

Safety Engineering & Risk Analysis Division



Newsletter

1st Quarter 2011

GENERAL DIVISION NEWS

A few words from SERAD Chair, Dr. Chinh Bui.....

My thanks and congratulations to all Executive members (ECs) and the participants in contributing to a successful International Mechanical Engineering Conference and Exposition (IMECE) 2010. This event was held in Vancouver, British Columbia in the week of November 17, 2010.

This year, we received more than 70 technical abstracts which culminated in eight technical sessions and 40 papers being published in the IMECE Technical Proceedings. We also hosted a Planetary Session given by the British Columbia Safety Authority. This session was well received and the words from the audiences were "refreshing". Our average attendance at each SERAD session was estimated to be more than double from past years.

The Student Safety Design Contest was conducted with significant interest from the Universities. There were thirteen entries involved 55 students from six schools in the United States, one school in Singapore, one school in India, and one school in Egypt.

The winning teams received a cash award at the 2010 SERAD Award Luncheon at IMECE 2010. The first place winners went to the United States Coast Guard Academy with the design titled "Lifeboat Release System". William Van Cleave and Benjamin Wiest together with one of their Advisors Dr. Carla J. Egelhoff were there to accept the award on behalf of their team. William and Ben provided an overview of their winning project. The second place winner was "Spike Setting Mechanism Project" by the student team from North Carolina State University.

The Award Luncheon was presided by the 2010-2011 SERAD Chair, Dr. Chinh Bui. A few individuals were also recognized for their significant contribution to SERAD. Dr. Enrique Susemihl was recognized for his leadership as SERAD Chair person from 2009-2010. Mr. Bill Byrd, President of RCP Inc., was recognized for his service as SERAD Program Technical Chair for IMECE-2010.

Given the current state of our economy, I am proudly said that our SERAD memberships are still at full strength of approximately 1250 Primary Members. In the next few weeks, our EC will convene and start planning for 2011 activities including selecting volunteers to serve on SERAD committees in various capacities. We have received several strong candidates. If you would like to volunteer to work in our committees, please contact any EC members on our EC list.

Last, I would like to take this opportunity to wish our SERAD memberships a great year with Prosperity and Good Health in 2011.

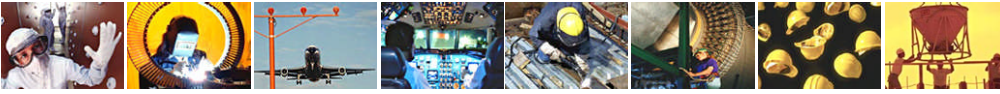
Regards,

Chinh Bui, PhD, P.E.
SERAD EC Chair, July 1, 2010 – June 30, 2011

SERAD AWARDS DINNER PHOTOS FROM IMECE 2010



SERAD EC Chair Chinh Bui presents SERAD 2010 IMECE Chair Bill Byrd with ASME Honorable Recognition Award



Chinh Bui presents Student Safety Design Award to the first place winners from the US Coast Guard Academy



SERAD Dinner Attendees listen to William Cleave and Benjamin Wiest from US Coast Guard Academy



Chinh Bui presents ASME Student Chapter Certificate of Merit to Dr. Egelhoff from US Coast Guard Academy

UPCOMING EVENTS

IMECE 2011 Call for Papers – Abstracts due February 28th

It is time to begin thinking about papers for the 2011 IMECE, November 11-17, 2011 in Denver, Colorado. The abstract submission deadline is coming soon – February 28th.

As in recent years, the SERAD program at IMECE 2011 will focus on four main areas:

1) Safety Engineering – Presentation of methods, models, techniques, concepts and applications in system safety management, safety fault detection, safety assessment, hazard mitigation and safety verification. Area of interests includes aerospace, manufacturing, power, medical and nuclear industries.

2) Risk Analysis – Presentation of methods and applications in risk assessment, risk management, and risk-informed design and decision making in various industries including aerospace, manufacturing, power, and medical

3) Reliability Methods – Presentation of methods, techniques and applications in reliability engineering. Areas of interest include reliability analysis, modeling, and/or prediction in any industry, with a primary focus on the link between these reliability engineering methods and safety or other risks associated with product or process unreliability.

4) Product or Process Safety – Presentation on the hazards and the hazard controls for consumer and industrial products and processes.

We look forward to seeing you at IMECE 2011.

