Event Modeling Risk Assessment using Linked Diagrams (EMRALD)

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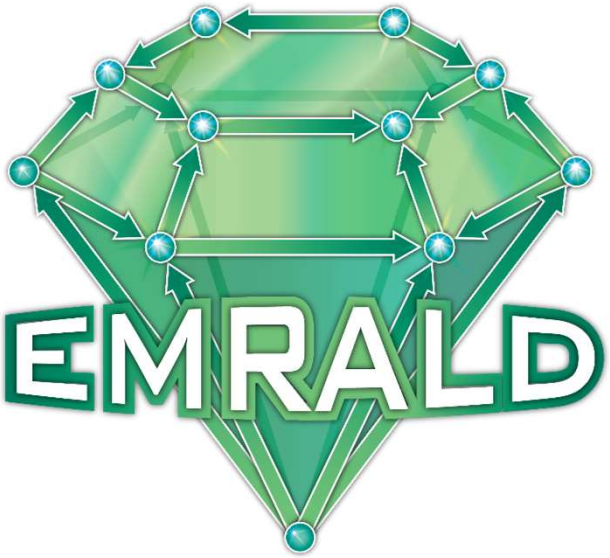

April 2018
TCF-17-13580
Oct 2017 – Sept 2018

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EMRALD Goals and Objectives

Probabilistically determine the who, how, why and when, of events leading to your system failures by simulating real world conditions.

Existing Capabilities

- Solve engine
- Specialized coupling 1-way and 2-way (with flooding simulation Neutrino)
- Demonstrations of nuclear power plant scenarios

Potential for multiple industries

- Electric grid
- Hydro
- Oil and gas

What is needed (TCF work)

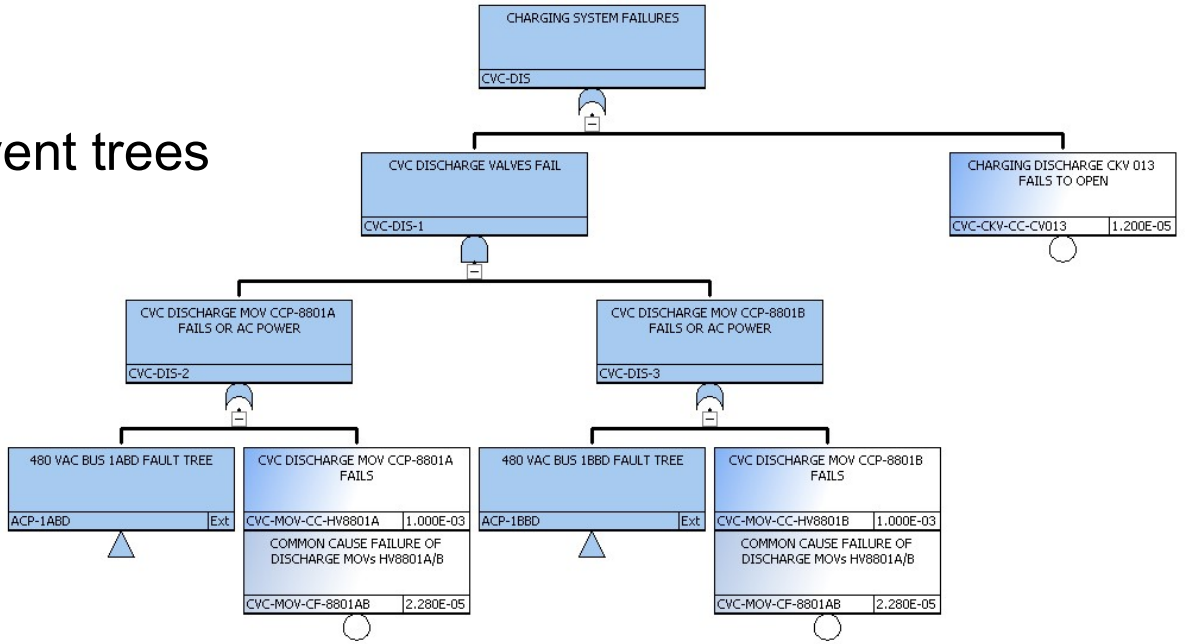
- Generic Communication Protocol & API [Feb 29, March 31]
- Web based User Interface (UI) [April 31]
- Test cases [July 31]
- Beta release [Sept 31]

