BIRDWEIGHT DISTRIBUTION OF LOW-LEVEL BIRDSTRIKES

Jeffrey J. Short, Major, USAFR
WRDC/FIVR
Wright-Patterson AFB, OH 45433

Background

Over 20 percent of all U.S. Air Force (USAF) birdstrikes occur during low-altitude, high speed training flights. These low-level birdstrikes are usually the most damaging in terms of aircraft damage and loss of aircrews. Since 1980, the USAF has lost five aircraft and seven aircrewmen during low-level and range training flights. According to the BASH Team records, the total cost of low-level birdstrikes during the last decade is in excess of $250 million.

Estimating birdstrike risk from bird population data known for a block of airspace is the method used by the USAF Bird Avoidance Model (BAM). Since the birdstrike risk is a function of the number of birds in the volume swept by the of the aircraft, the expected birdstrike rate is readily calculated. Birdstrikes can be avoided by changing the altitude, timing or location of a low-level flight. Simply avoiding bird-aircraft conflicts through better planning the route of flight and through flight schedule changes is an easy and cost-effective method of reducing birdstrike risk. However, collecting the bird census data entered into the BAM is time-consuming and not available for some remote areas, which is where low-level missions are flown.

Predicting birdstrikes is important to the development of aircraft components and systems that can withstand the tremendous impact forces. Mishap data typically provides the basis for determining the expected number of birdstrikes for a new aircraft or an old aircraft flying a new mission; e.g., the conversion of the F-15 from an air defense role to close air support. Once the expected number of birdstrikes has been calculated, the probabilty of damage is determined from the strength distribution of the particular component under investigation and the probable birdweight distribution. Berens et al (1989) provide a good review of the model formulation.

If sufficient birdweight data is available for the aircraft type and mission, then a specific birdweight distribution can be developed. The 4-pound birdweight distribution represents approximately 95 percent of all recorded birdstrikes (pre-1970) which were collected during a joint study by the USAF and the Federal Aviation Agency. Subsequent studies using pre-1981 birdstrike data show basically the same distribution (Figure 1). The 4-pound (1.8 kg) bird is usually considered the design standard for the aircraft structures and transparency systems. Although aircraft engines are designed to continue operation after multiple ingestions of smaller birds, the 4-lb bird is the standard for certain aspects of containment design.

Objective

The objective of this study is to reassess the birdweight distribution for low-level birdstrikes. The USAF Bird-Aircraft Strike Hazard (BASH) Team maintains a damaging and non-damaging birdstrike database containing 21,647 birdstrike records from 1975-89. The BASH Team has accumulated records of nearly 4,500 low-level birdstrikes in their database, most occurring after 1982. Of these, over 711 have been positively identified as to bird species involved in the mishap. Additional information about location, altitude, airspeed, and damage is also available for a large number of these birdstrikes. Analysis of these birdstrikes can update our understanding of the bird threat during low-level missions and to what new directions our "birdproofing" efforts should lie.

Methods

The "identified" low-level birdstrikes were used to generate cumulative birdstrike distributions for the low-level mission. The maximum species weight was calculated for each birdstrike from the average weights provided in Brough (1983) and Dunning (1984). When known, subspecies or gender weights were used. Birdstrikes occurring during range operations were not included.

Cumulative distribution frequencies for low-level birdstrikes were developed for different aircraft and mission. Descriptive statistics were also generated for the low-level birdstrike data from 1982-89. B-52 and F-4 aircraft are compared since they (1) have an extensive low-level flight history, (2) have dissimilar missions, and (3) have experienced a large number of birdstrikes throughout their operational range.

Results and Discussion

The cumulative distribution frequency (CDF) of low-level birdstrikes for all aircraft (Figure 2), where the species is positively identified, is skewed toward heavier birdweights than the 4-pound standard typically used to design bird tolerant aircraft systems. The 95 % intercept is approximately 8-pounds (3.6 kg).

A comparison of Figures 3 and 4 for F-4 (including RF-4 aircraft) and B-52 aircraft, which combined account for 50 % of identified low-level birdstrikes, show that the skew is due primarily to the "bomber" mission. This suggests that the 4-pound bird criteria is still reliable for the "fighter" mission but that the "bomber" mission typically hits larger birds. CDFs for other aircraft (A-10, A-7, F-16, F-15 and C-130) show a distribution closer to the F-4; but, they are not shown here since they each based on less than 100 birdstrike reports. Additional analysis is planned to further characterize the birdweight distribution for specific aircraft and locations.

