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Summary Report

USERS' MANUAL FOR THE SIMULATED LIFE ANALYSIS OF VEHICLE ELEMENTS (SLAVE) MODEL

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TELEDYNE BROWN ENGINEERING

Research Park • Huntsville, Alabama 35807

SUMMARY REPORT
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USERS' MANUAL FOR THE SIMULATED LIFE ANALYSIS OF VEHICLE ELEMENTS (SLAVE) MODEL

By

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Prepared For

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ABSTRACT

The Simulated Life Analysis of Vehicle Elements (SLAVE) Model described in this report was designed to perform statistical simulation studies for any constant loss rate. The outputs of the model consist of the total number of stages required, stages successfully completing their lifetime, and average stage flight life.

This report contains a complete description of the SLAVE Model. Users' instructions and interpretation of input and output data are presented such that a user with little or no prior programming knowledge can successfully implement the program.

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DEFINITION OF SYMBOLS

CPU	Central Processing Unit
N	Number of simulations to be performed
SLAVE	Simulated Life Analysis of Vehicle Elements
URAND	Pseudo Random Number Generator
$\overline{X}$	Mean (average) value
X_i	Parameter obtained from a single simulation of one program life
σ	One standard deviation

SECTION I. INTRODUCTION

This report contains a complete description of the Simulated Life Analysis of Vehicle Elements (SLAVE) computer model. The SLAVE Model is written in Fortran and was developed to provide data for the Shuttle booster concept selection. A detailed report of previous SLAVE Model usage is contained in Reference 1.

The primary use of the SLAVE Model is anticipated to be related to the Shuttle program, therefore the technical terms used in this report are associated with that program. The SLAVE Model described in this report may be used to obtain statistics for any piece of equipment that has a constant probability of loss. It should be noted that the equipment need not be restricted to the Shuttle program.

The SLAVE Model performs statistical simulation studies that require as input the following parameters:

- Random number generator seed
- Constant percentage loss rate
- Maximum stage lifetime.

The SLAVE Model generates the following output information:

- Total number of stages required
- Number of stages successfully completing their lifetime
- Number of stages failing to complete their lifetime
- Average flight life of all stages.

The above parameters are output as average values. The parameters also appear in histograms as data points which represent each program simulated. These histograms can be used to determine the range over which the output parameters may vary.

SECTION II. GUIDELINES AND ASSUMPTIONS

The guidelines and assumptions that were necessary to develop and utilize the SLAVE Model are as follows:

- The probability of loss for each flight is independent of previous flights
- One stage is used until it is lost or has completed its designed lifetime
- A new stage is immediately available when needed.
- The probability of losing a stage on any individual flight is a constant
- Each new stage performs at least one flight
- The mean (average) values referred to in this report are calculated by use of:

$$\bar{X} = \frac{\sum_{i=1}^{N} X_i}{N} \quad , \tag{1}$$

where

N = number of simulations to be performed

X_i = parameter obtained from a single simulation of one program life

$\bar{X}$ = mean (average) value

- The two sigma (σ) value is the number of stages necessary to accomplish approximately 97 percent of the flight program.

Program modifications and additional guidelines and assumptions are required when the SLAVE Model is used for distributions that do not have a constant probability of loss. However, the required changes are not included in the context of this report.

The statistical equations and tests used in this report were obtained from Reference 2.

SECTION III. INPUT DATA REQUIREMENTS

A. General Input Information

The SLAVE Model is written for use on a UNIVAC 1108 Digital Computer and requires the standard control cards for that machine. Explanations in this section will be given only for the input parameters and control cards necessary to run a case study. For a detailed explanation of the SLAVE Model see Section VI (Program Definition).

The SLAVE Model requires one data card with five parameter values for each case study. The model is designed to run multiple case studies with one submittal of the job to the UNIVAC 1108 by stacking data cards. The last data card on the stack is a stop control and should contain -999 ending in column 10.

Detailed descriptions of the input parameters required for the SLAVE Model are given below and a brief summary of the input requirements is contained in Table I.

- Parameter No. 1--Random Number Generator Seed
  This input parameter is used to start the Pseudo Random Number Generator (URAND). This subroutine generates a uniformly distributed sequence of random numbers in the range of 0.0 to 1.0. The random numbers are used to determine when a stage is lost by comparing a random number with the input parameter that designates the loss rate. The sequence of random numbers generated will always be the same for a particular seed. Therefore, a comparison of different input parameters for identical conditions can be made by using the same seed for each case study in the set. The parameter is located on the data card in columns 1 through 10, with the number required to end in column 10. The number used must be an odd integer not evenly divisible by 5 in the range of 1 to 3435973833, and must not contain a decimal point.

- Parameter No. 2--Constant Percentage Loss Rate
  This input parameter designates the stage loss rate to be used throughout the case study. The value used on the data card is to be the exact percentage value desired (not the corresponding decimal equivalent). This input parameter is

TABLE I. DATA CARD SUMMARY

Parameter No.	Description	Data Card Columns	Allowable Values	Ending Column	Decimal Point Required
1	Random Number Generator Seed	1 to 10	1 to 3435973833	10	No
2	Constant Percentage Loss Rate	11 to 20	0.0 or 100.0 or 0.00000001 to 99.9999999	20	Yes
3	Maximum Stage Lifetime • Finite • Infinite	21 to 30	1 to value of Parameter No. 5 >Parameter No. 5; <3435973833	30	No
4	Number of Simulations to be Performed	31 to 40	1 to 3435973833 (usually 100)	40	No
5	Number of Missions in One Complete Program	41 to 50	1 to 3435973833	50	No
	Stop Control	7 to 10	-999	10	No

used to determine when a stage is lost by comparing it with a random number. The parameter is located on the data card in columns 11 through 20, with the number ending in column 20. The range can be from 0 to 100 percent with a maximum of 9 significant digits. This parameter should contain a decimal point.

- Parameter No. 3--Maximum Stage Lifetime
  This input parameter is used to define the maximum number of flights a stage can make. When a stage has successfully completed the number of flights specified by this input parameter, it is designated as worn out, and a new stage is entered into the system. The number used for a finite maximum flight lifetime must be an integer in the range from one to the value of the fifth parameter on the data card. An infinite flight lifetime can be specified by any integer greater than the fifth parameter on the data card. The maximum stage lifetime parameter is located on the data card in columns 21 through 30, with the number ending in column 30. This parameter must not contain a decimal point.

- Parameter No. 4--Number of Simulations to be Performed
  This input parameter is used to establish the number of complete programs to simulate. This parameter should be sufficiently large, usually 100 or greater, to ensure valid statistical output. Each 100 simulations requires approximately 3.6 sec of UNIVAC 1108 Central Processing Unit (CPU) time. This parameter is located on the data card in columns 31 through 40, with the number ending in column 40. This number should be an integer in the range of 1 to 3435973833; however, because of the time required, care should be used in determining the actual size of this parameter. This parameter must not contain a decimal point.

- Parameter No. 5--Number of Missions in One Complete Program
  This number should be an integer in the range of 1 to 3435973833. The parameter is located on the data card in columns 41 through 50, with the number ending in column 50. This parameter must not contain a decimal point.

B. Program Deck Instructions

The complete UNIVAC 1108 program deck required to run case studies with the SLAVE Model is described in this section. All cards should be punched exactly as shown, except where otherwise stated. Figure 1 contains a complete listing of the program required to run a

```
@RUN, //P JOBNAM, JOBNUM, NAMExxBINxxx, T, PAGE
@ASG, T TAPE, T, REELNO
@REWIND TAPE.
@COPIN TAPE.
@XQT SLAVEC
    11221       20.0        20       100      445
     -999
@FIN
@FIN
```

FIGURE 1. PROGRAM LISTING FOR A SINGLE CASE STUDY UTILIZING THE SLAVE MODEL

single case study that has a 20.0 percent loss rate, a program life of 445 flights, and a maximum vehicle element lifetime of 20 flights. The required substitutions and a brief explanation of each card shown in Figure 1 are as follows:

- @RUN, //P JOBNAM, JOBNUM, NAMExxBINxxx, T, PAGE
  This card is an executive control card that tells the computer to schedule your run for initiation, and provide necessary accounting information. The following substitutions to the run card must be made:
  --JOBNAM: A six character name to be assigned to this job
  --JOBNUM: Your UNIVAC 1108 account number
  --NAMExxBINxxx: Your name in six characters and the bin number you want your output returned to in three numerals
  --T: The CPU time you expect your job to require in minutes. This value can be determined by multiplying the number of case studies by 4 sec per 100 simulations and converting to minutes. The number used should be the smallest integer value greater than the above calculation. This number is usually one, two, or three
  --PAGE: The maximum number of output pages your job is allowed to have. This number is usually 200.

- @ASG, T TAPE, T, REELNO
  This card is an executive control card that tells the computer which tape is required for this job. The following substitution to the ASG card must be made:
  --REELNO: The current SLAVE tape number. This number may be obtained by contacting Daryl D. Paul, Jr. at Teledyne Brown Engineering Company, telephone 532-1202.

- @REWIND TAPE.
  This card is an executive control card that winds the specified tape to the proper starting point. This is done in preparation to copying the SLAVE Model from the tape to the computer.

- @COPIN TAPE.
  This card is an executive control card that copies the SLAVE Model from the specified tape to the computer.

- @XQT SLAVEC
  This card is an executive control card that tells the computer to begin execution of the SLAVE Model.

- 1 1 2 2 1 20.0 20 1 0 0 4 4 5
  This card is a data card that contains the five parameters designated for this case study. If multiple case studies are desired there will be one data card of this type for each case study, located at this point in the deck.

- -999
  This card is a stop control used by the SLAVE Model to terminate this job submittal.
- @FIN
  @FIN
  These two cards are executive control cards that signify the end of this control deck.

SECTION IV. OUTPUT DATA INTERPRETATION

An explanation of the output data obtained from a typical case study that utilizes the SLAVE Model is contained in this section. The results of each case study are presented by two basic output formats. The first output format contains the study conditions and the average value of five parameters. The second output format appears four times per case study. This format contains a histogram and information associated with the histogram.

The example output presented in this section is the result of the input deck shown in Figure 1. The first output format is presented in Figure 2 and is interpreted as follows:

- RANDOM NUMBER SEED 11221
  When several case studies are to be compared this number should be the same for each case study. This ensures that the parameters being tested are operating under identical conditions.
- NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM 445
  The number of flights defined for the NASA Shuttle Traffic Model. This model is currently defined as 445 flights.
- NUMBER OF COMPLETE PROGRAMS SIMULATED 100
  This example problem makes 100 simulations of a 445 flight program.
- MAXIMUM STAGE LIFETIME 20
  Defines the maximum number of flights one stage may make before being discarded as worn-out. If this number is greater than the number of flights in one complete program, the maximum stage lifetime is infinite for that program. This program allows a stage to fly a maximum of 20 times.
- LOSS RATE (PERCENT) 20.000
  The probability of losing a stage on each flight--the probability of losing a stage in this case study is 20 percent per flight.
- AVERAGE NUMBER OF STAGES REQUIRED 90.14000
  The average number of stages required to complete the 445 flight program. This value is the average obtained from 100 individual simulations of the 445 flight program.

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	445
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	20
LOSS RATE (PERCENT)	20.000
AVERAGE NUMBER OF STAGES REQUIRED	90.14000
AVERAGE STAGE LIFE	4.98430
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	1.08000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	88.31000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.75000

FIGURE 2. CASE STUDY CONDITIONS AND AVERAGE DATA

- AVERAGE STAGE LIFE 4.98430
  The average number of flights each stage performed. This value is obtained by determining the average flight life for each program and then averaging over the number of simulations performed.

- AVERAGE NUMBER OF STAGES WHICH WEAR OUT 1.08000
  The number of stages that wear out and are discarded is determined for each program. The average is then calcaluated from these values.

- AVERAGE NUMBER OF STAGES WHICH ARE LOST 88.31000
  The number of stages that are lost is determined for each program. The average is then calculated from these values.

- AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM .75000
  This value is the percent probability of having an operational vehicle left at the end of the program.

For the conditions of this case study there is a 75 percent chance that a stage will be operational at the end of the flight program. This will allow a 446th flight if desired.

The histogram output formats presented in this section are the result of the input deck shown in Figure 1. These output formats appear after the format that specifies the study conditions and parameter averages. Four histograms are generated for each case study defined by the input deck. The titles of the histograms and their corresponding average parameter titles are shown in Table II. The histogram outputs for the example deck are shown in Figures 3 through 5.

The histograms contain the full range of data points generated during the 100 simulations specified by the input deck. Each histogram defines the number of data points it contains, the width of each cell and the number of points above or below the histogram's range. The histogram is output in three columns. The UPPER CELL LIMIT column defines the maximum value that can be contained in the cell. The CELL FREQ column contains the number of data points that are in each cell. The CUMULATIVE PROBABILITY column is the percentage of data points that fall equal to or below the cell.

The histogram of the total number of stages required per 445 flight program is presented in Figure 3 and is interpreted as follows:

- NUMBER OF DATA POINTS IN HISTOGRAM 100
  Each data point in the histogram represents the total number of stages required to complete one 445 flight program. The

TABLE II. TITLES OF HISTOGRAMS AND CORRESPONDING AVERAGE PARAMETER TITLES

Title of Parameter Average	Title of Corresponding Histogram
Average Number of Stages Required	Histogram of Total Number of Stages Required Per xxx Flight Program
Average Stage Life	Histogram of Average Stage Life
Average Number of Stages Which Wear Out	Histogram of Worn Out Stages
Average Number of Stages Which Are Lost	Histogram of Lost Stages
Average Number of Stages Which Are Still Operational at the End of the Flight Program	No Corresponding Histogram

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 445 FLIGHT PROGRAM
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 67.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 114.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
67.000	0	.000
68.000	1	.010
69.000	1	.020
70.000	0	.020
71.000	0	.020
72.000	0	.020
73.000	0	.020
74.000	1	.030
75.000	1	.040
76.000	2	.060
77.000	0	.060
78.000	3	.090
79.000	2	.110
80.000	3	.140
81.000	2	.160
82.000	4	.200
83.000	3	.230
84.000	7	.300
85.000	4	.340
86.000	3	.370
87.000	4	.410
88.000	2	.430
89.000	1	.440
90.000	6	.500
91.000	2	.520
92.000	2	.540
93.000	5	.590
94.000	8	.670
95.000	5	.720
96.000	4	.760
97.000	5	.810
98.000	4	.850
99.000	3	.880
100.000	3	.910
101.000	2	.930
102.000	1	.940
103.000	0	.940
104.000	1	.950
105.000	1	.960
106.000	1	.970
107.000	0	.970
108.000	1	.980
109.000	0	.980
110.000	1	.990
111.000	0	.990
112.000	0	.990
113.000	1	1.000
114.000	0	1.000

FIGURE 3. HISTOGRAM OF TOTAL STAGES REQUIRED

HISTOGRAM OF AVERAGE STAGE LIFE
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = .500
NUMBER OF DATA POINTS EQUAL TO OR BELOW 3.50= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 7.50= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
3.500	0	.000
4.000	1	.010
4.500	14	.150
5.000	42	.570
5.500	29	.860
6.000	11	.970
6.500	2	.990
7.000	1	1.000
7.500	0	1.000

HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW .00= 29
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 7.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
.000	29	.290
1.000	46	.750
2.000	19	.940
3.000	3	.970
4.000	1	.980
5.000	1	.990
6.000	1	1.000
7.000	0	1.000

FIGURE 4. HISTOGRAMS OF AVERAGE STAGE LIFE AND WORNOUT STAGES

HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 64.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 113.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
64.000	0	.000
65.000	1	.010
66.000	1	.020
67.000	0	.020
68.000	0	.020
69.000	0	.020
70.000	0	.020
71.000	1	.030
72.000	3	.060
73.000	0	.060
74.000	2	.080
75.000	0	.080
76.000	2	.100
77.000	3	.130
78.000	2	.150
79.000	2	.170
80.000	2	.190
81.000	6	.250
82.000	2	.270
83.000	6	.330
84.000	4	.370
85.000	0	.370
86.000	5	.420
87.000	2	.440
88.000	4	.480
89.000	3	.510
90.000	3	.540
91.000	4	.580
92.000	7	.650
93.000	6	.710
94.000	5	.760
95.000	3	.790
96.000	2	.810
97.000	4	.850
98.000	4	.890
99.000	3	.920
100.000	0	.920
101.000	2	.940
102.000	0	.940
103.000	1	.950
104.000	1	.960
105.000	1	.970
106.000	1	.980
107.000	0	.980
108.000	0	.980
109.000	1	.990
110.000	0	.990
111.000	0	.990
112.000	1	1.000
113.000	0	1.000

FIGURE 5. HISTOGRAM OF LOST STAGES

results for 100 of these 445 flight programs are contained in this histogram.

