



# WeibullNEWS™



Ninth Edition

From: Dr. Bob Abernethy & Wes Fulton

Fall 1995

## *Windows™ + WeibullSMITH™ = WinSMITH™*

When will it be ready?? WinSMITH may be in your Christmas stocking or even sooner! The final Beta test version is in operation. Look for these great features:

- Up to five plots can be displayed simultaneously and you move from plot-to-plot modifying as you go.
- Sample size limits for both suspensions and failures are eliminated.
- VisualSMITH™ transforms ASCII files into histograms. This allows data transfers from other software data banks.
- The test substantiation option will design reliability tests for Weibull, normal, and log normal zero failures, zero or one failure, zero or two failures, etc.!
- All WeibullSMITH features are in WinSMITH so your old data files are completely compatible.
- Print capability includes Windows clipboard transfer and Hewlett Packard graphics language plots.
- Kaplan-Meier survival analysis and plotting is added.
- Labels options are expanded with new capabilities.
- Data management is done in a spreadsheet format.
- Ranking and sorting large data sets is much faster.
- Repeated points are easily entered with a multiplier number which shows-up on the Weibull plot.

## *Are Two Weibull Data Sets...Different Or The Same?*

This is a complex statistical question. At the SAE 1995 Weibull Users Conference last March, it was the hottest topic. There are many applications:

- Is the new design better than the old design?
- Do different models have the same problem?
- Do slightly different parts have the same failure mode?
- Are the failures the same for different customers and locations?

The attendees tasked the authors to research available methods and recommend the best solution. We have spent months on this and are not finished. We are working the problem and will present our conclusions at the SAE 1996 User Conference.

Our objective is a simple, easy, accurate, graphical method that works for both small and large samples. Small samples are the challenge, but a solution is close.

Wes has improved MonteCarloSMITH™ *Version 3.8* to make this research easier. At the moment three methods look promising. One of the simplest methods is shown in Figure 1. We test two data sets to see if they are significantly different at the B10 level by adding confidence bounds to the plot. If there is space between the lower bound of the upper set and the upper bound of the lower set, the B10 lives are significantly different. A second method is to plot likelihood contours for two sets as in Figure 2. If the contours do not intersect, the two data sets are significantly different. The likelihood ratio test is also very promising.

## *Simplifying Goodness of Fit*

WSMITH provides a measure of goodness of fit known as the 90% critical correlation coefficient (CCC). If your correlation coefficient, "r", is larger than the CCC, you have a good fit. If your "r" is smaller than the CCC you have an significantly inferior fit.

The CCC is found by ranking the "r" values for the correlation coefficient from 1000 MonteCarloSMITH trials and choosing the highest value of the lowest 100 values. This is equivalent to tossing out the lower 10% of the ranked "r" values and including the upper 90% of the values as acceptable. Thus the 90% CCC occurs at the 10 percentile, 10P, of the MCSMITH values. If your "r" is larger than the CCC, the 10P, you have a good curve fit, but how good?

To compare the fit of one distribution with another, say a Weibull with a log normal, we need the **P value** for the correlation coefficient, "r", for each distribution. The distribution with the highest P value among competing distributions is the best choice. We are researching P value models. Our objective is to have WSMITH calculate the P value of your observed correlation coefficient for each distribution. The highest P value wins.

## *The New Weibull News - Second Edition*

There are many new methods to incorporate in the New Weibull Handbook<sup>®</sup>. If you have suggestions or comments, please call or FAX Dr. Bob. The Second Edition is planned for early 1996.

**Which Weibull Method is Best?**

WSMITH provides capability to regress X on Y, Y on X, or maximum likelihood or one of three Interval Data Options, six choices in all. Which method is most accurate under what conditions?

Competitive programs do not provide all of these options, or worse, their default method is the least desirable choice. This subject will be treated extensively in the Second Edition of the New Weibull Handbook so you can reach your own conclusions about which method is best. MonteCarloSMITH™ compares the accuracy of these methods. Table 1 shows a comparison of regressing X on Y versus Y on X for 1000 sets of various sample sizes. The median values shown were produced with MonteCarloSMITH™. **If you compare these median estimates with the true values, then X on Y is the clear winner over Y on X for all cases.**

Weibull [1961] said, "The parameters may now be determined by fitting a straight line to the data points  $(x_i - P_i)$  in such a way that the sum of the squared deviations  $d_i = x_i - x_{i, \text{line}} \dots x_n - x_{n, \text{line}}$  is minimized...If, however, the straight line was fitted by minimizing the squared deviations in the y-direction, the conclusions would not hold, and biased estimates would result." See also Handbook References [Berkson], [Natrella], and [Mann, et al].

