BIRD STRIKE COMMITTEE EUROPE

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AN ON-BOARD BIRD RECOGNITION DEVICE FOR THE PREVENTION OF BIRD STRIKES

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Summary

The paper details an on-board device for recognition and avoidance of birds, using radar cross section values of birds, the spectral structure of radar returns and their Doppler frequency.

Key Words: Radar, Detection, Avoidance,

1 INTRODUCTION

This paper describes a suggested method of radar recognition for the purpose of ensuring flight safety, and in particular for preventing bird strikes.

This problem of birdstrikes is acute - every year in USSR civil aviation some 1500 bird strikes occur nationally and approximately 4000 worldwide. (1, p 45).

The technique is aimed at reducing the probability of a birdstrike by decreasing the time taken for detection of birds and their avoidance, and by increasing the reliability of the system at distinguishing between birds and other objects.

2 METHOD

Figure 1 The layout of the control system for this system

Figure 2 Graphs showing the principle of selecting the threshold for detecting birds

Figure 3 The spectra of the signal reflected from Cormorants for a radar station with a 3cm range from the phase discriminator

Figures 4 and 5 show that the signal from several birds in comparison with a single bird is broader. Figure 4 here is a single Heron, taken from the same radar set up as Figure 3.

Figure 5 Again, a single Heron, but this time the distance from the radar is decreased. Again, taken using the same radar set up as before.

Figure 6 Shows the system developed for analysing data and steering the aircraft.

Figure 7 shows how the initial data is analysed to determine the change in direction of the aircraft.

Figure 8 shows the radar cross section of birds most dangerous to an aircraft

The birds are detected in the following way:

1 The value of the Radar Cross Section of the birds (Figure 8) The value of the effective surface for dispersion in birds in the cm band frequency makes up 0.5 - 3 cm for sparrows, 5 - 6 cm for Starlings, and 10 cm for Gulls. Figure 2 shows the distribution of the amplitude of signals reflected by birds in relation to the effective dispersal surface in 1 decibel. The decision about whether or not a detected object is a bird is made on whether or not the signal is greater than a threshold and smaller than a standard reference value.

2 Spectral structure (Figures 3, 4 and 5) of the signals reflected by birds (2, p 68) and their Doppler frequency. The interval of correlation can also be used for information for discerning the birds. For aircraft, the frequency of the reflected signal f_{ref} will be modulated by the frequency of the propeller (turbine) rotation, wherein is the harmonica number. The frequencies $f_{ref} = \eta f_{rot}$ being of considerable magnitude, the signal reflected from small aircraft have a relatively small effective dispersion surface, and will have a considerably smaller interval of correlation $T_k = 0.003$ for a

frequency of 0.1 m.

The trajectorial signs of the targets (2. p80) of the speeds of flight, with no wind, is equal to 25 - 85 km/h, the minimum speed of flight being with Gulls 25 - 35 km/h, with Chaffinches, thrushes, sparrows, rooks, crows, jays, herons 35 - 55 km/h.

The structural layout of the device for recognising the above signs have been described in the inventor's certificates, by the author of this paper and also in the work (4).

Taking into account that a bird can soar in flight, which will mean that there is no sign of frequency from wing flapping, it is necessary to combine signs of differing physical nature, such as infrared sensing for detection and recognition of birds.

