Some bivariate probability models applicable to aircraft collision with birds

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SOME BIVARIATE PROBABILITY MODELS APPLICABLE TO AIRCRAFT COLLISION WITH BIRDS

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SUMMARY

Collisions between aircraft and birds are the subject of growing interest. The uncontrollable nature of those factors which cause these collisions suggests that a probability model might be used to express the relationship between the number of birdstrikes and the number of damage cases and the relationship between the number of birdstrikes and the losses. It is clear that the number of damage cases (Y) and the losses (Z) are both positively correlated with the number of birdstrikes (X). In this investigation, two bivariate probability models will be studied: one for the joint distribution of the number of birdstrikes and the number of damage cases; and one for the joint distribution of the number of birdstrikes and the losses. In both models, the number of birdstrikes X at a certain location during a given time interval is assumed to follow a Poisson distribution with parameter β_1. In the first model, suppose that the variable Y_i assumes the value 1 if the ith aircraft collision with birds is associated with damage case and Y_i assumes the value 0 if the ith aircraft collision with birds is not associated with damage case, and these events occur with probabilities p and q=1-p, respectively. Thus, the variable $Y = Y_1 + Y_2 + \dots + Y_X$ represents the number of damage cases in a total of X aircraft collisions with birds. Clearly, $Y \leq X$, and the bivariate distribution f(x,y) represents the joint distribution of the number of birdstrikes and the corresponding number of damage cases. In the second model, the variable Z_i shall denote the losses in the ith aircraft collision with birds and it may take the values 0,1,2, ... In this case, the Z_i are assumed to follow a Poisson distribution with parameter β_2. Thus, the variable $Z = Z_1 + Z_2 + \dots + Z_X$ represents the losses in X aircraft collisions with birds, and the bivariate distribution g(x,z) represents the joint distribution of the number of aircraft collisions with birds and the corresponding losses. In this paper, the examples illustrating data processing are given where the losses associated with aircraft collisions with birds are expressed in terms of conventional units of the cost.

1. INTRODUCTION

Although birdstrikes are considered to pose one of the major problems to flight safety in the jet age by many aviation experts, the extent to which the problem is taken seriously varies enormously, both in terms of time and in terms of country and company. The relatively low rate of serious birdstrikes in civil aviation might explain why certain organizations, which have probably not suffered any damage or near-accidents for years don't give this subject the priority it deserves. For them it should be worth considering the fact that, despite the difficulty in confirming a birdstrike as the initial cause of an accident and the fairly general reluctance to disclose details about accidents, over 30 crashes of civil aircraft have been reported worldwide due to birdstrikes (Thorpe, 1982).

The above reference serves to illustrate the fact that flight safety is a problem of great importance. Various reasons may explain the widespread reluctance to tackle the birdstrike problem. Firstly, the design of a fully birdproof aircraft seems to be an unattainable ideal, due to engineering and economical constraints, whilst competition among aviation industries may also be a factor. Establishing internationally agreed flight safety requirements is far from easy. The by itself reasonable principle to accept a certain, very limited risk inevitably implies the necessity to reach a consensus on the extent of the acceptable risk. The same applies to flight restrictions to avoid situations of high bird density, especially in military low level training. Appreciable financial repercussions also hamper the implementation of internationally agreed standards for bird control on airfields. Secondly, the birdstrike problem is a very complex one and reflects the diversity and partial unpredictability of nature. As a result the problem can be, and actually is, interpreted in many ways. The same applies to preventive measures. The success of such measures is difficult to quantify, especially because there is usually no comparable situation to serve as reference. In addition, successes tend to be exaggerated while failures often remain undisclosed.

It is not the intention of this paper to review the entire birdstrike problem. Virtually all aspects have been dealt with in the book of Blokpoel (1976). The purpose of the present contribution is to focus attention on the probability models suitable for analysis of birdstrike statistics and the determination of birdstrike risks.

2. THE POISSON-BERNOULLI MODEL

Suppose that the number of aircraft collisions with birds X recorded at a specific location in a given time interval has a Poisson distribution with probability function

$$f_1(x) = e^{-\beta_1}\beta_1^x/x! \ , \ x=0,1,2, \ldots \ . \qquad (1)$$

Let Y_i be an indicator variable associated with ith aircraft collision with birds such that $Y_i=1$ if the ith collision is damage case of aircraft, and $Y_i=0$ if ith collision is no damage case. Further, suppose that the probability function of Y_i is given by

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$$\Pr(Y_i=1) = p \ ,$$
$$\Pr(Y_i=0) = q = 1-p. \tag{2}$$

Also, the total number of damage cases Y among the X aircraft collisions with birds occurring in the jth time interval is

$$Y = Y_1+Y_2+ \dots +Y_X. \tag{3}$$

Thus, if the Y_i are assumed to be mutually independent, then the conditional distribution of Y given that X=x is binomial with parameters x and p. That is,

$$f(y;x) = \binom{x}{y} p^y q^{x-y} \ , \ y=0,1,2, \dots ,x. \tag{4}$$

Hence, the joint distribution of the number of aircraft collisions with birds X and the corresponding number of damage cases Y has probability function

$$f(x,y) = f(y;x)f_1(x) = e^{-\beta_1}\beta_1^x p^y q^{x-y}/(y!(x-y)!),$$
$$x=0,1,2, \dots , \quad y=0,1,2, \dots ,x. \tag{5}$$

From the joint probability function given in (5) two other probability functions of interest may now be derived. The first of these is $f_2(y)$, the marginal probability function of the number of damage cases, given by

$$f_2(y) = \sum_{x=y}^{\infty} f(x,y) = \frac{p^y e^{-\beta_1}}{y!} \sum_{x=y}^{\infty} \frac{\beta_1^x q^{x-y}}{(x-y)!} \tag{6}$$

Upon setting v=x-y, $f_2(y)$ becomes

$$f_2(y) = \frac{p^y e^{-\beta_1}}{y!} \sum_{v=0}^{\infty} \frac{\beta_1^{v+y} q^v}{v!} \tag{7}$$

since $y \leq x$. And hence, it is readily seen that

$$f_2(y) = \frac{e^{-(\beta_1 p)}(\beta_1 p)^y}{y!} \ , \ y=0,1,2, \dots \tag{8}$$

which is the probability function of a Poisson random variable with parameter $\beta_1 p$. The conditional density function of X given Y=y can be found from (5) and (8) to be

$$f(x;y) = f(x,y)/f_2(y) = \frac{e^{-(\beta_1 q)}(\beta_1 q)^{x-y}}{(x-y)!} \ , \ x \geq y, \tag{9}$$

which is the probability function of a Poisson random variable with parameter $\beta_1 q$ which has been translated y units to the right.

