

# RELIABILITY & MAINTENANCE

COURSE SERIES - SPRING 2006

HOUSTON • THE HOUSTONIAN HOTEL

## Weibull Analysis Workshops

Dr. Robert B. Abernethy and Wes Fulton

**Basic Workshop**  
March 6-7, 2006

**Advanced Workshop**  
March 8-9, 2006

## How to Manage Equipment Assets

to Achieve Their Maximum Use, Effectiveness, and Lifetime Value

March 6-7, 2006

John Mitchell

## LIFE CYCLE COST

March 8-9, 2006

Paul Barringer

## Accelerated Testing

for predicting and improving product reliability

March 8-10, 2006

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RMS (Reliability-Maintainability-Safety-Supportability) engineering is emerging as the newest discipline in product development due to new credible, accurate, quantitative methods. Weibull Analysis and Crow-AMSAA are foremost among these new tools. Participants in the **Basic Workshop** will learn the essential methods and techniques, and how to use Weibull Analysis software to apply these methods to their specific problems. Laptop required.

The **Advanced Workshop** will familiarize participants with the latest techniques and advanced applications of in WinSMITH™ Weibull for risk forecasts with renewal and optimal component replacement will be illustrated with case studies. Students are fully qualified to conduct Weibull Analysis at workshop completion. Students May Bring Their Own Data for Analysis (laptop required).

## BASIC WORKSHOP

### PROGRAM

- Introduction & Overview
- How to do Weibull Analysis
- Interpretation of Good & Bad Weibulls - 2 & 3 Parameter
- Interpretation of Bad Weibulls - Cusps, Dog Legs, Curves, Outliers
- Failure Predictions and Weibull Risk Analysis: How Many Failures Will There be in the Next year, Five Years? With and Without Parts Replacement?
- Case Studies, Customer Usage, Maintenance Planning, Goodness of Fit with the New Critical Correlation
- Inspection Data: Special methods to improve accuracy - Inspection Option and Probit
- Goodness of Fit with the Best New Method
- Coefficients, Failure Forecasting
- Weibull Experiments, Wire Rupture, Torsion, LCF
- Suspension and Sample Size Effects on Uncertainty
- Classwork, Problems and Solutions
- An Introduction to WinSMITH™ Software, Features, Input, Analysis, Output
- The Logic Diagram - A summary of Weibull Methods
- Class Work Problems
- Experimental Wire Data Distribution Analysis
- "Playtime With SuperSMITH™" Tutorial, Hands-On Computer Experience with All Kinds of Problems
- Review and Discussion of Class Work and Playtime Exercises
- Introduction to Crow AMSAA The **Advanced Workshop** will familiarize participants with the latest techniques and advanced applications of in WinSMITH™ Weibull for risk forecasts with renewal and optimal component replacement will be illustrated with case studies. Students May Bring Their Own Data for Analysis (laptop required).

## ADVANCED WORKSHOP

### PROGRAM

- Postgraduate Weibull Analysis
- Maximum Likelihood Weibull and Log Normal Theory and Application including Reduced Bias Adjustments (MLE-RBA) for extreme accuracy with small samples
- Rank Regression vs. Maximum Likelihood, When Should I Use MRR vs. MLE vs. MLE-RBA, Advantages & Disadvantages?
- What is the best plotting position - Mean or Median or Blom or Hazen
- Extremely Small Samples Analysis, What is Best Practice for small samples?
- Inspection Methods: Inspection Option, Probit and MLE Interval analysis
- Goodness of Fit with the two best methods
- Predicting Future Failures with and without: Renewals, planned replacement of parts, seasonal usage, variable production additions
- Confidence Intervals, "The Good, the Bad and the Complicated," what is best practice for confidence intervals comparing the six different methods?
- Comparing Data Sets
- The Binomial & Poisson, Discrete Distributions Related to the Weibull and Useful for RMS & Quality
- Probabilistic Design: Convolutions of Life and Usage Distributions and crack and crack-to-rupture distributions
- Batch Problems: How can we detect batch problems and estimate the size of the batch?
- Crow-AMSAA Reliability Growth Modeling - New Useful Technology for Tracking
- Substantiation and reliability Testing with minimum cost and time and maximum accuracy
- The Exponential Distribution Related to the Poisson and the Weibull, Assumptions and Applications
- Kaplan-Meier Survival Analysis
- Production Process control with Weibull Analysis for major cost savings
- System Degradation Models: performance degradation, crack growth, vibration data
- Hands-on Computer Problems with the Playtime Tutorial
- The "Ph.D." Oral Examination