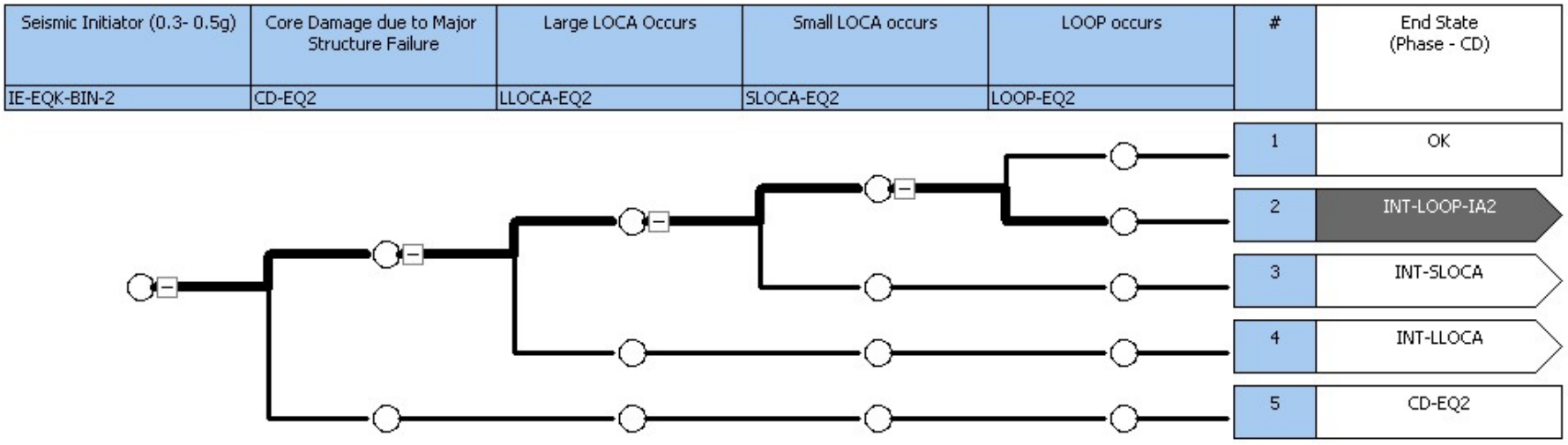
What is Probabilistic Risk Assessment (PRA)

Traditional PRA properties

- Basic events, fault trees, event trees
- Failure probabilities
- Fast calculations
- Static models
- No time aspect

(SAPHIRE developed at INL)