2.1 Maximum Likelihood Estimation of the Parameters β_1 and p

Given a bivariate sample $\{(x_j,y_j)\}$, $j=1,2,\ldots,n$ from a Poisson-Bernoulli distribution where x_j is the number of aircraft collisions with birds in the jth time interval and y_j is the number of damage cases of aircraft among the x_j birdstrikes in the jth time interval, the likelihood function L is given by

$$L = \prod_{j=1}^{n} \frac{p^{x_j}(1-p)^{x_j-y_j}e^{-\beta_1}\beta_1^{x_j}}{y_j!(x_j-y_j)!} \tag{10}$$

Upon taking the natural logarithm of L, the log-likelihood function is

$$\ln L = (\ln p)\sum_{j=1}^{n} x_j + \ln(1-p)\sum_{j=1}^{n}(x_j-y_j) - n\beta_1 + (\ln \beta_1)\sum_{j=1}^{n} x_j - \sum_{j=1}^{n}\ln y_j! - \sum_{j=1}^{n}\ln(x_j-y_j)! \;. \tag{11}$$

Differentiating (11) with respect to p gives

$$\frac{\partial \ln L}{\partial p} = \frac{\sum_{j=1}^{n} y_j}{p} - \frac{\sum_{j=1}^{n}(x_j-y_j)}{1-p} \tag{12}$$

and differentiation of (11) with respect to β_1 gives

$$\frac{\partial \ln L}{\partial \beta_1} = -n + \frac{\sum_{j=1}^{n} x_j}{\beta_1} \;. \tag{13}$$

Setting (12) and (13) equal to zero gives rise to the likelihood equations

$$\left.\begin{aligned} \sum_{j=1}^{n} y_j - p\sum_{j=1}^{n} x_j &= 0 \\ n\beta_1 - \sum_{j=1}^{n} x_j &= 0 \end{aligned}\right\} \;. \tag{14}$$

Solution of (14) gives the maximum likelihood estimators

$$\hat{p} = \sum_{j=1}^{n} y_j \Big/ \sum_{j=1}^{n} x_j \tag{15}$$

and

$$\hat{\beta}_1 = \sum_{j=1}^{n} x_j/n \;. \tag{16}$$

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These estimates are identical to those obtained by the method of moments since

$$E(X) = \beta_1 \tag{17}$$

and

$$E(Y) = \beta_1 p. \tag{18}$$

3. THE POISSON-POISSON MODEL

Suppose that the number of aircraft collisions with birds X recorded at a specific location in a given time interval has a Poisson distribution with probability function

$$g_1(x) = e^{-\beta_1}\beta_1^x/x! \ , \ x=0,1,2, \ \dots \ . \tag{19}$$

Let Z_i be a random variable associated with the losses (expressed in terms of conventional units of the cost) resulting from the ith aircraft collision with birds, and suppose that Z_i has a Poisson distribution with parameter β_2; that is,

$$\Pr(Z_i=k) = e^{-\beta_2}\beta_2^k/k! \ , \ k=0,1,2, \ \dots \ . \tag{20}$$

Now if the Z_i are assumed to be mutually independent, then the conditional distribution of

$$Z = Z_1+Z_2+ \ \dots \ +Z_X, \tag{21}$$

the total losses recorded among the X aircraft collisions with birds occurring in the jth time interval, is Poisson with parameter $\beta_2 x$. Thus,

$$g(z;x) = e^{-(\beta_2 x)}(\beta_2 x)^z/z! \ , \ z=0,1,2, \ \dots \ . \tag{22}$$

Hence, the joint distribution of the number of aircraft collisions with birds X and the corresponding losses Z is given by

$$\begin{aligned} g(x,z) &= g(z;x)g_1(x) = e^{-\beta_1}\beta_1^x e^{-(\beta_2 x)}(\beta_2 x)^z/x!z! \\ &= e^{-(\beta_1+\beta_2 x)}\beta_1^x(\beta_2 x)^z/x!z! \ , \\ & \quad x=0,1,2, \ \dots \ , \quad z=0,1,2, \ \dots \ . \end{aligned} \tag{23}$$

Having thus derived the joint distribution $g(x,z)$ of the number of aircraft collisions with birds and the losses in (23), it is desired to find $g_2(z)$, the marginal probability function of the losses, and $g(x;z)$, the conditional probability function of the number of aircraft collisions with birds given the losses. From equation (23), it follows that

$$g_2(z) = \sum_{x=0}^{\infty} g(x,z) = \frac{e^{-\beta_1}\beta_2^z}{z!}\sum_{x=0}^{\infty}\frac{(\beta_1 e^{-\beta_2})^x \, x^z}{x!} = \frac{e^{-(\beta_1-a)}\beta_2^z}{z!}\, m_z(a) \tag{24}$$

where

$$a = \beta_1 e^{-\beta_2} \tag{25}$$

and $m_z(a)$ is the zth crude moment of Poisson distribution with parameter a. This distribution has mean and variance given by

$$E(Z) = \sum_{x=0}^{\infty} \sum_{z=0}^{\infty} z \frac{e^{-\beta_1}\beta_1^x}{x!} \frac{e^{-(\beta_2 x)}(\beta_2 x)^z}{z!} = \sum_{x=0}^{\infty} \beta_2 x \frac{e^{-\beta_1}\beta_1^x}{x!} = \beta_1\beta_2 \tag{26}$$

and

$$\begin{aligned}
\mathrm{Var}(Z) &= \sum_{x=0}^{\infty} \sum_{z=0}^{\infty} z^2 \frac{e^{-\beta_1}\beta_1^x}{x!} \frac{e^{-(\beta_2 x)}(\beta_2 x)^z}{z!} - \beta_1^2\beta_2^2 \\
&= \sum_{x=0}^{\infty} ((\beta_2 x)^2+(\beta_2 x)) \frac{e^{-\beta_1}\beta_1^x}{x!} - \beta_1^2\beta_2^2 \\
&= \beta_2^2(\beta_1^2+\beta_1) + \beta_2\beta_1 - \beta_1^2\beta_2^2 = \beta_1\beta_2(\beta_2+1).
\end{aligned} \tag{27}$$

The conditional probability function $g(x;z)$ can be obtained from (23) and (24) as

$$g(x;z) = g(x,z)/g_2(z) = \frac{e^{-(\beta_1+\beta_2 x)}\beta_1^x(\beta_2 x)^z/x!z!}{e^{-(\beta_1-a)}\beta_2^z m_z(a)/z!} = \frac{e^{-a}a^x x^z}{x!m_z(a)} . \tag{28}$$

3.1 Maximum Likelihood Estimation of the Parameters β_1 and β_2

Given a bivariate sample $\{(x_j,z_j)\}$, $j=1,2, \ldots ,n$, from the Poisson-Poisson distribution,the likelihood function L is written as

$$L = \prod_{j=1}^{n} \frac{e^{-\beta_2 x_j}(\beta_2 x_j)^{x_j} e^{-\beta_1}\beta_1^{x_j}}{x_j!z_j!} . \tag{29}$$

Taking the natural logarithm of L gives

$$\begin{aligned}
\ln L = &-\beta_2 \sum_{j=1}^{n} x_j+(\ln \beta_2) \sum_{j=1}^{n} z_j+ \sum_{j=1}^{n} z_j(\ln x_j)-n\beta_1 \\
&+(\ln \beta_1) \sum_{j=1}^{n} x_j- \sum_{j=1}^{n} \ln x_j!- \sum_{j=1}^{n} \ln z_j! .
\end{aligned} \tag{30}$$

