

Weibull NEWS™

Thirteenth Edition

From: Dr. Bob Abernethy & Wes Fulton

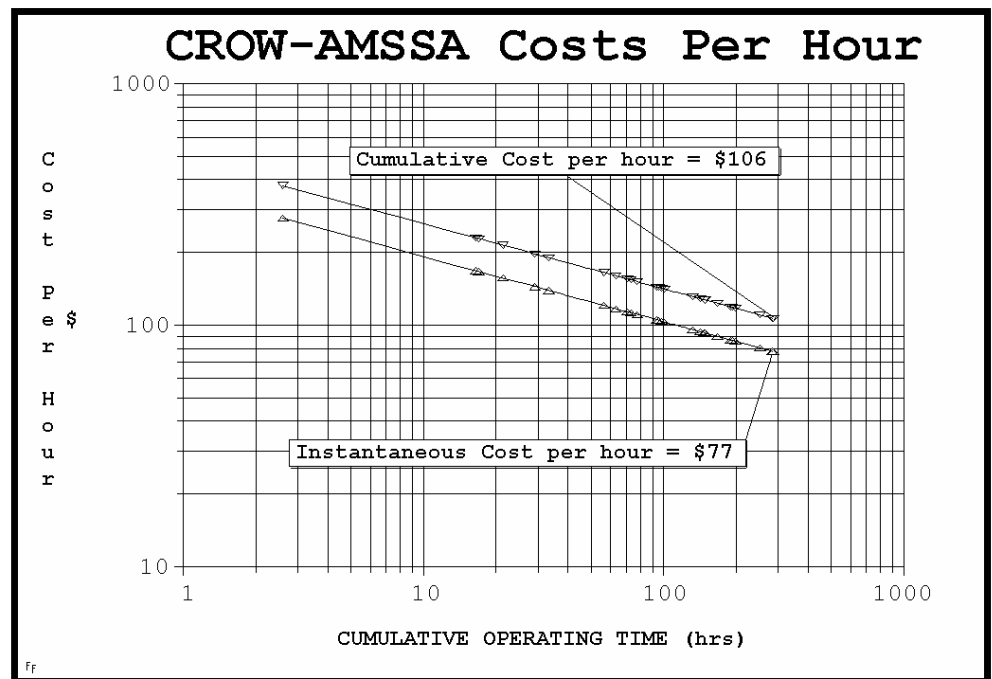
September 1998

Summary This edition of the WeibullNEWS presents the Third Edition of The New Weibull Handbook simultaneously with the Version 3.0 of the SuperSmith software and as always to present the latest research in life data analysis. Wes and Dr. Bob have been busy but enjoying it. The primary activities have been rewriting and updating The New Weibull Handbook and steadily enhancing the SuperSMITH software. The new "Playtime with SuperSMITH" has made a big improvement in our Weibull Workshops and we continually update it to reflect the latest options in SuperSMITH.

Dr. Bob: The Third Edition of The New Weibull Handbook©

The Handbook has become the national and international standard for Weibull analysis. It is in daily use throughout the world. Thousands of copies have been distributed. User industries include military, automotive, medical, electronics, materials & composites research, aerospace, computing, electrical power, nuclear power, dental research, advertising, bearings, compressors, pacemakers, v-belts, chain drives and on and on.

The **Third Edition** is being printed. It emphasizes best practices wherever there are alternative methods. The choice of best practice is based on objective research studies summarized or referenced in the Handbook. For example, median rank regression is recommended as the engineering standard based on new studies comparing maximum likelihood and other methods. However, the exceptions where MLE is better are indicated. There are related studies on plotting positions and regression X on Y versus Y on X. There are new applications for the likelihood ratio test. Monte Carlo and pivotal confidence intervals have been added. Warranty analysis using the Kaplan-Meier and Crow-AMSAA models include renewal if needed based on the warranty matrix as the input. Cost functions are described for failure forecasts, Crow-AMSAA, and optimal parts replacement. Accelerated testing designs



