Statistical Bulletin
Reliability & Variation Research

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Volume 18 August , 1988
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PREDICTING A SELLER'S WARRANTY LOSSES AND A BUYER'S POST WARRANTY LOSSES FROM TIME TO REPAIR DATA

INTRODUCTION

The reliability or unreliability of the operating condition of any system is always made evident by the number of repairs it requires in successive time intervals of its operating history. This is the reason why automotive vehicle sellers should collect what we call TIME TO REPAIR data, which tell us the number of repairs or corrections per active vehicle in successive 30 day periods of vehicle ownership. These same data will not only enable us to predict warranty costs to the seller, but, also, the post warranty expenses which must be paid by owners of the vehicles. These are what might be called vital statistics on the population of a particular vehicle model and all its parts and sub-assemblies.

In this bulletin we discuss the Entropy , i.e., the Cumulative Hazard, method of making reliability predictions from **TIME TO REPAIR** data. By attaching a Dollar Loss to each repair we can develop a program for eliminating the weakest links within the entire system, thus realizing continual reliability growth and more customer satisfaction. In other words, we will develop a LOSS FUNCTION depending upon the seriousness of a vehicle's deviation from the perfect performance customers desire. This is the same philosophy as that employed by proponents of the TAGUCHI APPROACH. In the Entropy approach we simply define LOSS PER VEHICLE as the DOLLAR ENTROPY.

A TYPICAL TIME TO REPAIR DATA SET

Consider the ownership experience of sold vehicles of a certain model type which lists vehicle ages since their delivery dates to their buyers in 30 day intervals, together with their total numbers and how many repairs have have been needed. Such a data list appears in the Table below for 9685 sold vehicles.

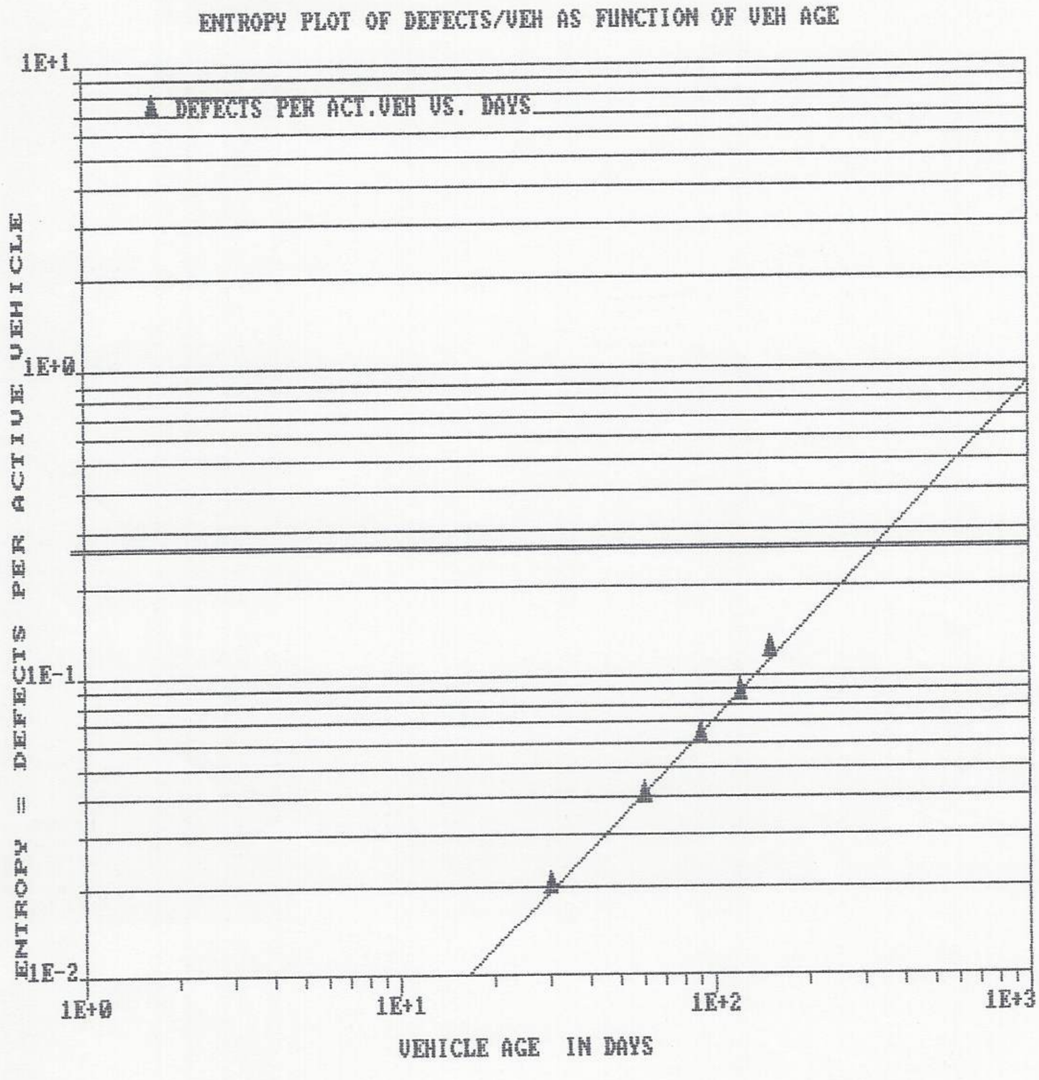
VEHICLE AGE (DAYS OF OWNERSHIP)	VEHICLE COUNT	NO. OF REPAIRS	COST OF THE REPAIRS
0 - 30 DAYS	2210	171	$5,501
31 - 60 DAYS	1965	130	$4,708
61 - 90 DAYS	1687	102	$3,910
91 - 120 DAYS	2553	61	$2,150
121 - 150 DAYS	1270	21	$ 960
THUS FAR :	9685 TOTAL SOLD	484 REPAIRS	$17,229 COST

