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THE REDUCTION OF F-111 LOW-LEVEL ENROUTE BIRD HAZARDS

MARCH 1976

FINAL REPORT: DECEMBER 1975

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AIR FORCE CIVIL ENGINEERING CENTER
(AIR FORCE SYSTEMS COMMAND)
TYNDALL AIR FORCE BASE
FLORIDA 32401

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The F-111 aircraft has experienced a serious bird strike hazard because of its high-speed, low-level flying mission. This report examines the possible solutions and associated problems related to reducing enroute bird hazards. Four methods are discussed: (1) route studies to determine the relationship of habitat to species abundance and occurrence, (2) the use of radar to detect migratory movements, (3) formulation of a migration prediction model, (4) determine scheduling adjustments to coincide with low bird density and reduced activity. The success of any of the proposed methods is dependent upon the

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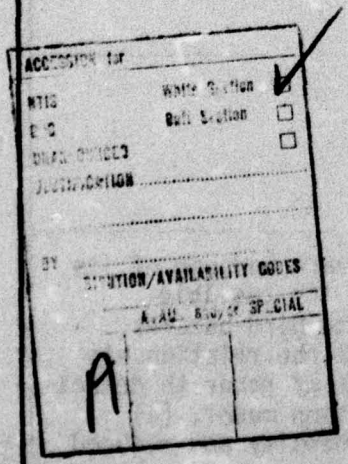
mission flexibility and available training alternatives at a given base. Results of the study may also apply to reducing bird strikes at Air Training Command student pilot training bases and to determine minimum bird hazards for proposed low-level routes for the B-1 Bomber.



PREFACE

This final report was prepared by the Operating Location, Air Force Civil Engineering Center, Kirtland Air Force Base, New Mexico 87117, under Program Element 63723F, Project 2103. Dennis E. Compton (DEE) was the Operating Location Project Officer-in-Charge.

This report has been reviewed by the Information Officer (IO) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

MICHAEL J. HARRISON
Captain, USAF
Project Officer

DONALD G. SILVA
Lt Col, USAF, BSC
Director of Environics

ROBERT E. BRANDON
Technical Director

HENDRICK D. MOL
Lt Col, USAF
Commander

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SECTION I

INTRODUCTION

Aircraft flying within a high density bird environment have a great potential of experiencing bird strikes. As flight speeds increase and flight altitudes decrease bird/aircraft collisions become a serious hazard. The F-111 aircraft because of its low-level, high-speed flying mission has experienced a high incidence of bird strikes.

The F-111 is an advanced tactical fighter bomber designed to penetrate enemy defenses by flying at high speeds and at altitudes below the levels easily monitored by radar. Each F-111 base utilizes several low-level routes to train and maintain the proficiency of F-111 aircrews. The low-level training routes average approximately 175 to 225 miles in length, passing over a variety of habitats and terrain. The F-111 aircraft fly these routes at altitudes between 200 and 1500 feet above ground level (AGL) traveling at speeds of 500 to 650 miles per hour.

Most bird flying activity occurs at altitudes below 5000 feet AGL and the highest concentrations of migrating birds are often found within the 500 to 1500-foot range (Reference 1). Over 75 percent of the migrants often fly at altitudes below 3000 feet (Reference 2). The probability of a bird/aircraft collision is greatly increased whenever aircraft fly at altitudes coincident with high bird densities and activity.

The greater incidence of bird strikes to the F-111 is apparent when the available bird strike data is reviewed. While the overall bird strike rate for all Air Force aircraft (including F-111) during 1974 was one strike per 8036 flying hours, the rate for the F-111 was one strike per 2098 flying hours (Reference 3). The high speeds flown by the F-111 compound the potential problem because of the significant increase in impact forces. Figure 1 is derived using the formula:

$$F = \frac{2\,WV}{3\,sg} = KW/3\,V \qquad \text{(Reference 4)}$$

where $s = 3.18W/3$; $g = 32.2$ ft/sec; $K = 0.705$;

W is the average weight in pounds of the species; and V is the aircraft velocity in knots indicated airspeed (KIAS) at 1000 feet AGL. From Figure 1 it is apparent that an increase in aircraft velocity is the most important factor in the magnitude of the impact force. Doubling the weight of the bird results in an increase of only about 1.6 times greater impact force, whereas, doubling the velocity results in an increase of four times the impact force.

