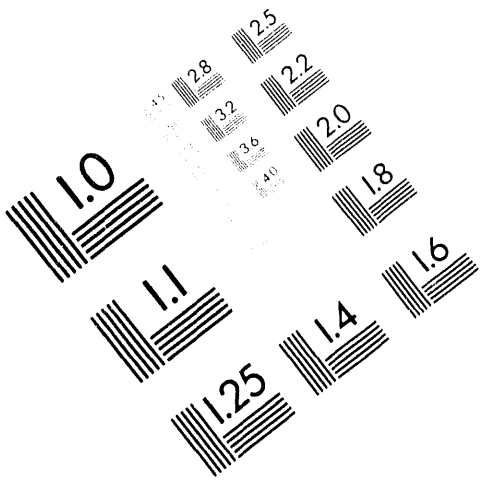
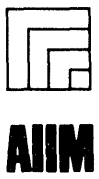


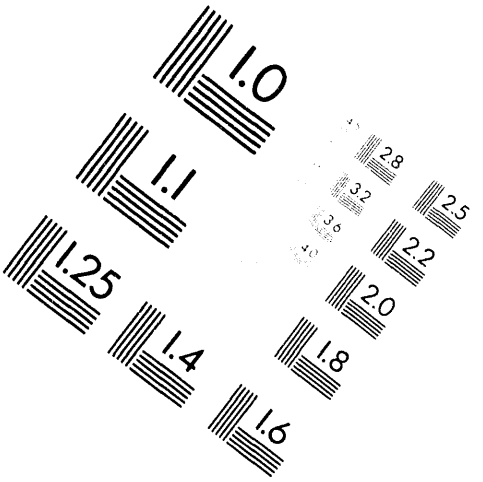


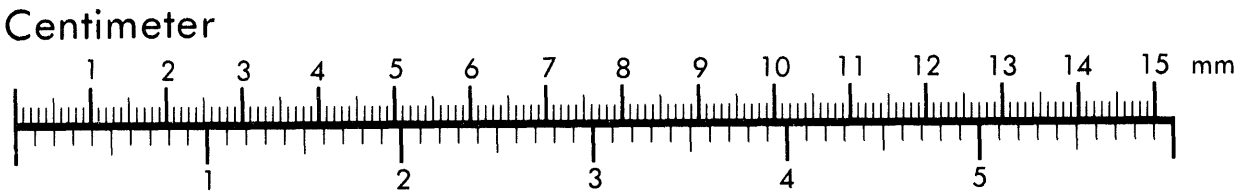
AIIM

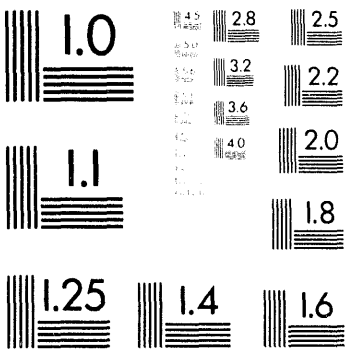
Association for Information and Image Management

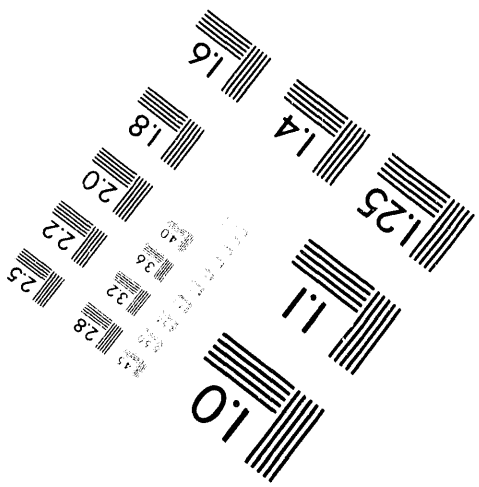
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

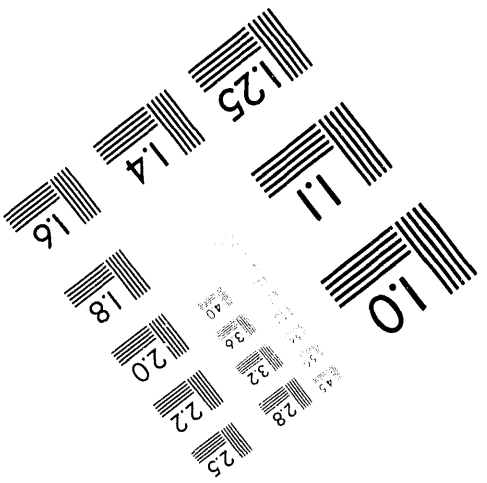








MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.



1 of 1

Recent Enhancements to Probabilistic Risk Assessment Software at Sandia National Laboratories*

Gregory D. Wyss and Sharon L. Daniel
Sandia National Laboratories
Risk Assessment and Systems Modelling Department
Albuquerque, New Mexico 87185-0747
(505) 844-5893 (505) 844-6473

In the 1970's and 1980's, Sandia National Laboratories developed a wide-ranging suite of risk analysis software for the U.S. Nuclear Regulatory Commission. This software, which was developed for mainframe computers, was designed to model the systems, responses, and phenomena associated with potential severe accidents at commercial nuclear power reactors by solving very large fault tree and event tree models. During the last few years, Sandia risk assessment analysts have expressed a renewed interest in these codes for modelling extremely complex risk analysis problems ranging from the transportation and storage of nuclear weapons to the post-accident investigation of the U.S.S. Iowa incident and the evaluation of design options for proposed research reactor facilities.

