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Pioneering Reliability Laboratory Addresses Information Technology

Written by the RAC Staff with the assistance of the Air Force Research Laboratory Information Directorate history office.

The Air Force Research Laboratory Information Directorate at the Rome (NY) Research Site is the current name for a laboratory which has been the DoD focal point for electronic reliability since the 1950s. Established in 1951 as the Rome Air Development Center (RADC), becoming the Rome Laboratory (RL) in December 1990, and officially adopting its present title in October 1997, the organization has been the primary DoD electronic reliability research and development agency since reliability was recognized as an engineering discipline. It has twice received the annual award of the IEEE Reliability Society, in 1974 and in 1998.

One of the first publications considering reliability as an engineering discipline was *Reliability Factors for Ground Electronic Equipment*, published by RADC in 1955. It's author was Joseph J. Naresky (see biography on page 5), who created the laboratory's reliability program and developed it from a personal commitment to a multi-faceted effort by about 100 specialists.

Another of the first reliability efforts of RADC was the publication of reliability prediction models. An RCA document, TR 1100, became the basis of an RADC technical report which was the first military reference on failure rates of electronic components. A series of RADC Reliability Notebooks provided updates, until RADC became the preparing activity for MIL-HDBK-217, *Reliability Prediction of Electronic Equipment*. Prediction models for electronic parts became the specialty of Lester Gubbins and, on his retirement, Seymour Morris.

The laboratory also produced references on failure rates for non-electronic parts, the prediction and demonstration of maintainability, and the use of Bayesian statistics for reliability demonstration. It was one of the first to develop the concept of system effectiveness, a figure of merit combining availability, reliability, and capability measures into a single measure of the overall worth of a system to its user. Early studies on operational influences on reliability foreshadowed more recent development of a means for translating desired operational parameters into reliability requirements. The original team created by Naresky for reliability technology development was a four man group: Edward Krzysiak (group leader), Anthony Coppola, Anthony D. Pettinato, Jr., and John Fuchs. As the number of reliability personnel grew, statistical studies in reliability were performed by various individuals and groups under the overall direction of David F. Barber and his successor Anthony J. Feduccia, division chiefs in a directorate headed by Naresky.

In 1961, the laboratory began to create facilities for research in reliability physics. These

Volume 6 Number 1

Inside this Issue

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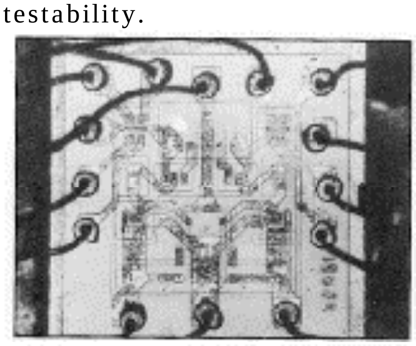
facilities included a variety of equipment useful for analyzing the cause of failures in microelectronic devices. These have been used to isolate and correct problems in operational Air Force systems such as the Minuteman missile. In 1962, the laboratory sponsored the first symposium on reliability physics, which has continued under IEEE sponsorship as the International Reliability Physics Symposium (IRPS).

With knowledge gained from an in-house thin film and monolithic microcircuit manufacturing facility created by Richard Nelson, the center produced RADC Exhibit 2867, *Quality and Reliability Assurance Procedures for Monolithic Microcircuits.* This document was the direct ancestor of MIL-STD-883, *Test Methods and Procedures for Microcircuits,* the foundation of both military and commercial microcircuit quality assurance, and of MIL-M-38510, the general specification for microcircuits under the military qualified parts program, both authored by center personnel. The laboratory later created MIL-I-38535 *General Specification for Integrated Circuits (Microcircuits) Manufacturing,* MIL-H-38534 *General Specification for Hybrid Microcircuits,* and MIL-STD-1772 *Certification Requirements for Hybrid Microcircuit Facility and Lines,* which are the basis of the current dual-use qualified manufacturers system.

The laboratory has always been heavily involved in the reliability and quality assurance of new technologies. John Farrell, for example, chaired the VHSIC (Very High Speed Integrated Circuits) qualification committee. More recently, Daniel Fayette led a program for multichip module (MCM) reliability and performance assessment. Hybrids, MMIC (Microwave Monolithic Integrated Circuits), solid-state Transmit/Receive modules, and most recently, Microelectromechanical (MEM) devices have all benefited from laboratory programs.

Noted leaders of the laboratory's microcircuit reliability and quality assurance activities through the years include Joseph Vaccaro, Joseph Brauer, Edward P. O'Connell, Al Tamburrino, Regis Hilow, Charles Messenger, and Dr. Robert Thomas, among others. In 1994, both the statistical studies and reliability physics were integrated into the Electronics Reliability Division under Eugene Blackburn. The new division instituted a program for integrating diagnostics for multichip modules permitting efficient chip to system testability.



One of the first pictures showing physics of failure phenomena, this 1960s RADC photo shows the beginnings of corrosion of aluminum circuit interconnections.

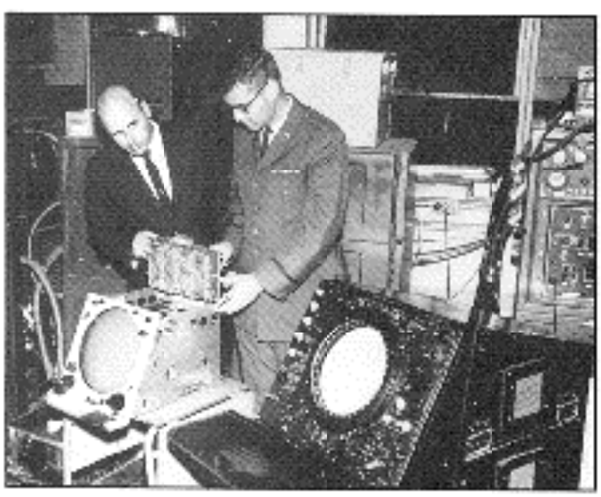
As reliability studies began in the 1950s, the laboratory also began studies into electro-magnetic compatibility (EMC) which resulted in, among other things, models used for analyzing the EMC problems of Air Force systems, such as the airborne command post, and the "HAVE NOTE" program, under which the laboratory tested a variety of Air Force weapons systems for susceptibility to electromagnetic interference. The laboratory also created numerous test sites in which aircraft were mounted inverted on pedestals so that their radiation patterns could be quickly and inexpensively measured, in comparison to in-flight tests. From these facilities, RADC became known as the keeper of the "upside down Air Force." Air Force aircraft ranging in vintage from the F-4 to the F-22, have appeared on the test stands, and recent participants have been the Navy EA-6B Prowler and some automotive communications systems. Other recent developments have been the use of infrared imaging to map electromagnetic fields without the perturbation of conventional probing techniques, and the development of an electro-magnetic performance monitor (EMPM) which can record the electromagnetic environment inside a system. Leading EMC and related studies through the years were Samuel Zaccari, Robert McGregor and Carmen Luvera.

The laboratory has often applied its knowledge of advanced technologies to create prototype equipment. In 1967, it contracted with General Electric for the development of MIRAGE (Microelectronic Indicator for Radar Ground Equipment) a technology demonstration model of a display having one-tenth the volume of the UPA-35 radar indicators in the field, and 100 times the reliability. RADC was designated the manager for a joint Air Force -FAA procurement of the FYQ-47 radar data digitizer, which was so superior in reliability to the FYQ-40 it replaced that a requirement for back up units in the field was rescinded. More recent activity included the development of the Time Stress Measurement Device (TSMD) to measure the environmental stresses in localized areas of an equipment, and the integration of the electromagnetic performance monitor (EMPM) into the TSMD. The development of the RH-32RISC (Radiation Hardened 32 bit Reduced Instruction Set Computer) is also a recent laboratory effort. These efforts were, and are, performed by teams cutting across the separate reliability offices at the Laboratory.

RADC also pioneered the use of computer aided design for reliability and the application of artificial intelligence as a diagnostic aid. Anthony Coppola, lead a Reliability Panel of the Air Force Project Forecast II in 1985. Leading a team of reliability specialists from various Air Force agencies he proposed and evaluated novel ideas for improving Air Force effectiveness. Coppola also chaired a committee on artificial intelligence applications to maintenance for a 1984 study on reliability and maintainability by the Institute for Defense Analysis. Since then, led by Dale Richards, the laboratory has been involved with the development of "SMART BIT" applying artificial intelligence to fault detection in the Joint Surveillance and Target Attack Radar System (JSTARS), and the development of an R&M Design Expert System integrating reliability, maintainability and testability analysis into a software tool capable of improving itself by learning from its experiences.

