

# Weibull NEWS™

The Latest in Life Data Analysis Research <sup>SM</sup>

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From: Dr. Bob Abernethy & Wes Fulton

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## New Ideas and Applications - by Dr. Bob Abernethy

**Batch Effects:** It seems we all have problems with batches or subsets within the sample that are "different" from the rest of the population. If the *Present Risk* estimate of the expected number of failures (now) is much greater than the observed number of failures, this may indicate a batch problem as described in Section 4.4.1 of The New Weibull Handbook (NWH). The question I often hear is "how much greater does it have to be?" Ann Azevedo at the Federal Aviation Administration gave me the answer. Use the Poisson distribution to put a lower 95% confidence bound on the Present Risk. If it does not include the observed number of failures, there is strong evidence of a batch effect. For example, say there are four failures observed and the Present Risk estimate is ten. The lower 95% bound is 5.4 so there is strong evidence that a batch may exist as the observed four is outside the confidence interval. The lower bound can be obtained from the Weber Charts in Chapter 8 of the The New Weibull Handbook (NWH) or from the calculator option (or from the new risk confidence capability ... see below) in WinSMITH Weibull. Thank you Ann!

Based on the applications I have seen in the past few months, the new concept for detecting batch effects, the Aggregated Cumulated Hazard function (ACH), is excellent and compliments the Now Risk method but it is more sensitive and works with complete samples as well as suspensions. It also works with maximum likelihood estimates. The method is described in Appendix J of the NWH. It may be exercised with any WinSMITH Weibull data set brought into WinSMITH Visual. To me it has a big advantage; it provides a picture, a plot, indicating the batch. David Navell and Geoff Cole at Rolls Royce are to be congratulated for this technical breakthrough.

**Production Process Control:** This new Weibull application is spreading like wildfire through the chemical and oil industries. The method is to plot the daily production quantities on the ordinate (time scale) of the Weibull. Usually this appears as the classic bi-Weibull mixture, shallow slope followed by steep. The shallow points represent the costly cutbacks and slow downs in production. If one year's data is employed it is easy to calculate the lost production amount as well as its cost. The characteristic life is the typical production and the B99.9 is maximum production. This may be compared to the name plate production. The plot inspires investigation and elimination of the reasons for cutback. Improvements in process control produce steeper slopes.

Paul Barringer is credited with developing this new important application described in Section 8.9 of the NWH. See Figure 1 for an example showing 30,000 Mlbs of lost production due to reliability issues (dark shaded area) and 25,000 Mlbs of efficiency and utilization losses (light shaded area). Note that the reliability losses appear to come from three separate types of causes, exhibiting three different Weibull slopes. Process Reliability is found to be 53.4%. Reference the article in the section below on software updates for additional information on this.

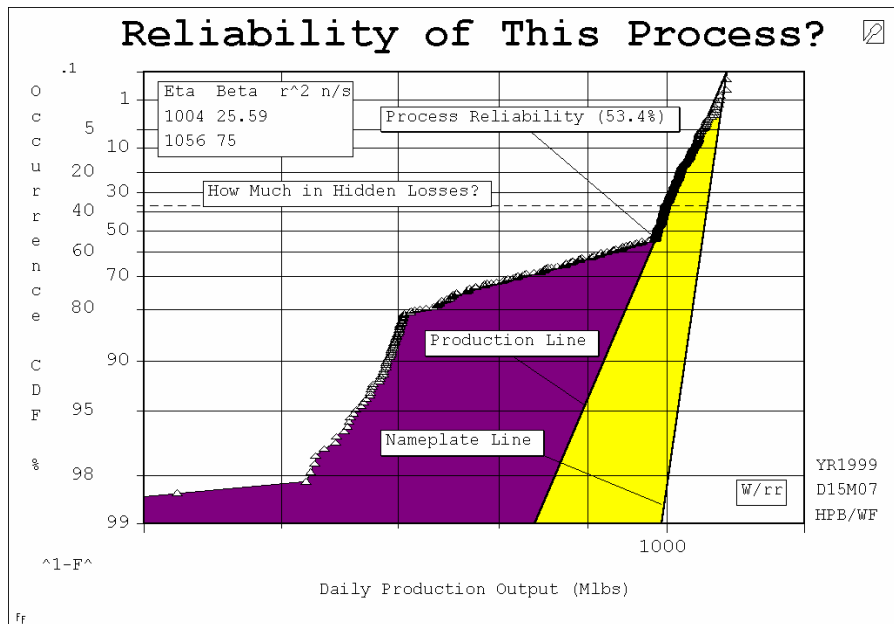


Figure 1. Production Process Control with WinSMITH™ Weibull

**Crow-AMSAA Model:** You have a severe problem monitoring in-service data. Management decides to take corrective action. After some period of time there are no new failures and management wants to know if their action was effective. Solution: just like Weibayes testing, assume the first failure is imminent and add it to the C-A plot. If the management

action was effective you will see a cusp and you can estimate how many failures and costs were avoided. See Case Study 9.15 in the NWH from David Williamson, Dow Chemical, Canada.

