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Dynamic PRA Tool EMERALD Update



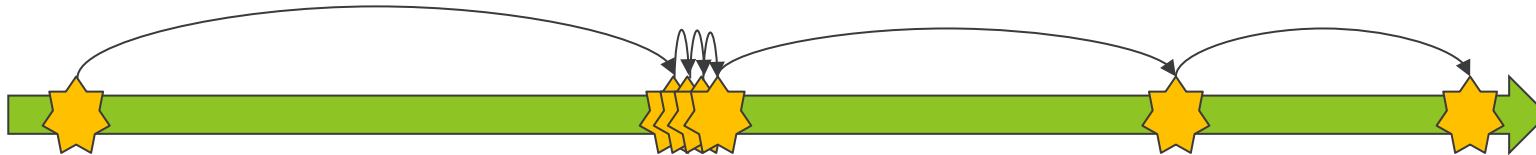
History

- (2005) Laboratory Directed Research and Development project - prove DPRAs methods
- (2016) LWRS – Updated with web modeling framework and ability to link to other analysis applications
- (2017- present) LWRS – Used for several projects, advanced flooding analysis, multi hazard, human reliability, physical security
- (2019) Open source and public facing user interface (UI)
- (2024) Version 3, updated UI with modern React Framework and new modeling capabilities

What is **EMRALD**? (Event Model Risk Assessment using Linked Diagrams)

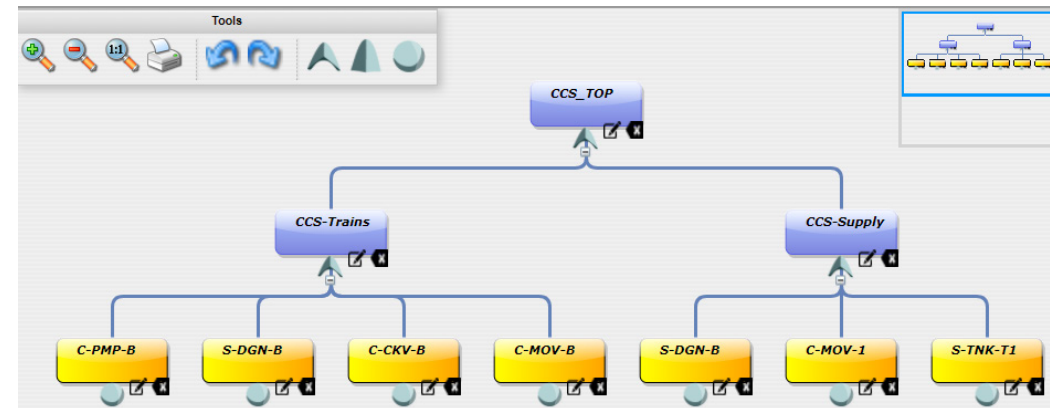
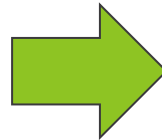
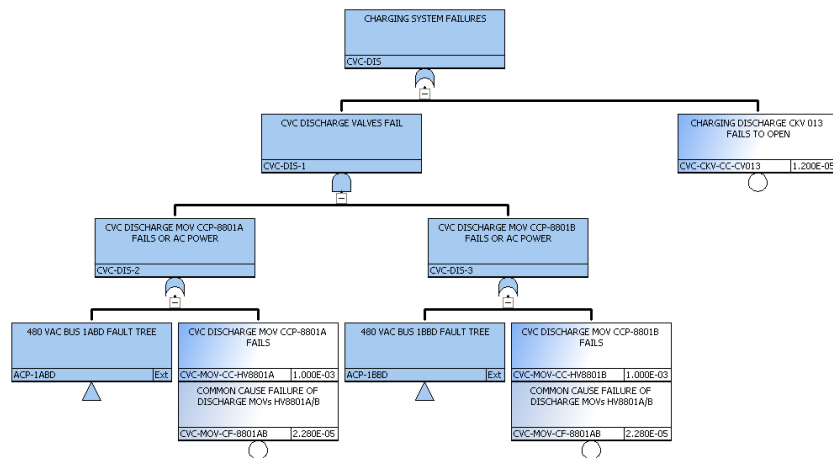
Dynamic probabilistic risk assessment (PRA) model based on a three-phased discrete event simulation.

- No time steps
- Jumps to next thing that happens in time.
- Monte Carlo sampling.
- Good for long and/or short time jumps.



