Boeing 767-322ER, N662UA, 1 September 1998

AAIB Bulletin No: 4/2001 Ref: EW/C98/09/06 Category: 1.1

Aircraft Type and Registration:	Boeing 767-322ER, N662UA
No & Type of Engines:	2 General Electric CF6-80 turbofan engines
Year of Manufacture:	N/K
Date & Time (UTC):	1 September 1998 at 0521 hrs
Location:	London Heathrow Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - N/K - Passengers - 203
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Birdstrike damage to left wing leading edge slats and flaps, nose radome, and left engine. Evidence of birdstrike on left main and nose landing gears and left stabiliser
Commander's Licence:	Airline Transport Pilot's Licence (USA)
Commander's Age:	58 years
Commander's Flying Experience:	14,000 hours (of which 3,000 were on type) Last 90 days - 200 hours Last 28 days - 70 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries by AAIB

The birdstrike encounter

The aircraft was arriving on a scheduled passenger flight from Washington Dulles (USA) and contacted the Heathrow Tower Controller at 0518 hrs while on final approach to Runway 09L. Shortly after this, another aircraft which had just landed on Runway 09L reported sighting a flock of geese to the right side of the runway which were flying towards Runway 09R (ie heading southbound). Another aircraft on final approach to Runway 09R was advised of this report. A Boeing 747 was next in sequence to land on Runway 09L and this aircraft landed without incident and vacated the runway. N662UA was then cleared to land on Runway 09L at 0520 hrs, when the surface wind was reported as being from 090° at 8kt.

The commander reported that when the aircraft was about 50 feet above the runway, a flock of geese flew into the aircraft's path from right to left (ie heading northbound). This particular flock of

geese had not been sighted by anyone until that time, although the pilot had heard the transmissions about the flock of geese heading southbound.

When the birdstrikes occurred the engines were at idle power and the aircraft was only one or two seconds from touchdown. Towards the end of the landing roll the commander reported the bird strike, and the fact that that there was bird debris on the runway, to the Tower controller. As there were no immediate indications of engine damage, the aircraft was taxied normally to Stand K16.

After the birdstrike had been reported, the Tower controller requested the Airport Operations bird control patrol vehicle to go and check the threshold of Runway 09L. When he got there the driver reported that there was bird debris on the runway which would need to be cleared and a subsequent approaching aircraft was instructed to go-around while this was in progress. The driver also reported seeing a flock of about 40 geese heading northbound across the Airport as he was approaching the area in which the birdstrikes had occurred. This information was relayed to another aircraft which was approaching Runway 09R at that time, and it completed its landing without incident.

Runway 09L was closed for about one hour until the debris from what was believed to be some 25 to 30 geese was removed from the area of Blocks 113 and 114.

Airport monitoring of geese activity

On the morning of this accident, the Airport Operations staff had been well aware that Canada Geese activity around the Airport was relatively intense and that they were being a particular nuisance. On the previous day their level of activity had caused the Operations Duty Manager to issue a Notice to Airmen (NOTAM), which was still in force on the morning of this accident, warning of the possible presence of flocks of geese in the local area, occasionally observed flying over the Airport below 500 feet. At 0529 hrs, the Heathrow Automatic Terminal Information Service (ATIS) recording was updated to contain the 0520 hrs weather observation, surface wind 090° at 6 kt, visibility 6 km, no significant weather or cloud, temperature +16°C, dew point +13°C, QNH 1010 mb. It also contained advice that flocks of geese had been sighted overflying the Airport.

At the time that N662UA was landing, the Airport Operations permanent bird control patrol, consisting of two trained operations personnel with a Land Rover, had been near Runway 09L but some distance to the east of the touchdown point. There was also one of the other Airport Operations vehicles, working in support, patrolling the area around the threshold of Runway 09R, checking on the reported flock of Canada Geese which had been seen flying south. Although, at the time of the birdstrikes, the permanent patrol was in the same general area as that in which this accident occurred, they had not seen the flock of geese involved before the accident.

On the day following this accident, the Airport Operations Safety Unit (AOSU) established that Canada Geese were using one of the lagoons in the Perry Oaks complex, a largely disused sewage treatment works between the two main runways and within the Airport boundary, as a roosting site and birds were seen to fly north from Perry Oaks, off the Airport. The Unit also made a number of off-Airport searches over a period of several days following this accident and confirmed the existence of what were believed to be established nearby feeding sites, one of which was observed to have more than 500 birds on it at one time. They were also able to establish the presence of roosting sites for large numbers of geese on nearby ponds and reservoirs, including one site on a

ornamental pond just outside the Airport boundary. Figure 1 shows the location of the Perry Oaks sewage lagoons and other water features adjacent to the western end of Heathrow Airport.

The AOSU instigated a roosting deterrence programme at the Perry Oaks lagoons and other areas within the Airport boundary which are under their control. The AOSU is not, however, empowered to take such action over the wider surrounding area from which the hazard derives without landowners' permission. In addition, the AOSU does not consider that they have the necessary resources to mount an effective roosting deterrence programme in those public areas where the geese which may overfly the Airport roost and breed.

Birdstrike damage to the aircraft

After the aircraft had been taxied to the stand, initial inspection showed that there was extensive damage to the radome and the left wing leading edge and slats. The left engine had evidence of bird ingestion and there was also evidence of bird strikes on the left and nose landing gears, left wing trailing edge flaps and the left stabiliser.