The author would be interested in collaborative work with others at BSCE

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References

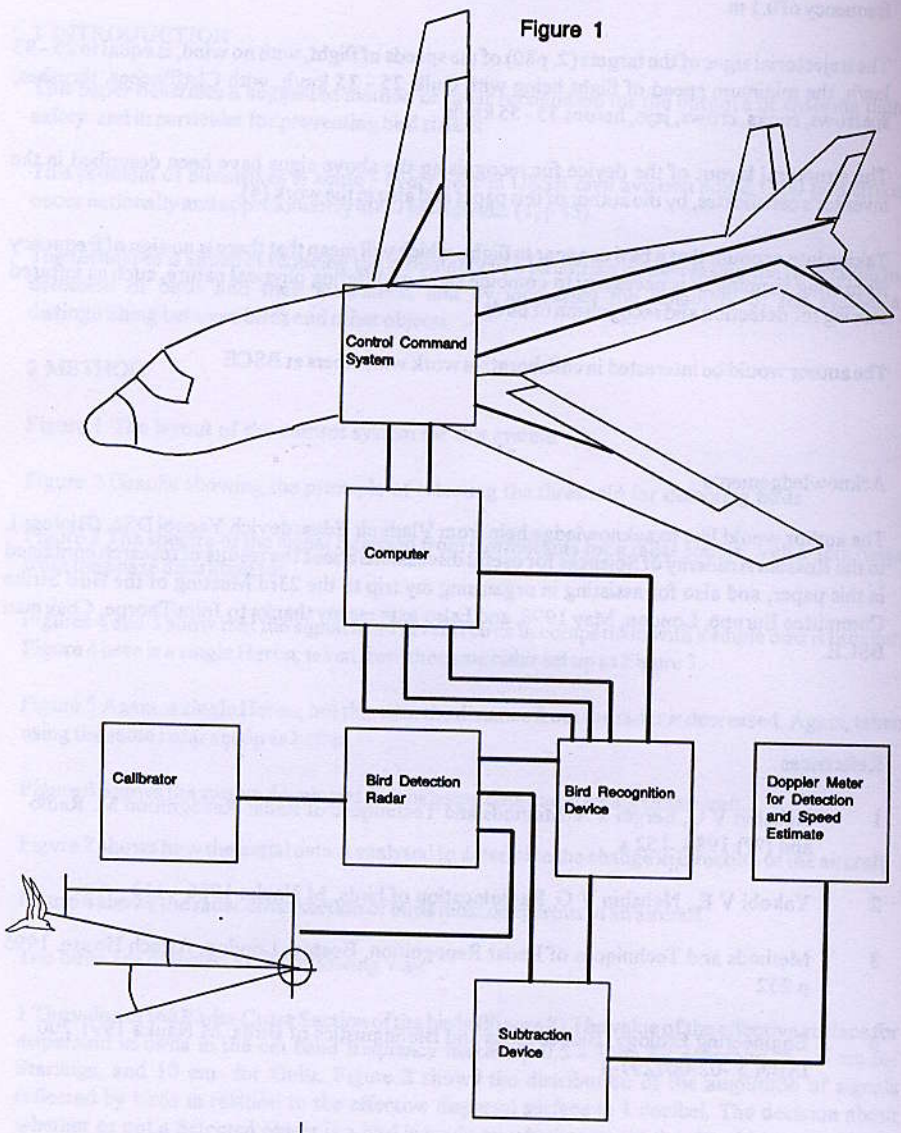
1 Nebabin V G, Sergei V V Methods and Techniques of Radar Recognition M.:Radio and (??) 1984. 152 s.

2 Yakobi V E., Nebabin V G, Radiolocation of birds, M Nauka 1986 - 113

3 Methods and Techniques of Radar Recognition, Boston, London, Artech House. 1995 p 252

4 Engineering Etology, Bioacoustics and Biolinguistics of Birds, M Nauka 1991 200 ISBN 5 -02-007297-4

Figure 1



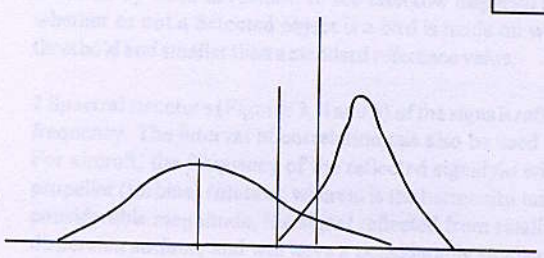
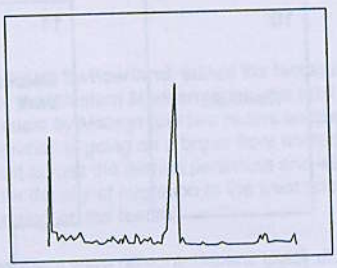