The laboratory ultimately became the custodian of most of the DoD Specifications, Standards, and Handbooks on reliability and maintainability. Many of these were written by laboratory personnel recognized as industry leaders in the specialties involved, including Jerome Klion, Eugene Fiorentino, et al. These experts also produced or technically guided the production of a library of technical references, such as a redundancy notebook, a thermal design guide, reliability management manuals, a built-in-test design guide, and many others. One of the organization's most popular products has been the Reliability Toolkit, first produced in 1988 as the *RADC Reliability Toolkit*, updated in 1993 as the *Rome Laboratory Reliability Toolkit*, and last produced in 1995 as the *Reliability Toolkit: Commercial Practices Edition*. The latter provides a guide for commercial products and military systems under the DoD acquisition reform policies. Preston MacDiarmid (now Director of The Reliability Analysis Center) initiated the series of toolkits and Seymour Morris was the principle architect of their evolution.

The laboratory has been a consultant in reliability engineering to system program offices since 1957, when Coppola initiated support to the acquisition of the 465-L Strategic Air Command Control System. Later systems support was managed principally by Anthony D. Pettinato, Jr., and, on his retirement, Bruce W. Dudley. Programs supported included the 412-L European Air Warning and Control System, 414-L Over the Horizon Radar, 425-L NORAD Command and Control System, 474-L Ballistic Missile Early Warning System, 440-L Over the Horizon Radar, and many other large systems. Laboratory personnel were significantly involved with JSTARS which received its baptism of fire in the Gulf War. Laboratory reliability engineers also supported virtually all Air Force ground radar programs and a host of other smaller equipment acquisitions.



Lee Lopez of General Electric and Capt. Edwin Deady of RADC compare the prototype MIRAGE display, on table, to the current (1967) standard UPA-35, right.

Laboratory personnel were also asked to support developments by the Wright Laboratory (the SPN/GEANs navigation system and the Electronically Agile Radar) and procurements by the Aeronautical Systems Division (the center won an Air Force Systems Command award for its performance in achieving unprecedented reliability in the AN/ARC-164 command radio, an ASD program). Center personnel were name requested for a series of command level "tiger teams" convened in the early 1970's to review reliability progress on avionic systems, including the F-111 Mark II avionics suite and the radars for the F-111, F-4 and F-20 aircraft. Air Force Divisions using laboratory reliability support included the Electronic Systems Division (ESD), The Aeronautical Systems Division (ASD), the Space and Missile Systems division (SAMSO) and the Armaments Division (AD), all since renamed.

The FAA was a joint sponsor with the Air Force for the AN/FYQ-40 and AN/FYQ-47 radar digitizer developments, and was so impressed by the reliability expertise of the laboratory personnel supporting these, that it requested their support for FAA radar procurements. Among the FAA systems supported under an interagency agreement were the ASR-8, ASR-9 and ASR-10 airport radars and the ARSR-2, ARSR-3 and ARSR-4 long range radars. The United States Bureau of Mines also obtained laboratory reliability support under an interagency agreement.

Reliability support activities also included advice on electronic part selection and control, based on the center-produced MIL-STD-965, *Parts Control Program*. Support in this area was led by John Farrell and provided to the F-16 and Advanced Medium Range Air To Air Missile (AMRAAM) programs, among others.

In 1961, the center initiated an electronics parts data repository, to collect, analyze and distribute information about the reliability of electronic parts. The initial in-house facility soon became a DoD asset called the Reliability Analysis Center (RAC) which is now one of 13 information analysis centers (IACs) funded by the Defense Technical Information Center (DTIC). Technical direction to RAC is still provided by the laboratory, specifically by Richard Hyle, DTIC's Contracting Officer's Technical Representative (COTR).

The laboratory has also pioneered the development of software engineering tools, including metrics and a software engineering framework, in another laboratory directorate concerned with software and not administered by Naresky or his successors. Principle contributors in these were Al Sukert, Samuel Dinitto and Andrew Chruscicki . These software specialists and Naresky's reliability specialists, notably Fiorentino, collaborated on developing models for combining hardware and software reliability predictions.

Many of the traditional reliability activities, such as maintenance of the specifications and standards, are being transitioned to other government agencies (although the organization recently produced a new maintainability handbook in response to DoD acquisition reform requirements for references providing technical guidance rather than mandating procedures).

The new Information Directorate, in fiscal year 98, is completing all commitments in the area of reliability sciences and transitioning activities where appliable towards research and development in information technologies. For esample, the experiences and knowledge obtained while working in the field of reliability are now being applied to development of computer aided design (CAD) tools and techniques for micro-electro-mechanical (MEM) devices; design and advanced packaging of wafer scale signal processors; design and development of adaptable re-configurable computers and modeling and simulation of information systems. After fiscal year 98, all reliability related tasks will be referred to other government organizations. "Rome Laboratory" has had a long heritage in the area of reliability sciences and accomplished many significant projects to advance the field of reliability. The efforts of "Rome Laboratory" personnel wil be missed but their legacy will go on.

For more information on technical activities at the Information Directorate of the Air Force Laboratory at the Rome Research Site, contact John Bart, AFRL/IF, 36 Electronic Parkway, Rome NY 13340. Tel: (315) 330-7701. E-mail: bartj@rl.af.mil. The Directorate has a web site at URL: http://www.rl.af.mil.

Joseph J. Naresky: Reliability Pioneer

Joseph J. Naresky, the architect of reliability engineering research and development at the then Rome Air Development Center (RADC) in 1955, was a leading figure in reliability engineering until his accidental death in July, 1982.

Mr. Naresky's accomplishments in reliability began when he produced the first general reference manual for reliability engineers, *Reliability Factors for Ground Electronic Equipment*. The document was widely used, including a Chinese translation by the People's Republic of China. Mr. Naresky also served on the Advisory Group for Reliability of Electronic Equipment, whose report in 1957 launched reliability as an engineering discipline throughout the Department of Defense.

From these pioneering efforts and a four man reliability group he founded at RADC, he developed a program recognized for its significant contributions and the largest concentration of reliability specialists in the Department of Defense. In 1980, RADC was awarded the Air Force Outstanding Unit Citation for its reliability contributions. Mr. Naresky's leadership earned him Sustained Superior Performance Awards in 1959 and 1966, and the Air Force Decoration for Exceptional Civilian service, the highest award that can be given to an Air Force civilian, in 1968. He also received the IEEE Reliability Society Award in 1974 and was elected an IEEE Fellow in 1976.

Mr. Naresky served with the U. S. Army Air Corps during World War II. After the war, he was employed by the Army's Watson Laboratories, Red Bank, NJ, which was transferred to Rome, NY as the Rome Air Development Center in 1951. While at RADC, he earned a Bachelor's degree in Physics and Master's Degrees in both Electrical Engineering and Engineering Administration from Syracuse University.

Mr. Naresky was a member of Sigma Pi Sigma, a physics honor society, the IEEE Reliability Society, Engineering Management Society and Electromagnetic Compatibility Group, and the AIAA Committee on Reliability and Maintainability. He was elected an Associate Fellow of the AIAA. He served as President of the Reliability Society, a member of the management committee for the Annual Reliability and Maintainability Symposium, and U. S. representative on the International Electrotechnical Commission Technical Committee 56 (Reliability). He was also President of the Rome Rotary Club in 1967 and 1968.

In 1979, he retired from government service and joined the IIT Research Institute, operator of the Reliability Analysis Center. His last project before his untimely death three years later was to complete the *Reliability Design Handbook*, now MIL-HDBK-338.

