



RIC 2007

PRA Models, Methods, and Tools

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Issues with Current Methods....

- **MODELING:** Fault/Event Tree Approach to PRA Modeling
 - Developed in 1970's gave shape to our risk modeling efforts.
 - Modern applications have introduced new issues
- **QUANTIFICATION:** PRA is a simplified estimate of risk
 - Simplifications to reduce calculation time (e.g., truncation and rare event approximation)
 - Risk metrics can change as a result the simplifications
- **DOCUMENTATION:** Visualization, Documentation & Navigation
 - Need to “control” PRA model, documentation, and applications
 - Demonstrate the PRA reflects “as-built” & “as-operated” plant

Solutions to these issues...

- New and improved logic modeling, quantification, and documentation techniques.
 - “Evolutionary” as opposed to “revolutionary”
 - Easy to develop, maintain, verify and review
- **Declarative Modeling** can advance current logic modeling.
- **Direct Probability Calculation (DPC) and BDD** can address many of the simplifications.
- **PRA DocAssist and KB3** can minimize resources associated with PRA documentation.

Overall Approach

- Long term (low cost) program to develop the next generation of risk tools
- Modular in nature – addressing each issue
- Prove in principle
- Develop several products with:
 - much more capability
 - Faster speed
 - Less simplification
 - “simulation” type environment

Declarative Modeling

- Allows attributes to be assigned to fault tree elements
 - Fault Tree Elements: Initiators, Basic Events, and Gates
 - Attributes include
 - Probability, frequency or conditional values
 - Settings under various conditions (True, False, or Probability)
 - Notes or comments
 - Others
- Adds flexibility to handle complex issues
 - Time phased analyses
 - Convolution
 - Conditional and dependent events
 - Simplify recovery analysis

Declarative Modeling

- Simplify model or quantification
 - **Recovery and Post Processing (2006 - 2007)**
 - Treat dependent human actions in the fault tree
 - Specify mutually exclusive events within fault tree
 - Handle phase mission times such as loss of offsite power recovery
 - Simplify Logic Model
 - Plant alignments and frequency without using additional events
 - Specify initiating event impacts without repetitive houses/events
 - Documentation and Reviewability
 - Notes to clarify logic development
 - Fault tree viewed by attributes, such as initiator specific trees or with and without dependent human actions or recovery

Direct Probability Calculation (DPC)

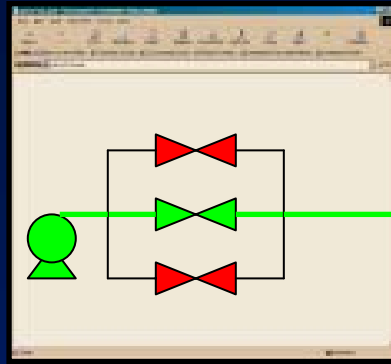
- DPC and Binary Decision Diagram (BDD) differ from minimal cutset upper bound (MCUB)
 - Rare event approximation is not used
 - Negated or “not” logic is handled appropriately
 - Provide an “exact” answer
 - Require considerable computer resources
- BDD cannot quantify large fault trees
- DPC produces no cutsets but can quantify to very low truncations

Exact Solution (ES) Research

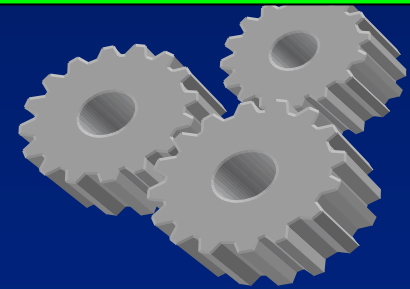
- Combination of available approaches
 - Determine truncation limit for MCUB
 - Use DPC to determine “exact” solution
 - Use BDD to determine cutset values and importances
- PROs
 - Fast “exact” solution with cutsets and importances
 - More stable importance measures
 - Removes or reduces simplifications
- CONs
 - Multi step process
 - Relatively slow (only DPC)
 - Some simplifications will remain

The Vision...“PRA Simulation Environment”

Visual Interface



Quantification Engine



Declarative Modeling



Project Tree:
 - Event Trees
 - Fault Trees
 - IEP
 - Component -> PFD
 - System -> C2

System level assumptions:
 1) The positions of the containment isolation valves in normal power operation are assumed to be the initial state of the valves, and are shown in the simplified flow diagram (Section 3.1).
 2) The containment isolation system is required to perform its isolation function on demand during all plant operating modes. "Fail on Demand" is the only failure mode modeled for the isolation valves in the analysis. The failure modes such as "stuck open" or "stuck to remain closed" are not modeled due to low probability.
 3) The "Four Tech. Spec." window for restoring the operable isolation valves to operable status is considered negligible due to the small contribution to the unavailability of the containment isolation system. Therefore, maintenance for the C2 system during normal operation is assumed to not affect the system function.
 4) Containment generators that are not used during power operation and are isolated by normally closed or latched closed manual isolation valves are not included in the analysis, because the probability of significant leakage of a closed valve is considered to be very low.

Component level assumptions:
 1) A fault assumption for this component



PRA DocAssist™ Database



PRA DocAssist™