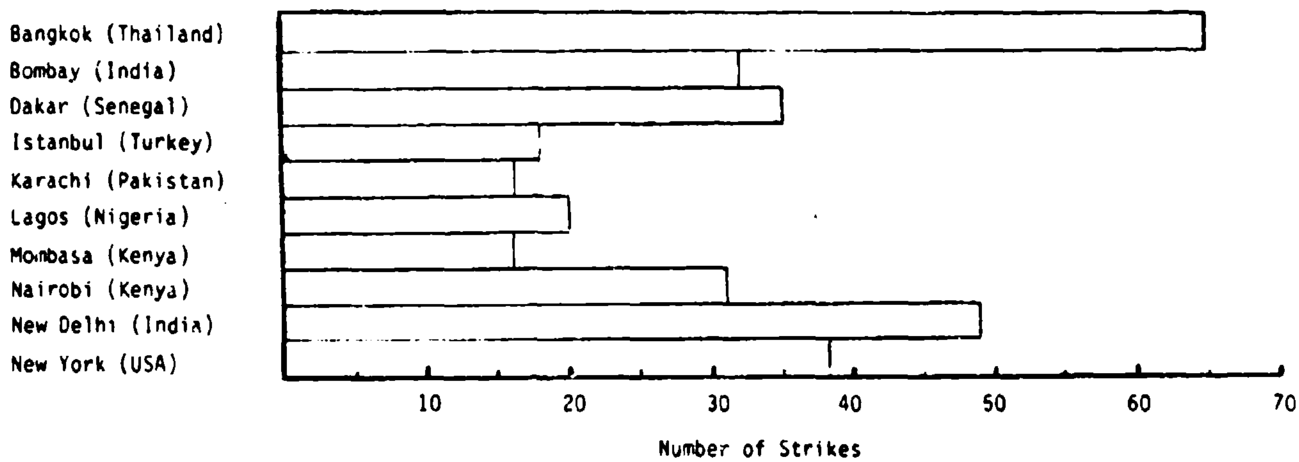


FIGURE 6 shows the non-European airports with the highest total of strikes reported by European Operators. Some of these airports are extensively used by European airlines. About 5% of strikes occurred en-route.

Fig. 6 Non-European Airports, Total Strikes to European Airlines



Birds

The birds involved were identified in 50% of incidents. The identification standard ranged from examination of bird remains by a trained ornithologist, to the fleeting glance of a pilot.

Fig. 7 Bird Species Struck

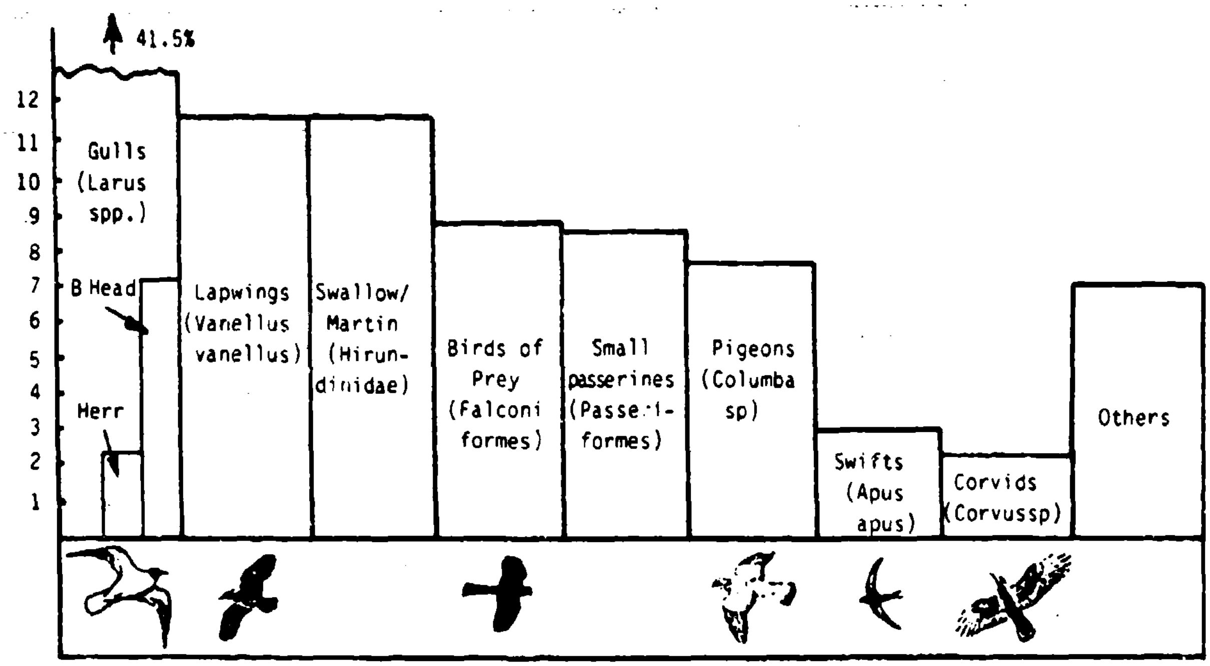


FIGURE 7 shows that gulls account for 41.5% (53% in previous period) of incidents where the birds have been identified. Of these the black-headed gull comprised 7%. The next most frequently struck bird was the lapwing (Vanellus vanellus) with 11.4%, followed by swallows and martins (Hirundinidae) at 11.4% and pigeons at 7.6%. The decrease in gull strikes from the previous period was offset by an increase in birds of prey and in swifts, swallows and martins.

From an airworthiness point of view the breakdown of bird weights is a most important feature. Unfortunately gulls span a weight range from 300 gm to 1.8 kg and fall into three weight categories and have therefore been excluded unless the exact gull type was known.

Fig. 8 Weight Distribution of Identified Birds

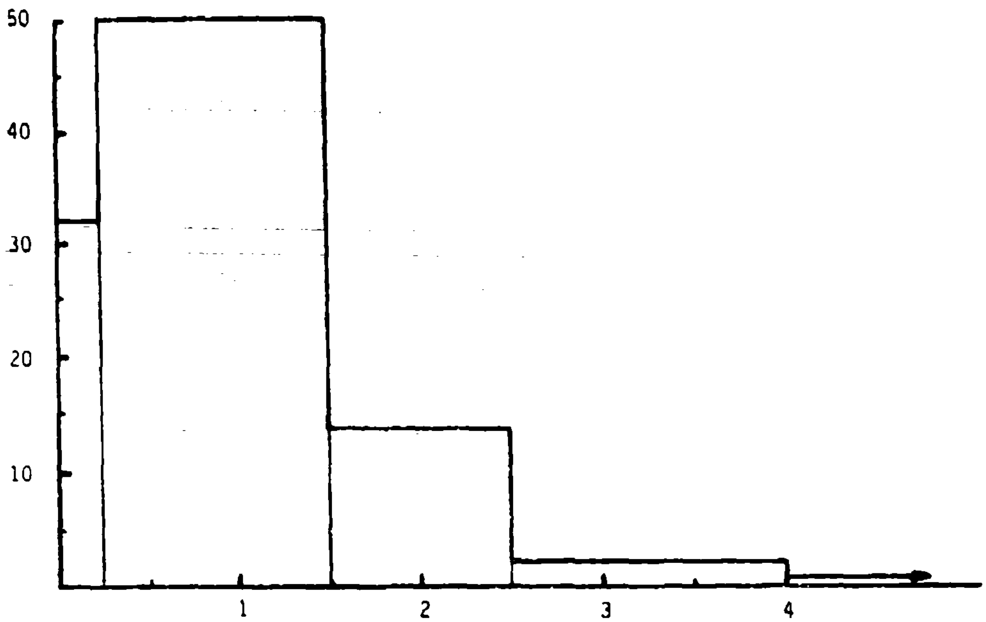


FIGURE 8 shows that 32% of birds struck weigh less than 110 gms (1/4lb), 50.7% lie between 110 and 680 gms (1/4 to 1½ lb) and 14.1% lie between 1½ and 2½ lb (681 gms to 1.13 kg). About 1% of incidents were known to involve birds of greater than 1.81 kg (4 lb).

Part Struck

Fig. 9 Part Struck

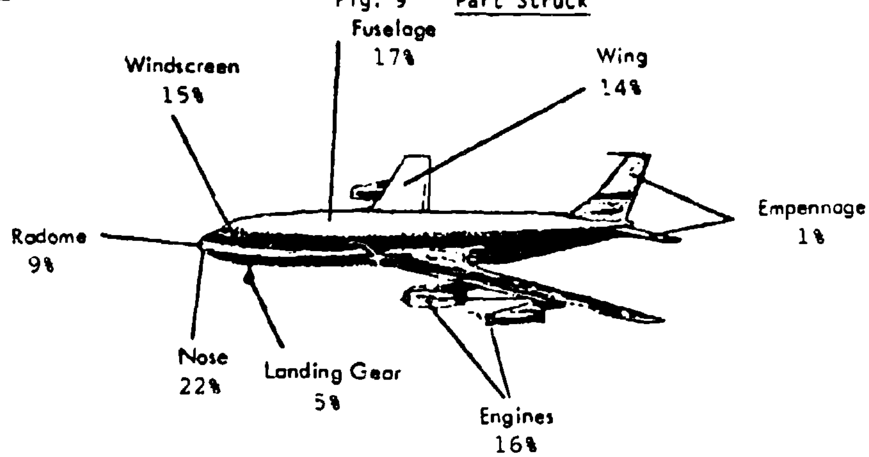
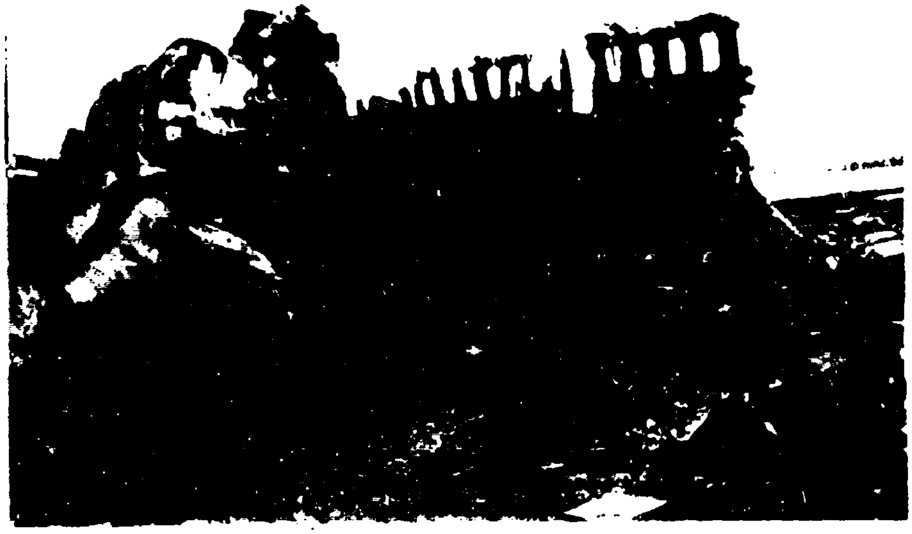


FIGURE 9 shows the nose and radome were struck in 31% of incidents, followed by the fuselage with 17.5%. Engine strikes accounted for 16% of strikes, in which 1%, a total of 76 incidents, affected more than one engine, and in 24 cases struck all engines. The multiple engine strike rate is about 1 per 200,000 movements. The tail area was very rarely struck. These percentages are influenced by the size of bird involved, since small birds (below 1/4 lb)are rarely reported as striking the engines, wing or landing gear, but are more frequently reported on the nose and windshield. The figures are similar to the previous period.

Effect (FIGURE 10)

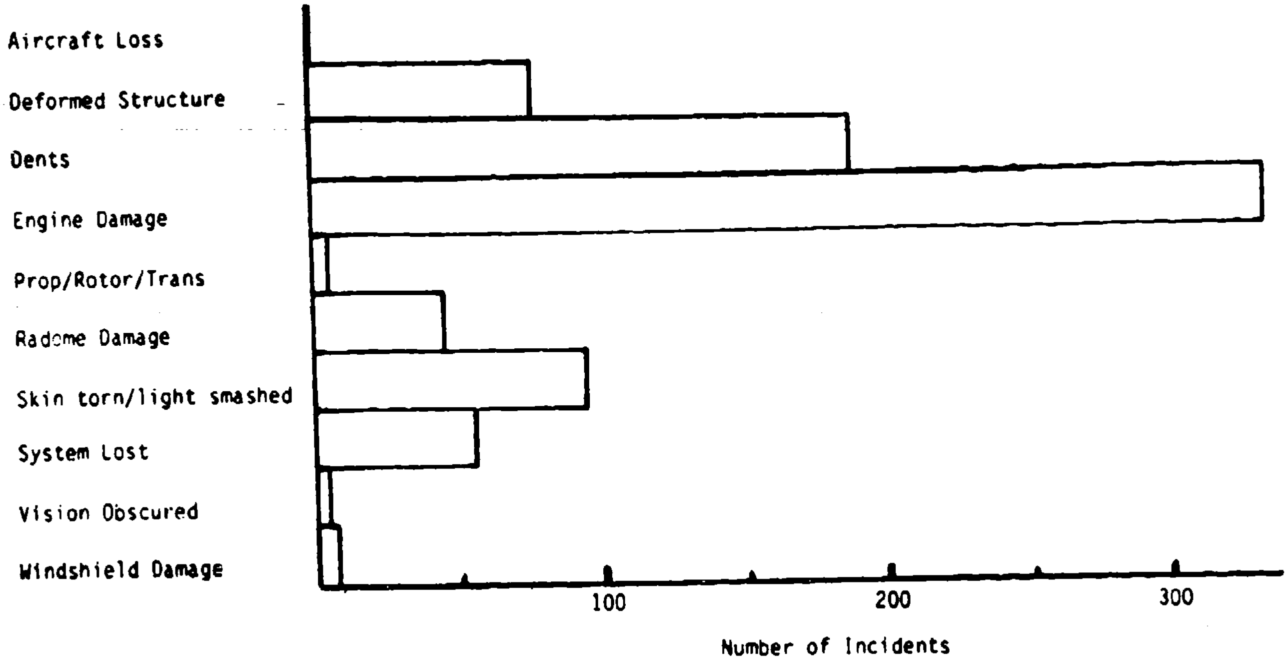
During the period covered by this paper a European registered Boeing 737 was written off during a touch and go training flight. The three crew escaped from the burning aircraft after take-off was abandoned at high speed resulting in the aircraft crossing a major road.



A total of 338 engines were damaged such that repair or replacement was necessary (damage which has been dressed out has not been counted. Of the 338 cases, 152 were in twin engined aircraft. It appears that 30% of engine strikes involves damage. Twelve windshields needed to be replaced, (only 1% of the 1124 windshield strikes). None of these involved windshield penetration. There were 45 cases of radome damage, out of 685 radome strikes (7%). The radome was in most cases only delaminated, few cases are known where it was shattered. The radome strength is usually determined by the dielectric properties necessary for satisfactory operation of the weather radar.

Examination of the bird weights shows, not surprisingly, that only 2% of small birds (below 1/4 lb) caused damage, whereas 40% of strikes with birds of over 4 lbs caused damage.

Fig. 10 Effect of Strike



Cost

Only a few countries have been able to provide information on cost. Using this known cost the estimated engineering cost to European airlines for the four year period is 16.1 million US dollars. In addition the value of about $4.5 million for the Boeing 737 must be added.

CONCLUSIONS

1. The overall strike rate for the 7608 strikes reported by European operators from 1976 to 1980 is 5.1 strikes per 10,000 movements. This is somewhat higher than the rate from the previous four year period.

2. There does not appear to be any close correlation between the strike rate and the aeroplane type, however, the strike rate for the group comprising wide-bodied aeroplanes does appear to be slightly above average.

3. Helicopters have a low strike rate.

4. Gulls were struck more frequently than other birds, being involved in 41% of incidents. Only 1% of strikes were believed to involve birds of greater than 1.8 kg (4 lb).

5. The nose section and radome were struck in 31% of incidents, followed by the fuselage with 17% and engines with 16%. About 1% of incidents involved multiple engine strikes, a rate of about 1 in every 200,000 movements.

6. Apart from the loss of a Boeing 737, the major effect was damage to 338 engines, about one in every three engine strikes. There was little windshield damage.

7. Based on information provided by four countries the estimated minimum engineering cost of bird strikes was at least 16 million US dollars.

AD-P004 182

1983 AIR FORCE BIRD STRIKES

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ABSTRACT

Since 1975, the Air Force Bird/Aircraft Strike Hazard (BASH) Team, located at Tyndall AFB FL, has been responsible for maintaining all Air Force bird/aircraft strike data. Information for 1983 has been compiled and trends determined in order to better define the extent of the bird/aircraft strike hazard potential. During the 1983 reporting period, there were over 2300 reported bird strikes costing more than $4 million. In addition, one major and several minor personnel injuries resulted from windshield/canopy penetrations by birds. This presentation identifies trends in the Air Forces' bird strike occurrences and emphasizes the continual need for reporting all bird strikes.

INTRODUCTION

Since 1975, the Bird/Aircraft Strike Hazard (BASH) Team, located at Tyndall Air Force Base, Florida, has been responsible for maintaining all Air Force bird/aircraft strike data. The data base contains information as far back as the early 1960's; unfortunately, that data is fairly sketchy. One of the reasons for the lack of detailed information was the change of reporting criteria over the years. Only within the last few years have all Air Force bird strikes been reported. As aircrew members no doubt know, pilots coming home after a long flight, perhaps to include a low-level flying mission, have a hard time finding the energy to fill out one more report on a bird strike that did little or no damage to their aircraft. The crew chief of the aircraft wipes off the evidence and everyone presses on with the mission. However, this is not always the case, in that many aircrews realize the importance of reporting all bird strikes and do so according to the regulation.

The BASH Team has suggested many ideas to increase BASH awareness of all personnel involved with the bird strike problem. Air Force Regulation 127-15 requires that all bird strikes--those that cause $1,000 or more in damage, as well as those that don't--be included in the overall statistics to properly define the problem. Only when all bird strikes are reported and analyzed can we view the true nature of the hazards birds cause to our aircraft.

From 1980-1982 the BASH Team recorded over 3900 bird strikes to Air Force aircraft. In 1983 over 2,300 strikes were reported. Either the Air Force is hitting more birds each year, more organizations are reporting bird strikes, or both. We believe that because of the increased emphasis on the importance of reporting strikes, more bird strikes are being reported. Likewise, with increased low-level flying, we do expose our aircraft to environments in which more birds are found. Thus, we could also be seeing an actual increase in the bird strike rate. Unfortunately, at this time, critical information is not available in order to perform a proper quantitative analysis.

BIRD STRIKES BY IMPACT POINT

TABLE 1

Percent of Bird Strikes by Impact Point

Impact Point	Percent
Engine/Engine Cowling	22.3
Windshield/Canopy	20.6
Wings	19.3
Radome/Nose	15.1
Fuselage	8.9
External tanks/pods/gear	6.7
Multiple hits	5.2
Other	1.9

Table 1 shows all areas of the aircraft are potentially vulnerable to birds. Of course, where a bird strikes the plane is a matter of chance unless the pilot is able to see the bird and maneuver the aircraft in such a way that the bird perhaps strikes the underside of the wing or radome. Normally, engine and windshield strikes pose the greatest damage and are the greatest threat for a crash or fatality. In reality, five percent of the windshield/canopy strikes resulted in birds penetrating the canopy, but only a few cases occurred where minor injuries resulted. Fortunately, in 1983, the Air Force did not lose any aircraft or aircrew due to bird strikes; however, total cost in damage was on the order of $4 million.

TIME OF BIRD STRIKE OCCURRENCE

Most bird strikes occurred during the day (67%), but a large number occurred at night (18%). Only 5% of the bird strikes occurred during the twilight hours. Since most of our flying is during the daylight hours, these statistics are not surprising. Unfortunately, we do not calculate a bird strike rate for day and night flying since it is difficult, time consuming, and expensive to obtain exact flight times per hour of the day. We do know, however, that birds are most active in early morning and late afternoon hours and that many bases we visit restrict flying during these times. Some bases restrict takeoffs and landings for an hour or more during dawn and dusk to reduce the chance of a bird strike.

Bird strikes occurred during all months of the year; however there were times of increased strikes. This increase coincides with the times of migration for birds. As seen in Figure 1, the number of bird strikes peak in the spring when birds are migrating north to breed; however, we observe a much higher peak in the fall when adult birds and their offspring are making the journey south for the winter. Since most birds begin their migratory flights shortly after dusk, the number of night strikes greatly increase while the number of day strikes only moderately increase.

By understanding the reasons why bird strikes increase during certain times of the day and year, we can assist aircrews in avoiding these higher risk times. We ensure that our bird strike awareness programs receive emphasis before the fall and spring migration periods by sending out messages that give pilots a "heads up." When bird activity increases in the early morning, the director of operations, at a base experiencing bird strikes, may delay takeoffs which could prove to be very prudent.

WHERE BIRD STRIKES OCCUR

Figure 2 shows almost half of the bird strikes occurred within the traffic pattern of our bases (e.g., takeoff, landing, approach). Obviously, by reducing the number of birds attracted to an airfield, we can effectively reduce the risk of bird strikes. Therefore, airfield environments receive the greatest emphasis in attempting to reduce the occurrence of strikes. Also, by increasing traffic pattern altitudes, we can reduce the chance of a bird strike in the majority of the environments flown.

The second most vulnerable phase of flight, with respect to hitting birds, is during low-level operations. High speed, (350-500 knots) low-level (1000-500 feet above ground level (AGL)) routes traverse the country in rural, sparcely populated areas, many of which are near wildlife refuges and reserves. Almost 25% of all strikes occurred in this flying environment. Since windshield/canopy penetrations by birds are more likely to occur while flying at these speeds, especially for our fighter aircraft, the risk of aircraft/aircrew loss is greater during low-level operations. As seen in Figure 3, most bird strikes occurred at or below 500 feet AGL. Should a bird penetrate the canopy, pilots have little time to react due to sudden loss of vision, possible lack of aircraft control and loss of engine thrust or some other severe circumstance at these low altitudes and high airspeeds. We recommend pilots increase low-level flight altitudes and reduce airspeeds when operationally feasible.

TYPES OF BIRDS ENCOUNTERED

The BASH Team has an ongoing program to identify bird remains as a result of bird strikes. Air Force Safety Officers send feathers and other nonfleshy remains to the BASH Team for identification. Of the 2300 strikes, approximately 26% are placed in a "bird-type" category (e.g., shorebirds, gulls). Without remains, another 22% are placed in a "small, medium, or large bird" category, depending on pilot observations. The remaining 52% are unknown as far as the type or size of bird impacting the aircraft.

TABLE 2

Types of Birds Involved in Bird/Aircraft Strikes
1983

Bird Type	Number of Strikes
Starlings	39
Shorebirds	17
Blackbirds	22
Horned Larks	27
Meadow Larks	29
Doves	41
Pigeons	19
Gulls	122
Egrets and Herons	21
Vultures	46
Hawks, Falcons and Eagles	126
Ducks	52
Geese	10
Unidentified Birds	
Small Birds	406
Medium Birds	38
Large Birds	50

By knowing the "bird-type" causing the problem, the BASH Team and other experts can more specifically channel their suggestions. For example, should the identified "bird-type" be a duck, there is less need to spray a pesticide for insectivorous birds than there is to look for a source of water to attract waterfowl. Raptors (vultures and hawks) and gulls continue to give military flying the most problems; because of their large size, they also pose our biggest threat.

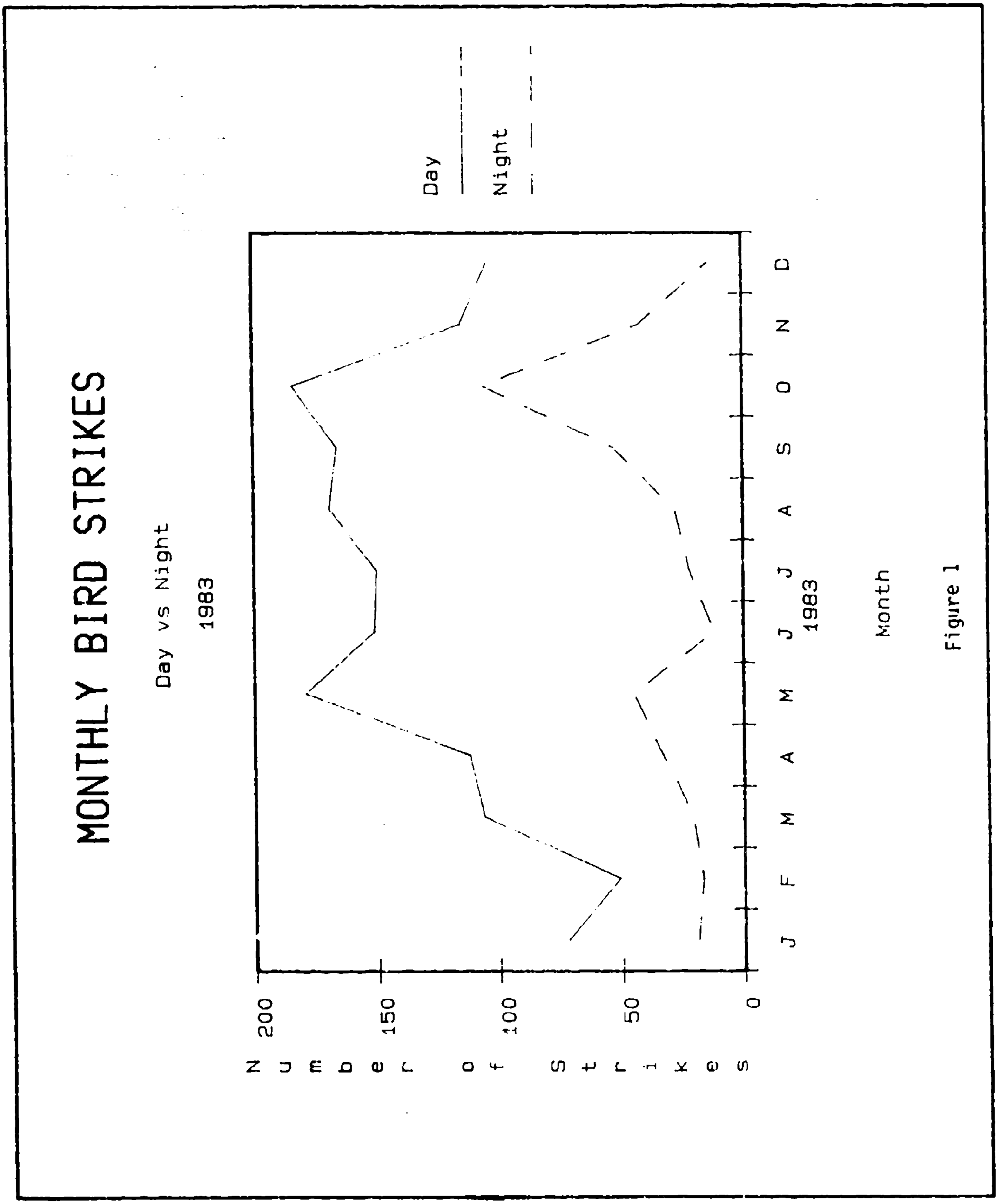
AIRCRAFT BIRD STRIKE RATES

The wide variety of aircraft flown by the Air Force and the missions they perform, create large differences between the bird/aircraft strike rates for specific aircraft. As seen in Figure 4, fighter aircraft experience the most strikes. This is due, in part, to fighters flying more hours, as well as flying more within the 500 feet AGL and below vulnerability area. But, bombers and cargo aircraft also have a substantial low-level flying mission and experience 7.9% and 28.4% of the bird strikes, respectively. Trainers also receive a large amount of strikes with 19.1%. By analyzing bird strike rates, we can provide information to aircraft designers so they can create a less vulnerable aircraft with respect to bird damage. Probably, the most well known of these programs is the aerospace transparency tests done by the Wright Aeronautical Laboratory at Wright-

Patterson AFB OH. By their efforts, incidents of windshield penetrations by birds have been reduced. This has saved the Air Force millions of dollars in potential damage as well as aircrew's lives.

CONCLUSION

By continuing to collect and maintain bird strike data, the Air Force has been able to channel its efforts toward reducing the risk of bird strikes to specific areas. Since we know the "bird-types" most frequently hit, when bird strikes most frequently occur, and under what conditions they occur, we can more effectively minimize the hazards caused by birds. Since types of aircraft change, mission profiles change, environments are altered, and personnel concerned with the bird strike hazard continue to move from base to base at approximately three year intervals, the need for collecting and maintaining bird strike data will be ever present.


MONTHLY BIRD STRIKES
Day vs Night
1983
Day
Night
Number of Strikes
200
150
100
50
0
J F M A M J J A S O N D
1983
Month
Figure 1

BIRD STRIKES BY PHASE OF FLIGHT

1983

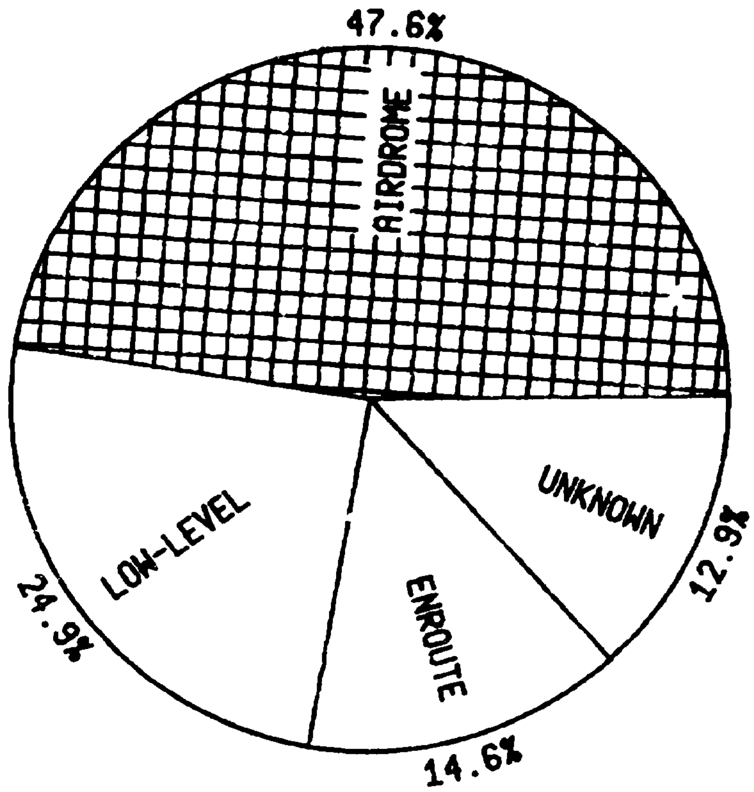


Figure 2

BIRD STRIKES BY ALTITUDE

1983

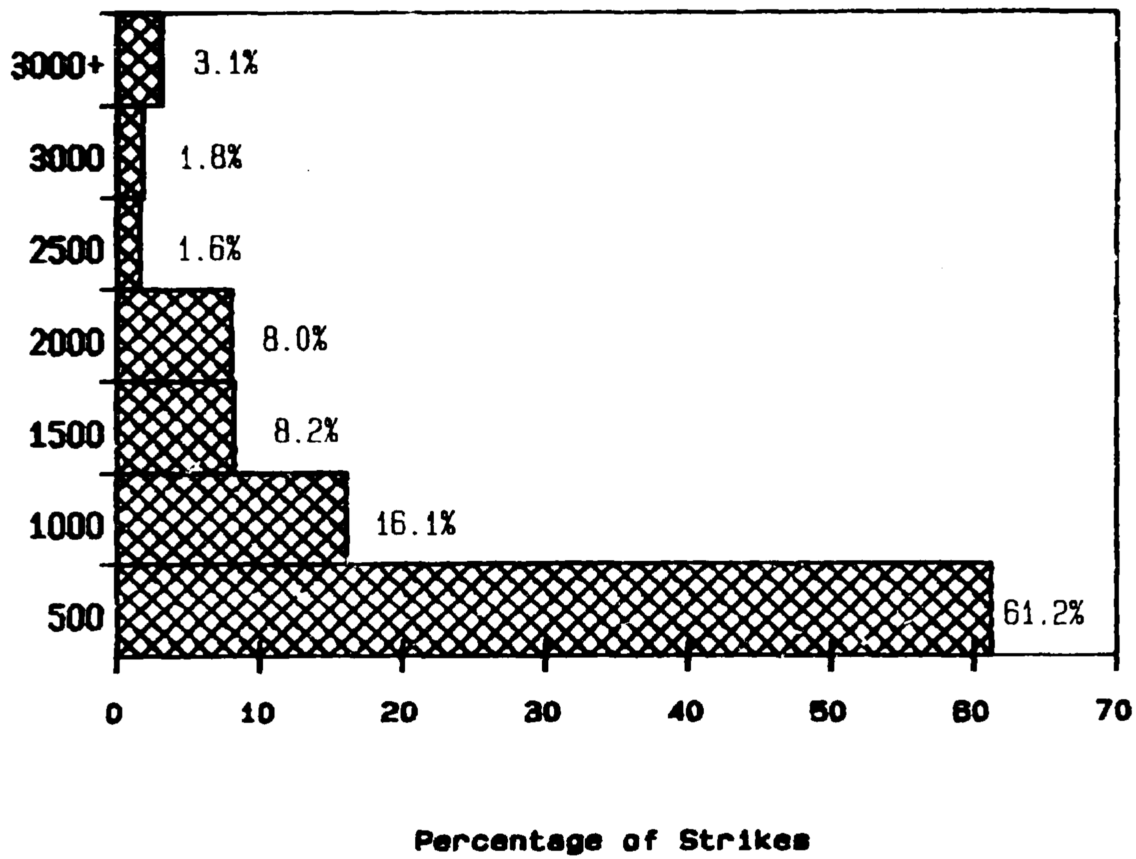


Figure 3

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BIRD STRIKES BY AIRCRAFT GROUP

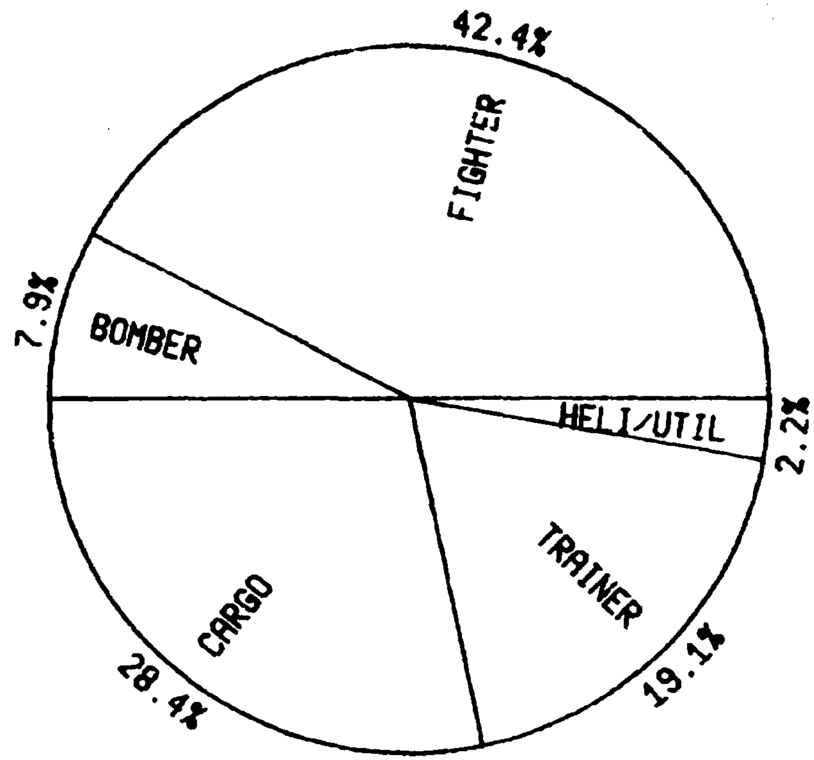

Figure 4

WORLDWIDE BIRDSTRIKE STATISTICS OF LUFTHANSA GERMAN AIRLINES

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Summary

Lufthansa German Airlines register an average number of 328 birdstrikes yearly. The costs of repairs, disregarding subsequent costs due to flight plan changes or cancellations, amount to 1 Mio DM yearly. According to a preliminary estimate damage costs are increasing strongly at the moment. During 1983 the costs amounted to nearly 6.0 Mio DM.

1. TEN-YEARS STATISTICS WORLDWIDE

During the last 10 years (1973-1982) Lufthansa German Airlines (DLH) registered 3288 birdstrikes worldwide. The yearly absolute number of incidents fluctuated between 250 and nearly 400, but the birdstrike rate decreased from 12.31/10,000 movements (1974) to 8.90/10,000 (1982) (Figure 1).

The monthly distribution averaged over 10 years is closely related to the bird migration (Figure 2), that is:

- March maximum = spring migration
- May/June maximum = intermigration
- July maximum = full intermigration and beginning of autumn migration (some species)
- October maximum = full autumn migration

The worldwide situation is the same as in Europe; only about 10% of DLH birdstrikes occur outside Europe.

In rating absolute and relative birdstrike number as to the effectivity of bird scaring methods/procedures it must be taken into consideration that the effect of the reporting system depends on the motivation of pilots from year to year.

2. MONTHLY STATISTICS ON THE CONTINENTS

Since 1967 in Asia 229 DLH birdstrikes occurred with maxima similar to those in Europe, but with a slight difference between the Near, Middle and Far East insofar as in the Western parts of Asia the birdstrike maxima occur in April and September, that means one month later or earlier than in the other parts of Asia and Europe; this may be a function of migration. (Figure 3)

In Africa 159 DLH birdstrikes occurred since 1967 equally distributed over North, East and Western Africa with nearly 33% each. The distribution over the months is similar to Europe and Asia but in North Africa a long lasting maximum can be observed in springtime caused by continuous bird migration from March until June. Moreover, a difference exists also between east and West Africa insofar as the birdstrike maximum in springtime differs by one month in either direction, possibly as a function of migration.

On the American continent there is a significant difference between South and North America. On the southern continent (78 birdstrikes since 1968) the April/May maximum is significant as it is in Africa, possibly depending on the migration situation. From July until November the number of birdstrikes is nearly the same, but increases from December until January depending on summertime migrations which are irregular in South America. On the western part of the continent bird density seems to be higher because of special migration routes when compared with the eastern coastal district where only 35% of the incidents occurred. The northern part of America (total number of birdstrikes since 1968 = 90) including Canada and Mexico shows three birdstrike maxima in May, August, and October, possibly depending on migration, as well.

On the Australian continent DLH had only 7 birdstrikes since 1971 from June until August; this number is too small to have a statistical value.

3. TENDENCY OF BIRDSTRIKES ON GERMAN AIRPORTS 1980 - 1982 DLH

As to the evaluation of birdstrikes on German airports they are subdivided into three types as follows:

- Take off/landing/roll/taxi (Table 1) within the airport area, f.i. strikes above 200 ft GND at landing and below 500 ft GND at take off,
- Descent/approach/climb (Table 2) in the airport surroundings, f.i. strikes above 200 ft GND at landing and above 500 ft GND at take off,
- Strikes in the airport area (Table 3) but without indication of flight phase and height.

This subdivision is necessary in order to get more genuine values and in order to analyse where the main problems with birds are, in the airport itself or in the surroundings.

As to the airports it can be ascertained that 44% of incidents occurred within the airport area and 38% outside (18% unknown); in some cases incidents outside were higher than inside.

4. TENDENCY OF BIRDSTRIKES IN THE AREA OF SOME IMPORTANT EUROPEAN AIRPORTS 1973 - 1982 DLH

During the last 10 years (1973-1982) DLH registered the most birdstrikes on the following European airports: AMS = 48, BCN = 24, BRU = 30, CPH = 30, IST = 26, LON = 39, MIL = 44, PAR = 67, VIE = 29, ZRH = 30. The rate situation regarding 10.000 DLH movements on the respective airport was the following:

Airport/Year	1973	1978	1982
AMS	8.85	7.36	16.65
BCN	25.53	5.05	9.66
BRU	15.54	14.00	9.12
CPH	3.61	6.38	4.39
IST	6.76	6.53	22.57
LON	3.13	1.71	3.97
MTL	?	?	14.10
PAR	7.84	13.16	14.98
VIE	7.85	11.31	0.00
ZRH	4.17	7.34	5.63

The main problems have been induced by gulls, lapwings, pigeons, swift/swallows and herons. During the last 5 years (1978-1982) 17 birdstrikes in AMS, BRU, CPH, IST, MIL, PAR and ZRH showed damages whose amount was nearly half a million DM. Birdstrikes DLH occurred since 1973 on 48 European airports.

5. TENDENCY OF BIRDSTRIKES IN THE AREA OF SOME IMPORTANT AIRPORTS OF THE ASIAN, AFRICAN, AND AMERICAN CONTINENTS 1973-1982 DLH

In the Asian region birdstrikes DLH were increasing since 1976. The most endangered airports seemed to be: ANK = 12 (average rate 8.20), BKK = 39 (31.56), BOM = 7 (7.47), DEL = 55 (68.73), HKG = 9 (10.55), KHI = 8 (?) and TLV = 11 (?). The costs amount to nearly 350,000. - DM since 1973. Birds of prey were the most dangerous birds because nearly 90% of the incidents occurred with this group of birds.

In the African region the following airports were highly dangerous for DLH: ADD = 6, CAT = 5, DAR = 4, DKR = 4, DKR = 33, EBB = 7, KRT = 8, LOS = 5, MBA = 5, NBO = 19 and TUN = 8 especially because of the high costs. The species mostly involved were birds of prey, herons, cranes, ducks and pigeons; the costs amount to nearly 1.2 Mio DM.

On the North American continent most birdstrikes happened in BOS (8) and JFK (18) mostly caused by gulls and waterfowl with costs of nearly 0.6 Mio DM.

In South America the following airport seemed to be the most endangered for DLH: GYE (11), LIM (11), RIO (6), SCL (14), and SAO (4); birds of prey were mostly involved and the costs amount to more than 1 Mio DM.

6. FLIGHT PHASES, AIRCRAFT TYPE, DAMAGES AND COSTS

Most birdstrikes in all continents occurred at take off (28.8%) and landing (26.5%), during approach (31.8%) and during the climbing phase (9.7%). Narly 71% of birdstrikes occurred during the daytime, 11% at dawn, but nearly 20% during the night.

All types of DLH aircraft have been involved in birdstrikes and perhaps it can be stated: the larger the aircraft the higher the relative number of birdstrikes according to the following rates/10.000 movements: B 747 = 35.52, DC 10 = 14.36, B 707 = 11.19, A 300 = 10.4, B 737 = 7.93 and B 727 = 7.75 (average rates from 6 years).

As to the parts of aircraft struck (Figure 4) most incidents occurred with the nose (20.01%), the fuselage (17.72%), the engine (16.74%), the windscreen (14.70%) and the radome (13.13%); in 34 incidents engine exchange was necessary.

Since 1973 DLH had to pay more than 5.0 Mio DM for birdstrike damages; in 1983 the costs were exploding with more than 5.0 Mio DM for one year. These costs are distributed among the aircraft types as follows: A 300/310 = 80%, DC 10 = 2%, B 747 = 5%, B 707 = 3%, B 727 = 1% and B 737 = 9%. They are distributed among the continents as follows: Germany = 78%, Europe = 2%, Africa = 15%, America = 4%, Asia/Australia = 1%.

The costs of repairs disregard subsequent costs due to flight plan changes or cancellations.

7. LITERATURE

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Statistics DLH/DELVAG since 1967.

Tab. 1: Number of birdstrikes DLH, 1980 - 1982 within the airport area of German airports

	1980		1981		1982	
	absolute	rate	absolute	rate	absolute	rate
BRE	6	11.23	3	4.88	6	10.50
CGN	3	1.81	7	4.37	7	4.52
DUS	11	3.53	12	3.61	22	7.21
FRA	19	2.02	15	1.48	16	1.67
HAM	10	3.28	9	2.84	10	3.23
HAJ	2	2.44	1	1.06	6	6.02
MUC	10	2.40	15	3.35	28	6.52
NUE	2	3.16	1	1.49	2	2.62
STR	3	1.31	2	0.89	5	2.73
SCN	-	-	-	-	-	-
total	66		65		102	
average rate		3.12		2.39		4.50

Rate = Number of birdstrikes per 10.000 movements of DLH.

Tab. 2: Number of birdstrikes DLH, 1980 - 1982, in the surroundings of German airports

	1980		1981		1982	
	absolute	rate	absolute	rate	absolute	rate
BRE	1	1,87	2	3.26	0	0
CGN	3	1.81	4	2.50	7	4.52
DUS	11	3.63	7	2.10	11	3.60
FRA	24	2,56	29	2.93	26	2,71
HAM	9	2.95	6	1.89	10	3.23
HAJ	1	1.22	3	3.16	2	2,00
MUC	2	0.48	12	2.67	8	1.86
NUE	1	1.58	2	2.98	2	2.62
STR	3	1.31	2	0,59	6	3.28
SCN	-	-	-	-	-	-
total	55		67		72	
average rate		1.74		2.23		2.38

Rate = Number of birdstrikes per 10.000 movements of DLH.

Tab. 3: Number of birdstrikes DLH, 1980 - 1982, in the area of German airports, but flight phase unknown.

	1980		1981		1982	
	absolute	rate	absolute	rate	absolute	rate
BRE	3	5.63	3	4.88	2	3.50
CGN	0	0	1	0.63	3	1.96
DUS	2	0.68	5	1.51	13	4.26
FRA	8	0.86	11	1.16	4	0.42
HAM	4	1.32	7	2.23	5	1.32
HAJ	1	1.22	3	3.16	5	5.07
MUC	3	0.73	4	0.89	5	1.17
NUE	0	0	0	0	0	0
STR	0	0	2	0.89	3	1.65
SCN	-	-	-	-	-	-
total	21		36		40	
average rate		1.04		1.53		1.96

Rate = Number of birdstrikes per 10.000 movements of DLH.

FIGURE 1

ABSOLUTE AND RELATIVE NUMBER OF BIRDSTRIKES DLH
1973-1982 WORLDWIDE

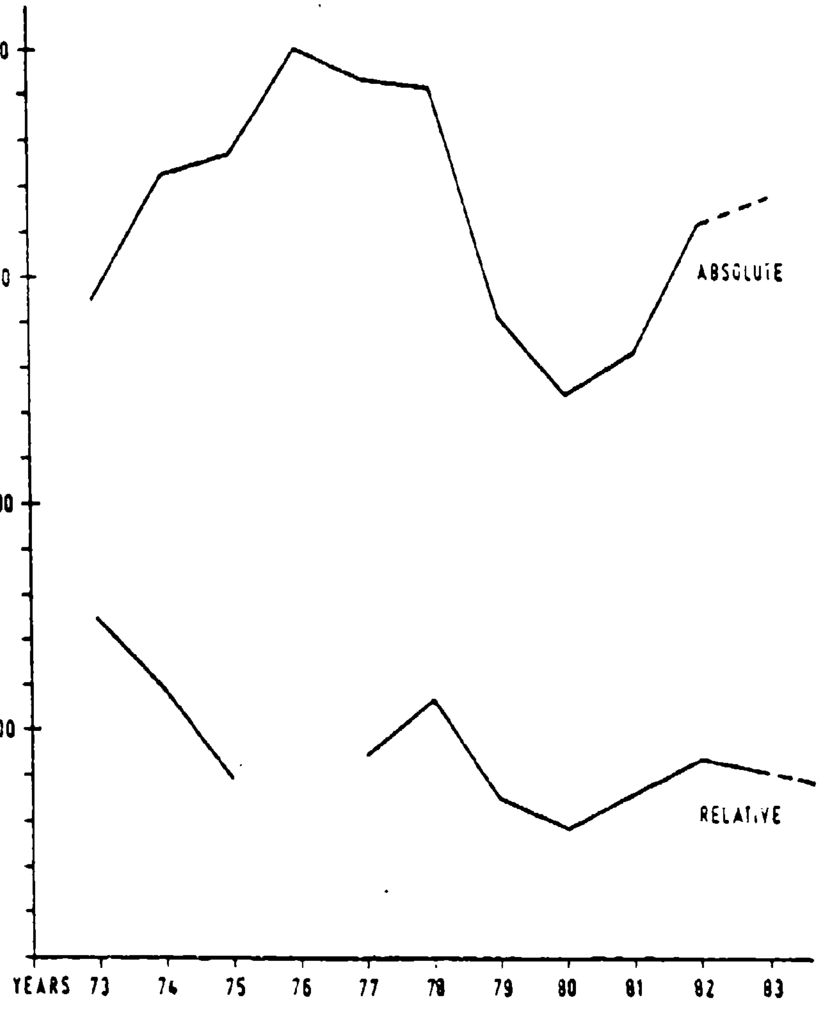


FIGURE 2

MONTHLY DISTRIBUTION ABSOLUTE NUMBER OF BIRDSTRIKES

DLH 1973-1982 WORLDWIDE AND EUROPE

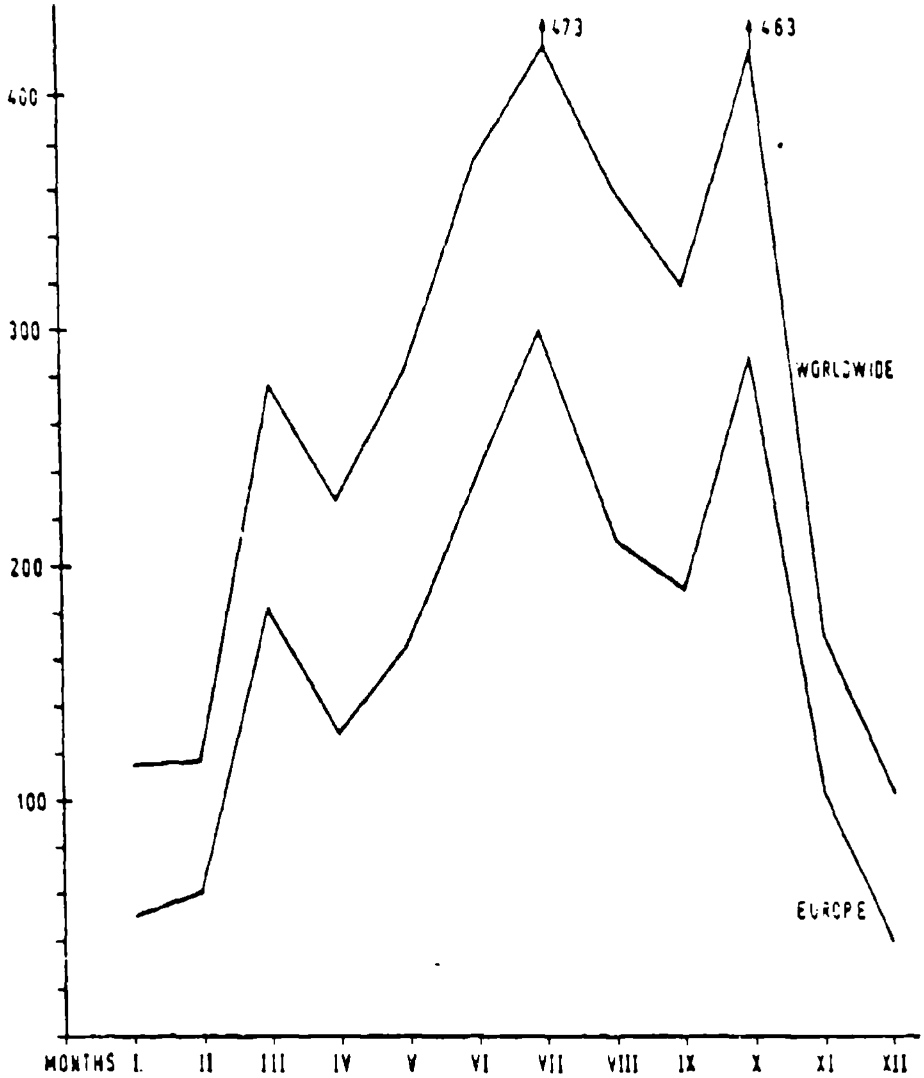


FIGURE 3

MONTHLY DISTRIBUTION OF BIRDSTRIKES OLH IN OTHER CONTINENTS
1967 - 1982

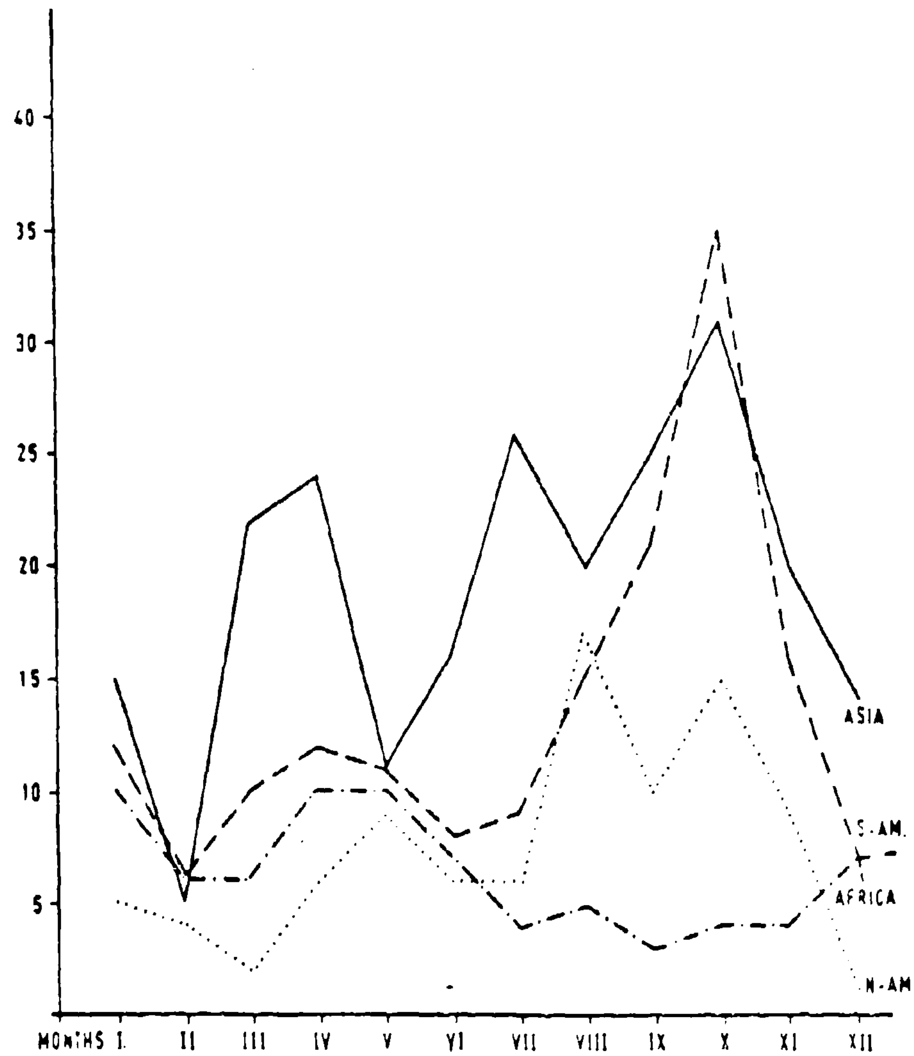
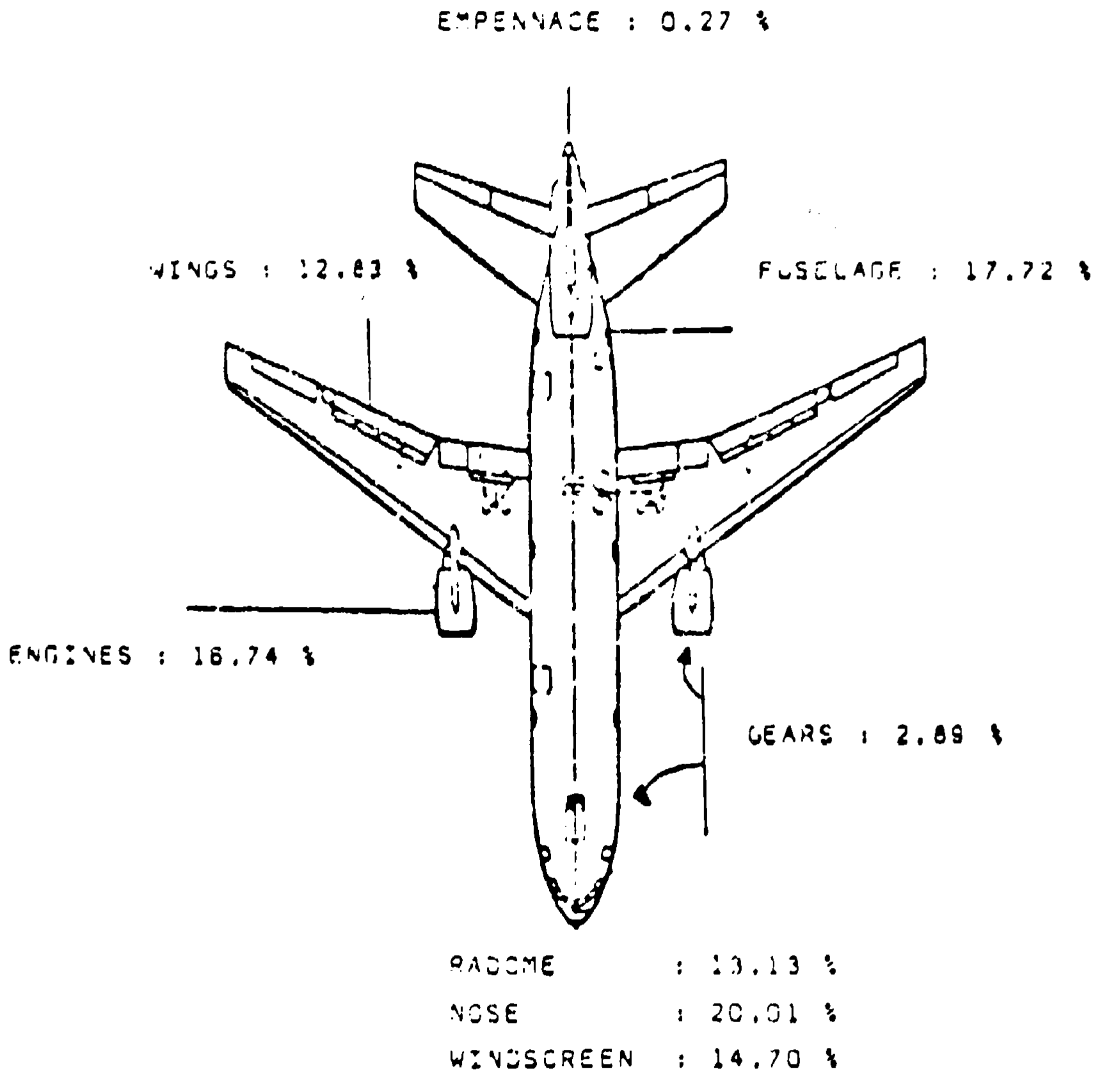


FIGURE 4

Aircraft parts struck by birds, 1977 - 1982 DLH



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BIRDS AND AIRCRAFT ENGINE STRIKE RATES

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A recent Canadian study involving the years 1977-1982 inclusive relates engine bird strike rates to different aircraft types and to different engine locations on similar-sized aircraft.

Incidents of engine damage, including simultaneous multi-engine strikes are related to aircraft types and engine locations. The data presented suggest high vulnerability to bird strikes, bird ingestion and related damage in the case of large, quiet, underwing-mounted engines. They also suggest much lower strike, ingestion and damage rates for small, noisy, rear-mounted engines. Where the same engines are used in both locations the strike rates are more than four times greater in the underwing location.

The implications for modern aircraft using 2 large, quiet, underwing-mounted engines (B767, B757 and A300) are considered.

In "Birds and Aircraft", (1973), and "Birds and Aviation", (1981), I discussed the history of bird hazards to aircraft and the work done on that subject in several countries. Those presentations covered site selection and design of airports and their buildings, air field maintenance techniques and emergency bird scaring as methods of reducing bird attractions including edible waste and sewage disposal areas, and agricultural crops directly or indirectly attractive to birds. In "The Birds Were There First and They Still Are", (1978), I stressed the high vulnerability of executing jet aircraft powered by small turbine engines and gave case histories of some serious engine bird strikes involving human injuries and fatalities.

In considering the special vulnerability of "executive" jet aircraft related to small engines, and the aircraft operational parameters, I was forced to the conclusion that an examination of relative bird strike rates for different kinds of jet engines should be undertaken. In that review consideration would also be given to engine position and forward projection of engine noise. Conjecture on the effect of noise on bird strike rates was put forward in Birds and Aviation as a result of some work done by E. Venturini (pers. comm. 1973) of the General Electric Co. Berger (1983) also referred to the effects of noise on birds.

Thorpe (1976) had shown from European bird strike data that different engine locations on commercial aircraft were associated with different bird strike rates (per 10,000 aircraft movements and per 10,000 engine movements). We, in Canada, have had for years Canadian data that showed different total aircraft bird strike rates at different airfields in Canada and in Europe.

To carry out the review we proposed we needed total aircraft engine bird strike data (including position of engine struck) from a group of airfields used by a variety of commercial aircraft types for which complete aircraft movement data were also available. With that type of data, a comparison of engine strike rates at the same airports and in the same time frame, related to engine location and aircraft type became possible. Even though the data did not eliminate all the variables we faced it gave us a chance to make comparisons we had not previously been able to make. Because some engines are used on different aircraft in different configurations we could also begin to see from Canadian data the importance under Canadian conditions of engine location as Thorpe (1976) had suggested.

I wish to acknowledge the excellent co-operation I have receive[illegible] rom Mr. A.J. Laflamme, Aviation Safety Bureau and Mr. W.P. McDonald, Air[illegible] Facilities Branch, Transport Canada in making engine bird strike and ai[illegible]r traffic data available for review.

The Canadian data covered the period from 1977 to 1982 inclusive. Prior to and during the period studied, strike data were reported by aircraft pilots, by airport staffs (mainly controllers and field maintenance personnel), and by aircraft engine maintenance units. The three-way system involved some duplications which were eliminated in processing. The three-way system, we believe, gave us reports on more than 80 percent of the bird strikes on commercial carrier aircraft at the airports studied.

An aircraft movement involves either a take-off or a landing. An aircraft engine bird strike rate of one per 10,000 movements means one bird strike incident (involving one or more engi[illegible]s) per 10,000 aircraft movements. An aircraft engine movement means that [illegible] engine has participated in an aircraft movement. On a 4 engine aircraft there are four engine movements for each aircraft movement. On a twin engine aircraft there are two engine movements for each aircraft movement. In table 1 the 234 engine bird strikes occurred in relation to 3.4 million aircraft movements and 8.7 million engine movements.

Table 1 summarizes data by year, by aircraft type, and by engine location. It is apparent that engine strike rates, per 10,000 aircraft movements and per 10,000 engine movements are related to engine intake size and are higher with bigger engines as Venturini (1973) and Berger (1983) have suggested. That may well be a result of the reduced sound warning time given by larger, quieter engines and the greater distance-to-escape as I suggested (Solman '81).

When one examines the figures for the B727, B737 and DC9 aircraft, all of which use Pratt and Whitney JT8D engines (not necessarily the same model) it is apparent, as suggested by Thorpe (1976) from European data, that tail-mounted engines have less than half as many strikes as the same engines on underwing mounts.

Multi-engine strikes have been reported 17 times involving 45 engines in the study period mainly (82%) on underwing engines in a total of 3.4 million aircraft movements. It may be expected that in the next 6 years, if the number of movements is similar to the past 6 years, a similar number of multi-engine strikes may occur. Recently the B767 aircraft has gone into service in Canada with large, quiet, underwing engines. It is suggested that it may experience multi-engine bird strikes. There are reports that multi-engine strikes have already occurred on the A300 aircraft which has similar-sized quiet engines and a somewhat similar configuration.

If we compare the 4.3 million movements of underwing engines (191 engine bird strikes) with the 4.3 million movements of rear mounted engines (43 engine bird strikes) we find a ratio of 0.44 to 0.10 or 4.4 bird strikes on underwing engines for each bird strike on a rear mounted engine.

In the future both aircraft manufacturers and aircraft operators may consider the relative costs of engine repairs, flight delays and public relations implications caused by aircraft engine bird strikes as a factor in deciding upon engine location on future aircraft.

The data we have suggest that reduction of bird hazards to aircraft at airfields will become increasingly important as we move to a higher proportion of aircraft with large, quiet, underwing engines.

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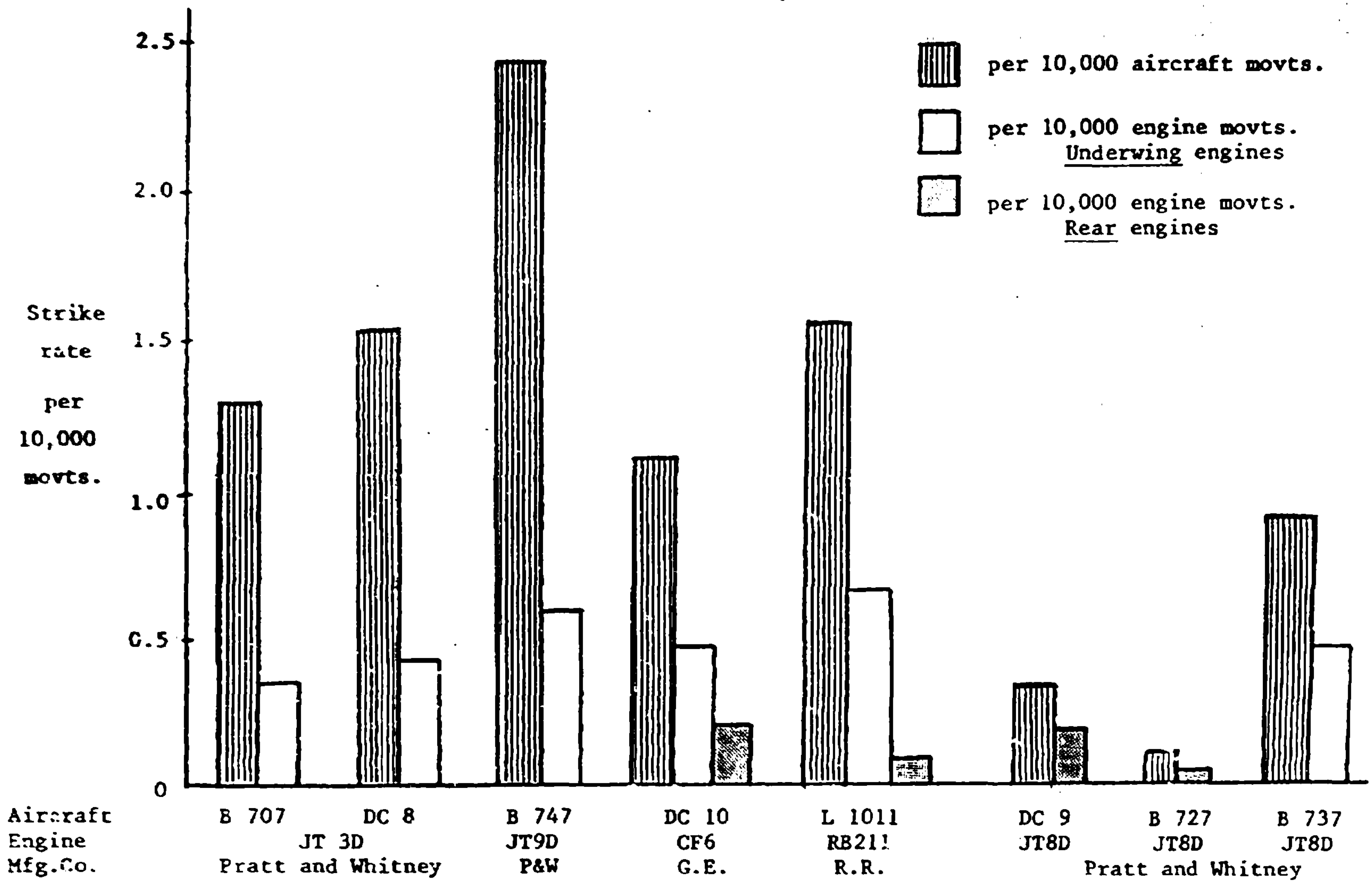
Table 1

BIRD STRIKES RECORDED ON AIRCRAFT ENGINES
EIGHT AIRCRAFT TYPES (JET) EIGHTEEN AIRPORTS (CANADA)
1977 - 1982 Inclusive

Aircraft type	Aircraft Movements	Engine Strikes U	Engine Strikes R	Engine Strikes per 10,000 aircraft movements	Engine Strikes per 10,000 Underwing engine movements	Engine Strikes per 10,000 Rear engine movements
B 707	54494	7		1.28	0.32	
B 727	674236		8	0.10		0.03
B 737	992426	86		0.87	0.43	
B 747	95617	23		2.40	0.60	
DC 8	339864	51		1.50	0.38	
DC 9	1,075524		33	0.31		0.15
DC 10	62988	6	1	1.11	0.47	0.16
L 1011	119047	18	1	1.51	0.71	0.08
TOTAL	3,424,196	191	43	Avg. 0.68	Avg. 0.44	Avg. 0.10
		234		3,424, 196/234	4,308, 822/191	4,355, 791/43

FIG. 1 - ENGINE BIRD STRIKE RATES
1977 - 1982 (18 airports 8 aircraft types)



REVIEW OF ENGINE INGESTIONS TO WIDE BODY TRANSPORT AIRCRAFT

by

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INTRODUCTION

In January 1981, the Federal Aviation Administration's (FAA) Northwest Region raised the issue of dual engine ingestion hazards to large, high bypass turbofan twin engine powered transport aircraft. The issue was whether dual engine failure was likely due to bird ingestions on twin engine aircraft equipped with high bypass turbofan engines. The Northwest Region, whose responsibility is certification of transport category aircraft, initiated a survey through air carriers worldwide, identifying damaging engine ingestions. The FAA's New England Region, who has responsibility for engine certification, initiated a review of engine ingestion data. In April 1981, an ad hoc team was formed to collect and analyze engine ingestion data. This paper presents some of the data and offers some considerations on how bird strike data should be collected and analyzed.

BIRD INGESTION DATA SET

Engine manufacturer data for the Pratt and Whitney JT9D, General Electric CF6, and the Rolls Royce RB211 were collected. Ingestion events for a period from 1969 through 1980 for the JT9D; 1972 through 1980 for the CF6; and April 1972 through August 1981 for the RB211 were examined. For purposes of data analysis, phase of flight was recorded. Where phase of flight was unknown, a proportional share of the unknowns were distributed amongst the known flight phases, based on other bird strike summary data from the British Civil Aviation Authority and other sources which indicate that approximately one-half of the bird ingestions occur during takeoff/climb.

All engine ingestion histories were reviewed to estimate the number of engines which failed. A failure was defined as a condition which precluded further use of that engine for production of significant thrust. Fifty percent thrust was a "rule of thumb" used for acceptability. An in-flight shutdown (IFSD) was not necessarily regarded as an engine failure unless other information supported such a conclusion. Many IFSD's are precautionary. If damage reports indicated the engine was capable of producing thrust had it been required, the event was not counted as a failure.

Typical damage for the engine failure category is a traverse fan blade crack with loss of a significant amount of the blade tip, repeated stalls, climbing exhaust gas temparature (EGT), or a 50 percent or greater power loss. Typical damage which does not of itself indicate an engine failure is fan blades bent or cracked with leading edge pieces broken out, high vibration, or a single surge/stall with recovery.

Most bird ingestion events had little or no operational effect on the engine. A few events were obvious engine failures. Some did not clearly indicate a failure or nonfailure condition. This last borderline group had engine damage, vibration and/or IFSD. Significant damage incidents were discussed in detail with the engine manufacturer and a determination was made as to whether the engine could have produced thrust if it had been required to do so. This was done by contacting the engine manufacturer who researched the incident files and by comparing damage on known failures with damages reported on these borderline incidents.

Based on these reviews, manufacturer estimates of engine capabilities and FAA technical staff judgment, · tabulation of bird ingestion events, and engine failures was compiled. Table 1 presents this information.

TABLE 1. Engine Bird Ingestions By Flight Phase

	Flight Phase			
Engine Type	Takeoff/Climb	Other Than Takeoff/Climb	Unknown or Not Reported	Total
JT9D Ingestion Events	215	42	346	603
JT9D Failures	36	1	0	37
Failures/Ingestion				6.14%
CF6 Ingestion Events	134	82	105	321
CF6 Failures	14	2	0	16
Failures/Ingestion				4.98%
RB211 Ingestion Events	71	36	59	166
RB211 Failures	4	0	0	4
Failures/Ingestion				2.41%
Total Events	420	160	510	1090
Total Failures	54	3	0	57

Applying a correctional factor of 50 percent for the Unknown/Not Reporteds, these events were distributed between Takeoff/Climb and Other than Takeoff/Climb.

TABLE 2. Distributed Bird Ingestions By Flight Phase

Engine Type	Flight Phase (Estimated) Takeoff/Climb	Other Than Takeoff/Climb
JT9D Ingestion Events	388	215
JT9D Failures	36	1
Failures/Ingestion(%)	9.28%	0.47%
CF6 Ingestion Events	186	135
CF6 Failures	14	2
Failures/Ingestions(%)	7.53%	1.48%
RB211 Ingestion Events	101	65
RB2111 Failures	4	0
Failures/Ingestion (%)	3.96%	-

Of the 1090 events, 49 involved multiple ingestions. Multiple ingestions are defined as ingestion of at least one bird into each of two or more engines on an aircraft during a bird encounter event. Unknown or unreported flight phase was distributed 50 percent to Takeoff/Climb and 50 percent to Other Than Takeoff/Climb. Multiple ingestion events involving small birds such as sparrows and starlings were excluded as not relevant to the study since small birds do not substantially damage large high bypass turbofan engines. These events were eliminated from the data set because the analysis focused on estimating multiple ingestions on nonrevenue departures were excluded because operations such as crew training, ferry flights, and touch-and-go takeoff are not typical of normal aircraft use.

TABLE 3. Multiple Ingestion Data

	Aircraft Type B747	DC-10	A300	L1011
Service Period	1969-1980	1977-1980	1974-1980	Apr 72-Aug 81
Revenue Departures	2,430,000	2,020,000	420,000	1,460,000
Takeoff/Climb Multiple Ingestions	16	6	4	2
Other Than Takeoff/Climb Multiple Ingestions	3	2	0	1
Unknown/Unreported Flight Phase Multiple Ingestions	15	0	0	0
Total	34	8	4	3
Multiple Ingestions per 10,000 Departures	0.14	0.04	0.10	0.02

The B747 ingestions included seven events in which three aircraft engines were affected and one event in which all four engines ingested birds. Table 3 treats these eight events as a dual engine ingestion event.

Table 4 provides aircraft fleet and engine combinations for aircraft and distribution of revenue departures by engine type. This data is useful in putting engine ingestion events into perspective.

TABLE 4. Wide Body Aircraft/Engine Data (As of 1/1/81)

	Aircraft Powered by Engine Type				
	B747	DC-10-30 DC-10-40	DC-10-10	A300	L1011
JT9D	390	38	0	3	0
CF6	64	171	122	119	0
RB211	20	0	0	0	192
Total Aircraft	474	209	122	122	192
JT9D Revenue Departure Distribution	0.894	0.105	0.000	0.001	0.000
CF6 Revenue Departure Distribution	0.042	0.330	0.443	0.185	0.000
RB211 Revenue Departure Distribution	0.021	0.000	0.000	.000	0.979

Approximately 89.4 percent of all JT9D departures were on B747 aircraft. If a higher incidence of B747 bird strike events occurred, it would correspondingly produce higher numbers of JT9D engine ingestion events, which from Table 1, is indeed the case. Likewise, if an aircraft type such as the L1011 were operated in locations with low bird activities, RB211 events and failures would be expected to be lower.

AIRPORT BIRD INGESTION FACTORS

The FAA's analysis of bird ingestion data resulted in calculating a failure rate for each engine. FAA was unable to consider exposure to bird hazards based on historical data from 1969 through 1980 because of the many variables in data collection from one country to another. Engine manufacturer data provided some information on individual ingestion events, but certainly not enough data to adequately describe all 1090 events.

The aircraft's (or engine's) exposure to the bird strike hazard must be considered. Table 5 illustrates the problem of geographic significance of the bird strike hazard problem. It lists the top ten airports contributing to wide body aircraft engine ingestions.

TABLE 5. Engine by Airport (1975-1980)
JT9D, CF6, and RB211

Airport	Engine Ingestions	Engine Failures	Multiple Engine Ingestions
J. F. Kennedy	48	6	5
Toyko	38	3	2
Bombay	27	3	0
Schiphol	21	2	2
Delhi	20	1	0
Heathrow	12	2	1
San Francisco	11	2	1
Paris Orley	10	1	2
Prestwick	8	2	1
Copenhagen	8	2	2
Total	203	24	16

Source: Engine Manufacturer Data (All flight phases included)

These 10 airports account for 16 of 49 multiple ingestion events and 24 of 57 failures. Improvements in bird control would significantly improve the engine failure rates.

Engine failure rates, ingestion rates, and other treatments of the data where the number of operations are factored into the ingestion data must also be analyzed in relation to the exposure the aircraft has to bird hazard risks. Since bird densities around airports are constantly changing, there are periods of the year when bird hazards are at an absolute minimum. During early spring and early summer, bird strikes decline while the number of operations increase. Likewise, on a given day, many of the U.S. air carrier served airports exceed the number of daily operations of any foreign airport. While Heathrow experienced a takeoff or landing every 5 to 6 minutes in 1979, some of the larger U.S. airports were moving aircraft at much shorter intervals. If more aircraft are operating at closer takeoff and landing intervals, the increased airport activity scares the birds away, and at the same time, bird control measures can be effectively employed to protect greater numbers of aircraft. Many of the bird strikes experienced on U.S. airports occur when airport operations are light, on takeoff or landing on other than the primary runways, and during periods when airport bird patrols are not on duty.

Another factor relates to daily and almost hourly changes in the airport bird densities. Many bird species hazardous to aircraft exhibit increased flight activity near sunrise and sunset. Other birds like vultures and kites use midday thermal air masses to soar and glide in search of food. Many flocking birds roost at night, not creating a bird hazard until they fly at dawn from their roost to feeding areas near the airport. Most bird strikes occur during daylight hours because of both increased bird activity and increased numbers of aircraft flight operations.

Figure 1 depicts the time distribution of 84 worldwide bird ingestions on high bypass turbofan engines where the local time of the bird strike was reported. These 84 events occurred over a one year period beginning in May 1981. Using the time, date, and location of the event, the time of occurrence was converted to reflect hours before or after sunrise and sunset. In those ingestion events where the bird were identified, most of the birds were species that roost at night. Ingestions which occurred at and after midnight involved owls. Greater numbers of bird strikes occur near sunrise through sunset for all categories of aircraft.

Table 6 lists the combined percentage of B747, DC-10, L1011, and A300 revenue departures at selected airports which departed between the hour before sunrise and the hour after sunset. These percentages will vary with airline passenger seasons; however, most bird strikes occur from late August through the winter months. Revenue departures during the month of September 1982 were used in Table 4, approximating departure schedules which would exist through the fall and early winter months when the bird hazard risks are greatest.

..GURE 1. Time Distribution of 84 Bird Ingestions
High-Bypass Turbofan Engines
Source: FAA Bird Strike/Incident Reports FAA Form 5200-7

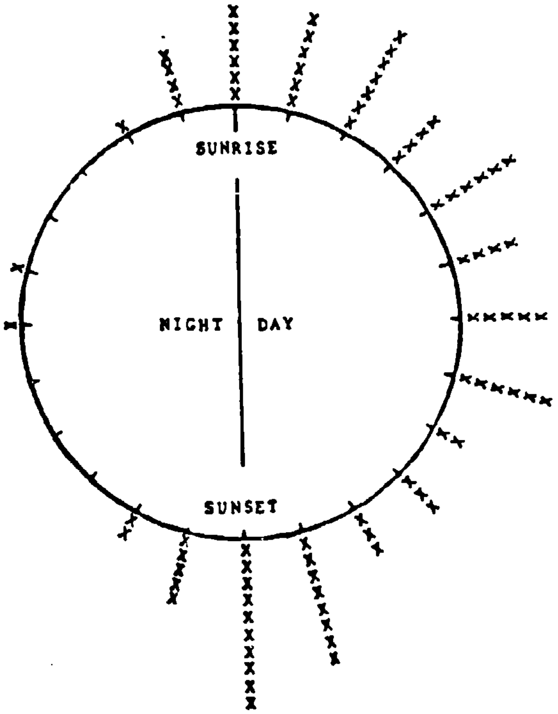

TABLE 6. Percentage of Departures
One Hour Before Sunrise to One Hour After Sunset

Airport	Percentage of Departures
John F. Kennedy	53.9%
Delhi	55.2
Bombay	59.3
Los Angeles	68.9
Boston	70.4
San Francisco	74.5
Miami	75.2
Paris Orley	76.7
Copenhagen	82.7
London Heathrow	86.1
Schiphol	88.2
Tokyo-Haneda	88.6
Sydney	92.1

Source: International Official Airline Guide, September 1, 1982

Table 6 shows that most of these airports have their greatest number ofrevenue departures during periods of daylight bird activity. Some airports like John F. Kennedy International have nearly half of their departures occurring after dark. At Kennedy, the predominant bird hazard problem involves gulls which usually roost at night away from the airport. With airport bird strike rates being calculated by dividing the total number of bird strike events by the total departures, an error is introduced in the rate because the rate is not adjusted for the actual exposure to the bird risk. A rate of 1.2 strikes per 10,000 operations at John F. Kennedy corrected to eliminate night revenue departures would be 2.2 strikes per 10,000 operations. Flight scheduling significantly affects the bird strike risk at many airports and should be considered when discussing bird strike rates and probabilities.

Aircraft flight schedules and bird flight habits cannot be used in assessments of historical bird ingestion data because the bird strike reporting systems did not report these factors. Any analysis of this data necessarily estimates a worldwide 24-hour average risk. The rates and probabilities derived from bird strike data consider all revenue departures, which is a greater number of departures than the actual departures exposed to the bird hazard at many major airports. If revenue departures were adjusted downward to more closely approximate bird hazard exposure, the computed rates would increase sharply. Factoring out departures where bird hazard risks are minimal could increase these rates by 20 to 30 percent at most airports.

CONCLUSIONS

While the FAA had taken a close look at historical bird ingestion data from 1969 through 1980, the ad hoc team also recognized the limitations on the data set. In May of 1981, the FAA's Technical Center initiated the most comprehensive data collection program ever undertaken on bird ingestions. Contracts were awarded to Pratt and Whitney, General Electric, and Rolls Royce to respond to bird ingestion events and collect data. The contract tasks included descriptions of damage, positive bird identification, date, time, phase of flight, weather conditions, and from the bird identification, bird weight. Narrative descriptions provided information on engine performance, damage, and numbers of birds. The data collection phase was completed in July 1983 and the draft report is currently being coordinated within FAA. In the 26 months of the study, 638 engine ingestion events on high bypass turbofan engines were recorded at 137 airports. Twenty-eight events involved multiple bird ingestions. Data contained in the Technical Center report will be extremely valuable in identifying the nature of the bird hazard risk to large high bypass turbofan engines.

AD-P004 186

AIRCRAFT TRANSPARENCY BIRD IMPACT ANALYSIS USING THE MAGNA COMPUTER PROGRAM

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ABSTRACT

The history of United States Air Force involvement in the development of bird impact resistant transparent crew enclosures for flight vehicles is briefly reviewed. The decision to develop analytical methods for the design of bird resistant transparencies is noted. The subsequent development of a finite element computer program called MAGNA is discussed and experience with the application of this code to the bird impact analysis of a tactical aircraft canopy is related. Results are presented which show MAGNA to be capable of realistically simulating the canopy response to bird impact. The strong dependence of the bird impact loading upon the dynamic response of the canopy is pointed out, and the need to develop the capability to independently account for the effects of this load-response coupling is stated.

INTRODUCTION

In recent years, United States Air Force Flight missions have involved more high speed, low altitude operations. Under these conditions, bird impacts on aircraft transparent crew enclosures pose a significant hazard and have resulted in unacceptable losses of aircraft and crewmembers. Between the years of 1966 and 1977, the cost of Air Force aircraft alone lost to confirmed transparency bird impact exceeded $80 million.[1] Six crewmembers lost their lives in these accidents. The total cost involved grows to a much higher level when worldwide military and commercial aircraft operations, and the expense of replacing damaged transparencies on recovered aircraft are taken into consideration.

The United States Air Force has been one of the leaders in reducing the scope of this problem since 1972. At that time the Air Force Flight Dynamics Laboratory formed the Improved Windshield Protection Advanced Development Program Office (ADPO). Since that time a second group, the Subsystems Development Group of the Crew Escape and Subsystems Branch, has also been formed and together these two offices are charged with the development, demonstration, and application of new technology for the design of improved aircraft transparent crew enclosures.

The major bird impact protection programs accomplished by the Flight Dynamics Laboratory to date have all involved the design of improved transparencies for existing operational aircraft. These retrofit programs have made extensive use of full scale bird impact testing for the screening of preliminary designs and the qualification of final designs.[2,3]

ANALYTICAL TOOLS

Since high cost and considerable time were inherent in these empirical methods, interest began to grow in the development of less costly analytical design tools. In 1975 the Air Force Flight Dynamics Laboratory awarded its first contract for the development of a computer program to fill this requirement. As a result, a code named IMPACT was developed and delivered to the Air Force in 1977.[4, 5, 6]

IMPACT was discussed at the 1978 Conference on Aerospace Transparent Materials and Enclosures.[7] It was found to be inadequate for simulating the bird impact response of a flexible tactical aircraft canopy due to the very large deflections (8 in.) observed during tests of the canopy. At the time, it was presumed that IMPACT could still serve as an analysis and design tool for transparencies exhibiting smaller deflections in response to bird impact.

However, subsequent evaluation of IMPACT performed under an in-house research program in the Subsystems Development Group found the code inadequate for the analysis of even a very stiff bomber-class windshield panel.[8] Even though the deflections observed in testing were less than 0.5 in., they were still too large to permit successful analysis.