Reliability Through the Years at the Air Force Rome, NY Facility: A Sampling

1951 Army Watson Laboratories becomes Rome Air Development Center (RADC)

1955 *Reliability Factors for Ground Electronic Equipment* published

1956 Four man reliability group organized

1957 Reliability support provided to "Big-L" System programs

1958 RADC Exhibit 2629 uses parts count to establish reliability requirements and sequential tests for verification

1959 MIL-R-26474, *Reliability Requirements for Production Ground Electronic Equipment*, prepared

1960 Microelectronics testing facility established

1961 Requirements for an electronic parts data repository established (led to creation of RAC)

1962 RADC sponsored first reliability physics symposium

1963 Reliability data collected on 412-L Air Weapons Control System sites in Germany

1964 Nondestructive screening techniques for electronic parts developed

1965 RADC supported Weapons Systems Effectiveness Industry Advisory Committee

1966 First compendium of storage failure rates for electronic parts published

1966 RADC Specification 2867 established screening requirements for integrated circuits (ancestor of MIL-STD -883)

1967 First microelectronic packaging handbook published

1968 Minuteman integrated circuit failures analyzed

1969 Tests of plastic encapsulated integrated circuits begin

1970 Reliability support provided to F-111 Mark II avionics development

1971 "Tiger Team" reviews of avionics systems reliability performed by command request

1972 Antenna measurement facility established (start of "upside down Air Force")

1973 F-16 Avionics Reliability Review Team chaired by RADC

1975 *Nonelectronic Reliability Notebook* published

1976 Guidelines for application of warranties formulated

1977 Liquid crystals used to test and analyze failures in large-scale integrated circuits

1978 Design guide for built-in-test published

1979 *Reliability and Maintainability Management Manual* published

1980 Artificial intelligence applications to testability identified

1981 Bayesian reliability test procedures developed for repairable equipment

1982 Parts derating guide published

1983 RADC sponsors Air Force Academy development of Bayesian tests for one-shot systems.

1984 Design considerations for fault tolerant systems identified

1985 "Smart BIT" concepts formulated

1986 Guide to electronic stress screening (ESS) published

1987 Finite element analysis applied to surface mounted package

1988 RADC *Reliability Engineer's Toolkit* published

1989 MIL-I-38535 *General Specification for Integrated Circuits (Microcircuits) Manufacturing*, and MIL-H-38534 *General Specification for Hybrid Microcircuits* published

1990 RADC becomes Rome Laboratory

1990 Thermal analysis program written for use on personal computers

1991 Guide to finite element analysis published

1992 Quantitative evaluation made of environmental stress screening (ESS) effectiveness

1993 *Rome Laboratory Reliability Engineer's Toolkit* published

1994 Techniques for on-wafer reliability testing of microwave monolithic integrated circuits (MMIC) developed

1995 *Reliability Toolkit: Commercial Practices Edition* published

1996 Integrated Diagnostics for Multichip Modules (MCM) developed

1997 Rome Laboratory becomes the Air Force Research Laboratory Information Directorate at the Rome site

1997 CAD for microelectromechanical (MEMs) devices started

1998 Organization receives second IEEE Reliability Society award

A complete history of the organization now designated the Air Force Research Laboratory Information Directorate at Rome will be available in 1998. Contact: Thomas W. Thompson, Chief History Office, AFRL/IFOIHO, 36 Electronic Parkway, Rome, NY 13440. Tel: (315) 330-2757.

ISSRE '97

By: Ellen Walker, Attendee

ISSRE '97, the 8th International Symposium on Software Reliability Engineering, was held Nov 2-5, 1997 in beautiful, sunny and warm Albuquerque, New Mexico. It was attended by more than 150 participants from government, industry, and academia with a strong showing from the telecommunications industry, and from the research community. Approximately one-third of the attendees were presenters. Other attendees were primarily leaders in quality or testing departments of their respective organizations. Of the 40 or more presentations given in three days, 80% addressed research in Software Reliability Engineering (SRE) with only a small number addressing actual experience.

The opening keynote address was given by Dieter Rombach, Director of the Fraunhofer Institute for Experimental Software Engineering, Kaiserslautern, Germany and was titled "Inspections and Testing: Core Competence for Reliability Engineering". The talk focused on the use of systematic inspections for early defect detection and the use of testing for reliability assessment and prediction. Much of what was said is also proposed in the "cleanroom" approach to software development and embodies some of the principles of total quality management although the "TQM" term was not mentioned.

His address was followed by a keynote titled "Launching Automated SRE Company Wide " given by James Tierney from Microsoft, a co-sponsor of the conference. ("Automated" refers to the automation of testing and measurement.) Terney claims that SRE has had great success at Microsoft and that improved customer usage data and useful predictions of ship dates have been invaluable. He later stated however that adoption of SRE is closer to 50% than 100% - leaving the interpretation of "great success" to be pondered.

Tuesday's Keynote, "Software Reliability in Theory and Practice" was given by Larry Dalton, Manager, High Integrity Software Systems Engineering, Sandia National Laboratories, Albuquerque, NM. His observation is that in surety critical applications such as nuclear weapons control, software-based systems are to be avoided, and if unavoidable, then "expect the unexpected" and make provisions to protect against it. He described dousing an aircraft (loaded with a nuclear weapon) with 1000 gallons of jet fuel and setting it on fire as a test to determine behavior of the detonator in the "unexpected" realm. He ended his keynote with Dalton's Axioms for Reliability in Theory and Practice:

Specify the RIGHT THING

Construct the THING RIGHT

The THING may fail, so reduce the consequences

This is not unlike the phrase "Do the Right Thing Right the First Time" which has been spoken so often in total quality training courses given in the last ten years. It is not unique to software engineering.

Presentations

Underlying threads of the presentations ranged from "Yes, you can test reliability into your software" to "You need to design reliability in because by the time you get to test it's often too late or too expensive to test it in." There was general consensus that you need a way to determine when the software is reliable and that is accomplished only through testing and tracking failures throughout the testing interval. Although much discussion centered around how to structure the testing, all the experts seemed to be in agreement that fault intensity is the primary metric and should be measured relative to the testing interval in terms of time or natural units. While it is difficult for many software engineers to accept this paradigm as relevant for software, it is nevertheless asserted to be necessary for determining software reliability.

In most sessions, regardless of the main emphasis of the topic, some form of reliability growth modeling was used to determine when the software would meet a pre-determined reliability objective.

Another reoccurring thread in many of the presentations was the concept of an "operational profile" driving the testing. In an organization adapting cleanroom methodology this might be called a "statistical usage probability distribution". If the organizational culture has roots in TQM, this might be referred to as focusing on the customer. In essence it reflects how the software is used rather than how it is built. The profile weights functionality according to frequency of use or criticality of the function. Weighting is then used to determine the quantity and types of test cases that will comprise testing, insuring that the most important or most serious errors will be detected early in the test cycle.

Major Challenges

There were very few sessions that addressed software reliability relative to system reliability. The thrust of one session was that true assessment of software reliability is very complex and we really can't have much confidence in the results given our current technology usage, so assume the worst and ensure that the system as a whole can tolerate an uncertain software reliability element. Determining what software reliability number to plug into the system reliability equation is perhaps still a mystery.

Software integration and its impact on reliability was addressed. Software products are no longer used in isolation. They must work with a multitude of other software products from competing vendors. Who is responsible for the reliability of the integration? Customers are often left in a vacuum because no one owns the integration. No one is responsible for the big picture. Each vendor accounts for what they perceive to be their part of the big picture. Standards for interoperability are becoming more important.

Concerns of Constituents

Some participants were expecting to hear about practical experiences in predicting and measuring software reliability in safety/surety critical applications. None were presented. A gentleman who works for a company that makes pacemakers seemed very confused by the reference to the operational profile and a comment that one can often negotiate reliability objectives with the customer.

Few, if any, presentations delineated how a specific reliability objective was set and then actually tracked to attainment. It is not clear whether this was due to the reviewing process, or simply to a lack of papers addressing actual implementation of software reliability engineering.

Concluding Thoughts

Throughout the conference I found myself relating topics under discussion to an underlying question posed by guest speaker Gerry Weinberg, renown software development consultant and author of *"Software Reliability, Why Aren't We Doing What We Know How To Do?"* He asked the question "Why don't we build reliable software?" of conference attendees and got a plethora of excuses that boiled down to the following:

- The business area is not aligned with the technical area.
- External issues force organizations to release software before it is ready.
- Software Engineers do not have equal status with hardware or system engineers and their recommendations are not taken seriously, or they are not consulted at all.
- It takes too much time to do the detailed requirements definition and testing needed to ensure the software is reliable. If we did that we would never make deadlines, and our products would cost too much.
- There is little confidence in the reliability metrics. Why waste time measuring if the results have little value to the decision-makers?