Differentiation of (30) gives

$$\frac{\partial \ln L}{\partial \beta_1} = -n + \sum_{j=1}^{n} x_j/\beta_1 \tag{31}$$

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Solution

$\hat{\beta}_1= \sum_{j=}^{n}$
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$$\frac{\partial \ln L}{\partial \beta_2} = -\sum_{j=1}^{n} x_j + \sum_{j=1}^{n} z_j/\beta_2 \ . \tag{32}$$

Setting the partial derivatives equal to zero gives the likelihood equations

$$\left.\begin{aligned} \sum_{j=1}^{n} x_j - \beta_1 n \quad &= 0 \\ -\beta_2 \sum_{j=1}^{n} x_j - \sum_{j=1}^{n} z_j &= 0 \end{aligned}\right\} \tag{33}$$

Solution of (33) gives the maximum likelihood estimates

$$\hat{\beta}_1 = \sum_{j=1}^{n} x_j/n \tag{34}$$

and

$$\hat{\beta}_2 = \sum_{j=1}^{n} z_j \Big/ \sum_{j=1}^{n} x_j \ . \tag{35}$$

These estimators are identical to those obtained by the method of moments since

$$E(X) = \beta_1 \tag{36}$$

and

$$E(Z) = \beta_1 \beta_2 \ .$$

4. APPLICATION OF THE MODELS TO BIRDSTRIKE DATA

In the present section, the application of both the Poisson-Bernoulli model of section 2 and the Poisson-Poisson model of section 3 to birdstrike data will be discussed. The source of the data is the airports of Latvian SSR. Applying the maximum likelihood estimates of unknown parameters β_1, β_2 and p, the fit of each model to its respective sample for the 153 days and the year 1983 (May-September) was measured using the chi-square goodness-of-fit criterion

$$X^2 = \sum_{\text{all } x,y} \frac{(\text{observed} - \text{expected})^2}{\text{expected}} \ . \tag{37}$$

TABLE 1. Observed and fitted distributions for the number of aircraft collisions with birds and the number of damage cases of aircraft. (Estimated Poisson-Bernoulli frequencies appear in parenthesis.)

Estimated values of the Poisson-Bernoulli parameters:

$$\hat{\beta}_1 = 0.856209$$

$$\hat{p} = 0.053435$$

		Number of damage cases of aircraft (Y)		
		0	1	Total
Number of aircraft collisions with birds (X)	0	69 (64.99)	- -	69 (64.99)
	1	48 (52.67)	3 (2.97)	51 (55.64)
	2	21 (21.34)	2 (2.48)	23 (23.82)
	3	5 (5.77)	1 (1.03)	6 (6.8)
	4	3 (1.17)	1 (0.58)	4 (1.75)
	Total	146 (145.94)	7 (7.06)	153 (153.00)

Value of the chi-square test of fit:

$$X^2_{PB} = 4.03019 \text{ (6 d.f.)}$$

$$Pr(X^2_6 \geq 4.03019) = 0.67.$$

TABLE 2. Observed and fitted distributions for the number of aircraft collisions with birds and the losses which are associated with these collisions and expressed in terms of conventional units of the cost. (Estimated Poisson-Poisson frequencies appear in parenthesis.) .

Estimated values of Poisson-Poisson parameters:

$$\hat{B}_1 = 0.856209$$

$$\hat{B}_2 = 0.053435$$

		Losses associated with aircraft collisions with birds (Z)			
		0	1	2	Total
Number of aircraft collisions with birds (X)	0	69 (64.99)	- -	- -	69 (64.99)
	1	48 (52.75)	3 (2.82)	0 (0.07)	51 (55.64)
	2	21 (21.41)	2 (2.29)	0 (0.12)	23 (23.82)
	3	5 (5.79)	1 (0.93)	0 (0.08)	6 (6.8)
	4	3 (1.18)	1 (0.25)	0 (0.32)	4 (1.75)

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$\hat{B}_1$ = 70.5

$\hat{p}$ = 0.322

5. CONCLUSION

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Total	146 (146.12)	7 (6.29)	0 (0.59)	153 (153.00)

Value of the chi-square test of fit:

$$X^2_{PP} = 6.47818 \text{ (10 d.f.)}$$

$$\Pr(X^2_{10} \geq 6.47818) = 0.77.$$

It will be seen that the agreement between the observed and expected values in each table is quite good.

Note that the Poisson-Bernoulli model is also an appropriate one for analyzing the joint distribution of the total number of birdstrike mishaps and the number of those associated with low-level routes. Observed distribution of birdstrike mishaps and those associated with low-level routes taken from Short (1982) is given below.

TABLE 3. Observed distribution of birdstrike mishaps and those associated with low-level routes

(j)	Total bird strikes (x_j)	Bird strikes along low-level routes (y_j)
January	34	19
February	37	9
March	83	41
April	105	43
May	96	19
June	45	6
July	49	6
August	68	9
September	82	27
October	134	54
November	71	29
December	42	11

Estimated values of the Poisson-Bernoulli parameters:

$$\hat{\beta}_1 = 70.5$$

$$\hat{p} = 0.322695 .$$

5. CONCLUSIONS

Using the maximum likelihood estimates of the parameters β_1, β_2 and p derived in sections 2 and 3, both the Poisson-Bernoulli model and the Poisson-Poisson model were fitted to birdstrike data.

The fit of each of these models to its respective samples was measured by the chi-square test. Based on an examination of the results of these tests, it must be concluded that the Poisson-Bernoulli and Poisson-Poisson models are too simple to describe adequately these types of bivariate data. The present approach to the problem of describing the joint distribution of the number of aircraft collisions with birds and the number of damage cases of aircraft, and the joint distribution of the number of aircraft collisions with birds and the losses, which are associated with these collisions and expressed in terms of conventional units of the cost, is straight-forward and quite basic. Since the distributional assumptions are generally accepted ones, it seems that the weakness of these models lies with the assumption of homogeneity of the data. Throughout this discussion, the data have been treated as having come from a single population. One possible approach to this problem would be to consider separate models for data arising from similar situations. Also separation of the data would permit one to evaluate the effect on the parameters β_1,β_2 and p of such factors as location, time of day, or weather conditions.

This paper (which should be regarded as a sequel to the essay (Nechval, 1987)) deals with the bivariate probability models applicable to the analysis of birdstrike statistics in order to indicate potential possibilities for improvements which may as yet not be sufficiently realized by engineers running test programs or by policy makers formulating requirements on airworthiness.

