CURRENT STAGE OF BIRD RADAR SYSTEMS

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ABSTRACT

Apart from pure science there is an increasing demand to quantify bird movements for environmental impact assessments (EIA's). Several radar systems have been developed to record bird movements on a local scale. Their main aim is to quantify bird movements in order to estimate potential collision risks with tall constructions (wind turbines, bridges, etc.). Within this development bird radar system are now also used as additional instruments on airports to prevent bird strikes. This is a very brief overview on bird detection by radar systems in general, which emphasizes the prospects and limits of current bird radar systems in connection with bird strike prevention on airports.

INTRODUCTION

Radar measurements of bird movements have long been used to verify seasonal patterns of flight activities, including directions, speeds and flight altitudes. This kind of information is used in parts of Europe and North America to apply nowcast and/or forecast warnings, mainly for military aviation (e.g. *http://public.flysafe.sara.*nl/bambas/*index.php*, *http://www.usahas.com/*).
These bird alert systems are based on medium to large surveillance radars or weather radars, describing the general pattern of the ongoing migration on a regional scale. They do not focus on providing tracks of single targets, but a relative number for a large specific area, representing categories of bird intensities (Bird Notice to Airman, BIRDTAM). They are most relevant for low flying aircrafts en route (below 1-2 km agl), which spend a long time in this crucial flight level. Military pilots have to take this information into account for planning their training flights. For most of civil aviation these data are not considered, as they cross these flight levels within relatively short time during landing and take-off. In addition, flight schedules of commercial aviation are so tight that they do not consider these large scale measures yet. In principle, these radar measurements inform about a general increase in the risk of a birdstrike, but they barely represent the specific local bird strike risk at a specific airport.

Recently, it has been claimed that new bird radar systems are able to fill in this gap. The aim of this paper is to describe briefly what can be done with existing systems and what could be done with radar within this context (at least theoretically). Performances of existing systems will neither be presented nor discussed, but we provide here what kind of measures can and could be achieved by specific bird radar systems. We tried to focus on aspects relevant for the airport management to assess the potential of the existing systems. Some background of radar ornithology has to be considered to understand what kind of information different radar systems can provide.

THE AIM

Our aim is to be informed in advance when birds (and bats) are most likely to fly into the range of a moving aircraft, i.e. we would like to have a real time surveillance and warning system for the relevant collision risks. The information can be used in two different ways; each with its own user group, consequences and technical solutions. Avian radars can be used in a strategic way or in a tactical way. When avian radars are used in a strategic way local/regional movements in the airport vicinity are used as a critical element of the bird hazard prevention program by bird control units. For tactical use, individual bird tracks in (near) real-time can be use for (1) automated local bird status, (2) Bird control, by efficiently increasing their job with timely and accurate information on bird movements (being at the right time at the right spot), (3) ATC, to adapt small changes in departure time due to runway crossings by predicted 3D bird tracks and finally in the far future (4) even by pilots, where predicted 3D+time bird track coincide with the predicted 3D+time aircraft path. Depending on the application, reaction time should be within a few minutes down to a few seconds.

THE TECHNIQUE

In theory, we can detect and track all birds (and bats) in the air with the existing radar technique (and sometimes even on the ground). In practise, there are two main problems, first, the surveillance of the whole airspace and second, the identification of the echo signal. We discuss them here in the following very briefly.

The first problem deals mainly with accuracy in time and space. If we use an antenna with a large surveillance angle we can survey a large volume within seconds but the accuracy is quite low, because the volume which is covered within one single pulse is large, e.g. a standard ATC-surveillance radar has a small opening angle in the horizontal plain, but a large opening angle in the vertical plain to cover all heights at the same time. With this kind of antenna you get a good position in the horizontal plain for all the echoes, but almost no height information. With a narrow pencil beam produced by dish antennas a 3D-postioning is possible (the narrower the better), but the surveyed air volume is getting smaller and smaller the more accuracy you want to have. To circumvent these restrictions stacked beam antennas, comprising multiple beams above each other, are in use for military surveillance. This technic is very expensive and not available, or at least not applied for ornithological use, for short range surveillance. Furthermore, there are tracking radar systems with dish antennas (also mainly military), which are designed for tracking a single target continuously. For all kind of beams the accuracy decreases with distance, because the surveyed volume of a single pulse increases with distance