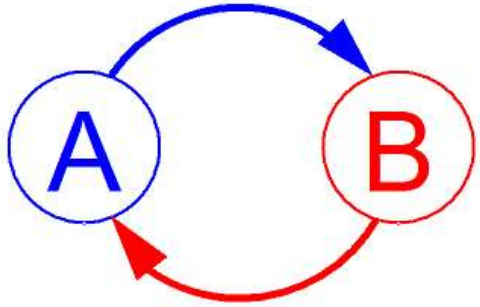


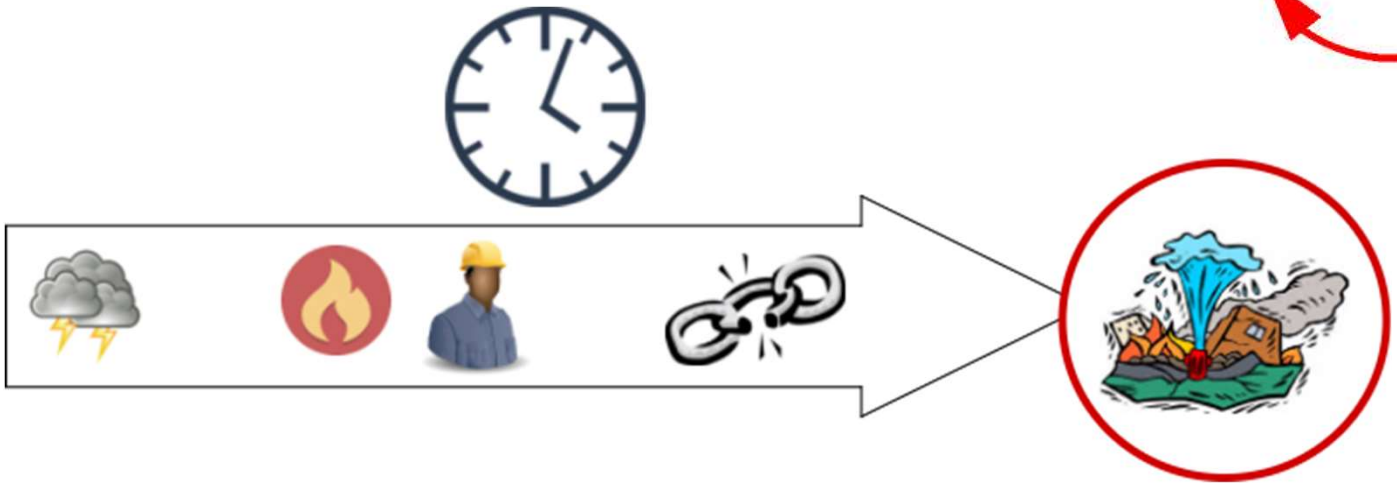


Dynamic PRA

Properties

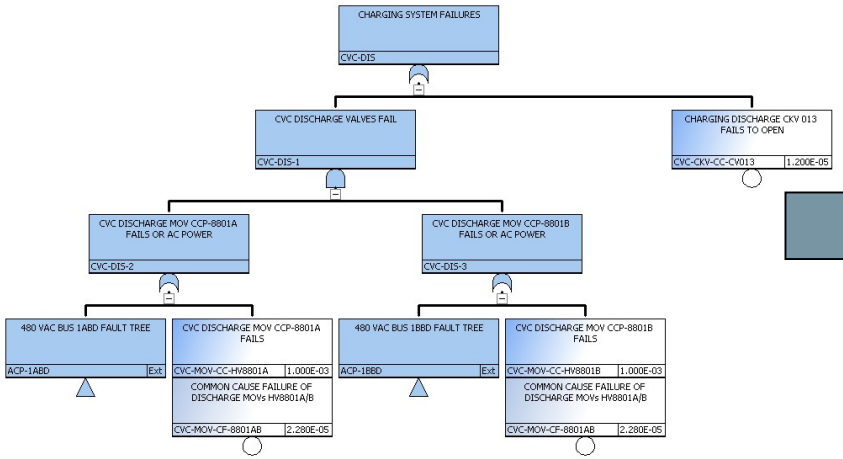
- Simulation based
- Captures feedback
- Cascade of events in time
- Couple with other simulation
- State based models
- Higher computation costs (Slower)

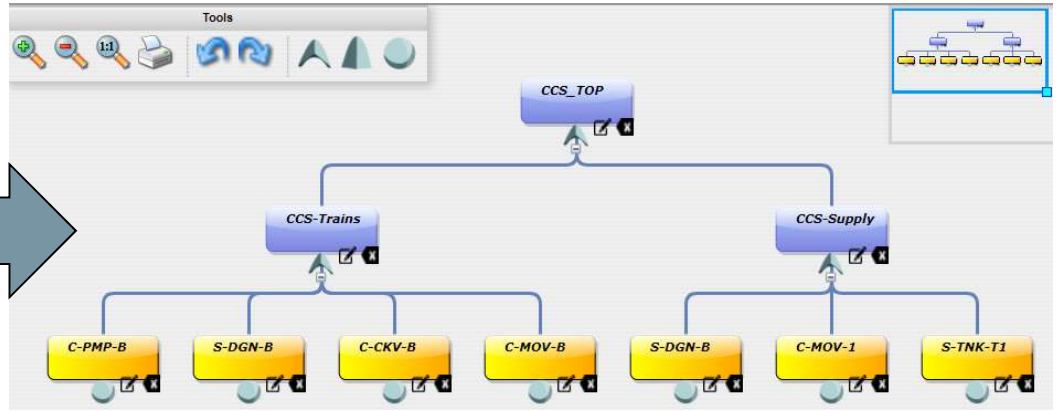




Why EMRALD

1. Combine modeling methods (existing and new PRA modelers)
2. Industry use focus for UI vs. scientific research



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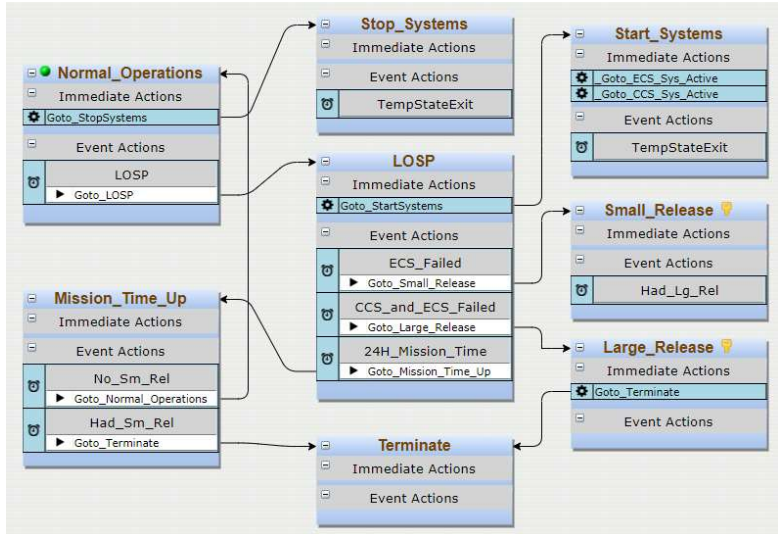
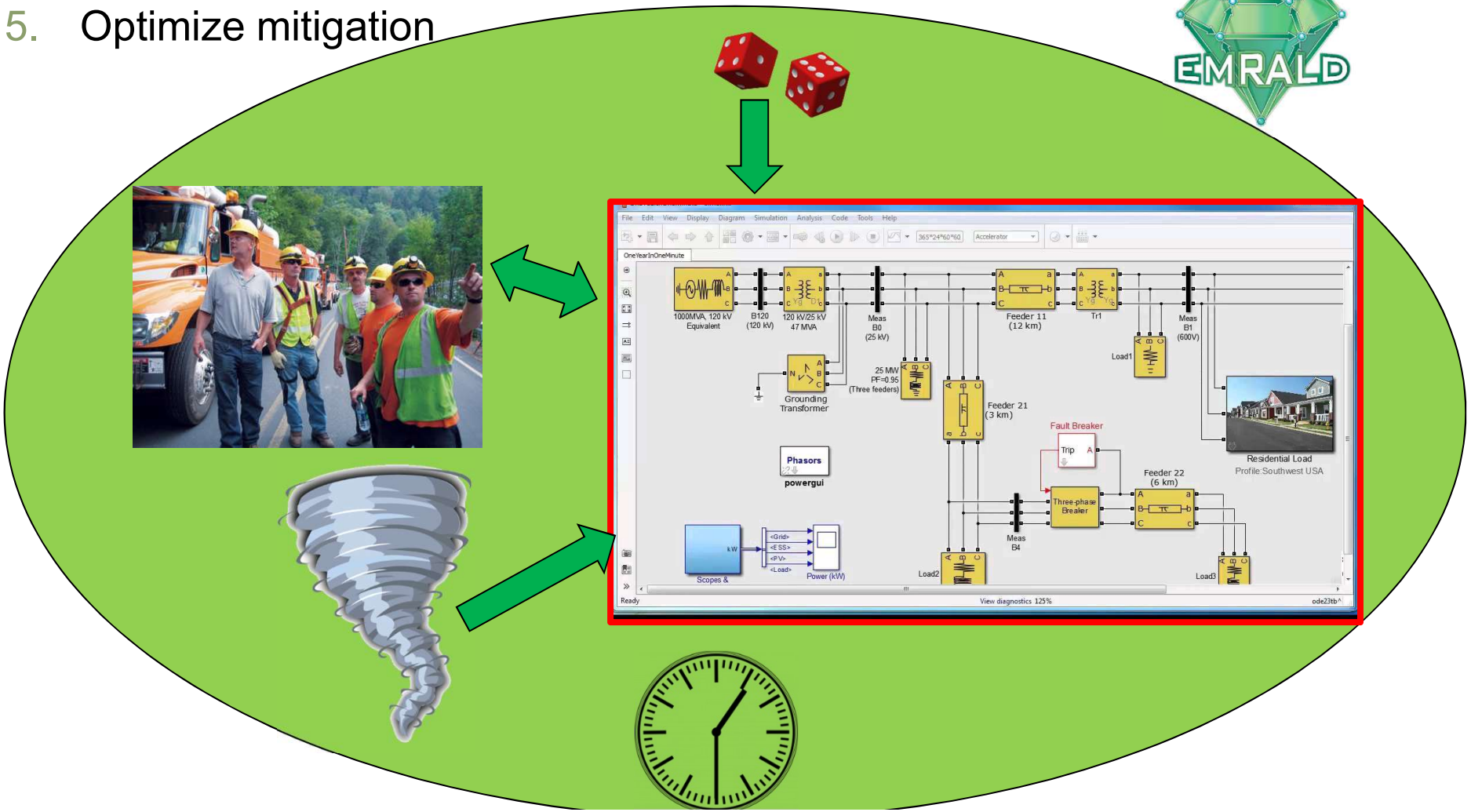