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1985-19

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Military aircraft. Bird strike analysis, 1985-1986

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MILITARY AIRCRAFT BIRDSTRIKE ANALYSIS - 1985/1986

INTRODUCTION

1. According to the recommendations of the 18th meeting of the Bird Strike Committee Europe (BSCE) the military birdstrike analysis was transferred to the German Military Geophysical Office (GMGO). The countries participating at the Analysis Working Group were requested to send the military statistics directly to the GMGO within 6 months, in the same format as currently used. Nevertheless only three countries contributed data for the years 1985-86 the worst result in reporting over all previous years. The following table shows a record of contributions to analyses since 1979:

	79	80	81	83	86	88
Belgian Air Force (BAF)	X	X	-	-	X	X
Royal Danish Air Force (RDAF)	X	X	X	X	X	-
French Air Force (EMAA)	(X)	-	-	-	-	-
German Air Force (GAF)	X	-	X	X	X	X
Royal Netherlands Air Force (RNLAF)	-	-	-	(X)	(X)	(X)
Royal Norwegian Air Force (RNoAF)	X	-	-	-	-	-
Royal Air Force (RAF)	X	X	X	X	X	X
Swedish Air Force (SAF)	X	-	X	X	X	-
United States Air Force (Europe) (USAF(E))	(X)	X	-	-	-	-
Total	6	4	4	4	5	3

2. Those contributions indicated as (X) denote that they were in an unusable format.

3. The small number of contributions, when compared with the number of countries participating in BSCE, may be attributed to the change of the compiler or may once again indicate that the usefulness of this report in its present format is in doubt. The Analysis Working Group has to decide if the military birdstrike analysis can be improved or should be finished.

BIRD SPECIES

4. Analysis of Tables 1 shows that the birds most commonly involved in strikes are Gulls (Laridae), Swallows/Swifts (Hirundinide/Apodidae), Pigeons (Columbidae) and Lapwing. 25 % of the bird remains belong to gulls, and more than 50 % of all birdstrikes with gulls damaged the aircraft. Nearly 20 % of the bird remains could be identified as swallows resp. swifts, but there is a significant difference in damage (swifts 36 %, swallows 12 %). 11 %

of the bird remains are pigeons with 58 % damage to aircraft. The lapwing showed a decline from 7,8 % (1985) to 4,4 % (1986). 35 % of the bird strikes caused by lapwings damaged the aircraft. Among the less common bird species attention should be directed to buzzards and kites (2.8 % of the bird remains, 77 % with damage), falcons (2 % of the bird remains, 41 % with damage), crows (2-3,5 % of the bird remains, 57 % with damage), and the starling (3,3 % of the bird remains, 29 % with damage). Geese and ducks are the most dangerous bird species. Though involved in strikes only with 2 %, they damaged in 90 % of all cases the aircraft. The figures confirm the tendency of previous years that the heavier birds are more likely to cause damage.

PART OF AIRCRAFT STRUCK AND EFFECTS

5. One aircraft was lost in 1985. Beyond that one minor and three slight injuries of flight crews were registered in 1985-86. Among the parts of the aircraft struck, engines showed a significant increase between 1979-82 but this levelled off in 1983 and reduced in 1984. This level could be maintained in 1985-86. The percentage of windscreens struck was in 1984 at its lowest level since 1979. The years 1985-86 showed again a similar level. The most significant increase of strikes concerned wings and air intakes. Since 1983 the number of strikes increased continously from 12.3 % upto 22.8 % (1986). The reported damage of all other birdstrikes is of minor nature. Birdstrikes causing no damage continoued, as in previous years, to be about 60 % of the totals reported.

6. As the percentage of damages to all parts of aircraft struck by unknown bird species is considerably higher than the damage caused by species identified from bird remains the relation of strikes to the weight categories A - D is doublful. As remains of small birds cannot be found in many cases, the actual percentage of these birds involved in strikes will be much higher than illustrated by tables 2 and 3.

7. Parts of aircraft struck and effects are dppending from the type of aircraft and the air currents around. As these details are not reported in tables 2 and 3, the significance of the two tables is relatively small with regard to constructive measures.

TABLE 1 - BIRD SP

COMMON NAME
Gull (Various)
Swift
Pigeons (Various)
Lapwing
Swallow/Martin
Skylark
Common Gull
Starling
Passeriformes
Black-headed Gull
House Martin
Herring Gull
Chaffinch
Buzzard
Feral Pigeon
Thrush
Crow (Various)
Kestrel
Song Thrush
Woodpigeon
Buzzard (Various)
Partridge
Sparrow
Sparrowhawk
Black Kite
Kite
Rook
Duck
Oystercatcher
Pheasant
Blackbird
Yellowhammer
Pied Wagtail
Swallow
Finch (Various)
Goose
Mallard
Snipe
Cattle Egret
Upland Goose
Shelduck
Hobby
Falcon
Golden Plover
Wader
Stock Dove
G-spotted Woodpecke
House Sparrow

TABLE 1 - BIRD SPECIES

COMMON NAME	LATIN NAME	AVERAGE WEIGHT	CATEGORY	STRIKES (DAMAGE)	% BASED ON 547
Gull (Various)	Laridae	120-1690	B	91 (51)	16,6
Swift	Apus apus	41	A	63 (25)	11,5
Pigeons (Various)	Columbidae	40-465	A/B	45 (31)	8,2
Lapwing	Vanellus vanellus	215	B	43 (13)	7,8
Swallow/Martin	Hirundinidae	13-19	A	29 (4)	5,3
Skylark	Alauda arvensis	39	A	24 (2)	4,3
Common Gull	Larus canus	420	B	20 (8)	3,6
Starling	Sturnis vulgaris	80	A	19 (7)	3,4
Passeriformes	-	6-1105	A/B	17 (5)	3,1
Black-headed Gull	Larus ridibundus	275	B	16 (5)	2,9
House Martin	Delichon urbica	17	A	15 (2)	2,7
Herring Gull	Larus argentatus	1020	B	12 (10)	2,2
Chaffinch	Fringilla coelebs	23	A	11 (1)	2,0
Buzzard	Buteo buteo	800	B	9 (9)	1,6
Feral Pigeon	Columba livia var	393	B	9 (3)	1,6
Thrush	Turdidae	67-131	A/B	9 (1)	1,6
Crow (Various)	Corvidae	234-1105	B	8 (6)	1,4
Kestrel	Falco tinnunculus	204	B	8 (2)	1,4
Song Thrush	Turdus philomelos	73	A	8 (1)	1,4
Woodpigeon	Columba palumbus	465	B	7 (3)	1,2
Buzzard (Various)	Buteo sp	785-1350	B	7 (3)	1,2
Partridge	Perdix perdix	400	B	5 (2)	0,9
Sparrow	Passer sp	20-32	A	5 (1)	0,9
Sparrowhawk	Accipiter nisus	190	B	4 (0)	0,7
Black Kite	Milvus migrans	780	B	3 (3)	0,5
Kite	Milvus sp	240-1020	B	3 (2)	0,5
Rook	Corvus frugilegus	430	B	3 (2)	0,5
Duck	Anatidae	324-2040	B/C	3 (2)	0,5
Oystercatcher	Haematopus ostralegus	500	B	3 (1)	0,5
Pheasant	Phasianus colchicus	1100	B	3 (0)	0,5
Blackbird	Turdus merula	106	A	3 (0)	0,5
Yellowhammer	Emberiza citrinella	27	A	3 (0)	0,5
Pied Wagtail	Motacilla alba	23	A	3 (0)	0,5
Swallow	Hirundo rustica	19	A	3 (0)	0,5
Finch (Various)	Fringillidae	20-30	A	3 (0)	0,5
Goose	Anser sp.	1300-3600	B-D	2 (2)	0,4
Mallard	Anas platyrhynchos	1080	B	2 (1)	0,4
Snipe	Gallinago gallinago	125	B	2 (0)	0,4
Cattle Egret	Bubulcus ibis	345	B	1 (1)	0,2
Upland Goose	Chloephaga picta	4000	D	1 (1)	0,2
Shelduck	Tadorna tadorna	1080	B	1 (1)	0,2
Hobby	Falco subbuteo	200	B	1 (1)	0,2
Falcon	Falconidae	105-1300	A/B	1 (1)	0,2
Golden Plover	Pluvialis apricaria	185	B	1 (1)	0,2
Wader	-	22-770	A/B	1 (1)	0,2
Stock Dove	Columba oenas	345	B	1 (1)	0,2
G-spotted Woodpecker	Dendrocopus major	80	A	1 (1)	0,2
House Sparrow	Passer domesticus	18	A	1 (1)	0,2

