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Abstract
Serious multi-engine strikes on civil aviation aircraft continue to occur despite bird control efforts at and around airports. Radar-based bird warning systems currently used in military aviation are largely unsuitable for operational use in civil aviation because of the considerable constraints and inflexibility inherent in civil aviation operations. Pilots of civil aviation aircraft need to get timely, pertinent information on bird hazards, complete with options on how to minimize the associated risk. Recent advances in the design of radars and computers allow for the development of a real-time radar-based system to detect and warn of high-risk situations involving birds. High-risk situations are those that may result in serious damage such as multi-engine power loss and/or fatalities. The bird information, as collected by a radar and analyzed for risk by a computer, could be passed on to the pilots either directly via an up-link or through the Air Traffic Services (ATS) providers. The airport bird controllers could obtain the bird warnings directly at the radar site and/or through the ATS providers. A radar-based bird warning system will need to be developed in close consultation with all the stakeholders involved, i.e., pilots, ATS providers, airlines, airport operators and their bird control staff, and regulatory agencies.

Key words: **bird warning system, local movements, migration, operational procedures, radar, risk assessment.**

Introduction
Serious multi-engine strikes on civil aviation aircraft continue to occur despite airport bird control efforts (Transport Canada, 2001). For the purpose of this paper, serious strikes are defined as collisions that cause multi-engine power loss and/or sufficient structural damage so as to jeopardize continued safe flight. These strikes could result in a serious incident or accident. Although some new aircraft in the fleet have increased levels of bird worthiness, no aircraft engine and few structures are designed to withstand the impact of heavy (more than 8 lbs) birds at normal flight speeds. The greatest threat is posed by flocks of large birds such as pelicans, swans, geese, cranes and herons. However, large flocks of medium-sized birds (such as waders) or small birds (starlings, snow buntings, etc.) can also cause serious damage, especially when ingested into the engines. Most strikes, including most serious strikes, occur at or near the airport, almost always (97%) at altitudes of less than 5000 feet agl, and with an overwhelming majority (94%) below 3000 feet agl (Cleary et al., 1999).

From a strike prevention point of view, we have two categories of strikes: 1-those occurring at or over the airport, and 2- those occurring outside the airport's perimeter. The first category can often be dealt with by the airport bird control staff on airport property, but the second category is harder to deal with because they occur at higher altitudes and they are beyond the reach of airport personnel. Serious strikes outside the airport boundary can be caused by flocks of birds making migratory or local flights, while serious strikes at an airport are often caused by flocks of foraging or resting birds.

What is needed, in our opinion, is a radar-based system that provides information both on birds at/over the airport *and* on birds in/near the airport's approach/departure routes. At large, modern airports it is often difficult to locate birds within the airport fence, and birds flying towards the airport will often only be noticed once they are at/over the airport. It is even more difficult to obtain useful information on the presence of birds in approach/departure airspace beyond the airport perimeter.

In this paper, we briefly mention a few radar studies of bird movements related to the bird strike problem. We also mention briefly radar based bird warning systems in military aviation in North America and we describe, in general terms, the requirements for a bird warning system in civil aviation.

Radar Studies of Bird Movements

Radar was developed during WWII and the echoes of unknown targets were referred to as “angels”. When later studies showed that many angels were in fact caused by birds, radar was used for a large number of studies of bird migration and local bird movements. Early studies were summarized in the 1967 book “Radar Ornithology” by E. Eastwood and many later studies were mentioned in the 1990 book “Bird Migration” by T. Alerstam.

Although most radar studies were carried out for academic reasons, some studies were done primarily to gather more knowledge about bird movements that could be used to help in preventing or reducing bird strikes. Just one example of such radar studies in Canada is the study of the spring migration of snow geese across the area around Winnipeg International Airport in southern Manitoba during 1970-1974. The impetus for this study was a very serious collision between a flock of snow geese and a B737 on approach to Winnipeg Airport in spring 1969. That study showed that the goose flocks show up very well on the AASR1 radar at Winnipeg, that the snow geese usually migrate in “waves” both during the day and the night (with the birds normally using favourable weather conditions), and that the actual timing of these waves could be predicted to a considerable extent based on weather predictions. However, those predictions were not nearly accurate enough for use in real-time aircraft operations (Blokpoel and Richardson, 1978).

Since those studies were conducted in the early 1970s, new radars (such as the phased-array radar) have been developed and the capabilities of computers have increased enormously. It is these technological developments that should now make it feasible to develop a radar based bird warning system for civil aviation. Before describing the requirements of such a system, we briefly mention bird warning systems in military aviation in North America.

Radar-Based Bird Warning Systems in Military Aviation in North America

In Canada, a simple bird migration forecast system was developed in the late 1960s at CFB Cold Lake, Alberta, using an 8-step scale to express bird density as seen on the PPI screen. Forecasts of night-time migration in spring and fall have been made for many years and low-level flying was restricted or stopped at different bird density levels. The forecasts were often checked against real-time radar observations (Blokpoel, 1973).