- CELL WIDTH = 1.000
  The width of each cell in this histogram is one unit.
- NUMBER OF DATA POINTS EQUAL TO OR BELOW 67.000 = 0
  The minimum number of stages required to complete one 445 flight program is 68. The percent probability of 68 stages completing the entire 445 flight program can be determined by referring to the cumulative probability column of the histogram corresponding to an upper cell limit of 68.000. It can be seen that the probability of completing the entire program with 68 stages is 1 percent.
- NUMBER OF DATA POINTS EQUAL TO OR ABOVE 114.000 = 0
  The maximum number of stages required to complete one 445 flight program is 113.000. The results of the simulation under the present set of specified conditions indicate that there is a 100 percent probability of completing the entire 445 flight program with 113 stages. However, care must be used when making unequivocal statements of this type. It is recommended when stating maximums that a positive 2σ limit ($\simeq$97 percent) be used in lieu of a 100 percent quote. The closest probability that is larger than or equal to the positive 2σ limit in the example histogram is 97 percent. Therefore, 106 stages are required to have a 2σ probability of completing the entire program.

The interpretation of the remaining three histograms generated by the SLAVE Model can be made in a manner similar to the detailed explanation presented above.

SECTION V. EXAMPLE PROBLEM

This section presents a hypothetical set of parametric case studies for which the statistics generated by the SLAVE Model are desired. The user needs to study information on a 580 flight program, and desires to know how many stages will be required to successfully complete the program. The analyst estimates that the probability of losing a stage could be 5, 10, or 20 percent. He also knows that the stage designers are considering a maximum flight life of 20 or 30 flights per stage.

In order to obtain statistically valid results the user decides 100 simulations are sufficient. In order to compare the results all the case studies should operate under the same conditions, therefore, the random number seed is identical for all the desired case studies. The listing of the required input deck appears in Figure 6. The results of this input deck are presented in Appendix A. A detailed report utilizing results from the SLAVE Model is presented in Reference 1.

```
@RUN,//P CASE01,567383,DDPAULBIN225,1,200
@ASG,T TAPE,T,13654
@REWIND TAPE.
@COPIN TAPE.
@XQT SLAVEC
      11221      5.0      20      100      580
      11221      5.0      30      100      580
      11221     10.0      20      100      580
      11221     10.0      30      100      580
      11221     20.0      20      100      580
      11221     20.0      30      100      580
       -999
@FIN
@FIN
```

FIGURE 6. EXAMPLE PROBLEM INPUT DECK

SECTION VI. PROGRAM DEFINITION

A. Program Description

The SLAVE Model requires approximately 20,000 words of UNIVAC 1108 core space. The program consists of a mainline and four subroutines. The read and write unit designators are designed to be easily adaptable to computers other than the UNIVAC 1108. The program has 8 subscripted variables with a total array size of 10,040 words. The program places data in 4 histograms of which 3 have 1000 cells of width 1. The fourth histogram has 2000 cells of width 0.5. The program operates by placing a stage in the system and using it until it is lost or has reached its maximum flight life. Variables are used to accumulate the data of each flight. When one complete flight program is finished the appropriate values are entered into histograms. This process is repeated for each simulation until all simulations requested are completed. The cumulative probability of obtaining each data point in all histograms is calculated. Mathematical manipulations are then performed to make the data suitable for printout and the output subroutines are initiated. At the completion of the output, a check is made to determine if another case study is desired; if so, the entire process is repeated. The narrative flow chart of the mainline is presented in Appendix B and a complete program listing is contained in Appendix C.

B. Individual Subroutine Descriptions

1. HISTO. This subroutine is used to compile a histogram of the data produced by the main program. Inputs to the subroutine consist of the upper and lower limit of the histogram, the cell width, and an initial entry indicator. The output of the subroutine is a histogram that contains the frequency of occurrence in each cell. The subroutine also outputs the total number of data points contained in the histogram. A narrative flow chart of subroutine HISTO is presented in Appendix B and a complete program listing in Appendix C.

2. CUMPF. This subroutine is used to calculate the cumulative probability function for the data generated by the histogram subroutine. The inputs to this subroutine are the number of data points in the histogram, the number of cells, and the frequency in each cell. The output is the cumulative probability of obtaining a value between the lower limit of the histogram and the upper limit of each cell. A narrative flow chart of subroutine CUMPF is presented in Appendix B and a complete program listing in Appendix C.

3. WHIST. This subroutine is used to write the information generated by the histogram and cumulative probability subroutines. This subroutine writes the number of data points in the histogram, the cell width, the number of data points below the lower limit of the histogram, and the number of data points above the upper limit of the histogram in sentence form. The upper cell limit, cell frequency, and cumulative probability are written in tabular form. The printed histogram consists only of the cells between the lowest and highest occupied cell. A narrative flow chart of subroutine WHIST is presented in Appendix B and a complete program listing in Appendix C.

4. URAND. This subroutine generates a uniformly distributed sequence of pseudo random numbers in the range of zero to one. The narrative flow chart is presented in Appendix B and a complete program listing in Appendix C.

REFERENCES

1. Paul, Daryl Jr.: Booster Fleet Size Studies Considering Different Loss Rate Distributions and Probabilities of Loss. Technical Letter ASD-ASTN-15331, Teledyne Brown Engineering Company, Huntsville, Alabama, February 22, 1972.

2. Miller, Irwin and Freund, John: Probability and Statistics for Engineers. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1965.

APPENDIX A. EXAMPLE PROBLEM RESULTS

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	580
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	20
LOSS RATE (PERCENT)	5.000
AVERAGE NUMBER OF STAGES REQUIRED	45.61000
AVERAGE STAGE LIFE	12.81811
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	15.94000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	28.77000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.90000

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 580 FLIGHT PROGRAM

NUMBER OF DATA POINTS IN HISTOGRAM 100

CELL WIDTH = 1.000

NUMBER OF DATA POINTS EQUAL TO OR BELOW 36.00= 0

NUMBER OF DATA POINTS EQUAL TO OR ABOVE 56.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
36.000	0	.000
37.000	1	.010
38.000	2	.030
39.000	2	.050
40.000	4	.090
41.000	5	.140
42.000	11	.250
43.000	9	.340
44.000	10	.440
45.000	8	.520
46.000	11	.630
47.000	5	.680
48.000	7	.750
49.000	9	.840
50.000	4	.880
51.000	2	.900
52.000	1	.910
53.000	5	.960
54.000	1	.970
55.000	3	1.000
56.000	0	1.000

HISTOGRAM OF AVERAGE STAGE LIFE

NUMBER OF DATA POINTS IN HISTOGRAM 100

CELL WIDTH = .500

NUMBER OF DATA POINTS EQUAL TO OR BELOW 10.50= 0

NUMBER OF DATA POINTS EQUAL TO OR ABOVE 16.50= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
10.500	0	.000
11.000	9	.090

11.500	3	.120
12.000	13	.250
12.500	12	.370
13.000	19	.560
13.500	19	.750
14.000	11	.860
14.500	9	.950
15.000	2	.970
15.500	2	.990
16.000	1	1.000
16.500	0	1.000

HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 7.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 24.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
7.000	0	.000
8.000	1	.010
9.000	0	.010
10.000	0	.010
11.000	1	.020
12.000	5	.070
13.000	9	.160
14.000	10	.260
15.000	17	.430
16.000	17	.600
17.000	15	.750
18.000	13	.880
19.000	5	.930
20.000	3	.960
21.000	2	.980
22.000	1	.990
23.000	1	1.000
24.000	0	1.000

HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 14.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 43.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
14.000	0	.000
15.000	1	.010
16.000	0	.010
17.000	1	.020
18.000	2	.040

19.000	3	.070
20.000	0	.070
21.000	4	.110
22.000	5	.160
23.000	1	.170
24.000	5	.220
25.000	9	.310
26.000	6	.370
27.000	5	.420
28.000	3	.450
29.000	9	.540
30.000	10	.640
31.000	8	.720
32.000	5	.770
33.000	4	.810
34.000	3	.840
35.000	1	.850
36.000	5	.900
37.000	1	.910
38.000	2	.930
39.000	1	.940
40.000	2	.960
41.000	3	.990
42.000	1	1.000
43.000	0	1.000

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	580
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	30
LOSS RATE (PERCENT)	5.000
AVERAGE NUMBER OF STAGES REQUIRED	37.20000
AVERAGE STAGE LIFE	15.82921
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	7.51000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	28.77000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.92000

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 580 FLIGHT PROGRAM
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 27.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 52.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
27.000	0	.000
28.000	1	.010
29.000	4	.050
30.000	0	.050
31.000	4	.090
32.000	4	.130
33.000	10	.230
34.000	7	.300
35.000	10	.400
36.000	10	.500
37.000	9	.590
38.000	3	.620
39.000	6	.680
40.000	9	.770
41.000	5	.820
42.000	4	.860
43.000	4	.900
44.000	3	.930
45.000	3	.960
46.000	0	.960
47.000	2	.980
48.000	1	.990
49.000	0	.990
50.000	0	.990
51.000	1	1.000
52.000	0	1.000

HISTOGRAM OF AVERAGE STAGE LIFE
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = .500
NUMBER OF DATA POINTS EQUAL TO OR BELOW 11.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 21.50= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
11.000	0	.000
11.500	1	.010
12.000	0	.010
12.500	3	.040
13.000	3	.070
13.500	7	.140
14.000	4	.180
14.500	14	.320
15.000	6	.380
15.500	3	.410
16.000	9	.500
16.500	10	.600
17.000	10	.700
17.500	7	.770
18.000	10	.870
18.500	4	.910
19.000	4	.950
19.500	0	.950
20.000	4	.990
20.500	0	.990
21.000	1	1.000
21.500	0	1.000

HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 1.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 13.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
1.000	0	.000
2.000	1	.010
3.000	0	.010
4.000	5	.060
5.000	6	.120
6.000	20	.320
7.000	24	.560
8.000	14	.700
9.000	13	.830
10.000	7	.900
11.000	8	.980
12.000	2	1.000
13.000	0	1.000

HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 14.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 43.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
14.000	0	.000
15.000	1	.010
16.000	0	.010
17.000	1	.020
18.000	2	.040
19.000	3	.070
20.000	0	.070
21.000	4	.110
22.000	5	.160
23.000	1	.170
24.000	5	.220
25.000	9	.310
26.000	6	.370
27.000	5	.420
28.000	3	.450
29.000	9	.540
30.000	10	.640
31.000	8	.720
32.000	5	.770
33.000	4	.810
34.000	3	.840
35.000	1	.850
36.000	5	.900
37.000	1	.910
38.000	2	.930
39.000	1	.940
40.000	2	.960
41.000	3	.990
42.000	1	1.000
43.000	0	1.000

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	580
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	20
LOSS RATE (PERCENT)	10.000
AVERAGE NUMBER OF STAGES REQUIRED	66.68000
AVERAGE STAGE LIFE	8.77390
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	7.80000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	58.06000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.82000

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 580 FLIGHT PROGRAM
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 52.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 84.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
52.000	0	.000
53.000	1	.010
54.000	0	.010
55.000	1	.020
56.000	3	.050
57.000	2	.070
58.000	4	.110
59.000	2	.130
60.000	4	.170
61.000	2	.190
62.000	6	.250
63.000	7	.320
64.000	8	.400
65.000	4	.440
66.000	8	.520
67.000	6	.580
68.000	4	.620
69.000	4	.660
70.000	5	.710
71.000	5	.760
72.000	6	.820
73.000	3	.850
74.000	6	.910
75.000	2	.930
76.000	2	.950
77.000	1	.960
78.000	0	.960
79.000	1	.970
80.000	1	.980
81.000	0	.980
82.000	1	.990
83.000	1	1.000
84.000	0	1.000

HISTOGRAM OF AVERAGE STAGE LIFE
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = .500
NUMBER OF DATA POINTS EQUAL TO OR BELOW 6.50= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 11.50= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
6.500	0	.000
7.000	1	.010
7.500	3	.040
8.000	14	.180
8.500	20	.380
9.000	22	.600
9.500	21	.810
10.000	12	.930
10.500	5	.980
11.000	2	1.000
11.500	0	1.000

HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 2.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 16.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
2.000	0	.000
3.000	1	.010
4.000	8	.090
5.000	5	.140
6.000	18	.320
7.000	19	.510
8.000	15	.660
9.000	9	.750
10.000	10	.850
11.000	6	.910
12.000	7	.980
13.000	1	.990
14.000	0	.990
15.000	1	1.000
16.000	0	1.000

HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 39.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 76.00= 0

UPPER CELL	CELL FREQ	CUMULATIVE PROBABILITY

LIMIT		
39.000	0	.000
40.000	1	.010
41.000	0	.010
42.000	1	.020
43.000	0	.020
44.000	1	.030
45.000	4	.070
46.000	1	.080
47.000	2	.100
48.000	2	.120
49.000	3	.150
50.000	3	.180
51.000	4	.220
52.000	2	.240
53.000	3	.270
54.000	5	.320
55.000	4	.360
56.000	2	.380
57.000	4	.420
58.000	10	.520
59.000	6	.580
60.000	2	.600
61.000	4	.640
62.000	9	.730
63.000	3	.760
64.000	5	.810
65.000	2	.830
66.000	4	.870
67.000	2	.890
68.000	2	.910
69.000	3	.940
70.000	1	.950
71.000	2	.970
72.000	1	.980
73.000	0	.980
74.000	0	.980
75.000	2	1.000
76.000	0	1.000