FINITE ELEMENT METHOD

The analysis method employed in the IMPACT computer program is known as the finite element method. This method was developed in the early 1960's as a structural analysis technique and has been successfully applied woldwide in a variety of technical disciplines since then.

The method is comprised of three basic steps. The first step involves treating the structure of concern as a group of subsections or elements instead of as a single entity. This representation is referred to as the "finite element model" of the structure.

The second step involves the definition of loads which are applied to the structure - bird impact loads in this case.

The third step involves the use of a (finite element) computer program to calculate the response of the structure which has been modelled to the loads which have been defined.

In general, when the deflections resulting from applied loads reach a certain level, a nonlinear finite element code is required for analysis of the problem. The IMPACT computer program discussed in the last section was a linear program, i.e., it was based on the assumption of very small deflections everywhere in the structure. As previously mentioned, the deflection of even very stiff aircraft transparencies (glass bomber windshield) in response to bird impact loads has been found to be "large" for the purpose of finite element analysis.[8] Therefore, it should come as no surprise that IMPACT could not serve as an effective transparency bird impact analysis tool.

MAGNA COMPUTER PROGRAM

In 1978, when the need for a nonlinear code had been confirmed, the Air Force Flight Dynamics Laboratory made a second contract award to obtain a finite element program for transparency bird impact analysis. As a result, a nonlinear code named MAGNA was delivered to the Air Force in 1979.[9]

MAGNA can accurately analyze large deflection problems[9] and it is hoped that it will eventually serve as a valuable tool for the aircraft transparency design community. Toward this end, the Subsystems Development Group is under contract through 1984 for continued improvement of MAGNA and the ADPO is under contract to have MAGNA used as an analysis tool for some improved transparencies.

The MAGNA code is installed on the scientific computers at Wright-Patterson Air Force Base, and is available for use by any United States Government office or any firm under contract to such an office. At the present time MAGNA is being exercised by its developer, the University of Dayton Research Institute, Dayton, Ohio, and by several US Air Force offices and contractors.

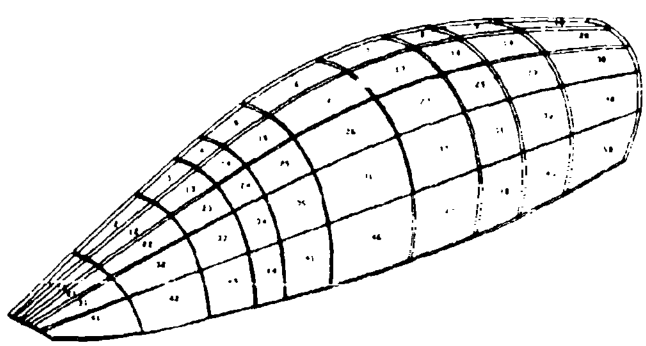
The Subsystems Development Group is conducting a continuing in-house research program to evaluate MAGNA as the development of the code proceeds and to attempt to validate it via simulation of various full scale bird impact tests. The results of these simulations are being compared to stress, strain, and deflection data acquired during full scale testing.[1, 10]

During 1980, the Subsystems Development Group simulated the bird impact response of a very flexible canopy for a tactical aircraft. This is regarded as a severe test of MAGNA because the deflections of the canopy are so large.

BIRD IMPACT ANALYSES

Figure 1 shows the finite element model of the canopy analyzed under the Subsystems Development Group in-house study. Only half of the structure has been modelled because of the symmetry of the problem. The model contains fifty finite elements.

FIGURE 1. Finite Element model of Tactical Aircraft Canopy



The shape of the loaded area over which the bird impact loads were applied has been determined experimentally for rigid targets.[11] That is, the loading "footprint" corresponds to the case for which the canopy does not deflect during the impact event.

A simplistic approach was taken in calculating the loads which are applied over this footprint by the bird. Reference 8 discusses the same approach to modelling bird impact loads, but in greater detail. After impact, the component of the bird's initial linear momentum, normal to the canopy surface has been delivered to the canopy and is therefore equal to the impulse. Again, it was assumed that no deflection of the canopy occurs during impact. The average force applied to the canopy during impact was then determined by dividing the impulse delivered to the canopy by the period of the event. Since only half the canopy was modelled, only half this average force is used in the simulation. This description of loads is referred to as "uncoupled" since it involves the assumption that the bird impact loads are independent, or "uncoupled," from the resulting deflection of the canopy during impact.

Linear, Uncoupled Analysis

MAGNA can be used to perform either linear or nonlinear analyses. For the purpose of comparison with earlier studies of the same problem with IMPACT,[4,7] a linear analysis was performed first. The uncoupled description of loads was used in conjunction with this analysis. A 4.0 lb bird impacting the canopy at 575 fps was simulated; the period of the impact event was 2.3 ms.

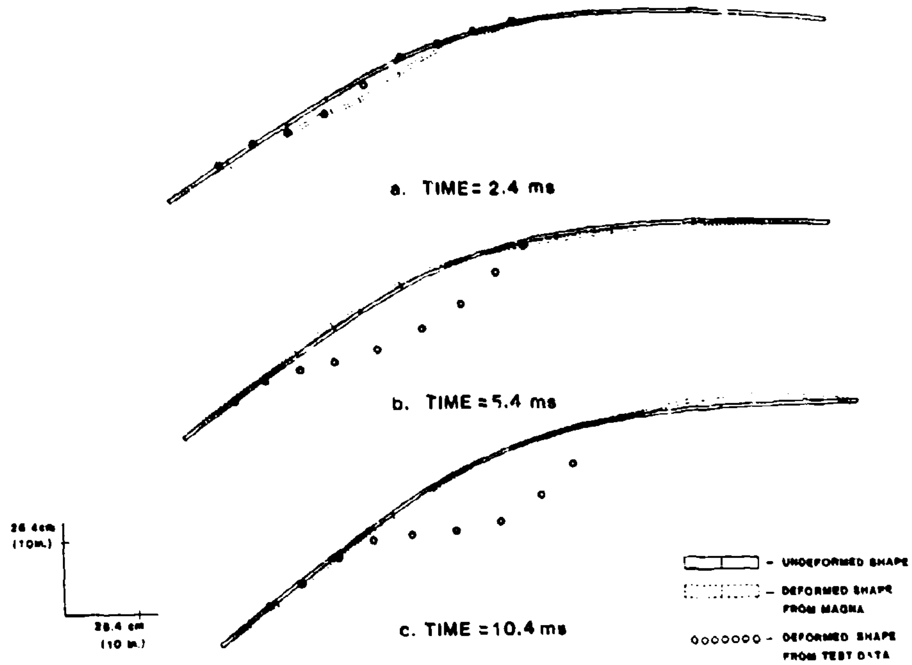
Figure 2 shows the results of this analysis. The solid lines represent a profile view of the undeformed shape of the canopy along its centerline or plane of symmetry. The dotted lines represent the deformed shape of the canopy calculated by MAGNA. The small circles represent data reduced from high speed film records of the actual test.

The results illustrated are similar to those of earlier linear studies performed.[4,7] The computed deflections are much smaller than those observed during the test. One of the reasons for such poor correlation is that the simulation was not a large deflection analysis. It can be seen from the experimental data that a very large depression formed in the canopy during the test and moved aft over the structure. The linear analysis results also show the formation of a depression (of much less depth) which travels aft, but the speed of propagation is too high. At 10.4 ms, the linear deformation has already reached the aft edge of the transparency and has been reflected as an outward displaced wave while the experimentally observed depression has only begun to travel slowly aft.

Nonlinear, Uncoupled Analysis

Next a nonlinear (large deflection) analysis of the same bird impact test was accomplished with MAGNA. Much anticipation accompanied this analysis because it was the first nonlinear dynamic analysis of bird impact on the aircraft transparency with MAGNA. It was hoped that taking into account the effects of large deflections would prove to be all that was required in order to realistically simulate the test results. The uncoupled description of the loads was used again as for the linear analysis. Figure 3 shows the results obtained. The format is the same as for Figure 2.

FIGURE 2. Canopy Centerline Deflection, Linear Uncoupled Analysis



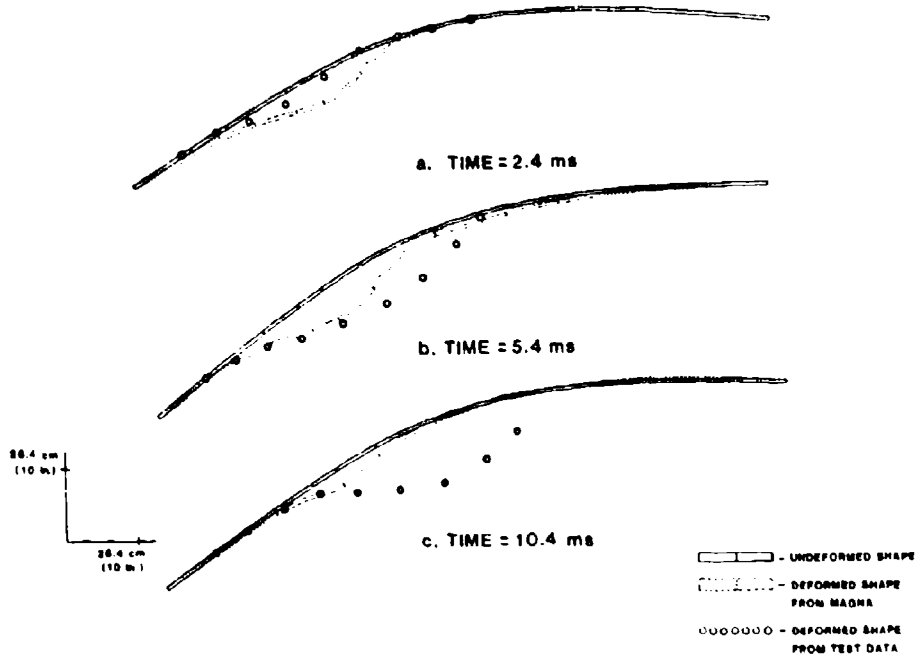
It is apparent that the effects of large deflections are indeed very significant for this problem. The displacements computed by MAGNA are much larger than those from the linear analysis, but something is still wrong. The displacements computed at early times (2.4 ms) are too great and those computed at later times are too small. Even though a relatively large depression in the canopy is predicted by MAGNA, it doesn't travel aft over the canopy at all.

The conclusion drawn from these results was that even though the effects of large deflections are important, some very significant aspect of the problem had apparently been overlooked in the analysis. Similar disappointing results have been reported by other investigators.[12]

Nonlinear Coupled Analysis

The aspect of the nonlinear uncoupled analysis which was most highly suspect as the cause of the poor correlation seen in Figure 3 was the assumption made that the canopy did not deflect during the impact event. To examine the validity of this rigid target assumption, high speed film records of the actual bird impact test were studied.

FIGURE 3. Canopy Centerline Deflection, Nonlinear Uncoupled Analysis



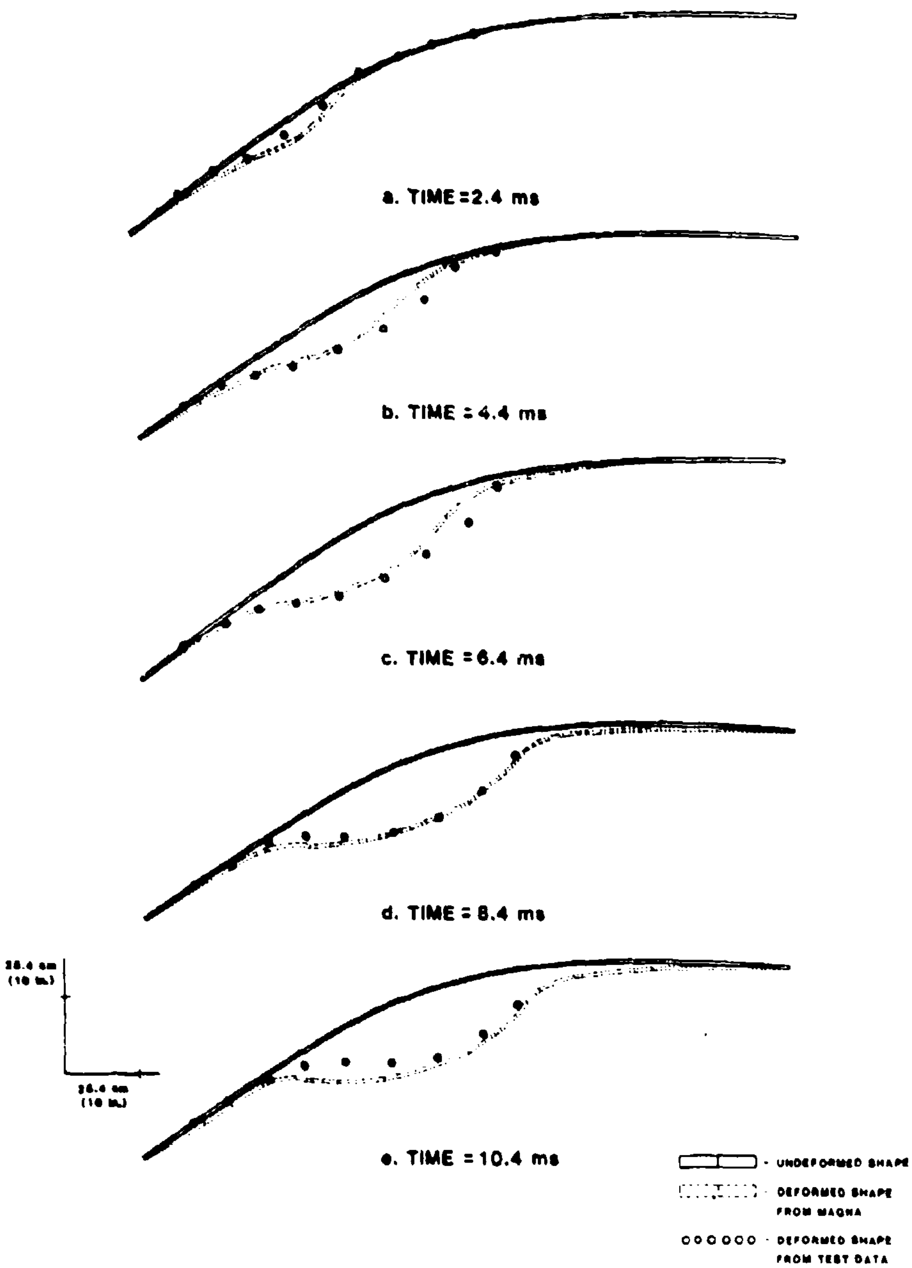
The area over which the bird impact loads actually acted was estimated from a scuff mark left on the canopy after impact which was visible in the test film. It was obvious from the film that the surface area of the canopy loaded by the bird is very sensitive to deflection of the canopy during impact. The size of the actual footprint was many times that for the rigid target case.

Next, an estimate of the actual period of impact was obtained from the film records. The film from a camera which had been placed inside the canopy during the test showed plainly the time at which the bird material stopped sliding over the surface and ceased to make contact with the canopy. The film estimate of the period was 8.5 ms compared to 2.3 ms for the rigid target case, so again the effect of canopy deflection during impact was very pronounced.

From the analysis of the test film, a second definition of bird impact loading was derived. This definition will be referred to from here on as "coupled loading" because it takes into account some of the effects of target deflection during impact.

Figure 4 shows the results of repeating the MAGNA nonlinear analysis but with the coupled description of loading, i.e., with the more realistic footprint area, and impact period. The results are dramatically improved over

FIGURE 4. Canopy Centerline Deflection, Nonlinear Coupled Analysis



those from the nonlinear uncoupled simulation. The deflections grow slowly at early times as in the actual test - a result of the lower average impact force. The deflections at late times are larger - a result of the longer impact period. The size and shape of the depression in the canopy are realistic at all times. The motion of the depression aft over the canopy is very similar to that observed during the actual test.

In general, correlation with the data is excellent for the coupled case especially in view of the coarseness with which impact loads were defined. Apparently, the most significant aspect of this problem is the strong coupling which exists between the impact loads and the response of the canopy. The response is very sensitive to the loads and vice versa.

It is important to note at this point that a priori knowledge of test results was required before realistic simulation of the full scale test became possible. High speed film of the test was used to define impact load parameters for use in the MAGNA analysis. This means that in accomplishing the solution to one problem, another has been uncovered. A computer program, MAGNA, has been developed which is technically capable of realistically simulating the severely nonlinear response of a tactical aircraft canopy to bird impact. This is the solution to the birdstrike analysis problem which the Flight Dynamics Laboratory has been seeking since 1975. But it has been learned in the process that the capability to accurately define bird loading on flexible transparencies for use in MAGNA analyses is lacking. The loads depend so strongly upon the response of the canopy that estimates of the loads made without a priori knowledge of the response (uncoupled description of the loads) produce completely unrealistic results (Figure 3). This defeats the use of the computer program as a transparency design tool.

Two new investigations are suggested by the results just discussed. One is a work effort to perform more correlation studies with MAGNA but for other, less flexible aircraft transparencies in hopes of finding some for which the effects of coupling may safely be ignored. Some work along these lines has already been accomplished.[10] This work helps define the range of target response over which an uncoupled or rigid target description of loads remains valid. In general, it has been determined that an uncoupled or rigid target description of loads remains valid for any monolithic or laminated glass transparency design because of the relatively small deflections exhibited during bird impact.[10]

The second investigation which is warranted in the light of results presented here is one to develop the capability to account for the effects of load-response coupling during a MAGNA bird impact analysis. This capability would be internal to MAGNA and transparent to the user. It would require only the definition of some initial parameters related to the impact event such as bird mass, bird velocity, and impact point. The internal workings of the finite element solution would then compute, step by step, the appropriate bird impact loading based on the instantaneous state of the transparency structure as it deforms in response to impact loads. If such a capability can be realized, then this tool should prove valuable in the design of all new bird-resistant transparencies. A contractual program currently in progress is intended to provide this capability in 1984.

Since the aircraft transparency birdstrike problem requires large deflection analysis and since the case treated in this paper involves the largest deflections ever observed during Air Force full scale bird impact testing, it may be stated that MAGNA is ready for use in post-test analysis for all types of aircraft transparencies. It may also be used at the present time in the design of those new bird-resistant transparencies for which the effects of load-response coupling may safely be ignored. (An interim method of handling moderate coupling has also been developed[14].)

CONCLUDING REMARKS

The MAGNA computer program is technically capable of realistically simulating nonlinear dynamic structural response of aircraft transparencies to bird impact loading.

It it not yet possible to accurately define a priori the loads resulting from bird impact on very flexible aircraft transparencies. This is true because the magnitude of the loads as well as the surface area and period of time over which they act depend strongly on the dynamic response of the transparency. That is to say, for very flexible aircraft transparencies, the bird impact loads are strongly coupled to the dynamic response of the transparency.

MAGNA is ready for use as a post-bird-impact-test analysis tool for all types of transparencies and even as a design tool for new, relatively stiff transparencies, i.e., transparencies for which the effects of load-response coupling may safely be ignored or are only moderate.

If and when the capability to directly account for the effects of load-response coupling is implemented in MAGNA, it will provide valuable service as a design and analysis tool for all types of bird-resistant aircraft transparencies. Significant savings in cost and time will be realized with such an analysis tool.

Use of MAGNA is not limited to aircraft transparency birdstrike analysis but may be extended to the analysis of any problem involving the linear or nonlinear response of a structure subject to static or transient loads. In the particular area of aircraft transparency design, it may be used to analyze the effects of cockpit pressure loads, in-flight aerodynamic pressure loads, runway or in-flight temperatures, or supersonic aerodynamic heating loads.

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BIRD IMPACT EVALUATION OF THE F/RF-4 TRANSPARENCY SYSTEM

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ABSTRACT

Birdstrikes to the crew enclosures of USAF F/RF-4 aircraft have resulted in major aircraft damages coupled with severe fatal pilot injuries. Analysis of operational bird impact statistical data indicates that the trend of damaging bird impacts of the F-4 is continuing to rise. Impacts to the F-4 transparency system also continue to rise resulting in a continued flight safety risk to the aircraft and the aircrew. The Air Force Wright Aeronautical Laboratories, Improved Windshield Protection Office has initiated a program to develop a transparency system for the F-4 aircraft which has four pound, 500 knot bird impact capability. The first step in this program was to experimentally determine the existing transparency system capability by bird impact testing full scale flight hardware. Eight impact locations on the windshield and forward canopy were tested to failure with four pound birds. Tests on experimental, laminated windshield side panels were also conducted to investigate the capability of the windshield frame. The baseline birdstrike test results are presented through the use of post test photographs and an impact capability diagram.

INTRODUCTION

Due to the advancement in radar detection techniques as well as the development and increased use of terrain following instrumentation, an increased amount of high-speed flight time is performed at altitudes below 10, 000 feet. Many air force high-speed aircraft transparency systems were not designed to meet the increased bird impact risk associated with this phase of the flight operation. The F/RF-4, Figure 1, is but one example of an aircraft which was not designed with a transparency system capable of surviving the bird impact event. Analysis of birdstrike statistical data obtained from the Air Force Inspection and Safety Center at Norton AFB, California shows that during the period January 1971 to March 1981, 30 of the 68 reported birdstrikes against the transparency resulted in penetration into the crew compartment. Associated with these penetrations were 12 injuries (some permanently disabling) to aircrew personnel, loss of one aircraft, and one pilot fatality. Recent birdstrike data continues to show an increase in the number of impacts and, without significant changes in the mission requirements that have resulted in this increasing birdstrike rate, an even larger number of damaging birdstrikes may be expected for the F/RF-4 aircraft in the future.

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BACKGROUND/OBJECTIVE

As a result of the loss of a USAF F-4E aircraft and a pilot fatality due to a windshield birdstrike in November 1980, the Improved Windshield Protection Program Office was directed to develop an improved bird impact resistant transparency system for the F/RF-4 aircraft. The initial phase of this program included an experimental test series which was conducted to determine the baseline bird impact capability of the current F/RF-4 transparency system.

The primary objective of this bird impact test program, conducted during the periods August-October 1982 and February 1983 was to determine the minimum bird penetration velocity as a function of birdstrike location for the windshield and forward canopy. Secondary objectives of the test program were to: (1) collect sufficient data (photographic, strain, and accelerometer) to support the subsequent transparency system redesign effort; and (2) to investigate the capability of the windshield support structure to absorb (and transfer into the fuselage) the energies associated with the bird impact event.

EXPERIMENTAL PROCEDURE

The bird impact testing of the F/RF-4 transparency system was accomplished at Range S-3 of the von Karman Gas Dynamics Facility of the Air Force System Command's Arnold Engineering Development Center. Figure 2 shows the test area arrangement. Capabilities of th S-3 Range are continued in Reference 1. The basic procedure emplcyed in testing in the S-3 Range consists of launching bird carcasses at specified velocities (using an air-driven launcher) into predetermined impact locations on a test article. For the F-4 baseline tests, six impact locations on the windshield and forward canopy were investigated with the fuselage aligned at 0° pitch and 0° yaw relative to the launch path. Side impact tests were conducted at one location on the windshield side panel and one on the forward canopy with the fuselage yawed at 15° relative to the launch path.

Test Fixture/Test Articles

To more closely simulate the actual bird impact response of the transparency and to get realistic load transfer, an F-4 forward fuselage section was used as the test fixture (see Figure 3). All transparencies and related hardware were actual aircraft structures removed from aircraft in storage at the Military Aircraft Storage and Disposition Center at Davis-Monthan AFB, Arizona. Test articles consisted of the forward windshield assembly (two plexiglass side panels, laminated glass center panel, and supporting structure) and the forward canopy assembly. The cross-section of each transparency component is shown in Figure 4.

The windshield frame capability was determine by utilizing laminated side panels which were designed, developed, built, and donated by Goodyear Aerospace Corporation, Litchfield Park, Arizona. The laminated panel cross-section may be seen in Figure 5. When a transparency failed in a test, it was removed from the frame, the frame was inspected, and if no structural damage had occurred, another transparency was mounted in place.

Projectiles and Sabots

Projectiles launched during this test program were nominally four-pound chicken carcasses. The birds were asphyxiated, quick-frozen, and stored at 0°F until needed. Prior to testing, the carcass was thawed in still air at room temperature (75°F) for approximately 24 hours or until the body cavity temperature was 70 ±10°F. Adjustments to the bird carcass weights were required to achieve the desired weight within ±0.1 pound. These adjustments were accomplished by clipping carcass appendages or injecting water into the body cavity. In no case did the adjustment exceed 10 percent of the bird weight.

The packaged bird was mated to the launch tube using a one-piece sabot of balsa wood construction. The sabot materials density was nominally 10 lb/ft^3 providing a sabot weight of 1.7 lb and a total launch weight of 5.7 lb. Separation of the bird and sabot after launch was accomplished with the use of the tapered and threaded cylindrical sabot stripping section attached directly to the vent section of the launch tube (Figure 2). As the launch package entered the stripper section, the sabot velocity was gradually decreased by the shearing of thin layers of sabot material, permitting the bird to exit in free-flight.

Instrumentation

Instrumentation for this series of tests was primarily designed to collect data for use with analytical transparency analysis tools. Four to five high-speed movie cameras were used to record the impact event. The cameras were situated in such a manner as to gain an overall perspective of the impact point (Figure 6). In addition to the high-speed cameras, still photographic coverage was used to record pre- and post-test conditions.

A total of 20 strain gages were monitored during each impact. These gages were located in such a manner as to record the load characteristics of the transparency support structure during impact.

Two accelerometers were used to monitor the motion of the frame during bird impact. X-ray shadowgraphs were used to monitor the bird position and orientation prior to the impact (Figure 2). They were also used to verify the impact velocity.

Test area temperature was measured by two thermcouples positioned near the test transparencies.

Impact Location/Impact Velocities

The eight impact locations used may be seen in Figure 7. These locations were chosen through the use of an angle of incidence study and represent areas where the maximum energy could be transferred from the traveling bird to the stationary structure. At least two impact locations on each transparency system component were investigated so that a capability map could be developed for the entire system. Impacts at locations "A" through "G" were made with the fuselage section aligned at 0° pitch and 0° yaw relative to the launcher flight path. Impact locations "H" and "I" were chosen to investigate the transparency capability in the sill area. Impacts at these two locations were made with the fuselage yawed at a 15° (clockwise) angle so that sufficient bird contact could be made with the test article.

The initial impact velocity was slightly below the expected failure velocity. Failure velocities were analytically determined at each impact location by employing the prediction methods found in Reference 2. Succeeding impact velocities were increased until transparency failure at that location occurred. The failure velocity range could then be bracketed between the highest velocity at which failure had not occurred and the velocity at which failure had occurred.

TEST RESULTS

The baseline birdstrike capability for the F/RF-4 transparency system was defined with a total of 25 bird impacts at eight locations on the transparency system. The results of these tests have been summarized in a capability diagram as shown in Figure 8. This diagram presents the four-pound bird impact capability of the existing windshield system with the fuselage oriented at 0° pitch and 0° yaw. This diagram is based on the actual test data with the areas being defined after considering the recorded post-test observations, the high-speed movies, the strain data, the impact angle of incidence, and the proximity to the edge attachment. The values represent an approximate threshold of failure velocity (in knots) for various areas on the windshield and canopy.

Windshield Side Panel

The most critical impact location was on the forward area of the 0.38-inch thick stretched acrylic windshield side panel, impact point "A." The impact angle of incidence was 27 degrees at the target point. Impact point "A" was initially impacted with a four-pound bird at 190 knots which resulted in no damage. A subsequent shot at 200 knots resulted in about half of the four-pound bird penetrating the transparency (see Figure 9). The transparency frame was not damaged.

The aft area of the windshield side panel was tested at location"B" and was found to have a failure threshold of 210 knots. The small increase was due to the reduced angle of incidence: 21 degress.

Windshield Center Panel

The 1.2-inch-thick laminated glass windshield center panel demonstrated the highest capability of any part of the current transparency system. A four-pound, 300 knot shot on the forward end of the glass center panel (location"D") resulted in a substantial amount of glass spalling off the inside surface; however, no bird penetrated. A shot at 375 knots at location "D" resulted in the failure of the glass center panel. This test was classified a failure because much of the lower half of the transparency spalled into the cockpit, and the pilot would have been facing a considerable wind blast even though no bird actually penetrated (see Figure 10).

A four-pound, 375 knot shot was made on the aft end of the windshield center panel at location"C" and resulted in a small amount of the bird penetrating the windshield and canopy frames. Some glass was spalled into the cockpit; however, neither the glass nor the bird would have posed a serious threat to the pilot, and this test was classified a pass.

A 450 knot shot at location "C" resulted in a substantial amount of spalled glass. In addition, the center panel was pushed down, buckling the windshield arch supports, and the bird impacted the forward frame of the forward canopy. This failed the canopy frame and transparency, resulting in several large pieces of spalled acrylic as shown in Figure 11. This test was classified a failure because of the potential injury to the pilot.

One shot was made at 300 knots on the sheet metal panel forward of the windshield center panel. Some bird penetrated the structure and the capability was estimated to be 250 knots.

Forward Canopy

The 0.30-inch thick stretched acrylic canopy was impacted seven times at three locations ("F," "G," and "I"). The demonstrated capabilities were 240 knots at location"F," 220 knots at location"G," and 230 knots at location"I." A 300 knot area was added in the capability diagram to reflect the decreased angle of incidence. No damage to the frame or support structure was found in any of the tests. The transparency, when failed, spalled several large pieces of acrylic (estimated at over 8 sq. in.), in addition to many small pieces. This spalled acrylic could cause serious injury to the pilot. Also, the pilot would be subject to considerable wind blast and buffeting through the large holes left in the transparency (Figure 12).

Windshield Frame

The capability of the F-4 production frame was determined by utilizing laminated panels formed in the F-4 side panel shape. The panels were mounted in the framework using aircraft grade bolts. Five impacts were made on the windshield structure with the laminated panels installed, one at location "A" and four at location "B." The impact at location A and the first impact at location "B" were performed at 450 knots with catastrophic failure of the frame occurring in both instances. The impact point "B" failure resulted in parts of the windshield arch entering the forward cockpit, posing a significant hazard to the pilot (Figure 13). For this reason, it was determined to perform additional tests at location "B." The three subsequent tests at location "B" resulted in a frame failure at a velocity of 375 knots. Failure at this velocity could have been predicted from a plot of the strain data taken at gage location GL4 (closest gage to the failure point) and the impact velocity (Figure 14). Note how rapidly the stress rises with velocity in this particular loading situation; the magnitude of the loads in the structure appear to be extremely sensitive to velocity in the 350-to-375 knot range. Frame baseline capability was accepted as 375 knots.

CONCLUSIONS

The F/RF-4 transparency birdstrike tests have established the existing capability of the transparency system and have generated a useful data base for designing and evaluating various bird impact resistant designs. In-field service has demonstrated the need for improved birdstrike protection and these tests confirm this need.

The data generated from these tests show that the acrylic side panels and forward canopy must be replaced with bird resistant designs which will provide the degree of protection required. Also, the tests indicated that a new or reinforced windshield frame is required.

A program currently under way will evaluate several alternative bird impact resistant transparency system designs. The result will be an affordable transparency system which will protect the F/RF-4 crew during high speed, low level flight.

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Figure 1. F/RF-4 Aircraft.

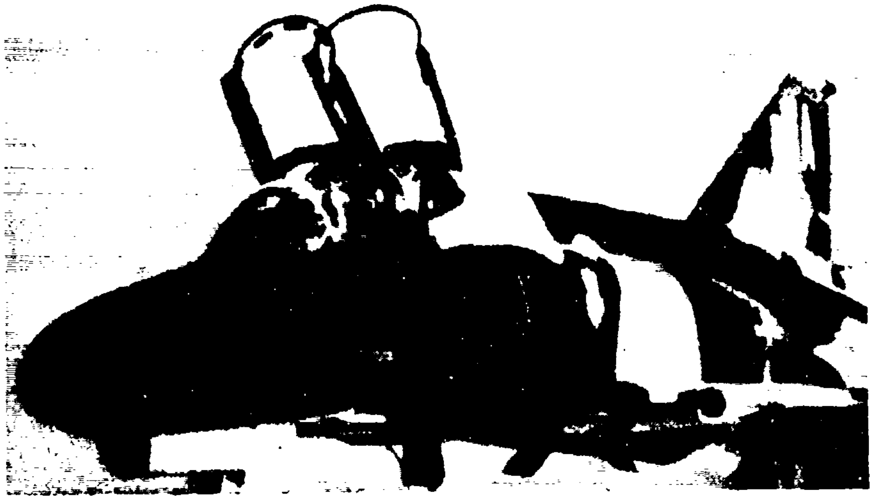


Figure 2. AEDC Test Area Arrangement.

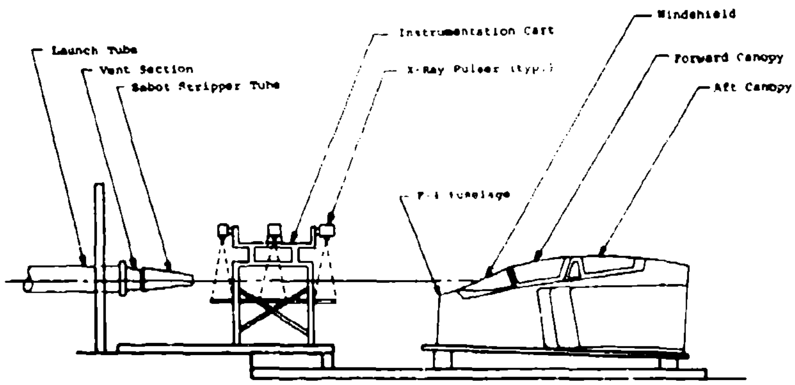


Figure 3. F-4 Forward Fuselage Installed in S-3 Range

Figure 4. Cross-Sections of Production Transparency System.

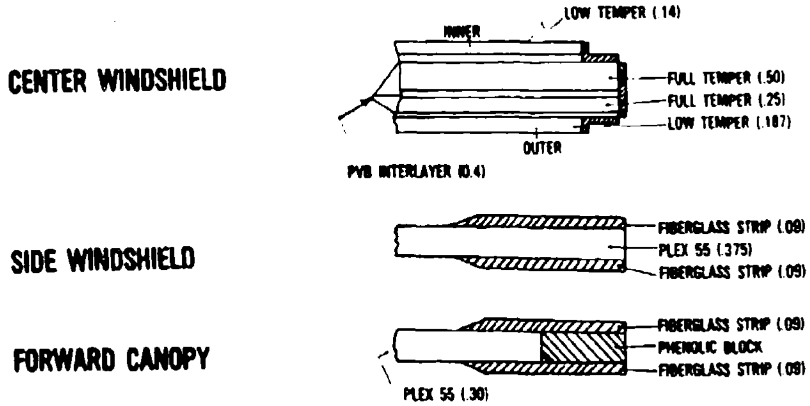


Figure 5. Laminated Side Panel Cross-Section.

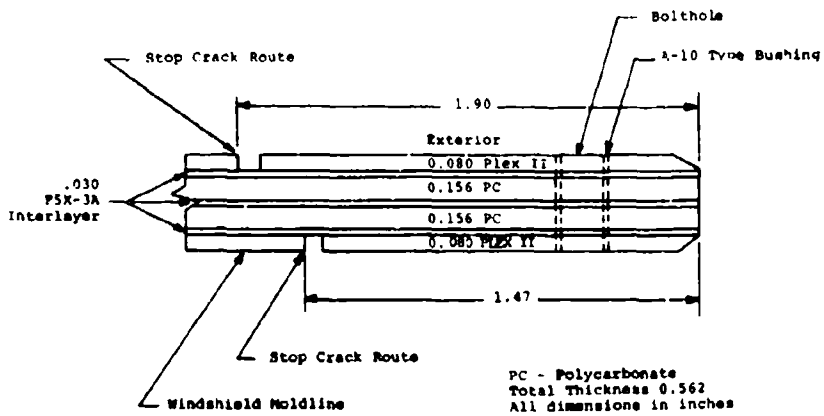


Figure 6. Location of Motion Picture Cameras.

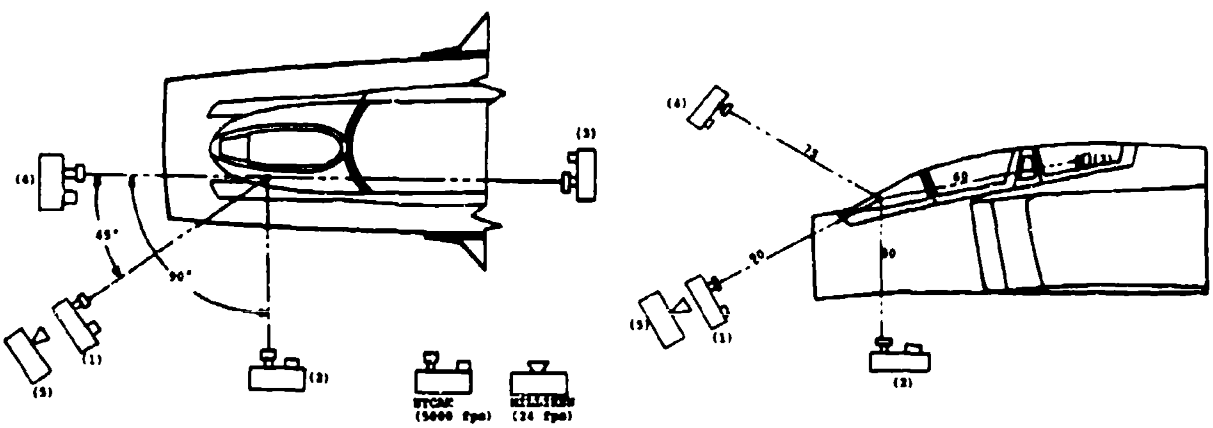


Figure 7. Impact Locations.

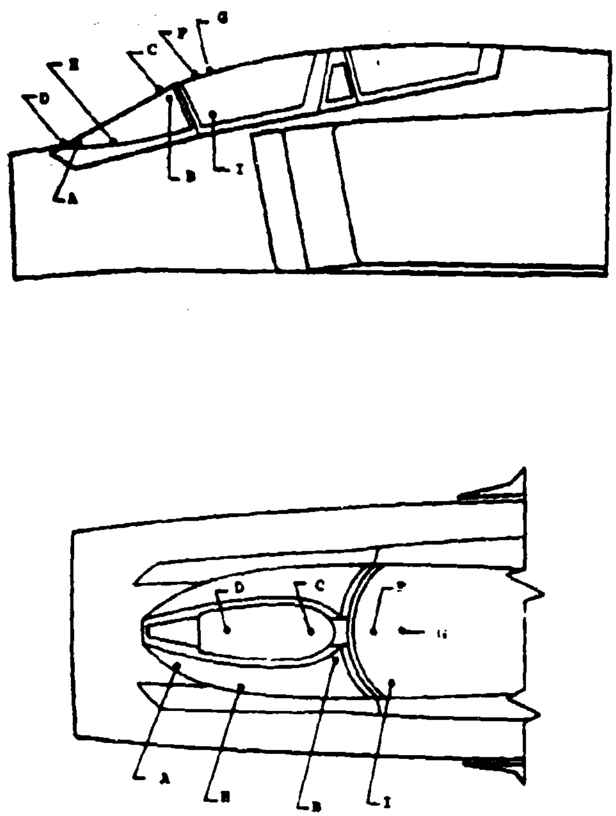


Figure 8. Bird Impact Capability Diagram.

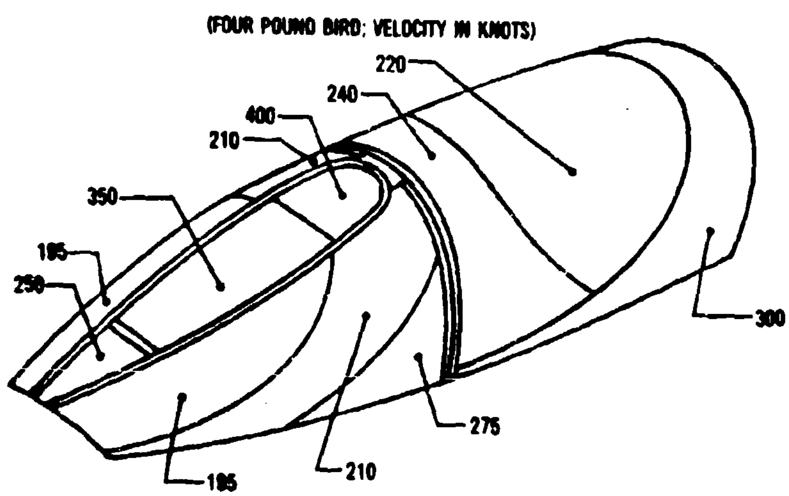


Figure 9. Post Test Damage, 200 Knot Side Panel Impact.

Figure 10. 375-Knot Impact Low on Center Panel.

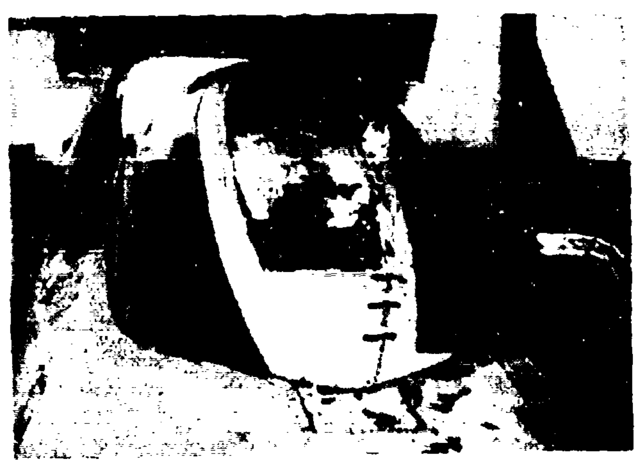


Figure 11. Post Test Damage, 450-Knot Impact Upper Center Panel.

Figure 12. 270-Knot Impact, Centerline of Forward Canopy.

Figure 13. Failed Windshield Arch Fragments.

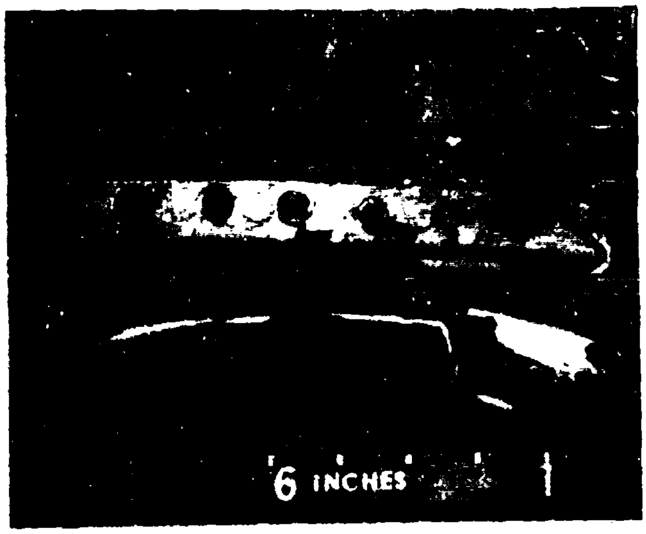
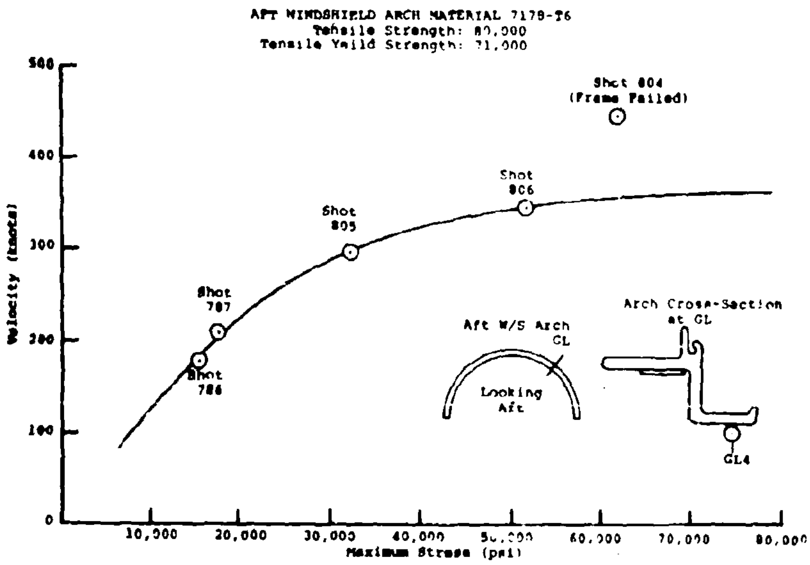


Figure 14. Maximum Stress vs. Velocity Gage GL4 Impact on Location B.



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MICROSCOPIC IDENTIFICATION OF FEATHERS IN ORDER TO IMPROVE BIRDSTRIKE STATISTICS

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ABSTRACT

In the period 1960-1983, 1132 bird remains resulting from collisions with aircraft were sent to the Zoological Museum Amsterdam. Before 1978, these remains were identified macroscopically by comparing them with feathers from bird skins. During this period the results strongly depended on the skill of the examiner and on the condition of the feather remains. On average, 26, mostly large remains, were sent annually to the museum, of which 80% could be recognized. The remains received represented roughly 30% of the total number of reported birdstrikes. Thus birdstrike statistics could be easily biased by over-representation of nearly complete bird corpses. In order to improve the existing identification method, a microscopic key to the determination of feather remains was developed, and used in combination with macroscopic methods from 1978 on. From 1976, airfield personnel were convinced of the importance of collecting even the smallest bird remains in and on aircraft. Consequently, the total number of remains sent to the museum strongly increased to some 110 per year. Identification results from 1960-1977 are compared with those from 1978-1983, and the effect of the introduction of the microscopic key on birdstrike statistics is discussed.

INTRODUCTION

Feather remains from collisions between birds and aircraft can in the best cases be identified to species, and even sometimes to the age and sex of the bird involved. Determination at this level gives an indication of the weight of the bird, an important issue in birdstrike analysis. Furthermore, the identification presents information on which to base a biological bird control method. For these reasons, proper identification of feathers is essential.

In the late 1950s, when the Royal Netherlands Air Force (RNLAF) was confronted with some 90 birdstrikes in 4 years, the importance of species recognition after collisions became evident. Since 1960, bird remains resulting from strikes with Dutch military aircraft were sent to the Zoological Museum Amsterdam (ZMA) for investigation. Such museums with large skin collections are invaluable in aiding in the identification of feather remains. In later years, feathers were occasionally identified for civil organizations too.

The standard procedure was as follows. Feathers or feather remains were examined on shape and structure in order to establish whether they were wing, tail, or body feathers. Then they were compared with bird skins in the museum collection on colour and size. In this way, tracing the bird species involved is rather time consuming and the results of this macroscopic method strongly depend on the skill of the examiner and on the presence of characteristic feathers in the sample. Some birdstrikes leave the investigator with more or less intact birds or with a number of easily recognizable feathers, whereas in other cases the remains consist of totally destroyed feathers or a mere smear of blood. As a consequence, the frequency distribution of hidden species will be easily biased by the nearly complete bird corpses that can be recognized quickly. These largely intact remains are generally found after collisions at the runway and not after "en route" collisions.

RNLAF initiated a study to improve the only existing microscopic identification key of feather remains (Day, 1966). This work resulted in a far more extensive and fully modified key (Brom, 1980). During the 14th Meeting of the Bird Strike Committee Europe in The Hague, Brom & Buurma (1979) reported on this identification method and its application to miniscule bird remains found in engines and on airframes. Further, the consequences of the results from the improved identification rate for RNLAF birdstrike statistics have been preliminarily discussed (Buurma & Brom, 1979).

The quality as well as the quantity of identifications increased significantly during the last 6 years on account of three reasons:

1) the introduction of the microscopic analysis as the first step of identification in difficult cases;
2) the improvement of the general reporting standard: bird control units pursueing pilots and crewchiefs for data and remains (Buurma, 1977);
3) the skipping of all identifications by unauthorized persons because of the high percentage of obvious uncertain data.

The effect of the first two points can be visualized by comparing the identification results in the period 1960-1977 with those from 1978-1983. In order to make a fair comparison, all remains, identified by several staff members of ZMA prior to 1978, were checked (macroscopically) by the author (all material is still preserved at ZMA), but corrections had to be made in only very few cases.

MICROSCOPIC KEY

In the microscopic key features are used that are found at the most basal and downy portion of a feather (fig. 1). When making preparations, only this part is taken. The downy barbs are cut off close to the shaft of the feather and are sandwiched between an object-glass and a cover-slip, which are glued together along the edges. When feather remains are very dirty or greasy they are agitated in a container of warm water to which a liquid soap or detergent has been added. After being washed, the feathers are rinsed and then dipped in alcohol for a few seconds to speed drying. Dirty or twisted feathers can usually be restored to their original shape by this procedure.

The downy barbules consist of a base and a pennulum, and it is here that we find the features on which many groups or even species of birds can be distinguished.

FIGURE 1. Body feather of the Buzzard *Buteo buteo* showing the most basal and downy portion.

The following characters can be used:

1) The borders of the cells by which pennulae are formed may be enlarged or show <u>prongs</u>. On lower magnification, the barbules are clearly subdivided into <u>nodes</u> and <u>internodes</u> in this way. Pigmented nodes vary from heart--shaped to round to elongated and prongs vary in length in the different groups.
2) The <u>position of the nodes</u> along the barbules may vary from only at the base to only distally. Some barbules show so-called <u>multiple nodes</u>. These are built up by single nodes becoming loose and sliding along the internodes to the adjacent node. This proces may be repeated until 8-10 nodes collect at one point.
3) The bases of the barbules may show <u>villi</u> (outgrowths).
4) The length of the barbules as well as the number of nodes (or prongs) per millimeter are distinctive for certain groups.

Feather preparations of some 350 bird species have been made to build up a reference collection and to design the microscopic key. A number of the most often encountered bird species is depicted here to illustrate the above mentioned features (for a detailed description of the identification method, see Brom, 1980).

Microscopic identification of feathers is based on the theory that the microscopic structures of feathers from each species of bird differ just as do other characters. The more closely two species are related, the more alike the feather structures appear, and conversely. It has also been shown that the complexity of feather structures generally follows the taxonomic order (Chandler, 1916; Brom, 1980), although the exact value of this set of characters for avian taxonomy still has to be evaluated.

FIGURE 2. Breast-feather of Mallard [illegible] heart shaped nodes only at the tips of the barbules.

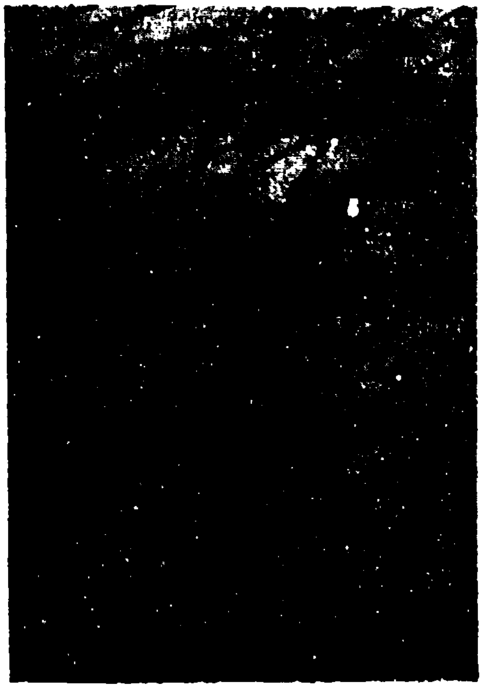


FIGURE 3. Breast-feather of Buzzard [illegible] long and unpigmented barbules.

FIGURE 4. Mantle-feather of Swift [illegible] heavily pigmented barbules.

FIGURE 5. Breast-feather of Skylark [illegible] villi at the bases of the barbules.

FIGURE 6. Mantle-feather of Pneasant *Phasianus colchicus*: multiple nodes.

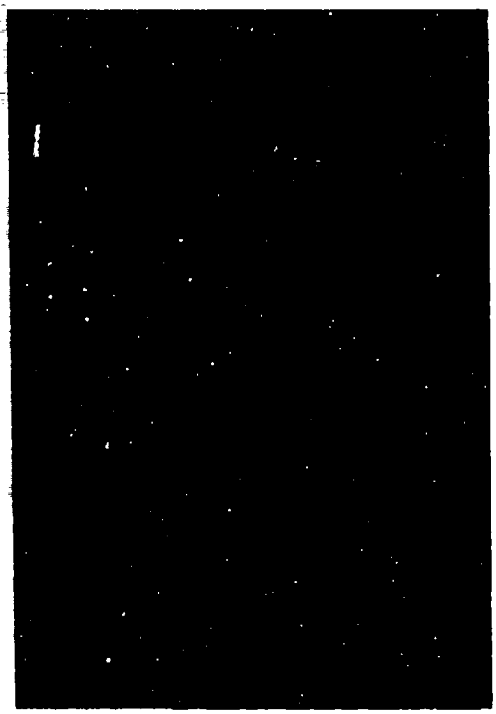
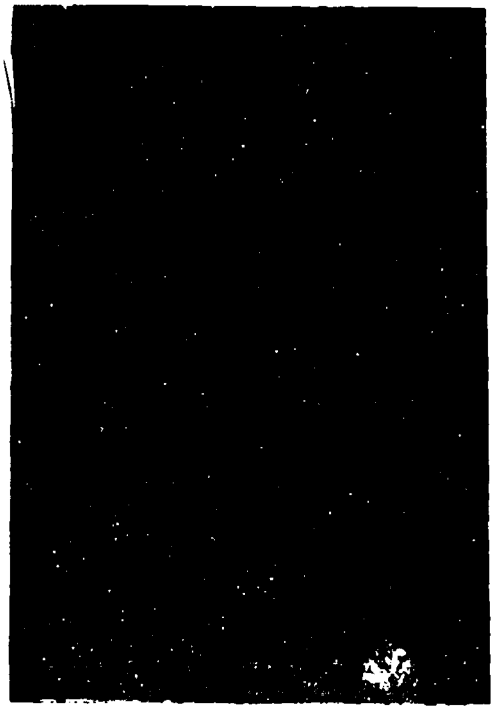


FIGURE 7. Upper tail-covert of Black--headed Gull *Larus ridibundus*: nodes rapidly decreasing in size over short distance.

FIGURE 8. Rump-feather of Lapwing *Vanellus vanellus*: barbules clearly subdivided into pigmented nodes and internodes.

FIGURE 9. Belly-feather of Oystercatcher *Haematopus ostralegus*: unpigmented barbules.



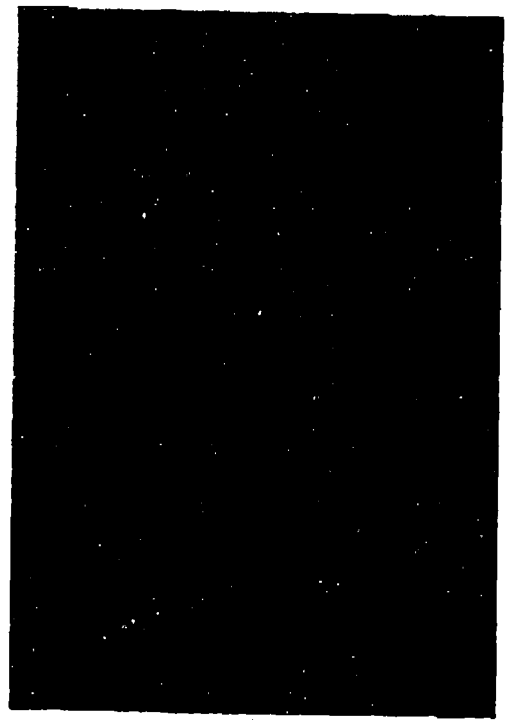


FIGURE 10. Breast-feather of Wood-pigeon (Columba palumbus): barbules long with flattened, plate-like nodes.

FIGURE 11. Belly-feather of Kestrel (Falco tinnunculus): long and wavy barbules with small pigmented nodes and long internodes.

Applying the above mentioned method, most of the bird orders can be distinguished easily. Thus, here we have the first big advantage: within a very short time one can establish the order in which one has to look further (by microscope or macroscopically), saving considerable time spent by comparing feathers by trial and error. However, the potential of this identification method does not end at order level. Within many orders or families of birds (e.g. Passeriformes - perching birds, Strigiformes - owls, Laridae - gulls, Sternidae - terns, Rallidae - rails, Falconiformes - falcons) a tendency has been found to exist that larger birds possess fewer nodes per millimeter than smaller ones. In this way an indication of the weight of the bird can be often obtained without exactly knowing the species involved. For example, within the Passeriformes, crows can always be distinguished from small songbirds. In a similar way a distinction can be made between ducks, geese, and swans in the order Anseriformes.

Whether we will actually reach the species level with this method is yet not clear. Practical experience using this method will [illegible] the skill of the investigator as is the case with the macroscopic method. The differences between families and especially species [illegible] that descriptions and quantifications in order to design a key at this level have failed up till now. However, it is clear that [illegible] can also successfully work at species level. [illegible] when microscopic methods were used for identification [illegible] feather remains ([illegible], [illegible]; Messinger, [illegible]).

FIGURE 10. Breast-feather of Wood-pigeon [illegible]: barbules long with flattened, plate-like nodes.

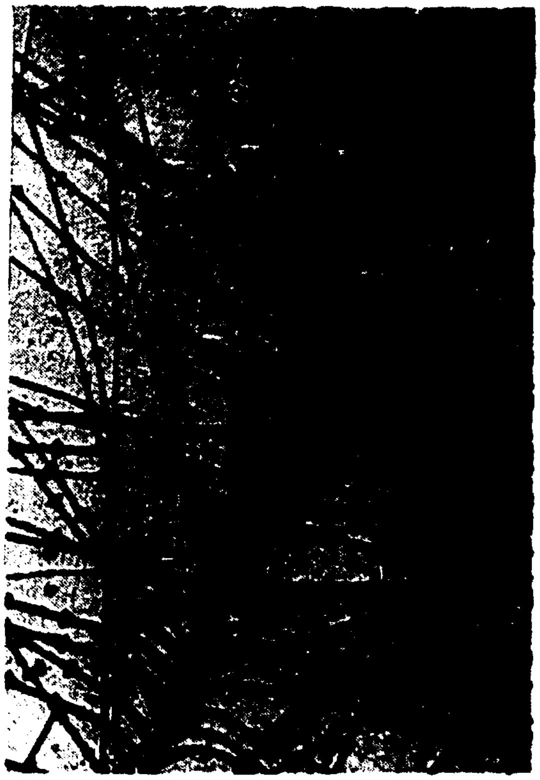


FIGURE 11. Belly-feather of Kestrel [illegible]: long and wavy barbules with small pigmented nodes and long internodes.

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Whether we will actually reach the species level with this method is yet not clear. Practical experience using this method will improve the skill of the investigator as is the case with the macroscopic method. The differences between families and especially species are so small that descriptions and quantifications in order to design a key at this level have failed up till now. However, it is clear that a well trained person can also successfully work at species level. This was shown for example when microscopic methods were used for identification of archeological feather remains (Hargrave, 1965; Messinger, 1965).

COMPARISON BETWEEN IDENTIFICATION RESULTS FROM 1960-1977 AND 1978-1983

In the period 1960-1983, ZMA received 1132 bird remains to be identified. Those sent in by the RNLAF came from strikes with all kinds of military aircraft. In 3% of all cases the remains originated from civil aircraft. In total, 72 species were recognized belonging to 12 different orders.

From 1960-1977, 474 remains (= 26 cases on average per year) were examined representing roughly 30% of the total number of birdstrikes reported during the period. In 90% of the cases the bird order could be established (fig. 12). From this figure one would conclude that Charadriiformes (gulls, waders etc.) by far is the most frequently involved group (42% of all identifications at order-level), followed by the Passeriformes (perching birds; 19.3%), Columbiformes (doves and pigeons; 16.3%), and Apodiformes (swifts; 9.4%).

In 80% of the cases the bird species could be established (fig. 13), proving the Lapwing *Vanellus vanellus* the most frequently identified species.

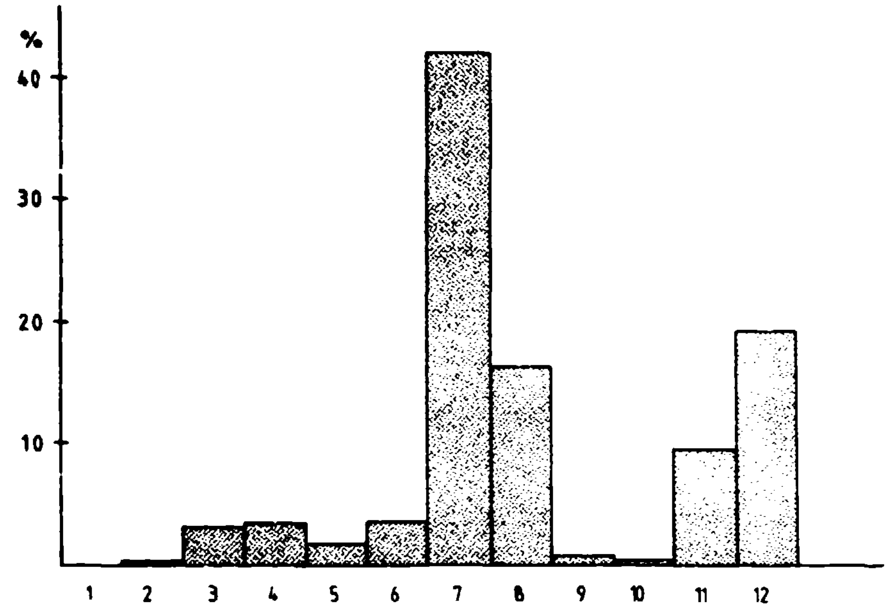
After the introduction of the microscopic method as a routine procedure in analyzing bird remains, and the improvement of the general reporting standard in the RNLAF, 658 bird remains were received (= 63% of all reported birdstrikes in the period 1978-1983). In 97% of all cases the bird order could be established, resulting in a completely different picture (fig. 14). In the remaining 3% of the cases a birdstrike usually can be confirmed but the material is not sufficient for further identification. Now we see that the order Passeriformes is by far the most frequently involved order (46% of all identifications at order-level), followed by the Charadriiformes (20.1%) and Apodiformes (14.9%).

In 47% of the cases the species could be established. Of course, this percentage is lower than in the period 1960-1977, as from 1978 onward also miniscule bird remains were included. In contrast to the percentage of orders, this percentage will always be strongly influenced by the ratio "intact bird corpses/miniscule scrapings" (see figs. 16-19). Now we see (fig. 15) that the top position is held by the Swift *Apus apus* (30.1% of all identifications at species level), even though this bird is accident prone only 3-4 months a year.

From figures 14 and 15 we can conclude that strikes with gulls form only a low percentage of the total number. This is remarkable, considering the geographical location of the Netherlands, with coastal zones and many wet lowlands. Of course this result should not be interpreted as an indication that gulls only constitute a moderate problem. It only means that these large and white, and therefore easily noticed, and well known birds tend to be over--represented in general birdstrike statistics. The opposite occurs with small and darker bird species, as is reflected by the order Passeriformes (compare figs. 12 and 14) and the Swift *Apus apus* (compare figs. 13 and 15). Only the Danish military statistics (Joensen, 1978) show some resemblance to these findings and this is probably related to the fact that in Denmark professional museum identifications have also been promoted.

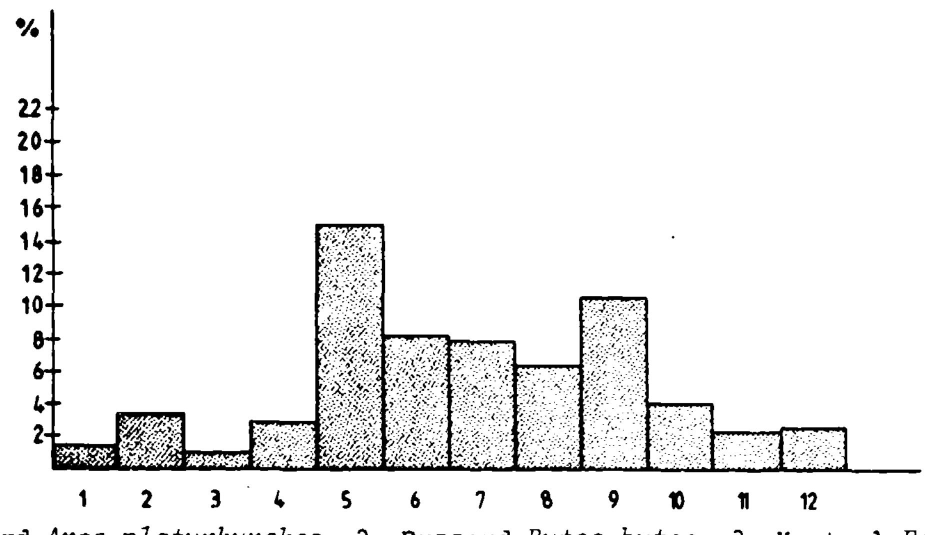
Besides the fact that the microscopic analysis greatly improves birdstrike statistics (see e.g. Buurma, 1982, 1984), it also has a positive feed-back on the collecting of remains. Now that the airfield personnel have learned that identification of miniscule scrapings is often possible, they will start looking more consciously for even the smallest remains. And this, of course, is essential for achieving complete and reliable birdstrike statistics.

FIGURE 12. Identifications 1960-1977 in which bird order could be established (total number of identifications to order level = 100%).



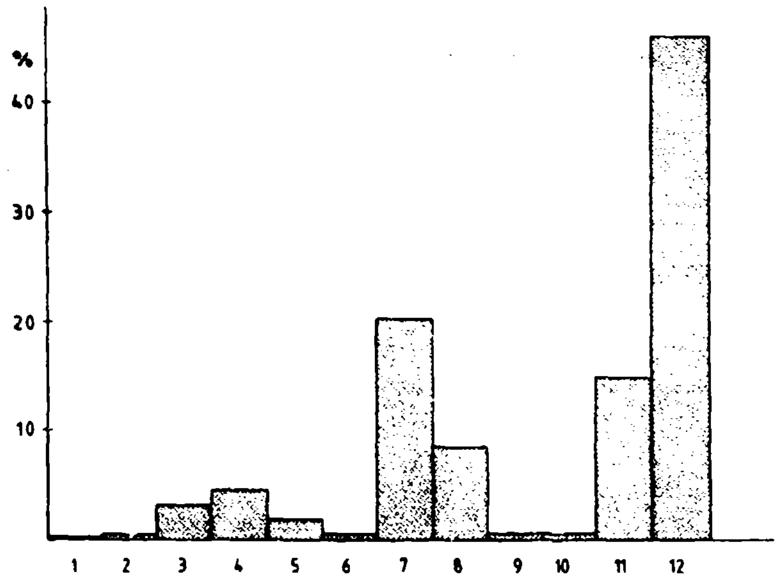
1 = Pelecaniformes (pelicans, gannet etc.), 2 = Ciconiiformes (herons, storks), 3 = Anseriformes (ducks, geese, swans), 4 = Accipitriformes (birds of prey), 5 = Falconiformes (falcons), 6 = Galliformes (pheasants, partridges etc.), 7 = Charadriiformes (gulls, waders etc.), 8 = Columbiformes (doves and pigeons), 9 = Strigiformes (owls), 10 = Caprimulgiformes (nightjars), 11 = Apodiformes (swifts), 12 = Passeriformes (perching birds).

FIGURE 13. Identifications 1960-1977 in which bird species could be established (total number of identifications to species level = 100%; only most frequently identified species included).



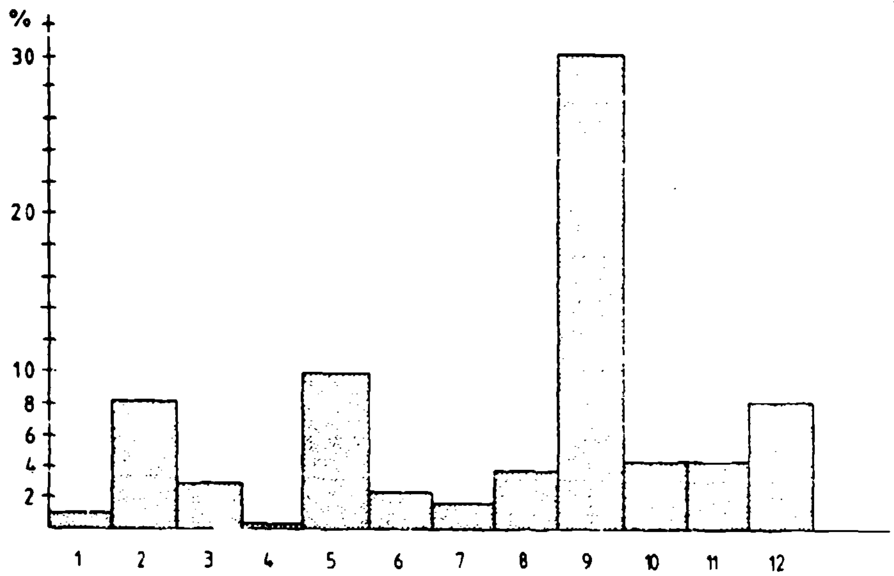
1 = Mallard *Anas platyrhynchos*, 2 = Buzzard *Buteo buteo*, 3 = Kestrel *Falco tinnunculus*, 4 = Partridge *Perdix perdix*, 5 = Lapwing *Vanellus vanellus*, 6 = Black--headed Gull *Larus ridibundus*, 7 = Feral dove *Col'mba livia*, 8 = Woodpigeon *Columba palumbus*, 9 = Swift *Apus apus*, 10 = Skylark *Alauda arvensis*, 11 = House martin *Delichon urbica*, 12 = Swallow *Hirundo rustica*.

FIGURE 14. Identifications 1978-1983 in which bird order could be established (total number of identifications to order level = 100%).



For explanation of numbers 1-12 see figure 12.

FIGURE 15. Identifications 1978-1983 in which bird species could be established (total number of identifications to species level = 100%; only most frequently identified species included).



For explanation of numbers 1-12 see figure 13.

FIGURE 16.

Almost complete Lapwing *Vanellus vanellus*.

FIGURE 17.

Wing of Skylark *Alouda arvensis*.

FIGURE 18.

Scrapings containing remains of Swift *Apus apus*.

FIGURE 19.

Scrapings containing remains of gull or tern fam. Laridae/Sternidae.

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THE USE OF SMALL MOBILE RADARS TO DETECT, MONITOR, AND QUANTIFY BIRD MOVEMENTS.

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ABSTRACT

This paper describes a mobile research laboratory that has been developed for the Electric Power Research Institute (EPRI) to monitor local and migratory movements of birds near transmission lines during the day and at night. The mobile laboratory has two small marine radars: a fixed-beam type that can be directed vertically to measure the altitude of migrating birds and a surveillance type that can be used to examine the geographical patterns of movement within a range of a few kilometers. ~~The laboratory is also equipped~~ with an image intensifier for visual studies of bird movements at night. A closed circuit television system and a video cassette recorder are used to record information from the fixed-beam radar and the image intensifier. A 16-mm movie camera with an electronic shutter control is used to record the display of the surveillance radar. Although the mobile laboratory was designed to study bird movements in the vicinity of transmission lines, it can also be used to gather valuable information on the patterns of bird movements in the vicinity of airports that have potential bird strike problems.

INTRODUCTION

Powerful weather and airport surveillance radars can be used to detect, monitor, and quantify migratory movements of birds (see Eastwood 1967, Gauthreaux 1970, 1980), however these units are not very useful in gathering detailed information on bird movements within a few kilometers of the radar station. Moreover the geographical distribution of these large, fixed-base radars is such that a unit may not be located near a desired study site. In contrast, small marine surveillance radars can provide useful information on the movements of birds within a range of a few kilometers, the units are relatively inexpensive, and they can be mounted on a small truck or van and powered by a small 500 kw gasoline generator (Flock 1972, Williams et al. 1972, Sielman et al. 1981). In this paper I discuss the operational characteristics of small marine radars and present two applications that have been developed to study local and migratory movements of birds.

MOBILE LABORATORY

A mobile research laboratory with two radars and electro-optical devices (image intensifier, low light level television cameras, and other closed circuit equipment) was developed and tested from mid-May 1980 through February 1983. The development consisted of the modification of a 23.5 ft (7.2 m) Coachmen motor home, installation of equipment, and the machining of parts that could not be purchased (e.g., the radar antenna pedestal for the fixed-beam radar system, and the electronic shutter control for the 16-mm cine camera that records the screen of the surveillance radar). The performance of the mobile laboratory was evaluated at many different sites throughout the United States from March 1981 through April 1984.

The two radar systems in the mobile laboratory are operated in totally different configurations. One radar has a modified parabolic antenna that does not rotate in the conventional manner and is used primarily as a range finder. The other marine radar is used in the conventional surveillance mode.

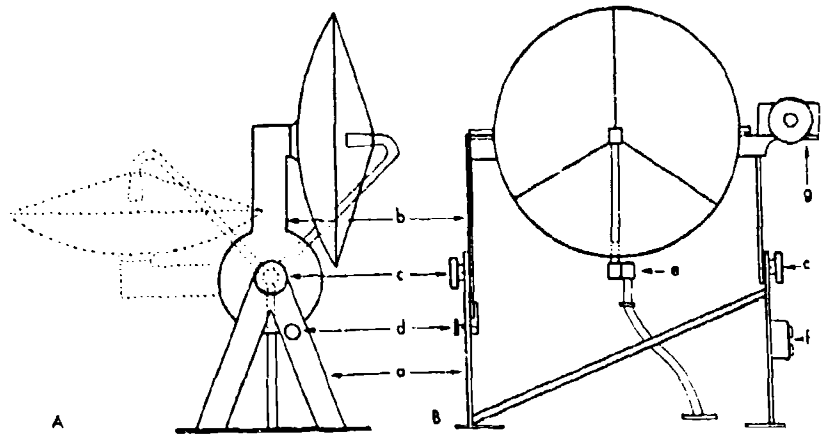
Fixed-beam Radar

The marine radar (Canadian Marconi Company, LN 66) is a 10 kw, X-band (3 cm wavelength) and consists of three separate, interconnecting units. These are: the antenna (or scanner) with its associated motor and gear box assembly; the transmitter/receiver (T/R) unit that contains the I.F. amplifier and power supply; and the display unit. The original antenna and gear box were eliminated and replaced with a new antenna and pedestal that permit stationary-beam monitoring in a horizontal or a vertical configuration (Figure 1).

The new antenna is a 24 in (60 cm) parabolic dish with X-band feed and a WR-90 flange input (Radio-Research Instruments Co. Part No. 20-3-24X). The antenna is mounted on a pedestal that enables the entire antenna assembly to swing from a vertical position for fixed-beam horizontal monitoring to a horizontal position for fixed-beam vertical monitoring (Figure 1). The 3 cm radar waveguide from the antenna feed goes to an X-band rotary joint, and a piece of flexible waveguide passes through the roof of the vehicle and connects the rotary joint with the T/R unit of the radar. Except for the waveguide, no electrical connection exists between the antenna and the T/R unit. To prevent excessive scattering of radar energy from the shallow parabolic antenna, an aluminum collar (12 in, 0.31 m high) was designed to fit around the antenna. The collar is easily removed after a period of observation and before the vehicle is moved.

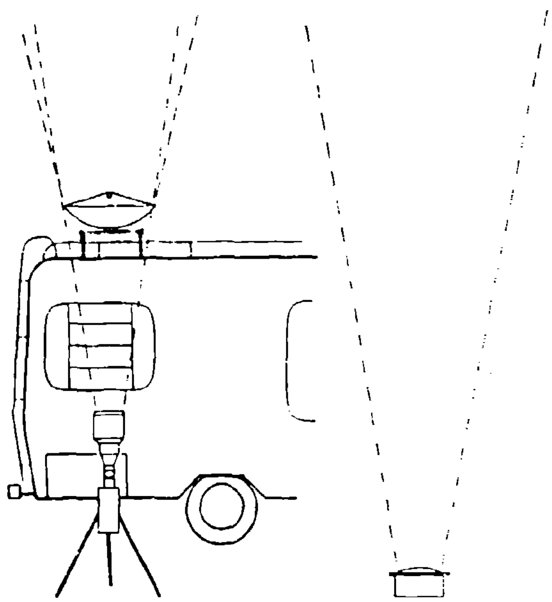
The transmitter has a peak output of 10 kw, a frequency of 9345 to 9405 MHz, and pulse widths of 0.05 microseconds in the 0.5, 1.5, and 3 mile (0.8, 2.4, and 4.8 km) ranges and 0.5 microseconds in the 6, 12, and 24 mile (9.7, 19.3, and 38.6 km) ranges. The pulse repetition is 1250 pulses per second in the 6,

FIGURE 1. Radar Antenna Pedestal.



A diagram of the radar antenna pedestal from a side view (A) and a front view (B). The basic components are (a) the supporting base, (b) the movable antenna frame, (c) the large locking screws, (d) the brake mechanism and screw, (e) the waveguide rotary joint, (f) the power outlet box and coaxial cable connectors, and (g) the antenna frame extension for the video camera. The radar antenna is 24 in (60 cm) in diameter.

FIGURE 2. Vertical Radar and Image Intensifier.



The arrangement of the video camera and night vision scope in relation to the vertically pointing radar beam and spotlight. This arrangement is used for observing birds flying overhead at night.

12, and 24 mile ranges and 2500 pulses per second in the 0.5, 1.5, and 3 mile ranges.

The display unit has a 10 in (25 cm) diameter cathode ray tube. The range scales available are 0.5, 1.5, 3, 6, 12, and 24 statute miles (0.8, 2.4, 4.8, 9.7, 19.3, and 38.6 km). A variable range marker gives a direct range reading for any target on the Plan Position Indicator (PPI), and this reading is plus or minus one per cent of the indicated range. The display unit has adjustments for tuning, sweep amplitude, off-centering, sensitivity time control (sea clutter and rain-fast time constant), beam intensity, video gain, long or short pulse, and panel lights. The input voltage to the radar is 115 volts AC, 2.1 amps, 50-60 Hz and this is changed to 36 volts by power supply. The power supply has reversed polarity protection and has a transistorized series type voltage regulator.

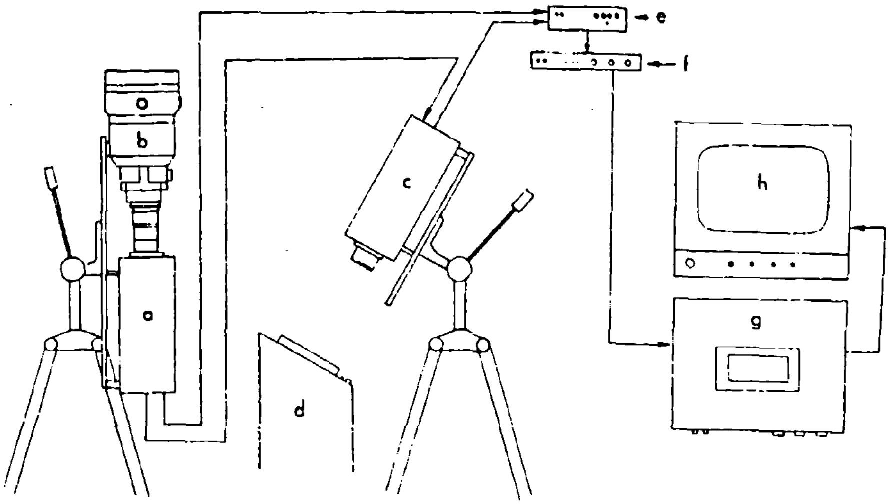
During operation the sea clutter and rain-fast constant (FTC) must be turned off, because these circuits reduce the sensitivity of the radar. The radar can be tuned only when on long pulse (0.5 microseconds).

The fixed-beam radar in the mobile laboratory can detect birds flying overhead as well as the larger and more powerful (500 kw) surveillance radars operated by the National Weather Service (the WSR-57 radar) and the Federal Aviation Administration (ASR-5, 6, 7). When the fixed-beam radar is operated on long pulse it is more sensitive but resolution is lost and birds cannot be detected within 0.09 mi (0.14 km) of the antenna. On short pulse, targets less than 27 yd (25 m) above the antenna can be detected but sensitivity is reduced. Consequently, a small bird (5 in, 12.5 cm) flying at a high altitude (0.31 mi, 0.5 km) would not be detected when the radar is operated on short pulse, but it would probably be detected if the radar were operated on long pulse and properly tuned. In general single small songbirds cannot be detected at ranges beyond 0.75 mi (1.2 km), but single larger birds (e.g., Ring-billed Gull, *Larus delawarensis*) can be detected out to 1.5 mi (2.4 km).

Although the fixed-beam radar can be operated with the antenna locked at any angle between horizontal and vertical, most data to date have been gathered with the antenna adjusted to point vertically to monitor bird movements overhead. In this mode the radar functions as a range finder.

During the night a television camera coupled to an image intesifier is directed vertically to observe the flight behavior of birds through the radar beam (Figure 2). The night vision device is the AN/TVS-5, a second generation crew served weapon sight (model 9865) manufactured by Varo, Inc., Garland, Texas. The video camera is always positioned so that the top of the screen of the television monitor is toward the north, the right is west, and the left is east. A vertical light beam is used to provide illumination when in areas where no ground lighting

FIGURE 3. Closed Circuit Video System.



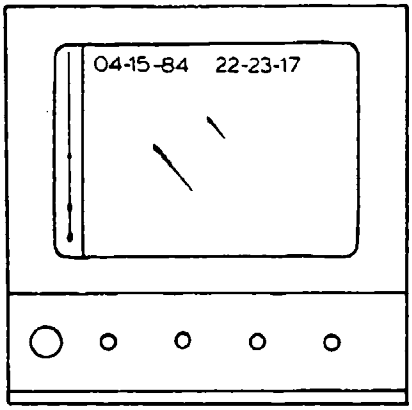
A diagram of the closed circuit video system in the mobile laboratory. (a) camera TC 1005/01, (b) image intensifier, (c) camera TC 1005/H01, (d) display unit of the LN 66 marine radar, (e) splitter/inserter TC 1470, (f) date and time generator TC 1440B, (g) video recorder NV 8200, (h) video monitor TC 1217.

reflects skyward. The light beam has no detectable effect on the flight behavior of the birds.

By using another video camera inside the mobile laboratory to monitor the screen of the fixed-beam radar it is possible to record birds passing through the visual field and the radar beam simultaneously on the screen of a television monitor (Figure 3). This is achieved by having the signals from the two video cameras go to a video splitter/inserter unit. The radar beam is displayed on the monitor in a narrow, vertical band on the extreme left side of the screen while the view through the image intensifier fills the remainder of the screen. A date and time generator displays the date and time at the top of the screen. With this arrangement it is possible to record the flight direction of a bird overhead and see its echo along the radar beam at the same time (Figure 4). A video recorder is used to record observations, particularly when bird flight activity is great.

During daylight hours visual observations of the airspace in the vertical radar beam are made two ways. One procedure is to direct a 20x telescope or 10 or 20x binoculars up the radar beam such that flight directions of the birds can be recorded (see Gauthreaux, 1969 for detailed methodology). In this case the altitudes of the birds are either recorded directly from the radar display by a second observer or the altitudes are recorded on video tape for later analysis. The second procedure uses a

FIGURE 4. Split Screen of Television Monitor.



Two bird targets moving to the northeast can be seen in the image intensifier portion of the screen. The radar echoes, displayed to the left on the screen, show that the birds are flying at different altitudes.

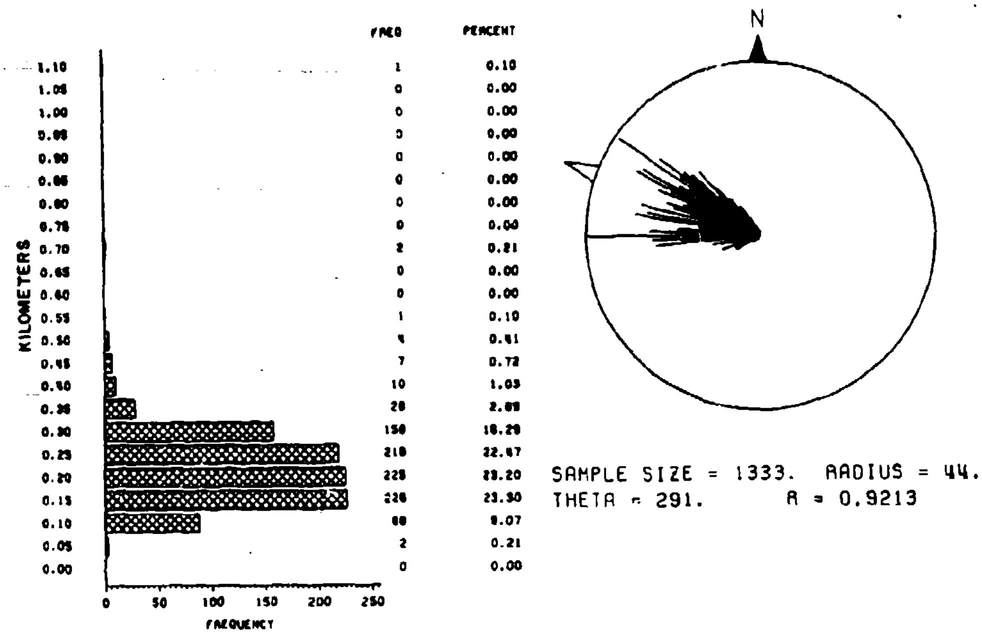
television camera with a 10x telephoto lens in place of the image intensifier used for night observations. In addition to the radar-video information, simultaneous direct visual observations can be dictated into a microphone to become part of the video tape record. In these instances the video tape contains a record of the radar and video camera information and a voice commentary.

The video tapes can be analyzed whenever time permits. The following information is recorded on the data forms and entered into computer files: time of event, direction of movement, altitude of movement, type of bird(s), and the number of birds. Special computer programs have been written to produce histograms of altitudinal distributions and circular plots of the directional data (Figure 5). On the circular plot, the solid triangle indicates true north and the open triangle shows the resultant vector (theta) of the circular distribution. The radius is the maximum number of birds recorded for any given direction, and all other vectors are plotted in relation to the maximum value. R is a coefficient of directionality (a value of one indicates that all birds are moving in the same azimuth direction, and a value of zero indicates no directional tendency).

