

SAPHIRE Risk and Reliability Assessment Software

Curtis Smith
CLS2@INEL.GOV

*Idaho National Engineering and
Environmental Laboratory*

SAPHIRE Risk Assessment Software Topics

- Overview of SAPHIRE
- Important features
- SAPHIRE database structure
- SAPHIRE Users Group

Overview of SAPHIRE - What is SAPHIRE?

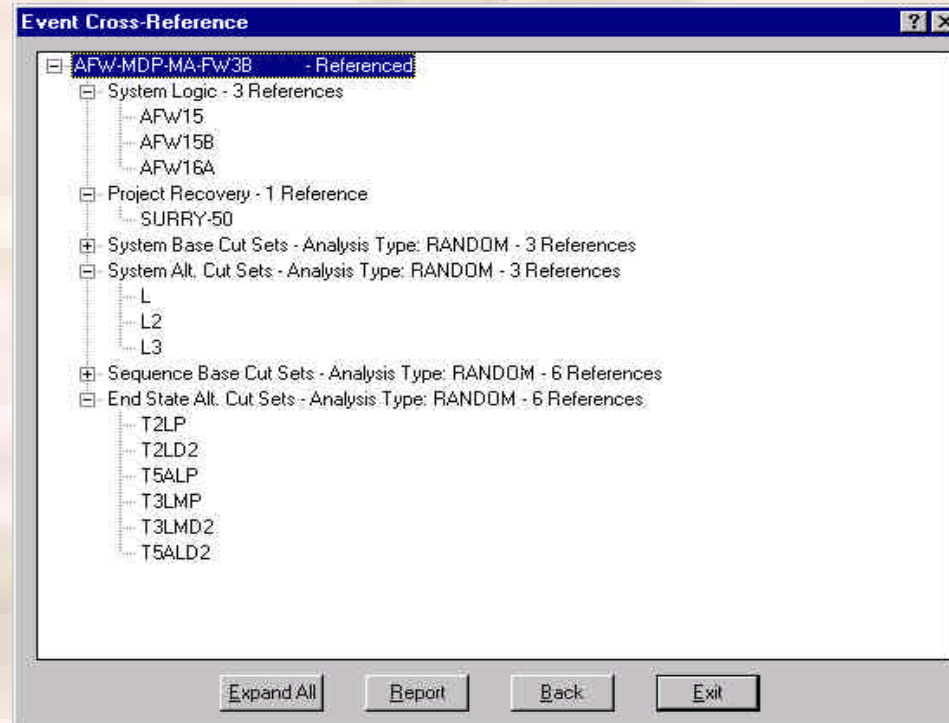
- SAPHIRE - Systems Analysis Programs for Hands-on Integrated Reliability Evaluations
- 32-bit software to perform either
 - Reliability assessment (e.g., fault trees)
 - Risk/safety (i.e., event trees, core damage frequency, Level 2) assessment
- Runs under Microsoft Windows

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.
- 1992 Creation of 32-bit IRRAS, Version 5, resulted in an order-of-magnitude decrease in analysis time.
- 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