have been expanded. The use of different types of inspection and interval data including the Kaplan-Meier survival model, has been expanded. Some methods in the earlier editions are now obsolete and have been omitted. The figures and equations have been enlarged and enhanced. Two new independent studies of Weibull methodology produced by experts Dr. Maggie Wenham and Dr. Chi-Chao Liu, are summarized. The Handbook has been reorganized to improve the presentation. Chapters 5, 6, and 10 have been completely rewritten. There are two new additions that present more complex but useful methods for (1) detecting batch problems (Appendix F from Geoff Cole-Rolls Royce) and (2) mixtures with and without batch problems (Appendix J from Carl Tarum at Bathtub Software, Inc.). The graphics are improved with new SuperSMITH capability for high resolution and font selection.

Free Copies of the Handbook are offered to all the universities and colleges in North America by The Society of Automotive Engineering, (SAE) supported by the author and Wes Fulton. This includes demonstration copies of the software. Ruth Walker is the SAE sponsor at 724-772-8523. Call her if your alma mater has not received their copy. We are working on extending the offer to Great Britain and Ireland. The objective is to encourage teaching Weibull analysis on campus.

Wes: New Features in Version Three of SuperSMITH™ Software

1. Free Copies of the Software - DEMO Capability: The fastest way to get the latest version of the SuperSMITH™ for Windows™ is to use the new DEMO capability. In a few minutes on the Internet you have the DEMO version with full version capability, but it cannot be used for serious analysis. The DEMO version will make small random adjustments to any data entered into it, unless it is reading a file saved previously by the FULL version. Users of the free DEMO can evaluate all of the program features without any time limits. This capability may be especially useful for any instructor that wants to have all of his or her students using the software so we are providing it to universities. Every student can have a free copy of the DEMO software. The instructor only needs to have one FULL version for saving files with example data sets that the DEMO reads unchanged. Also, the DEMO version can be converted to FULL with the appropriate password. The DEMO program can now be purchased electronically downloaded from the Internet at any location around the world and then unlocked to FULL capability in minutes. Ain't science grand! Fast download over the Internet is possible because of very small memory requirements. SuperSMITH™ software has the most comprehensive and advanced life data analysis capability with the best user interface and yet is much smaller than other software.

2. New Confidence Methods: SuperSMITH¹ Weibull™ has exclusive capability for determining Monte Carlo confidence bounds on the Weibull fit line. This is needed for small data sets, since all of the readily available analytical methods are significantly biased for small samples. This capability was formerly only available within MonteCarloSMITH™. However, MonteCarloSMITH is no longer distributed in the SuperSMITH™ package and no longer actively marketed, since the capability is now in SuperSMITH Weibull. Choose either the new Monte Carlo (mc) method or the new pivotal (pv) method based upon a pivotal statistic. The Chrysler Corporation requested the pivotal confidence bounds. When the normal distribution is appropriate and there are no suspensions, then the normal (nr) confidence selection in SuperSMITH™ Weibull may be used to get confidence bounds. This confidence method is based upon standard error and Student's t distribution.

3. Mixture Analysis: SuperSMITH™ Weibull has new unique competing risk mixture analysis. Competing risk mixture is a common type of analysis for dirty data where two competitive failure modes affect product life. The best policy is to separate the data so each mode can be analyzed individually. This is not always possible. We have developed a maximum likelihood technique that provides a normalized p-value rating for mixture strength indication. If the p-value is at least 90 percent, then you can be 90 percent sure that the data indicates competing risk mixture. However, a word of caution is needed with respect to mixture analysis. A valid p-value or critical correlation value rating is crucial to deciding whether mixture exists or not. Further, a minimum of 20 data values is recommended for the simplest mixture analysis model (4-parameter). The old capability for mixture analysis was in BiWeibullSMITH™. However, BiWeibullSMITH is no longer marketed as it is obsolete and the new improved capability is in SuperSMITH Weibull. More comprehensive mixture analysis is available with YBath™ software. Please telephone Carl Tarum at 517-791-4405 for details on YBath features.