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	580
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	30
LOSS RATE (PERCENT)	10.000
AVERAGE NUMBER OF STAGES REQUIRED	61.19000
AVERAGE STAGE LIFE	9.60096
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	2.31000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	58.86000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.82000

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 580 FLIGHT PROGRAM
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 44.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 79.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
44.000	0	.000
45.000	1	.010
46.000	1	.020
47.000	0	.020
48.000	0	.020
49.000	2	.040
50.000	4	.080
51.000	1	.090
52.000	3	.120
53.000	4	.160
54.000	1	.170
55.000	3	.200
56.000	5	.250
57.000	6	.310
58.000	3	.340
59.000	3	.370
60.000	8	.450
61.000	5	.500
62.000	6	.560
63.000	3	.590
64.000	8	.670
65.000	8	.750
66.000	7	.820
67.000	1	.830
68.000	2	.850
69.000	5	.900
70.000	2	.920
71.000	2	.940
72.000	0	.940
73.000	2	.960
74.000	2	.980
75.000	0	.980
76.000	0	.980
77.000	1	.990

78.000	1	1.000
79.000	0	1.000

HISTOGRAM OF AVERAGE STAGE LIFE
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = .500
NUMBER OF DATA POINTS EQUAL TO OR BELOW 7.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 13.50= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
7.000	0	.000
7.500	1	.010
8.000	5	.060
8.500	9	.150
9.000	18	.330
9.500	17	.500
10.000	19	.690
10.500	11	.800
11.000	8	.880
11.500	4	.920
12.000	6	.980
12.500	0	.980
13.000	2	1.000
13.500	0	1.000

HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW .00= 9
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 6.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
.000	9	.090
1.000	24	.330
2.000	25	.580
3.000	19	.770
4.000	15	.920
5.000	8	1.000
6.000	0	1.000

HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 39.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 76.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY

39.000	0	.000
40.000	1	.010
41.000	0	.010
42.000	1	.020
43.000	0	.020
44.000	1	.030
45.000	4	.070
46.000	1	.080
47.000	2	.100
48.000	2	.120
49.000	3	.150
50.000	3	.180
51.000	4	.220
52.000	2	.240
53.000	3	.270
54.000	5	.320
55.000	4	.360
56.000	2	.380
57.000	4	.420
58.000	10	.520
59.000	6	.580
60.000	2	.600
61.000	4	.640
62.000	9	.730
63.000	3	.760
64.000	5	.810
65.000	2	.830
66.000	4	.870
67.000	2	.890
68.000	2	.910
69.000	3	.940
70.000	1	.950
71.000	2	.970
72.000	1	.980
73.000	0	.980
74.000	0	.980
75.000	2	1.000
76.000	0	1.000

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	580
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	20
LOSS RATE (PERCENT)	20.000
AVERAGE NUMBER OF STAGES REQUIRED	118.09000
AVERAGE STAGE LIFE	4.95310
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	1.37000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	115.95000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.77000

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 580 FLIGHT PROGRAM
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 91.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 141.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
91.000	0	.000
92.000	1	.010
93.000	0	.010
94.000	1	.020
95.000	1	.030
96.000	0	.030
97.000	2	.050
98.000	0	.050
99.000	0	.050
100.000	1	.060
101.000	0	.060
102.000	2	.080
103.000	0	.080
104.000	1	.090
105.000	4	.130
106.000	1	.140
107.000	4	.180
108.000	1	.190
109.000	2	.210
110.000	4	.250
111.000	5	.300
112.000	1	.310
113.000	4	.350
114.000	5	.400
115.000	2	.420
116.000	1	.430
117.000	1	.440
118.000	5	.490
119.000	3	.520
120.000	1	.530
121.000	5	.580
122.000	5	.630
123.000	3	.660
124.000	7	.730

125.000	2	.750
126.000	0	.750
127.000	2	.770
128.000	2	.790
129.000	5	.840
130.000	3	.870
131.000	2	.890
132.000	3	.920
133.000	1	.930
134.000	3	.960
135.000	2	.980
136.000	0	.980
137.000	1	.990
138.000	0	.990
139.000	0	.990
140.000	1	1.000
141.000	0	1.000

HISTOGRAM OF AVERAGE STAGE LIFE
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = .500
NUMBER OF DATA POINTS EQUAL TO OR BELOW 4.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 7.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
4.000	0	.000
4.500	21	.210
5.000	37	.580
5.500	29	.870
6.000	10	.970
6.500	3	1.000
7.000	0	1.000

HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW .00= 27
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 8.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
.000	27	.270
1.000	35	.620
2.000	25	.870
3.000	7	.940
4.000	2	.960
5.000	2	.980
6.000	1	.990
7.000	1	1.000
8.000	0	1.000

HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 87.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 139.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
87.000	0	.000
88.000	1	.010
89.000	1	.020
90.000	0	.020
91.000	1	.030
92.000	0	.030
93.000	0	.030
94.000	1	.040
95.000	2	.060
96.000	1	.070
97.000	0	.070
98.000	0	.070
99.000	1	.080
100.000	1	.090
101.000	1	.100
102.000	1	.110
103.000	4	.150
104.000	3	.180
105.000	0	.180
106.000	3	.210
107.000	1	.220
108.000	5	.270
109.000	2	.290
110.000	4	.330
111.000	3	.360
112.000	2	.380
113.000	4	.420
114.000	1	.430
115.000	1	.440
116.000	3	.470
117.000	4	.510
118.000	3	.540
119.000	3	.570
120.000	4	.610
121.000	7	.680
122.000	4	.720
123.000	3	.750
124.000	0	.750
125.000	0	.750
126.000	3	.780
127.000	4	.820
128.000	3	.850
129.000	3	.880
130.000	3	.910
131.000	3	.940
132.000	0	.940
133.000	1	.950

134.000	3	.980
135.000	0	.980
136.000	1	.990
137.000	0	.990
138.000	1	1.000
139.000	0	1.000

RANDOM NUMBER SEED	11221
NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM	580
NUMBER OF COMPLETE PROGRAMS SIMULATED	100
MAXIMUM STAGE LIFETIME	30
LOSS RATE (PERCENT)	20.000
AVERAGE NUMBER OF STAGES REQUIRED	116.87000
AVERAGE STAGE LIFE	5.01075
AVERAGE NUMBER OF STAGES WHICH WEAR OUT	.15000
AVERAGE NUMBER OF STAGES WHICH ARE LOST	115.95000
AVERAGE NUMBER OF STAGES WHICH ARE STILL OPERATIONAL AT THE END OF THE FLIGHT PROGRAM	.77000

HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER 580 FLIGHT PROGRAM
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 89.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 139.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
89.000	0	.000
90.000	1	.010
91.000	1	.020
92.000	1	.030
93.000	0	.030
94.000	0	.030
95.000	1	.040
96.000	2	.060
97.000	1	.070
98.000	0	.070
99.000	0	.070
100.000	0	.070
101.000	2	.090
102.000	1	.100
103.000	1	.110
104.000	5	.160
105.000	2	.180
106.000	0	.180
107.000	3	.210
108.000	3	.240
109.000	4	.280
110.000	2	.300
111.000	3	.330
112.000	3	.360
113.000	1	.370
114.000	5	.420
115.000	1	.430
116.000	1	.440
117.000	3	.470
118.000	4	.510
119.000	3	.540
120.000	3	.570
121.000	5	.620
122.000	6	.680

123.000	4	.720
124.000	2	.740
125.000	1	.750
126.000	0	.750
127.000	3	.780
128.000	5	.830
129.000	4	.870
130.000	2	.890
131.000	2	.910
132.000	3	.940
133.000	0	.940
134.000	2	.960
135.000	2	.980
136.000	1	.990
137.000	0	.990
138.000	1	1.000
139.000	0	1.000

HISTOGRAM OF AVERAGE STAGE LIFE
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = .500
NUMBER OF DATA POINTS EQUAL TO OR BELOW 4.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 7.00= 0

UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
4.000	0	.000
4.500	17	.170
5.000	40	.570
5.500	25	.820
6.000	12	.940
6.500	6	1.000
7.000	0	1.000

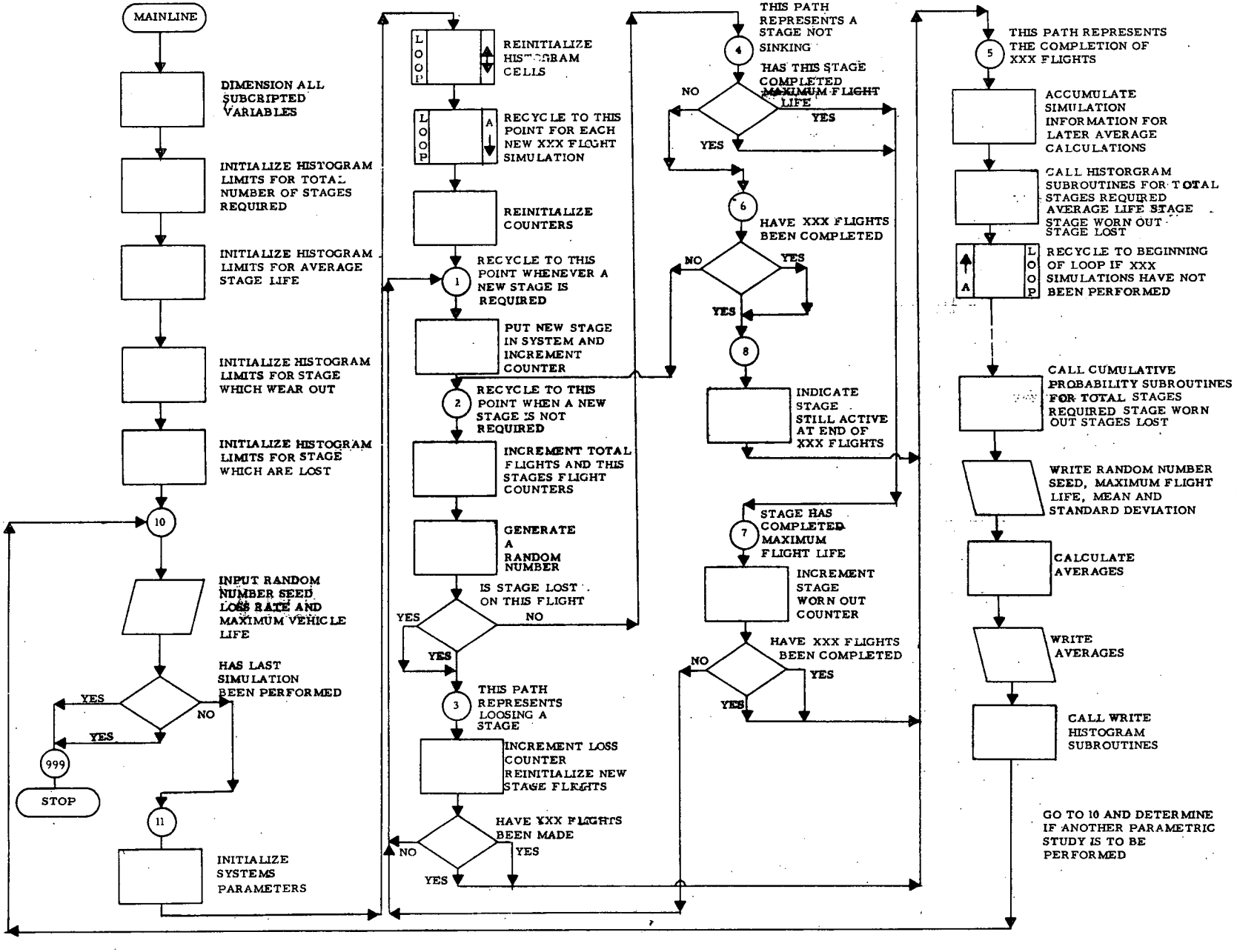
HISTOGRAM OF WORN OUT STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW .00= 85
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 2.00= 0

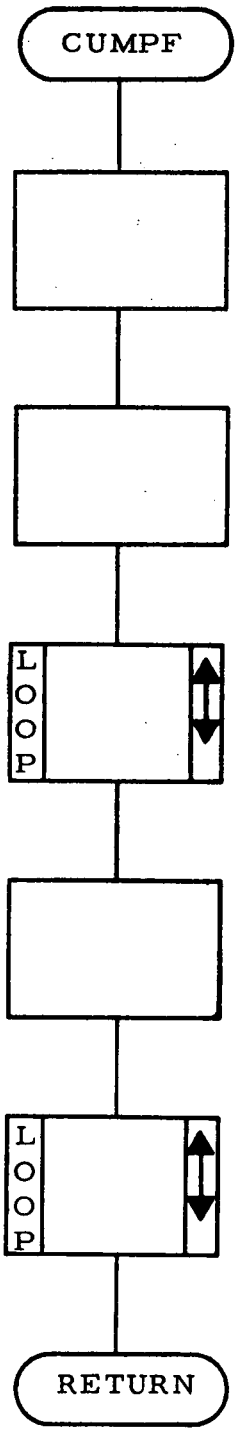
UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
.000	85	.850
1.000	15	1.000
2.000	0	1.000