IMECE 2011 Website:

<http://www.asmeconferences.org/Congress2011/>

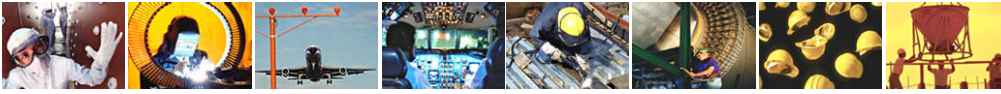
TECHNICAL CORNER

SAPHIRE Fault Tree Analysis Software

Article Submitted by: Curtis Smith, Idaho National Laboratory

Introduction

SAPHIRE is a probabilistic risk and reliability assessment software tool. SAPHIRE stands for Systems Analysis Programs for Hands-on Integrated Reliability Evaluations. The software was developed for the U.S. Nuclear Regulatory Commission (NRC) by the Idaho National Laboratory (INL). Development



began in the mid-1980s when the NRC began exploring two notions:

1. That Probabilistic Risk Assessment (PRA) information could be displayed and manipulated using the emerging microcomputer technology of the day
2. The advancement of PRA technology required a relatively inexpensive and readily available platform for teaching PRA concepts to students.

Consequently, SAPHIRE version 1 was born as a teaching tool and helped to usher in the age of PC-based PRA analysis. Currently, agencies such as the Nuclear Regulatory Commission, the National Aeronautics and Aerospace Agency, the Department of Energy, and the Department of Defense use version 7 of the SAPHIRE software for many of their risk-informed activities. Later in this article we describe how the software may be obtained.

The History of SAPHIRE

1987 Version 1 of the code called IRRAS (now known as SAPHIRE) introduced an innovative way to draw, edit, and analyze graphical fault trees.

1989 Version 2 is released incorporating the ability to draw, edit, and analyze graphical event trees.

1990 Analysis improvements to IRRAS led to the release of Version 4 and the formation of the IRRAS Users Group.

1992 Creation of 32-bit IRRAS, Version 5, resulted in an order-of-magnitude decrease in analysis time. New features included: end state analysis; fire, flood, and seismic modules; rule-based cut set processing; and rule-based fault tree to event tree linking.

1997 SAPHIRE for Windows, version 6.x, is released. Use of a Windows user-interface makes SAPHIRE easy to learn. The new "plug-in" feature allows analysts to expand on the built-in probability calculations.

1999 SAPHIRE for Windows, version 7.x, is released. Enhancements are made to the event tree "linking rules" and to the use of dual language capability inside the SAPHIRE database.

2005 SAPHIRE for Windows, version 8.x, undergoes development.

2008 SAPHIRE for Windows, version 8.x, is released for beta testing.

The evolution of software and related analysis methods has led to the current generation of the SAPHIRE tool. The current SAPHIRE software code-base started in the mid-1980s as part of the NRC's general risk activities. In 1986, work commenced on the precursor to the SAPHIRE software – this software package was named the Integrated Reliability and Risk Analysis System, or IRRAS. IRRAS was the first IBM compatible PC-based risk analysis tool developed at the INL, thereby allowing users to work in a graphical interface rather than with mainframe punch

cards. While limited to the analysis of only fault trees of medium size, version 1 of IRRAS was the initial step in the progress that today has led to the SAPHIRE software, software that is capable of running on multiple processors simultaneously and is able to handle extremely large analyses.

Advanced Analysis

SAPHIRE contains an advanced minimal cut set solving engine. This solver, which has been fine tuned and optimized over time, has a variety of techniques for analysis, including:

- Extensive use of recursive routines
- Restructuring and expansion of the logic model
- Conversion of complemented gates and treatment of success branches
- Logic pruning due to TRUE or FALSE house events
- Coalescing gates and the identification of modules and independent sub-trees
- Intermediate results caching
- Bit-table Boolean absorption

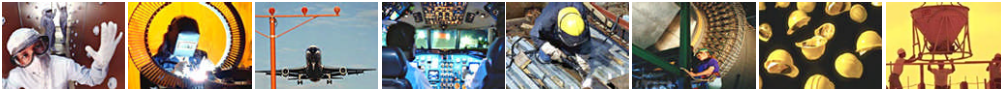
Use of these and other optimization methods has resulted in SAPHIRE having one of the most powerful analysis engines in use for probabilistic risk assessment today. For additional details on the analysis algorithms, see NUREG/CR-6116 [Russell et al; 1994] or Russell and Rasmuson [1993].