Maximum likelihood estimation (MLE) is preferred by statisticians over all other estimates because MLE estimates have excellent statistical characteristics. For the Weibull parameters, maximum likelihood estimation, (MLE), is complex. A computer is required. Unfortunately for small and moderate samples, less than 100 failures, the maximum likelihood estimates are biased as shown in Table 1. For very large samples, MLE will be more accurate than rank regression. We recommend you use rank regression X on Y, for small and moderate size samples. Maximum likelihood estimates are recommended for very large samples, 500 failures or larger. The Y on X method is not recommended except for the Probit plotting of interval data.

Sometimes the time-to-failure data may include precision error in addition to the statistical scatter. Studies including both errors and recommendations for your review will be summarized in the Second Edition of The New Weibull Handbook. MonteCarloSMITH allows easy comparisons between these methods for your specific conditions.

**1996 Weibull User Conferences.** Our 1995 User Conference was outstanding, the best ever with 59 attendees. It was a great forum with a wonderful exchange of information.

- Our next Weibull User's Conference will be **SAE's Third Annual in Detroit, February 29-March 1, 1996.** I am very pleased to announce that **Dr. Jerald Lawless** will be joining **Wes and I** as the Conference Keynote Speaker. The Expert Panel is tentative but we hope to have the leading Weibull experts from **Honda - Rooma Hartman, Ford - Jim Lempke, GM - Carl Tarum, TRW - Mary Rowsee, RAC - Patrick Hetherington,** and the Union Pacific Railroad - **Hans Iwand.** Call SAE for a brochure, 412-772-4841.

- ASME will host the **Second Annual ASME Weibull User Conference in Boston June 10-11, 1996.** We are pleased to have **Dr. Dimitri Kececioglu** as the keynote speaker. and the Expert Panel will include top Weibull analysts from **CHIPCOM - Joseph Dzekevich,** American Nuclear Insurers - **Stan Focht,** Volvo Aero of Sweden - **Sten-Ake Irell,** Reliability Consultant - **Paul Barringer,** and the Federal Aviation Administration - **Tom Boudreau.** Call ASME at 212-705-7398.

We will be pleased to see you at these User Conferences.

**Weibull Seminars & Workshops, 1995 & Beyond:** Join us:

- October 23-27, 1995, **Reliability Analysis Center** Sponsor at Cooperstown, NY, a 5 day seminar with Dr. Bob, Dr. Larry Crow and Dr. Wayne Nelson, (800) 526 4803 [**Late word: Sold Out!**]

- November 12-14, 1995. Dr. Bob, **Gulf Publishing Process Plant Reliability Conference,** Houston, Texas, 3-day. Call 713-520-4444.

- December 13-15, 1995 **Wes, University of Tenn,** (3-day). Call 615-393-7276

- Feb 5-8, 1996, Dr. Bob, 4-day **ASME New Orleans.** Call 212-705-7398

- Feb 26-28, 1996, **Wes & Dr. Bob, SAE Detroit** 3-day. Call 412-772-4841

- June 26-28, 1996 Dr. Bob, **ASME Seattle** 3-day. Call 212-705-7398

- June 16-18, 1997 **Wes, ASME Seattle** 3-day. Call 212-705-7398

- November 20-22, 1997 **Wes, ASME Phoenix** 3-day. Call 212-705-7398

**Other Reliability Activities & Seminars of Interest:**

• We are pleased to be working with the Reliability Analysis Center (RAC). RAC is chartered by the Department of Defense to serve as a government and industry focal point in improving reliability, maintainability and quality. RAC provides consulting, training, publications and a newsletter. **Patrick Hetherington** is our contact at 315-339-7084.

• **James McLinn** will do two seminars on Practical Reliability at Georgetown University, December 11-15 and February 11-15, 800-424-9773, and one on FMEA at the University of Minnesota January 17-18, 612-624-0106.

• **Dr. Wayne Nelson**, will do two seminars at the University of Michigan - Dearborn, 313-271-0909, Reliability Data Analysis, April 23-25, 1996 and Accelerated Testing, May 20-23, 1996. Wayne will also do the Accelerated Testing in London next year, call him for details 518-346-5138.

**Paul Barringer**, will be doing his two-day "Reliability Engineering Principles" before our ASME Weibull Workshops listed above.

**Motorola** engineers, **Andrew Mawer**, (512) 933 5824, and **Robert Darveaux** received the "Best Of Conference Award" for their Weibull paper, "Thermal and Power Cycling Limits of Plastic Grid Array Assemblies" at the Surface Mount International Conference in August. *Congratulations!*

