# Weibull NEWS™

## *What's New???*

- *WinSMITH™ **Visual** is available as you read this!*
- *The New Weibull Handbook[©] **Second Edition** is in for fourth printing.*
- *The brand new **"Playtime with SuperSMITH[©]"** is a friendly tutorial designed to demonstrate all the options and capabilities now available to you in the SuperSMITH™ software. It includes the new **Benchmark validation problems** for making comparisons with other software easier and a diskette with all the Playtime & Benchmark data sets.*
- *Many new options have been added to **WinSMITH** and **MonteCarloSMITH™** soft1ware.*

**WinSMITH Visual** has the friendly features of WinSMITH™ Weibull, the same format, the familar icons, and of course, the great capability of VisualSMITH™. Just a mouse click away from WinSMITH Weibull you will find the PDF, and CDF plots for any and all WinSMITH Weibull data sets, the failure forecast plots, the optimal component replacement plots, and much easier Duane-AMSAA PLOTS. The input and output now have all the Windows additives, like cut and paste to and from the clipboard. In many ways this is the partner for WinSMITH™ Weibull and a "must-have" for the Weibull analyst. [Wes help...].................[I may go to columns here]

**"The New Weibull Handbook " Second Edition** is a complete rewrite. The figures and equations are bigger and bolder. Material rendered obsolete by newer methods has been deleted. New and expanded material includes:

- comparisons of alternate methods with the objective to identify best practice for each situation,
- failure forecasting with and without parts replacement,
- system failure forcasting and optimal replacement of wearout parts,
- zero or one failure allowed Weibull tests plus normal and log normal tests,
- three new methods for testing two [or more] data sets for significant differences,
- Weibayes with and without failures, at any confidence level,
- new test substantion designs
- a new appendix on mixtures of failure modes by Carl Tarum,
- new case studies from Union Pacific Railroad, Chrysler, and dental research at Northwestern University
- an index.

**"Playtime & Benchmarking with SuperSMITH "** This new product is designed for:
1. analysts that want to try all the new options at their leisure,
2. novice users that want a home study package with The New Weibull Handbook and the software, and
3. anyone that wants to benchmark and validate Weibull software programs.

Paul Barringer made this tutorial simple and easy to use. The data sets are provided on new versions of SuperSMITH on a special function to avoid the drugery of hand input. There are many problems with an excellent index to make choosing relevant problems easy. For the novice, the first several problems have mouse click-by-click, step-by-step instructions. Wes and Dr. Bob have added comments on the meaning and interpretation of the results. References to the methodology in the Handbook are provided

The benchmarking is for analysts that want to compare other software to SuperSMITH results, either in-house programs or commercially available programs. The menu contains famous problems from the hallmark textbook for each method. The data sets are included. The authors include Wayne Nelson, Jerald Lawless, Larry Crow, and D. R. Cox. The use of this standard benchmark provides confidence that important decisions may be related to SuperSMITH™ results. If there is good agreement, it will also provide confidence in other software. It also provides an easy comparison of other Weibull programs to the standard SuperSMITH software.

***New Options in WinSMITH  Weibull Software***  These options respond to requests and suggestions from our customers.
- Probabilistic design considers the convolution of  the **strength-load** or **life-usage** distributions. When the load or usage exceed the strength or life value, a failure occurs.  WinSMITH provides the solution. The new options will be found on the calculator menu. The default provides 30,000 pairs of random samples from the two distributions. The proportion of negative values is the estimate of proportion failed. The precision of the proportion is provided as two sigma (95%). If it is unacceptable, larger samples, up to one million pairs, may be sampled. The distributions may be any combination of normals, log normals, and two or three parameter Weibulls.  To convolve this analytically is a nightmare, but it is simple with WinSMITH Weibull.
- The calculator icon  provides access to the **Windows calculator**.
- **Confidence bounds** may be estimated based on:
    1. Johnson's Beta-Binomial  method
    2. Nelson's Fishers Incomplete Matrix
    3. Lawless's Likelihood Ratio
    4. Greenwood's Variance for Kaplan-Meier
    5. Binomial for Probit Analysis
    6. Likelihood Ratio Contours
- With multiple data sets on a plot, each set may or may not have a confidence bounds.
- Weibull's Mean rank $[i/(N+1)]$ and Nelson's $[(i-0.5)/N]$ plotting positions have been added. The default is still Benard's plotting position $[(i-.3)/(N+.4)]$ which approximates the median rank. Exact beta-binomial median ranks are also available. This allows comparisons between plotting positions.
- Failure forecasting now includes the predicted time of the next failure.
- For accelerated testing, distribution parameters  may be calculated as functions of engineering parameters. For example, beta might be a function of load, stress, or temperature tested at several levels. This new option was suggested by Dr. Wayne Nelson.
- An icon has been added that provides easy  transfer to the other SuperSMITH DOS programs with one mouse click.
- The gridlines may be removed from the plot entirely, or just the vertical or horizontal gridlines with the label icon.
- With the three parameter Weibull, the horizontal scale may be in the t zero time domain or the real time domain.
- The Zoom icon expands or shrinks the scales and allows removal of the data points or the lines from plot, set by set.
- Expanded batch capability for network operations.
- More pull down menus.