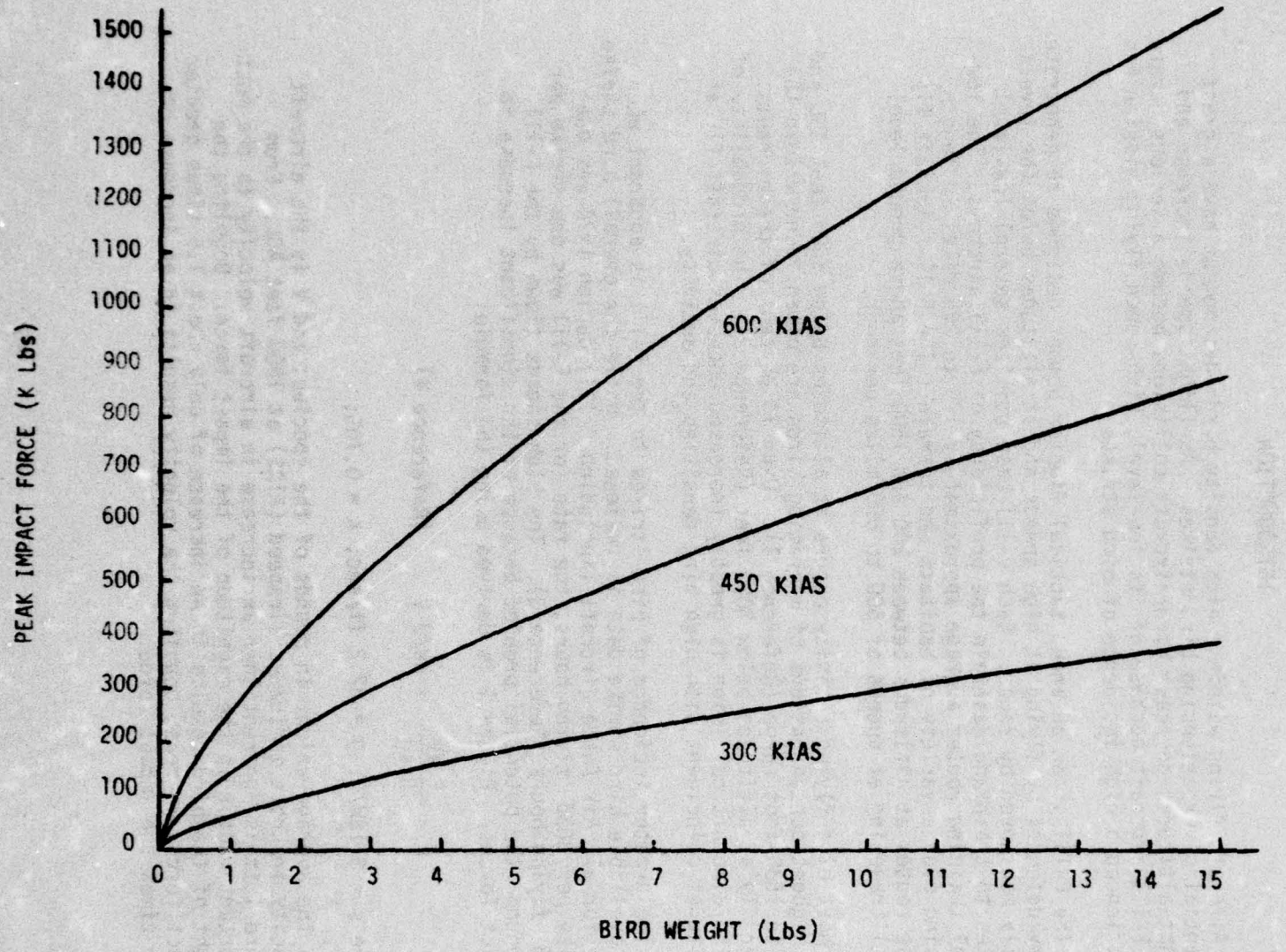

Figure 1. Bird Strike Impact Forces

The serious nature of the problem is evidenced by the records of past bird strike damage and/or loss of aircraft. The feasibility of several alternative solutions needs to be examined to determine the most successful and cost-effective methods for reducing low-level enroute bird hazards. This study analyzes the possible means of reducing the problem and recommends alternative courses of action.

SECTION II

SUMMARY OF THE F-111 BIRD STRIKE HAZARD

Flight testing of the F-111 aircraft began in 1967 but it was not until 1971 that extensive flying was underway at several bases. Currently, F-111s are assigned to three Tactical Air Command bases in the U.S. located at Cannon AFB, New Mexico; Mountain Home AFB, Idaho; and Nellis AFB, Nevada. The Strategic Air Command operates two FB-111 bases at Pease AFB, New Hampshire and Plattsburgh AFB, New York.

Bird strikes have occurred at each of these bases but the intensity and characteristics of the bird strikes differ from base to base. During the period from 1971 through 1974 bird strikes occurred in all months except December. Figure 2 shows the cumulative distribution of bird strikes by month from 1971 through 1974. Forty-nine percent (34 of 70) of the strikes occurred during September and October of the fall migratory season.

