BIRD STRIKE COMMITTEE EUROPE

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GLOBAL STATISTICAL APPROACH TO THE BIRD STRIKE

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ABSTRACT

The multivariate analysis gives more information from the data collected on the reporting form. Several couples of variables are explored. The main factors leading to a strike are the number of hours of flight and the mean speed of the aircraft.

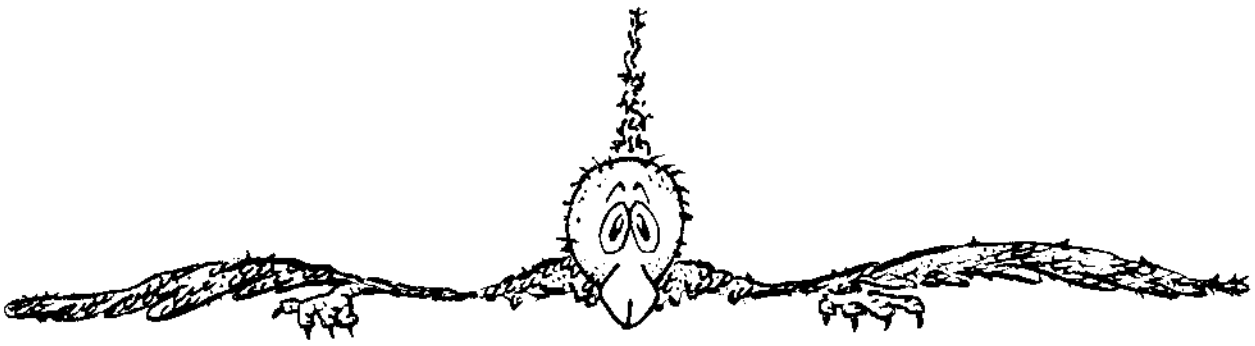
GLOBAL STATISTICAL APPROACH TO THE BIRD STRIKE

Abstract : The multivariate analysis gives more information from the data collected on the reporting form. Several couples of variables are explored. The main factors leading to a strike are the number of hours of flight and the mean speed of the aircraft.

Actions : 1 - In each country, to complete the reporting form with the above data (number of hours and mean speed) and with the number of birds and their time of presence on the territory. This will allow a good prediction of the number of strikes in a year.

2 - To analyze the differencies, if any, between climb and descent.

3 - To use the relationship between main factors to give generality to local experience.