***New  Options  in  MonteCarloSMITH***   The new Mode option on the Main Menu provides  capability to use convoluted variables from two distributions. For example, the time-to-initial-crack may be a Weibull distribution while the crack-to-rupture life might be log normal.  The total life-to-rupture is the addition of pairs of samples, one from the Weibull and one from the log normal. The distribution  of the sum is usually unknown so a single sample of say 100 sums may be generated and transfered to WinSMITH for a distribution analysis.  Let say the best fit turns out to be log normal.  Returning to MonteCarloSMITH   and selecting log normal, provides  the usual MonteCarloSMITH output for the total life distribution: confidence intervals and bias estimates for  all the parameters, B lives and reliabilities, and distribution analysis for any parameter.  The convolution may be based on any of the usual algebraic operations, $(+, -, /, *, \wedge)$. This feature is very useful for those working with probabilistic design.

New options were added to allow research on the problem of testing two or more data sets to see if they are significantly different. For example, one method is make the comparison at the B10 level and determine if the lower bound of the upper set is greater than the upper bound of the lower set. Up to one million pairs may be compared to determine the proportion of the sets that are "alike".  Another approach is to merge the two sets and see if confidence bounds around the merged set either of the median lines of both sets.  Finally the likelihood ratio test may be exercised to compare two <u>or more</u> pairs of sets. The likelihood ratio test may be exercised with and without the Fulton Factor that reduces  small sample bias of the standard test.

In the standard single sample mode, the analysis may be done with any two of the three distributions simultaneously. For example, we might want solutions from the Weibull and the log normal from the same sample of data.  The uncertainties of Sudden Death testing may be measured against the alternative of testing all units to failure.

Optimal plotting position may be determined using the new option that allows median ranks, mean ranks and Nelson's rank to be selected for MonteCarloSMITH  simulations. A brief study is described in the next section.

***Which is best: Median Ranks, Mean Ranks, or Nelson Ranks??*** The following results are median values from 3,000 simulation trials with sampling from true values: Eta=1000, Beta=3.0, B1=215.8. Benard's approximate median ranks appear to be the best choice.

| Sample Size | Median Ranks | | | Mean Ranks | | | Nelson's Ranks | | |
|---|---|---|---|---|---|---|---|---|---|
| | Eta | Beta | B1 | Eta | Beta | B1 | Eta | Beta | B1 |
| 4 | *996.54* | *3.032* | *216.392* | 1,013.53 | 2.568 | 168.733 | 983.23 | 3.544 | 266.667 |
| 6 | *992.26* | *2.942* | *207.067* | 1,009.83 | 2.566 | 167.567 | 986.30 | 3.333 | 246.667 |
| 10 | *996.00* | *2.985* | *209.933* | 1,010.90 | 2.667 | 179.033 | 995.30 | 3.236 | 237.533 |
| 30 | *997.83* | *2.940* | *208.633* | 1,004.57 | 2.778 | 192.467 | 997.73 | 3.102 | 224.933 |
| 100 | *1,000.02* | *2.970* | 211.767 | 1,001.77 | 2.889 | 203.400 | 998.63 | 3.035 | *218.633* |