As I reviewed in my mind the various strategies and research presented I discovered that very little of what was presented is "new". We really do know how to test. We know how to gather requirements, and who to communicate with in requirement definition. We know that our organizational culture impacts what we actually do versus what we know we should do. Technology is providing us with new challenges so fast that we are caught up in it and the basic principles of software engineering often go by the wayside.

Is ISSRE '97 simply an instance of IEEE "preaching to the choir" in that it is attended primarily by the research community and not by software people with real world problems seeking real world solutions? Is there another forum for addressing practical software reliability issues than this conference? Or is it simply reflecting the possibility that proportionately few software engineers are concerned specifically with software reliability? Is software reliability engineering actually being practiced by the software community at large? Do the "real world" software people use other names for software reliability issues?

In closing, in spite of the concern over attendance, and the fact that the conference was research focused, I came back with a sense of personal responsibility to my role as a software engineer that I did not have before the conference. I simply have to start "doing what I know how to do". I wonder what the impact would be if every attendee was called to action in the same way?

About the Author:
Ellen Walker is a RAC specialist in software reliability. She holds Bachelor Degrees in Mathematics and Computer Science and a Masters Degree in Management. In a twelve-year tenure as a computer scientist, she has worked with all phases of the software development cycle and supported both engineering services and business processes. She has been a facilitator and technical consultant for several long term quality initiatives, and is an Examiner for New York State's Excelsior (Quality Awards) program.

Calls for Papers

1998 Military/ Aerospace (Transportation) COTS Conference, to be held August 26-18, 1998 in Albuquerque, NM, seeks papers on assuring the highest quality, availability, reliability and cost effectiveness in micro-electronic technology and its insertion into high per-formance, affordable systems. Authors are requested to submit five copies of a one-page abstract by May 31, 1998 to:

Edward B. Hakim
The Center for Commercial Component Insertion, Inc.
2412 Emerson Ave.
Spring Lake NJ 07762.
Tel. and Fax: (732) 449-4729.
E-mail: ebhakim@bellatlantic.net

The International Journal of Quality and Reliability Management (IJQRM) is seeking papers that focus on the practice of quality, reliability and maintainability. IJQRM is a major journal that will be entering its 15th year of publication. Authors should submit three copies of the article to the North American Editor:

Professor Christian N. Madu
Dept. of Management and Management Science
Lubin School of Business
Pace University
1 Pace Plaza
New York, NY 10038
Tel: (212) 346-1919
Fax: (212) 346-1573.
E-mail: ChrisMadu@aol.com

The 69th Shock and Vibration Symposium to be held October 12-16, 1998 in Minneapolis/St. Paul, Minnesota is seeking two categories of papers: full papers to be published in the symposium proceedings and short topics to be discussed at the conference but not published. Abstracts are due by May 4, 1998. Submittal details were not available at receipt of this announcement, but will be posted on the Shock and Vibration Information Analysis Center (SAVIAC) website at URL: http://saviac.xservices.com, and published in future issues of the SAVIAC Current Awareness Newsletter. For subscription to the latter, mail request to SAVIAC, 2231 Crystal Drive, Suite 711, Arlington VA 22202, or Fax to (703) 412-7500.

Call for Memories

In December 1998, the IEEE Reliability Society will publish a special issue of the IEEE Transactions on Reliability commemorating the 50th anniversary of the founding of the society. The issue will include a feature presenting interesting experiences of practitioners in any of the assurance sciences. Your funny, poignant or historically relevant memories may be submitted at any time up to 1 August 1998. Reminiscences will not be refereed, but will be edited to fit the available space. Send to the special issue editor:

Anthony Coppola
IITRI
201 Mill Street
Rome NY 13440
Tel: (315) 339-7075
Fax: (315) 337-9932
E-mail: acoppola@rome.iitri.com

New from RAC

New Catalog Available

Just released is the new *RAC Catalog of Products and Services.* Besides presenting the latest listing of RAC printed and software products and their prices, the catalog provides descriptions and contacts for:

- RAC consulting services
- RAC training courses
- The RAC Data Sharing Consortium
- Selected Topics in Assurance Related Technologies (START), a set of introductory pamphlets available free from RAC
- RAC Journal subscriptions (also free) and advertising rates (not free)
- The RAC website

The catalog includes descriptions of products still in development. For example, computer text files for MIL-HDBK-338, *Electronic Reliability Design Handbook,* and for MIL-HDBK-470, *Maintainability Design Handbook,* are described, priced, and labeled "available soon."

The catalog is free on request to RAC. Use any of the contact data listed on the back cover of this issue, or call (888) 722-8737.

Failure Modes and Mechanisms Reference Updated

In 1991, RAC published FMD-91, *Failure Modes/ Mechanism Distributions,* providing component failure modes and their relative probabilities of occurrence as an aid to fault tolerant design, the preparation of diagnostics, and failure modes, effects and criticality analysis (FMECA). A new document, FMD-97, adds about 50% new data to that of FMD-91. The hardcopy document contains data on electronic, mechanical and electromechanical parts and assemblies. It is available at a cost of $100 for U.S. orders, and $120 for Non-U.S. orders. The order blank on the inside rear cover of this issue may be used to obtain a copy. For more information, call (888) 722-8737.

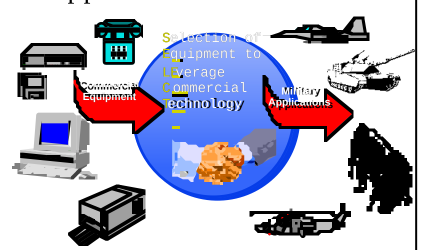
FMD-97 will also soon be made available on CD-ROM or 3.5" diskette software packages for use on personal computers under Windows 95 or NT. When available, the software will include graphical user interfaces and help files at an expected price of $100 for U.S. orders and $120 for Non-U.S. orders. Order code will be FMD-CD. Availability will be announced in the *RAC Journal.*

Optoelectronics to be Next Component Applications Guide Subject

Available in the Spring of 1998 will be *Reliable Applications of Optoelectronic Devices,* a compilation of information to assist optoelectronic equipment designers in enhancing the reliability of their products. It will provide criteria for selection of devices, failure rate data, failure mode data, potential reliability concerns and other information necessary to apply the part in a reliable manner. The product will the latest in a series of application guides (See *Help From RAC,* this issue). Ordering information will be presented in the *RAC Journal* when the publication is released.

New Software Tool Will Aid COTS Selection

A software tool, *Selection of Equipment to Leverage Commercial Technology* (SELECT), will be offered by RAC to quantify the estimated reliability and risk of using equipment designed for relatively benign environments in applications where the expected stresses (temperature, vibration, shock, humidity, etc.) are considerably more severe. The tool was originally developed by IIT Research Institute (operator of the RAC) under contract to Rome Laboratory (now called Air Force Research Laboratory Information Directorate - Rome Site). In addition to allowing relative risk comparisons between different commercial off-the-shelf (COTS) equipment, the tool identifies the predominant environmental and process risk drivers of each equipment being considered, quantifying the impact of design changes and testing options on the risk scores and estimated reliability. Release is expected in Spring, 1998. Order code will be SELECT, and the price will be $300 for U.S. orders and $340 for Non-U.S. orders.

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Industry Brief

ISO 9000 in the News

Recent news about ISO 9000, the family of Quality Management System international standards, includes:

- AS 9000, Aerospace Basic Quality System Standard, is now available from the Society of Automotive Engineers (SAE) as a guide to quality management in the Aerospace industry. Like QS 9000, the Automotive Quality System Standard, it contains a verbatim citation of ISO 9000 provisions and industry specific additional requirements and notes. For more information on AS 9000, Contact SAE, 400 Commonwealth Drive, Warrendale PA 15086-0001. Tel: (412) 776-4970.

- Despite recent statements that the automotive sponsors of QS 9000 would discontinue the verbatim citation of ISO 9001, present plans are to retain the ISO standard.

- ISO plans to "integrate" ISO 9000 and ISO 14000, Environmental Management System, apparently do not intend a merger of the documents, but rather the creation of the capability to audit a site for compliance to either or both in a single visit.

