SOFTWARE APPLICATIONS FOR FIELD RELIABILITY DATA

Dr.ing. Adrian Stere **PARIS,** Univ. Politehnica Bucharest

Abstract *The paper details the peculiarities of processing the field reliability data to find the reliability function or the cumulative distribution function assisted by the regression analysis. An overview of the application software for statistical and reliability calculi, particularly for field data, is presented with the main characteristics.*

K**ey words***: field data reliability, software applications*

1.Introduction

The ultimate test of a manufactured product is how well it performs in the field, in the hands of the customer. Accordingly, the collection and analysis of data on the field performance or reliability of products is important to manufacturers and consumers alike [13]. Such data can be used in many ways by a manufacturer, including (i) to asses field reliability and make comparisons with engineering predictions, (ii) to provide information for product modification and improvement, (iii) to asses the effects of design changes, (iv) to estimate and explain warranty costs, and (v) to aid in the design of warranty, maintenance and parts replacement programs[14].

2. Field reliability data

Nevertheless, many manufacturers pay insufficient attention to the collection of field performance data. One reason is that comprehensive data are often seen as expensiv to obtain; another may be a lack of familiarity with methods for response-selective observational schemes and for combining information from different sources[13]. Foe some problems methodology indeed needs to be developed. This paper deals with reliability, which is an important component of field performance [14].

Reliability prediction models depend on observed lifetime data. There are several means of acquiring lifetime data for a system such as artificially stressing a system, initial laboratory tests and the like. Most data sources have some sort of bias, and the historic military preference has been for field data: information acquired by observing the lifetime of components in their normal use [12].

Prediction models depend on this data for several reasons:

- the prediction formula are themselves derived from field data, without some idea of the natural life spans of the components.
- engineers building new components plug existing field data into their derived prediction models to make an estimate. Field data is one of a group of data types that can be used, but it is usually the most thorough [2].

Acquiring field data is a relatively onerous task: by definition, field data is gathered by observing parts fail in situ. A well designed part is less likely to have a long life time, leading to extended waiting time for any useful information. Because the task is so time consuming, there are relatively few sources, usually from the manufacturers themselves [2].

Figure 1 illustrates the problem of matching a reliability or risk prediction to the eventual field performance. In practice, prediction adresses the component-based ‘design reliability’ and is necessary to take account of the additional factors when assessing the integrity of a system.

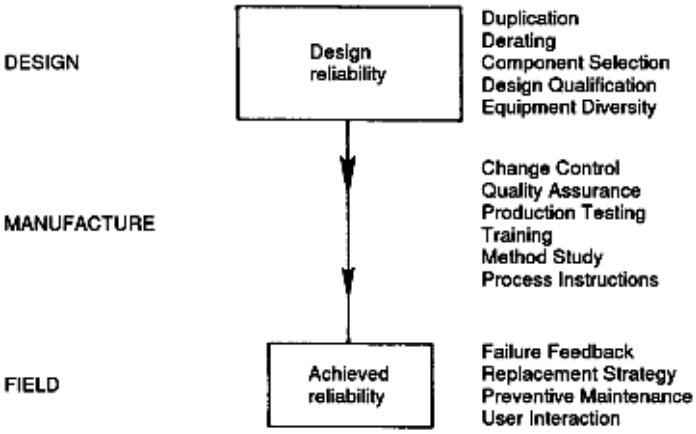


Fig.1 *The complete chain of reliability*

1.Failure Data types

A Reliability data set can contain complete data, right censored data, interval censored data and left censored data. An overview of this is presented in fig. 2. The common case is obvious for the first variant (fig. 2), respectively non-grouped data, all failed, exact time to failure. Even this is not the present case; it is preferred for the facilities of data processing (only the packages with specialized reliability applications enable censured data), the result being a distorted information.

