Philip M. Besuner
Component Reliability Engineer

Services in Statistical and Probabilistic Analysis and Reliability Engineering

BACKGROUND: Statistics, Science, and Engineering. • Over 40 years' experience analyzing and evaluating statistical safety, risk, reliability, and related engineering issues.

• Have published numerous peer-reviewed papers and reports on statistical issues of wide scope and depth, including—as Principal Investigator—state-of-the-art surveys and summaries for the National Aeronautics and Space Administration (NASA) and the Ship Structures Committee/National Academy of Science/National Research Council.

• Have developed and applied advanced statistical estimation techniques to forecast and improve failure rates of mechanical components ranging from artificial heart valves to jet engines. • Experienced in working with sparse, scattered, and/or incomplete data. • Have frequently applied comprehensive statistical modeling techniques in conjunction with engineering principles. • Have testified on many statistical subjects, including in federal court.

Specialized Professional Competence

Statistics and Probabilistic Risk

Statistical analysis and improvement of failure, injury, and fatality rates
Statistical analysis of warranty, complaint, and other incident and event data
Probabilistic engineering analysis and modeling
Risk and economics-based inspections and repairs
Failure prevention and analysis
Software development
Consulting and expert testimony

Engineering

Risk, reliability, and survival analysis of mechanical components
Fracture mechanics and fracture control analyses
Weld defect analysis
Evaluation of effects of structural imperfection and residual stress
Fatigue, creep, and corrosion analysis
Stress analysis
Principal developer of BIGIF computer program[1] for advanced fracture mechanics and elastic-plastic stress concentration analyses

Equipment Analyzed

Jet engine components and airframe structures
Cars, vans, and sport utility vehicles
Consumer products, from artificial heart valves to toilet tanks
Residential piping and other plumbing fixtures
Pressure vessels, piping, boiler and steam generator tubes
Cycling fossil and nuclear power plants

[1] Many companies (such as GE) and government entities (such as India) purchased and used BIGIF. Later many BIGIF methods and algorithms were used in a similar Exponent and NASA computer program called "NASCRAC", now a trademark of Exponent, Inc.

Industries Served

Aerospace (Commercial and Military)
Automotive and Other Transportation
Construction
Power Generation
Health Sciences
Manufacturing

Education and Distinctions

University of Michigan	M.S.E., Engineering Mechanics, with Honors	1966
Rensselaer Polytechnic Institute	B.S., Applied Mechanics	1965

Highlights of Project Experience

- Developed analytical probabilistic retirement-for-cause criteria for critical aircraft components (for U.S. Air Force and Pratt and Whitney).
- Under three separate projects, developed methods to predict and improve the reliability of fracture-critical space shuttle main engine welds (for Rocketdyne, NASA, and Boeing Aerospace Operations).
- Developed and implemented the first deterministic and probabilistic fracture mechanics design systems at Pratt & Whitney. These systems were for environment-assisted fatigue and fracture control of critical gas turbine engine hardware.
- For ITT Federal Electric, performed mechanical reliability analyses of space hardware for Project Apollo, including failure mode and effects analyses of Skylab hardware.
- For Boeing, analyzed the fatigue life variability of aircraft structures.
- Performed statistical analysis of the effects of many variables and components on failure, accident, injury, and fatality rates in cars, light trucks and other components (for several firms). [Vehicle variables include type, weight, dimensions, dynamics, impact direction, and other crash characteristics. Driver and passenger variables include age, gender, driver performance/error, and use of seatbelts, alcohol, and drugs. US and Indian vehicle databases include national and state fatality and injury data and manufacturer and regulator warranty and complaint data.]

  Included studies of the effectiveness of accident countermeasures such as seat belts, airbags, electronic stability control, and roof strengthening.
- Other motor vehicle projects have included real-world data analysis of accident and fatality rates due to rollover of sport utility and other motor vehicles.
- Co-authored a docket submission on the National Highway Traffic Safety Administration (NHTSA) technical paper: “Effectiveness of Lap/Shoulder Belts in the Back Outboard Seating Positions.”
- Also evaluated NHTSA’s vehicle rollover rating study and assisted in related analyses for presentation (by JP Research) to a National Academies of Science committee.
- Consulted on a multi-year study of vehicle size/mass compatibility under the USCAR program. Involved in finding the best size and weight metrics for passenger cars and light trucks, modeling their safety in collisions, and using these models to gauge and improve the safety impact of introducing lighter but full-sized vehicles into the US vehicle population(for JP Research).
- As an undergraduate lab assistant, responsible for both fatigue testing and statistical analysis of the fatigue lives of specimens with very thin coatings.