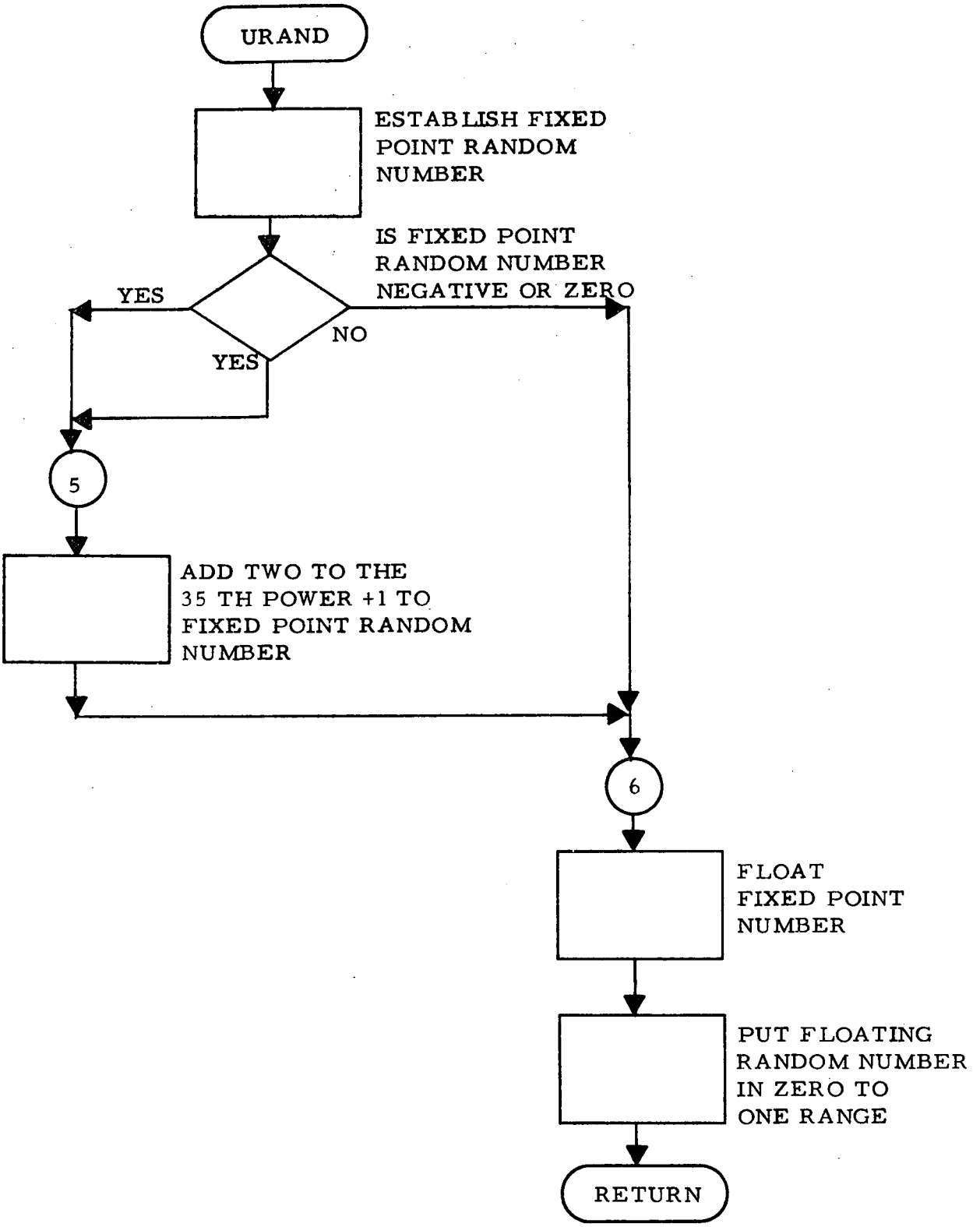
HISTOGRAM OF LOST STAGES
NUMBER OF DATA POINTS IN HISTOGRAM 100
CELL WIDTH = 1.000
NUMBER OF DATA POINTS EQUAL TO OR BELOW 87.00= 0
NUMBER OF DATA POINTS EQUAL TO OR ABOVE 139.00= 0

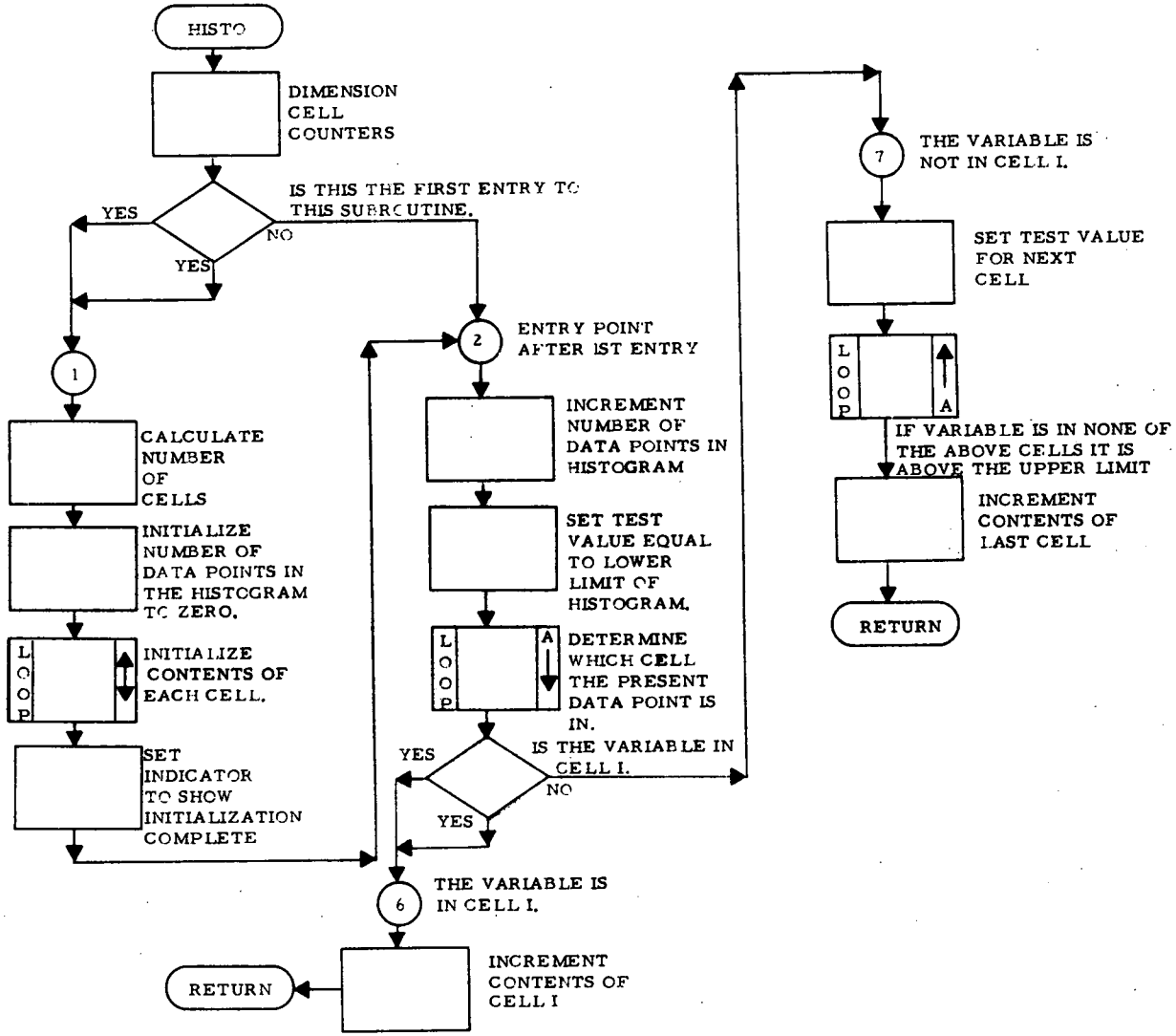
UPPER CELL LIMIT	CELL FREQ	CUMULATIVE PROBABILITY
87.000	0	.000
88.000	1	.010
89.000	1	.020
90.000	0	.020
91.000	1	.030
92.000	0	.030
93.000	0	.030
94.000	1	.040
95.000	2	.060
96.000	1	.070
97.000	0	.070
98.000	0	.070
99.000	1	.080
100.000	1	.090
101.000	1	.100
102.000	1	.110
103.000	4	.150
104.000	3	.180
105.000	0	.180
106.000	3	.210
107.000	1	.220
108.000	5	.270
109.000	2	.290
110.000	4	.330
111.000	3	.360
112.000	2	.380
113.000	4	.420
114.000	1	.430
115.000	1	.440
116.000	3	.470
117.000	4	.510
118.000	3	.540
119.000	3	.570
120.000	4	.610
121.000	7	.680
122.000	4	.720
123.000	3	.750
124.000	0	.750
125.000	0	.750
126.000	3	.780
127.000	4	.820
128.000	3	.850
129.000	3	.880
130.000	3	.910
131.000	3	.940
132.000	0	.940
133.000	1	.950
134.000	3	.980
135.000	0	.980
136.000	1	.990
137.000	0	.990
138.000	1	1.000
139.000	0	1.000

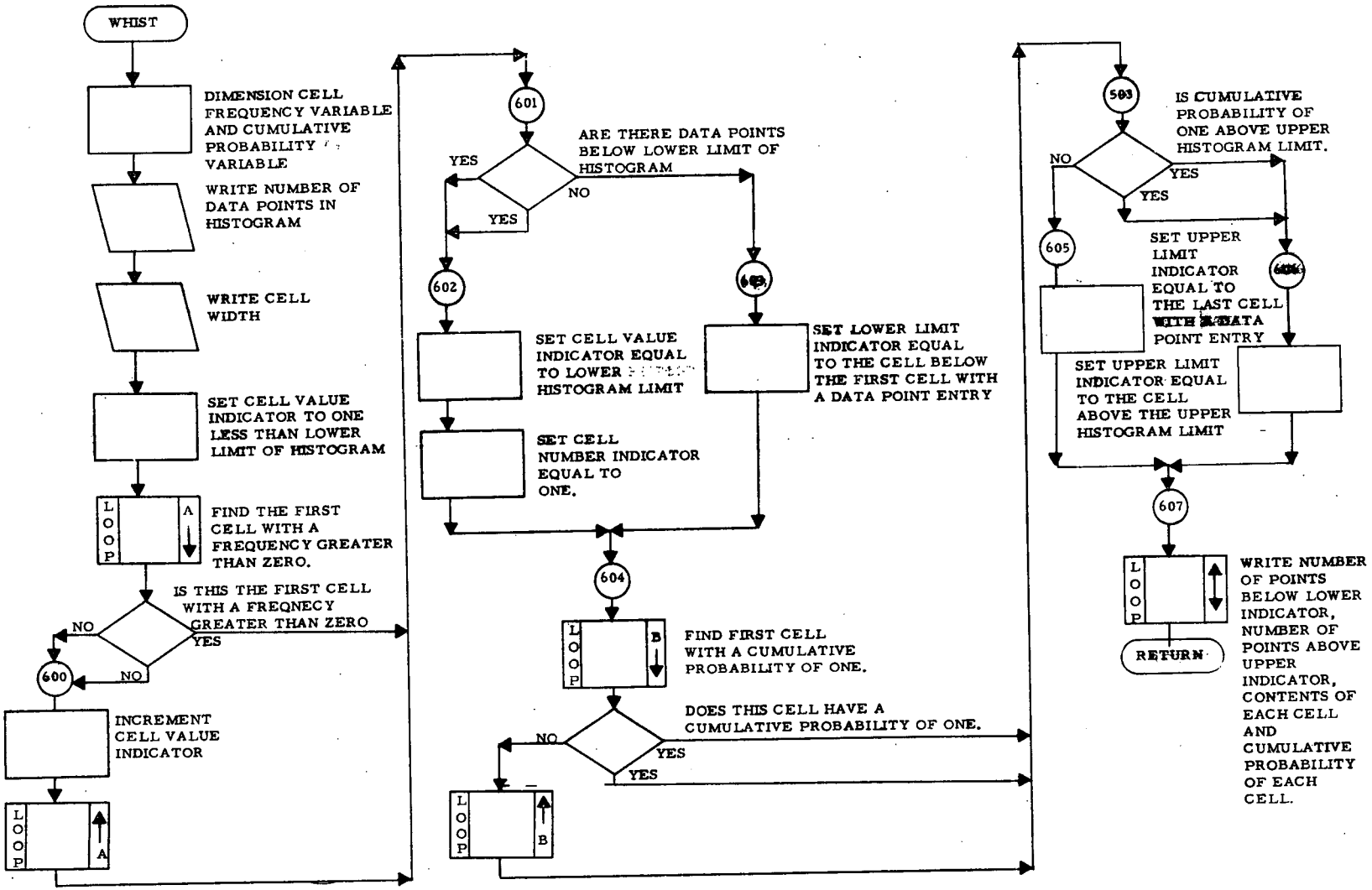
APPENDIX B. SLAVE MODEL NARRATIVE PROGRAM FLOW CHARTS


MAINLINE
DIMENSION ALL SUBSCRIPTED VARIABLES
INITIALIZE HISTOGRAM LIMITS FOR TOTAL NUMBER OF STAGES REQUIRED
INITIALIZE HISTOGRAM LIMITS FOR AVERAGE STAGE LIFE
INITIALIZE HISTOGRAM LIMITS FOR STAGE WHICH WEAR OUT
INITIALIZE HISTOGRAM LIMITS FOR STAGE WHICH ARE LOST
10
INPUT RANDOM NUMBER SEED LOSS RATE AND MAXIMUM VEHICLE LIFE
HAS LAST SIMULATION BEEN PERFORMED
YES
NO
YES
999
STOP
11
INITIALIZE SYSTEMS PARAMETERS
LOOP
REINITIALIZE HISTOGRAM CELLS
LOOP
A
RECYCLE TO THIS POINT FOR EACH NEW XXX FLIGHT SIMULATION
REINITIALIZE COUNTERS
1
RECYCLE TO THIS POINT WHENEVER A NEW STAGE IS REQUIRED
PUT NEW STAGE IN SYSTEM AND INCREMENT COUNTER
2
RECYCLE TO THIS POINT WHEN A NEW STAGE IS NOT REQUIRED
INCREMENT TOTAL FLIGHTS AND THIS STAGES FLIGHT COUNTERS
GENERATE A RANDOM NUMBER
IS STAGE LOST ON THIS FLIGHT
YES
NO
YES
3
THIS PATH REPRESENTS LOOSING A STAGE
INCREMENT LOSS COUNTER REINITIALIZE NEW STAGE FLIGHTS
HAVE XXX FLIGHTS BEEN MADE
NO
YES
YES
4
THIS PATH REPRESENTS A STAGE NOT SINKING
HAS THIS STAGE COMPLETED MAXIMUM FLIGHT LIFE
NO
YES
YES
6
HAVE XXX FLIGHTS BEEN COMPLETED
NO
YES
YES
8
INDICATE STAGE STILL ACTIVE AT END OF XXX FLIGHTS
7
STAGE HAS COMPLETED MAXIMUM FLIGHT LIFE
INCREMENT STAGE WORN OUT COUNTER
HAVE XXX FLIGHTS BEEN COMPLETED
NO
YES
YES
5
THIS PATH REPRESENTS THE COMPLETION OF XXX FLIGHTS
ACCUMULATE SIMULATION INFORMATION FOR LATER AVERAGE CALCULATIONS
CALL HISTORGRAM SUBROUTINES FOR TOTAL STAGES REQUIRED AVERAGE LIFE STAGE STAGE WORN OUT STAGE LOST
A
LOOP
RECYCLE TO BEGINNING OF LOOP IF XXX SIMULATIONS HAVE NOT BEEN PERFORMED
CALL CUMULATIVE PROBABILITY SUBROUTINES FOR TOTAL STAGES REQUIRED STAGE WORN OUT STAGES LOST
WRITE RANDOM NUMBER SEED, MAXIMUM FLIGHT LIFE, MEAN AND STANDARD DEVIATION
CALCULATE AVERAGES
WRITE AVERAGES
CALL WRITE HISTOGRAM SUBROUTINES
GO TO 10 AND DETERMINE IF ANOTHER PARAMETRIC STUDY IS TO BE PERFORMED