Why EMRALD (cont.)

3. Evaluate existing design models & tools in operating conditions!
4. Identify key risk contributors
5. Optimize mitigation



EMRALD Modeling - States

Types

- Start – Initiating state for a diagram.
- Standard – a normal state representing no special conditions.
- Key State – marks a state of interest, to be tracked.
- Terminal – ends the simulation run.

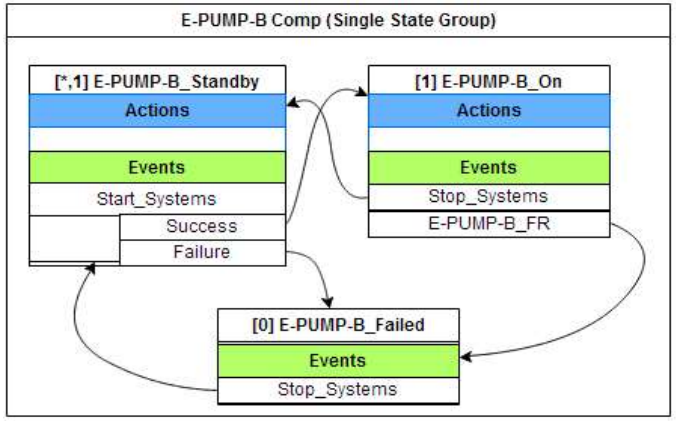
Immediate Actions Section – Actions taken when a new state is entered.

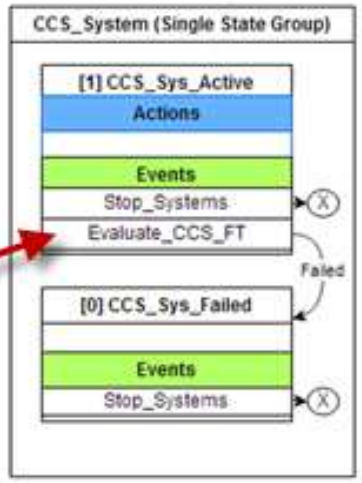
Event Actions – Events to look for when in this state and what action to take if the event is triggered. (Time or Condition)