SLDA Coolers Developed Through SBIR Program

Semiconductor laser diode arrays (SLDAs) require a high degree of thermal stability to maintain specified laser beam wavelengths and optimum efficiency. However, they generate large amounts of heat which must be removed, and existing cooling technology has been inadequate. Under a Small Business Innovation Research (SBIR) program sponsored by the former Air Force Phillips Laboratory, Saddleback Aerospace, Los Alamitos, CA, has developed water-cooled heat sinks using microchannel coolant flow passages . One of the prototype units exhibited the lowest thermal resistance ever reported for these types of devices. Saddleback is now manufacturing units in a variety of shapes, sizes and materials.

MTIAC Supporting Internet Product News Network

The Manufacturing Technology Information Analysis Center (MTIAC), one of three Defense Technical Information Center (DTIC) information analysis centers operated by IIT Research Institute, is providing manufacturing expertise to assist the Thomas Magazine Group in the launch of it's new commercial internet venture, the "Product News Network." MTIAC is developing hierarchical nomenclatures for six categories of industrial products: adhesives and sealants; data acquisition; machine tools; quality control; automatic identification systems; and plant maintenance and equipment. The Product News Network is intended to be an on-line source of up-to-date product information. The Thomas Magazine Group is the publisher of the "Thomas Register of Manufacturers."

ADPA + NSIA = NDIA

On March 1, 1997, the American Defense Preparedness Association (ADPA) and the National Security Industrial Association (NSIA) merged. On October 1, 1997, the resulting organization was officially named The National Defense Industrial Association (NDIA). The association headquarters is located at 2111 Wilson Boulevard, Suite 400, Arlington VA 22201. Tel: (703) 522-1820. Fax: (703) 522-1885. E-mail: cmadeira@ndia.org.

DTIC Offers IAC Directory

The Defense Technical Information Center (DTIC) is offering a Directory of the DoD and service sponsored Information Analysis Centers (IACs). For a copy contact: Mr. Ron Hale, IAC Program Management Office, Defense Technical Information Center, 8725 John J. Kingman Road, Suite 0944, Ft. Belvoir VA 22060-6218. Tel: (703) 767-9171. Fax: (703) 767-9119. E-mail: rhale@dtic.com. The directory can also be downloaded from the IAC hub page on the DTIC webesite: http://www.dtic.mil/iac/. An Adobe reader is needed.

From the Editor

The Quality Troika

How often has been heard the complaint that schedule and cost are the enemies of quality (or reliability, maintainability, testability, logistics planning, etc.)? I would like to suggest, rather, that cost and schedule are appropriate and valid measures of quality. David Garvin once identified five categories of quality measures, including value-based measures and user-based measures. Value-based measures integrate “goodness” and the cost involved (Phil Crosby’s “cost of quality “ would be a value-based quality measure). User-based measures try to quantify the ability to satisfy the customer. I submit all measures must ultimately be user-based (no one else’s opinion really counts) and that cost and schedule are customer measures of quality, just as important as freedom from defects or features of the product.

For example, when in the market for a car, would you consider a Rolls-Royce? It has a reputation for unsurpassed engineering, elegant appointments, and freedom from defects, making it one of the highest quality automobiles in conventional quality (“goodness”) terms. Yet the average person considers the cost of an automobile important, and the Rolls-Royce does not have the property of being priced low enough for consideration by most car buyers. I contend this demonstrates cost is indeed a quality factor.

How about schedule as a quality factor? If you picked a new car to replace the one you have, but had to wait for a year before it was delivered, wouldn’t you pick another to buy? Perhaps you would wait, but I suspect you would think long and hard about it. QED: quality includes timely delivery.

My conclusion is that measures of “goodness” join with measures of cost and measures of schedule to form a “quality troika,” the three legs of which must all be considered in making decisions. This is essentially a premise of total quality management, (TQM), where the word “total” implicitly recognizes the existence of the troika.

So where does this lead? First, we need to measure our efforts in three dimensions. Among all the different parameters, we can perhaps select major factors for “goodness,” cost and schedule and use this troika as an overall indicator of our performance. Continuing our automotive example, an automaker might measure defect rate, sticker price and time from order to delivery. With this, or an equivalent set of three measures, he could track his progress and benchmark his performance against the competition. These three parameters, and many others, are certainly used now by the automotive industry, but I am suggesting that a troika of the top three goodness, cost and schedule parameters may have value as an overall figure of merit. Also, each component of an organization can select their own appropriate troika as their metric for overall performance. And the recommendations of the assurance specialists should include a three-dimensional estimate of impact, using an appropriate quality troika.

A characteristic of the quality troika is that any change which improves one leg without adversely affecting the other two is always a winner. Many process improvements fall into this category, and pay off handsomely. It is the case where an improvement in one leg hurts another that requires a trade-off analysis. In the past, the relatively less visible “goodness” parameters suffered when they crossed cost or schedule. In the current climate where quality (in terms of “goodness”) is recognized as a customer demand, I think management is more willing to listen. However, it’s up to the analyst to have his facts ready to clearly show the trade-off involved, or, better, to find a way where no leg of the troika suffers a loss (TQM, again).

Considering cost and schedule as quality parameters, the assurance specialist may begin to understand why his recommendations have not always been accepted. More importantly, this may be a way for the specialist to communicate better with the decision makers, and it can improve the value of his recommendations. Better communication of better recommendations should improve his success ratio.

Anthony Coppola, Editor

What do you think? Letters to the editor on this, or any other topic, are always welcome. Those of general interest may be printed, unless the author requests otherwise.

Letter to the Editor

Dear Sir,

Reference "FMEA - A Curse or Blessing" by S.J. Jakuba, in the RAC Journal, Volume 5, Number 4, I would like to make the following comments:

The article was very well developed and written, and I feel it hit the right note regarding the impressions the subject gives to both analysts, designers, and other personnel normally exterior to reliability, who regard the usefulness of a FMEA without any real understanding of its aims and achievability.

In discussing the uses of a FMEA Stan Jakuba does not address the uses of a FMEA when an item of equipment or a system has to be modified or is an existing item (off-the-shelf) where no previous FMEA has been developed or produced. In such cases one of the main uses of the FMEA is to define the types, numbers, frequencies and safety related hazard quantifications, so that the information can be used in developing the Logistics Support Analysis for Maintenance Planning. It also provides the basis for Life-Cycle Cost optimization, and is one of the most important building blocks in the development of a support plan.

Nevertheless, in his appraisal of the design and development of systems he has put his finger on the most misused and misunderstood analysis, which if implemented and used in the manner he has suggested will benefit all areas of system / equipment development.

Currently in the European environment most weapon platform acquisition programmes utilize a mixture of existing / modified / new development equipments or a system comprising existing / modified items with new software. With software and software / hardware configurations, existing FMEA methods do not suffice, but as Stan points out, it is the manner in which the FMEA is approached, the timing and how it is assessed, that is most important, and which if implemented correctly will provide the most rewards.

However, what must be clearly defined in each programme is why the FMEA is to be developed, and what are the aims of the FMEA. Most people involved in any system / equipment development programme fail to lift their heads out of the water and remind themselves what they are trying to achieve, and why they are doing such tasks.

On the matter of training, Stan has it just right; experience, team effort, and teamwork are the only answer. Too often the team leader thinks that the rest of the team do the work and he / she is the team! Education is one possibility, but the real answers are far reaching, and go well beyond the subject of quality and reliability.

Please, let's have more articles like that of Stan Jakuba's. The more people that read and digest such articles, the better are the chances of improving the quality of our programmes.

Yours very truly,
Stewart Allen
Logistics Executive Director,
Philotech GmbH

Some Observations on Demonstrating Availability

By: Anthony Coppola

Availability is easy to measure. It is also easy to measure MTBF and MTTR and calculate inherent availability by the formula:

$$A_i = \frac{MTBF}{MTBF + MTTR}$$

The problem is in assigning risks. For example, suppose we wanted an availability of 95%. If we had one failure in 100 hours and it took one hour to repair, we have measured an availability of 99%, well over spec. However, we would be basing the conclusion on one failure and one repair, which would be quite risky. We would feel more confidence if we had more data (i.e. more failures and repairs). There are established procedures for computing confidence intervals around MTBF measurements and for confidence intervals around MTTR estimates. (confidence = 1-risk. A confidence of 90% that a calculated MTBF or better has been achieved means a 10% risk of being in error. In turn a 10% risk of error means a probability of 0.10 that the true MTBF will be lower than the calculated value.) As might be expected, the more data available, the closer will the calculated values for a specified confidence be to the measured value.