The second problem deals with signal filtering. There is a good reason why the ATC is mainly based on secondary radar, because in primary radar you will not see only additional flying targets, but also ground clutter, precipitation and various kinds of anomalous signal propagations. Consequently, at close distance to the ground the problem with signal filtering increases dramatically, which has a strong negative effect on the detection of birds. There are only few parameters available from the radar to discriminate bird echoes from all other targets. Birds fly within a restricted range of airspeeds (7 to 20m/s), which is highly influenced by wind. Thus, only airspeed can provide a helpful criterion. The echo intensity and its variation in time is a product of the bird's size (and the number of birds in a flock), its position with respect to the radar (aspect) and its wing beat pattern. Birds vary in size by almost four orders of magnitude (0.02kg – 10kg). In addition, they can fly in large flocks exceeding several thousands of individuals. Maximum intensity varies dramatically and even within the same individual, lateral and frontal view can differ in orders of magnitude for radar. As a consequence there is a huge variation in echo intensity within the group of birds. Therefore, single blips, as they encounter on the radar PPI while scanning, are hardly suitable to identify species or species categories, at least a few seconds of continuous tracking is needed to use the variation of the echo intensity as a classifier.

THE PERFORMANCE OF EXISTING SYSTEMS

To our knowledge the bird radar systems available on the market do provide a general surveillance of a restricted area within or around the airport. For this surveillance these systems use a T-bar antenna providing good horizontal but no height information. A second radar is used to monitor information on the height distribution of the targets. This can be done by a similar radar, also with a T-bar antenna rotating in the vertical plane, or a radar with a dish antenna. In both cases there is no allocation of the targets seen by the two radar systems. There is one system where the second radar pinpoints to specific targets seen by the horizontal surveillance radar and allows to track this single target. It can track only one target at a time.

These surveillance radars can combine single blips from sequences into individual tracks to get direction, speed and “echo intensity” of a given target. To discriminate between birds and other targets they use groundspeed and clutter masks for the static ground clutter. The variation of echo intensity cannot be used, because in the scanning mode the target is only hit by a small fraction of a second (s. above). This can either be achieved by tracking a single target with an additional radar (s. above) or by using a radar in a fixed mode, where the birds fly through a stationary beam. For birds flying singly, the echo signature reflects the wing beat pattern, while flocks provide generally stronger but more variable patterns. Signal analysis software can be used to classify targets, mainly based on reference data.

Detection range is crucial for the operational task of radar systems. It depends on the performance of the whole radar system (e.g. pulse peak power, antenna gain, wave length, noise level, etc.) and the size of the target. Therefore, a statement on detection must always include the size of a bird reference (or a radar cross-section). Severe collisions rarely occur with single flying small songbirds (like Robins, pipits, swallows). However, there is no lower size limit defined yet at which single birds or flock of birds are no more relevant for birdstrike prevention.

CONCLUSIONS AND OUTLOOK

Up to now there is not one radar system that can provide the input necessary for the warning system we are aiming for (s. above). The existing systems provide information on the general local activity, but do not give the necessary 3D-image of the individual bird movements. The state of the (automated) target identification is progressing quickly, but still a field where further development is needed.

Most local bird movements occur within the lowest 50m above ground level (agl). Due to ground clutter birds are very difficult to be detected in this air layer. Obviously trees, buildings and other constructions on an airport are reflecting and blocking the radar waves, i.e. you can’t see the birds behind obstructions.

Finally, a huge part not yet touched, will be to implement this potential information into the safety system of the ATC and the airport safety system (concept-of-operations or CONOPS).

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