As a result of the birdstrike damage the radome, weather radar and the No 4 outboard slat had to be replaced. The strikes on the leading edge at the No 5 slat position had also resulted in the rupture of an anti-icing duct which required replacement. A borescope inspection of the left engine did not reveal any evidence of damage to the core of the engine, but it was considered necessary to replace all the fan blades before the next flight.

Birdstrike hazard at Heathrow Airport

This accident occurred some nine months after another birdstrike, involving a Grey Heron and a Boeing 747 (G-AWNJ), which was under investigation by the AAIB. That investigation resulted in a number of Safety Recommendations being made in the associated report in AAIB Bulletin 9/99. Although that previous accident had involved the ingestion of a single Heron into the left inboard (No 2) engine, information obtained during the investigation had indicated that there was cause for serious concern about the numbers of large waterfowl, of several species, resident in the Heathrow area.

Canada Geese, in particular, were identified as presenting the most serious birdstrike hazard because, in addition to their large size (typically between 1.5 and 7.5 kg), they were numerous in the area and, unlike Swans and Herons, have a flocking nature. There was also a general view, particularly on the part of the Airport Operations staff, that the Canada Goose population was growing rapidly. However, because no systematic survey of the birds and their habits had been conducted around Heathrow Airport, there was no quantified evidence of size of the local population or its growth rate, nor precise knowledge of the roosting sites and activity patterns of the flocks.

The CAA Powerplant Division has commissioned a one year study of the Canada Geese population in the Heathrow area, the primary purpose of which is to provide data for reviewing the validity of the engine birdstrike certification criteria currently in use. Current engine certification requirements (FAR 33.77, and JAR-E 800 with associated Advisory Circular ACJ E 800) specify tolerance to bird ingestion; a 'large' bird is specified as one with a weight of 1.8 kg for engine ingestion certification purposes. This survey was arranged to include two-weekly revisiting of known roosting and feeding sites around Heathrow Airport over the year and should produce more detailed information of the habits of the resident population, its rate of increase and seasonal variations.

This study was started in June 1999, before the report into the previous, Heron, accident was published and knowledge of the instigation of this survey whilst the report was being compiled resulted in the AAIB making Safety Recommendation No 99-18, which stated: *'The CAA should expand the remit of its sponsored current study by the Central Science Laboratory Birdstrike Avoidance Team of the habitat, population and transit flight behaviour of flocking large bird species around Heathrow Airport to include the formulation of recommendations on the best means of managing and reducing the associated hazard of multiple birdstrike encounters involving departing or arriving public transport aircraft.'*

This latest accident has confirmed that the population of geese resident around Heathrow is already sufficiently large for it to be considered a specific air safety hazard. If the goose population in the vicinity of the Airport increases, then the attendant risk of collision between an aircraft and a skein of geese in the early part of the climb-out will also increase, unless effective procedures are introduced to counter this threat. The investigations of the AOSU highlighted the presence of the Perry Oaks lagoons as being a major attraction for all species of waterfowl. As the Perry Oaks complex is situated between the western ends of the two main runways, it tended to encourage concentrations of birds to a location where they constituted a particularly serious threat (see 'Safety action' later).

The significance of geese as a particular hazard to aviation

In the past, goose populations generally migrated seasonally from breeding grounds in remote and unpopulated areas, which were relatively unimportant to mainstream commercial aviation, to traditional wintering grounds, some of which are in areas important to commercial aviation. The huge flocks of geese in transit during seasonal migrations, mainly in North America, have always been and will continue to be a matter of concern for aviation as an 'en-route' hazard.

In North America however, probably as a result of changes in conditions brought about by agricultural and urban developments, a large number of geese, particularly Canada Geese, appear to have abandoned their migratory instincts and become residential, some around airports. Where this has occurred, it has been observed that the incidence of collisions between geese and aircraft, during the landing or take off phase, has been more frequent. There are no reports of any other large flocking bird species having similar tendencies.

In the UK, the main native goose populations are grey geese which migrate from breeding grounds within the Arctic Circle to over-winter in Scotland and northern England, as far south as Lancashire. These may cause a seasonal hazard, particularly around Edinburgh and Glasgow but, to date, no collisions with geese have occurred at either of these airports, although there have been 3 collisions with Whooper Swans which have a wintering ground adjacent to Glasgow Airport and a collision with 3 Greylag Geese at Flight Level 100 near Edinburgh on the 19 January 2001. There have also been collisions with grey geese at Inverness which is within the migration zone. Brent and Barnacle Geese, the other main native species, are coastal dwellers and have caused no concerns for major airports.

The major UK concern appears to be the development of large non-migratory populations which have developed from introduced ornamental birds. The main species of this type is the Canada Goose which now has a very large UK population and London Heathrow appears to be the most seriously affected Airport in this regard within the UK. There is also an increasing concern about the native Greylag Geese which have been introduced into the southern UK, considerably south of their normal wintering range, and which are developing rapidly increasing and non-migratory

populations. Although not a large proportion of the population in the Heathrow area, Greylag Geese are now present in the area and increasing in numbers. As the population of Canada and Greylag Geese around Heathrow is resident, they present a continual threat to operations.

The increasing hazard presented by the development of resident goose populations around airports has been perceived by both the FAA and the CAA as representing a potential change in the foreseeable birdstrike threat to commercial jet aircraft operations and has led them to review the current birdstrike certification requirements for engines. It is this which has prompted the current CAA sponsored survey of the goose population in the Heathrow area and whilst the results of this, and other similar surveys, may assist in formulating new birdstrike certification requirements for future engines, the aircraft and engines presently in service and built to current requirements will constitute the vast majority of the world civil fleet for many years.