The problem with availability is that there is no easy way to compute confidence limits about a measured availability.

Following is a procedure for calculating risks on availability from confidence intervals on MTBF and MTTR.

First, collect data on MTBF and MTTR. (MTBF is operating hours/failures: MTTR is down time/failures not counting administrative and logistics delays). The data is collected to the end of the last repair so that the operating time does not extend beyond the time of the last failure.

Then use the Chi-square procedure described below to calculate MTBF and MTTR at a desired risk. We shall be using 10% risks, and calculating a value of MTBF for which there is only a .10 probability that the true MTBF will be lower, and a value of MTTR for which there is only a .10 probability that the true MTTR will be higher. The resultant values are an MTBF and MTTR demonstrated to a 90% confidence. (Note: this method assumes the exponential distribution applies to both times between failure and times to repair: there are procedures for computing confidence intervals based on other distributions, such as the log-normal, which is more commonly assumed for MTTR).

Selected values from a Chi-square table are:

Degrees of freedom (= 2 x no. of failures)	Chi-square value at tenth percentile	Chi-squared value at 90th percentile
2	.211	4.61
4	1.064	7.78
6	2.20	10.64
8	3.49	13.36
10	4.87	15.99
12	6.30	18.55
14	7.79	21.06
16	9.31	23.54
18	10.86	25.99
20	12.44	28.41
22	14.04	30.81
24	15.66	33.20
26	17.29	35.56
28	18.94	37.92
30	20.60	40.26
40	29.05	51.81
50	37.69	63.17
60	46.46	74.40
80	64.28	96.58
100	82.36	118.5

We then use the formulas:

$$MTBF = \frac{2 \text{ x total operating time}}{\text{Chi - square value for 2 x no. of failures at 90th percentile}}$$

$$MTTR = \frac{2 \text{ x total downtime}}{\text{Chi - square value for 2 x no. of repairs at tenth percentile}}$$

The MTBF formula gives the value of MTBF which we are 90% sure will be exceeded by the true MTBF (there is a .10 probability that the true MTBF is less that that calculated by the formula).

The MTTR formula gives the value of MTTR which we are 90% sure will not be exceeded by the true MTTR (there is a .10 probability that the true MTTR is grater than that calculated by the formula).

These values may be used to calculate an availability at some risk determined by the risks on MTBF and MTTR. We shall discuss later what the risk on the calculated availability might be.

Example: for 1000 hours of operating time with 10 failures which required 10 hours of repair time:

$$\text{Measured MTBF} = \frac{1000}{10} = 100 \text{ hours;}$$

$$\text{Measured MTTR} = \frac{10}{10} = 1 \text{ hour.}$$

Using the formulas given above:

$$\text{MTBF} = \frac{2000}{28.41} = 70.4 \text{ hours}$$

$$\text{MTTR} = \frac{20}{12.44} = 1.6 \text{ hours}$$

The results are interpreted as showing only a 10% chance that the true MTBF will be less than 70.4 hours, and that there is only a 10% chance that the true MTTR will exceed 1.6 hours.

Calculating availability by the formula A = MTBF / (MTBF+MTTR):

$$\text{Measured availability} = \frac{100}{100+1} = \frac{100}{101} = .99$$

Availability using calculated MTBF and MTTR:

$$A = \frac{70.4}{70.4+1.6} = \frac{70.4}{72} = .978$$

If the desired availability were .98, the measured results would indicate achievement, but the calculated results would show that when the MTBF and MTTR are calculated to a 90% confidence, the availability is not demonstrated as being achieved. More test data would be needed to resolve the issue.

The important, as yet unanswered, question is: what is the risk on the calculated availability number?

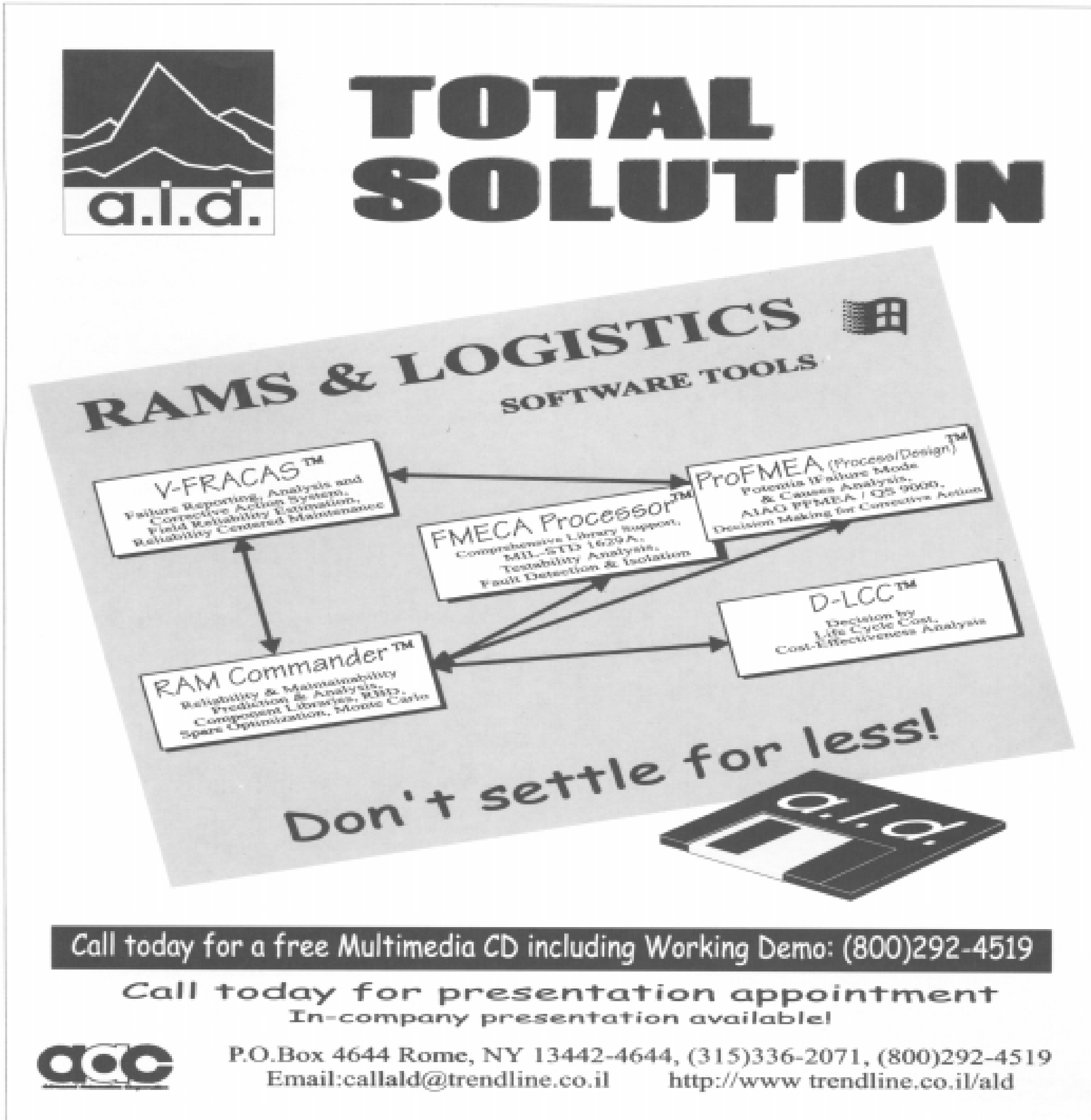
In attempting to answer the question, note that the calculated MTBF will be exceeded by the true MTBF with probability .90 and the true MTTR will be less than the calculated MTTR with probability .90. Hence, the probability of both figures of merit being better than calculated is .90 x .90 = .81. When both figures of merit are better than calculated, the true availability must exceed the value calculated from the calculated MTBF and MTTR. So our confidence in the calculated availability (the probability that the true availability will be greater than the calculated value) is at least 81%. (we shall show that it is more).