4. Translations: New languages are available for SuperSMITH™ software including English, French, German, Spanish and Swedish. (Did you know that Waloddi Weibull was Swedish?) These languages can be selected in the Setup section of the software. Setup options are available during software operation by clicking on the computer icon, and none of them require software or computer restart (take a lesson, Mr. Bill Gates). More languages will be added to support growing worldwide usage. Please contact Fulton Findings to help with adding your language.

5. Editing And Output Features: New tab controls are located above the active plot window to make changing back and forth between plot and report output easy. You can switch between the plot output and the report output with a single click. Editing of set labels couldn't be simpler with the new data grid edit feature. Simply use the right-side mouse button to click in the set label area of the data grid, just above the first data value. Other features include selection for either ToolTips-like or label display of icon information by clicking on the icon directly under the blue question mark Help icon. There is now more control of significant figure display by clicking on the Setup icon (computer) and then the Language/Date/Time/Decimal icon (two people talking). The plot fit line thickness can be toggled between Minimize and Maximize after clicking on the Zoom icon (magnifying glass). Plot output to the printer uses the high-resolution capability of the device when HI-RES is selected from the Hard Copy / Firm Copy menu selection. The HI-RES option is recommended for presentation quality output directly to the Windows printer. Using the Label option different fonts, sizes, and colors may be selected for the titles, labels and grids. 3D Likelihood plotting is available in the Predict section of SuperSMITH Weibull for a rendering of the likelihood mountain. The more useful 2D log likelihood contours (viewed in SuperSMITH Visual) are the basis of likelihood ratio confidence intervals. Both of these contour techniques are available in the SuperSMITH™ software.

6. Report Options: Predictions for the next 1, next 2, next 5 and next 10 events are given on the report option for the Crow/AMSAA (Duane) reliability growth model of SuperSMITH™ Visual. This projection is based upon simple extension of the fit line. Crow/AMSAA implementation now includes Dr. Larry Crow's confidence bounds. It is best practice for (1) extremely dirty data, (2)

¹ SuperSMITH Weibull was formerly called WinSMITH Weibull.

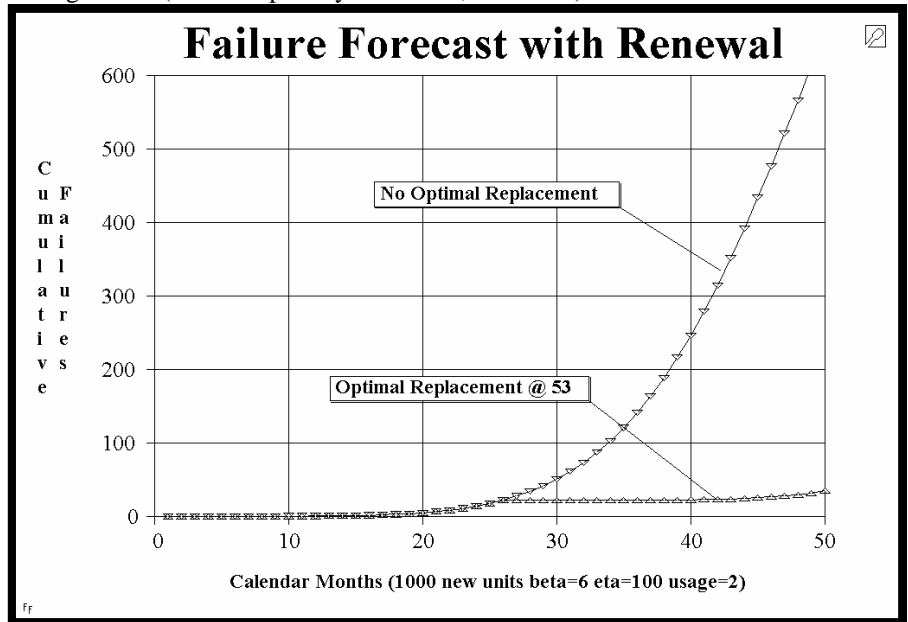
R & D component development, (3) management trending, (4) warranty claims forecasting by calendar date, and especially (5) for monitoring processes like petro-chemical production and maintenance of fleets of systems. Mean occurrence sum value is available in the SuperSMITH™ Weibull report and predict options. It is commonly known as average value and is useful in certain situations where there are no suspensions

