

Reliability Society

NEWSLETTER

October 1995

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President's Report

As history repeats itself, maybe it is time for the Reliability Society to choose a logo. One that will identify the work of our members and provide the recognition so gratefully deserved. We are now starting to be more active in many areas and we are associating with different groups both inside and outside of the IEEE domain. A logo would be helpful to show that we are participating in activities and that our concerns and thoughts are being considered. To this end we will discuss the prospects of a logo at our next ADCOM meeting and how it should be selected. You might send in your suggestions as to how this logo might be obtained. One thought is to have a competition and request members to submit their ideas. A group of judges, possibly past presidents will select the final design. Appropriate recognition will be awarded to the person or group that submits the design. Watch for the rules and the award in the next newsletter.

I would like to give special recognition to those outstanding Chapters that were winners of last years chapter competition. They are:

- 1st Place Tokyo Section \$500
- 2nd Place Dallas Section \$300
- 3rd Place Philadelphia Section \$200
- Entered Washington Section \$100
- Entered Cleveland Section \$100

All chapters should start submitting the paperwork for this years chapter awards. All entries receive \$100 and you might be selected as the top winner (\$500). The rules have been tailored to make it a level playing field. It does not favor size but does favor accomplishments and services to its members. For further information on this subject please contact the Chapters Coordinator, Bud Trapp (E-mail, otrapp@crl.com).

We just released the Software Reliability Tutorial. It is outstanding even for those who are presently working in software reliability. This is the first in a series of Reliability video tutorials and was recorded at the AT&T recording studio. The three speakers are leaders in the field of software reliability. They are Dr. Sam Keene (Senior Past President of our Reliability Society), John Musa, and Ted Keller. We believe that this video tutorial will receive very wide distribution because of its important and timely subject matter. The title is "Developing Reliable Software in the Shortest Cycle Time". This is an emerging technology and is extremely important for both commercial industry and military products. We rely on software to operate and control many of our advanced systems, surpassing hardware in importance in some equipment. This tutorial was aired over satellite TV on the 11th of September with the three speakers answering telephone questions. For those wanting to view the tutorial or share it with their company, they should contact Elizabeth Santos at IEEE Headquarters (esantos@tab.ieee.org) or see the advertisement in this newsletter. We hope with the proven success of this video tutorial, to have other tutorials on various reliability topics. The areas that we are considering include projects at Rome Labs, University of Maryland, University of Arizona, Mechanical Reliability, etc.

To report on our ADCOM group, we had our third meeting of the year on the 15th of July in Boulder, Colorado. We had an excellent attendance with 12 voting members present which was

5 over a quorum. This is outstanding considering that no other meeting or conference was scheduled with our meeting. The major agenda items included: Interest in improving our membership activities; setting up a CEU criteria for continuing education. Also, it was decided that this year the Chapters Award Presentation would be at the IRPS Conference in Texas, in May 1996.

Two fast growth areas in our society are the Standards Committee and the CDROM area. Conferences are considering CDROM as an alternate for their Proceedings and Tutorials.

Standards is a major area of participation for the Reliability Society. I would like to thank Mike Cushing, Ken LaSala, Mike Pecht, and Dev Raheja for their active participation with special recognition to Mike Cushing for his outstanding leadership in representing our Society on the IEEE Standards Board.

To report on the Technical Activities Board (36 IEEE Society Presidents + more). We had our second meeting of the year on 22 - 24 June in Washington, D.C. The Reliability Society had an excellent attendance with five Society members attending various meetings (normally only the Society President attends). This was necessary since we had special reports to three committees by Carl Rust (Executive Director, CALCE Electronic Packaging Research Center) on the ARIES project from the RAMS conference. We also had a special meeting with key members of the IEEE Standards Board and Headquarters Staff. In attendance for the Reliability Society were Mike Cushing, Ken LaSala, Thomas Stadterman, and myself. The meeting went very well and we established a strong position for our societies' participation in the standards development process.

Thanks to Junior Past President Dr. Tom Weir, I was appointed to three major committees of TAB. These are the Design and Manufacturing Engineering (DME) Committee, the Products Council and the New Products Committee. Also, I was appointed to the Competitiveness Committee of the Technology Council to USAB. We have a close working relationship with the Regional Activity Board (RAB) and the Standards Board along with the Educational Activities Board and Headquarters staff. With this active participation by the Reliability Society, the society members are being well served.