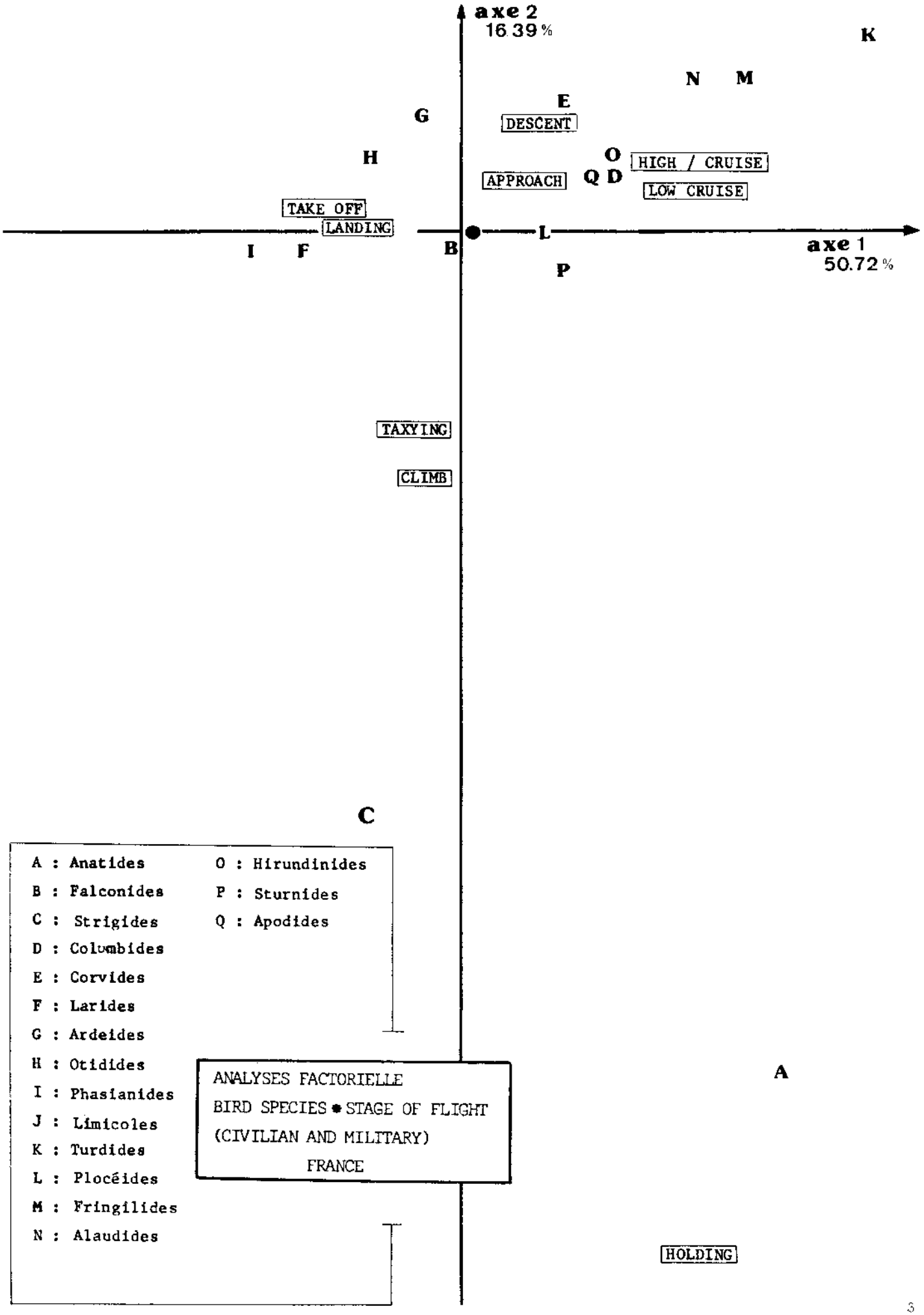


GLOBAL STATISTICAL APPROACH TO THE BIRD STRIKE

Henri CESBRON-LAVAU

OPERATIONAL RESEARCH GROUP OF THE FRENCH AIR FORCE

Link between past - to day's souvenir - and future - to day's dream -, statistics may appear as the holy oracle or the disguise of ignorance. In this paper, we'll first show in which way the dead figures coming out the bird strike reporting form help the souvenir. Then, as the Phenix awaking to life among his ashes, the results will indicate how to dig into a few of future's secrets. As the meaning of statistics is relevant to the existence of a policy, it allows for a choice between alternative proposals.


axe 2
16.39 %
axe 1
50.72 %
K
N
M
E
G
DESCENT
H
O
HIGH / CRUISE
APPROACH
Q
D
LOW CRUISE
TAKE OFF
LANDING
I
F
B
L
P
TAXYING
CLIMB
C
A
HOLDING
A : Anatides
B : Falconides
C : Strigides
D : Columbides
E : Corvides
F : Larides
G : Ardeides
H : Otidides
I : Phasianides
J : Limicoles
K : Turdides
L : Plocéides
M : Fringilides
N : Alaudides
O : Hirundinides
P : Sturnides
Q : Apodides
ANALYSES FACTORIELLE
BIRD SPECIES * STAGE OF FLIGHT
(CIVILIAN AND MILITARY)
FRANCE

I - THE MULTIVARIATE ANALYSIS

Many factors bring about a strike. The usual analyses give the variations of one factor at a time. Other methods (as the multiple regression used further) are bound to a linear model. The originality of the "analyse factorielle" used here, is to give a graphic representation of a double-entry array. There is no presupposed model. The map just brings together the point of a factor (let us say the LARIDES (F) among the bird species) with the points of the other factor (as we see on the graphic BIRD SPECIES ★ STAGE OF FLIGHT, the TAKE OFF and LANDING) which cooccurs the most.

This has been explained in appendix D of BSCE/10 WP/19. Let's have a look at such maps.