The hazard that birds cause to aircraft, in relation both to airframe components and engines, has long been recognised. It has resulted in the formulation of design requirements for both airframes and turbine engines which, at the time they were made, reflected a reasonable safeguard against the threat from the average mix of birds in the areas where the great majority of commercial aircraft flying took place. Amongst the tenets on which engines have been certificated as adequately robust against birdstrikes has been that birds of the size which may cause a complete loss of thrust from an engine during take off and initial climb, and which are likely to be encountered around airports, are normally solitary. As a result, the pilots of an aircraft encountering a large bird during this phase of flight could expect that the thrust from one engine might be lost, but would be able to continue flight with sufficient thrust and control available to return safely to the airport.

However, if such large birds are in a flock the possibility of thrust loss on more than one engine, of the types certificated to current standards, is increased and the tenet upon which the current birdstrike certification requirements are based must be compromised.

The increased threat to twin engined aircraft

The vulnerability of twin engined aircraft involved in a collision with a sizeable skein of geese is an issue of particular concern.

An encounter at Montreal Dorval International Airport, Canada, on 19 November 1998 between a flock of Snow Geese and a Boeing 747, G-BBPU, which was executing a missed approach, resulted in damage to three of the aircraft's four engines, one of which had to be shut down immediately. Subsequent inspection of the aircraft after landing showed widespread airframe and system damage had been sustained. Comparison of the geometry of the Boeing 747 with that of the Boeing 777 (see Figure 2), currently the largest twin engined transport aircraft in service, shows that the spanwise distance covering three engines on a Boeing 747 is 120 feet, whereas that covering both engines of a Boeing 777 is only 75 feet. The spanwise spread of birdstrike damage observed on the Boeing 747 at Montreal, therefore, indicated that any twin engined aircraft encountering such a flock could, potentially, suffer a complete loss of thrust from both engines, or of sufficient thrust to safely sustain flight.

Another aspect which is of particular relevance to large twins, with the latest generation of large intake diameter engines, is the spacing between geese as they fly in skeins. Geese typically fly in 'Vee' formation and in the diagonal lines the birds are spaced about 10 to 12 feet apart. Since the very large engines currently in service have, typically, intake diameters of between 8 and 11 feet, there is a real possibility that, in the event of a large twin engined aircraft encountering a skein of

geese, each engine could ingest two birds, or more depending upon the orientation of the goose formation in relation to the flight path of the aircraft, and intake entrainment effects particularly during take off.

A paper entitled 'A model to determine the severity of a birdstrike with flocks of Canada Geese' which was produced by the Birdstrike Avoidance Team of the UK Central Science Laboratory, was published in 'Birdstrike 99' following its presentation at a joint meeting of the USA and Canadian Birdstrike Committee. This paper described the use of a pair of stereo digital video cameras to film 14 flocks of Canada Geese in locations in the UK where their behaviour was similar to that found on and around airfields, especially low-level transiting flights between feeding and resting areas. Time coded video frames were converted to computer images so that the position of each bird could be derived from XYZ co-ordinates. A statistical probability model was then developed to indicate the number of geese which might be ingested by single and twin engines when an aircraft passed through such flocks. The model simulated 1,000 passes through a flock of 29 Canada Geese by an aircraft with two engines, 15.63 metres (51 feet) apart, with engine intake diameters of 100 inches.

The model indicated that during such bird encounters, bird ingestion would occur to one engine on 82% of encounters, and both engines would suffer bird ingestion on 18% of encounters. When the model results were compared to data from the historical Canada Goose birdstrike record, which comprised data from 50 incidents where one or more geese had been struck, this showed bird ingestion had occurred to one engine in 82% of such incidents and two engines had suffered bird ingestion in 18% of the incidents, showing remarkable correspondence with the model results. This report stated:

' Results from the model indicate that when even relatively small Canada Goose flocks, of no more that 30 birds, are struck by an aircraft, an ingestion is more likely than not to occur, and multiple ingestions will occur, with an engine of this size - 100 inches in diameter, on nearly a third of encounters.

There would be an ingestion into more than one engine on nearly one fifth of encounters with engines of this size and a separation of 16 metres (52.5 feet). A similar ratio of flock encounters to multiple engine ingestion is found in operation.'

and: 'In 2% of cases, our model indicates that more than one bird (Canada Geese) would be ingested into each of the two engines; in a larger flock this could be more likely.'

It is unrealistic to consider that any likely changes to the bird ingestion certification requirements for large engines might include the ability to suffer a double 5 kg bird strike, or more, and still retain a capability of sustaining 50% thrust. In addition, it is apparent that there is a trend towards increased utilisation of large twin engined public transport aircraft, for reasons of economy, and therefore such aircraft constitute a growing proportion of the global fleet of large transport aircraft, and thus of departing and arriving aircraft at London Heathrow Airport.

The situation in the USA

Recognition of the dangers inherent in birdstrikes has led to the NTSB issuing Safety Recommendations (A-99-86 through -94) to the FAA on 19 November 1999. The following is a précis of the parts of the recommendation document which are relevant to the UK situation together with the NTSB recommendations which could apply equally well in the UK.