Why EMERALD

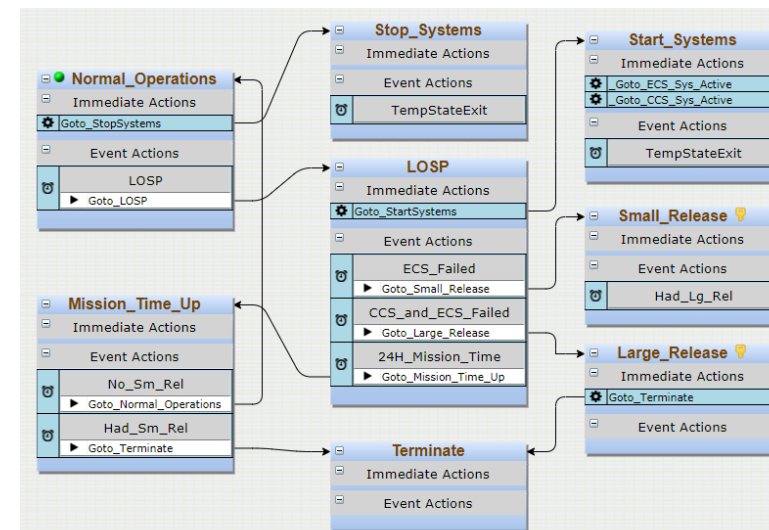
1. Combination of dynamic with traditional modeling techniques
2. Industry design focus for UI