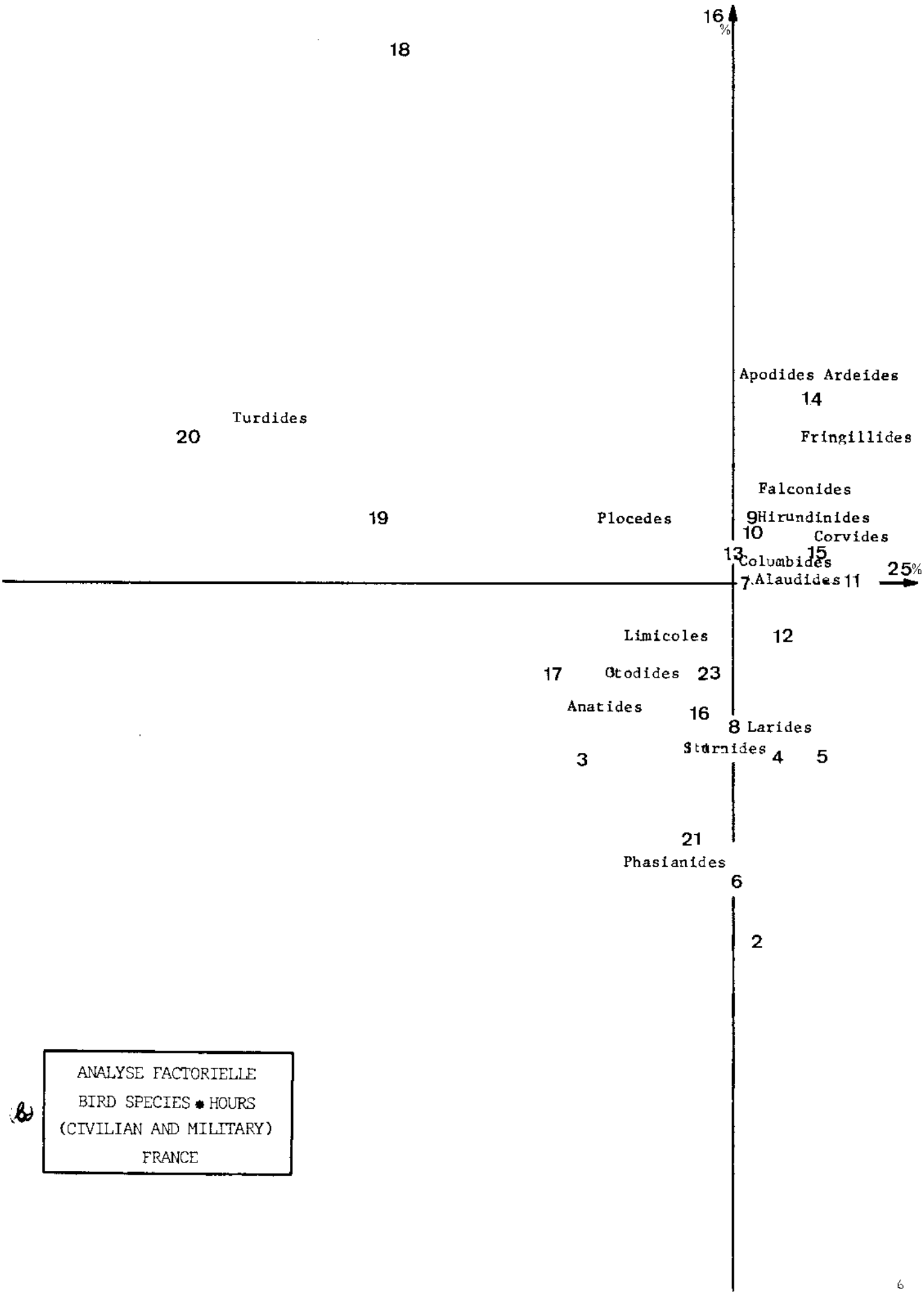
a/ Bird species versus stage of flight

- 17 Bird species
- 9 Stages of flight

The map gives 67,11 % (50,72 + 16,39) of the information from the double entry array. We find near take off and landing, the larides (F), phanisiades (I) and otidides (H). Falconides (O) is near the center. And this means that we find it in most of the stages of flight. On the other hand, Anatides (A) is very far from the center. As it occured very few times, it has not reached a level of statistical significance. This is often the fact of points far from the center. So the points on which we have to draw our attention are the one situated in a medium position. They will give us too the meaning of the axis. And this will bring us to a better understanding of the relationship between the two factors. The first axis has a great importance (50,72 %). It goes from the left to the right through higher altitudes.

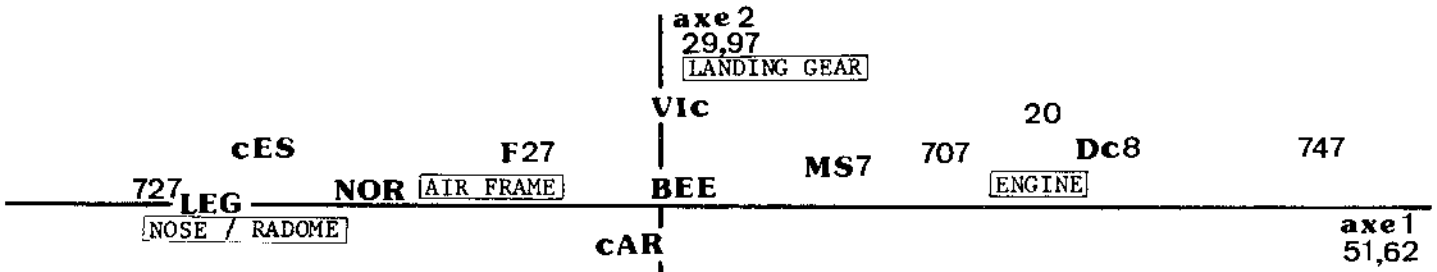
.../...

The altitudes is then the most important factor to determine the type of species. This is not surprising. But the second axis of smaller importance (16,39 %) brings to an unexpected conclusion. Its meaning is from climb to descent. At a given level of altitude (axis 1), the type of bird species is not the same when the plane goes up than when it goes down. This result may be interesting for ornithologists since it gives different behaviours among the species.



ANALYSE FACTORIELLE
BIRD SPECIES * HOURS
(CIVILIAN AND MILITARY)
FRANCE

(b)



AVIONS CIVILS

707 : Boeing 707
727 : Boeing 727
747 : Boeing 747
CAR : Caravelle
F27 : Fokker 27
20 : Mystere 20
BEE : Beeches
DC8 : DC8,DC8F
LEG : Avions légers
AL2 : Alouette 2
DC3 : DC3
FG : Fouga
VAU : Vautour
252 : Nord 252
MET : Météore
VIC : Vicomte
DC1 : DC10
MS7 : Paris (MOR 760)

Dc1

(C) ANALYSE FACTORIELLE
LOCATION OF STRIKE * TYPE OF PLANE
(CIVILIAN)
FRANCE

MISCELLANEOUS

b - Bird species vs hours

The information given by the map is lower : 41 %. No particular direction comes clearly out of the double-entry array.
A meaning of the groups appearing may be given by ornithologists.
For instance the feeding hours are groupped together.

Better analysis may be done if we had the time related to sun rise and sun set.

c - Location of strike vs type of plane (civilian)

- 14 types of planes
- 5 locations of strike

A good information is given here (81 %). Axis 1 shows an opposition between "air frame" and "engine". The Boeing's 727, 707 and 747 are placed along this axis. Which is not surprising.
Besides the high percentage above, the dependency between civilian airplanes and location of strike is not that high. (It is given by the square root of the largest eigen-value of the var-covar Matrix and equals 41%). So, it is mostly given by the first axis. The second axis is due to irregular sample.

This will be improved in the next years, when there will be more reporting forms.