This increased birdweight distribution could be an artifact of the bias to report birdstrikes that involve the more noticeable, large birds over those "wipe offs" that cause no damage. However, the converse situation may be true for the earlier birdweight distributions (See Figure 1) which may include an inordinately large number of small birds even though they may not be a factor on most low-level missions. In general, throughout the daylight hours, most small (<0.5 kg) birds tend to remain relatively close to the ground unless involved in migration activities. Small birds are not usually a factor for low-level operations unless during migration. Larger birds,

including
frequentl
often put
The
shows the
Fall seem
aircraft
rate each
significa
Fall bird
low-level
exposure
throughou
sizes.

Mont

N
Month
January
February
March
April
May
June
July
August
September
October
November
December

Based on

Note: Per
rounding e

An in
birdstrike
distribute
occur duri
migrationa
(0900-1600
identified
aura), whi
of migrati
As a
spend abou
operations
their over
level trai

including gulls, raptors, waterfowl and some shorebirds frequently use higher altitudes to move to feeding areas which often puts them into the path of low-flying aircraft.

The distribution of low-level birdstrikes by month (Table 1) shows the usual increase in birdstrikes during the Spring and Fall seen worldwide for all aircraft and missions. The F-4 aircraft distribution shows a relatively consistent birdstrike rate each month throughout the year, while the B-52 has more significant low-level birdstrike increases during the Spring and Fall bird migrations. This seems logical since generally B-52 low-level routes are longer, flown at slower airspeeds (i.e., the exposure to birds is greater) and are frequently flown at night throughout the year which would include migrating birds of all sizes.

TABLE 1
Monthly Distribution of Low-level Birdstrikes (1982-89)

N Month	F-4 1588	B-52 1557	All 4494	Identified[1] 711
January	5 %	3 %	4 %	5 %
February	5 %	5 %	4 %	5 %
March	6 %	7 %	7 %	10 %
April	9 %	11 %	9 %	11 %
May	9 %	17 %	11 %	10 %
June	9 %	6 %	7 %	6 %
July	9 %	6 %	8 %	7 %
August	10 %	9 %	10 %	7 %
September	8 %	9 %	12 %	9 %
October	15 %	14 %	15 %	13 %
November	9 %	6 %	8 %	10 %
December	6 %	7 %	6 %	5 %

[1] Based on birdstrikes from (1975-89)

Note: Percentages may not add up to 100 percent due to rounding errors.

An inquiry into the time of day that the low-level birdstrikes occur, shows that B-52 birdstrikes are rather evenly distributed throughout the 24 hours and that most birdstrikes occur during the hour following midnight, the time when migrational activity is high. F-4 birdstrikes peak during midday (0900-1600) and from 2000-2100 hours. Over 64 % of the identified F-4 birdstrikes involve Turkey Vultures (Cathartes aura), while B-52s hit a large (>7.5 pounds or 3.4 kg) percentage of migrating birds (geese, and cranes).

As a rule of thumb, aircraft that fly low-level routes spend about one-third of the flight actually engaged in low-level operations. However, in the case of the B-52, the majority of their overall birdstrike history (55.5 %) occurs during low-level training missions. Over half of all low-level birdstrikes occur at or below 500 feet AGL (Table 2).

TABLE 2
Altitudinal Distribution of Low-level Birdstrikes from 1982-89.

Aircraft	F-4	B-52	All	Identified[1]
N[2]	1226	1249	4049	570
Altitude (ft)				
0- 500	68 %	47 %	56 %	52 %
501-1000	15 %	32 %	28 %	34 %
1001-1500	7 %	5 %	7 %	6 %
1501-2000	4 %	10 %	5 %	4 %
2001-2500	1 %	2 %	1 %	2 %
2501-3000	2 %	2 %	2 %	1 %
Above 3000	3 %	3 %	2 %	<1 %

[1] Based on birdstrikes from (1975-89)
[2] Number of birdstrikes where altitude was reported

Note: Percentages do not necessarily add to 100 percent due to rounding errors.

