Weibull NEWS™

What has Wes Fulton done?   The objective of the WeibullNEWS is to present the latest research and software improvements in life data analysis. The research may be our own or borrowed from the world's leading experts. In this edition we will present new technology from Wes… And some others too. For my part, the creation of our new "Playtime with SuperSMITH" and updating "The New Weibull Handbook" have kept me occupied. And to fill-in our free time we have produced on-site workshops at Allied Signal Automotive and Aerospace (3), Entergy, Tennessee Valley Authority, Teleflex, Rockwell Automotive, Mack Trucks, TRW, SAE, ASME, GKN Automotive in England and Germany, and Dow Chemical this year plus an ASME Weibull User Conference and four SAE Weibull Workshops.

The Best Choice for Weibull Confidence Bounds The three primary analytical confidence bounds methods are (1) Johnson's Beta-Binomial, (2) Nelson's Fishers Incomplete Matrix, and (3) Lawless's Likelihood Ratio. These are all available in WinSMITH Weibull. However, none of these methods are good for all data sets, small and large samples, with and without suspensions. What we need is one universal method that works with for all cases. Wes Fulton has solved the problem with his new MonteCarlo Confidence Bounds which are now in WinSMITH Weibull. They appear to be excellent under all the conditions. As an alternative Monte Carlo method, there are also pivotal confidence bounds as described in Lawless text. However they appear to be very wide, very conservative.
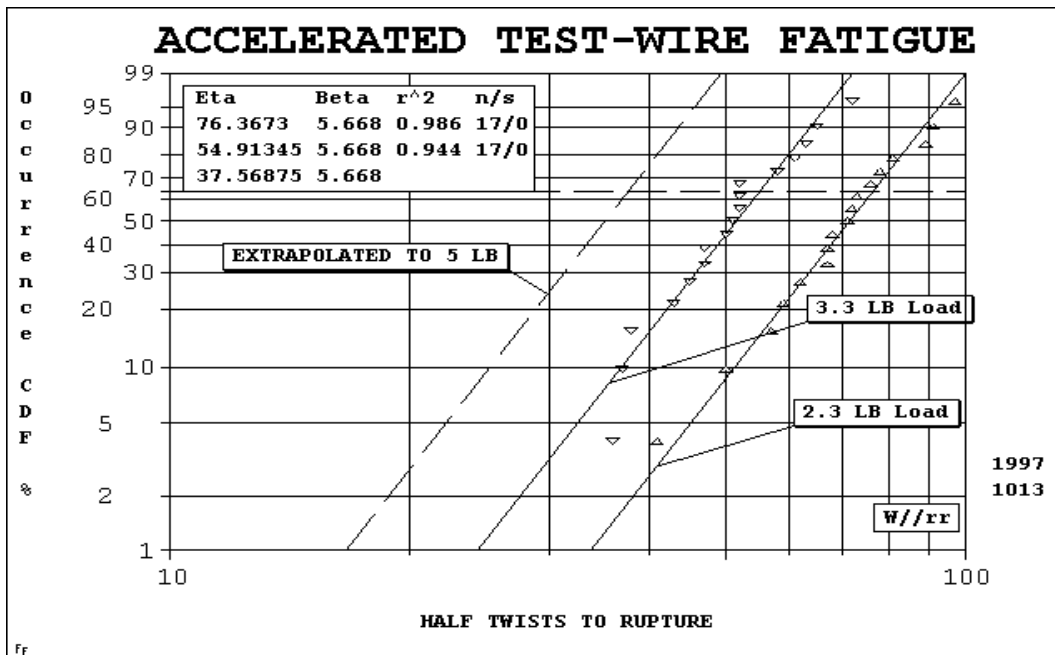
Improved Analysis of Accelerated Test Data
Based on data from tests at two or more loads, eta may be determined as a function of engineering parameters with or without a constant beta. Several different functions are available and a plot of the relationship may be produced with WinSMITH Visual. Further, Weibull lines may be produced for untested loads. For example, eta might be a function of load, stress, or temperature tested at several levels. This new option was suggested by Dr. Wayne Nelson and is based on likelihood solutions