Marine Surveillance Radar

The mobile laboratory has an unmodified Decca 150 marine surveillance radar. The Decca 150 is a 3 cm, 10 kw radar with essentially the same specifications as the fixed-beam radar. The major difference between the two is that the transmitter/receiver unit of the Decca 150 is a part of the scanner assembly and enclosed in a molded, fiberglass-reinforced plastic casing

FIGURE 5. Altitudinal and Directional Plots.



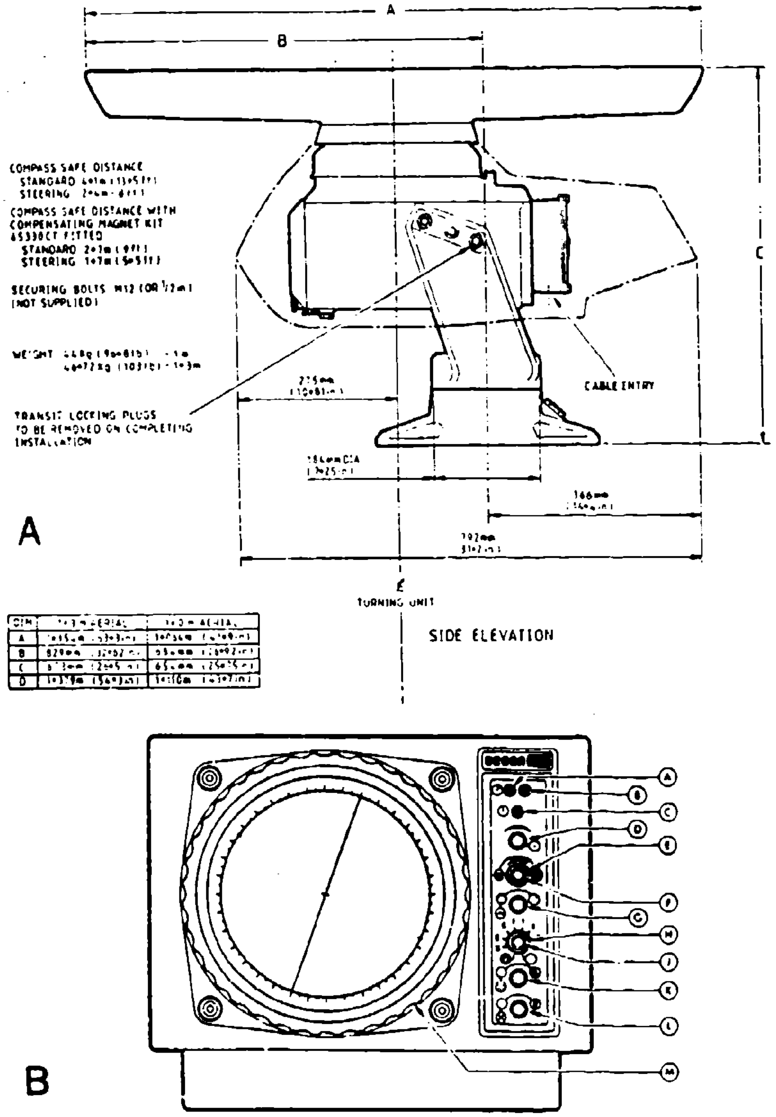
A sample histogram of the altitudinal distribution from the vertical radar (left) and a circular plot of the directional data from the image intensifier (right). Nocturnal migration, 1 May 1982, Lake Charles, La.

(Figure 6A). A rectifier produces an output of 32 volts direct current from the 115 volt alternating current generated in the mobile lab. The 32 volts DC drives the power supply and the motor of the scanner unit.

The display unit contains all the circuitry necessary for processing received echoes and displaying them along with internally generated data (e.g., range marks) on the PPI (Figure 6B). To maximize sensitivity the anti-sea clutter and anti-rain clutter dials (e and g in Figure 6B) should be in the off position. Most data on bird movements have been gathered with the radar on 3 nautical mile range for large birds (e.g., cranes, waterfowl, flocks of migrating hawks) and on 0.75 nautical mile range for small songbirds flying singly (e.g., warblers, vireos, swallows).

Viewing bird movements directly on the PPI is difficult because the echoes fade rapidly. When time lapse cine films of the PPI are made, the movements are much more obvious and careful study with a motion analyzer is possible. To make a film record of the bird movements on the display of the Decca 150, an automatic cine filming system was developed. The system consists of a spring-wound 16 mm Bolex camera with a solenoid shutter control that is switched on and off by the heading marker signal

FIGURE 6. Decca 150 Marine Surveillance Radar.



A. Scanner unit (aerial, turning motor and drive mechanism, transceiver and filter box). B. Display unit: (a-c) heading; (d) tuning; (e, g) anti-clutter; (f) gain; (h) range; (j) range rings; (k) brilliance; (l) panel lights; (m) rotating cursor.

from the radar. A single frame of 16 mm film is exposed to one entire sweep of the radar antenna, and the next sweep is not filmed (while the frame is advancing). Thus every other radar sweep is filmed. A light-tight hood attached to the front of the display unit permits filming throughout the day irrespective of ambient light conditions.

A comparison of three marine radars can be found in Table 1. The radars range from a small 5 kw unit with a 1.06 m antenna to a larger 25 kw unit with a 1.82 m antenna. The T/R units of the 5 and 10 kw radars are a part of the scanners. The T/R unit is separate in the 25 kw radar. In Table 1, the lines showing pulse lengths correspond to the lines in the listing of range scales (e.g., for the 5 kw radar, the pulse length for the ranges 0.25, 0.75, and 1.5 is 0.08 microsecond). Marine radars operating in the surveillance mode can be used to gather valuable information on the movements of birds within a range of a few kilometers. Because of the low power and antenna configuration, these units are most useful in studies of local and low-level migratory flights.

ACKNOWLEDGEMENTS

The mobile laboratory was developed with contractual support from the Electric Powerr Research Institute (EPRI) of Palo Alto, California. Initial radar and direct visual studies were supported by grants from the Life Sciences Directorate of the Air Force Office of Scientific Research. The work on the mobile lab would not have been possible without the generous cooperation of several individuals and organizations. Several individuals associated with the electrical, mechanical, and carpentry shops in the College of Sciences at Clemson University assisted in modifications and installations of equipment in the mobile laboratory including: James Eubanks, Donald Daugherty, James Mann, Lamar Durham, and Jewel Harper. The personnel of the National Weather Service stations at Lake Charles, Louisiana, and Beaumont, Texas, assisted me in gathering weather data and using the WSR-57 radar at the Lake Charles station. The Federal Aviation Administration offices at the Lake Charles Municipal Airport and the Jefferson County Airport near Beaumont were helpful in permitting me to use the ASR-5 and ASR-7 radars at those installations. The FAA technicians and supervisor in the Sector Field Office at Lake Charles were especially cooperative during the field tests at Lake Charles, particularly Isaac Davis, Jr., Edward Lee, Herbert Bartie, Ezell Brown, and their supervisor, Robert Sears, Sr. Gene Guidry, the Manager of the Lake Charles Municipal Airport, permitted the use of airport facilities and utilities during my work, and his secretary Doloris Crater frequently assisted me with clerical matters. The personnel of the FAA Flight Service Station at Lake Charles kindly provided weather data and other assistance, particularly Cecilia Shilling, Enrique San Miguel, Jonathan Wright, Thomas Krushall, Paul Franklin, Elwyn Crawford, Ted Brookshire, Deborah McClintock, and their chief, James Ashbury. Several associates have provided assistance during my research with the mobile laboratory including: Jeffery Beacham, Vern Bingman, Paul Hamel, Paul Kerlinger, Harry LeGrand, Jr., Anna Ross, and Steven Wagner. Isaac Davis, Jr. was particularly generous in giving technical assistance.

TABLE 1. Operational Characteristics of Small Marine Radars.

Characteristics	Marine Radar Raytheon 3400	Decca 150	Decca RM 926C
TRANSMITTER			
Magnetron peak power	5kw	10kw	25kw
Radar frequency	9380-9440MHz (3cm; X-band)		
Pulse length (microsec.)/ pulse rep. frequency	0.08/3000Hz 0.35/1500Hz 0.70/750Hz	0.08/1500Hz 0.55/750Hz	0.05/3300Hz 0.25/1650Hz 1.0/825Hz
ANTENNA			
Type (slotted waveguide)	end-fed	center-fed	end-fed
Size	1.06m (3.5ft)	1.22m (4ft)	1.82m (6ft)
Rotation (rpm)	26	23	28
Beam width (Horiz.)	2.4°	1.9°	1.2°
(Vert.)	25°	28°	20°
DISPLAY UNIT			
Cathode-ray tube	178mm (7in)	216mm (8.5in)	229mm (9in)
Range scales (nautical miles)	.25,.75,1.5, 3,6,12, 24,48	.25,.75,1.5, 3,6,12,24,48	.25,.50,.75,1.5, 3,6,12, 24,48,60
Minimum range	25m (<27yd)	25m (<27yd)	13.6m (15yd)
Range discrim.	20m (22yd)	23m (25yd)	9.1m (10yd)
RECEIVER			
Type	Gunn local oscillator with balanced mixer		
IF band width (pulse)	10MHz (short) 3MHz (long)	8MHz (short) 8MHz (long)	18MHz (short) 5MHz (long)
IF amplifier center freq.	38MHz	30MHz	60MHz

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ON THE ALTITUDINAL DISTRIBUTION OF BIRDS AND BIRD STRIKES IN THE NETHERLANDS

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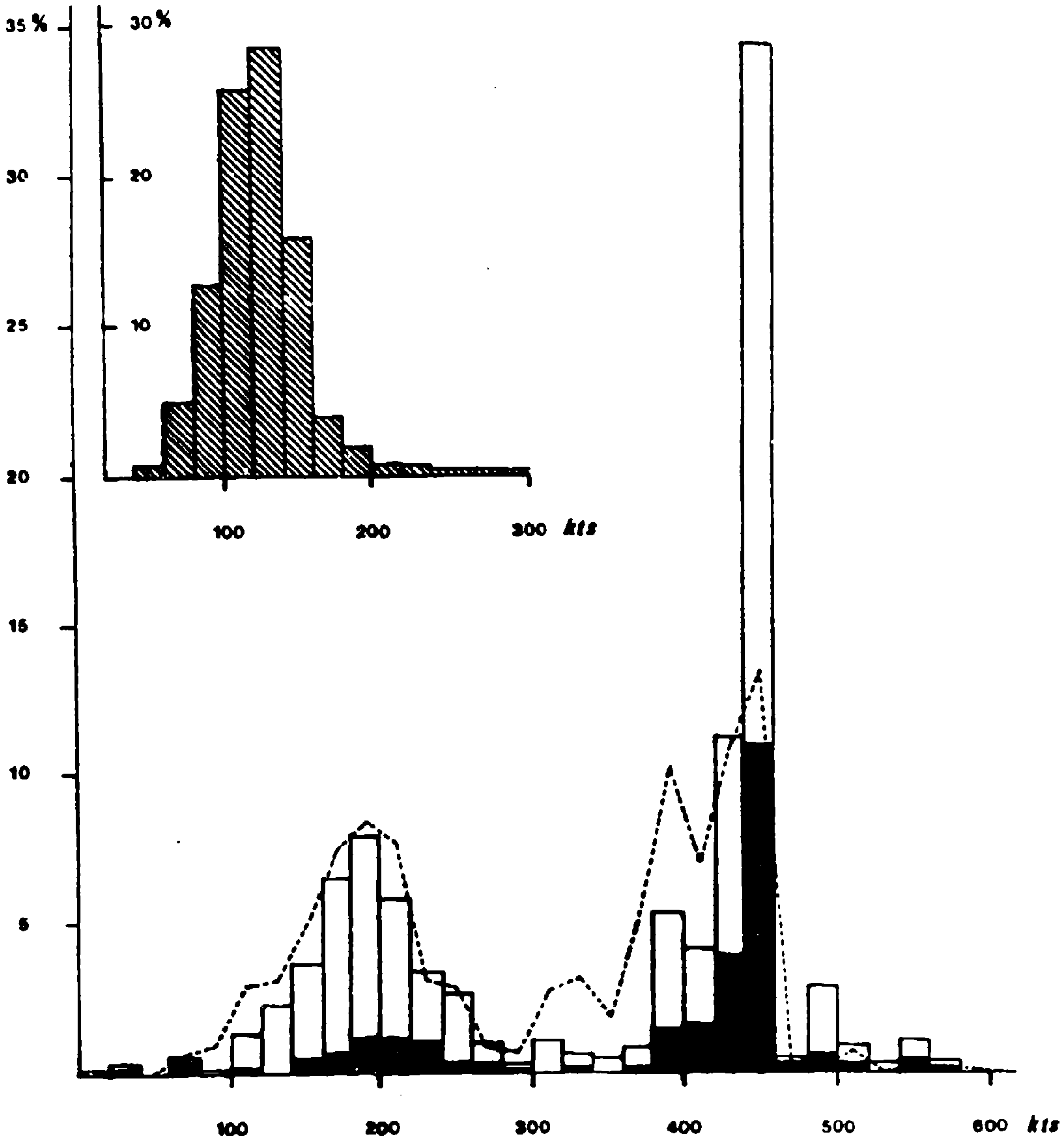
SUMMARY

Bird strikes, radar observations and visual counts are discussed and used to reconstruct altitudinal distributions of bird movements over The Netherlands. Bird density curves, particularly for the lowest 1000 ft, are urgently needed with respect to solving the problem of a recent rapid increase of bird strike rates due to the intensification of low level training by RNLAF fighter aircraft. The long range surveillance radars, presently in use to provide data for bird migration warning systems in several West European countries, fail to cover the lowest air layers. This gap may be filled up by field observers and/or small radars. Parallel to visual observations and time lapse film recordings at the long range surveillance radar in NW Holland, a series of altitude measurements has been collected. This preliminary study with a tracking radar of the type "Flycatcher" provided the data to illustrate the problem and its possible solutions.

INTRODUCTION

Several West European air forces face a growing bird strike problem. This recent increase in the number of collisions between jet fighters and birds occurred rather suddenly as far as the RNLAF is concerned. Thanks to the very accurate reporting even of the most insignificant non-damage bird hits, the microscopic identification of minuscule bird remains (see Brom, this conference) and the limited size of the air force, we were able to analyze the trend in detail (Buurma 1983). The main cause appeared to be the recently agreed intensification of training at very low level. Different bird strike rates could be traced back to the task of individual squadrons. The rate of 16 collisions per 1000 flying hours for the Dutch recce F-104 Starfighters, a fourfold increase within two years, indicates that these fighters face a sudden increase of bird density by decreasing their flight level.

FIGURE 1: Frequency distribution of RNLAF bird strikes per 200 kts speed class for the years 1977 - 1982; black parts of bars: cases with damage; white parts: without damage; dashed line: similar distribution for the years 1964 - 1976; insert: percentage distribution for UK registered aircraft (from Thorpe 1973).



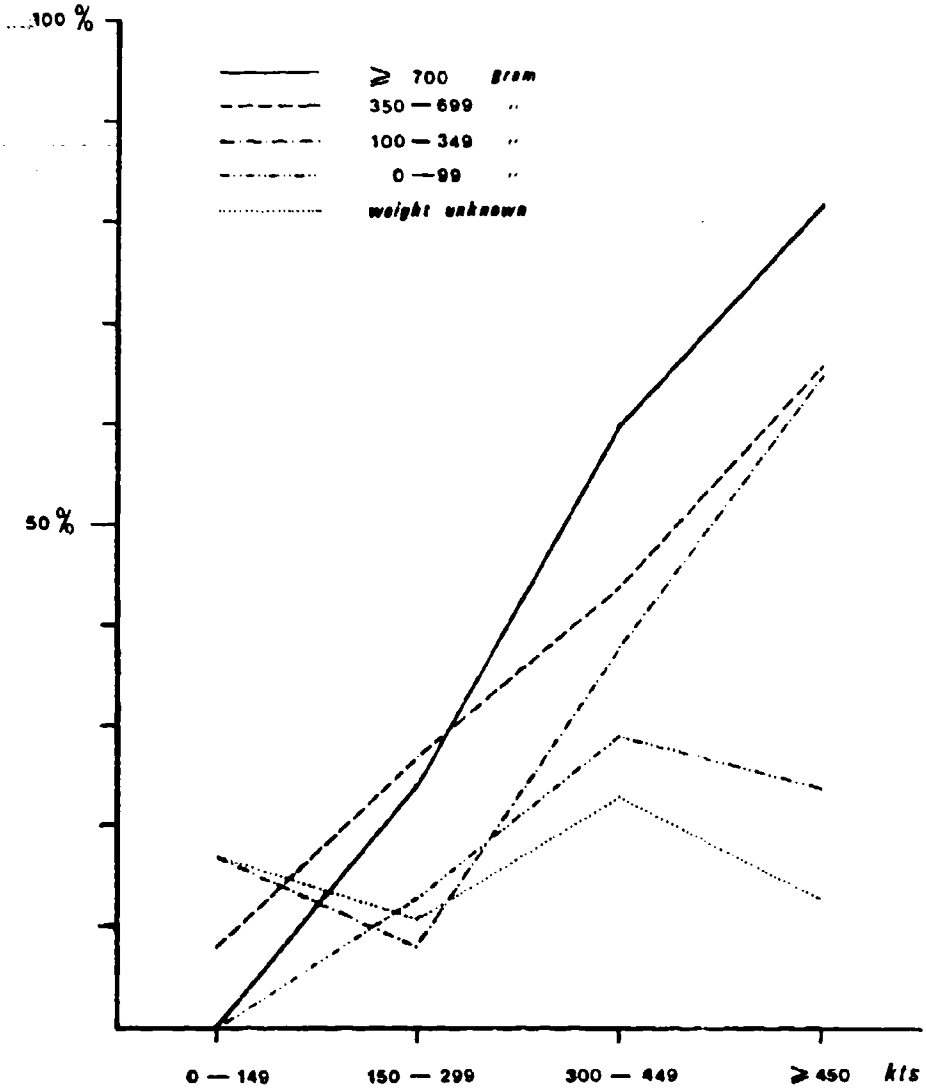
It has been known for a long time that low-level navigation is a major factor causing the military bird strike problem to be much more considerable than the bird problem in civil aviation. In addition to bird strikes at or near airfields all air forces experience collisions "en route". In order to explain that these two types of bird strikes are incidents (and frequently also accidents) of a very different nature figure 1 shows the relative distribution of RNLAF bird strikes according to aircraft speed. For comparison civil data have also been included. The bird strikes occurred during the period 1977 - 1982, while the dashed line indicates this distribution for the period 1964 - 1976. The proportion of damage incidents is given by the black parts of the bars. It is clearly visible that "local" and "en route" collisions between jet fighters and birds can be separated by simply taking aircraft speed as a criterion. Considering that take-off and landing and possibly one or more "touch and go's" or "overshoots" are only a few per cent of a flying hour, it is evident that the bird strike frequency at or near the air base, at low level, is many times higher than "en route". Mutatis mutandis, this means that "en route" bird strikes (over 300 kts) are not caused by high densities of birds but by the amount of time spent in flying in relatively poor bird air masses.

The question raised in this paper is how do the flying activities of aircraft and birds interfere in space and time, in particular with respect to altitude choice. This question should be answered in a quantitative way, because thus realistic decisions on guidelines for avoiding dense bird airlayers can be taken and optimal monitoring procedures and equipement can be chosen or developed. One would wish that this is simply a matter of measuring the spatial flight activity distributions of both parties. Indeed, for the aircraft this is possible by asking the pilots for estimates and, nowadays, also by using modern flight data recordings. However, the knowledge of the number of birds in the air under varying conditions is very limited, notwithstanding the existence of highly sophisticated radar studies. In the second part of the paper I shall deal with some direct measurements of the altitude distributions of birds and with the problem of how to use them operationally. First, I shall discuss the indications on bird altitude distributions produced by the bird strikes themselves. A closer look at the altitude aspect of collisions between jet fighters and birds might enhance in the first place military flight safety, but, possibly, may also clear the way for future civil application.

ON THE USE OF BIRD STRIKE DATA

A serious objection to the using of bird strike data is that they usually are evaluated differently according to amount of damage or to the conditions under which the collision occurred. This may have an effect on the inclination to report bird strikes. We have solved the problem simply by asking to report all bird collisions irrespective of the occurrence and amount of damage. Our analysis (Buurma 1983) clearly indicated that an increased emphasis on proper reporting since 1977 benefitted only the quality and completeness of the reports, not the quantity. The fighter pilots appeared not to register any more hits than they already did, while the proportion of bird strikes discovered after flight by ground personnel rose only from 9.1 % to 14.1 %. Two findings strongly supported our conclusions. First, the per-

FIGURE 2: The percentage of damage cases among bird strikes within four speed-classes given separately for 5 groups of bird weights (RNLAF jet fighters 1977 - 1982).



centage of damage incidents is extremely stable over the years and per aircraft type. It was not at all affected by the increased emphasis on bird strike reporting. The figures for the three fighters used by the RNLAF were F-104: 26 % (± 5 %, n = 533), F-5: 25 % (± 5 %, n = 362) and F-16: 21 % (± 7% , n = 117). In the second place, we found that for birds weighing less than 100 grams there is a correlation between the chance of suffering damage and the aircraft speed, which sharply deviates from the curves in the case of heavier birds (figure 2). This indicates that most small passerine birds are not able to penetrate the compressed air in front of fast flying aircraft. Like snow flocks, they must have followed the air stream around the highly tapered fighter, perhaps not even touching the skin. When they did hit the aircarft and produced a mere smear of blood mixed with a few minuscule parts of downy feathers, a microscopic examination at the Institute of Taxonomic Zoology in Amsterdam revealed the bird order and sometimes the family or species name and at least a weight indication. Without the application of a specially developed key (Brom 1980) we used to have practically no indication of the type of birds involved in collisions "en route". To day, we do have a complete picture and conclude from the parallel curves shown in figure 2 concerning birds of less than 100 grams and the unknown cases that the bird strikes not leaving macroscopically visible bird remains concern mainly small passerines posing no real threat to flight safety at the moment. The fact that small songbirds are underrepresented in bird strikes should be borne in mind when using the altitude distribution of bird strikes as an indication for bird activity in height.

ALTITUDINAL DISTRIBUTION OF "LOCAL" BIRD STRIKES

Since aircraft usually climb and descend at fixed angels to the earth's surface, they cover equal distances in each 100 ft air layer below, approximately, 1500 ft, except just before touching down on the runway. Assuming that speed differences within this altitude range and above take-off speeds do not significantly affect the bird strike rate with respect to evasive actions of the birds, the "bird sample size" taken by the aircraft is roughly the same for each layer of air. As appropiate flight phases have been considered "take-off", "climb", "final", "landing", "touch and go" and "overshoot". In all phases the bird strikes occurred at speeds below 300 kts. The proportional distribution of these socalled "local" bird strikes is given in figure 3 A. For comparison, a civil example is included in this figure (taken from Thorpe,1973). One may have doubts about the assumption that evasive actions of birds in case of low aircraft speeds do not hamper this distribution and lead to a reduced strike rate. This could especially be the case in the lowest 100 ft. On the other hand, the (flight)path is here somewhat longer, which in turn might raise the number of bird strikes.

Using a certain caution for this lowest altitude class, we consider figure 2 A as reasonably representative for the average altitudinal distribution of the birds involved in bird strikes over the years. The main conclusion is that the majority of birds fly around in the very lowest air layer and indeed cause only an major problem to aviation when aircraft penetrate this environment at very high speeds. On the contrary, birds flying higher appear to be distributed fairly evenly over a large altitude range.
It is now possible to explain the Gausian type of distribution of "local" bird strikes per speed class in figure 1 as being formed by the decreasing bird density with height (right side) and by the success of birds escaping from the aircraft approaching them too slowly (left side). Note the remarkable similarity between the military and civil distributions in this respect, despite of the different average speeds.

Figure 1 and 3 give relative data. It is also possible to evaluate the average bird density in a more absolute manner, by comparing the bird strike ratios of aircraft with different lift: table 1. At a similar forward speed the fighters with a large wingload , such as the F-5 and F-16, have a higher vertical speed than the rocket-like F-104. Consequently, the last mentioned jet fighter covers the longest distance within the bird rich lowest air layers and reaches the highest score of "local" bird strikes.

FIGURE 3: Altitudinal distribution of "local" (A) and "en route" (B) bird strikes of Dutch jet fighters; shaded distribution in A: civil data taken from Thorpe 1973.

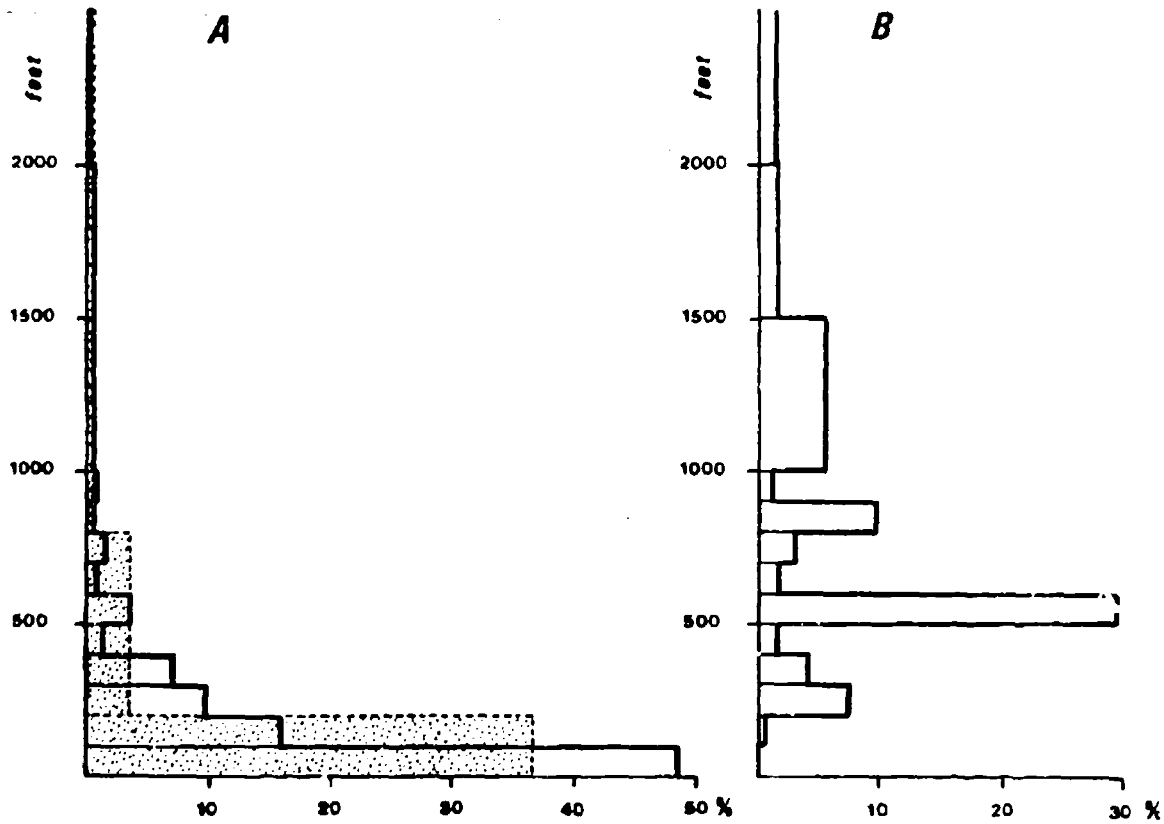


TABLE 1 : Number of "local" bird strikes per 1000 flying hours for three types of jet fighters flown by the RNLAF

type	rate	standard deviation	n(years)	n(bird strikes)
F-104	1.88	0.55	7	178
F-5	1.23	0.23	7	139
F-16	1.25	0.44	4	30

ALTITUDINAL DISTRIBUTION OF "EN ROUTE" BIRD STRIKES

The altitudinal distribution of bird collisions "en route" differs entirely from the "local" bird strikes: figure 3 B. A comparison learns that most bird strikes during the flight phases "low level en route" and "cruise" (all at speeds of over 300 kts) do not occur in the dense bird air-layers but in the first place at altitudes most frequently flown by the aircraft. Indeed, the recent intensification of extremely low level training resulted in a rapidly growing number of bird encounters below 500 ft. It should be noted that these "en route" figures show a certain rounding off towards full numbers of feet. The possibility that pilots fill in the planned rather than the actual flight level also cannot fully be excluded. The altitude distribution of "local" bird strikes indicates that the number of "en route" bird strikes at 500 ft increases fourfold when the flight level is changed to 250 ft AGL.

The bird strike frequency not only increases due to lower flights of aircraft but also to a higher flying by the birds. This becomes clearly apparent from a graph compiled by the German Air Force: figure 4. The seasonal and altitudinal variations of the bird strike frequency is indicated by lines connecting points with equal ratios. As is the case for RNLAF fighters the highest rates were found in August at low levels, which is when and where many young and unexperienced birds wander around. But the graph also reveals distinct peaks in the months of March and October, when migratory birds may reach very high flight levels.

ON THE USE OF RADAR AND ITS RESTRICTIONS

Sampling the spatial and temporal variations in the flying activity of birds by means of aircraft might have its own advantages but it is time consuming and expensive. We would do better by measuring bird movements directly in order to prevent aircraft and birds from colliding. Moreover, we wish to know the hourly and daily variations in actual bird distributions, in stead of average figures because such knowledge might create the possibility of minimizing the amount of flight restrictions while maximizing flight safety. Separation of aircraft and birds is rewarding, particularly, when the density of birds in the air has a strongly fluctuating character. This makes it possible to utilize certain poor bird conditions for low-level training (of course persistent differences in bird density for different geographical areas and localities are another matter which is not discussed here).

Numerous radar studies, as summarized by Eastwood (1967), might give the impression that it is possible to quantify the flying activity of birds accurately and over vast areas. Unfortunately, however, only very few authors report to have succesfully related their radar measurements to absolute numbers of birds aloft. Two important examples are the studies on nocturnal bird migration of Nisbet (1963) and Gauthreaux (1977). Nisbet carefully measured the rate at which bird echoes on the radar screen thin as the distance from the radar increases. By extrapolating backward he estimated the bird density above the radar station and translated his echo density figures into real numbers of birds by parallel counts of birds passing the disc of the moon. His dimensionless thinning rate was established empirically and includes

Figure 4: Lines connecting points with equal numbers of bird strikes per 10000 hours of low level flying by the German Air Force: data versus altitude. Reproduced with kind permission of Dr J. Hild.

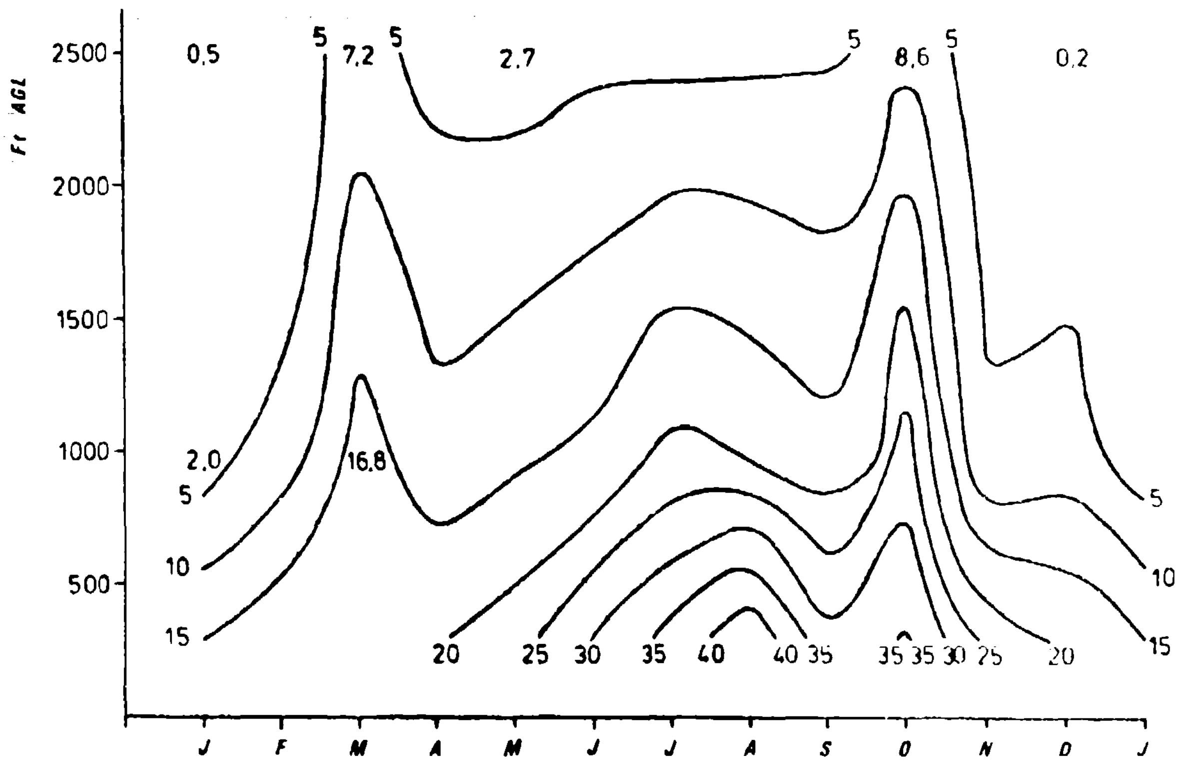


TABLE 2 : Diurnal (D) and nocturnal (N) "subsaturation" densities of bird echoes on the screen of search radars and minimum detection heights; the figures are rough indications of experiences in practice, not reflecting theoretical considerations

Wave lenght	N/D	counting range in nM	subsaturation densities per nM^2	min. detect. height in ft	source and remarks
23 cm	N	20 - 30	0.4 - 1.0	600	Nisbet 1963
	D	15 - 25	1 - 2	?	Geil et al 1974
10 cm	N	30 - 40	ca 35	300	Buurma unpubl.
	D	30 - 40	ca 10	300	id
	N	10 - 20	20 - 25	var	Gauthreaux 1977
	D	10 - 20	6 - 8	var	id
	D	5	30 - 40	?	Gehring 1963
3 cm	N	1 - 2	250 } potentially	75	Buurma unpubl.
	D	1 - 2	150 } potentially	75	id

several factors of an entirely different nature. Nisbet therefore warned not to transplant his results to other situations and other radar equipments. However, the need for a distance dependent correction of echo densities in one form or another is apparent because radar screens soon become saturated with bird echoes even in the case of only moderate bird migration. Gauthreaux tried to solve this saturation problem by reducing the sensitivity of the radar step by step until he reached a standard, measurable echo density at a certain distance from the radar. He then used the attenuation rate as an measure for actual migration traffic rates (MTR, number of birds passing one nautical mile per hour) after calibration with direct bird counts against the moon and in the beam of a ceilometer.

Nisbet's average MTR figures appear to be considerably lower than those of Gauthreaux (table 2). This might in part be a geographical matter, but could also be explained by the type of radar used. Nisbet filmed the screen of a high powered long range surbveillance radar operating at 23 cm wavelength, while Gauthreaux detected birds by means of medium powered 10 cm weather radars at a much shorter range. There are serious reasons to believe that the numerous small songbirds are totally invisible to 23 cm radar when flying solitary in the resolution cell. On the contrary, radars with wavelengths shorter than 10 cm may even detect airborne insects at considerable distances.

The wavelength effect and many other factors determining the bird detection capacity of radars seriously complicate the interpretation of bird echo patterns. Not only radar parameters but also size and even the behaviour of the bird affect the results. Speed, angle of body axis to radar beam and grouping behaviour are the best known aspects. In addition, the flying height of the birds may be a very critical factor, especially by day when, generally speaking, bird migration occurs at lower levels than at night. The few quantification studies there are like those of Nisbet and Gauthreaux concern nocturnal bird movements. Attempts to do the same for diurnal bird movements are even more scarce and unsuccessfull in so far as they claim to have included all bird species en route.

This last statement is partly a personal view based on my own experience with several types of radars operating in The Netherlands. The extreme flatness of our country favours radar studies of low-level bird movements. Nevertheless, even here a comparison of radar and visual bird counts produce totally contradictory results. It indicates that overlap in the altitudinal coverage of radar and field observers is mostly totally zero. For Sweden Mascher et al (1962) came to similar conclusions using a medium powered airport radar near Stockholm. He and Evans (1966), both using 10 cm wave length, described visible migration and bird migration detected by radar as complementary.

The relative density of the flying bird population at very low level is shown indirectly by a comparison between "subsaturation" densities of bird echoes on the radar screens and average MTR's observed visually in the field. Some radar data are reproduced in table 2. As an example of visually observed bird densities, the daily early morning counts of broad front migration near Arnhem during the month september, october and november 1982 (Kwak & Lensink 1983) may be used. The highly experienced observers included only birds flying within 100 meters. Their rough classification of altitudes indicates that the majority of the birds observed flew below 50 meters. Given an average ground speed of 45 km/hour, they got an average number of 35 flocks and solitarily flying birds per square nautical mile, while on peak migration days up to a ten times higher figure could be counted. Comparing these figures with the "sub-echo-saturation" densities on radar screens (table 2) the conclusion must be that the lowest 50 meters of air may contain more flying birds than the entire air space higher up.

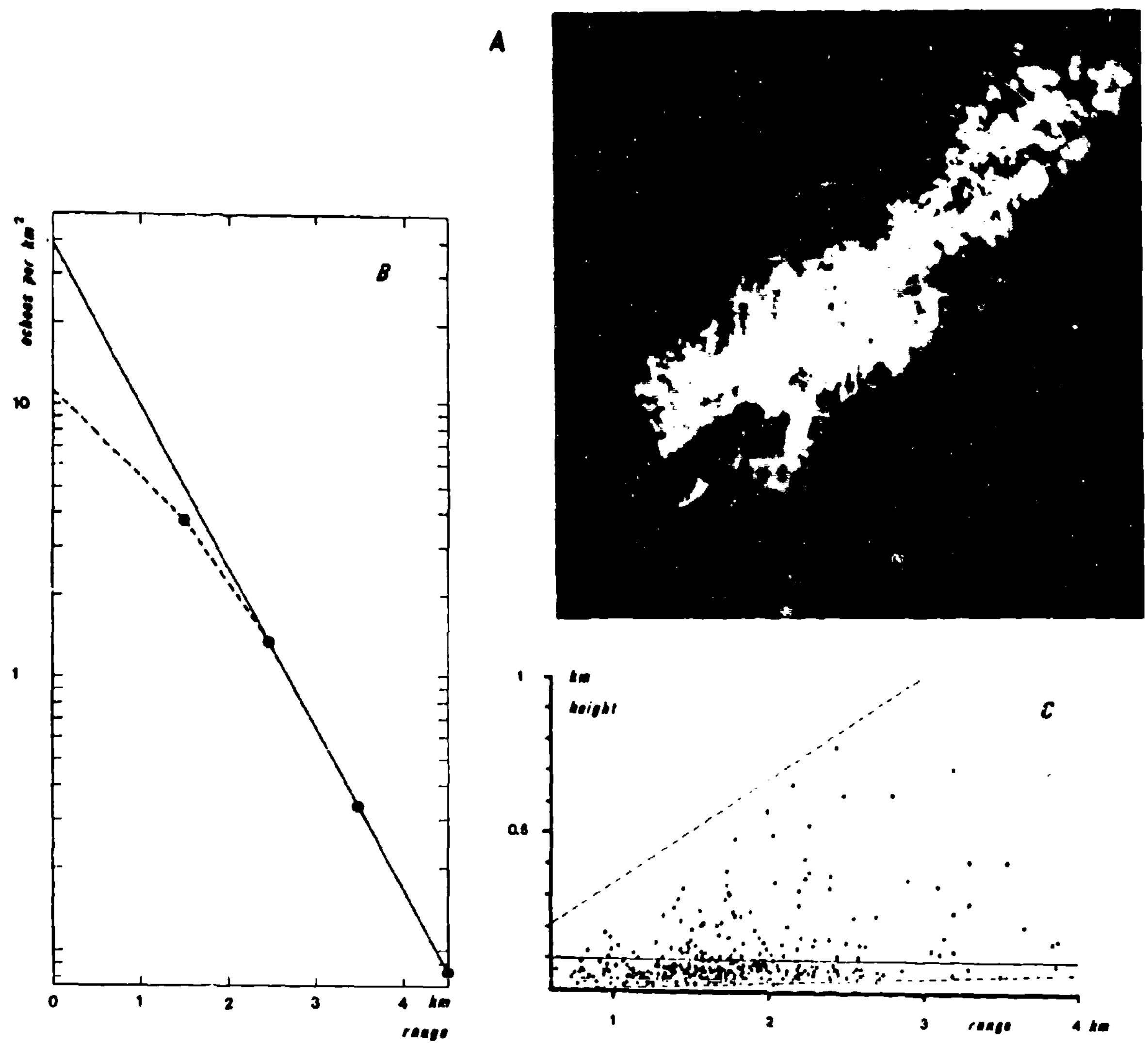
RECONSTRUCTION OF THE TOTAL ALTITUDINAL DISTRIBUTION ON THE BASIS OF TRACKING RADAR MEASUREMENTS

The recent increase of bird strikes and the realization that a large quantity of low altitude bird movements are missed by long range radar caused the RNLAF to initiate a preliminary tracking radar study on flying heights of birds. The fire control radar used for this purpose is a product of the Dutch firm Hollandse Signaal in Hengelo (type "Flycatcher"). This radar combines a 3-cm search beam (vertical angle 19^{o}) with a tracking beam operating in either X-band or kA-band depending on the quality of the tracking process. Especially, the last feature allowes for extremely good tracking at low altitude. During daylight hours the objects locked on can be evaluated visually on a monitor, fed by a video camera with a 400 mm lens parallel to the tracking beam. Our first objective was only to evaluate the bird detection capacities of the radar and the necessary modifications. But we could also collect a reasonable sample of tracks by day and at night as well as photographic recordings of the search scope. During 5 mornings simultaneous visual observations were carried out 47 nM to the SW, along the same track of the broad-front stream of migrants. Simultaneous time lapse films were made at the long range surveillance radar in the NW of The Netherlands. Similar studies will be set up in other seasons in the near future

Here, we report on the average altitude distribution reconstructed by combining the visual counts, the search photographs and the tracking results totalized from the recordings on 28, 31 october, 1, 2 and 3 november 1983. Bird echoes on the search scope (figure 5 a) appeared to thin with increasing distance from the radar in a comparable manner as in the studies of Nisbet (1963): figure 5 b. How to fit this roughly exponential relation is yet unsure because nocturnal observations indicate that near the radar the echo density does not increase to the same extent with decreasing range as indicated by the straight line. Therefore I included in figure 5 b a second curved line and arrived at two values for the absolute number of bird flocks per nM^2 between which the real figure must lie, 35 and 110. As many echoes as possible were tracked. Figure 5 c shows the range and altitude of those echoes and indicates the performance of the radar at very low altitude. The stability of the tracks decreased of course when the bird flew very low, but the tracking system managed to lock on some birds flying below 100 ft at 1 - 2 nM. The sensitivity of the tracking beam was such that a solitary flying song bird with wingbeat frequency of 24 Hz "seen" in tailview could be tracked up to at least 1.6 nM. The distribution of all birds tracked is indicated in figure 6. This distribution was considered to be indicative for the real situation as far as birds flying higher than 50 meter are concerned. Visual observations at the station learned that notwithstanding the excellent tracking properties many very low flying flocks of song birds (below treetop height) were missed.

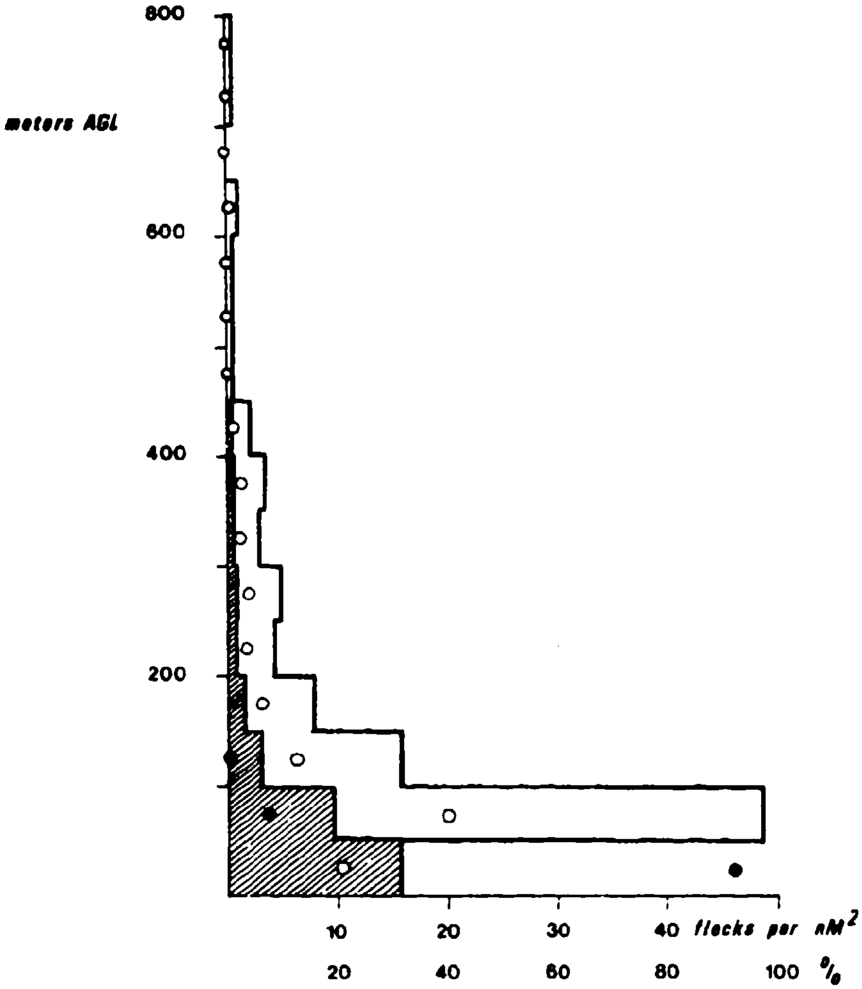
The field observers in Arnhem claimed to have detected all birds passing within 100 meter and below 50 meter and they were also registered as such. When we subtract their average density of 16 flocks per nM^2 (calculated on the basis of a average ground speed of 25 nM/hour) then, the remaining birds can be distributed over the altitudes according to the distribution of radar tracks above 50 meter.

FIGURE 5: Flycatcher tracking radar data from 5 mornings with weak - moderate migratory activity. A: example of a time exposure photo (30 sec) with groundclutter (white patches), bird echoes (streaks) and 5 km range ring. B: thinning of echo density with increasing range (after correction for groundclutter blindness). C: range and heights at which bird(flock)s were locked on after selection at random on the search screen.



As a result we find two total bird altitude distributions as shown in figure 6. With some reserve we may conclude that the field observers saw 15 - 46 % of all birds (let us say one third), while the tracking beam missed the lowest third to a certain as yet unknown extent. The altitude distribution for the 5 early mornings considered here is somewhat less skewed to the very lowest air layer than the distribution of "local" bird strikes in figure 3a. most likely due to the preponderance of migrants over local birds. However, also figure 6 shows clearly the importance of the flying activity of birds in the lowest 100 meters.

FIGURE 6: Reconstruction of the average altitudinal distribution of diurnal bird movements for 5 late autumn mornings (centered around one hour after sunrise). Birdflock/echo density figures given per nM^2 for air layers of 50 meter thick. Calculated on the basis of the assumption that fieldobservers counted all bird(flock)s within 100 meter and below 50 meter. A minimum (shaded) and maximum (white) distribution is given according to the two extrapolations in figure 5 B.
Open dots represent the percentage distribution of all birds tracked; black dots indicate the altitude distribution as observed visually.



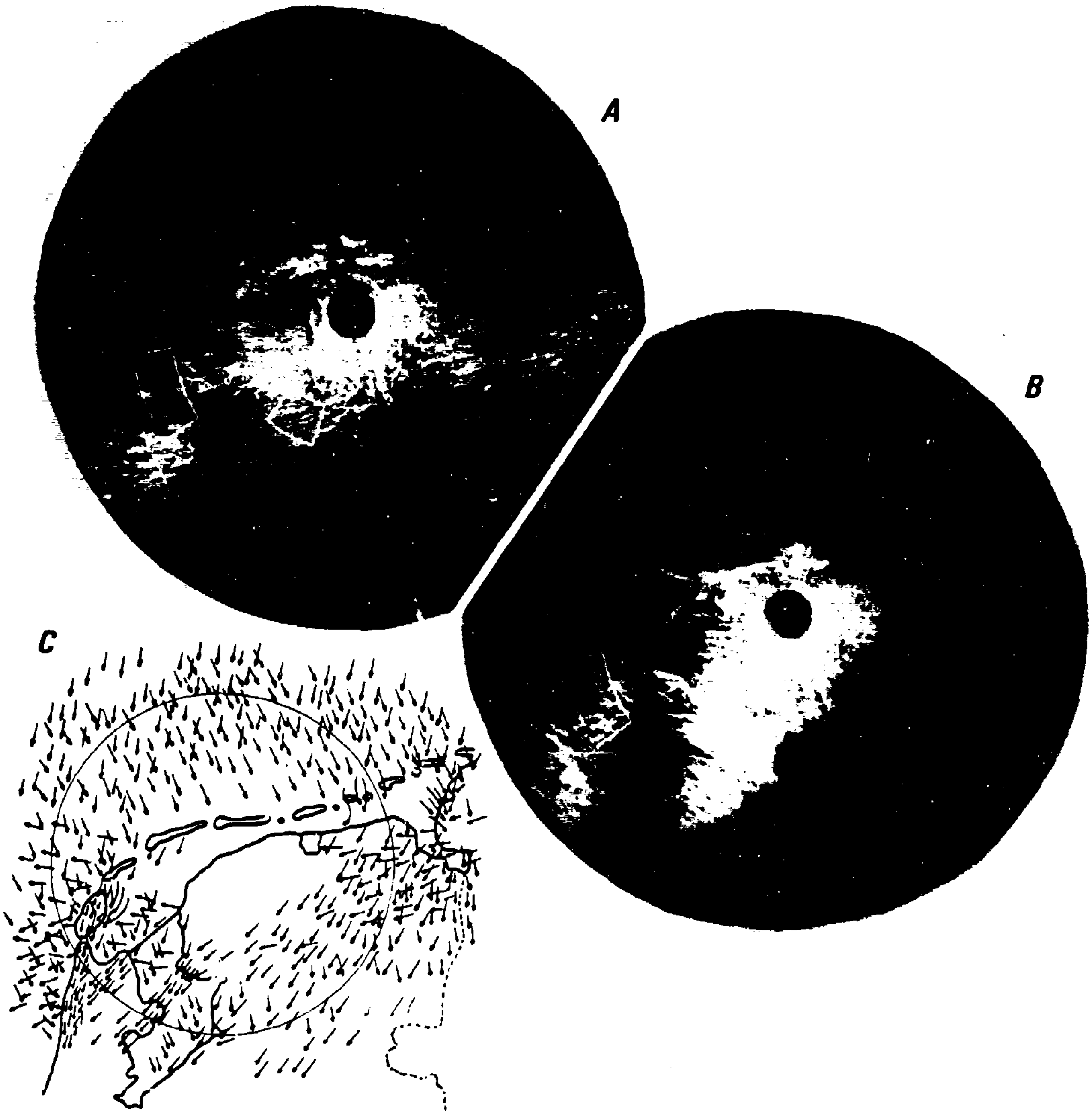
THE PRESENT AND FUTURE OPERATIONAL USE OF RADAR WITHIN THE RNLAF

In common with several other West European air forces, since the sixties the RNLAF uses a long range surveillance radar for operational bird warnings. Before 1975 time exposure photographs were taken on the technical screen of a 23-cm air defence radar in Den Helder. Since 1979 an electronic counting system is used called KIEVIT (Kast met Integrale Elektronische Vogeltrek Intensiteit Tellers) and installed at a 10-cm stacked beam radar, also in the north western part of the country. From all of the beams in the vertical plain only the lowest two show bird echoes. The raw video signal of these lowest beams is filtered by a microprocessor in order to select bird echoes from ground clutter and rain echo fields. The hit counting includes a distance dependent weighing. Electronic quantification occurs within 5 replaceable windows. Birds can be detected at distances of far over 73 nM, our normal range setting for photographic recordings. Figure 7 includes some examples of time exposure pictures of bird movement patterns and an overview of the simultaneous appearance of different major October migration waves during the morning of 17 October 1979 as depicted from a time lapse film. Figure 7 b illustrates a phenomenon already discoverd in 1949 by fieldoberservers, namely the ascent of migrating land birds when setting out over sea (Deelder 1949; Klomp 1956). The implication of this picture is that the same bird movement was totally invisible to the radar above land! Broad front migration at low level is of particular importance under headwind conditions. In certain autumns with prevailing SW winds a low total passage is therefore recorded by radar. The autumn of 1983 is an example of such an situation.

Without any doubt, the radar is perfectly able to detect the very intense bird migration waves as such. It is also clear that clusters of bird strikes occurring when pilots do not use the bird migration warnings can be avoided by imposing more rigorous flight restrictions related to the radar measurements. However, the recent increase in low level training and the simultaneous increase in bird strike frequency cannot be tackled by the existing warning system. The distribution of bird strikes over the year has changed since the intensification of low level flying. The peaks during the migration seasons have become less pronounced and the day to day variation in the number of bird strikes is less clustered. It is clear that low level bird migration and local bird movements now cause an extra, very serious bird strike risk. Procedures to separate aircraft from birds by means of radar warnings now will only be accepted as rewarding if the pilots find out that the radar bird warnings fit in with their experience on bird encounters in the air. This implies that the system should include detailed altitude information and be of much higher quality as far as low-level bird movements are concerned.

We hope to improve the present system by means of the Flycatcher tracking radar studies recently started. Parallel to these measurements of altitude distributions (considering species and group sizes) we will continue in taking time lapse films at the stacked beam radar and perform visual observations. The Flycatcher data may help to upgrade the operational use of the large scale radar-bird-registrations and of the future contribution of field observers (e.g. bird control units at airbases).

FIGURE 7: Examples of patterns of bird migration over The Netherlands as detected by the lowest beam of a 10-cm stacked beam long range surveillance radar in the NW of the country.
A: fairly strong WNW - SW migration by day at rather high altitudes and therefore visible up to the margin of the ppi (set at 73 nM);
B: WNW movements only visible above sea, not above land;
C: schematic representation of different bird cohorts simultaneously in the air during the morning of 19 October 1979; the figure includes the coastlines of the Northern half of The Netherlands and the 50 nM range ring.



The improvements in the first approach include a rough 3-D interpretation of the 2-D radar pictures and electronic counts, and, in addition, a better use of the information gathered from the second radar beam. The inclusion of visual observations in the operational warning system is possible only after verifying the varying limitations of the human eye to detect different bird and group sizes under different environmental conditions. Whether field observations or small radars or a combination of both is the best solution to the recent low-level bird strike problem remains to be seen.

ACKNOWLEDGEMENTS

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BLACKBIRDS AND STARLINGS: POPULATION ECOLOGY AND HABITS RELATED TO AIRPORT ENVIRONMENTS

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Abstract: The Red-winged Blackbird (Agelaius phoeniceus) is the most abundant bird in North America today. It is often joined in roosting assemblages by Common Grackles (Quiscalus quiscula), Brown-headed Cowbirds (Molothrus ater), and Starlings (Sturnus vulgaris). The combined populations of these 4 species exceed 500 million birds during the winter roosting season and increase to over 1 billion birds after the young are fledged in summer. In spite of their abundance, they are involved in only about 6% of the bird strikes to aircraft, less than 1/7 the number of strikes caused by the less abundant gulls (Larus spp.). However, the rather infrequent collisions between aircraft and blackbirds or Starlings can be catastrophic, even though these species have less than 10% the weight of most gull species. Because blackbirds and Starlings are prolific and well adapted to modern land-use practices, attempts to eradicate populations at airports through killing will provide only temporary relief. The key to reducing blackbird and Starling activity in the vicinity of airports lies in the elimination of preferred roost sites through habitat modifications and in the reduction of food supplies through changes in agriculture.

In the early 1800's the Passenger Pigeon (Ectopistes migratorius) was the most abundant bird in North America with a population size of at least 3 billion (Schorger 1955). With the clearing of forests in the East and Great Lakes Region, food supplies and cover were depleted and the Pigeon population declined rapidly. As the population concentrated in the remaining forested areas, large-scale market hunting accelerated the inevitable decline. The population was extinct in the wild by 1900 and the last individual died in captivity in 1914.

The land-use changes that precipitated the demise of the Pigeon population signaled a period of growth and expansion for populations of other avian species. Members of the family Icteridae, particularly the Red-winged Blackbird, Common Grackle, and Brown-headed Cowbird, were especially adapted to the open agricultural land that replaced the forests. In addition, the Starling, introduced from Europe in 1890, was also adapted exceptionally well to this environment, and its population expanded rapidly. These four species, which often join together in large fall and winter roosts, have replaced the Passenger Pigeon as the most abundant group of birds in North America today.

Because these species roost together in large congregations and closely associate with agriculture, they have long conflicted with farming activities (e.g., Meanley 1971, Dolbeer 1980). Another type of conflict has evolved especially since World War II with the tremendous growth of air traffic and the development of jet aircraft. The sheer numbers of blackbirds and Starlings and their propensity to fly and forage in dense flocks in open areas can create hazardous conditions for departing and arriving aircraft at airports. The objectives of this paper are to: (1) briefly document the current status of blackbird and Starling populations in North America, (2) summarize data on collisions that have occurred at airports between aircraft and blackbirds or Starlings, and (3) review information on migration patterns and roosting behavior of these species relevant to their management in airport environments.

POPULATION STATUS OF BLACKBIRDS AND STARLINGS

The Red-winged Blackbird is the most abundant bird in North America today (Table 1), nesting throughout the 48 contiguous States and most of the 10 Canadian Provinces. Peak breeding-season densities are found in the upper midwestern States of Ohio, Illinois, Iowa, and Wisconsin (Dolbeer and Stehn 1983). Major reasons for the numerical abundance of Red-wings are their adaptability to a variety of marsh and agricultural habitats and their strong sexual dimorphism. Females weigh about 41 grams, only 65% the weight of males (Table 2). The two sexes often select different foods (McNicol et al. 1982), thus reducing direct competition. Conservately, the breeding-season population of Red-wings in North America equals 220 million birds.

Starlings have increased from a few hundred birds released in New York City in 1890 to become the third most abundant bird in North America today. The breeding-season population is at least 130 million birds (Table 1). Starlings have dispersed throughout the continent, even to Alaska, although their highest breeding-season densities are still found in the eastern United States (Ohio, Rhode Island, New Jersey, Delaware). Both sexes weigh about 80 grams, about 20% more than male Red-wings (Table 2).

Common Grackles are found throughout the United States and southern Canada east of the Rocky Mountains, reaching their highest breeding-season densities in Delaware, Maryland, Kentucky, and New Jersey. They are the largest of the four species, the males averaging about 120 grams and the females 97 grams (Table 2). Although their range is restricted to east of the Rockies, they are probably the fifth most abundant bird species in North America today with a breeding-season population of at least 110 million birds (Table 1).

Brown-headed Cowbirds are the least abundant and smallest of the four species with a breeding-season population of perhaps 45 million birds (Table 1). The species is found throughout the United States and southern Canada (with the exception of the extreme southeastern U.S.) with the highest breeding-season population levels in the Plains States from Oklahoma to North Dakota. Cowbirds are also sexually dimorphic; the female (38 grams) weighs about 78% that of the male (Table 2). Cowbirds are notable for being the only parasitic nesting bird in North America. The female always lays her eggs in the nests of other birds, being incapable of building her own nest.

The combined breeding-season population of these four species is conservatively estimated at 512 million birds (Table 1). This population swells to over 1 billion birds by the end of the nesting season in July of a typical year. Between July and the nesting season of the following year, about 500 million blackbirds and Starlings die, returning the population to the level of the previous year (Fig. 1). Adults have an annual mortality rate of about 40% and hatching-year birds a mortality rate of over 50%. Thus, there is a tremendous fluctuation in numbers and turnover in individuals in the population each year.

Although blackbird and Starling populations have certainly increased within historic times, Cowbirds are the only species currently showing a significant increase in numbers in North America. The Cowbird population has increased by about 20% since 1966 (Table 3), the increases primarily occurring in the Upper Plains and Southeastern Regions of the United States. Red-wing, Grackle, and Starling populations, although stable on a continental basis, have shown strong regional changes in the past 16 years (Dolbeer and Stehn 1983).

BLACKBIRD-STARLING COLLISIONS WITH AIRCRAFT

Seubert (1968) compiled a list of all bird species reported in strikes by commercial aircarriers in the United States from 1961-67. Blackbirds and Starlings comprised 6% of the 609 identified birds compared to 35% for gulls. In the United Kingdom, Rochard and Horton (1980) reported about 4% of all strikes to civil and military aircraft, 1966-76, were by Starlings (blackbirds of the family Icteridae are not found in Europe), and 42% were by gulls. Joensen and Schneider (1976) reported a similar finding for military aircraft in Denmark from 1966-73; Starlings comprised 5% of the identified birds striking aircraft whereas gulls comprised 40%. Thus, in spite of the abundance of blackbirds and Starlings in North America (and Starlings in Europe), they consistently are involved in only about 4-6% of the strikes, less than 1/7 the number of strikes caused by the less abundant gulls (Table 4).

However, the rather infrequent collisions between aircraft and blackbirds and Starlings can be catastrophic, even though these species have less than 10% the weight of most gull species. Blackbirds and Starlings normally fly in dense flocks so any collisions usually result in multiple strikes occurring almost simultaneously. Since 1960, there have been four bird strikes to civilian aircraft at airports (during take-offs or landings) in the United States that have resulted in human fatalities. Two of these four incidences involved blackbirds or Starlings (Table 5). Thus, the management of these abundant species around airports should be a high priority item. The following discussion summarizes information on migration and roosting of blackbirds and Starlings of relevance to their management at airports.

MIGRATION PATTERNS AND ROOSTING HABITATS

Blackbirds and Starlings are generally sedentary during the nesting season, April-early July, when populations are widely dispersed. Little migration or roosting activity occurs at this time. By mid-July, blackbirds and Starlings begin to concentrate, congregating in nighttime roosts usually within 160 km of their nesting localities (Dolbeer 1982). The birds disperse ily ut to 80 km to forage (Meanley 1965) although most activity is within of the roost (Dolbeer 1980). Flightlines of birds are densest when e birds depart from the roost at daybreak and return in the evening M ummer roosts are only active for a few weeks, the birds coalescing .. fewer, larger roosts as autumn progresses (Caccamise et al. 1983). Migration usually occurs in early November when the birds gradually move to the southern United States ahead of cold weather (Dolbeer 1982). Winter roosts form in November and last until early March when the birds begin moving northward.

Almost all blackbirds winter south of 38° latitude. However, many Starlings, especially birds 1 year or older, winter north of 38° latitude, often forming roosts under bridges, on buildings, or in parks in cities. Blackbirds nesting south of 38° latitude generally migrate 200-400 km to the deep south, being replaced in winter by more northern migrants. Starlings nesting south of 38° latitude usually do not migrate. Because there are differences in migration patterns among the four species and between age and sex classes within species, populations from a given nesting area in the north often become widely dispersed and intermingled with other populations in winter. Ind idual birds show little faithfulness to the same winter roost site from year to year but strong site fidelity to their previous nesting location (Dolbeer 1982).

Although all U.S. States and most Canadian Provinces contain blackbird or Starling roosts at some time during the year, the greatest concentrations of these birds occur in the Mississippi Delta Region in winter. A survey in the winter of 1974-75 revealed at least 59 roosts with more than a million birds each in Louisiana, Arkansas, and Mississippi. This survey located a total of 723 roosts containing 537 million birds in 42 states, including 137 roosts with more than a million birds each in 20 states (Meanley 1976).

Sites chosen for roosting vary considerably with season, bird species composition, and region of North America. However, all sites contain two key factors: cover at the site itself and abundant food in the foraging area around the roost. About 77% of 358 winter roosts surveyed in eastern North America in 1974-75 were in deciduous trees, deciduous thickets, or conifers (Table 6). The remaining roosts were located in man-made structures, cane, bamboo, or marshes. Lyon and Caccamise (1981) found that the vegetation species were rather unimportant in roost-site selection; rather the structure of the vegetation was critical. Blackbirds and Starlings generally preferred sites with high tree densities (700-3500 trees/ha) and compact, enclosed canopies.

Most roosts are located in areas of agriculture where a dependable source of food is available. Maturing corn, rice, oats, and sunflowers are preferred foods of blackbirds in late summer, and waste grain in harvested fields are staple foods in winter (Dolbeer 1980, Dolbeer et al. 1978, Meanley 1971, McNicol et al. 1982, Linz et al. 1983). Feedlots, garbage dumps, and fruit crops can also serve as important sources of food for these birds (especially Starlings) as can a wide variety of insects and weed seeds.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Blackbirds and Starlings are well adapted to modern land-use practices in much of North America, and as long as these practices remain in effect, these birds will remain abundant. Thus, attempts to eradicate populations of blackbirds and Starlings at airports though killing (e.g., surfactant applications, Lefebvre and Seubert 1970) will provide temporary relief at best. These prolific and mobile species will quickly replenish depopulated areas as long as cover and food supplies remain (White 1980). Habitat management is the key to reducing blackbird and Starling activity at airports in most situations. Potential and actual roost sites can be eliminated or made less desirable by habitat alterations (e.g., tree thinning) as discussed by Lyon and Caccamise (1981) and Good and Johnson (1978). Foraging activity can be reduced in the immediate vicinity of airports by eliminating certain agricultural crops (corn, oats, sunflowers, rice) and activities (feedlots) and by prohibiting solid-waste disposal. These long-term practices, combined with timely programs of bird harassment and dispersal whenever temporary concentrations of blackbirds and Starlings appear, will significantly reduce the likelihood of bird-aircraft strikes in the airport environment.

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TABLE 1. The 13 most abundant species of birds in North America and total population estimates for Red-winged Blackbirds, Starlings, Common Grackles, and Brown-headed Cowbirds based on the mean number of birds recorded per Breeding Bird Survey (BBS) route for 2400 routes run in 1966-79. Each survey consisted of 50 3-minute censuses at 0.8 km intervals along a 40 km route.

Species	Mean Birds/BBS Route[a]		Total Breeding Season population ($\times 10^6$)[b]	% of 4 Species total
Red-winged Blackbird (Agelaius phoeniceus)		53.7	220	43
House Sparrow (Passer domesticus)	40.8			
Starling (Sturnus vulgaris)		32.8	133	26
Western Meadowlark (Sturnella neglecta)	29.6			
Common Grackle (Quiscalus quiscula)		26.8	113	22
Mourning Dove (Zenaidura macroura)	25.0			
Horned Lark (Eremophila alpestris)	20.8			
Robin (Turdus migratorius)	20.4			
Common Crow (Corvus brachyrhynchos)	16.5			
Eastern Meadowlark (Sturnella magna)	13.0			
Barn Swallow (Hirundo rustica)	11.9			
Cliff Swallow (Petrochelidon pyrrhonota)	11.9			
Brown-headed Cowbird (Molothrus ater)		11.3	46	9
Total for Red-wings, Starlings, Grackles, and Cowbirds		124.6	512	100

[a]Means are weighted by relative land areas of ecological strata in which routes are run. (Unpublished data provided by D. Bystrak, Patuxent Wildlife Research Center, Laurel, Maryland.)

[b]Population estimates for Red-wings based on conversion of BBS index to density estimate (Clark et al. 1983). Estimates for other 3 species were based on their numbers relative to Red-wings. The total population estimate of the 4 species for North America (512 million) is similar to the total population estimate obtained from the 1974-75 survey of winter roosts (537 million) by Meanley and Royall (1976).

TABLE 2. Mean body weights of blackbirds and Starlings in Pennsylvania, April-June (Clench and Leberman 1978). Sample sizes are in parentheses.

Species	Mean Body Weight (g) Male	Female	Female weight as % of male weight
Common Grackle	120 (100)	97 (37)	81
Starling	79 (14)	80 (12)	101
Red-winged Blackbird	63 (14)	41 (191)	65
Brown-headed Cowbird	49 (89)	38 (586)	78

TABLE 3. Continental changes in numbers of Red-winged Blackbirds, Common Grackles, Brown-headed Cowbirds, and Starlings from 1966-69 to 1978-81 based on a paired comparison of 1288 Breeding Bird Survey routes run in both sets of years (Dolbeer and Stehn 1983).

Species	Mean birds/ route (1966-69)	Mean birds/ route (1978-81)	Mean diff. (1978-81 minus 1966-69)	Mean % change	No. of routes
Red-wing	49.3	46.8	-2.5	-5.1	1288
Grackle	23.9	23.2	-0.7	-2.9	
Cowbird	9.8	11.7	+1.9*	+19.9*	
Starling	28.4	26.8	-1.6	-5.6	

* = $P < 0.05$

TABLE 4. Bird species reported in strikes with aircraft in the United States (Seubert 1968), United Kingdom (Rochard and Horton 1980), and Denmark (Joensen and Schneider 1976).

Species	Commercial Aircraft United States (1961-67)		Civil and Military Aircraft, U.K. (1966-76)		Military Aircraft Denmark (1968-73)	
	No. of strikes	% of total	No. of strikes	% of total	No. of strikes	% of total
Gulls	214	35	650	42	50	40
Waterfowl	111	18				
Birds of Prey	39	6			8	6
Blackbirds & Starlings[a]	38	6	57	4	6	5
Pheasants	32	5				
Lapwings			215	14	9	7
Pigeons			146	9		
Swifts			86	6		
Skylarks			60	4	11	9
Sparrows					9	7
Barn Swallows					7	6
Other	175	29	327	21	25	20
Total birds	609	100	1541	100	125	100

[a]Only Starlings in United Kingdom and Denmark

TABLE 5. Bird strikes of civilian aircraft during take-off or landing resulting in loss of human life in the United States.[a]

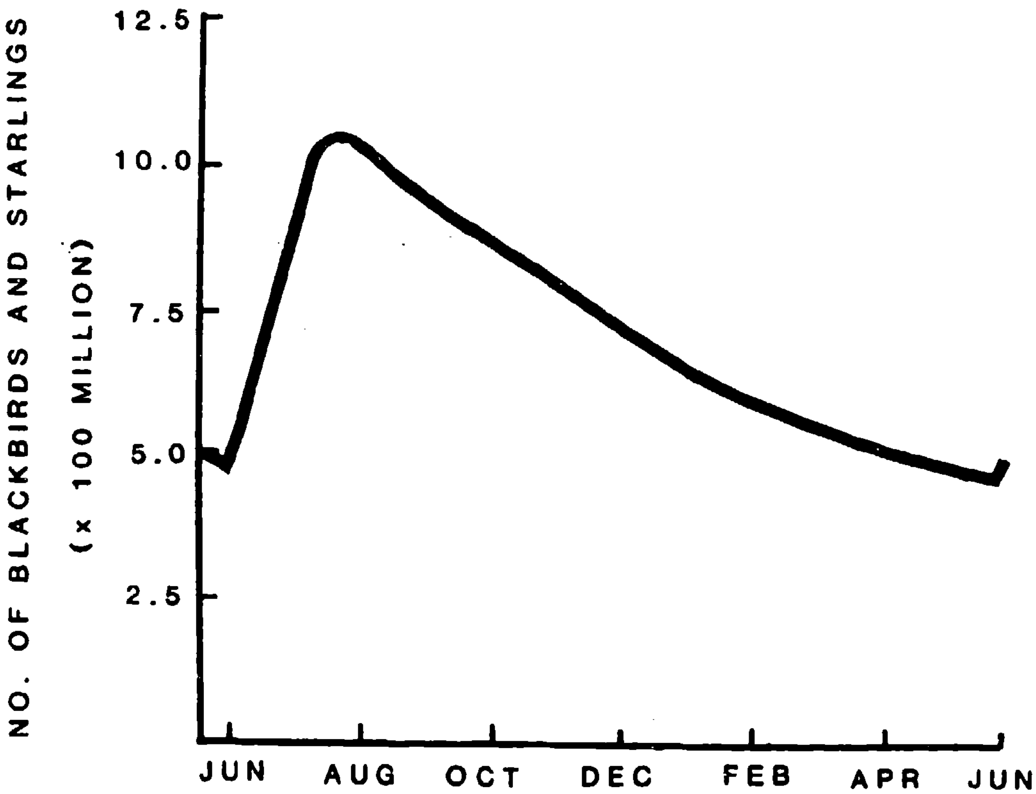
Year	Airport Location	Aircraft	Human Fatalities	Bird Species
1960	Boston	Electra	62	Starlings
1973	Atlanta	Learjet	7	Cowbirds
1977	Chicago	Turbo Commander	4	Gulls
1979	Palo Alto	Swearingen	2	Gulls

[a]From Solmon (1981) and A. J. Godin (Unpubl. Rep.)

TABLE 6. Roosting habitat for blackbirds and Starlings in winter in eastern North America, 1974-75 (Meanley 1976).

Habitat Type	No. of Roosts	Percent of Total
Deciduous trees & thickets	147	41
Conifers	122	34
Man-made structures	32	9
Bridges	17	5
Buildings	15	4
Cane or bamboo	29	8
Marshes	21	6
Live oaks	7	2
Total	358	100

FIGURE 1. Estimated average annual cycle of the blackbird (Red-winged Blackbird, Common Grackle, Brown-headed Cowbird) and Starling population in North America derived from a population model (Dolbeer et al. 1976).



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CATTLE EGRET HAZARD ASSESSMENT

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ABSTRACT

Cattle Egrets (Bubulcus ibis) have become established in the U.S. as a well-known species since their immigration from South America in the early 1950's. They have shown themselves to be well-adapted to new environments, and have expanded into most parts of North America. The Air Force has recorded several bird/aircraft strikes with Cattle Egrets, resulting in thousands of dollars in damage and aircraft down time. Behavorial aspects of the birds such as reproduction and feeding, combined with large populations, make Cattle Egrets a particularly bad problem in some areas. One particular Air Force location required extensive measures be taken in order to eliminate a roost site adjacent to an active airfield runway. These methods could provide some insight into dealing effectively with Cattle Egrets near airports.

INTRODUCTION

Cattle Egrets have been expanding their range since first sighted in the U.S. in the 1950's. They have steadily moved north along the eastern seacoast even into Canada, and are now a well-established migratory species in many inland states. They roost in colonies in almost any low vegetation which has moderate protection. When roosting near an airdrome, they pose a threat to aircraft by flying over the runway and through the traffic pattern. Birds may be ingested into aircraft engines, or collide with the framework, causing severe damage; or they may penetrate the windshield/canopy and impact the pilot.

In the past eight years, the Air Force has experienced 23 confirmed Cattle Egret strikes. This paper will discuss some of the characteristics of Cattle Egrets, and why they are a threat to aircraft. Information is based on recent literature, Air Force data, and observations made during a survey of a southern Florida Air Force base.

HISTORY

Cattle Egrets were first identified in South America in 1937, when a specimen was collected in British Guiana (Crosby 1972). Apparently they survived the transatlantic flight from their native Africa; although what caused them to make the flight is unknown. After establishing themselves in the northern parts of South America, they began to expand both southward and northward. Several sightings were made in the U.S. in the late 1940's, but in 1952 a bird was photographed in Florida and a specimen was taken in Massachusetts, thus confirming both their presence and range. Nests were recorded the following year. By 1956 Cattle Egrets had been collected or sighted in 15 states as well as in Canada (Crosby 1972).

BEHAVIOR

Nesting and Reproduction

The rapid spread of Cattle Egrets throughout the New World has caused many to investigate their tremendous reproductive success. Studies have revealed unique strategies which have enabled more offspring to survive the nesting and juvenile periods. It is interesting to note that when Cattle Egrets first came to North America, they may have migrated north with groups of herons and nested in similar areas. Crosby (1972), Burger (1978), and McCrimmon (1978), found Cattle Egrets at two separate locations nesting among several other species of herons and egrets. Cattle Egrets, however, arrive at nest sites later in the season than all other species, thereby avoiding some of the early spring storms which can destroy many nests (Weber 1975). They also avoid the initial competition between species over preexisting nest sites and materials for new nests. Apparently, upon arrival, they often occupy and repair old or abandoned nests; however, Burger (1978) noted intense competition and fighting over nests by Cattle Egrets with other species, perhaps due to the small number of available nest sites in the study area. McCrimmon (1978) observed that Cattle Egrets arrived at a heronry over time in limited numbers, thus reducing the potential for competition for nest sites. When building their own nests, Cattle Egrets were less selective and built smaller nests than those of other species, and laid eggs soon after nest completion.

Nesting periods for Cattle Egrets are long, perhaps to reduce the loss of all young birds from a single event, such as a storm (Weber 1975). Studies by Weber indicate that an average of 2-3 eggs are laid at 2-day intervals, followed by about 3 weeks of incubation. The chicks are fed in the order that they hatch; the largest chicks must be satisfied before the next can feed. In many cases, a third or fourth chick will starve to death (Weber 1975). This strategy seems to insure that at least one or two will survive the nest even in the poorest feeding areas.

Feeding

Cattle Egrets appear to be one of the best adapted feeders in the heron family. One only need point to their establishment over the entire Western Hemisphere within the past 40 years to confirm this. Normally, the birds leave their resting/roosting site early in the morning and fly to areas where food may be found. Within 10-20 minutes, an entire roost may disperse to feed in areas as far as 20 kilometers away (Custer and Osborn 1978). Thousands of egrets may fly in long streams to many different fields where grass mowers or cattle will stir up insects. Cattle attract a variety of insects which are preyed upon by Cattle Egrets. By feeding on the insects around cattle, they also seem to have taken a previously unoccupied niche (Fogarty and Hetrick 1973). Apparently, this technique was brought from Africa where egrets caught insects which were near or on grazing animals. In the U.S., they feed largely on orthopterans (grasshoppers, crickets, etc.), flies, and other species by walking along side grazing cattle (Burns and Chapin 1969). When no cattle are nearby, they are able to forage for insects in a variety of areas such as pastures, garbage dumps, and caterpillar infestations (Burger and Gochfield 1982).

Also, cases have been documented where, for lack of cattle to stir up insects, egrets utilize a method of "leap-frogging" to cause insects to fly. While one group foraged, the other flew over the heads of the first, whipping up the grass with their wings and causing insects to stir (Fogarty and Hetrick 1973, Weise and Crawford 1974).

In addition to insects, Cattle Egrets also feed opportunistically on vertebrates, such as small frogs, lizards, and snakes (Jenni 1973). Thus, it is clear that Cattle Egrets are adept at finding whatever food is available. Such successful feeding behavior has led some to investigate means of habitat modification to exclude the birds from areas such as airfields. Whitesell (1983), for instance, examined the effects of grass height on Cattle Egret feeding. Many Air Force bases presently spray insecticide on airfields to reduce bird-attracting insect populations. A knowledge of Cattle Egret feeding habits would certainly be helpful in determining methods of reducing their numbers around airports.

POPULATION LEVELS

Since their establishment in the early 1950's, Cattle Egrets have moved into practically all sections of the U.S. Their numbers have increased significantly, and growth curves indicate that until recently, they appear to have moved into a virtually unlimited environment (Bock and Lepthien 1976). Christmas bird count studies show that wintering populations of Cattle Egrets in Florida and along the Gulf Coast have grown exponentially until 1971, after which there has been a decline (Larson 1982). Explanations of the reduced count are varied. Since Cattle Egrets migrate south for the winter to gulf states, deaths during severely cold winters of the late 1970's might be the reason for the drop off; or numbers may be reduced because of shifts in breeding habits due to the drainage of wetlands for commercial development in Florida. Another suggestion is that there is no decrease at all, but that the birds have merely migrated to South America instead, to avoid winter population pressures (Larson 1982, Browder 1973). This seems quite possible, as other survival strategies (e.g., breeding and feeding) reduce competition, and Cattle Egrets have the ability to migrate great distances. If this is the situation, and egrets are indeed increasing, larger flocks will result, causing roosts to expand and more birds for aircraft to contend with. Airfields, with their large expanses of insect-infested grass, may become significant attractants to egrets looking for food. In any case, we do not yet know what is really happening to the birds; and as Larson (1982) points out, Cattle Egret population studies over the next 10-20 years should determine whether the population is decreasing or beginning to stabilize.

CATTLE EGRET STRIKES RECORDED ON AIR FORCE AIRCRAFT

The Threat

Air Force aircraft experience several thousand bird strikes each year causing millions of dollars in damage and aircraft down time. Pilots may also be threatened, if birds impact the windscreen or canopy. In addition to flying "normal" altitudes, similar to commercial airliners, Air Force aircraft are tasked with flying along military low-level routes and low altitude training areas. Speeds exceeding 400 knots at 100-500 feet above ground level are not uncommon for these flights. A 12-ounce Cattle Egret can do a great deal of damage at high speeds. For instance, in April 1982, an F-106 Air National Guard aircraft from Jacksonville FL collided with a flock of Cattle Egrets while flying a low-level route. At least one bird entered the cockpit, impacting the pilot and causing injury. Other birds were ingested into the engine and impacted parts of the plane, resulting in a total damage cost of over $13,000.

Another vulnerable time for aircraft is during takeoff and landing, when thrust and air speeds are important to sustain flight. Cattle Egrets normally fly at low altitudes when moving to and from roosting/nesting sites, or when in search of feeding areas. Should a jet aircraft lose an engine during takeoff due to Cattle Egret ingestion, it is not likely that there would be sufficient air speed to turn around and land.

Airfields provide excellent habitat for Cattle Egrets. Usually they are built away from urban areas because of aircraft noise (to which bird habituate), and have large, uniform areas of grass, providing egrets with suitable habitat to search for insects. Several Air Force bases in the southern U.S. have documented Cattle Egret problems, mostly during the spring and fall months, when they roost or feed on the airfield (Godsey 1977).

The Data

The Bird/Aircraft Strike Hazard (BASH) Team at Tyndall AFB FL is tasked with maintaining records of all Air Force bird strikes world-wide. Between 1976-1983, 23 Cattle Egret strikes were recorded, plus 30 suspected strikes, worth over $2.8 million in damage. All but three of these were in southern U.S. bases; the others were in Panama (1) and Japan (2). Of these, 21 impacted or were ingested into the engine, and six hit the windshield/canopy with two penetrations. All confirmed Cattle Egret strikes were at altitudes below 3,000 feet above ground level. Over half of the recorded strikes were within the airdrome environment. Takeoffs accounted for seven of these. Eight strikes were located on ranges or along low-level routes.

With such a small amount of data, we can only speculate on ways to deal with these birds. Cattle Egret strikes are very few when compared with gulls, for instance, which were involved in 709 strikes for the same time period. Still, Cattle Egrets account for almost all of the strikes at some bases, and must be managed. For these bases, egrets on or adjacent to the airfield present a tremendous hazard to flying. With almost three million dollars in damage attributed to the birds, the Air Force has cause for concern.

CASE STUDY

Almost half of all Air Force bird strikes occur in the airdrome environment (Gillespie 1980, Kull 1983). With this in mind, the BASH Team frequently conducts surveys, at the request of Air Force installations, to aid in reducing the attractiveness of airfields to birds. We visited Homestead Air Force Base FL, where personnel notified us that thousands of Cattle Egrets were roosting adjacent to their runway, posing a major threat to safe flying activities.

When we arrived on 8 Sept 82, we saw over 2,000 roosting Cattle Egrets within 500-600 feet of the runway in willow trees 20-30 feet high. The roost was located in water 2-3 feet deep and in a 300 by 150 foot area. We observed egrets entering the roost from two directions (010° and 230°) between 1745 and 1930 hours. They left the roost between 0645 and 0730 hours using the same routes. We did not determine why only two general routes were taken. However, we assumed that farmers were discing their fields and egrets were going out to feed in those areas.

At approximately 1700 hours on 9 September, we began removing trees from the roost with a chain saw. This process was very slow, and by the time birds started to arrive at 1800 hours, only a very few had been cut down, owing partly to the difficulty in our moving through the water in hip-boots. As birds arrived, they were at first hesitant to land near the sound of the chain saw, but they soon overcame this and perched about 50 feet away. At that time we began firing 12-gauge scare cartridges at them, which caused them to move to tall pine trees about 200 feet from the edge of the roost and away from the runway. Jet aircraft continued normal operations throughout the evening. As more Cattle Egrets arrived at the roost, they became persistent in trying to establish themselves, and more frequent firing of scare cartridges was required. We broadcast Cattle Egret distress sounds with speakers from the top of a truck, but by that time, the noises of the uneasy egrets had drowned out everything but the sound of passing jet aircraft. After firing about 300 rounds of pyrotechnics and successfully keeping the birds out of their roost, we ran out of scare cartridges and the egrets quickly moved into the roost. We killed a few birds to see if we could continue to disrupt them, but they seemed to ignore us. Having concluded that, with persistence, roost disruption was possible, we gathered our equipment and departed as the egrets were quieting down for the evening.

In our staff assistant visit report (Kull and Will 1982) we recommended persistent harassment to disrupt the roost. We also recommended removal of the trees from the roost area. In February 1983, the trees had been removed from the roosting site along the runway. In the Spring and Fall of 1983 egrets changed roosting sites to some unknown location (Kushin 1983).

SUMMARY

Cattle Egret populations have increased tremendously over the past 40 years, and they are well-adapted to survival in the U.S. Their numbers and locations pose a potential threat to Air Force aircraft; however, only continued studies can provide anything conclusive. Brief observations and attempts at dispersal offer an indication that roost disruption is possible using scare tactics; and roost removal can be successful using habitat modification.

CONCLUSION

This paper has presented a short overview of the Cattle Egret situation as seen with respect to Air Force bird strikes. Cattle Egrets will continue to be attracted to airfields in their search for food and will continue to present a hazard to aircraft. Insect control and habitat modification offer partial solutions for airdromes, but more study is needed to reduce egret hazards, especially along low-level routes. Awareness is the first step. Through the combined efforts of researchers and airfield personnel, these problems can be reduced.

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BIRDS ON AIRPORTS : THE REASON FOR THEIR PRESENCE

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SUMMARY

This audio-visual setting is aimed at explaining the reason which make airports attractive for birds. The factors considered are the presence of food sources, shelter and relative peace. The setting is meant for persons in charge of managing and maintaining airports.