TABLE 1 - BIRD SPECIES (cont'd)

COMMON NAME	LATIN NAME	AVERAGE WEIGHT	CATEGORY	STRIKES (DAMAGE)	% BASED ON 547
Tufted Duck	Aythya fuligula	740	B	1 (0)	0,2
Hawk	Accipitridae	150-1026	B	1 (0)	0,2
Curlew	Numenius arquata	770	B	1 (0)	0,2
Redshank	Tringa totanus	130	B	1 (0)	0,2
Sanderling	Calidris alba	57	B	1 (0)	0,2
Dunlin	Calidris alpina	50	A	1 (0)	0,2
Lesser B-backed Gull	Larus fuscus	1080	B	1 (1)	0,2
L-eared Owl	Asio otus	273	B	1 (0)	0,2
Tawny Owl	Strix aluco	480	B	1 (0)	0,2
Carrion Crow	Corvus corone	530	B	1 (0)	0,2
Redwing	Turdus iliacus	67	A	1 (0)	0,2
Meadow Pipit	Anthus pratensis	18	A	1 (0)	0,2
Willow Warbler	Phylloscopus trochilus	10	A	1 (0)	0,2
Gold Finch	Carduelis carduelis	16	A	1 (0)	0,2

Notes:

1.1 Bird weight and Latin names can be obtained from Average Bird Weights by T. Brough, July 1983. Unless there is positive evidence to the contrary, the AVERAGE weight should be assumed.

1.2 The bird Categories based on current Civil Airworthiness requirements are:-
CAT A below .11 kg ($\frac{1}{4}$ lb)

CAT B .11 kg to 1.81 kg ($\frac{1}{4}$ lb)

CAT C over 1.81 kg to 3.63 kg (4 lb to 8 lb)

CAT D over 3.63 kg (8 lb)

1.3 Those birds not positively identified should be tabled as unknown.

1.4 Large (CAT C or D) birds are often not positively identified, but the Category these are assumed to be in should be stated.

1.5 Percentages should be based on the total of identified birds.

TABLE 1 - BIR

COMMON NAME
Gull (Variou
Swift
Pigeons (Var
Swallow/Mart
Passeriforme
Lapwing
Herring Gull
Black-headed
Starling
Skylark
Crow (Various
House Martin
Feral Pigeon
Chaffinch
Common Gull
Kestrel
Buzzard
Oystercatcher
Swallow
Buzzard (Vari
Woodpigeon
Duck
Rook
Thrush
Golden Plover
Falcon
Reed Bunting
Goose
Mallard
Partridge
Song Thrush
Yellowhammer
Tree Sparrow
Pheasant
Blackbird
Meadow Pipit
Sparrow
Greylag Goose
Gannet
Stork
Linnet
Lesser B-backed
Grey Plover
Snipe
Fieldfare
Black Redstart
Great Tit
Corn Bunting
Sparrowhawk
House Sparrow

BASED N 547
0,2
0,2
0,2
0,2
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0,2
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0,2
0,2
0,2
0,2
0,2
0,2

TABLE 1 - BIRD SPECIES

COMMON NAME	LATIN NAME	AVERAGE WEIGHT	CATEGORY	STRIKES (DAMAGE)	% BASED ON 458
Gull (Various)	Laridae	120-1690	B	82 (50)	17,9
Swift	Apus Apus	41	A	54 (17)	11,8
Pigeons (Various)	Columbidae	40-465	A/B	36 (21)	7,9
Swallow/Martin	Hirundinidae	13-19	A	30 (4)	6,5
Passeriformes	-	6-1105	A/B	22 (7)	4,8
Lapwing	Vanellus vanellus	215	B	20 (9)	4,4
Herring Gull	Larus argentatus	1020	B	16 (11)	3,5
Black-headed Gull	Larus ridibundus	275	B	15 (4)	3,3
Starling	Sturnus vulgaris	80	A	15 (3)	3,3
Skylark	Alauda arvensis	39	A	14 (1)	3,1
Crow (Various)	Corvidae	234-1105	B	11 (7)	2,4
House Martin	Delichon urbica	17	A	10 (1)	2,2
Feral Pigeon	Columba livia var	393	B	9 (4)	2,0
Chaffinch	Fringilia colebs	23	A	9 (0)	2,0
Common Gull	Larus canus	420	B	8 (3)	1,7
Kestrel	Falco tinnunculus	204	B	8 (3)	1,7
Buzzard	Buteo buteo	800	B	7 (6)	1,5
Oystercatcher	Haematopus ostralegus	500	B	7 (2)	1,5
Swallow	Hirundo rustica	19	A	7 (0)	1,5
Buzzard (Various)	Buteo sp	785-1350	B	6 (5)	1,3
Woodpigeon	Columba palumbus	465	B	6 (3)	1,3
Duck	Anatidae	324-2040	B/C	5 (5)	1,1
Rook	Corvus frugilegus	430	B	5 (1)	1,1
Thrush	Turdidae	67-131	A/B	5 (1)	1,1
Golden Plover	Pluvialis apricaria	185	B	4 (3)	0,9
Falcon	Falconidae	105-1300	A/B	4 (2)	0,9
Reed Bunting	Emberiza schoeniclus	20	A	4 (1)	0,9
Goose	Anser sp	1300-3600	B-D	3 (3)	0,7
Mallard	Anas platyrhynchos	1080	B	3 (3)	0,7
Partridge	Perdix perdix	400	B	3 (1)	0,7
Song Thrush	Turdus philomelos	73	A	3 (1)	0,7
Yellowhammer	Emberiza citrinella	27	A	3 (1)	0,7
Tree Sparrow	Passer montanus	20	A	3 (0)	0,7
Pheasant	Phasianus colchicus	1100	B	2 (0)	0,4
Blackbird	Turdus merula	106	A	2 (0)	0,4
Meadow Pipit	Anthus pratensis	18	A	2 (0)	0,4
Sparrow	Passer sp	20-32	A	2 (0)	0,4
Greylag Goose	Anser anser	3325	C	1 (1)	0,2
Gannet	Sula bassana	2900	C	1 (1)	0,2
Stork	Ciconia ciconia	3400	C	1 (0)	0,2
Linnet	Carduelis cannabina	19	A	1 (0)	0,2
Lesser B-backed Gull	Larus fuscus	820	B	1 (0)	0,2
Grey Plover	Pluvialis squatarola	200	B	1 (0)	0,2
Snipe	Gallinago gallinago	125	B	1 (0)	0,2
Fieldfare	Turdus pilaris	99	A	1 (0)	0,2
Black Redstart	Phoenicurus ochruros	16	A	1 (0)	0,2
Great Tit	Parus major	19	A	1 (0)	0,2
Corn Bunting	Emberiza calandra	48	A	1 (0)	0,2
Sparrowhawk	Accipiter nisus	190	B	1 (0)	0,2
House Sparrow	Passer domesticus	18	A	1 (0)	0,2

