Weibull NEWS (TM)

The Latest in Life Data Analysis Technology (SM)
From: Dr. Bob Abernethy and Wes Fulton

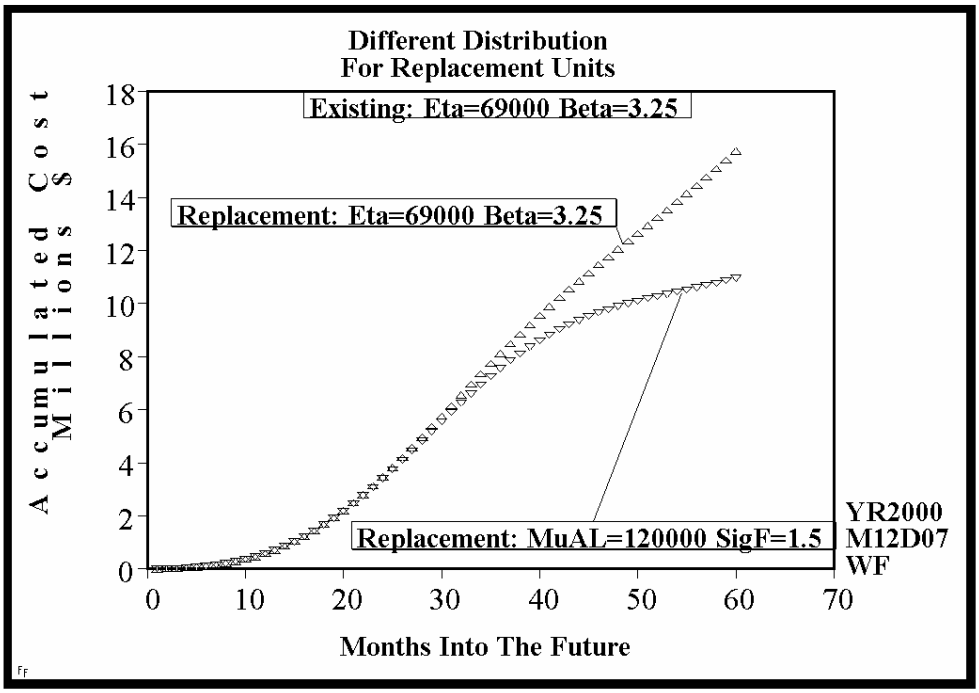
Sixteenth Edition Winter 2000-2001

Three Fours!

- ***4th Edition - New Weibull Handbook©***
- ***Version 4.0 – SuperSMITH™ Software***
- ***4th Update Weibull Workshop***

Dr. Bob and Wes spent most of the year developing new methods and incorporating them in the 4th Edition/Version/Update. And as usual we have had lots of help from people like Paul Barringer, Charles Sica, David Smith, Dick Rudy, Steven Duffy, M. A. Vasan and Richard Petschauer. It has been fun but it did delay this WeibullNEWS. Forgive us? So we have lots to tell you in this WeibullNEWS. There are many new tools for your life data analysis. All are described in the (1) Handbook, (2) available in the software, and (3) presented in the Weibull workshops.

Failure forecasting and warranty claims forecasting may be based on fixed average usage, seasonal usage, or distributions of usage, fixed average production, seasonal production or distributions of production; in addition, forecasting may be desired when the replacement part has a different life distribution. Based on customer requests, Wes Fulton developed these enhancements now in the version 4.0 software. Further there is a way to account for warranty period in months and/or miles for warranty claims predictions.



Failure Forecast allows a different distribution model for **replacement parts** than existing parts (see the figure). Also, new options A…All and F…Expected are available for planned replacement. The difference between these two options is that the A…All option assumes that all parts (existing units from the very beginning) were replaced on a scheduled replacement basis. The new F…Expected option accounts for the common scenario where parts that did not have a planned replacement are now put under a new maintenance philosophy of planned replacement for the future.

Failure forecast predictive intervals have been changed to a WeiBayes related technique. **Cost analysis** has been added to failure forecasting, warranty analysis, and Crow/AMSAA modeling as many industries are more cost oriented than event oriented. **Kaplan-Meier is best practice** for modeling warranty claims by system age, where **Crow/AMSAA is best practice** for predicting warranty claims by calendar month. Dr. Wayne Nelson's Graphical Repair analysis is now available in the Handbook as an Appendix and provides a more rigorous alternative to Kaplan-Meier if there are repeated repairs of the same part influencing the warranty claims.