Making airports and their surroundings inhospitable for birds that is one of the goals pursued to reduce the risk of bird ingestion or bird strikes on aircraft.

But the presence of birds on the airport grounds and in the vicinity is never due to chance. It results from the needs that they must satisfy to ensure their survival

The result is a situation of conflict, as well as encounters - sometimes grave - which endanger the safety of aircraft, passengers and crew.

Knowing the present causes for the presence of birds and forecasting the future causes can make it possible to eliminate certain attractions of the airport environnement for bird populations.

Airports present vast open spaces, free of all obstacles. This open environnement is particularly suitable for certain birds species : Black-headed gull, Lapwing, Buzzard, Starling, Black-kite, Partridge, Montagu's harrier, Rook, Stone-curlew, Herring gull.

THE NUMBERS OF BIRDS PRESENT ON THE AIRPORT GROUNDS AT ANY ONE TIME DEPENDS UPON NUMEROUS FACTORS :

<u>The Season</u>

At Toulouse-Blagnac, the lapwings are present from october to march.

<u>The Geographical Position</u>

From their grounds in the Camargue region, flamingos make frequent incursions into the Marseilles-Marignane airport.

The Environment

The proximity of a source of food, such as the upwelling of a sever discharge, causes massive movements of Gulls across the runways of Nice-Cote d'Azur airport.

Nature and state of the ground

Ducks and teals are attracted to the marshes of the poorly drained bottom land at Roissy-Charles de Gaulle.

Meteorological conditions

In the presence of high winds and heavy rain, sea gulls move inland and take refuge on airport grounds.

Airport activity

In the absence of traffic sea gulls land on, and remain on parking aprons.

SOURCE OF FOOD, EXISTENCE OF SHELTER AND RELATIVE TRANQUILITY : PRESENCE OF BIRDS.

Source of food

The unused zones on the airport grounds are not subjected to agrosanitary (pesticid) treatments. Consequently rich in small prey, they attract numerous bird species :

The starlings find larva and insects.

The buzzard captures small mammals.

During plowing, the soil's microfauna provides choice meals for gulls.

Insects, nested eggs, and small mammals are exposed by mowing ; birds of prey profit from this windfall.

Starlings are particularly on the lookout for the seeds of wild and domestic plants.

The corpses of animals killed by aircraft attract crows and raptors.

Nocturnal insects killed by marker lights are appreciated by crows.

Other insects are actively chased in flight by swifts swallows, and black-headed gulls.

The pasturing of sheep to an increase in certain insect, populations, which in turn draw lapwings, starlings, gulls, swifts, and swallows to the airport area.

Basins, ponds, marshes, and wet zones all are favorable to the presence of birds.

Existence of shelter

The vast open spaces found on airport grounds offer preferred "rest areas" for certain bird species, such as the little bustard and the gloden plover.

The runways, the taxiways, the aprons, and fields in freshly plowed or seeded state, all are privileged landing zones for black-headed gulls and hering gulls.

For species preferring cover, such as partridges and pheasants, grain fields, including wheat, corn and sorghum, and colza fields are highly appreciated.

Beacon poles, masts, and antennas ; power-supply shelters ; and fences all serve as shelters, perches, and lookout towers for nocturnal and diurnal raptors.

Finally, the airport buildings themselves often offer excellent shelter to certain hawks, starlings, sparrows, and swallows, of course.

Relative tranquillity

This is evidently present for the birds, becouse the human activities on the airport grounds are accomplished in vehicles on the roads and runways, construction or agricultural machines, and aircraft, of course.

The presence of man as an isolated silhouette associated with a menace for the birds is generally excluded, wich is not the case outside the airport environment.

All in all, the airport is almost a refuge for the species that are capable of rapidly adjusting to the visual and acoustic perturbations common to airport activites.

However, the very presence of all of these birds on or near the runways must be considered as a veritable obstacle to safe operations. More complete knowledge of this obstacle will certainly make it possible to improve the safety conditions.

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LA PRATIQUE DE LA FAUCONNERIE COMME MOYEN DE DISSUASION SUR UN AEROPORT

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RESUME

Les résultats obtenus sur la Base Aérienne d'Istres le Tubé avec l'Autour des Palombes (Accipiter gentilis) contre les Goélands argentés (Larus argentatus) et sur l'Aéroport de Toulouse-Blagnac avec le Faucon pélerin (Falco péregrinus) contre les Vanneaux huppés (Vanellus vanellus) montrent que la fauconnerie peut être employée avec succés comme moyen de dissuasion sur un aéroport. Cela, à condition que sa mise en pratique soit conduite en fonction du cas particulier de l'aéroport considéré et de l'espèce d'oiseau indésirable.

La présence d'une espèce d'oiseau sur un aéroport peut être considérée comme le résultat d'un choix entre différents sites possibles. Le jeu des exigences biologiques spécifiques du moment place alors l'aéroport au sommet de la hiérarchie.

L'attrait de la plate-forme aéroportuaire s'exerce au travers de l'existence de trois facteurs fondamentaux : la tranquillité relative, l'existence d'abris et la présence de nourriture. Du premier de ces trois facteurs dépend l'exploitation des deux autres.

En agissant sur le facteur primordial qu'est la tranquillité relative, il est possible d'induire les oiseaux à rechercher hors de l'aéroport de meilleures conditions d'accueil. La fauconnerie peut être considérée comme un moyen de créer un tel climat d'insecurité.

Dans ce but, une section de fauconnerie a été mise en place sur la Base Aérienne d'Istres-Le Tubé et une expérience ponctuelle de 6 mois a été tentée sur l'Aéroport de Toulouse-Blagnac.

Ce sont les premiers résultats de ces deux expériences que nous allons relater ici.

RESULTATS OBTENUS A L'ENCONTRE DES GOELANDS ARGENTES SUR LA BASE AERIENNE D'ISTRES.

Les Goélands argentés (Larus argentatus) sont des oiseaux puissants dont le poids varie entre 800 et 1300 grammes.

A Istres ces oiseaux survolent la plate-forme au cours des transits bi-quotidiens entre les dortoirs et la source de nourriture constituée par une décharge d'ordures ménagères.

A partir du mois de février jusqu'à la fin de juillet, les immatures se regroupent en bandes et se posent, une fois repus, sur des endroits dégagés. Ils affectionnent la base aérienne et il n'est pas rares d'en voir, rassemblés, plusieurs centaines sur la piste ou les voies de circulation.

De nombreuses collisions se sont produites dans ces conditions.

Autour contre Goélands.

Afin de faire fuir et de dissuader les Goélands de stationner sur la base, la femelle d'Autour des Palombes (Accipiter gentilis) s'est avérée être l'oiseau de fauconnerie le plus performant.

Dressé à jaillir d'un véhicule en marche utilisé par le fauconnier, l'Autour attaque les Goélands posés, les obligeant à s'élever et à fuir pour se mettre hors de portée du prédateur.

L'Autour ne poursuit pas très longtemps les Goélands et s'élève peu mais les attaques très rapides et la soudaineté de son intervention provoquent un affolement caractéristique. La prise d'un Goéland par l'Autour n'est pas toujours la conclusion d'une attaque. Lorsqu'elle se produit, la prise augmente considérablement l'effroi du reste de la bande. La panique se manifeste alors par un vol tourbillonnant, avec prise progressive d'altitude au-dessus de l'Autour posé sur la proie, puis par le décantonnement de la bande.

De façon concomitante, la réaction de fuite accompagnée de l'émission de cris d'alarme par les oiseaux attaqués est perçue par les autres groupes de Goélands posés plus loin. Bien qu'ils n'aient pas subi d'attaque, ces oiseaux alertés prennent leur essor et fuient. Des envols et des décantonnements en chaine sont ainsi provoqués à partir de l'intervention de l'Autour.

Cette réaction de fuite à l'attaque de l'Autour dressé à cet effet est caractéristique du comportement des Goélands argentés : assurés de trouver aux alentours de nouveaux endroits pour se poser, ils n'hésitent pas à quitter la base sur laquelle ils ont ressenti une certaine insécurité.

Avantage de l'utilisation de l'Autour

- taille et puissance en rapport avec celle des Goélands.
- tactique de protection généralement adoptée par l'Autour qui neutralise la défense du Goéland en le saisissant par le bec et le cou.

- rapidité d'utilisation et de reprise de l'Autour après un vol d'attaque ce qui permet une grande souplesse d'intervention et une grande mobilité opérationnelle sur la plate-forme.

- possibilité de dissuader les Goélands qui transitent, de se poser sur la piste, en pratiquant des vols de rappel de l'Autour près des axes.

Mission du fauconnier sur la Base d'Istres.

La presence de Goélands étant fonction du lever et du coucher du soleil, de la saison et des conditions météorologiques, le travail du fauconnier est adapté en conséquence à l'activité aéronautique de la base.

- chaque jour, vers 17 h, le fauconnier s'informe de l'heure du premier décollage et des prévisions météorologiques du lendemain.

- chaque matin, le fauconnier fait une inspection de piste préventive, 30 mn avant le premier mouvement d'avion.

- pendant la matinée, il recherche, localise et harasse les Goélands autour des Pistes et voies de circulation. Si besoin est, il poursuit les oiseaux au delà de l'emprise aéroportuaire. Si aucune manoeuvre de dissuasion n'est nécessaire, le fauconnier entraine son Autour à la capture de Goélands qu'il lache à son intention.

- durant la journée, le fauconnier fait une inspection accompagnée d'une dissuasion s'il y a lieu, avant chaque atterrissage ou décollage de gros porteur et en particulier de ravitailleur en vol.

- pendant les trois dernières heures de la journée, il recherche, localise et poursuit les rassemblements de Goélands qui auraient tendance à se constituer en pré-dortoirs sur la base.

- à tout moment de la journée le fauconnier intervient bien évidemment en tout point de la plate-forme à la demande du contrôleur.

Résultats obtenus.

Depuis la création en Mai 1980 de la Section de Fauconnerie, le nombre de collisions a régulièrement diminué jusqu'à être nul en 1983. Pendant la même période, l'activité aérienne de la Base d'Istres-Le-Tubé est restée sensiblement la même.

RESULTATS OBTENUS A L'ENCONTRE DES VANNEAUX HUPPES SUR L'AEROPORT DE TOULOUSE-BLAGNAC.

Les Vanneaux huppés (Vanellus vanellus) constituent sur l'aéroport de grandes bandes pendant l'hivernage. On a pu en observer jusqu'à 8000 certains hivers aux conditions climatiques défavorables à l'espèce, plus au nord.

D'un poids compris entre 200 et 300 grammes, ces oiseaux peuvent devenir très confiants sur l'aéroport lorsqu'ils n'y sont pas pourchassés. Dans le cas contraire, ils acquièrent vite une grande méfiance.

Toutefois, le nombre de collisions sur ce terrain demeure relativement faible, compte tenu du nombre d'individus présents. Par contre, une collision aux conséquences catastrophiques est cependant à redouter. La compacité des vols de plusieurs centaines de Vanneaux peut faire craindre de multiples impacts et une perte de puissance irrémédiable au décollage.

Ce sont les raisons pour lesquelles la fauconnerie a été expérimenté sur cet aéroport à l'encontre des Vanneaux au cours de l'automne-hiver 1983-84.

Faucons pélerins contre Vanneaux.

L'espèce proie connait de façon innée le vol d'attaque du prédateur. Elle sait adapter son processus de fuite à cette manifestation.

C'est ainsi que les Vanneaux cantonnés sur l'Aéroport de Toulouse-Blagnac ont acquis la notion d'insécurité. Ils ont associé l'approche du véhicule de fauconnerie à celle d'un danger redoutable. De jour en jour, leur méfiance a été plus grande et la distance d'envol plus importante. De ce fait le handicap en défaveur du prédateur laché du véhicule de fauconnerie a été de plus en plus préjudiciable.

Une fois sur l'aile, les Vanneaux ont adopté comme procédure de sauvegarde de s'élever rapidement. Cela, afin de se soustraire à l'attaque du prédateur.

Grâce à leur surface alaire et à leur faible poids, les Vanneaux montent aisément, beaucoup plus vite que le Faucon pélerin (Falco peregrinus), oiseau de haut vol. Ils se maintiennent ainsi hors d'atteinte de ce dernier qui doit les dominer avant de les attaquer. Dans ce cas, le faucon perd confiance dans la possibilité de conclure une attaque et abandonne la poursuite.

Les Vanneaux restent cependant en vol et tournoient en altitude au-dessus de la plate-forme sur laquelle ils seraient prêts à se reposer sitôt la source de perturbation éloignée.

L'adoption, par les Vanneaux, de cette position de rempli en altitude peut être considérée comme l'étape transitoire dans le processus de dissuasion recherchée. En effet, une fois ce refuge adopté, la présence continue des fauconniers et de leurs oiseaux en vol, entretient une pression de perturbation telle que les Vanneaux se sentent constamment agressés. Maintenus en vol, ils sont dans l'impossibilité de se nourrir et de se reposer.

L'aéroport a ainsi acquis un climat d'insécurité aux yeux des Vanneaux. Les conditions d'accueil offertes à l'extérieur de la plate-forme sont désormais acceptables. Les Vanneaux indésirables sur l'aéroport vont s'en accomoder.

L'attrait intrinsèque à l'aéroport, exercé par l'existence d'abris et la présence de nourriture, demeure cependant. Si bien que, pour perpétrer les résultats positifs obtenus de jour en jour par la fauconnerie il est nécessaire d'exercer une pression de perturbation continue.

La réalisation du scénario précédemment décrit a été réitérée chaque jour à l'encontre des Vanneaux qui avaient tendance à s'installer sur la plate-forme ou à y revenir. Cela a nécessité une présence opérationnelle constante accompagnée d'une vigilance soutenue de la part des fauconniers.

La difficulté de pouvoir engager une poursuite dans de bonnes conditions a conduit à l'abandon de l'Autour au profit du Faucon pélerin. Même parmi ces derniers, tous n'ont pas été d'un comportement utile à l'effarouchement des Vanneaux.

Les Faucons pélerins les plus performants sont ceux qui témoignent d'une grande aisance pour monter rapidement et d'une grande opiniatreté dans leur agressivité vis-à-vis des Vanneaux.

Résultats obtenus.

A titre comparatif, la Base Aérienne de Francazal proche de l'Aéroport de Toulouse-Blagnac a servi de terrain témoin de la présence des Vanneaux dans la région. Alors que les Vanneaux sont restés présents en grand nombre sur la base militaire où seuls les moyens pyrotechniques étaient utilisés, ils ont été maintenus hors de l'Aéroport de Toulouse-Blagnac grâce à la pratique soutenue de la fauconnerie.

CONCLUSION

Lorsque de grandes bandes d'oiseaux sont présentes sur un aéroport, elles y sont soit pour de nombreux jours et c'est le cas des Vanneaux en hivernage, ou bien s'y trouvent seulement de façon occasionnelle comme les Goélands argentés au cours de leur erratisme journalier.

Un rapace sauvage, tel qu'un Autour des Palombes ou un Faucon pélerin, peut vivre sur le site et exercer une prédation au dépend des rassemblements d'oiseaux. Suivant l'espèce et la motivation de sa présence, l'attitude adoptée par les oiseaux agréssés est bien différente.

De la connaissance des réactions de l'espèce proie, à la prédation exercée par un rapace sauvage, peuvent être tirées des procédures permettant à la fauconnerie d'améliorer considérablement les conditions de sécurité pour les mouvements d'avions.

Toutefois, il faut garder à l'esprit que, dans la nature, la chasse du prédateur sauvage ne vide pas le territoire de l'espèce proie. En effet, pour assurer la perennité de l'espèce, le rapace sauvage prélève les proies qu'il lui faut en quantité qu'il convient. De ce fait, la prédation exercée au dépend d'une même population de proies est sporadique. De longues périodes de coexistence pacifique témoignent de la connaissance de ce modus-vivendi par l'espèce proie. Cela se traduit par une certaine accoutumance à la présence du prédateur.

Prenons deux exemples :

Une bande de Vanneaux installés sur le terrain subit la prédation d'un Faucon pélerin. Elle n'abandonne pas ce dernier pour autant : elle est indifférente à l'égard du prédateur tant qu'il ne se montre pas agressif. Elle éprouve une véritable panique au moment de l'attaque et fuit vers une remise au sol ou en altitude. Sitôt l'attaque conclue par la capture d'un individu, le reste de la bande se contente généralement de se tenir à distance du rapace plumant sa proie.

Cette attitude est caractéristique des oiseaux dépendants des conditions offertes par l'aéroport : nourriture, abris, tranquillité.

Si malgré les attaques du prédateur, le terrain reste au sommet de la hiérarchie des sites possibles exploitables par les Vanneaux, ces derniers continueront à y séjourner. Cet attachement au site aéroportuaire sera d'autant plus grand qu'à cette période de l'année, le Vanneau fait partie des oiseaux considérés comme gibier dans notre pays.

Suivant la pression de chasse et le niveau des perturbations d'origine humaine exercées à son encontre à l'extérieur, la bande de Vanneaux trouvera sur la plate-forme, des conditions d'existence acceptables malgré la présence du prédateur naturel.

Par contre, un groupe de Goélands argentés aura tendance à abandonner le terrain sitôt l'attaque d'un Autour des Palombes sauvage. Les oiseaux recherchent alors plus loin, une nouvelle source de nourriture et un nouvel abri.

Ce comportement reflète le caractère opportuniste des Goélands argentés. Ils se libèrent aisément de leur dépendance vis-à-vis du site. Cela, avec d'autant plus de facilité que leur statut d'espèce protégée leur assure une grande tranquillité hors de l'aéroport.

Ainsi, des conditions offertes aux oiseaux hors de l'emprise aéroportuaire et de l'attitude naturelle des oiseaux vis-à-vis des prédateurs, dépendent les moyens à mettre en oeuvre et les tactiques à adopter pour les dissuader d'y séjourner.

Par conséquence, la pratique de la fauconnerie comme moyen de lutte contre la présence d'oiseaux dangereux doit être conduite en fonction du cas particulier de l'aéroport considéré et de l'espèce indésirable. Les résultats obtenus sur la base aérienne d'Istres-Le-Tubé avec l'Autour sur les Goélands argentés et sur l'Aéroport de Toulouse-Blagnac avec le Faucon pélerin sur les Vanneaux huppés sont là pour en témoigner.

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CONTROL OF MAMMALS AT AIRPORTS

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Airport designers and planners, when considering the natural environment within and around the airport, have two options. Those options are: to create as sterile an environment as possible thereby excluding fauna, or to create an aesthetically pleasing environment, a pride to both city and traveller, with all the attendant problems of pest control required for safety: In effect an artificial ecological island. Design considerations can be devised to include landscaping models which exclude some mammals and meet aesthetic requirements. Technological means to eliminate or repel mammals from airports such as trapping, chemical repellents, removal of attractants, aversive conditioning, and mechanical or electronic scaring devices are now available and their relative value has been reviewed.

It is unrealistic not to anticipate problems. If the above-mentioned technology is employed, ad hoc measures such as human intervention (patrols) may be considered. This method tends to be costly in terms of man-power and time and is somewhat unreliable as well. The problem of control of mammals exists in many airports, particularly in more isolated areas or in the environs of high productivity wildlife areas. It is a problem which cannot be ignored and whose solution would benefit both human and wildlife interests.

Introduction

Given that any major airport site will be designed as an entirely artificial environment, in order to avoid mammal problems it must also be designed as a sterile environment. Architects and engineers, however, have a penchant for landscaping the surrounding terrain or for locating the airport in a scenic place so that travellers can get a good first impression of the area served by the airport. This kind of attitude, though very natural, spells trouble in the long run. Further, there is a strong temptation for airport managers to put all the vacant land not required for runways to some useful purpose. As a result, trees, grass, and hay or cereal crops are grown, thereby attracting mammals, large and small. Any or all of these combinations is a bad mix for aircraft.

There are two apparent options available to increase air safety at airports. The first, although not aesthetically pleasing, is to create a "cordon sanitaire" or biological desert, at least around the runways, if not on the entire site. The second is to create an artificial ecological island where pest species only need be controlled.

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To create the first situation is not technically or technologically difficult, provided such measures as the use of lethal chemicals, chemosterilants, trapping, hunting (shooting), and baiting among other such Draconian measures are permitted by federal, state, or county law. There is some question as to whether modern western society accepts such measures, particularly as they pertain to lethal chemicals (Peters, 1974). Notwithstanding this concern, some "closed system" eradication procedures could be tried, the major considerations being the prevented ingress of new animals to fill the vacuum and the prevented egress of chemically-poisoned animals to avoid secondary poisoning. Drainage systems must also be internalized to avoid broad dispersion of harmful chemicals through surface run-off or ground-water flow.

It may be that such a neutral or sterile state can be never be achieved, except at great expense, and that the aritficial ecological island concept may require fewer resources and be self-sustaining. Such an "island" would eliminate those species which could conceivably be a threat to aircraft. Such species include all the ungulates and larger predators, including bear, wolf and perhaps coyote, and those small mammals that usually attract birds.

Several problem mammals have been identified (Green 1981). These include moose, elk or wapiti, deer pronghorn antelope, coyote, hare and rabbits, and bats. Wolves should also be included, for, although they are not found in the continguous United States (except for the Superior National Forest area in Minnesota and the Yellowstone National Park area in Wyoming), nor in the settled parts of Canada, they do pose problems in northern Canada and Alaska by chewing electrical cables and snapping at landing lights.

Many of the small mammals, ground-squirrels, voles, and mice, attract birds and predators. However, it is this mix (small mammals - small predators) that shows the best promise for the development of the "artificial ecological island" concept.

Site Selection and Design

Many of the airports of North America, and perhaps elsewhere in the world, have already been built, but many are in a constant state of terminal or runway extension or rejuvination. Some, even yet, remain as "white elephants", built before their time. One such facility in the planning stage, opted for a sterile environment within the airport zone proper but with plans for a zoo distanced a drive of approximately 15 minutes from the terminal building. Air travellers with hours to kill between flights would probably prefer to see their animals that way rather than roaming around the runway. Given time, each airport should have, as a matter of record, an inventory of the species within the perimeter of the airport proper with an indication of which are undesirable to airport authorities, namely those dangerous to aircraft.

Preventive Measures

The perimeter of most established airports serving the larger cities of North America is usually fenced to keep out larger species of mammals.

Fencing is expensive and, as a result, it is not usually erected around smaller airports or northern airports. Moose, in particular, have a certain disdain for the standard 8-foot chain-link or paige-wire fence. Deer, on a good day, can easily jump it. Snow-drifts piled against the fence (chain-link more so than paige wire) make it easier to traverse. Nevertheless, there are increasingly better designs for deer - proof fencing such as the short-long obstacle fence used by orchardists in Nova Scotia, or the flexible electrified fences now in use at some airports in the United States. For those airports without fencing, repellents such as Hinder, for example, are the only solution other than the use of expensive trapping and removal techniques. Hunting, particularly out of season, is not socially acceptable, although an harassed airport manager can get special authorization for this in certain circumstances. A number of other methodologies have been tried or suggested:

1. Aversive conditioning - adding a distasteful substance to the normal food of animals so that the target animal learns to avoid it as a conditional avoidance response.

2. Electronic or mechanical scaring devices.

3. Manual scaring devices or dogs under control.

4. Removal of attractants.

5. Biological control - manipulation of the habitat to provide a low-quality food source for all herbivores and seed eaters. This would include planting of trees and grasses not normally the food of the local herbivores (Mullen and Rongstad, 1978); the alteration of the soil base to decrease fertility; and dewatering to drop the water table out of reach of plants.

All of the methods alluded to are acceptable to society provided that they are humane, or perceived to be so. Nevertheless, it is not always the persistent problem but rather the non-recurring or seldom-occuring problem that continually nags at the back of the airport manager's mind. On a sunny but cold winter day, caribou will wander onto a black-topped runway for warmth. Foxes and wolves are attracted by landing lights which give off some heat, causing damage to them. Lighting cable is vulnerable to a host of animals including gnawing species (rodents) and biting and chewing species (canids). Feral animals, dogs, cats, and other livestock may pose even greater problems because of earlier habituation to man and his works and for this reason are not so easily alarmed. The list is seemingly endless but fortunately not all the problem mammals occur at the same airport at the same time.

In conclusion, it is evident that the impact of mammal pests on airports, and particularly on aircraft safety, should not be taken lightly. For the future, there are many areas of research yet to be pursued in this field. Until then, problems will continue.

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DEER CONTROL USING 7 STRAND VERTICAL FENCE

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Many types of fences have been tried over the years for deer control with varying amounts of success. Virtually all fence designs have experienced some deer penetration and most have been quite expensive. The 7 strand vertical fence is working very well and is cost effective. Small areas (5 acres or less) would cost $.74 per foot while larger areas would cost about $.48 per foot for materials. These figures vary from site to site.

Site preparation is essential. A path 20 feet wide should be cleared by mowing or bulldozing. If land is very rough, bulldozing really aids in construction and effectiveness of the fence. The smoother the right-of-way the better the fence, as the favorite way for deer to penetrate is by crawling under at a dip in the ground.

Approaches to the fence should be clear 6 to 10 feet back on both sides. This area should be maintained by mowing or herbicide application. If weeds and brush are allowed to grow up on the fence, the fence appears to be a physical barrier and deer will jump it. The fence works because deer think they can go through, and in the process get shocked and decide to find better things to do.

This fence must be constructed of 12½ gauge high tensile steel wire, class III galvanized, with a breaking point of 1700 lbs. Any lesser wire may break when deer hit it. Each wire is pulled to 200 - 250 lbs. tension with a device called a strainer or winch. With wires this tight we can extent post spacing up to 120 feet apart for posts in the ground and battens (float on top of the ground) may be placed every 40 feet; closer if ground is uneven. In-line posts and battens can be wood or fiberglass. Fiberglass is easily installed, is strong, rot free and self insulated.

Wire spacing is crucial. The first wire is on the ground, the second is 8 inches above this and the other 5 wires are spaced 10 inches apart the rest of the way up the fence to yield a total height of 58 inches. Spacing too close encourages jumping. Spacing too wide allows deer to "dive" through.

Corners and ends must be braced extremely well to hold the pressures of the fence. Use properly treated wood posts and set them with a driver wherever possible. This is a long lasting fence if corners and ends are build correctly and the fence will seldom require repairs.

Springs can be used to hold tension on fence wire with a spring in every wire. Each spring will handle 1500 feet of wire. This is not essential but is a buffer for thermal expansion and contraction, as well as heavy snow loads, and sudden loads occurring if deer get into the fence.

To make this fence effective a low impedance type energizer must be used. These energizers have high voltage and high wattage and can carry many miles of wire with considerable weed loads and still stay effective. Energizers of the highest possible wattage should always be used regardless of fence size to insure a strong shock.

The Bi-Polar energizer has really made a difference in deer fence effectiveness. The Bi-Polar puts out both positive and negative electricity on alternating wires. (Example: On a 7 strand deer fence the 2nd, 4th and 6th wires are positive and the 3rd, 5th and 7th wires are negative. All wires are hot.) The 1st wire in the fence is at ground level and is attached to the energizer ground field as well as to additional ground rods driven every 2500 feet along the fence line. This is done to optimize the chances that a deer will be shocked when it touches any wire in the fence on its initial approach. Also to optimize the chance of initial shock the Bi-Polar now on the market has a faster pulse rate; 67-70 per minute. This is 10% faster than standard energizers and allows less dead time between pulses.

When a deer touches any wire, either positive or negative, and conditions are such that earth return is working, the deer will be repelled. If ground is dry, frozen, or snow covered so the deer is not grounded or if the deer is just persistent and tries to go between two wires in the fence, it will always receive a shock thats available on any single wire.

The same thing can be accomplished with a standard energizer by alternating a hot wire and ground wire. The only thing wrong with this is you have dead wires on the fence. Deer try to go through fences with dead wires, as a dead wire does not shock them when they first sniff the fence.

These electric fences are not always 100% effective but in every fence we have been associated with damage has been taken from as much as 100% to a very low level which the landowner can live with. If deer are truly facing starvation or a major element of their diet is taken from them more penetration will occur but even under these conditions we have not found deer jumping this fence. Even under extreme conditions the fence excludes the majority of deer and must be considered truly a cost effective method of controlling deer movement.

AIRPORT SITE SELECTION AND DESIGN

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Airport site selection involves a compromise among many physical factors as well as those biological and physical factors that affect wildlife use of an area.

Once the site is selected the design of the airport including its drainage system, its buildings, and its ground cover can, and should be, carried on in a way that minimizes the attraction to birds, and other species. Agriculture on leased land on the airport as well as on adjacent land can provide bird attractions almost as great as those provided by disposal areas for food wastes and sewage treatment products. All of those attractions should be reduced to the lowest possible level, by design.

Even after all the desirable steps in airport site selection and design have been accomplished there is still a need for the design and utilization of an effective wildlife control organization with proper equipment, staff and motivation to be ready to deal with unexpected bird visitors or other pest species attracted by the large open space of the airport which cannot by design alone, be rendered completely unattractive to birds.

Airport site selection usually involves a series of compromises. A relatively level site is needed, with geomorphological characteristics that will permit construction of runways and taxiways for heavy aircraft and buildings. Drainage is always a factor as is the ability to support a suitable ground cover to control erosion. Clear approaches are mandatory as is freedom from magnetic and other anomalies that can cause difficulties in radio communication and interfere with sophisticated approach path equipment. The airport needs to be near enough to the municipality being served to be convenient yet not so close as to cause annoyance.

As if the items listed above were not enough to render the work of the planner difficult, we must point out that, for reduction in bird hazards, a few other parameters must be included. A good-quality soil should be avoided because it supports heavy vegetation which will furnish seeds and support populations of invertebrates and small mammals, all of which will attract birds. If possible, the site should not be located on major migratory bird or mammal travel routes or near areas with a history of heavy bird or mammal use. Such areas include marshes, swamps, and shores of rivers, lakes or oceans.

Having said all that, it must be realized that no airport site I know has managed to avoid all the undesirable features outlined so far. That means that the design of the airport, its drainage, its vegetative cover, its buildings, and other physical items must be engineered carefully to reduce, as much as possible, the problems of bird and mammal attraction associated with the site selected.

Airport design requires the removal of forests and other kinds of vegetation more than 20 cm high from all parts of the field within 100 metres of the edges of surfaces used by moving aircraft. In this way wildlife concentrations will be minimized in those areas of vegetation from which they may move quickly onto or across runways or taxiways and pose a threat of collision with aircraft.

In addition to removal of major areas of tall vegetation up to 100 metres from "active" surfaces, there must be careful control of low vegetation (usually grasses) within 100 metres of "active" surfaces. Frequent grass mowing alone is not enough. Care must be taken to maintain the vegetation at a height suitable to control the birds on a specific airfield. That height will always be a compromise between a level low enough to prevent build-up of small mammal numbers, to a level which attracts hunting hawks and owls - frequently hit by aircraft, yet not so low as to attract small, short-legged birds in flocks, which also pose a strike threat to aircraft.

Because maintenance of grass cover at the least bird-attractive height may require frequent expensive mowing, there have been attempts to find suitable substitutes for grass which would be less bird-attractive and would require less costly maintenance. Substitutes considered involved paving of the whole airport, use of synthetic turf (as on playing fields) and the selection of suitable non-grass cover-plants. In those studies the requirement of a suitable ground cover material included the following considerations:

1. Dust and soil erosion control;

2. Ability to sustain passage of wheeled vehicles;

3. Fire resistance;

4. Absence of flowers, seeds or insects which attract birds or mammals;

5. Absence of small mammal populations and habitats;

6. Absence of drainage or snow removal problems;

7. Low maintenance costs;

8. Low establishment cost.

Paving of the whole airport succeeded in 1, 2, 3, 4, 5 but failed on 6, 7 and 8. Synthetic turf failed on 3, 6 and 8. Nearly all the plant species tried failed on 3 and 8. In the long view well-mowed grass comes nearest to meeting the desired requirements and therefore is most-widely used. The search for substitutes will likely continue since grass fails on 7 and, when improperly maintained, may fail requirements 4 and 5.

The ground cover problem may be further complicated in unexpected ways. Urea, used for ice control on runways, is also a fertilizer. The run-off is concentrated along the sides of the paved runway so the grass there is greener, grows faster, and, on prairie airfields, harbours more and fatter ground squirrels which in turn attract raptorial birds directly along the runway edges - where they are most troublesome. In certain areas, deer and elk are attracted to this food supply in early spring.

On some airfields, routine grass mowing causes problems. Flying gulls may follow the mower closely, ready to descend quickly to catch small mammals fleeing the disturbance caused by the mower. Occasionally two gulls may fight for possession of a mouse while flying low across a busy runway. We had to have a second operator to ride shotgun on the mower at one prairie airfield to discourage gull activity.

Next in importance after ground cover comes control of water. Open water in ponds or ditches is very attractive to many bird and mammal species and should be avoided, if possible. Overgrown pond edges or ditch banks are very attractive to some birds for nesting and escape cover purposes. Control of that vegetation may require special slope-mowing equipment which some airports have found advantageous to provide. Beaver and muskrat may occupy ponds and cross runways.

When we look at buildings we soon realize that airports require architectural help to reduce bird-related problems. Overhanging roofs may shelter wall areas where swallows build nests of mud and raise many families of young. One hangar studied had more than 175 swallow nests on one end. The birds were a direct hazard to moving aircraft. Their entry into the hangar through the doors, open much of the time in summer, added feathers and droppings to other foreign objects to which engine and instrument repair facilities were exposed. Without a roof overhang the swallows could not have nested on the building. The fix was wire netting over the wall area under the overhang which physically kept the birds from nesting there. Flat roofs may, if poorly drained, support pools of water used by birds. When the roof parapet prevents observation of the birds the problem may not be realized until the pilot of an aircraft, making an approach over the roof, is confronted by gulls rising off the roof pool, in panic, directly into his flight path. The first time a pilot reported that problem to us, the roof concerned was on a factory outside the airport boundary. A visit from an airport official resulted in improved drainage so the roof pool would no longer be a hazard to aircraft with possible liability to the factory owner in the event of a bird strike.

Foundation plantings and architectural details of terminal buildings may attract nesting and/or feeding birds as may the design of lamp standards and other hardware. We have had to screen parts of building surfaces to keep birds out of an "attractive" wall design.

Putting the support structure for a large terminal building on the outside would have enhanced the interior appearance but would have provided more than 1000 ready-made nest cavities for pigeons where the structural members intersected. Fortunately we caught that one at the scale model stage with the result that pigeon nest sites were not built.

Anything that can be done to reduce the attraction of birds to the site selected for an airport along with all the ingenuity that can be used to minimize bird attraction in building design and airport and building maintenance is worthwhile. Even when all that is done there will still be some bird problems but you can be sure they will be significantly less numerous than if site selection, planning, construction and maintenance have not followed the above mentioned precepts.

The factors in site selection have been discussed thus far mainly as they pertain to birds. Pest species other than birds may affect the safe operation of an airport. It is only in the past few years that problems with big-game, smaller mammals, reptiles and insects have been recognized as an acute and a significant safety hazard, although documented occurrences have been reported as early as 1954.

Many of the more serious problems of animal pests at airports can be addressed during the site selection stage for a new airport. An inventory of wildlife species and habitat can be quickly assembled by an experienced biologist to identify any potential problems. For example, a proposed runway across the traditional migratory pathway of big game can be identified and the runway relocated in the design phase. Failure to do so will pose continuing control problems since traditional migratory routes of animals are not easily changed.

Although I have noted an increased awareness of the problem of animals at airports in the past few years - witness the number of conferences and workshops such as this one and the attendance - there is still a large community worldwide that must be informed. For example, the International Air Transport Association (IATA) in Montreal has had only one request by a member state concerning control techniques for animals (other than birds) in the past 12 years. That one was the problem of elephants on a runway at an airport in India. Judging by the participation at this Conference and the variety of subjects being discussed, I cannot believe this one request of IATA is representative of the total number of animal problem incidents worldwide.

In conclusion, almost any animal species can be a problem at airports; control techniques are available to eliminate or reduce these problems; and research is continuing to improve our ability to address hazards to aircraft caused by aircraft collision with birds and mammals. Our largest remaining problem is the education of public officials that there is a problem when wildlife and airports come together and that there are solutions that of necessity must be utilized.

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LANDSCAPE MANAGEMENT ON AIRPORTS FOR REDUCTION OF BIRD POPULATIONS

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SUMMARY

By special provisions of landscape management it was possible to reduce the number of birdstrikes on German military airfields; on civil airports the birdstrike situation has been improving slowly over the past few years.

Agricultural use and pasturing on airfields/airports has been forbidden; on grassland areas special methods of grass mowing have been practised e.g. long-grass-procedure and/or use of growth inhibitors. Large areas have been afforested with small/low woods with a high density; heather and swamp/bog areas have been promoted. So an exchange of large birds against small size birds could be reached.

In the airport surroundings it was necessary to eliminate all areas attractive for birds; especially with respect to artificial lakes detailed provisions and landscape management has been carried out to minimize birdstrike risk during approach and climbing.

1. INTRODUCTION

In the German Federal Republic nearly 1000 birdstrikes yearly are registered in military and civil aviation (Table 1). The statistics show a more or less unchanged situation on German civil airports as well as a significant improvement of the birdstrike situation on German military airfields. The reasons for those differences were the following:

a. For German civil airports obligatory regulations of Ministry of Transport only exist since 1974. These regulate provisions for birdstrike prevention on the basis of ecological investigations. The corresponding reports have been completed in 1980/1981 and some time is needed before they are affective.

b. For the military airfields regulations by the Ministry of Defence already exist since 1968; the ecological investigations have meanwhile been transposed into practical application, so the first successful results could be reached.

In the principal one must distinguish between provisions within the direct airport area and within a special area of the airport/airfield surroundings (Figure 1).

2. LANDSCAPE MANAGEMENT WITHIN THE DIRECT AIRPORT AREA

This management covers the following problems:

- Agricultural use and pasturing -
- Grassland areas (plan, size and form of cultivation) -
- Woods/shrubs (types and cultivation) -
- Heather-, bog- and swamp-areas -

The quantity and quality of bird species always depends on the type, the form, and the cultivation of these types of vegetation.

The abundance values of breeding pairs and individuals indicated in the following are valid for special areas of northern Germany (EGGERS, 1975, BERNDT/MEISE, 1959) but nevertheless they show the tendencies in pair- and individual-numbers depending on the type of vegetation.

2.1. AGRICULTURAL USE AND PASTURING

According to BERNDT/MEISE (1959) the abundance of bird species in agricultural areas (i.e. districts with intensive use) is low with 6.9 pairs/10 species/100 ha, but for the relevance of birdstrikes not the pair-abundance is important, but the abundance of individuals. This abundance of individuals can at times be the ten- or hundredfold of the pair-abundance depending on the phenological phase (HILD, 1980). This situation is similar in pasture areas; here the pair-abundance is 9.8 - 14.5 pairs/10 ha (EGGERS, 1975) but the abundance of individuals is more than 50-fold.

In consequence pasturing has been forbidden and agricultural areas have been changed into grassland or shrubbery.

2.2. GRASSLAND AREAS

According to BERNDT/MEISE (1959) the abundance of bird species on grassland is 6.5 pairs/9 species/100 ha. The abundance of individuals can be higher on cultivated grassland areas which are under extensive or intensive use (factor 100 - 500). The reasons for bird appearance on those areas are: permanent short cutting/mowing, intensive fertilization, high portion of vegetable mould, high quota of earthworms, insects, larvae and other arthropodae. Especially the offer of food is of high importance for the appearance of swarming birds (Figure 2, Table 2). the number of these small soil animals can be reduced by pesticides, but in some cases it will be impossible to use pesticides, so that other measures must be taken, e.g. long-grass-use, minimum fertilization, reduction of mowed biomass, rolling of grassland. That means changing the intensive grassland use into more extensive cultivation/handling or generally a change in the type of vegetation. Some grassland areas of the airports must be mowed short because of ATC demands. For these areas it would be convenient to use special seed-mixtures with dominantly short growing species, when they are replanned.

2.2.1. LONG-GRASS-CULTIVATION

This type of cultivation should be possible and practicable under all climatic conditions; it can be recommended and in the Federal Republic of Germany it is practised by all civil and military airports/airfields with increasing success at low costs. The suitability of this method follows from the investigations of BROUGH (1982) (Table 3).

The following long-grass-methods are practicable:

- Depending on soil class, 1 - 2 yearly mowings as hay or for silage, but in each case removal of the grass after a few days,

- Long-grass-mowing and chaffing without removal of the grass-material, remowing after grass grows to 25 - 30 cm length in airports/airfields where a direct removal is not possible because of the movement frequency.

2.2.2. MODERATELY SHORT-GRASS-CULTIVATION

In special areas of the airports/airfields - along the runways and taxiways as well as around ILS-installations - a long-grass-cultivation is not possible. In these cases growth inhibitors or regulators can be used e.g. according to GRIEGER/HOPPNER, (1982) application of EMBARK (active substance = mefluidide) twice a year with a quantity of 2-3 kg in spring and autumn; by this application the number of short cuttings can be reduced to 3-4 within one vegetation period, but during the mowing period the bird quantity will increase.

Another chemical substance for growth inhibiting or regulating is MH 30 (= malein-acid-hydracide) together with CF 125 (= chlorflurenol). This combination can be used once in springtime and brings a maximum grass-length of about 20-40 cm in years with normal weather conditions. Under moderate climatic conditions special quantities are recommendable (Table 4).

Because of the possible environmental relevance of the above mentioned chemicals, some special biological investigations have been carried out (HILD, 1981). The results are shown in Table 5.

2.2.3. SEED - MIXTURES

By suitable choice of seed-mixtures the problem of long- or short-grass-cultivation can be minimized by using slow and short growing mixtures and species in corresponding combinations. In the Federal Republic of Germany the following standard mixture is used and is recommended for most airports/airfields with some modifications depending on soil and precipitation: Agrostis tenuis (10%), Festuca ovina (35%), Festuca rubracommutata (20%), Festuca rubra-rubra (20%), Lolium perenne (5%) and Poa pratensis (10%).

2.3. WOODS AND SHRUBBERY

According to BERNDT/MEISE (1959) "natural" woods (=mixed forest with various vegetation layers) show an abundance of 73 breeding-pairs/55 species on 100 ha. In such woods the portion of birds which is relevant for birdstrikes is nearly 25% (EGGERS, 1975) in case these woods are older than 80 years. The more dense the woods are and the more they develop into shrubbery the smaller the abundance of breeding-pairs and individuals is. A significant abundance and dominance of small singing birds replaces the bird species of the free grassland-landscape in young wood-shrubberies which are cultivated as low forests. Such shrub-woods should be constructed closed and dense i.e. avoiding small areas with a high ecological potency and hedges in order to avoid corresponding biological effects (edge effects). On middle European airports/airfields such shrub-like low-woods has been planted by using special trees e.g. as saplings but they must be set on the stock from time to time in order to avoid a natural wood-development (Table 6).

2.4. HEATHER-, BOG- AND MOIST AREAS

According to BERNDT/MEISE (1959) the breeding-pair abundance in heather areas is 6.8/13 species on 100 ha. The individual abundance is lower and among the dominant and subdominant species 90% are small singing birds and only 10% are species like partridge or pheasant which are significant for flight safety. Therefore, heather areas growing only under special ecological conditions are optimal as vegetation on airports/airfields; they could be extended by a special management, they are not intensive for cultivation, but they should be cut every 2 years in order to guarantee their regeneration.

Bogs, swamps and moist areas show a very different ecological situation; their average breeding-pair abundance is 27.4/12 species on 100 ha. Within the types swamp and bog only 5% of the birds are found which may induce a birdstrike risk; therefore it will not be necessary to drain the area as it has been done 20 years ago; the management on those areas should aim at removal of small shrubs.

On the other hand moist areas offer other favourable conditions to birds, but one should distinguish between grassland areas which are moist and in which lapwings may appear with a dominance of only 3.2% and such grassland or waste land areas which are inundated from time to time so that waterfowl, lapwings, gulls can appear periodically reaching nearly 50% dominance (EGGERS, 1975). In such cases draining-and melioration provisions would be necessary.

3. LANDSCAPE MANAGEMENT IN AIRPORT SURROUNDINGS

In the Federal Republic of Germany the airport surroundings are characterized by a so-called outer obstruction line (Figure 1). Within this area the following provisions are necessary according to regulations of the Ministry of Transport:

- Ecological analysis and diagnosis of the area -
- Influence on agricultural, pasturing, forestry and hunting use which is highly difficult and only possible by compromises,
- Prohibition of homing pigeons which can be enforced,
- No additional waters due to gravel and/or sand-mining; this can often only be reached by compromises to avoid the risk of liability for damages,
- Remowing and prohibiting new refuse dumps -

The most important problem within the airport/airfield surroundings is the construction of artificial waters because it correlates with special provisions of landscape management. The appearance of waterfowl is dependent on:

- the trophological situation in the waters,
- the size, vertical and horizontal, and
- the shape of the waters.

So the provisions of a possible landscape management for flight safety purposes are fixed. Depending on the trophological situation one distinguishes in semi-natural or nature-near waters (Figure 3) between:

- oligotrophic waters (lakes) -
- hypertrophic (=eutrophic, polytrophic) waters, and
- fish waters influenced by anthropogeneous factors.

The waters poorest in species are the oligotrophic waters, but they are not at the same time poorest in individuals, because in wintertime they are the most prefered resting and assembling places if not frozen over. In the area of Frankfurt airport such waters show an abundance of individuals of 300 - 500/10 ha. Richer in species but mostly not richer in individuals are the hypertrophic waters which have larger summer breeding populations (breeding-pair abundance 10 - 20/10 ha). Last not least fish waters show special individual and species selection caused by special use.

Moreover a dependency of the dominance on the structure of the banks and subsequently on the vegetation exists. Oligotrophic waters with significant and poorly covered steep banks show e.g. four waterfowl species (KALBE, 1978), eutrophic waters have significant shallow banks with significant belt-like vegetation zones and 16 waterfowl species, and fish waters show nine waterfowl species influenced by anthropogeneous use.

Of high importance are the waters size and the relation between vegetation zone and the zone without any vegetation, for all waterfowl species -except mallard, mute swan, coots - observe distinct safety distances to humans and even trees on the banks. Therefore the net useful area of waters for birds is always smaller (BLAB, 1984) than the actual area of the waters; e.g. a lake of 100 ha. has a net useful area for birds of nearly 64 ha.

When new waters are constructed in connection with landscape management the trophological situation, the vegetation zones, the bank type, the shape of the waters and their size should be regarded as most important parameters for biros (Figure 4a/4b) and its appearance during the single seasons. These parameters decide whether waters will become breeding, assembling or wintering places or are unattractive for waterfowl. Such an unattractiveness can be reached by:

- avoiding islands and peninsulas,
- avoiding small and narrow bights,
- using steep banks (1:2, 1:3) instead of shallow banks (1:5, 1:6),
- dispensing with fisheries and fertilization,
- restricting use by swimming and sporting,
- avoiding breeding habitats by vegetation zones,
- constructing dams for subdivision of waters, and
- planting trees high growing on the dams with dense shrubs between rows of trees.

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TABLE 1

Birdstrikes in German military and civil aviation 1977/1982		
Civil airports	1977	1982
Within the airport area	-	107
Airport surroundings(16 nm radius)	-	66
Unknown	-	37
Total number	211	210
Average rate/10.000 movements	9.2	8.9
Military airfields	1977	1982
Within the airfield area	45	37
Airfield surroundings(6 nm radius)	67	55
Unknown	40	26
Total	152	118
Average rate/10.000 movements	4.8	1.5

TABLE 2

Soil animal on airport DUS, 15 March to 13 November 1975, I=moist ruderal areas, II=moist-fresh grassland, III=loose pine shrubs with dry sandy soils, IV=relatively dry and poor grassland (number of individuals) after HILD, 1980.

Animal Group	I	II	III	IV	total	Months
Araneae(spiders)	252	488	157	279	1176	III-VIII
Opilionae(longleg spiders)	35	54	-	160	249	VI-X
Isopodae(isopods)	-	-	3	2	5	no maximum
Myriapodae(millepedes)	19	-	3	6	28	no maximum
Rhynchotae(bugs,cicadas)	3	3	3	14	23	no maximum
Carabidae(carabids)	188	49	14	146	397	VI-VIII
Staphylinidae(staphylinids)	88	31	36	67	222	VIII-IX
Curculionidae(curculionids)	18	1	99	3	121	no maximum
var.Coleopterae(coleopters)	11	12	40	12	75	no maximum
Larvae(larvae)	29	20	6	23	78	III-IV IX -X

TABLE 3

Bird observations on long and short grass areas of seven UK airfields after BROUGH, 1982; 1= number of airfields, 2= number of observations, 3= % on long grass, 4= % on short grass.

Bird species	1	2	3	4
Gulls (Larus spec.)	7	5775	2	98
Lapwings (Vanellus vanellus)	7	13323	6	94
Oystercatcher (Haematopus ostr.)	2	1907	20	80
Crows (Corvus spec.)	7	3209	13	87
Starling (Sturnus vulgaris)	7	13227	32	68
Wood pigeon (Columba palumbus)	6	7369	49	41
Kestrel (Falco tinunculus)	2	16	71	29
Partridge (Perdix perdix)	3	320	22	78
Thrushes (Turbus spec.)	5	4527	15	85
Small birds(finches,sparrows)	3	2832	44	56

TABLE 4

Quantities of growth inhibitors after ANHÄUSER (1982).

Soil	pH	Concentration
Loam, sandy loam, para-brown earth	7.6 - 7.9	14 1 MH 30 and 12.5 1 CF 125/ha
Loam, fine sandy loam brown earth	5.0 - 6.0	16 1 MH 30 and 12.5 1 CF 125/ha
Loamy sand, sand and poor clay, para-brown earth, brown earth, podzol	6.2 - 6.7	16 1 MH 30/ha without CF 125

TABLE 5

Effectiviness of growth inhibitors and regulators on monocotyl and dicotyl plant species in areas with 13 years of application.

1968	before first application intensive grassland use	15 gramineae species 25 dicotyl species
1969-1970	application of MH/CF	appx.90 % decrease in dicotyl species
1971-1980	extensive use without any application of inhibitors	increasing regeneration of dicotyl species
1981	final bonitur	15 gramineae species (1 species change)
	total loss	6 species
	total gain	11 species

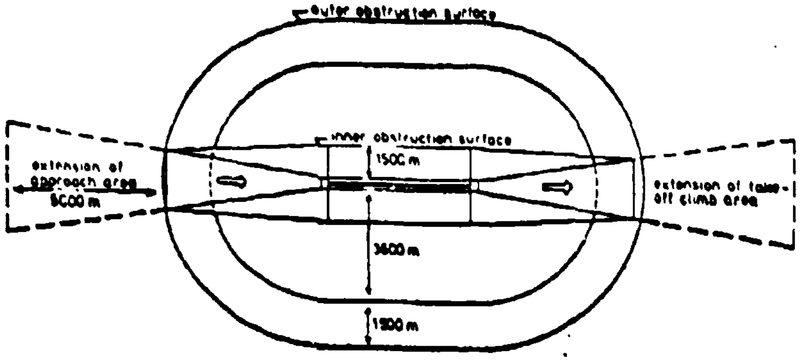
TABLE 6

Tree species suitable for airports and soil conditions

Species	Soil conditions
Acer campestre	moderate dry - fresh loamy
Alnus glutinosa	moist, loamy, pH 6.0-6.5
Alnus incana	loamy, sandy, gravel; wet and dry
Betula alba	fresh, loamy, sandy
Betula pubescens	moist, pH 6.0
Carpinus betulus	fresh, eutrophic, pH more than 7.0
Cornus mas	warm
Cornus sanguinea	without any demands
Elaeagnus angustifolia	loose, light, moderate moist
Fagus sylvatica	fres, eutrophic
Fraxinus excelsior	fresh, moist, uetrophic
Populus alba	sandy, gravel
Populus tremula	without any demands
Populus nigra	moist or wet
Populus euamericana(forms)	moist and wet
Robinia pseudoacacia	without any demands
Salix spec.	fresh,moist or wet
Ulmus spec.	eutrophic

FIGURE 1

Surroundings of airport/airfield according regulations Ministry of Transport.



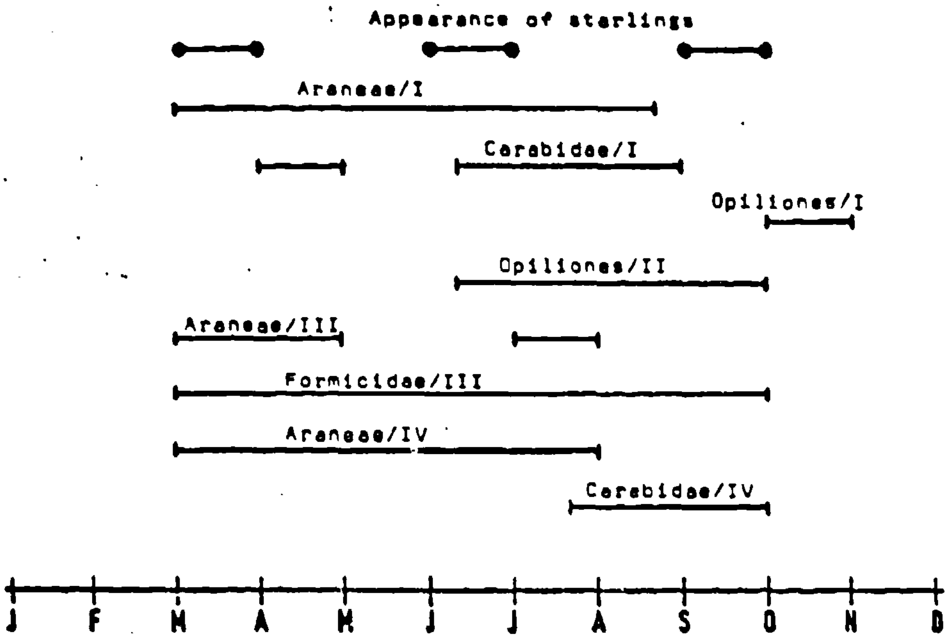


FIGURE 2

Phenology of some soil arthropodae on the airport Dusseldorf compared with starling appearance on different areas (Tab.2)

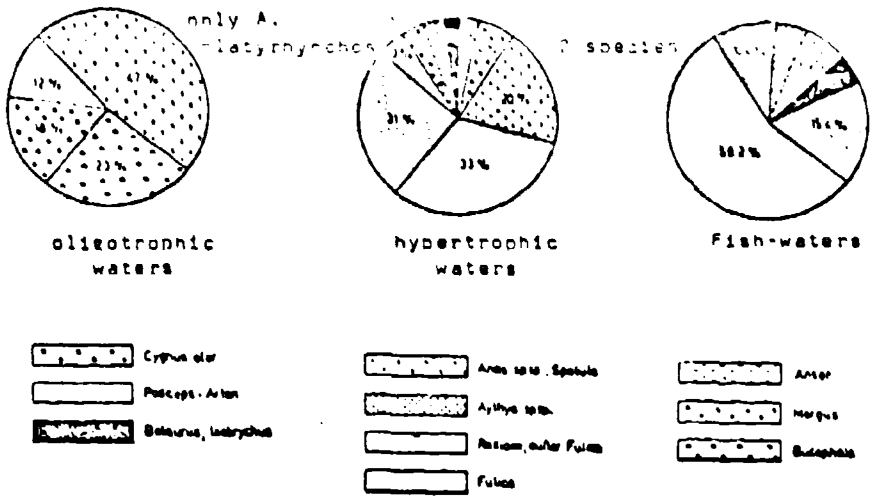


FIGURE 3

Types of waters (oligotrophic, hypertrophic and fish-lake. Dominance of waterfowl according KALBE, 1978)

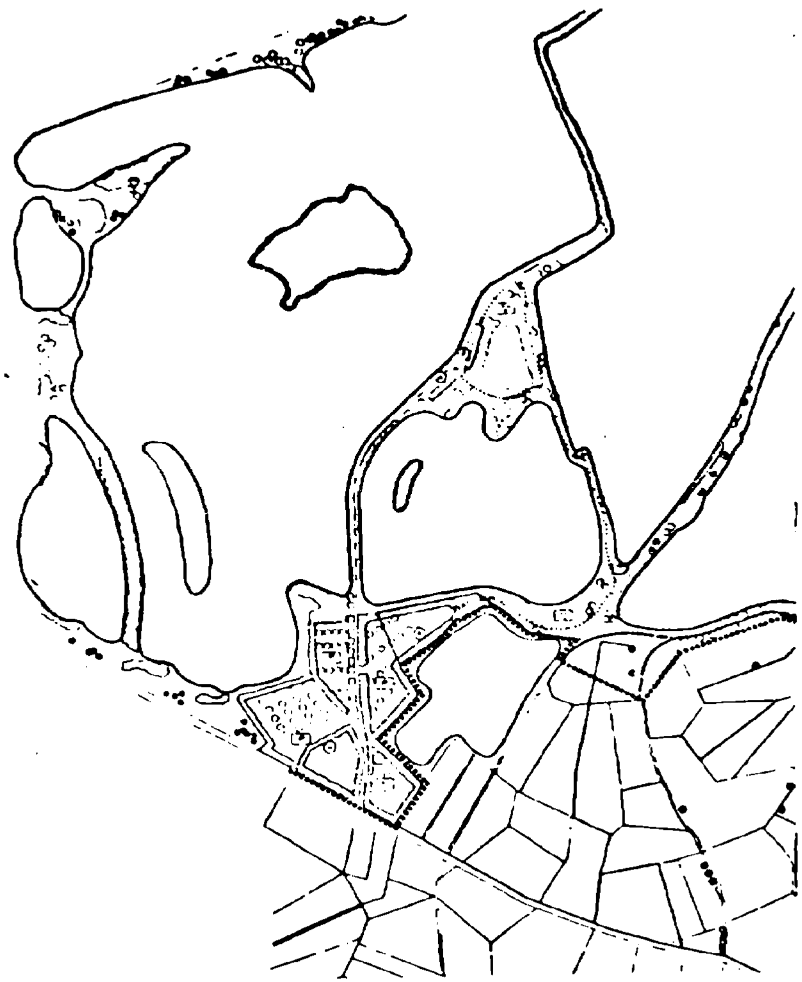


FIG. 4 A

LAKE AREA WITH SHALLOW WATER AREAS AND BREEDING ISLANDS. SIZE NEARLY 200 HA.

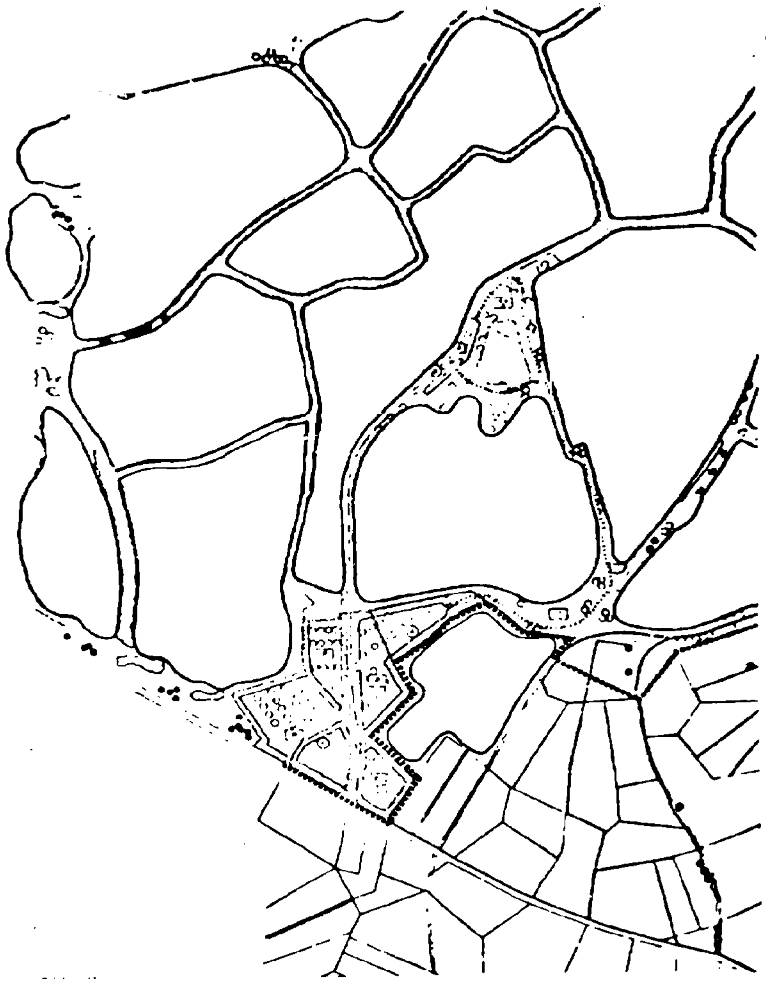


FIG. 4 B

LAKE AREA WITH STEEP SHORES AND DAMS; MAXIMUM LAKE SIZE NEARLY 20 HA.

INEXPENSIVE MULTIPURPOSE LANDSCAP‾‾G

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High altitude, small budget, limited staff and severe weather makes landscaping difficult and more easily dismissed than mastered. In Leadville, Colorado at Lake County Airport, elevation of 9,927 feet, twenty years after construction the fixed based operation, ramp and terminal areas looked like a forgotten incomplete construction site. The growing season is short (three months maximum) and few things grow at all. The value of landscaping to enhance customer first impressions is not disputable. By creating beds of rocks (abundant in the Rocky Mountains) bordered with discarded railroad ties, various flotsam and jetsam from the forests and local mining dumps, visual impact is strong and the results attractive, durable and multi-purpose.

It was a major concern--how to deal with construction devastation--twenty years later. At high altitude very little grows, and that which does, grows at an extremely slow rate. Things leaf and bud in late June, bloom in July and August and the last hardy Mountain Asters survive into September. The aspen begin to turn golden by late August and are barren by October when the snows are again falling. Evergreens--pine and blue spruce grow by the quarter inch and half inch per yea nd are not easily transplanted. The soil is rocky and hard, a... when not in the forest, generally poor. The cost of fertilizers and top soil required to landscape an airport for three short months of splender is not realistic.

Yet, the visual impact of gardens and landscaping as counterpoint to tarmac, hardware, metal buildings and aircraft is a great asset in an airfield and fixed based operation. Order and grounds neat in appearance are a delight to the viewer--our customers. In Leadville, Colorado we have seven to eight months when the surroundings are not entirely snow covered but neither is there any possibility of vegetation except for the three short summer months. Our solution was to landscape with other than greenery and blossoms.

The construction of the airport left heaps of dirt and low areas were filled with mud. The asphalt ramp edges were breaking apart. We began with the rocks, abundant in these mountains. Areas around the ramp cut by heavy equipment were covered with the rock. Edges were bound with larger rocks or railroad ties discarded by the railroad which lie along the tracks that run through our valley. Within one rocked area, we added small plantings of trees; aspen, pine and spruce. These were replanted with great effort from the nearby forest and bordered by ties and rocks to hold the precious soil gleaned by the bucketful in dry creek bottoms. Treasures from mine dumps including old hardware, picks and shovels, ore buckets, fools gold, etc. are sported in another rocked area. A third rock garden has pine cones and wooden treasures from the forest. The ground by the terminal has a floor of railroad ties set in small rocks where we placed some chairs to serve as a patio looking towards the magnificent Continental Divide--Mount Elbert and Mount Massive. During our spring--summer we add planters of bright flowers.

This form of creating order has a number of advantages; no up keep at all, that is; no mowing, trimming, planting, pruning or watering; dust from wind and running aircraft is at a minimum; small litter, debris and animal waste disappears of itself. Perhaps, most important, from the air the ramp and parking areas are clearly demarked and referenced by pilots. The rocks do not conceal chocks or obstruct wings as there is no height to this type of grounds keeping. Winter snowplowing damage is easily repaired. Newly added areas or changes and repairs of rock and wood do not appear new among the old. Paths for foot traffic are controlled and limited by the rocks preventing persons from approaching the ramp unobserved and willy--nilly. Those indigenous plants that spring up through the rock, various types of sage and lupines, for example, appear significant and planned. Weeds and odd grasses are controlled. Heavy rains and snow run off do not make a quagmire of unsurfaced areas. The architecture of the airport is satisfyingly melded into the mountain landscape through the visual impact of the rocks. The rock is natural and proper looking in the Rocky Mountains.

Finally, the construction scarring of years ago and more recent work, including, septic tank burying, hangar, road and ramp building are concealed. This was accomplished with approximately two hours a day of rock hauling by two persons, a pickup truck, strong backs and willpower over a six month period. So successful has this been that we plan further work to include landscaping out buildings and parking areas for automobiles. The cost for the project thus far was one of labor and gasoline only--the response and effect tremendous. With no unsightly ground, users of the airport enjoy the aircraft and vista of the mountains. Time spent at the airport by the average user has increased as has business and the reputation of Lake County Airport.

REDUCING GULL USE OF SOME ATTRACTIONS NEAR AIRPORTS

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Gulls may visit airports to utilize the open space for loafing or other activities. They are more likely to do so if there are attractive feeding areas nearby. One of the more important food attractions, particularly for ring-billed gulls, is that provided by areas in which large volumes of edible refuse (domestic or industrial) are exposed. If gulls can be prevented from feeding in such areas they are much less likely to loaf on neighbouring areas, including airports. Recent work has demonstrated the efficiency of widely spaced suspended, very fine wires and fine nylon monofilaments in discouraging gull feeding in areas over which the wires (lines) are stretched. The technique does not impose an easily visible physical barrier such as traditionally used at fish hatcheries. The few birds that penetrate under the fine wires (lines), when disturbed, appear to have no difficulty flying up and out through the wires. That is in contrast to the more than 80 percent of birds that will not penetrate the wired area from above to get at the food.

It appears as if the wires constitute some kind of psychological deterrent to landing, perhaps related to flight approach patterns and gull vision.

The first serious bird strike I investigated was in the 1950's and involved a collision between a DC-6 aircraft on take-off and 25 ring-billed gulls. The damage was widely distributed over the airframe and engines, but, after a few scary moments, presented no problem in making a safe emergency landing a few minutes later. It did make the point that gulls near, or on, an airfield create a hazard to aircraft.

By the time the N.R.C. Associate Committee on Bird Hazards to aircraft began operation in late 1962, we had entered the era of turbine-powered aircraft; so birds had taken on a greatly increased importance as hazards to aircraft. A turbo-prop Electra had been knocked down by starlings at Boston in 1960 with a loss of more than 60 human lives and a Viscount had been destroyed in a crash near Baltimore after collision with a whistling Swan in 1962 with a loss of 17 lives. One of the first reviews made by the Associate Committee showed that gulls were involved in more collisions with aircraft then any other group of birds, not only in Canada, but also in other countries where there were records of bird strikes on Canadian Aircraft. When we encouraged our European friends to create a multi-national agency, now called "Bird Strike Committee, Europe", their early studies showed that gulls were a big part of the problem there also.

In Gulls and Aircraft (1978) I made the point that, although gulls were involved in many collisions with much damage to aircraft, they had caused few fatalities. That was true even in the 1975 destruction by gulls of a DC-10 at New York. In that incident, although there were more than 100 people on the aircraft, they were all airline employees and none was killed. The report by the National Transportation safety board on that incident stated: "The rapid and successful egress of all the occupants may be partially attributed to the fact that nearly all passengers were trained crew members and all were airline employees with knowledge of the aircraft, evacuation procedures, and facilities. Serious evacuation problems could have been experienced had this been a routine passenger flight with untrained airline passengers."

In the past we have been lucky to have so few fatalities caused by gull strikes. We must not depend on luck and must, therefore, try harder in future to keep gulls out of the paths of aircraft in order to avoid serious accidents and casualties.

We have tried several methods of gull control over the past 30 years including environmental modification of the airfield, and, with public assistance, also off the airfield. We have used a variety of scaring devices such as recorded distress calls; flying repellents, including live, trained falcons and falcon-shaped, radio-controlled model aircraft; and patrols using sounds, lights, exploding shotgun shells, live ammunition, and automatic exploders.

All of those techniques work at some times and places but no single one works under all circumstances and all depend on human action and motivation, neither of which is infallible.

One method of reducing gull problems is to prevent large groups of gulls from using nearby attractive areas including edible-waste disposal facilities sometimes called sanitary landfills or more correctly garbage dumps. Many of the scaring devices, including the use of live falcons, will work as effectively as at airports, but one must still rely on human activity and motivation with their shortcomings.

We have recently been involved in trials of a method of excluding most gulls from attractive areas by the use of overhead wiring.

Mc. Atee and Piper (1936) reported the exclusion of fish-eating birds from fish ponds by using a grid of wires. That technique involves heavy wires with supports. Its use is limited by cost and wire strength.

Amling (1980) reported the use of widely spaced high-strength fine wires on long spans to keep birds off reservoirs.

Blokpoel and Tessier (1983 b) and (1983 c) reported successful use of a similar technique over limited areas of special attraction, including a fast-food outlet and a nesting area, to exclude ring-billed gulls.

Laidlaw et.al. (1984) reported on a project to exclude ring-billed and other gull species from a sanitary landfill near an airport. The observations he quoted, for a 6 month period, indicated a large reduction in use of the area by ring-billed gulls. The reduction was in contrast to gull-use rates at nearby landfill sites with similar food availability. In some situations a large reduction in gull numbers in an area is an effective solution to a problem. Where that is so, the use of fine parallel stainless steel wires (0.4 mm) or nylon monofilament on spacings of 6 or 12 metres may reduce gull numbers to the desired degree. In some installations wire spans of up to 200 metres have been used. The wire is strong and light and can be suspended from simple telescopic towers made of pipe. The telescope design permits the tower height to be adjusted easily when used on a sanitary landfill so that there is always room for equipment to operate under it, as the landfill level rises.

The reason for the success of the overwiring in the exclusion of most gulls from an area is not known. It does not form a physical barrier and other birds, including pigeons, ignore the wires. Gulls that find themselves under the wires may fly up through them with no apparent difficulty. It is believed that the effectiveness of the wires as a barrier relates to the path gulls follow to approach a feeding area on a shallow angle of descent. The wires seem to be invisible until the gulls are quite near them or collide with them, perhaps because the gulls' eye are focused on food, or other things far below. In one case where the wires were 11 metres above the ground, they were visible from the ground only with difficulty and were invisible under certain sky conditions.

The wires may form a psychological barrier to gulls though not, apparently, to other species.

Whatever the mechanism involved, this technique can exclude many gulls from areas where they are not wanted.

We believe this technique has demonstrated that its use can result in reduced gull use of areas under the wire. We hope others will try the technique so more data on reductions in gull members will become available. Increased trials can be expected to aid the understanding of how the technique works and may lead to even better techniques. I believe the technique merits wide use in gull control. Since some North American gull populations are expanding (Blokpoel, 1983) the need for control techniques will not decline soon.

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FAA POLICY REGARDING SOLID WASTE DISPOSAL FACILITIES

by

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SUMMARY

The Federal Aviation Administration's (FAA) policy regarding solid waste disposal facilities on and near airports is based on bird strike data, accident information and aircraft performance. Distance criteria used in FAA Order 5200.5, FAA Guidance Concerning Sanitary Landfills on or Near Airports, coincides with distances specified in Federal Aviation Regulation (FAR) Part 77, Objects Affecting Navigable Airspace. FAR Part 77 provides obstruction standards for use in several FAA safety programs designed to provide aircraft with proper clearance from objects.

HISTORICAL DEVELOPMENT OF POLICY

On February 26, 1973, a Learjet departed Peachtree-Dekalb Airport in Atlanta, Georgia, and struck a flock of Brown-headed Cowbirds resulting in complete failure of one engine and partial failure of the other. The pilot was unable to continue the takeoff climb and the plane crashed, killing both pilots, five passengers and one person on the ground. Adjacent to the airport was a sanitary landfill which attracted large numbers of birds. As a result of this accident and because several airports in the FAA's Southern Region also had garbage dumps nearby, the regional office developed a policy specifying that solid waste disposal sites on and near airports represented an incompatible land use.

On October 16, 1974, the Southern Region's policy was adopted nationally and is specified in FAA Order 5200.5. The purpose of an FAA national order is to define FAA policy or procedures and provide guidance to FAA employees on specific issues. Employees of the FAA are responsible for implementing policy within guidelines established in agency orders. With respect to FAA Order 5200.5, FAA employees are expected to assist airport owners in seeking compatible land use through local or state regulations and land use zoning for safety purposes.

CRITERIA DEVELOPMENT

FAA Order 5200.5 was written after consultation with air safety specialists and ornithologists. The order evolves logically from a concept of direct conflict between aircraft and birds. Aircraft are in a high-risk condition from bird strikes during takeoff, initial climb, approach and landing. These airport-dependent flight phases place the aircraft in the low altitude environment which is also occupied by birds. By examining aircraft flight maneuvers and combining information about birds and bird strikes, a high-risk scenario can be developed, forming the basis for the criteria contained in FAA Order 5200.5.

Approximately 62 percent of all reported bird strikes occur at or below 500 feet above ground level (AGL). As altitude increases, the likelihood for bird strikes decreases. In the next 500 foot increment, up to 1,000 feet AGL, only an additional 7 percent of reported bird strikes are added. If an aircraft can takeoff and climb above 500 feet, the bird hazard risk is substantially reduced. As evidenced by bird strike statistics, most bird flight activity is below 500 feet AGL. With the notable exception of migratory flights, most day-to-day flight activity of birds is at low altitudes.

In developing criteria for FAA Order 5200.5, the agency took 500 feet AGL as the level below which a high-risk condition exists from bird hazards. Under normal operating conditions, an aircraft is in this high-risk area the longest during approach and landings, since takeoff and climb occur at a greater rate of change in altitude (feet/nautical mile). It is the approach and landing phase of flight which was used in developing distance criteria for the order.

Two types of fixed-wing aircraft are considered in the order, those powered by engines with pistons and those which are turbine powered (including turboprops). The need to distinguish between these two types of powerplants exists primarily because piston engine power aircraft are most often flown under visual flight rules and approaches are flown in a racetrack style traffic pattern. Turbine engine powered aircraft more frequently fly instrument approaches and straight-in landings as opposed to the visual racetrack pattern flown by piston engine powered aircraft.

The point at which the aircraft descends through 500 feet AGL was used to determine the distance criteria in the order. For piston powered aircraft, this horizontal distance is 5,000 feet. It represents the distance the aircraft is from the runway when it descends through 500 feet during the turn to final for the runway. For turbine engine powered aircraft, the distance is 10,000 feet, which corresponds to passage of the aircraft into the high-risk area at 500 feet while performing a descent on a 3 degree glideslope. These two distances, 5000 feet for airports used by piston engine powered aircraft, and 10,000 feet for airports used or planned to be used by turbine engine powered aircraft, represent minimum distances a solid waste disposal facility should be located from the airport. Some states have already adopted these criteria in their solid waste regulations.

Solid waste disposal facilities outside of these minimum distances are also subject to scrutiny by the agency on a case-by-case basis. If the landfill or other type of disposal facility is located below the conical surfaces defined in FAR Part 77, the landfill may be considered incompatible. The issue here is with birds who frequently feed at landfills (mainly gulls) and soar or spiral over the site to altitudes as high as 3000 feet, where this bird flight behavior may present a hazard to aircraft. FAA would consider the solid waste site as incompatible with air safety because of the hazard caused by soaring gulls or other birds.

The fourth and final criteria relating to compatible use is difficult to address from a zoning standpoint. It covers the situation where a solid waste site is located such that it attracts birds flying from other feeding, watering and/or roosting areas to the solid waste site and in the process, birds fly through aircraft flight patterns. Many of these situations exist and the agency must rely on observations of bird movements in documenting the problem. Likewise, proponents of new solid waste sites find it extremely difficult to determine whether their proposed site may create a flight hazard. Before FAA makes known its position regarding compatibility with a landfill which falls into this criteria, considerable data collection and review of bird and aircraft flight paths is required.

IMPLEMENTING POLICY

Depending on state and local solid waste laws and regulations, FAA states its policy position on specific landfill sites in many ways. In some states, FAA has approval authority on solid waste permit applications. The other extreme of the spectrum is similar to citizen participation in review of a proposed land use. Many states and communities hold administrative hearings before granting or denying permits. FAA frequently provides written and oral testimony at these hearings. FAA also reminds airport management of its responsibilities to achieve safe, compatible land use and FAA frequently works with state aviation organizations to assure safety of flight through compatible land use.

Unique situations may arise where a proposed land use will not create a hazard. Authority to waive criteria rests with FAA's Associate Administrator for Airports in consultation with other headquarters elements. Regional and field personnel provide necessary information for review of the situation. FAA will usually respond to the state or local community with a letter specifying no objection to a proposed permit or license to operate if evidence shows no hazard will exist.

CONCLUSION

FAA Order 5200.5 defines the policy regarding solid waste related bird hazards which has worked well since 1974 in preserving aviation safety. FAA is encouraging states to adopt solid waste regulations protecting the aircraft operator from unnecessary bird hazards. A copy of FAA Order 5200.5 is included in this paper.

ORDER

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

5200. 5

10/16/74

SUBJ: FAA GUIDANCE CONCERNING SANITARY LANDFILLS ON OR NEAR AIRPORTS

1. PURPOSE. This order provides guidance concerning the elimination or monitoring of open dumps, waste disposal sites, and sanitary landfills on or in the vicinity of airports.

2. DISTRIBUTION. This order is distributed to Washington headquarters and Regional Airports, Flight Standards and Air Traffic offices to division level; all Airports District Offices; and Flight Standards and Air Traffic field facilities.

3. BACKGROUND. Garbage dumps, sanitary landfills or whatever title is used for this type of operation attract rodents and birds, erodes the airport environment, and where the dump is ignited, creates smoke - all which are undesirable and are potential hazards to aviation.

While the chance of an unforeseeable, random bird strike in flight will always exist, it is nevertheless possible to define the high-risk conditions within fairly narrow limits. Those high-risk conditions exist in the take-off, climb-out, approach and landing areas on and in the vicinity of airports. The increasing number of bird strikes reported on aircraft has become a matter of concern to the FAA and to airport management. Various studies and observations have resulted in the conclusion that sanitary landfills are artificial attractants to birds. Accordingly, landfills located in the vicinity of an airport may be incompatible with safe flight operations. Those conditions that are not compatible must be eliminated, to the extent practicable. Airport owners need guidance in making this decision, and the FAA must be in a position to assist. Some airports are not under the jurisdiction of the community or local governing body having control of land usage in the vicinity of the airport. In these cases, the airport owner should use its influence and best efforts to close or control landfill operations within the general vicinity of the airport.

4. ACTION.

a. Sanitary landfills located within the areas established for an airport by these guidelines as set forth in paragraph 5 of this order should be closed. If a sanitary landfill is determined as

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incompatible land use under guidelines of paragraph 5 and cannot be closed within a reasonable time, it should be designed and operated in accordance with the criteria and instructions issued by the Environmental Protection Agency, the Department of Health, Education and Welfare, and other such regulatory bodies that may have applicable requirements. FAA should advise airport owners against locating, permitting or concurring in the location of a landfill on or in the vicinity of airports.

b. The operation of a sanitary landfill located beyond the areas described in paragraph 5 and designed in accordance with the guidelines identified in the foregoing paragraph must be properly supervised to insure compatibility with the airport. If at any time the landfill, by virtue of its operation, presents a potential hazard to aircraft operations, the owner shall take action to correct the situation or terminate operation of the landfill. Failure to take corrective action could place the airport owner in noncompliance with the commitments under a grant agreement.

c. An inspection of current operations at existing landfill sites which have a reported potential bird hazard problem will periodically be made and evaluated. A Bird Hazard Group formed under Order 5200.4 dated 11/20/73 could appropriately be available for consultation regarding this activity. Should it be found that birds attracted to the landfill site do in fact constitute a potential hazard to aircraft, the condition will be reported to AAT-430, National Flight Data Center (NFDC), for possible inclusion in the Airman's Information Manual. The appropriate FAA office should immediately evaluate the situation to determine compliance with the grant agreement and take such action as may be warranted under the guidelines as prescribed in Order 5190.6, Airports Compliance Requirements.

d. This order does not apply to landfills used exclusively for the disposal of rock and earth.

e. This order is not intended to resolve all related problems, but is specifically directed toward eliminating sanitary landfills in the proximity of airports, thus providing a safer environment for aircraft operations.

f. The airport operations manual should require landfill site inspections at least semimonthly for those landfill operations that cannot be closed to assure that bird population is not increasing.

g. Additional information on solid waste disposal, bird hazard and related problems may be obtained from the following agencies:

Bureau of Sport Fisheries and Wildlife
U.S. Department of the Interior
18th and C Streets, N.W.
Washington, D.C. 20240

Office of Solid Waste Management
Programs (HM-562)
U.S. Environmental Protection Agency
1835 K Street, N.W.
Washington, D.C. 20406

U.S. Department of Health, Education & Welfare
330 Independence Avenue, S.W.
Washington, D.C. 20201

5. CRITERIA. Sanitary landfills will be considered as an incompatible use if located within areas established for the airport through the application of the following criteria:

a. Landfills located within 10,000 feet of any runway used or planned to be used by turbojet aircraft.

b. Landfills located within 5,000 feet of any runway used only by piston type aircraft.

c. Landfills outside of the above perimeters but within the conical surfaces described by FAR Part 77 and applied to an airport will be reviewed on a case-by-case basis.

d. Any landfill located such that it places the runways and/or approach and departure patterns of an airport between bird feeding, water, or roosting areas.

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AIRPORT BIRD HAZARDS ASSOCIATED WITH SOLID WASTE DISPOSAL FACILITIES

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ABSTRACT

Research has shown that all types of refuse disposal facilities (landfills, open dumps, etc.) that handle putrescible wastes have the potential to attract birds. Birds are attracted to these sites principally to scavenge for food. When solid waste disposal facilities are located in the vicinity of airports, the probability of bird strikes is increased. Accordingly, solid waste disposal facilities located in the vicinity of an airport may be incompatible with safe flight operations. Those conditions that are not compatible must be eliminated, to the extent practicable. The Federal Aviation Administration (FAA) and the Environmental Protection Agency (EPA) have developed guidelines for identifying and eliminating airport bird hazards associated with solid waste disposal facilities. FAA Order 5200.5 is directed towards airport owners and managers to promote safe airport operations. The EPA criteria (44 FR53438) were adopted from the FAA recommendations and are directed towards the State agencies responsible for ensuring that solid waste disposal facilities are operated according to public health and safety standards. Commitment by both of these target groups (airport owners/operators and State agencies) to encourage and enforce compliance with the guidelines is required to successfully reduce airport bird hazards associated with solid waste disposal facilities. This paper is an overview of the bird hazard problem due to solid waste disposal facilities including a discussion of the Federal guidelines and programs to promote proper land use near airports with respect to these facilities.

BACKGROUND

A bird strike "hazard" is the exposure of aircraft to increased risk or danger of a bird strike beyond the low probability of a random bird strike. This definition acknowledges that the possibility of a bird strike always exists when an aircraft is in the bird's domain. The term "random" is used to describe the ever present possibility of hitting a bird in flight, emphasizing the lack of artificial attractions that would bring birds and aircraft into direct conflict. When birds are attracted to the vicinity of aircraft activities due to the presence of food, water, or shelter as may exist at a solid waste disposal facility, there is a greater probability of a bird strike occurring and therefore a bird strike "hazard" would exist.

Bird strike data and other associated research have shown waste disposal facilities sited adjacent to airports are not a compatible land-use. The attraction of large numbers of birds to these facilities substantially increased the bird strike hazard at airports when the landfills are located in close proximity to the airport. The bird hazard created may be classified as an "away from airport" hazard, an "at airport" hazard, or as both. The "away from airport" bird hazard results from the daily bird flights to the landfill (feeding flights) or other activities that place the birds in conflict with aircraft approaching or leaving the adjacent airport. The "at airport" hazard results from the attraction airports present to birds, often resulting in large congregations of birds on runways and adjacent areas. The "at airport" bird hazard greatly increases the probability of a bird strike during the takeoff and landing phases of flight, and increases in airport bird activity can frequently be attributed to a nearby food source.

SOLID WASTE DISPOSAL FACILITIES

Solid waste disposal facilities often attract birds when the refuse collected for disposal includes putrescible wastes (garbage). The putrescible waste material is a potential food source for birds. When these solid waste disposal facilities are located on or near airports, they have a greater potential for creating a bird hazard. Large flocks of birds have been observed feeding at sanitary landfills and open dumps. Studies conducted by various government agencies have documented the hazard that these facilities pose to airports (1, 2). The information concerning solid waste disposal facilities near airports indicates that they are a major attraction to birds and are responsible for many bird hazards that occur.

Solid waste is generated within all communities. It is often categorized as residential, commercial, or industrial depending upon its origin. Solid waste is defined as all discarded items from these sources. These wastes may be either putrescible or non-putrescible in nature. Putrescible wastes are usually composed of discarded residential food waste, restaurant waste, etc., and are a potential source of food for vectors and birds. Since vectors (flies and some rodents) are, by definition, capable of transmitting diseases to man, laws have been passed by federal, state and local authorities addressing the proper disposal of refuse. These laws require refuse, particularly putrescible wastes, to be disposed of in a manner that minimizes its availability to these vectors. When properly operated and maintained, refuse disposal areas are not breeding and harborage sites for vectors.

Refuse is usually disposed of in sanitary landfills. One of the characteristics of a sanitary landfill operation is the periodic placement of a soil cover over the compacted refuse. The application of this cover material usually occurs at the end of each operating day. Vector populations are usually absent in properly operated sanitary landfills, but birds are still able to feed since they take advantage of the availability of the putrescible wastes before it is covered with soil at the end of the day.

Unacceptable refuse disposal facilities that attract or have a potential to attract vectors as well as birds are called "open dumps".

As the name implies, these are often areas where refuse is deposited without being properly compacted and/or covered. The operation of an open dump is in violation of many federal, state, and local laws since they are a potential public health hazard. But state and local inspection and enforcement are often lacking. Therefore, in spite of regulation to control the existance of these facilities many open dumps are in operation throughout the United States.

BIRDS ATTRACTED TO SOLID WASTE DISPOSAL FACILITIES

The birds attracted to solid waste facilities are scavenging-type birds. Generally, these consist of gulls, crows, starlings, blackbirds, pigeons, sparrows and vultures. All areas of the United States contain populations of at least some of these bird types.