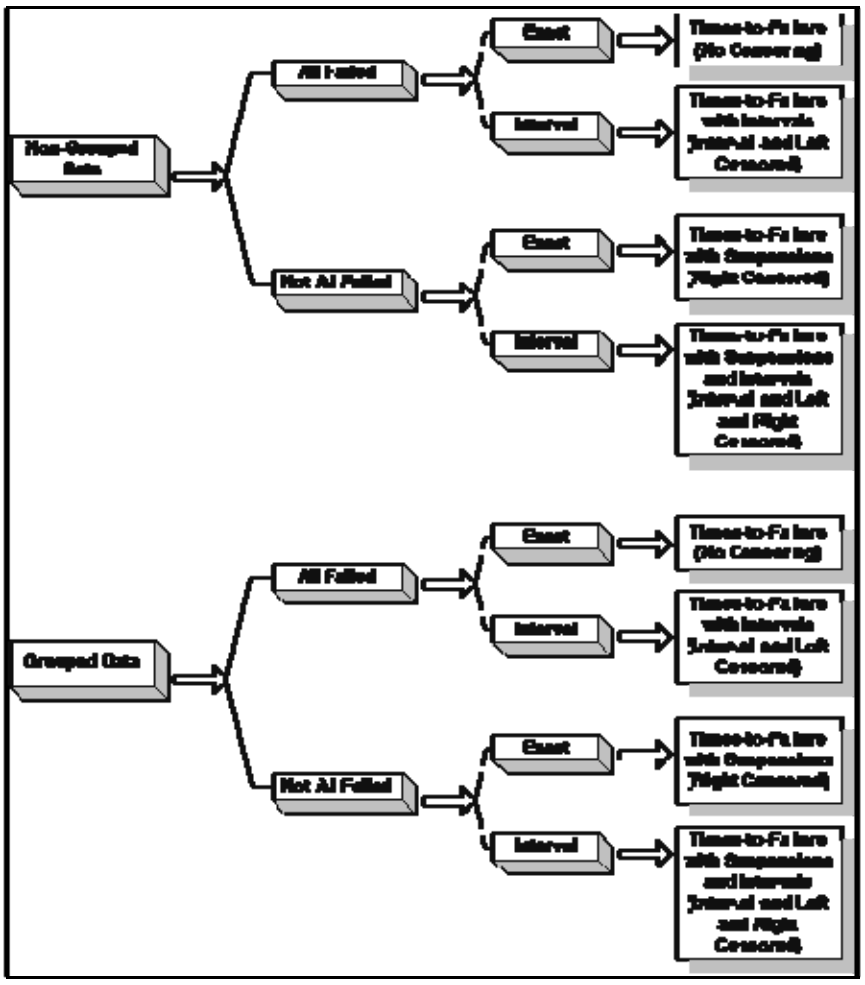


Fig.2. *Classification of reliability data types*

3. Processing field reliability data and software packages

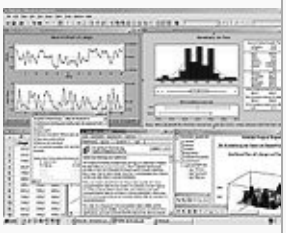
Even the simplest computer aided processing of field reliability data becomes difficult without specialized applications: frequently it starts with times to failures (TTF – for non- repairable products) or times between failures (TBF- for repairable products), generally t_i. For the regression analysis data couples (x_i, y_i) are necessary. As such it should be determined t the y_i values.

The reliability specialized software provide this automatically, but in the case of general statistical packages, the allocations of y_i values should be manually accomplished using ranking (mean or median rank), based on the ordered range t_i (empirical cumulative distribution frequency is approximated).

There are two approaches to fit reliability distribution to the failure data:

- derive directly from the data an empirical reliability function
- a theoretical distribution, such as exponential, Weibull, normal, etc.[1;15], the most preferred approach

An overview of statistical packages with a wider application area for field data is given in Table 1[4], (here excerpts for a few packages). Price note [1] indicates a promotional one (higher prices are for current purchases); note [2] indicates that lower/penetration pricing is offered to academic purchasers. (Tab.1Examples of statistical packages)

Product	Example(s)	Developer	Latest version	Cost (USD)	Software license	Interface	Written in	Scripting languages
Minitab		Minitab Inc.	May 18, 2010	$895–$1395[2], $542 annual, $30/…. academic	Proprietary	CLI/GUI		
Origin		OriginLab		$699	Proprietary	GUI		
R		R Foundation	2011	Free	GNU GPL	CLI/GUI [6]	C	Perl by Statistics Rmodule
SAS		SAS Institute	March 2008	Ac+stud free Com. ~$6000	Proprietary	CLI/GUI		
SPSS		IBM	2007	$1599[2]	Proprietary	CLI/GUI	Java	Python
STATISTICA		StatSoft	2010	>$695	Proprietary	GUI		
StatPlus		AnalystSoft	2007	$150[1][2]	Proprietary	GUI		
XLSTAT		Addinsoft	2009	$395[2]	Proprietary	Excel		

A detailed analysis of software special applications is developed in Table 2. It is visible the connection with reliability data in the column "Survival analysis". An example of the utilization of such programs is presented in fig. 3 (for Minitab 15) [16]. (Tab.2 Examples of statistical packages with reliability connection).