Because of this renewed interest, Sandia National Laboratories has undertaken a user-driven software development project with the following objectives: (1) enhance the usability of the codes by adapting them to run on IBM-compatible personal computers without loss of capability, while retaining the flexibility to move particularly long and difficult calculations to other, more advanced computing platforms; (2) develop new Windows-based input and graphical output formats that will make the codes accessible to casual risk analysis users; (3) remove the need for manual intervention in calculations by providing integrated data handling between code modules; and (4) provide enhanced model development and analysis features as requested by the Sandia Risk Assessment Code Users' Group. These goals are being realized in the current implementation. The result has been a dramatic reduction in model development and analysis time. At the same time, analysts report improved insights into the analysis results because the new systems allow a graphics-based integrated uncertainty analysis to be performed quickly and easily at all phases of model development.

Event Tree Analysis

Historically, Sandia's software suite for analyzing very large event trees has included the EVNTRE, PSTEVNT, and LHS codes. Because of the renewed interest in these codes, we have combined these codes into an integrated event tree analysis environment called SETAC - the Sandia Event Tree Analysis Code suite. SETAC supports all of the strengths of the underlying EVNTRE event tree analysis code, including the ability to solve very large event trees (over 100 multi-branch questions leading to millions of possible endstates) by using logical statements instead of graphics to define the event tree structure. It can also make branching decisions based on "side calculations." For example, consider a situation in which hydrogen is released by three different sources. If the probability of detonation is related to the total amount of hydrogen present, an analyst could have SETAC sum actual kilogram values from the various hydrogen releases and determine a branching probability based on the total amount of hydrogen produced. In addition, since each of these quantities is likely to be uncertain, SETAC supports the statistical sampling of all quantities (variables, probabilities, parameters, etc.) through the LHS Latin Hypercube and Monte Carlo sampling code.

SETAC enhances the power of the old EVNTRE code by allowing the user to provide all event tree model and uncertainty input in a single keyword-driven free format file. This new input format completely eliminates all references to question and branch *numbers*, and allows branch and distribution *names* to be used in their place. This has greatly simplified the process of developing and debugging the event tree input. Global analysis options are specified through a Microsoft Windows front end that assists the user by performing input verification, file

* This work was supported by the United States Department of Energy under Contract DE-AC04-94AL85000.

management, and code supervision functions. Since the analysis software runs in the multi-tasking Windows environment, a user can perform a SETAC analysis and other unrelated computing functions simultaneously. Finally, a Windows-based graphics package has been developed to allow the analyst to plot the SETAC results as distributions and to paste those graphics directly into other Windows applications for use in reports or presentations.

Sandia has also developed the SANET code for modelling smaller event trees that are conducive to graphical representation. SANET is an easy to use mouse-driven package that supports point-estimate quantification of graphical event trees and provides accident sequence logic to the SABLE fault tree analysis package. A Windows-based version of SANET is currently under development. When completed, it will support all current SANET features plus color plotting, enhanced format flexibility, and the ability to plot portions of the SETAC output.

Fault Tree Analysis

In the 1970's, Sandia developed what was then the state-of-the-art fault tree analysis software (SETS). In the early 1980's, Sandia extended its fault tree analysis code suite to include the first major integrated uncertainty analysis codes (LHS and TEMAC). As other fault tree analysis codes have been unable to solve some of the extremely complex models required by our current customers, Sandia has sought to once again make available these powerful analysis tools.

The Sandia fault tree analysis suite consists of SEATree, SABLE, LHS, and TEMAC. SEATree, supported jointly by Sandia and Los Alamos National Laboratories, is a Windows application that helps the risk analyst build and plot fault trees quickly and accurately by making available a library of predeveloped fault tree modules for commonly used components. The resulting fault tree logic file is evaluated by SABLE (the Sandia Automated Boolean Logic Evaluation code). SABLE's analysis engine is derived from the SETS fault tree analysis code. Our users have noted that the powerful capabilities of SETS come at the expense of requiring the analyst to navigate a cumbersome and difficult user interface. SABLE removes this barrier through a Windows user interface that develops appropriate SETS input for most common fault tree analyses. SABLE also allows the user to enter or modify quantification information in a spreadsheet-like format and to directly read LHS output to assure consistency of data between point estimate and uncertainty analyses. In addition, SABLE is able to directly process event sequence information from the SANET event tree analysis code to generate sequence cut sets.

TEMAC (Top Event Matrix Analysis Code) performs uncertainty and sensitivity analysis of the cut set expressions produced by SABLE. LHS (Latin Hypercube Sampling) generates Latin Hypercube and Monte Carlo samples from designated distributions. Recent activities have created direct links between SABLE, LHS, TEMAC, and Sandia's SETAC event tree analysis code suite. Finally, we have developed a Windows-based graphics package to allow the analyst to plot distributions generated by LHS and TEMAC, and to paste those graphics directly into other Windows applications for use in reports or presentations.

Summary

Sandia's fault tree and event tree analysis software represent powerful tools that can be used to perform a wide variety of risk analysis tasks for DOE facilities and processes. Ongoing studies using these tools include such diverse topics as the transportation and storage of nuclear weapons, nuclear reactor accident progression, electronic systems, healthcare issues modelling, and nonreactor nuclear facility incidents. These studies indicate that the adaptation of these codes, and especially the improved code-to-code interactions, has reduced model development and analysis time, eliminated many potential sources of error, improved the scrutability of the analysis, and provided improved insights into the analysis results by allowing the integrated uncertainty analysis to be performed quickly and easily at all phases of model development.

DISCLAIMER

DATE
FILMED
7/6/94
END