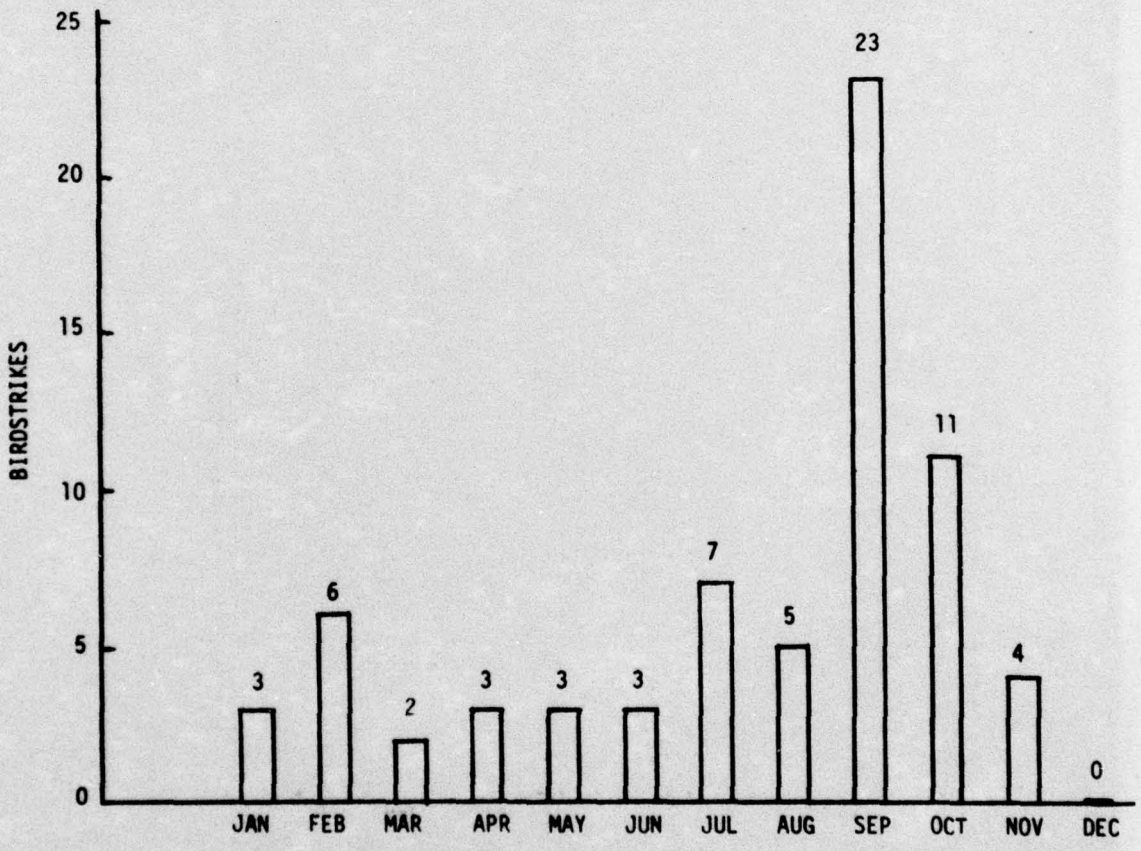

Figure 2. Bird Strikes by Month, 1971-1974 at Cannon, Mountain Home, Nellis, Pease, and Plattsburgh AFBs

Although some of the bird strike problems are similar, each base must be considered individually to obtain an accurate evaluation of the bird hazards. Figure 3 shows the number of bird strikes in relation to the number of hours flown at each of the five bases, and Table 1 lists the respective bird strike rates. From these data it is clear that the intensity of the problem varies greatly from base to base and even from year to year at the same base. Each base and its respective low-level routes are located within different geographic regions with differences in habitats, topography and land use. Different species of birds may be found in the respective areas at various times throughout the year. Depending on specific local conditions the major problem at a base may be either on the airdrome or enroute. The approach to the problem must be adapted to each base's specific circumstances.

Cannon has experienced the highest bird strike rate of all F-111 bases with one bird strike per 1568 flying hours during the period from 1971 through 1974. During this same period, Mountain Home had the lowest bird strike rate with one bird strike per 6982 flying hours. Although bird strike rates are a good indicator of the bird hazard at a given base, it should not be inferred that this should be the only consideration. The size, behavior, distribution and abundance of all potentially hazardous species of bird must be considered as well.

TABLE 1. F-111 BIRD STRIKE RATES

AF BASE	(FLYING HOURS/NUMBER OF BIRD STRIKES)				
	1971	1972	1973	1974	CUMULATIVE
Cannon	832 (4,991/6)	1727 (8,633/5)	3700 (14,800/4)	1217 (17,036/14)	1568 (45,460/29)
Mountain Home	--- (1,045/0)	15,211 (15,211/1)	6187 (18,560/3)	5260 (21,041/4)	6982 (55,857/8)
Nellis	3303 (29,726/9)	4733 (28,396/6)	7422 (14,844/2)	---- (13,586/0)	5091 (86,552/17)
Pease	2415 (4,829/2)	2586 (10,345/4)	6906 (6,906/1)	3828 (7,655/2)	3304 (29,735/9)
Plattsburgh	3505 (3,505/1)	---- (11,999/0)	9623 (9,623/1)	2189 (10,944/5)	5153 (36,071/7)
All bases listed above from 1971 - 1974 = 3624 (253,675/70)					