Selected Teaching Activities / Lectures

Principal or assisting instructor for numerous courses and lectures on deterministic and probabilistic fracture mechanics, with a major emphasis on probabilistic and statistical aspects of failures of structures with cracks. These include:

Component Reliability
- Lecture at Naval Postgraduate School, Monterey, California (1986)

Fracture Mechanics,
- Three-Week Short Course at ARDE Corporation, Mahwah, New Jersey (1985)
- Principal Lecturer, One-Week Short Course at United Technologies Corporation, Connecticut (1983)

Probabilistic Engineering Analysis
- Short Course on for IBM San Jose Engineering Staff, California (1984)

Offshore Structural Reliability
- Industrial Associates Seminar at the California Institute of Technology (1984)

Advanced Software for Structural and Fracture Mechanics Analysis
- Short Course at Union College, Schenectady, New York (1983 and 1984)

Risk Analysis
- Regional Lectures, ASME, San Mateo, California (1982)

Probabilistic Fracture Mechanics and Risk Analysis
- Short Course at UCLA Los Angeles, California (1981 and 1984)

Nuclear Component Reliability
- Continuing Education Course at George Washington University, Wash., D.C. (1976)

Risk Benefit Methodology and Application
- Lecture at Asilomar Conference Grounds, California (1975)

Professional Experience

Component Reliability Consultants, LLC, Los Altos, California
Component Reliability Engineer and Consultant
As both a private consultant and as the Principal and founder of Component Reliability Consultants, have analyzed and testified concerning: • Trends in reported incidents of unintended acceleration in cars and light trucks. • Claims and failure data for a variety of components, ranging from truck bearings to residential plumbing pipes and valves. • Statistical data on disease and illness probabilities in a defined population. • Impact of wind and solar power generation on the operation of remaining (mainly fossil fuel) power system generators. ["Operation" includes but is not limited to cycling events and costs; forced outage frequency and severity; and NOX, SOX, and carbon emissions.] • Influence of natural phenomena such as wind speeds and rainfall (complementing older work on wave heights and earthquake intensities).

Have consulted on and performed injury prevention analyses on effectiveness of seat belts, air bags, vehicle roof designs, and other vehicle properties. Provided statistical expertise on the USCAR vehicle compatibility study and on projects evaluating the effectiveness on safety of ESC (electronic stability control) systems, vehicle seat back strength, glazing, side airbags, etc.

Aptech Engineering Services, Inc. (now **Intertek AIM**), Sunnyvale, California
Principal Engineer; Engineering Consultant
Provided both staff and consultation services for Intertek/Aptech. Projects ranged from fatigue analysis, inspection, and testing for jet engines; to airframe reliability and failure probability studies; to failure, economic, and survival analyses of cycling power plants and residential plumbing. Early work focused on power plant life and outage prediction using component reliability and economic outage and optimization models. Developed structural life extension prediction techniques for several clients. Principal developer of

fatigue/creep interaction damage calculation engine for COSTCOM[2]. Principal developer of cost minimization and dispatch optimization calculation engine for Utility Cycling Advisor[3].

Failure Analysis Associates (now **Exponent, Inc.**), Menlo Park, California
Chief Analytical Engineer
Principal investigator for several fracture control surveys sponsored by the United States Coast Guard, National Academy of Science, and NASA. Developed fatigue analysis software for NASA applications and nuclear steam generator and piping component inspection and repair. Also led projects focused on applied mechanics and mechanical engineering related to areas of fatigue, dynamics, reliability, and stress analysis. Developed analytical life prediction methods and retirement-for-cause criteria for critical aircraft components.

Pratt & Whitney, Aircraft Division
Research Engineer
Performed failure analysis of jet engine structures and components, especially rotating disks and blades. Devised and implemented several fracture mechanics-based jet engine component design and analysis tools still in use at the company. Instructed project engineers on the use of these tools.