As you can see, there are a lot of activities in the Reliability Society and these activities need your support. We look forward to anyone wishing to help, to choose an area of interest and contact either myself or any of the Vice Presidents. We are particularly looking for people to help with our standards activities and also with the technical activities committees.

Richard L. Doyle (r.doyle@ieee.org)
President, Reliability Society

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Editor's Column

Industrial society has been criticized for its lack of pride in workmanship as it has shifted away from small handcrafted shops to large factories and production lines. The workers/owners of the small shops had pride in each item produced and needed to maintain a reputation to continue selling the products. Worker empowerment, as a major component of Total Quality Management (TQM), is a means of retaining this pride in craftsmanship. It gives the individuals a role in planning as well as execution of the tasks. Ownership is a significant contributor to productivity as workers are allowed to think for themselves on the front lines where the work is being done. Process improvement teams provide the forum for the exchange and generation of new ideas. The teams must know they have the authority to act on

their ideas. While the process action team tends to be the primary focus of TQM, we shouldn't forget that it is individuals who drive the organizations forward. Tom Peter's book, "In Search of Excellence", uses the term champion to describe these individuals who push the frontier for new and better ways of doing business. It is management's role to encourage both the teams and the motivated individuals. But the job doesn't stop with management's empowerment of workers. This isn't a reason for management to sit back and run the organization on cruise control. They need to set it the task gets done does not change with the use of worker empowerment. It's just another improvement to the system that can make everyone happier and more productive.

Bruce Bream (bruce.bream@lerc.nasa.gov)
Editor

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Newsletter Inputs

All Reliability Society Newsletter inputs should be sent to the editor at:

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Newsletter Input Due Dates

Newsletter	Due Date
January	November 19
April	February 26
July	May 28
October	August 27

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Chapter Activities

Boston Chapter

The Boston Chapter kicked off the 95-96 season with a September meeting featuring the illustrious Gene Bridgers discussing the role of an R&M Program Manager for a Commercial Off-The-Shelf (COTS) product. Gene has first-hand experience in this role, having served as R&M Program Manager for a successful family of digital magnetic compass navigation systems used in the Bradley Fighting Vehicle. Gene had plenty of good advice and, as you can imagine, several interesting anecdotes. Our monthly meeting program consistently falls on the second Wednesday of every month from September through May excepting October and April, where other events supplant it.

The bi-monthly Technology Development Workshop series continued with a meeting the following week in which attendees discussed several general reliability technical issues and

exchanged some excellent pointers. The previous workshop featured a presentation by Joe Dzekevich who evaluated the strengths and weaknesses of several computer-based Weibull analysis toolsets. Upcoming workshops will be focusing on Reliability Simulation, Environmental Stress Screening, and other topics.

By the time you read this, we should be into our Fall Lecture Series on Software Reliability and Structural Models with Case Studies, featuring the renown Dr. David Heimann. This two-night lecture series focuses on the important field of software reliability and its role in the software development process.

The topic of the annual Boston Reliability Chapter Spring Symposium scheduled for next April is "Reliability: Investing in the Future". Can Reliability Engineering survive the economics of the '90s to remain a viable profession into the next century? We've issued the Call for Papers; interested parties should contact Harvey Bloom at 508-482-3193 bloom_harvey@waters.com or Giora Kedem at 508-490-5662 gkedem@chipcom.com. Here is your opportunity to share successes with a very active reliability engineering community and participate in shaping the future of the profession.

Don Markuson, Chairman
d.markuson@ieee.org

Cleveland Chapter

The Cleveland Chapter had two meetings during this reporting period:

1. Our May meeting was on History of Aeronautics. Dr. Robert Graham, Consultant, explained: our Vision of Aeropropulsion, Aeropropulsion Resources at Lewis Research Center, Facility Capabilities and Central Process System Description, Data Acquisition and Computational Resources. A timely, well received topic with just about a full house.
2. Our July meeting was an update on Cleveland's Progress on Issues. The honorable Michael White, Mayor, City of Cleveland, took time out from his busy schedule to talk to us about our combined efforts to make our city a safe, growing community. We realize how important Cleveland is to Lewis Research Center and Lewis Research Center is to Cleveland. Both have developed into large multicultural centers of activity. Education is the key to solving all of our issues. One area of hard work is the Airport: Cleveland needs some of our land for expansion; we need the land for our research. Some compromise is being worked out. More progress is being made on our Journey to Excellence. This meeting had a full house; some viewed it live on our LINK Video Broadcast.