There are several reasons why birds are attracted to solid waste disposal facilities. The major attraction is that a source of food is readily available. At open dumps, the garbage is dumped in piles. At those facilities, birds may pick through the mounds of refuse to obtain the edible portions. The larger the dump area, the greater the potential for exposure of garbage. Even small dumps can support large populations of birds. At sanitary landfills, the situation is often not much better than at a dump. It has been observed that birds will often consume most of the accessible garbage within one half-hour of its being dumped. Therefore, a sanitary landfill that accepts refuse all day and is covered only at the end of the day provides little or no discouragement to scavenging birds. The operation of a landfill has an additional attraction to birds, the compaction process. This procedure involves the use of a front end loader or similar device to spread the waste over the working face and compact it into layers. The spreading operation acts to expose the formerly inaccessible garbage making it available to birds. Gulls in particular become very bold when accustomed to the presence and noise of this machinery and will often feed immediately behind the front-end loader. Gulls have been observed to be so bold as to sit on the equipment while it is spreading refuse, waiting for a morsel to be exposed.

There are other relatively minor attractions to birds associated with landfills. These consist of the exposure of soil organisms when cover material is collected at the end of the day, insects present at open dumps, etc. Generally, several factors can be identified as influencing the attractiveness of waste disposal sites to birds. They are: (a) disposal technique, (b) location, (c) volume and type waste, (d) presence of rest areas and (e) lack of disturbance. The combination of these factors that exist at a solid waste disposal facility will determine the type and number of birds attracted. It can be stated that all conventional methods presently used for the land disposal of refuse have the potential to attract birds.

The occurrence and number of birds at landfills varies with geography, season, weather, volume of waste and time of day. Many bird populations are not stationary during the entire year; they often move to various predictable regions during breeding (nesting), migration and wintering periods. For example, blackbirds are rarely a problem at sanitary landfills in their northern breeding ground during the spring. During late summer and fall (post-nesting period), populations may congregate and feed at sanitary landfills in their northern range. Fall migration may result in periodic problems further south and large wintering populations often feed at sanitary landfills in the bird's southern range. Gull populations at the sanitary landfills are frequently very large. This is especially true during the wintering period when they are gregarious. Their numbers have been observed to be greatest during mid-day periods. As many as 15,000 or more gulls have been observed at a single landfill at one time (3). Since nearly half of all birds strikes involve gulls, their behavior and attraction to landfills warrants concern when landfills are placed in areas where attracted gulls may become a bird strike hazard at adjacent airports.

Many of the bird species attracted to landfills are gregarious for at lease a portion of the year. This is particularly common during the post-nesting season and during migration. During the nesting season, most birds are territorial and frequently behave as individuals regarding activities such as feeding. Therefore, aggregations of birds during spring and early summer periods are not common, except where birds nest in colonies. However, after the nesting season, the bird populations consist of adults and the newly fledged offspring (juvenile birds) feeding and roosting in large groups. This social behavior advances as the fall migratory season approaches, reaching its maximum during the winter months when large concentrations of birds are at their wintering grounds (southern range), where food, water and shelter are available.

The importance of the seasonal social activity of birds attracted to landfills is that when these flocks form, the spacial concentration of birds (number of birds in a specified area) increases. When the daily activities of these birds bring them in close proximity to airports, the greater the spacial concentration, and, consequently, the higher the probability of bird strike incidents.

When an airport or its approach paths lie between or near these points of daily activity, there exists a great potential for the occurrence of bird strikes. Studies by Forsythe (3), Drury (4), and Seubert (5) have indicated that major portions of the populations of birds flying in the airspace of aircraft were species that utilized waste disposal sites as a focus of their activities.

The literature concerning bird strikes indicates over sixty species of birds have been reported in aircraft strikes in North America. Not all of these species present the same hazard. The following characteristics of a species will determine its potential as a hazard to aircraft.

Size. The size of a bird correlates with the force of impact and therefore the extent of damage. Large birds such as ducks, geese and gulls often cause extensive damage due to their size. A turbine-powered engine may completely lose power after ingestion of a gull whereas a smaller bird such as a sparrow may be injested with little or no damage.

Social Organization. The social organization of a species of bird relates to whether or not it tends to feed, roost, or fly in flocks. Flocking birds that congregate in large numbers present a greater hazard to aircraft than do solitary species due to both the greater probability of a bird strike occurring and the potential for multiple bird ingestions. Engines in turbine-powered aircraft are designed to sustain the ingestion of small birds individually, but multiple ingestions have a higher potential for engine damage.

Behavioral Characteristics. The behavioral characteristics of a species of bird pertain to the daily and/or seasonal activities of the species. For example, species that prefer open, flat areas such as the conditions at most airports, are more likely to be an aircraft hazard than a species that is restricted to the dense woods. Behavioral characteristics cause birds to be attracted to the airport or its vicinity are a major factor in the bird hazard problem. Often if these behavioral characteristics can be identified, the airport or vicinity can be changed to make them less attractive to birds.

The activities of gulls warrant particular attention since they account for nearly half of all reported bird strikes. There are primarily six species of gulls that are commonly attracted to landfills to feed. The species attracted to any particular region will vary with the geographic location and season. Gulls have several behavioral characteristics that are common among the different species. The following characteristics make gulls vulnerable to collisions with aircraft:

Flocks. Gulls often fly in groups from their roosting site to the feeding grounds (solid waste disposal facilities).

Feeding Flights. Gulls arrive in small groups and begin circling the landfill. Elevation achieved while circling are in the range of 500-3,000 feet (152.4 - 914.4M). As the flock becomes larger, the gulls begin to descend onto the landfill to feed.

Storms. Stormy weather bring larger numbers of gulls inland to feed at landfills.

Immature Gulls. Several studies have documented that 90-95 percent of the immature Herring gulls feed at artificial food sources such as landfills. Other species may also exhibit this characteristic .

Distance. Gulls may travel as far as 100 miles in a day to reach available food sources.

Swarm Circling. On sunny days, flocks of gulls often ride thermal air currents (swarm circling) near their feeding grounds, achieving altitudes of 3,000 feet (914 M) or higher. Often single gulls will begin to ride a thermal air current above a landfill. This behavior usually attracts other gulls in the vicinity to join in forming a "swarm". These birds may ride these thermal air currents for extended periods of time before descending upon the landfill or leaving the area for other locations such as other feeding sites, loafing areas or their evening roost. This behavior is also referred to as "towering".

Attempts to correlate gull numbers with either the amount of refuse dumped or the surface area involved have been inconclusive, but Forsythe (3) indicated that open dumps attracted about 50 percent more gulls than do sanitary landfills. In this study and others, there was a very close correlation between the activity at the landfill and the attraction to gulls. It has been determined that gulls and other birds feed only at active sites. As observed at sites with irregular schedules, gulls only appeared when garbage was being dumped (3). This information indicates that the abandonment or closure of a refuse disposal facility will cease the attraction to birds. Actual landfill or dump closings substantiate the relationship between active dumping and attraction to birds. Where airports are in the vicinity of a dump, closure of the dump reduced the bird hazard. At San Francisco International Airport, a very significant reduction in the total number of gulls occurred after the closing of the Oyster Point dump, From a peak of approximately 8,000 in the fall of 1968, the number of gulls was reduced to a maximum of about 4,000 in the winter of 1969-70. Other landfills in the general vicinity, operated in a sanitary manner, accounted for the remaining birds.

LAND USE NEAR AIRPORTS

The placement and planning of solid waste disposal facilities are conducted at the local and state level with ownership or operation by municipal, county or private concerns. The state and local planning officials must be concerned with the political and economic ramifications of locating solid waste facilities. Few people like to have a solid waste facility located near their homes due to the noise, smell, and aesthetic degradation often associated with landfills. Therefore, sanitary landfills are usually located in rural areas or where the urban population density is low. The extent to which sanitary landfills may be placed away from residences is often influenced by several economic factors. The distance that these facilities may be located from the waste-generating source (urban area) is limited by cost. The further the facility is from the source of the waste, the more man-hours that must be spent in transit and the greater the fuel usage. Additional cost considerations are the cost of land and the cost of constructing an all-weather road to the refuse facility. Costs can be deferred by utilizing existing roadways, such as those leading to airports. These cost factors must be minimized for the cost-effective placement and operation of a solid waste facility.

The factors considered in the location of solid waste facilities are very similar to those required for the placement of an airport, which is why they are frequently located in close proximity. The airport must be located near populated areas, but because noise and traffic are not desired near homes, they must be located on the periphery of populated areas. As with sanitary landfills, the cost of land must be minimized and it is necessary to have a good all-weather road leading to the airport. The cost of land for the two types of facilities will often bring them to the same areas. Therefore, it is often attractive for planning agencies to locate these facilities in the same area. One of the purposes of this paper is to point out the hazards to aviation associated with this planning practice and discourage the conflict of land use.

Conflicts in land-use near a[illegible]ts with regard to solid waste disposal facilities are expecte[illegible]rease in the future if present trends are not altered. This [illegible]o several factors that include the following:

(1) increase in the number of airports to meet the transportation needs of the public

(2) increase in the need for development of sanitary landfills due to closure of open dumps and increasing waste volume

(3) limited land availability due to urbanization.

In recognition of the conflict in land-use between airports and solid waste disposal facilities, the FAA issued Order 5200.5 (6). This order specifies that sanitary landfills will be considered as an incompatible land-use if located within areas established for the airport through the application on the criteria.

The distances specified in the Order concerning the distance land disposal facilities should be located from airports are based upon bird strike data and should be maintained to minimize the bird strike hazard near airports. These criteria originally developed for the FAA Southern Region, were adopted by the other FAA Regions and, in 1974, were made national criteria and presented in FAA Order 5200.5.

<u>FAA Order 5200.5 Criteria</u>. Sanitary landfills will be considered <u>as an incompatible use</u> if located within areas established for the airport through the application of the following criteria:

a. Landfills located within 10,000 feet of any runway used or planned to be used by turbojet aircraft.

b. Landfills located within 5,000 feet of any runway used only by piston type aircraft.

c. Landfills outside of the above perimeters but within the conical surfaces described by FAR Part 77 and applied to an airport will be reviewed on a case-by-case basis.

d. Any landfill located such that it places the runways and/or approach departure patterns of an airport between bird feeding, water, or roosting areas.

The FAA Order functions as an official FAA recommendations and guideline for owners and operators of public-use airports to follow. The Order does not entail enforcement action by FAA and there is limited legal recourse to encourage implementation of FAA Order 5200.5. This is due to the fact that solid waste disposal facilities are generally not on the airport property and therefore not under their jurisdiction to control, particularly where existing facilities are present.

The Environmental Protection Agency (EPA) is the federal agency responsible for ensuring public health and environmental quality with respect to solid waste management and therefore the regulatory agency for solid waste disposal activities in the United States. In this capacity EPA developed "Criteria for Classification of Solid Waste Disposal Facilities and Practices." The criteria provided minimum national standards for the protection of health and the environment from adverse effects resulting from solid waste disposal. These criteria were promulgated on September 10, 1979 (44 FR 53438) under the authority of Sections 4004 and 1008 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 405(d) of the Clean Water Act. The criteria were published in the Federal Register on September 13, 1979 (Vol. 44, No. 179, p. 53438). Those facilities that are evaluated by the states and found not to comply with the criteria are to be reported to the EPA and published in the Open Dump Inventory as required in Section 4005 of RCRA. No Federal enforcement actions are authorized as a result of a determination that the facility is in violation of the criteria. However, state enforcement actions may result from violations of state legal requirements.

Included in the adopted regulations is section 257.3-7 entitled "Safety". Subsection (c) of the safety criteria addresses bird hazards to aircraft. These criteria were adopted from the FAA criteria with respect to the distance a facility must be from an airport as follows:

CHAPTER 2(c)

SAFETY - BIRD HAZARDS TO AIRCRAFT

Criterion and Definitions

(c) Bird hazards to aircraft. A facility or practice disposing of putrescible wastes that may attract birds and which occurs within 10,000 feet (3.048 meters) of any airport runway used by turbojet aircraft or within 5,000 feet (1.524 meters) of any airport runway used by only piston-type aircraft shall not pose a bird hazard to aircraft.

(e) As used in this section:

(1) "Airport" means public-use airport open to the public without prior permission and without restrictions within the physical capacities of available facilities.

(2) "Bird hazard" means an increase in the likelihood of bird/aircraft collisions that may cause damage to the aircraft or injury to its occupants.

(7) "Putrescible wastes" means solid waste which contains organic matter capable of being decomposed by microorganisms and such a character and proportion as to be capable of attracting or providing food for birds.

The evaluation of existing solid waste disposal facilities in accordance to the established criteria is referred to as 'the Subtitle D Program'. The Subtitle D Program of RCRA seeks to improve solid waste management in the United States through funding of grants to states to support the development and implementation of state solid waste management plans. The plans were to be developed in accordance with guidelines promulgated under Sectin 4002(b) of RCRA on July 31, 1979 (44 FR 45066) (7). In accepting a subtitle D grant, the State agreed to develop a state plan which lays out a scheme for closing or upgrading existing open dumps (i.e., those facilities found to be in violation of the criteria) and to prohibit new open dumps. The state also was to agree to work toward development of regulatory power to implement the plan, i.e., to enforce the prohibition of new open dumps and the closure or upgrading of existing open dumps.

The program barely got off the ground when it fell victim to the budget cuts of federal programs under the Reagan Administration. Funds for the program were allocated in fiscal years 1980, and 1981 but they have since not been allocated and all subtitle D money has been depleted for two years. The result of this action is that during the past year only seven states have participated in the Open Dump inventory and reported results to the EPA. This is down from 49 states participating in the program during the first two years when the program was founded.

In the first published listing of 'open dumps' in 1981, twenty two (22) facilities were identified as open dumps based upon the bird/aircraft hazard. However, the inventory reflected only the initial efforts of the states in evaluating a small portion of the total facilities and the listing only represented a fraction of the total number of open dumps likely to exist. In addition, not all facilities reported were evaluated for all parts of the Criteria; failure to comply with any part of the Criteria resulted in their classification as an open dump. Therefore the number of facilities reported as bird/aircraft hazards do not accurately reflect the magnitude of the problem.

Reliance upon EPA guidance and funding for elimination of airport bird hazards associated with solid waste disposal facilities is not feasible. The conclusion is based upon the following observations:

(1) State solid waste management plans that adopt the federal criteria for properly operated facilities are not being required by EPA.

(2) State inspection and enforcement of landfill operations with respect to proper operations are dependent upon individual state resources and state emphasis. Without federal funding the states have historically not given landfill operation and bird hazards near airports a high priority.

(3) Even if a state has adopted an appropriate solid waste management plan and funds and inspection and enforcement program, the inspections are generally conducted by personnel not sensitive to the airport bird hazard and may not identify the existence of this type of hazard if inspection of facilities are infrequent. This is particularly true if a facility attracts birds only during a particular time of the year. It is also unlikely that inspections would identify facilities that are within the conical surfaces described by Aviation Regulations Part 77.

(4) Evaluation and identification of solid waste disposal facilities as bird/aircraft hazards is not conducted in a uniform manner and therefore a nationwide data base of problem facilities cannot be developed.

SUMMARY

Solid waste disposal facilities often attract birds when the refuse collected for disposal includes putrescible wastes. Bird strike data and other associated research have shown waste disposal facilities sites adjacent to airports are not a compatible land use. The attraction of large numbers of birds to these facilities substantially increases the bird strike hazard in the airport vicinity. The degree of hazard that can or will be developed as a result of a solid waste disposal facility near an airport is dependent upon a number of factors. These include the type of waste being disposed, location, method of disposal, types of birds attracted, season, etc. Historically, the reduction of bird hazards at airports has focused on scaring or killing the birds creating the hazard. These are temporary controls at best. Therefore, it is recommended that all existing landfills creating bird hazards to aircraft be closed and restrictions on future land use near airports be developed at the state and local levels.

The FAA developed criteria for identifying incompatible land use when solid waste disposal facilities are located within areas established for airport use. These criteria specify distances from the runways that must be maintained from landfill activities as well

as specifying conflicting airspace. The FAA Order 5200.5 was directed at airport authorities to notify them of FAA policy and encourage them to participate in promoting actions aimed at implementing compatible land use in the airport vicinity.

The EPA adopted the FAA criteria in its Criteria for Classification of Solid Waste disposal Facilities. The existence of a bird/aircraft hazard at a landfill site classifies the facility as an 'open dump' and therefore subject to state enforcement action to close the facility. The EPA program for identifying open dumps is called the "Subtitle D Program " and was funded for only two years, therefore most states have relaxed their efforts to identify open dumps and enforce their closure. Without the federal funds to support the open dump regulations, states are not obligated to adopt the program. So, presently there is not a national program for identifying or eliminating solid waste disposal facilities creating bird hazards in the United States.

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SUCCESSFUL CONTROL OF GULLS AND OTHER BIRDS AT A SANITARY LANDFILL

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ABSTRACT

Under some circumstances, it may be desirable to prevent gulls and other birds from concentrating at landfills and thereby reduce the risk of bird-aircraft collisions or other potential impacts on adjacent property. Between 17 September 1978 and 7 March 1980, data were collected on the occurrence of Ring-billed Gulls, Herring Gulls, Turkey Vultures, American Crows and European Starlings at a Maryland landfill. Control procedures involving pyrotechnics were implemented on 6 January 1979. The effectiveness of control procedures on the various species is discussed. The results demonstrate that gulls can be prevented from concentrating at a landfill as can the other species but persistence and dedication on the part of bird control personnel are required in order to succeed.

INTRODUCTION

The attractiveness of landfills to gulls is well documented. In the eastern United States, Herring Gulls (*Larus argentatus*) and Ring-billed Gulls (*L. delawarensis*) are regular visitants at landfills, particularly those within about 60 km of coastlines. The number of gulls foraging at these sites varies seasonally, with concentrations peaking during the nonbreeding season. Assemblages of thousands of gulls at landfills frequently create actual or potential problems for adjacent landowners, municipal water supplies and aircraft safety. In such cases, it may be desirable to reduce the numbers of gulls and other birds or even to keep the landfill environment completely free of foraging gulls.

In 1978, a new landfill opened in Prince George's County, Maryland near Bowie. The site was close to areas considered sensitive by a Federal agency and there was great concern about gulls being permitted to concentrate at the landfill and possibly impacting activities on the adjacent property. Although the concerns of the agency were not well founded, the company operating the landfill decided to implement a bird control program to ensure that a problem would not develop. This paper describes the procedures used and provides data for evaluating the success of the program.

The objectives of our study were: (a) to monitor the occurrence of all bird species at the landfill, (b) to implement a bird control program if the need arose, and (c) to evaluate the effectiveness of the control program.

METHODS

Between 17 September 1978 and 7 March 1980, two teams of two ornithologists spent 92 man-days at the landfill monitoring bird occurrence. The site was visited during every month of the year except May, June and July when gull occurrence was minimal or nil in the area. During most visits the team arrived at the landfill when it opened in the morning (07:00) and remained until the covering operations were completed at the end of the work day (ca. 17:00 on weekdays, 13:00 on Saturdays). Occasional visits also were made to the landfill on Sundays, when the site was not operational, to determine bird reaction to the area without equipment. Each member of the two-person team alternately served as observer and recorder. Most observations were made from a vehicle parked in the vicinity of the area where dumping was occurring that day.

At the end of each work day the garbage was thoroughly covered with a minimum of 15 cm of clay. This clean operating procedure minimized the amount of area suitable for foraging by gulls and other birds and simplified application of control measures, particularly in the case of gulls.

This landfill became operational during the summer of 1978. Our observations between 17 September 1978 and 5 January 1979 were in advance of any bird control measures and served to document the establishment of a population of foraging gulls. By early January it was apparent that the area was going to have a major concentration of gulls, particularly during November through March, unless control measures were started and diligently applied. The necessary State and Federal permits were obtained and the control program was begun on 6 January 1979.

A decision was made to rely on pyrotechnic devices (see H. Blokpoel 1976. Bird Hazards to Aircraft. Clarke, Irwin & Co.) because they caused fewer potential problems for equipment operators and they would be immediately effective. Problems were encountered, however, in obtaining shellcrackers from the supplier and they were not available when we desired to start the program. Rather than delaying the program and thereby allowing the gulls to become more accustomed to feeding at the landfill, we decided to use a 12-gauge shotgun with regular ammunition. The procedure of using shotshells provided us with the option of reinforcing our scarce tactics with the actual killing of an occasional bird and was provided for in the permits that were issued directly to W.E. Southern. Use of shotshells has several limitations: (a) the report of the weapon is near the ground where it is likely to be obscured by equipment noise, (b) it lacks the visual and concussion stimuli associated with shellcrackers that can be directed so as to explode near some birds, and (c) they are hazardous to use at a busy landfill. Shellcrackers were obtained by 16 March 1979, and were used in the 12-gauge weapon until 7 March 1980, when two Repel pistols were acquired for launching pyrotechnic devices.

We initiated control procedures and then turned the process over to the compactor operators at the landfill. Periodically we resumed use of the weapons in order to demonstrate more effective application of the devices. Until 7 March 1980, only one weapon was available, which limited the ability of the person responsible for control to adequately scare birds from his usual work location. Thereafter, two Repel pistols were available, which provided an opportunity for integrated control efforts by two persons at different locations.

Without question, Repel pistols are the preferred method of control from the operator's standpoint. Fewer problems result from use of this device than from either of the other two methods used. It is important that operators feel comfortable with the method they are using and the pistols achieved this goal. Operators became very hesitant to use live 12-gauge ammunition because of the recoil, the risks involved, and the difficulty associated with maneuvering the long barrel within the cab of their machine. Effective control suffered at times because of this. Shellcrackers also were a problem because they fouled the weapon's barrel thereby subjecting the firer of the weapon to the risk of flashburns. Repel pistols alleviated both of these problems and additionally operators found it easier to use this short weapon from their equipment with less interruption to their regular duties.

Initially operators were told to prevent gulls from landing and feeding at the site. Later this directive was expanded to include Turkey Vultures (Cathartes aura), Black Vultures (Coragyps atratus), American Crows (Corvus brachyrhynchos) and European Starlings (Sturnus vulgaris). We demonstrated the most effective use of pyrotechnics for controlling birds and encouraged equipment operators to be persistent in their application of the technique. Emphasis was placed on having the charges detonated in close proximity to some birds in a flock so that the concussion, visual and auditory stimuli were maximized. Random firing and firing in unnecessary volleys were discouraged. We did not, however, have direct control over the operators and great disparity existed in the day to day application of the techniques. Basically, however, the procedures were applied with sufficient consistency to achieve the desired result in the case of gulls.

RESULTS

Responses of Gulls

No gulls were recorded at the landfill between the time it became operational (about May 1978) and 10 November 1978. The first gulls were sighted on 11 November 1978, and although they circled overhead, none of these actually landed at the site (Table 1). In subsequent weeks, there was a substantial increase in the number of gulls sighted and a sizeable proportion of those observed actually landed and foraged at the landfill. The largest number of gulls recorded at the site occurred on 6 January 1979, the day we started the control program (Table 1). On this date, we recorded about 1333 gulls per hour of observation time.

From 6 January on, a sufficient number of shotshells (1-29/day, $\bar{x}$ 11.57) or later shellcrackers (1-93/day, $\bar{x}$ 45.0) were fired daily to discourage gulls from landing at the landfill. At the onset, this task was more difficult than later because the birds had become accustomed to feeding at the site and it was necessary to convince them to abandon what previously had been a good foraging area. We achieved this by showing a level of determination during bird control that was at least equal to the persistence the birds expressed while trying to feed at the site. A total of six gulls (4 on 6 January, 2 on 19 January) were killed during the early stages of the program but none were killed thereafter. The equipment operators who were assigned the bird control task considered it very demanding as it was an added duty and the methods used initially (i.e. shotshells) necessitated stopping their machine and using live ammunition around co-workers. It is possible, therefore, that their use of shotshells during our absence was not at the intensity we recommended. Nevertheless, the control effort resulted in a noticeable decline in the number of gulls observed per hour at the landfill between 6 January and 11 February

1979. The proportion of the gulls observed that circled or landed, however, remained similar to what occurred previously. Although the number of gulls associated with the landfill was significantly reduced, the equipment operators were not preventing some gulls from landing and the few that did served as attractants to passing gulls that investigated the site by circling overhead. On 10 and 11 February, we temporarily took over the control procedures and demonstrated the effectiveness of directing the control effort at the more persistent gulls. Our efforts resulted in two days during which no gulls landed at the landfill, the first since 17 November 1978 (Table 1). Having shown the operators that a bird-free landfill was possible, we returned responsibility for bird control to them. Unfortunately, however, the equipment operators were tiring of using the shotgun and shotshells and their dissatisfaction peaked around 5 March which is revealed by the 17-fold increase in the number of gulls recorded at the landfill (Table 1). At this time, about 61% of the gulls observed were actually landing at the landfill.

By 16 March a shipment of shellcrackers arrived and the effectiveness of the bird control program again improved. This was the turning point in the program and from this date on the number of gulls visiting the site never approached that recorded in early January 1979. Since pyrotechnic devices were first used, very few gulls have landed at the site and those that did were present for only a few minutes (Table 1). These procedures have continued into 1984 and the level of effectiveness is reported to be consistent with that shown here (pers. comm. Waste Management personnel).

The data collected between the onset of control measures on 6 January 1979 and the termination of our study (8 March 1980) document that gulls can be discouraged from foraging at a landfill and the number of gulls passing or visiting the site also can be reduced significantly. Once a gull-free site is achieved, considerably less effort is required to keep it that way. Through diligent use of pyrotechnics, the procedure can have long-term effectiveness. Although the methods described will not prevent some gulls from entering the air space over the landfill, they will significantly reduce the numbers doing so. Gulls accustomed to foraging at landfills appear to be attracted by the equipment and will check out the site when passing, possibly while en route to other foraging areas. Without other gulls on the ground, and ideally without any foraging birds of other species being present, most gulls investigating the site for the first time are hesitant to land. Such individuals are relatively easy to discourage from remaining around the site.

The activities of gulls at a landfill are energy related. Unless they are able to get a return for their investment in time spent, it becomes increasingly unlikely that they will continue to include an isolated landfill site in their foraging itinerary. Success of a program is dependent, therefore, on preventing all gulls from having an opportunity to feed at the landfill.

To achieve a gull-free landfill operation, the gull control personnel fired up to 93 rounds of pyrotechnic devices per day. Usually, however, the number of shots required daily was considerably less (less than 10 shots/day on 56.5% of the observation dates; 10-20 shots, 26.1% of dates; 21-30 shots, 8.7% of dates; more than 31 shots, 8.7% of dates). Not infrequently the compactor operators fired more shellcrackers than necessary. The technique is far more effective if a few shellcrackers are properly timed and positioned to maximize their effect on birds attempting to land.

Responses of Other Bird Species

Vultures (Black and Turkey), American Crows and European Starlings also occurred at the landfill but their numbers never approached those of gulls. These species differed greatly with respect to their behavior at the landfill but all attempted to forage at some time during the study and periods existed during which noticeable increases in population sizes occurred. Because gulls appeared to be more likely to attempt a landing if other birds were present at the site, we decided to discourage the activities of all other birds in the vicinity of the working face of the landfill (i.e. the site where garbage delivered that day is deposited). Our goal, however, was not to prevent these species from occurring anywhere on the property as this would have required someone other than the compactor operators to be involved in bird control. Consequently the data presented are not comparable with that given for gulls in Table 1.

Turkey and Black Vultures seldom attempted to forage at the landfill during operating hours. They regularly soared over portions of the landfill site or over neighboring property. In the afternoon, however, they often spent more time in the vicinity and it soon became apparent that they were awaiting departure of the equipment. After the covering operation was completed for the day and human activity was minimal, several vultures often landed and gleaned the newly covered area for items that were inadequately covered. From their behavior during the day, it seemed that they were attracted to the area by olfactory cues. Conditions were never optimal for foraging by this species, however, as the daily covering process was very thorough and expanses of exposed garbage did not accumulate as happens at some landfills.

The number of vultures recorded per hour during the project exceeded that initially recorded (16 October 1978) on only five occasions (Table 2). Four of these occasions were on successive census dates in late summer and early fall (17&18 Aug., 10&14 Sept. 1979), and the other was a few weeks later on 12 October. At this time vultures were establishing a nocturnal roost site in a deciduous woodland bordering the landfill. On 14 September, after the highest number of vultures recorded in the area on a single day had been logged, we decided to disperse the birds from the roost site. We fired two shellcrackers amongst the first birds entering the roost on 14 September, which had a noticeable effect on the number recorded during the remainder of that day as well as on the following day (Table 2). On 15 September, we fired one shellcracker at the first vultures to arrive which prevented any from using the site that night. Since the operators did not continue this effort during our absence, a number of vultures were again using the roost when we returned on 12 October. Six shellcrackers were used that evening and this was sufficient to discourage them from attempting to resume roosting attempts on the property. As can be seen in Table 2, there was a noticeable decline in the number of vultures that circled over the site or landed on the property after 12 October. It is very likely that the intensive use of pyrotechnics to prevent gulls from visiting the site also discouraged vultures from approaching the site. These data suggest that it would be relatively easy to control the occurrence of vultures at a landfill through use of pyrotechnics, but some after-hours attention to bird occurrence may be necessary.

The situation was not the same in the case of crows and starlings, however. Both of these species were more abundant toward the end of the project than they had been at the onset, although the influx of starlings appeared seasonal since the numbers also increased in January and February 1979. Between 8 December 1979 and 9 February 1980, these species were regular visitors at the landfill (Tables 3 and 4). There were sizeable increases in the number of each species observed at the landfill site and the number actually landing at the site. This occurred although the gull program was in full operation and was successfully deterring both Ring-billed and Herring Gulls from foraging.

Unless control efforts are directed at individuals of particular species, thereby assuring that they are exposed to the full effect of the technique (in this case pyrotechnics), some birds become acclimated to the procedure and are not dispersed by it. On 8 February 1980, we directed our control efforts at these two species, as well as at gulls, to determine if we could prevent them from foraging. Twenty shotshells were fired at crows and starlings on this date, primarily to scare them but 13 individuals were killed (3 crows, 10 starlings). On 9 February we continued the program but only four shotshells were necessary (1 starling killed). We then assigned the job of controlling these species as well as gulls to the equipment operators. On 7 and 8 March 1980, no starlings were frequenting the landfill and the number of crows observed and landing had decreased significantly (Tables 3 and 4). The results again show that an intensive effort can discourage birds from using a site, even one as attractive as a landfill face, for foraging.

On the basis of our experiences and the data presented in this paper, we are convinced that it is possible to discourage bird occurrence at landfills and other sensitive sites through the proper use of pyrotechnic devices, such as shellcrackers. Persons applying the control measures must be conscientious and assure that birds are subjected to the maximum intensity stimuli produced by the devices. A manual prepared for Waste Management, Inc. after this project is used by the company to assist their personnel with development of bird control programs.

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TABLE 1. Gull Occurrence at a New Landfill Before and During Control Efforts.

Date	Gulls Obs/Hr	% Passed Site	% Circled or Meandered	% Landed to Forage
17 Sep. 1978	0	0	0	0
16 Oct.	0	0	0	0
27 Oct.	0	0	0	0
3 Nov.	0	0	0	0
10 Nov.	0	0	0	0
11 Nov.	2.50	0	100.00	0
17 Nov.	25.05	0	50.42	49.58
18 Nov.	66.72	39.61	59.95	0.44
24 Nov.	308.14	0	41.08	58.92
5 Jan. 1979	1006.33	0	37.26	62.74
6 Jan. ∇	1332.92	7.64	54.41	37.95
19 Jan.	260.56	2.13	34.92	62.94
20 Jan.	41.33	0	43.55	56.45
9 Feb.	32.00	0	75.63	24.37
10 Feb.	31.57	24.42	75.58	0
11 Feb.	26.23	25.43	74.57	0
5 Mar.	438.47	7.89	31.29	60.82
16 Mar. ∞	121.16	19.26	75.79	4.95
17 Mar.	106.57	0	82.44	17.56
30 Mar.	0.58	50.00	0	50.00
31 Mar.	3.00	0	100.00	0
13 Apr.	18.72	0.96	98.08	0.96
14 Apr.	44.33	36.09	63.91	0
17 Aug.	0.60	0	100.00	0
18 Aug.	0	0	0	0
10 Sep.	0	0	0	0
14 Sep.	5.60	95.18	4.82	0
15 Sep.	0	0	0	0
12 Oct.	0.12	0	100.00	0
13 Oct.	22.50	95.56	2.22	2.22
8 Dec.	65.33	78.57	21.26	0.17
9 Dec.	0.89	75.28	24.72	0
10 Dec.	10.60	45.13	54.87	0
19 Dec.	11.80	20.93	76.02	3.05
20 Dec.	31.85	55.56	44.44	0
11 Jan. 1980	38.91	64.48	35.52	0
12 Jan.	48.66	68.29	31.71	0
8 Feb.	17.72	50.00	50.00	0
9 Feb.	17.45	52.09	47.91	0
7 Mar. Ψ	146.50	65.52	34.48	0
8 Mar.	151.56	56.45	43.55	0

∇Control measures started using 12 ga. shotshells.
∞Began using shellcrackers.
ΨStarted using Repel pistol.

TABLE 2. Vulture Occurrence at a New Landfill Before and During Control Efforts.

Date	Vultures Obs/Hr	% Passed Site	% Circled or Meandered	% Landed to Forage
17 Sep. 1978	0	0	0	0
16 Oct.	5.00	36.40	9.00	54.60
27 Oct.	2.73	61.54	38.46	0
3 Nov.	1.52	87.50	0	12.50
10 Nov.	4.25	47.06	52.94	0
11 Nov.	2.25	55.56	44.44	0
17 Nov.	4.42	0	0	100.00
18 Nov.	8.14	61.43	0	38.57
24 Nov.	0	0	0	0
5 Jan. 1979	0	0	0	0
6 Jan. ∇	0.55	100.00	0	0
19 Jan.	0	0	0	0
20 Jan.	0	0	0	0
9 Feb.	0.40	50.00	50.00	0
10 Feb.	0.85	83.53	16.47	0
11 Feb.	1.77	24.86	24.86	50.28
5 Mar.	1.20	100.00	0	0
16 Mar. ∞	0	0	0	0
17 Mar.	2.14	0	100.00	0
30 Mar.	2.29	100.00	0	0
31 Mar.	0	0	0	0
13 Apr.	3.45	63.19	36.81	0
14 Apr.	0.67	100.00	0	0
17 Aug.	7.20	44.44	44.44	11.12
18 Aug.	13.40	61.19	0	38.81
10 Sep.	52.00	0	50.00	50.00
14 Sep.	6.14	0	43.49	56.51
15 Sep.	1.00	20.00	0	80.00
12 Oct.	7.04	37.93	37.93	24.14
13 Oct.	0	0	0	0
8 Dec.	3.11	100.00	0	0
9 Dec.	0.22	100.00	0	0
10 Dec.	0.13	0	100.00	0
19 Dec.	1.09	100.00	0	0
20 Dec.	1.38	100.00	0	0
11 Jan. 1980	0.91	100.00	0	0
12 Jan.	3.94	78.17	0	21.83
8 Feb.	1.57	91.08	8.92	0
9 Feb.	0	0	0	0
7 Mar. Ψ	3.5	100.00	0	0
8 Mar.	0.22	100.00	0	0

∇Control measures started using 12 ga. shotshells.
∞Began using shellcrackers.
ΨStarted using Repel pistol.

TABLE 3. Crow Occurrence at a New Landfill Before and During Control Efforts.

Date	Crows Obs/Hr	% Passed Site	% Circled or Meandered	% Landed to ForageΦ
17 Sep. 1978	0	0	0	0
16 Oct.	5.91	100.00	0	0
27 Oct.	7.57	75.03	0	24.97
3 Nov.	15.43	91.38	0	8.62
10 Nov.	1.00	100.00	0	0
11 Nov.	8.00	96.88	0	3.12
17 Nov.	1.05	80.00	0	20.00
18 Nov.	7.57	88.64	0	11.36
24 Nov.	0.29	0	0	100.00
5 Jan. 1979	0.83	0	100.00	0
6 Jan. ∇	2.18	8.26	0	91.74
19 Jan.	2.22	40.09	0	59.91
20 Jan.	0.44	0	0	100.00
9 Feb.	0	0	0	0
10 Feb.	3.15	72.70	0	27.30
11 Feb.	0.88	50.00	0	50.00
5 Mar.	0.20	100.00	0	0
16 Mar. ∞	0	0	0	0
17 Mar.	0.29	0	100.00	0
30 Mar.	0.86	66.28	0	33.72
31 Mar.	5.00	100.00	0	0
13 Apr.	7.27	74.97	0	25.03
14 Apr.	8.50	84.35	0	15.65
17 Aug.	4.80	50.00	25.00	25.00
18 Aug.	2.00	70.00	0	30.00
10 Sep.	0	0	0	0
14 Sep.	2.26	41.15	58.85	0
15 Sep.	0.60	100.00	0	0
12 Oct.	9.45	100.00	0	0
13 Oct.	1.50	83.33	0	16.67
8 Dec.	26.44	68.49	0	31.51
9 Dec.	133.79	35.55	1.17	63.28
10 Dec.	43.33	46.46	0	53.54
19 Dec.	91.15	84.71	0	15.29
20 Dec.	78.92	20.86	0	79.14
11 Jan. 1980	10.9	13.30	0	86.70
12 Jan.	31.42	0	0	100.00
8 Feb.	82.29	56.94	0	43.06
9 Feb.	36.73	49.50	0	50.50
7 Mar. Ψ	13.50	100.00	0	0
8 Mar.	6.00	92.67	0	7.33

∇Control measures started using 12 ga. shotshells.
∞Began using shellcrackers.
ΨStarted using Repel pistol.
ΦAnywhere on excavation or in perimeter trees; not just working face.

TABLE 4. Starling Occurrence at a New Landfill Before and During Control Efforts.

Date	Starlings Obs/Hr	% Passed Site	% Circled or Meandered	% Landed to ForageΦ
17 Sep. 1978	0	0	0	0
16 Oct.	10.00	100.00	0	0
27 Oct.	0	0	0	0
3 Nov.	13.14	100.00	0	0
10 Nov.	11.75	100.00	0	0
11 Nov.	1.00	100.00	0	0
17 Nov.	8.42	100.00	0	0
18 Nov.	2.71	100.00	0	0
24 Nov.	0	0	0	0
5 Jan. 1979	66.67	25.00	0	75.00
6 Jan. ∇	62.73	0	0	100.00
19 Jan.	53.33	0	0	100.00
20 Jan.	22.22	0	0	100.00
9 Feb.	74.80	1.07	16.58	82.35
10 Feb.	24.00	91.08	0	8.92
11 Feb.	45.78	0	0	100.00
5 Mar.	0.40	100.00	0	0
16 Mar. ∞	5.50	0	0	100.00
17 Mar.	0	0	0	0
30 Mar.	0.29	100.00	0	0
31 Mar.	2.00	100.00	0	0
13 Apr.	34.55	80.00	5.79	14.21
14 Apr.	5.17	80.66	0	19.34
17 Aug.	0	0	0	0
18 Aug.	0	0	0	0
10 Sep.	0	0	0	0
14 Sep.	0	0	0	0
15 Sep.	0	0	0	0
12 Oct.	0	0	0	0
13 Oct.	0	0	0	0
8 Dec.	58.89	37.73	0	62.27
9 Dec.	133.33	50.00	0	50.00
10 Dec.	25.34	57.89	0	42.11
19 Dec.	22.87	23.13	0	76.87
20 Dec.	18.16	32.21	0	67.79
11 Jan. 1980	37.27	73.17	0	26.83
12 Jan.	24.57	0	0	100.00
8 Feb.	282.14	29.62	9.11	61.27
9 Feb.	160.00	29.54	0	70.46
7 Mar. Ψ	0	0	0	0
8 Mar.	0	0	0	0

∇Control measures started using 12 ga. shotshells.
∞Began using shellcrackers.
ΨStarted using Repel pistols.
ΦAnywhere on excavation or in perimeter trees; not just working face.

EFFECTIVENESS OF AN OVERHEAD WIRE BARRIER IN DETERRING GULLS FROM FEEDING AT A SANITARY LANDFILL

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ABSTRACT

On behalf of Browning-Ferris Industries (BFI), we assessed the effectiveness of fine parallel overhead wires in deterring herring and ring-billed gulls from landing at an active sanitary landfill in Niagara Falls, N.Y. BFI was responsible for design and installation of the wire system; LGL Ltd. was responsible for the study of wire effectiveness from January to December 1983. The study design consisted of alternating periods with and without wires over the active portion of the test landfill, plus control observations at two other landfills.

Overhead wires at 12 m (40 ft) spacing deterred most herring gulls from feeding. Ring-billed gulls were largely deterred by wires at 12 m spacing when limited garbage was present, but penetrated wires at 12 m spacing when attracted by large amounts of garbage. Wires at 6 m (20 ft) spacing deterred most ring-billed gulls in late spring even with large amounts of garbage present. In summer, when peak numbers of gulls visit landfill sites in the area, numbers of feeding ring-billed gulls were substantially reduced by wires 6 m apart, but the deterrent effect was less marked than at other seasons. A large proportion of gulls feeding under the wires in summer were young-of-the-year.

INTRODUCTION

Many species of gulls are opportunistic feeders and most sanitary landfills attract gulls at one time or another. At sites receiving large quantities of household refuse, it is usually impossible to cover the refuse quickly enough to prevent gulls from feeding.

Exclusion of gulls from sanitary landfills is desirable for a number of reasons. Gulls often carry refuse away and deposit uneaten items elsewhere, creating both a nuisance and a potential health hazard. When a landfill is near an airport, gulls feeding at the landfill can be a significant hazard to aircraft (Blokpoel 1976). In the Great Lakes area, the explosive population growth of the ring-billed gull _Larus delawarensis_ (Blokpoel 1983) with attendant nuisance and, in some areas, hazard to aircraft problems, has been attributed at least partly to the availability of man-made food.

Most attempts to deter gulls from feeding at santiary landfills are only partially successful and the methods available are usually labor-intensive and expensive (e.g. scaring) or impractical (e.g. night dumping). The development of a cheap, effective method of deterrence would have wide applicability. Anecdotal evidence suggested that overhead wires could be such a method.

Overhead wires have been used at some fish hatcheries for many years to protect the fry (McAtee and Piper 1936) but only within the last few years have wires been used in other areas. Widely-spaced wires have been used to exclude gulls from reservoirs in California (Amling 1980) and two urban parks in Toronto, Ontario (Blokpoel and Tessier 1984). Unpublished accounts suggest that wires have successfully excluded gulls from sanitary landfill sites in California (Ichikawa 1981; Wyeth 1982). However, the attraction of gulls to the California site visited by Wyeth may have been low since it was 31 km inland. Numbers of gulls present before and after wires were installed are not known for either California site. Wire spacing over the reservoirs, parks and landfills ranged from 2.5 m to 35 m. Thus, the wires apparently constitute a 'psychological' rather than a physical barrier to gulls.

The present study was designed to determine, over a 1 yr period, the effectiveness of overhead wires at an active sanitary landfill site about 2.5 km from both the Niagara Falls International Airport and the Niagara River, a noted concentration area for gulls. We used an experimental approach to determine an appropriate configuration for the wires and to measure the effectiveness of the wire barrier. This was the first systematic test of wire effectiveness as a deterrent to gulls at an active sanitary landfill.

This study was funded by Browning-Ferris Industries of New York, Inc. Inquiries regarding physical aspects of wire usage should be directed to Brian F. Swartzenberg, BFI Buffalo District, 2321 Kenmore Ave., Buffalo, N.Y. 14207 (phone 716-873-7500). We thank BFI and we also thank V.E.F. Solman, formerly of Canadian Wildlife Service, Ottawa for suggesting and R.K. Wyeth of Recra Research, Inc. for developing the use of a wire barrier system.

METHODS

The study was conducted from 29 Dec 1982 to 30 Dec 1983 at BFI's Pine Avenue site in Niagara Falls, N.Y. Gulls are present year round in the Niagara region. On the BFI site, herring gulls (Larus argentatus) predominated in the periods 29 Dec 1982 to 25 Jan 1983 and 22 Oct to 30 Dec 1983. Ring-billed gulls predominated from 20 Feb to 21 Oct 1983. No gulls were on the BFI site from late January to late February, although some gulls were in the area throughout the winter.

The experimental design involved counting gulls during several alternating periods with the wires in place followed by periods with no wires, along with simultaneous counts at control landfills without wires. Each replicate was intended to include one week without wires followed by three weeks with wires. If the wires are effective, gull numbers should decrease each time the wires are installed and increase each time they are removed. In addition to this series of wires up/wires down cycles, the wires were to be in place for a final period of several months to assess whether habituation occurred. The actual procedure varied somewhat from this design because of logistical factors. The wires were in place for four periods varying in length from three weeks to 4.5 months; periods without wires varied from two weeks to one month (see Tables 1 and 3).

Wires covered only the active sanitary landfill (hereafter ASL), a trapezoidal area measuring approximately 300 m by 150-180 m. Areas adjacent to the ASL are part of the BFI site but received no putrescible waste and were not covered by wires. The wires were 0.8 mm (0.032 in) in diameter and spanned the 300 m dimension of the ASL. Monofilament was used initially but was replaced by wire because of frequent breakage. Each wire was supported about 10 m above the ASL by two metal poles. The poles were telescopic to allow increased height as the level of the ASL rose.

Nominal spacing between adjacent wires was originally 12 m (40 ft) but this was reduced to 6 m (20 ft) for the third and fourth periods with the wires in place because of the ease with which ring-billed gulls were able to penetrate the 12 m spaces. Actual spacing between adjacent wires approximated the 12 or 6 m nominal spacing in most cases. However, problems with pole placement resulted in spaces wider than 12 m over the east side of the ASL during the second period with the wires in place. A storm in late October felled several poles, with the result that all spaces were 12 m or more for the last six weeks of the fourth period. In addition to the parallel overhead wires, we used various arrangements of horizontal wire or monofilament at lower levels around the perimeter of the ASL. These wires were attached between adjacent poles in attempts to prevent gulls from reaching the ASL by flying between poles below the level of the overhead wires.

Gulls on the ASL and adjacent loafing areas were counted several times per day on seven days per week from 29 Dec 1982 to 15 Mar 1983 and on three to six days per week from 15 Mar to 30 Dec 1983. Gulls circling overhead were also counted. In addition, we counted gulls at two control landfills (North Tonawanda and Modern Disposal), both located within 15 km of the BFI site, twice per week between the hours of 1030 and 1530 EST.

In the presentation of the results, we use four daily counts from the BFI site. These counts are (1) the daily maximum on the whole BFI site, (2) the daily maximum on the ASL, (3) the midday (1030-1530 EST) count on the whole BFI site and (4) the midday count on the ASL. The midday counts are used for comparison with counts at control sites. Statistical comparisons were made with the Mann-Whitney U-test.

One factor that affects numbers of gulls on a landfill site is the amount of edible refuse present. Most household refuse in the Niagara area is burned at an Energy From Waste (EFW) plant. When the plant is operating, very little edible refuse is brought to either our experimental site or the North Tonawanda site. This was the case from 27 Dec to 17 Mar and again from 11 Oct to 30 Dec. During these two periods we arranged to have about 20 T of household garbage per day diverted from the EFW plant to the BFI site to provide at least a minimum amount of edible waste. From 18 March to 11 October, the EFW plant operated at capacity only intermittently, and large quantities of edible refuse were available regularly at both the BFI site and the North Tonawanda control site.

The second control site (Modern Disposal) was not licensed to receive putrescible waste and we have no definite information about what was dumped there. However, our observations of gulls on this site suggest that edible material was often present.

RESULTS AND DISCUSSION

Ring-billed Gull

The ring-billed gull was the dominant species (>90%) of gull on the BFI site from 22 Feb to 21 Oct 1983. During this period the wires were in place three times: 1 Mar-1 Apr, 16 Apr-24 June and 25 July-21 Oct. From 1 Mar to 1 Apr, spacing between wires was 12 m. The wires were reinstalled at 12 m spacing on 16 Apr and spacing was reduced to 6 m between 16 and 22 Apr. Spacing then remained at 6 m until 24 June. Spacing was also 6 m from 25 July to 24 Oct.

Number of Gulls on the Site. -- Migrating ring-billed gulls arrived in the Niagara Falls area in late February when the wires were absent. Numbers of gulls on the BFI site rapidly increased from zero to a maximum of 650 on 25 February. The mean daily maxima during the last week of February were 338.6 gulls on the site and 297.1 gulls on the ASL (active sanitary landfill; Table 1). During the first half of March, with wires in place at 12 m spacing, the mean daily maxima were 61.3 and 15.8 gulls, respectively (Table 1). The reduction was attributable to the wires, since numbers at both control sites increased from late February to early March (Fig. 1).

On 17 Mar the EFW plant ceased operation and large quantities of edible refuse began arriving at the BFI site and the North Tonawanda control site daily. Presumably in response to the much larger amount of edible refuse present, gull numbers at the BFI site increased in late March (mean daily maxima of 103.6 on the ASL and 276.2 on the whole site). However, the wires were apparently still having an effect, since numbers at the North Tonawanda control site increased to a much greater extent (Fig. 1).

Wires were absent during early April and were reinstalled at 12 m spacing on 16 Apr. Spacing was reduced to 6 m by addition of new poles and wires between 16 and 22 Apr. While the wires were absent, the maximum daily counts were over 300 gulls on the whole BFI site and over 150 gulls on the ASL. Numbers decreased when wires were reinstalled at 12 m spacing but the reduction was much greater after 6 m spacing was achieved. From late April through June with wires at 6 m spacing, the mean daily maximum was 71.6 on the whole site and 25.6 on the ASL. These numbers were lower than numbers at control sites, particularly North Tonawanda (Fig. 1).

The wires were again removed at the BFI site on 24 June. Numbers on both the site and the ASL increased dramatically (Table 1). Numbers on both control sites also increased in early July but to a much lesser extent than numbers at the BFI site (Fig. 1). This increased use of landfill sites in July was expected based on an earlier study (LGL Ltd. 1974). However, the greater increase at the BFI site when the wires were removed is noteworthy. Ring-billed gulls hatched in 1983 did not contribute substantially to the initial increase in numbers at the BFI site after the wires were removed. Only seven young-of-the-year were identified on the site up to 7 July. Hatch at the Niagara River colonies began about 17 May (pers. obs.) and the peak of fledging probably occurred about 1 July.

On 8-24 July, in the absence of wires, the mean daily maxima were 3607.1 gulls on the whole BFI site and 800.0 on the ASL. From 25 July to 4 Sep, the wires were in place at 6 m spacing, and numbers declined by 33% and 68%,

TABLE 1

Numbers of ring-billed gulls on the BFI site during periods with and without wires. Based on daily maximum counts.

Date	No. of gulls	
	Active landfill	Whole site
No wires		
22-28 Feb	297.1	338.6
Wires up--12 m		
1-17 Mar	15.8	61.3
18 Mar-1 Apr[1]	103.6	276.2
No wires		
2-15 Apr	222.7	395.8
Wires up		
16-22 Apr--12 m	92.0	183.4
23 Apr-24 Jun--6 m	25.6	71.6
No wires		
25 Jun-7 Jul	432.5	1389.3
8-24 Jul	800.0	3607.1
Wires up--6 m		
25 Jul-4 Sep	254.8	2433.1
5 Sep-21 Oct	116.3	712.8

[1] Large volumes of household refuse came to the site daily after 17 March. Prior to 17 March only small amounts of edible refuse arrived each day.

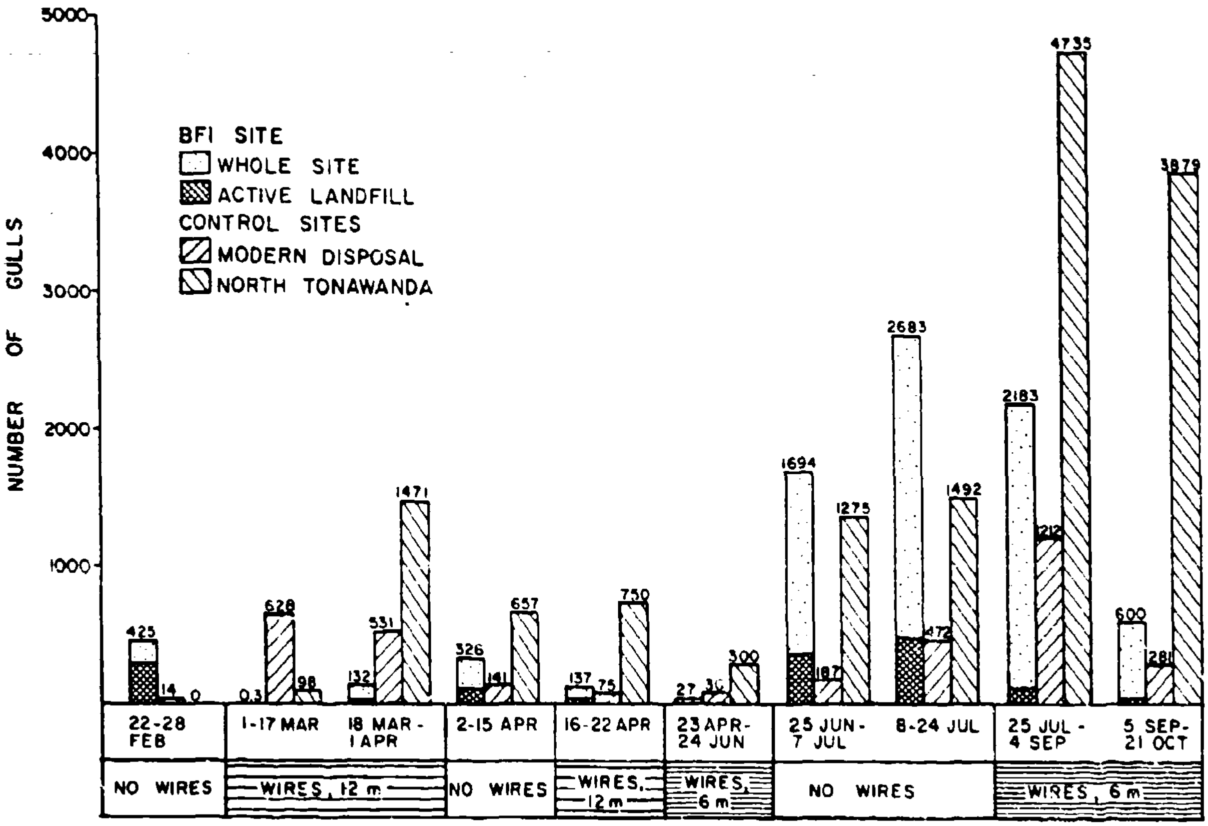
respectively, to 2433.1 and 254.8. In contrast, numbers at both control sites increased by a factor of three over the same period (Fig. 1). Through September and October, numbers of gulls at both the BFI site and control sites decreased as ring-billed gulls began migration south to wintering areas; numbers on the ASL were again low compared to numbers on the whole BFI site and on the control sites (Fig. 1).

Many of the gulls that penetrated the wires during the late summer period were young-of-the-year. We estimated that young gulls rarely comprised less than 20% and frequently comprised 50% or more of the individuals under the wires. Young gulls averaged only 9.8% of the gulls on the whole site in late summer.

Test of Wire Effectiveness.--To test whether the wires had a significant deterrent effect against ring-billed gulls, we used the Mann-Whitney U test to compare numbers of gulls on the BFI site during periods with and without wires. We used counts at control sites to standardize data from the BFI site for seasonal variation in gull numbers. The midday counts at the ASL and on the whole BFI site were divided by the midday count at a control site for that day. Ratios during a period with wires were then compared with rati[illegible] during adjacent periods without wires (Table 2). Days when there were [illegible]ulls at neither the BFI site nor the

FIGURE 1.

Numbers of ring-billed gulls at the BFI site compared to numbers at two control sites for periods with and without wires. Bars for the BFI site are based on counts made near midday on days when counts were made at control sites.



respective control site were excluded. When the denominator was zero, i.e. no gulls at the control site but gulls at the BFI site, we treated the ratio as larger than any calculated value. These cases were all treated as ties in the ranking procedure for the Mann-Whitney U test.

Substantial numbers of ring-billed gulls came to the BFI site as a whole when wires were in place at 12 m spacing in March, especially during the second half of the month (mean midday count of 132.0 gulls, Fig. 1). Nevertheless, gull numbers at both control sites were much larger. The standardized numbers of gulls at the BFI site were much smaller during March than during the adjacent periods without wires. For example, the BFI/Modern Disposal ratio for the whole site was 2.65 without wires but only 0.24 while the wires were in place. Similarly, the BFI/North Tonawanda ratio for the whole site was 0.61 without wires but 0.13 with wires. Regardless of which control site was used to standardize the data, gull numbers on both the active landfill and the whole BFI site were significantly lower when the wires were in place at 12 m spacing during March than when wires were absent during adjacent periods (Table 2).

TABLE 2

Statistical comparisons of numbers of gulls during periods with and without wires. Counts were standardized for seasonal effects by dividing counts at the BFI site by the count at a control landfill (North Tonawanda or Modern Disposal) on the same date.

	12 m spacing R-b. gull dominant[1]		6 m spacing R-b. gull dominant[2]		12 m Spacing Her. gull dominant[3]	
	Whole site	Active landfill	Whole site	Active landfill	Whole site	Active landfill
BFI/Modern Disposal						
Ratio with wires	0.24	0.05	1.84	0.08	0.60	<0.01
Ratio without wires	2.65	1.37	5.83	1.23	3.78	2.17
N_1, N_2[4]	12,5	11,5	42,12	32,11	10,4	10,3
Mann-Whitney U	1	6.5	182.5	12.5	3	6.5
Probability level	<0.002	<0.02	NS	<<0.001	0.02	NS
BFI/North Tonawanda						
Ratio with wires	0.13	0.02	0.31	0.01	0.07	<0.01
Ratio without wires	0.61	0.32	1.36	0.29	0.79	1.56
N_1, N_2	12,5	10,5	47,12	47,12	15,8	15,6
Mann-Whitney U	2	6	60	39	16.5	16
Probability level	<0.002	0.02	<<0.001	<<0.001	<0.02	<0.02

[1] The period with wires (1 Mar-1 Apr 1983) was compared to periods lacking wires (22-28 Feb 1983, 2-15 Apr 1983).

[2] Periods with wires (23 Apr-24 June 1983, 25 July-21 Oct 1983) were compared to periods lacking wires (2-15 Apr 1983, 25 June-24 July 1983).

[3] Periods with wires (18 Jan-6 Feb 1983, 28 Oct-15 Dec 1983) were compared to periods lacking wires (9-17 Jan 1983, 7-18 Feb 1983, 16-30 Dec 1983 for North Tonawanda; 9-17 Jan 1983, 7-18 Feb 1983 for Modern Disposal).

[4] N_1 represents counts with the wires in place; N_2 counts without wires.

The two periods with wires at 6 m spacing were analyzed together. There was a highly significant difference in gull numbers on the whole BFI site for periods with versus without wires when counts at North Tonawanda were used as the basis for standardization. The difference was not significant when counts at Modern Disposal were used as the basis for standardization, largely because gulls used Modern Disposal only intermittently during May and June. Regardless of which control site was used as the basis of standardization, gull numbers on the ASL at the BFI site were significantly lower during periods with wires in place at 6 m spacing ($P << 0.001$; Table 2).

Behavior and Habituation. -- Gulls often become habituated to active deterrent techniques such as scaring. Some habituation apparently did occur when the wires were spaced at 12 m in March. Ring-billed gulls appeared to learn that they could penetrate 12 m spaces without danger. Numbers on the ASL increased and gulls spent a larger proportion of the day loafing on areas adjacent to the ASL toward the end of March.

However, gulls apparently did not become accustomed to wires at 6 m spacing. Although fairly large numbers of gulls did penetrate the barrier in summer, the wires affected both the hourly pattern of use of the ASL and the behavior of the gulls while on the ASL. When wires were absent, at least a few gulls fed and many gulls loafed on the ASL at most times of day. With wires in place, gulls did not loaf on the ASL itself but arrived from adjacent loafi - areas to feed three or four times per day. In the absence of wires c ing , gulls began to feed in early morning. Wires were reinstalled .. ly. Through August and September, feeding tended to begin progressive later in the day.

Besides chang ng their feeding pattern, ring-billed gulls also responded differently to vehicles after the wires had been in place for some time. In the absence of wires, only gulls directly in the path of a vehicle usually flushed and these birds merely flew a few metres to the side and landed again. When wires were overhead, a vehicle moving through a group of gulls caused the whole group to flush and usually to leave the ASL at least temporarily. When more than one group of gulls was on the ASL, the flushing of one group often resulted in the flushing of all groups. This response became more consistent in late August and September when the wires had been in place for several weeks.

Since use of the wire barrier was intended to reduce the gull hazard to aircraft using the Niagara Falls airport, we also counted gulls circling over the BFI site. Gulls attempting to reach the ASL through the wires sometimes circled just above wire level but these birds rarely spiralled upwards. We saw gulls at altitudes greater than 100 m above ground much more frequently when wires were absent than when they were present and we saw gulls above 300 m only when wires were absent.

Although no individual gulls were marked, the pattern of feeding in only 3-4 bouts per day suggests that some gulls on the site in late summer loafed but did not feed there. On most days in August and September, the maximum number of gulls on the ASL during a feeding bout was 300 or less. During a feeding bout there was little interchange of gulls between the ASL and surrounding loafing areas. Even if each gull fed during only one feeding bout per day, only about 1200 gulls could have fed at the ASL on one day. On most days in August, over 2000 gulls loafed on the site (Table 1). Moreover, the estimate of 1200 gulls obtaining food on the ASL each day is probably excessive. During most feeding bouts 25-50% of the gulls under the wires were young-of-the-year, even though the average number of young on the site each day was only about 200 during late summer. Thus, young gulls seemed more persistent and perhaps more successful than adults in their attempts to penetrate the wire barrier.

The young of many species of gulls are less efficient and less successful than adults in obtaining food (e.g., Verbeek 1977; Searcy 1978). The fact that we observed young ring-billed gulls to be proportionately more successful than older gulls in penetrating the wire barrier suggests that penetration of the barrier is not primarily a learned skill. Rather, older gulls probably have learned to be wary of unusual situations such as the unexpected appearance of a fine wire as they descend to feed. In addition, the food requirements of young gulls and, therefore, their motivation for penetrating the wires, are likely higher than those of adults. Whether gulls that first encounter the wires as fledglings will penetrate the barrier as adults remains unknown.

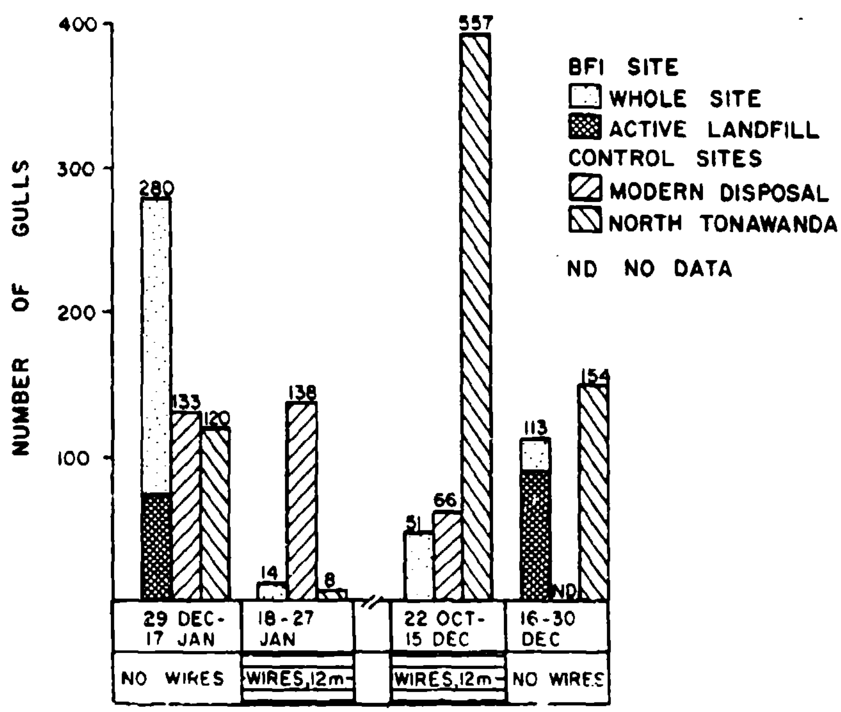
Herring Gull

Herring gulls predominated on the BFI site during two periods--29 Dec 1982 to 25 Jan 1983 and 22 Oct to 30 Dec 1983. These periods encompassed the control period before the wires were installed for the first time (29 Dec 1982-17 Jan 1983), the first period with wires (18 Jan-6 Feb 1983), a 7-wk period with wires in late fall (22 Oct-15 Dec 1983), and a final 2-wk period with no wires (16-30 Dec 1983). Except for the last week of October, wires were at 12 m spacing when herring gulls predominated.

After wires were installed on 18 January, the average daily maximum number of gulls on the whole BFI site and especially the active sanitary landfill (ASL) decreased substantially (Fig. 2, Table 3). Within a few days, gulls stopped coming to the BFI site altogether. Gulls also stopped visiting the North Tonawanda control landfill about this time, but they continued to go to the Modern Disposal control site for a further two weeks. Herring gulls that did come to the BFI site during the first few days after the wires were installed seemed unwilling to penetrate the wires. The maximum seen on the ASL was 25 and these gulls remained under the wires for only about 2 min.

FIGURE 2

Numbers of herring gulls at the BFI site compared to numbers at two control sites for periods with and without wires. Bars for the BFI site are based on counts made near midday on days when counts were made at control sites.



Herring gulls again came to the BFI site in substantial numbers in late fall (Table 3). However, these birds rarely penetrated the wire barrier and the maximum seen on the ASL in late fall was 20 gulls. Gulls that loafed adjacent to the ASL sometimes flew low over the wires but made no concerted

TABLE 3

Number of herring gulls on the BFI site during periods with and without wires. Based on daily maximum counts.

Date	No. of Gulls: Active landfill	No. of Gulls: Whole site
No wires		
27 Dec - 17 Jan	150.3	198.4
Wires up		
18 - 27 Jan	6.1	60.4
28 Jan - 6 Feb	0.4	1.9
No wires		
7 - 21 Feb	0.7	1.1
Wires up		
22 Oct - 15 Dec	0.8	86.2
No wires		
16 - 30 Dec	135.7	140.3

effort to penetrate the barrier. After the wires were removed in mid December, numbers on both the site and the ASL increased (Table 3), while numbers decreased at North Tonawanda, the only control site receiving waste in late December (Fig. 2).

Numbers of herring gulls on the whole BFI site were significantly lower when wires were in place than in adjacent periods without wires regardless of which control site was used to standardize the data (Table 2). For the ASL, differences were significant when counts at the North Tonawanda control site were used to standardize the data, but not when counts at Modern Disposal were used. The latter result was attributable to low sample size for Modern Disposal rather than to any real lack of effectiveness of the wires; the BFI/Modern ratio as well as the BFI/Tonawanda ratio was much reduced during periods with wires (Table 2).

During both periods when herring gulls predominated on the BFI site, less than 25 T of edible refuse were dumped at the ASL each day. This refuse was quickly covered over. Although herring gulls will dig for food (Verbeek 1977), the BFI site was not very attractive to herring gulls. As a result, we have not shown conclusively that a wire barrier would effectively deter herring gulls when they were attracted by large amounts of food. Nevertheless, the amount of refuse going to the control sites was probably no greater than the amount going to the BFI site and the wire barrier was certainly successful in the circumstance we observed.

CONCLUSIONS

We found that fine parallel wires strung about 10 m above an active sanitary landfill will deter most gulls from landing on the active area. Numbers loafing nearby are also reduced, but to a lesser extent, and numbers circling overhead are either reduced or unchanged. Success of the deterrent varied with species of gull, season, wire spacing, and the amount of edible refuse present. Herring gulls were very effectively deterred in fall and winter by wires spaced 12 m apart when only small amounts of edible refuse were present. We have no information about the reactions of herring gulls to wires when large amounts of edible refuse are present. Most ring-billed gulls were deterred by wires 12 m apart when little edible material was present, but 12 m spacing was less effective with much edible refuse. Wires at 6 m spacing effectively deterred most ring-billed gulls in spring, even with large amounts of refuse. In summer, numbers of gulls present on the active sanitary landfill when the wires were in place were substantial, but low relative to the very large numbers present without wires.

In general, widely spaced horizontal wires above the active portion of a sanitary landfill markedly reduced its attraction of gulls. It is especially significant that the wire system remained effective for many weeks without any use of supplementary scaring methods. A combination of wires plus other methods might be considered if wires alone were not a sufficient deterrent.

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EFFECTIVENESS OF AN OVERHEAD WIRE BARRIER SYSTEM IN REDUCING GULL USE AT THE BFI JEDBURG SANITARY LANDFILL, BERKELEY AND DORCHESTER COUNTIES SOUTH CAROLINA

By

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ABSTRACT

Studies were conducted at the 110a BFI sanitary landfill near Jedburg, Berkeley and Dorchester counties, South Carolina to determine what bird species actively fed at the landfill and to measure the effect an overhead wire barrier system had on bird populations and behavior. The control study was conducted during 2 December 1983 - 5 January 1984; the wire barrier system was installed 6-7 January 1984, and the experimental observations were done during 7 January - 3 February 1984. The main species at Jedburg were Ring-billed Gulls, Fish Crows and Common Crows. The wire system reduced the mean number of gulls and crow by as much as two-thirds,but did not effect the hour to hour variation in gull and crow numbers. The wire system also reduced the number of gulls and crows soaring over the BFI landfill when compared with the Dorchester County-SCA landfill. This study showed that a wire barrier system effectively reduced the numbers of gulls and especially crows feeding and loafing at Jedburg.

INTRODUCTION

Studies were conducted at the 110a Browning-Ferris Industries (BFI) sanitary landfill near Jedburg, Berkeley and Dorchester counties, South Carolina (1) to determine what bird species actively fed at the landfill, and (2) to measure the effect an overhead wire barrier system had on bird populations and behavior.

METHODS AND MATERIALS

From 2 December 1983 through 5 January 1984, daily counts were made on week days from sunrise to sunset, and the species, age ratios, and movement patterns of gulls, crows and other bird species potentially hazardous to aircraft were recorded. On 6-7 January 1984, a wire barrier system consisting of stainless steel wire placed transversely to the trench access at 20ft spacing with additional wires placed parallel to the trench, were installed over trench #16 in the Berkeley County portion of the landfill. This trench was 50ft wide by 14ft deep and 700ft long. The area covered underneath the wires was designated the active area. The active face was the relatively small area at the south end of the trench where solid waste was actually being dumped. An area 50ft wide surrounding trench #16 was designated as the adjacent area and the remainder of the landfill as elsewhere. During December and January all edible solid waste was dumped in trench #16 alone. From 7 January thru 3 February 1984, after the wire barrier system was installed, observations were made of bird activities as in the preceding December. Emphasis was placed on bird activity in the adjacent and active areas and on bird behavioral responses towards the wire barrier system.

During the study period, population counts of gulls and crows were made once a week at mid-day at all the active landfills in the greater Charleston area. These landfills included: the 60a combined Dorchester County-SCA landfill about 11 mile inland from the BFI Jedburg site, the 76a Charleston County Solid Waste Reduction Center, located on Romney Street adjacent to the Cooper River, 5 mile from Charleston Harbor, and the 112a Charleston County Bee's Ferry landfill about 17 mile southeast of Charleston off US Highway 17.

RESULTS

Bird Species Present and Actively Feeding at the Jedburg Sanitary Landfill

Although a variety of bird species were observed during this study at Jedburg, only five species were large enough or occurred in large enough numbers to be considered a potential hazard to aircraft. Chief among these species was the Ring-billed Gull (Larus delawarensis). As was true for the previous study (Forsythe 1982), ring-bills numbers fluctuated greatly from virtually no birds to populations of 400-600. The largest numbers occurred when there were passages of major cold fronts through the area. Such fronts were found during 19-21 December, 22-23 December, 27-30 December, 3-5 January, 18 January, and 30-31 January. The other main species were mixed flocks of Fish Crows (Corvus ossifragus) and Common Crows (C. brachyrhynchos) with the former the predominant species.

Gull Movements and Activities During Control Phase, 2 December 1983 - 5 January 1984

Gull movements were similar to those seen in the previous study (Forsythe 1982). Most ring-bills arrive in the morning from the southeast and probably came up Interstate Highway 26 from Charleston Harbor and other coastal roosting sites. Other gulls arrived from the northeast, after stopping at a water filled borrow pit at the junction of Interstate 26 and Route 16, a favorite loafing area. During the day there was movement between the landfill and the borrow pit as well as movement northwest towards the Dorchester County-SCA landfill. Little gull activity or movement towards the south was seen. Such movement would have carried birds over the adjacent J. E. Locklair Jr. Memorial Airport. In the evening gulls departed southeast towards Charleston Harbor.

On many days, Ring-billed Gulls would stop briefly at the BFI landfill before heading northeast towards the Dorchester County-SCA landfill. During periods of high gull activity at Jedburg, gulls spend most of their time loafing and feeding. The main loafing area was a field adjacent to trench #16. In addition gulls loafed on dirt piles along side the trench and at the nearby borrow pit. Almost all gull feeding occurred on the active face within trench #16.

Crow Movements and Activities During Control Phase

Crow movements differed somewhat from those found for Ring-billed Gulls. Most crows arrived in flocks from the south. Like ring-bill, crows move northwest from the BFI landfill towards the Dorchester County-SCA landfill. Crows spend much of their time loafing in the woods north and south of the landfill and to a lesser extend in the west field adjacent to trench #16. While crows fed with gulls on refuse on the active face, they also fed in corn fields to the east and southwest of the landfill.

Comparison of Wire Barrier System as a Deterrent to Birds

Solid waste volume was similar for the two periods. A total of 1807 tons of which 1084 tons consisted of edible garbage, was dumped during December. In January 1827 tons consisting of 1096 tons of edible garbage was dumped. All solid waste was dumped in the test trench. Dumping occurred on Mondays through Saturdays between 0930 and 1400 hours except on Saturdays when it stopped at 1200 hours. Peak volume was on Mondays and Fridays.

The wires were first installed over the trench on 6-7 January 1984. During 27 December thru 5 January, a mean maximum of 238.1 Ring-billed Gulls were recorded at the active area, 31 in the adjacent area, and 435 elsewhere. During the same period the mean maximum number of crows was 113 on the active, 50 adjacent, and 279 elsewhere.

On 7 January, the first day the wires were in place, a maximum of 55 gulls were present in the active area and they stayed less than 1 minute within the wire system. A total of 55 gulls was the maximum in the adjacent area and 200 were present elsewhere. This is compared with 5 January, the last day before the wires were in place when 230 gulls were present in the active area, 20 in the adjacent, and 740 elsewhere. Gulls would fly over the wires but avoid entering the trench. What birds that did go into the trench walked in from the south through the active face. Even in these situations, the birds remained for very little time and virtually no feeding was observed. Through the test period, gulls were reluctant to fly into the barrier system, but would on occasion walk in from the entrance over the active face. Even in these situations, gulls would not remain long underneath the wire barrier.

The response of crows to the barrier was even more impressive than for Ring-billed Gulls, no crows entered the active area on 7 January, 30 were present in the adjacent, and 87 elsewhere. This is compared with over 110 present in the active area on 5 January, none in the adjacent and over 200 elsewhere on the landfill. The situation for crows was similar if not more dramatic. Crows seemed especially to "avoid" the barrier system. Tables 1 and 2 show that the wire barrier system effectively reduced gull and crow numbers.

Hour to Hour Variation in Bird Numbers

During both the control and test periods, gull activity on the active and adjacent areas was greatest during mid-morning (0900-1300 hours), after a smaller peak at 0700-0900 (Figure 1). These hourily variations also show the effectiveness of the wire barrier system as maximum numbers durin the test period were all lower than during the control period. Similar patterns in activity and reduction in number of birds during the test period were seen for crows (Figure 2).

Number of Birds Soaring Over the BFI-Jedburg Landfill

Gulls and crows soaring on thermals over a landfill are a potential hazard to aircraft. Numbers of circling gulls and crows at the BFI landfill were recorded at various intervals throughout the study. During both the control and test situations, the greatest percentage of counts with gulls present were in the 50ft-500ft level (Table 3). A few birds soared at levels of 500ft-1000ft and most movements less that 50ft were of brief duration and consisted of birds moving to and from loafing and/or feeding areas.

For all altitudes, the mean number of soaring gulls was reduced with the installation of the wire barrier system. However, the percent of counts with soaring ring-bills at the 50ft-500ft level increased with the wire barrier system in place. Perhaps this was the result of the restriction of feeding in the trenches with consequent increasing movements to birds from one place to another.

TABLE 1. Mean Daily Maximum Number of Ring-billed Gulls on the Ground at the Jedburg BFI Landfill Duing Periods With and Without Wires

	Mean Number of Ring-billed Gulls		
	Active Area A	Adjacent to Active B	Elsewhere C
Initial Control			
2 Dec-6 Jan	138	28	228
Wires up			
7-23 Jan	44	19	158
24 Jan-3 Feb	*86	27	158

TABLE 2. Mean Daily Maximum Number of Crows on the Ground at the Jedburg BFI Landfill Duing Periods With and Without Wires

	Mean Number of Crows		
	Active Area A	Adjacent to Active B	Elsewhere C
Initial Control			
2 Dec-6 Jan	138	33	224
Wires up			
7-23 Jan	30.2	14.1	66
24 Jan-3 Feb	*56	30	155

*Putrescible material dumped on road adjacent to active area because of inclement wather 24-31 January.

FIGURE 1. Hour to hour variation in the mean number of Ring-billed Gulls on the active and adjacent areas of the BFI-Jedburg sanitary landfill.
solid bars: active area, open bars: adjacent area

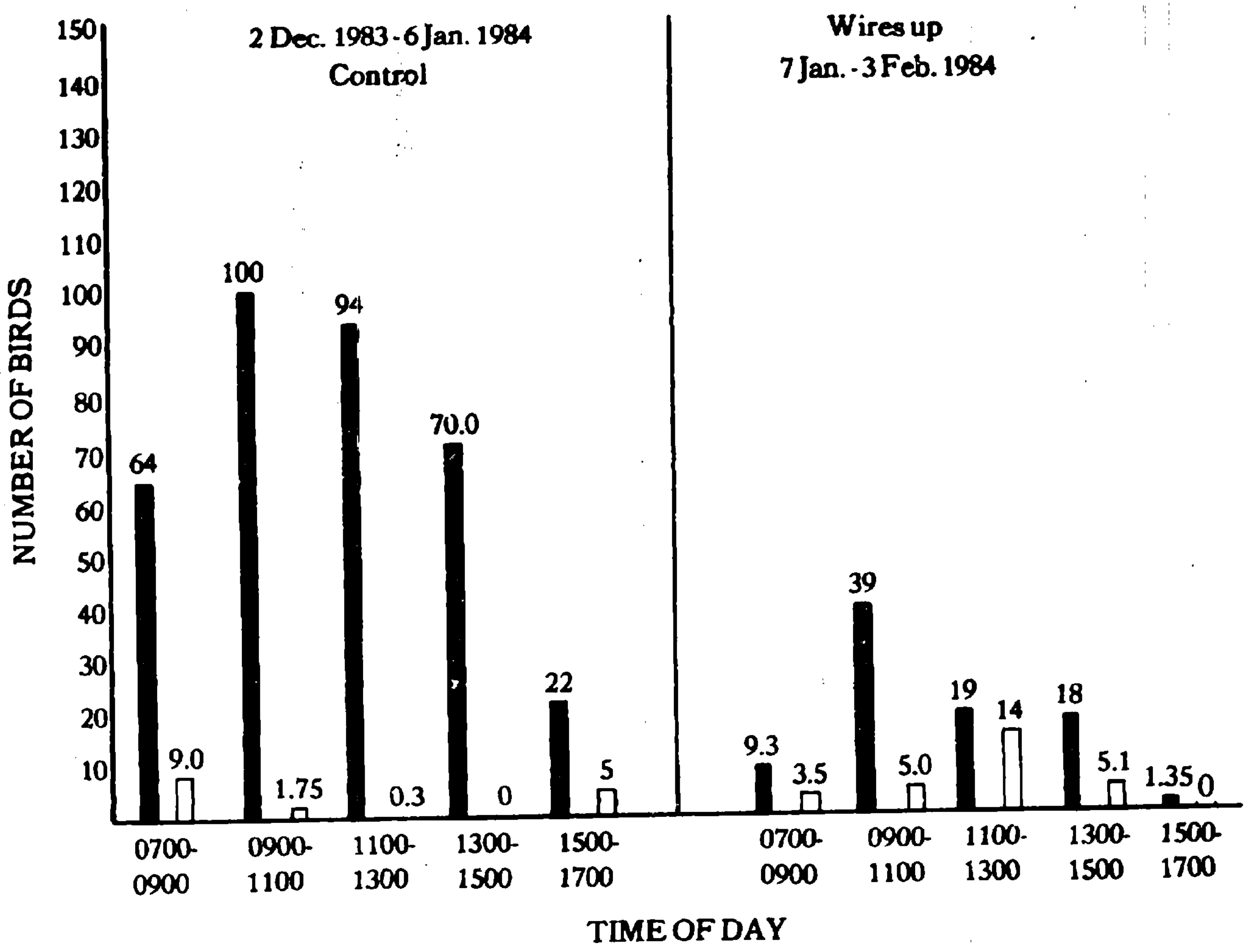


FIGURE 2. Hour to hour variations in mean number of crows on the active and adjacent areas of the BFI-Jedburg sanitary landfill.
solid bars: active area, open bars: adjacent area

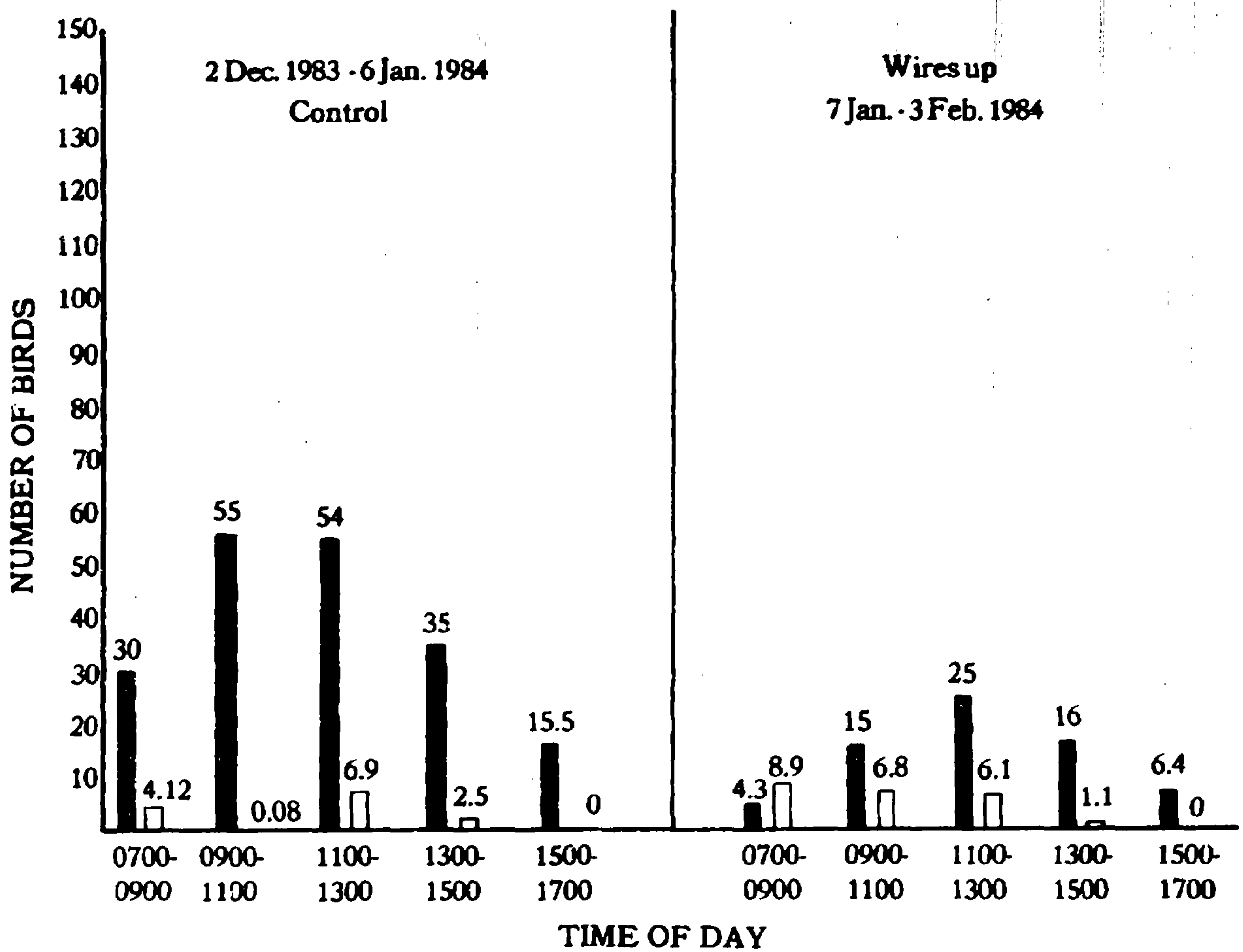


TABLE 3. Mean Numbe of Ring-billed Gulls Circling over the BFI-Jedburg Landfill at Various Altitudes During Periods With Wires and Without Wires

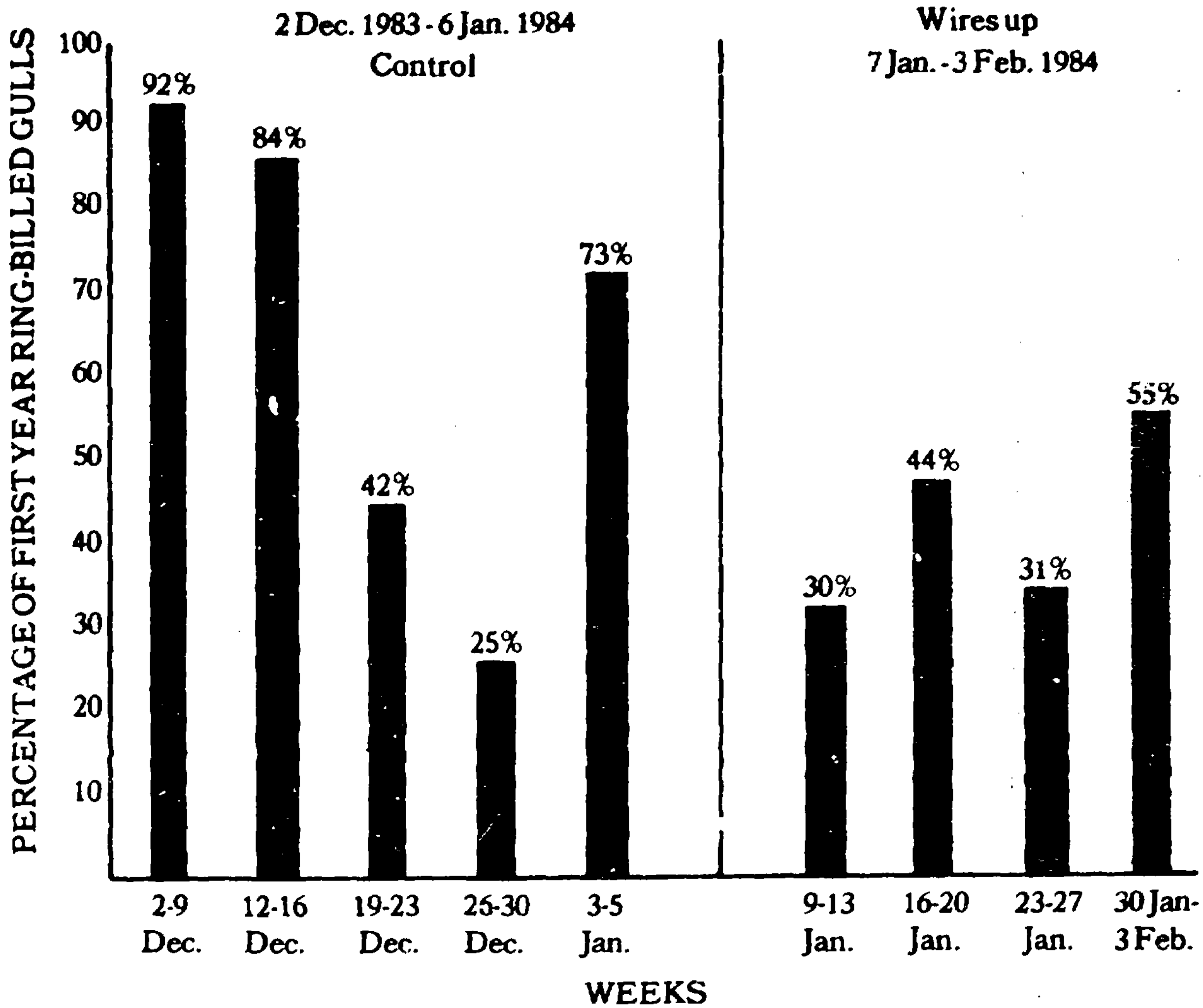
Date	Days of Observation	No. of Counts	% of Counts with Gulls	Mean No. of Gulls per count	Maximum No. of Gulls
		0-50ft			
Control					
2 Dec-6 Jan	24	725	5	84	400
Wires up					
7 Jan-3 Feb	20	767	2	32	200
		50-500ft			
Control					
2 Dec-6 Jan	24	725	12.6	49.8	325
Wires up					
7 Jan-3 Feb	20	767	41.9	22.9	260
		500-1000ft			
Control					
2 Dec-6 Jan	24	725	3	45.2	230
Wires up					
7 Jan-3 Feb	20	767	0.2	9.0	11

Similar results were found for soaring crows (Table 4) with most crows soaring either at less than 50ft or in the 50ft-500ft category. As with gulls, the mean number of soaring birds for all three categories were reduced significantly with the installation of the wire barrier system. Unlike the situation with gulls, the percentage of counts with soaring crows was also greatly reduced in all categories. For crows, the wire barrier system was especially effective in reducing the potential for bird-aircraft collision resulting from soaring.