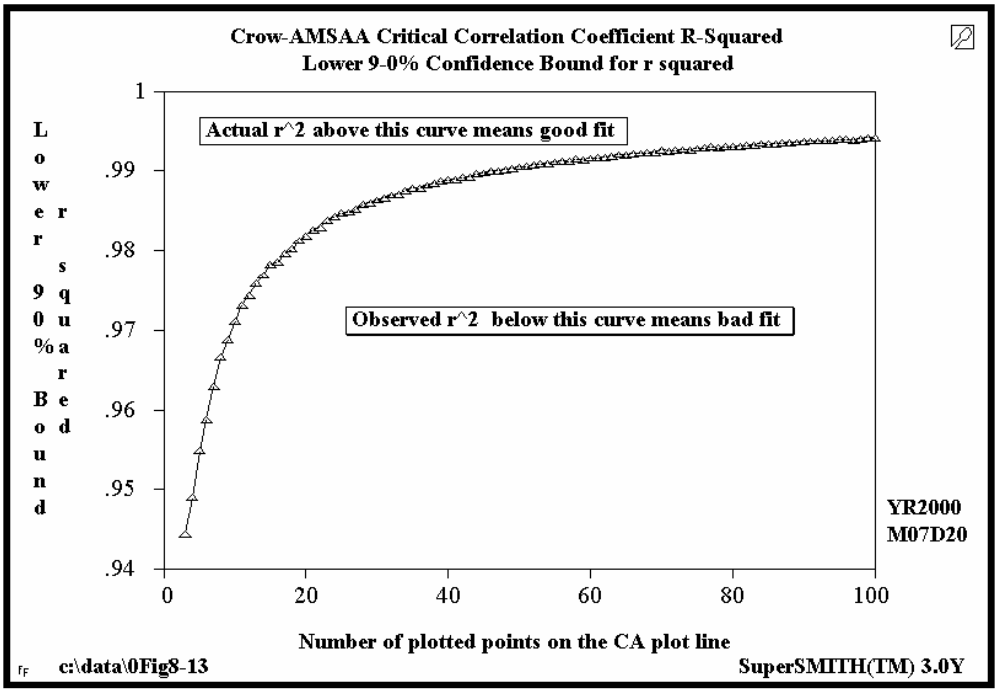
Paul Barringer's use of Weibull plots to **control production processes** continues to be one of the hottest new applications for Weibull. The petro-chemical industry has adopted this marvelous application "lock, stock and barrel." How much do cutbacks, "crash & burn" reductions, and outages cost your company? What are maximum and typical production rates? How does your production process compare with others? Find this new technology in the mixture section of WinSMITH(TM) Weibull.

Gumbel lower and Gumbel upper distributions are available. The lower **extreme value type I (Gumbel)** distribution applies to minimum data such as drought water levels (or Tiger Woods' golf scores). The upper distribution applies to peak data such as wind gust loading (or Wes's golf scores). The Weibull distribution is **extreme value type III minmum** and is directly related to Gumbel lower (extreme value).

Is Crow/AMSAA More Important Than Weibull? Larry Crow (now with RAC/IITRI in Huntsville, Alabama) took J. T. Duane's original idea and developed the necessary statistical methods to allow rigorous analysis. His Crow/AMSAA (C/A) method is considered by many to be more important than Weibull for at least six applications…

1. Estimating reliability growth of R&D components; forecasting in-service reliability for the latest configuration
2. Tracking significant events for management like outages, accidents, crashes, scrams, accidental accelerations
3. Tracking reliability-maintainability performance of fleets of repairable systems
4. Predicting warranty claims by calendar months
5. Handling really dirty data, mixtures of failure mechanisms, missing data, changing reliability
6. Cost analysis of all the above

WinSMITH(TM) Visual software incorporates the C/A method for reliability growth modeling in a simplified format with occurrence rate (or MTBF) transforms, instantaneous line, and confidence lines. Data can be imported from any Windows-compatible application. The standard C/A plot puts TIME on the horizontal scale (X) and EVENTS on the vertical (Y). Also, the C/A model can now be accessed in batch mode for automatic processing.