EMRALD Modeling - Diagrams

Components

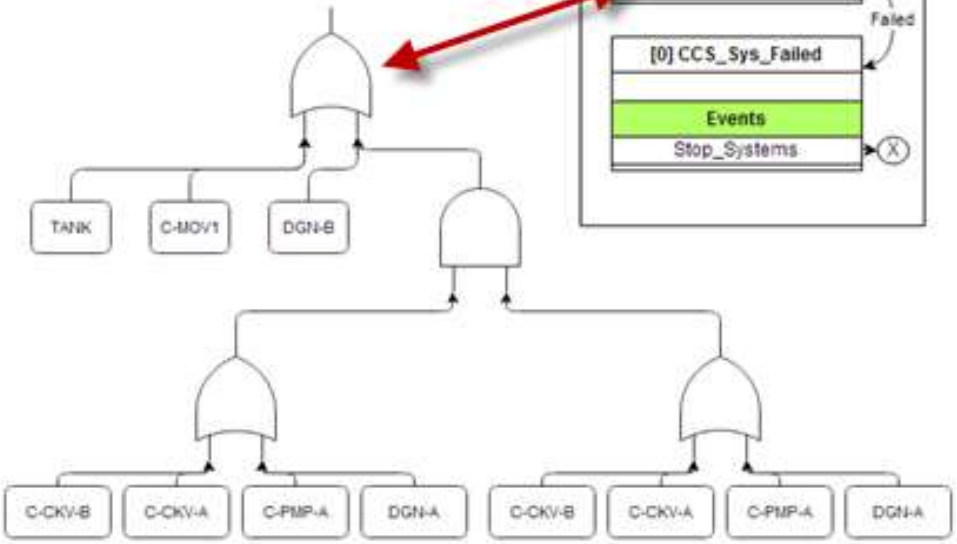
- Failure rates
- Status
- Operator actions





Systems

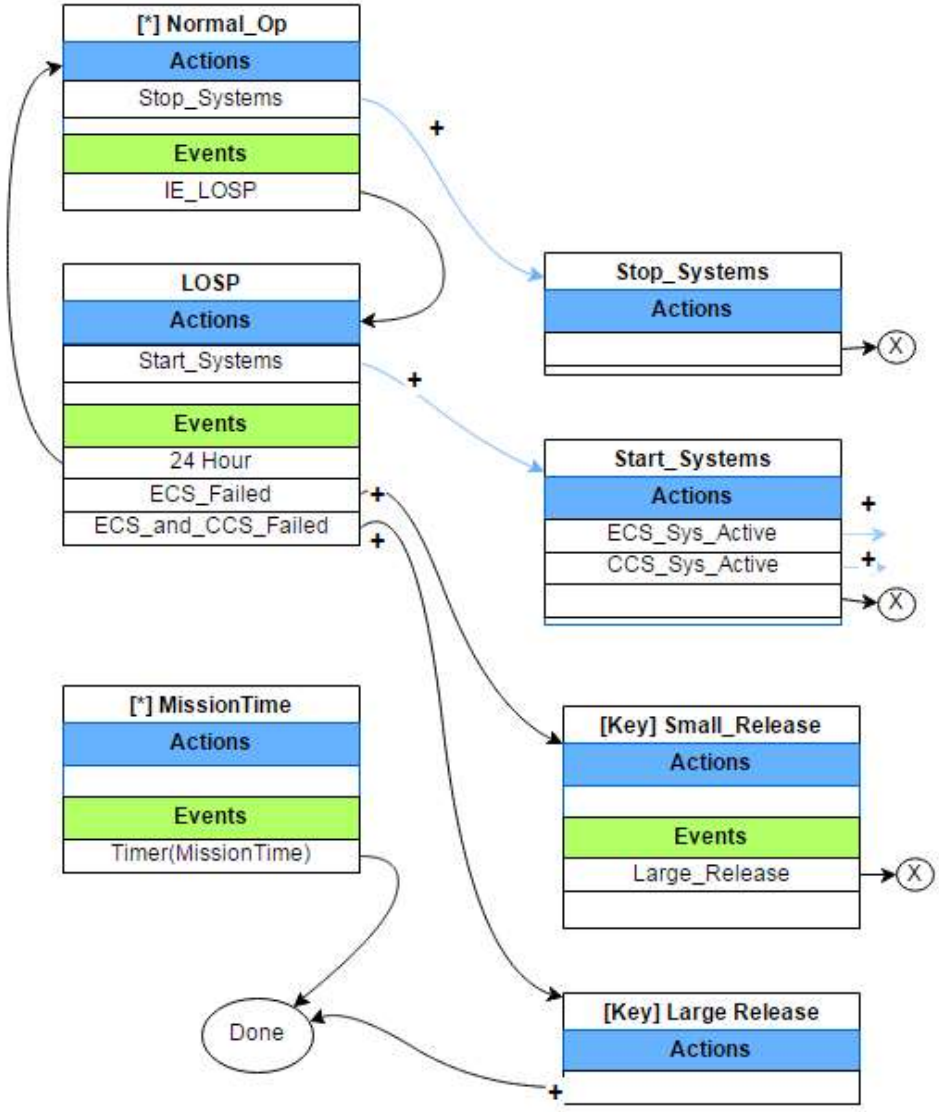
- Component interaction
- Evaluate logic trees