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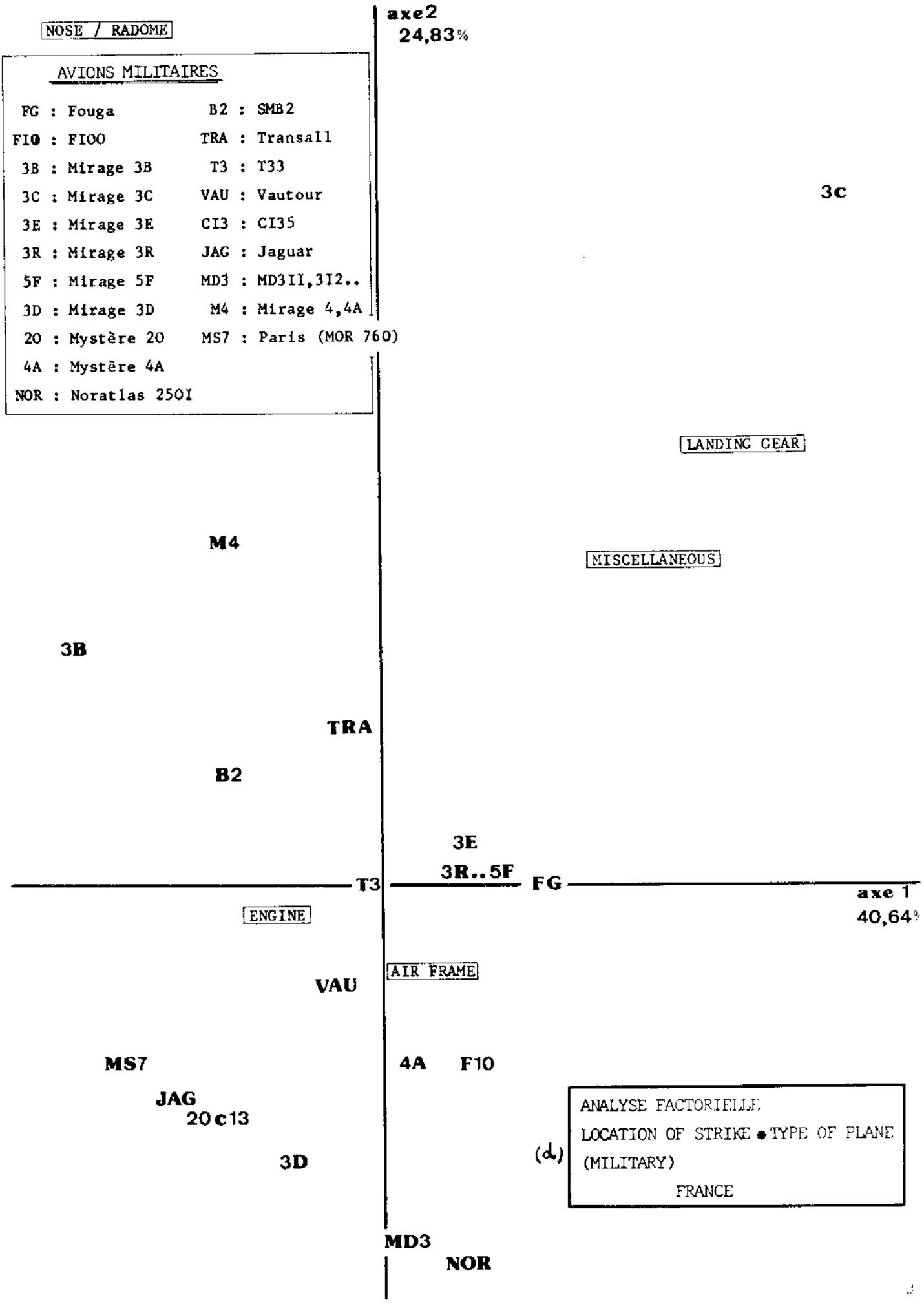
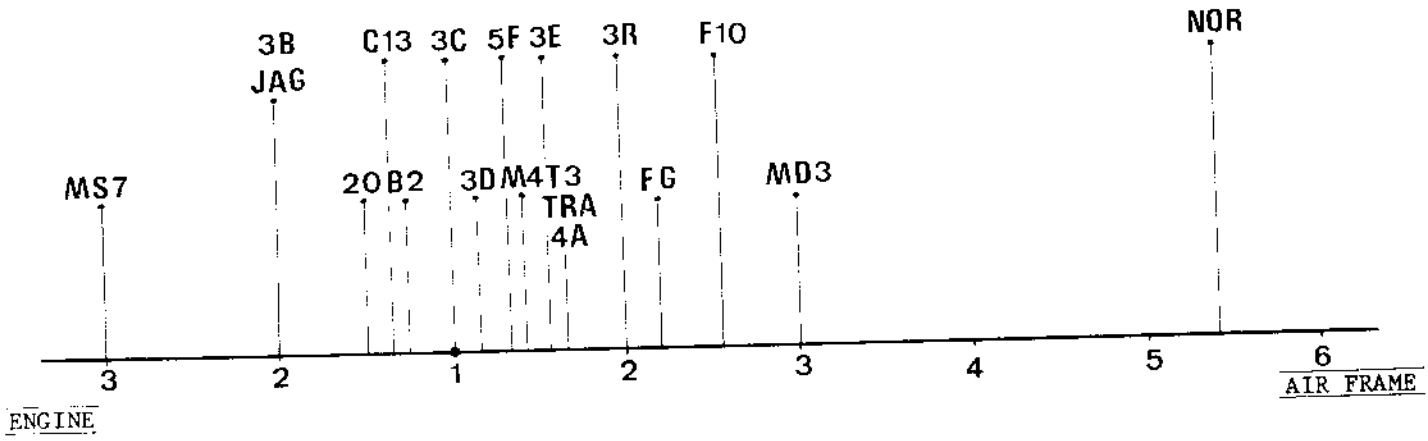
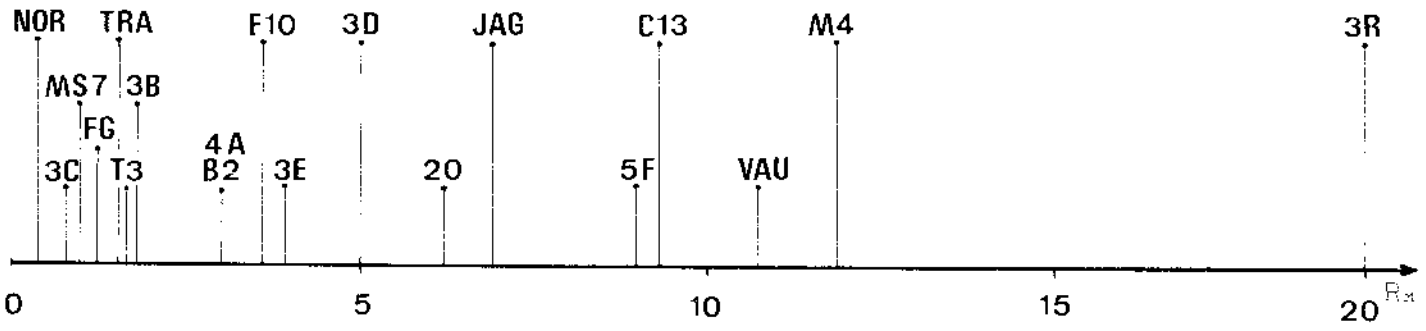

