

QRE CENTER NEWSLETTER

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Quality & Reliability Engineering (QRE) Center

NSF/Industry/University Cooperative Center - Rutgers University & Arizona State University

System Reliability Models With Uncertain Component Reliability Estimates

The QRE Center has successfully completed a project involved with developing system reliability models that explicitly account for the uncertainties in component reliability estimates. Sensitivity measures were also developed as an aid in allocating reliability improvement and testing resources. This project has important implication that can lead to more robust, and less risky, engineering designs.

In the assessment of new system designs, the component reliability is not known exactly, but must be estimated based on a model, information from field failure reporting databases or from life tests. The resulting reliability estimates may be based on very few recorded failures or require an uncertain extrapolation. This is particularly true for designs in competitive markets with very compressed design schedules. An unbiased estimate of reliability is insufficient because of the variability involved. It is also important to consider the estimation variance or lower confidence limits for system reliability because system designers and users tend to be risk-averse regarding reliability. They would often prefer a design with a slightly lower reliability estimate if it is known that the estimate is accurate compared to another design with suspect or unknown estimation accuracy.

System sensitivity measures include the Value of Perfect Information (VPI), used to access the need for additional testing or analysis, and the Value of Perfect Reliability (VPR), used to access the need for improved reliability.

Many system designs include both standard technology components, where reliability data or accurate predictions can be made, and newer technology components where only uncertain reliability predictions are available, e.g., accelerated life tests. Traditional system-level reliability models ignore these uncertainties although the design and reliability engineers are well aware of them. New system designs may involve the comparison of less expensive components, with only limited reliability data, with more expensive, but more thoroughly tested technologies. An intelligent decision can not be made without considering the system-level ramifications of the uncertainties. The new models are based on the propagation of component reliability estimation variances to the system-level.

For more information on this project, contact the Project Director: Dr. David W. Coit at 732-445-2033 or coit@rci.rutgers.edu. The models have also been automated. Windows-based software is available for QRE Center members.

ASU Professor Receives ASQ's Brumbaugh Award

J. Bert Keats, Professor of Industrial Engineering at Arizona State University, with co-author Mani Janakiram of Motorola Semiconductor Products has won the 1998 Brumbaugh Award.

The Brumbaugh Award is given annually to the author(s) of "the paper published in an American Society for Quality (ASQ) journal which has made the greatest contribution to the development of industrial applications of quality control".

Keats and Janakiram's paper is entitled "Combining SPC and EPC in a Hybrid Industry". It was published July, 1998, in the Journal of Quality Technology. The other ASQ journal is Quality Engineering. Professor Keats also won the Brumbaugh Award in 1994.

Dr. Keats and Mr. Janakiram were presented with the Award (a plaque) in Anaheim, California at the annual ASQ meeting in May at an Awards Luncheon. ASQ has approximately 135,000 members worldwide.

New QRE Company Members

Durel Corporation, Motorola and Rohm & Hass have joined the QRE Center as new company members in 1999.

Durel is the market leader in the development, design production of electroluminescent (EL) lamp products. EL lamps are primarily used for lighting applications in the watch, wireless communication and automotive industries. To complement lamp sales, DC-to-AC inverters and EL lamp systems are also sold. These products are sold world-wide.

Durel Corporation was formed in June 1988 as a joint venture between 3M and Rogers Corporation. In 1991, Durel introduced a new patented technology for micro-encapsulating the phosphor particles used in making EL lamps, and in 1994, an inverter product line was introduced to provide a more cost effective and miniaturized method to power EL lamps. An EL lamp is electronically similar to a capacitor and consists of several layers of proprietary inks screen-printed on a transparent substrate. The lamps are typically custom designed.

QRE Meeting - October 19-20, 1999

The next QRE meeting will be held on October 19-20, 1998. The meeting will be held at the Rutgers campus in Piscataway, NJ. On October 19, Prof. Elsayed A. Elsayed will present a tutorial on accelerated life testing to QRE Center member company representatives. Each company can send as many representatives as they wish to attend the course. The meeting will also feature status reports on the research projects and new project proposals.