EMRALD Modeling - Diagrams

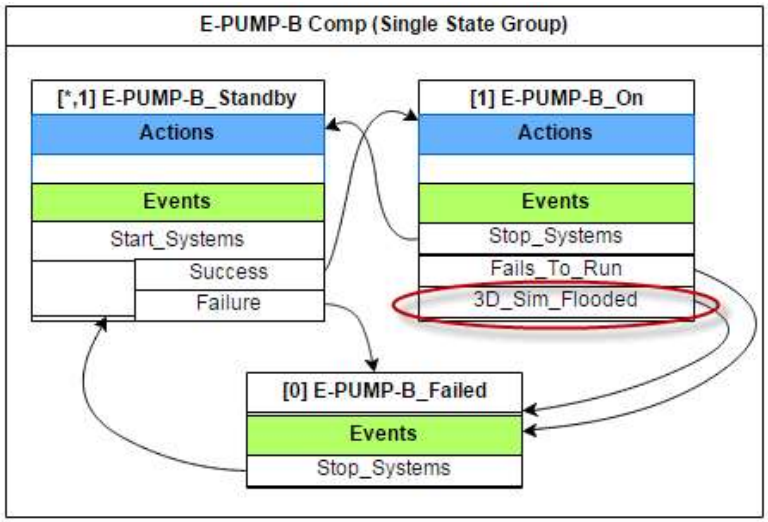
Plant Response

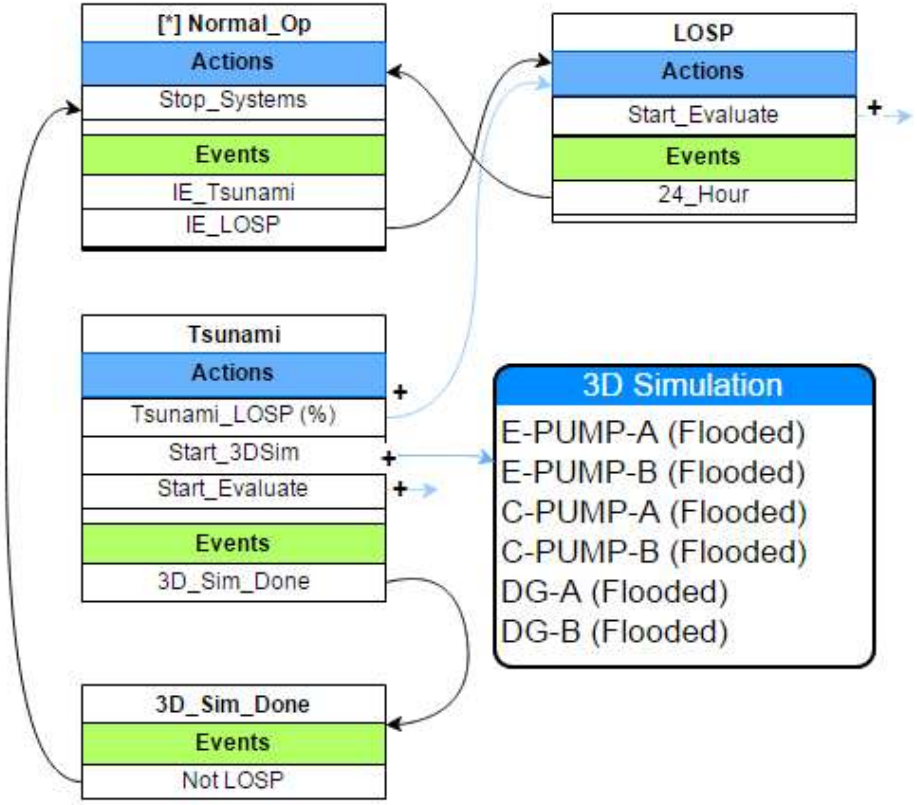
- Overall Operation
- Key States
- Mission Time
- Termination



Incorporating Other Simulations

- One or Two way coupling
- Modify external simulation through actions
- Monitor external changes through events