Speaking of Weibayes, is a Crow-AMSA library valuable like a Weibull library to estimate beta? Absolutely! At the beginning of an R&D development program for a new design we observe a few failures. On the C-A plot lay in a line with betas from your best and worst previous R&D programs to determine months, perhaps years, in advance whether you will make program reliability goals. Note this is proactive, allowing timely management action if needed.

**Hungarian:** As you may know the WinSMITH Weibull and WinSMITH Visual software programs have built-in language capability for French, German, Spanish and Swedish. Simply click on the setup icon (showing a computer) and select the language icon (showing two people talking). Hungarian will be added next and there will be a Hungarian version of the NWH available soon. Language translation is relatively easy for the SuperSMITH™ programs. If you would like the software translated into your language, please contact Wes Fulton as listed below. □

### SuperSMITH™ Software Update - by Wes Fulton

**Failure Forecast Improvements:** The Abernethy Risk Analysis option in the newest WinSMITH™ Weibull now has confidence capability. Enter confidence level in the input selection menu and choose upper or lower bound (as mentioned in the Batch Effects article above). The output table will show Present Risk, Next Expected Occurrence and Failure Forecast results at the specified confidence. Confidence values displayed in the output table show only statistical uncertainty, not that associated with prediction intervals due to possible changes in trends, etc. Figure 2 is a plot of these confidence results in WinSMITH™ Visual for Case Study 4.5.2 in the NWH.

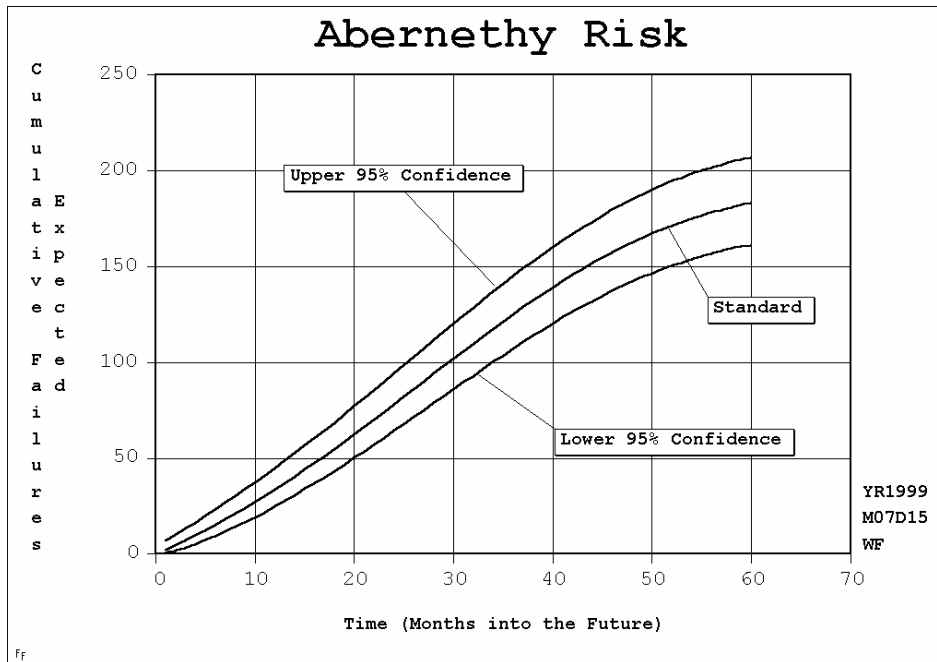


Figure 2. Standard Risk Analysis Output and 90% Double-Sided Confidence

**Probabilistic S/N Curve Analysis:** A Weibull Workshop for the Torrington Company brought up some interesting questions and led to a new feature in WinSMITH™ Weibull. If my memory serves correctly, Mitchell Krysiak and Mark De Bisschop asked the author whether Weibull analysis could estimate total reliability after several load applications to the same part at different stress levels. Combining loads is usually done by applied-mechanics specialists using the appropriate S/N curve (reference MIL-HDBK-5). These specialists then use Miner's rule or some scheme such as the "rainflow" technique to combine the individual loads for total damage. But this information can also be found on the Weibull graph! The standard S/N curve and the Weibull graph are two different views of the same thing. The S/N curve emphasizes stress level display while the Weibull graph emphasizes reliability display. Reliability-centered analysis can be difficult with the standard S/N curve (most S/N analysis is worst-case and not reliability centered), but it is easy on the Weibull graph.

The Parameter as Function of Engineering Variable (PFEV) option in WinSMITH Weibull is generally used for analysis of Accelerated Testing results and predicting reliability under normal loading. It can also be used to perform Probabilistic S/N Curve analysis for design purposes. The results from different combinations of stress levels can be shown as separate lines on the Weibull plot. The software will produce a multi-parameter solution to model effects of each type of stress on product life. Designers can then compare different loading or specify simpler but equivalent loading conditions for writing accelerated testing plans. The newest release of the software has improvements to make Probabilistic S/N Curve analysis easier. The selection of the terminology "Probabilistic S/N Curve" by the author denotes that S/N Curve analysis for fatigue data can be centered on reliability, rather than on the standard but less-efficient worst-case basis. Look for a paper on this subject to be given by the author at the 8-10 May 2000 ASQ Annual Quality Congress in Indianapolis.