CUMPF
CHECK TO SEE IF DIMENSION FOR THE INTERNAL VARIABLE 'ADD' IS LARGE ENOUGH.
SET INTERNAL VARIABLE EQUAL TO NUMBER OF DATA POINTS IN HISTOGRAM.
LOOP
PUT CONTENTS OF EACH CELL INTO FLOATING POINT ARRAY.
ESTABLISH CUMULATIVE PROBABILITY OF FIRST CELL.
LOOP
ESTABLISH CUMULATIVE PROBABILITY OF THE OTHER CELLS.
RETURN


URAND
ESTABLISH FIXED POINT RANDOM NUMBER
IS FIXED POINT RANDOM NUMBER NEGATIVE OR ZERO
YES
NO
YES
5
ADD TWO TO THE 35 TH POWER +1 TO FIXED POINT RANDOM NUMBER
6
FLOAT FIXED POINT NUMBER
PUT FLOATING RANDOM NUMBER IN ZERO TO ONE RANGE
RETURN


HISTO
DIMENSION CELL COUNTERS
IS THIS THE FIRST ENTRY TO THIS SUBROUTINE.
YES
NO
YES
1
CALCULATE NUMBER OF CELLS
INITIALIZE NUMBER OF DATA POINTS IN THE HISTOGRAM TO ZERO.
LOOP
INITIALIZE CONTENTS OF EACH CELL.
SET INDICATOR TO SHOW INITIALIZATION COMPLETE
2
ENTRY POINT AFTER 1ST ENTRY
INCREMENT NUMBER OF DATA POINTS IN HISTOGRAM
SET TEST VALUE EQUAL TO LOWER LIMIT OF HISTOGRAM.
LOOP
A
DETERMINE WHICH CELL THE PRESENT DATA POINT IS IN.
YES
IS THE VARIABLE IN CELL I.
NO
YES
6
THE VARIABLE IS IN CELL I.
INCREMENT CONTENTS OF CELL I
RETURN
7
THE VARIABLE IS NOT IN CELL I.
SET TEST VALUE FOR NEXT CELL
LOOP
A
IF VARIABLE IS IN NONE OF THE ABOVE CELLS IT IS ABOVE THE UPPER LIMIT
INCREMENT CONTENTS OF LAST CELL
RETURN


WHIST
DIMENSION CELL FREQUENCY VARIABLE AND CUMULATIVE PROBABILITY VARIABLE
WRITE NUMBER OF DATA POINTS IN HISTOGRAM
WRITE CELL WIDTH
SET CELL VALUE INDICATOR TO ONE LESS THAN LOWER LIMIT OF HISTOGRAM
LOOP A
FIND THE FIRST CELL WITH A FREQUENCY GREATER THAN ZERO.
IS THIS THE FIRST CELL WITH A FREQNECY GREATER THAN ZERO
NO
YES
NO
600
INCREMENT CELL VALUE INDICATOR
LOOP A
601
ARE THERE DATA POINTS BELOW LOWER LIMIT OF HISTOGRAM
YES
NO
YES
602
SET CELL VALUE INDICATOR EQUAL TO LOWER HISTOGRAM LIMIT
SET CELL NUMBER INDICATOR EQUAL TO ONE.
SET LOWER LIMIT INDICATOR EQUAL TO THE CELL BELOW THE FIRST CELL WITH A DATA POINT ENTRY
604
LOOP B
FIND FIRST CELL WITH A CUMULATIVE PROBABILITY OF ONE.
DOES THIS CELL HAVE A CUMULATIVE PROBABILITY OF ONE.
NO
YES
YES
LOOP B
503
IS CUMULATIVE PROBABILITY OF ONE ABOVE UPPER HISTOGRAM LIMIT.
NO
YES
YES
605
SET UPPER LIMIT INDICATOR EQUAL TO THE LAST CELL WITH A DATA POINT ENTRY
SET UPPER LIMIT INDICATOR EQUAL TO THE CELL ABOVE THE UPPER HISTOGRAM LIMIT
607
LOOP
WRITE NUMBER OF POINTS BELOW LOWER INDICATOR, NUMBER OF POINTS ABOVE UPPER INDICATOR, CONTENTS OF EACH CELL AND CUMULATIVE PROBABILITY OF EACH CELL.
RETURN