How good is the Crow/AMSAA fit? Acceptable? Paul Barringer did the research! We now have a critical correlation coefficient (CCC) for the best-practice C/A model thanks to Paul. Additionally his C/A research indicates that our new default method, regression (RGR), is less biased than the previous default method of maximum likelihood estimation (MLE). In this respect the results for C/A agree with life data results, which indicate less bias with regression. Call Paul at 281-852-6810 or e-mail him at hpaul@barringer1.com on the web for information on his Reliability Engineering Principles (REP) class.

Surf by http://www.weibullnews.com on the internet to download **DEMO copies** of the **SuperSMITH(TM) version 4.0** software. The 32-bit self-extracting file for WinSMITH Weibull takes 10-15 minutes with a slow modem. The 16-bit self-extracting file for WinSMITH Weibull takes only about 5-10 minutes. There are so many improvements and additions to both WinSMITH Weibull and WinSMITH Visual there isn't enough room here to list them all. A few good changes are:

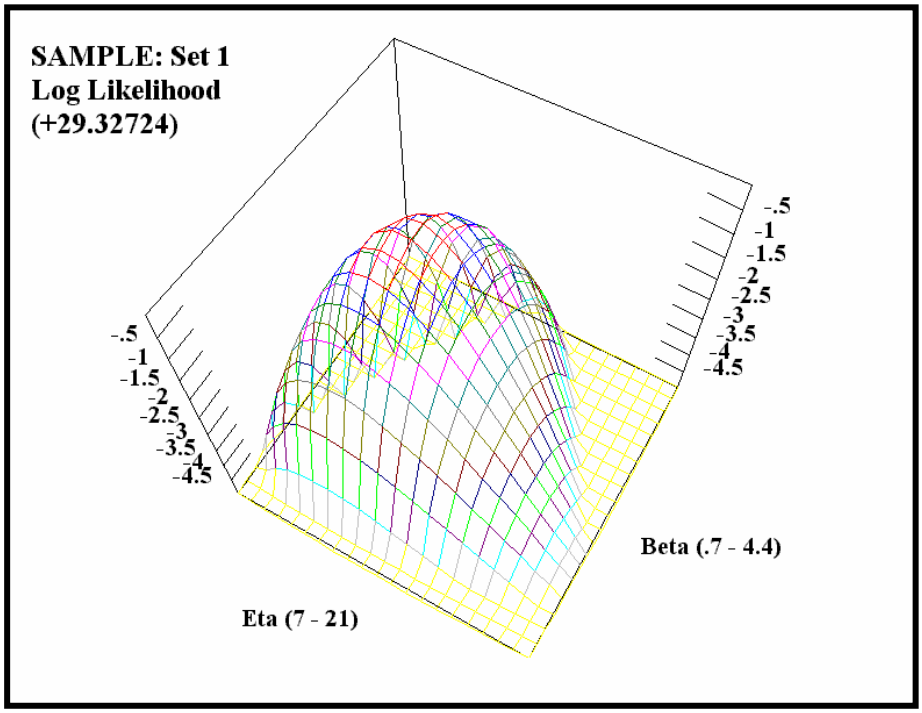
The 16-bit and 32-bit versions of the SuperSMITH software are more compact due to rearrangement and consolidation. The 16-bit versions of both WinSMITH Weibull and WinSMITH Visual still fit on one floppy diskette each, while the 32-bit versions take two diskettes per program. The smaller 16-bit version works on all major Windows platforms, while the 32-bit version will handle long file names and should interface better with network printers. (32-bit software designed for Windows 95, 98, NT, and up, doesn't work on old versions of Windows like 3.1.) We ship the 32-bit version unless otherwise requested.

WeiBayes is now a selection in the Setup portion of the WinSMITH Weibull software (computer icon on the main screen). Activating WeiBayes this way applies the method to all data sets. Exponential (Beta=1) and Rayleigh (Beta=2) are now specific choices under WeiBayes in Setup. Change probability plot types easily by clicking on the equation name (e.g. Weibull or LogNormal, etc.) just to the right of the drop-down menus.

Accelerated testing parameter as a function of engineering variable (PFEV) and probabilistic S/N curve (PSN) methods have been enhanced to provide greater flexibility and accuracy. The PSN technique relates S-N curves and Weibulls to estimate

effects of complex loading combinations on the same part. It was described in the 15th edition of WeibullNEWS and at the ASQ 2000 conference. The latest WinSMITH(TM) Weibull improves on this original technique for greater accuracy and consistency.

