"Smart SAMGs"
Dynamic, robust severe accident management guidelines

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Risk and Reliability Analysis

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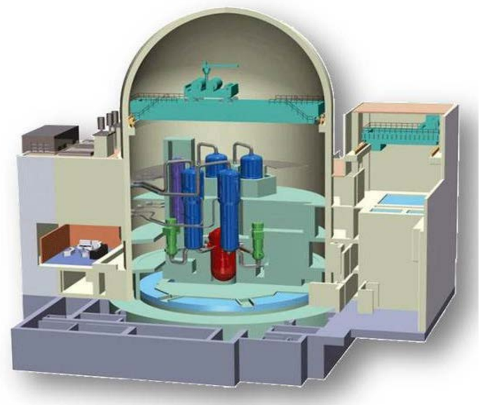
Introduction

Problem: Nuclear power plants (NPP) can exhibit non-intuitive responses during severe accidents (e.g., Fukushima).

Existing Solution: Expert knowledge is used to create SAMGs to prevent core damage or radiation releases.



Proposed Solution: Simulate potential accident responses (similar to examining parallel universes in Star Trek™) and use automated reasoning to guide operators to robust responses to plant conditions.

Objectives

Enhance nuclear safety by building comprehensive, context-specific severe accident management guidelines

Reduce human error by providing operators with detailed, specific guidance for fault detection and data gathering

Leverage advances in simulation and computation to **build comprehensive understanding of accidents, before they happen.**

Approach

Generate spectrum of accident scenarios

Goal: Use modern computational tools to identify potential accident scenarios and human interfaces

Method: Discrete event simulation

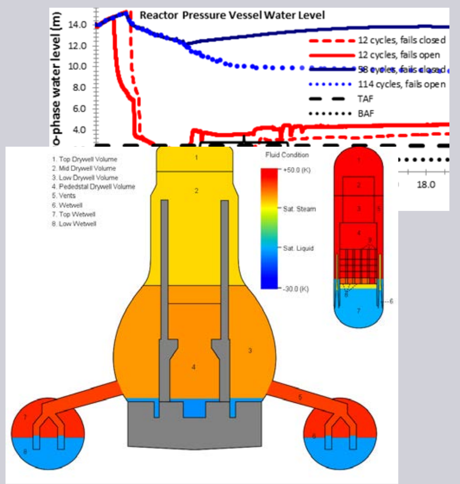
Tool: The ADAPT simulation scheduler

Simulate plant physics for each scenario

Goal: Predict range of plant parameters for known system faults

Method: Multi-phase thermal fluid and structural modeling

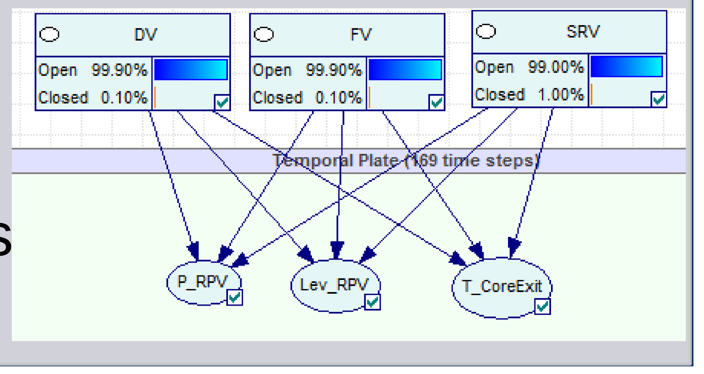
Tool: MELCOR Multi-physics simulation



Encode simulation results in a generic knowledge base

Goal: Build a knowledge base relating known plant parameters to known system faults

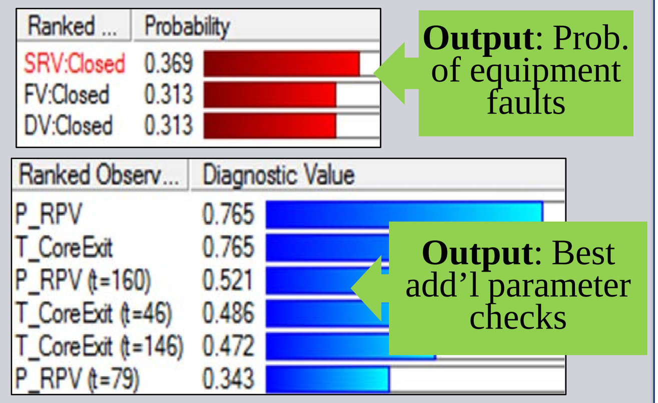
Method: Probabilistic graphical models (Bayesian Networks)



Operators query knowledge base for specific conditions or faults

Goal: Streamline operator response and determine the adequacy of current instruments.