APPENDIX C. SLAVE MODEL FORTRAN LISTINGS

```
$RUN,//T SLAVE1,420025,DUPAULBIN225,3,150
$ASG,T TAPE,1,SAVE02
$FOR,IS MAIN,MAIN
C                                                                      SLAV0000
C                                                                      SLAV0010
C-----------------------------------------------------------------------SLAV0020
C                                                                      SLAV0030
C                              DARYL D. PAUL, JR.                      SLAV0040
C                              TELEDYNE BROWN ENGINEERING              SLAV0050
C                              JANUARY 28,1972                         SLAV0060
C                                                                      SLAV0070
C                                                                      SLAV0080
C     PROGRAM TO DETERMINE THE NUMBER OF STAGES REQUIRED TO COMPLETE   SLAV0090
C     ALL MISSIONS IN THE PROGRAM LIFE. THE NUMBER OF STAGES REQUIRED  SLAV0100
C     VARIES ACCORDING TO THE ESTIMATED LOSS RATE PER FLIGHT AND MAXIMUMSLAV0110
C     FLIGHTS A STAGE MAY PERFORM. THIS PROGRAM MAY BE USED TO CALCULATESLAV0120
C     THE REQUIRED STATISTICS FOR ANY ELEMENT OF HARDWARE WHICH IS USED SLAV0130
C     REPEATEDLY FOR WHICH A LOSS RATE MAY BE ESTABLISHED.             SLAV0140
C-----------------------------------------------------------------------SLAV0150
C                                                                      SLAV0160
C                                                                      SLAV0170
C                                                                      SLAV0180
C-----------------------------------------------------------------------SLAV0190
C                              VARIABLE IDENTIFICATION                 SLAV0200
C                                                                      SLAV0210
C     ABOST=  AVERAGE NUMBER OF STAGES REQUIRED                        SLAV0220
C                                                                      SLAV0230
C     ALEFT=  AVERAGE NUMBER OF STAGES STILL OPERATIONAL               SLAV0240
C             AT THE END OF EACH PROGRAM SIMULATION                    SLAV0250
C                                                                      SLAV0260
C     ALIFE=  AVERAGE STAGE LIFE                                       SLAV0270
C                                                                      SLAV0280
C     ALIVE=  AVERAGE STAGE LIFE ACCUMULATOR                           SLAV0290
C                                                                      SLAV0300
C     AMEAN=  MEAN LOSS RATE PERCENTAGE                                SLAV0310
C                                                                      SLAV0320
C     ASINK=  AVERAGE NUMBER OF STAGES LOST                            SLAV0330
C                                                                      SLAV0340
C     AWEAR=  AVERAGE NUMBER OF STAGES WHICH WEAR OUT AND ARE DISCARDED SLAV0350
C                                                                      SLAV0360
C     BOOST=  FLOATING POINT REPRESENTATION OF NUMBER OF STAGES REQUIREDSLAV0370
C                                                                      SLAV0380
C     CELLW=  CELL WIDTH FOR TOTAL NUMBER OF STAGES REQUIRED HISTOGRAM SLAV0390
C                                                                      SLAV0400
C     CELL1=  CELL WIDTH IN AVERAGE STAGE LIFE HISTOGRAM               SLAV0410
C                                                                      SLAV0420
C     CELL2=  CELL WIDTH FOR WORN OUT STAGE HISTOGRAM                  SLAV0430
C                                                                      SLAV0440
C     CELL3=  CELL WIDTH FOR LOST STAGE HISTOGRAM                      SLAV0450
C                                                                      SLAV0460
C     FLITE=  THE NUMBER OF FLIGHTS A STAGE MADE BEFORE BEING LOST     SLAV0470
C                                                                      SLAV0480
C     INIT=   INDICATOR TO THE TOTAL REQUIRED HISTOGRAM SUBROUTINE     SLAV0490
C             TO INITIALIZE ITSELF                                     SLAV0500
C                                                                      SLAV0510
C     INIT2=  INDICY FOR INITIALIZATION OF TOTAL REQUIRED              SLAV0520
C             STAGES HISTOGRAM                                         SLAV0530
C                                                                      SLAV0540
C     IRAND=  USED TO RETAIN THE INITIAL RANDOM NUMBER SEED            SLAV0550
C             FOR SUBSEQUENT PRINTOUT                                  SLAV0560
C                                                                      SLAV0570
C     IX=     RANDOM NUMBER GENERATOR SEED                             SLAV0580
C                                                                      SLAV0590
C     IIST=   INDICATOR TO AVERAGE STAGE LIFE HISTOGRAM SUBROUTINE     SLAV0600
C             TO INITIALIZE ITSELF                                     SLAV0610
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C                                                                       SLAV0620
C     I2ND=    INDICATOR TO THE WORN OUT STAGE HISTOGRAM SUBROUTINE      SLAV0630
C              TO INITIALIZE ITSELF                                     SLAV0640
C                                                                       SLAV0650
C     I3RD=    INDICATOR TO THE LOST STAGE HISTOGRAM SUBROUTINE         SLAV0660
C              TO INITIALIZE ITSELF                                     SLAV0670
C                                                                       SLAV0680
C     JBOST=   NUMBER OF STAGES REQUIRED ACCUMULATOR                    SLAV0690
C                                                                       SLAV0700
C     JSINK=   NUMBER OF STAGES WHICH ARE LOST ACCUMULATOR              SLAV0710
C                                                                       SLAV0720
C     JWEAR=   NUMBER OF STAGES WHICH WEAR OUT AND ARE DISCARDED        SLAV0730
C                                                                       SLAV0740
C     KKK=     INDICY FOR NUMBER OF PROGRAM SIMULATIONS REQUIRED        SLAV0750
C                                                                       SLAV0760
C     KREAD=   THE READ UNIT OF THE COMPUTER BEING                      SLAV0770
C              USED TO RUN THIS PROGRAM                                 SLAV0780
C                                                                       SLAV0790
C     KRITE=   THE WRITE UNIT OF THE COMPUTER BEING                     SLAV0800
C              USED TO RUN THIS PROGRAM                                 SLAV0810
C                                                                       SLAV0820
C     LCELL=   NUMBER OF CELLS IN THE TOTAL REQUIRED STAGE HISTOGRAM    SLAV0830
C                                                                       SLAV0840
C     LCEL1=   NUMBER OF CELLS IN AVERAGE STAGE LIFE HISTOGRAM          SLAV0850
C                                                                       SLAV0860
C     LCEL2=   NUMBER OF CELLS IN WORN OUT STAGE HISTOGRAM              SLAV0870
C                                                                       SLAV0880
C     LCEL3=   NUMBER OF CELLS IN LOST STAGE HISTOGRAM                  SLAV0890
C                                                                       SLAV0900
C     LEFT=    ACCUMULATOR OF STAGES STILL ACTIVE AT THE END            SLAV0910
C              OF A PROGRAM SIMULATION                                  SLAV0920
C                                                                       SLAV0930
C     LIAD0=   AN ARRAY WHICH CONTAINS THE HISTOGRAM OF STAGES REQUIRED SLAV0940
C              PER 'NSIM' PROGRAM SIMULATIONS                           SLAV0950
C                                                                       SLAV0960
C     LIAD1=   AN ARRAY WHICH CONTAINS THE HISTOGRAM OF                 SLAV0970
C              AVERAGE STAGE LIFE                                       SLAV0980
C                                                                       SLAV0990
C     LIAD2=   AN ARRAY WHICH CONTAINS THE WORN OUT STAGE HISTOGRAM     SLAV1000
C                                                                       SLAV1010
C     LIAD3=   AN ARRAY WHICH CONTAINS THE LOST STAGE HISTOGRAM         SLAV1020
C                                                                       SLAV1030
C                                                                       SLAV1040
C     LNTRY=   THE NUMBER OF DATA POINTS IN THE TOTAL                   SLAV1050
C              STAGE REQUIRED HISTOGRAM                                 SLAV1060
C                                                                       SLAV1070
C     MAXLF=   MAXIMUM NUMBER OF FLIGHTS A STAGE CAN MAKE BEFORE BEING  SLAV1080
C              DISCARDED AS WORN OUT                                    SLAV1090
C                                                                       SLAV1100
C     NBOST=   NUMBER OF STAGES REQUIRED PER PROGRAM SIMULATION         SLAV1110
C                                                                       SLAV1120
C     NFLIT=   NUMBER OF FLIGHTS EACH STAGES MAKES BEFORE BEING         SLAV1130
C              LOST OR DISCARDED AS WORN OUT                            SLAV1140
C                                                                       SLAV1150
C     NMISS=   NUMBER OF FLIGHTS IN ONE PROGRAM                         SLAV1160
C                                                                       SLAV1170
C     NSIM=    NUMBER OF PROGRAM SIMULATIONS TO BE MADE                 SLAV1180
C                                                                       SLAV1190
C     NSINK=   NUMBER OF STAGES WHICH ARE LOST                          SLAV1200
C                                                                       SLAV1210
C     NTFLT=   NUMBER OF FLIGHTS ACCUMULATOR USED TO CHECK FOR END      SLAV1220
C              OF EACH PROGRAM SIMULATION                               SLAV1230
C                                                                       SLAV1240
C     NTRY1=   THE NUMBER OF DATA POINTS IN THE AVERAGE                 SLAV1250
C              STAGE LIFE HISTOGRAM                                     SLAV1260
C                                                                       SLAV1270
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C
C     NTRY2=  THE NUMBER OF DATA POINTS IN THE WORN OUT STAGE HISTOGRAM SLAV1280
C                                                                      SLAV1290
C     NTRY3=  THE NUMBER OF DATA POINTS IN THE LOST STAGE HISTOGRAM    SLAV1300
C                                                                      SLAV1310
C     NWEAR=  NUMBER OF STAGES WHICH ARE WORN OUT AND DISCARDED        SLAV1320
C                                                                      SLAV1330
C     PERDS=  AN ARRAY WHICH CONTAINS THE CUMULATIVE PROBABILITY       SLAV1340
C             FUNCTION OF STAGES REQUIRED                              SLAV1350
C                                                                      SLAV1360
C     PERD1=  AN ARRAY WHICH CONTAINS THE CUMULATIVE PROBABILITY       SLAV1370
C             FUNCTION OF AVERAGE STAGE LIFE                           SLAV1380
C                                                                      SLAV1390
C     PERD2=  AN ARRAY WHICH CONTAINS THE CUMULATIVE PROBABILITY       SLAV1400
C             FUNCTION OF WORN OUT STAGES                              SLAV1410
C                                                                      SLAV1420
C     PERD3=  AN ARRAY WHICH CONTAINS THE CUMULATIVE PROBABILITY       SLAV1430
C             FUNCTION OF LOST STAGES                                  SLAV1440
C                                                                      SLAV1450
C     PLOSS=  LOSS RATE(PERCENT)                                       SLAV1460
C                                                                      SLAV1470
C                                                                      SLAV1480
C     PROGRAM= A TERM USED ON COMMENT CARDS ONLY. THIS TERM REPRESENTS SLAV1490
C             A COMPLETE PROGRAM LIFE OF NMISS FLIGHTS                 SLAV1500
C                                                                      SLAV1510
C     SIM=    FLOATING POINT EQUIVALENT OF NSIM                        SLAV1520
C                                                                      SLAV1530
C     STDDV=  STANDARD DEVIATION FROM THE MEAN LOSS RATE               SLAV1540
C                                                                      SLAV1550
C     TLOST=  NUMBER OF STAGES LOST PER PROGRAM SIMULATION             SLAV1560
C                                                                      SLAV1570
C     UP=     UPPER LIMIT OF CELLS IN THE TOTAL STAGES                 SLAV1580
C             REQUIRED HISTOGRAM                                       SLAV1590
C                                                                      SLAV1600
C     UP1=    UPPER LIMIT OF CELLS IN AVERAGE STAGE LIFE HISTOGRAM     SLAV1610
C                                                                      SLAV1620
C     UP2=    UPPER LIMIT OF CELLS IN WORN OUT STAGE HISTOGRAM         SLAV1630
C                                                                      SLAV1640
C     UP3=    UPPER LIMIT OF CELLS IN LOST STAGE HISTOGRAM             SLAV1650
C                                                                      SLAV1660
C     URAND=  THE NAME OF A FUNCTION USED TO CALCULATE A UNIFORM RANDOM SLAV1670
C             NUMBER IN THE RANGE 0 TO 1                               SLAV1680
C                                                                      SLAV1690
C     WEAR=   THE NUMBER OF WORN OUT STAGES PER PROGRAM SIMULATION     SLAV1700
C                                                                      SLAV1710
C     XLOW=   THE LOWER LIMIT OF CELL VALUE IN THE TOTAL               SLAV1720
C             STAGES REQUIRED HISTOGRAM                                SLAV1730
C                                                                      SLAV1740
C     XLOW1=  LOWER LIMIT OF CELLS IN AVERAGE STAGE LIFE HISTOGRAM     SLAV1750
C                                                                      SLAV1760
C     XLOW2=  LOWER LIMIT OF CELLS IN THE WORN OUT STAGE HISTOGRAM     SLAV1770
C                                                                      SLAV1780
C     XLOW3=  LOWER LIMIT OF CELLS IN THE LOST STAGE HISTOGRAM         SLAV1790
C                                                                      SLAV1800
C     YFL=    THE VALUE OF THE RANDOM NUMBER GENERATED BY URAND        SLAV1810
C                                                                      SLAV1820
      KREAD=5                                                          SLAV1830
      KRITE=6                                                          SLAV1840
C-----------------------------------------------------------------------SLAV1850
C                                                                      SLAV1860
C                                                                      SLAV1870
      DIMENSION LIADD(1005),PERDS(1005)                                SLAV1880
      DIMENSION LIAD1(2005),PERD1(2005)                                SLAV1890
      DIMENSION LIAD2(1005),PERD2(1005)                                SLAV1900
      DIMENSION LIAD3(1005),PERD3(1005)                                SLAV1910
C                                                                      SLAV1920
C     INITIALIZE UPPER AND LOWER LIMITS AND CELL WIDTH FOR             SLAV1940
```

```
C     TOTAL NUMBER OF STAGES REQUIRED                                   SLAV1940
      XLOW=0.0                                                          SLAV1950
      UP=1000.0                                                         SLAV1960
      CELLW=1.0                                                         SLAV1970
      INIT=0                                                            SLAV1980
C                                                                       SLAV1990
C     INITIALIZE UPPER AND LOWER LIMITS AND CELL WIDTH FOR              SLAV2000
C     AVERAGE STAGE LIFE                                                SLAV2010
      XLOW1=0.0                                                         SLAV2020
      UP1=1000.0                                                        SLAV2030
      CELL1=0.5                                                         SLAV2040
      I1ST=0                                                            SLAV2050
C                                                                       SLAV2060
C                                                                       SLAV2070
C     INITIALIZE UPPER AND LOWER LIMITS AND CELL WIDTH FOR              SLAV2080
C     STAGES WHICH WEAR OUT                                             SLAV2090
      XLOW2=0.0                                                         SLAV2100
      UP2=1000.0                                                        SLAV2110
      CELL2=1.0                                                         SLAV2120
      I2ND=0                                                            SLAV2130
C                                                                       SLAV2140
C                                                                       SLAV2150
C     INITIALIZE UPPER AND LOWER LIMITS AND CELL WIDTH FOR              SLAV2160
C     STAGES WHICH ARE LOST                                             SLAV2170
      XLOW3=0.0                                                         SLAV2180
      UP3=1000.0                                                        SLAV2190
      CELL3=1.0                                                         SLAV2200
      I3RD= 0                                                           SLAV2210
C                                                                       SLAV2220
C                                                                       SLAV2230
C-----------------------------------------------------------------------SLAV2240
C     RECYCLE TO THIS POINT                                             SLAV2250
C     FOR A COMPLETE SIMULATION WITH NEW INPUT PARAMETERS               SLAV2260
C-----------------------------------------------------------------------SLAV2270
C                                                                       SLAV2280
   10 CONTINUE                                                          SLAV2290
C                                                                       SLAV2300
C     INPUT THE RANDOM NUMBER SEED,LOSS RATE (PERCENT),MAXIMUM          SLAV2310
C     BOOSTER LIFE AND NUMBER OF FLIGHTS IN ONE PROGRAM                 SLAV2320
      READ (KREAD,180) IX,PLOSS,MAXLF,NSIM,NMISS                        SLAV2330
C                                                                       SLAV2340
C                                                                       SLAV2350
C     CONVERT PERCENT LOSS RATE INPUT TO DECIMAL VALUE                  SLAV2360
      AMEAN=PLOSS/100.0                                                 SLAV2370
C                                                                       SLAV2380
C                                                                       SLAV2390
C-----------------------------                                          SLAV2400
C     IF THE RANDOM NUMBER SEED INPUT IS ZERO OR NEGATIVE               SLAV2410
C     THERE ARE NO MORE CASE STUDIES                                    SLAV2420
C     TERMINATE THE RUN                                                 SLAV2430
      IF(IX)340,340,20                                                  SLAV2440
C-----------------------------                                          SLAV2450
C                                                                       SLAV2460
C                                                                       SLAV2470
C-----------------------------                                          SLAV2480
   20 CONTINUE                                                          SLAV2490
C     INITIALIZATION OF VARIABLES REQUIRED TO CALCULATE AVERAGES        SLAV2500
      SIM=NSIM                                                          SLAV2510
      LEFT=0                                                            SLAV2520
      JBOST=0                                                           SLAV2530
      ALIVE=0.0                                                         SLAV2540
      JSINK=0                                                           SLAV2550
      JWEAR=0                                                           SLAV2560
      LNTRY=0                                                           SLAV2570
      NTRY1=0                                                           SLAV2580
      NTRY2=0                                                           SLAV2590
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      NTRY3=0                                                          SLAV2600
      IRAND=IX                                                         SLAV2610
C-----------------------------                                         SLAV2620
C                                                                      SLAV2630
C                                                                      SLAV2640
C-----------------------------                                         SLAV2650
C     INITIALIZE HISTOGRAM CELLS                                       SLAV2660
      DO 30 INIT2=1,1005                                               SLAV2670
      LIAD0(INIT2)=0                                                   SLAV2680
      LIAD1(INIT2)=0                                                   SLAV2690
      LIAD2(INIT2)=0                                                   SLAV2700
      LIAD3(INIT2)=0                                                   SLAV2710
   30 CONTINUE                                                         SLAV2720
      DO 40 INIT2=1006,2005                                            SLAV2730
      LIAD1(INIT2)=0                                                   SLAV2740
   40 CONTINUE                                                         SLAV2750
C-----------------------------                                         SLAV2760
C                                                                      SLAV2770
C                                                                      SLAV2780
C                                                                      SLAV2790
C                                                                      SLAV2800
C-------------------------------------------------------------------------SLAV2810
C     RECYCLE TO THIS POINT FOR EACH NEW PROGRAM SIMULATION            SLAV2820
C-------------------------------------------------------------------------SLAV2830
C                                                                      SLAV2840
      DO 130 KKK=1,NSIM                                                SLAV2850
C-----------------------------                                         SLAV2860
C                                                                      SLAV2870
C                                                                      SLAV2880
C-----------------------------                                         SLAV2890
C     REINITIALIZE COUNT VARIABLES FOR EACH NEW PROGRAM                SLAV2900
C                                                                      SLAV2910
      NFLIT=0                                                          SLAV2920
      NTFLT=0                                                          SLAV2930
      NSINK=0                                                          SLAV2940
      NBOST=0                                                          SLAV2950
      NWEAR=0                                                          SLAV2960
C-----------------------------                                         SLAV2970
C                                                                      SLAV2980
C                                                                      SLAV2990
C-----------------------------                                         SLAV3000
C     RECYCLE TO THIS POINT WHENEVER A NEW STAGE IS REQUIRED           SLAV3010
C                                                                      SLAV3020
   50 CONTINUE                                                         SLAV3030
      NBOST=NBOST+1                                                    SLAV3040
C-----------------------------                                         SLAV3050
C                                                                      SLAV3060
C                                                                      SLAV3070
C-----------------------------                                         SLAV3080
C     RECYCLE TO THIS POINT WHEN A NEW STAGE IS NOT REQUIRED           SLAV3090
   60 CONTINUE                                                         SLAV3100
      NFLIT=NFLIT+1                                                    SLAV3110
      NTFLT=NTFLT+1                                                    SLAV3120
C                                                                      SLAV3130
C-------------------------------                                       SLAV3140
C     GENERATE A RANDOM NUMBER                                         SLAV3150
      YFL=URAND(IX)                                                    SLAV3160
C-------------------------------                                       SLAV3170
C                                                                      SLAV3180
C-----------------------------                                         SLAV3190
C     IS THE RANDOM NUMBER SMALL ENOUGH TO CAUSE THE LOSS OF THIS STAGE SLAV3200
      IF (YFL-AMEAN)70,70,80                                           SLAV3210
C-------------------------------                                       SLAV3220
C                                                                      SLAV3230
C                                                                      SLAV3240
C-----------------------------                                         SLAV3250
```

```
C
C     THIS PATH REPRESENTS A SINKING STAGE                                  SLAV3260
   70 CONTINUE                                                              SLAV3270
      NSINK=NSINK+1                                                         SLAV3280
      FLITE=NFLIT                                                           SLAV3290
      NFLIT=0                                                               SLAV3300
C     HAS THE COMPLETE PROGRAM OF 'NMISS' FLIGHTS BEEN COMPLETED            SLAV3310
      IF(NTFLT-NMISS)50,120,120                                             SLAV3320
C-----------------------------                                              SLAV3330
C                                                                           SLAV3340
C                                                                           SLAV3350
C-----------------------------                                              SLAV3360
C     THIS PATH REPRESENTS A STAGE NOT SINKING                              SLAV3370
   80 CONTINUE                                                              SLAV3380
C     HAS THIS STAGE COMPLETED MAXIMUM FLIGHT LIFE                          SLAV3390
      IF(NFLIT-MAXLF) 90,110,110                                            SLAV3400
C     NO THIS STAGE HAS NOT COMPLETED MAXIMUM FLIGHT LIFE                   SLAV3410
   90 CONTINUE                                                              SLAV3420
C     HAS THE COMPLETE PROGRAM OF 'NMISS' FLIGHTS BEEN COMPLETED            SLAV3430
      IF(NTFLT-NMISS)60,100,100                                             SLAV3440
  100 CONTINUE                                                              SLAV3450
      LEFT=LEFT+1                                                           SLAV3460
      GO TO 120                                                             SLAV3470
C     YES THIS STAGE HAS COMPLETED MAXIMUM FLIGHT LIFE                      SLAV3480
  110 CONTINUE                                                              SLAV3490
      NWEAR=NWEAR+1                                                         SLAV3500
      NFLIT=0                                                               SLAV3510
C     HAS THE COMPLETE PROGRAM OF 'NMISS' FLIGHTS BEEN COMPLETED            SLAV3520
      IF(NTFLT-NMISS)50,120,120                                             SLAV3530
C-----------------------------                                              SLAV3540
C                                                                           SLAV3550
C                                                                           SLAV3560
C-----------------------------                                              SLAV3570
C     THIS PATH REPRESENTS THE COMPLETION OF THE COMPLETE 'NMISS'           SLAV3580
C     FLIGHT PROGRAM                                                        SLAV3590
C     CALCULATE AVERAGE STAGE LIFE                                          SLAV3600
C     AND INCREMENT TOTAL NUMBER OF                                         SLAV3610
C     STAGES REQUIRED,STAGES WORN OUT,STAGES LOST                           SLAV3620
  120 CONTINUE                                                              SLAV3630
      BOOST=NBOST                                                           SLAV3640
      ALIFE= FLOAT(NMISS)/BOOST                                             SLAV3650
      JBOST=JBOST+NBOST                                                     SLAV3660
      ALIVE=ALIVE+ALIFE                                                     SLAV3670
      JWEAR=JWEAR+NWEAR                                                     SLAV3680
      JSINK=JSINK+NSINK                                                     SLAV3690
      WEAR=NWEAR                                                            SLAV3700
      TLOST=NSINK                                                           SLAV3710
C                                                                           SLAV3720
C     CALL HISTOGRAM SUBROUTINE TO ACCUMULATE CELL DATA FOR                 SLAV3730
C                                                                           SLAV3740
C     TOTAL NUMBER OF STAGES REQUIRED HISTOGRAM                             SLAV3750
C     AVERAGE STAGE LIFE HISTOGRAM                                          SLAV3760
C     WORN OUT STAGE HISTOGRAM                                              SLAV3770
C     LOST STAGE HISTOGRAM                                                  SLAV3780
C                                                                           SLAV3790
      CALL HISTO(UP,XLOW,CELLW,INIT,BOOST,LIAUD,LCELL,LNTRY)                SLAV3800
      CALL HISTO(UP1,XLOW1,CELL1,IIST,ALIFE,LIAD1,LCEL1,NTRY1)              SLAV3810
      CALL HISTO(UP2,XLOW2,CELL2,I2ND,WEAR,LIAD2,LCEL2,NTRY2)               SLAV3820
      CALL HISTO(UP3,XLOW3,CELL3,I3RD,TLOST,LIAD3,LCEL3,NTRY3)              SLAV3830
C                                                                           SLAV3840
  130 CONTINUE                                                              SLAV3850
C-----------------------------                                              SLAV3860
C                                                                           SLAV3870
C                                                                           SLAV3880
C                                                                           SLAV3890
C                                                                           SLAV3900
C-------------------------------------------------------------------------SLAV3910
```


