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NAVAL POSTGRADUATE SCHOOL
Monterey, California

FACTORS INVOLVED IN THE VARIABILITY OF

MONTHLY MAJOR AIRCRAFT ACCIDENT RATES

by

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Rear Admiral I. W. Linder, USN   Jack R. Borsting
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The purpose of this report is to inform the sponsor of
results obtained using multiple regression techniques to identify
human and/or aircraft variables which account for the variability
in monthly major aircraft accident rates.

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Results are presented showing the development of regression
equations to help determine human and/or aircraft variables which
appear to account for the variability in monthly major aircraft
accident rates.

FOREWARD

This report is one of several being generated during a two year investigation into a variety of questions concerning major aircraft accidents.

NOTE: All reference to accident rates in this paper are in terms of the number of accidents per 10,000 flight hours.

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1. Introduction.

Previous work by this author and military officers working for him has been reported in Poock (1976) and Maxwell and Stucki (1975).

This report represents the work of the author and two military officers, Lt. Gary Johnson and Lt. Cdr. Lawrence Bucher who are currently working with the author in an attempt to use multiple regression techniques to identify variables which account for the variability in monthly major aircraft accident rates. The research described here deals with the data at an aircraft type and command level, versus the work of Maxwell and Stucki (1975) which concentrated on a macro view of the Navy as a whole.

The purpose of this paper is to present the equations which have been developed during the past three months. Each equation is the best result at this point in time, after having tried approximately ten different forms of equations for each of the aircraft types and commands. As the reader is probably aware, the development of a regression equation is somewhat of an art because the number of variables and forms of those variables is limitless, i.e., one can use the raw data, the square of the raw data, the cube root of the raw data, etc., which is purely up to the equation developer. Hence what is presented here is the best equations developed so far, after having tried some ten different alternative forms and combinations of variables. Better equations accounting for more of the variability in major aircraft accident rates may be found in future efforts but no guarantee can be

made, since the best combination of variables may already have been found. One should also note that the regression technique is used here to identify important variables rather than to be used as a predictive technique. Prediction would not always be possible as some variables are only known after the accident occurs. If possible, future efforts will examine "non-accident" pilots to compare distributions of their variables with "accident" pilot variable distributions.

2. Equation Development.

The regression program used was that of a forward inclusion type. It first brings in the independent variable most highly correlated with the dependent variable (monthly accident rate) and then continues to search for the next variable if it will account for a significant additional amount of the variability in the dependent variable. Equation development is termianted when unused variables would be of no useful benefit when inserted in the equation.

The following variables were mutually chosen by the investigator and Safety Center personnel for analysis at a command level and an aircraft type level. The analysis in each case uses data for the time period July 71 - June 74.

The dependent variable was monthly accident rate for the command or aircraft type.

Independent variables used from each accident were:

1. DNA - Years experience as a designated Naval aviator.

2. TTIME - Pilot's total flight time in aircraft model in which accident occurred.

3. AGE - pilot's age

4. TOT90 - Total flight hours in previous 90 days

5. NITE90 - Total night flight hours in previous 90 nights.

6. CLDAY - Number of day carrier landings in last 30 days.

7. CLNITE - Number of night carrier landings in last 30 nights

8. ACTOUR - Number of aircraft tours for the
    aircraft.

9. ACHRS - Aircraft flight hours since last major
    or minor inpsection.

10. DAY90 - Total day flight hours in previous 90
    days.

Various forms of the independent variables and some
combinations of the variable were used to arrive at the follow-
ing equations. The R^2_{adj} figure is the amount of variability
in the dependent variable, accident rate (Y), accounted for
by the independent variables in the equation. The $(1 - \alpha)$
figure can be interpreted to refer to the confidence level with
which one can assume that these variables properly belong in
the equation. The α level usually means there is an α amount
of chance that the equation is not statistically correct, but
the reverse $1 - \alpha$ interpretation may be easier for some to
interpret or understand.

3. Aircraft Analysis:

The following equations apply to the respective indivi-dual aircraft or combinations of aircraft as designated and for which sufficient data were available

A-7 R^2_{adj} = .55016   (1 - α) of .99

$$Y = 0.27170 \sqrt{CLDAY} - 0.01856 \, (CLNITE)^2$$

$$+0.21346 \sqrt{NITE90} + 4.01164 \sqrt{DNA}$$

$$- 0.88896 \, (DNA) - 3.70545$$

A-6 R^2_{adj} = .40275   (1 - α) of .75

$$Y = 16.28967 - 0.04604 \, (DNA)^2 + 2.33592 \sqrt{DNA}$$

$$- 20.30561 \sqrt{ACTOUR} + 5.34649 \, (ACTOUR)$$

$$+ 0.05874 \sqrt{TTIME}$$

A-4 R^2_{adj} = .45907   (1 - α) = .99

$$Y = -0.02157 \, (DNA)^2 + 0.00151 \, [ACTOUR \times ACHRS]$$

$$+ 0.85168 \sqrt{DNA} + 0.54683 \sqrt{NITE90}$$

$$- 0.0096 \, [TOT90 \times NITE90] - 1.23815$$

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ATTACK R^2_{adj} = .74021 $(1 - \alpha)$ = .99
(A3,A4,A5,A6,A7)

  $Y = 1.01024 - 0.01845 (ACTOUR)^2 + 0.00445 (ACHRS)$

   $- 0.00763 [NITE90 \times CLDAY] + 0.94584 \sqrt{CLNITE}$

   $- 0.0001 [TTIME \times DAY90]$

FIGHTERS R^2_{adj} = .40458 $(1 - \alpha)$ = .99
(F4, F8, F9)