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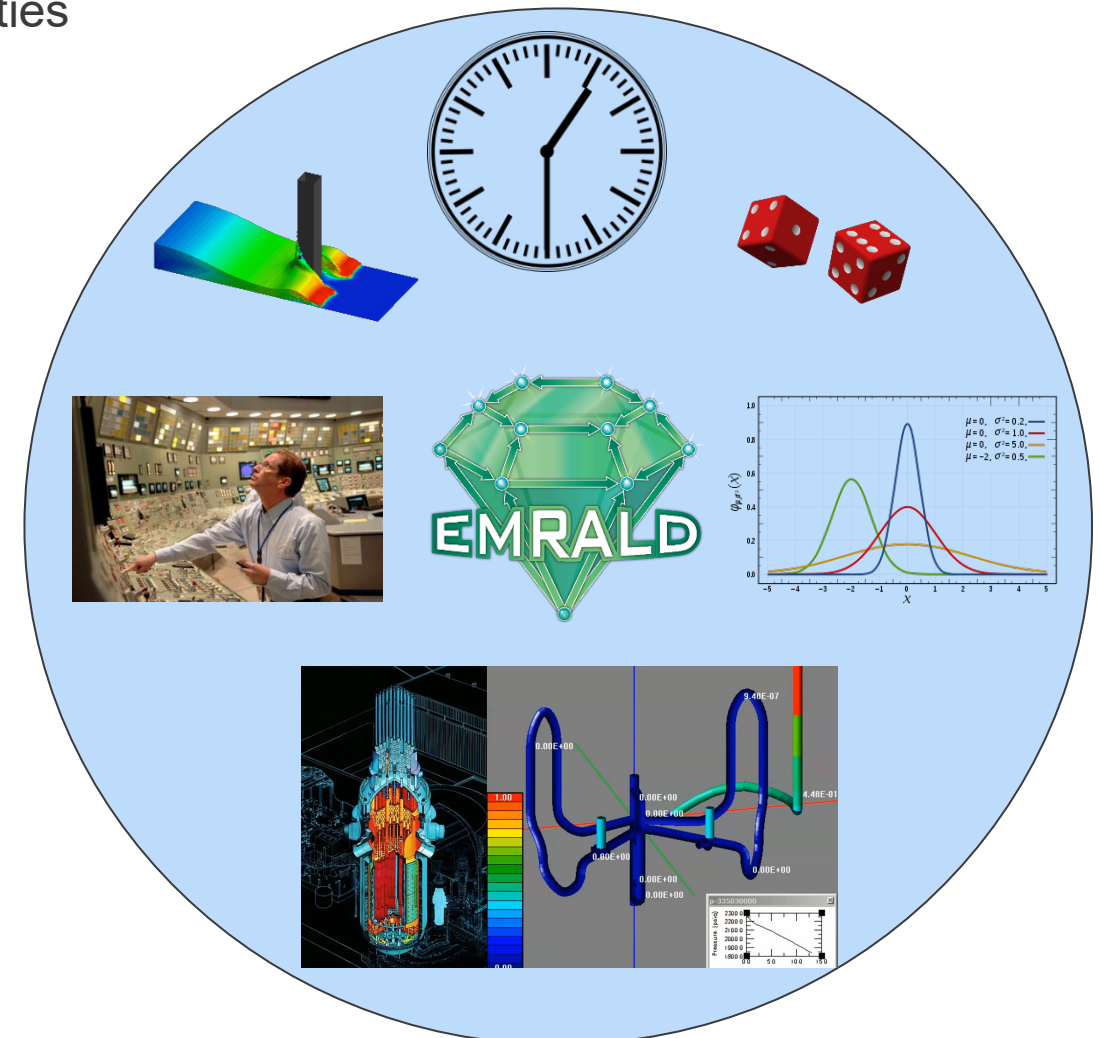
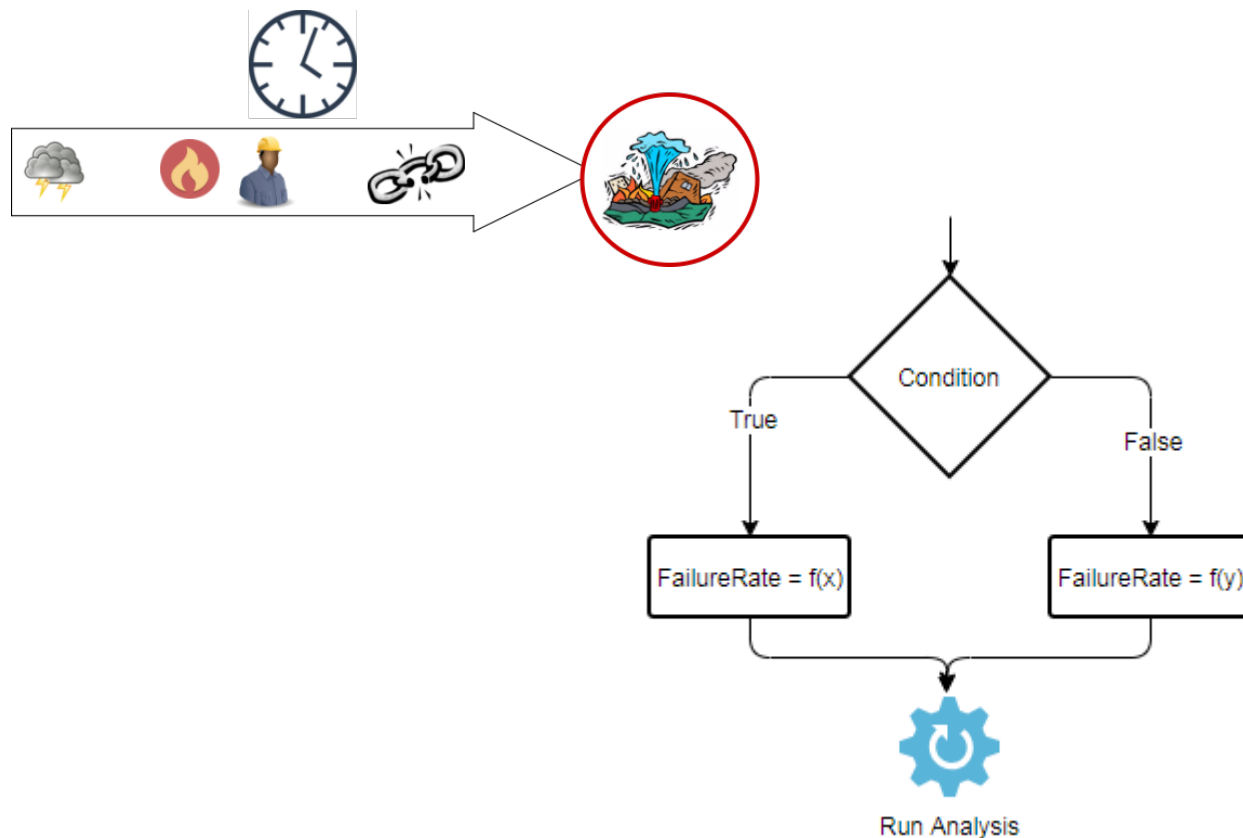
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VS