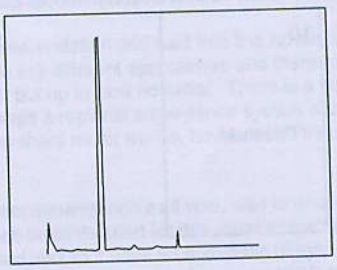
Figure 2

Figure 3



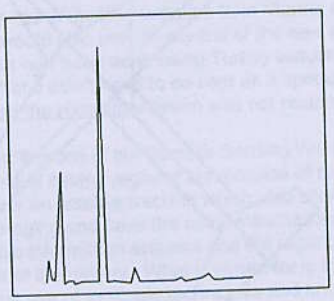
Spectrum of a Flock of Cormorants

Figure 4



Spectrum of a Single Heron

Figure 5



Spectrum of a single Heron
(As figure 4, but with Heron closer to radar)

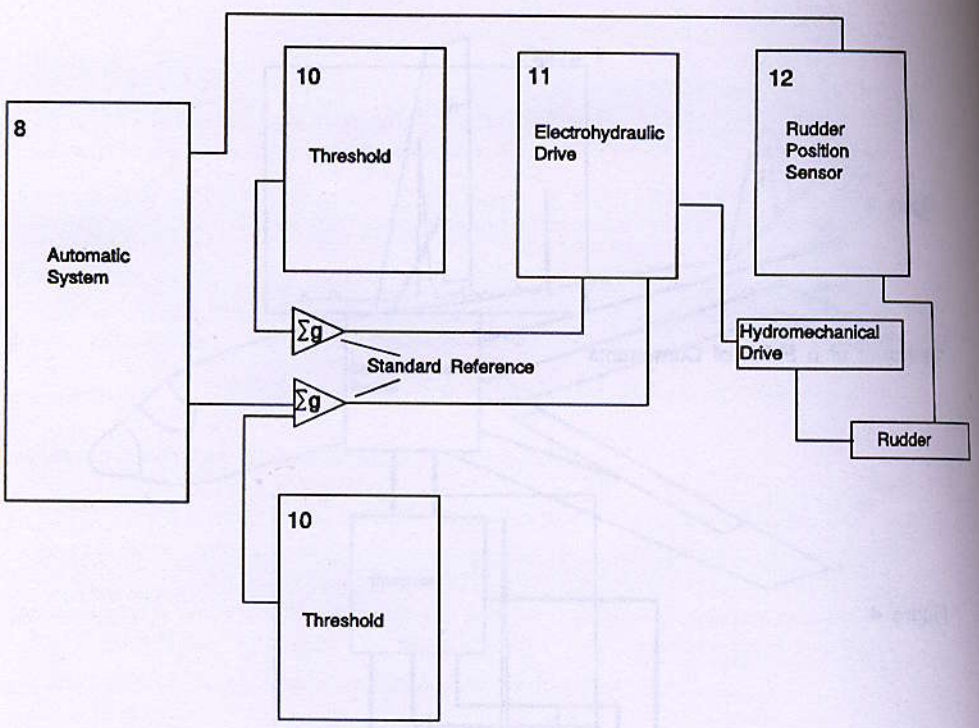
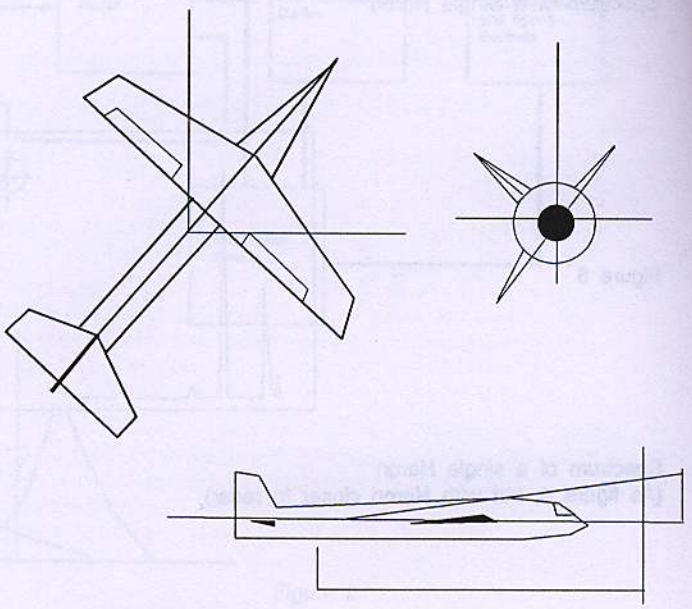