Product	s/w type [18]	Descriptive statistics		Nonparametric statistics		Quality control	Survival analysis			Data processing	
		Base stat.[19]	Normality tests[20]	CTA[21]	Nonparametric comparison, ANOVA			Cluster analysis	Discriminant analysis	BDP[22]	Ext.[23]
Mathemathica	**S**	+	+	+	+	+	+	+	+	+	+
Minitab	**S**	+	+	+	+	+	+	+	+	+	+
Origin	**S**	+	+	-	-	**+**	**+/-**	-	-	+	+
R	**St**	+	+	+	+	+	+	+	+	+	+
STATISTICA	**S**	+	+	+	+	+	+	+	+	+	+
StatPlus	**S**	+	+	+	+	+	+	-	-	+	+
SPSS	**S**	+	+	+	+	+	+	+	+	+	+
XLSTAT	**X**	+	+	+	+	-	+	+	+	N/A	+

where: 18 means S = Standalone executive; St = Standalone executive, primitive textual (DOS or terminal) interface; A = Access Add-in; X = Excel Plug-In ;19- Base Statistics (such as t-test, f-test, etc.); 20- Normality Tests, data exploring; 21-Contingency Tables Analysis; 22-Base Data Processing, f.ex. sorting; 23- Extended (data sampling, transformation)

4. Reliability software packages

The extended importance of reliability and the diversification of applications has determinates the development of reliability software packages, with main role to give an extended application of reliability techniques. A few will be mentioned below:

1.Weibull++7, offered by ReliaSoft Corporation [8] (Reliasoft Single user 1165 $) provides a toolset available for reliability life data analysis; other packages are for Accelerated Life Data Analysis (ALTA - from 4500$), System Analysis Software using RBDs or Fault Trees (BlockSim – from 3150$), Software for Reliability Growth Analysis and Repairable System Analysis (RGA – from 3150$), Reliability Centered Maintenance Software (RCM – from 4500$), etc., more than 200 software packages for FMEA, maintenance, DOE, etc. Supplementary are organized courses, training and consulting services;

2.Reliability Workbench 11, offered by Isograph Ltd [10], is a complex software package, with applications to maintainability prediction, FMECA and FMEA, FaultTree+ Fault Tree Analysis, Reliability Block Diagram analysis, Reliability Allocation and Growth, Event Tree and Markov Analysis, Weibull Analysis of historical failure data, Parts Libraries, etc.

3.Reliass Inc. [11], offers ASENT toolkit- reliability and maintainability computer-aided engineering solutions**,** EAGLE - an enhanced integrated logistics support software system, the Advanced Integrated Maintenance Support System (AIMSS), LOGAN- Fault and Event Tree module, LOGAN Monte Carlo analysis module, Raptor -Reliability Simulation Tool, Plant Availability Modelling with RAMP, etc.
4.DfRSoft (Design for Reliability) [9] provides low priced design (only 249$, based in Excel) for reliability software with applications for Reliability Plotting, System Reliability Analysis, Field Return Analysis, Accelerated Reliability Growth Multi Test Modules and Traditional Growth Analysis, Design-FMEA With Failure Mode Look-Up Table, Distributions and Confidences, Cpk Assessment, etc.