QRE Center Activities

- Dr. **Hoang Pham** of Rutgers was the General Chair and Dr. **Ming Wei Lu** of DaimlerChrysler Corp. was the Program Chair for the Fifth ISSAT International Conference on Reliability and Quality in Design held in Las Vegas, NV on August 11-13,
- A National Workshop on Risk Analysis and Safety Performance Measurement in Commercial Air Transportation was held at Rutgers on July 20-22, 1999. The workshop pertained to the concepts and models associated with aviation system safety and risk analysis. The event's sponsors included Rutgers and the FAA. Dr. **James Luxhoj** of Rutgers was a workshop leader, and was responsible for organizing the event.
- Dr. **David Coit** of Rutgers was an invited speaker at the United Technologies Systems Reliability Research Conference on July 19-20, 1999.
- Dr. **E. A. Elsayed** presented a tutorial on accelerated life testing at Daimler Chrysler on July 1999.
- The Industrial Engineering Research Conference (IERC) was held on May 23 - 25, 1999 in Phoenix, AZ. Many Arizona State and Rutgers faculty members and graduate students participated.
- Dr. **Shanxing Wang** joined the faculty of Rutgers' Industrial Engineering Department in January 1999. Dr. Wang recently received his PhD from the University of California at Berkeley. He works in the area of laser micro-machining.
- Dr. **David Coit** of Rutgers and Dr. **John English** of the University of Arkansas presented a tutorial at the 1999 RAMS conference in Washington DC on January 18-21, 1999. The tutorial was titled "Intelligent Use of Regression Analysis."

ARDEC Wins Quality Awards

U. S. Army TACOM-ARDEC, located at Picatinny Arsenal, NJ has been a QRE member since the center's inception. They have also been a leader in the Quality area, as exemplified by several recent prestigious quality awards. ARDEC received the 1999 Army Communities of Excellence Award and the 1998 New Jersey Quality Achievement Award. The New Jersey Quality Achievement Award is the top award given by Quality New Jersey (QNJ). Previous winners have been Merrill Lynch, IBM, Lockheed Martin and AT&T since the award was initiated. ARDEC is the first Government agency to win the award.

To receive the New Jersey Quality Award, an organization's business processes must be rated excellent in seven specific areas: leadership, strategic planning, customer and market focus, information and analysis, human resource focus, process management and business results. The areas are identical to the criteria used for the annual Malcolm Baldrige National Quality Award competition.

ARDEC is part of the U.S. Army Tank-Automotive and Armaments Command (TACOM), a major subordinate command of the U.S. Army Materiel Command (AMC).

Rutgers Professors Receive New Grants

Profs. David W. Coit and E. A. Elsayed from Rutgers University have recently been awarded new grants from the National science Foundation (NSF) and New Jersey Commission of Science & Technology (NJCST)

Dr. Coit was recently awarded a NSF CAREER grant, "Stochastic Optimization of System Reliability with Risk-Averse Decision Makers," for \$200,000. The grant is to develop optimization algorithms for system reliability considering component reliability estimation uncertainties and user's risk profile. The new work is an extension of earlier work supported by the QRE Center.

Prof. Elsayed, working with Rutgers post-doc Daniel Kling, have been awarded two recent grants to study new manufacturing processes. The grants are "Innovative New Sheet Forming Processes" from NSF for \$270,724; and "Application of a New Mathematical Theory in Sheet Forming Processes" from NJCST for \$219,196.

Rutgers IE Department Working Paper Series

The Rutgers University Industrial Engineering Department maintains an active working paper series of technical reports authored by their faculty. Recent papers are as follows.

- 99-101 A Comparative Review of Two-Valve Fluid-Flow Systems with Storage in Between, U. Ozdogru and T. Altiok
- 99-102 System Reliability Optimization with k -out-of- n Subsystems, D. Coit and J. Liu
- 99-105 System Reliability Sensitivity Measures, T. Jin and D. Coit
- 99-106 Software Reliability and Cost Modeling by a Quasi-Renewal Process, H. Pham and H. Wang
- 99-107 Optimum Initial Process Mean and Production Cycle for Processes with a Linear Trend, J. Jang, D. Ahn, M. Lee and E. Elsayed
- 99-108 Decentralized Control and Routing Flexibility in Automated Manufacturing Cells, T. Boucher and A. Yalcin
- 99-109 Process Mean and Screening Limits for Filling Processes Under Two-Stage Screening Procedure, M. K. Lee and E. Elsayed
- 99-112 Signature Analysis and Defect Detection in Layered Manufacturing of Ceramic Sensors and Actuators, T. Fang, M. Jafari, S. Danforth, A. Safari
- 99-113 Reliability Estimation of Degraded Structural Components Subject to Corrosion, M. Ettouney and E. Elsayed
- 99-114 Multivariate Monitoring of Batch Process Startup, R. Wurl, I. Shiffer and S. Albin
- 99-115 Queuing Analysis of a Transmission Policy in ATM Networks, T. Atmaca, T. Altiok and G. Hebuterne
- 99-116 On-Line Surveillance and Monitoring, H. Jeong and E. Elsayed
- 99-117 - System Reliability Prediction Prioritization Strategy, D. Coit
- 99-118 Reliability Estimate using Degradation Data, G. Eghbali and E. Elsayed
- 99-121 Variance of System Reliability Estimates With Arbitrarily Repeated Components, T. Jin and D. Coit
- 99-122 Allocation of Test Units to Minimize System Reliability Estimation Variability, T. Jin and D. Coit
- 99-123 Genetic Algorithm to Maximize a Lower-Bound for System Time-to-failure with Uncertain Component Weibull Parameters, D. Coit, A. Smith
- 99-124 Software Reliability Models with Time Dependent Hazard Function Based on Bayesian Approach, L. Pham and H. Pham

