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RADAR TECHNIQUES FOR AIR FORCE APPLICATIONS IN AVOIDANCE OF BIRD-AIRCRAFT COLLISIONS AND IMPROVEMENT OF FLIGHT SAFETY

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13. ABSTRACT

During the year three major objectives were accomplished: (1) an evaluation of airborne radar systems for possible detection of birds aloft, (2) an evaluation of the FAA airport surveillance radar (ASR-4) for monitoring bird movements in the vicinity of airports, and (3) an evaluation of the precision approach radar (PAR) or ground control approach (GCA) radars for monitoring bird movements through airport landing corridors. The precision approach radar or ground control approach radar along with the airport surveillance radar were found to provide all the necessary data to avoid bird/aircraft collisions. Furthermore, the flight controllers are in contact with the pilots and can warn them of dangerous concentrations of birds in their flight paths.

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AFOSR GRANT 71-1974A

RADAR TECHNIQUES FOR AIR FORCE APPLICATIONS

IN AVOIDANCE OF BIRD-AIRCRAFT COLLISIONS

AND IMPROVEMENT OF FLIGHT SAFETY

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INTRODUCTION

The following report contains a review of the accomplishments on my grant (AFOSR-71-1974A) from 1 December 1971 to 1 December 1972. During the year three major objectives were accomplished: 1) an evaluation of airborne radar systems for possible detection of birds aloft, 2) an evaluation of the FAA airport surveillance radar (ASR-4) for monitoring bird movements in the vicinity of airports, and 3) an evaluation of the precision approach radar (PAR) or ground control approach (GCA) radars for monitoring bird movements through airport landing corridors. These areas of investigation were to provide badly needed data on migratory and roosting movements of birds in an effort to reduce the hazards that birds pose to military aircraft and their pilots. The following report will document the progress that I have made along these lines.

AIRBORNE RADAR SYSTEMS

Initial work on the feasibility of using airborne weather radar was undertaken at Shaw Air Force Base at Sumter, South Carolina. The radar, the APS-27, has specifications that suggest it would readily detect birds at ranges within five nautical miles. The radar was operational in RB-66 aircraft, but the cockpit of the aircraft was classified, and I was not permitted to use the units directly. Instead 35-mm film of the scope was provided to me for analysis, but this film was made when the aircraft was flying low (2,000 ft) over the ground. The film was unacceptable for my purposes since the exact settings of the radar were not recorded by the pilot. Film of the radar scope while the aircraft was at the end of the runway prior to takeoff was not made available. Hopefully, this test can be conducted shortly. The precision approach radar or ground control approach radar along with the airport surveillance radar was found to provide all the necessary data to avoid bird/aircraft collisions. Furthermore, the flight controllers are in contact with the pilots and can warn them of dangerous concentrations of birds in their flight paths.

AIRPORT SURVEILLANCE RADAR

The evaluation of FAA airport surveillance radar (ASR-4) was undertaken at the Greenville Municipal Airport and Shaw Air Force Base, South Carolina, in the fall of 1971. The ASR-4 is called the FPN-47 radar at Shaw Air Force Base, but it is the same equipment as that at the Greenville Municipal Airport. The unit is an S-band (2700 to 2900 megacycles) radar with a peak power of 425 kilowatts. The range resolution is such that targets as little as 615 feet apart at 6 to 10 mile ranges can be separated. The azimuthal resolution of equidistant targets is 2.25°. The maximum range is 60 nautical miles, but birds rarely appear on the radar screen (PPI) beyond 30 nautical miles. The radar is equipped with a moving target indicator (MTI), sensitivity time control (STC), and two cross-section sensitivity (CSS) circuits. The MTI removes all ground clutter from the PPI, the STC and CSS circuits reduce receiver sensitivity and reduce the number of weak echoes displayed on the radar screen. The initial work during the fall of 1971 demonstrated that the ASR-4 can detect even small birds. Birds were present on the radar screen nearly every night except when hard rain covered most of the surveillance area. A Polaroid camera mounted on a tripod in the maintenance area in front of the maintenance PPI permitted me to record radar data without disturbing the flight controllers. Because the controls of the radar are in the main flight control room, I would request that certain settings be made when I took a photograph. This was usually only a 2-3 minute interruption and fit in with normal control operations quite well. Simultaneous direct visual observations at night were made just behind the FAA building. On cloudless nights around the full moon period, I monitored the passage of birds with the aid of a 40X Questar directed to the moon. These data after analysis yielded quantitative estimates of the amount of bird migration taking place and the direction of movement. On moonless nights I employed a portable ceilometer which projected a vertical beam of intense light. With binoculars (10 x 50) directed up the beam, I recorded the numbers and directions of birds as they passed through the field of the binoculars.