The weekly average percentage of first year Ring-billed Gulls at Jedburg are shown in Figure 3. The percentage was greatest during the first and second weeks of December (92% and 84% respectively), and then fluctuated between 73% and 25% throughout the remainder of the study. The low percentage of first year birds was surprising. As all earlier studies in the Charleston area had indicated winter populations on landfills with over 90% first year birds (Forsythe 1974, 1979). This low percentage of first year Ring-billed Gulls was not restricted to the Jedburg landfill, similar proportions were seen at Romney Street and especially high adult populations were found at Bee's Ferry.

The percentage of first year birds was lower during the test than during the control periods. It is difficult to document that this reduction was due to the wire barrier system or whether it was due to weather or other exdogenous factors. However, if the wires were especially effective in

FIGURE 3. The mean percent of first year Ring-billed Gulls at the BFI-Jedburg sanitary landfill by week for control and test conditions.



excluding first year birds, this would be important as inexperienced birds are particularly vulnerable to causing bird-aircraft collisions.

Comparison of Ring-billed Gulls and Crow Populations at BFI-Jedburg With Other Landfills

As an additional test of the effectiveness of the wire barrier system, gull and crow populations at Jedburg were compared with those of the Dorchester County-SCA landfill, 11 miles northwest of Jedburg. Earlier studies (Forsythe 1982) showed that gulls and crows fed at both landfills and in fact fed mainly at the Dorchester County-SCA landfill using Jedburg as a stop over point. These data were substantiated by Table 5 showing that during both control and test periods gull numbers were twice as high at Dorchester County-SCA landfill as at BFI-Jedburg. However, crow numbers were about equal at both sites during the control period (Table 6).

For both crows and gulls the relative numbers decreased dramatically at Jedburg when the wire barriers were in place and when compared with the Dorchester County-SCA landfill (Table 5 and 6). These decreases were even more dramatic than those found for the Pine Avenue New York site (McLaren, Harris, and Richardson 1983) and testify to the effectiveness of the wire barrier system in excluding gulls and crows.

TABLE 4. Mean Number of Fish and Common Crows Circling over the BFI-Jedburg Landfill at Various Altitudes During Periods With Wires and Without Wires

Date	Days of Observation	No. of Counts	% of Counts with Gulls	Mean No. of Gulls per count	Maximum No. of Gulls
		0-50 ft			
Control					
2 Dec-6 Jan	24	725	8	115.1	500
Wires up					
7 Jan-3 Feb	20	767	0.1	4	4
		50-500 ft			
Control					
2 Dec-6 Jan	24	725	9	113	450
Wires up					
7 Jan-3 Feb	20	767	7.1	66.3	300
		500-1000 ft			
Control					
2 Dec-6 Jan	24	725	0.6	142	300
Wires up					
7 Jan-3 Feb	20	767	0.1	30	30

TABLE 5. Comparison of Gull Numbers at the BFI-Jedburg Site With Those of the Dorchester-SCA Landfill. Based on Counts During the Mid-day Period (1130-1530 EST). For Jedburg, the Values Represent Averages of Counts Only on Days When Counts Were Made at Control Landfills

Date and Wire Condition at Jedburg	Mean No. of Gulls: Jedburg (total) A	Jedburg (active) B	Dorchester Co. SCA C	Relative No. of Gulls: C/A	C/B
Control					
2 Dec-6 Jan	316	166	589.4	1.80	3.43
Wires up					
7 Jan-3 Feb	117.5	47.5	683	3.83	14.4

TABLE 6. Comparison of Crows Numbers at the BFI-Jedburg Site With Those of the Dorchester-SCA Landfill. Based on Counts During the Mid-day Period (1030-1530 EST). For Jedburg, the Values Represent Averages of Counts Only on Days When Counts Were Made at Control Landfills

Date and Wire Condition at Jedburg	Mean No. of Gulls: Jedburg (total) A	Jedburg (active) B	Dorchester Co. SCA C	Relative No. of Gulls: C/A	C/B
Control					
2 Dec-6 Jan	187.6	84.6	179.6	0.96	2.12
Wires up					
7 Jan-3 Feb	117.5	65.0	272.5	2.32	4.19

DISCUSSION AND CONCLUSIONS

This study showed the ability of a wire barrier system with 20ft spacing to deter Ring-billed Gulls and crows at the BFI-Jedburg landfill. The wires effectively reduced bird feeding activity, reduced bird populations, and reduced the number of crows soaring over the landfill. Thus wire barrier system proved an effective deterent to a possible bird-aircraft collision hazard at the nearby Locklair Airport because of solid waste disposal at the BFI-Jedburg landfill. Experience at Jedburg showed the wire barrier system was inexpensive to construct and require little maintenance. Wires only had to be replaced on a few occasions when broken by Turkey Vultures, (*Cathartes aura*) trying to fly through the wires.

The results of this study were similar to those found for the larger and more complex Pine Avenue landfill site, Niagra Falls, New York (McLaren, Harris and Richardson, 1983). However, they were not as effective as reported by Wyeth for the Puente Hills landfill in Los Angeles County, California (Wyeth in McLaren, Harris and Richardson, 1983).

Although the situation may be different for other landfills in other geographic areas, the BFI-Jedburg site is ideal for the use of the wire barrier system to allow dumping of putrescible waste within 5000ft of the adjacent airport without creating a potential for bird-aircraft strike hazard. This is because the landfill is an inland site visited by large numbers of gulls only intermittently during cold and rainy winter weather. Also the fact that most gulls only stopped over at Jedburg on the way to the Dorchester County-SCA landfill reduced the potential bird-aircraft collision problem.

ACKNOWLEDGEMENTS

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EVALUATION OF EFFECTIVENESS OF BIRD-SCARING OPERATIONS AT A SANITARY LANDFILL SITE NEAR CFB TRENTON, ONTARIO, CANADA

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ABSTRACT

During 1 April - 24 June 1983, daily bird-scaring operations were undertaken by a private contractor at Quinte Sanitary Landfill Site (SLS) to help reduce gull numbers at nearby CFB Trenton. We made independent bird observations each week during that same period both at Quinte SLS and at two control SLS's where no bird-scaring operations took place. The effectiveness of individual visits to Quinte SLS by the bird-scaring personnel was usually of short duration; about 30 minutes after departure of the bird-scaring personnel gull numbers increased to those prior to the scaring operations.

Prior to bird-scaring operations, gull numbers at Quinte SLS were most likely similar to those at the control SLS's. The frequent (2 or more a day) bird-scaring visits to Quinte SLS resulted in a large reduction in gull numbers, as compared to gull numbers at the control SLS's and to the number of gulls that was most likely present before the scaring program. The long-term, cumulative effect of the persistent harassment of the gulls was a large drop in gull numbers, despite the fact that individual bird-scaring visits had only limited success.

INTRODUCTION

Birds are a world-wide hazard at airports due to the potential for strikes with aircraft or their ingestion into engines. Bird hazards can be particularly troublesome at airports located near sanitary landfill sites (SLS's) or other areas where birds may congregate. Gulls, especially, are a problem because of their relatively large size, slow flight, soaring behavior and gregarious nature (Blokpoel, 1976).

In Ontario, this situation is worsened by an increasing gull population that will forage at any available food source in inland as well as coastal areas. At airports where gulls and other birds are a particularly severe hazard, bird-scaring teams are hired to deter them from the runways and neighboring areas such as a SLS. To be effective, these teams must work from dawn to dusk from early spring to late fall. A more permanent solution to the problem of gulls congregating at SLS's near airports would be over-wiring. Wires have proven useful as a means to exclude gulls at public parks (Blokpoel and Tessier, in press a), breeding colonies (Blokpoel and Tessier, in press b), fish ponds (Ostergaard, 1981) and water reservoirs (Amling, 1980).

A study was planned to determine the effectiveness of overhead wires at the Quinte SLS near CFB Trenton in southern Ontario. Bird observations at the

Quinte SLS and two similar nearby control SLS's began in April 1983 two months prior to the scheduled time of wire installation. Due to engineering difficulties however, the wires could not be installed and the project was cancelled. Bird observations were stopped in June 1983. During the bird observations period a bird-scaring team conducted bird-scaring operations at CFB Trenton and at the Quinte SLS. When the overwiring project was cancelled we decided to use the bird data obtained to evaluate the bird-scaring operations.

This report documents the effectiveness of the bird-scaring operations at Quinte SLS during the period from 1 April to 24 June 1983. This represents the first evaluation of a bird scaring team in Ontario despite the fact that in recent years more than $300,000 was spent on contracts to control nuisance birds at three Ontario airports. This report does not evaluate the effectiveness of the individual components of the bird-scaring operations, but merely describes their overall effectiveness.

METHODS

Study Areas This study was conducted at three SLS's located within 60 km of CFB Trenton in southeastern Ontario (Fig. 1). The bird-scaring operations were carried out at Quinte SLS, which is located about 2 km NE of the end of the major runway of CFB Trenton. Cobourg SLS and Brighton SLS were used as control sites in this study. Quinte SLS, Cobourg SLS and Brighton SLS receive 200, 65, and 40 tons of domestic garbage per day, respectively. All three SLS's have regular, daily (Monday to Saturday) trash dumping.

All three SLS's were within 36 km of two large gull colonies located on Gull Island and High Bluff Island in Lake Ontario south of Brighton (Fig. 1). A total of approximately 40,000 pairs of Ring-billed Gulls and fewer than 200 pairs of Herring Gulls nest in these two colonies (Blokpoel, 1977; G.A. Fox, pers. comm.). The next nearest large gull colonies are at Little Galloo Island in eastern Lake Ontario (Blokpoel and Weseloh, 1982) and at the Eastern Headland of the Toronto Outer Harbour in western Lake Ontario (Blokpoel, 1982).

The Ring-billed Gulls generally arrive at the colonies in mid-March. Egg laying occurs in mid-April, incubation takes about 25 days and the young fledge after about 5 weeks. After the breeding season adults and young-of-the-year leave the colony and disperse throughout the lower Great Lakes area. After freeze-up, usually in late November or December, most gulls migrate to the Atlantic coast of the southeastern US (Southern, 1974).

Bird Counts and Observations One or more counts were conducted each week during 1 April - 24 June at each SLS (Table 1). During a count all gulls at or over the SLS were identified and counted (or estimated in the case of large groups). Their behavior was also noted. During a week's observation period at a SLS, counts were conducted every ten minutes and were repeated for as long a time period as possible. Accuracy of estimates was checked by comparisons with estimates of other observers or by actual counts of the group if possible. Other information influencing bird numbers such as the dumping or burying of garbage, presence of the bird-scaring team or weather was also recorded as observed.

Other bird species could not always be counted due to their generally smaller size and more frequent movements. Their presence or absence was usually recorded instead.

On several occasions, early morning watches were conducted to determine the direction and time of arrival of birds at the Quinte SLS. These observations showed that most gulls arrived within two hours of sunrise and departed within two hours of sunset.

Bird-scaring Operations Bird-scaring operations were conducted by a private contractor who had a contract from 1 April to 31 December 1983. As he was required to scare gulls from both CFB Trenton and Quinte SLS, he was not always present at the SLS. The contractor was aware of our presence but he did not know the schedule of our visits to the SLS. At the time of the fieldwork, neither he, nor we, knew that the data were going to be used to evaluate the effectiveness of his operations.

RESULTS AND DISCUSSION

Birds Observed at Quinte SLS Through the course of this study, 14 bird species were observed feeding on dumped material at the Quinte SLS (Table 2). In general, most of the small passerines and the shorebirds would appear to present little hazard to aircraft flying over the landfill site. Many of the species did not flock and usually stayed at or very close to the ground. The flocking species such as the dove, crow, starling, blackbirds, grackle and gulls could represent a greater hazard to aircraft due to their numbers. With the exception of the gulls, however, the flocks of these species usually stayed close to the ground and did not appear to pose a threat to air traffic in and out of CFB Trenton.

Gulls appeared to represent the most serious threat to aircraft. They often circled the landfill site and during the hottest part of the day they towered on thermals rising off the landfill site or nearby fields. Aircraft were occasionally observed landing underneath towering gulls. Based on these observations as well as concerns noted by others (e.g., Blokpoel, 1980), the remainder of this report deals with gulls only. Of the four gull species observed at Quinte SLS (Table 2), the Ring-billed Gull was usually the most numerous species (often comprising more than 80% of all gulls). The Herring Gull was the second most numerous species, while Great Black-backed and Glaucous Gulls were seen only rarely.

Daily Fluctuations in Gull Numbers at Quinte SLS Early in the study, gull numbers at Quinte SLS appeared to peak around 1200-1300 hours each day, but by June numbers were more randomly distributed with no predictable peak. At control sites, numbers of gulls were more stable both during a day and during the study period. Because gull numbers were highest during "mid-day" (i.e. between 2 hours after sunrise and 2 hours before sunset), we use below the gull counts made during this "mid-day" period to compare gull numbers at the three SLS's.

Short-term Effect of the Bird-scaring Operations The routine of the bird-scaring personnel included two or more visits to Quinte SLS each day. Visits were more frequent or of longer duration during periods of intense gull activity. Each visit lasted an average of 41.8 minutes (n = 27) during which time a variety of bird-scaring methods were used including line flying of falcons or hawks, firing of shellcrackers, throwing dead gulls in the air, firing of #2 ammunition and operation of a propane-powered automatic cannon. The sequence of methods used by the team during visits and the timing of visits varied so that gull habituation remained low.

A general measure of the overall amount of effort expended by the bird control personnel in performing their duties at Quinte SLS can be obtained by estimating the total amount of time that they spent at the site. Based on 528 counts with continuous coverage of 10 or more minutes, the bird control team was present for 126 of them, or 23.9% of the periods. This suggests that they spent slightly less than a quarter of the day (dawn to dusk) at Quinte SLS.

During some of our bird observation periods at Quinte SLS, the bird-scaring personnel made a visit to frighten the gulls away. This allowed us to measure the duration of the effect of such visits by comparing gull numbers counted before, during and after the visits. In Fig. 2 we present gull numbers before, during and after those bird-scaring visits that took place during the "mid-day" period. During the bird-scaring operations gull numbers became greatly reduced, but 30 minutes after the end of the visits gull numbers increased to levels observed before the visits.

Long-term Effectiveness of the Bird-scaring Operations Although the effects of the individual bird-scaring visits were of relatively short duration, their cumulative long-term effect was nevertheless high. Our bird counts at Quinte SLS began on 1 April, the day that the bird-scaring operations started at that site. Thus we have no reliable data for the period prior to bird-scaring. However, personnel of CFB Trenton reported "hundreds" of gulls present at Quinte SLS during late March. As soon as bird scaring began the average number of gulls dropped rapidly and remained low compared to the "hundreds" of gulls reported in late March (Table 3 and Fig. 3). The maximum number of gulls seen at Quinte SLS during the first week of bird-scaring (i.e. 492 gulls, see Table 3), is probably a reasonable estimate of the minimum number of gulls that were present in late March. Average gull numbers dropped steeply at Quinte SLS, but at the control SLS's average gull numbers remained more or less the same with a large but temporary increase during the middle of June (Fig. 3).

Maximum gull numbers (i.e. the highest numbers observed during any count) at Quinte SLS also dropped after bird-scaring began, but not nearly as much or as consistently as the average numbers (Table 3). After the first week of scaring operations, the maximum gull numbers at Quinte SLS were always lower than the maximum numbers observed at the control SLS's. Nevertheless, after ten weeks of bird-scaring at Quinte SLS a maximum of 260 gulls was counted there on 9 June (Table 3). Early on that day, two bird-scaring visits were made during 1030-1200 hours and 1245-1300 hours. At 1600 hours (when gull numbers had already increased to 50 birds) the arrival of a large flock increased the number to 260 gulls. These birds were then frightened away during a third visit by the bird-scaring personnel (1610-1630 hours). By 1700 hours gull numbers had increased to 10 birds, which were scared away during a fourth bird-scaring visit (1700-1900 hours).

A comparison of gull numbers (both weekly averages and weekly maxima) at Quinte SLS with those at Cobourg SLS and Brighton SLS, shows 73.4% to 97.0% fewer birds at Quinte SLS during the course of the entire study (Table 4).

From the above results we arrive at the following conclusions:

(1) prior to bird-scaring at Quinte SLS, gull numbers there were most likely comparable to those at the control SLS's;

(2) as a result of the bird-scaring, average gull numbers at Quinte SLS declined sharply and remained low throughout the study period;

(3) even when average gull numbers were low, there were occasions when maximum numbers were high for a relatively short period of time between bird-scaring visits;

(4) bird-scaring operations have to be carried out in a persistent manner because either the gulls become habituated to the bird-scaring or new gulls venture onto the Quinte SLS each day.

ACKNOWLEDGEMENTS

We thank J. Graham and R. Bruce (Quinte Sanitation Service), E.R. Ibbotson (Murray Township Landfill Site) and J.E. Eagleson (Cobourg Landfill Commission) for allowing access to the SLS's. W. Lee (Canadian Wildlife Service, Belleville) and Majors Dupuis and Ananny (both with CFB Trenton) provided useful advice during the fieldwork. U. Watermann and P. Serwylo (both with U.W. Enterprises) discussed their bird-scaring procedures with us.

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Table 1: Dates of fieldwork and total number of counts conducted at each sanitary landfill site.[a]

Week	Mid-date[b]	Dates of Fieldwork (1983)	Number of Counts					
			Brighton		Cobourg		Quinte	
			Mid-day[c]	Total	Mid-day	Total	Mid-day	Total
1	1 Apr	1-2 Apr	-[d]	-	2	2	47	71
2	8 Apr	8 Apr	-	-	-	1	53	61
3	15 Apr	15-16 Apr	-	-	10	10	44	51
4	22 Apr	21-23 Apr	37	45	2	2	32	35
5	29 Apr	28-29 Apr	10	10	4	4	20	27
6	6 May	5 May	1	1	1	1	20	20
7	13 May	11-12 May	7	7	7	7	46	56
8	20 May	18-19 May	5	5	17	17	55	64
9	27 May	27 May	-	-	1	1	1	1
10	3 Jun	2-3 Jun	-	-	4	4	75	77
11	10 Jun	9-10 Jun	3	3	3	3	65	74
12	17 Jun	16-17 Jun	4	4	4	4	4	46
13	24 Jun	23-24 Jun	4	4	3	3	57	58

[a] Counts were actual counts or estimates made at ten minute intervals of all birds at or over the sanitary landfill site.

[b] Mid-date is the date on the Friday of each week. Dates of fieldwork centered on Friday.

[c] "Mid-day" counts were made between two hours after sunrise and two hours before sunset.

[d] No counts made.

Table 2: List of bird species observed feeding at the Quinte SLS.

Killdeer	(*Charadrius vociferus*)
Spotted Sandpiper	(*Actitis macularia*)
Glaucous Gull	(*Larus hyperboreus*)
Great Black-backed Gull	(*Larus marinus*)
Herring Gull	(*Larus argentatus*)
Ring-billed Gull	(*Larus delawarensis*)
Rock Dove	(*Columba livia*)
Blue Jay	(*Cyanocitta cristata*)
Common Crow	(*Corvus brachyrhynchos*)
European Starling	(*Sturnus vulgarus*)
House Sparrow	(*Passer domesticus*)
Red-winged Blackbird	(*Agelaius phoeniceus*)
Common Grackle	(*Quiscalus quiscula*)
Brown-headed Cowbird	(*Molothrus ater*)

Table 3: Numbers of gulls observed on "mid-day" counts at each SLS during each week.

		Average Number[a]			Maximum Number		
Week	Mid-Date	Brighton	Cobourg	Quinte	Brighton	Cobourg	Quinte
1	1 Apr.	-	392.5	92.3	-	410	492
2	8 Apr.	-	246.0[b]	23.5	-	246	130
3	15 Apr.	-	239.3	14.3	-	359	90
4	22 Apr.	310.2	378.0	14.0	1850	610	110
5	29 Apr.	241.0	239.5	0.5	657	413	8
6	6 May	314.0	193.0	27.7	314	193	120
7	13 May	362.1	262.0	3.1	385	374	27
8	20 May	207.8	240.1	13.8	401	327	53
9	27 May	-	250.0	0.0	-	250	0
10	3 Jun.	-	348.8	13.4	-	377	50
11	10 Jun.	594.0	509.0	18.2	771	532	260
12	17 Jun.	353.5	631.3	2.3	384	723	29
13	24 Jun.	283.8	344.0	1.5	300	379	13

a Sample size for each average is given in Table 1.

b The only count conducted at Cobourg SLS during this week was done before the "mid-day" period. Thus, this value may be conservative if all gulls had not yet arrived.

Table 4: Comparison of gull numbers at Quinte SLS with those at the two control SLS's (data from Table 3).

Quinte SLS versus Cobourg SLS (13 weeks of data)

	Cobourg	Quinte	Difference
mean of average weekly numbers	328.7	17.3	-94.7%
mean of maximum weekly numbers	399.5	106.3	-73.4%

Quinte SLS versus Brighton SLS (8 weeks of data)

	Brighton	Quinte	Difference
mean of average weekly numbers	333.3	10.1	-97.0%
mean of maximum weekly numbers	632.8	77.5	-87.8%

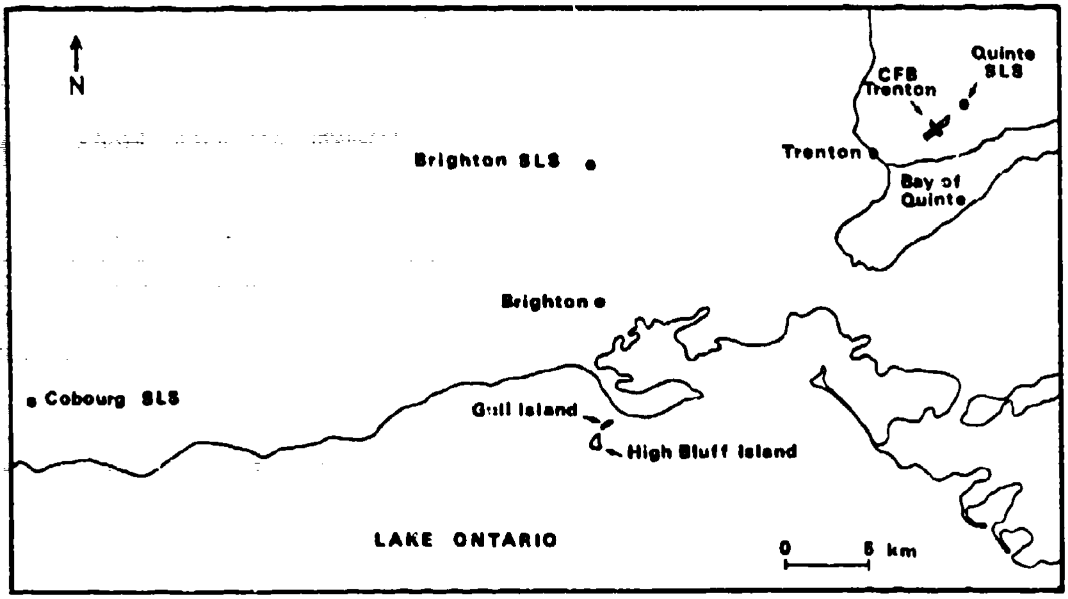

Figure 1: Map showing locations of sanitary landfill sites, C.F.B. Trenton and two gull colonies.

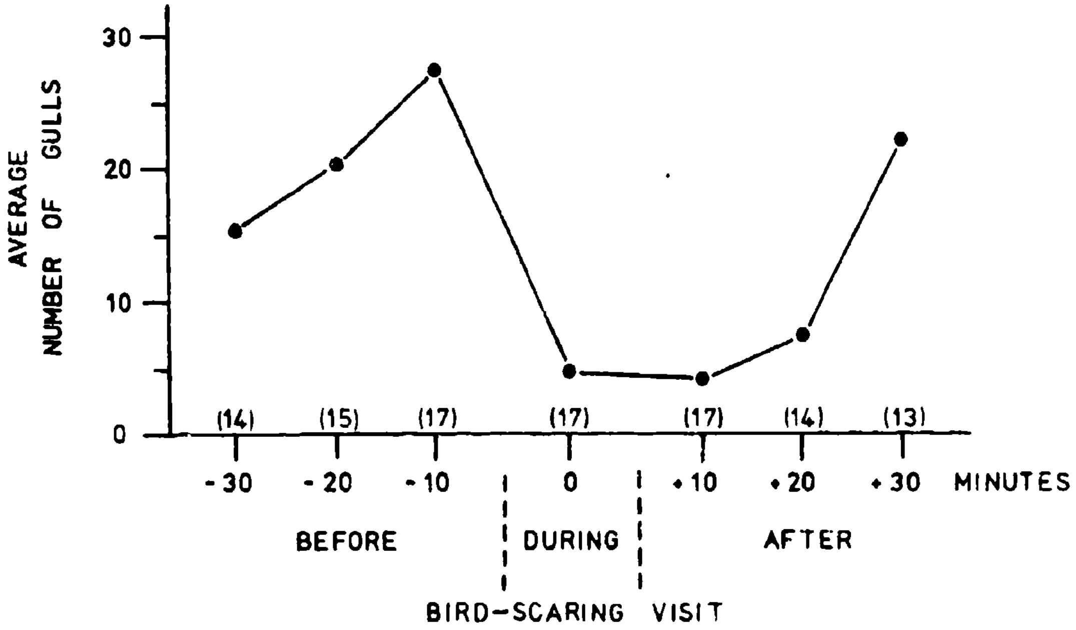

Figure 2: Average number of gulls observed before, during and after bird scaring visits. The number of bird-scaring visits for each time period is shown in parenthesis.

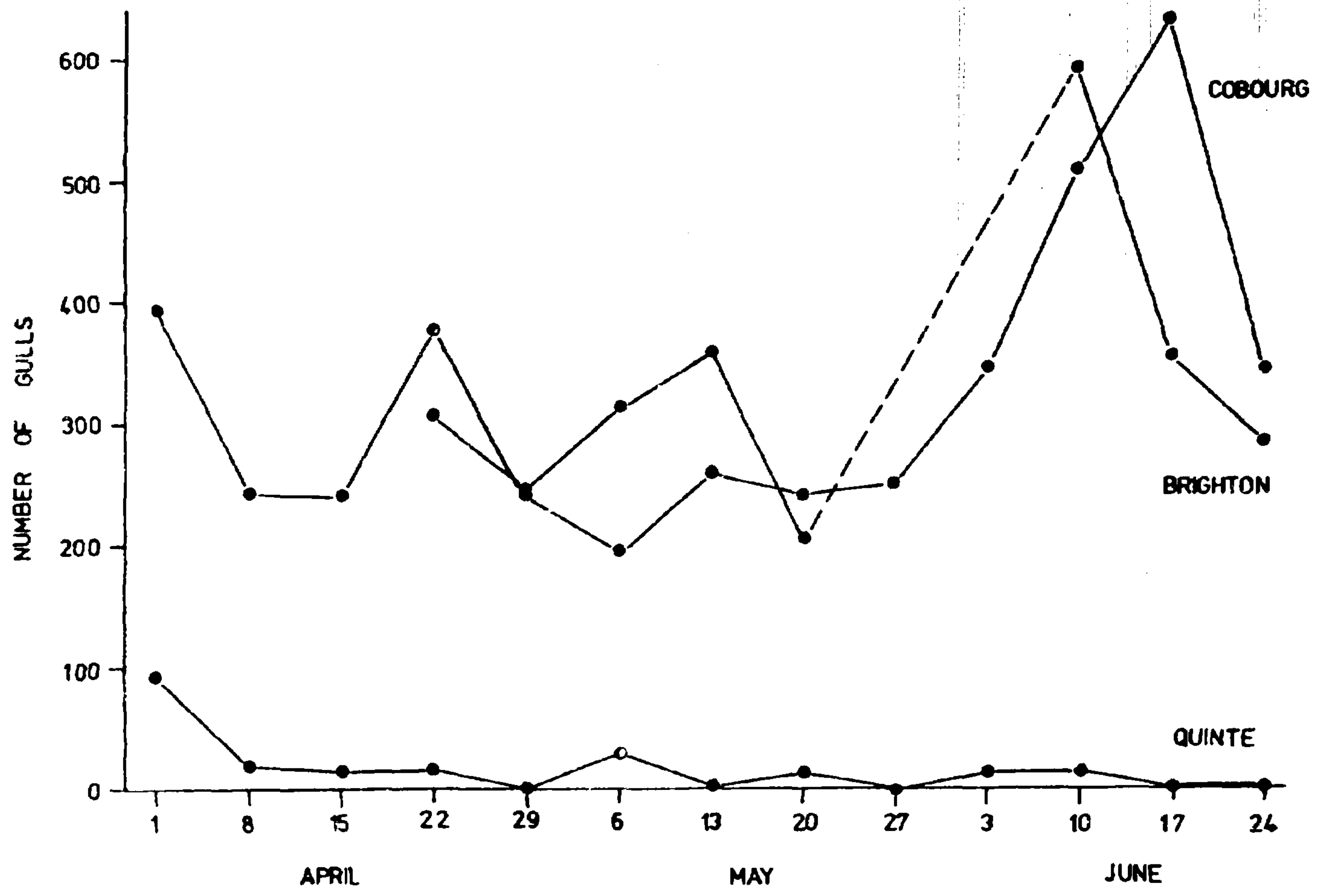

Figure 3: Average number of gulls observed on all mid-day counts during each week of the study period. Data from Table 3.

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DEVELOPMENT OF BIRD HAZARD REDUCTION FOR AIRPORT OPERATIONAL SAFETY

Kaye Reznick
Portland International Airport
7000 N.E. Airport Way
Portland, Oregon 97218

Portland International Airport established its bird hazard reduction program in November 1978. At that time, bird control was a fairly new area to public airports in the U.S. Many concepts were available for hazard reduction, but there were not many tried-and-true programs in existance. PIA was recognized by the FAA as having one of the worst bird strike hazard problems in the country by strike reports that they received and by aircraft damage reported.

The hazard reduction program produced dramatic results. A year's average total for strikes after the programs inception has been consistantly less than an average 2-3 months total prior to its implementation. Aircraft damage has been almost nil for five years.[1] Dealing with a bird strike hazard means dealing with a problem that will probably never be eradicated, but can definitely be controlled with proper identification of causes and solutions.

We have considered the bird hazard reduction program to be an integral part of our safety responsibility that has developed with our operation over the past five years. The perspective of this paper is to outline, from an airport operator's standpoint, the ways that solving the problem integrated into the airport's operation, the sources that we relied upon for technical assistance and cooperation, and those elements of the program most valuable to its success.

Portland International Airport is located on the bank of the Columbia River, approximately seven miles from the City of Portland. The habitat around the airport is ideal for many species of birds. We are surrounded by waterways, ponding, swamp and agricultural areas. The airfield itself developed habitat conditions that drew birds into the in-field areas and contributed to a major portion of our bird strike potential. Gulls, hawks, owls, herons, starlings, blackbirds, crows, and ducks were all major problems on the field. Different seasons changed emphasis on different species, but major hazards existed day and night, year round.

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1 I have learned never to write a statement like this. It is a definite threat to a program's success. After this was written, we experienced a major gull strike to a 767 which totally destroyed one engine. It occurred during a period of heavy gull activity and personnel shortage.

Our initial contact in the program's formation was through Mike Harrison, then on loan to the FAA from the military to assist airports in setting up bird control programs where Safety and Compliance had identified a need. Our basic outline was formulated then. Since that time, six areas have emerged as the key subjects that we had to explore and develop to achieve results. They are:

1. The role and total perspective of the staff performing the program.

2. The identification of the bird attractions and implementation of habitat modifications to reduce them.

3. The use of necessary dispersal and control techniques.

4. The relationships we needed with outside agencies for technical resources, mutual assistance and informational pools.

5. In-house relationships to integrate program necessities into the airport's priority structure for support and resources.

6. A useful record-keeping program.

Our bird control program is carried out by airfield operations personnel who are responsible for overall airfield safety and coordination of any airfield activity. They are on the airfield or available at all times. The important point to consider is that bird control is only one aspect of a major responsibility that these people carry for airfield safety. This means that:

A. They have a good understanding of overall airfield operation.

B. They are accustomed to coordinating resources for any safety concern.

C. They are motivated by an over-all mission and do not tend to separate areas into trivial and non-trivial.

Bird control may be their utmost concern on a hazardous day of high bird activity. Other emergency concerns may take precidence or be coinciding at another time. They are trained to approach each safety concern in terms of long-term improvement, daily maintenance, and over-all precidence in an emergency. If the staff carrying out the program is of the quality to be able to set these airfield priorities, they will have pride and motivation to include all aspects that might be affecting airfield safety.

At the onset of our program, which started at the same time that Portland obtained its airfield "Operations Coordinator" staff, there was a tendency to identify the operations job with bird control only. Bird control was immediately picked up by the media, usually portrayed as an "eccentricity" of the aviation community. Fellow airport staff and airport businesses tended to trivialize the problem (until one of their planes was damaged), which made the staff in operations tend to shy away from being identified with the issue. By directing the development of the OPS Department towards a full airfield safety function and by having a staff capable of this responsibility, bird control became a small aspect of a big picture for airfield safety - an aspect that took up a larger portion of the picture when safety dictated, just as any portion of the picture would.

Media and airport business education was also involved, particularly as the program began to achieve results so that there was a better understanding of the hazard involved, what we were achieving and why we were proud of doing every function that added to airfield safety. We were also saving a substantial number of feathered fliers in Portland, judging by past littered runways, which always appealed to the media even when they did not understand the safety impact involved.

We found it to be immediately true that habitat modifications are the utlimate key to long-term effectiveness of a program. As the airfield attractions are lessened, any form of dispersal becomes proportionately more effective for longer periods of time. Finding a balance between what habitat modifications are possible and what types of dispersal will continue their effectiveness is the goal.

Food source elimination solved a good portion of our strike potential on the field. When our program began, we had a severe infestation of meadow mice in all in-field grass areas. We coordinated a baiting program with the U.S. Fish and Wildlife Service in which we broadcast spread a grain coated with a 1% solution of zinc-phosphide to cut down the rodent population without harming other wildlife on the field. When we began the bird control program, we had a daily population of approximately 30 hawks (mostly Red-tailed), 6-12 Great Blue Herons, and a large number of barn and short-eared owls. They needed to expend very little effort to catch their meals. After the baiting program had been carried out, the populations of rodent-eaters remained very low (example: 0-4 hawks per day), and those that did pay us a visit were much easier to disperse because the attraction had been reduced.

Since we had raptors hunting in the grass areas, we wanted to obtain an average grass height long enough to hinder this activity. We found that we also had to keep it short enough so that the pheasants in the surrounding areas did not seek shelter in the airfield grass. The optimum height for us seems to be 7-10 inches to achieve both purposes.

Another successful modification that we found necessary was the topping of runway directional signs with a product that consists of a formation of stainless steel spikes that very effectively discourages perching on the signs. [2] Perches should not be provided adjacent to all aircraft movement areas!

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2 Niksalite of America, P.O. Box 817, Rock Island, Ill. 61201

We have had mixed success in other areas of habitat modification, such as drainage improvement and control of surrounding agricultural activity. Although some ponding areas have been eliminated during individual runway construction projects, we have to live with water problems a great deal of the year in Oregon. The ponding in the grass areas brings in ducks in winter months. (They are usually very gun-shy, however, and easy to disperse.) Excessive wetness in the infield brings earthworms up onto pavement surfaces, which in turn attracts the gulls. We can predict when these situations will occur and we have to plan for extra observation and dispersal during these periods. It was suggested to us that we try sweeping the worms from runway surfaces, but we found it to be more disruptive to traffic and less effective than our dispersals.

We have a lease arrangement with a farmer who grazes cattle and grows crops outside the perimeter fenceline. In the warmer months insects follow the cattle droppings and the starlings and blackbirds move in to pursue the insects. Because of the business concerns involved in modification of the lease, it took over two years to make some adjustment. We were finally able to limit the grazing during some of the summer months - a compromise that we are still hoping to improve upon. When we mow the airfield area or when the farmer tills his perimeter land, we must also plan for extra monitoring. Because the attraction (turn-over of insects and mice) remains until the mowing or tilling activity ceases, we came to realize that there were times when it was best to leave the birds on the ground. If they are dispersed while the attraction remains so high, they are likely to circle or spiral above the area and return. It is often best in a situation like this to leave them low until the activity ceases and then carry out the dispersal.

Dispersals must be individualized to the species. We have found that a variety of cracker shells and noise making shells are sufficient for dispersal of starlings, blackbirds, crows and ducks. With gulls, gun dispersals alone are not effective. By obtaining gull distress call tapes[3] to match the species of gulls that we dealt with, and with proper training of personnel, we developed a very successful system for gull control. The gull activity on the airfield consists mostly of flocks that loaf on pavement surfaces seeking the warmth or the worms. A vehicle with broadcast capability is positioned

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3 Tape source used: Department of Air Force
Headquarters Air Force Engineering & Services Center
Tyndall Air Force Base
Florida 3240_
(904) 283-6240

approximately 200-300 feet from the gulls, and the tape is played for 20-30 seconds until the gulls rise and approach the sound to investigate. Then the tape is turned off, and dispersals with cracker or noise making shells are carried out. The birds leave quickly and tend to stay away longer when a tape is used correctly. Again, personnel who understand the aircraft movement areas and who can coordinate dispersals carefully with the tower are essential. Quality of broadcasting equipment is also important so that the tapes are not distorted.

Hawks do not tend to disperse well, especially if you are providing them with a moveable feast, as we were. During times when we could not coordiate the rodent-baiting, or simply to remove a few stubborn raptor "residents", we found it necessary to trap, band, and transport hawks to another location. The hawks were banded to judge the rate of return. The release location was usually 30-50 miles away and planned for suitable habitat. We have had only two returns in three years of trapping (Total 31 trapped). While this is effective for short-term removal and reduction of numbers, the results are not long-lasting without habitat modification (for us, removal of food source) because other birds will eventually move in if the attraction remains.

We shied away from any sort of static control device (gas cannons, owl statues, timed calls or visual signals) because we found that anything predictable trains the birds very quickly as to its real threat capability. We also found that any form of dispersal in the infield area should be at least visually coordinated with air traffic so that the dispersal doesn't inadvertently send a flock of birds into a flight path. This was our objection to the timed noise-making devices. Even cracker shell dispersals should be mixed with noise making shells [4] (we have two varieties), to avoid predictability. One static device that we found to be temporarily effective was the placement of a carcass of a bird that had been hit, but that was still intact, off of the runway edge. For a short time it seems to keep gulls, in particular, from returning to "the scene of the crime". If you have a large area to cover on a high bird-activity day this can be helpful.

Although we obtain permits [5] for "lethal" control by chemicals (Avitrol) or by shooting, our other control methods have proven

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4 Source for noise making shells: Marshall Hyde
Box 497
Port Huron, MI 48060
(Racket & whistle bombs, 15mm launcher pistols and .22 crimp blanks)

5 See Appendix - Depredation Control Permit

effective enough to preclude the use of the permit. Our own philosophy has always been to benefit both birds and planes by keeping them apart, unless the hazard is such that immediate lethal bird controls are needed. This has not occurred since the program's inception. Lethal controls used alone are not in a program's interest, because if shotgun patrols or poison controls are instigated without going through the steps of habitat modification - it merely clears airspace for more birds responding to the same attractions. With habitat modifications and coordinated dispersals, lethal controls will not be ncessary in most cases. Many public relations headaches will be avoided by a program that succeeds in hazard reduction with lethal control on the last resort list.

At the same time that our program began, the U.S. Fish and Wildlife Service signed an agreement with the FAA [6] to provide technical assistance and advice to airports requesting their expertise. Their contribution to us has been invaluable. They coordinated our original rodent-baiting program, our hawk trapping program, pointed us in the right direction for our necessary permits, gave us information and training on the species involved, assisted in attraction identification on the field, and directed us to dispersal supplies. I "apprenticed" on a U.S. Fish and Wildlife employees bird banding permit to learn the identification techniques, banding requirements and methods, and handling techniques to carry it out while learning under his supervision.

The Audubon Society was helpful to us in locating sources to take in injured birds (including their own rehab center) for the ones that don't quite lose the battle with the "big" guy.

Mike Harrison [7], who is now a Safety and Compliance Specialist for the FAA, has consistently supplied our airport with informational updates in the field of bird hazard reduction. He has a perspective on national and international programs that is a tremendous resource upon which we have relied.

The local FAA in Portland, particularly our air traffic control personnel, has developed a mutually beneficial relationship with the airport's operations staff. The Ops staff makes every effort to coordinate any airfield activity with the tower and assists them as

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6 See Appendix - Copy agreement with FAA

7 Mike Harrison
FAA AAP720
800 Independence Avenue
Washington, D.C. 20591
(202) 426-3854

their main informational source for field conditions or operations. In turn, the A.T.C.'s keep them informed and assist in operations' activities. They report any visual sightings of birds on the field. They are very good about reporting strike information and coordinating with Ops for dispersals. We call upon them to broadcast bird hazard advisories on the ATIS (Automatic Terminal Information Systems) during continually hazardous conditions, and occasionally we will coordinate runway closures for bird control purposes. We value this mutual reliance and do everything possible to carry on a professional operation to retain their trust and assistance. We have always been able to coordinate with, rather than dictate to the tower, which has set the tone for our mutual assistance.

While our relationship with the tower remains in this "honeymoon" state, we have at times had less success with our in-house relationships. We relied on other departments for some of our activities (particularly for habitat modifications), but each department operated off of their own priority list. Priorities were not coordinated between department managers and an activity carried out one year might slip by for another two. The solution obviously was a strong authority to set and balance priorities. Our role was to justify the program's safety function and to gain the resources that we needed. Some of the airport operator's bird strike liability cases now being tested in the courts have strengthened our cause! [8]

The final area to stress in a bird control program is a record keeping system that will provide a history to predict and prepare for upcoming hazardous conditions. Once we had compiled a year's worth of records, the effort became a downhill run. We were also able to gauge the success of the program through our records. These included daily logs for notations on populations, weather conditions, field attractions, and dispersal results. We keep a monthly report to summarize problem areas, strikes, control activities, and results. A bird strike report form is filled out by operations personnel after each reported incident to obtain as much information as possible. Patterns soon develop by seasons, locations, species, time of day, and weather conditions that will greatly assist in planning.

NOTAMS (Notice to Airmen) can be useful as another source of information to airport users during particularly persistent hazardous conditions. We issue a Notam to advise caution when the smelt run on the Columbia River attracts gulls to the river area. It is a condition not usually affecting the airfield (the gulls seem too occupied to bother the field itself), but it is a surrounding condition of concern that we cannot control.

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8 Reference: South Dakota vs. U.S. District Court
Civ No. 77-1012
Safeco Insurance Company of America, Plaintiff,
vs. City of Watertown, South Dakota
A Municipal Corporation, Defendant

In Summary, Portland has reduced a major bird strike hazard in the course of the program. My purpose in this paper has not been to cover the technical or scientific aspects of bird hazard management, but rather to demonstrate how, with reliance on good technical sources, a program integrated into an airport's operation. We have seen a definite distinction of areas that are important to the program and will need to be dealt with by any airport anticipating the formation of a bird control program. It is my hope that by sharing these important aspects and some of their development, we can convey to other airports that the bird strike hazard problem is continual and changeable but it is also consistently controllable.

Attachment A

Memorandum of Agreement
Between the Fish and Wildlife Service
U.S. Department of the Interior
and the
Federal Aviation Administration
U.S. Department of Transportation

I. PURPOSE

The purpose of this agreement is to establish procedures and administrative arrangements that will provide for a working relationship between the Fish and Wildlife Service, U.S. Department of the Interior, and the Federal Aviation Administration, U.S. Department of Transportation, to provide more effective means of identifying vertebrate pest hazards and procedures for planning, developing and coordinating measures to minimize these hazards to the aviation industry for the benefit of the Nation's safety and well-being.

II. BACKGROUND AND AUTHORITIES

The Fish and Wildlife Service is charged with the responsibility for carrying out programs relating to fish and wildlife throughout the Nation, in accordance with the Animal Damage Control Act of March 2, 1931 (7 U.S.C. 426-426b); the Migratory Bird Treaty Act (16 U.S.C. 703-711); Fish and Wildlife Coordination Act (16 U.S.C. 661-667e); and with other authorities.

The Federal Aviation Administration is charged with assuring that operators of airports serving air carrier aircraft are properly equipped and able to conduct a safe operation (Section 612 Federal Aviation Act of 1958). Federal Aviation Regulation Part 139.67 requires applicants for an airport operating certificate to establish instructions and procedures for prevention or removal of factor on the airport that attracts, or may attract birds. The FAA currently is proposing new regulations which will also require airport operators to implement bird management plans at airports where bird hazards exist.

Many programs conducted by the Fish and Wildlife Service are in cooperation with other Federal, State and local agencies and include dissemination of useful and practical wildlife management information, man/wildlife conflicts, research findings, environmental assessments and surveys of mutual interest to these agencies. Accordingly, cooperation and coordinated efforts in the conduct of such vertebrate pest management programs will be mutually beneficial and will minimize property damage and possible loss of human life involving aircraft, personnel and passengers in accordance with agency mandates.

III. RESPONSIBILITIES OF AGENCIES

A. Pursuant to this agreement, the Fish and Wildlife Service will:

1. Provide technical assistance on vertebrate pest matters to the Federal Aviation Administration.

2. Make its published reports and other information available to the Federal Aviation Administration.

3. Cooperate with the Federal Aviation Administration in the development and support of training programs designed to assist aviation interests with vertebrate pest management problems.

4. Assist the Federal Aviation Administration with the implementation of pest management techniques.

5. Advise the Federal Aviation Administration of the status of Fish and Wildlife Service program goals, relevant research findings and proposed legislative changes, or of any Service action that may impact an FAA facility.

B. Pursuant to this agreement, the Federal Aviation Administration will:

1. Identify and request assistance to meet needs, including training and areas of wildlife conflicts and to cooperate with the Fish and Wildlife Service in the development and support of training programs designed to assist aviation interests with vertebrate pest management problems.

2. Provide channels of communication and distribution of the Fish and Wildlife Service information relating to vertebrate pest problems to the aviation industry.

3. Coordinate with the Fish and Wildlife Service in the development and conduct of vertebrate pest management programs.

4. Evaluate and provide feedback and information from the aviation industry to the Fish and Wildlife Service of current recommendations on vertebrate pest problems and to assist the Fish and Wildlife Service in evaluating cooperative programs and in developing new techniques of mutual interest.

IV. PROGRAMMING, BUDGETING AND REIMBURSEMENT ARRANGEMENTS

This agreement is not a fiscal or funds-obligating document. Any joint endeavors involving reimbursement obligation or transfer of funds between the parties to this agreement will be handled in accordance with prescribed financial procedures and will be the subject of subsidiary agreement that shall be effected in writing by representatives of both parties to this agreement.

V. PUBLIC AFFAIRS/PRESS LIAISON

Release to the press, public announcements and communication with the Congress concerning joint programs can be made by either party to this agreement following coordination by representatives of each party.

Credit will be given to the Fish and Wildlife Service and the Federal Aviation Administration interests as appropriate.

VI. AMENDMENTS AND REVIEW

This agreement will be reviewed periodically but not less than annually. It may be subject to reconsideration at such other times as may be required and as agreed to by the parties of this agreement.

VII. IMPLEMENTATION

The Fish and Wildlife Service and the Federal Aviation Administration will assign and identify senior staff to serve in a liaison capacity to satisfy requirements of this agreement.

VIII. TERMS OF THE AGREEMENT

This agreement will become effective upon the signature of both approving officials of the respective agencies entering into this agreement.

The terms of this agreement will remain in effect until termination by (1) mutual agreement or (2) ninety-day advance written notice by either party.

September 28, 1978
DATE

Langhorne Bond
Administrator, Federal Aviation Administration

October 16, 1978
DATE

Lynn A. Greenwalt
Director, Fish and Wildlife Service
U.S. Department of the Interior

ATTACHMENT B

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
500 NE Multnomah, Suite 1490; Portland, OR 97232

3-201
(2-76)

FEDERAL FISH AND WILDLIFE PERMIT

1. PERMITTEE PORT OF PORTLAND Post Office Box 3529 Portland, Oregon 97208	2. AUTHORITY STATUTES Migratory Bird Treaty Act REGULATIONS (attached) 50 CFR 13 and 21
	3. NUMBER PRT 2-1127-PT (RENEW)
	4. RENEWABLE ☒ YES ☐ NO — 5. MAY COPY ☒ YES ☐ NO
	6. EFFECTIVE 1/1/83 — 7. EXPIRES 12/31/83
8. NAME AND TITLE OF PRINCIPAL OFFICER (If #1 is a business) M. Kaye Reznick, Operations Coordinator	9. TYPE OF PERMIT AIRPORT DEPREDATION CONTROL

10. LOCATION WHERE AUTHORIZED ACTIVITY MAY BE CONDUCTED

PORTLAND INTERNATIONAL AIRPORT; HILLSBORO AIRPORT; TROUTDALE AIRPORT

11. CONDITIONS AND AUTHORIZATIONS:

A. GENERAL CONDITIONS SET OUT IN SUBPART D OF 50 CFR 13, AND SPECIFIC CONDITIONS CONTAINED IN FEDERAL REGULATIONS CITED IN BLOCK #2 ABOVE, ARE HEREBY MADE A PART OF THIS PERMIT. ALL ACTIVITIES AUTHORIZED HEREIN MUST BE CARRIED OUT IN ACCORD WITH AND FOR THE PURPOSES DESCRIBED IN THE APPLICATION SUBMITTED. CONTINUED VALIDITY, OR RENEWAL, OF THIS PERMIT IS SUBJECT TO COMPLETE AND TIMELY COMPLIANCE WITH ALL APPLICABLE CONDITIONS, INCLUDING THE FILING OF ALL REQUIRED INFORMATION AND REPORTS.

B. THE VALIDITY OF THIS PERMIT IS ALSO CONDITIONED UPON STRICT OBSERVANCE OF ALL APPLICABLE FOREIGN, STATE, LOCAL OR OTHER FEDERAL LAW.

C. VALID FOR USE BY PERMITTEE NAMED ABOVE, and any person who is under the direct control of or who is employed by or under contract to the permittee only to the extent necessary to carry out their obligation in accomplishing the purpose authorized herein.

D. Authorized to take any migratory birds (except eagles and endangered species) by shooting in minimum numbers necessary when emergency conditions exist.

E. Incidental gull mortality is authorized, resulting from the application of Avitrol 200. Such application must comply with state and Federal environmental regulations.

F. Birds killed under the authority of this permit shall be picked up and disposed of by burning or burial.

G. This permit does not supersede any county, state, or municipal laws relating to the discharge of firearms.

H. This permit is revocable at the discretion of the Regional Director, USFWS, or of the issuing officer.

I. Authorized to live-trap, transport, and release raptors which are causing a safety hazard near the airport.

☐ ADDITIONAL CONDITIONS AND AUTHORIZATIONS ON REVERSE ALSO APPLY

12. REPORTING REQUIREMENTS Permittee shall report to the Special Agent in Charge, USFWS, Lloyd 500 Bldg., Suite 1490, 500 NE Multnomah Street, Portland, OR 97232, within ten days after the expiration of this permit, listing the number and species of birds killed.

ISSUED BY	TITLE	DATE
Wesley K. Moholt	Asst. Special Agent in Charge Law Enforcement District #1	June 1, 1983

ORIGINAL

cc: SRA/Portland OR Dept. F&G

AD-P004 203

The Bird Strike Situation and Its Ecological Background in the Copenhagen Airport, Kastrup.

(Presented by H. Dahl)

Directorate of Civil Aviation
Gammel Kongevej 60
1850 Copenhagen V
Denmark

Summary

The paper contains a description of the measures taken at Copenhagen Airport to reduce the bird strike problem during the last 20 years. Apart from shooting and otherwise scaring away the birds, the ecological countermeasures are described. They include a change of the agricultural areas of the airport into grass fields with the grass cut to a length of about 20 cm, a close down of a large dump only 5 km to the west of the airport, and measures against a very large breeding colony on the island of Saltholm in the Øresund 5 km to the east. The measures at the island include spraying of the nests in the colony with an emulsion of oil and water with the result that the colony production of young birds has diminished. Further, it includes killing of the birds by use of alfa-chloralosis contained in tablets and put into dead herrings placed in the gulls' nests. The result has been a reduction from about 37,000 pairs of herring gulls to less than 10,000 pairs of herring gulls breeding on the island. Approximately 100,000 US dollars are used every year to finance the different actions against the birds. The use of long grass has caused an increase in mice and as a result hereof an increase in kestrels involved in bird strikes.

According to the pilots' records of bird strikes the rate in Copenhagen Airport has for some years been about 2.5 per 10,000 movements. This figure is at the level of number of other airports, but the rate is certainly high enough for the airport authorities to make great efforts to try to keep the rate down. The actual number of strikes with Danish and foreign aircraft exceeding 5,700 kg reported by pilots is about 40 a year. But the pilots do not observe all strikes and do not report all strikes, and quite a number are recorded in other ways, for instance by the airport personnel which observes the strikes or find dead birds on the runways. This makes an annual total of about 60 bird strikes in the Copenhagen Airport.

The obvious solution to handle the bird strike problems is to scare the birds away from the airport. Regular bird scaring methods have started in Copenhagen as early as in 1963 after the symposium at Nice. It is still considered an indispensable measure against the risk of bird strikes and has been intensified during the years. The whole area is patrolled by car, and any flock of larger birds is scared away by shooting or by firing shell crackers.

The scaring methods, however, are not always effective, even when supplemented by loud speaker transmitted distress calls of the bird species in question. When a large flock of birds for some reason is attracted to the airport, it can be moved from one place to another, but frequently it cannot be scared away from the airfield. This is mainly due to the size of the area, about 1100 ha. Therefore, other actions have to be taken, first of all it is attempted to change the environment in and near the airport to make the area less attractive to birds. In order to apply this ecological method to the bird strike problem, it is necessary to know exactly which species are involved in the strikes, and what attracts them to the area.

During the last 10 years all birds that have been found dead on or near the runways of the Copenhagen Airport, have been sent to the Zoological Laboratory of the University of Copenhagen for examination and identification. Consequently, by now it is known which bird species are the most dangerous ones, and at what time of the year and day, and under what circumstances they are most likely to cause strikes with aircraft. The following species are at the top of the bird strike list of Copenhagen, covering the years 1974-1980: Herring gull (83), black-headed gull (30), common gull (29), kestrel (18), partridge (16), oyster catchers (15), common pigeon (13), and lap wing (12). Less than 8 strikes are reported with each of 13 other species. During the period 1974-1980 serious incidents have been caused 5 times by herring gulls, 3 times by black-headed gulls, twice by common gulls, and once by oyster catchers, pigeons and partridges respectively. It is evident from these data that the three species of gulls are the most dangerous species in Copenhagen Airport, and therefore, most of the attention of the airport authorities has been given to these species. In 1966-1967 a comprehensive ornithological and ecological study on the birds in the airport was made by an ornithologist. Later special studies have been made on the herring gull, the black-headed gull and the oyster catcher in order to find out where and when these birds come to the airport. Further the stomach contents of birds found on the airport have been investigated to learn about their local feeding habits. The bird scaring personnel has recorded the number of gulls and some other species several times every day for many years, and now the authorities have a fairly good knowledge of the daily and seasonal changes of the bird frequency.

The situation of the airport close to the sea is the main cause that gulls, and for instance oyster catchers, play a major role in the strikes. These birds are breeding in great numbers not far away, and they often move around near the coast line. Here they feed or rest in large flocks, and since they prefer to have a good look-out, the wide open areas of the airport are very attractive to them.

Some years ago the agricultural areas of the airport were preferred feeding places for several bird species during some periods of the year, for instance gulls and lap wings. The very first bird sent to the Zoological Laboratory for examination after a collision with an airplane was a herring gull, which had its stomach filled with barley grains, and just by that time the barley fields in the airport had been sowed. To reduce the feeding opportunities of gulls, all the agricultural areas of the airport were changed into grass fields in 1974-1975. However, grass fields are also attractive to gulls and shore birds. Therefore, in 1973-1974 a number of experiments were made to compare the frequency of gulls in areas with grass of short, high and medium length respectively. In the latter case the grass was cut to a length of about 20 cm. The result was very clear. By far the smallest number was counted in the grass of medium height. It is due to the fact that the gulls do not like to walk around among the long, stiff straws. Since then the grass areas of the airport have been cut to a height of approximately 20 cm.

Three environmental factors have been, and two of them are still to some degree, of major importance for the occurrence of herring gulls in the Copenhagen Airport: The situation of a large garbage dump only 5 km to the west, a very large breeding colony on the island of Saltholm in Øresund 5 km to the east, and during autumn and winter a large communal resting area on the same island. Radar and field observations showed that the gulls every day made one or several feeding excursions from the island to the dumps, passing over or very close to the airport, and frequently, especially during rain and in the morning and in the evening, they came down into the airport. Sometimes several thousand herring gulls were feeding or resting near the runways. The stomach contents of gulls showed that they actually had been feeding in the airport as well as in dumps.

About 10 years ago the policy of treating the garbage in Copenhagen changed, and the large dumps were closed down. It probably caused a reduction in the number of gulls staying in the Copenhagen area during the winter season, and it certainly changed the daily routine of the gulls in favour of the bird strike situation in the airport. But there are still other dumps 20-50 km away on Sjælland and in Sweden, i.e. within the radius of the feeding movements made by the gulls on Saltholm. Efforts are made to get those dumps closed too, because in doing so, the size of the local population of gulls might be further reduced.

In 1970 about 37,000 pairs of herring gulls were breeding on Saltholm, in a very large colony, being quite unpleasant neighbours of an airport. There had been an explosive growth of the population during the latest 10-15 years creating a number of problems and not only to the air safety. In 1969 the airport authorities in close co-operation with ornithologists and the Department of Nature Conservation started an attempt to reduce the size of the colony. Every year since then the nests in the colony have been sprayed with an emulsion of oil in water. The oil closes the pores of the eggs and kills the embryos, while the adults continue to incubate the eggs without replacing them by a new clutch. One effect has been that the colony produces very few young birds, and since the young gulls are more likely to hit the aircraft than the old ones, this should cause a reduction in gull strikes in the airport. In fact, the statistics show a significantly lower proportion of strikes with young herring gulls than with young gulls of other species.

In the first 4-5 years the oil spraying treatment of the gulls' eggs also had the effect that the breeding population was reduced to about 20,000 pairs. In order to obtain a further reduction, it became necessary to remove a number of adult gulls from the colony, and this has been done since 1976 by the use of alfa-chloralosis. A tablet containing this chemical is put into a dead herring, which is then placed in the gull's nest. When the gull returns, it eats the bait and sleeps into death. The dead birds are picked up and carried away for destruction. Due to this treatment in part of the colony and oil spraying in the rest of it, the herring gull population on Saltholm has been reduced to about 9,500 pairs in 1981. The goal is approximately 5,000 pairs. Since our investigations have shown very clearly that the great majority of strikes with herring gulls is caused by birds from the local breeding population, the overall effect should be a reduced bird strike risk.

Bird strikes during the night produce special problems in the airport. The large flat area near the coast without trees and bushes makes the airport an attractive place for gulls to stay overnight, and in periods flocks of herring gulls and black-headed gulls try to do so. If for some reason the flock is scared during the night, the risk of serious strikes is relatively high. That is because the gulls are not able to avoid the aircraft in the darkness. One way to reduce the risk is to take care that all flocks are scared away from the area before it gets dark. It may be difficult because some flocks arrive late in the evening. Also flocks of partridges leaving their night shelter very early in the morning when it is still dark, sometimes cause critical bird strike situations because these birds are relatively heavy, they fly relatively close together, and they are not capable of making quick manoeuvres. For instance, a strike with eleven partridges has been reported. To avoid these situations, partridges are kept away from the airport by shooting; and planting of hedges and scrubs which might provide shelter for this bird species, is not allowed within 300 m from the runways.

Approximately one million Danish Kroner is used every year to finance the different actions against the birds. Unfortunately, it is very difficult to measure the effect of these efforts because a number of other factors may influence the occurrence of birds in the airport and the number of reported strikes. There is, however, no doubt that the bird strike situation is much better now than 12 years ago, and there are strong indications in the statistics, which include the latest 7 years, that strikes with gulls have decreased considerably, perhaps by about 50 per cent. Also the regular counting of gulls in the airport shows that their number has decreased. On the other hand strikes with kestrels have increased. This may be a result of having relatively long grass on the airfield since the long grass favours the occurrence of mice which are preyed upon by the kestrel. However, until now strikes with kestrels have not caused any damage because they are rather light solitary birds. Therefore, strikes with kestrels may be accepted at the cost of having fewer gull strikes.

AD-P004 204

BIRD CONTROL PROGRAM

ORLANDO INTERNATIONAL AIRPORT

Efren T. Gonzalez

Greater Orlando Aviation Authority
Post Office Box 30004
Orlando, Florida 32862

ABSTRACT

This short paper will attempt to explain Orlando International Airport's bird problem and solution to that problem from an airport operations viewpoint. It should be of interest to airport operators with a bird problem who are considering formulating a bird control program and/or are interested in a program at a large hub airport.

BACKGROUND

The Orlando International Airport, operated by the Greater Orlando Aviation Authority, is located seven miles southeast of the City of Orlando. The airport contains approximately 7,000 acres in land area, of which one-half remains undeveloped woodlands for future expansion. 3.8 million passengers were enplaned in 1983, along with 163,613 aircraft operations. This represents a 16% and 8% increase in activity, respectively, over 1982.

Prior to the opening of the $300 million terminal complex in September of 1981, bird activity at the airport was minimal. The decommissioning of the overcrowded Jetport Terminal and subsequent opening of the new terminal has made large pavement areas on airport property attractive to sea gulls from northern and coastal areas during winter months (primarily November through March). The sea gulls appear to be attracted to the warmth retained in the concrete and asphalt, as well as to ponding in some locations. They generally congregate in flocks that vary in size from 20 to over 500 in number. Their presence is particularly notable during early morning hours and cloudy/rainy IFR conditions.

THE SEA GULL PROBLEM

Although other species of birds are attracted to the airport property, the sea gull population poses the greatest potential for hazard to aircraft operating at Orlando International Airport. This is due not only to the large numbers of gulls, but also to their relatively large size and weight. Bird strike reports (see FIGURE 1) compiled from December 1981 through January 1984 document 40 bird strikes at Orlando International Airport, with the majority involving sea gulls (see FIGURE 2). Other species involved include herons, egrets, doves, starlings, sparrows and hawks. Because the actual number of strikes involving sea gulls was greatest, as well as the visual impact of large flocks on ramps and taxiways, the Operations Department formulated a bird control program aimed primarily at the sea gull population.

Of the 40 documented bird strikes, only one was known to have resulted in damage. That occurred to a Republic DC 9 which sustained damage to one engine during takeoff roll after passing through a flock of gulls. The takeoff was successfully aborted and no one was injured.

PROGRAM FORMULATION

Our research lead us into several areas, but the U.S. Fish and Wildlife Service appeared to have a succinct approach. They recommend that "the first priority in reducing a bird hazard is to immediately establish a viable shotgun patrol so that real-time protection can be given to aircraft within the airport perimeter. Harassment is highly reliable and an immediate means of repelling birds.[1]" The shotgun patrol at Orlando International Airport was formulated with the budget in mind, but not at the expense of safety. It was decided to initially keep the program basic - one shotgun, one 15mm launcher, shells and pyrotechnic devices. Once a full winter season with the shotgun patrol is realized, effectiveness of the program will be measured, and, if necessary, additional ideas will be incorporated to expand the program.

PERMITS REQUIRED, COSTS AND SUPPLIERS

Because the harrassment techniques utilized require occassional kills to reinforce scare tactics, permits for depredation control were obtained from the Florida Game and Fresh Water Fish Commission and the U.S. Fish and Wildlife Service. These permits are required because sea gulls and other migratory birds are protected by state and federal laws. These permits are renewable, and contain restrictions on killing, disposal of carcasses, and maintaing records of birds taken.

The initial startup costs for the bird control program were approximately $860 for firearms, ammunition and related safety items. Manpower costs were not computed, as the bird control program became the responsibility of the Operations Department's airfield Agent on duty during daylight hours. The Aviation Authority presently staffs Supervisors and Agents on duty 24 hours daily. All participants in the program are trained by a licensed firearms instructor, courtesy of the Orlando Police

[1]"Controlling:Birds at Airports" - Department of Interior/U.S. Fish and Wildlife Service.

Department's Airport Division. Annual costs, assuming the program remains in its present size, should be under $500.

The Aviation Authority was able to find two corporations which supply a similar line of pyrotechnic devices: Sutton Agricultural Enterprises of Salinas, California; and Marshall Hyde, Inc. of Port Huron, Michigan. Both corporations are cost competitive, but shell crackers are in sporadic supply and not always readily available.

PROGRAM DETAILS

To document bird activity (other than bird strikes) on the airfield, a "Bird Incident Report" form (see FIGURE 4) was created, which will show schematically where birds are active, and will indicate action taken. This form, along with bird strike reports, will be useful in measuring the effectiveness of the program, and will be reviewed for suggestions on improving it.

The Operations Department utilizes "Operations Procedure Letters" for its personnel to assure uniformity and consistency in certain procedures. FIGURE 5 illustrates the procedure letter used for the bird control program at Orlando International Airport. The intent of the program, procedures, requirements, restrictions and responsibility are all clearly defined in the letter.

The success of the program rests largely on the motivation of the persons assigned to carry it out. At Orlando International, it is anticipated that the Agents will remain motivated because the program is an additional responsibility assigned to the Agent in the airfield. This will help eliminate the boredom factor that can occur if bird control becomes an exclusive duty. The Agent's present rotating schedule assigns one individual to airfield duty approximately once every fourth week, which is intended to stimulate the Agent's awareness on the airfield, and exposes the birds to different patterns unique to each individual.

SUMMARY

Due to a significant increase in documented bird activity at Orlando International Airport during the '81/'82 and '82/'83 winter seasons, the Operations Department has initiated a bird control program consisting of a shotgun patrol designed to discourage bird activity on airport property. Because the program was just recently implemented, there has been no true measure of its effectiveness. However, it is anticipated that the shotgun patrol will be a successful technique in reducing the bird hazard to aircraft operating at Orlando International Airport.

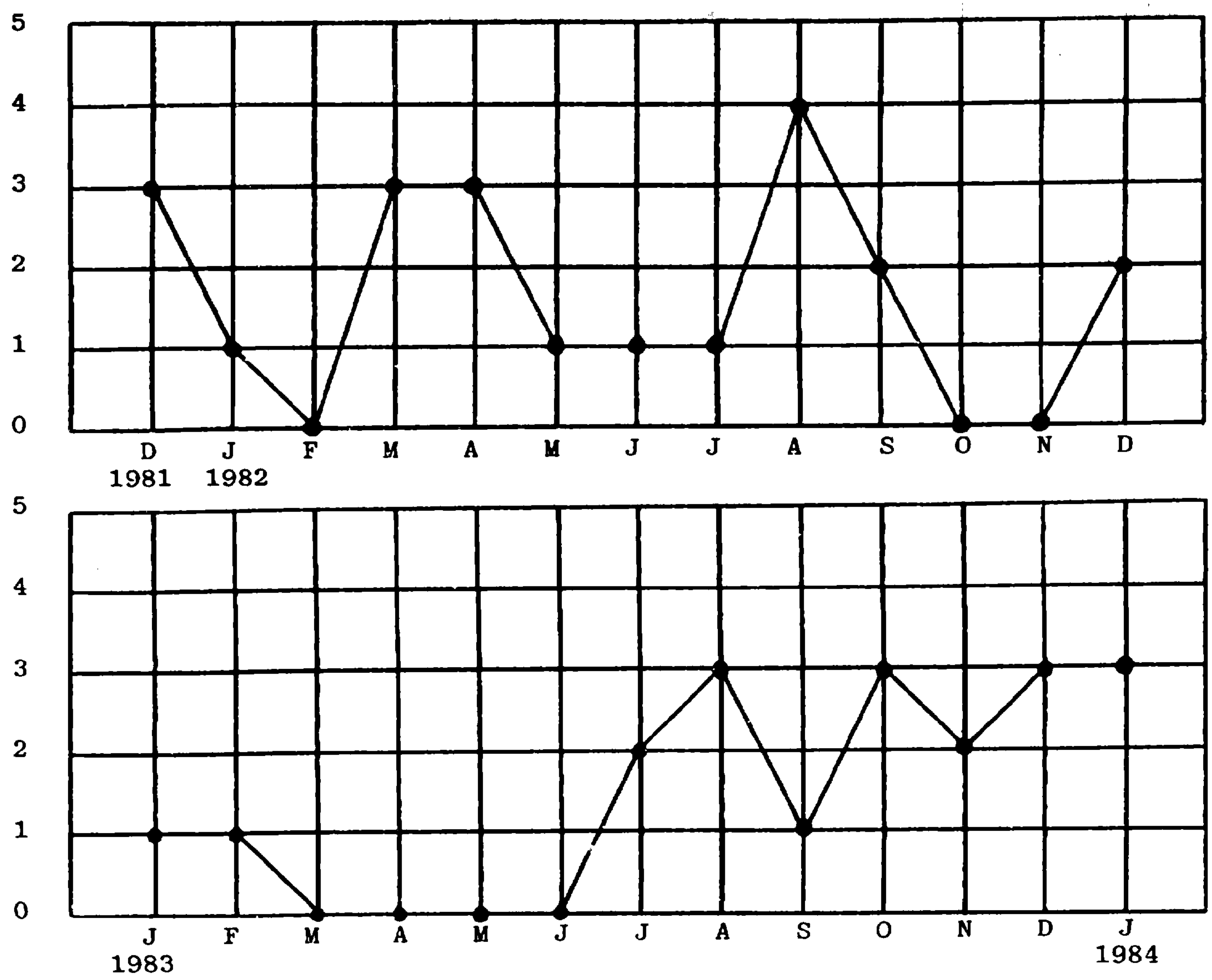

FIGURE 1. Bird Strikes at Orlando International Airport

FIGURE 2. Bird Strikes by Bird Type

(December 1981 through January 1984)

Sea gulls	18*
Doves	3
Larks	3
Hawks	2
Herons	2*
Sparrows	2
Egret	1
Kite	1
Kildeer	1
Sandpiper	1
Starling	1
Unidentified	6
Total	41

*One strike involved two types of birds.

Greater Orlando Aviation Authority

ORLANDO INTERNATIONAL AIRPORT

BIRD INCIDENT REPORT

DATE: ______________________

TIME: ______________________

NUMBER AND SPECIES: ________

____

LOCATION - CIRCLE ON MAP

TOWER COORDINATION:

____YES ____NO

WEATHER: ____________________

____

____

____

____

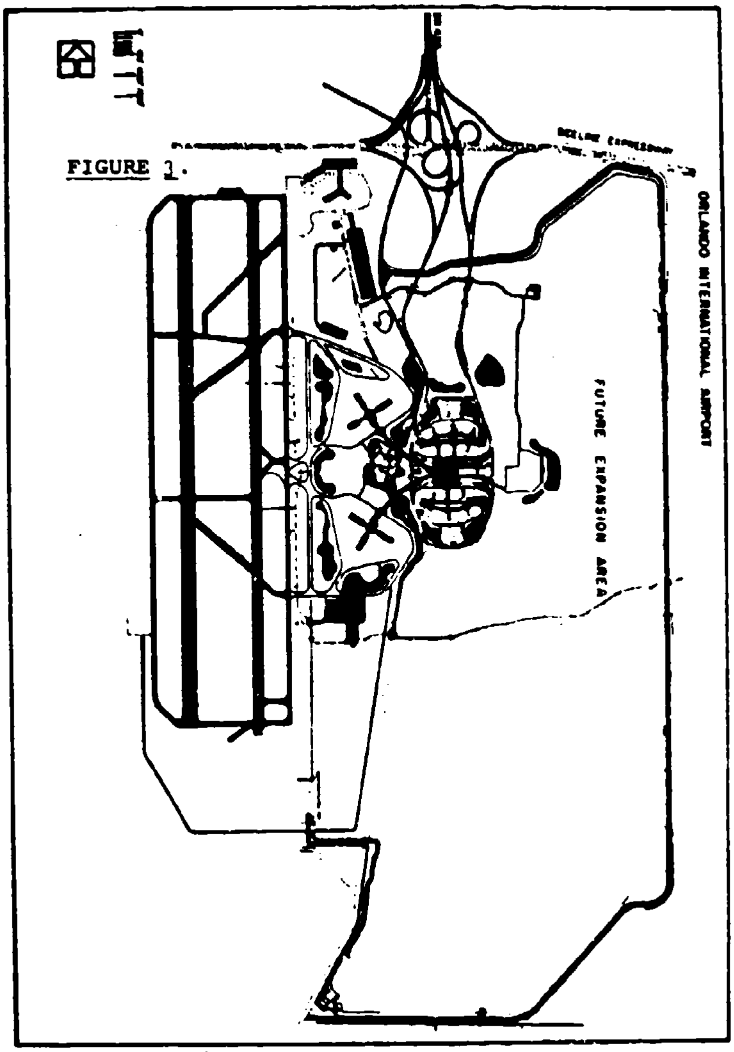

FIGURE 1.

ACTION TAKEN: ____

____

DIRECTION OF DISPERSAL: ______________________________________

BIRDS KILLED (INDICATE EXACT NUMBER AND TYPE): ________________

____

____

SUBMITTED BY: ________________________________ Page ___ of ___

FIGURE 4.

OPERATIONS PROCEDURE LETTER NO. 122.52 DECEMBER 1983

To: Airport Operations Personnel

A. Subject: OIA Bird Control Program

1. General

The objective of the OIA Bird Control Program is to reduce the potential hazard of bird strikes to aircraft operating at OIA. The program will become the responsibility of the Operations Supervisor/Agent on duty during daylight hours. Harassment techniques will be utilized to discourage birds from congregating on the AOA.

2. Equipment

The following equipment is available to the Operations Supervisor/Agent for bird control purposes:

a. 12 Gauge Shotgun - used to fire Schrekpatronen (scare cartridges), which give a loud report at 75 yards; used to fire shotgun shells for occassional kills.

b. 15mm Launcher - used to fire Whistle Bombs, which give a loud whistle for 125 yards; used to fire Racket Bombs, which give a loud racket for 125 yards.

3. Procedure

The success of the program will be directly proportional to the effort put into it by the Operations Supervisor/Agent on duty. New ideas and suggestions will be an important part of the program, and successful techniques should be shared. The following are general requirements:

a. Any Supervisor/Agent participating in the program will be required to be trained in the proper handling and utilization of firearms used in the program by a licensed firearms instructor designated by GOAA.

b. Safety in handling and utilization of firearms is of the utmost importance. Deviations from safe operating practices will not be tolerated. Use of firearms/ammunition for purposes other than the Bird Control Program may result in disciplinary action.

FIGURE 4.

4. Permit Requirements

This program is aimed primarily at the winter sea gull population, however, it may be used against any bird threat to aircraft. Sea gulls, as migratory birds, are protected by law, and any killing of protected species requires permits from state and federal agencies.

a. OIA has applied for and received the necessary renewable permits required by the Florida Game and Fresh Water Fish Commission, as well as the U.S. Fish and Wildlife Service. The permits give authorization "to kill by shooting migratory birds when necessary to prevent the destruction of life and property (aircraft)."

b. Kills are restricted to airport property by the permits, and, unless authorized, will be conducted only on the AOA.

c. Kills will be held to a minimum commensurate with adequate protection of life and property. Kills will normally be carried out only when it becomes necessary to reinforce scare tactics (ie. when scare cartridges and bombs become ineffective).

d. The carcasses of all birds killed shall be buried or incinerated.

e. All bird activity (except bird strikes) shall be entered on the "Bird Incident Report" form. Please be specific as possible when identifying birds. A bird identification book has been provided for this purpose. Permit requirements call for an annual report of operations listing names and number of birds taken.

5. Restrictions

a. Any bird control measures taken will be done whenever possible in coordination with the Control Tower in advance by radio or telephone. This will allow the Tower to advise or direct traffic flow on the ground as necessary.

b. Bird control activity is restricted to daylight hours only.

FIGURE 4.

5. Restrictions (cont.)

c. Firearms will not be discharged as follows:
- on or towards the Airside Ramps;
- on or towards any occupied sections of the West Ramp;
- near or towards any aircraft;
- near or towards any refueling activity, fuel truck/pumper, fuel farm, fuel tank or fuel pump;
- towards any occupied buildings, persons, vehicles, active streets or highways;
- towards any FAA navigational facilities, lighting or instruments.

d. When not in use, firearms will be properly secured, unloaded and stored with all safety devices in place.

6. Responsibility

The Senior Operations Supervisor in charge will assure that the procedures outlined in this Letter are complied with.

(original signed by)
Gary W. Green
Director of Operations

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AD-P004 205

STAFF ASSISTANCE TO BASES FOR BIRD HAZARDS

BY
CAPTAIN ROBERT C. KULL, JR.
HQ AIR FORCE ENGINEERING AND
SERVICES CENTER
TYNDALL AFB FLORIDA 32403

ABSTRACT

One of the primary functions of the Air Forces' Bird/Aircraft Strike Hazard (BASH) Team is to assist bases worldwide with their bird hazards. Due to the wide variety of environments of bases, as well as the diverse missions of the aircraft, in-depth staff assistance proves to be a real challenge. Coupled with these difficulties is the added problem of personnel reassignment which does not allow for corporate memory to exist for an extended period of time. To combat these problems, the BASH Team has written a BASH Guidance Package, a base self-inspection checklist, and the Handbook on Bird Management and Control. In addition to these publications, the Team provides on-site assistance for specific and more difficult situations. Each of these items are described in more detail.

INTRODUCTION

The US Air Force formed the Bird/Aircraft Strike Hazard (BASH) Team in 1975 after several catastrophic bird strikes with jet fighter aircraft. The BASH Team, stationed at Tyndall Air Force Base, Florida, is responsible for all aspects of the bird strike reduction program. Their main responsibility is to provide assistance to Air Force bases, worldwide, to reduce the hazards created by birds. Due to the wide variety of environments of bases, as well as the diverse missions of our aircraft, in-depth staff assistance proves to be a real challenge.

The BASH Team consists of three biologists of varying backgrounds and expertise, and the team leader has aircrew experience. In order to provide the assistance required, the Team developed management tools that would get information efficiently to the users. These tools or techniques include a BASH Guidance Package, a base self-inspection checklist, and the Handbook on Bird Management and Control. In addition to these publications, the Team provides bases with bird strike data, low-level route bird strike risk graphs, and on-site assistance.

BASH GUIDANCE PACKAGE

The BASH Guidance Package, proposed to be incorporated into an attachment to an Air Force regulation, provides the base with general information concerning bird control and methods to reduce bird strikes to aircraft. The BASH Team wrote the Guidance Package with the intention of providing a single document reference. As an attachment to a regulation, the document can be easily updated when changes in methodology occur.

The Guidance Package describes how to set up a base bird strike reduction program. The program requires that a written plan be developed in order to establish tasks for each organization responsible for certain aspects of the bird strike reduction program. The plan suggests that a bird hazard working group be formed with the tasked organizations. Once the working group is developed, potential bird hazards must be identified and addressed. As described in the Guidance Package, airfield bird control may be classified into two categories: passive and active controls. Passive controls include habitat modification and proper land management in order to discourage the attraction of birds to an area. The Guidance Package describes typical areas of concern to an airfield manager. Active controls, on the other hand, include the use of bioacoustics, pyrotechnics, depredation and various other methods to scare or eliminate birds from the airfield. The Guidance Package includes a description of each active control ...re, the equipment required, and stock numbers needed to order the ...t. In addition to these control measures, the BASH Team suggests operational changes in order to reduce the potential for strikes. ...so contained in the Guidance Package is a base self-inspection checklist on the bird strike reduction program.

BASE SELF-INSPECTION CHECKLIST

Self-inspection checklists are used extensively throughout the Air Force as effective management tools. These checklists, used by the tasked organization, query each aspect of a particular job. In this way, a manager can objectively evaluate the programs and take corrective action on those items found deficient. The BASH self-inspecion checklist (see Addendum) is a series of questions intended to query aspects of the bird strike reduction program. The bird hazard working group can review the checklist to ensure that the program is functioning properly. The checklist is flexible in that questions can be added, deleted, or altered depending on changes in the mission and location of the organization.

HANDBOOK ON BIRD MANAGEMENT AND CONTROL

The Handbook on Bird Management and Control (referred to here as the Handbook) by Lucid and Slack (1980), is another tool we use to increase the knowledge of those working the bird strike reduction program. The Handbook was prepared to assist Air Force pest managers on how to control birds (Will, 1983). As described by Will, the book provides a step-by-step approach to bird management for the inexperienced pest controller. The Handbook is also used as a text in the Air Force pest manager technical training courses. For this reason, chapter review questions are included to help emphasize key points that will be important to the pest manager in the field.

OTHER ASSIST

The BASH Team maintains all Air Force bird strike data in order to establish trends and to provide consolidated information to bases and higher headquarters. The data dates back to 1975 and allows the Team to establish trends for many variables concerning bird strikes (Kull, 1983).

Coupled with the inherent hazards of flying in and around the airdrome environment, the Air Force must fly low-level missions. These low-level flights are normally flown at speeds of 350-600 knots at approximately 500 feet above the ground. Flying in this environment is exceptionally hazardous for many reasons (Ramachandran, 1980), one of which is the danger of hitting birds at a high rate of speed. In fact, 25.7% of the Air Forces' bird strikes occur during low-level flights (Kull, 1983). Many of these low-level flights are flown on published Department of Defense (DOD) low-level routes.

In 1981 the BASH Team developed a computer-generated Bird Avoidance Model (BAM) (Skinn and Berens, 1980), for these published DOD low-level routes. This model, based on 40 years of waterfowl migration data (Bellrose, 1971 and 1976), predicts the risk of a waterfowl strike while flying these routes during the migration season. As seen in Figure 1, a BAM graph displays the risk of flying a given route during the day, dawn/dusk, and night. Figure 2 displays the risk of flying a variety of routes during the same time of day. In either case, a pilot, schedules, or safety officer can easily evaluate the bird strike risk for time of day and time of year for many routes. Given that the individual has the opportunity to make a choice, the BAM graphs provide information to assist in the decision. These graphs are readily available to our user agencies.