3D Likelihood Surface viewing is significantly improved by encoding internally and eliminating third-party software. 3D images of the likelihood surface are easier with smaller memory requirements. Access this capability when using the maximum likelihood method by clicking on the Prediction / Precise-Plot-Reading-From-Plot / Likelihood icon on the main screen (showing four arrowheads).



Calculation routines have been tweaked. Normal distribution accuracy has been improved with help from Dick Petschauer (new statistical analysis software from Dick mentioned below). Dick also suggested a new PRESENT RISK calculation method now implemented for Abernethy Risk analysis producing better estimates for samples without suspensions. Outliers are detected with an option on the calculator portion of the software useful for such complete samples. Additional research is needed for samples with suspensions. There is now an automatic data transform available when changing between grouped data methods such as Probit2, Probit3 and Kaplan-Meier if no intermediate Kaplan-Meier suspensions, and the calculator option includes a probability plot rank value readout.

The **"Vasan-Fulton Former Usage Ratio"** technique has been added to the 3-parameter menu selections. This method, developed by Wes Fulton in response to a request by M. A. Vasan of ArvinMeritor, uses a linked 3-parameter solution to find the **ratio between laboratory test time and the equivalent actual in-service usage time**. Units with known service usage are tested until failure in the laboratory. With several examples at each service age, a ratio solution can be found.

Confidence selection has been simplified while providing several implementations of the Fisher-matrix method. The precise confidence method for the normal distribution (no suspensions) can now applied to the lognormal distribution as well. The unique **pivotal (pv) confidence** method in WinSMITH Weibull is our **best-practice** recommendation for small samples when using median rank regression. The **MLE-RBA method with likelihood ratio (lr) confidence** is a precise alternative for small samples, plus confidence contours are less biased with **JLF adjustment**. MLE-RBA and JLF are described in our RAMS 2000 paper (MLE-RBA in the 14th edition of WeibullNEWS too). Other confidence methods (fm and bi) are useful only for large sample sizes. Parameter confidence for the **beta-binomial** method is now included based upon a reference found by Dr. Bob.

WinSMITH(TM) Visual improvements include smoothed data points on PDF, CDF, RDF and HDF plots based upon new transform algorithms developed by Wes Fulton. The aggregate cumulative hazard (ACH) calculation for interval MLE has been improved for increased accuracy. The function menu now includes normal function choices PDFn and CDFn, Weibull function choices PDFw and CDFw, and Gumbel upper function choices PDFx and CDFx. Arrhenius fit (plus activation energy E value display) has been added to the curve fit selections.

Friendly user interaction with extended pull-down menu choices provide an alternate way to access all of the major categories of analysis. Improved Zoom icon, improved data import, Y-axis label toggle between side-by-side and stacked, updated batch operation, risk confidence highlighted in red print, addition/multiplication and data quantity global edit capability for the data wizard, y-value column added to probit/Kaplan-Meier rank table, and improved range lock input in zoom combine to make software use even easier.

Security has been improved for the DEMO-to-FULL code saved to disk. This code is now encripted. Text code in the file must be unscrambled by the software to get the original password code. This provides security so that no person can get someone else's code from the file. Please, save your DEMO-to-FULL code, but if lost then just contact us for another code.

Updated Weibull Workshops With good ideas from our clients and students and some new technology, the original Weibull workshop continues its evolution as the most popular seminar on life data analysis. The new fourth edition workshop is based on the fourth edition of The New Weibull Handbook and the fourth version of the SuperSMITH software. The standard workshop is a focused 3-day session including all major areas of Weibull engineering analysis. One feature keeping it on the leading edge is that each student receives the complete SuperSMITH(TM) software package … not just a DEMO but the FULL capability software. This enables workshop graduates to immediately put their new knowledge to use. The SuperSMITH software included is capable of all techniques covered in the workshop. Wes Fulton has taken the best capabilities from MonteCarloSMITH(TM) and BiWeibullSMITH(TM), improved the technology, and added them to the WinSMITH(TM) Weibull software. Therefore, each student has all the tools needed for life data analysis after workshop completion.