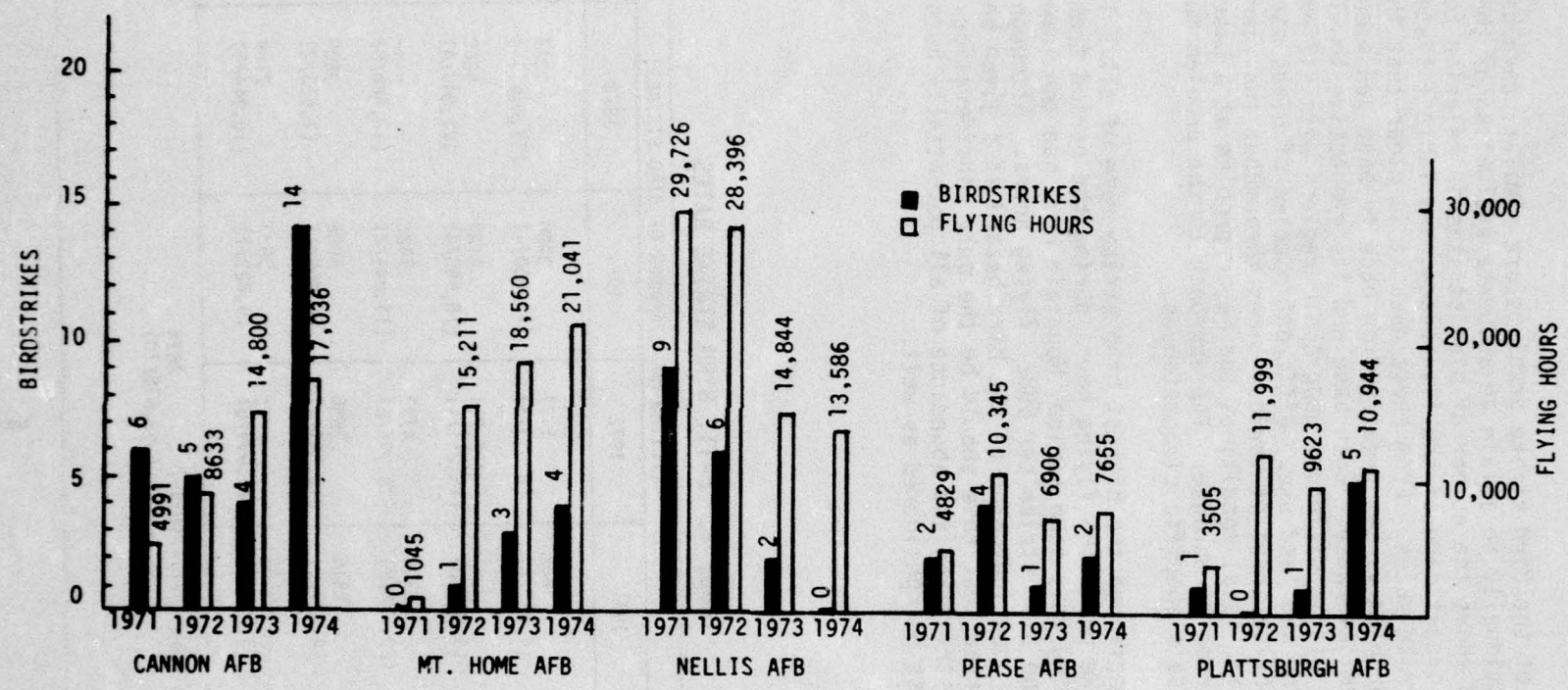

Figure 3. Relationship of Bird Strikes to Flying Hours

A base that has had several strikes on the airdrome with small ground-dwelling passerines (songbirds) cannot be equated with another base that has had only a few recorded strikes, but a serious potential problem with relatively large species such as raptors, cranes or waterfowl.

Cannon, Mountain Home and Nellis AFBs are tactical fighter wings and fly similar missions, although over different geographical regions. Normal enroute flight altitudes average about 1000 feet AGL and the length of sorties average about 3 hours with 1/2 to 1 hour in the low-level training route. Pease and Plattsburgh AFB are fighter bomber wings and have a slightly different mission and fewer flying hours. Both bases are located in the same geographic area and use the same low-level training routes. The length of sorties average about the same as Tactical Air Command F-111s, however, enroute flight altitudes are somewhat lower at about 500 feet AGL.

Recorded bird strikes and pilot reports of bird sightings are the only available source of empirical data; however, most of the important parameters are either unknown or have not been listed in the reports. Exact locations, specific routes, or general geographic locations have often not been recorded. If this information were available, it would enable a more accurate evaluation of bird hazards. Similarly, time of day is often not listed when at least a time span or simple day/night classification might be given for that particular mission. The species of bird involved in a strike are also rarely identified in the reports. Although there are many instances when bird remains are unavailable, the presence of only a few feathers are usually enough to be identified by the U.S. National Museum of Natural History. Species identification is necessary to determine whether migratory or local species are involved. All information concerning bird strikes and bird sightings should be recorded as exactly and specifically as possible under the circumstances.

In subsequent paragraphs a summary of the bird strike problem is given for each F-111 base within the United States. Most of the data have been summarized from the computerized bird strike records on file at the Air Force Inspection and Safety Center (AFISC), Norton AFB, CA (Reference 5). Additional information was obtained from Cannon to supplement the AFISC data. Similar data should be obtained from each of the remaining bases to insure accuracy and obtain a better understanding of that base's problem.

From 1971 through 1974 Cannon experienced 29 bird strikes (Figure 4). Sixteen (55 percent) of these strikes occurred during the month of September and seven (24 percent) during January and February. In the 4-year period Cannon did not have any strikes during the months of April, May, June and December. While more hours were being flown during the day, 59 percent (17 of 29) of the strikes at Cannon occurred at night with only 41 percent (12 of 29) occurring during the day. As shown in Figure 5 the distribution of night bird strikes has been limited to the migratory seasons. The strikes have been equally distributed between the airdrome and enroute environment. At Cannon 48 percent (14 of 29) of the strikes have