axe2
24,83%
NOSE / RADOME
AVIONS MILITAIRES
FG : Fouga
F10 : F100
3B : Mirage 3B
3C : Mirage 3C
3E : Mirage 3E
3R : Mirage 3R
5F : Mirage 5F
3D : Mirage 3D
20 : Mystère 20
4A : Mystère 4A
NOR : Noratlas 250I
B2 : SMB2
TRA : Transall
T3 : T33
VAU : Vautour
CI3 : CI35
JAG : Jaguar
MD3 : MD3II,3I2..
M4 : Mirage 4,4A
MS7 : Paris (MOR 760)
3c
LANDING GEAR
MISCELLANEOUS
M4
3B
TRA
B2
3E
3R..5F
T3
FG
axe 1
40,64%
ENGINE
AIR FRAME
VAU
MS7
4A
F10
JAG
20
c13
3D
MD3
NOR
ANALYSE FACTORIELLE
LOCATION OF STRIKE * TYPE OF PLANE
(MILITARY)
FRANCE
(d)

(d') (Military airplanes)



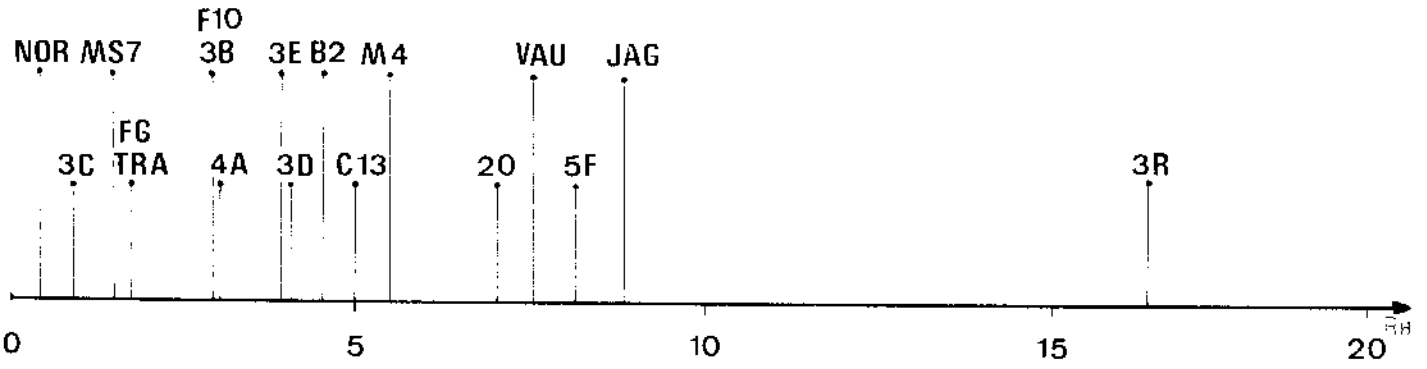
$$\text{RATIOS} : \quad \text{MAX}\left\{ \frac{\text{number of "Air Frame" strikes}}{\text{number of "Engine" strikes}} , \frac{\text{number of "Engine" strikes}}{\text{number of "Air Frame" strikes}} \right\}$$

NOTA : If a plane appears on the right of 1, let say in 2 , it means that AIR FRAME strikes have occured twice more than ENGINE strikes for this plane.
If a plane appears on the left of 1 , let say in 2, it means that ENGINE strikes have occured twice more than AIR FRAME strikes.



Rate of strikes per IO 000 mouvements

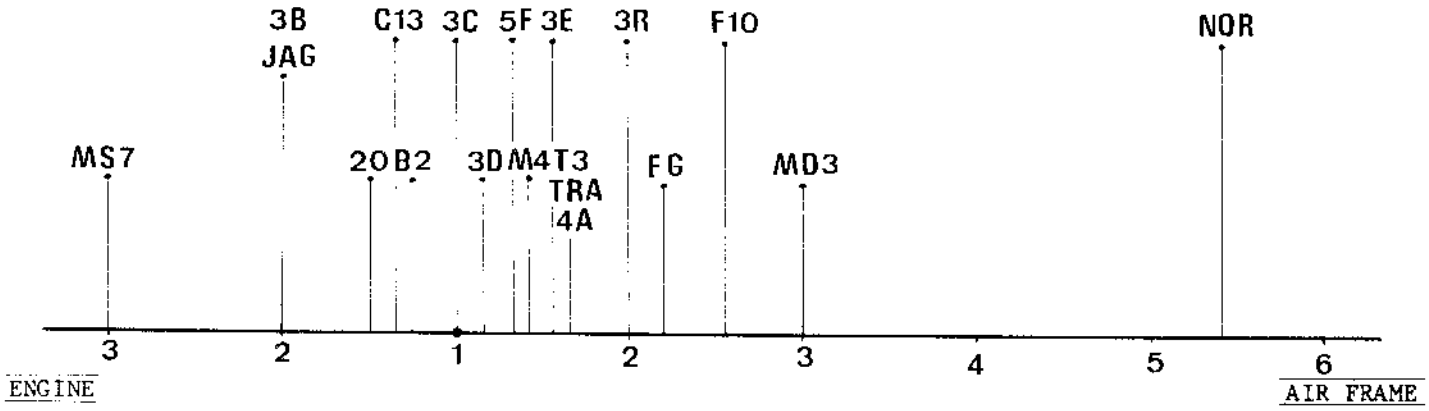
(Military airplanes)