BiWeibull, TriWeibull and the Bathtub Curve Carl Tarum of General Motors has devoted years to solving the general problem of analyzing mixtures of competitive failure modes including batch effects. This is a complicated subject. Carl has reported his progress at each SAE Weibull User Conference. At last his program, **YBATH,** is fully developed and is now part of the SuperSMITH family replacing the BiWeibullSMITH program which is now obsolete. YBATH provides both regression and maximum likelihood solutions for up to three competitive modes with or without a batch effect. YBATH is included in "SuperSMITH Plus." Carl Tarum will present YBATH at the SAE Weibull User Conference February 26-27, 1998 in Detroit.

The Standard Method - Median Rank Regression X on Y For many years we have recommended that the median rank regression, X on Y, is the best practice, the preferred choice for engineering analysis among all the other methods suggested. If an engineer could only use one method, median rank regression, X on Y, is the clear choice over (1)MLE, (2) Rank Regression Y on X, (3) Mean Rank Regression, X on Y, (4) Hazen's Ranks, X on Y. Median Rank Regression, X on Y, is the most accurate, least biased, and a good choice for minimum mean square error for typical data sets. It provides a good graphic plot of the data. Most of the engineering world agree and use this method as their standard method. However, there are many in the mathematical world that disagree. Mathematical statisticians prefer maximum likelihood and until this year, all of the competitive commercial Weibull programs regressed Y on X.   Two new exhaustive and independent studies have corroborated our conclusion, supporting the standard method:

- Dr. Maggie Wenham of GKN Technology in England will present her studies <u>with and without late suspensions</u> at our SAE Weibull User Conference in February 1997.
- A doctoral thesis accepted at the University of Nottingham written by Chi-Chao Liu arrived at the same conclusion, <u>with and without random suspensions</u>. The thesis compares Weibull and log normal analysis with data sets from both distributions. Another important conclusion from the thesis is that Weibull analysis is almost always a better predictor and more conservative than the log normal for small data sets, even when the data is log normal.

Of course there are a few special cases where MLE or regressing Y on X is preferred as indicated in The New Weibull Handbook. For comparisons of all methods based on bias, precision and mean square error use MonteCarloSMITH.

Goodness of Fit and "P" Values We have recommended the largest positive difference between r squared and CCC squared as the best indicator for selecting the best distribution for a set of data. Now we have a better measure using the "P" value of the r squared. The P value relates to the observed r square. We take a thousand Monte Carlo sets of samples from the same parent Weibull, eta, beta and sample size and rank the r squares. The P value is the percentile of the observed r square. It is also the alpha, one minus the confidence level , that the data supports for the r square. The higher the P value the better the fit. It requires MonteCarloSMITH to calculate the P value but Wes Fulton has put the algorithm in WinSMITH Weibull. This is by far the most accurate method for judging which distribution best fits your data set.