Kelly Clunn, Cleveland Convention Bureau has invited the RAMS Site Selection Committee to come to Cleveland for a site inspection. What are the issues? Please come to Cleveland so we can talk about them.

We have organized a RAMS Session for the "Interdisciplinary Integration of Aerospace and Manufacturing in Northern Ohio." Five papers were selected: HITEMP Overview, An NDE Approach for Characterizing Quality Problems in Polymer Matrix Composites, Improving the Durability of Protective Coatings on PMC, Simulation of Ceramic Matrix Composites Behavior Including Progressive Fracture and Load Redistribution and The Role of Arc Spray Process Parameters in Minimizing Fiber Damage: Statistically Designed Experiments With SiC/Ti3Al Composites. The Symposium will be held at Cleveland State University on September 14, 1995.

All-in-all here in Cleveland we are having fun staying active and

trying to serve our members.

Sincerely,
Vince Lalli, Chair

Dallas Chapter

The Dallas Reliability Chapter completed our planning for the '95 - '96 season. The season will kick-off in September with a paper by Bill Hanson, Member of the Group Technical Staff in the Microelectronics Center at Texas Instruments. Bill will speak on "Plastic Encapsulated Microcircuits (PEMs) in Military/Government Electronic Systems --Concerns To Be Addressed."

Our October meeting will be in conjunction with the Dallas Section. This year, the Section will sponsor the "Advanced Electronics Expo '95" in Plano, Texas, and our chapter, along with other society chapters, will meet there to allow increased communication among the chapters and to attract new members. Dennis Hoffman, Director of Support Engineering Strategy and Tools at TI, will speak at this meeting. His presentation is entitled, "Exciting Times -- Ain't Change Fun." It's not clear what this will cover, but with Dennis speaking, there is a 92.3% confidence it will be interesting and informative! At this same session, we will also provide an open forum (perhaps a poster fair) to discuss selected reliability subjects, such as software reliability, FMEA, and reliability software tools.

Topics planned for future meetings this season are: Reliability Reporting, Design for Disassembly, Highly Accelerated Life Testing and Stress Screening (HALT/HASS), and Software Reliability. We plan to hold a joint meeting with ASEE for the software presentation.

Joe Childs, P.E.
Chairperson, Dallas IEEE Reliability Society

Washington DC/Northern VA Chapter

The Washington DC/Northern VA Chapter recently elected its 1995-1996 officers. They, with their respective telephone and e-mail addresses, are:

Dr. Ken LaSala (Chairperson)
Tel: (301)713-3352
E-mail: klasala@eng.umd.edu
kenl@sao.noaa.gov

Lynn Fugate (Vice Chairperson)
Tel: (301)731-8647
E-mail: lynn_fugate@ccmail.gsfc.nasa.gov

Harry Ascher (Program Chairperson)
Tel: (301)762-4779
Fax: (301)984-8628

Ron Combs (Secretary)
Tel: (703)553-1733
E-mail: combsr@vitro.com
roncombs@aol.com

One initiative that the chapter is taking is to broaden awareness of how reliability impacts emerging technologies and other aspects of engineering. Consequently, its meetings are including presentations on subjects that are not strictly reliability to pics; e.g., virtual reality, power supply design, software quality, and standardization. The chapter also is updating its membership list and converting to e-mail meeting notifications. Chapter members are requested to call or send their current names, mailing addresses, telephone and FAX numbers, and e-mail addresses to Ron Combs.

Ken LaSala
Washington DC/Northern VA Chapter

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Results of Reliability Society AdCom Election Ballot

As you know, a ballot for the election of six members to the IEEE Reliability Society Administrative Committee (AdCom) was issued on July 14, 1995. The ballots returned have been counted, and the following candidates have been elected for a three-year term beginning January 1, 1996:

- J.R. Adams
- Michael J. Cushing
- Paul Gottfried
- Kenneth. P. LaSala
- Michael Gerard Pecht
- Art Rawers

We wish the newly elected member of the Administrative Committee success and thank all candidates for their willingness to serve and for permitting their names to be included on the ballot.