To enhance the "hands-on" experience, students are now strongly encouraged to bring their own real problems to analyze in the seminar with help from one of us. Clients like NAVAIR, Honeywell, and General Electric, have added a fourth day for a forum of student presentations of the problems and their solutions to upper management. This provides live home-grown examples for upper management review, and gives students a degree of confidence with their new skills. A "Ph.D." oral examination is used to summarize all the methods and interpretations in life data analysis. Bob Rock of PACCAR has organized this information into a logic diagram, now in the handbook, that takes the novice step-by-step through typical analysis decisions. On-site workshops are tailored to specific company needs and allow the students to work their own problems. One new development in the last few years is the explosion in easy data access through local and wide area networks. On-site facilities offer the advantage of direct linkage to company databases. Many on-site students can retrieve data they are currently analyzing for input to the Weibull software while they are in the workshop. There is a special exercise, #8 in the PlayTIME(TM) Tutorial booklet, requesting analysis and interpretation of student-supplied data. Some of the fourth day may be budgeted for an overview presentation to senior managers. For moderate size classes a site license for the SuperSMITH software will be included at no extra charge. These in-house workshops are cost effective and tailored to your specific needs. They are often an attractive alternative to the added cost of travel and accomodations associated with sending students to public workshops. Contact either Dr. Bob Abernethy or Wes Fulton to get a detailed proposal for a workshop at your facility. Check the www.weibullnews.com website on the internet for the current workshop schedule.

Weibull Process Control Charts? Did You Know … at the American Society of Quality (ASQ) 2000 Conference there were two papers presented on **process control charts** using the Weibull distribution instead of the normal? Many processes produce non-normal data. These are the first papers of note that addresses this issue. The Weibull distribution provides excellent fits to both normal and non-normal data. This is a great new and much needed application of Weibull.

Dr. Bob Abernethy was made a fellow of ASQ at this 2000 conference, and Wes Fulton and Mike Macdonald (of Ingersoll-Rand) also presented a paper titled "Probabilistic S/N Curves for Accelerated Testing". This method, improved for consistency, is now in WinSMITH. The ASQ Reliability Division is recruiting new members. Contact them at www.asq.org on the internet.

AIAG Reliability Group Results: M. A. Vasan of ArvinMeritor headed up the group that developed usage rate profiles for heavy vehicles. This was an amazing collaboration between competitive OEM's (original equipment manufacturers) that supply "big-rigs" for the trucking industry. Usage information was shared among competitors in a creative way so that a standard could be adopted to improve reliability assessments for the overall industry. The effort was sponsored by the Automotive Industry Action Group (AIAG … www.aiag.org on the internet). The SuperSMITH(TM) software now includes these usage profiles for easy generation of reasonable suspension data for heavy vehicles. Applicaton of these profiles is the recommended alternative to using the Dauser Shift for heavy trucks.

Additional Analysis Software includes **YBath(TM)** by Carl Tarum, CEO of Bathtub Software, Inc. This package remains the best set of models for advanced mixture analysis. The possible models range from the standard 2-parameter Weibull solution to a 7-parameter bathtub curve solution. Also available: Dick Petschauer's **WStats(TM)** software for general statistics and Monte Carlo simulation. A detailed description of all of the software is provided at http://www.weibullnews.com on the internet.

SAE Congress 2001 Coming! Reserve your place for the best seminar on the planet to be held 5-7 March 2001 at the Rennaisance Center in downtown Detroit, Michigan. Both Dr. Bob Abernethy and Wes Fulton will lead the 3-day Weibull / Lognormal Workshop. The workshop comes with the latest versions of The New Weibull Handbook(c), the PlayTIME(TM) tutorial booklet, and the WinSMITH(TM) Weibull and WinSMITH Visual software included for all the students. Each student receives the complete SuperSMITH(TM) self-study package to get full capability for tackling most reliability / maintainability issues. Contact SAE Professional Development at 724-772-7148 or www.sae.org for more information and reservations.

Other SAE Workshops … Wes Fulton will be teaching Weibull again for SAE on days 11-13 of June 2001 in Troy, Michigan, and on days 24-26 of September 2001 in Troy as well.

The Recent RAC Seminar in Orlando taught by Dr. Bob Abernethy was a big success… Contact RAC Professional Development at http://rome.iitri.com/rac on the internet for 2001 schedules.