ITT Federal Electric Corporation,
Senior Reliability Engineer
Modeled system reliability of components related to astronaut safety.

Boeing Commercial Aircraft
Research Engineer
Performed fatigue and fail safety analysis of critical commercial aircraft wing fuselage and landing gear structures. Executed most statistical analyses for and co-authored major report on the fatigue life variability of airframe structures for the Air Force Material Laboratory.

Selected Reports, Publications and Presentations

Publications/Presentations

"A Quantitative Approach to Risk-Based Inspection Methodology of Main Steam and Hot Reheat Piping Systems," *Proceedings of the ASME Pressure Vessels and Piping Conference*, 2008 (with M. Cohn and J. Fong).

"Impacts of Wind and Solar on Fossil-Fueled Generators," Presented at IEEE Power and Energy Society General Meeting San Diego, California July 22–26, 2012, *National Renewable Energy Laboratory,* conference paper NREL/CP-5500-53504, August 2012 (with D. Lew, G. Brinkman, N. Kumar, D. Agan, and S. Lefton). http://www.nrel.gov/docs/fy12osti/53504.pdf

"Analysis of Cycling Impacts on Combined-Cycle Heat Recovery Steam Generators and Evaluating Future Costs of Countermeasures to Reduce Impacts," *Energy-Tech Magazine* (Energy-tech.com), ASME Power Division Special Section, April 2009 (with S.A. Lefton, G.P. Grimsrud, D.D. Agan and J.L. Grover).

"The Cost of Cycling Coal Fired Power Plants," Power Plant O&M and Asset Optimization, *Coal Power Magazine*, Winter 2006 (with S. Lefton).
http://www.wecc.biz/committees/BOD/TEPPC/External/0612_CostCycling_%20CoalPlants.pdf

"Review of the Technical Paper: 'Effectiveness of Lap/Shoulder Belts in the Back Outboard Seating Positions'," Comments on the National Highway Traffic Safety Administration Docket for NHTSA DOT HS 808 945, November 1999 (with J. Padmanaban).

---

[2] Intertek program COSTCOM® is a Windows™-based real time, plant damage and cost monitoring simulation software that is designed to be easily added to the current generation of power plant data acquisition and control systems (DACS). COSTCOM computes plant wide damage accumulation rates and dollar costs for specific types of base load and cycling operation.

[3] The Intertek Cycling Advisor™ program is used on a daily or weekly basis to provide guidance on optimal dispatch schedules including wear-and-tear costs due to cycling. Application of the program, if used effectively, could save millions of dollars per year in overall costs.

"Long Term Damage Management Strategies for Optimizing Steam Generator Performance," presented at Steam Generator Repair/Replacement Workshop, Denver, Co., July 1990 (with G.R. Egan and E.A. Merrick).

"Failure Rate Predictions for High Temperature Aircraft Engine Blades with Defects and Vibration Problems," *Life Assessment & Repair. Technology for Combustion Turbine Hot Section Components*, ASM and EPRI Conference Proceedings GS-7031, edited by R. Viswanathan and J. M. Allen, pp. 65-75, April 1990.

"Transformer Failure Prediction Using Bayesian Analysis," IEEE Paper 90 WM 181-8 PWRS, February 1990 (with E. Gulachenski).

"Probabilistic Fracture Mechanics," Chapter 9 in the Book *Probabilistic Fracture Mechanics and Reliability*, J. Provan, editor, Nijoff: 1987.

"Statistical Aspects of Design: Risk Assessment and Structural Integrity," *Philosophical Transactions of the Royal Society of London,* Series A, *299*, pp. 11-136, 1981 (with C.A. Rau).

"Role of Micromechanical Models in Risk Analysis," *Metal Science,* 1980 (with C.A. Rau and K.G. Sorenson).

"Risk Analysis and Probabilistic Fracture Mechanics," *Product Engineering,* 1979 (with C.A. Rau).

"Probability Analysis of Rail Defect Data," *Proceedings,* Heavy Hull Railway Conference, Perth, Australia, September 1978 (with D. Stone, K. Schoenberg, and M. DeHerrera).

"A Workable Approach for Extending the Life of Expensive Life-Limited Components," *Fatigue Life Technology*, 1977 (with K.G. Sorenson and D. Johnson).