Warranty Data Matrix Analysis The standard warranty matrix can now be input, as is, into both WinSMITH Weibull and WinSMITH Visual. For predicting warranty claims for a fleet of systems by age, Kaplan-Meier is the best practice using WinSMITH Weibull. For predicting warranty claims by calendar month, Duane-AMSAA is best practice employing WinSMITH Visual. The matrix provides the input without further modification including the actuarial correction for the Kaplan-Meier model. Both renewal and no renewal solutions are available.
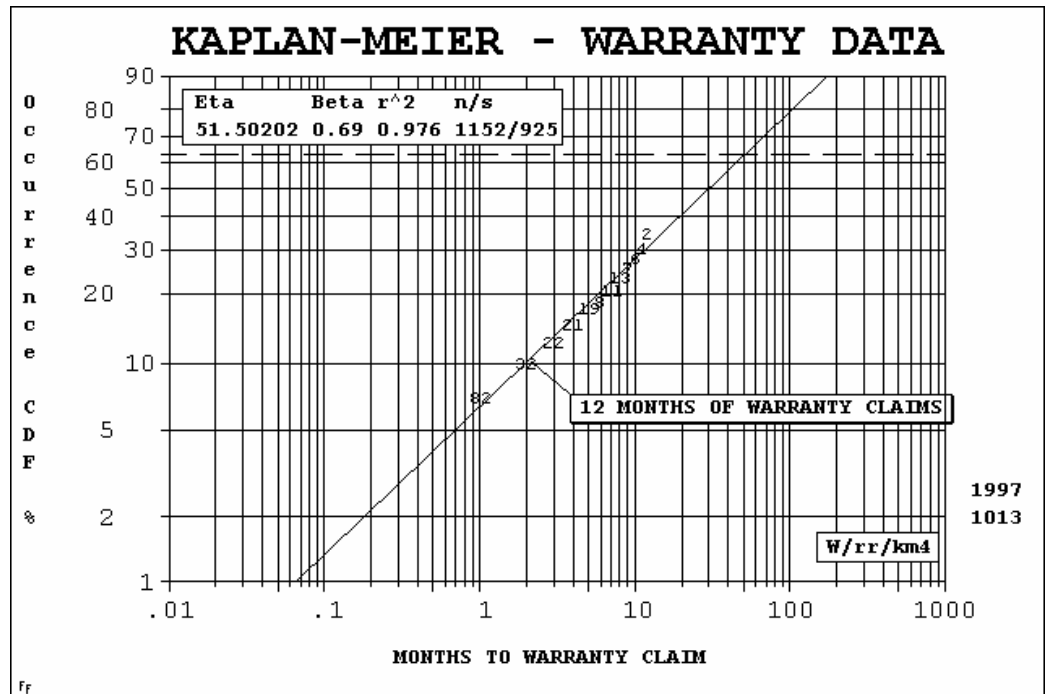
"PlayTIME with SuperSMITH©"   This computer tutorial illustrates all the options in the SuperSMITH software with dozens of step-by-step problems. Data sets are provided. This document will be useful for both the novice as a home study course, and the expert that wants an update on the latest techniques. There is also a complete tour of all the icons. PlayTIME is included with all our workshops and SuperSMITH as well. Playtime compliments The New Weibull Handbook and the extensive user manuals on the Help icons.

SAE Weibull User's Conference Pencil in February 26-27, 1998 for the best Weibull User Conference yet! The Keynote speaker is **Dr. Larry Crow, from Lucient**, the world's leading expert on the Duane-AMSAA model. Our preliminary list of industry experts includes:

- **Dr. Maggie Wenham - GKN England,**
- **Sten-AKE Irell - Volvo Flygmotor Sweden,**
- **Geoff Cole - Rolls Royce England,**
- **Paul Reisinger - Allied Signal Automotive,**
- **Dick Rudy - Chrysler,**
- **Carl Tarum - GM Delphia,**
- **Hans Iwand - Union Pacific Railroad, and**
- **M. A. Vasan - MERITOR**

Attendees will have sit-down lunches and a social with Wes and I, the experts, and the Keynote Speaker. Attendees are invited to submit problems to be discussed by the expert panel. Wes Fulton, Carl Tarum and I will provide an update on the latest technology and new options in the software. There will be a try-it-out on the computer session as well. This conference will be sold out early so call Ruth Walker at SAE to reserve a place. Ruth is at 412-772-7148.

Parlez-Vous Francais? Wes is adding a menu of languages to WinSMITH Weibull and WinSMITH Visual . We have help from Sweden, France, Germany and Holland. More help is needed for other languages.