7. Unique Advanced Warranty Analysis: SuperSMITH™ software has warranty data matrix transform capability. This capability is easy to use, simply by copying existing data (in any Windows-compatible spreadsheet) and then pasting the data into the SuperSMITH data grid. Warranty type data in the standard triangular matrix form will be automatically converted to SuperSMITH input. This works with the SuperSMITH Weibull software for a Kaplan-Meier Weibull plot to predict claims by age of the component. SuperSMITH Visual software will also “eat” the matrix for a Crow/AMSAA plot to predict claims by calendar month. A limit correction capability has been added to this warranty data transform to account for percentage-out-of-warranty components or systems in the original data. Also, the warranty coverage limit (for example 6 years or 60,000 miles) is accounted for in the new warranty length limits in the risk section.

8. Failure Forecast - Risk Options and Cost Functions: Optimal parts replacement intervals may be input to risk analysis to forecast failures with and without planned replacement. Variable usage rate and variable production rate (for seasonal products) has been added to the risk model as well. By adding cost per failure to the input the predicted failure forecast becomes a predicted cost function. This cost capability has also been added to the Crow-AMSAA input in SuperSMITH Visual.

SuperSMITH Adopted as the Standard

Many organizations have adopted the SuperSMITH software acquiring site licenses including TVA, Allied Signal, BICC cables, GKN Automotive, Meritor Automotive, Teleflex, Guidant’s Cardiac Pacemaker (CPI), Chrysler, General Electric, Rolls Royce, Gates Rubber, the FAA, and the US Naval Air Arm (NAVAIR).



Weibull Workshops Enhanced

Without increasing fees, the students at our Weibull Workshops now receive the full SuperSMITH package: (1)SuperSMITH Weibull, (2)SuperSMITH Visual, (3)Playtime with SuperSMITH and (4)The New Weibull Handbook. Further, on-site workshops for twenty or more students include a one-time site license. Both of the authors produce the Weibull Workshop. Contact Dr. Bob for information and scheduling and a brochure on workshops tailored to your needs. The three-day workshop is \$7496.00 for eight students, total price including travel, \$712.00 for extra students over 8. Since our last WeibullNEWS we produced on-site workshops at American Association of Railroads, Maxtor, Chandler-Evans, Cardiac Pacemakers – Guidant, US Naval Air Arm, Rolls Royce In England, Gates Rubber Company, American Medical, Rockwell International, and Allied Signal. In the next few months we will be at General Electric, Volvo Flygmotor and SAAB Automotive in Sweden, Sikorsky, Mobil Oil, Torrington Bearing, GKN Automotive, BICC Cables, and the Federal Aviation Administration.

Our public workshops include: •SAE Detroit, MI: September 23-25 1998, March 1-3,1999, Seattle June 7-9, 1999, Indianapolis September 13-15, 1999. \$1,525.00. Call 412-776-4841. FAX 412-776-4955.

•Gulf Publishing 25-27 October 1998 Gerald Babin 800-231 6275

•Reliability Analysis Center. Orlando, FL, December 1998. Call RAC at 800-526-4803

•ASME Phoenix January 20-22, 1999, New York City, May 5-7, 1999. \$1430.00. Call 212-705-7398.

Dr. Bob would like to hear from you at weibull@worldnet.att.net. Wes Fulton's web site <http://www.weibullnews.com> contains much of interest, the WeibullNEWS, and the DEMO software. Links to other organizations and suppliers are provided in these two web sites to help connect you to the World of Weibull.