The BASH Team also maintains a library (currently being computerized) on all aspects of the bird strike problem. Literature contained in the library includes technical reports, scientific research, seminar proceedings, and related articles. Upon request we provide our bases with literature concerning their specific problems.

The Team also maintains a tape library of recorded bird distress and alarm calls. These tapes are recommended in our active control techniques in order to get birds in the air. Once in flight, we recommend using pyrotechnics to scare the birds away. Over 21 species of bird recordings are located in our library. As with the other material, we ensure that the tapes are easily available to Air Force bases by simply requesting the material by telephone.

On many occasions, birds present unique hazards that require a BASH Team visit. Since Air Force personnel rotate jobs frequently, corporate memory of airfield problems is sometimes lost. For this reason, follow-up visits are sometimes required in order to ensure the program is working effectively. Upon visiting a base, the Team meets with safety, base operations, and environmental planning personnel concerning specific aspects of the BASH program. The Team uses the base self-inspection checklist in order to ensure all aspects of the program are examined. Recommendations on ways to reduce the hazards of birds to aircraft are presented to the Commander. The Team must consider the Air Force's mission and the feasibility of the recommendations in order that base personnel will receive the suggestions in the right light. Unreasonable recommendations could reduce the Team's creditibility and the program would not be enhanced.

CONCLUSIONS

With only three BASH Team members, providing assistance to Air Force bases worldwide is a real challenge. In order to meet these requirements, effective management tools were developed by the BASH Team. With single source references and telephonic requests for specific assistance needed, bases can run an effective bird strike reduction program.

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INSPECTION CHECKLIST	PAGE 1 OF 4 PAGES	
TITLE/SUBJECT/ACTIVITY/FUNCTIONAL AREA BASE SELF-INSPECTION CHECKLIST	OPR	DATE

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	1. Is AFR 127-4 current and readily accessible for your reference?			
	2. Is AFR 127-15 current and readily accessible for your reference?			
	3. If the base has a flying mission, has a BASH reduction program been established?			
	4. Does the program establish a Bird Hazard Working Group (BHWG) or similar organization?			
	5. Are base agencies such as Safety, Civil Engineering, and Operations assigned responsibilities for the BASH program?			
	6. Is there an assigned OPR of the BHWG?			
	7. Does the BHWG meet on a regular basis as a separate meeting or in conjunction with another meeting containing the same members?			
	8. Are flight safety briefings to the aircrews accomplished on a regular basis?			
	9. Are topics for the briefings varied so as to make them interesting and informative?			
	10. Are different types of media used in the briefings (e.g., movie, slides, personal testimony, statistics, etc.)?			
	11. Are posters, pictures, maps, etc. related to BASH posted in the aircrew briefing areas?			
	12. Are local bird problems documented?			
	13. Are both damaging and nondamaging bird strikes recorded?			
	14. Is all the information concerning the bird strike as listed in AFR 127-15 recorded?			
	15. Are all nondamaging bird strikes reported to HQ AFESC/DEVN, Tyndall AFB semiannually?			
	16. Are all damaging bird strikes reported with all the proper addresses?			
	17. Are bird remains (feathers, beaks, feet) collected as a result of a bird strike?			
	18. Are the bird remains sent to a local authority (US Fish and Wildlife Service, university, or local ornithologist) for identification?			

AF FORM 2519

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	19. Are bird remains sent to AFESC/DEVN at Tyndall AFB if identification is not possible in the local area?			
	20. Is the bird strike information tracked so as to facilitate the identification of trends (e.g., type of bird, route, time of day, type of aircraft)?			
	21. Are statistical analyses of bird strike data accomplished?			
	22. As part of the bird awareness program, do you have a bird identification book?			
	23. Are daily surveys taken of the airfield and surrounding area to observe potential/ actual bird hazards?			
	24. Are the daily surveys taken at various times of the day?			
	25. Are records of daily observations kept in order to establish trends?			
	26. During the surveys, are areas like standing water, food sources, or areas for protection noted?			
	27. Is the vegetation on the airfield particularly attractive to birds?			
	28. Does the base have agricultural contracts (outleases) to mow the airfield?			
	29. Does the contract specify that the grass be maintained at a height of 8-12 inches?			
	30. Does the base practice controlled burning?			
	31. If controlled burns are practiced, are changes in operations done or burning accomplished during down times?			
	32. Are trees or shrubs located close to the runways?			
	33. Are these trees/shrubs attractive to birds?			
	34. Are birds attracted to the taxiways or active runways?			
	35. Has it been determined why the birds are attracted to the taxiways/runways?			
	36. Has it been determined what type of birds are attracted to the taxiways/runways?			
	37. Are the areas with water (ponds, lakes, swamps, etc.) attractive to birds?			
	38. Are the birds feeding in these wet areas?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
39.	Has it been determined what type of birds are attracted to these wet areas?			
40.	Do the wet areas contain vegetation along its perimeter?			
41.	Do the wet areas contain a lot of fish or amphibians (frogs or salamanders)?			
42.	Are there other areas near the runways that attract birds (horse stables, recreation areas, golf courses, etc.)?			
43.	Has it been determined what is attracting the birds?			
44.	Has it been determined what type of bird is being attracted to these other areas?			
45.	Are there farms in the surrounding area of the base that attract birds?			
46.	Has the farmer been approached by the base and asked to change crop or eliminate the attractiveness of the area?			
47.	Is the base notified of the plowing times in order to alter operations?			
48.	Does the farmer practice controlled burning after harvest?			
49.	Does the base outlease cropland on adjacent annex areas?			
50.	Does the lease provide for restrictions concerning BASH?			
51.	Are there garbage dumps, landfills, or sewage lagoons in the area near the base?			
52.	Is the garbage dump/landfill/sewage lagoon covered daily with dirt/screen or netting?			
53.	Does the garbage dump/landfill/sewage lagoon attract birds?			
54.	Are there other areas attractive to birds near the base (e.g., lakes, ponds, swamps, cemeteries, wildlife areas)?			
55.	Have the aircraft hangars/buildings been inspected for pest birds?			
56.	Do the bird droppings cause problems by accumulating on equipment/aircraft?			
57.	Is equipment covered and aircraft cockpits closed each night to provide protection against bird droppings?			
58.	Are hangar doors left open all the time?			

NO.	ITEM (Assign a paragraph number to each item. Draw a horizontal line between each major paragraph.)	YES	NO	N/A
	59. Is the cost of cleaning up the bird droppings and any damage incurred less than any type of solution to the problem?			
	60. Is there an active hunting club on base?			
	61. Are the game birds/deer controlled so as not to interfere with flying operations?			
	62. Is there a designated bird control team that actually manages/controls birds?			
	63. Is the control team actively patrolling the airdrome?			
	64. Does the control tower warn operations/ pilots of birds in the airdrome?			
	65. Does the control team use distress tapes to get rid of birds on the airfield?			
	66. Does the control team use pyrotechnics?			
	67. Is Avitrol or other avicide used to control/kill birds?			
	68. Does the control team possess a permit issued by the US Fish and Wildlife Service to kill birds?			
	69. Have State authorities been notified concerning the depredation permit?			
	70. Are traps used to capture birds?			
	71. Does the BHWG suggest ways of altering the situation or changing the habitat to discourage birds from the area, before using elimination/ reduction techniques?			

BIRD STRIKE AVOIDANCE SYSTEM FOR DOVER AFB, DELAWARE

PAUL DESAULNIERS

MILITARY AIRLIFT COMMAND

SCOTT AFB ILLINOIS

The Traffic Control and Landing System (TRACALS) Directorate, Military Airlift Command (MAC/DCF) developed, tested and implemented an innovative bird strike advisory system for aircraft operations at Dover AFB DE. With the support and participation of representatives from HQ Air Force Systems Command (AFSC), HQ Air Force Communications Command (AFCC), Rome Air Development Center (RADC), Air Force Engineering and Services Center (AFESC), and the USAF Airlift Center (USAFALCENT), HQ MAC/DCF successfully conducted problem analyses and the evaluation of solution alternatives to alleviate a severely critical instrument flight rule (IFR) safety hazard. The resultant procedures have greatly contributed to diminishing the bird strike hazard in the Dover flying area, and achieved establishment of an effective bird detection/advisory system. System limitations have been identified and are being addressed through equipment enhancements and local community cooperation.

BACKGROUND

Dover AFB is located in the Atlantic flyway, through which millions of birds migrate each year, and in very close proximity to several national, state, and private wildlife areas and refuges. Three of these areas, Bombay Hook National Wildlife Refuge, Little Creek Wildlife Area, and the Logan Lane Tract of the Little Creek Wildlife Area are located either within or adjacent to the confines of the Dover AFB local flying area. Nine other areas within a thirty mile radius result in a very large acreage of wildlife habitat. Environmental actions taken by the State of Delaware, have substantially enhanced the area's attractiveness to waterfowl. An abundant food supply, mild winters, and an improved habitat have contributed to ever increasing numbers of wintering waterfowl. The migratory population includes: snow geese, canada geese, and numerous varieties of ducks. Also, huge flocks of blackbirds, cowbirds, grackles, and starlings plague aircraft operations in the Dover area. Geese arrive in October with approximately half the population continuing the migration farther south along the Atlantic coast. Populations increase again in March, and migrate north by April. Resident wintering waterfowl populations reach as high as 150,000.

Observations by local wildlife officials and an AFESC Bird/Aircraft Strike Hazard (BASH) Team indicated that an extremely high number of geese make feeding flights across traffic patterns at Dover. The problem is further complicated by hunting pressures and weather phenomena. Feeding flights begin around dawn and continue for approximately two hours. Geese return to the refuges at dusk or into the evening hours. Overcast skies may cause waterfowl to fly throughout most of the day.

The spark that triggered this initiative was a catastrophic bird strike between a C-5 Galaxy (the world's largest aircraft) and a flock of snow geese in January 1983. As a result of this near tragedy, the Commander-in-Chief of the Military Airlift Command (CINCMAC) requested action be taken to develop a Bird Strike Avoidance System for Dover AFB.

In February 1983, an intercommand working group was formed to determine the extent of the problem, and to evaluate possible alternatives to achieve a reduction in the bird strike threat. Radar was determined to be the most likely technology to provide "real time" assessment of bird conditions.

In March 1983, an Army TPN-18A, X-Band mobile radar was deployed to Dover to monitor bird movement and relay bird information to aircrews through the command post.

TASK

Since sufficient data was not obtained during the March 1983 feasibility testing of the bird strike advisory system, additional verification and operational testing was required. Critical questions, such as, correlation between the number of geese and radar display target size, detection range versus target size, radar uptime rate, and information concerning aircrew acceptance of system procedures were not adequately addressed.

A comprehensive three-phase test program was established. The purpose was to determine the optimum radar system to be utilized and to evaluate the adaptability of the proposed procedures to varied environments. Phase One was a thorough engineering verification of candidate radars to document system capabilities. Phase Two evaluated the operational implementation of the total bird strike advisory system. Phase Three studied near, mid, and long term objectives, procured necessary equipment, and refined operational procedures.

In October 1983, Phase One was completed. Evaluated radars included: a van mounted marine X-Band (9000-9200 MHz) system, a marine S-Band(3.0-3.2GHz) radar utilizing a rain-rejection antenna, the deployed Army TPN-18A, and the in-place AN/GPN-20 air traffic control S-Band radar (2.7-2.9 GHz). Test results indicated that the GPN-20 was far superior to the other candidate systems in detecting levels of bird activity. Additionally, the capability of providing bird movement information on flocks of 3-5 geese to individual aircraft was now being detected. Phase Two began immediately after the selection of the GPN-20. HQ MAC/DCF and the 2016 Communications Squadron (CS) specialists, working with 436 Military Airlift Wing (MAW) operations personnel, developed procedures to utilize the extensive bird movement information now available. Aircrew and air traffic control interfaces were designed and implemented on 14 Nov 83.

Phase Three began almost simultaneously with the development of the operational concept. Additional equipment was identified, procured, and installed by 24 Jan 84. All 2016 .S Radar Approach Control (RAPCON) personnel were trained on bird watch procedures, advisories were placed in flight publications, and the 436 MAW Command Post began informing aircrews of the availability of bird advisories. System limitations associated with equipment characteristics and environmental conditions were identified. Possible system enhancements in both the equipment acquisition and environmental control areas were defined, and a full briefing was prepared and presented to the Commanders of both MAC and AFCC.

CONCEPTS

Rapid Development

The increased population of wintering waterfowl in the Dover area presented a bird strike potential that was limiting the wing's capability to perform its mission. A warning system had to be installed as soon as possible while remaining within the economic constraints imposed by available discretionary funds. Additionally, the imminent hazard would not allow the lead time necessary for a full developmental effort. Off-the-shelf technology would have to be utilized. Within 60 days of the Jan 83 major bird strike, a preliminary avoidance system utilizing an Army radar and ATC personnel was in place. Aircraft now had at least some idea of the hazard level they faced.

Continuation of Training Flights

Following the Jan 83 strike all local training sorties at Dover were cancelled. Attempts were made to obtain training capabilities at other east coast airfields, but the wake turbulence criteria associated with the C-5 made it unwelcome at most locations. Aircrew proficiency was being adversely affected. The continuous monitoring of bird movements now gave the wing the capability of determining when a minimal hazard was present, and training flights could be scheduled to coincide with these periods. ATC personnel provided information directly to the Command Post whenever significant activity changes occured.

Reduce Risk to Mission Aircraft

Prior to the installation of the Bird Avoidance System, mission aircraft were dependent on visual sightings for hazard assessment. Bird activity outside of visual contact due to distance or climatological phenomena was an unknown factor. Unlike training, mission flights could not be cancelled, so aircraft operations were often conducted without knowing the potential for a catastrophic bird strike. The Jan 83 flight that encountered a flock of geese was a mission departure during a period of reduced visibility. Although only minimal delays could be tolerated, knowledge of both bird activity levels and locations allowed mission operations to be based on real time information. Departures could be held while large flocks of waterfowl cleared the departure path or alternate runways could be chosen when operationally feasible. Arrivals could be diverted, held, or routed to less hazardous runways.

Quantify Risk Levels

The only information on bird activity available prior to the bird watch system was that provided by wildlife experts. Specifically, this general behavior pattern information indicated that in periods of clear weather bird movement was concentrated in the dusk and dawn time periods. However, ornithologists also noted that overcast conditions created an increase in activity that occurred at unpredictable intervals throughout the day. While movement after dark was less prevalent it did occur and presented an unknown risk factor. Some rescheduling of wing operations could be made to adjust to this limited knowledge, but attempting to reschedule all transient operations was an impossible task. With a 24 hour bird watch system in place, the wing could now quantify risk levels, and provide advance warning to both transient and wing aircraft on bird strike potential. A bird hazard condition (BHC) scale was designed, using red, yellow, and green coding for BHCs. A green BHC is limited to those time periods when most waterfowl are residing in their northern Canadian habitats (i.e. May-Sep). Flying continues as normal. The yellow BHC is instituted as soon as southern migratory movement into the Dover area is detected, and remains the minimum risk level until the northern migration is completed. The bird watch function is actuated and movement information is made available to all aircraft. A red BHC is reached whenever visual or radar sightings indicate extensive bird activity in the vicinity of arrival and departure corridors. Number and size of flocks necessary to reach this level have been defined, and are in use by bird watch and command post personnel. During BHC red training flights are either cancelled or diverted.

Provide Real Time Information to Aircrews

With the incorporation of the bird watch and Bird Hazard Condition (BHC) systems at Dover, aircrews were now aware of the levels of activity at any given time. However, as noted, all aircraft operations continued during a yellow BHC, and mission aircraft still had to meet schedules during both a red or yellow BHC. For the Army TPN-18A radar, providing real time information on bird flocks that might present a hazard to an individual aircraft was hampered due to equipment limitations. Flocks of less than 30 geese, and birds within 5 miles of the airfield were not visible on this radar. With the adaption of the GPN-20 to the bird watch mission, flocks as small as 3-5 geese, and movement within 1 mile of the airfield were now readily observable. The bird watch system could now provide converging target information, recommended heading changes and departure directions to individual aircraft at any point within the radar's coverage.

Fully Integrate Air Traffic Control (ATC) and Bird Watch

ATC responsibility to pass bird movement advisories to aircrews is predicated on the fact that ATC radar is not a reliable system for bird detection due to the use of special circuitry designed to eliminate all but aircraft targets. Hence, the Federal Aviation Administration dictates that bird movement information must be derived or verified by visual means (i.e. aircrew or ground personnel). However, at Dover AFB, it was determined through visual correlation by both ground personnel and special helicopter flights, that the GPN-20 has a very high probability of detecting a flock of 3-5 geese. This high probability factor covers flocks that are between 150-2500 feet above the ground, and within 20 miles of the airfield. This probability of detection fluctuates only slightly, regardless of what special circuitry is utilized. When circuitry integration does result in some target loss to the bird watch controller, ATC will provide "quick-look" opportunities whenever possible. The ATC mission of the radar is the first consideration whenever these conflicting demands occur. To facilitate this dual utilization of the GPN-20, an additional radar indicator has been placed in the 2016 CS RAPCON for the bird watch function. It was also determined, that to maximize the system's potential, air traffic controllers would man this position. This minimized training requirements and utilized individuals who most understood both bird movements and aircraft flight patterns.

RESULTS

Within 10 months of CINCMAC's request a bird strike avoidance system is in operation that allows aircraft, both wing and transient, to operate in and out of Dover AFB, DE regardless of bird activity or weather conditions. The possibility of the Jan 83 bird strike reoccuring has been significantly reduced. Air traffic control, flight and wing operations personnel are continuously exchanging information on bird movements. Flight operations in the Dover area have returned to a level near the pre-Jan 83 time frame. Bird strikes for the 1983-84 season have been greatly reduced, have involved less that 5 birds, and have resulted in relatively minor damage.

The status of the present system has been made known to the MAC and AFCC Command Staffs. Research continues toward further risk reduction through additional technological applications and/or environmental changes. AFCC and the Bird Aircraft Strike Hazard (BASH) Team are looking into the possibility of adapting the Dover system to other USAF locations.

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BIRD STRIKE COMMITTEE EUROPE

(Presented by H.Dahl)
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1. HISTORY OF BSCE

Although the problem of collisions between birds and aircraft (bird strikes) has existed since the first man-made aircraft took off from the solid soil, a world-wide systematic work with the problem birds present to aircraft, was not started up till the early 1960s. The start was brought about by the introduction of fast jet driven airplanes which had increased the danger of aircraft and birds sharing the same airspace.

In November 1963 a symposium was arranged by the French authorities in Nice for discussions and lectures concerning this section of the air safety work.

Three years later at the request of the NATO countries' flight safety committee a meeting was held in Frankfurt, Germany, in July 1966 with the attendance of both military and civil personnel engaged in the question of flight safety, and at that meeting an organization called Bird Strike Committee Europe was created with the aim to begin a continuous international activity.

After the first meeting, yearly meetings have been arranged until 1978 where it was decided that meetings should be held with intervals of eighteen months. During the first years only the NATO countries took part in the BSCE meetings, but later other European countries appeared, and for some years there has been participation from countries in Eastern Europe, especially the Soviet Union, where the last Bird Strike Committee Europe Meeting took place in August 1982. Since the beginning civil elements in the meetings have increased.

Because of the rather informal way in which the organization was established, the BSCE could be considered as an organization composed of people working in a rather voluntary way. The committee has no special office and no secretariat, and therefore, the work has to be done by the committee chairman and members of a small committee, a steering committee, composed by chairmen or sub-committees. The chairman keeps the documents of the committee and has to cover the main part of its correspondence.

Nevertheless, BSCE has become more and more associated with the International Civil Aviation Organization in questions dealing with bird strike problems of aviation. In this way BSCE has acted in an advisory capacity to ICAO, working through the European office of ICAO on matters concerning the hazards to aviation caused by birds.

An important part of the co-operation between ICAO and BSCE has during the last years been a series of regional work shops on bird hazards which started in 1978 in Bangkok.

BSCE experts have also assisted ICAO with the new automatic system for analysis of bird strike reports (IBIS). For the time being BSCE works hard to assist ICAO with a revision of ICAO documentation dealing with bird strike problems.

We have also co-operated with the European Civil Aviation Conference (ECAC) and the International Air Transport Association (IATA).

At the 13th ECAC Intermediate Session in Paris last year the Director Generals of the participating European countries while recognizing the problem of birds at aerodromes and the potential hazards which birds present to air transport, recommended to member states to use the information on bird control methods contained in the BSCE document "Some Measures Used In Different Countries For Reduction of Bird Strike Risks Around the Airport", to take adequate steps to improve these methods where necessary, and to act through international agencies to have that information used as much as possible in conjunction with Part III of ICAO Airport Services Manual.

2. METHODS OF WORK

The meetings of BSCE including its working groups have been the main forum for new ideas about dealing with the bird problem of aviation in Europe. New ideas have been described in papers presented at the meetings, and dealing with all sections of this flight safety work. The number of working papers has from a very modest beginning increased to about 30 papers and more during the last meeting. Till now 16 meetings of the committee have taken place, and the next meeting will take place in Rome in three months' time.

To describe the work within the committee, I shall mention the terms of reference of the BSCE, and these are as follows:

> BSCE consists of civil and military participants from Europe with a common interest in the bird strike problem. Attendance is open to participants from other parts of the world. The committee shall collect, analyze, and circulate to all concerned data and information related to the bird strike problem in the European region.

The work of the committee is performed both in plenary sessions, but also in six sub-committeess created by the plenary sessions. These sub-committees are the following:

Working Group - Aerodrome
Working Group - Analysis
Working Group - Bird Movement
Working Group - Radar and other Sensors
Working Group - Communications
Working Group - Structural Testing of Airframes

The main obligation of the Working Group - Aerodrome is to study and develop methods to control the presence of birds on or near aerodromes. The Aerodrome Working Group has issued a booklet "Some Measures Used In Different Countries For Reduction of Bird Strike Risks Around the Airport".

The reason for the work is that it is a known fact that birds are attracted by airports because they find a place at the airport to breed, rest and/or roost. Therefore, it is unwise and really uneconomical to try to disperse birds if you are still offering all or a great part of these facilities to birds. In our view action to be taken should be lead by preliminary studies of the following kind:

a) What are the bird species seen on a specific airport?
This information should encompass data on topics, such as
"Are they permanently there?
"Is the number of birds of special species increasing?"

b) What is the typical behaviour of each of the species?

c) What is the potential danger caused by birds?
You will have to take into account the bird strike reports, birds found killed on the runway or within the airport perimeter, and to try to identify the species more often involved in strikes.

d) What is the amount of resources available for that purpose?
It be equipment or man-power.

e) What is done elsewhere as accompanying measures, especially on environmental management?

During our discussions in the BSCE we have been aware that many experiments have been made in Europe and elsewhere to test the methods for bird scaring and to indicate those measures which have appeared to be promising. We have seen an advantage to develop uniform methods for use on airports in some cases. Some methods are still on the experimental stage, and for the time being only indications could be provided of the efficiency of such measures.

The collection of measures as indicated in the booklet does not intend to freeze any methods, but rather to offer some possible ways to help the airport managers to decide on what could be done, and it is the intention at certain intervals of approximately 3-5 years to issue new editions of the booklet in order to revise the information on the items in connection with the work to minimize the bird strike risk at airports.

The Working Group - Analysis has as main obligation to analyse the data provided by ICAO after the introduction of the IBIS system operated by ICAO, to cover the military data, to act as a forum for discussion and dissemination, and to deal with European information as ICAO will cover the world-wide information.

The Working Group - Bird Movement and the Working Group - Radar and other Sensors are working on movements and tracks of birds. Radar is used for the study of both local and migrational movements of birds. Much of the result of these groups is used by the other groups for its tasks to map the air routes of birds. Regarding the BSCE radar studies, there has been a high interest for the last few years to establish the so-called radar chain along the Alps and the coastal areas of the North Sea.

The Working Group - Communications has as objective to develop procedures enabling a quick and reliable exchange of messages regarding bird hazard warnings. For the last few years this group has widthened its sphere of interest and is now called Communications and Flight Procedures Group.

The youngest working group of BSCE is the Structural Testing of Airframe Working Group. It has as aim to collect and analyse results of any bird impact structural testing. The knowledge and experiences which are gained through the studies of this group, will then have to be used for the assistance to the national organizations in the production design and guidance material for bird impact resistant airframes.

BIRDS AND AIRPORT AGRICULTURE IN THE CONTERMINOUS UNITED STATES: A REVIEW OF LITERATURE[1]

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This report is a review and analysis of literature pertinent to the use of airport lands for agriculture in the conterminous United States (U.S.). The paper is based on articles that (1) either document bird utilization of 85 crops or rate the appropriateness of 15 farming activities for airports and (2) identify the North American bird species that utilize these crops and activities. Our review shows that 57 crops were documented as utilized by at least one species; no reports of bird use were found for 28 crops. According to three bird-aviation authorities, only one farming activity (i.e., non-pasture stock farming) is suitable for practice within two miles of the airport center. Altogether, 69 species of birds are reported to damage or utilize agriculture in the U.S. Although numerous reports have designated gulls as the most hazardous species to air traffic, this review indicates that certain species of blackbirds, waterfowl, and gallinaceous birds pose greater hazards—at least in conjunction with airport agriculture.

INTRODUCTION

Some airport authorities in the U.S. and abroad reportedly utilize portions of airport lands for agricultural purposes (Solman, 1973; Williams, 1974; van Tets et al., 1977). Although information on U.S. facilities, crops, acreages, and revenues are unavailable (C. Wagner, Federal Aviation Agency, 1982, personal communication), agriculture on airport lands raises questions of air-traffic safety due to the potential attraction of birds.

The literature concerning bird hazards to aircraft is replete with advice on how to reduce risks of bird-aircraft strikes near airports (e.g., Aldrich et al., 1961; Boudreau, 1975; Blokpoel, 1976; Godin, 1982; Lefebvre and Mott, 1983; Seubert, 1968; Solman, 1966, 1973, 1981). A major theme of these articles is "habitat manipulation"—the reduction of potential bird hazards at airports by altering or eliminating habitat likely to attract birds. Airport agriculture generally contradicts this principle. Most crops and farm activities provide excellent food, water, and cover for birds

[1]Supported by Memorandum of Agreement DTFA 01-81-Y-30556 and Cooperative Agreement 14-16-0009-81-988 (Task C) between the U.S. Federal Aviation Agency and U.S. Fish and Wildlife Service. The assertions contained herein are the views of the authors and are not to be construed as official or as reflecting those of the U.S. Fish and Wildlife Service or U.S. Department of the Interior.

(e.g., Besser, 1984; Murton and Westwood, 1976; Solman, 1973). Still, bird utilization of specific crops or activities differ. Some crops or activities may increase bird utilization relative to non-agricultural habitats; others may actually lower bird use relative to naturally-occurring foliage, terrain, and drainage.

This report is based on a comprehensive review and analysis of select aviation, agricultural, and biological literature relevant to agricultural use of airport lands within the conterminous U.S. The objectives were to: (1) document bird depredations of 24 grain/seed/silage, 25 vegetable, 33 fruit/nut, and 3 specialty crops, plus evaluate patterns of approval/disapproval recommendations for 15 farming activities reported by several well-known bird-aviation authorities and (2) identify the species of North American birds that pose the greatest problems for airports engaging in agriculture.

RATIONALE AND APPROACH

Specific studies to assess relationships among bird species, bird numbers, and bird-aircraft strikes associated with airport agriculture are virtually non-existant. Nevertheless, numerous reports document bird depredations of specific crops, and several sources provide recommendations concerning the practice of farming activities (e.g., dairies, feedlots, tree nurseries) near runways. In our review, we assumed that the relative frequency of these reports, or the concensus among recommendations, can be used to index greater or lesser risks of bird-aircraft strikes associated with specific crops or activities. Of course, the validity of this approach depends upon (1) the thoroughness of literature search and retrieval efforts and (2) the comprehensiveness of reports and studies to document species utilization and damage of agricultural crops or activities.

The review and analysis involved a three-step procedure: (1) Crop/Activity Selections, (2) Search, Retrieval, and Evaluation of Literature, and (3) Identification of Agriculture-Linked Bird Species. Initially, the potential crops and farm activities to be considered were selected. This allowed "directed searches" for relevant published and unpublished materials by specific crop and activity. Following completion of search and retrieval efforts, we prepared composite lists of all reported damage or utilization to the crops or activities by specific species. The following is a detailed description of each procedural step.

Crop/Activity Selections.-- Potential crops and farming activities were derived from seven main sources: (1) Crop Production 1982 Annual Summary, Acreage, Yield, Production (USDA, 1983a), (2) Vegetables 1982 Annual Summary, Acreage, Yield, Production, and Value (USDA, 1983b), (3) Noncitrus Fruits & Nuts, Production, Use, and Value (USDA, 1983c), (4) Citrus Fruits, Production, Use, and Value, 1981-82 Crop Year (USDA, 1982), (5) Bird Hazards to Aircraft (Blokpoel, 1976), (6) Some Measures Used in Different Countries for Reduction of Bird Strike Risks Around the Airport (BSCE, 1979), and (7) Ecologie de la Zone de l'Aeroport International de Montreal: Les Oiseaux et Le Peril Aviare (McNeil et al., 1976). A total of 85 crops and 15 farming activities were chosen for consideration; these consisted of 24 grains/seeds/silages, 25 vegetables, 33 fruits/nuts, 3 specialties, and 15 activities (Table 1). The list of crops for grains/seeds/silages, fruit/nuts, and specialties were taken directly from the 1982 Crop Production Summary (USDA, 1983a), 1982 Noncitrus Fruits & Nuts Summary (USDA, 1983c), and 1981-82 Citrus Summary (USDA, 1982); six crops unique to Hawaii and specific categories listed for California were omitted. Vegetables were those cited in the 1982 Vegetables Summary (USDA, 1983b) and 14 additional ones added by the authors. Farming activities were selected from lists published by either Bird Strike Committee Europe (1979), Blokpoel (1976), or McNeil et al. (1976).

Search, Retrieval, a[illegible] [illegible]tion of Literature.—Published and unpublished reports of bir[illegible] [illegible]cion, -agricultural, and -biological information were retrieved by a "directed-search strategy." Two annotated bibliographies containing 595 and 345 citations, respectively, were instrumental to initiation of search and retrieval efforts: Selected Bibliography on Bird Hazards to Aircraft (DeHaven, 1983) and Publications of the Section of Bird Damage Control (USFWS, 1980). Key articles relating specific species with agricultural damage or other crop utilization were identified and read. These were gleaned for the following information: Type of Utilization/Damage (i.e., type of use or damage to plants during the crop/activity cycle), State (i.e., location of data collection), Species, and Magnitude of Use/Damage (i.e., subjective classification of bird use or damage to agriculture conveyed in article -- Major or Minor). To assess potential hazards associated with farming activities, recommendations of three bird-aviation authorities were compared (i.e., Blokpoel, 1976; BSCE, 1979; McNeil et al., 1976).

Identification of Agriculture-Linked Bird Species.— Approximately 645 species of birds are found in Canada and the U.S. (Robbins et al., 1966). Certain species were assummed to pose greater or lesser hazards to airport agriculture based on their empirical association or non-association with crops and activities. A list of the species positively reported to damage or use the cited categories of crops (i.e., grain/seed/silage, vegetable, fruit/nut, and specialty) was prepared. No list of species associated with farming activities was assembled, but certain species associated with specific activities were pointed out in the text.

OUTCOMES: CROPS LITERATURE

Grains/Seeds/Silages

Of the 24 grains/seeds/silages, 18 crops (i.e., barley, grain corn, forage corn, silage corn, flaxseed, hay, oats, potatoes, rice, rye, grain sorghum, forage sorghum, silage sorghum, sugarbeets, sugarcane, sunflower, winter wheat, and spring wheat) were reportedly damaged by at least one bird species. Six grain/seed/silage crops (i.e., cotton, cottonseed, dry edible beans, hops, soybeans, and sweet potatoes) were undocumented as damaged by birds. Typical damage occurred as sprout pulling and ingestion of grain or seed during ripening. Corn, oats, rice, sunflower, and wheat were reported as vulnerable to birds throughout the crop cycle.

TABLE 1. List of grain/seed/silage, vegetable, fruit/nut, and specialty crops, plus miscellaneous farming activities, considered for airport agriculture in the U.S.[1]

Grains/Seeds Silages	Vegetables	Fruits/Nuts	Specialties	Farming Activities
Barley	Artichokes	Fruits	Peppermint oil	Dairy farming
Corn	Asparagus	Apples	Spearmint oil	Stock farming
for grain	Beans (all)	Apricots	Tobacco[2]	(pasture)
for forage	Beets	Avocados		(non-pasture)
for silage	Broccoli	Blackberries		Stock feedlots
Cotton	Brussels	Blueberries		Piggeries
Cottonseed	sprouts	Cherries (sweet)		Landscape
Dry-edible	Cabbage	(tart)		Nurseries
beans	Cantalope	Cranberries		(including
Flaxseed	Carrots	Dates		Christmas
Hay (all)	Cauliflower	Figs		Trees)
Hops	Celery	Grapes		Sod Farming
Oats	Corn (sweet)	Kiwifruit		Seed Farming
Potatoes	Cucumbers	Nectarines		Crop Farming
Rice	Eggplant	Olives		Fruit Tree
Rye	Endive	Peaches		Farming
Sorghum	Garlic	Pears		Stockyards
for grain	Lettuce	Plums (incl. prunes)		Fur Farming
for forage	Melons (all)	Pomegranates		Poultry Farming
for silage	Onions	Raspberries		Rabbitries
Soybeans	Peas	Strawberries		Apiaries
Sugarbeets	Peppers (all)	Citrus Fruits		
Sugarcane	Spinach	Grapefruit		
Sunflower	Squash (all)	Lemons		
Sweet potatoes	Tomatoes	Limes		
Wheat (winter)	Turnips	Oranges		
(spring)		Tangelos		
		Tangerines		
		Temples		
		Nuts		
		Almonds		
		Filberts		
		Peanuts[2]		
		Pecans		
		Pisatachios		
		Walnuts		

1 USDA considers many of the cited vegetables and fruits/nuts to be specialties (e.g., artichokes, garlic, figs, kiwifruit, pomegranates filberts, pistachios). For purposes of this report, these crops were generally classified according to generic names (e.g., vegetables, fruits, citrus fruits, nuts) whenever possible.

2 Tobacco and peanuts are grown by producers that have been granted production allotments for these crops; cultivation of these is controlled.

Altogether, 41 species of birds were reported to cause major or minor losses to the 18 damaged crops. Blackbirds were the most frequent birds linked with crops; 10 (i.e., Eastern Meadowlark and Western Meadowlark; Yellow-headed, Red-winged, Tri-colored, Rusty, and Brewer's Blackbird; Boat-tailed and Common Grackle; and Brown-headed Cowbird) of the 12 members of this family were reported to damage grains/seeds/silages. At least one of these species was associated with damage to 13 of the 18 documented crops: barley, grain corn, forage corn, silage corn, oats, rice, rye, grain sorghum, forage sorghum, silage sorghum, sunflower, winter wheat, and spring wheat. The extensive ranges of blackbirds pose risks to air traffic at airports considering cultivation of these 13 crops throughout the lower 48 states.

Vegetables

Of the 25 vegetables considered, 15 were linked with bird use: beans, beets, brocolli, cabbage, cantalope, carrots, sweet corn, lettuce, melons, onions, peas, peppers, spinach, tomatoes, and turnips. Although 10 vegetables (i.e., artichokes, asparagus, brussel sprouts, cauliflower, celery, cucumber, eggplant, endive, garlic, and squash) were undocumented as damaged by birds, it is difficult to conceive of any vegetable crop not attracting birds, especially during seeding or sprouting. High insect burdens also make these crops suspect for airports in most locales and, the high-risk, labor-intensive nature of vegetables present concerns relative to agricultural use of airport lands (e.g., profits, security).

As expected, the most documentation of bird damage to vegetables was associated with sweet corn. Other vegetables frequently confirmed as damaged included: beans, broccoli, cantalope, lettuce and melons. Damage to avocados, cabbage, carrots, and onions was confirmed by only one or two sources, but all of these reports indicated major damage by particular species.

Twenty-three species of birds were reported to damage vegetables. The most frequently reported species was the Horned Lark. This widely distributed bird was linked with sprout pulling for 12 of the 15 damaged vegetables (i.e., beans, beets, broccoli, carrots, lettuce, melons, onions, peas, peppers, spinach, tomatoes, and turnips). As with grains/seeds/silages, various species of blackbirds were also frequently implicated in foraging of vegetables; five species were involved (i.e., Brewer's, Red-winged, and Yellow-headed Blackbirds, plus Brown-headed Cowbird and Common Grackle). These species were all linked with damage to sweet corn, whereas the Horned Lark was absent from the reports on this most-vulnerable crop. Other species reported to damage multiple vegetables were: Common Crow, Black-billed Magpie, Yellow-billed Magpie, European Starling, House Finch, Crowned Sparrow, and House Sparrow.

Fruits/Nuts

Fruits/nuts were subdivided into three classes: fruits, citrus fruits, and nuts (Table 1). Results of our search are given for each class.

Fruits.— Altogether, birds were reported to damage 17 of the 20 fruits surveyed; dates, kiwifruit, and pomegranates were not damaged by birds. Numerous reports of damage were found for apples, apricots, blueberries, cherries (sweet and tart), figs, grapes, nectarines, olives, peaches, and pears. These indicated that damage occurred mainly during the ripening cycle (i.e., ripening and mature fruit); observations of bud removal also occurred frequently for apples and apricots. Three fruits were confirmed as damaged on the basis of single sources (i.e., cranberries, olives, and peaches).

Forty species of birds were linked with fruit damage. Blueberries were damaged by the most kinds of birds, with 21 species involved in some crop destruction. Grapes and sweet cherries were reported as the next most-damaged crops by the most birds (i.e., 16 and 13 species, respectively). Interestingly, one of the few citations confirming gull foraging on crops occurred within this category -- cranberries (Smith, 1966); and, this crop was the sole fruit linked with only one bird. The species most often mentioned as pests of fruit were the House Finch and European Starling; these utilized nine and 10 crops, respectively.

Citrus Fruits.— The retrieved data for citrus was the most easily interpreted. Only one reference linking crows with minor damage to oranges was found, and the type or location of destruction was not specified. While the attraction of birds to feed on citrus fruit was not demonstrated, groves of these fruit trees would provide shelter and roost harborage. This, coupled with the long periods needed for grove development (i.e., 8-12 years), makes citrus crops undesirable for airports.

Nuts.— Damage to nut crops by birds was well documented, with five of the six types of nuts categorized as extensively damaged (i.e., almonds, peanuts, pecans, pistachios, and walnuts). Only filberts was void of evidence of bird damage. Areas of nut production were centered largely in California and several Southern states (e.g., Arkansas, Georgia, Oklahoma, and Texas).

Eighteen species of birds were associated with reports of damage to nut crops. The single-most harmful species was the Common Crow; it was reported to damage all five of the nuts previously mentioned as vulnerable to birds. With the exception of debudding of almonds by House Finches and Goldfinches, all references indicated that birds damaged the mature crops. The nut crop damaged by the most-diverse group of birds was almonds, with 11 species as potential pests. Peanuts and walnuts were damaged by six and five species respectively. Pecans and pistachios were linked with two species each (i.e., Brewer's Blackbird and Common Crow and Scrub Jay and Common Crow, respectively).

Specialty Crops

Only three specialty crops were considered: peppermint, spearmint, and tobacco. No references linking mint-oil crops with bird damage were found. These crops are commercially produced only in the Great Lakes and Pacific Northwest Regions.

One brochure indicated that blackbirds caused damage to tobacco plants, but the nature of the damage was not described. Sprout pulling, use of plants for shade, and insect feeding within maturing fields are all potential attractions for birds. Because tobacco is grown only by allotments, we considered it an unlikely crop for airport agriculture.

OUTCOMES: FARMING-ACTIVITIES LITERATURE

Table 2 is a checklist of the approval/disapproval ratings for three arbitrary agricultural-use zones provided in reports by Bird Strike Committee Europe (1979), Blokpoel (1976), and McNeil et al. (1976) for the 15 farming activities. These zones are: Interior Zone— $\leq$2-mile radius of airport center; Intermediate Zone—a 1-mile-wide band located between 2 and 3 miles from airport center; and, Exterior Zone—a 2-mile-wide band located between 3 and 5 miles from airport center or runways. Ratings for eight of the activities were common to all three sources; whereas, four activities (i.e., crop farming, fruit-tree farming, stock yards, and fur farming) were only rated by two of the sources and three (i.e., poultry farming, rabbitries, and apiaries) were unique to McNeil et al. (1976). Each of the research groups provided separate ratings for the suitability of an activity within the Interior, Intermediate, and Exterior Zones.

Because of the relatively small size of U.S. airports (i.e., average of 306 acres for the 5,846 public-use airports; M. Harrison, Federal Aviation Agency, 1983, personal communication), farm activities within the Interior Zone were considered most relevant. The only activity unanimously approved for this Zone was stock farming. Both Bird Strike Committee Europe (1979) and Blokpoel (1976) provided general recommendations for both pastured and non-pastured stock breeding; these authors allowed stock breeding in all three zones. McNeil et al. (1976) discriminated these two activities, allowing stock breeding only in situations where animals were stabled with covered feed troughs or beyond 3 aerial miles from the airport center. This recommendation also must be qualified for areas inhabited by the Cattle Egret, a bird known to be attracted to insect movements caused by grazing animals (J. Seubert, Fish and Wildlife Service, 1984, personal communication; Fellows et al. 1983). Neither Blokpoel (1976), BSCE (1979), nor McNeil et al. (1976) addressed potential hazards of this species to stock farming.

Additionally, two activities were approved by a majority of the research groups for the Interior Zone, and four other activities were approved for this Zone by one of the groups. Bird Strike Committee Europe (1979) and Blokpoel (1976) agreed that dairy farming and landscape nurseries posed no hazard to air traffic within the 2-mile radius of airport center. McNeil et al. (1976), on the other hand, approved piggeries and apiaries without restrictions in the Interior; fur farming and poultry farming were also allowed, but animals were required to be enclosed and fed dry materials.

Only two activities were approved by all three sources for the Intermediate Zone: stock farming (non-pasture) and landscape nurseries (including Christmas Trees). Dairy farming, stock farming (pasture), sod farming, and seed farming were approved by different combinations of two sources each. Stock feedlots, piggeries, fruit-tree farming, and stock yards were generally disapproved within this Zone.

TABLE 2. Approval(+)/disapproval(-) ratings for conduct of 15 farming activities on airport lands as derived from Bird Strike Committee Europe (1979), Blokpoel (1976), and McNeil et al. (1976).

Farm Activities	BSCE (1979) Airport Zone[1]			Blokpoel (1976) Airport Zone			McNeil et al., (1976) Airport Zone		
	Int.	Inter.	Ext.	Int.	Inter.	Ext.	Int.	Inter.	Ext.
Dairy Farming	+	+	+	+	+	+	-	-	+[2]
Stock Farming[3] (pasture)	+	+	+	+	+	+	-	-	+
Stock Farming[3] (non-pasture)	+	+	+	+	+	+	+[4]	+[4]	+
Stock Feedlots	-	-	-	-	-	+	-	-	+
Piggeries	-	-	-	-	-	+	+	+	+
Landscape Nurseries (including Christmas Trees	+	+	+	+	+	+	-	+[5]	+
Sod Farming	-	-	+	-	+	+	-	+	+
Seed Farming	-	-	+	-	+	+	-	+	+
Crop Farming	-	-	+	-	+	+			
Fruit Tree Farming	-	-	-	-	-	+			
Stockyards	-	-	-	-	-	+			
Fur Farming	-	-	-				+[6]	+	+
Poultry Farming							+[7]	+[7]	+
Rabbitries							-	+	+
Apiaries							+	+	+

1 Airport zones are defined by Bird Strike Committee Europe (1979) and Blokpoel (1976) as follows: Interior (Int.)-- $\leq$2-mile radius of airport center; Intermediate (Inter.)--a 1-mile-wide band located between 2 and 3 miles of airport center; and, Exterior (Ext.)--a 2-mile wide band located between 3 and 5 miles of airport center. This zonal scheme is similar to that of McNeil et al. (1976), but their zones refer to distances from runways instead of airport center and include a fourth category (i.e., Fenced Zone) which is the close-in, fenced area adjacent to airport buildings and runways.

2 Feasible for Interior and Intermediate Zones if ecological control of vertebrates is in effect.

3 Note.--Bird Strike Committee Europe (1979) and Blokpoel (1976) do not differentiate pasture and non-pasture stock farming.

4 Restriction that animals be kept within stables (feed covered) in Interior and Intermediate Zones.

5 Restriction excludes fruit-bearing cherry trees.

6 Restriction that animals be fed dry-food materials only.

7 Restriction that poultry be kept in buildings.

Approval ratings for activities in the Exterior Zone generally concurred. All sources approved dairy farming, stock farming (pasture and non-pasture), landscape nurseries (including Christmas Trees), sod farming, and seed farming. Blokpoel (1976) and McNeil et al. (1976) also agreed on the setup of stock feedlots and piggeries in the Exterior Zone. The only prohibitions imposed were by Bird Strike Committee Europe (1979) for stock feedlots, piggeries, fruit-tree farming, stockyards and fur farming. The care taken to ensure covered feeding troughs (e.g., piggeries), enclosure of facilities, (e.g., poultry) and proper disposal of wastes greatly affected the feasibility of these activities.

AGRICULTURE-LINKED BIRD SPECIES

Table 3 lists the common names of 69 birds reported to damage one or more of the crops or activities considered in our review. These represent about 10 percent of the 645 species that inhabit the U.S. and Canada (Robbins et.

TABLE 3. Common names of the 69 North American Bird Species documented as involved in agricultural depredations within the conterminous states of the U.S.[1]

Canada Goose	Mallard	Mottled Duck
Northern Pintail	Blue-winged Teal	Fulvous Whistling Duck[2]
Wild Turkey	California Quail	Northern Bobwhite
Ring-necked Pheasant	Cattle Egret	Sandhill Crane
Franklin's Gull	Rock Dove	White-winged Dove
Mourning Dove	Northern Flicker	Red-headed Woodpecker
Acorn Woodpecker	Lewis' Woodpecker	Western Kingbird
Horned Lark	Barn Swallow	Blue Jay
Scrub Jay	Black-billed Magpie	Yellow-billed Magpie
Common Raven	American Crow	Black-capped Chickadee
Northern Mockingbird	Grey Catbird	Brown Thrasher
American Robin	Eastern Bluebird	Western Bluebird
Cedar Waxwing	European Starling	House Sparrow
Bobolink	Eastern Meadowlark	Western Meadowlark
Yellow-headed Blackbird	Red-winged Blackbird	Tri-colored Blackbird
Rusty Blackbird	Brewer's Blackbird	Boat-tailed Grackle
Great-tailed Grackle	Common Grackle	Brown-headed Cowbird
Northern Oriole[3]	Western Tanager	Scarlet Tanager
Northern Cardinal	Rose-breasted Grosbeak	Black-headed Grosbeak
Blue Grosbeak	Indigo Bunting	House Finch
Pine Siskin	American Goldfinch	Dickcissel
Rufous-sided Towhee	Savannah Sparrow	Field Sparrow
White-crowned Sparrow	Golden-crowned Sparrow	Song Sparrow

1 Several articles referred only to bird families (e.g., blackbirds, sea gulls, waterfowl) without identifying actual species; these are not included in the table.

2 Formerly called Fulvous Tree Duck

3 Formerly called Baltimore Oriole

al., 1966), confirming that a relatively small portion of species actually damage U.S. agriculture or pose risks to air traffic due to farming of airport lands. Of course, many of the listed species are among the most-numerous, wide-ranging birds on the continent. Interestingly, all 12 species of blackbirds and six species of waterfowl were linked with damage to a variety of crops; whereas, few references implicated gulls in agricultural damage.

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THE FAA GRANT-IN-AID ASSURANCES, FAR PART 139, AND AIRPORT HAZARDS

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The promises made to the FAA by airport operating authorities, which are found in grants-in-aid, or as a result of certification under 14 C.F.R. Part 139, are more than agreements for construction compliance. They can prove to be the basis of multi-million dollar lawsuits where hazards exist in the airport environment, and are found by courts to be the proximate cause of an aviation accident.

I. FAA PROMOTION OF AVIATION SAFETY

I realize that there is a hazard of boredom to those of you better schooled than I in the FAA Safety Programs. As you know, under the FAA Act of 1958, a promulgation of 14 C.F.R. Part 139 serves to implement the operating rules for certificated airports. Part 139 is independent of grant-in-aid requirements and assurances under 14 C.F.R. Part 152, and serves the primary purpose of providing safety regulations for certificated air carrier airports. Under Part 139, Airport Operation Manuals must set forth appropriate procedures for identifying, assessing, and disseminating information to air carrier users of it's airports by Notices to Airmen, or other means acceptable to the Administrator, concerning conditions on and in the vicinity of it's airport that affect, or may affect the safe operation of aircraft.

Working in tandem with the Part 139 operating rules for certificated airports, implementing the FAA Act of 1958, has been the 14 C.F.R. Part 152 grant-in-aid "operating rules" for certificated airports under the Airport and Airway Development Act of 1970 (AADA). Pursuant to AADA the FAA promulgated Part 152 and it's Appendix D "Assurances", with the regulatory requirements for a "safe and servicable condition" of the airport and all facilities relating thereto, including the paragraph 23 provision concerning "Airport Hazards", relating to easements, zoning to prevent objects in the approach areas, and the paragraph 24 provision concerning use of adjacent land. Part 152 provides for the inclusion of "special conditions", further limiting use of the airport for safety reasons. Assurances provided by special conditions cannot be arbitrarily or capriciously required by the FAA. Legality of assurances could only be tested by litigation. If the court so ruled, the FAA would be required by an appropriate Federal Court to comply with a reasonable standard -- at least as reasonable as the Airports Division can convince the judge is necessary to promote aviation safety under the existent circumstances. Fortunately, the scarcity of such lawsuits would indicate that the FAA has traditionally not been unrealistic in dealings with grant-in-aid applicants. Since AADA is the funding authority for past grants, it remains the statutory authority for Part 152 assurances and enforcement of contractual language.

It appears that when AADA expired in 1970, it was thought to be an easy matter for enactment of a new statute doing essentially the same thing. However, a missing ingredient in such thinking was a novel government interest in de-federalization, which resulted in a decrease in the number of grants-in-aid. Coupled with the de-federalization issue has been the implementation of the Aviaton Safety Noise Abatement Act of 1979 (ASNA). Subsequent to inactment of the Airport and Airway Improvement Act of 1982 (AIP), [1/] there have yet been no regulations promulgated to replace Part 152. Compliance and enforcement under AIP would therefore fall within the contractual provisions of the grant-in-aid itself.

II. GRANTS-IN-AID AND REGULATIONS

Section 18 of the Airport and Airway Development Act of 1970, 49 U.S.C. § 1718(3)(4) required the government to obtain assurances from any airport receiving federal funds, that the approaches will be cleared and protected, and that land adjacent to the airport will be used only for purposes compatible with customary airport operations. Section 1718 imposes a duty upon the government to obtain these assurances before dispersing federal funds, and section 27, 49 U.S.C. § 1727, grants the FAA the authority to enforce these assurances. However, case law indicates that the failure to obtain assurances or the failure to enforce them once they were given, is not actionable under the FTCA. Sellfors v. U. S.[2/] Congress enacted the Airport and Airway Development Act of 1970 to spur the development and improvement of airports and airway networks in order that these critical operations could be expanded quickly enough to keep pace with the demand placed on the surfaces by a burgeoning population. But nowhere in the statute or it's legislative history is there any indication that in enacting this legislation Congress intended to impose upon the FAA the duty to supervise all phases of the airport operation to insure that the airport is run safely. To receive these grants of federal money, the applicant must assure the

FAA that the airport will be operated safely.

There was no purpose or intention of Congress in passing the Federal Airport Act or the Airport and Airway Development Act for the FAA to insure the individual safety of each user of an airport receiving Federal Aid. Standards for airport construction, operation and maintenance have been developed, but the FAA does not certify that these standards have been met. On most air carrier airports, the airport owner has contracted to adhere to federal standards, but the FAA cannot guarantee that the contractual obligations are being maintained. Even in cases of noncompliance by an airport operator with the standards, the remedies available, after notice of non-compliance and a finding of default pursuant to procedures, are limited to either withholding federal grants applied for, or the filing of a civil lawsuit based on violation of the grant-in-aid agreement for recovery of funds provided. The FAA issues operating certificates to airports serving air carriers formerly certificated by the Civil Aeronautics Board, and to be certificated in the future by the FAA. After investigation, the FAA will issue a Part 139 certificate where it finds that the airport is properly and adequately equipped to conduct a safe operation in accordance with applicable law and regulations. Where an airport is not an "air carrier airport" it is not certificated by the FAA as to it's adequacy for the safe conduct of flight operations.

Recovery in litigation against the United States under the Federal Tort Claims Act is not necessarily available simply because of approval by the FAA of the plans for development and modernization of an airport under the Federal Airport Act as repealed by the Airport and Airway Development Act.

Design and construction of an airport's development included in an airport layout plan are not the basis of recovery for tort liability under the FTCA. This would not necessarily be true in those cases involving property owned and operated by the United States, like National or Dulles Airports.

A. Airport Master Record

A history file and Airport Master Record for airports open to the public are maintained by regional offices, and pursuant to recommendations found in Handbook 5010.4, Airports Division personnel in the FAA regional offices are requested to make annual inspections of these airports, if they have sufficient travel funds and personnel. Airport inspections are therefore normally conducted by regional office personnel with the purpose of determining whether any changes to the airport effecting safety have occurred since the time of the last inspection. 14 C.F.R. § 157.3 requires that notice be given by persons proposing certain projects. In the case of an airport available for public use (14 C.F.R. § 77.2), standards have been established pursuant to 14 C.F.R. 77.3 for determining obstructions to air navigation, and a notice of proposed construction is mandated by Subpart B of part 77 for the purpose of an aeronautical study described in Subpart D.

In the event that the regional office does not have sufficient inspectors or funds, the Airport Master Record form from the previous year is supplied to the airport manager, who is requested to note any changes to the airport or surrounding area which might have an effect upon airport usage. Though there is no known Federal case law in this area, should an airport manager fail to disclose information which the FAA would expect to receive in the normal course of business, it could be argued in a lawsuit by an injured third party, that the airport operator, through it's negligent manager, was liable for such injuries -- provided that the plaintiff could prove that it was a proximate cause of the accident. The Airport Master Record form is transmitted by the regional office to the National Flight Data Center (NFDC) (located in the Air Traffic Division rather than the Airports Division), so that the material can be included on the new Airport Master Record computer printout, and any changes meeting their criteria can be made on publications offered to the aviation community. The NFDC will publish appropriate comments in the daily National Flight Data Digest (NFDD), from which certain data may be selected by the NFDC for inclusion in the FAA published airport directory. The final copy of the computer printout of the Airport Master Record providing data as to tne location of the airport, type and length of runways, etc. is not itself made available to pilots. However, it does provide information as to obstructions, approaches, surface and length of runways, etc.

The approach data concerns what is called the "controlling obstruction," for which the "approach ratio" for a particular runway is determined, though it may be a grain elevator or a large object somewhat far removed from the extended center line of the runway. The "approach ratio" and the means of determining the same is a term of art, which I have come to believe is subject to numerous and sometimes conflicting interpretations. Remarks as to runway layout and other obstructions provided for inclusion in the Airport Master Record forms supplied by an airport operator could conceivably be the basis of an airport operator's liability under certain conditions. This could involve location of a tower, or obstacle in the "primary surface" of a runway, or other "imaginary surfaces" utilized in the establishment of standards for construction projects on airports open to the public, and described in 14 C.F.R. § 77.23, particularly § 77.23(b)(2), and § 77.25.

Negligence of the FAA and the airport operator might be alleged on the basis that information normally supplied as part of the "Content Criteria for Airman's Information Manual" described in FAA Order 7920.1A was not published. The "Criteria" described in paragraph C of that order provides:

> "Airports without Control Towers. Data concerning field conditions that would be helpful to a pilot or operator in deciding to use that landing area shall be published. For example, . . . a runway or a portion thereof closed, an unusable portion of the runway, . . . or critical obstructions, . . . unusual runway conditions shall be published."

A pilot in command might therefore allege that if he had known about the erection of a tower, power line, grain elevator, etc., he would have taken additional precautionary measures, such as altering his flight path.

B. 14 C.F.R. § 77.

Part 77 describes notice, standards, studies, and hearing for "objects effecting navigable airspace" with relation to airports available for public use. As seen in 14 C.F.R. § 77.3, the administration of the Federal-Aid Airport Program, the development of technical standards for "guidance" in the design and construction of airports, and the imposition of notice and hearing requirements, are imposed in the future sense -- proposed construction projects on either airports receiving federal aid, airports open to the public, or on projects which will affect navigable airspace. Part 77 is directed to construction standards for future project, rather than flight procedures by a VFR pilot, or limitations upon an aircraft's operation.

Though the FAA is to receive notice of the construction of obstructions pursuant to 14 C.F.R. Part 77, it is done for the purpose of making a "hazard" or "no hazard" determination. Though this may have some effect upon the applicant obtaining insurance for construction of such an obstruction, such a determination by the FAA cannot prevent construction. If the object is over 200 feet in height, it is then to be included by the FAA on appropriate aviation charts for the purpose of warning pilots. There might be state laws requiring some additional type warning for obstructions, such as minimum lighting or marking requirements.

It was only late in the 1960's that the FAA described in an Advisory Circular, certain guidelines for airport design, including a safety area extending horizontally 200 feet from the threshold ("primary surface" described in 14 C.F.R. § 77), and vertically, a VFR airport approach service on a 20 to 1 ratio beginning with the primary surface. The current design height criteria restriction for proposed projects within the primary surface area of 200 feet is a 15 foot height restriction for non-Interstate Highways, for example. The regulation could not, however, restrict operations at a noncertificated airport. Operational (in addition to construction design) restrictions can be mandated for airports serving air carriers that hold certificates of public convenience and necessity issued by the CAB (see 14 C.F.R. § 139). Just as part 77 could not be used by the FAA to restrict operations at a noncertificated airport, it could not be used by the FAA to require any action by an airport operator in the absence of any application by the operator for a grant in aid from the FAA.

However, an FAA action to enforce a regulation or a grant agreement is not the same animal as a lawsuit by an injured person seeking money damages for an accident causing pain and suffering. Just because Part 77 is not applicable, that does not mean that an airport operator won't be sued in state court by an injured party for its failure to comply with some state safety standard, such as the marking or lighting of obstacles.

C. Grants In Aid For Influencing An Airport

The FAA can theoretically take action to recover grant in aid payments if a sponsor airport fails to comply with any condition incorporated in the grant. Old grants offered under the Federal-Aid Airport Program (FAP), under the Federal Airport Act, particularly with 20 year limitations, leaves open the question as to what the authority would be for enforcement of grant-in-aid provisions.3/ I'm sure you are all familiar with the boiler-plate language in the grants, including a sponsor assurance to the effect that it will promote safety at the airport, and in addition to such general language, will fulfill any safety requirements innumerated as conditions of the grant-in-aid. It is seen, particularly in the development of older airports, that airport offices were somewhat reluctant to require conditions considered too stringent, because applicants might simply withdraw their applications. In many cases, "advice" to a non Part 139 airport operator by the FAA to clear an approach to a runway of obstructions where no grant-in-aid to the airport exists, might serve as a recommendation only. It would appear that acceptance of even a planning grant under the Airport and Airway Development Act of 1970 (see 14 C.F.R. § 152) might not put any conditions upon the owner of the airport. This, of course, would appear to be even truer in the case where the present owner of an airport is not the owner which received a prior grant.

D. 14 C.F.R. § 139, Operations Manual

The failure of an airport operator's employees to comply with the provisions of the Airport Operations Manual have been found to constitute negligence, and can be basis of liability on the part of the airport operator. This is seen in Alitalia v. U. S.,4/ where the operations' duty officer was required to provide a field condition report, and make inspections when snow was a factor. This is presently the subject of litigation in the World Airways crash at Logan Airport in Boston. As a result of such officer's inspection, he is required to issue NOTAMS which are transmitted by telegraph to all offices at the airport having receiving equipment. One of the recipients is a FAA Flight Service Station which, pursuant to it's Operations Manual, compiles airport NOTAMS relating to runway landing conditions, and distributes them nationally. In the Alitalia case, it was found that there was some confusion as to reporting procedures and the ultimate purpose behind the same. The FSS Handbook, FAA Order 7930.1, is not intended to supply all information provided by the airport operating authority on the teletype distribution system of the FAA. When the information is received by telegraph, the FSS publishes only that material which is included in the criteria described as follows:

a. "Material meeting the following criteria shall be transmitted by telecommunications means as a NOTAM when:

(1). a landing area conditions exists which precludes safe operation of aircraft. This concerns only situations which would normally result in a pilot's or operator's decision to divert aircraft."

Even when, for instance, information relating to taxiways is included on an airport operator's report, the FSS would not include it for national distribution on it's telecommunications network. The responsibility of FAA air traffic controllers to provide such information to a pilot is another matter. With respect to accidents, this paper will later discuss some case law developments with respect to Part 139 safety requirements.

E. Interpreting Part 139

The reason why courts might often disagree in the interpretation of Part 139, with respect to the duties to be performed by different parties, can be found in the countless number of factual situations involving different grants, special conditions, manuals, etc. In addition, a court must make determinations as to the adequacy of performance, guided by Part 139, FAA Airports Division Manuals, Airport Operations Manuals, good operating procedures, and common sense.

How would a court go about interpreting Part 139? The Supreme Court has acknowledged a traditional presumption in favor of an agency's interpretation of it's own regulations,5/ like the FAA's administration of Part 139. In the everyday functions of the FAA, that presumption of agency regularity is the device by which the FAA enforces standard, rather than arbitrary procedures, on all airports and under generally similar circumstances. The rub comes when the facts relating to one airport or grant application are not precisely the same as another. Such factual dissimilarities may require a certain subjectivism in the FAA Airport Division's application of it's procedural manuals. Since beauty and safety requirements may both exist "in the eye of the beholder", there will obviously be occasions where the application of Part 139 through agency manuals and procedures may be subject to differing opinions.

The finality as to the "correct" interpretation of Part 139 -- as applied to specific facts -- could only come from the U. S. Supreme Court. Such an interpretation is not likely to arise, since the Supreme Court normally does not become involved unless there is a pressing legal question relating to a widespread, Constitutional, or federal statutory issue. If an airport operator were to test the FAA's interpretation by a lawsuit, the ultimate interpretation of Part 139 would normally be rendered by a U. S. District Court. Of course, even the judges of District Courts may disagree in their interpretations, and it is certainly possible for Circuit Courts of Appeal to disagree as well.

As a practical matter, a decision of the U. S. District Court located in your state, addressing an interpretation of some portion of Part 139, would generally resolve the issue. If, however, the facts were so unusual, or the traditional interpretation was in conflict with the FAA's interpretation, the decision might be appealed by the FAA. In the absence of an appeal, the FAA's procedures might be altered, or the FAA might resign itself to a loss under those particular circumstances, with the hope that such circumstances would not occur again.

I could attempt to provide my interpretation of Part 139 under a wide variety of factual situations, but others might disagree. Only the U. S. Supreme Court might satisfy me that I am wrong, but because of the unlikelihood of such a case going to the Supreme Court, in the everyday functioning of the FAA's administrative system, the knowledge and expertise of Airport Division personnel is called upon to make decisions based on their procedures and expertise.

Since many or all of you have reviewed Part 139 from time to time, and could undoubtedly pose arcane questions calling for individual interpretations, I can only suggest that I refer to certain cases relating to Part 139.

F. Letter of Correction

Though a "letter of correction" is indicative of an airport's noncompliance with the 14 C.F.R. § 139 requirements, thereby permitting FAA enforcement action as a civil penalty, on a much larger financial scale, it can be utilized in tort litigation resulting from an aircraft accident, as the basis of a finding of negligence on the part of the airport operator. It could result in a cost of millions of dollars to the state. In Alitalia, a letter of correction was issued against the airport operator for noncompliance with 14 C.F.R. § 139.69(b)(4) because of the operator's failure to accurately report on it's telautograph report the existence of snow banks (windrows) on the taxiway involved. This can serve as proof of the operator's failure to comply with the "Airport Condition Assessment and Reporting" provision in 14 C.F.R. § 139.69. The record did not disclose any notice to air traffic controllers in the tower as to the width of the taxiway cleared, or the height of the windrows. As it turned out, plaintiff's pilot admitted at trial that Alitalia had received the telautograph information concerning snow conditions before departure from Rome, though the dimensions were incorrect. The court found that pilots would rely, as a matter of common practice, on the airport operator conforming to the aviation community standard of reasonable conduct in clearing or reporting unusable taxiways to the FAA or airport users. Since the accident occurred in the evening some distance from the tower, the court found that there was no notification to FAA employees as to any taxiway or clearance problems.

Liability could also be based on the failure of the airport operator to expeditiously respond to a call for emergency assistance in the case of an accident on the field. Evidence of a standard of care required of an airport operator in a rescue operation might well be found in the airport's Operations Manual, and other representations made to the FAA concerning operable equipment available, and the reasonable time frame within which they could respond.

III. LITIGATION (LAWSUITS) - "PLAINTIFF" SUES; "DEFENDANT" IS THE ONE SUED

A. Federal Courts[6/]

1. U. S. Supreme Court - any decision by it takes precedence over all other courts.

2. U. S. Circuit Courts of Appeal-(thirteen throughout the U. S.)- decisions of the Circuit encompassing your state takes precedence over any other Circuit or any Federal District Court (see attached diagram for geographical composition).

3. U. S. Federal District Courts - at least one per state
   a. Generally the starting point of any accident litigation -- a plaintiff is alleging that an employee(s) of the United States (FAA) was negligent.

   b. An airport operating authority may also be sued as another defendant for the alleged negligence of it's employees.

   c. Regulatory enforcement actions -- Satisfaction of a penalty assessed by the FAA against an airport operator (air carrier, pilot, mechanic, etc.) can be enforced in the U. S. Federal District Court located in that state, or appealed to it by the regulated party.

   (Airport operating authorities can also be sued by private parties in a state court for the alleged negligence of it's employees -- the U. S./FAA cannot be sued in state courts).

   d. If the U. S./FAA is sued alone and believes that the ultimate responsibility was that of the airport operator, it can after it is sued, file a third party action against the airport operator for "indemnity" (repayment of all it should lose) or "contribution (repayment by the state of that portion the court finds is attributable to the operator's negligence).

4. Court of Claims - for disputes involving the U. S./FAA relating to payments disputed in grants-in-aid.

IV. LITIGATION INVOLVING THE U. S./FAA AND AIRPORT OPERATING AUTHORITIES

A. Contract actions in the Court of Claims relating to disputes as to interpretation of the grant-in-aid, contract revisions, quality of work, payments, etc. These cases typically involve interpretation of the contractual agreements, standards, time of performance, and work completion.

B. Accidents -- Liability for negligent conduct (tort) of government and/or state airport operating authority employees in the performance of their duties. These cases relate to accidents allegedly caused by the action or inaction of FAA employees or airport operator employees, and are filed in a U. S. District Court when the United States is a defendant.

Once the FAA assumes the duty under the Federal Aviation Act of 1958, or in the administration of Federal Aviation Regulations (FAR's) like 14 C.F.R. § 139, it is possible that it will be held liable for the negligent acts of it's employees which has led to the injury of a person. These types of acts are customarily the operational functions of an employee, rather than the policy decisions of administrative officials at higher levels based on national FAA programs and manuals. Where clear standards are set forth in manual provisions, to which a court can match the actual facts as to the performance of an FAA employee (or the representations of an airport operator's employees), courts will generally rule that the judgment of the employee was "operational", rather than "discretionary". Typically, for instance, the negligent failure of the FAA to adopt proper safety regulations has been found by the Supreme Court to fall within what is known as the "discretionary function exception" of the Federal Tort Claims Act (FTCA). This is seen in the significant case of Dalehite v. U. S.7/ For instance, the decision of the FAA to provide a grant-in-aid for construction of a new runway, which is only a 3000 feet long. If an aircraft crashes while landing on it because it needed a longer runway, the U. S. would not be liable. As long as decisions relating to construction of the runway complied with FAA criteria, the fact that the decision was made by the FAA to require runways of only a certain length, that decision, based on technical manual provisions, would not be the basis of liability on the part of the United States. Similarly, because the airport operating authority constructed the runway in accordance with the FAA guideline, the pre-emptive standards established by the FAA would mean that the airport operating authority also complied with the standards established, and therefore it also would normally not be liable if it were sued.

Once the FAA does elect to assume a duty, it is more likely that it will be held liable for the negligence of it's employees. Indian Towing v. U. S.8/

Claims that the FAA was negligent in the enforcement of regulations such as 14 C.F.R. Part 139, like limiting the use of an airport for safety reasons, or in failing to promulgate stricter safety precautions, or failing to mitigate a bird problem, has been ruled by the 11th Circuit to jurisdictionally bar claims because of the discretionary function exception. This is seen in Sellfors v. U. S.9/, involving the deaths of 7 people on board a Learjet which crashed after ingesting birds in it's engines while taking off from the DeKalb-Peachtree Airport. In that case, over a two year period preceding the accident, the FAA was unable to convince the county to close the garbage dump adjacent to the county owned airport. The FAA Compliance Handbook outlines procedures and guidelines to be used by the Airports Division when an airport does not honor it's grant-in-aid agreements. The airport was not certificated under Part 139, and the previous Navy-owned airport had been given to the county a number of years earlier. After the accident, the FAA went to the Department of Justice, which sought a restraining order in the Federal District Court in Atlanta to stop the garbage dumping, but the Court refused to issue such an order, because the dump was needed more than the airport. The Court issued a partial restriction prohibiting jet traffic from the airport for six weeks. In the tort lawsuit against the United States for the death of one of the pilots, the District Court found that the discretion of the FAA not to take enforcement action against the airport operator could not be the basis of U. S. liability. The Airports Division of the FAA would have to convince the FAA Regional Counsel's Office, and it in turn the Department of Justice10/, that there had been noncompliance with a specific grant-in-aid provision, and invoke that provision as a basis for bringing a legal action to enforce that contractual provision -- the ultimate remedy of the FAA for an airport not certificated under Part 139 would be to recover the money provided in the grant-in-aid, and to bar future grants. For a Part 139 airport, the FAA would have the additional clout of de-certifying the airport as safe under Part 139.

Though there is not a large number of cases involving interpretations of Part 139, the language common to such cases will hopefully give you a feel for what legal conclusions will be reached in a similar set of circumstances. In a Second Circuit case,11/ the FAA brought an action to have a New York law transferring title of Republic Airport from the MTA to the New York State Department of Transportation, and imposing a curfew between 11:00 p.m. and 7:00 a.m., ruled in contravention of terms of grant-in-aid agreements. The jurisdiction to review FAA "orders" (neither interpretation of a regulation nor a tort action) lay exclusively in the Circuit Court of Appeals. The court found that the MTA could not disavow agreements reached with the FAA in return for FAA funding, nor could it avoid such obligations by attempting to transfer title of the airport to another political body. The court recognized that the AADA of 1970 was superceded by the AIP of 1982. The court found that the grant-in-aid to Republic had been conditioned by requirements that:

1. The facilities be available for use by government aircraft.

2. At all times have arrangements for operating aeronautical facilities whenever required.

3. Not dispose of or encumber title to Airport property during the period of Government interest.

4. Without FAA approval could not enter into any transaction that would operate to deprive it of any of the rights and powers necessary to perform any of it's contractual covenants.

The Court ruled that the FAA may attach legally enforceable conditions to it's grants of federal assistance and to prevent the disavowal of conditions on which the Government in good faith had relied. Even if the FAA did not question the ability of the New York DOT to operate the airport safely, safe operating conditions are not the sole prerequisite to certification. The FAA is also required to look to the public interest (49 U.S.C. §§ 1421(b), 1429(a), 14 C.F.R. § 139.7(a)(1). Public interest required the State of New York to recognize the sactitity of the contracts at issue, enacted for the benefit of the general public, which has a substantial investment in the airport. In addition, the court also found that though only final "orders" of the FAA are reviewable, the term "order" should be liberally construed, including any which "imposes an obligation, denies a right, or fixes some legal relationship".

Cases involving airplane accidents similarly discuss the safety requirements of an airport, whether or not it is strictly based on Part 139, or state law, and not necessarily involving the FAA. In an Alaska case12/, the court ruled that when extending an airport runway the state was negligent in failing to place a ditch or fence around the extension to prevent moose from coming onto the runway, and in failing to clear trees and brush from the area so that airport personnel could see if moose were on the runway extension.

In a 5th Circuit case involving the United States[13/] ten years later, the court ruled that there was no duty on the part of the FAA under an Advisory Circular specifying the proper mode of marking a runway closed for resurfacing pursuant to a grant-in-aid, to assure that it had been complied with.

In a South Dakota case[14/], a Sabreliner crashed after gulls were ingested while taking off from the airport. Plaintiff claimed that the FAA negligently certificated the airport under Part 139, and was subsequently negligent in failing to enforce regulations under Part 139. The Court ruled that an applicant for aid ". . . must show that it has established instructions and procedures for the prevention or removal of factors on the airport that attract, or may attract, birds." The United States was found not to be negligent in this case. A copy of the SAFECO decision is attached in order to provide you with language utilized by the courts to describe an airport operator's responsibilities.

Like the SAFECO case, a similar decions from Connecticut[15/] ruled that the city had not failed it's responsibility to make the airport less attractive as a food source for gulls, had implemented certain scare devices, but had failed to issue a NOTAM regarding the gulls during certain seasons of the year, and under certain weather conditions.

I also attach for your perusal, a copy of a decision from Massachusetts[16/] which should provide you with a feel for judicially imposed requirements relating to airport operation. I would be remiss in not drawing to your attention the fact that most of the cases involving wildlife hazards have originated in the past five years, and may prove to be an indicator of the trend in future litigation. There is invariably alot more money in the treasury of a public body than there is in a pilot's savings account.

FOOTNOTES

1/ 14 U.S.C. §§ 201, *et. seq*.

2/ 697 F.2d 1362 (11th Cir. 1983).

3/ See 14 C.F.R. § 151 for present implementation.

4/ 17 Avi. 18,060 (D. Mass. 1982); copy attached.

5/ *U. S.* v. *Larionoff*, 431 U.S. 864, 872 (1977).

6/ Attached is a diagram depicting the geographical breakdown of Federal Courts.

7/ 346 U. S. 15 (1953).

8/ 350 U. S. 61 (1955).

9/ 697 F.2d 1362 (1983).

10/ The discretion to bring legal actions on behalf of the U. S. is rested in the Attorney General. See: 28 U.S.C. § 515, U. S. Const. Art. 2.

11/ *State of New York* v. *FAA*, 712 F.2d 806 (1983).

12/ *Alaska Airlines Inc.* v. *State of Alaska*, 12 Avi. 18,056 (1973).

13/ *Brooks* v. *U. S.*, 695 F.2d 984 (1983).

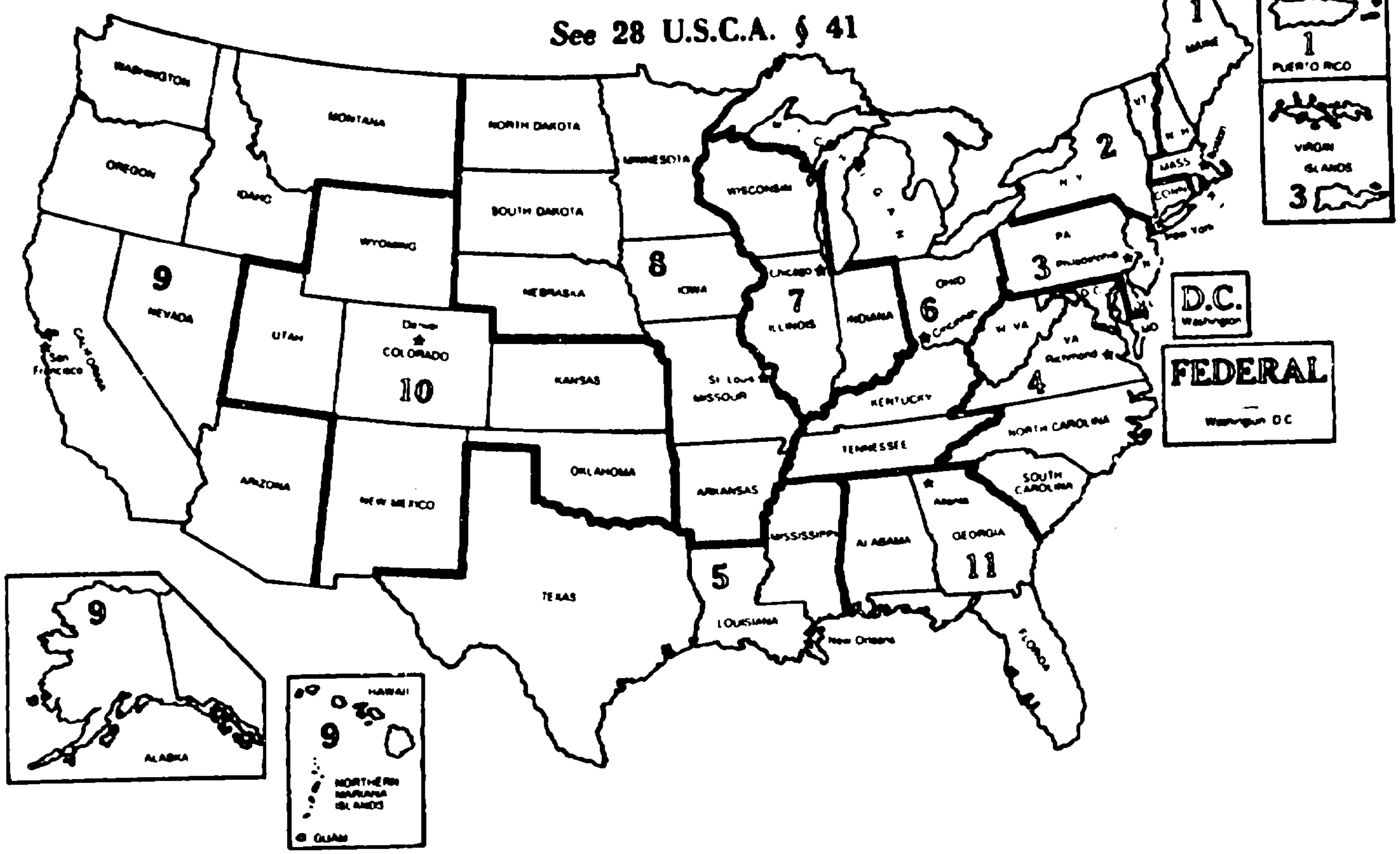
14/ *SAFECO* v. *U. S. and City of Watertown*, 529 F. Supp. 1220 (1981).

15/ *Insurance Company of North America* v. *U. S. and City of New Haven*, 574 F. Supp. 373 (1983).

16/ *Alitalia* v. *U. S.*, 17 Avi. 18,060 (1982).

The Thirteen Federal Judicial Circuits

See 28 U.S.C.A. § 41



628, 631 (S.D.N.Y.1976). For similar reasons plaintiff's contentions based on State law of unfair competition must fail, too. See, e.g., *Coca-Cola Co. v. Snow Crest Beverages, Inc.*, 64 F.Supp. 980 (D.Mass.1946), *aff'd*, 162 F.2d 280 (1st Cir.), *cert. denied*, 332 U.S. 809, 68 S.Ct. 110, 92 L.Ed. 386 (1947).

In summary, the Court holds that defendant is entitled to judgment as a matter of law because there is no genuine triable issue of fact that defendant returned plaintiff's Wildcat submission to plaintiff without it being examined by anyone connected with game development, and that it developed King Oil independently from plaintiff's submission, entirely on the basis of the Charlesworth submission of Oil Baron and its own refinements, and because no liability may be predicated upon the alleged misappropriation through Baron.

The parties will submit proposed forms of judgment within fifteen (15) days after receipt of a copy of this decision.

SO ORDERED.

SAFECO INSURANCE CO. OF AMERICA, Plaintiff,

v.

CITY OF WATERTOWN, SOUTH DAKOTA, A Municipal Corporation, Defendant.

SAFECO INSURANCE COMPANY OF AMERICA, Plaintiff,

v.

UNITED STATES of America, Defendant.

Civ. Nos. 77-1012, 81-1015.

United States District Court, D. South Dakota, N. D.

Dec. 31, 1981.

Plaintiff, as subrogee of its insured, brought actions to recover for property damage to a twin jet aircraft which crashed on takeoff from a municipal airport. The District Court, Donald J. Porter, J., held that: (1) federal regulations providing for certification of airport following FAA investigation did not impose any sort of duty under South Dakota law on FAA that would give rise to a tort action for its violation; thus, United States could not be held liable under the Federal Tort Claims Act for damage to an airplane which crashed on takeoff from a municipal airport after gulls were ingested into the plane's jet engines causing loss of all power; (2) city, as operator of airport, was negligent in failing to warn pilots of the possible presence of gulls; and (3) given the color of the gulls and the rainy weather conditions and the necessary speed generated for takeoff, crew of jet had a reasonable excuse for not seeing the gulls on the runway in time to avoid the accident and therefore were not contributorily negligent under South Dakota law.

Judgment in favor of plaintiff against city.

1. Aviation ⚷222

Federal regulations providing for certification of airport following FAA investigation did not impose any sort of duty under South Dakota law on FAA that would give rise to a tort action for its violation; thus, United States could not be held liable under the Federal Tort Claims Act for damage to an airplane which crashed on takeoff from a municipal airport after gulls were ingested into the plane's jet engines causing loss of all power. 28 U.S.C.A. § 2671 et seq.

2. Action ⚷3

Generally, a statute which does not purport to establish a civil liability but merely makes provision to secure the safety or welfare of the public as an entity, is not subject to a construction establishing a civil liability.

3. Negligence ⚷1

Basic elements of a negligence action are that there be a duty owed by defendant to plaintiff, that there was a breach of that duty, and breach of the duty was proximate cause of plaintiff's injury.

4. Aviation ⇐232

City, as operator of airport, was negligent in failing to warn pilots of the possible presence of gulls; thus, city could be held liable under South Dakota law for damage to airplane which crashed on takeoff after gulls were ingested into plane's jet engines causing loss of all power.

5. Negligence ⇐4

Under South Dakota law, the greater the danger, the greater the care required, so that a very high degree of danger calls for a very high degree of care which amounts to ordinary care in view of the situation and circumstances.

6. Aviation ⇐232

Airport flight service station personnel were not negligent in failing to warn jet, which crashed on takeoff after gulls were ingested into plane's jet engines causing loss of power, of presence of gulls on the day of the accident where those personnel neither saw gulls on the airport nor received any reports of their presence; furthermore, flight service station personnel did not have adequate knowledge of the actual extent of the persistent gull problem at the airport to be found negligent for failing to issue, independently of the airport management, a permanent warning for gulls.

7. Aviation ⇐233

Given the color of the gulls and the rainy weather conditions and the necessary speed generated for takeoff, crew of corporate jet, which crashed on takeoff after gulls were ingested into plane's jet engines causing loss of all power, had a reasonable excuse for not seeing the gulls on the runway in time to avoid the accident and therefore were not contributorily negligent under South Dakota law.

8. Negligence ⇐65, 82

Under South Dakota law, contributory negligence is conduct for which plaintiff is responsible amounting to breach of a duty which the law imposes upon persons to protect themselves from injury, and which, concurring and cooperating with the actionable negligence for which defendant is responsible, contributes to the injury complained of as a proximate cause.

9. Negligence ⇐65

Under South Dakota law, standard by which a plaintiff's conduct is tested is that which a reasonable man would conform under like circumstances.

10. Negligence ⇐67

Under South Dakota law, if a plaintiff has a duty to maintain a lookout, and if he does look, it is implied that he looked effectively and in such a manner that he would see what was in plain sight unless some reasonable excuse for not seeing is shown.

11. Negligence ⇐67

If an object is so well camouflaged as not to be discernible within the range of vision, an actor may not be held under South Dakota law to the duty of seeing it.

MEMORANDUM OPINION

DONALD J. PORTER, District Judge.

CASE SUMMARY

Plaintiff, as subrogee of its insured, Kerr-McGee Corporation, brought these actions, (consolidated for trial) to recover for property damage to a twin jet Kerr-McGee aircraft which crashed on take-off from the Watertown Municipal Airport. Jurisdiction of plaintiffs' tort action against the City of Watertown, owner and operator of the airport, is grounded in diversity, 28 U.S.C.

§ 1832(a). Plaintiff sued the United States under the Federal Tort Claims Act, 28 U.S.C. § 2671, et seq.; jurisdiction lies under 28 U.S.C. § 1346(b). After trial to the court, on the merits, this Court finds from all the evidence, and adjudges (1) that the negligence of defendant City was the proximate cause of the loss; (2) that plaintiff was not contributorily negligent; and (3) that the United States is not liable under the Federal Tort Claims Act.

FACTUAL BACKGROUND

A Saberliner jet aircraft owned by the Kerr-McGee corporation arrived at the airport in Watertown, South Dakota, at approximately 11:00 a. m. on Saturday, June 14, 1975. At approximately 4:30 p. m., the airplane, piloted by Kerr-McGee's chief pilot, Jack Irwin, and co-piloted by Ralph Hill, began its departure. They were informed by employees of the Federal Aviation Administration (FAA) in the Flight Service Station (FSS) at the airport that the visibility was about a mile and a quarter (the day was rainy) and that because of the prevailing wind, the "favored" runway was 17–35, running north-south.

The Saberliner taxied to the north end of 17–35, turned, and started its take-off roll. About 3,000 to 3,500 feet down the 6,900 foot runway, the aircraft reached take-off speed and lifted off. Almost immediately, and while at an altitude of 25 to 100 feet, the plane encountered a flock of Franklin gulls. Some of the gulls were ingested into the airplane's two jet engines, all power was lost, and the pilot made an emergency landing in a field south of the airport. The pilot and co-pilot and one passenger received some injuries; the Saberliner was a total loss. The parties have stipulated the loss to be $1,787,872.00.