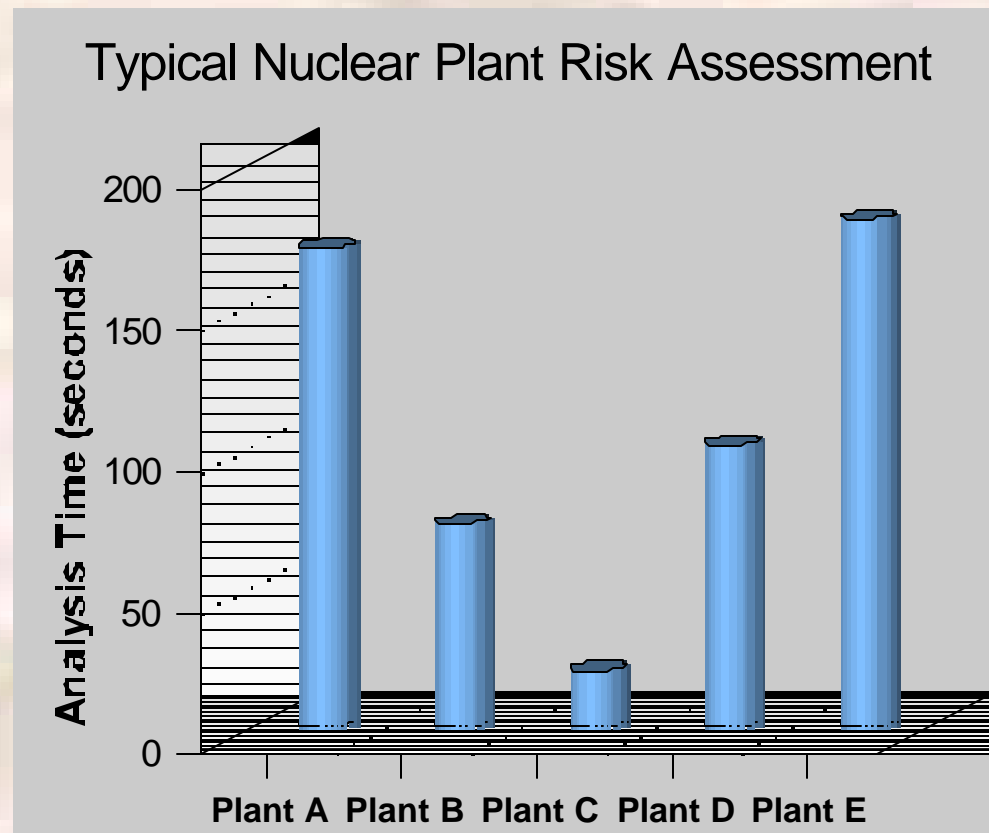
Example Operations	Example Objects
Generate Data	Data Set
Solve Logic	Fault Trees
Display Cutsets	Event Trees
Recover Cutsets	End States

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

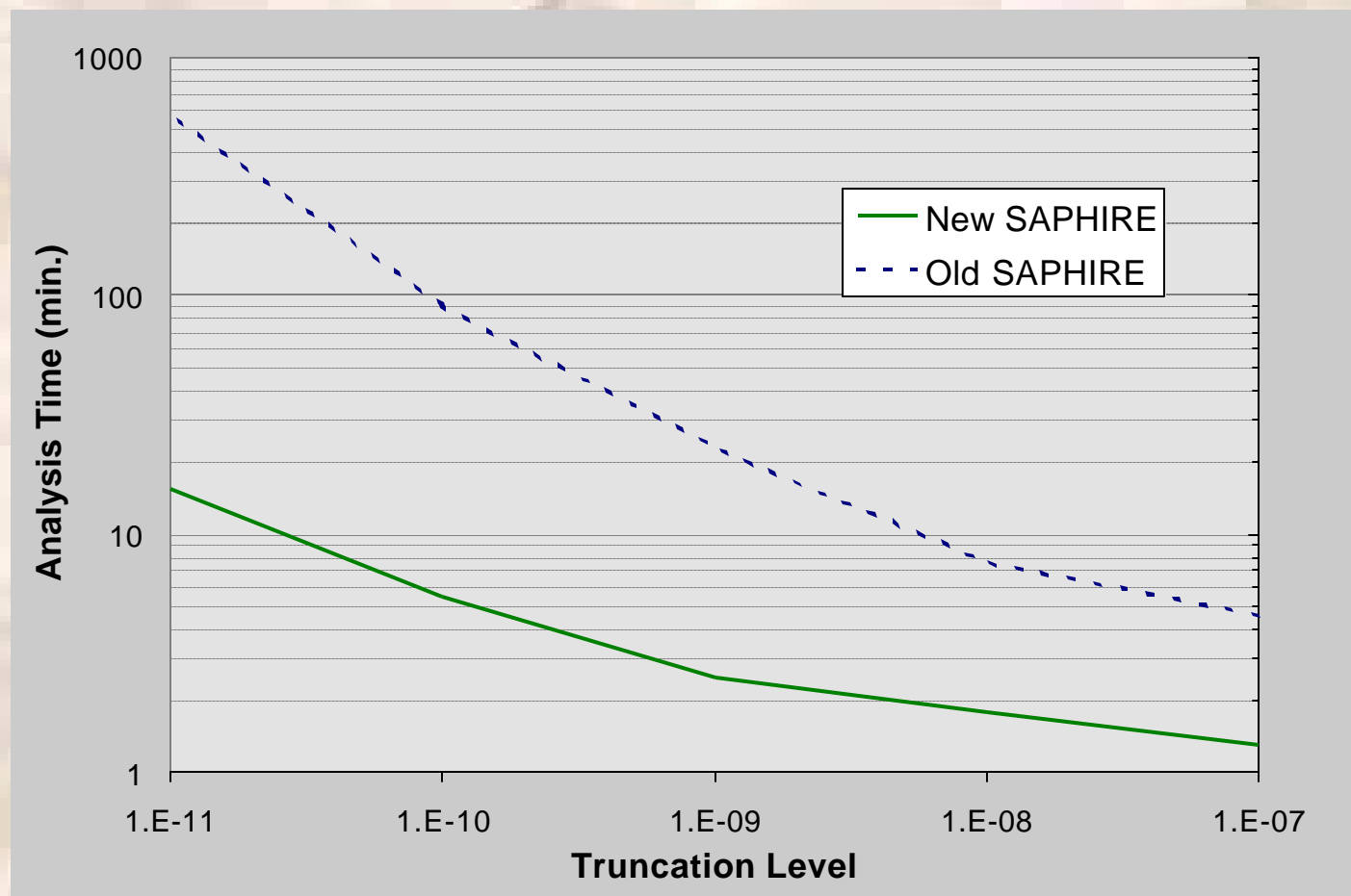
Important Features - Analysis Capabilities