WinSMITH Visual for Windows has the friendly features of WinSMITH Weibull, the same format, the familiar icons, and of course, the great capability of VisualSMITH™. Just a mouse click away from WinSMITH Weibull you will find:
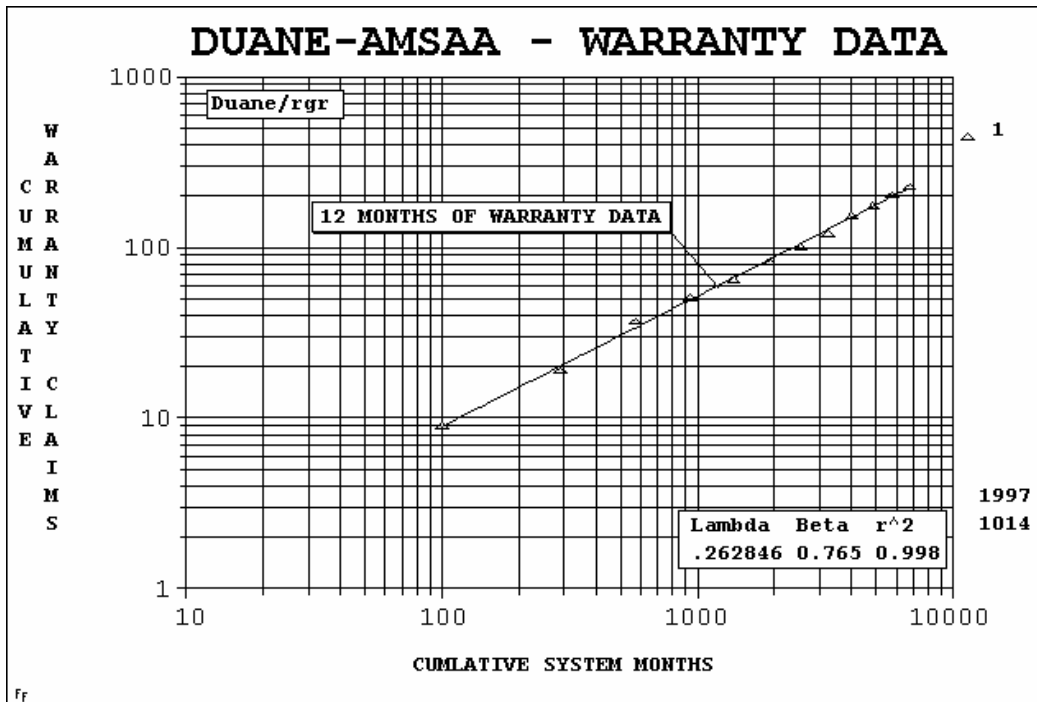
PDF, and CDF plots for any and all WinSMITH Weibull data sets, conversion of the WinSMITH Weibull failure forecasting and optimal component replacement tables into plots that are easier for managers to grasp, Duane-AMSAA analysis and plotting with automatic failure rate and MTBF plots, histogram view of suspensions and "total" picture plots, likelihood contours from the likelihood ratio confidence bounds in WinSMITH Weibull, general curve fitting and mathematical transformations of data. The input and output have all the Windows additives, like cut and paste to and from the clipboard. Warranty data matrixes are accepted as data input producing the Daune-AMSAA plot, the most accurate method for predicting warranty claims by calendar month, with or without renewal.

e-mail Comments & Questions Dr. Bob would like to hear from you at *weibull@worldnet.att.net.* Would you like to receive your WeibullNews early by e-mail in Microsoft Word Version 7.0 ? Let Dr. Bob know. Wes Fulton has a web site at *http://www.weibullnews.com..* Also check out Paul Barringer's web site at *http://www.barringer1.com.*

Weibull Workshops and User Conferences: *All workshops provide "The New Weibull Handbook," "Playtime with SuperSMITH," and WinSMITH Weibull software as part of the fee.*

• **On-Site,** call Dr. Bob 561-842-4082 for the new brochure on workshops tailored to your needs. $7496.00 for eight students, $712.00 for extra students over 8.