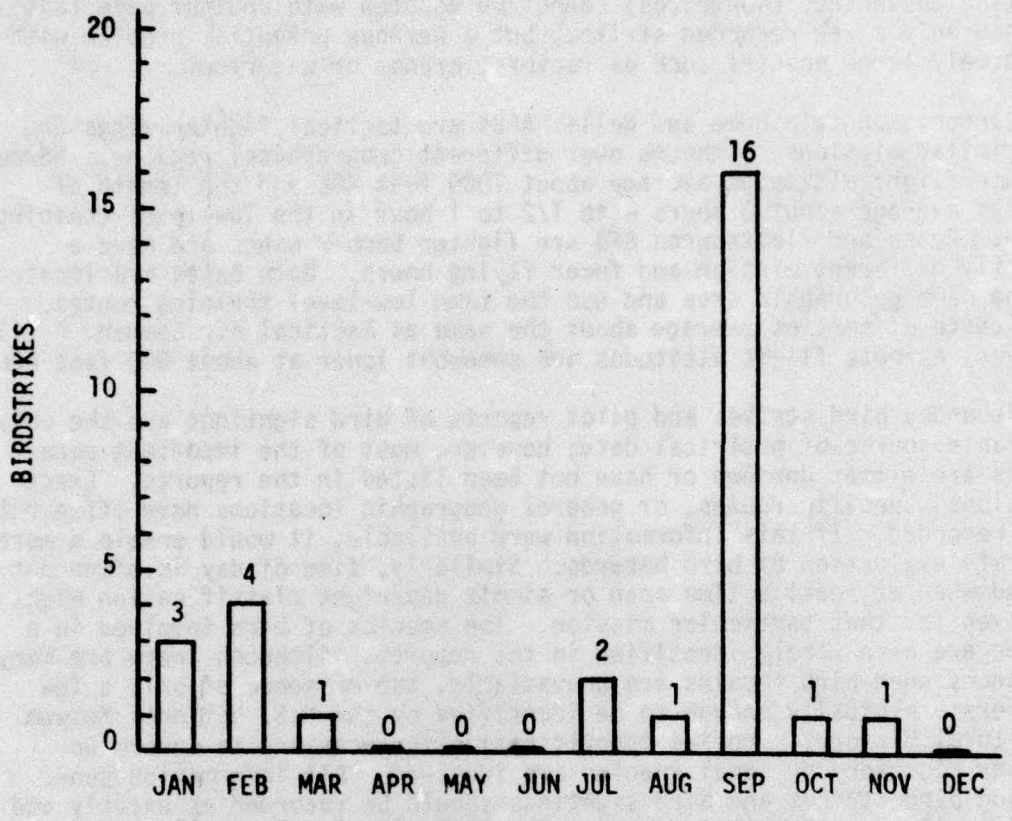

Figure 4. Cannon AFB Bird Strikes, 1971-1974

occurred enroute, 38 percent (11 of 29) in the Cannon area, 7 percent (2 of 29) near the Melrose Bomb Range and 7 percent (2 of 29) at unknown locations. Cannon has the highest bird strike rate of any of the five F-111/FB-111 bases (Table 1).

During the same 4-year period, although relatively few hours were flown in 1971 (Figure 3), Mountain Home AFB had only eight strikes with 50 percent occurring during the fall migratory season (Figure 6). No strikes have been recorded from November through March. These data may indicate reduced bird populations and activity during the winter in northern latitudes. Mountain Home AFB has the lowest bird strike rate of the five F-111/FB-111 bases (Table 1).

The 23 strikes reported at Nellis (Figure 7) are equally distributed throughout the year, although September, October, November and April account for 57 percent (13 of 23) of the reported bird strikes.

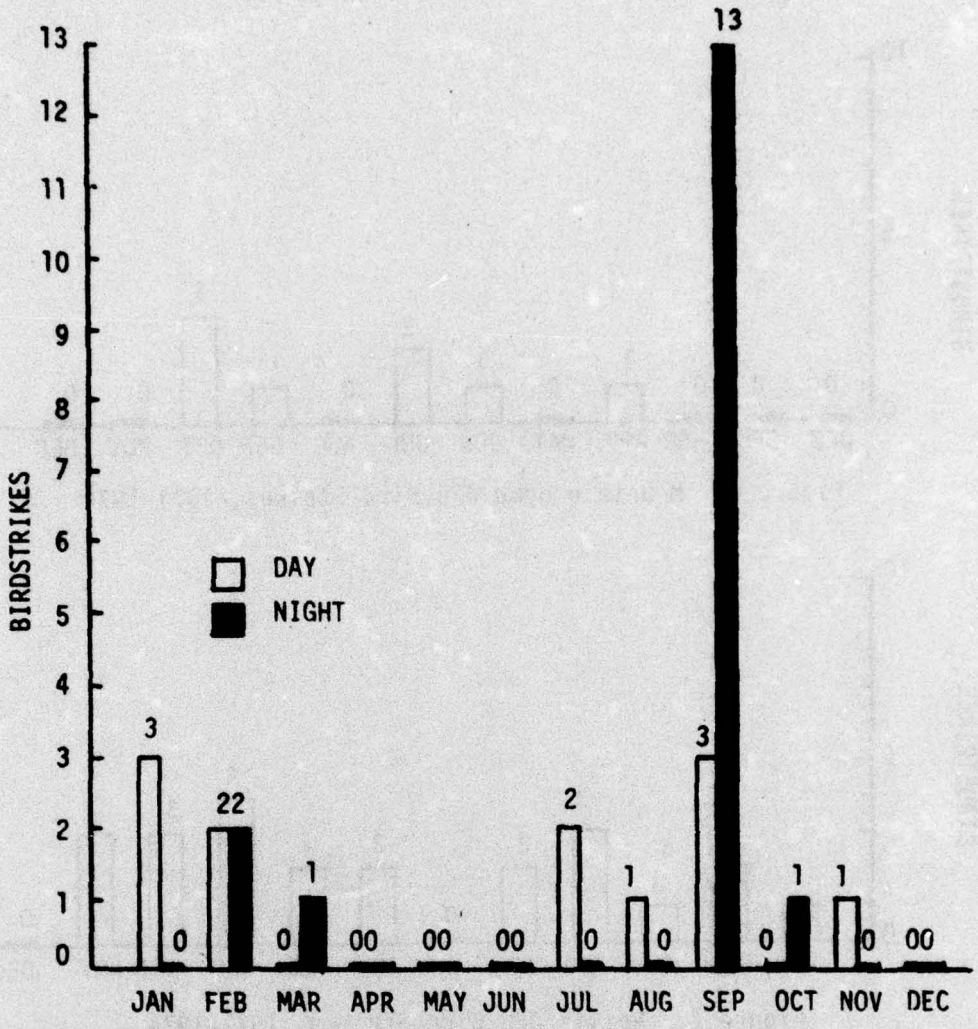

Figure 5. Cannon AFB Bird Strikes, 1971-1974 by Time of Day

Pease AFB had nine strikes from 1971 to 1974 (Figure 8). Seven of these (78 percent) occurred during September and October. Pease has not had any strikes from November through May.