Table 1 shows some of the results of analysis of nocturnal spring migration data. As can be seen, the direct visual data agree very well with the radar data. I am now attempting to quantify the radar photographs in terms of the quantitative moon-watch data with the aim of having a graded series of bird echo densities on the ASR-4 radar and the equivalent quantitative migration densities (migration traffic rates). Such a series would greatly aid flight controllers in estimating the number of migrating birds aloft based on their density on the radar screen. Similar data were gathered from Greenville and Charleston, South Carolina this fall and are presently being analyzed.

Thus far this winter I have started gathering density information on roosting blackbirds in the vicinity of ASR-4 radars at airports in South Carolina. This project will help in quantifying the dot or flock echoes of birds that appear on the ASR-4. Preliminary analyses of duck and shorebird flocks indicate that they can be readily identified on the radar screen of the ASR-4 and some estimate of the number of birds in each flock is possible. The greatest shortcoming of the ASR-4 radar system is the lack of accurate altitude information on the bird echoes displayed on the radar screen.

PRECISION APPROACH OR GROUND CONTROL APPROACH RADARS

At Shaw Air Force Base and Charleston Airport in South Carolina these units are in operation in conjunction with the ASR-4 radars. These approach radars constantly monitor hazardous concentrations of birds in the sampled air space. The radars yield very accurate altitudinal information, but unfortunately do not sample altitudes above 5,000 feet. The resolution of the radars is such that individual birds can be seen, and flocks of birds appear so large as to constitute a problem when an aircraft is being watched on the PPI. My initial findings with this unit suggest that it can be very valuable in warning pilots on landing approaches of birds in their line of flight. This unit and the ASR-4 comprise an excellent system for monitoring bird movements in the vicinity of busy airports and for issuing warnings of hazardous bird concentrations. Direct visual identification of birds displayed on the GCA radar is now underway and is expected to yield data that will aid flight controllers in identifying the types of birds displayed on the radar screens of the GCA units.

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The influence of wind on the orientation and evolution of bird migration. Delivered at the 90th Annual Meeting of the American Ornithologists' Union at the University of North Dakota, Grand Forks, North Dakota. 15-17 August 1972.

DATE	WIND (SURF)	RADAR	DIR. VISUAL	COMMENTS
28 March	270° 2 kts.	20°	30°	moderately heavy
3 April	20° 6 kts.	25°	0°	heavy
4 April	220° 4 kts.	210°	201°	light
15 April	40° 9 kts.	40°	44°	heavy
17 April	240° 5 kts.	230°+300°	289°	moderately heavy
18 April	calm	10°	360°	very heavy
24 April	230° 6-8kts.	220°	209°	light
25 April	200° 4-6kts.	200°	219°	light
26 April	360° 3 kts. 160° 4 kts.	15° 65°	7° 50°	heavy
27 April	50° 4 kts.	25°-30°	20°-30°	moderately heavy
29 April	350° 3 kts.	----	353°	moderately heavy
30 April	calm	10°	10°	moderately heavy
1 May	40° 4 kts.	----	39°	moderately heavy
3 May	50° - 10 kts. 160° - 5 kts.	360°-10°(low) 80° -90°(high)	79°	moderately heavy
4 May	140° - 4 kts.	90°-100°	96°	light-medium
7 May	calm	10°	350°	medium-light
[illegible] May	60° 3-5 kts.	50°-60°	47°	medium
9 May	180° 9 kts.	180°	123°	light
10 May	90° 2-3 kts.	320°-340°	340°	medium-moderately heavy
15 May	60°-[illegible] kts.	50°-60°	60°-70°	light-medium