TABLE 2 PART OF AIRCRAFT STRUCK

1985

PART	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON 1866
Nose (excluding radome and windscreen)	147	45	69	-	261	14,0
Radome	83	11	28	-	122	6,5
Windscreen	209	62	40	-	311	16,7
Fuselage (excluding the above)	109	22	58	-	189	10,1
Engine:-						
1 engine struck	157	60	101	-	318	17,0
2 out of 3 struck	-	-	-	-	0	0
2 out of 4 struck	1	1	-	-	2	0,1
3 out of 4 struck	-	-	-	-	0	0
all struck (on multi-engined aircraft)	1	1	2	-	4	0,2
Wing + Air Intakes	244	50	89	1	384	20,6
Rotor/Propeller	11	16	28	-	55	3,0
Landing Gear	19	11	23	-	53	2,8
Empennage	27	-	13	-	40	2,1
Underwing Stores/Tanks	68	4	26	-	98	5,3
Part Unknown	18	5	6	-	29	1,6
Total	1094	288	483	1	1866	100

Notes:

2.1 The Total in Table 2 and 3 may be higher than other tables, as one bird can strike several parts.

2.2 The percentages should be based on incidents where the part struck is known.

2.3 Multiple strikes should be counted as one strike, unless for example both wings or both landing gears are struck, when two incidents should be recorded.

TABLE 2 PART

Part
Nose (excludin and windscreen
Radome
Windscreen
Fuselage (excl
Engine: -
1 engine str
2 out of 3 st
2 out of 4 st
3 out of 4 st
all struck (o engined air
Wing + Air Inta
Rotor/Propeller
Landing Gear
Empennage
Underwing Store
Part Unknown
Total

Notes:

2.1 The Total i
can strike

2.2 The percent
known.

2.3 Multiple st
both wings
be recorded

BASED 1866
14,0
6,5
16,7
10,1
17,0 0 0,1 0 0,2
20,6
3,0
2,8
2,1
5,3
1,6
00

TABLE 2 PART OF AIRCRAFT STRUCK 1986

Part	WEIGHT UNKNOWN	CAT A	CAT B	CAT C & D	TOTAL	% BASED ON 1372
Nose (excluding radome and windscreen)	95	34	42	1	172	12,5
Radome	64	8	21	1	94	6,9
Windscreen	140	30	26	-	196	14,3
Fuselage (excluding the above)	89	25	44	-	158	11,5
Engine: -						
1 engine struck	107	27	63	-	197	14,4
2 out of 3 struck	-	-	-	-	0	0
2 out of 4 struck	-	-	1	-	1	0,1
3 out of 4 struck	-	-	-	-	0	0
all struck (on multi-engined aircraft)	2	-	3	-	5	0,4
Wing + Air Intakes	187	31	93	2	313	22,8
Rotor/Propeller	14	7	15	-	36	2,6
Landing Gear	22	6	19	-	47	3,4
Empennage	20	5	14	-	39	2,8
Underwing Stores/Tanks	54	-	13	-	67	4,9
Part Unknown	28	11	8	-	47	3,4
Total	822	184	362	4	1372	100

Notes:

2.1 The Total in Table 2 and 3 may be higher than other tables, as one bird can strike several parts.

2.2 The percentages should be based on incidents where the part struck is known.

2.3 Multiple strikes should be counted as one strike, unless for example both wings or both landing gears are struck, when two incidents should be recorded.

TABLE 3 EFFECT OF STRIKE

1985

EFFECT	WEIGHT UNKNOWN	CAT A	CAT B	CAT C	CAT D	TOTAL	% BASED ON 1357
Loss of Life/Aircraft	-	-	1	-	-	1	0,1
Flight Crew Injury							
Major	-	-	-	-	-	0	0
Minor	-	-	-	-	-	0	0
Slight	-	-	2	-	-	2	0,1
Engine damage requiring repair:-							
on single engined aircraft	16	11	23	-	-	50	3,6
1 on a 2 engined aircraft	29	7	29	-	-	65	4,7
2 " 3 " "	-	-	-	-	-	0	0
1 " 4 " "	2	1	4	-	-	7	0,5
2 " 3 " "	-	-	-	-	-	0	0
2 " 4 " "	-	-	-	-	-	0	0
3 " 4 " "	-	-	-	-	-	0	0
all engines on a multi	-	-	-	-	-	0	0
Windscreen Cracked/Broken	13	3	10	-	-	26	1,9
Radome Changed	14	-	12	-	-	26	1,9
Deformed Structure	42	2	44	-	-	88	6,4
Skin Torn	*46*	*4*	*24*	-	-	*74*	*5,4*
Skin Dented	79	12	35	1	.	127	9,3
Propeller/Rotor Demaged	-	-	4	-	-	4	0,3
Aircraft System Lost	1	-	2	-	-	3	0,2
Underwing Stores/Tanks damaged	35	1	18	-	-	54	3,9
Miscellaneous	9	3	6	-	-	18	1,3
Nil Damage	506	158	159	-	1	824	60,6
Unknown	7	-	5	-	-	12	-
TOTAL	799	202	378	1	1	1381	100,2

Notes:-

3.1 Multiple strikes should be counted as one strike, unless for example both wings are damaged, or both windscreens are broken, in which case two incidents should be recorded.

3.2 Definition of Injury requiring medical treatment:
Major - causing absence of 21 days or over
Minor - causing absence of 7 to 21 days
Slight - injury not in above 2 categories.