Background

The National Transportation Safety Board has been concerned about bird strike hazards to aircraft for many years. Since 1973, it has issued 16 safety recommendations to the Federal Aviation Administration (FAA) to prevent accidents from bird strikes. Most recently, in 1996, the Safety Board issued five safety recommendations based in part on a September 22, 1995, US Air Force (USAF) Boeing E-3B accident in Alaska, which killed all 24 people on board. The USAF investigation determined that a flock of Canada geese had flown in front of the airplane as it became airborne. Birds were ingested into two of the airplane's four engines, which caused them to lose power. Investigators found the remains of nearly three dozen birds on the runway after the accident and thousands of Canada geese living on the airport grounds.

On July 8, 1996, the Safety Board issued 5 Safety Recommendations A-96-38 through -42.

More recently two other incidents gave rise to concern.

On March 4 1999, at 2200 central standard time, a DC-9 encountered a flock of large birds while on final approach for landing at Kansas City International Airport. During the encounter, several birds were ingested into both engines, resulting in severe engine power loss. The pilot regained enough power in one engine to continue the approach and land the airplane without further incident. There were no injuries. Night visual meteorological conditions prevailed at the time of the encounter.

On February 22, 1999, about 1455 eastern standard time, a Boeing 757 penetrated a flock of birds, just as the main landing gear had lifted off of the runway, during take off from Cincinnati. The captain observed no change in engine performance or flight characteristics during or after the event. There were no injuries, but the airplane was substantially damaged.

Recently, Safety Board staff held meetings with bird strike experts to identify additional areas in which improvements were needed to reduce bird strike hazards to aircraft. Representatives from the FAA, the US Department of Agriculture (USDA), the USAF Bird Aircraft Strike Hazard (BASH) Team, the Air Line Pilots Association, the Fish and Wildlife Service and two independent consultants, attended the meetings. The Safety Board has identified several improvements that could significantly reduce bird strike hazards.

Avian-Hazard Advisory System

The Avian Hazard Advisory System (AHAS) operated for the USAF, is designed to track migration patterns, in near real time, using next-generation weather radar (NEXRAD) and determine if that activity is hazardous to aviation. Although AHAS is still in development, USAF BASH personnel believe the system will help minimise bird strike hazards.

The Safety Board concludes that AHAS technology, if applied to civil aviation, could provide bird strike risk warnings to ATC and flight crews, and possibly prevent serious bird strike incidents.

Other Bird Hazard Technologies

Bird hazard reduction technologies, such as cannon or gun fire and vegetation maintenance, have been of limited effectiveness. USDA and FAA representatives indicated that a need exists for increased research and development for new bird hazard reduction technologies, such as chemical

repellents, lasers, thermal imaging, pulsed microwaves, ultraviolet stimuli, vegetation types, and automated (bird-triggered) frightening devices. The Safety Board agrees that such research and development is needed. Therefore, the Safety Board believes that the FAA, in co-ordination with the USDA, should conduct research to determine the effectiveness and limitations of existing and potential bird hazard reduction technologies.

Wildlife Hazard Assessments

According to the USDA, a critical need exists for many US airports to undergo an initial wildlife hazard assessment to determine the level of bird/wildlife control needed. According to the FAA, the amount of control needed at an airport varies depending on the geographical location of the facility, local and regional wildlife, and aircraft movements. For example, an airport located in a coastal area, with wetlands on the airport and heavy traffic (for example, John F Kennedy International Airport, New York) may be at a greater risk of a bird strike than a less heavily trafficked airport located in the desert (for example, Tucson International Airport, Tucson, Arizona).

Title 14 CFR 139.337 currently requires that certificated airport operators must conduct an ecological study only when any of the following events occur on or near an airport: (1) an air carrier aircraft experiences a multiple bird strike or engine ingestion, (2) an air carrier aircraft experiences a damaging collision with wildlife other than birds, or (3) wildlife of a size or number capable of causing one of the events described in paragraph (1) or (2) of this section is observed to have access to any airport flight pattern or movement area. Following its review of the ecological studies, the FAA determines the need for a formal wildlife hazard management programme.

However, because bird/wildlife reporting is voluntary in the USA, many events that would require an airport to conduct a study are not reported to the FAA. To prevent this from recurring, the Safety Board concludes that a wildlife hazard assessment should be conducted at all 14 CFR Part 139 airports. Therefore, the Safety Board believes that the FAA, in consultation with the USDA, should require that wildlife assessments be conducted at all 14 CFR Part 139 airports where such assessments have not already been conducted. The Safety Board also believes that the FAA should require the development of a wildlife hazard management programme for all airports determined to need one as a result of the wildlife hazard assessment proposed in Safety Recommendation A-99-88. In addition, the FAA should ensure that the wildlife hazard management programmes are incorporated into the airport certification manuals and periodically inspect the programmes progress.

Reporting of Bird Strikes and Species Identification

The FAA does not mandate bird strike reporting; however in April 1995 the USDA National Wildlife Research Centre, through an interagency agreement with the FAA, initiated a project to obtain more objective estimates of the magnitude and nature of the bird strike problem for civil aviation in the United States. Collected data include the bird species, aircraft and engine types, phase of flight, type of damage, airports, and time of day and year. Such reports are critical to determine the nature and economic costs of wildlife strikes and the magnitude of the problem so that appropriate corrective actions can be implemented.

Currently, the FAA's Wildlife Strike Database contains about 23,000 strikes, which were reported between 1990 and 1998. However, the FAA estimates that less than 20 percent of strikes are reported to the FAA; thus, its database reflects only a fraction of the actual strikes and grossly

underestimates the magnitude of the problem. Bird strikes are estimated to cause in excess of 501,560 hours per year of aircraft down time, $237.43 million per year in direct monetary losses, and $77.21 million per year in associated costs to the US civil aviation industry. The Safety Board concludes that the voluntary reporting system has not resulted in the provision of adequate data on bird strike hazards and this has hindered the proper evaluation of the problem and implementation of safety improvements. Therefore, the Safety Board believes that the FAA should require all airplane operators to report bird strikes to the FAA.