8
Automatic System
10
Threshold
11
Electrohydraulic Drive
12
Rudder Position Sensor
Σg
Standard Reference
Σg
Hydromechanical Drive
Rudder
10
Threshold

Figure 6



10 DISCUSSION OF REMOTE SENSING AND MILITARY LOW FLYING PAPERS

Acting Chairman, **Prof Dr Bruno Bruderer, Switzerland**, stated the last studies using tracking radar were in Israel and would now be heading for the Western Mediterranean, the next project being in Spain, two tracking radars will be located on the coast by Malaga and two radars on the Balearic Islands. The main question will be whether nocturnal migration is going on a broad front across the land bridges and the sea or whether there is concentrated migration across the Iberian peninsula and with the data from Israel we will also have the possibility to compare the density of migration to the west and to the east. He hoped that within two years he would be able to report on the results.

Dr Jurgen Becker, Germany, said as there were no contributions to the discussion, that the Vienna recommendations should be looked at and it could be decided whether to keep them, change them or make new ones. He noted that it would be very hard to find many new recommendations as had been suggested by IBSC Chairman.

Prof Dr Bruderer then read the recommendations from the Vienna meeting for the Remote Sensing Working Group. These can be seen in the Chairman's Report at the front of these Proceedings. It was agreed by the meeting that the first two recommendations need not be repeated.

Prof Dr Bruderer read the third recommendation and said that it is an issue which is still needed because there is no dedicated bird radar, there are different approaches and there are very clear ideas how a dedicated radar for birds should work but up to now no radar. There is a state of having to decide what radar should be implemented in perhaps a regional surveillance system and there is hesitation to because there really is no ideal radar, probably there never will be, however, he thought that this recommendation should remain.

Mr John Thorpe, UK, thought the recommendation as it was, was to encourage manufacturers to produce a low-cost radar. No specification has been decided for this radar and what it would have to do, what its range should be, how it would be used, would it have an automatic trigger system, etc. He thought the recommendation should be slightly reworded to reflect the need for IBSC to encourage development of a specification for radar and then when we know what we want we can take it to the manufacturers and ask how much it will cost, what problems it has etc.

Prof Dr Bruderer said that this issue had been discussed and a list of requirements had been made for such radars and a sentence would be good to include it in the recommendations if there were no objections. There were none.

Prof Dr Bruderer then read out the fourth recommendation from Vienna and suggested that it was included into a new recommendation which would also include several of the new techniques. Recommendation five was then read, he said assessments had been done using Turkey vulture, therefore he didn't know whether it should be retained. He thought that it didn't need to be kept as a special recommendation and asked for opinions. None were forthcoming so the recommendation was not retained.

Prof Dr Bruderer said that the contributions of the Remote Sensing Working Group had really opened new perspectives. The paper on the idea of having regional surveillance of bird migration, which is a new perspective, then the excellent paper on satellite tracking which also showed that with this new technique we can jump over 10/20 years of bird ringing and have the same information within a few weeks or months. Then we have the use of geographic information systems and the urgent need for reliable information which was a problem brought up in some of the papers. What is aimed for is to integrate maximum information for bird strike reduction, making optimal use of available techniques and knowledge. Dr Leshem is in favour of all this being used towards education and in favour of the peace process in the Middle East. Therefore with all these new ideas a new recommendation something like - IBSC may suggest to create a small working group outside of this body here with the aim to enhance the use of modern techniques in order to increase flight safety (such as GIS, satellite telemetry, satellite weather forecasts, radars to optimally cover horizontal distribution of bird migration on a regional level and to inform about vertical distribution in relation to weather). He asked for any additional suggestions.

Mr Thorpe thought that the possibilities that a device, such as the one suggested in the Ukraine paper might contain, for on-board detection of birds with a device that will filter and trigger only the things that are of use for us to know should not be overlooked, nuisance warnings are not needed, about 90% of fire warnings on aircraft are false alarms, it is not wanted for false alarms to happen with an on-board development to detect and filter bird warnings. He suggested a recommendation along the lines that IBSC encourages the development of on-board equipment which will filter and signal appropriately when encountering flocks of hazardous birds.