Note that the probability of the true MTBF being worse than that calculated is .10 and the probability of the true MTTR being worse than that calculated is also .10. Hence the probability of both values being worse is (.10 x .10 = .01). In such a case, the true availability must be worse than the calculated value using the calculated MTBF and MTTR. Hence the risk on the calculated availability is at least 1% (we shall show it is more) and the confidence (1 - risk) cannot exceed 99%

The above cases cover 82% of all possibilities. This leaves 18% probability that the true value of one of the figures of merit (MTBF or MTTR) is better than the calculated value and the true value of the other is worse. In this case the true value of availability may be either better or worse than the calculated availability. Unfortunately, the majority of the time, the true availability will be worse, rather than better than that calculated. This is because a slight deviation in the percentile towards the tails of the distribution (the bad way) makes a bigger difference (in calculating MTBF or MTTR) than the same deviation towards the center (the good way). For example, The difference in the 90th and 91th percentile values is greater than the difference between the 90th and 89th percentiles. Hence, in less than half the cases will the true availability exceed the calculated value. So the contribution of this 18% probable situation to the confidence in the calculated value will be less than 9%. The exact value will depend on how sharp the curves are skewed and the ratio of MTBF to MTTR.

We can conclude that calculating the availability using the 90% confidence values of MTBF and MTTR will provide a confidence of something more than 81% but less than 90% (81% + less than 9% as shown above) that the true availability will exceed the calculated value. This will often be satisfactory.

Using other values of confidence (e.g., 95%) for the calculation of MTBF and MTTR will result in other ranges of confidence on availability. The above procedure, and a more complete chi-square table will be needed. Note however, that the higher the confidence demanded, the longer the test time needed to achieve it. Also note that all this assumes that the measured availability (that calculated from the measured MTBF and MTTR) exceeds the specified availability. If the measured availability is inadequate, the confidence in any higher value must be less than 50% (a poor bet).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24th Annual Reliability Testing Institute
Contact: Dr. Kececioglu, University of Arizona, Aerospace and Mechanical Eng. Dept., 1130 N. Mountain Avenue, Bldg. 119, Room N517, PO Box 210119, Tuscon, AZ 85721-0119. Tel: (520) 621-6120. Fax: (520) 621-8191. E-mail: dimitri@u.arizona.edu.

May 19-21, 1998 — Adelaide, Australia
Maintenance Engineering '98
Contact: Secretariat, Maintenance Engineering '98, PO Box 5142, Clayton Victoria 3168, Australia. Tel: 61 3 9544 0066. Fax: 61 3 9543 5905.

June 4, 1998 — Pittsburgh. PA
November 5, 1998 — Arlington, VA
SEI Visitor's Days
Contact: Customer Relations, Software Engineering Institute (SEI), Carnegie Mellon University, Pittsburgh, PA 15213-3890. Tel: (412) 268-5800. E-mail: customer-relations@sei.cmu.edu. More info at website at URL: http://www.sei.cmu.edu.

June 8-10, 1998 — Crystal City, VA
SEI Conference on Risk Management
Contact: Customer Relations, Software Engineering Institute (SEI), Carnegie Mellon University, Pittsburgh, PA 15213-3890. Tel: (412) 268-5800. E-mail: customer-relations@sei.cmu.edu. More info at website at URL: http://www.sei.cmu.edu.

June 15-17, 1998 — Dallas, TX
10th Annual RMSL
Reliability, Maintainability, Supportability, and Logistics Workshop
Contact: Professional Development Division, SAE, 400 Commonwealth Drive, Warrendale PA 15096-0001. Tel: (724) 772-7148. Fax: (724) 776-4955. E-mail: profdev@sae.org.

June 23-25, 1998 — Munich, Germany
FTCS-28: Fault Tolerant Computing Symposium
Contact: Ram Chillarege, IBM Watson Research, 30 Saw Mill River Road, Hawthorne, NY 10352. Tel: (914) 784-7375. Fax: (914) 784-6267. E-mail: ftcs@chillarege.com

July 15-17, 1998 — Tokyo, Japan
5th ISPE International Conference on Concurrent Engineering
Contact: Prof. Shuichi Fukuda, Dept. of Production, Information and Systems Engineering, Tokyo Metropolitan Institute of Technology, 6-6, Asahigaoka, Hino, Tokyo 191, Japan. Tel: 81 425 83 5111 x3605. Fax: 81 425 83 5119. E-mail: fukuda@mgbfu.tmit.ac.jp.

July 27-30, 1998 — San Diego, CA
Seventh Applied Reliability Engineering and Product Assurance Institute for Engineers and Managers
Contact: Dr. Kececioglu, University of Arizona, Aerospace and Mechanical Eng. Dept., 1130 N. Mountain Avenue, Bldg. 119, Room N517, PO Box 210119, Tuscon, AZ 85721-0119. Tel: (520) 621-6120. Fax: (520) 621-8191. E-mail: dimitri@u.arizona.edu.

August 26-28, 1998 — Albuquerque, NM
1998 Military/Aerospace (Transportation) COTS Conference
Contact: Edward B. Hakim, The Center for Commercial Component Insertion, Inc., 2412 Emerson Ave., Spring Lake, NJ 07762. Tel: (732) 449-4729. E-mail: ebhakim@bellatlantic.net

September 13-17, 1998 — New York, NY
International Conference on Probabilistic Safety Assessment and Management
Contact: Dr. R. A. Bari, Brookhaven National Laboratory, PO Box 5000, Upton, NY 11973-5000. tel: (516) 344-5266. Fax: (516) 344-5266. E-mail: Bari@bnl.gov.

September 14-19, 1998 — Seattle, WA
16th International System Safety Conference
Contact: Clif Ericson, 18247 150th Ave SE, Renton, WA 98058. Tel: (253) 657-5245. Fax: (253) 657-2585. E-mail: clifton.a.ericson@boeing.com

September 22-25, 1998 — Ypsilanti, MI
Practical Implementation of Probabilistic Methods Workshop
Contact: SAE Professional Development, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Tel: (724) 772-7148. Fax: (724) 776-4955. E-mail: profdev@sae.org.

October 6-8, 1998 — Reno, NV
20th Annual EOS/ESD Symposium
Contact: ESD Association, 7900 Turin Rd., Bldg. 3, Suite 2, Rome, NY 13440-2069. Tel: (315) 339-6937.

October 26-29, 1998 — Annapolis, MD
20th Space Simulation Conference
Contact: Institute of Environmental Sciences & Technology, 940 East Northwest Highway, Mount Prospect, IL 60056. Tel: (847) 255-1561. Fax: (847) 255-1699. E-mail: Instenvsci@aol.com.