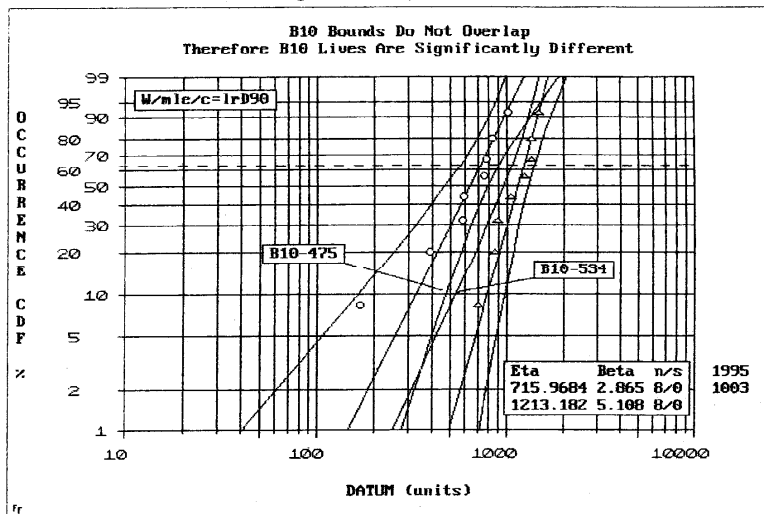


Figure 1 Non-Overlapping Bounds

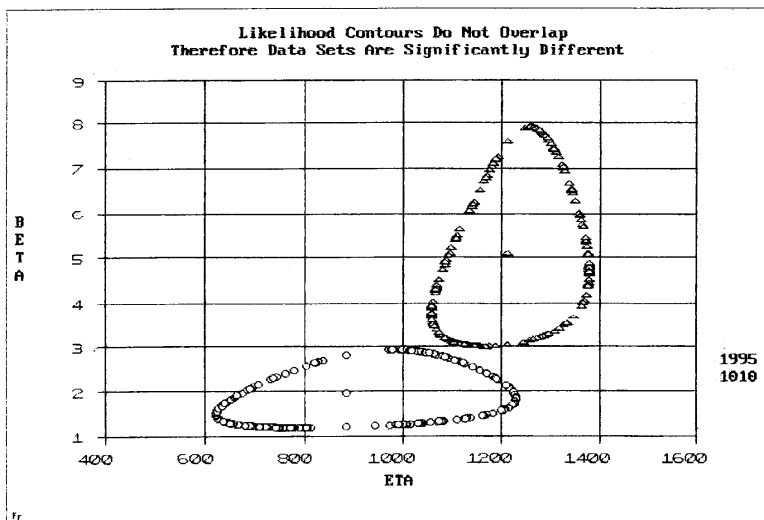


Figure 2 Likelihood Contours

**Table 1 - Comparison of X on Y versus Y on X Regression - Most Accurate is Boldfaced  
Based on 1000 Data Sets - Weibull True Values  $\beta=3.0$   $\eta=1000$   $B1=216.0$**

Sample Size	X on Y Eta	Y on X Eta	MLE Eta	X on Y Beta	Y on X Beta	MLE Beta	X on Y B1	Y on X B1	MLE B1
N=4	<b>994</b>	1009	981	<b>3.02</b>	2.75	4.00	<b>213</b>	190	312
N=10	<b>996</b>	1014	990	<b>2.95</b>	2.79	3.32	<b>205</b>	193	245
N=30	<b>999</b>	1011	998	<b>2.98</b>	2.86	3.11	<b>212</b>	204	227
N=100	<b>1000</b>	1006	999	<b>2.98</b>	2.92	3.03	212	208	<b>219</b>
N=500	<b>1000</b>	1002	999	2.99	2.97	<b>3.00</b>	214	213	<b>216</b>
N=1000	<b>1000</b>	1001	999	2.99	2.98	<b>3.00</b>	215	213	<b>215</b>

**Ordering Handbooks, WinSMITH, and SuperSMITH™ Software:** Orders may be sent or FAXed to either Dr. Bob or Wes, checks for Handbooks, purchase orders or checks for software. We now ship Airborne Express Select Delivery in the USA. The special introductory price below for WinSMITH will increase in 1996. If you purchased WeibullSMITH™ in 1995 the special introductory discount price to obtain WinSMITH is half off (\$190). Early orders for WinSMITH will be shipped first. Call or FAX us for questions, quantity discounts, upgrades, & requests. Order from Wes or Dr. Bob.

**Order Form for The New Weibull Handbook & SuperSMITH Software**

To: Dr. Robert B. Abernethy, 536 Oyster Road, North Palm Beach, FL 33408-4328...Voice/FAX(407) 842 4082  
Or To: Mr. Wes Fulton, 1251 W. Sepulveda Blvd., #800, Torrance, CA 90502.....Voice/FAX..(310) 548 6358

	<u>List Price</u>	<u>Quantity</u>	<u>Total</u>
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WinSMITH™ Weibull	380.00Each	X _____	= \$ _____
WeibullSMITH™	380.00Each	X _____	= \$ _____
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**SuperSMITH™** :Specify WinSMITH™ (Windows) or WeibullSMITH™ (DOS)  
"All above"=(Hbk + 4 Software) 840.00 Each X \_\_\_\_\_ = \$ \_\_\_\_\_  
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Software is on 3.5" diskettes unless 5.25" diskettes are requested.  
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