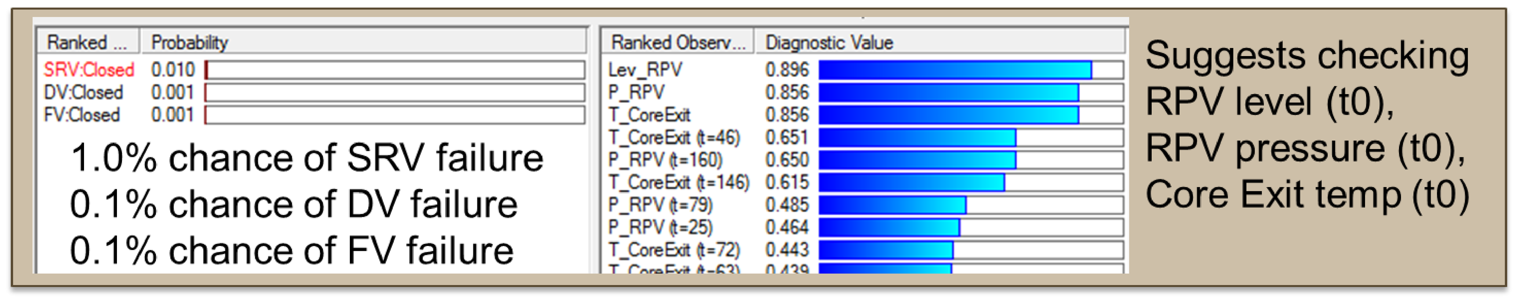
Method: Formulate the cross-entropy of new information and use differential diagnosis to focus the operator on the correct instruments.



Example

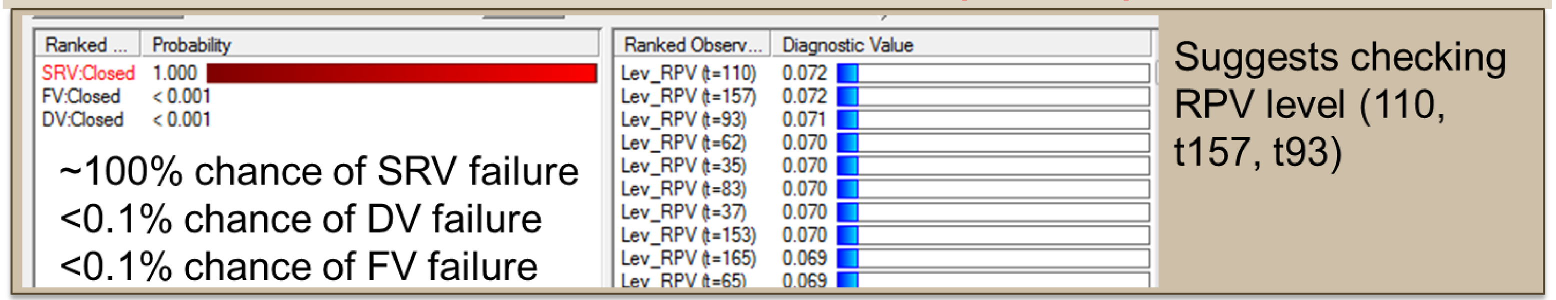
Assisted diagnosis

Generic accident conditions:



Condition-specific guidance:

For condition: RPV Level (time 0) = low



A single key observation can dramatically change belief about plant status and value of additional data /observations

Significance

New paradigm for accident management: evidence-based, automation-assisted guidance

- Comprehensive –thousands of scenarios
- Detailed – Examines accidents that experts may overlook.
- Defensible – Built on the best knowledge
- Faster-than-real-time – allows operators to project future states, and predict future impact of various corrective actions.

Implications for SMR safety management

Inform I&C performance criteria

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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