  $Y = 1.21906 \sqrt{ACTOUR} + 0.23768 \sqrt{DAY90}$

   $+ 0.01897 (CLDAY)^2 + 2.38695 \sqrt{CLDAY}$

   $- 0.92126 (CLDAY) - 2.48215$

F-4 R^2_{adj} = 0.34799 $(1 - \alpha)$ = .95

  $Y = 0.19142 \sqrt{DAY90} - 0.03663 (CLNITE)^2$

   $+ 0.17982 \sqrt{TTIME} - 0.01302 (DNA)^2$

   $- 1.59073$

HELO R^2_{adj} = 0.09308 $(1 - \alpha)$ = .90

  $Y = 0.00062 (TTIME) + 0.65405$

PROPS R^2_{adj} = 0.43250 $(1 - \alpha)$ = .95

$$Y = 0.00002 \,[\text{TTIME} \times \text{NITE90}] - 0.00022 \,(\text{NITE90})^2$$

$$- \; 0.00001 \,[\text{AGE} \times \text{TTIME}] + 0.00108 \,[\text{CLDAY} \times \text{DNA}]$$

$$- \; 0.00595 \,[\text{CLNITE}]^2 + 0.35935$$

4. Command Analysis

CNATRA R^2_{adj} = .33 $(1 - \alpha)$ = .90

$$Y = - \,.31346 + .11248 \,\sqrt{\text{ACHRS}}$$

$$- .00003 \,(\text{ACHRS})^2 - .00002 \,(\text{DAY90})^2$$

$$+ .03482 \,\sqrt{\frac{\text{TTIME}}{\text{DNA}}} \; - \; .00092 \left(\frac{\text{TTIME}}{\text{DNA}}\right)$$

MARPAC R^2_{adj} = .392

$$Y = 1.26335 - .32047 \,(\text{ACTOUR})^2$$

$$+2.21178 \,(\text{ACTOUR}) + .01042 \,(\text{NITE90})^2$$

$$-19.20769 \left(\frac{\text{NITE90}}{\text{DAY90}}\right) \; - \; .00565 \,(\text{ACHRS})$$

$$- \; .00462 \,(\text{WINGS})^2$$

where WINGS $\approx$ AGE - DNA

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AIRLANT R^2_{adj} = .429 $(1 - \alpha)$ = .99

$$Y = .89771 + .11823\sqrt{ACHRS} - .00002(ACHRS)^2$$

$$- \frac{464.21653}{(TOT90)^2} - .00002 \left(\frac{DNA}{TTIME}\right)^2$$

$$- 4.76996 \sqrt{\frac{TTIME}{DNA}}$$

AIRPAC R^2_{adj} = .457 $(1 - \alpha)$ = .995

$$Y = 1.47479 - \frac{670.77272}{(DAY90)^2} - .00134 (WINGS)^2$$

$$+ .15733 (ACTOUR) + \frac{304.94442}{(ACHRS)^2}$$

$$+ .00001 (ACHRS)^2$$

MAR LANT R^2_{adj} = .565 $(1 - \alpha)$ = .99

$$Y = - .17128 + .88657 \sqrt{DNA} + .52634 \sqrt{NITE90}$$

$$- .06351 (NITE90) - 57.37027 \left(\frac{DNA}{TTIME}\right)$$

$$- .00115 (TTIME) + .06901 (CLNITE)^2$$

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<u>MARTC</u> $R^2_{adj} = .799$ $(1 - \alpha) = .99$

$$Y = - .36132 + 65.28325 \left(\frac{NITE90}{DAY90} \right)$$

$$+ .00328 \ (TTIME) - .00008 \left(\frac{TTIME}{DNA} \right)^2$$

$$- .41913 \ (NITE90) + .00385 \ (WINGS)^2$$

<u>NAVAL RESERVES</u> $R^2_{adj} = .813$ $(1 - \alpha) = .999$

$$Y = .83553 + .00084 \ (NITE90)^2 - .56367 \left(\frac{NITE90}{DAY90} \right)^2$$

$$- \frac{311.23233}{(ACHRS)^2} - .22889 \sqrt{CLDAY}$$

$$+ .00002 \left(\frac{TTIME}{DNA} \right)^2$$

<u>NASC + RDTE</u> $R^2_{adj} = .808$ $(1 - \alpha) = .95$

$$Y = - 1.21331 + .71262 \ (NITE90)^2$$

$$+ .23598 \sqrt{TTIME} + \frac{19.68521}{(DNA)^2}$$

$$- .61421 \sqrt{\frac{DNA}{TTIME}} + \frac{182.91525}{(TOT90)^2}$$

$$+ .38527 \ \sqrt{TOT90}$$

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5. <u>Summary.</u>

The foregoing represents purely mathematical results
of an attempt to use regression analysis to help identify
variables and/or combinations of functions of variables which
help to explain the variability in monthly accident rates for
major aircraft accidents.

Mathematical results were presented by aircraft type
and also at a command level. Logical and meaningful expla-
nations of why some variables may account for accident rate
variability will be the subject of the next phase in the
research, i.e. does it seem meaningful, besides being mathe-
matically correct, that two variables may be combined in an
equation and possibly make sense because they combine into
what one might call pilot proficiency, or aircraft worthi-
ness, etc. Logical analysis of the equations and possibly
more advanced equations will be presented in the master's
theses of Lt. Gary Johnson and Lt. Cdr. Lawrence Bucher in
about October 1976.

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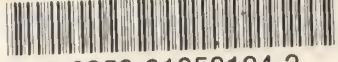
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