These reports are available to the public by contacting Ms. Cindy Ielmini at (732) 445-3654 or by email at ielmini@rci.rutgers.edu

Calendar of Events

INFORMS National Meeting
November 7-10, 1999
Philadelphia, PA
Philadelphia Marriott Hotel
Phone: (800) 343-0062
EMail: meetings@informatics.org

1999 DoD Maintenance Symposium & Exhibition
Nov 15 - Nov 18, 1999
St. Louis, MO
Phone: (703) 522-1820
Email: adekleine@ndia.org

70th Shock and Vibration Symposium
Nov 15 - Nov 19, 1999
Albuquerque, NM
Phone: (703) 289- 5134
Email: damanda_sue@bah.com

Annual Reliability and Maintainability Symposium (RAMS)
Jan 24 - Jan 27, 2000
Los Angeles, CA
Los Angeles Airport Marriott
Phone: (603) 863-2832
Email: r.w.sears@ieee.org

8th International Conference on ISO 9000
Feb 7 - Feb 8, 2000
Orlando, FL
Phone: (412) 782-3383

SAE 2000 World Congress
March 6-9, 2000
Cobo Hall, Detroit, Michigan, USA

Industrial Engineering Research Conference (IERC)
May 21-23, 2000
Cleveland, OH
International Reliability Physics Symposium Apr 10 -
Apr 13, 2000
San Jose, CA
Email: wtonti@us.ibm.com

INFORMS National Meeting
November 7-10, 2000
Salt Lake City, UT
Salt Palace Convention Center
Phone: (800) 343-0062
EMail: meetings@informatics.org

Software Reliability

by Hoang Pham

The book *Software Reliability* by Prof. Hoang Pham of Rutgers University is now available from Springer-Verlag. The book provides a general introduction to software reliability. It describes analytical models, methodologies and tools to assess the reliability of software systems.

Current QRE Projects

- ***Multivariate Control of the Startup Period in Batch Processing*** (98-01) - Project Director: Dr. Susan L. Albin, Rutgers U.
- ***Reliability Modeling for Aging Under Multimodal Stress levels*** (98-02) - Project Director: Ronald Askin, University of Arizona
- ***Repairable Systems Reliability: Planning and Assessment Tools*** (98-03) - Project Director: Dr. David W. Coit, Rutgers U.
- ***A General Reliability Model for Accelerated Life Testing: Statistics-Physics Relationship and Experimentation*** (98-04) - Project Director: Drs. Elsayed A. Elsayed and Jian Zhao, Rutgers University
- ***Process Monitoring and Control: Low PPM Rates*** (98-05) - Project Director: Drs. Douglas C. Montgomery and J. Bert Keats, Arizona State University
- ***Statistical Methodology for Characterization, Control and Optimization of Industrial Processes*** (98-06) - Project Director: Drs. Douglas C. Montgomery and J. Bert Keats, Arizona State University
- ***Determining Quality Protection When A Sequence of Samples or Units are Inspected*** (98-07) - Project Director: Drs. Douglas C. Montgomery and J. Bert Keats, Arizona State
- ***IC Manufacturing Process Control*** (98-08) - Project Director: Drs. George Runger and Douglas C. Montgomery, Arizona State
- ***A General Reliability Model for Combining Hardware and Software Systems*** (98-09) - Project Director: Dr. Hoang Pham, Rutgers University