Combined Agency Effort

Various Federal agencies involved in aviation and wildlife protection have different missions and, sometimes, conflicting responsibilities and mandates. For example, the goals of improving aviation safety and promoting wildlife conservation through habitat protection, restoration, and enhancement sometimes conflict. The Safety Board concludes that the various agencies need to meet to consider a unified approach to the problem of bird strike hazards and to reconcile their different agendas. Therefore, the Safety Board believes that with representatives from the USDA, the Department of the Interior, the Department of Defence, and the US Army Corps of Engineers, the FAA should convene a task force to establish a permanent bird strike working group to facilitate conflict resolution and improve communication between aviation safety agencies and wildlife conservation interests.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Evaluate the potential for using Avian Hazard Advisory System technology for bird strike risk reduction in civil aviation and if found feasible, implement such a system in high-risk areas, such as major hub airports and along migratory bird routes nationwide. (A-99-86).

In co-ordination with the US Department of Agriculture, conduct research to determine the effectiveness and limitations of existing and potential bird hazard reduction technologies. (A-99-87).

In consultation with the US Department of Agriculture, require that wildlife assessments be conducted at all 14 Code of Federal Regulations Part 139 airports where such assessments have not already been conducted. (A-99-88).

Require the development of a wildlife hazard management programme for all airports determined to need one as a result of the wildlife hazard assessment proposed in Safety Recommendation A-99-88. (A-99-89).

Ensure that the wildlife hazard management programmes are incorporated into the airport certification manuals and periodically inspect the programmes progress. (A-99-90).

Require all airplane operators to report bird strikes to the Federal Aviation Administration. (A-99-91).

Contract with an appropriate agency to provide proper identification of bird remains, establish timely procedures for proper bird species identification, and ensure that airport and aircraft maintenance employees are familiar with the procedures. (A-99-92).

With representatives from the US Department of Agriculture, the Department of the Interior, the Department of Defence and the US Army Corps of Engineers, convene a task force to establish a permanent bird strike working group to facilitate conflict resolution and improve communication between aviation safety agencies and wildlife conservation interests. (A-99-94).

Discussion

The discussion section from the previously mentioned report on the earlier Heron strike, which was published in AAIB Bulletin 9/99, is reproduced below in italics:

'Whilst, in this incident involving ingestion of a single bird, only one engine was damaged and the aircraft made a successful recovery to Heathrow, the investigation has highlighted not only the potential secondary damage which could arise from large nacelle parts falling from damaged engines onto busy areas adjacent to Heathrow, but also the increasing hazard of multiple birdstrikes on aircraft taking off or landing at the Airport.

The increase in this hazard, specifically from feral Canada Geese, was quantified in a report entitled 'Feral Canada Geese as a Hazard to Aircraft in Europe: Options for Management and Control' (BSC E22 WP3) which was compiled by the Birdstrike Avoidance Team and presented at a meeting of the Bird Strike Committee Europe in Vienna in August/September 1994. This report, based on periodic summer census figures from 1953 onwards, showed that as a result of deliberate relocation of hundreds of geese to southern UK around that time, the small and previously stable UK population of about 3,000 geese in 1953 began to increase at an average rate of about 8% per year. This resulted in a UK population of over 60,000 geese in 1991 and, if the rate of increase has been sustained, about 110,000 geese currently.

The existing Heathrow Airport bird control patrol is primarily responsible for scaring birds away from within the airport boundary, but cannot provide a reliable means of early detection and warning of transiting large birds or formations.

An automatic system to monitor such transit activity could provide timely warnings of such incursions so that the flight crews of aircraft about to take off could be alerted before related conflicts occurred, possibly by using related warning lights located near the ends of the runways. ATC could advise aircraft on approach of potential bird conflicts. In this context, it appears that radar technology already exists which may be suitable for adaption to detect large birds and associated formations. Other types of automated systems may be feasible and thus a review of such technical options would be required, in addition to assessment of potential effectiveness and of ATC integration problems within a busy operational environment.

Thus whilst such a technical development could potentially improve the protection of departing or arriving aircraft against such multiple bird strikes, such an automated system would be unlikely to be made available in the short term.

Consequently, in order to effect some reduction in this multi birdstrike risk in the near term it will be necessary to more effectively manage the large bird habitat and population adjacent Heathrow Airport, which Heathrow Airport Limited (HAL) currently has little direct influence to control, since such areas lie outwith the Airport boundaries. Effective management of such areas will therefore require enhanced co-operation between HAL, associated local authority bodies and related land owners in order to alleviate this transport/environment problem. Such co-operation between the operators of other major airports and associated local authorities etc should be also

be undertaken to improve the management of any significant bird roosting and feeding sites within those external areas which could affect aircraft operations where they have the potential to cause a major accident to a public transport aircraft during departure or late stages of approach to land.'

