SAPHIRE Risk and Reliability Assessment Software

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SAPHIRE Risk Assessment Software Topics

- Overview of SAPHIRE
- Important features
- SAPHIRE database structure
- SAPHIRE Users Group
Overview of SAPHIRE - What is SAPHIRE?

- SAPHIRE - Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
- 32-bit software to perform either
  - Reliability assessment (e.g., fault trees)
  - Risk/safety (i.e., event trees, core damage frequency, Level 2) assessment
- Runs under Microsoft Windows
Overview of SAPHIRE - History

- 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 formation of the IRRAS Users Group.
- 1997 SAPHIRE for Windows is released.
Important Features - Relational Databases

- SAGE database (INEEL developed)
- ALL data is indexed in relational database files (e.g. cross-referencing feature)
Important Features - Integrated Operation

- Analysis and database development operations are integrated into single executable (SAPHIRE.EXE)
- Software has a “context-centered” structure to perform operations on objects

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Important Features - Integrated Operation

- Built in features include
  - Generation, display, and storage of cut sets
  - Graphical editors (fault tree and event tree)
  - Database editors
  - Uncertainty analysis
  - Data I/O via ASCII text files (MAR-D)
  - Special analysis features (e.g., seismic, fire)
  - Dual language support (e.g., Russian and English)
  - “Plug-in” architecture
One of the more important SAPHIRE capabilities is analysis speed.
Important Features - Analysis Capabilities

- The analysis speed has been improved
Important Features - Analysis Capabilities

- Analysis speed is carried over to entire code
  - Relational database one of the fastest
  - Importance measure calculation is very quick
    - Example: A power plant model with 107,428 minimal cut sets. Seven seconds to calculate and display importance measures for 923 basic events.
Important Features - Analysis Capabilities

- Capability to handle both small and large databases
- Capability to perform different analysis methodologies
  - Fault tree linking
  - Event trees with boundary conditions (aka, large event trees)
  - Cut set “matching”
“Change Sets” allow for “what if…” analysis

- Ability to modify single event(s)
- Ability to change a group of events
- “Change sets” are stored as a part of the database for later use
- “Change sets” allow modification to
  - Probabilities and failure rates
  - Unreliability/unavailability model
  - Logic TRUE/FALSE
  - Uncertainty parameters
Important Features - Analysis Capabilities

- Specialized analysis tools are built-in
  - Fire/flood transformation
    - AFW-PUMP-B --> FIRE-ZONE-3B
    - LPI-MOV-21 --> PIPE-SEG-1971C
  - Seismic Fragility analysis
    - FRAGILITY integrated with HAZARD = PROBABILITY
Important Features - Analysis Capabilities

- “Recovery Rules” allow for rule-based post processing of cut sets
- Rule-based or sequence-based end state analysis
  - Rule-based analysis can gather cut sets based on
    • system (i.e. top event) failures or successes
    • content of cut set
  - Sequence-based analysis can gather cut sets using the end states identified on the event tree
Level 2/3 PRA model tools allow two methods to obtain results

- Sequence transfers can pass cut sets from one tree to another
  - Level 1 cut sets into Level 2 event trees
- Rules are available to
  - Gather and quantify sequence cut sets
  - Build “bridge” tree (e.g. Level 1 to Level 2)
  - Use quantified frequency from gathered cut sets as new initiator frequency for “bridge” tree
Important Features - Analysis Capabilities

- Comprehensive uncertainty analysis package
  - Monte Carlo and Latin Hypercube uncertainty propagation
  - Twelve uncertainty distributions are available

- Traditional importance measures are available
  - Fussell-Vesely and Birnbaum
  - Risk Increase Ratio (aka RAW)
  - Risk Reduction Ratio
  - Uncertainty Importance
  - New “risk-informed” importance measures
**Important Features - Analysis Capabilities**

- Cut set manipulation/reporting tools assist the analyst
  - “Path search” will tell you where a cut set comes from for either
    - fault trees
    - event trees
    - end states
  - “Slice” will allow you to separate a list of cut sets into a subgroup based upon events of interest
  - Cut set reports can be output to disk file, printer, screen, or an end-state record in database
Important Features - Analysis Capabilities

- Basic events have multiple attributes
  - Unreliability/unavailability model
    - Probability (e.g., fails on demand)
    - Fails to operate (without repair)
    - Fails to operate (with repair)
    - Fails while in standby
  - Textual identifiers (ID, descriptions, train, etc.)
  - Vulnerability (seismic, fire, flood)
  - Uncertainty assignments
  - Compound events via “plug-in” architecture
Important Features - Analysis Capabilities

- Example of current compound “plug-ins”
  - Common cause failure module
    - Alpha factor
    - MGL
  - Supercomponent
  - Standard unreliability models [e.g., 1 - EXP(-8T)]
  - Flow accelerated corrosion (FAC)

- Open specification so anyone can construct custom “plug-in”
Database Structure - General Structure

- All database information is stored in the SAGE relational database
Database Structure - General Structure

- Textual records are set up to handle dual language for international customers
  - Available in version 7.x and newer
  - Text can be “mixed mode” (e.g., Cyrillic and English)
  - Text language output can be toggled for results and graphics
Database Structure - General Structure

- Data “templates” are available
  - Templates provide storage for data such as
    • generic failure data
    • uncertainty parameters
    • other data attributes
  - User can refer to a single template event multiple times rather than enter same data again and again
Database Structure - MAR-D

- MAR-D allows an analyst to
  - Globally change information in the data ASCII files
  - Document database information and analysis results
  - Archive and share data files
  - Convert data from other PRA codes into SAPHIRE
The SAPHIRE Users Group is an INEEL-sponsored activity to
- Distribute the SAPHIRE software
- Provide on-call support and training
- Develop educational material such as the SAPHIRE FACETS newsletter
- Maintain the SAPHIRE Internet web site
- Provide an avenue for bug report, code enhancements, etc.

- http://saphire.inel.gov
Benefits of the SAPHIRE Users Group are

- Electronic software updates
  - Latest version is always available
  - Ability to download just the code, help file, or both
- Access to software developers
- Access to technical risk, reliability, HRA experts
- Participation with the SAPHIRE discussion group
- The timely information provided in the SAPHIRE FACETS newsletter
Extensive SAPHIRE documentation exists
- NUREG/CR-6116 Volumes 1-10 cover version 5
  - Technical Reference
  - Users Guide
  - Data Loading Manual
  - V&V, etc.
- SAPHIRE Basic, Advanced SAPHIRE, and workshops provide training material
- 3.5 Mb of on-line electronic help files are shipped with SAPHIRE for Windows
- SAPHIRE FACETS provide “tips and tricks” along with full-length, how-to articles