## BENEFITS OF ATTENDING

By attending this workshop, you will be able to use Weibull's unique capabilities to:

- Analyze design, development, production, and service failures
- Model product lifetime and reliability
- Evaluate calibration & maintainability plans
- Analyze inspection data
- Reduce test substantiation, time and costs

## WHO SHOULD ATTEND

Engineers responsible for reliability, safety, supportability, maintainability, materials, warranties, life cycle cost, design, structures, instrumentation and logistics will find these Weibull techniques extremely useful.

## TEXT & SOFTWARE INCLUDED

Each attendee will receive the entire SuperSMITH package, a \$960 value. SuperSMITH contains: the *New Weibull Handbook*, written by Dr. Robert B. Abernethy, along with classwork, answers, and references; the latest version of WinSMITH Weibull and WinSMITH Visual software which is used in the workshop; and the *Play-Time Tutorial Software Workbook*. This state-of-the art, Windows software includes **Normal & Log Normal Analysis** and allows the student much more time for actual hands-on PC experience, interpreting data of all types.

All students must bring a laptop computer.

Upon completion of each course, participants will be eligible to receive 1.2 Continuing Education Units (CEUs).

## INSTRUCTORS

**Dr. Robert B. Abernethy** is known worldwide for his expertise in jet engine performance, measurement uncertainty analysis, and Weibull analysis. More than 8,000 students have attended his seminars. More than 15,000 copies of his textbook, *The New Weibull Handbook*, have been sold. Dr. Abernethy graduated from Rensselaer Polytechnic Institute with a B.Sc.ME and in 1958 received his M Sc in Industrial Management. He was the Fulbright Scholar for science and math to Great Britain, where he obtained his DIC and PhD degrees in statistics from the Imperial College of Science in 1965. He retired from Pratt & Whitney Aircraft after 32 years as Manager of Reliability, Safety, Maintainability, and Statistical analysis. He has awards from AIAA, ASME, ASQ, ISA. and SAE for his work in Weibull analysis and measurement uncertainty.

**Mr. Wes Fulton** received his B.S.M.E. from Georgia Institute of Technology and his M.S.M.E. from California State Univ. at Long Beach. He is Founder and CEO of Fulton Findings. He was a program engineer/manager for AiResearch Los Angeles Div., Allied-Signal Aerospace Corp. He has extensive experience developing systems and components for aerospace applications and 15 years experience as a private programmer. He has developed WinSMITH™ Visual, WeibullSMITH™, LogNormSMITH™, Normal+SMITH™, Visual\*SMITH™, BiWeibullSMITH™, and MonteCarloSMITH™ analysis software.

# Accelerated Testing

for predicting and improving product reliability

March 8-10, 2006 • Instructor: Dr. Wayne Nelson

Many products last for years under normal use conditions. However, product tests must quickly yield reliable information for management and engineering decisions. Accelerated testing quickly yields such information. Test specimens are subjected to higher than normal levels temperature, voltage, humidity, vibration, etc., and fail much sooner. Then a physical-statistical model is fitted to the early failure data, yielding estimates of product reliability under normal use conditions, including the failure rate, the population percentage failing on warranty or during design life, the mean time to failure, etc. This course shows how to measure and improve the reliability of diverse products.

## APPLICATIONS

The methods are applied to a variety of products including:

- Electronics, including microprocessors, semiconductors, solid-state devices, conductors, encapsulants, connections, and capacitors.
- Metal components undergoing fatigue, creep, creep-rupture, and corrosion.
- Electrical insulations and dielectrics in cables, motors, capacitors, electronics, transformers, etc.
- Ceramics, plastics, composites, and other materials.
- Pharmaceuticals, foods, paints and protective coatings, rubber and elastic materials, and chemicals.
- Munitions, propellants, and other energetics.

You will apply the methods to actual applications, including your own data, which you are asked to bring.

## WHO SHOULD ATTEND?

This course will benefit engineers, statisticians, and others working in product development, reliability, testing, manufacturing, procurement, and data analysis. You will learn to plan efficient accelerated tests and to accurately estimate product reliability and improve reliability using test data. To benefit fully, you need a working knowledge of a basic Statistics course.