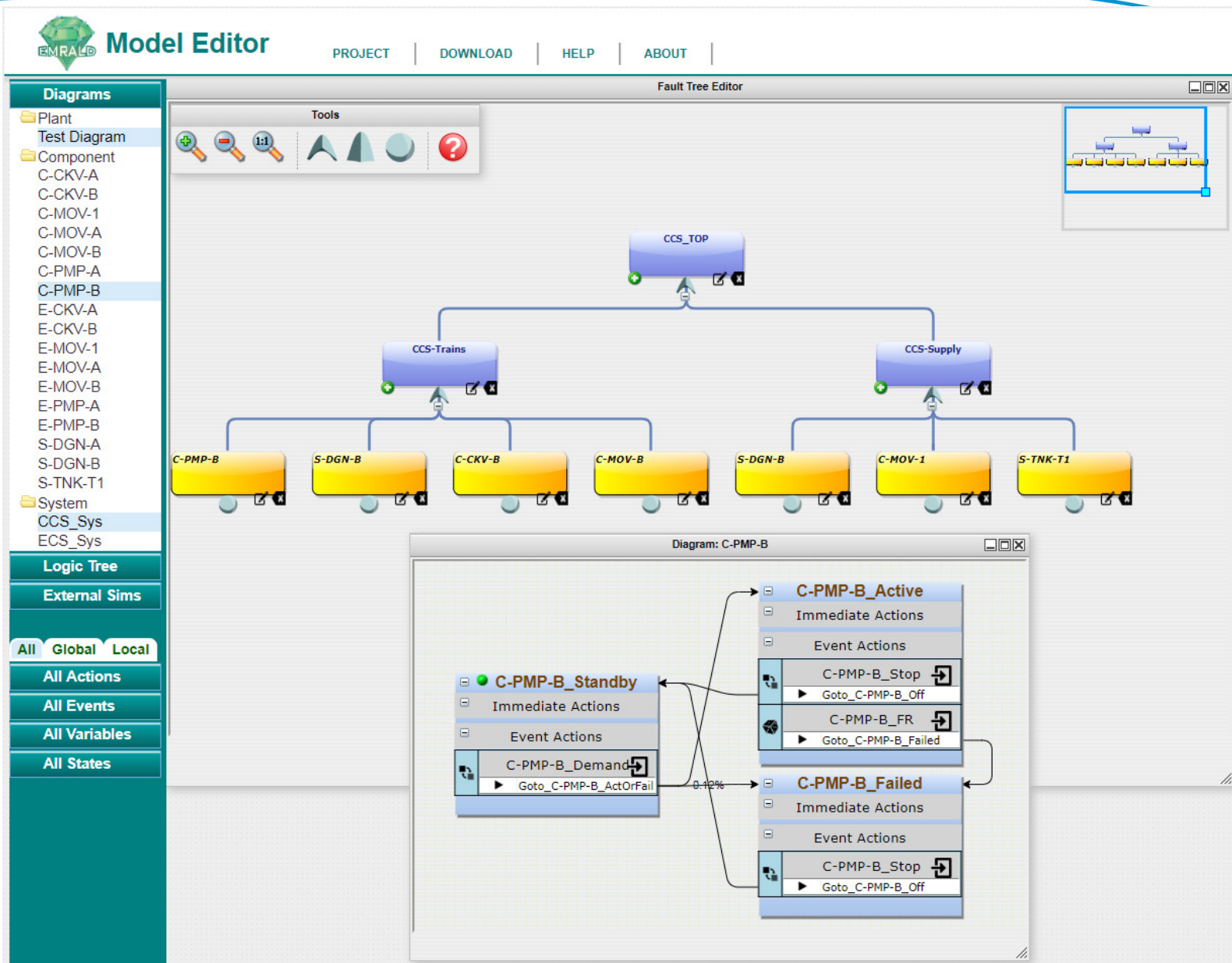
Why EMERALD (cont.)