"A Workable Approach for Extending the Life of Expensive Life-Limited Components," *Failure Data and Failure Analysis: In Power and Processing Industries*, American Society of Mechanical Engineers, PVP-PB-023, 1977 (with K.G. Sorenson).

"How Safe is Safe Enough," in *Social Consequences of Engineering*, L.S. Hagar editor, Dun-Donnelly Publishing Corporation 1979 (with A. Tetelman).

"Probabilistic Fracture Mechanics," *Nuclear Engineering and Design 43*, 99-114 99 North-Holland Publishing Company, 1977 (with A.S. Tetelman).

"How Safe is Safe Enough?" *Nuclear Engineering and Design 43*, 1977 (with A.S. Tetelman).

"Residual Life Estimate for Structures with Partial Thickness Cracks," ASTM STP 590, 1976.

"Residual Life Prediction for Surface Cracks in Complex Structural Details," *Journal of Aircraft*, Vol. 12, No. 4, pp. 369-375, 1975 (with T.A. Cruse).

"Applications of the Two-Dimensional Integral Equation Method to Engineering Problems," *Boundary Integral Equation Methods: Computational Applications in Applied Mechanics*, ASME AMD-Vol. 11, pp. 101-117, New York, 1975 (with D.W. Snow).

Technical Reports

Power Plant Cycling Costs, National Renewable Energy Laboratory subcontract report NREL/SR-5500-55433, July 2012 (with N. Kumar, S. Lefton, D. Agan, and D. Hilleman).
http://www.nrel.gov/docs/fy12osti/55433.pdf

"Investigation of the Row '0' Compressor Blade Failures of the Moss Landing Gas Turbines," December 2004 (with T. Kuntz and S. Lefton).

Size/Mass Effects Study, Final Report, USCAR/NHTSA FreedomCAR Project, December 2002 (with J. Padmanaban, M.S. Davis, R. Besuner, S. Watson).

"Recent Developments in Measurement and Evaluation of FAC Damage in Power Plants," November 1998 (with Y. Garud and M. Cohn).

"Life Cycle Management of Aging Plant Equipment to Assure Mechanical Integrity" (with G.R. Egan, P. Ruebush, and E.A. Merrick).

"Economically Optimize Power Plant Cycling Costs, Life, and Reliability," October 1995 (with S.A. Lefton, G.P. Grimsrud, and G.L. Norman).

"Developing Suitability-For-Service Criteria for Degraded Components Using Tolerable Flaw Diagrams," August 1990 (with S.R. Paterson, R.C. Cipolla, and K.J. Clark).

"Economic Tradeoffs Among Load, Life, and Reliability of Power Plant Equipment," May 1990 (with S. Lefton).

"Application of Combined Analysis to Two Important Power System Problems," New England Electric Company, May 1986.

A Review of Fracture Mechanics Life Technology, NASA Contractor Report 3957, 1986 (with D.O. Harris and J.M. Thomas).[4]

Fracture Control for Fixed Offshore Structures, Department of Transportation, United States Coast Guard and Ship Structure Committee Report SSC-328, 1985 (with K. Ortiz, J.M. Thomas, and S.D. Adams).

"Analysis Methods for F-100 Engine Component Retirement for Cause," Failure Analysis Associates, Report FaAA-81-12-5, 1981 (with R.A. Sire, S.W. Hopkins, J. Padmanaban, J.N. Robinson, and C.A. Rau).

BIGIF: A Computer Program Which Performs Engineering Fracture Mechanics Computations for Structures Under Complex Stress Gradients, Manuals 1, 2, and 3, Electric Power Research Institute, Technical Report MP-838, 1981 (with R. Cipolla, J.L. Grover, et al.).

Retirement-for-Cause: A Workable Approach for Structural Life Extension and Response to In-Service Problems, Electric Power Research Institute, Technical Report MP-955, 1978 (with K.G. Sorenson and D. Johnson).

Reliability Analysis Approach to Fatigue Life Variability of Aircraft Structures, Wright-Paterson Air Force Base, Air Force Material Laboratory, Report AFML-TR-69-65, 1969 (with I.C. Whittaker).

[4] The authors of this publication received special recognition and cash rewards from NASA for quality of work and reporting.