## TEXT

The course text *Accelerated Testing: Statistical Models, Test Plans, and Data Analyses*, published by Wiley (2004), was written by Wayne Nelson. The textbook, plotting papers, computer program information, and other reference materials are furnished at the course.

## COURSE PROGRAM

### Survey

Applications, types of data, types of accelerated tests and stress loading, practical engineering and statistical considerations, and common tests (overstress, ESS, HALT, HASS, burn-in, single test condition, elephant).

### Models

Statistical life distributions (exponential, Weibull, lognormal, and others) and physical life-stress relationships (Arrhenius, inverse-power, Coffin-Manson, Peck's, fatigue, etc.), including multivariable models for the effect of design, materials, manufacturing, operating, and other engineering variables.

### Graphical Analysis

Simple probability plots (Weibull, lognormal, etc.) and relationship plots (Arrhenius, inverse-power, etc.) that yield estimates of product life under use conditions and assessments of the data and proposed model (distribution and relationship).

**Computer Analysis:** Maximum likelihood fitting of models to censored data with runouts to obtain estimates and confidence limits for product reliability and model parameters, and to assess the data and model.

**Test Plans:** How to choose test conditions and the number of specimens at each, including optimum, traditional, and good compromise plans.

**Competing Modes:** The series-system model for products with a number of failure modes, graphical and computer analysis of such data, and the effect of specimen and product size.

### Step and Varying Stress

Models for cumulative exposure and data analyses for step and varying stress.

**Degradation Testing:** basic models and data analyses for accelerated performance degradation data.

**Better Accelerated Testing:** an overview of important points.

## BENEFITS OF ATTENDING

You will learn how to use the latest methods to successfully:

- Determine test purposes.
- Accelerate tests through overstress, high-usage rate, termination of the test before all specimens fail, specimen design, degradation, cycling, etc.
- Plan efficient tests that yield the most accurate product information for the allotted test time, cost, and constraints.
- Model and understand how product life or degradation depends on the accelerating stresses and on design, manufacturing, materials, and operating variable - thereby learning how to improve product reliability.
- Analyze data with simple and informative plots to estimate reliability and to assess the data and presumed model.

## CONTINUING EDUCATION UNITS

Upon completion of the course, participants will be eligible to receive 1.7 CEUs.

## INSTRUCTOR

**Dr. Wayne Nelson** consults privately on and teaches engineering applications of Statistics for many companies. Formerly with General Electric Co. for 23 years, he consulted across many company divisions. He was elected a Fellow of the Inst. of Electrical and Electronic Engineers (IEEE), the Amer. Soc. for Quality (ASQ), and the Amer. Statistical Assoc. (ASA) for his contributions to Reliability data analysis and Accelerated Testing. In addition to the course text, he authored *Applied Life Data Analysis* (Wiley 1982), *Recurrent Events Data Analysis for Product Repairs, Disease Recurrences, and Other Applications* (ASA-SIAM 2003), and two ASQ booklets. The ASQ awarded him the 2003 Shewhart Medal for his technical innovations. The IEEE Reliability Society presented him the 2004 Lifetime Achievement Award for his contributions to Reliability. Among his 120+ literature publications, he received the Brumbaugh Award, Wilcoxon Prize, and Youden Prize of ASQ and eight Outstanding Presentation Awards of ASA. He has a Ph.D. in Statistics and an M.S. in Physics from the Univ. of Illinois and a B.S. in Physics from Caltech. Contact him at [WNconsult@aol.com](mailto:WNconsult@aol.com) and [www.members.aol.com/WNconsult](http://www.members.aol.com/WNconsult).

# LIFE CYCLE COSTING

March 8-9, 2006 • Instructor: Paul Barringer

**T**his course covers fundamentals of how to cost projects and optimize equipment selection while taking into account equipment survival/failure and the total cost incurred during the project life. LCC are summations of cost estimates from inception to disposal for both equipment and projects as determined by an analytical study and estimate of total costs experienced during their life. The objective of LCC analysis is to choose the most cost-effective approach from a series of alternatives so the least long-term cost of ownership is achieved.

The course focuses on the economic selection of equipment considering:

- Equipment grades and cost
- Life-limiting conditions for installation
- Life-limiting conditions from operating practices and
- Life-limiting conditions from maintenance practices

Analyses are summarized in a net present value (NPV) format by Monte Carlo simulation for taking into account variations and by Excel spreadsheets for simple models—spreadsheet models will be presented to the Students. The model provided with the course can be altered to reflect many different types of equipment. Students are encouraged to use the model as a basic building block for equipment in a plant so that capital equipment decisions can be made logically and quickly with updates for prices and life-performance.