After the AAIB Bulletin 9/99 was finalised, the AAIB became aware of a meeting which was to be held by the FAA in Washington in August 1999 to review, in conjunction with US government agencies, radar manufacturers and armed forces representatives, the current state of bird detection systems and proposed developments. This meeting had apparently been convened by the FAA as a result of concern expressed by the American Airline Pilots Association (AALPA) regarding the hazards associated with birdstrikes, particularly those involving twin engined aircraft. In view of the pertinence of this meeting and the evident FAA interest in this hazard, a representative of the AAIB, who had been involved in the earlier Heron birdstrike accident investigation, attended this meeting in Washington. During related presentations and discussions at the meeting, Lockheed described modification and development of a Microburst detection radar system which was considered to have excellent potential to detect birds up to a range of some 8 nm around airports.

With regard to this aspect of possible bird detection systems, subsequent to publication of the earlier AAIB Bulletin report on the Heron birdstrike the question was raised by a concerned reader, who had a technical background, as to whether infra-red thermal imaging detection might be a useful technique to explore for the detection of birds around airfields. He suggested that such thermal imaging cameras, which are currently used on Police helicopters and apparently can identify even single birds quite readily, could be trialled on airport bird control patrol vehicles to assess whether they might be capable of improving their bird detection capabilities, including during night operations.

This current investigation has reinforced the evidence which led to the statement that '*The existing Heathrow Airport bird control patrol is primarily responsible for scaring birds away from within the airport boundary, but cannot provide a reliable means of early detection and warning of transiting large birds or formations.*' reproduced in the discussion section above. The Airport Operations permanent bird control patrol vehicle was in the sector of the Airport in which the birdstrike occurred, and yet this large flock of geese had not been seen. It is considered unrealistic to believe that one or two ground patrols, relying on visual detection only, can constitute a reliable bird presence detection and warning service over such a large area as Heathrow. Additionally, since geese may also fly at night, no visual spotting patrol system is going to be useful during the hours of darkness. Furthermore, early information from the CAA sponsored survey has indicated that many of the birds (including goose formations) crossing the Airport on short journeys fly below 50 feet and are difficult to detect visually, as they are obscured by buildings and trees.

Safety action

Since the findings arising from this investigation confirmed the concerns expressed in the report on the Heron birdstrike to the Boeing 747, G-AWNJ, which was published in AAIB Bulletin 9/99, the three Safety Recommendations made in that report relating to improved birdstrike protection are set forth below, with the published CAA Follow-Up Action On Occurrence Report (FACTOR F22/99) responses to these recommendations and later CAA progress, in addition to the responses from HAL:

Previous recommendation (AAIB Bulletin 9/99):

Recommendation 98-58: In view of the apparent increased incidence of large bird formation (eg Canada Geese) transit flying over London Heathrow Airport, with the attendant increasing risk of multiple birdstrike occurrence involving departing or arriving public transport aircraft, it is recommended that Heathrow Airport Limited and the CAA should set up a working group, in conjunction with Airport Operators, to review available technology to determine if a radar based large bird flock detection system, or an alternative automated system, could more effectively alert pilots and ATC to potential multiple birdstrike encounters.

CAA Response:

'The Authority accepts this Recommendation.

The CAA will invite relevant sections of the industry to work with it in order to review different technologies and determine if an early warning system would be effective and practicable in reducing the probability of bird strikes to aircraft. The current work in this area being undertaken by the FAA will form a major part of this review, which is expected to be completed by December 2000.'

In addition, the CAA response to the Draft version of this Bulletin included the following paragraph on bird strike statistics:

'Heathrow has over the past few years been gathering data on bird counts as part of their bird risk assessment required under the aerodrome licensing process. The CAA, as part of its regulatory oversight, has audited the bird hazard management at Heathrow and believe overall that the level of effort on bird patrols matches the risk. The bird strike statistics at Heathrow show a marked improvement over the past few years. If this is looked at in a global sense British Airways logged 31 bird strikes in between 1 August and 30 September this year (2,000) in almost 49,000 aircraft sectors. Heathrow logged 36 (bird strikes) for the whole of 1998 involving 451,000 movements. In comparing these statistics BA had 31 bird strikes in 98,000 movements, Heathrow had 36 strikes in 450,000 movements, almost four and a half times better than the global average for one carrier.'

The CAA also included the bird strike incident statistics for Heathrow, the tabulated data of which is reproduced at Table 1. It may be seen from this table that the recorded number of incidents involving bird strike(s) at Heathrow in 1990 was 33, which rose to a peak of 85 in 1995, before reducing to 49 in 1999. These annual figures provide an average rate of 52.7 incidents of bird strike(s) per year over this 10 year period, ie approximately one incident involving birdstrike(s) every week. It should be noted that these recorded birdstrike statistics include incidents involving bird species other than geese, such as gulls, pigeons, crows etc.

The CAA has also reported the following progress on this recommendation:

'The CAA Working Group reviewed historic data and literature; commissioned presentation by RACAL Decca of trials of marine radar-based goose warning system for RAF Kinloss; consulted RNLAF radar ornithology specialist; and will review conclusions when results are available of delayed Lockheed Martin trial of a modified microburst radar at Panama City.

Interim conclusions are:-

* It is apparent that radar is currently the only technology with practical potential.

* Existing radar-based bird warning systems are routinely used in North America and Europe by the military to warn of mass migrations over wide areas and long time scales. The data they provide is inadequate for real time warnings of hazardous bird movements in the aerodrome vicinity.

* Modern radars - especially pencil beam stacked array radars - have the potential to detect reliably and resolve bird and flock sizes in 3 dimensions, and international Bird Strike Committee has made the case for development studies, but so far there have been no firm proposals, finance or developments.

* Even if an ideal system were to be developed, it is not possible to see how warnings could (be) translated into actions by ATC or pilots at busy civil airports that would reduce the risk.