PROGRESSIVE RISE OF DEFECTS (REPAIRS) PER ACTIVE VEHICLE

If we want to trace in a predictive fashion the growth of defects in these vehicles we must determine how many active vehicles should be used as the divisor for the repair count of each time interval in order to calculate the risk (hazard) of a failure occurance requiring repair in that interval. Those vehicles within any interval we assume have gone (on the average) halfway through the interval, while all other subsequent vehicle have gone all the way through the interval (since they are beyond the end point of the interval). Thus, we get the following tabulation from the data on page 2 :

VEHICLE AGE (SINCE SOLD)	NO. ACTIVE	NO. OF REPAIRS	RISK (HAZARD)	ENTROPY (REPAIRS/ACT VEH.) (CUM. HAZARD)
0 - 30 DAYS	8580	171	.01993	.01993
31 - 60 DAYS	6492.5	130	.02002	.03995
61 - 90 DAYS	4666.5	102	.02186	.06181
91 - 120 DAYS	2546.5	61	.02395	.08576
121 - 150 DAYS	635	21	.03307	.11883

LOG-LOG GRID



THE REGRESSION POLYNOMIAL OF LINE 1 -

(-3.329E+00) + (1.093E+00)*X
THE VARIANCE - 2.745E-04

Weibull Slope = 1.093 (Slope of Line)

Characteristic Life = 1,111 Days (at Entropy = 1)

B-10 Life = 142 Days [at Entropy = -ln(.9)]

FIGURE 1

DETERMINING THE DOLLAR LOSS PER VEHICLE VS. AGE

VEHICLE AGE	NO. ACTIVE	DOLLAR LOSS	DOLLAR HAZARD	DOLLAR ENTROPY
0 - 30 DAYS	8580	$5,501	.64114	.64114
31 - 60 DAYS	6492.5	$4,708	.72514	1.36628
61 - 90 DAYS	4666.5	$3,910	.83789	2.20417
91 - 120 DAYS	2546.5	$2,150	.84430	3.04847
121 - 150 DAYS	635	$ 960	1.51181	4.56028

By least squares curve fitting on log-log paper

Abscissa = ln (Age) ; Ordinate = ln (Dollar Entropy)

