SAND--97-1400C
SAN097-1400C
CONF-971125--

Application of the ARRAMIS Risk and Reliability Software to the Nuclear Accident Progression

Gregory D. Wyss, Sharon L. Daniel, Kelly M. Hays, and Thomas D. Brown
Risk Assessment & Systems Modeling Department
Sandia National Laboratories[1]
Albuquerque, New Mexico 87185-0747

Introduction

The ARRAMIS risk and reliability analysis software suite developed by Sandia National Laboratories enables analysts to evaluate the safety and reliability of a wide range of complex systems whose failure results in high consequences. This software was originally 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. However, because of its power and versatility, ARRAMIS and its constituent analysis engines have recently been used to evaluate a wide variety of systems, including nuclear weapons, telecommunications facilities, robotic material handling systems, and aircraft systems using hybrid fault tree-event tree analysis techniques incorporating fully integrated uncertainty analysis capabilities. This paper describes recent applications in the area of nuclear reactor accident progression analysis using a large event tree methodology and the ARRAMIS package.

[1]Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

DISCLAIMER

Methodology

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 updated them and combined them with several others into an integrated risk and reliability analysis environment called ARRAMIS, the Advanced Risk and Reliability Assessment Model Integrated Software. ARRAMIS is a Microsoft Windows 95/NT software package whose functionality includes all aspects of fault tree and event tree creation and solution, and supports state-of-the-art uncertainty and sensitivity analysis techniques. ARRAMIS is based on a flow chart paradigm, with the user laying out modules containing portions of their analysis. Data transfer is accomplished by "connecting the dots" between modules. The ARRAMIS event tree module supports all of the strengths of the underlying EVNTRE event tree analysis code, including the ability to use logic statements (instead of graphics) to define and solve extremely large event trees.

ARRAMIS addresses the shortcomings of the old EVNTRE code by allowing the user to provide all event tree model and uncertainty input using a free format keyword-driven logic specification language. This new language 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 user interface that assists the analyst by performing input verification, file management, and code supervision functions. ARRAMIS provides a number of tools for displaying distributions and summarizing event tree input and output results.

Application

The power, flexibility, and ease of use of the ARRAMIS software suite have recently been successfully demonstrated for large event tree applications that are typical of the analysis of nuclear reactor accident progressions. The accident progression event trees (APETs) developed in the landmark NUREG-1150 study exemplify the large event tree approach. It is not uncommon for these trees have more than 100 top events, with many of these events having more than two branches. As these models still form the backbone for detailed accident progression analysis sponsored by the Nuclear Regulatory Commission, there exists the need to be able to easily and quickly modify and evaluate these models. ARRAMIS provides these capabilities.

In ongoing research programs sponsored by the Nuclear Regulatory Commission, several of the APETs developed in the NUREG-1150 study were recently modified and evaluated using ARRAMIS. In this effort, the original NUREG-1150 event trees were (1) translated into the improved event tree language, (2) modified to account for additional accidents, different modes of operation, and updated plant information, and (3) evaluated, including an assessment of the uncertainty in the model predictions. The translation from the original APET format to the new language structure proved to be a straightforward and simple process. Furthermore, the new event tree language simplified the construction and incorporation of new top events into the tree and the development of dependencies between events. Also, because uncertainty information is easily incorporated into the event tree as it is being developed, the tree can be evaluated and tested in the uncertainty mode as it is being constructed. This resulted in an uncertainty analysis that

is truly integrated into the model instead of simply laid on top of an existing analysis. A common complaint about the large event tree approach is the visualization of results. A feature of ARRAMIS that has proven particularly useful in addressing this complaint is the ability to organize the thousands of sequences into many fewer "bins" that summarize key events from the large event tree. These bins can then be displayed in a traditional event tree format. With ARRAMIS, the capability now exists to construct, modify, and evaluate large event trees and then process the results for incorporation into reports, all from a desktop through use of a PC.

Summary

ARRAMIS provides a platform that has enabled a large body of historically significant work (the NUREG-1150 accident progression analysis models) to be reused for a whole new body of risk studies. The revised logic model definition language as well as the integration of uncertainty studies into all phases of model development have made it easy to adapt them to new applications and to validate the revisions to these important models. This has resulted in a dramatic cost savings over what would have been required to either revise the models without using ARRAMIS or to reconstruct the accident progression models from scratch for those projects for which they have been used.

Report Number (14) SAND--97-1400C
CONF-971125--

Publ. Date (11) 199706
Sponsor Code (18) DOE/DP, XF
UC Category (19) UC-700, DOE/ER

DOE