C.2

```
C     THIS PATH REPRESENTS THE COMPLETION OF 'NSIM' PROGRAM SIMULATIONS SLAV3920
C     FINAL STATISTICS FOR THE INPUT PARAMETERS ARE CALCULATED AND      SLAV3930
C     OUTPUT FROM THIS SECTION                                          SLAV3940
C                                                                       SLAV3950
C                                                                       SLAV3960
C     CALL CUMULATIVE PROBABILITY FUNCTION SUBROUTINE                   SLAV3970
C                                                                       SLAV3980
C     FOR TOTAL STAGES REQUIRED HISTOGRAM                               SLAV3990
C     FOR AVERAGE STAGE LIFE HISTOGRAM                                  SLAV4000
C     WORN OUT STAGE HISTOGRAM                                          SLAV4010
C     LOST STAGE HISTOGRAM                                              SLAV4020
C                                                                       SLAV4030
      CALL CUMPF(LNTRY,LIADD,LCELL,PERDS)                               SLAV4040
      CALL CUMPF(NTRY1,LIAD1,LCEL1,PERD1)                               SLAV4050
      CALL CUMPF(NTRY2,LIAD2,LCEL2,PERD2)                               SLAV4060
      CALL CUMPF(NTRY3,LIAD3,LCEL3,PERD3)                               SLAV4070
C                                                                       SLAV4080
      WRITE(KRITE,190)                                                  SLAV4090
      WRITE(KRITE,250) IRAND                                            SLAV4100
      WRITE(KRITE,320) NMISS                                            SLAV4110
      WRITE(KRITE,330) NSIM                                             SLAV4120
C-----------------------------                                          SLAV4130
C                                                                       SLAV4140
C                                                                       SLAV4150
C-----------------------------                                          SLAV4160
      IF(MAXLF-NMISS)160,140,140                                        SLAV4170
  140 CONTINUE                                                          SLAV4180
      WRITE(KRITE,150)                                                  SLAV4190
  150 FORMAT(' MAXIMUM STAGE LIFETIME',26X,'INFINITE')                  SLAV4200
      GO TO 170                                                         SLAV4210
  160 CONTINUE                                                          SLAV4220
      WRITE(KRITE,240) MAXLF                                            SLAV4230
  170 CONTINUE                                                          SLAV4240
C-----------------------------                                          SLAV4250
C                                                                       SLAV4260
C                                                                       SLAV4270
C-----------------------------                                          SLAV4280
      WRITE(KRITE,310) PLOSS                                            SLAV4290
      ABOST=JBOST                                                       SLAV4300
      ALEFT=LEFT                                                        SLAV4310
      AWEAR=JWEAR                                                       SLAV4320
      ASINK=JSINK                                                       SLAV4330
      ABOST=ABOST/SIM                                                   SLAV4340
      ALIVE=ALIVE/SIM                                                   SLAV4350
      AWEAR=AWEAR/SIM                                                   SLAV4360
      ASINK=ASINK/SIM                                                   SLAV4370
      ALEFT=ALEFT/SIM                                                   SLAV4380
      WRITE(KRITE,200)ABOST                                             SLAV4390
      WRITE(KRITE,210) ALIVE                                            SLAV4400
      WRITE(KRITE,220) AWEAR                                            SLAV4410
      WRITE (KRITE,230) ASINK                                           SLAV4420
      WRITE(KRITE,300) ALEFT                                            SLAV4430
C                                                                       SLAV4440
C-----------------------------                                          SLAV4450
      WRITE (KRITE,260) NMISS                                           SLAV4460
      CALL WHIST(XLOW,UP,LCELL,PERDS,CELLW,LIADD,LNTRY,KRITE)           SLAV4470
      WRITE(KRITE,270)                                                  SLAV4480
      CALL WHIST(XLOW1,UP1,LCEL1,PERD1,CELL1,LIAD1,NTRY1,KRITE)         SLAV4490
      WRITE(KRITE,280)                                                  SLAV4500
      CALL WHIST(XLOW2,UP2,LCEL2,PERD2,CELL2,LIAD2,NTRY2,KRITE)         SLAV4510
      WRITE(KRITE,290)                                                  SLAV4520
      CALL WHIST(XLOW3,UP3,LCEL3,PERD3,CELL3,LIAD3,NTRY3,KRITE)         SLAV4530
C-----------------------------------------------------------------------SLAV4540
C                                                                       SLAV4550
C                                                                       SLAV4560
C-----------------------------                                          SLAV4570
```

```
C     RECYCLE TO BEGINING OF PROGRAM AND SEE IF ANOTHER                 SLAV4580
C     PARAMETRIC STUDY IS TO BE PERFORMED                               SLAV4590
      GO TO 10                                                          SLAV4600
C-----------------------------                                          SLAV4610
C                                                                       SLAV4620
C                                                                       SLAV4630
C                                                                       SLAV4640
C                                                                       SLAV4650
C-----------------------------------------------------------------------SLAV4660
C                              INPUT/OUTPUT FORMATS                     SLAV4670
C                                                                       SLAV4680
  180 FORMAT(I10,F10.0,3I10)                                            SLAV4690
  190 FORMAT(1H1)                                                       SLAV4700
  200 FORMAT(' AVERAGE NUMBER OF STAGES REQUIRED',13X,F10.5)            SLAV4710
  210 FORMAT(' AVERAGE STAGE LIFE',28X,F10.5)                           SLAV4720
  220 FORMAT(' AVERAGE NUMBER OF STAGES WHICH WEAR OUT',7X,F10.5)       SLAV4730
  230 FORMAT(' AVERAGE NUMBER OF STAGES WHICH ARE LOST',7X,F10.5)       SLAV4740
  240 FORMAT(' MAXIMUM STAGE LIFETIME',30X,I4)                          SLAV4750
  250 FORMAT(' RANDOM NUMBER SEED ',27X,I10)                            SLAV4760
  260 FORMAT(//' HISTOGRAM OF TOTAL NUMBER OF STAGES REQUIRED PER',I5,' SLAV4770
     1FLIGHT PROGRAM')                                                  SLAV4780
  270 FORMAT(//' HISTOGRAM OF AVERAGE STAGE LIFE')                      SLAV4790
  280 FORMAT(//' HISTOGRAM OF WORN OUT STAGES')                         SLAV4800
  290 FORMAT(//' HISTOGRAM OF LOST STAGES')                             SLAV4810
  300 FORMAT(' AVERAGE NUMBER OF STAGES WHICH ARE STILL'/' OPERATIONAL AS SLAV4820
     1T THE END OF THE FLIGHT PROGRAM',2X,F10.5)                        SLAV4830
  310 FORMAT(' LOSS RATE (PERCENT)',27X,F10.5)                          SLAV4840
  320 FORMAT(' NUMBER OF FLIGHTS IN 1 COMPLETE PROGRAM',7X,I10)         SLAV4850
  330 FORMAT(' NUMBER OF COMPLETE PROGRAMS SIMULATED',9X,I10)           SLAV4860
C-----------------------------------------------------------------------SLAV4870
C                                                                       SLAV4880
C                                                                       SLAV4890
  340 CONTINUE                                                          SLAV4900
      STOP                                                              SLAV4910
      END                                                               SLAV4920
```

```
*FOR,IS HISTO,HISTO
      SUBROUTINE HISTO (UPLIM,XLOWL,CELLW,IIST,VAR,IADD,NCELL,INTRY)     HIST0000
C                                                                        HIST0010
C                                                                        HIST0020
C-------------------------------------------------------------------     HIST0030
C                                                                        HIST0040
C                              DARYL D. PAUL JR.                         HIST0050
C                              TELEDYNE BROWN ENGINEERING                HIST0060
C                              JANUARY, 1971                             HIST0070
C                              MARCH, 1972 (REV. A)                      HIST0080
C                                                                        HIST0090
C                                                                        HIST0100
C                                                                        HIST0110
C     THIS SUBROUTINE IS USED TO ESTABLISH A HISTOGRAM OF INDIVIDUAL     HIST0120
C     DATA POINTS.  SUBROUTINES WHICH SHOULD BE USED IN CONJUNCTION      HIST0130
C     WITH THIS SUBROUTINE ARE CUMULATIVE PROBABILITY (CUMPF) AND        HIST0140
C     WRITE HISTOGRAM (WHIST).                                           HIST0150
C-------------------------------------------------------------------     HIST0160
C                                                                        HIST0170
C                                                                        HIST0180
C-------------------------------------------------------------------     HIST0190
C                              DEFINITIONS                               HIST0200
C                                                                        HIST0210
C     CELLW-        WIDTH OF EACH CELL. ESTABLISHED OUTSIDE OF THE       HIST0220
C                   SUBROUTINE                                           HIST0230
C                                                                        HIST0240
C     I-            CELL NUMBER                                        HIST0250
C                                                                        HIST0260
C     IADD(I)-      NUMBER OF POINTS OF VAR WHICH FALL IN CELL I.      HIST0270
C                   IADD MUST BE DIMENSIONED IN THE MAINLINE WITH A VALUEHIST0280
C                   AT LEAST EQUAL TO THE FOLLOWING EQUATION           HIST0290
C                   NUMBER OF CELLS=((UPLIM-LOWLM)/CELLW)+2.0          HIST0300
C                                                                        HIST0310
C     IADD(1)-      ALL VALUES FOR VAR WHICH FALL BELOW LOWLM.          HIST0320
C                                                                        HIST0330
C     IADD(NCELL)- ALL VALUES OF VAR WHICH FALL ABOVE UPLIM.           HIST0340
C                                                                        HIST0350
C     IIST-         NEEDED FOR INITIALIZATION.  THIS TERM MUST BE SET TO HIST0360
C                   ZERO IN THE MAINLINE INITIALIZATION.               HIST0370
C                                                                        HIST0380
C     INTRY-        THE NUMBER OF POINTS IN THE HISTOGRAM.             HIST0390
C                                                                        HIST0400
C     NCELL-        TOTAL NUMBER OF CELLS GENERATED BY THIS SUBROUTINE  HIST0410
C                                                                        HIST0420
C     UPLIM-        UPPER LIMIT OF HISTOGRAM                           HIST0430
C                                                                        HIST0440
C     VAR-          VARIABLE FOR WHICH HISTOGRAM IS TO BE OBTAINED.    HIST0450
C                                                                        HIST0460
C     XLOWL-        LOWER LIMIT OF HISTOGRAM                           HIST0470
C                                                                        HIST0480
C-------------------------------------------------------------------     HIST0490
C                                                                        HIST0500
C                                                                        HIST0510
      DIMENSION IADD(1)                                                  HIST0520
C                                                                        HIST0530
C                                                                        HIST0540
C-----------------------------                                           HIST0550
C     INITIALIZE THE SUBROUTINE IF IIST IS EQUAL TO ZERO                 HIST0560
      IF (IIST) 10,10,30                                                 HIST0570
C                                                                        HIST0580
   10 CONTINUE                                                           HIST0590
C     CALCULATE NUMBER OF CELLS                                          HIST0600
      NCELL=((UPLIM-XLOWL)/CELLW)+2.0                                    HIST0610
C                                                                        HIST0620
C     INITIALIZE NUMBER OF POINTS IN HISTOGRAM.                          HIST0630
```

```
C     INITIALIZE NUMBER OF POINTS IN HISTOGRAM                          HIST0640
      INTRY=0                                                           HIST0650
C                                                                       HIST0660
C     INITIALIZE CONTENTS OF EACH CELL                                  HIST0670
      DO 20 I=1,NCELL                                                   HIST0680
      IADD(I)=0                                                         HIST0690
   20 CONTINUE                                                          HIST0700
C                                                                       HIST0710
C     SET IIST TO INDICATE INITIALIZATION COMPLETE                      HIST0720
      IIST=10                                                           HIST0730
C-----------------------------                                          HIST0740
C                                                                       HIST0750
C                                                                       HIST0760
C                                                                       HIST0770
C-----------------------------------------------------------------------HIST0780
C     THE SUBROUTINE WILL START AT THIS POINT EVERY TIME AFTER THE FIRSTHIST0790
C-----------------------------------------------------------------------HIST0800
C                                                                       HIST0810
C                                                                       HIST0820
C-----------------------------                                          HIST0830
   30 CONTINUE                                                          HIST0840
C     NUMBER OF POINTS IN HISTOGRAM                                     HIST0850
      INTRY=INTRY+1.0                                                   HIST0860
C-----------------------------                                          HIST0870
C                                                                       HIST0880
C                                                                       HIST0890
C-----------------------------                                          HIST0900
C     INITIALIZE A VALUE TO TEST WHICH CELL VAR IS IN.                  HIST0910
      TEST = XLOWL                                                      HIST0920
C-----------------------------                                          HIST0930
C                                                                       HIST0940
C                                                                       HIST0950
C-----------------------------                                          HIST0960
C     THE FOLLOWING DO LOOP DETERMINES WHICH CELL THE VARIABLE IS IN.   HIST0970
      N=NCELL-1                                                         HIST0980
      DO 60 I=1,N                                                       HIST0990
      IF (VAR-TEST) 40,40,50                                            HIST1000
C     THE VARIABLE IS IN CELL I                                         HIST1010
   40 CONTINUE                                                          HIST1020
      IADD(I)=IADD(I)+1                                                 HIST1030
      RETURN                                                            HIST1040
C     THE VARIABLE IS NOT IN CELL I                                     HIST1050
C     SET TEST FOR NEXT CELL                                            HIST1060
   50 CONTINUE                                                          HIST1070
      TEST=TEST+CELLW                                                   HIST1080
   60 CONTINUE                                                          HIST1090
C-----------------------------                                          HIST1100
C                                                                       HIST1110
C                                                                       HIST1120
C-----------------------------                                          HIST1130
C     IF THE VARIABLE IS IN NONE OF THE ABOVE CELLS IT IS               HIST1140
C     ABOVE THE UPPER LIMIT                                             HIST1150
      IADD(NCELL)=IADD(NCELL)+1                                         HIST1160
C                                                                       HIST1170
C                                                                       HIST1180
C-----------------------------                                          HIST1190
C                                                                       HIST1200
C                                                                       HIST1210
      RETURN                                                            HIST1220
      END                                                               HIST1230
```

```
&FOR,IS CUMPF,CUMPF
      SUBROUTINE CUMPF (INTRY,IADD,NCELL,PERDS)                          CUMP0000
                                                                         CUMP0010
C                                                                        CUMP0020
C-------------------------------------------------------------------     CUMP0030
C                                                                        CUMP0040
C                              TELEDYNE BROWN ENGINEERING                CUMP0050
C                              FRED J. GHIGLIERI                         CUMP0060
C                              DARYL D. PAUL JR.                         CUMP0070
C                              APRIL, 1971                               CUMP0080
C                              MARCH, 1972 (REV.A)                       CUMP0090
C                                                                        CUMP0100
C                                                                        CUMP0110
C  SUBROUTINE TO CALCULATE PROBABILITY FOR CUMMULATIVE                   CUMP0120
C  PROBABILITY FUNCTION. THIS SUBROUTINE IS USED IN CONJUNCTION WITH     CUMP0130
C  THE SUBROUTINE HISTOGRAM (HISTO).                                     CUMP0140
C-------------------------------------------------------------------     CUMP0150
C                                                                        CUMP0160
C                                                                        CUMP0170
C-------------------------------------------------------------------     CUMP0180
C                              DEFINITIONS                               CUMP0190
C                                                                        CUMP0200
C  ADD(I) - CONVERT INTEGER IADD(I) TO REAL NUMBER                       CUMP0210
C                                                                        CUMP0220
C  ENTRY - CONVERT INTEGER INTRY TO REAL NUMBER                          CUMP0230
C                                                                        CUMP0240
C  IADD(I) - NUMBER OF POINTS OF VARIABLE WHICH FALL IN CELL I           CUMP0250
C                                                                        CUMP0260
C  INTRY - NUMBER OF POINTS IN HISTOGRAM                                 CUMP0270
C                                                                        CUMP0280
C  NCELL - TOTAL NUMBER OF CELLS IN HISTOGRAM                            CUMP0290
C                                                                        CUMP0300
C  PERDS - PERCENT OF CUMMULATIVE PROBABILITY FUNCTION TO CELL I         CUMP0310
C                                                                        CUMP0320
C  TEMP - TEMPORARY STORAGE OF TOTAL CUMMULATED POINTS IN HISTOGRAM      CUMP0330
C-------------------------------------------------------------------     CUMP0340
C                                                                        CUMP0350
C                                                                        CUMP0360
C-----------------------------                                           CUMP0370
C  NOTE - ADD(1) MUST BE DIMENSIONED IN THIS SUBROUTINE                  CUMP0380
C  NOTE - IADD(I) MUST BE DIMENSIONED IN MAINLINE                        CUMP0390
C  NOTE - PERDS(1) MUST BE DIMENSIONED IN MAINLINE                       CUMP0400
C                                                                        CUMP0410
      DIMENSION IADD(1),PERDS(1)                                         CUMP0420
      DIMENSION ADD(2005)                                                CUMP0430
C-----------------------------                                           CUMP0440
C                                                                        CUMP0450
C                                                                        CUMP0460
C-----------------------------                                           CUMP0470
C     CHECK TO SEE IF DIMENSION FOR THE                                  CUMP0480
C     INTERNAL VARIABLE 'ADD' IS LARGE                                   CUMP0490
C     ENOUGH.                                                            CUMP0500
      IF(NCELL-2005)30,30,10                                             CUMP0510
   10 CONTINUE                                                           CUMP0520
      NUMB=NCELL-2005                                                    CUMP0530
      WRITE(6,20) NUMB                                                   CUMP0540
   20 FORMAT(1X,20('*'),' THE DIMENSION OF ADD IN SUBROUTINE CUMPF       CUMP0550
     1MUST BE INCREASED BY AT LEAST'/21X,I4,' TO ACCOMODATE THE NUMBER   CUMP0560
     2OF CELLS GENERATED BY THE HISTOGRAM SUBROUTINE')                   CUMP0570
   30 CONTINUE                                                           CUMP0580
C-----------------------------                                           CUMP0590
C                                                                        CUMP0600
C                                                                        CUMP0610
C-----------------------------                                           CUMP0620
C     FLOAT THE NUMBER OF DATA POINTS IN THE HISTOGRAM                   CUMP0630
      ENTRY = INTRY
```

```
C-----------------------------                                    CUMP0640
C                                                                 CUMP0650
C                                                                 CUMP0660
C-----------------------------                                    CUMP0670
C     FLOAT EACH POINT IN THE HISTOGRAM ARRAY                     CUMP0680
      DO 40 I = 1,NCELL                                           CUMP0690
      ADD(I) = IADD(I)                                            CUMP0700
   40 CONTINUE                                                    CUMP0710
C-----------------------------                                    CUMP0720
C                                                                 CUMP0730
C                                                                 CUMP0740
C-----------------------------                                    CUMP0750
C     ESTABLISH CUMULATIVE PROBABILITY OF THE FIRST CELL          CUMP0760
      PERDS(1) = ADD(1) / ENTRY                                   CUMP0770
C-----------------------------                                    CUMP0780
C                                                                 CUMP0790
C                                                                 CUMP0800
C-----------------------------                                    CUMP0810
C     INITIALIZE ACCUMULATOR                                      CUMP0820
      TEMP = ADD(1)                                               CUMP0830
C-----------------------------                                    CUMP0840
C                                                                 CUMP0850
C                                                                 CUMP0860
C-----------------------------                                    CUMP0870
C     CALCULATE THE CUMULATIVE PROBABILITY OF THE OTHER CELLS     CUMP0880
      DO 50 J = 2,NCELL                                           CUMP0890
      TEMP = TEMP + ADD(J)                                        CUMP0900
      PERDS(J) = TEMP / ENTRY                                     CUMP0910
   50 CONTINUE                                                    CUMP0920
C-----------------------------                                    CUMP0930
C                                                                 CUMP0940
C                                                                 CUMP0950
      RETURN                                                      CUMP0960
      END                                                         CUMP0970
```

```
$FOR,IS WHIST,WHIST
      SUBROUTINE WHIST(XLOW,UP,LCELL,PERDS,CELLW,LIADD,LNTRY,KRITE)      WHIS0000
C                                                                        WHIS0010
C                                                                        WHIS0020
C-------------------------------------------------------------------     WHIS0030
C                              TELEDYNE BROWN ENGINEERING                WHIS0040
C                              DARYL D. PAUL JR.                         WHIS0050
C                              FEBRUARY, 1972                            WHIS0060
C                                                                        WHIS0070
C                                                                        WHIS0080
C     HISTOGRAM(HISTO) AND CUMMULATIVE PROBABILITY (CUMPF) MUST          WHIS0090
C     BE USED IN CONJUNCTION WITH THIS SUBROUTINE                        WHIS0100
C     THIS SUBROUTINE WRITES THE INFORMATION OBTAINED BY HISTO           WHIS0110
C     AND CUMPF IN A FORM WHICH CONTAINS ONLY THE VALUES BETWEEN THE     WHIS0120
C     FIRST NON-ZERO CUMMULATIVE PROBABILITY AND THE FIRST CUMMULATIVE   WHIS0130
C     PROBABILITY OF ONE.                                                WHIS0140
C-------------------------------------------------------------------     WHIS0150
C                                                                        WHIS0160
C                                                                        WHIS0170
C-------------------------------------------------------------------     WHIS0180
C                              DEFINITIONS                               WHIS0190
C                                                                        WHIS0200
C     CELLW=   WIDTH OF EACH CELL. ESTABLISHED OUTSIDE OF THE SUBROUTINE WHIS0210
C                                                                        WHIS0220
C     JJ=      USED TO DETERMINE NUMBER OF LOWEST NONZERO CELL.          WHIS0230
C                                                                        WHIS0240
C     KCELL=   NUMBER OF CELL IMMEDIATELY ABOVE THE FIRST CELL           WHIS0250
C              WITH A CUMMULATIVE PROBABILITY OF ONE                     WHIS0260
C                                                                        WHIS0270
C     KK=      USED TO DETERMINE NUMBER OF THE FIRST CELL                WHIS0280
C              WITH A CUMMULATIVE PROBABILITY OF ONE                     WHIS0290
C                                                                        WHIS0300
C     LCELL=   NUMBER OF CELLS IN HISTOGRAM.                             WHIS0310
C                                                                        WHIS0320
C     LIADD=   FREQUENCY OF VAR IN CELL                                  WHIS0330
C                                                                        WHIS0340
C     LNTRY    THE NUMBER OF DATA POINTS IN THE HISTOGRAM                WHIS0350
C                                                                        WHIS0360
C     LOWLM=   NUMBER OF CELL IMMEDIATELY BELOW THE FIRST                WHIS0370
C              NONZERO CELL IN THE HISTOGRAM                             WHIS0380
C                                                                        WHIS0390
C     N=       INDICY FOR WRITING HISTOGRAM                              WHIS0400
C                                                                        WHIS0410
C     PERDS=   PERCENT OF CUMMULATIVE PROBABILITY FUNCTION TO CELL       WHIS0420
C                                                                        WHIS0430
C     TOP=     VALUE OF CELL IMMEDIATELY ABOVE THE FIRST CELL            WHIS0440
C              WITH A CUMMULATIVE PROBABILITY OF ONE                     WHIS0450
C                                                                        WHIS0460
C     TXLOW=   CELL VALUE INDICATOR.                                     WHIS0470
C                                                                        WHIS0480
C     UP=      UPPER LIMIT OF CELL VALUES FOR HISTOGRAM                  WHIS0490
C                                                                        WHIS0500
C     XLOW=    LOWER LIMIT OF CELL VALUES FOR HISTOGRAM                  WHIS0510
C                                                                        WHIS0520
C-------------------------------------------------------------------     WHIS0530
C                                                                        WHIS0540
C                                                                        WHIS0550
C-----------------------------                                           WHIS0560
      DIMENSION PERDS(1),LIADD(1)                                        WHIS0570
C-----------------------------                                           WHIS0580
C                                                                        WHIS0590
C                                                                        WHIS0600
C-----------------------------                                           WHIS0610
C     WRITE NUMBER OF DATA POINTS IN HISTOGRAM AND THE CELL WIDTH        WHIS0620
      WRITE(KRITE,1301) LNTRY                                            WHIS0630
```