3.3 Injuries as a consequence of a strike, e.g. ejection injuries should be included

3.4 Aircraft system lost includes for example electrical, hydraulic, brake, air conditioning, de-icing.

TABLE 3 EFFEC

EFFEC
Loss of Life/A
Flight Crew In
Major
Minor
Slight
Engine damage r
repair:-
on single eng
1 on a 2
1 " 3
1 " 4
2 " 3
2 " 4
3 " 4
all engines c
Windscreen Cra
Radome Changed
Deformed Struct
Skin Torn/light
Skin Dented
Propeller/Rotor
Aircraft System
Underwing Store damaged
Miscellaneous
Nil Damage
Unknown
TOTAL

Notes:

3.1 Multiple s
are damage
be recorde

3.2 Definition
Major -
Minor -
Slight -

3.3 Injuries a

3.4 Aircraft s
brake, air

Military

TABLE 3 EFFECT OF STRIKE

1986

EFFECT	WEIGHT UNKNOWN	CAT A	CAT B	CAT C	CAT D	TOTAL	% BASED ON 1225
Loss of Life/Aircraft	-	-	-	-	-	0	0
Flight Crew Injury							
Major	-	-	-	-	-	0	0
Minor	-	-	1	-	-	1	0,1
Slight	1	-	-	-	-	1	0,1
Engine damage requiring repair:-							
on single engined aircraft	24	7	16	-	-	47	3,8
1 on a 2 " "	20	4	19	3	-	46	3,7
1 " 3 " "	-	-	-	-	-	0	0
1 " 4 " "	-	-	1	-	-	1	0,1
2 " 3 " "	-	-	-	-	-	0	0
2 " 4 " "	-	-	-	-	-	0	0
3 " 4 " "	-	-	-	-	-	0	0
all engines on a multi	-	-	1	-	-	1	0,1
Windscreen Cracked/Broken	19	-	9	-	-	28	2,3
Radome Changed	12	-	8	-	-	20	1,6
Deformed Structure	21	2	23	1	-	47	3,8
Skin Torn/light glass broken	36	2	25	4	-	67	5,5
Skin Dented	101	12	39	2	-	154	12,6
Propeller/Rotor Damaged	1	-	2	-	-	3	0,2
Aircraft System Lost	2	-	4	1	-	7	0,6
Underwing Stores/Tanks damaged	21	1	7	-	-	29	2,4
Miscellaneous	5	-	-	-	-	5	0,4
Nil Damage	496	142	129	1	-	768	62,7
Unknown	-	-	-	-	-	-	-
TOTAL	759	170	284	12	-	1225	100

Notes:

3.1 Multiple strikes should be counted as one strike, unless for example both wings are damaged, or both windcreens are broken, in which case two incidents should be recorded.

3.2 Definition of Injury requiring medical treatment:
Major - causing absence of 21 days or over
Minor - " " of 7 to 21 days
Slight - injury not in above 2 categories.

3.3 Injuries as a consequence of a strike, e.g. ejection injuries should be included

3.4 Aircraft system lost includes for example electrical, hydraulic, brake, air conditioning, de-icing.

Measures to minimize bird hazard at low level

(J. Becker, Germany)

Summary

The Bird Movement Working Group (BMWG) shall develop preventive measures to minimize the bird hazard to low flying aircraft.

A survey of the existing procedures for military low level flights was given during two meetings "Bird Hazard at Low Level". The participants emphasized the necessity of regular radar observations, standardized birdstrike warnings (BIRDTAM) as well as standing procedures for the flying units. They recommended the improvement and standardization of the existing procedures, and the distribution of all information concerning large-scale bird movements of medium and high intensities beyond national borders.

1. Introduction

According to the recommendations of BSCE 18, Copenhagen, the Bird Movement Working Group (BMWG) shall develop preventive measures to minimize the bird hazard to low flying aircraft. During two meetings "Bird Hazard at Low Level" held at the German Military Geophysical Office (GMGO), Traben-Trarbach/FRG, November 24-26, 1986, and September 09-11,1987 participants from Belgian Air Force (BAF), Canadian Forces in Europe (CFE), German Air Force (GAF), Royal Air Force in Germany (RAFG), Royal Netherlands Air Force (RNLAF), and United States Air Force in Europe (USAFE) discussed the existing procedures, and emphasized the significance of standardized observations and warnings with regard to permanent and temporary bird concentrations.

2. Information available on bird concentrations and bird movements

Bird concentration areas with high numbers of breeding, resting or wintering species are generally well known and specified in bird hazard maps based on the results of the BMWG. The maps are published in the national AIPs, and pilots are strongly advised not to cross these areas below 1000 ft AGL. A first attempt of standardization was the map "Birdstrike Danger Areas Europe" issued by the GMGO in 1979, but the size and the colour of the different areas could not be completely standardized with regard to the average number of birds due to the lack of detailed information for all countries.

When on actual migration, most birds cross large areas at flight levels between 500 and 4000 ft AGL in contrast to their flying at relatively low altitudes during their stay in the concentration areas. According to radar observations bird migration often occurs over a broad front, covering thousands of square kilometers. The birdstrike hazard caused by these large-scale bird movements cannot be described point-like, because it is advancing with the "wave" of migrating birds. This kind of migration gives rise to a temporary birdstrike risk, and can only be detected by a sophisticated observation network.

Continous observations of migrating birds by radar are performed in Denmark, Belgium, The Netherlands, and West Germany. They use different techniques for the identification of bird movements:

- in Denmark 1 radar station is using an electronic countig system for bird echoes ("FAUST"-system). The separation of bird echoes and clutter is imperfect, and the system does not give height information, (see BSCE 8/WP 6-2).

- in Belgium 1 radar station is using an advanced electronic counting system for bird echoes ("BOSS"-system). This system uses an improved altitude discrimination with 4 height layers, and electronic determination of echo strength and density (see BSCE 18/WP 16).

  A 2nd radar station is still using polaroid pictures of the radar screen for the identification of bird movements.

- in The Netherlands 1 radar station is observing bird migratory movements by a sophisticated electronic counting system ("KIEVIT") using the two lowest beams of a 3 D-radar. Clutter and bird echoes are discriminated by two seperate thresholds. However, due to the filter process many birds may eleminate each other when the echo density is too high. Therefore, the system still needs an experienced person to evaluate the figures. In the near future the identification and discrimination of bird echoes will be further improved by a new computer analyses ("ROBIN"-system).

- in the Federal Republic of Germany 10 radar stations are still using the photographic system for the identification of bird movements (see BSCE 18/WP 5). Disadvantages of the photographic system are a loss of information in the video processing as well as the identification and determination of bird echoes by different persons. With regard to the new HADR-System the possibility of a computerized clutter analysis will be tested in the future.

Supplementary information concerning bird migration can be obtained by GCA- and Wx-radar equipments as well as pilot reports and visual observations on aerodromes, but the identification of bird echoes respectively the calibration of bird hazard intensities are relatively difficult.

RAFG can detec
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new US weather
tion and ident
classes of tar
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The visual obs
ding on the si
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is not possibl
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always roughl

The calibratio
different type
make the basis
intensities are

3. The content

Birdstrike warn
flight performa
or transformati
determine the l

RAFG can detect medium to heavy bird movements by the AR 1 Search Radar at altitudes below 1000 ft AGL. Similar observations might be possible on CFE and USAFE aerodromes if a suitable guidance with typical pictures of different bird intensities will be existing.

Weather radars are generally suitable for the detection of bird movements. Good results have been reported from Sweden (see BSCE 11/WP 7) an the USA (see BSCE 18/WP 7). The Weather radar METEOR 200 needs a photographic equipment for the identification of bird echoes. The new US weather radar "NEXRAD" would solve many problems of bird detection and identification. The system can distinguish the different classes of targets and can distinguish birds from weather. Ultimately this system will provide real-time bird hazard warning information on a continent-wide scale.