In the US, the Bird Aircraft Strike Hazard (BASH) team of the USAF has developed a computer-based Bird Avoidance Model (BAM) to help pilots plan their high-speed low-level flying exercises. This system uses GIS technology and historic data on bird density and distribution from a variety of sources including the Breeding Birds Survey and the Christmas Bird Counts. Further refinements are being developed and much information is already available on the Internet (Short, 1998).

A network of WSR-88D weather radars has recently been installed to cover nearly all of the contiguous USA and parts of southern Canada. This new radar (also referred to as NEXRAD, for next generation radar) has good capabilities for detecting weak targets, such as insects and small birds (Larkin, 1984). Algorithms (or computer programs) were developed which would permit the WSR-88D radar “to process, quantify, and issue real-time information on bird echoes received by the radar, without human intervention.” (Larkin, 1994). More recently, it was pointed out again that, because these new radars readily detect birds in the atmosphere, they “can play an important role in warning pilots of hazardous concentrations of birds thus reducing the likelihood of serious bird-aircraft collisions.” (Gauthreaux and

Belser, 1998). The National Transportation Safety Board recently issued flight safety recommendations pertaining to bird strike problems, including the need to develop an AHAS (Avian Hazard Advisory System), based on the system used by the USAF (NTSB, 1999). At present, further work is done to improve the use of the NEXRAD radar for real-time, operational bird warnings in civil aviation. This would require cooperation of the primary users would involve additional computer programming, as discussed in the next sections (Kelly et al., 2000 and pers.comm.).

There are a number of differences between scheduled and non-scheduled commercial flights and military low-level training flights and these differences make it virtually impossible to use the military system in civil aviation. Civil aviation is constrained by tight schedules, assigned flight corridors and altitudes. In contrast, military pilots in peace-time have the option of using alternate routes, flight profiles, and times of the day for their training flights. Civil aircraft have very limited maneuverability due to their size and speed, and are thus severely limited in their potential to make bird-avoidance maneuvers. Whereas civil aircraft often carry hundreds of passengers (resulting in enormous potential liability in the event that passengers die or become disabled in a crash caused by birds), military aircraft, especially fighters, normally have just one or two crew members, who are frequently equipped with ejection seats (often used with good success after the plane became disabled by a bird strike).

Civil aircraft have 2 to 4 engines and these engines meet stringent bird strike certification standards. Their airframes also meet specific bird strike standards. Thus, bird induced crashes of modern civil aircraft are likely to be extremely rare, although extremely serious, events. In contrast, bird induced crashes of military aircraft such as fighters are more likely to occur, albeit with less serious results, and without the public profile that is the norm with accidents in the civil environment.

Requirements for a Bird Warning System for Civil Aviation

A---Operational requirements

Any operational system will need the active cooperation of all stakeholders: pilots, airlines, ATS providers, airport operators and their bird control staff, and the national regulatory body. There are, therefore, a number of **operational issues that may well be more challenging to resolve than the technical issues.** If a system is developed by radar engineers or biologists without input and buy-in from the user groups there will be resistance to the introduction of the new system. Transport Canada strongly favours a System Safety Approach (SSA) to deal with the bird strike problem. The SSA aims to reduce the exposure, probability and severity of bird strikes and cooperation and timely communication are key aspects of this approach (Transport Canada, 2001).

Pilots will have no interest in general warnings of “bird activity in the area”. Instead they will want hard specific data pertaining to their specific flight profile. The bird information has to be analyzed and “digested” before it can be passed on to the pilot as a specific warning. The warning has to be timely so that the pilot can make the necessary decisions. The most useful warnings could include a number of options, including a recommended one, for consideration by the pilot.

As **airline companies** operate in a highly competitive environment, they will be interested in a bird warning system only if it will clearly improve flight safety and/or reduce costs. If flights are periodically delayed or rerouted because of high levels of bird risk there will, of course, be costs to the airline and the entire system. These systemic costs would have to be assessed against the “occasional” costs that result from serious bird strikes in the absence of a warning system. A fatal-hull-loss-jet transport accident resulting from a bird strike will result in monumental liability exposure (Robinson, 1996), and the public’s unwillingness to accept the fatality density associated with such an accident will precipitate the commitment required to develop and implement a bird warning system. A warning system that demonstrably prevents serious bird strikes and that is, at the same time, designed to minimally interfere with operations should be welcomed by the industry.

ATS providers may have the crucial role of passing on the bird risk information to pilots in a manner that allows for reasonable alterations in flight profiles. Controllers operate in often stressful working conditions, and any increase in their work load and responsibilities can only be accommodated after proper preparations. There will be a need to develop specific procedures for different levels of bird risk and for different types of aircraft. If the efficacy of the system can be demonstrated with respect to flight safety, ATS providers will probably accept additional duties if they are given proper training and additional resources.

Like the airlines, **airport operators** work in a fiercely competitive environment. On the one hand they do not want their airport to become associated with serious bird strikes, but on the other hand they do not want to acquire a reputation for frequent flight delays caused by birds. A system that causes minimal operational disruption and prevents serious bird strikes will likely be welcomed by airport operators as long as they have a say in its development and implementation. **Bird control staff** will use information on the whereabouts of high-risk birds to improve their bird control operations.