The problem at Plattsburgh AFB, as indicated by the strike record, is a migratory and summer problem (Figure 9). Forty-three percent (3 out of 7) of the strikes occurred during October. The remainder of the strikes occurred from May through August. No strikes occurred from November through April.

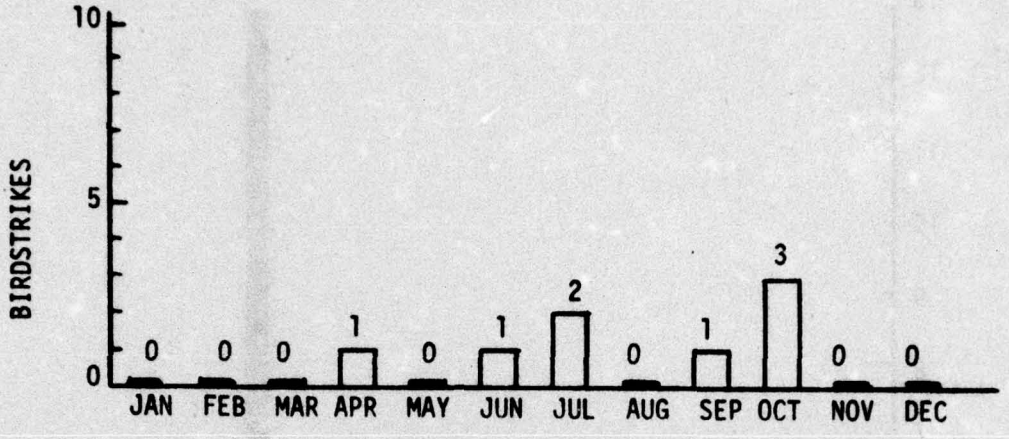

Figure 6. Mountain Home AFB Bird Strikes, 1971-1974

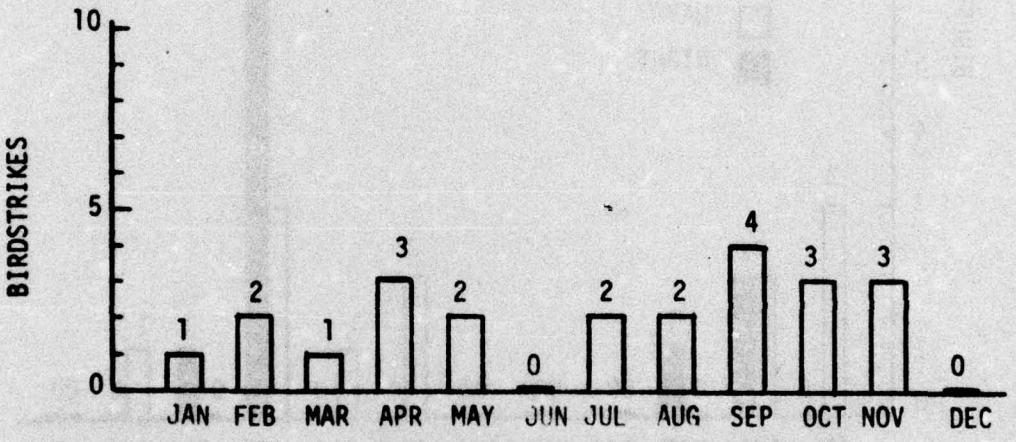

Figure 7. Nellis AFB Bird Strikes, 1971-1974

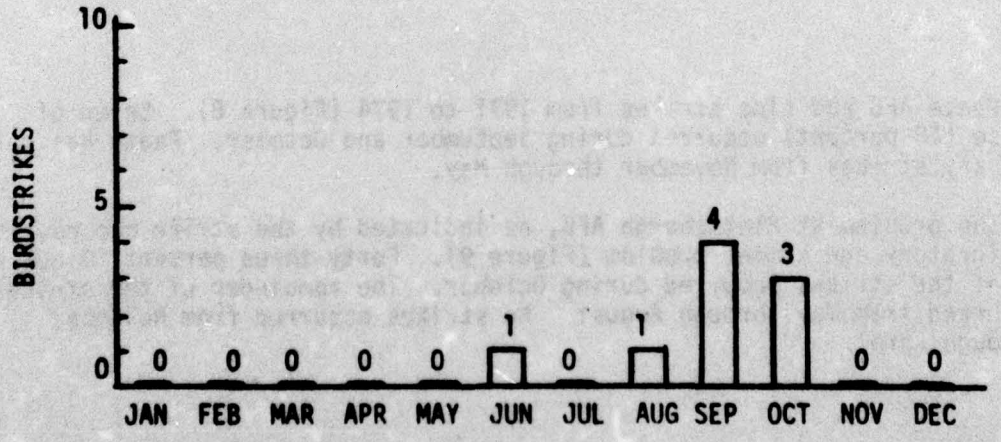

Figure 8. Pease AFB Bird Strikes, 1971-1974

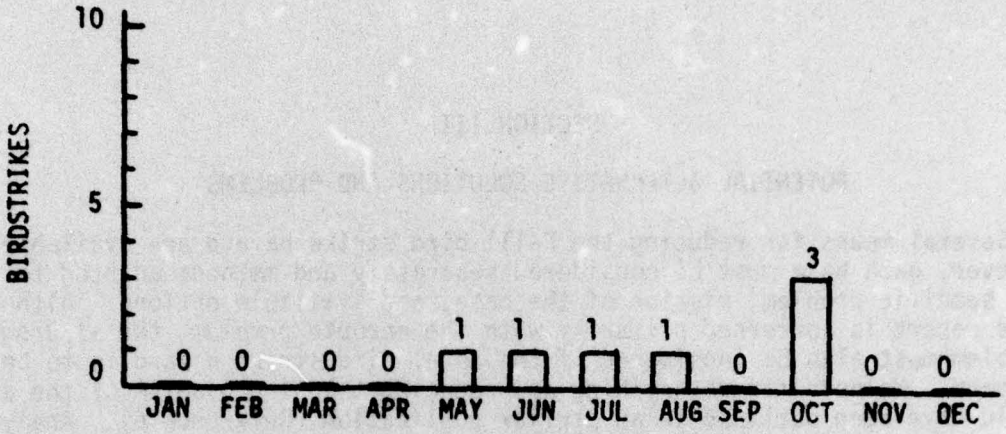

Figure 9. Plattsburgh AFB Bird Strikes, 1971-1974

From the limited data available, nearly all the bases have their greatest problem during the fall migratory season. During the months of March through June, few strikes have been recorded (Figure 2). None of the bases have experienced any strikes during December. The three bases, Mountain Home, Pease, and Plattsburgh, located in the northern latitudes, did not record any strikes during the 5-month period from November through March. This may be an indication of reduced numbers of birds and reduced bird activity in the northern latitudes during winter months. Excluding December, Cannon and Nellis experienced strikes over the same 5-month period from November through March. One possible explanation may be that Cannon and Nellis are located within the winter ranges of a great number of species.

Although the problems may be similar at the different bases, it is important that the bird hazards at specific bases and their routes be considered separately due to differences in habitat and species. Because of natural variations in species composition, populations and distribution, all potential hazards should be considered as well as the known problems identified by previous bird strikes.

SECTION III

POTENTIAL ALTERNATIVE SOLUTIONS AND PROBLEMS

Several means for reducing the F-111 bird strike hazard are available; however, each base must be considered separately and methods adapted to the specific problem, mission of the base, and available options. Although this report is concerned primarily with the enroute problem, the airdrome problem must also be considered if the total bird strike hazard is to be reduced. Methods for determining and reducing the bird problem of the airfield have been outlined in an earlier publication (Reference 6). Analysis of the airdrome problem should also include the area surrounding the airfield, especially the approach and departure corridors. Nearly half of all Air Force bird strikes occur within these areas. A thorough knowledge of the birds and potential hazards in the immediate area is necessary to determine effective methods of control. Bird species behavior, quantity, status and relationships to the airfield should be identified. Upon close examination of the problem it may be found that certain changes in flight scheduling or modifications in local traffic patterns would significantly reduce the bird hazards on the airfield from some of the local species.

The enroute problem is generally more serious than the airdrome problem and much more complex. Greater areas must be considered with the potential of more species and greater numbers of birds encountered. Enroute airspeeds are higher, greatly increasing the potential for damage. Species distribution and concentrations within a route will vary with the quantity and quality of specific types of habitat. Environmental, seasonal and biological changes will continually alter the overall situation.