Robert T. Wangemann
Managing Director
IEEE Technical Activities

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Reliability Modeling and Prediction Survey

Dear Colleague,

I am involved in a study of reliability prediction techniques that hold promise of producing improved reliability estimations and also to put better focus on the reliability aspects of design and other development processes. I am soliciting your involvement in this study. This is firstly asking your help in answering some questions to baseline current practices. I will feed back the results of the survey to all who participate. I will also share further results as they become available and would welcome your dialogue on these results. I hope you find this of interest and are interested in participating with me. The questions below apply to any product that you have supported and feel comfortable about providing information. The collected data will only be shown in aggregate of all responses received. Your input to me will not be disclosed in any manner.

Reliability Survey

1.0 Your Product Definition

- 1.1 Commercial or Military
- 1.2 Application (e.g., Computer system tape drive, etc.)
- 1.3 Size of the product (e.g., FRU/LRU, box, power supply, subsystem, system)
- 1.4 Extent of embedded software and the number of lines of source code (e.g., KSLOC)

2.0 Your Prediction Technique

- 2.1 Tool used. (e.g., MIL-HDBK-217, Bellcore, etc.)
- 2.2 How do you customize it to your needs? (e.g., scaling factors, manufacturer's data, etc.)
- 2.3 Who uses your predictions? (e.g., Field engineering)
- 2.4 How are your results used by those people identified in 2.3?
- 2.5 Do you validate your prediction results? How?
- 2.6 Do you know how close your predictions come to field

- performance?
- 2.7 How satisfied are you with your prediction tool?
- 2.8 What improvements would you like to see with prediction tools?
- 2.9 Do you also estimate the software failure contribution to your product and how do you do that?
- 2.10 Any comments

3.0 Your Field Data Perspectives

- 3.1 Do you know the relative contributions of hardware to software failures in the field?
- 3.2 For the answer in 3.1, do you know how long the product has been fielded?
- 3.3 Do you have any perspective on the breakdown of root cause areas of product failures? For instance, what is the contribution to failure stemming from defects in:
 - Requirements
 - Design
 - Test
 - Manufacturing
 - Supplier quality problems
 - Human factors
 - Random Arrhenius part failures
 - Wearout
 - No defect found
 - Other (know, unknown?)
- 3.4 Any Comments

Please jot down any other thoughts that come to mind as you go through this questionnaire. These would potentially be valuable points of discussion and consideration. May this study benefit us all in effecting better, more reliable designs and being able to perform better predictions of operational reliability. Thanks in advance for your participation.

Dr. Sam Keene
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Boulder, CO 80304 USA
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Fax: (303)440-3879
E-mail: sam_keene@stortek.com

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Chapter Awards and Criteria

Reliability Society Chapter Awards are recognition of local chapters' efforts to develop and maintain a comprehensive program for encouraging member advancement in all professional areas of reliability. The awards are:

- First Place \$500.00
- Second Place \$300.00
- Third Place \$200.00
- All Others \$100.00, for all chapters who return a completed award form.

These awards are for chapter activities for the period, 1 July 1994 through 30 June 1995. Your participation and prompt response is requested. Attached are the award rules. Please use the enclosed form for your response. All completed forms and supporting documents must be received by November 15, 1995 at the address below. Awards judging will take place in December 1995 - January 1996. The Reliability Society AdCom will present the 1995 awards April 29, 1996, at the IRPS Symposium in Dallas, TX.

Chapter Awards Criteria And Rules - 1995

The judgment of the Reliability Society Awards Committee is final.

Meeting records, reports, references, etc., furnished by the chapter and verified by the awards committee, will be used for all point measurement. Chapter chairpersons, please send the numbers of IEEE members on your chapter mailing list and their ZIP Codes; this is to assist us in determining the chapter area.

Awards are on a yearly basis with the period of measurement from July 1 through the following June 30. A chapter must be authorized by IEEE prior to July 1 of the measurement period. The awards are made by the AdCom upon recommendation of the Awards Committee.

Recipients of the Reliability Society Chapter Awards are determined on the basis of total score calculated as follows:

1. Meeting Points [Do not include 2. Symposium or Conferences or 3. Training Courses (below)].

100 points are earned for every program meeting in which a chapter participates. Joint meetings with other IEEE Chapters or Sections count for this category. Points are based on the IEEE Meeting Report Form 1-31, which must accompany the awards questionnaire.

