Statistical Bulletin
Reliability & Variation Research

DETROIT RESEARCH INSTITUTE
P.O. BOX 36504 • GROSSE POINTE, MICHIGAN 48236 • (313) 886-7976

LEONARD G. JOHNSON
EDITOR

WANG H. YEE
DIRECTOR

Volume 17
Bulletin 7



---

# COMPUTER ANALYSIS OF FIELD FAILURE DATA USING THE CUMULATIVE ENTROPY CONCEPT

## INTRODUCTION

Whenever we are dealing with a failure process it invariably involves a process of breakdown or deterioration. As such, it reminds us of the Natural Law of Increasing Entropy with a system's age. This concept of Entropy, defined as the absolute value of survival probability, has been found to be most useful in evaluating the reliability of a manufactured system, such as a motor vehicle model operated by customers in the field. For maximum accuracy in predicting field reliability we need to have a sample of customer histories of both unfailed and failed vehicles and their true mileages at the time of analysis. This will involve the calculation of the number of active vehicles in each mileage interval between failures.

The entire analysis is done automatically in DRI's special computer program having the title ENTFLD, which is an abbreviation for ENTROPY IN FIELD. In this bulletin we shall give directions for using the program*.

Results will be discussed for a typical example of vehicles in the field .

---

*Listing of the source code in BASIC on diskette for IBM PC & Compatibles is available from DRI for a fee.

---

## DATA ELEMENTS IN A FIELD EXAMPLE

1. The number of customer vehicles in the survey, i.e., the total sample size (denoted by the letter N)

2. The number of customer vehicles failed.(denoted by letter R)

3. All vehicles mileages, each with index 0 or 1 .

Index 0 indicates that the vehicle is unfailed at its mileage.

Index 1 indicates that the vehicle is failed at its mileage .

---

## A TYPICAL FIELD EXAMPLE

Suppose we survey 15 vehicles of a certain model. Suppose these vehicles have the following mileages. (Note that 4 have failed and 11 are still unfailed.)

| VEHICLE NO. | MILEAGE | CONDITION | INDEX |
|---|---|---|---|
| 1 | 5350 | unfailed | 0 |
| 2 | 12100 | unfailed | 0 |
| 3 | 18805 | failed | 1 |
| 4 | 19200 | unfailed | 0 |
| 5 | 27400 | unfailed | 0 |
| 6 | 31229 | failed | 1 |
| 7 | 32000 | unfailed | 0 |
| 8 | 37800 | unfailed | 0 |
| 9 | 42400 | unfailed | 0 |
| 10 | 49357 | failed | 1 |
| 11 | 56905 | unfailed | 0 |
| 12 | 64100 | unfailed | 0 |
| 13 | 65711 | failed | 1 |
| 14 | 68000 | unfailed | 0 |
| 15 | 72000 | unfailed | 0 |

---

## COMPONENTS OF THE ANALYSIS

We divide the data collection into 4 mileage intervals between failures. These are the followings:

INTERVAL #1: 0 Miles to 18805 Miles

INTERVAL #2: 18805 Miles to 31229 Miles

INTERVAL #3: 31229 Miles to 49357 Miles

INTERVAL #4: 49357 Miles to 65711 Miles

Within each interval there are two types of vehicles as far as activity is concerned. These types are

(A) Fully Active Vehicles

(B) Partially Active Vehicles

The fully active vehicles for any interval are those which have reached or surpassed the end point of the interval. For example, at the end of INTERVAL #1 there are 13 fully active vehicles, i.e., those 13 with mileages at least 18805. The unfailed vehicles in INTERVAL #1 (5350 Miles and 12100 Miles) are only partially active, i.e.,5350/18805 + 12100/18805 = .9279. Thus , the total number of active vehicles in INTERVAL #1 is 13 + .9279 = 13.9279 .

---

## ENTERING THE DATA INTO THE PROGRAM "ENTFLD"

There are four DATA STATEMENTS in ENTFLD . These are STATEMENTS 11, 12, 30, and 80 .

STATEMENT 11 consists of failure mileage only . For the example, we write STATEMENT 11 as follows:

```
11 DATA 18805,31229,49357,65711
```

STATEMENT 12 involves indexing the number of failure mileage. In the example , STATEMENT 12 would be written as follows :

```
12 FOR J = 1 TO 4
```

(Thus, STATEMENT 12 Indexes the 4 failure mileages.)

STATEMENT 30 records the No. Failed, the Total Sample Size, followed by mileages with INDEX 0 if UNFAILED and INDEX 1 if FAILED .

For the example , STATEMENT 30 would be written as follows:

```
30 DATA 4,15,5350,0,12100,0,18805,1,19200,0,27400,0,31229,1,32000,0,
37800,0,42400,0,49357,1,56905,0,64100,0,65711,1,68000,0,72000,0
```

STATEMENT 80 involves indexing all mileages up to and including the final failure. In the example, we would write it as follows :

```
80 FOR I = 1 TO N - 2
```

2 is subtracted from N in 80 because of mileages beyond last failure .

THE LAST TWO PAGES ARE THE COMPUTER PRINTOUT FOR THE EXAMPLE

---

COMPUTER PRINTOUT FOR THE EXAMPLE

```
Ok
 RUN
ENTFLD PROGRAM

NO. FAILED= 4
TOTAL SAMPLE= 15

LIFE= 5350
INDEX 0

LIFE= 12100
INDEX 0

LIFE= 18805
INDEX 1

INTERVAL END PT.= 18805
NO. ACTIVE= 13.92795
ENTROPY INCREMENT= .0717981
CUM. ENTROPY= .0717981
LIFE= 19200
INDEX 0



LIFE= 27400
INDEX 0

LIFE= 31229
INDEX 1

INTERVAL END PT.= 31229
NO. ACTIVE= 10.7236
ENTROPY INCREMENT= 9.325227E-02
CUM. ENTROPY= .1650504
LIFE= 32000
INDEX 0

LIFE= 37800
INDEX 0

LIFE= 42400
INDEX 0

LIFE= 49357
INDEX 1
```

---

INTERVAL END PT.= 49357
NO. ACTIVE= 7.021238
ENTROPY INCREMENT= .142425
CUM. ENTROPY= .3074754
LIFE= 56905
INDEX 0

LIFE= 64100
INDEX 0

LIFE= 65711
INDEX 1

INTERVAL END PT.= 65711
NO. ACTIVE= 4.363031
ENTROPY INCREMENT= .2291985
CUM. ENTROPY= .5366739

WEIBULL SLOPE= 1.573836

CHAR. LIFE= 100052.6

CORR.COEFF.= .9984036

| WEIBULL SLOPE | B-10 LIFE | MEDIAN LIFE | CHAR. LIFE | INDEX OF FIT |
|---|---|---|---|---|
| 1.573836 | 23946.79 | 79266.63 | 100052.6 | .9984036 |

Ok