**Automatic Software operation:** Batch automated processing in WinSMITH Weibull and Visual is enhanced. With this you can preset the analysis to have the computer process your data while you are not there. Invoke this capability by including filenames and extra information after the program name on the command line. For regular WinSMITH Weibull interactive use, the command line is SMITHW.EXE (with appropriate path in front). This command is invoked to start the program from the program icon. To see this for yourself, right-mouse-button click on any icon and look at the Properties.

For batch processing use, the command line would be SMITHW.EXE C:\INPUT.DAT [PC] for example to read input data from the file C:\INPUT.DAT and send the resulting plot to the clipboard. Also, you could use [PP] at the end to send the plot to the printer or [PFC:\OUTPUT.DAT] to send the plot to file C:\OUTPUT.DAT. WinSMITH Weibull now provides automatic Risk Analysis and Optimum Replacement Analysis output, with [QC] and [OC] respectively. You can also specify data input format. Use SMITHW.EXE C:\X.DAT -IB [QP] for example to load data from ASCII two-column file C:\X.DAT with age values in the first column and quantity values in the second column for Risk Analysis output to the printer. Check the Help file in the software for descriptions of more batch processing options.

**Improvements to Barringer Process Reliability:** Selection of inputs and alternatives is easier for the BPR capability in WinSMITH™ Weibull based upon suggestions from Paul Barringer. Selections that are made in the BPR input menu now result in returning directly to that menu. Specification of the process reliability value can be input graphically. See the BPR graphical analysis output in the Production Process Control article above for more information. □

### **Spreading the Weibull Word**

**New Course at Penn State:** We are enclosing a flyer for a new course with the mail-out of this newsletter. Dr. Stewart K. Kurtz at Penn State University (What makes a lion Nittany or not?) has developed course E E 497B with comprehensive coverage of reliability including the best of Weibull. This is a "fully interactive, multimedia Web-based course" available from the World Campus of Penn State targeted for off-site students around the world. The curriculum involves the use of software plus case studies for learning Weibull analysis techniques with the computer. The software provided on CD includes fully functional DEMO versions of WinSMITH™ Weibull and WinSMITH Visual software specially designed for instruction. Contact Penn State by calling 1-800-252-3592 (free in the U.S.) or 1-814-865-5403 (international), or by e-mail at [psuwd@psu.edu](mailto:psuwd@psu.edu), or by visiting their website [www.worldcampus.psu.edu](http://www.worldcampus.psu.edu) on the internet.

**Continuing Donations of Handbooks:** Dr. Bob Abernethy initiated a library donation program designed to enhance the introduction of Weibull analysis at the college level. This effort is sorely needed, since most Weibull users have had to learn on-the-job or by trial and error; and most Weibull Workshop participants have had no exposure to Weibull theory in high school or college. Our library donation program has been successful in getting the NWH into many engineering university libraries. Last year this program was supported by the Society of Automotive Engineers (SAE). Wes Fulton and Dr. Bob continue these contributions. Let Dr. Bob know if your university library needs a copy of the handbook. □

### **Upcoming Public Workshops and User Conferences**

SAE. 13-15 Sep 1999. Weibull Workshop, <b>Indianapolis, IN (USA)</b> . INSTRUCTOR: <b>Wes Fulton</b>
SAE. 15-17 Nov 1999, 6-8 Mar 2000, 18-20 Sep 2000. Weibull Workshop, <b>Detroit/Troy, MI (USA)</b> . INSTRUCTOR: <b>Wes Fulton</b>
RAC (IITRI). 7-9 Dec 1999. Weibull Workshop, <b>Orlando, FL (USA)</b> . INSTRUCTOR: <b>Wes Fulton</b>
SAE. 9-10 Mar 2000. Weibull Software Users' Conference, Detroit, MI (USA). CO-CHAIRMAN: <b>Wes Fulton and Dr. Bob Abernethy</b> . KEYNOTE SPEAKER: <b>Paul Barringer (Barringer &amp; Assoc.)</b> . INDUSTRY EXPERTS: <b>Ann Acevedo (FAA)</b> , <b>Dick Rudy (DaimlerChrysler)</b> , <b>M. A. Vasan (Meritor)</b> , <b>Dan Sommers (GE Lighting)</b> , <b>Randy Pirtle (AlliedSignal)</b> , <b>Arne Høglund or Lars Andersson (Saab)</b> .

### **Workshop Proposals and Registration Contacts:**

Send requests for workshop pricing and availability to Dr. Bob at (561) 842-4082 or send e-mail to [weibull@worldnew.att.net](mailto:weibull@worldnew.att.net) for private classes. We come to your facility and provide the same course that is given publicly, but with greater emphasis on specific problems associated with your product or service. Book early, our workshop schedule is nearly full. Contact SAE at 724-772-7148 or at <http://www.sae.org> on the internet. Contact RAC at 800-526-4803 or at <http://rome.iitri.com/rac> on the internet. □

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