Basic Event Probabilities

General basic event probability capabilities for SAPHIRE include:

- Four different Markov models to represent the failure of a single component
- A common cause module to determine a group common cause failure probability for groups of up to six redundant components
- A load-capacity calculation allowing the user to specify a load and capacity distribution to determine $P(\text{Capacity} < \text{Load})$
- A human reliability analysis calculator to determine a human failure event probability based upon the task type and compounding performance shaping factors
- The use of template events which allow for failure information to be shared where applicable
- A seismic fragility method that uses an associated earthquake acceleration level to determine a components failure probability
- House events to set basic events to logically true or false or to ignore the event
- A module to determine the loss-of-offsite power frequency and recoverability

SAPHIRE has been designed to handle large fault trees, where a tree may have up to 64,000 basic events and gates. To handle the



fault trees, two mechanisms for developing and modifying the fault tree are available – a graphical editor and a hierarchical logic editor. Analysts may use either editor; if the logic is modified SAPHIRE can redraw the fault tree graphic. Conversely, if the user modifies the fault tree graphic, SAPHIRE automatically updates the associated logic. Applicable objects available in the fault tree editors include basic events and several gate types, including: OR, AND, NOR, NAND, and N-of-M. In addition to these objects, SAPHIRE has a unique feature known as “table events” that allows the user to group up to eight basic events together on the fault tree graphic, thereby compacting the size of the fault tree on the printed page or computer screen. All of these objects though represent traditional static-type Boolean logic models. Models explicitly capturing dynamic or time-dependent situations are not available in current versions of SAPHIRE.

Obtaining SAPHIRE

The INL has developed a comprehensive software application for performing PRA known as SAPHIRE. Using SAPHIRE on a PC, an analyst can perform a variety of risk-informed applications for complex systems, facilities, or processes.

To request a copy of the SAPHIRE software, point your Internet browser to:

<http://www.nrccodes.com/>

Scroll down to the SAPHIRE section. There will be a link to a non-disclosure agreement (NDA). Click the link, fill out the Acrobat form, sign the form, and then return the NDA as indicated on the form. The software is provided for no fee, although no technical assistance is provided. Note though that technical assistance can be obtained by joining the SAPHIRE Users Group (<https://saphire.inl.gov/registration.cfm>).

References

Russell, K. D. and D. M. Rasmuson, 1993, “Fault Tree Reduction and Quantification – An Overview of IRRAS Algorithms,” *Reliability Engineering and System Safety*, 40, p. 149-164.

Russell, K. D., C. L. Atwood, W. J. Galyean, M. B. Sattison, and D. M. Rasmuson, 1994, *Systems Analysis Programs for Hand-on Integrated Reliability Evaluations (SAPHIRE) Version 5.0*, Technical Reference Manual, NUREG/CR-6116, Vol. 1.

SERAD VOLUNTEER OPPORTUNITIES

Throughout the year, there is always a need for volunteers to assist with SERAD activities. Some specific needs are listed below. You can also volunteer for other activities or general assistance by contacting any of the SERAD Executive Committee members listed in the Contacts section of this newsletter.

SERAD Awards Dinner Committee: Organization of the annual SERAD Awards dinner, typically held at ASME IMECE in November. Duties would include finding a guest speaker, arranging for a banquet room, selection of dinner menu, sending invitations. Contact any of the SERAD Executive Committee members listed in the Contacts section of this newsletter.

SERAD Technical Paper Reviewers: Peer review technical papers for SERAD sessions at future conferences. There are immediate needs for reviewers for abstracts / papers submitted for IMECE 2011, from March through July 2011. If you are interested, please contact the SERAD IMECE 2011 Chair or Vice Chair listed in the Contacts section of this newsletter.

SERAD Website Maintenance: Assistance with all aspects of maintaining the SERAD website, updating content for the website. Contact any of the SERAD Executive Committee members listed in the Contacts section of this newsletter.

REMINDER

Remember that one of the benefits of being a SERAD member is the opportunity to purchase a subscription to the Elsevier journal, *Reliability Engineering and System Safety*. Normally not available to individuals, as a SERAD member, you can purchase a year-long (12 issue) subscription to this valuable journal for \$181. See the Important Website Links section below for a hyperlink to the order form on the SERAD website.

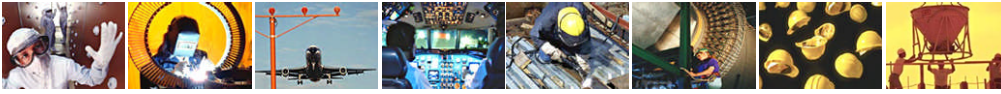
IMPORTANT WEBSITE LINKS

Elsevier Journal, “Reliability Engineering and System Safety” SERAD Member Order Form:

<http://files.asme.org/Divisions/SERAD/22426.pdf>

ASME IMECE 2011

<http://www.asmeconferences.org/Congress2011/>



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