Bias = (Median -True) / True

| Sample Size | Median Ranks | | | Mean Ranks | | | Nelson's Ranks | | |
|---|---|---|---|---|---|---|---|---|---|
| | Eta | Beta | B1 | Eta | Beta | B1 | Eta | Beta | B1 |
| 4 | *-0.00346* | *0.017* | *0.01421* | 0.013533 | -0.144 | -0.2181 | -0.01677 | 0.181222 | 0.23571 |
| 6 | *-0.00774* | *-0.01922* | *-0.04047* | 0.009833 | -0.14467 | -0.22351 | -0.0137 | 0.110889 | 0.14303 |
| 10 | *-0.004* | *-0.005* | *-0.02719* | 0.0109 | -0.111 | -0.17037 | -0.0047 | 0.078778 | 0.10071 |
| 30 | *-0.00217* | *-0.01989* | *-0.03321* | 0.004567 | -0.07389 | -0.10812 | -0.00227 | 0.034111 | 0.04232 |
| 100 | *0* | *-0.00989* | -0.01869 | 0.001767 | -0.03711 | -0.05746 | -0.00137 | 0.011778 | *0.01313* |

Mean Square Error
$True^2$

| Sample Size | Median Ranks | | | Mean Ranks | | | Nelson's Ranks | | |
|---|---|---|---|---|---|---|---|---|---|
| | Eta | Beta | B1 | Eta | Beta | B1 | Eta | Beta | B1 |
| 4 | 0.031083 | 0.76556 | 0.667448 | *0.03073* | *0.66751* | *0.6598* | 0.03231 | 1.083239 | 0.69380 |
| 6 | *0.00897* | 0.315465 | *0.19256* | 0.019921 | *0.25766* | 0.427775 | 0.019434 | 0.417499 | 0.41730 |
| 10 | 0.012337 | 0.116079 | 0.264915 | *0.0119* | *0.11479* | *0.25549* | 0.01224 | 0.161617 | 0.26282 |
| 30 | 0.00422 | *0.03272* | 0.090621 | 0.004208 | 0.03436 | 0.090364 | *0.00419* | 0.04028 | *0.09002* |
| 100 | *0.00124* | *0.0102* | *0.0267* | 0.001282 | 0.0105 | 0.027537 | 0.001317 | 0.011211 | 0.02828 |

***Weibull Seminars & Workshops*** *:*

- **On-Site,** call Dr. Bob 561-842-4082 for the new brochure for workshops tailored for small and large groups.
- **SAE** Detroit: January 21-23, 1997, February 24-26,1997, May12-14, 1997.
  Fourth Day Monte Carlo, Detroit February 27, 1997 Call 412-776-4841.
- **ASME** Seattle June 16-18, 1997, Toronto May 1998. Call 212-705-7398.
- **Reliability Analysis Center** Cooperstown, NY, October 27-30, 1997, a 5 day seminar with Dr. Bob & Wes, Dr. Larry Crow, and Dr. Wayne Nelson. Call RAC at (800) 526 4803.
- **Gulf Publishing Sponsor at the Process Plant Reliability Conferences,** Houston, Texas, October 1997; Call 713-520-4444.
- **University of Tennessee Space Institute**, Tullahoma, Dec 1997. Call 615-393-7276.

***The NewWeibull Handbook$^©$:*** The new expanded 2nd edition Handbook includes all of our new techniques and methodology incorporated in WinSMITH Weibull, plus more case studies. The figures and equations are larger. Best practices are identified and there is an Index. This is the leading Weibull source book and the reference text for all the SuperSMITH *$^{TM}$*software.

***WinSMITH $^{TM}$ Weibull Software -*** The leading Windows-based 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 (lr), probabilistic design, accelerated testing analysis. Replaces WeibullSMITH *$^{TM}$*(DOS).

***WinSMITH™Visual*** plotting program with functions, fits, and transforms, Duane-AMSAA modeling, failure forecast and optimal replacement plots, lr contours, PDF,  and CDF plots. Extends WinSMITH Weibull and replaces VisualSMITH (DOS).

***\*MonteCarloSMITH™-*** DOS program provides confidence bounds and uncertainties for all reliability parameters many of which cannot be obtained  by any other method. A "must" for small sample & suspensions. Probability distribution modeling.

***\*BiWeibullSMITH™-*** DOS program *s*olves the classic competing risk mixture for warranty data without data partitioning.

..*Available in Windows version  March 1977.