Prof Dr Bruderer fully agreed with the recommendation. He asked if there were any additions or questions to the suggested recommendation.

Dr Jan Wattel, The Netherlands asked if it would be possible for the aircraft to manoeuvre out of the way, when flying at high speed, of the birds as they would have to be detected at a great distance to avoid hitting the birds.

Prof Dr Bruderer suggested that it is a far reaching idea because it would also be more difficult to filter out false alarm signals from birds than from aircraft. It would also be very difficult to avoid a flock of birds that is already very close. The problems would be big but it was still worth keeping the recommendation, although separate from the last recommendation.

Major Russell DeFusco, USA had done a paper on this several years ago in the United States using the F15 as a model because it is highly manoeuvrable, reacts almost instantaneously to control inputs. At 500 kts (which he realised commercial aircraft could not reach) it takes a minimum of two thirds of a mile for a pilot to physiologically register on his retina the image of a bird and then make the decision to react, maximum control deflection and then move the aircraft 15ft in vertical space. This is for an individual bird. This is assuming everything works properly, the background imagery and contrast is available and the pilot's not looking at any other object other than straight ahead so for a pilot to make that kind of decision in high speed aircraft it is physiologically impossible to make those kind of inputs. There is no chance for individual birds that it would be possible. Maybe for flocks it could be possible. The suggested automated system that could do this for you is a very different system and he agreed with Prof Dr Bruderer that this has to be a very separate recommendation from the last one because it is a forecasting system as opposed to an on-board, on-line system. He was not sure that would be mechanically possible, at least with the techniques available to engage such an on-board system, the reason was that the USAF have terrain following radars in their aircraft right now and the pilot has always got his hand on the stick because of all these incredible deflections of the control surfaces and in terms of take-off and landing scenario you can't afford to have the aircraft doing any kind of manoeuvring when you are under powered. Although he was not sure about the technical feasibility of this, he wouldn't want to discourage research in this area. He warned that careful wording would be needed for this recommendation from the committee.

Prof Dr Bruderer was grateful for the comment as he thought the committee should not make recommendations without input from people who know more about the subject.

Mr Thorpe thought that the recommendation should only be there to keep the door open for work in this area and pointed out that Terminal Collision Area Avoidance System (TCAS) in the air traffic world is operational and apparently works, although there are some false warnings, a lot of the time it has saved aircraft from colliding. With regard to the terrain following radar and the way the pilot keeps his hands very close to the control, civil airliner flight deck crew are ready to snatch the controls if anything should go wrong while doing an automatic landing. Therefore, people do have faith in their systems but have to be ready to take over when things go wrong. He felt there was an idea that had been dropped into the IBSC pool that must be actively encouraged because something may well come of it in several years time. The door must be kept open.

Mr Adam Kelly, USA said that it wasn't a new idea as he had looked at it with the RAF in the UK in 1983 and there are enormous technical problems involved. Taking commercial airliners, he gave one example of why the idea wouldn't work, the Airbus crash when the pilot was doing a missed approach and he ploughed into the ground, it takes so long for the engines to spool up to give the energy to initiate a manoeuvre in the airfield environment it will not occur, there aren't the detection capabilities to match up with the reaction times that are involved. Its simple physics and there is not the capability there so a recommendation like this, although it sounds promising, doesn't match up with technical realities.

Mr Ralph Speelman, USA saw the value in this as the artificial intelligence side of either a ground-based or an air-based warning system to the pilot to take action. He had been in the aircraft technology application wherein the pilot is relieved of duties or additional duties are added to him and taking control of the aeroplane away from the pilot to an automatic system is something the pilots have never gone along with, including systems which would eject the pilot from a military aircraft that was unflyable, the pilot still wants to retain that decision. Part of what the Wright Laboratory is doing is looking at creating an automatic warning system to the pilot or to the ground controllers or to the tower that says you'd better do something in the next 30 seconds or you are going to have a catastrophic collision. You do that with aeroplanes, we do it on the ground now, part of that system has to be an artificial intelligence loop that takes a look at this overwhelming amount of data, sorts out that which is important and feeds a message back that says you'd better take some action, it doesn't take the action but warns of the need for it. He saw tremendous value here because they have been talking about the logic for an artificial intelligence loop, this piece of work just saved probably $40,000 in the contract to develop the preliminary thought process for artificial intelligence, therefore, the work has already paid off.