Most bases have a number of routes available that they may fly to accomplish a specific training mission. Each of these routes cross over different geographic regions and habitats exposing aircraft to a variety of bird species and concentrations. Consequently, the potential bird hazards will differ within the respective routes. It is feasible that certain routes may be available that have a lower relative bird hazard during a particular season or as a result of the quality and availability of certain habitats. Aside from some of the more obvious differences in bird hazards among the various routes, a thorough evaluation may be difficult when considering the number of routes, the many variables (habitats, seasons, species, etc.) and the constraints of the flying mission. At most of the F-111/FB-111 bases much of the low-level flying activity terminates at a practice bomb range. Certain of the low-level routes are more convenient for this type of operation and hence are flown more often. For example, during 1974 Cannon flew 16 different routes. Five of the routes (TCC 207, TCS 289, OB 18, FMN 288 and TCC 279) accounted for nearly 80 percent of the total flying. Two of these routes (TCC 207 and TCS 289) accounted for over 60 percent of all flying. If a base has few alternative routes available within relatively confined

geographic regions it will be more difficult to find significant differences in the bird hazards among the various routes.

New low-level routes are becoming more difficult to establish because of the increasing amount of air traffic and more restrictions due to increased environmental concerns and greater dispersal of human populations.

Bird hazard evaluation of low-level routes would have to be considered at each base. In the opinion of the author the potential success of evaluating the bird hazards within each of the individual routes will be complex. Although species and numbers of birds vary depending on the available habitat (Reference 7), each of the low-level routes encompasses so much area that some segments with high concentrations of resident or migrant species will almost always be crossed. Furthermore, the status of bird populations within an area is continually changing throughout the year due to dispersal and migratory movements. Consequently, potential bird hazards are also changing and may be difficult to adapt to.

Detection of hazardous bird concentrations presents another possibility of reducing the enroute bird strike hazard. The use of radar for the detection of birds has been well documented (Reference 8) and its use with respect to reducing bird/aircraft collision hazards has been described (Reference 9). The greatest value of ground based radar would be in detecting migratory bird movements and the intensity of migration, although local movements may be picked up throughout the year. Existing radars would not be very effective in determining enroute bird hazards outside of the migratory season except in a few isolated instances.

Radar detection of birds beyond 10 or 15 miles from the radar antenna is limited to birds flying at altitudes of 1000 to 1500 feet AGL. A high percentage of bird migration occurs between 500 and 1500 feet AGL (References 1 and 2). Consequently, a single radar can provide information on migration occurring within the altitude range of the F-111 for only a small portion of an entire low-level route. Access to a number of radars along the route may be necessary to determine the potential hazard under most circumstances. Each radar site could effectively sample migration within a 25 to 50 nautical mile radius. Provided that an adequate number of radar sites were available along a route, the intensity of migration and potential bird hazards could be accurately determined.