We find that

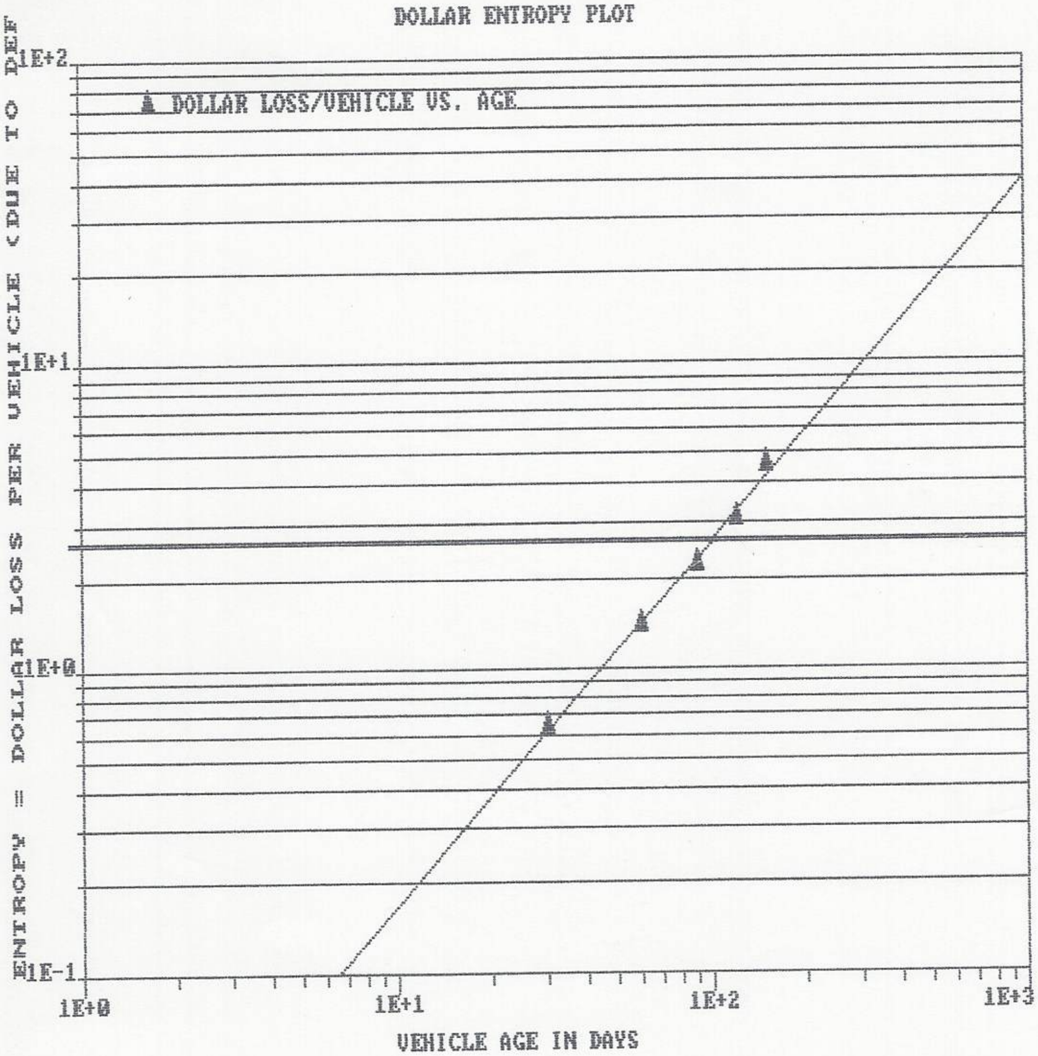
Slope = 1.19 Correlation Coefficient = .99707

$1 per vehicle in 45 days

$10 per vehicle in 311 days

$12.08 per vehicle in 365 days (first year)

The graph of these data appears in Figure 2 .



THE REGRESSION POLYNOMIAL OF LINE 1 -

(-1.966E+00) + (1.190E+00)*X
THE VARIANCE - 5.081E-04

Weibull Slope = 1.19

$1.00 per Vehicle in 45 Days

$10.00 per Vehicle in 311 Days

$12.08 per Vehicle in 365 Days (First Year)

FIGURE 2

CONCLUSION

The two graphs (Figures 1 and 2) shown clearly that while a set of vehicle defects may appear to have an alarming total number of cases (like a B-10 life of only 142 days), the actual dollar losses per vehicle could be something trivial (like $12.08 per vehicle in the customer's first year of ownership). This all goes to show that in addition to counting repairs we should also count the costs involved.