2. Chapter Sponsored Symposium or Conferences

To be eligible for these points, the Chapter must supply an announcement and written description of the symposium or conference. 500 points will be earned for each one day of a symposium or conference arranged and sponsored by the chapter alone or in conjunction with another IEEE Chapter or the IEEE Section. 250 points will be earned for such activity co-sponsored with a non-IEEE organization. 100 additional points will be earned if transactions or presentation viewgraphs are published for the conference. (A copy must accompany award records.)

3. Chapter Sponsored Training

To be eligible for these points, the Chapter must supply a written description of the course with a record of number of IEEE member registrations and total registrations. The first sponsored training will receive credit as follows: < 7 hours = 250 points; 7-13 hours = 500 points; 14-20 hours = 750 points; > 20 hours = 1000 points. Repeat training courses will receive 50% point credit. The training course can be one of those prepared by the Reliability Society AdCom or can be one of college or university level, provided this training course was motivated and developed by the Chapter.

4. Attendance

For a given meeting, symposium or conference, and training course, points are earned based on attendance. These points earned = the number of attendees.

5. Written Papers And Meeting Participation (Professional only - not reports prepared or presented within one's own company)

a) Papers - Professional

100 points will be earned for a reliability paper authored or co-authored by a member of a chapter if selected for presentation at or, published by, an IEEE meeting, conference or symposium. If selected for the RAMS, IRPS, or IRW an additional 100 points will be earned.

100 points will be earned for each technical paper written by a member of the chapter and published; if in the IEEE Reliability Transactions or the IEEE Proceedings, 200 points will be earned.

Points will be awarded on an individual paper basis; thus more than one author from the chapter on a given paper will not increase the total points awarded on the given paper. 50% credit will be given for papers in non-IEEE journals or meetings.

b) Meeting Participation - Professional

100 points will be earned for each chapter member participating as a session organizer, moderator, or panel member at an IEEE conference or symposium other than those contained in 2. Symposium or Conference and 3. Training, above. 50% credit will be given for participation in non-IEEE meetings. Only one credit per member per meeting.

6. Reliability Society Newsletter Items

200 points will be earned for a chapter when it has submitted information to the IEEE Reliability Society Newsletter editor that is actually published. The points will be awarded for each Newsletter in which such chapter information appears. Only 200 points per issue are available. Submit copy of items.

7. Membership

50 points will be earned for each percentage point increase in chapter membership. Maximum points available per year = 500 points.

SCORING

The total score for a given chapter is determined as follows:

- A. A normalizing factor will be derived by dividing one by the number of members in the Chapter, on June 30, 1995.
- B. The points earned in category 5 will be multiplied by the normalizing factor.
- C. The points earned in all categories, except 5 and 7, will be summed.
- D. The total Chapter score will be the sum of points in B and in category 7 plus the sum of the points in C in multiplied by (10 times the normalizing factor).

There is still time to improve chapter records and get your input to the chapter awards. The award forms must be submitted by November 15, 1995.

Bud Trapp

E-mail: otrapp@crl.com

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Seminars

The 33rd Annual Reliability Engineering and Management Institute
13-17 November 1995, Hotel Park Tucson, Tucson, AZ USA
Contact: Dr. Dimitri Kececioglu, The University of Arizona,
Building #16, Room 200-B, Tucson, AZ 85721-0663, Tel:
(602)621-2495, Fax: (602)621-8191

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IEEE Reliability Society Newsletter

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Reliability Society

NEWSLETTER

October 1995

Space Shuttle Probabilistic Risk Assessment

NASA has recently completed a Probabilistic Risk Assessment (PRA) of the space shuttle vehicle. This study is the latest in a line of quantitative assessments of the shuttle reliability which date back to pioneering efforts undertaken in the aftermath of the Challenger accident. In the subsequent decade NASA has experimented with quantitative assessments of reliability and risk initially as a result of the Rogers and Slay Commission reports. These reports recommended that NASA consider the advances which had been made in quantitative probabilistic technology in the nuclear and other industries and apply the technology to their systems. Individuals involved in NASA programs in the later stages of the Apollo program and throughout the initial shuttle era are familiar with the absence of quantitative assessments on NASA programs. The successes of Apollo seemed to institutionalize its qualitative risk management approach based primarily on the Failure Mode and Effects Analysis ! (FMEA) tool to focus attention on identified items summarized on a Critical Items List developed from FMEA insights. While this approach has been shown by history to produce reliable spacecraft when combined with the extensive test and analysis budgets available during the Apollo era it became questionable as resources became more restricted.