Radar could also prove useful on a short term basis on the airdrome and bombing range environment if flying operations could be adjusted according to the changing levels of migratory activity. Problems may be encountered here, however, due to extensive training commitments. For radar to be effective, flying operations would have to be modified within hazardous areas during times of high bird activity. This would involve operational changes during the spring and fall migratory seasons.

The final consideration is to develop the ability to predict bird movements. If possible, this would give the advantage of allowing time to enable better scheduling of flying operations. Previous studies have already attempted to relate the effects of weather on migration and to predict when migration may occur using general weather patterns and the synoptic weather (References 10 through 20). Most efforts have resulted in indifferent success. The great number of species and many variables tend to make any predictions very complex. For predictions to be manageable, the number of species would have to be limited to not more than one or two particularly hazardous species at each base. Even in studies where only one species has been considered, the accuracy of the prediction has been less than 80 percent (Reference 10). Although reliable predictions of migration would provide important information to help reduce the number of bird/aircraft collisions, it is unlikely predictions could enable more than general warnings of potential migratory activity. The specific times, locations, numbers and altitudes of migrating flocks would also be necessary to successfully divert aircraft from hazardous situations.

The potential success of any of the preceding methods is dependent upon the flexibility of the F-111 flying operations. The flying mission of the F-111 makes it more susceptible to birdstrikes, e.g., high-speed, low altitude flight, high numbers of sorties, takeoffs and landings. Missions are flown during both day and night (16 sorties/day and 8 sorties/night) from about 0900 to 2400 hours each day. 5 days a week, throughout the year. Training schedules require a certain amount of flying to be conducted within a given period of time. All of the available methods discussed require that modifications can be made in the training schedule, e.g., if radar displays heavy migration in an area, flying activities should be reduced or terminated until conditions improve. Similarly, if one route is known to have particularly high bird concentrations during a certain time of the year then flying activities should be reduced or terminated within that route as long as the increased bird hazards exist.

SECTION IV

RECOMMENDATIONS

DISCUSSION

The greatest obstacle to reducing enroute bird hazards at this time appears to be the inflexibility of F-111 flying operations. The question is whether scheduling modifications can be adapted at the F-111 bases without seriously degrading the quality of the training program. Some seasonal adjustment in flying will be necessary if one hopes to significantly reduce bird hazards. F-111 flying activity during the migratory season would have to be adjusted so flights could be directed to routes with lower bird concentrations during times of reduced migratory activity.

Because of the complexity of the problem, a step-wise approach would offer the most effective means for reducing low-level enroute bird hazards. A single F-111 base should be selected as a trial case and enroute bird strike reduction techniques tested and refined. With the experience and success gained at one base, the techniques could then be effectively adapted to the remaining F-111/FB-111 bases. A test base should be selected that has an enroute and airdrome problem involving migratory and local movements of birds. From the data, Cannon AFB, New Mexico, appears to offer the most challenging problem and would be the author's recommendation for the experimental base.

After the overall feasibility of reducing enroute bird strikes has been established and tested at Cannon, the problems at the remaining F-111 bases should be studied, training options and flexibility determined and agreements reached with operations personnel outlining alternative courses of action to reduce bird strikes. A thorough analysis of the bird strike hazard at each of the F-111 bases will be necessary to provide the reliable data to determine the best approach to the problem according to the requirements and available options.

Improvements will be required in the future collection and recording of bird strikes and bird sightings as outlined in Section II. Exact records of species, location, time, and altitude are necessary to enable an accurate evaluation of the problem and to adopt the most effective strike reduction techniques. Complete cooperation will be required from aircrews in order to improve the source of empirical data on bird strikes and sightings on the low-level training routes.

An initial survey to establish local contacts and make preliminary observations of the airdrome and enroute bird hazards should be made by the Air Force Civil Engineering Center Bird/Aircraft Strike Hazard (BASH) Team in cooperation with the U.S. Fish and Wildlife Service and the respective state game and fish departments. Subsequent seasonal surveys

should be made to determine the bird hazards throughout the year. Specific considerations should include the geographic location of the base, topography, land use, location of routes, habitats associated with low-level routes, route usage, characteristics of the base flying mission, the relationship of the base and routes to known migratory flyways, an analysis of the seasonal changes in the numbers of hazardous bird species and populations and the determination of potentially hazardous behavior. Each of the bases should respond with a listing of available resources and the flexibility of their flying operations.

Each base should assume the responsibility for implementing the bird hazard reduction techniques with consulting assistance from the Air Force Civil Engineering Center. These techniques include the use and evaluation of radar to detect bird migration and the determination of scheduling and route changes to coincide with the times and areas of least bird activity.

The relationship of available training routes to habitat, species abundance and occurrence should be studied to determine potential bird hazards and to evaluate the relative hazards on each route. The feasibility of using prediction models to forecast intense migratory activity should be studied to determine the potential effectiveness and practicability for use on an operational level.

The objective of all phases of the study should be to provide flying unit commanders with necessary data and procedures to evaluate potential bird hazards throughout the year. The decision to fly a given route should be based on a combination of empirical data, training requirements and the availability of other flying route options.

SUMMARY

Select one of the five F-111 bases to test and refine enroute bird strike reduction techniques.

Conduct initial and seasonal surveys to obtain a thorough analysis of the bird hazards.

Determine the latitude and flexibility of the flying mission at each base.

Conduct studies of the routes to determine the relationships of habitat to species abundance and occurrence.

Perfect the use of radar to determine migratory bird movements.

Formulate a prediction model to enable forecasting of major migratory movements.

Implement bird strike reduction techniques at the remaining F-111 bases as they are perfected at the test base.

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