Conclusions

If the new generation of bombers fly the same type of mission as the B-52, it is likely that they will encounter the same type of bird hazard. This is could have significant implications for design criteria for bird tolerant aircraft systems as well as bird avoidance procedures. While the current design criteria provide an adequate margin of safety for fighter aircraft, they may require reassessment for future upgrades. The 4-pound criteria may not be adequate for the bomber mission which flies on routes or at times when larger birds are encountered. Further analyses are planned to more closely scrutinize the tradeoffs between bird avoidance and bird tolerance.

Literature Cited

Berens, A.P., B.S. West and D.R. Bowman. 1989. A Probabilistic Model for Evaluating Birdstrike Threat to Aircraft Crew Enclosures. UDR-TR-89-92. University of Dayton Research Institute, Dayton OH: 43 pp.

Bowman, D.R. 1989. Birdstrike Probability Program User's Manual. Flight Dynamics Laboratory, Wright Research and Development Center, Air Force Systems Command, Wright-Patterson AFB, OH Technical Report, WRDC-TR-89-3112.

Brough, T. 1983. Average Weights of Birds. Aviation Bird Unit, Worplesdon Laboratory, Ministry of Agriculture, Fisheries and Food, Publication: 133 pp.

Dunning, J.B. 1984. Body Weights of 686 Species of North American Birds. Western Bird Banding Association, Monograph No.1. Eldon Publishing; Cave Creek, AZ: 38 pp.