History therefore led NASA away from the assessment of uncertain data using distributions of probability to a more deterministic approach based upon whether something had or had not worked in the past. As Feynman indicated in his personal observations the problem of shuttle risk, "...has to be understood as a probabilistic and confusing, complicated situation. It is a question of increasing and decreasing probabilities." Insights such as these led some NASA pioneers to initiate programs based upon the quantitative assessment programs previously undertaken in the nuclear industry. These early efforts included a quantitative evaluation of the effect of shuttle initiated accident scenarios on the nuclear payloads with the Galileo and Ulysses missions. Here the nuclear nature of the risk made the motivation to utilize quantitative risk assessment techniques more obvious. Despite the nuclear payload focus of these studies a great deal of insight was gained into the value of understanding the relative contributions of various shuttle elements to risk at least during the ascent phases of the mission. Program management began to use the results in project prioritization decision making and in explaining to NASA upper management and to Congressional overseers the motivation behind the priorities assigned.

The early successes resulting from these studies convinced shuttle program management to undertake the more comprehensive study just completed. This study covered the entire shuttle system from a loss of vehicle perspective throughout the entire operational mission from T-6 secs. to nose wheel stop on landing. In addition to the broader scope the study also went into greater depth in the determination of the risk driving elements of the shuttle system.

The results of the study which are summarized in the companion figure show in a clear integrated fashion insights which in some cases may have been widely presumed but in other cases were somewhat surprising and may provide helpful guidance in developing new space systems. For instance while propulsion systems still dominate the shuttle risk representing a 53% contribution as is the case with conventional launch vehicles the orbiter also represents a significant contribution 39% due to its

requirement to survive throughout the mission duration and return safely to earth. The orbiter risk is dominated by failures due to damage of its thermal protection systems (TPS) on descent and common cause failure loss of multiple auxiliary power units (APUs). The latter is the dominant risk contributor and becomes more and more of a contributor as the shuttle mission is extended beyond the nominal duration. The study also showed that both the space shuttle main engines (SSMEs) and the integrated solid rocket boosters (ISRBs) continue to dominate ascent risk overwhelmingly. However, the contribution of the solids while still significant may now well be less than the SSMEs. This is due to the design modifications in the SRBs made since Challenger and the additional assurance provided by inspection and testing between flights. While prudence based on the uncertainty involved requires that

In addition to indicating that investments in the SSME were well placed, the study also indicated that the areas selected for improvement were clearly associated with those risk dominant in the SSME design. In fact, as NASA has quoted in the media, the risk reduction potential of the design changes represents 51% of the existing SSME risk. While risk reduction potential does not necessarily imply risk capture it does indicate that the ongoing modifications are consistent with a proper management risk focus concerning the solid rockets. The study indicated that despite the design changes after Challenger, hot gas leaks through booster joints still remained a dominant risk driver albeit at a significantly reduced level. What was also indicated was that design changes to the booster field joints had shifted the risk to igniter and nozzle joints. Nozzle joint Number 3 was identified as one of particular interest. This identification is consistent with the recent experience with this joint on missions STS-71 and STS-70 which caused shuttle missions to be delayed this summer. The PRA not only was useful in identifying this particular joint as a potential concern but it was also useful to focus the attention of NASA managers on potential modes of common cause failure that might cause a sustainable breach of the room temperature vulcanizing (RTV) material to initiate an erosion of both the primary and secondary O-ring barrel seals.

The comprehensive and in depth nature of the analysis and the living nature of the PC based model which now embodies it should make the shuttle PRA useful to both system design analysts in general and shuttle analysts and managers in particular. Those individuals interested in obtaining a copy of the study should contact the Center for Aerospace Information (CASI) in Washington, DC at (301) 621-0390 or via Fax at (301) 621-0134. Refer to Record Numbers 95N26398, -399, -400, -401, -403. Reproductions are available for free to members of the NASA community and are available to all others at a reasonable reproduction cost.

[Shuttle PRA Process \(Image\)](#)

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