Rate of strikes per IO 000 hours of flight

(Military airplanes)

(d') (Military airplanes)



$$\text{RATIOS} : \quad \text{MAX}\left\{ \frac{\text{number of "Air Frame" strikes}}{\text{number of "Engine" strikes}} , \frac{\text{number of "Engine" strikes}}{\text{number of "Air Frame" strikes}} \right\}$$

NOTA : If a plane appears on the right of 1, let say in 2 , it means that AIR FRAME strikes have occured twice more than ENGINE strikes for this plane.
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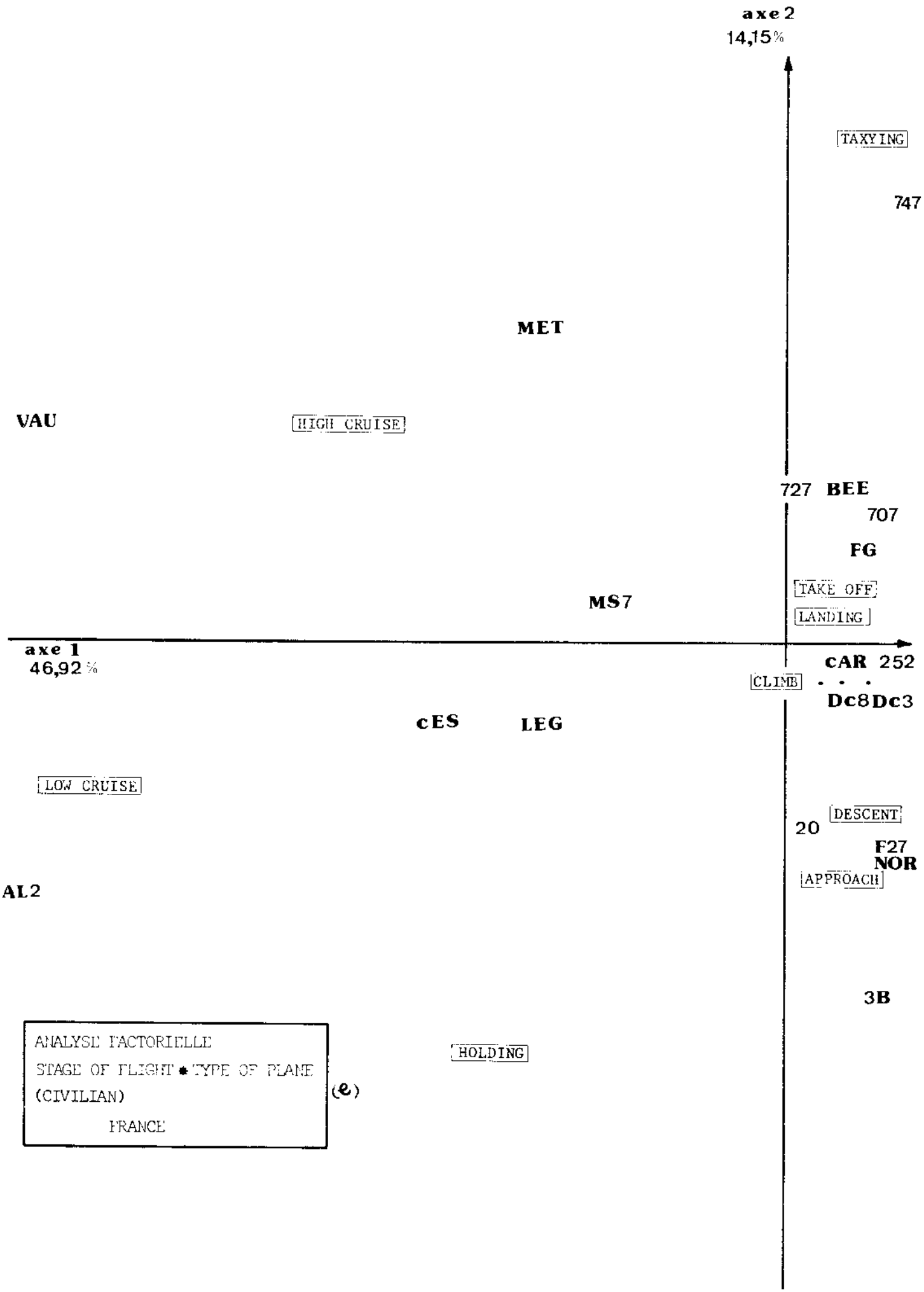
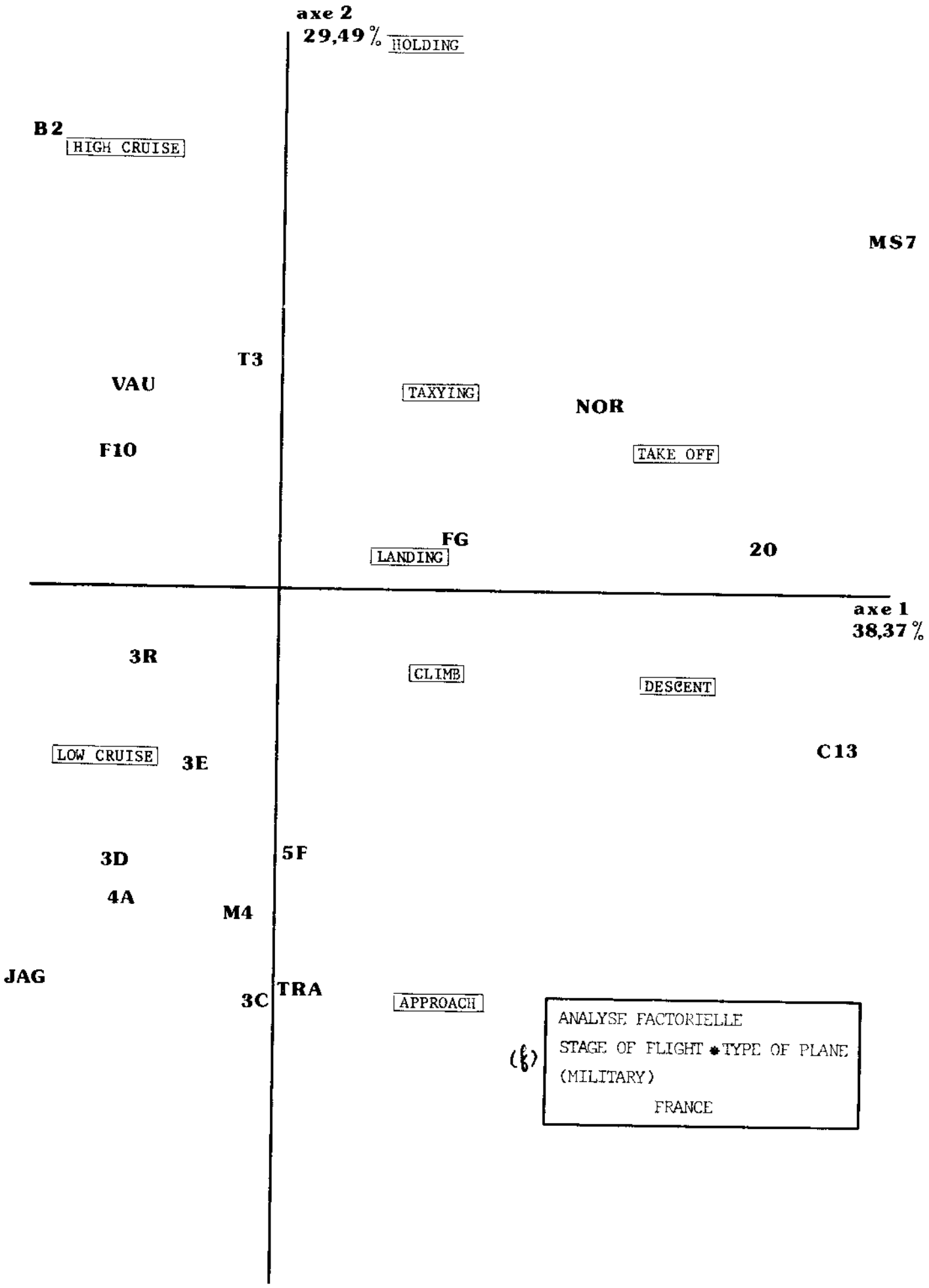