Simulation software is provided to simulate equipment failures and finding the cost of replacements over many years. The course emphasizes making long-term cost of ownership decisions rather than only choosing the lowest first cost. Students learn how to merge cost data and reliability data for making profit-driven business decisions.

## COURSE PROGRAM

- Life cycle cost definitions
- Why use LCC?
- Alternatives for engineering considerations
- Sustaining cost templates
- Effectiveness equation trade-off tools for LCC
- Reliability
- Capability
- LCC facts driven by data
- Alternatives with acquisition/sustaining costs
- Choosing the analytical cost model
- Cost profiles for each year of study
- Pareto charts of vital few cost contributors
- Risk of high cost items and occurrences
- Adding uncertainty to the LCC results
- How both end-user and suppliers use LCC
- Economic business facts of life for engineers
- Discounted cash flow and net present value
- Acquisition cost templates
- SAE LCC cost template
- Availability
- Maintainability
- Defining the LCC problem
- Preparing the cost breakdown tree
- Gathering cost estimates and cost models
- Break-even charts for alternatives
- Sensitivity analysis of high cost items
- Selecting preferred course of action
- Performing NPV Monte Carlo simulations
- Using NPV and the effectiveness trade-offs

## BENEFITS OF ATTENDING

Subjects discussed in the course are generally connected to money issues. Engineers will learn enough accounting and business principles to communicate with accountants. Because few accountants are willing to learn the engineering details for reliability calculations, engineers must learn enough cost details to improve their teamwork with accountants and financial professionals. LCC helps engineers think like MBAs and act like engineers for profit-making enterprises.

## CONTINUING EDUCATION UNITS

Upon completion of the course, participants will be eligible to receive 1.0 Continuing Education Units (CEUs).

## WHO SHOULD ATTEND

Maintenance and reliability professionals, reliability engineers and technicians, maintenance managers, engineering supervisors, operating engineers, facility managers.

## INSTRUCTOR

**H. Paul Barringer** is a leading manufacturing, engineering, and reliability consultant. The author of the basic training courses *Reliability Engineering Principles*, *Process Reliability*, and *Life Cycle Cost*, he has more than 35 years of engineering and manufacturing experience in design, production, quality, maintenance, and reliability of technical products. Paul is particularly experienced in the technical and bottom-line aspects of operating a business with an understanding of how reliable products and processes contribute to financial business success. He has held positions as director of engineering in an ISO 9001 facility; director of manufacturing, engineering, and plant manager for domestic and international facilities at an oilfield tubular goods firm; and operations manager in a multi-plant manufacturing operation for high-speed equipment.

# How to Manage Equipment Assets to Achieve Their Maximum Use, Effectiveness, and Lifetime Value

March 6-7, 2006 • Instructor: John Mitchell

This course reveals real-world equipment life-management processes developed and used by today's industry leaders. It delivers insights gleaned from face-to-face interviews with top reliability professionals. This powerful two-day course demonstrates how equipment life-management processes are evolving from a combination of the best elements of current practices such as:

- Reliability Centered Maintenance (RCM)
- Failure Modes, Effects, and Criticality Analysis (FMECA)
- Total Productive Maintenance (TPM)
- Preventive Maintenance (PM)
- Condition-Based Maintenance (CBM)
- Root Cause Failure Analysis (RCFA)

## BENEFITS OF ATTENDING

After attending this workshop you will be able to expand the lifetime performance, effectiveness, value, and overall return of your plant's manufacturing and production equipment. Course materials supply you with full details on objectives, concepts, requirements, and specific improvement processes you can immediately put to use. You will learn why work process and technical results must be expressed in financial terms. This is how you demonstrate to management the full value of reliability-driven equipment life management. You will learn first-hand about best practices developed through hard-won experience and lessons learned.

## WHO GAINS

Facility managers, maintenance and reliability professionals, maintenance managers, engineering supervisors, and operating engineers.

## TEXT

In addition to the extensive course notes, participants will receive a copy of John Mitchell's widely acclaimed *Physical Asset Management Handbook*. See details at right.

## CONTINUING EDUCATION UNITS

Upon completion of the course, participants will be eligible to receive 1.2 Continuing Education Units (CEUs).