- 3. Couple existing physics tools with Dynamic PRA capabilities
- 4. Analyze time dependent conditions
- 5. Conditionally adjust failure rates and loops

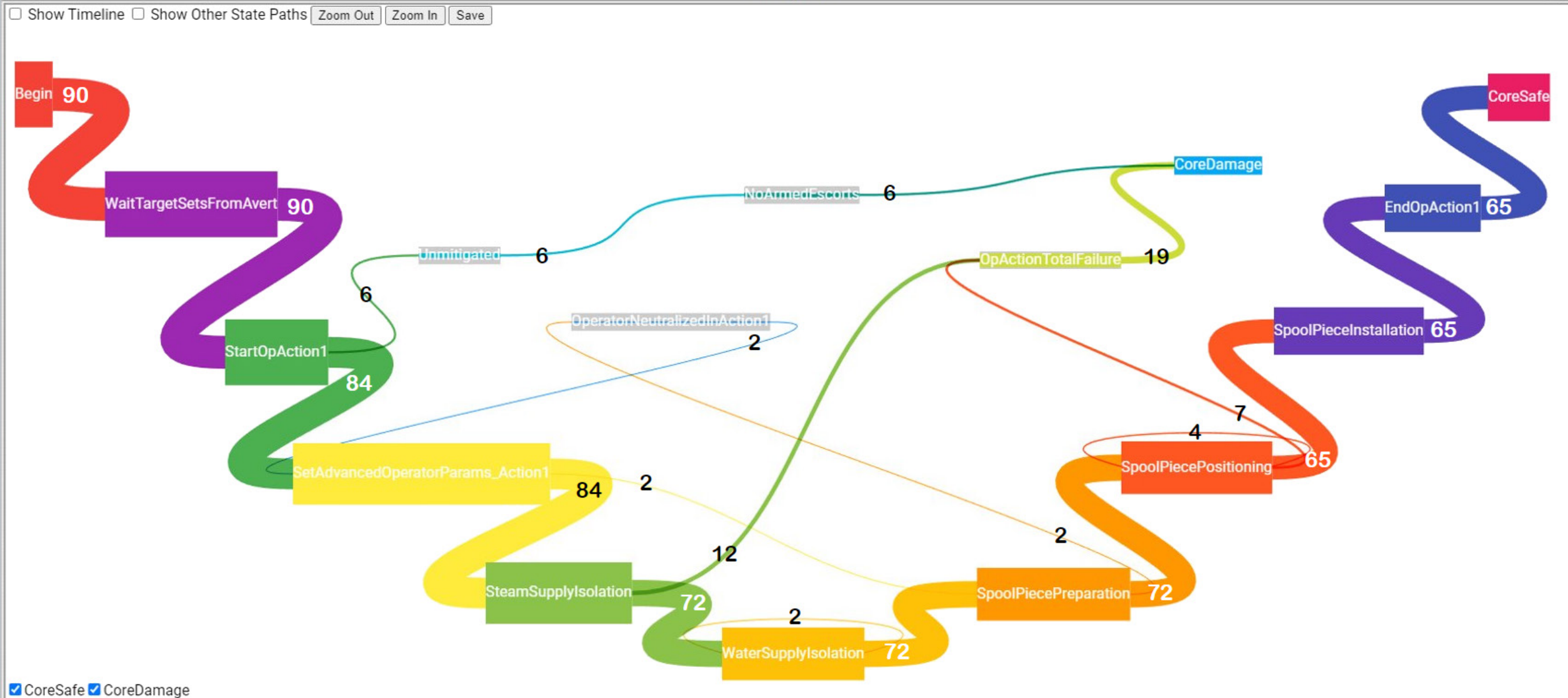


Graphical Modeling

- Web Based
- Drag and Drop
- Online Documentation



Sankey Results Visualization



Use Cases

Models that include any of the following:

- Operator action modeling
- Self checking systems
- Recovery models
- Complex on demand system modeling
- Down-time or up-time estimation
- Degraded equipment repair strategy optimization
- Dose exposure calculations
- Automated control evaluation

Can be calculated in EMRALD and used as a rate in traditional PRA

User Interface Upgrade

The old UI used unsupported Angular JS and MX Graph.

Goal: Develop a new UI while maintaining user interactions as much as possible but easier to maintain packages and update process.