axe 2
14,15 %
TAXYING
747
MET
VAU
HIGH CRUISE
727 BEE
707
FG
MS7
TAKE OFF
LANDING
axe 1
46,92 %
cAR 252
CLIMB
Dc8 Dc3
cES
LEG
LOW CRUISE
DESCENT
20
F27
NOR
APPROACH
AL2
3B
HOLDING
ANALYSE FACTORIELLE
STAGE OF FLIGHT * TYPE OF PLANE
(CIVILIAN)
FRANCE
(e)


axe 2
29,49 %
HOLDING
B2
HIGH CRUISE
MS7
T3
VAU
TAXYING
NOR
F10
TAKE OFF
FG
LANDING
20
axe 1
38,37 %
3R
CLIMB
DESCENT
LOW CRUISE
3E
C13
3D
5F
4A
M4
JAG
3C
TRA
APPROACH
ANALYSE FACTORIELLE
STAGE OF FLIGHT * TYPE OF PLANE
(MILITARY)
FRANCE

d - Location of strikes vs type of plane (military)

- 20 types of planes
- 5 locations of strike

The bound between the two factors is not as tight with military planes (65 %) than with the civilian (81 %). This may be due to the less regular trajectory of a military planes.

However, to compare with the civilian, we give on the following page (d') the ratios comparing air frame strikes to engine strikes.

e - Stage of flight vs type of plane (civilian)

- 20 types of planes
- 9 stage of flight

The information (61 %) is reenforced by a good canonical correlation between the set of planes and the set of stages (given by the square root of the first eigen-value 58 %).

The meaning of axis 1, is "how far from the airport are we ?" The meaning of axis 2 is "are we flying through a light or a thick density of birds".

f - Stage of flight vs type of plane (military)

- 21 type of planes
- 9 stages of flight

As below, the information (68 %) is reenforced by a good correlation (50 %). The axes have the same meaning.

.../...

II - THE TWO LEVELS OF THE USE OF STATISTICS

How interesting the interpretation of the preceeding maps may be, the airplane specialist usually explores them in order to verify his experience on it. And usually he is amazed to see a confirmation of his experience.

To a certain extent the method brings enthusiasm, on the matters of confirmation.

To verify what we know is better than the converse but what new things can we learn from the map ? First the axes usually give a synthesis of the influence of one factor towards the other. Then our attention is brought on the points which are not located where they were expected. That means, we have to go back to experience and try to find out what may explain the position of these points.

(After verification that the unexpected result is not due to mistakes in the reporting form). As far as we saw it up today, the airplane specialist will try to find an answer to the question why were there at the same place and time a bird and a plane ? Only far back comes very seldom the question : what was the final reaction of the bird and the plane before the occurence of the strike if any ?