Visit us at  
[www.clarion.org](http://www.clarion.org)  
for complete details  
and to register online

## INSTRUCTOR

John S. Mitchell has served as maintenance engineer, engineering supervisor, and consultant engaged for more than 30 years in developing, advocating, and implementing technical, business, and operating strategies for managing the lifetime of industrial equipment.

He has delivered numerous papers and presentations and conducts training courses detailing the technology, financial, and business benefits of Equipment Management, Profit-Centered Maintenance, condition assessment and Condition-Based Maintenance to audiences throughout the world. He is a long-time member of ASME and is past chair of ASME's Plant Engineering and Maintenance division.

He is the author of the best-selling *An Introduction to Machinery Monitoring and Analysis* and editor of the recently published *Physical Asset Management Handbook, Third Edition*, which details processes and best practices for equipment management.

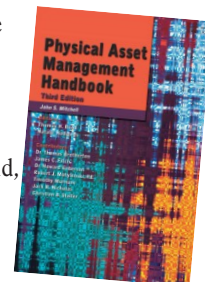
## COURSE PROGRAM

Leading ideas and specific topics covered include:

- Equipment Life Management—A composite process
- Best practices
- Benchmarking
- Metrics and key performance indicators (KPIs)
- Information requirements
- Team organizations
- Results-based compensation
- Spares management
- Outsourcing

Physical Asset Management is a "better way" of managing corporate equipment assets. It blends the best processes, practice and technology to assure highest effectiveness in your specific business, operating, organizational and material conditions. The purpose of Physical Asset Management is to ensure that the means of production/operation are available to meet mission, availability, yield, schedule, quality, and cost commitments at optimum effectiveness and return.

This definitive handbook provides a practical overview for executives, managers, and team members charged with gaining maximum productivity and effectiveness from systems and equipment in response to stated mission/business/operating imperatives. Editor-in-Chief John Mitchell and coordinating editors Thomas Bond and Natalie Nodianos have crafted their experience-based contributions, and those of seven leading practitioners of Physical Asset Management, into a top-to-bottom review of the processes, practices, technology, implementation, and results attainable with Physical Asset Management. *Physical Asset Management Handbook, Third Edition* addresses financial requirements, including conservation of capital. It illustrates how generic processes and technology can be assembled to provide maximum results for a given mission, business, and set of operating conditions. "Soft" issues—such as culture, organization, communication, ownership, compensation, and training—are addressed as integral elements that are vital to the success of Physical Asset Management.



To order the book, visit [www.clarion.org](http://www.clarion.org) or call (713) 521-5929.

Cost is \$100 plus shipping and applicable taxes (TX only).

Note: the book is included FREE as part of the materials for this course.

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## REGISTRATION FORM

### FEES (check as appropriate)

- BASIC WEIBULL (MARCH 6-7): \$1495**
- ADVANCED WEIBULL (MARCH 8-9): \$1495**
- ACCELERATED TESTING (MARCH 8-10): \$1795**
- HOW TO MANAGE EQUIPMENT ASSETS (MARCH 6-7): \$1495**
- LIFE CYCLE COST (MARCH 8-9): \$1495**

### DISCOUNTS (check as appropriate)

- Discount for enrolling in more than one course** – take \$300 off the combined fees
- Simultaneous multiple registrations** from the same company \$50 discount per person
- Early Registration** (received prior to February 13, 2006 - \$50 discount (in addition to discounts above)

### ACCOMMODATION

Please book your accommodation, if needed, directly with the hotel: The Houstonian Hotel  
111 North Post Oak Lane • Houston, Texas 77024  
Email: [reservations@houstonian.com](mailto:reservations@houstonian.com)

**Be sure to** mention that you are attending the CLARION Technical Courses to obtain our Group rate.

### CANCELLATIONS/SUBSTITUTIONS

Cancellations made in writing and received on or before 10 business days prior to the event, will be refunded less a \$100 handling fee. Cancellations received after 10 business days prior to the event, will not be refunded, and the full invoice fee will be payable regardless of whether you attend the course or not. Substitutions may be made at any time. Confirmation will be made in writing upon receipt of payment and will be sent to the email or other address given on the registration form. **The organizers reserve the right to cancel any course due to insufficient enrollment.** In this event, fees will be refunded in full. **The organizers assume no liability for travel or any expenses other than fees paid.**

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