The main tools used by the new UI:

- React – main website architecture
- React Flow – Graphing tools
- Vitepress – Documentation

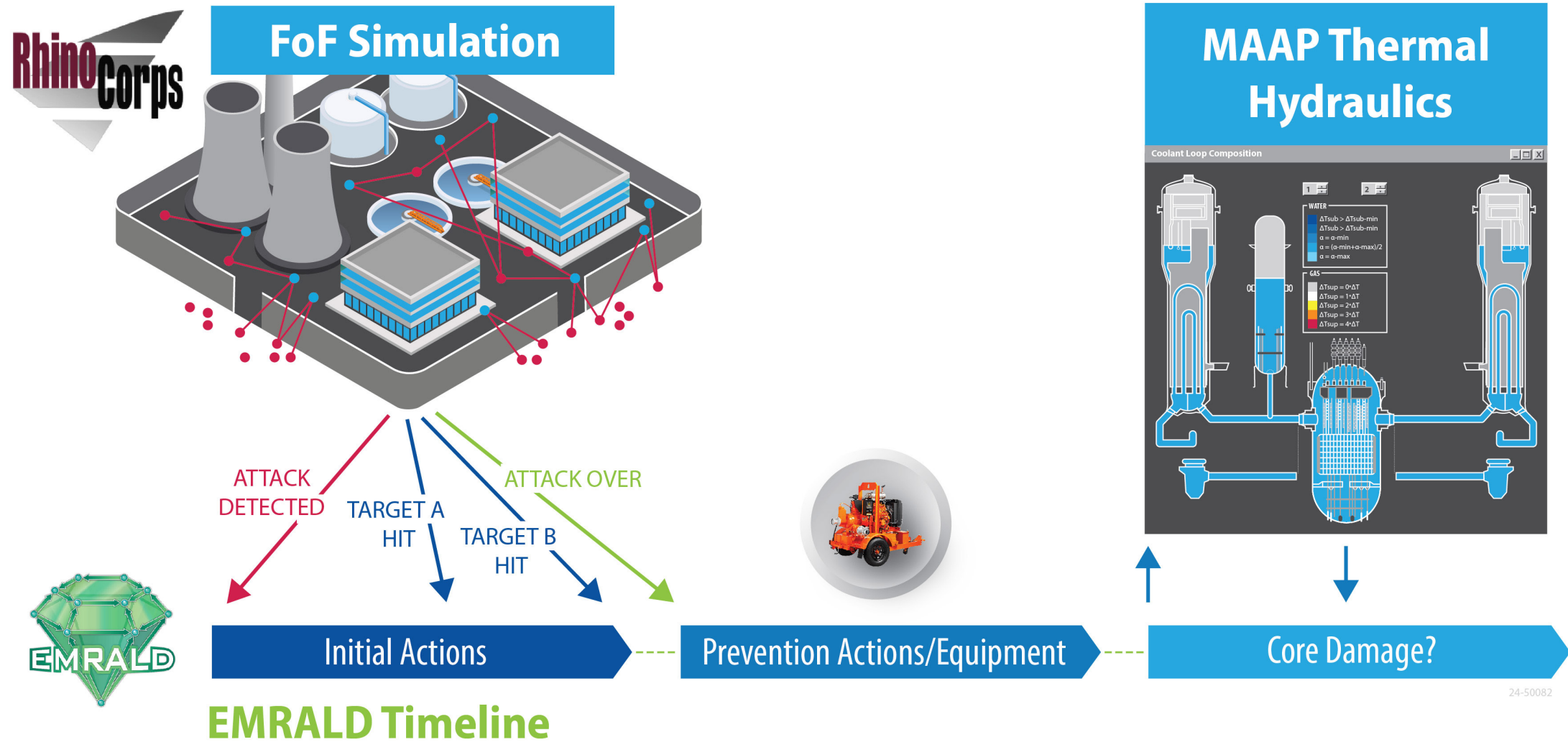
Key design process

- Model Schema developed and used many processes and auto generated documentation
- Common upgrade code for UI and backend solver



Current Use Cases

Physical Security Case Study



Example Post Reduction

Adversary Success % (Exaggerated Scenarios)		
Scenario	FOF Sim Results	Added EMRALD Sim
	Primary Targets Hit	Core Damage
A	51.2%	4%
B	68.4%	13.4%
C	52%	14.4%
...
D	26.4%	25.2%
E	71.6%	37.6%