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      WRITE(KRITE,160) CELLW                                              WHIS0640
C-----------------------------                                            WHIS0650
C                                                                         WHIS0660
C                                                                         WHIS0670
C-----------------------------                                            WHIS0680
C     SET CELL VALUE INDICATOR TO ONE CELL WIDTH LESS THAN LOWER LIMIT    WHIS0690
      TXLOW=XLOW-CELLW                                                    WHIS0700
      TUP=UP                                                              WHIS0710
C-----------------------------                                            WHIS0720
C                                                                         WHIS0730
C                                                                         WHIS0740
C-----------------------------                                            WHIS0750
C     FIND THE FIRST CELL WITH A FREQUENCY GREATER THAN ZERO              WHIS0760
      DO 20 JJ=1,LCELL                                                    WHIS0770
      IF(PERDS(JJ))10,10,30                                               WHIS0780
   10 CONTINUE                                                            WHIS0790
      TXLOW=TXLOW+CELLW                                                   WHIS0800
   20 CONTINUE                                                            WHIS0810
C-----------------------------                                            WHIS0820
C                                                                         WHIS0830
C                                                                         WHIS0840
C-----------------------------                                            WHIS0850
C     ESTABLISH AND SET LOWER LIMIT CELL NUMBER INDICATOR                 WHIS0860
   30 CONTINUE                                                            WHIS0870
      IF(JJ-1) 40,40,50                                                   WHIS0880
   40 CONTINUE                                                            WHIS0890
      TXLOW=TXLOW+CELLW                                                   WHIS0900
      LOWLM=JJ                                                            WHIS0910
      GO TO 60                                                            WHIS0920
   50 CONTINUE                                                            WHIS0930
      LOWLM=JJ-1                                                          WHIS0940
   60 CONTINUE                                                            WHIS0950
C-----------------------------                                            WHIS0960
C                                                                         WHIS0970
C                                                                         WHIS0980
C-----------------------------                                            WHIS0990
C     FIND FIRST CELL WITH A CUMMULATIVE PROBABILITY OF ONE               WHIS1000
      DO 70 KK=1,LCELL                                                    WHIS1010
      IF(PERDS(KK)-1.00) 70,80,80                                         WHIS1020
   70 CONTINUE                                                            WHIS1030
C-----------------------------                                            WHIS1040
C                                                                         WHIS1050
C                                                                         WHIS1060
C-----------------------------                                            WHIS1070
C     ESTABLISH AND SET UPPER CELL NUMBER INDICATOR                       WHIS1080
   80 CONTINUE                                                            WHIS1090
      IF(KK-LCELL)90,100,100                                              WHIS1100
   90 CONTINUE                                                            WHIS1110
      KCELL=KK+1                                                          WHIS1120
      KK=(LCELL-2)-KK                                                     WHIS1130
      TUP=TUP-KK*CELLW                                                    WHIS1140
      GO TO 110                                                           WHIS1150
  100 CONTINUE                                                            WHIS1160
      KCELL=KK                                                            WHIS1170
      TUP=UP+CELLW                                                        WHIS1180
C-----------------------------                                            WHIS1190
C                                                                         WHIS1200
C                                                                         WHIS1210
C-----------------------------                                            WHIS1220
C     WRITE THE NUMBER OF DATA POINTS ABOVE AND BELOW THE UPPER           WHIS1230
C     AND LOWER LIMITS OF THE PRINTED OUTPUT OF THE HISTOGRAM             WHIS1240
  110 CONTINUE                                                            WHIS1250
      WRITE(KRITE,140)TXLOW,LIADD(LOWLM)                                  WHIS1260
      WRITE(KRITE,170)TUP,LIADD(KCELL)                                    WHIS1270
      WRITE(KRITE,180)                                                    WHIS1280
C-----------------------------                                            WHIS1290
```

```
C                                                                       WHIS1300
C                                                                       WHIS1310
C-----------------------------                                          WHIS1320
C     WRITE THE HISTOGRAM                                               WHIS1330
      DO 120 N=LOWLM,KCELL                                              WHIS1340
      WRITE(KRITE,150)TXLOW,CUADD(N),PERDS(N)                           WHIS1350
      TXLOW=TXLOW+CELLW                                                 WHIS1360
  120 CONTINUE                                                          WHIS1370
C-----------------------------                                          WHIS1380
C                                                                       WHIS1390
C                                                                       WHIS1400
C-----------------------------                                          WHIS1410
  130 FORMAT(' NUMBER OF DATA POINTS IN HISTOGRAM',I5)                  WHIS1420
  140 FORMAT(' NUMBER OF DATA POINTS EQUAL TO OR BELOW',F8.2,'=',I3)    WHIS1430
  150 FORMAT(1X,F10.3,5X,I5,5X,F10.3)                                   WHIS1440
  160 FORMAT(' CELL WIDTH =',F7.3)                                      WHIS1450
  170 FORMAT(' NUMBER OF DATA POINTS EQUAL TO OR ABOVE',F8.2,'=',I3)    WHIS1460
  180 FORMAT(/5X,'UPPER',8X,'CELL',7X,'CUMULATIVE'/5X,'CELL ',8X,'FREQ',WHIS1470
     17X,'PROBABILITY'/5X,'LIMIT')                                      WHIS1480
C-----------------------------                                          WHIS1490
C                                                                       WHIS1500
C                                                                       WHIS1510
      RETURN                                                            WHIS1520
      END                                                               WHIS1530
```

```
$FOR,IS URAND,URAND
      FUNCTION URAND(NR)                                          URAN0000
      NR=NR*316251                                                URAN0010
C     THE VALUE IS(2 TO THE 35 POWER)+I                           URAN0020
      IF(NR) 10,10,20                                             URAN0030
   10 NR=NR+34359738367                                           URAN0040
   20 RN=NR                                                       URAN0050
      URAND=RN/34359738384.E2                                     URAN0060
      RETURN                                                      URAN0070
      END                                                         URAN0080
```


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