* Strategically, a radar system has potential (it) to elucidate bird movements in more detail and more quickly than can be achieved with ground-based observations.'

While radar technology is available to track birds and the USA is clearly taking the lead in exploring the use of such radar at Panama City Airport, it appears that the CAA envisage only the strategic use of such radar detection because of perceived difficulties in providing related 'real time' information to ATC and pilots.

It should be recalled in this context that in this birdstrike accident at Heathrow on 1 September 1998 involving N662UA, the 'strategic' information concerning the geese problem around Heathrow had already been promulgated to flight crews by a NOTAM which had been issued on the previous day and was still in force at the time of this accident. In addition, although the permanent bird control patrol and another supporting vehicle were actively checking for reports of Canada Geese flying within the airport, the permanent patrol had not seen the flock of geese involved before the accident occurred.

Such circumstances illustrate that even if Heathrow Airport is duly equipped with effective bird detection radar, if it is used solely in a strategic role to assist in the promulgation of related warnings such as NOTAMS and ATIS information to flight crew, serious birdstrike accidents will continue to occur.

It may be argued, reasonably, that an aircraft approaching to land may be better to continue its late approach in the presence of potential birdstrikes, because of the greater risks associated with bird collisions during a go-around initiation with the engines at high power. However, there appears little justification for allowing an aircraft to initiate its take off run if there is a radar detected birds threat which could result in related birdstrikes during its take off and initial climb phase. The decision to deny flight crews such information before they initiate their take off run, on the basis that bird radar detection should only be used for strategic information and data, would be very difficult to justify in the aftermath of such an apparently preventable accident.

The 'real time' use of bird detection radar to inform ATC and flight crews, particularly on aircraft about to take off, should therefore continue to be actively examined, by operational personnel, to find practical ways of implementing this safeguard. In this context, the bird radar procedures being developed at Panama City Airport should be closely monitored so that related successful strategies may be adopted in the UK where applicable, and as soon as possible at major airports such as London Heathrow.

Previous recommendation (AAIB Bulletin 9/99):

Recommendation 98-59:

In order to reduce the risk of multiple large birdstrike encounters, involving bird formations over-flying London Heathrow Airport conflicting with departing or arriving public transport aircraft, Heathrow Airport Limited should seek maximum co-operation with the relevant local authority bodies and associated land owners to expedite effective management of the associated large bird habitat and population around Heathrow Airport. Similar co-operative initiatives should be actively promoted by the CAA around other affected major airports in the UK.

CAA Response:

'The Authority accepts this Recommendation.

The CAA will continue to promote co-operative initiatives where it can, and within its legal remit. A facilitation role by the Department of the Environment, Transport and the Regions in this area would greatly assist aerodrome licensees and the Authority is actively pursuing the Department's assistance in this matter.'

The CAA in its response to the Draft version of this later Bulletin stated:

'The CAA still believe that the DETR should be the focal point for action under this recommendation.'

The CAA also reported the following progress on this recommendation:

' The CAA carried out its part of the Recommendation as follows:-

* Formed a working group and held discussions with DETR (both Transport and Environment interests), English Nature and Scottish Natural Heritage (the latter via SSSI and SPA designation for a site adjacent to GLA (Glasgow Airport) frequented by Whooper swans).

* In the course of the above discussions, CAA has become aware that the EC Bird Directive under the RAMSAR Convention has resulted in the mandatory designation of SSSIs (Sites of Special Scientific Interest) and SPAs (Special Protection Areas) without consultation with aviation interests (by oversight), which could at least have introduced conditions permitting control of hazardous species. However, except for the GLA site, there are currently no critical examples. English Nature and SNH are now consulting CAA and the affected aerodrome over some late designated SPAs.

* The aerodrome safeguarding process protects against the most important bird-attracting developments. With the imminent transfer of responsibility for safeguarding to the airports, CAA is encouraging operators to develop robust safeguarding systems for developments with the potential to attract hazardous birds, and providing on-going technical back-up.'

In addition, the Safety and Security Director of Heathrow Airport Limited (HAL) responded to the Draft version of this Bulletin as follows:

" **DETR Co-ordination:** Your report notes the situation in the USA whereby a 'combined agency effort' be undertaken to pull together the many different bodies involved in the USA. Given the concerns that we voiced about our limited powers to influence the actions of landowners, local authorities and other agencies, we believe it is essential that the DETR take more of a lead in

establishing a similar cross-departmental focus involving all relevant parties in the UK. The 8 mile safeguarding radius would seem a minimal starting point and we believe the DETR have a key role to play in raising the awareness of these issues."

In view of these responses by HAL and the CAA, Safety Recommendation No 98-59 was amended (see later).

HAL also listed the actions which it had taken in response to the previous Safety Recommendation (No 98-59), in addition to a later Draft Safety Recommendation (No 99-63 relating to dewatering of the Perry Oaks sewage site; see later) made as a result of this investigation:

1. Liaising with local farmers to reduce the attractiveness of their nearby land.

2. Ensuring actions are taken to reduce the attractiveness of nearby water bodies by working with landowners.

3. Increasing recordings of bird sightings by liaison with rangers and conservation wardens and others in the local areas to collate data.