Giving the priority to the man of experience, statistics will take this as an indication for further research.

a - Global factors

In order to compare the weight of different factors leading to a strike, we performed a multiple regression using the stepwise method.

The stepwise method chooses among the factors those which give the better explanation. The score is given by a number between 0 and 1. (1 means that the selected factors give a perfect explanation). As results, the hours of flight and the mean speed at usual level of flying are the two important factors.

.../...

Although thez only explain 40 % of the variable "number of strikes" (score 0,4), the other factors have to be numerous to explain the rest. The importance of these two factors, only related to the aircraft, not to the birds, shows how scarce is the part of the informations collected on the reporting form. For, the hours of flight and mean speed are collected on companies statistics. And I guess that if we had the hours of flight of birds, we would explain another 40 %. The careful registration of the following items number of strikes, mean speed of each type of aircraft, hours of flight by type of aircraft, number of birds by species and mean time of staying, would give a good appreciation of the global efficiency of any policy about bird hazards. But these results will be ex post.

b - Local factors

In order to decide ex ante the good opportunities, it is necessary to implement, different policies and to compare the results. Since, the cost of a policy may be high, the implementation will be done locally. However to give a general validity, the results will be related to the preceeding relationship.

For instance, it is decided that lights will be on during a week in a particular airport. The efficiency of this policy will be obtained after having related the number of strikes to the number of take-off, , mean speed of planes at take-off, number of alive birds by species.

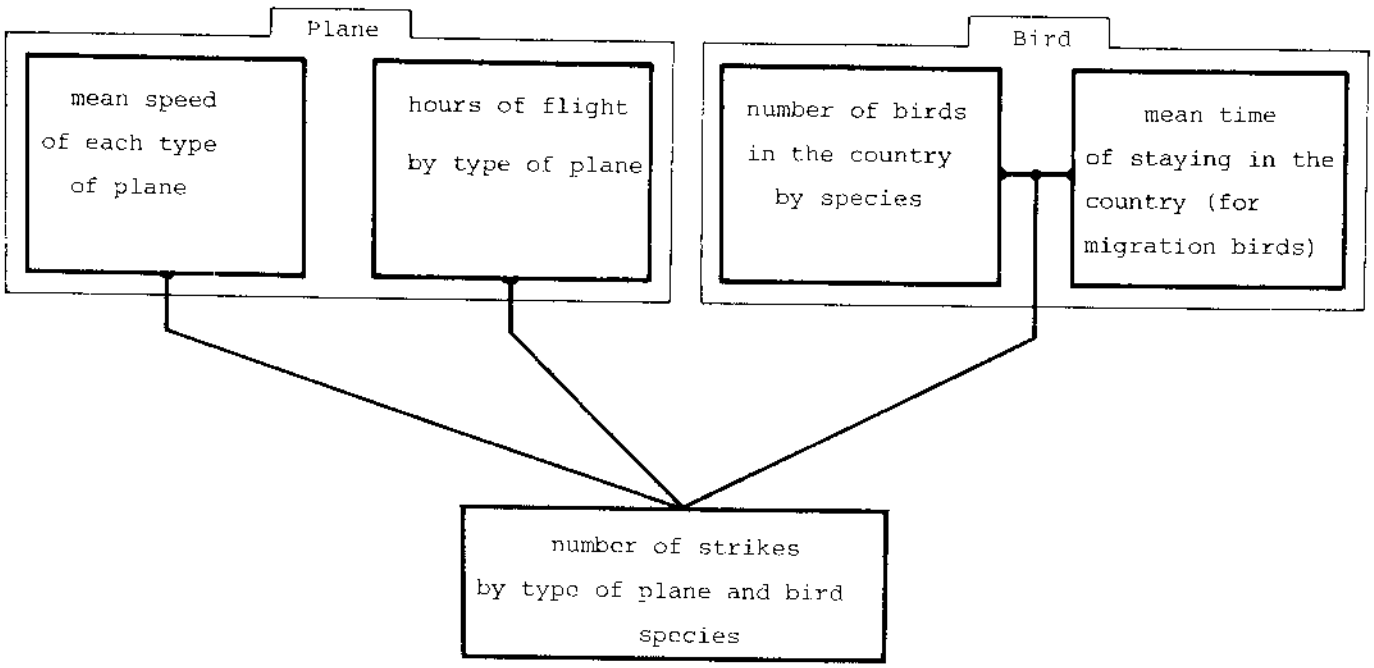
On another hand, it may be decided to use another route avoiding migrations of bird. The policy's efficiency is given after having related the number of strikes to the number of flights, the mean speed, and the number of alive birds by species.

CONCLUSION

No policy will come out of statistics. But any policy needs to be tested by statistics.

On this matter, the following actions :

1 - To bring together each month the data concerning :



This will bring to a good prediction of the total bird strikes during a year.

.../...

2 - Another global approach to the birds'behaviour may be done through the differencies between climbing and descent. A plane is supposed to be as many times in the first stage of flight as in the second. And statiscally speaking, the weather conditions, density of birds in the airport environnement are the same. So we have there the same stakes for all the variables except what is concerning the plane : stage of flight, speed, noise. These dofferencies have an influence on the type of species striken (see first map). It would be interesting that ornithologist's try to find out the birds' reasons. As climb or descent induces different stimuli, this may help to know the stimuli which are effective on each species.

3 - On a particular level, to implement for short time and in one or a few places, different policies. When the number of strikes will be lower than the prediction given by the relationship given by the first action, the policies will be accepted and generalized.

4 - It is obvious to tell that the quality of the further results is bound to regularly filled reporting forms. But, it may be necessary to insist on giving informations to the pilots on the benefit, they may get from good statistics.