Mr Thorpe was not sure from the paper whether the application was designed for military aircraft (which would react more sharply) because any civil aircraft has an awful lot of inertia, engines that spool up very slowly, he used to be in flight test in industry and they used to do this on all new production aircraft to check that the engine did spool up within a certain margin and also the other problem, you wouldn't want to be flying along at 25,000ft with the drinks service going on and it suddenly manoeuvres very sharply!

Mr John Seubert, USA said not to forget that within the area of an airport aircraft are restricted to 250 kts and if you reduce your speed from 500 to 250 kts the force of impact goes down a lot and the more you reduce speed the more the impact force goes down. It is also agreed that most birds are rather low to the ground, 500 or 1000ft therefore one of the best tools now is a sight and ground radar that can help with warning systems, its just working with the speed of the aircraft among other things.

Prof Dr Bruderer asked if people were in favour of such a recommendation. He asked that people who felt confident with the matter to help in the decision as to whether such a recommendation should be included or not.

Major DeFusco made a suggestion that a recommendation for continuing to search for emerging technologies and to do research into on-board warning systems.

Prof Dr Bruderer agreed that this was a good suggestion and maybe could be agreed upon.

Mr Kelly suggested the wording not to shut this idea down for all time but that when the technologies could match up this area could be revisited.

Prof Dr Bruderer said it was agreed that the recommendation should be rephrased. This was agreed by the meeting.

Dr Becker said all the work on these matters in spite of good results seen this morning, changing the scientific results into operational procedures can only proceed slowly. He felt one good general recommendation was better than several detailed recommendations. The technical possibilities are so advanced, the main problem in Germany and, he believed, in other countries as well was the need to convince the authorities who spend the money.

Major DeFusco suggested the science behind this needs to be tightened up and then also the delivery of products to the field. One of the things that impressed him at this meeting was the level of science being put into the technology. There are very good statistics, controlled experimentation etc and it needs to be encouraged rather than colloquial or anecdotal type of approaches to some of these technologies that are being used, especially if its to be sold to the authorities in various countries. Care must be taken not to create a product that is going to be put to the field, either to a pilot or to an administrator that he can't understand. There are two aspects to this, one is that the science is developed for the biologists, engineers etc that understand that science and then there's another step where that technology is taken and transferred to a useable form, as in Mr Kelly's presentation, where pilots have a minute or so to look at this technology and make a critical decision so it is needed to address the format by which we educate people as Dr Leshem was saying as well and also deliver the products of the science to the user.

Mr Kelly thought the hardest thing in this field is the interaction between biology and engineering and electronics. He felt he had had an extremely fortunate background working with the Air Force where he had become aware of a great many of those disciplines but as a biologist and somebody who programmes things into computers it is a tough discipline to embrace all those other technologies and bring them together and that requires massive teamwork and that's when ideas about dodging birds with radar may seem like a great concept but you have to pull those people together to be able to thrash out exactly what the requirements are and then why it is physically possible or not possible to do one of those types of things.

Dr Becker fully agreed with the two statements and said it is always hard work to combine the different knowledge and interest and when specialists have their own languages it is difficult to bring information together and especially difficult to bring the information to people who should spend the money because they are not normally familiar with the problem. It is only in the countries with such high strikes by birds, as in Israel perhaps, that there has been a success. Whereas in Germany and most of the other countries in Europe the authorities have the idea that a problem is generally solved but its not clear because there are problems and the systems must be improved. He believed that in the United States the fatal accidents of the past had given authorities the idea that assistance must be improved. If there are no fatal accidents improvement seems not to be necessary but if such an accident occurs then there is the question 'how can it be possible'. He believes IBSC must promote their work, systems must be improved and always try to convince the authorities.

Dr Becker thanked the participants and closed the joint session.