November 5, 1998 — Arlington, VA
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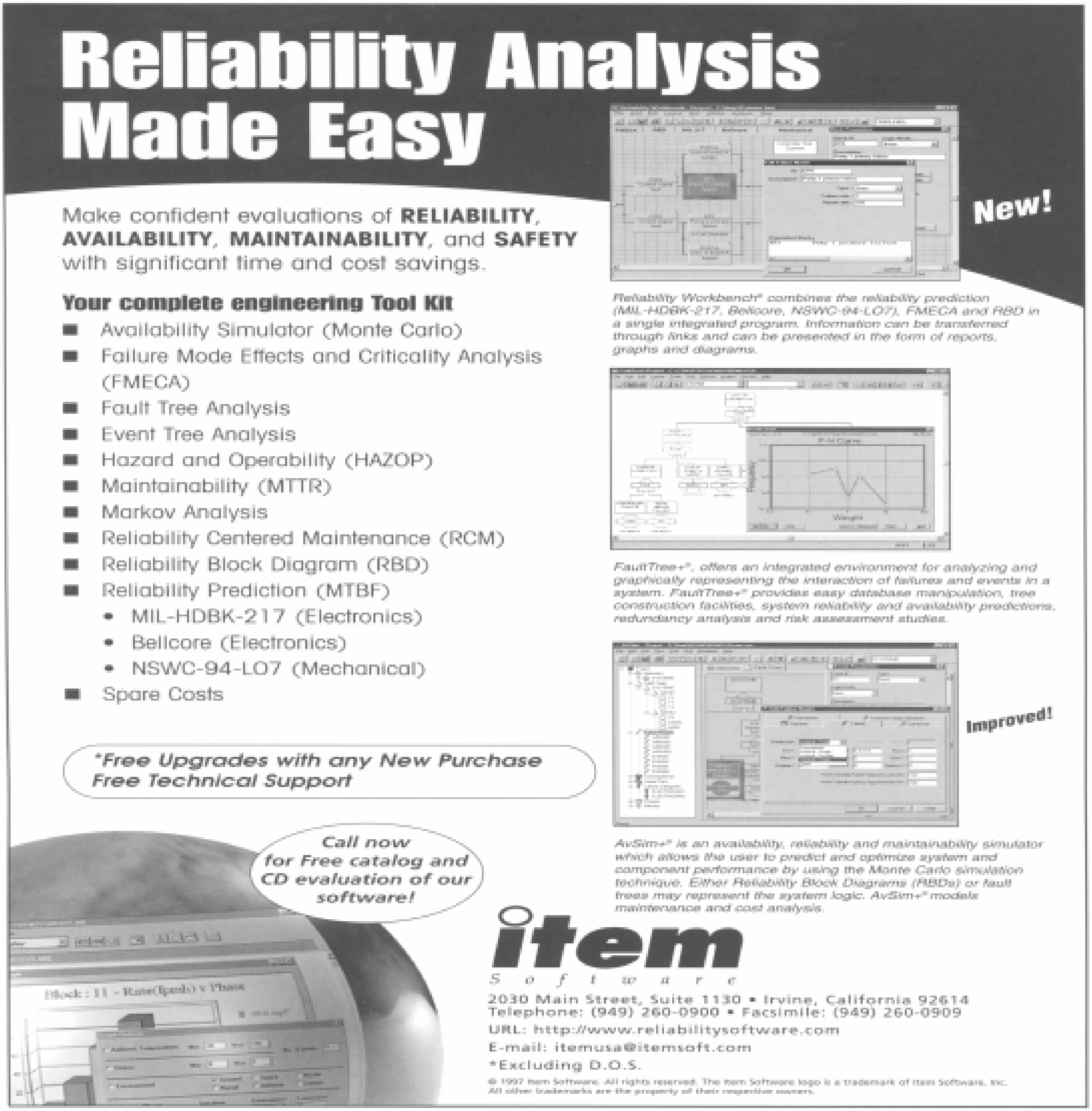
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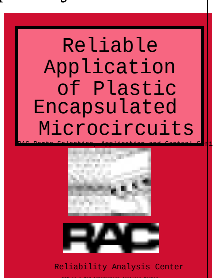
Help from RAC

Complementing the RAC product in process on the reliable application of optoelectronics devices (see *New From RAC*, this issue) are several currently available publications on applying other part types and on general parts management. Descriptions follow:

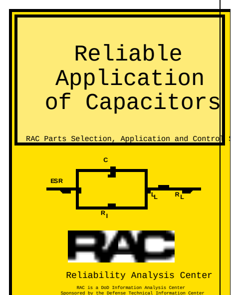
Reliable Application of Plastic Encapsulated Microcircuits addresses the interest in applying plastic encapsulated microcircuits (PEMs) in all environments including military and telecommunication systems with strict reliability demands and harsh environments. This interest stems from real and perceived improvements in PEM reliability, quality and cost. The publication provides information on PEM parts control, procurement, failure modes and mechanisms, reliability and quality. A reliability prediction model for PEMs is also provided.



Order Code: PEM2
Price: $75 U.S., $85 Non-U.S.

Reliable Application of Multichip Modules addresses hybrid microcircuits, multichip packaging and multichip modules (MCMs). It provides an overview of the methodology and tools to ensure that these components and their vendors are selected, controlled and tested effectively for the specific end product and usage, so that the favorable weight and size advantages of these devices may be successfully exploited.
Order Code: MCM
Price: $50 U.S., $60 Non-U.S.

Reliable Application of Capacitors provides information on the failure modes of the various capacitor types, their observed failure rates and specific areas of concern when selecting a capacitor. It also contains quantitative relationships describing the change in electrical parameters (capacitance, dissipation factor and equivalent series resistance) as a function of time and temperature. A thorough bibliography is provided.



Order Code: CAP
Price: $50 U.S., $60 Non-U.S.

The first publication in RAC's series on the reliable application of parts was ***Parts Selection, Application and Control***, an overview document addressing topics of a general nature affecting all types of parts. It identifies specific selection and procurement methods and tools for properly applying electrical and electronic parts most suitable for the unique requirements of a given application, military or commercial.
Order Code: PSAC
Price: $50 U.S., $60 Non-U.S.

To help bridge the gap between the use of military specifications and standards, and new policies in acquiring military equipment under the DoD acquisition reform program, RAC compiled a handbook, ***Processes for Using Commercial Parts in Military Applications***. The handbook provides an overview of the acquisition reform process, its relationship to system engineering functions, and its impact on reliability and quality issues. It also provides guidance for a parts management program under the new groundrules, and case histories to illustrate practical experience and "lessons learned."
Order Code: PUCP
Price: $25 U.S., $35 Non-U.S.

Orders may be placed using the order blank on the following page, or by telephone to (888) 722-8737. Other RAC products are listed in the RAC Product and Services Catalog, recently revised. Ask for your free copy.

RAC on the Web

RAC maintains a home page on the World Wide Web at URL: http://rome.iitri.com/RAC/. From there, the user can obtain:

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- RAC products and training information: catalog of products, on-line order form, training schedules, available courses
- RAC services: RAC user guide, bibliographic searches, technical support, databases
- Links to other DoD Information Analysis Centers (IACs), and other reliability, maintainability and quality information sources

Pay us a visit at:

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RAC Order Form

Send to: Reliability Analysis Center, 201 Mill Street, Rome, NY 13440-6916

Call: (888) RAC-USER (722-8737), (315) 339-7047 Fax: (315) 337-9932

E-mail: rac@rome.iitri.com

Qty	Title	Price Each	Total
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RAC Training Courses

Course Dates:

June 9-11, 1998

Course Fee:

$995

Location and On-Site Accommodations:

Virginia Beach Resort Hotel & Conference Center
2800 Shore Drive
Virginia Beach, VA 13451
(757) 481-9000

System Software Reliability

Featuring hands-on software reliability measurement, analyses and design, this course is intended for those responsible for measuring, analyzing, designing, automating, implementing, or ensuring software reliability for commercial or government programs.

Design Reliability

This intensive overview covers theoretical and practical aspects of reliability through concurrent engineering. Reliability analysis, test and evaluation, parts selection, circuit analysis, and applicable standards and information sources are addressed.

Mechanical Reliability

Practical applications of mechanical engineering to system and component reliability are covered in this popular course. Basic theories of mechanical reliability and the essential tools of mechanical reliability analysis are covered and reinforced through problem solving and discussion.

Accelerated Testing

The course describes the statistical models for accelerated tests, how to plan efficient tests, and how to estimate and improve product reliability. The methods will be illustrated with many applications to electronic, mechanical, and other products, including your own data, which you are encouraged to bring.

Bring RAC Training Courses to Your Facility

RAC provides training courses to government and industry in virtually every aspect of reliability and quality. On-site training is often more cost-effective for organizations, particularly since on-site “closed” courses can be tailored to specific customer products and processes. Subjects addressed by RAC training include but are not limited to:

- Design for Reliability
- Reliability Modeling
- Fault Tree Analysis
- Failure Analysis
- Statistical Process Control
- Software Engineering
- Software Reliability
- Failure Data Systems
- Mechanical Reliability
- Reliability Testing
- Testability Analysis
- Reliability Analysis
- Reliability Management/Planning
- Quantitative Methods
- Microelectronics Standardization
- Worst Case Circuit Analysis
- Maintainability Testing
- Failure Mode, Effects & Criticality Analysis
- Total Quality Management
- Environmental Stress Screening
- Parts Selection and Control
- Reliability-Centered Maintenance
- Probabilistic Mechanical Design
- Qualified Manufacturers List

For further information on scheduled RAC training courses contact Ms. Nan Pfrimmer at the Reliability Analysis Center, (800) 526-4803 or (315) 339-7036. For information about on-site and custom training arrangements contact Mr. Patrick Hetherington at (315) 339-7084..

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Reliability Analysis Center
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Rome, NY 13440-6916

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Contact Gina Nash at (800) 526-4802 or the above address for our latest Product Catalog or a free copy of the RAC Users Guide.