The visual observation of bird migration is very limited. It is depending on the size, colour and motion of the birds, the contrast to the background, and the visibility. An exact correlation between the number of birds observed and the intensity according to the 0-8 scale is not possible. In Germany visual observations complete the radar network in areas and times without radar observation of birds, but the intensities of bird migration based on visual observations are always roughly estimated.

The calibration and standardization of bird intensities obtained by different types of radar, and by different techniques of identification make the basis of standardized warnings. Exact measurements of bird intensities are still missing.

3. The content and format of birdstrike warnings

Birdstrike warnings should include all information important to safe flight performances, but no information demanding interpretations or transformations to the pilot. The content and format of these warnings determine the liability of the warning. For this reason a format similar to NOTAM is very suitable, even if there are no specific ICAO regulations existing for birdstrike warnings. Meanwhile the ICAO considered a requirement for the introduction of a specific message relating to bird concentrations, possibly a form of NOTAM or BIRDTAM with the abbreviation BIR as a prefix for such messages.

The data important to pilots are specified as follows:

- areas should be well defined by use of GEOREF indicator or geographic coordinates and range,
- bird intensity according to the international 0 to 8 scale, because flight restrictions are depending on bird movement intensities,
- altitudes including the lower and upper limits of birdstrike danger with regard to the bird movement intensity indicated,
- validity as a well defined period between 2 and 4 hrs.

If countries are not able to collect and disseminate all information required they may limit the content of the message to those items known by the issuing station.

In the past the different national formats of birdstrike warnings/birdtam/bird risk warnings/bird migration warnings had differed strongly from each other. Therefore the NATO standardization agreement STANAG 3879 FS had been drawn up with the aim to standardize the procedures for the exchange of information on birdstrike warning to enable operational commanders to reduce the risk of birdstrikes.

Birdstrike warnings will be sent by telex (BFSTA/AFTN) using a format similar to the ICAO format of NOTAM Class I whenever a bird intensity of 5 and greater is present.

According to the proposal of the ICAO an easy recognisable name for the birdstrike warning should be chosen. The well-known name "BIRDTAM" was generally approved by the participants of the meetings as a most clearcut indicator.

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Birdstrike warnings/BIRDTAM are regularly issued by Belgium, Denmark, Germany and The Netherlands. CFE, RAFG and USAFE use the warnings as well for operational purpose.

4. Flight restrictions by birdstrike warnings

As a jet aircraft has a mean speed of 200 m/sec it is nearly impossible for the pilot to avoid a collision if the bird is flying directly in front of him. Therefore flight restrictions are the only possibility to reduce the number of birdstrikes over areas covered by dense bird migration indicated by birdtam.

For the Belgian Air Force (BAF) flight restrictions to jet aircraft are in force if a bird intensity of 5 and greater is present. Flight performances are allowed from 1000 ft above the upper altitude limit and 1000 ft below the lower limit respectively above 5000 ft AGL, if no altitude has been specified. Gunnery ranges are closed at an intensity of 5 or greater.

The German Air Force (GAF) has the following regulations:

- areas with bird intensities 6-8 are completely restricted to jet aircraft.
- areas with bird intensities 4-5 are restricted to jet aircraft except national and NATO exercises as well as take off/landing/touch and go approaches if ATC does not observe any birds. The approach to gunnery ranges is permitted if the bird activity is low over the range area.

For the Royal Air Force in Germany (RAFG) areas with bird intensities 6-8 are completely closed to jet aircraft. At intensity 5 some advisory regulations are existing. Low level flights are also prohibited within 5 NM either side of the coastline and over areas with moderate to high or high birdstrike risk. Beyond that advisory regulations are existing that low flying during 2 hours after sunrise and 1 hour either side of sunset should be avoided.

The Royal Netherlands Air Force (RNLAF) has flight restrictions to jet aircraft at bird intensities 7-8 and advisory regulations at intensities 5-6 northwest of a line Boulogne - Venlo - Hannover - Hamburg. Regulations concerning the flyways through the Wadden Sea are in preparation. The speed of helicopters flying below 600 ft AGL should not exceed 80 kts, if flight restrictions to jet aircraft are in force.

The Canadian Forces in Europe (CFE) restrict low level flying at bird intensities of 5 and greater. The USAFE has no general regulations concerning birdstrike warnings. Flight restrictions in case of high bird activity in certain areas are left to the individual base or local command.

If birdstrike warnings/birdtam are valid before take-off pilots must change in advance their flight schedule to avoid the areas and altitudes with high birdstrike risk. If pilots are just enroute the fixer frequencies can be used for the transmission of warnings, but blocking of the frequency by too many messages must be avoided.

The reduction of speed when there is evidence of a higher than normal birdstrike risk can reduce the impact force of a birdstrike. However, the effect is relatively small, for the minimum speed commensurate with safe operation of the aircraft must be taken into consideration.

4. Recommendations

1. The Bird Movement Working Group (BMWG) has two objectives:
   - knowledge of the flying behaviour of birds in the vicinity of aerodromes/airfields
   - procedures of birdstrike prevention for aircraft flying at low level.

   The fundamental aspects of radarornithology and remote sensing should be left to the Radar Working Group. The operational aspects should be subject of the BMWG.

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2. The calibration and standardization of bird intensities obtained by radar are the basis of standardized warnings. An exchange of radar data should start between the radar stations of Belgium. The Netherlands and NW-Germany. As a second step computer programs for counting birds should be standardized.

3. The existing radar observation network should be extended to GCA-radar (ASR and PAR) whenever possible. For this purpose it must be tested whether the ATC-radar can detect and, in conjunction with PAR-system, determine the height of bird activities. A standard observation and reporting system must be developed that will enable the radar controllers to determine bird intensities and altitudes. Bird observation messages should include date and time of the observation, an estimation of the bird intensity (medium/high) and if possible the altitude of bird migration.

4. The new US weather radar "NEXRAD" should be brought to an operational use also for the observation of bird movements. As soon as NEXRAD will be established at US bases in Germany regulations for the observation of bird movements should be developed.

5. For birdstrike warnings the name "BIRDTAM" should be used by all countries in accordance to the requirement of the Air Navigation Commission of the ICAO. The Military Agency for Standardization (MAS) should also agree to the name "BIRDTAM" in the STANAG 3879 FS.

6. The existing bird hazard maps should be improved with regard to recent knowledge concerning the average numbers of birds in different areas. A periodically updating of the maps will be necessary. More emphasis should be focussed to local bird movements in any way (esp.airfield vicinity maps).

7. Air traffic authorities, flying units, and radar personnel need more information concerning the extent and the fluctuation of the birdstrike risk. They should be convinced by movies and video tapes illustrating the birdstrike hazard in relation to migratory movements of birds.

8. As borders do not stop the bird migration, all countries participating at the meetings of the BSCE are requested to exchange actual data concerning medium and high intensities of bird migration as well as birdstrike warnings (BIRDTAM) in a standardized format via the civil and military ATC-networks.

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(M.ª Jesús Vicent

Spanish birds and their influence on flight and mission planning

(M.ª Jesús Vicente y Clemente Ros, Madrid)