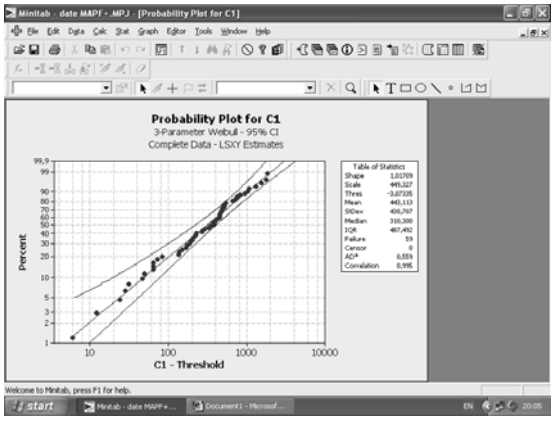


Fig.3*. Cumulative density function plot [16]*

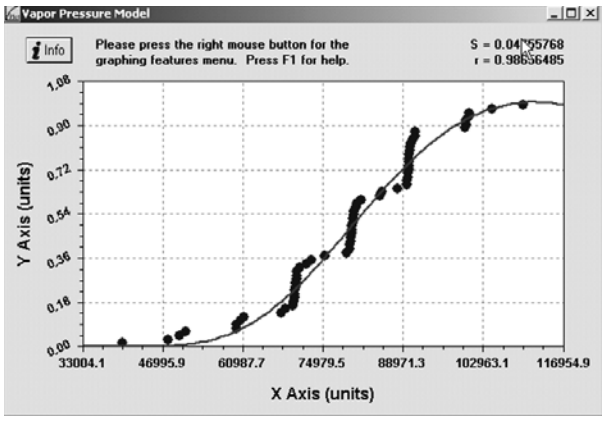


Fig.4. *Vapor pressure failure function: [19]*

5. Regression and curve fitting for reliability data

Regression is a conceptually simple technique for investigating functional relationship between output and input decision variables of a manufacturing process and may be useful for process data description, parameter estimation, and control [17]. A large body of techniques for carrying out regression analysis has been developed. Familiar methods such as linear regression and ordinary least squares regression are parametric, in that the regression function is defined in terms of a finite number of unknown parameters that are estimated from the data. Nonparametric regression refers to techniques that allow the regression function to lie in a specified set of functions, which may be infinite-dimensional [6].
Curve fitting is the process of constructing a curve, or mathematical function, that has the best fit to a series of data points, possibly subject to constraints [5].
All the important statistical packages offer a regression module [19], but there are also low cost solutions. Of course, the use of regression and curve fitting to determine the reliability from field data suppose a well known practical situation, to choose the adequate model.
A first accessible opportunity to calculate the regression curve for the reliability field data (fig.4) is the software CurveExpert, a comprehensive curve fitting system (freeware, Curveexpert professional for Win 70$)[3].
A similar opportunity is LABFit [7], a curve fitting software, with nonlinear regression - least squares method, Levenberg-Marquardt algorithm -, almost 500 functions at the library with one and two independent variables, functions finder, etc. (shareware, professional 85$).

6. Conclusions

A few elements of field reliability data processing are presented in the paper. A concise overview of statistical software with life data analysis is developed with extension to specialized reliability software. The usual costs of these packages are also detailed. A final choice for adequate software for field reliability data processing should consider the customer conditions for accuracy, data volume and necessary investment. As an example, for a few data samples and less details it is cheap to use low cost or freeware/shareware software packages.

References

[1]. Abernethy, R., B. - *The New Weibull Handbook,* 4th ed. Gulf Publishing Co., AT Houston, Texas 2005.
[2]. Collins, M. - *Error Prediction Models and Field Data,* Carnegie Mellon University Spring 1998 (http://www.ece.cmu.edu/~koopman/des_s99/traditional_reliability/index.html)
[3]. http://curveexpert.software.informer.com/1.3/
[4]. http://en.wikipedia.org/wiki/Comparison_of_statistical_packages#General_information
[5]. http://en.wikipedia.org/wiki/Curve_fitting
[6]. http://en.wikipedia.org/wiki/Regression_analysis
[7]. http://webcache.googleusercontent.com/search?q=cache:http://www.labfit.net/
[8]. http://weibull.reliasoft.com/?gclid=CJ3h98LRy6gCFRWazAod5yvjqw
[9]. http://www.dfrsoft.com/
[10]. http://www.isograph-software.com/index.htm
[11]. http://www.reliability-safety-software.com/products/product_asent.htm
[12]. http://www.theriac.org/ (EPRD)
[13]. Lawless, J.,F. - *Statistical Models and Methods for Lifetime Data*, 2nd edition. John Wiley and Sons, Hoboken (2003).
[14]. Lawless, J., F., Kalbfleisch, J., D., - *Some Issues in the collection and analysis of field reliability data*. In: Survival analysis: state of the art, vol.211, NATO ASI Series, Applied Sciences, NATO Advanced Study Institute, NATO Science Series E, Editors, Klein, J., P., Goel, P., K., Springer Verlag, 1992, pp141-152
[15]. Liu, C., C. - *A Comparison between the Weibull and Lognormal models used to analyse the reliability data,* Ph.D. Thesis (University of Nottingham 1997)
[16]. Paris, A., S. - *Models in mechanical reliability data* 3rd Symposyum *„DURABILITY AND RELIABILITY OF MECHANICAL SISTEMS"* Univ C. Brancusi Tg. Jiu, mai 2010, In: Fiability and Durability, no. 1(5)/2010, Editura "Academica Brâncuşi" , Târgu Jiu, ISSN 1844 – 640X p.81-86
[17]. Paris, A,. S., Târcolea, C., - *Regression models applied to manufacturing systems*, (2010), Proceedings in Manufacturing Systems, Editura Academiei Române, vol.5, nr.4, pp. 249-253.
[18]. Smith, D., J. - *Reliability, maintainability and risk: practical methods for engineers*, Ed. Butterworth-Heinemann, Oxford, UK, 2005
[19]. Târcolea, C., Paris, A., S., , Discriminant Analysis and Applied Regression UPB, BSG Proceedings 18, DGDS-2010, Geometry Balkan Press, 2011, pp. 93-98