4. Employing the specialist advice of CSL to advise on all aspects of HALs bird deterrent programme.

5. Formulating a specific bird hazard reduction plan for the Perry Oaks site and putting in place the infrastructure to de-water the site and

HAL alsoremove habitat attractive to birds.

stated:

'With regard to Perry Oaks and specifically draft safety recommendation 99-63 we are working closely with Thames Water and have put in place a site management plan having installed de-watering equipment. These actions have been carried out with specialist advice from.. ..CSL and I would also note that CSL have been responsible for annual auditing of HAL's bird deterrent programme for the past three years.' (Figures 3, 4 and 5 show de-watering of sedimentation lagoons in progress).

Previous recommendation (AAIB Bulletin 9/99):

Recommendation 99-18:

The CAA should expand the remit of its sponsored current study by the Central Science Laboratory Birdstrike Avoidance Team of the habitat, population and transit flight behaviour of flocking large bird species around Heathrow Airport to include the formulation of recommendations on the best means of managing and reducing the associated hazard of multiple birdstrike encounters involving departing or arriving public transport aircraft.

CAA Response:

'The Authority accepts this Recommendation.

The CAA will use its bird hazard consultant to work with the Central Science Laboratory (CSL) during its current study to revisit the bird hazard control methods, in particular for the area outside aerodrome boundaries.'

The CAA also reported the following progress on this recommendation:

'At LHR (London Heathrow Airport), reducing the hazard of Canada geese is being approached in several ways with the support of the CAA':-

* CSL studies to identify the most hazardous local sites and movements with a view to reducing numbers and site management.

* HAL working to reduce geese population at nearby sites and in Perry Oaks.

* HAL obtaining agreements from farmers to modify cropping regimes to reduce food.

* BA controlling nesting at their Waterside site.

At a meeting on 13 November at the AAIB, which was attended by representatives of the CAA, HAL, the DETR and the CSL, the CAA and HAL emphasised their lack of powers outside the boundaries of airports to influence local authorities and landowners. There appeared a clear need to educate those bodies and parties around major airports, such as Heathrow, with regard to the birdstrike threat posed by flocks of birds, and the potential consequences of such strikes and ingestion on the ability of affected aircraft to continue safe flight. It was felt that such matters had to be discussed with local authorities and landowners so that conflicts of interests could be resolved and a clear policy established to reduce such threats.

CSL reported that there were some 2,000 to 3,000 geese in the area of Heathrow which tended to fly from the reservoirs and other areas of water south-west of Heathrow to feed in the fields of Harmondsworth, just north of the airport (see map at Figure 1). During the CSL Survey, flocks of Canada Geese varying in size from some 100 to 400 birds have been observed transiting on any one day. However, apparently many other geese from elsewhere also use this feeding area, and only about 10% of the geese which frequent Harmondsworth are from the local area. CSL intend to 'ring' geese which use Harmondsworth during this summer and to fit radio tracking equipment so that their flight paths and areas of origin can be assessed. Almost all of the geese which live around Heathrow roost on private land.

In the context of policy, the CAA are only licensed to control birds on aerodromes, but have no power to control birds off aerodromes within those local areas which pose a threat to arriving and departing aircraft.

Furthermore, the CAA and HAL raised concern over the recent introduction under European Community legislation of Special Protection Areas (SPAs) for wildlife, since such sites (and Sites of Special Scientific Interest, SSSIs) can be set up within the areas surrounding major airports in the UK with no planning requirement to consult airport authorities and the CAA regarding the potential effects of such protected areas upon the frequency and seriousness of associated birdstrikes on aircraft. A recent example of this was the setting up of an SPA in the vicinity of Glasgow Airport, despite CAA concerns made regarding the potential birdstrike threat to aircraft posed by Whooper swans, a resident species within this area. Whilst the increased protection of wildlife habitat generally is clearly to be welcomed, the potential effects on the incidence of

birdstrikes around major airports should be seriously considered before such protection areas are established in their region.

Safety recommendations

In view of the above concerns relating to this question of achieving effective bird control at London Heathrow and other affected major airports in the UK, the following additional Safety Recommendations are made:

Recommendation 99-63

Heathrow Airport Limited should take measures to reduce the attractiveness of the Perry Oaks sewage treatment complex to waterfowl as far as is possible by the elimination of all lagoons which are no longer required for its current usage.

Recommendation 2001-32

In order to reduce the risk of multiple large birdstrike encounters, involving bird formations over-flying London Heathrow Airport conflicting with departing or arriving public transport aircraft, the Department of the Environment, Transport and the Regions (DETR) should organise and lead a working group of representatives of relevant local authority bodies, private land owners and Heathrow Airport Limited (HAL) to expedite effective management of the associated large bird habitat and population around Heathrow Airport. Similar co-operative initiatives should be actively promoted by the DETR and the CAA around other affected major airports in the UK.

Recommendation 2001-33

In view of the incidence of large bird formation (eg Canada Geese) transit flying over London Heathrow Airport with the attendant risk, particularly to twin operations during the take off and early climb phase, of multiple birdstrike occurrence and resultant power loss, it is recommended that suitable bird detection radar be developed and installed at Heathrow Airport for trials as soon as possible and related procedures developed to more effectively alert ATC and pilots to potential birdstrike encounters, before aircraft are cleared for take off.

Recommendation 2001-34

In order that the aviation safety of public transport flights is not adversely affected by an increased potential for bird strikes, the Department of the Environment, Transport and the Regions (DETR) should review the implementation of the EC Bird Directive in the UK to ensure that, where the designation of any SSSIs and/or SPAs are being considered in the general region of major airports, the affected airport authorities and the CAA must be consulted for their assessment of the potential effects of increased habitat protection upon the incidence and frequency of bird strikes on such aircraft.