I.

Duty of the United States under 14 C.F.R. Part 139.

[1] Plaintiff's first ground for recovery against the United States is that the FAA negligently certificated the Watertown airport under 14 C.F.R. Part 139, and thereafter was negligent in failing to enforce its regulations under that Part. The certification process, which was initiated in 1973, required that no person could operate an airport "serving any CAB-certificated air carrier operating aircraft into that airport, . . . without . . an airport operating certificate."[1] 14 C.F.R. § 139.3 (1975). As the regulations state, an airport is eligible for a certificate if the FAA "after investigation, finds that the applicant is properly and adequately equipped and able to conduct a safe operation in accordance with this part, and approved the airport operations manual submitted with and incorporated in the application." 14 C.F.R. § 139.11(b)(1975). Among many other requirements for the preparation of the airport operations manual, the "applicant . . . must show that it has established instructions and procedures for the prevention or removal of factors on the airport that attract, or may attract, birds. However, the applicant need not show that it has established these instructions and procedures if the Administrator finds that a bird hazard does not exist and is not likely to exist." 14 C.F.R. § 139.67 (1975).

When Watertown submitted its airport operations manual in compliance with these regulations, it stated, under the category of "Birds", that there were "[n]o problems at present time." The FAA accepted this statement and, without an independent inspection of the Watertown airport, approved the manual and issued a certificate to the airport in March, 1973. The FAA thereafter conducted annual inspections of certificated airports, 14 C.F.R. § 139.5 (1975). The Watertown airport's 1975 FAA inspection took place on June 4, ten days prior to the Saberliner accident. The report of this inspection, in a letter of June 6, 1975, from the Chief, Airport Certification Staff to the Watertown airport manager found "no discrepancies or violations to Federal Aviation Regulation Part 139."

1. At all times material the airport served North Central Airlines [now Republic Airlines], a CAB-certificated air carrier

Plaintiff alleges that the FAA knew or should have known that the Watertown airport did in fact have a bird problem, that the FAA was negligent in allowing Watertown to have a valid certificate without requiring it to embark on a bird control program, and that the FAA was negligent in later failing to discover the bird problem and in not thereafter requiring a bird control program. To make out a cause of action under the Federal Tort Claims Act (FTCA) using this theory, plaintiff must overcome the authority of a number of cases, including *Davis v. United States*, 395 F.Supp. 793 (D.Neb.1975), aff'd, 536 F.2d 758 (8th Cir. 1976). In *Davis*, an OSHA inspector issued a citation for a dangerous trench, but never made a follow-up inspection. A short time later, plaintiff's decedent was killed at the site of the inspection when a trench collapsed on him. An action was brought alleging negligence on the failure to follow up. The United States raised the defense it raises here—that since the law of the state in which the accident occurred, Nebraska, placed no duties on private persons like the duties undertaken by OSHA inspectors, the complaint did not state a claim under the FTCA.[2] The court granted defendant's motion to dismiss, saying that OSHA's "thrust is to require designated federal officers to investigate, issue citations, and apply for enforcement orders by a federal court. Nothing resembling those duties devolves on a private person under OSHA.... To the extent that the complaint ... is rooted in federal law as a source of duties of the United States or its compliance officer, it must fall." 395 F.Supp. at 795–96. The case was distinguishable from cases in which persons who controlled dangerous operations were held to have a duty to protect workers; "here the federal compliance officer was not in control, either actually, contractually, or otherwise. He performed inspection duties solely because of the federal laws and cannot be said by the common law of Nebraska to have been 'responsible' for or in 'control' of the project." 395 F.Supp. at 796.

[2] This ruling was consistent with *Kirk v. United States*, 270 F.2d 110 (9th Cir. 1959), where the plaintiffs alleged that the United States had been negligent in failing to carry out an accident prevention and rescue program for the employees of one of its independent contractors at a dam site. This duty, the plaintiffs contended, was enjoined by statute and regulations. The *Kirk* court found that the plaintiffs had "utterly failed to establish the existence of the legal duty upon which they rely.... [T]he general rule is that a statute which does not purport to establish a civil liability, but merely makes provision to secure the safety or welfare of the public as an entity, is not subject to a construction establishing a civil liability." 270 F.2d at 117. *See also United States v. Smith*, 324 F.2d 622 (5th Cir. 1963); *Gelley v. Astra Pharmaceutical Products, Inc.*, 610 F.2d 558 (8th Cir. 1979); *In re Franklin National Bank Securities Litigation*, 478 F.Supp. 210 (E.D.N.Y.1979); *Mercer v. United States*, 460 F.Supp. 329 (S.D. Ohio 1978); *Thompson v. United States*, 592 F.2d 1104 (9th Cir. 1979): ("the mere provision for government safety inspections, or the ability to stop an activity for failure to comply with safety standards, does not impose liability on the government for failure to do so. A government safety manual or safety program does not impose a special duty on the government." 592 F.2d at 1110).

Both plaintiff and defendant United States urge the case of *Clemente v. United States*, 567 F.2d 1140 (1st Cir. 1978), as persuasive authority, and to varying degrees it does support both parties' positions. *Clemente* arose out of the crash of a private plane, with plaintiffs alleging that the crash had been caused by the negligence of the FAA in failing to warn the passengers that the aircraft was overweight and lacked a proper flight crew. Plaintiffs argued

2. "[t]he District courts ... shall have exclusive jurisdiction of civil actions on claims against the United States ... under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred." 28 U.S.C. § 1346(b).

that the duty to warn had been imposed on the FAA by an order issued by the FAA Director of the Southern Region. Analyzing the issue, the *Clemente* court observed that:

> [n]ot all acts and orders of the United States government are so sovereign that they must be treated as commands which create legal duties or standards, the violation of which involves breaking the law. A considerable part of the government's conduct is in the context of an employer-employee relationship, a relationship which includes reciprocal duties between the government and its staff, but not necessarily a legal duty to the citizenry. 567 F.2d 1144.

Clemente, however, seemed to suggest that liability could be imposed on the United States under certain factual circumstances, particularly those falling within the "Good Samaritan" doctrine and *Indian Towing Co. v. United States*, 350 U.S. 61, 76 S.Ct. 122, 100 L.Ed. 48 (1955).[3] "[W]hen the government gratuitously undertakes to perform a service upon *which members of the public justifiably rely*, it will be held to an appropriate standard of care in carrying the service out." 567 F.2d at 1148. (emphasis in original). But, the *Clemente* court pointed out, "[t]here is no indication in the present case that plaintiffs' decedents or anyone else for that matter have ever relied on the FAA to inspect a charter aircraft before they embark on a private flight." *Id.*

The *Indian Towing*—Good Samaritan doctrine has been more fully developed in several other cases, notably *United Scottish Ins. Co. v. United States*, 614 F.2d 188 (9th Cir. 1979). This case also arose out of the crash of an airplane which, plaintiffs alleged, had been negligently inspected by the FAA. *United Scottish* expressly differed with the Eighth Circuit's ruling in *Davis v. United States, supra*, saying that "[w]hile the existence of a federal statutory duty as the reason for undertaking the action will not automatically create liability, neither will such a duty preclude liability. The crucial inquiry is whether, in undertaking the inspection, a duty arose under state law because of the relationship thereby created—the good samaritan rule." 614 F.2d at 193–94. But the requirements of the Good Samaritan doctrine—"[the defendant] in some positive way must have contributed to the injury, either by increasing risk of harm, . . . by interposing himself between another person and the duty that the other person owed to someone else, . . . or by inducing reliance on his undertaking.'" 614 F.2d at 195, citing *Blessing v. United States*, 447 F.Supp. 1160, 1199 (E.D. Penn.1978)—must be satisfied. If these elements are not met, said *United Scottish*, "the government may not be held liable pursuant to the Act for negligence in inspection of private activities or property, although federal statutes or regulations direct that government employees undertake the inspection activity." 614 F.2d at 195.

As plaintiff points out, South Dakota does recognize the Good Samaritan doctrine. *Steckman v. Silver Moon*, 77 S.D. 206, 90 N.W.2d 170, 173 (1958), stated the elements of the doctrine in a manner equivalent to that stated in *United Scottish* and *Blessing*: "[t]he liability in most cases has arisen because defendant made the situation worse, either by increasing the danger, or by misleading plaintiff into the belief it had been removed, or by inducing him to forego the possibility of help from other sources." Though, as noted above, it is by no means clear that this Circuit recognizes claims brought under the FTCA for the violation of federal regulations, even taking the Good Samaritan doctrine into consideration, it makes no difference in this case, because this Court finds that plaintiff has failed to prove that it has satisfied the elements of the Good Samaritan doctrine. Plaintiff does not claim, and could not

3. The Coast Guard need not undertake the lighthouse service. But once it exercised its discretion to operate a light on Chandeleur Island and *engendered reliance on the guidance afforded by the light*, it was obligated to use due care to make certain that the light was kept in good working order. *Indian Towing Co. v. United States*, 350 U.S. 61, 69, 76 S.Ct. 122, 126, 100 L.Ed. 48 (1955). (Emphasis supplied)

prove if it did, that the FAA's certification and inspection program increases the risk of bird strikes at certificated airports.[4] Neither does plaintiff allege, and the evidence would not support the contention, that the FAA has interposed itself between the Watertown airport and the duty that airport may have owed plaintiff. For, to be rendered liable under this Good Samaritan element, the FAA must have undertaken "not merely to *supplement* the [airport's] own safety inspections, but rather to *supplant* those inspections," *Blessing*, 447 F.Supp. at 1194, (emphasis in original) and this circumstances does not appear in this case.[5]

Plaintiff does claim to meet the reliance requirement, but here again, the evidence does not support this contention. There is no indication in the testimony of the pilot and co-pilot that either man was even aware of the certification process under 14 C.F.R. Part 139, let alone that they relied on it. Plaintiff contends that "[a]ll pilots rely on government certified airports to be clear of hazards," but any such reliance would appear to be a reliance on the airport *manager* to keep the airport hazard-free, not on FAA inspectors to ensure that the manager is doing his job. This is reflected in the testimony of the pilot, who in response to the question of what could have been done to avoid the crash, said "the only thing I can see would be—have the—some *airport personnel* have closer inspection of the runway conditions and report it to the flight service station, where it could be reported to the pilots." (Irwin deposition, p.82) (emphasis supplied). Similarly, the co-pilot testified that "the *airport authority, or whomever is in charge of the airport*, whoever that is, would be responsible for reporting the birds, as I would see it." (Hill deposition, p.56) (emphasis supplied).

The pilots' lack of reliance upon the FAA certification program is understandable, since the program had only commenced in 1973, with this accident occurring in 1975. As the court in *Clemente* noted, "[i]t may be that in carrying out [the regulations] over a period of time, the FAA staff's conduct will engender sufficient justifiable reliance to create an actionable duty of care, but this is fundamentally different than deriving such a duty from the mere issuance of [regulations]." 567 F.2d at 1149.

This Court must therefore reject plaintiff's contention that 14 C.F.R. Part 139 imposed any sort of duty under state law on the FAA that would give rise to a tort action for its violation. But even if it be assumed that such a duty could exist, plaintiff has failed to show the requisite reliance necessary to recover under *Indian Towing* and the Good Samaritan doctrine. Thus, insofar as the complaint purports to state a cause of action against the United States for a negligent violation of 14 C.F.R. Part 139, either in issuing a certificate or later failure to discover and correct the bird problem, it must be dismissed.

II.

Negligence of the Watertown Airport Operator.

[3, 4] The basic elements of a negligence action are that there be a duty owed by the defendant to the plaintiff, that there was a breach of this duty, and that the breach of the duty was the proximate cause of plaintiff's injury. *Stoner v. Eggers*, 77 S.D. 395,

4. *See* Restatement of Torts 2d, §§ 323(a), 324A(a). It could hardly be said that the mere fact that the FAA issues certificates and conducts yearly inspections increases the "actual danger of harm" contemplated by these sections. Certainly, the gulls did not become more numerous *because* of the FAA's additional regulatory activity at the Watertown airport; any increased risk of harm in this case would have to result from a reliance by third parties on some expectancy that the FAA's certificate and inspections were a guarantee of a bird-free environment. As this opinion makes clear, plaintiff has failed to prove any such reliance.

5. Although [inspection] functions are carried out pursuant to statute or to regulations, they do not arise from a primary duty to provide the service in question ... the government does not purport to relieve other actors of the primary duty to see that the underlying activity is accomplished safely or consistently with some other important public policy. *United Scottish*, 614 F.2d at 193.

92 N.W.2d 258 (1958). This Court has no hesitation in finding, and defendant City of Watertown [City] does not appear to dispute, that the operator of a public airport has a duty independent of federal statutes and regulations to the pilots using the airport to use reasonable care to keep the airport free from hazards, or at least use reasonable care to warn of hazards not known to the pilots.[6] Neither does defendant City seem to dispute that, at least when jet aircraft are involved, birds are one of the hazards that must be controlled at an airport. Defendant City does dispute, however, that there had ever been a problem with birds, specifically Franklin gulls, at the Watertown airport. Much of the trial time was spent attempting to resolve this issue, and this Court finds that the preponderance of the evidence is contrary to defendant City's position.

There seemed to have been almost a complete uniformity of opinion among the witnesses who were familiar with the Watertown airport that gulls were there in substantial quantities from early spring to late fall for as long as any of the witnesses had been there. Only two witnesses testified to seeing no birds: William Moore, FAA inspector, who was at the Watertown airport only one day a year, and James Jacobson, the pilot who last used the airport before the crash,[7] and had used the airport only eleven times in 1975. The witnesses who saw the gulls, on the other hand, were mostly those who were either stationed at the airport, or who used it frequently.

Every one of the witnesses who saw gulls saw them everywhere on the airport property, including the runways, at various times, and all of these witnesses seemed to consider them a threat to the aircraft that used the airport. Bernard Letze, the airport manager, had chased them off before June 1975, and had apparently arranged for warning Notices to Airmen (NOTAMs) to be issued in the fall when he considered them to be particularly bad. Kenneth Baenen and Dale Dahl, the personnel at the FAA flight service station (FSS) on duty the day of the accident, had both seen gulls and had gulls reported to them, and had issued warnings prior to June 1975. Jerry Wyland, a North Central Airlines ticket agent, had seen gulls and warned the airline pilots and informed the airport management three to five times a month prior to June 1975. Marvin Nelson, a Minnesota Rubber Co. pilot flying Lear Jets, who had been using the airport twice a week since 1966, had seen gulls everywhere on the airport property. He testified that he had made passes to avoid the gulls, had hit gulls flying in, and had told the airport management about them. And several local pilots and mechanics, Ed Shell, Ron Kaszowski, and Bob Gisie, had all seen large numbers of gulls around the airport, Kaszowski going so far as to say he had seen enough to cover a section of the runway.

6. *See* Restatement of Torts, Second, § 344:

A possessor of land who holds it open to the public for entry for his business purposes is subject to liability to members of the public while they are upon the land for such a purpose, for physical harm caused by the accidental ... harmful acts of ... animals, and by the failure of the possessor to exercise reasonable care to

(a) discover that such acts are being done or are likely to be done, or

(b) give a warning adequate to enable the visitors to avoid the harm, or otherwise protect them against it.

See also § 343:

A possessor of land is subject to liability for physical harm caused to his invitees by a condition on the land if, but only if, he

(a) Knows or by the exercise of reasonable care would discover the condition, and should realize that it involves an unreasonable risk of harm to such invitees, and

(b) should expect that they will not discover or realize the danger, or will fail to protect themselves against it, and

(c) fails to exercise reasonable care to protect them against the danger.

Section 344 was adopted by the state supreme court in *Nicholas v. Tri-State Fair & Sales Association*, 82 S.D. 450, 148 N.W.2d 183 (1967). Section 343 has been recognized by *Norris v. Chicago, M. St. P. & P. R. Co.*, 74 S.D. 271, 51 N.W.2d 792 (1952).

7. Jacobson took off on runway 17-35 in his Cessna 182 shortly before 3 p.m. the day of the crash approximately one hour and forty minutes before the Saberliner take-off.

The testimony seems to indicate that the heaviest gull infestation was in the early spring or in the fall, not in June. The only NOTAMs Letze mentioned were issued two weeks in the fall; Ed Shell said the gulls coincided with the planting in April and May; Jerry Wyland said usually in March, April and May; Marvin Nelson said spring and fall, though mainly in the fall. But though the greatest number of gulls were in the months before or after June, there were usually a significant number of gulls at the airport in June. Dahl, one of the FSS personnel in Watertown since 1950, said he had seen gulls in the vicinity in June, on the ramp surfaces at the airport within the week before his June, 1978 deposition, and that there had been no difference in the gull presence on the airport paved surfaces since 1960. Letze, whose deposition was taken at the same time, acknowledged that he had chased gulls off the ramp ten days earlier in June, 1978. Baenen said he saw gulls in the vicinity in the days before the crash, and David Windham, an attorney for Kerr-McGee who investigated the accident, testified at length about the flock of gulls he saw on the same runway three days after the crash, as well as the gulls he saw nearby the runway on June 15, 1975, the day after the accident.

There was also testimony on the question of whether rainy weather like that on June 14, 1975, would make it more likely for the gulls to be present. Baenen, one of the FSS personnel at Watertown, and Donald Woodward, an FSS specialist who had worked in Minnesota, denied that there was any correlation between the weather and the gulls. On the other hand, Marvin Nelson, the pilot who reported having had the most trouble with gulls, said they were more prevalent if it was a rainy and cold day, and Bob Gisie repeated this. Johnsgaard, plaintiff's ornithologist, said that wet weather forces worms, a source of food for gulls, out of their holes, and Letze conceded that worms might go onto the runway during "awful heavy rains", though he did not consider the rainfall on June 14, 1975, to be an "awful heavy rain."

It seems significant that Warner, defendant's ornithologist, went no further in his testimony than to say that there was nothing about the Watertown airport that would attract gulls more than would any other place in South Dakota, and that the gulls occurred in the same frequency in the neighboring fields. It might be observed that Letze testified by deposition in June, 1978 that it was not unusual for there to be thousands of gulls in a *plowed* field a mile from the airport, and Dahl said there had been gulls in the Watertown area in the summer since he first arrived in 1950.

Finally, there is the point urged by Letze and Dr. Warner that there is no "bird problem" unless the birds are there habitually and predictably, coming every day to the same place, at the same time, in the same number. It is true that the witnesses agreed on the unpredictability of the gulls: Letze, Wyland, Kaszowski, and Nelson all said that there might be days or weeks when gulls wouldn't be seen, and both ornithologists emphasized the unpredictability of the age-type of gulls that were involved in the wreck. Letze said that the gulls could be *anywhere* on the airport, runway, ramp, or fields, and favored no particular place. Yet, given the testimony set forth above, the conclusion seems inescapable that it was reasonably foreseeable by the City, as airport operator since about 1946, that gulls could be on the runway on June 14, 1975, and if they were, they would constitute a hazard to jet aircraft, especially on take-off.

[5] The gulls were a particularly serious hazard, given their physical attributes and instincts. As described more fully in a later part of this opinion, the gulls are small in size and difficult to see because of their dark coloring. The gulls flock together—they were usually in a flock when Letze saw them—and when frightened, take off in a mass. This take-off is especially dangerous for fast-moving aircraft, since the gulls with their long wings move slowly and go straight up into the path of the aircraft, rather than moving out of the way to the side. Letze acknowledged that he had seen

them go up over an airplane, then settle back down on the same section of runway. Considering the speed which a Saberliner must achieve to reach take-off, between 130–150 miles per hour, the correspondingly reduced time in which to react to emergencies, and the power loss on take-off from bird ingestion in a jet engine, the hazard becomes very serious indeed. The facts must be evaluated in light of the doctrine that "[n]egligence arises from breach of duty and is commensurate as to time, place and circumstances. The greater the danger, the greater the care required, so that a very high degree of danger calls for a very high degree of care which, however, amounts to ordinary care in view of the situation and circumstances." *Bucholz v. City of Sioux Falls*, 77 S.D. 822, 91 N.W.2d 606, 612 (1958).

It may be true, as defendant City of Watertown contends, that it would have been impossible to eliminate the gull problem. Certainly, both ornithologists testifying indicated that there was virtually nothing that could be done in varying the land use around an airport, including use of a "scorched earth" policy of poisoning and defoliation, that would guarantee that the gulls would not be present.[8] It may also be true, as Watertown suggests, that because of the unpredictability of the gulls, no reasonable amount of inspection would have revealed their presence before the accident.[9] But there was another method of dealing with this problem: the issuance of NOTAM warnings.[10]

This method was known to airport management. Letze himself testified that he had previously caused NOTAMs to be issued in the fall when he considered the gull presence to be particularly heavy. Even if this procedure had not been specified in the regulations, this Court holds that defendant City would not have been relieved of its duty to warn, but because the method of warning *is* specified in the regulations, it is additional proof of the negligence of defendant City. 14 C.F.R. § 139.69 (1975) states:

> (a) The applicant for an airport operating certificate must show that it has appropriate procedures for identifying, assessing, and disseminating information to air carrier users of its airport, by Notices to Airmen or other means acceptable to the Administrator, concerning conditions on and in the vicinity of its airport that affect, or may affect, the safe operation of aircraft.
>
> (b) The procedures prescribed by paragraph (a) of this section must cover the following conditions: . . .
>
> (7) The presence of a large number of birds.

William Moore of the FAA testified that many of the airports in this region have permanent NOTAMs, apparently printed in the Airmens' Information Manual, and there is no indication why it would not have been possible for one to be issued for the Watertown airport.

The pilot of the wrecked aircraft testified that it was normal procedure to "check all the NOTAMs on every place you were going in on . . . to be sure there weren't any birds as a normal—normal bird hazard in the area . . . some airports are more notorious for birds than others." And, when asked what could have been done to avoid the accident, the pilot complained that "we had no notification of there ever having been birds in the area or even on the runway or in the area, as far as that's concerned; we had no NOTAM-NOTAMs or no notification of there ever being any birds

8. Because of this testimony, this Court does not find that plaintiff's separate allegation that Watertown encouraged the presence of gulls by conducting farming operations on the airport property, is a valid basis of liability.

9. Watertown's airport operations manual required daily inspections, which were normally conducted once a day at 8:00 A.M. At the time of the accident which occurred on a Saturday, however, no inspections were made on the weekend.

10. There was some testimony that bird warnings should be given by AIRADs (aircraft advisories) rather than NOTAMs, but the record makes clear that there is no real difference between the two warnings.

arou ' that particular airport." With warning, testified plaintiff's expert Saberliner witness, the pilot and co-pilot would have used a variety of cautionary procedures, and probably avoided the accident entirely. If the gulls had been seen before the Saberliner lifted off the ground, which this Court must find would have been more likely with a warning, the airplane could have stayed on the ground until it was past the flock, and then taken off (half the runway was still left), or even if it had reached take-off speed, take-off could have been safely aborted. The danger to the jet from the gulls on the runway was greatest immediately after lift-off, at which time the birds were first seen rising up from the runway, into the path of the plane.

This Court therefore finds that the Watertown airport, under all the circumstances, owed the pilots of the crashed Saberliner jet a duty to warn them of the possible presence of gulls; that defendant City breached this duty by failing to so warn; and that the failure to warn was the proximate cause of the crash.

III.

Negligence of the Watertown Airport Flight Service Station Personnel.

[6] Plaintiff also contends that the FAA employees at the Watertown airport were negligent in failing to warn the Saberliner of the gulls on the day of the accident. These personnel were in the Flight Service Station (FSS) located on the ground floor of the Watertown airport terminal, and their duties involved the dissemination of weather information and flight advisories. FSS personnel may also relay air traffic clearances to pilots from an Air Route Traffic Control Center, but they do not "control" air traffic; [there is no control tower at the airport] rather, FSS personnel merely act as a conduit of certain types of advisory information for pilots.

This advisory information includes hazards presented by birds, and both FSS personnel on duty on June 14, 1975 acknowledged they had issued bird warnings prior to the day of the accident. These warnings, like the other information disseminated by FSS personnel, were issued after the personnel had either made a direct observation of a condition, or were informed of the existence of a condition by airport management or pilot reports. On the day of the accident, however, the FSS personnel testified that they neither saw gulls on the airport nor received any reports of their presence.

It might still be argued, though, that knowledge of a persistent gull problem had to be common property at a small airport like that at Watertown, and that a warning should have been given the Saberliner even without the FSS receiving a report. But there are problems with this position. The FSS personnel stepped just outside their station once each hour to check the weather, from which point they were, because of terrain or high grass, unable to see the runway surface on 17–35, the runway involved here. Moreover, their view from inside the station of portions of the airport, particularly runway 17–35, was somewhat restricted. The FSS personnel appeared to have little knowledge of the airport inspection program, and seemed not even to know there was no weekend inspection. The airport management, on the other hand, was the only entity (aside from aircraft) authorized to be on the runway surface, and except on Saturdays and Sundays, performed daily inspections of the airport area. Also, in the summer, airport management conducted farming operations on the area, thus gaining a greater familiarity with the airport grounds and any problems potentially hazardous to aircraft in the airport area. And, it should be noted, when witnesses testified that they had complained about the gulls, they said they spoke to the *airport manager*, who presumably then relayed the information to the FSS.

Further, under the airport operations manual, which was required to be kept current under 14 C.F.R. § 139.31(b), the airport management was "responsible ... for all General Supervision of the Watertown Municipal Airport. The Airport management is responsible for all the operation management and maintenance of the airport and all its facilities and equipment." Further, federal regulations in 14 C.F.R. Part 139 (1975) indicate that it appears to be the *airport operator's* duty to identify safety problems on the airport and to disseminate this information by NOTAMs.[11]

These regulations appear to formalize what would in any case be the reasonable method of conducting operations at an airport such as that at Watertown. Because of the management's much greater familiarity with the airport, stemming from its direct responsibility for airport inspection and overall operation maintenance, the primary duty must be on the management to keep informed concerning conditions potentially hazardous to aircraft using the runways, and to arrange with the FSS for an appropriate warning to be given.

Considering that the management can see the problems "close up", while the FSS personnel only appear to know of most problems at second-hand, it would seem to cast an unreasonable burden on the FSS personnel to decide that some problem is of such magnitude that it requires a permanent NOTAM without first receiving a decision to that effect from the management.[12] If the FSS personnel could be shown to have actually observed, or learned from a radio report from a pilot flying on or over the airport of a hazardous condition developing and thereafter failed to report it, a different case would be presented. But there is no indication that either of the FSS personnel on duty on June 14, 1975 saw or were notified of the gulls present on the airport runway that day. This Court can find no basis for holding the FSS personnel negligent for failing to give the Saberliner any warning of gulls for June 14, 1975. The Court also takes the view that plaintiff has not made a sufficient showing that the FSS personnel had adequate knowledge of the actual extent of the persistent gull problem at the Watertown airport to be found negligent for failing to issue, independently of the airport management, a permanent NOTAM warning for gulls.

IV.

Pilot's Contributory Negligence.

[7-9] This Court must next consider whether the Saberliner pilots were contributorily negligent under South Dakota law, and if so, the applicability of SDCL 20-9-2, the South Dakota comparative negligence statute.[13] As defined by the State courts, "[c]ontributory negligence is conduct for which the plaintiff is responsible amounting to a breach of duty which the law imposes upon persons to protect themselves from injury, and which, concurring and cooperating with the actionable negligence for which defendant is responsible, contributes to the injury complained of as a proximate cause." *Cowan v. Dean*, 81 S.D. 486, 137 N.W.2d 337, 341 (1965). The standard by which a plaintiff's conduct is tested is "that to which a reasonable man would conform under like circumstances." *Haase v. Willers Truck Service*, 72 S.D. 353, 34 N.W.2d 313, 314 (1948).

There is no dispute that the "pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft." 14 C.F.R. § 91.3(a). This includes a duty to see what can be seen, and to separate his aircraft

11. *See also* 14 C.F.R. §§ 139.57(c), 139.85, 139.89(c); Exhibit 65, Department of Transportation, FAA, 1975 Flight Services Manual, p.56 ("Airport management is responsible for observing and reporting the condition of landing areas.")

12. The same point would seem to refute an argument that a temporary warning should have been issued on June 14, 1975 because the weather may have made the presence of gulls more likely; there is no proof that the FSS personnel knew of this debated circumstance, and certainly the airport management was in a better position to pass such a judgment.

13. In all actions brought to recover damages for damages to a person or to his property caused by the negligence of another, the fact that the plaintiff may have been guilty of contributory negligence shall not bar a recovery when the contributory negligence of the plaintiff was slight in comparison with the negligence of the defendant but in such case, the damages shall be reduced in proportion to the amount of plaintiff's contributory negligence.

from obstructions and hazards, including birds. The parties were agreed that a pilot should learn about possible obstructions at an airport before flying into that airport.

Irwin, the pilot of the wrecked Saberliner, was aware that birds were a possible hazard to jets such as the one he flew. He had flown 22,000 miles over many years to all parts of the United States, including one prior flight to Watertown some years before, and eight or ten trips to other sections of South Dakota and frequent trips into Minnesota. Hill, the co-pilot, had himself flown since 1943, and had made many trips with Irwin. He also had been aware of the hazard birds could present to aircraft.

Before the flight to Watertown, Irwin testified that he checked NOTAMs for warnings on the Watertown airport, and found nothing relating to birds. There was light rain at Watertown when the Saberliner arrived there, and it continued throughout the day. An hour or so before the time of departure, when Irwin filed his flight plan, the FSS personnel told the Saberliner crew that there was mile and a quarter visibility, though the pilot was of the opinion that the visibility was actually a half-mile to three quarters of a mile, or "maybe more." When the passengers boarded the aircraft at about 4:15 p. m. that afternoon, the Saberliner crew radioed the FSS and asked for their clearance for takeoff. The clearance, which the FSS relayed to the Saberliner from Minneapolis, was radioed to the crew just before the Saberliner began its taxi, or as it taxied out the approximately 2,500 feet to the north end of runway 17–35. The crew was not using the windshield wipers on the Saberliner. At least some of its lights were turned on.

At the end of the runway, the Saberliner either hesitated only briefly, or turned immediately onto the runway to begin its takeoff. Both pilot and co-pilot looked down the runway, but saw no obstructions. As the aircraft accelerated, rapidly approaching the lift-off speed, the co-pilot spent virtually all his time looking down at the instruments, while the pilot alternated between looking at the instruments and looking at the runway. When the Saberliner began to leave the ground, the co-pilot looked up, saw a flock of gulls around the Saberliner coming up from below, and told the pilot. Almost immediately thereafter, the aircraft lost power, and crashed beyond the end of the runway.

Thus, the total precautions which the crew took against a possible bird hazard seem to have been to check for NOTAMs concerning the Watertown airport, and to look briefly down the runway before beginning their takeoff. Though it is unclear how many of the Saberliner's lights were on, those lights that were switched on do not appear to have been turned on as a bird precaution. Likewise, the engine ignitions and the radar appear to have switched on, procedures which have been described as bird precautions; but the testimony of the crew does not suggest that these were, in fact, intended as precautions. But, "the taking of some safety precaution, however inadequate it proved to be to prevent the accident, [has] significance" in the determination of a plaintiff's negligence. *Associated Engineers, Inc. v. Job*, 370 F.2d 633, 641 (8th Cir. 1966).

It has been argued that pilots with the extensive experience of the Saberliner crew, having flown to every part of the United States, should have been more cautious about possible bird hazards, even in the absence of a NOTAM for the Watertown airport. The particular birds involved in this accident, Franklin gulls, have a widespread migration pattern throughout this region, and it is clear that there are bird hazard problems at airports other than Watertown. William Moore of the FAA testified that there are permanent birds NOTAMs at many airports in the region, and Marvin Nelson, another jet pilot who frequently flew into Watertown, said he was constantly on alert for and took precautions for birds at every airport he flew into and out of, whether or not he actually knew there was a bird problem at that airport. Though it seems to be clear that Nelson's particular precaution, turning on the engine ignition during takeoff, was, in fact, ineffective to prevent this accident due to the heavy damage the gulls caused to the Saberliner's engines, it is still argued that there were other precautions that could have been taken which might have been more successful. These precautions include turning on the landing lights to attempt to scare the gulls away, using a different runway, taxiing down the runway for a look, asking the co-pilot to deviate from his normal duties to help keep a lookout, or turning on the windshield wipers.

Yet almost all these precautions amount to relatively significant alterations of the normal routine in the takeoff of a Saberliner. The use of the windshield wipers in the light amount of rain present on takeoff that day was described by virtually all the pilot witnesses as being extremely unusual and, perhaps, would have contributed nothing to visibility. The Saberliner had a slanted windshield and, according to the pilot, "water runs off faster than the wipers can keep up with it on a light rain." The wipers had to be turned off shortly after takeoff, adding to the crew's complex procedures; otherwise, on a jet aircraft, they would be destroyed by the high speed. It is significant that the co-pilot testified that in his thirty-four years of flying, he had seen the windshield wipers used on takeoff only three or four times.

A taxi down the length of the runway would also have been an exceptional deviation from the normal routine. There was some evidence that it is generally thought necessary for an aircraft to get out of the runway environment as quickly as possible at uncontrolled airports like Watertown where aircraft need not have a radio to ask permission to land. Further, the testimony of the co-pilot indicated that the Saberliner's clearance for takeoff was good only for four or five minutes from the time it was received, and if the Saberliner was not airborne by that time, the clearance would become void. Though it does not appear from the record how much time the Saberliner had left on its clearance at the point at which it reached runway 17–35, the fact that there appeared to be definite time constraints on the takeoff suggests that the crew would not normally taxi the runway in search of birds unless there had been a considerable reason to think that the birds were there.

Similarly, the use of a different runway would seem quite unusual in the absence of a definite warning. Runway 17–35 was the "favored" runway because of the wind direction and, though the pilot was not required to use it, unless he had some reason not to, it was the runway he would prefer. There is no real suggestion that the gulls were more likely to be on one runway than another; the most that can be said about the advantage runway 12–30 had over 17–35 with respect to birds is that 12–30 was more visible to the FSS and that if there were birds there, the FSS would be more likely to know of it. Yet, the Saberliner crew had no reason to know this.

Though it is possible that the use of landing lights on take-off might have frightened away the gulls, there is no convincing evidence in the record that this would have guaranteed an accident-free flight. Rather, the record has extensive references to the unpredictability of the birds, and the difficulty of finding any reliable method to prevent them from coming to the airport or to scare them away once there. It certainly cannot be considered negligence to have failed to use a possibly unreliable precaution.

Finally, there is the question of whether the crew should have looked more closely at the runway when they reached the north end from the taxi ramp, that the pilot should have seen the gulls while he watched the runway as the Saberliner accelerated down the runway for take-off, and that the co-pilot should have spent part of the take-off helping to watch for birds. As to this last point it must be observed that the evidence shows that the usual procedure in a Saberliner was that which was followed that day—that the co-pilot should spend his time on take-off looking at the instruments. As the co-pilot himself testified, when asked if he ever looked up from the time the Saberliner reached the runway to the time it left the ground, "I got too many jobs in there. If you distract yourself for a brief second, then you get behind the airplane. Things are happening too fast. I have to call speeds and power settings and things that are happening pretty fast and you have got to really concentrate on what you are doing or you will miss it, get behind it." Thus, the alteration of what appears to have been a very sensitive take-off procedure in order to allow the co-pilot to help the pilot watch the runway would not seem justified unless the Saberliner crew had some strong reason to suspect the presence of birds.

Further, and of great importance in determining the crew's negligence, there must be considered the sheer difficulty of seeing the gulls. The gulls were apparently at a point about 3,500 feet from the north end where the Saberliner turned onto the runway. On a clear day, several pilots testified, you could see at least 6,000 feet down the 6,900 foot runway. But the day of the accident was overcast and rainy. If the visibility was a mile and a quarter, or 6,600 feet, then the 3,500 foot point should have been visible. If the visibility was what the pilot reported, either a half-mile (2,640 feet) or three-quarters of a mile (3,960 feet) or "maybe more", the 3,500 foot point would be on the edge of visibility. But the inquiry could not end here, because there are also the gulls themselves to be taken into the reckoning.

Though Franklin gulls have a twenty-seven inch wingspan, their bodies are small, less than ten ounces, and low to the ground, less than ten inches high. The gulls mainly involved in this accident, which were of an immature age, were of a mostly white and gray color. It is evident that on the clearest of days, such a bird would be difficult to see, especially on pavement, and that on a grey, overcast day such as that on the day of the accident, the birds would almost completely blend into their background.

[10, 11] Under South Dakota law, if a plaintiff has a duty to maintain a lookout, and if he does look, "it is implied that he looked effectively and in such a manner that he would see what was in plain sight unless some reasonable excuse for not seeing is shown." *Cowan v. Dean*, 81 S.D. 486, 137 N.W.2d 337, 342 (1965). Further, if there was a shortened visibility on the day of the accident, the Saberliner crew should have at least used heightened vigilance to keep a lookout for obstructions that might have been outside their range of vision, see *King v. Farmers Educational & Cooperative Oil Co.*, 72 S.D. 280, 33 N.W.2d 333 (1948); but at the same time, "[i]f an object is so well camouflaged as not to be discernible within the range of ... vision [an actor] may not be held to the duty of seeing it." *Dwyer v. Christensen*, 76 S.D. 201, 75 N.W.2d 650 (1956). This rule has mainly been applied in cases where unlit or poorly lit vehicles were encountered on the highway at night. In *Corey v. Kocer*, 86 S.D. 221, 193 N.W.2d 589 (1972), for example, plaintiff collided with the back of a slow-moving combine which was not exhibiting any red lights to the rear. "If any duty [to take a precaution] existed, it did not arise until [plaintiff] discovered the falsefront or 'camouflaged' danger defendants had created." 193 N.W.2d at 597. Or, in *Audiss v. Peter Kiewit Sons Co.*, 190 F.2d 238 (8th Cir. 1951), a case decided under South Dakota law, defendants were operating a poorly lit dark green road roller in the dark. It was either stopped, or barely moving, and plaintiff's deceased, unable to see the roller, collided with it. In reversing the trial court's dismissal of the complaint, the court of appeals said "a driver is not held to the duty of seeing objects which are not discernible. No one would hold a driver to the duty of seeing an object perfectly camouflaged on the road within his range of vision." 190 F.2d at 242. *See also Knapp v. Styer*, 280 F.2d 384 (8th Cir. 1960); *Winburn v. Vander Vorst*, 75 S.D. 111, 59 N.W.2d 819 (1953).

This Court has no difficulty in determining that, given the authority of the cases just cited, the crew of the Saberliner had a "reasonable excuse for not seeing" the gulls on the runway in time to avoid the accident, given the color of the gulls and the weather conditions, and the necessary speed generated for take-off. Further, under the three factors analyzed in *Associated Engineers, Inc. v. Job*, 370 F.2d 633, 641 (8th Cir. 1966) in "appraising the quality of a plaintiff's negligence: the precautions he took for his own safety; the extent to which he should have comprehended the risk as the result of warnings, experience, or other factors; and the foreseeability of injury as a consequence of his conduct," this Court is unable to conclude that the actions of the crew contributed in any significant way to the accident. The pilot did check to see if there were any NOTAMs issued for the Watertown airport; this precaution was ineffective only because Watertown had failed to issue any warning of the presence of birds. The Saberliner crew did look down the runway before embarking on the take-off. That this was ineffective is due largely to the "camouflaged" nature of the gulls. There is nothing in the record to show that the Saberliner crew could be charged with more than a highly generalized awareness that birds were a hazard, and that there was always a possibility that birds could be at an airport.[14]

Finally, there is nothing to indicate that injury was in any way foreseeable as a consequence of the crew's conduct. The record is replete with indications that the crew followed their normal procedures on takeoff, and that any deviation from these procedures as a precaution against unknown hazards would not have been reasonable, given the circumstances. Though the crew could possibly have taken a longer look at the runway before beginning their take-off, they did at least look and this Court cannot say that they "blindly" or "needlessly" proceeded into a zone of danger. *See Engel v. Stock*, 88 S.D. 579, 225 N.W.2d 872 (1975); *Pleinis v. Wilson Storage and Transfer Company*, 75 S.D. 397, 66 N.W.2d 68 (1954); *Friese v. Gulbrandson*, 69 S.D. 179, 8 N.W.2d 438 (1943).

Considering everything that has been discussed to this point, the Court can perceive no conduct on the part of the Saberliner crew which amounted to a breach of their duty to protect themselves. It follows from this that the actions of the pilots were no proximate cause of the accident, and can in no way be held to be contributorily negligent. Since the Saberliner crew was not causally negligent, there is thus no need to consider the application of the comparative negligence statute, SDCL 20-9-2.

Judgment will therefore be entered for plaintiff against defendant City of Watertown for the full stipulated value of the crashed Saberliner.

The foregoing represents the findings of fact and conclusions of law of the Court.

14. Implicit in the argument that the Saberliner crew should have used greater precautions regardless of the presence or absence of a bird NOTAM for Watertown is an assumption that NOTAMs are not a true guide, and that many airports have bird hazards, yet do not bother to warn. This Court is without sufficient evidence to make a finding of the accuracy of this assumption. In any event, this Court expressly holds that a failure of other airports to warn of bird hazards did not relieve defendant City of Watertown of its duty to issue a warning of the hazard at its airport.

CITY OF NEW ORLEANS, Through NEW ORLEANS AVIATION BOARD

v.

VICON, INC., et als.

Civ. A. Nos. 79-4878, 79-4987, 80-211 and 80-3409.

United States District Court, E. D. Louisiana.

Jan. 4, 1982.

Action was brought arising out of alleged negligent construction of airport runways. The District Court, Beer, J., held

The Court finds that DOHSA is not the exclusive remedy for the legal claims alleged in the plaintiff's complaints and accordingly remands all three cases to the Connecticut courts.

SO ORDERED.

—Footnote—

[1] The Court is cognizant of the fact that these cases relied, in part, on the legislative history of DOHSA, to reach the conclusion that DOHSA was intended to place exclusive jurisdiction in the federal courts for deaths on the high seas. The Supreme Court, however, has reviewed the legislative history of DOHSA and refused to reach the same conclusion. In *Moragne v. States Marine Lines*, 398 U.S. 375, 400 n. 14 (1969), the Court stated: "The only discussion of exclusive jurisdiction in the legislative history is found in the House floor debates, during the course of which Representative Volstead, floor manager of the bill and chairman of the Judiciary Committee, told the members that exclusive jurisdiction would follow necessarily from the fact that the Act would be part of the federal maritime law. 59 Cong. Rec. 4485. This erroneous view disregards the 'saving clause' in 28 U.S.C. §1333, and the fact that federal maritime law is applicable to suits brought in state courts under the permission of that clause. . . . From this we can derive no expression of policy bearing on the matter under discussion."

ALITALIA-LINEE AEREE ITALIANE, S.p.A. v. UNITED STATES OF AMERICA and MASSACHUSETTS PORT AUTHORITY

United States District Court, District of Massachusetts, Civil Action 79-2149-MA, November 15, 1982.

AIRPORTS—NEGLIGENCE—OBSTRUCTION OF TAXIWAYS—DAMAGE TO AIRCRAFT.—The negligence of an airport operator and the negligence of an air carrier caused or contributed to the cause of damages incurred by an aircraft when one of its engines struck a bank of ice-encrusted snow while the aircraft was taxiing at the airport. The airport operator was negligent by its failure to exercise reasonable care in discharging its obligation to clear the runways, its failure to exercise reasonable care in its inspection of the airport, and its failure to provide accurate information about runway conditions to the crew of the aircraft. The air carrier was negligent by failing to use ordinary care to provide the aircraft crew with a field condition report that the carrier received prior to the departure of the aircraft and by the crew's failure to see and avoid the obvious and visible danger posed by the snow bank encroaching onto the taxiway. The proportion of fault of the airport operator was 60%, and the contributing portion of fault of the air carrier was 40%.

OPINION

MAZZONE, D.J.: The plaintiff, Alitalia-Linee Aeree Italiane, S.p.A. (Alitalia), brings this action to recover for damages incurred by one of its aircraft at Logan Airport on January 30, 1977 when the Number 3 inboard engine struck a bank of ice-encrusted snow on an inner taxiway of the airport. It alleges the defendant, United States, by its agency, the Federal Aviation Administration (FAA), was negligent in failing to provide Alitalia with proper information, warnings, and instructions about the dangerous accumulation of snow on the inner taxiway. Alitalia next alleges that the defendant, Massachusetts Port Authority (Massport) was negligent in permitting the accumulation of snow on the taxiway and was negligent in failing to provide accurate, up-to-date information concerning field and taxiway conditions.[1] The defendants deny liability and allege that Alitalia was negligent in failing to provide field condition reports to its crew and in failing to properly operate the aircraft to avoid the obvious danger posed by the snowbanks. Jurisdiction against the United States is invoked under the Federal Tort Claims Act, 28 U.S.C. §§1346(b) and 2671 *et seq.* Jurisdiction against Massport is based on diversity of citizenship, 28 U.S.C. § 1332. Venue is properly set in this district.

The case was tried to the Court without jury. Pursuant to Fed.R.Civ.P. 52(a), I make the following findings of fact and conclusions of law.

I.

On January 30, 1977, at about 4:20 p.m. Greenwich mean time or 10:20 a.m. Boston time, Alitalia Cargo Flight AZ 926, departed from Fiumicino Airport, Rome, Italy on a flight to Boston and New York. The aircraft, a DC8-62-F, was piloted by Captain Pietro LoCurto. Also on board were four Alitalia employees, the first officer or co-pilot, the navigator, the flight technician and a trainee. Before leaving Rome, the entire crew had received the routine pre-flight briefing dealing with meteorological conditions along the route and at the destination. The crew did not receive any report of field conditions at Logan Airport from Alitalia's Rome office. Captain LoCurto was an experienced pilot, and had flown this same flight to Boston and New York on at least four prior occasions in mid-winter, though not in recent years.

There had been almost 23 inches of snowfall at Logan Airport between January 7, 1977 and January 30, 1977, nearly double the average snowfall. The temperature at Logan Airport on January 30, 1977 ranged from a low of 7°F to a high of 19°F. The Logan Airport Automatic Terminal Information Service (ATIS) is a recorded message containing weather, operations and airport landing information. The ATIS information is broadcast by the FAA on the Logan frequency to approaching aircraft, usually at hourly or two hour intervals. At 3:00 p.m., Boston time, before Flight AZ 926 received any ATIS information, the transmission warned of a closed outer taxiway and snow and ice surfaces. The remaining portion of that transmission stated:

> The remaining portion of the airport, the apron, inner and outers are covered with some hardpacked snow and ice; braking has been reported as fair; there are snow piles in the vicinity of Tango, November and Kilo and in the cargo area. Snow flags marking caution advised.

ATIS transmissions are the responsibility of the FAA. Massport was required to issue airfield condition reports daily after its personnel made periodic inspections of the airport. Those reports were furnished to the FAA.

The FAA is responsible for the safe and efficient use of the country's airspace. It distributes information by three methods, one of which is the Airman's Information Manual. The aeronautical information is disseminated according to its time-critical nature. Specifically, the Manual contains the following directions:

> 4. Information which is primarily of an advisory or "nice-to-know" nature, plus data on airports not included above that can be given to the pilot upon request on an "as-needed" basis before departure, while en route, or prior to landing, ... Examples of this type are: Men and equipment crossing a runway, snowbanks off the side of runways, taxiway closed, etc.

Further, the Manual further states that instructions pertaining to taxiing are predicated on known traffic and known physical conditions.

The FAA also promulgates regulations (FARs) that govern the operation of the airplane by the pilot. Those regulations are found in 14 C.F.R., Part 91, with additional rules for air taxi operations in Part 135. The FAA regulations required the air traffic controllers to notify pilots of airport conditions necessary for safe operation including snow drifts or piles of snow on or along the edges of the area and extent of any plowed area. Despite being provided information of the snow encroachment along the inner taxiway by Massport, and despite the fact that its earlier ATIS broadcast at 3:00 p.m. had warned of "snow piles in the vicinity of Tango, November and Kilo and in the cargo area," the FAA deleted this information from its next transmission at 4:00 p.m. It did not reinstate this information in any later transmissions.

The Alitalia Boston office had also received the field condition report from Massport via telautograph. That report stated that taxiway surfaces were mostly covered with ice patches, rutted to 3 inches in some areas. The braking by car was fair to poor. There were "windrows" to 3 feet up to 10 feet inside some light lines and windrows to 2 1/2 feet along most light lines.[3] The entire report also described the presence of snow windrows and ice along some taxiways and runways, some of which were closed. The entire report was transmitted to Alitalia's dispatch office in Rome via teletype, but was not provided to the crew.

The flight was uneventful. Upon approaching Logan Airport, Flight AZ 926 tuned to the Logan frequency. The ATIS message it received advised of the temperature and wind conditions but contained no information concerning the presence of snow piles on the airport, that earlier information having been deleted by the FAA. AZ 926 was ordered to land and depart by runway 27. The transmissions to AZ 926 as it approached and landed at Logan were from Boston Approach Control, Boston Local Control and Boston Ground Control. These transmissions were the responsibility of the FAA. None of them made any reference whatsoever to the conditions of the airport.

Flight AZ 926 landed on Runway 27 at about 8:00 p.m., and, following the instructions of ground control, turned right onto Echo taxiway to the outer taxiway to Foxtrot taxiway where it turned left onto the inner taxiway. It taxied past the terminal to the Alitalia gate position located beyond the terminal in the North area. As it taxied, the nose taxi lights and wing taxi lights were on. These lights clearly illuminated the runways and taxiways for both the Captain and the co-pilot. Both were seated forward in the cockpit and had a clear view of the taxiway directly ahead. The Captain was responsible for any obstruction to the left of the center line and the co-pilot was responsible for any obstruction to the right of the center line. Their views were unobstructed except for the window struts, and, with the wing and nose and the ground flood lights on, the taxiway was clearly illuminated to a distance of 150 to 200 feet from the cockpit.[3]

The Captain was aware of a bank of snow all along his right side as he taxied on the inner taxiway. There was no snow to his left. The inner taxiway was 100 feet wide, divided by a yellow center line. Under normal conditions, the light line along the right edge of the taxiway, 50 feet from the center line, would be visible to the crew. Rather than the snow being 10 feet inside the light line, or about 40 feet from the center line, as stated on Massport's field condition report, the snowbank was actually about 25 to 27 feet from the center line. It was, however, clearly visible, and should have been seen, not only by the pilot, but also by the co-pilot who had an even clearer view of the snowbank by virtue of his position on the right side of the cockpit. Both men could see, or should have seen, that the right inboard engine would either pass over the snowbank or strike it. The taxi lights located on the wings were on and clearly illuminated the snowbank. The Captain, however, taxied directly down the center line, or slightly to the right of the center line, given his position on the left side of the cockpit. The Captain did not move to the left of the center line although there was 200 feet of taxiway and adjacent apron cleared entirely of snow. He saw no obstacle to his left, but clung devotedly to the center line as his guide despite the snowbank to his right. The Captain and crew were covered by FAA rules and regulations when operating in the United States. Federal Aviation Regulation, 14 C.F.R. (FAR) §913. Those rules and regulations placed the prime responsibility for the operation of the aircraft on the crew.

Upon arriving at the Alitalia gate, the plane was inspected and damage was discovered to the Number 3 inboard engine. There was snow and ice inside the engine cowling and a part of a broken stick. The Captain, together with the station chief and a representative of Massport, retraced the route taken by AZ 926 and located the point where the Number 3 engine struck a bank of crusted snow approximately 3 feet high and about 25 feet from the right edge of the taxiway.

That point was on the inner taxiway leading to the cargo area, and opposite the terminal. At this precise point, the taxiway had the yellow center line and an outer edge line to the north (or right) side, 50 feet from the center line. The center line was clearly visible on the bare taxiway surface, and there were hard crusted snowbanks about 3 feet high within 25 feet to the right of the center line.[4] The entire area to the left (or south) side was cleared of snow all the way to the terminal. There was about 200 feet of cleared apron in the area to accommodate parked aircraft and other vehicles used in the loading and unloading operations.

The snowbank which was located at the point of impact had a depression or groove about 4 inches from the top of the snowbank and 25 feet from the center line. The inboard engine is located 25 feet 7 inches from the center of the fuselage and the outboard engine is located 44 feet 6 inches from the center. The inboard engine is 2 feet 5 inches from the surface and the outboard engine has 4 feet 2 inches clearance. The bank was marked with flags, but was not lighted. One flag on the snowbank was broken and that piece matched the broken piece found in the engine pod. The snow pile was about 25 feet from the center line and not 10 feet from the light line reported in the field condition report.

Snow removal was the responsibility of Massport. The airport had not been completely cleared of snow because of the heavy precipitation that had occurred in January, unaccompanied by any thaw. About 10% of the airport area was still closed on January 30, 1977. Massport's Snow Removal Plan for 1976-1977 specified the clearance for inboard engines of a DC8-63 at 25' 9" from the center line and 2' 6" from the surface. Massport's Operations Supervisor had inspected the inner taxiway earlier that day. The inspection consisted of driving a vehicle along the taxiways and estimating the height of the snow piles and their distance from the center line. The inspection results were included in the Massport field condition report and were not changed in any subsequent report. That report inaccurately stated that windrows of 2-3 feet high were located 10 feet from the light lines. Massport's field condition reports were to include:

> The presence of snow drifted or piled on or next to, runways or taxiways in such height that all aircraft propellers, engine pods and wingtips will not clear the snowdrifts and snowbanks when the aircraft's most critical landing gear is located along the full strength edge of the runway or taxiway.

14 C.F.R. § 139.69.

As a result of the impact, Number 3 engine was damaged. The fair and reasonable value of the replacement parts was $55,445.60.[5] These parts included the reverse thrust ring, hot section cowlings, fan fin tail section, oil supply lines, fin mast drain, forward fire wall, fire detection loops, electric cannon plugs, thermocouples and welded V-support for the nacelle. The fair and reasonable value of the labor required to repair the damage at Fiumicino Airport was $2,488.60. The fair and reasonable value of the expenses incurred at Logan as a result of the impact was $8,496.47. These expenses consisted of transportation of cargo to New York, hotel accommodations for the crew in Boston, rental of hangar space for the plane, towing services, and mechanical repair services.

After immediate repairs were made, the plane returned to Rome where the cowlings were replaced. These repairs took 2 days to complete during which time Alitalia suffered a 2 day loss of use of the aircraft. That loss was shown by the cost analysis of North America flights, the hours, the revenue and the lost time. The loss for 2 days was $26,754.19. The total damage incurred by Alitalia as a result of this incident was $93,184.86.[6]

II.

The initial burden is on Alitalia to show by a preponderance of the evidence that its damage was proximately caused by the negligent breach of duty by the United States and by Massport. *Delta Air Lines, Inc. v. United States* [14 Avi. 17,967], 561 F.2d 381, 389 (1st Cir. 1977). The controlling law in Federal Tort Claims Act cases is the law of the state in which the accident happened, here Massachusetts. *Hess v. United States*, 361 U.S. 314 (1960). In Massachusetts, actionable negligence is predicated on the want of ordinary care. *Mason v. Geddes*, 258 Mass. 40 (1926).

Similarly, Massachusetts law provides that the defendants, United States and Massport, bear the burden of proving contributory negligence by Alitalia by a preponderance of the evidence. If Alitalia's share is more than 50%, it cannot recover. If its share is less than 50%, damages are reduced proportionately. M.G.L. c. 231 § 85. *Graci v. Damon*, 374 N.E.2d 311 (1976), *aff'd*, 376 Mass. 788 (1978).

On the basis of the foregoing findings of fact and the applicable law, I conclude that while all three of the parties involved in this incident were responsible to some degree, it was the negligence of Massport and Alitalia that caused or contributed to causing the accident in the following ways.

(1) Massport was negligent and its negligence was a proximate cause of the injury to Alitalia by (a) its failure to exercise reasonable care in discharging its obligation to clear the runways, (b) in failing to exercise reasonable care in its inspection of the airport, and (c) in failing to provide accurate information about runway conditions to AZ 926.

Specifically, Massport violated its duty to remove snow from runways and taxiways. Federal Aviation Regulation 139.85 requires the airport operator to move any piled snow off useable taxiways and position snow or snowbanks off those surfaces so that aircraft engine parts, propellers and wings will clear the snowbank. If unable to comply, Massport was required to issue a notice to airmen describing the existing conditions. Massport's snow removal plan recognized this requirement and specifically stated that windrows were to be removed. Yet Massport failed to remove the snowbank, or position it so that aircraft engine parts would clear it and failed to offer any reason why it was unable to do so.

Secondly, Massport's inspections of the taxiways were superficial and cursory. Estimating the height of the snowbanks while driving down the taxiways was not the exercise of reasonable care.

Finally, Massport's failure to measure the snowbank caused it to provide inaccurate information about the taxiway conditions. Had Massport measured the height and distance from the light lines of the snowbank along the inner taxiway, it would have known that the snowbank was an obstacle to certain aircraft, including this one, described in its snow removal plan and was not a wind-caused accumulation of snow alone.

Massport was also responsible directly for the FAA's failure to provide accurate field conditions regarding snowbanks on the inner taxiway to AZ 926 and in deleting the information regarding snow encroachment on the inner taxiway from its ATIS transmission.

The FAA has an obligation to inform aircraft of airport conditions. The FAA Handbook 7110.65, the Air Traffic Control Handbook, Chapter 5, paragraph 940 states that control must

> ... issue airport condition information necessary for an aircraft's safe operation and in time for it to be useful to the pilot. Include the following, as appropriate: ... D. snow drifts or piles of snow on or along the edges of the area and the extent of any plowed areas....

At 3:00 p.m., the ATIS transmission warned of snow piles in certain areas including the cargo area. Yet that information was deleted from the subsequent broadcasts. There was no evidence that the snowbanks' height or location was known or should have been known to the FAA. The FAA relied entirely on Massport to furnish it with accurate information. Massport's information was not only inaccurate, but it disclosed no hazard to AZ 926, or any other aircraft for that matter, and, accordingly, the FAA did not know, nor should it have known of the danger.

Massport's failure to adhere to any of the above requirements was a direct and substantial cause of the accident.

(2) Alitalia was negligent in its (a) failure to use ordinary care to provide the crew with the field condition report received in Rome prior to the departure of AZ 926 for Boston, and (b) the failure of the crew to see and avoid the obvious and visible danger posed by the snowbank encroaching 25-27 feet from the center line of the inner taxiway.

Specifically, Alitalia received a field condition report in ample time to provide it to the crew of AZ 926 at the pre-flight briefing in Rome. While conditions may have changed in the 9 hour flight between Rome and Boston, the report was complete and comprehensive and would certainly have served to alert the Captain to the abnormal conditions at Logan Airport. Again, no explanation was offered as to the failure of the Alitalia dispatch office to provide this report to the crew.

Secondly, the FARs, binding upon the pilot, have the force and effect of law. *Tilley* v. *United States* [10 Avi. 17,199], 375 F.2d 678, 680 (4th Cir. 1967), and their violation is negligence *per se*, *Gatenby* v. *Altoona Aviation Corp.* [10 Avi. 18,184], 407 F.2d 433, 446 (3rd Cir. 1968). It is also assumed that the pilots read and know the FARs and the provisions of the Airman's Information Manual. *Associated Aviation Underwriters* v. *United States* [15 Avi. 17,495], 462 F.Supp. 674, 680 (N.D. Tex. 1979). The thrust of the rules, therefore, is to place the primary responsibility for avoiding obstacles on the pilot because he is generally in the best position to see them. *Miller* v. *United States* [15 Avi. 17,529], 587 F.2d 991, 996 (9th Cir. 1978).

Against that backdrop, the conduct of the pilot and/or co-pilot contributed substantially and directly to the accident. Visibility was clear, and both men knew or should have known of the presence of a substantial snow pile under the Number 3 eight inboard engine. There was sufficient illumination. The chalks provided by Massport's aviation safety expert showed clearly that their views were largely unobstructed. The Captain admitted he could not judge the height of the snowbank, yet he followed blindly what he believed to be the "security" of the center line. The Captain also admitted that there was substantial room to his left clear of snow piles, yet he did not deviate from his course.

The insistence in following the center line when he knew of snow piles closely on his right and no snow on his left, was inexcusable. It was the pilot's duty to inform himself of conditions he did not fully understand. He was aware of the "see and avoid" principle that applies in visible approaches. The Captain and co-pilot were both in a position to see and avoid the snowbanks and their failure to take corrective action by moving 2 or 3 feet to the left of the center line was a contributing cause of the accident.

Having concluded that Alitalia and Massport both were negligent and that their negligence was a substantial factor in causing the accident, the final question is what proportion of fault, expressed as a percentage, should be allocated between them.

My analysis leads me to conclude that Massport must bear the preponderate share of the responsibility for the accident because of its failure to remove the snow piles from a critical part of the taxiing area. At the same time, the Captain and crew did not take obvious corrective action to avoid the snow piles.

Based on the foregoing findings and conclusions I find that the proportion of fault of Massport is 60% and the contributing proportion of fault of Alitalia is 40%.

Accordingly, judgment will be entered in favor of Alitalia against Massport in the amount of $55,910.91. Judgment will be entered in favor of the United States against Alitalia.

SO ORDERED.

—Footnotes—

[1] Alitalia also alleged this same conduct by Massport constituted a breach of contract and breach of warranty. These claims were not asserted in the Stipulation filed prior to trial, nor were they pursued at trial.

[2] Webster's New Collegiate Dictionary defines "windrow" as a "bank, ridge or heap," or "a row heaped up by or as if by the wind."

[3] I have accepted Captain LoCurto's testimony that all the lights were on as including the ground floor lights, although the evidence was not clear on that point. And I have relied heavily on the charts provided by Massport's aviation safety expert as the basis of my finding that the views were unobstructed and well illuminated.

[4] These hard crusted snowbanks would not qualify as "windrows" as defined earlier.

[5] There is a substantial discrepancy between the claim of $107,839.36 for two parts from McDonnell Douglas and the testimony of McDonnell Douglas' pricing director that these parts were listed at $55,339. I have accepted the latter testimony as more reliable. Also, I have not credited the testimony that most of this discrepancy was attributable to storage costs. There was not a sufficient, nor reliable foundation for such an expense for parts that were admittedly purchased for immediate use in the repair of the aircraft.

[6] There was substantial dispute over discovery relating to damages. There is no doubt that Alitalia was derelict in its adherence to discovery rules, not due in any way to its Boston trial counsel, who endeavored mightily to secure the cooperation and compliance of his Italian counterparts. Distance and language added to his difficulty. However, I do not see that the defendants were prejudiced in any way and their motion in limine to exclude evidence of damages is denied. As the text indicates, I have accepted their evidence as to the cost of the major replacement costs and the other expenses, all documented and necessary, cannot be seriously disputed.

There was also a motion by the United States to excuse it from those claims that were not included in the administrative claim filed by Alitalia, namely, the loss of use of the aircraft. Such a claim is mandatory under the Federal Tort Claims Act, 28 U.S.C. § 2675(a)(b). I also deny that motion. It is clear from the claim filed that property damage to the aircraft of the extent described would involve some loss of use. Although no specific claim was made, the loss of use claim is clearly inferable from the description of the claims made.

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THE POTENTIAL OF THE NEXRAD RADAR SYSTEM FOR WARNING OF BIRD HAZARDS

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ABSTRACT

Flying birds pose a dangerous and costly problem for aviation. Warning to pilots of hazardous movements of birds could be available with the Next Generation Weather Radar (NEXRAD) currently being developed cooperatively by three U.S. government agencies. For several kinds of bird hazards, it should be feasible to develop computer algorithms to provide automated hazard warnings in real time. Reflectivity, Doppler speed, and differential reflectivity data taken with a prototype 10-cm NEXRAD radar establish the usefulness of NEXRAD for obtaining information on birds.

INTRODUCTION

The problem of collisions once airborne (the "enroute" problem) is one of encounters with birds that are engaged in long-distance migration and shorter-distance local movements, such as feeding flights, homing, and other activities that take the bird into altitudes frequented by aircraft. Two approaches have been used in attempting to reduce the enroute problem: warning the flight crew of potential collision hazards (Blokpoel, 1973), and making the aircraft more visible or salient to flying birds. The present report will concentrate on the first method.

With respect to the enroute problem, "the most practical results can be expected to come from bird radars. . .to convert bird density data into bird strike risk. . . . Further research and development work in this area is likely to be most fruitful." (Blokpoel, 1976) The usefulness of radar for detecting and following the movements of airborne animals has been known for over 20 years (reviewed in Richardson, 1979).

NEXRAD is a modern 10-cm Doppler radar system being designed to replace the present network of weather radars (JSPO, 1981a,b). NEXRAD is a joint effort of the Department of Commerce, the Department of Transportation and the Department of Defense. It will replace present systems being used by these three agencies with a single, comprehensive system of radars that will cover the continental United States at 200 km intervals. Installations in other parts of the world are also being planned. The NEXRAD network will remain in place for 20 years or more after being completed.

NEXRAD has been envisioned as a weather detection system; however, it will be capable of detecting bird targets at long range (450 Km for a Herring

Gull; Larkin, 1983 Appendix). Flexibility generated by computerization in the NEXRAD system will provide information considerably more detailed and at the same time more comprehensive than existing operational radar systems can provide. The mechanical and electronic (hardware) characteristics of the NEXRAD radars will not easily be subject to modification, either late in the development phase or subsequently in the field; therefore, much of the NEXRAD design work to be done in the next one or two years will consist of designing, coding, and testing computer programs to be used in meeting user requirements.

This paper addresses the following questions: (1) Can bird targets be readily detected with NEXRAD and distinguished from other radar echoes? If so, how would the information be extracted from the NEXRAD system? (2) Is automatic monitoring of bird targets feasible and to what extent could analyses of NEXRAD data be used to reduce the problems involved in collisions between birds and aircraft? Implementing this objective would involve expansion of NEXRAD uses from detection of weather echoes to detection of both weather echoes and those from flying animals, especially birds.

The NEXRAD system is designed for extremely high availability in that user information would be available more than 99 percent of the time at intervals of approximately 5 to 15 minutes. Thus, it might be possible to provide real-time warnings of the presence of hazardous birds to be made available to flight controllers and ultimately to aircraft pilots. This paper examines the extent to which this extremely desirable objective is in fact possible and examines situations in which NEXRAD would or would not provide immediate, reliable bird hazard information to the pilot.

POSSIBLE TECHNIQUES FOR IDENTIFYING REGIONS OF BIRD HAZARD USING NEXRAD

It is hereafter assumed that the reader has a basic knowledge of pulsed radars. In any potential application of the NEXRAD system to flying animals, it is more correct to refer to discrimination than to detection of biological targets. The radar hardware detects a signal in the form of an above-threshold echo positioned in a certain place in the polar coordinates of the radar at a certain time. The problem is therefore one of classifying an echo, that is determining whether it is water, airborne debris, birds, bats, insects, anomalous propagation, or unidentified clutter. Clearly, there will at times be cases where an individual radar pulse volume will contain mixed echoes of more than one of the former types, resulting in an ambiguous or stochastic classification.

Information from the NEXRAD system can be divided into primary echo characteristics and a host of secondary, or computed values related to these primary characteristics. The primary NEXRAD radar data are functions of the three polar coordinates of azimuth, elevation, and range, providing a position in 3-dimensional space, and of the time at which the echo was received. NEXRAD data will be available in a sequence of stacked azimuthal scans known as a "volume scan" at 5 minute intervals. The NEXRAD system gathers data on echo intensity in decibels (dBZ), radial speed from the Doppler relationship and the spectral width of the Doppler-derived speed estimate. Of course, the echo intensity will vary strongly with the slant range to the target, and the radial speed will ignore speed components transverse to the radar site.

Some secondary characteristics of bird echoes as they might appear on NEXRAD radars are concerned with distribution in space. Bird targets are often confined to certain altitude regions (Blokpoel, 1969; Able, 1970; Bruderer, 1971), sometimes associated with certain topographic features (Richardson, 1972), and similarly associated with certain habitats. They show aspect-dependent echo strength at least with some polarization values (Edwards and Houghton, 1959; Schaefer, 1968). It is problematical whether a sophisticated mosaicking capability (JSPO, 1981, Section 2.2.7) will be initially implemented to allow spatial distributions of bird movements to be monitored across neighboring NEXRAD radar systems. Presumably, such mosaicking capability would be later added to NEXRAD software as refinement and installation of NEXRAD algorithms progresses. Avian targets can appear as spatially distriubted targets or as dot echoes. NEXRAD software dealing with dot echoes would presumably operate in parallel with weather-identification software; one supposes that implementation would be primarily a question of price.

Avian targets show nonrandom distribution in time. Temporal distribution of flying animals varies according to weather and other conditions. Bird targets have a rather predictable annual and diel distribution and will in addition be affected by temperature, wind direction, cloud cover, presence of convective activity, and other environmental conditions (Richardson, 1978). Some of these parameters will be readily available to NEXRAD.

Flying animal targets have a velocity relative to the air around them, in contrast to passively-moving meteorological targets. Under some conditions it will be possible to observe that biologically-generated echoes are moving relative to the air; at other times, their motion will result in error in computation of the wind velocity. In many cases, it will be possible to identify bird targets as apparent extreme vertical wind shear under conditions when actual vertical wind shear is unlikely.

Under some conditions, spectral width of the Doppler measurement may be useful in identifying certain kinds of bird echoes. The issue of spectral width is not further discussed in this report due to present lack of data on appropriate avian targets.

DATA COLLECTION AND ANALYSIS

Observations on birds engaged in long-distance migration were performed using a prototype radar for the NEXRAD system known as the CHILL. The unit was located at Willard Airport near Champaign in east-central Illinois. The CHILL is very similar to NEXRAD and was operated in a volume scan mode, which is the normal mode of operation of NEXRAD. The CHILL system has a 65 dB dynamic range, 150 m range resolution, 1.0 microsecond pulse width, 0.6 MW peak power, and a conical 1 degree beam. In computing dBZ an R^{-2} correction was assumed; this is not strictly correct for small numbers of dispersed targets per pulsed volume (Drake, 1981), but use of this range correction factor is effective in testing a system designed to be a weather radar.

Operating in conjunction with the 10-cm radar was a smaller 3-cm unit located 4.6 km at an azimuth of 225° from the CHILL. This GPG pencil-beam tracking radar is described in previous publications (Larkin and Eisenberg, 1978; Larkin and Thompson, 1980). The 3-cm radar, having a much smaller pulse volume than the large 10-cm unit, served to obtain detailed target identification and other information which could then be related to reflectivity measurements of the larger unit. The massive nocturnal migrations of land birds were studied because they provide a significant bird hazard (Hunt, 1975, 1976), and because they provided a predictable and reliable source of flying birds during the duration of this project (Graber, 1968).

When many kinds of birds move long distances, they do so at night. Birds take to the air at approximately sunset, usually flying for several hours before descending sometime after midnight. These movements, comprising many different species of birds, were studied during four nights of observation. Three of these nights occurred during peak spring passerine movements during spring, 1982 (Table 1). Details are given in Larkin (1983). On 19 May 1982, bird targets and weather intermixed in a complex and changing fashion. Bird targets were distributed in distinct strata in a changing wind system. Low-altitude targets were confirmed to be birds with the coaxially-mounted searchlight and binoculars.

By 14 June 1982 in Illinois, almost no species of passerine birds are still migrating (R. Graber, pers. comm.). No birds were seen in searchlight observations on this date nor on 17 June. Only one target per night with a wing beat signature resembling a bird was observed on the GPG A-scope display on 14 and 17 June. Targets detected on 14 June were insects rather than birds.

TABLE 1. General conditions during four nights of observation.

Date	Wind direction toward (degrees)	Cloud	Bird Migration Density	Migration Altitude Concentration (m)	Remarks
13 May	0°	clear	heavy	700-1300	CHILL azumuth problem
14 May	350-0°	clearing	heavy	500-1300	headings of birds NE
19 May	shear	frontal & cumulus cloud	heavy	2 layers	Figure 2
14 June	350-040°	clear	none	none	insect targets only

<u>Nocturnal bird migration on a NEXRAD radar</u>. Data from nocturnal bird migration and published data were used to assess the feasibility of a NEXRAD system to detect birds and to discriminate birds from other kinds of targets. Results in this section are organized according to the NEXRAD parameters which might be used to separate birds from other targets. The parameters are listed in Table 2, along with expectations derived from theory or published observations. Great potential exists in the NEXRAD system for identifying nocturnal bird migration. Figures 7-10 of Larkin (1983) show CHILL displays of bird migration.

TABLE 2. NEXRAD parameters for identifying nocturnal bird migration.

Parameter	Expectation	Useful ?
Available in NEXRAD as presently envisioned:		
Reflectivity	< most precip.; > clear air	Yes
Altitude	Movements confined to layers	Yes
Spatial distribution	Symmetrical in azimuth	Sometimes
Azimuthal aspect	Dubbell shape PPI display	No
Doppler speed	Discriminates birds from ground targets	Yes
Time of year	Seasonally distributed	Yes
Time of day	Increase at dusk; decrease after midnight	Yes
Wind direction	Relationship depends on season and location	Yes[1]
Doppler spectral width	Apparent stratified "turbulence"	?[1]

[1]No data from this study were gathered to evaluate this parameter. "Yes" entries are deduced from extensive evidence in published biological literature.

Reflectivity data are given in Figures 3 and 4 for a night of heavy bird migration and a night with few or no migrating birds present. As shown in the curve on the right of Figure 3, echoes from migrating birds approached 25 dBZ; one would expect that the maximum reflectivity from migrating birds would depend on their density but also on their altitudinal clumping. Birds may be widely distributed in altitude, as was the case on 14 May, or they may be more strongly confined to one or more altitude strata. Echoes from birds are clearly much stronger than clear air echoes and echoes from insects in this study. At this point, it is not possible to estimate from the published literature what maximum echo intensities from flying insects might be North America, however, many areas of North America will probably have fewer insect echoes than central Illinois.

Altitude is an important parameter governing bird migration. Bird targets, confirmed using binocular observations on the 3-cm radar, were virtually confined to a layer below 750 m (2000 ft). These targets are shown as individual dot echoes on the finer resolution display of the vertically-pointing 3 cm unit in Figure 1 after 2045. Weather echoes will usually have components above 1500 m altitude. Spatial distribution of nocturnal migrants is often uniform over flat or rolling topography. Thus, the azimuthal distribution of nocturnal bird targets should be left-right symmetrical with respect to the radar, around the direction toward which the animals are oriented. Over mountainous areas or near seacoasts this may not always be the case. Data collected in spring, 1982 met this expectation except when mesoscale weather systems affected the birds' distribution in space. On 19 May, 1982 a front was evident before migrating bird targets were present in numbers (Figure 2). After bird targets were present, frontal structures in a different location apparently caused the birds to be highly nonrandomly distributed in space around the radar. Therefore, spatial distribution of migrating birds can only sometimes be used in helping to discriminate birds from weather.

Azimuthal aspect of bird echoes produces a classic dumbbell shape on the PPI display of many radars. This effect was not evident in studies with the

CHILL radar; no dumbbell shape was seen during the three nights of observing migrating birds. Presumably, the horizontal polarization of the radar influenced azimuth aspect effects. Headings of birds measured with the 3-cm tracker were variable on these nights, certainly reducing the net aspect dependence of the bird targets. Unless further data delineate conditions under which aspect effects are large, we must discard aspect as a possible means of identifying migrants under these conditions.

Doppler speeds discriminate bird targets from ground targets and also from anomalous propagation. Figures 3 and 4 showing power as a function of altitude were derived by setting a speed threshold below which targets were not counted. VAD data could be readily used to study Doppler velocities of bird targets (Larkin, 1983). Time of year has a strong effect on the number of birds migrating. Time of day is important; most bird migrants take off around dusk and descend during the latter part of the night. Onset of migration is shown in Figure 1 and increase in reflectance due to migrating birds is shown in Figure 3. Wind direction has a strong influence on migrating birds (Gauthreaux and Able, 1970; Richardson, 1978; Larkin and Thompson, 1980). Wind direction as a function of altitude is one of the primary outputs of the VAD algorithm in NEXRAD. Winds during the periods studied for this report were usually favorable for spring migration.

NEXRAD AND THE BIRD/AIRCRAFT COLLISION PROBLEM

Results of studying nocturnal bird migration with a NEXRAD prototype system, combined with radar ornithology findings in the literature, indicate that it would be feasible to implement a NEXRAD algorithm to recognize and provide real-time warning of hazardous concentrations of nocturnal migrants. The next steps would be severalfold:

(1) Collecting data on NEXRAD parameters for which data are presently absent. Doppler spectral width is the only such variable now known. (2) (2) Setting levels to use in threshold or decision-sum applications. In particular, careful attention should be paid to the degree of hazard indicated by a given level of reflectivity due to birds. (3) Collecting a test data set on migrating birds, with which to develop and validate an algorithm. Releases of individual known birds from aircraft should be a part of this data-gathering program. (4) Designing an algorithm to provide real-time bird hazard warning. The output of the algorithm should be a scalar indication of the degree of hazard as a function of time of day, altitude, and possibly geographical sector. Unlike some weather hazards, previous knowledge of cost/benefit of flying a certain course will be nearly absent; the relative costs of false negatives and false positives will have to be determined as part of designing the algorithm. The algorithm should include a provision for archiving bird hazard warnings, if not actual bird density data. (5) Modifying the algorithm to suit each geographical location. Perhaps the simplest approach might be to mask in software those regions in polar coordinates that might disturb the general picture of migration over the coverage of a NEXRAD radar. Such regions would presumably have features such as mountains, seacoasts, etc. that affect the spatial distribution of migrating birds. A more sophisticated approach would be desirable at some later time to provide more comprehensive bird hazard coverage.

Nocturnal bird migration comprises only a part of bird hazard to aircraft. A discussion of other bird hazards is available in Larkin (1983).

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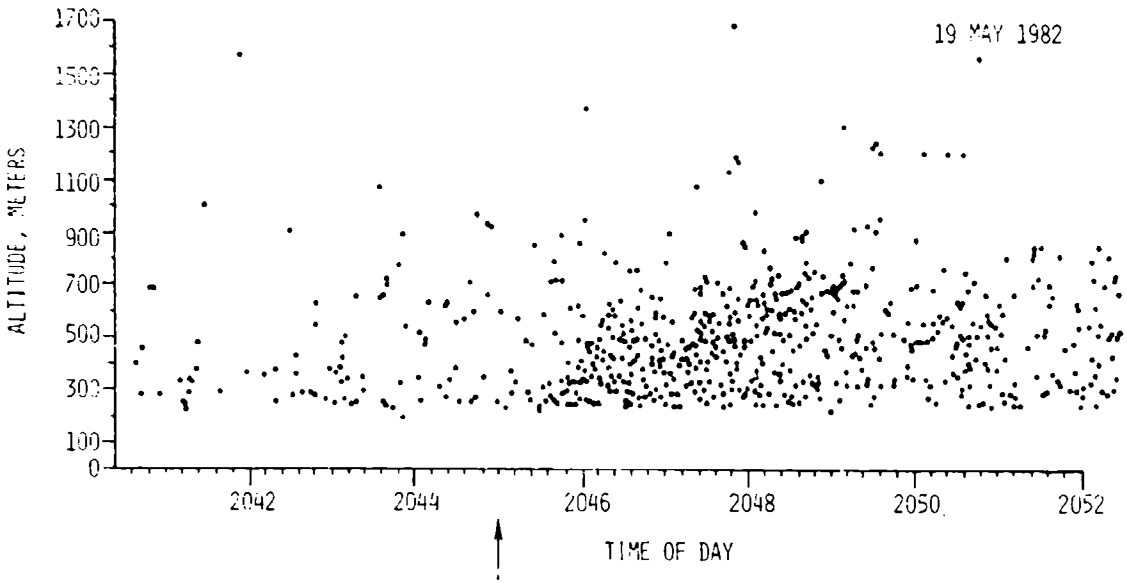

Figure 1. Passage of dot-echo targets through the vertically-pointing 3-cm radar beam before and after passage on the ground of a small front (see Fig. 2) at 2045 on 19 May. The method of recording vertical-beam data is described in Larkin, 1982.

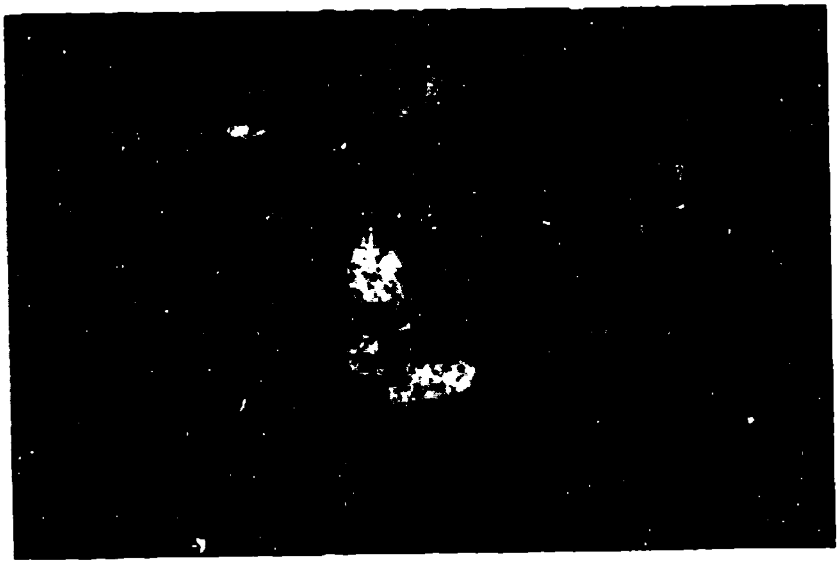

Figure 2. CHILL PPI reflectivity display of mixed meteorological and biological echoes on 19 May, time 2031. Antenna elevation 2.6°; range rings are at 20 km intervals.

Echoes closer than about 5-6 km from the radar are mixed biological targets and ground clutter. Strong patches of echo at 50-100 km range, and similar strong echoes 20-50 km range to S and SE are convective clouds and precipitation. Diffuse echoes 10-20 km from the radar are mostly insects. A front extends to 50 km range SW of the radar; its passage was associated with the sudden influx of bird targets seen on the GPG 3-cm radar at about 2045 (Fig. 3).

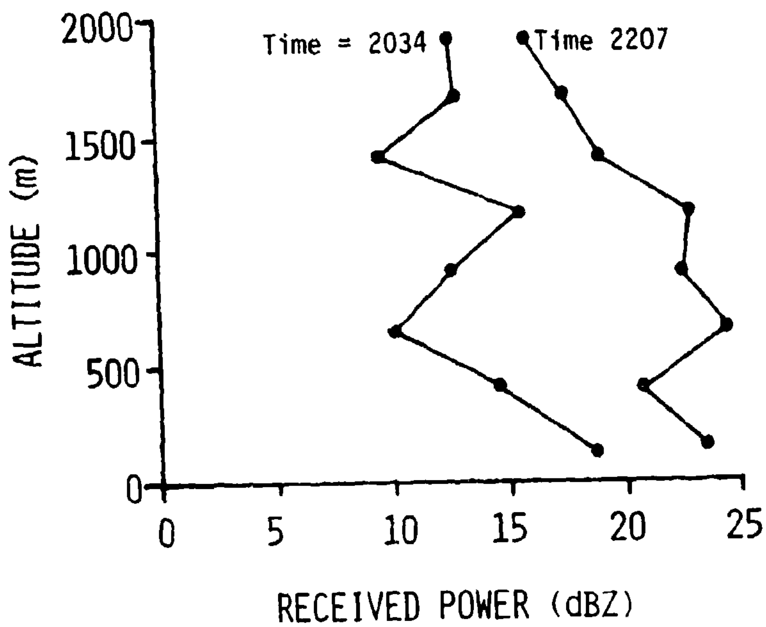

Figure 3. Average receiver power for moving targets as a function of altitude for an epoch about 15 min. before the start of nocturnal bird migration (2034) and an epoch during the peak of bird migratory activity (2207). Receiver power is computed as the average power from range cells having a return at least 0.5 dB above the noise level and a radial speed at least 0.8 ms^{-1} in magnitude.

At 2034, targets (mostly insects) produced relatively weak echoes except at the very lowest altitudes. At 2207, bird targets generated much more intense echoes up to altitudes of 1000-1250 m. Insects probably contributed to the radar return at 2207 to a minor degree at altitudes above 250 m and to an unknown degree below this altitude.

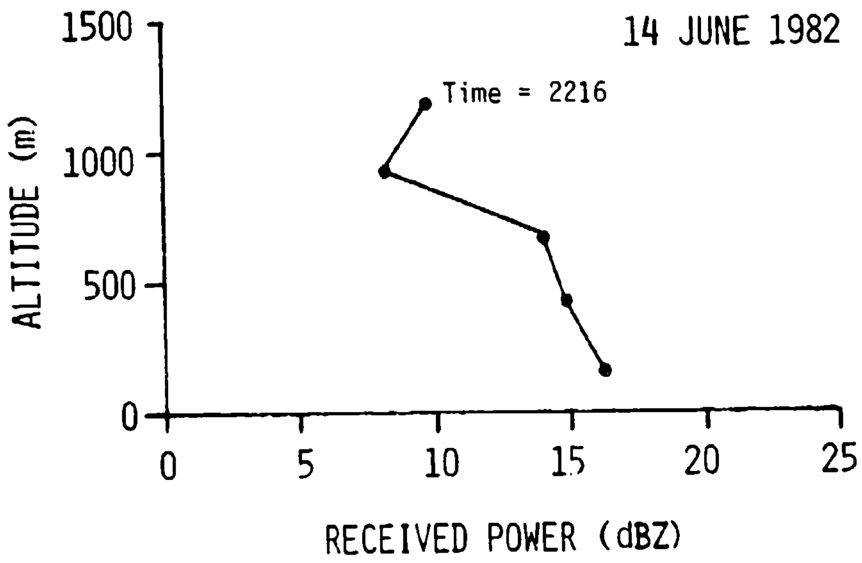

Figure 4. Average receiver power as a function of altitude during peak activity on a night of insect migration.

Conventions as in Figure 3.

Radar return above 1250 m was insufficient to compute average power. Echoes below 1000 m were heavily skewed toward reflectivities (R^2) of about -10 dBZ, with a few cells having reflectivities for moving targets of 0-20 dBZ. Presumably, the latter cells contained concentrations of insects or perhaps the occasional bird or bat.