- 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”

Important Features - Analysis Capabilities

- “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

Important Features - Analysis Capabilities

- 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

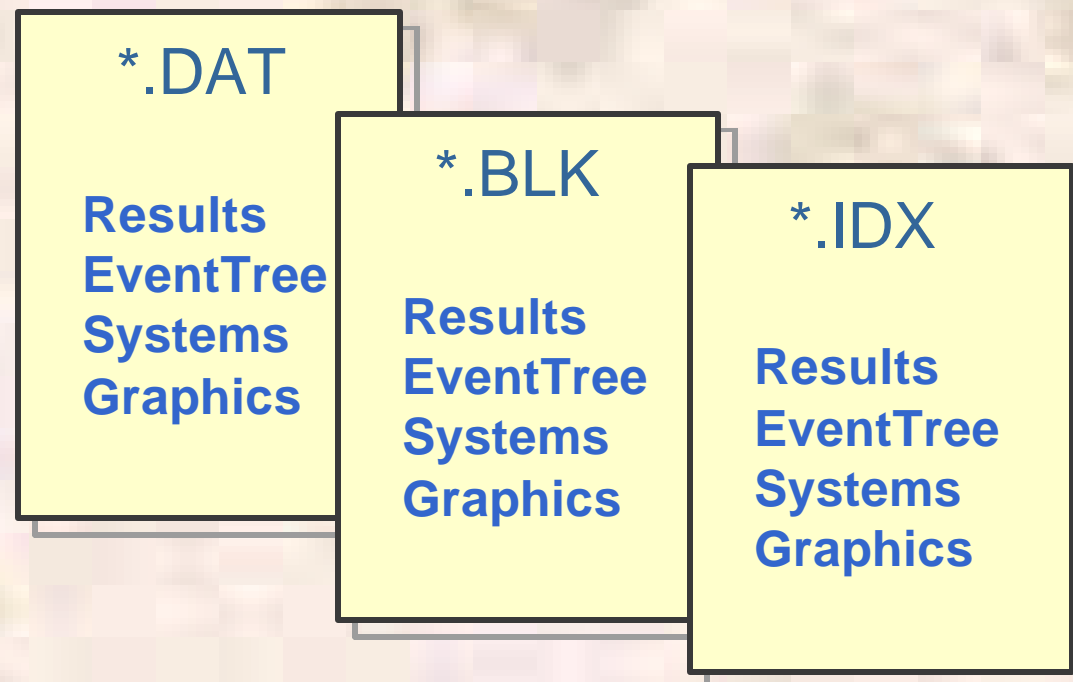
- Basic events have multiple attributes
 - Unreliability/unavailability model
 - Probability (e.g., fails on demand)
 - Fails to operate (without repair)
 - Fails to operate (with repair)
 - Fails while in standby
 - Textual identifiers (ID, descriptions, train, etc.)
 - Vulnerability (seismic, fire, 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

SAPHIRE Users Group

- 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>

SAPHIRE Users Group

- 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

SAPHIRE Users Group

- 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