- **SAE** Milwaukee Sept 8-10, 1997; Detroit October 6-8, 1997, February 23-25, 1998 and Sept 23-25,1998, Long Beach, June 1-3, 1998; $1,525.00. Weibull User Conference, Detroit February 26-27,1998. Call 412-776-4841. FAX 412-776-4955 for brochures.
- **ASME** Seattle June 9-11, 1997, $1430.00 Toronto May 11-13, 1998. Call 212-705-7398.
- **Reliability Analysis Center** Cooperstown, NY, October 27-30, 1997, a 4 day seminar with Dr. Bob, Dr. Larry Crow, and Dr. Wayne Nelson. Call RAC at (800) 526 4803. Only one day on Weibull.. Orlando, Florida December 9-11, 1997, 3-day Weibull Workshop.

Order Form for Handbooks & Software Valid until June 30,1998

__The New Weibull Handbook__© *-* This the reference text for all the SuperSMITH software. The Handbook includes the latest techniques and methodology incorporated in the software, illustrated with many case studies. The figures and equations are larger. Best practices are identified and there is an Index. This text is constantly updated.

__WinSMITH Weibull Software__ ™ *-* The leading Weibull analysis software in the world including many new options not available elsewhere: Weibull, Weibayes, Normal, Log Normal data analysis and plotting with Chi-Square, Poisson, Binomial probability calculations, failure forecasting, optimal parts replacement, substantiation test designs, likelihood ratio tests, probabilistic design, accelerated testing, Monte Carlo confidence bounds, warranty data matrix analysis, and analysis of mixtures of competitive modes. This Windows-based software replaces WeibullSMITH ™(DOS).

__WinSMITH Visual__ ™ - This plotting program provides functions, fits, and transforms, Duane-AMSAA modeling, failure forecast and optimal replacement plots, likelihood contours, PDF, and CDF plots. This is WinSMITH Weibull's logical partner.

__MonteCarloSMITH__ ™ *-* This DOS program provides confidence bounds and uncertainties for all reliability parameters many of which cannot be obtained by any other method. It is a "must" for small sample & suspensions.

__YBATH__ ™ *-* This brand new Windows software described above replaces BiWeibullSMITH.

__Playwin Computer Tutorial… with data sets__ For the beginner and for updating the experts, "PlayTIME with SuperSMITH©," will be invaluable. It includes three dozen step-by-step problems illustrating all the options.

__Ordering Handbooks, WinSMITH, and SuperSMITH Software__: Orders may be sent or FAXed to either Dr. Bob or Wes or e-mailed to Dr. Bob. Payment should be by check for Handbooks and purchase orders or checks for software. In the USA we ship Airborne Express Second Day. Add shipping and handling as below. Call or FAX us for questions, quantity discounts, & upgrades.

Dr. Bob Abernethy, 536 Oyster Road, N. Palm Beach, FL 33408-4328, Voice/FAX.(561) 842 4082 or weibull@worldnet.att.net or… Mr. Wes Fulton, 1251 W. Sepulveda Blvd., #800, Torrance, CA 90502, Voice/FAX.(310) 548 6358. Software is on 3.5" diskettes.

	List Price	Quantity		Total
The New Weibull Handbook© (2nd Edition)	$78.00 Each X _____		=	$_____
*WinSMITH™ Weibull (Windows)	480.00 Each X _____		=	$_____
*WinSMITH™ Visual (Windows)	280.00 Each X _____		=	$_____
MonteCarloSMITH™ (DOS)	280.00 Each X _____		=	$_____
YBATH™(Windows) ??	280.00 Each X _____		=	$_____
Playwin Computer Tutorial (May 1997)	48.00 Each X _____		=	$_____

PLUS SHIPPING AND HANDLING $8.00 (OR $16.00 FOREIGN) FOR __EACH__ HANDBOOK AND SOFTWARE:

S&H Each Item	$8.00(OR $16.00)	X _____	=	$_____
SuperSMITH™:"(Hbk + * 2 Software + Playtime)	$680.00 Each X _____		=	$_____
SuperSMITH-Plus™:"All above"=(Hbk + 4 Software + Playtime)	$890.00 Each X _____		=	$_____

PLUS SHIPPING & HANDLING $16 USA (OR $32 FOREIGN) TOTAL = $_____

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