Possible response force posts reduction ~20%

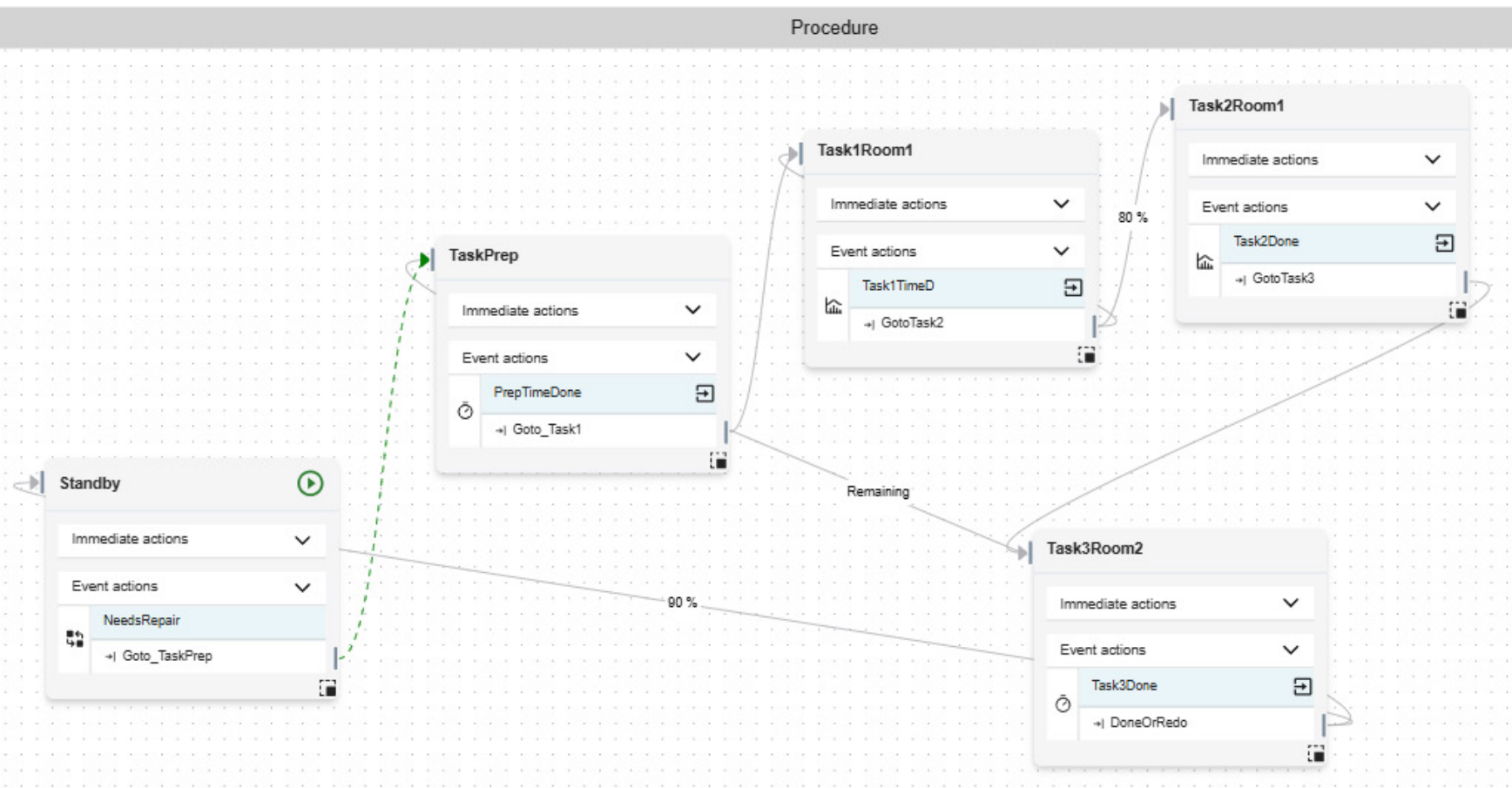
Risk Informed Dose Analysis

- Using higher enriched fuels causes higher dose calculations.
- Could cause more non-compliance instances.
- Risk informed dynamic methods = margin & relaxed equipment performance requirements.

How it works

- Dynamic EMRALD model of scenarios captures plant behavior and operator actions.
- Cumulative variables tracks dose rates for different task steps.
- EMRALD simulation results provide an average, 5th, 95th and uncertainty for the scenarios.

Example



Edit Properties: DoseCalc

Edit Variable

Type
 Double

Name
 DoseCalc

Description

Scope
 Accrual

State Accrual Variables

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Task3Room2	<input checked="" type="radio"/> Static <input type="radio"/> Dynamic	Accrual Multiplication Factor 1000 per Multiplication Rate Hour	



Demo



Sustaining National Nuclear Assets

lwrs.inl.gov