EMRALD Simulation

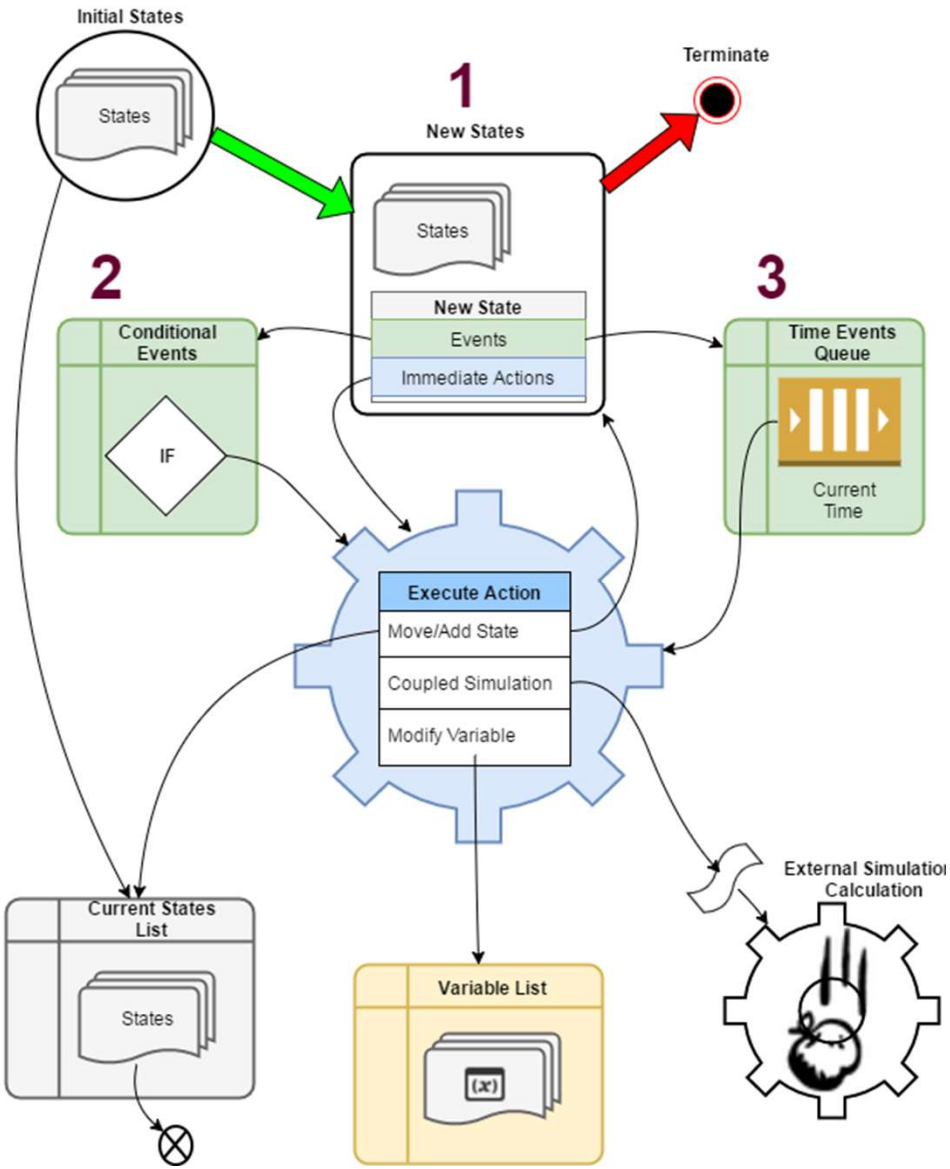
Based on a three-phased discrete event simulation.

To begin, add initial start states to Current and New States List.

1. While there are States in the New Sates list, For each State :
   - Add the Events to the Time Queue or Conditional List.
   - Execute any Immediate Actions