One of the main roles of **regulatory bodies** is to enforce and enhance flight safety by promulgating (and when warranted revising) regulations pertaining to virtually all aspects of civil aviation. The development of an effective operational bird warning system should be encouraged by regulatory bodies. Ideally, the regulators operate in concert with the other stake holders, but in situations where that is not feasible they have the authority to take the lead in developing and promoting new regulations.

B---Technical requirements

It is not our intention in this paper to present detailed technical specifications for a radar-based bird warning system, but rather to give a rough outline of what sort of system we think is both desirable and feasible. The system would consist of a radar to detect and track birds and a computer with software to analyze the radar data for threat level and to provide bird warnings.

The radar would detect birds on the ground (the runways and their vicinity) as well as birds in the air (flying towards or above the runways, and flying towards or in the approach/departure airspace). The computer system would assess and track bird echoes. It would provide warnings of high-risk bird activity for use by pilots *and* by bird control staff. The bird warning could be passed to pilots directly through an up-link or via the ATS providers. There could also be two ways to bring the bird warnings to the attention of the bird controllers: they could have direct access to the bird radar (or a remote screen of it), or they could be informed by ATS providers.

In order to be useful to a pilot, the bird warnings would have to be specific to his individual real-time flight profile *and* to the performance characteristics of the aircraft he is operating. The computer would determine whether or not the bird echoes represent high-risk birds or bird flocks and, if so, would track their three-dimensional courses and provide a possible conflict resolution for the individual pilots who would be affected. In other words, the computer would keep track of all high-risk birds and bird flocks in the vicinity the runway and its approach/departure airspaces, and then determine the probability of a collision for each aircraft operation, taking into account the characteristics of the aircraft. Examples of possible conflict resolutions could include: delay of arrival or departure, a detour around or above a flock, slower speed, or steeper approach/climb-out.

The system would also provide information to the bird controllers at the airport. The controllers would be provided with information on birds foraging or loafing on the airport, as well as birds heading towards the airport. Most useful might be information on bird activity during low light conditions. This information could allow for more effective resource use by bird control teams.

A ground-based, three-dimensional radar could benefit airport operators in Canada in their efforts to comply with Transport Canada's proposed amendment to the Canadian Aviation Regulations, Wildlife Management and Planning.

References

Alerstam, T. 1990. Bird Migration. Cambridge University Press. 420 pages.

Blokpoel, H. 1973. Bird migration forecasts for military air operations. Canadian Wildlife Service Occasional Paper 16. 18pages.

Blokpoel, H. and W.J. Richardson. 1978. Weather and spring migration of Snow Geese across southern Manitoba. Oikos 30: 350-363.

Cleary, E.C., S.E. Wright and R.A. Dolbeer.1998. Wildlife Strikes to Civil Aircraft in the United States 1991-1997. Federal Aviation Administration, Wildlife Aircraft Strike Database, Serial Report Number 4. 34 pages.

Eastwood, E. 1967. Radar Ornithology. Methuen and Co Ltd., London. 278 pages.

Gauthreaux, S.A. and C.G. Belser. 1998. Displays of bird movements on the WSR-88D: patterns and quantification. Weather and Forecasting 13 (2): 453-464.

Kelly, T. A., R. Merritt, R. White, A. Smith, and M. Howera. 2000. The Avian Hazard Advisory System (AHAS): Operational Use of Weather Radar for Reducing Bird Strike Risk in North America. Paper Presented at the Symposium ”Weather Radar and its Application to Ornithology”, held during the Combined Meeting of the Wilson Ornithological Society and the Association of Field Ornithologists, and hosted by the Houston Audubon Society and the Gulf Coast Bird Observatory at Galveston, Texas.

Larkin, R. 1984. The Potential of the NEXRAD Radar System for Warning of Bird Hazards. Pages 369-379 in Proceedings of the Wildlife Hazards to Aircraft Conference and Workshop, Charleston, South Carolina, USA.

Larkin, R. 1994. NEXRAD Algorithm for Bird Hazard Warning. Final Report to US Fish And Wildlife Service, Contract 14-16-009-87-1221.

NTSB. 1999. Safety Recommendation, A-99-86 through -94. National Transportation Safety Board, Washington, DC. 7 pages.

Robinson, M. 1996. The potential for significant financial loss resulting from bird strikes in or around an airport. Pages 353-367 *in* Proceedings and Papers, 23rd Meeting, International Bird Strike Committee, 13-17 May 1996, London.

Short, J.J. 1998. A description of the USAF BASH Bird Avoidance Model. Pages 79-85 in Proceedings and Papers, Part Two, IBSC 24, Stara Lesna, Slovakia, 14-18 September 1998.

Transport Canada. 2001. Sharing the Skies -An Aviation Industry Guide to the Management of Wildlife Hazards. Aviation Publishing Division, Transport Canada, Ottawa, Canada. 316 pages.