FIGURE 2

BIRDSTRIKE DISTRIBUTION

ALL AIRCRAFT

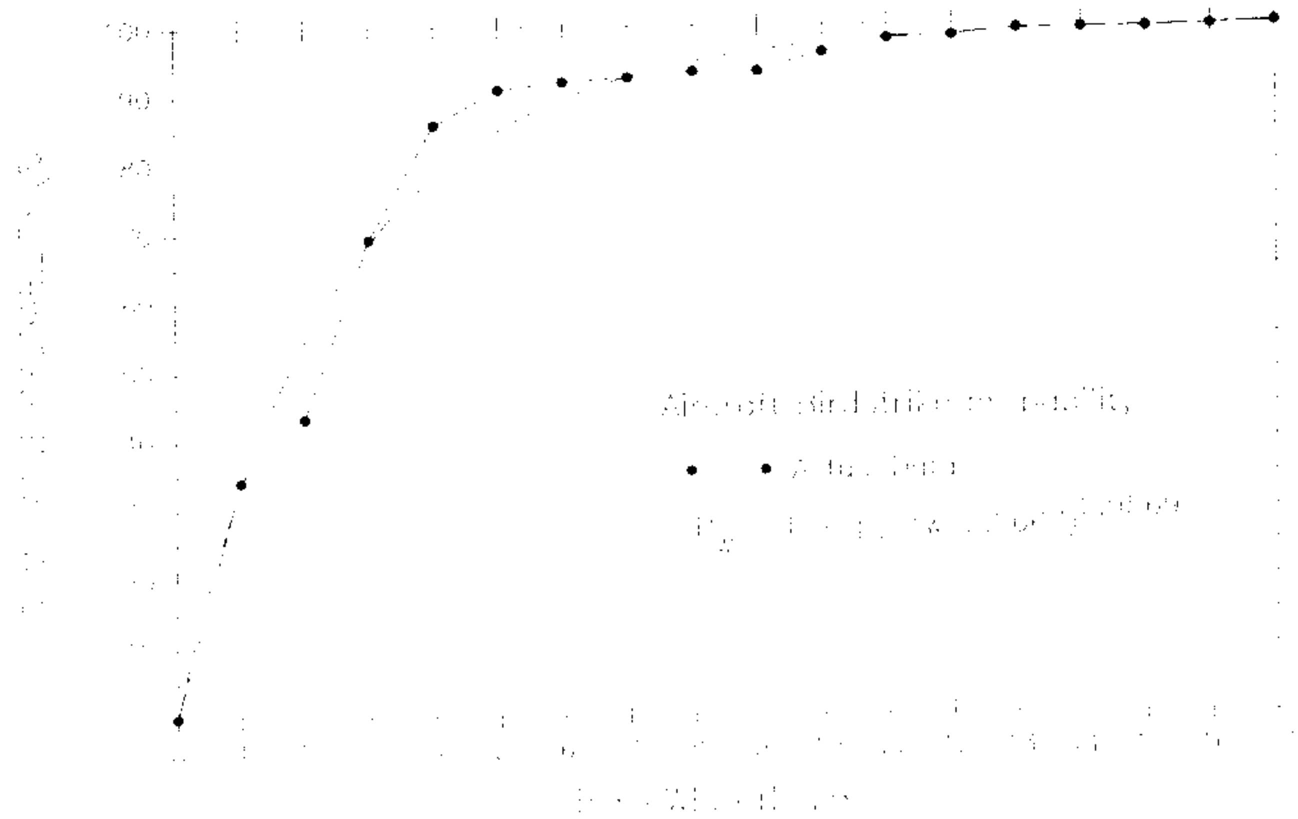

FIGURE 3.

FIGURE 3.

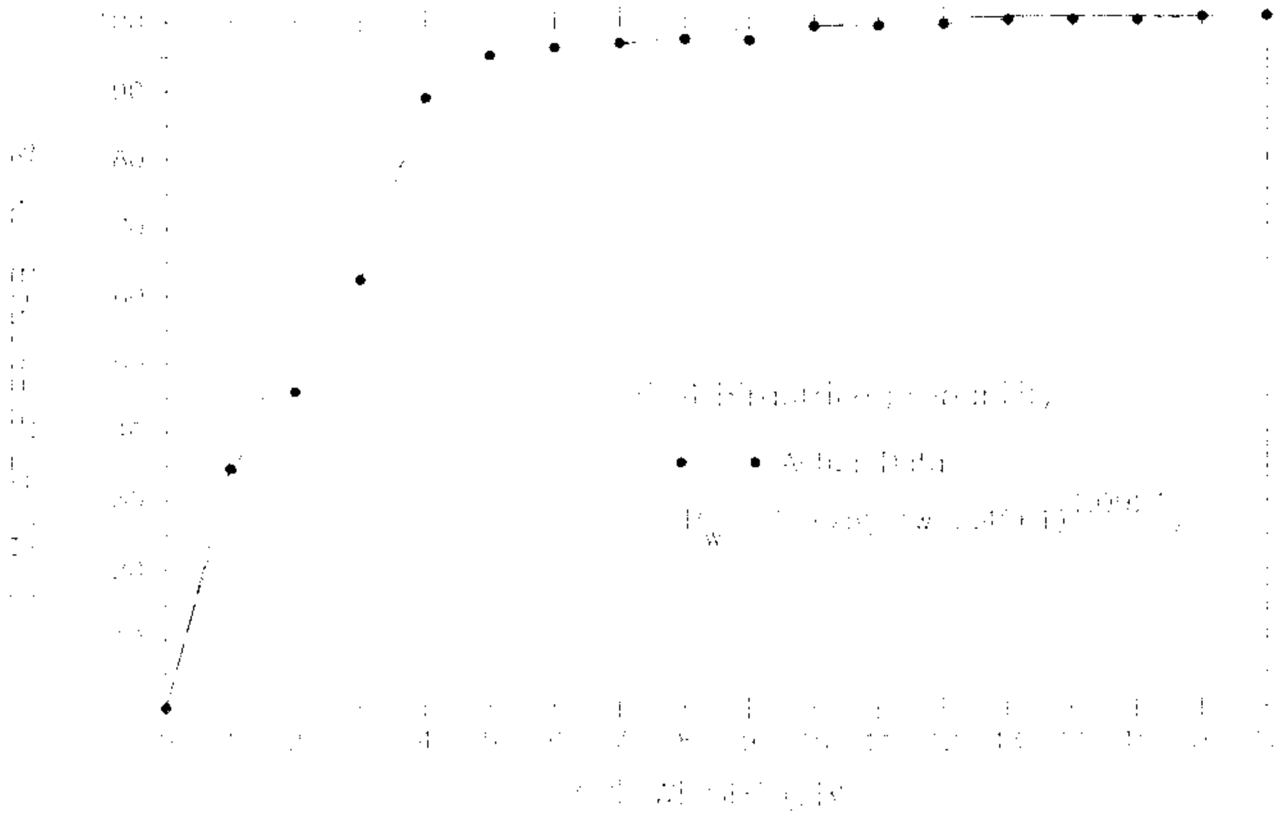

FIGURE 4.

BIRDSTRIKE DISTRIBUTION

B-52 AIRCRAFT