2. If any Conditional Events criteria is met.
   - Execute that events action/s.
   - (Go to Step 1)

3. Jump to the next chronological event.
   - Process that event's actions.
   - (Go to Step 1)

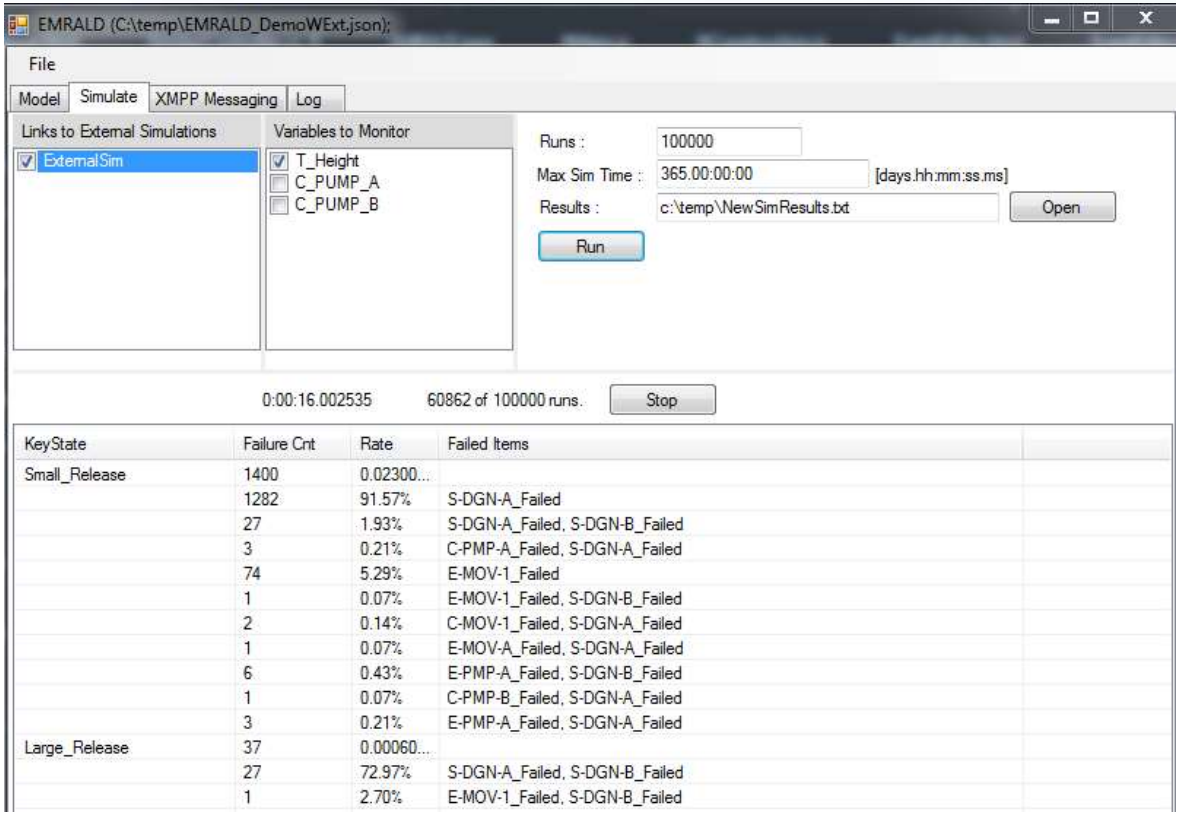


EMRALD Solve Engine & Results

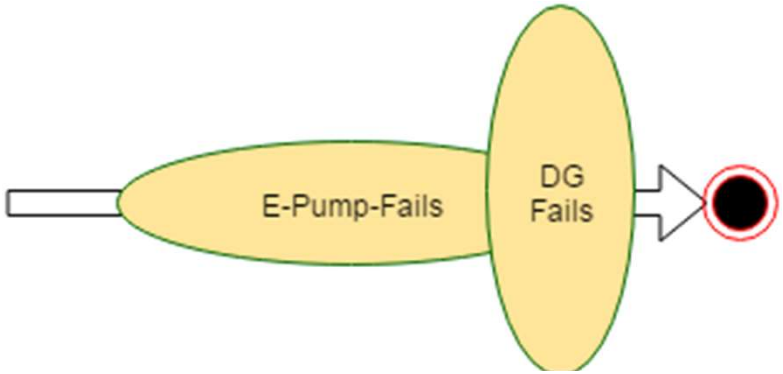
Features

- Decoupled from modeling UI
- Command line or UI
- Monitor progress
- Monitor coupled communication

Results include timing and events for component failures.

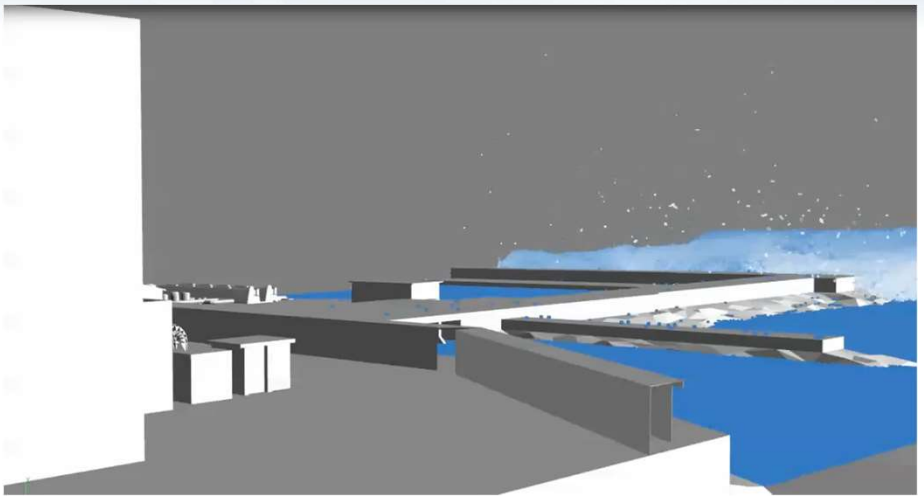


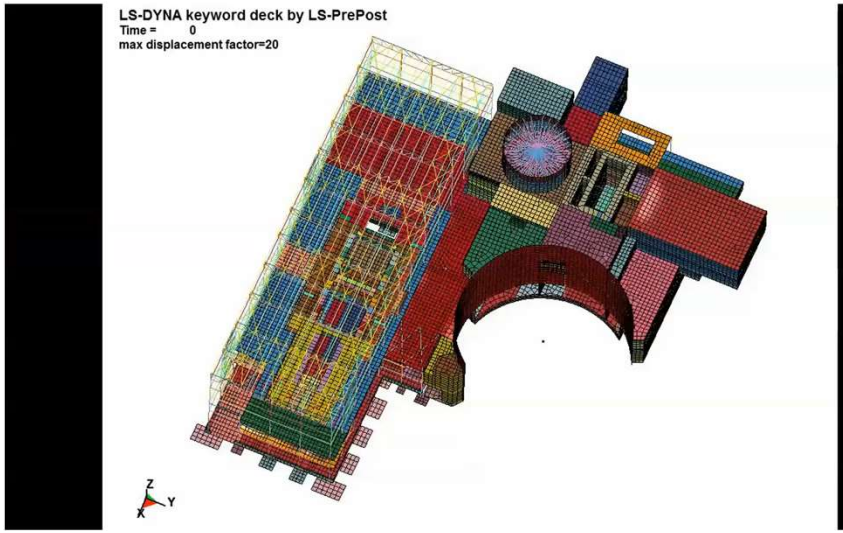
Need to develop visualization for clustering failure contributors.

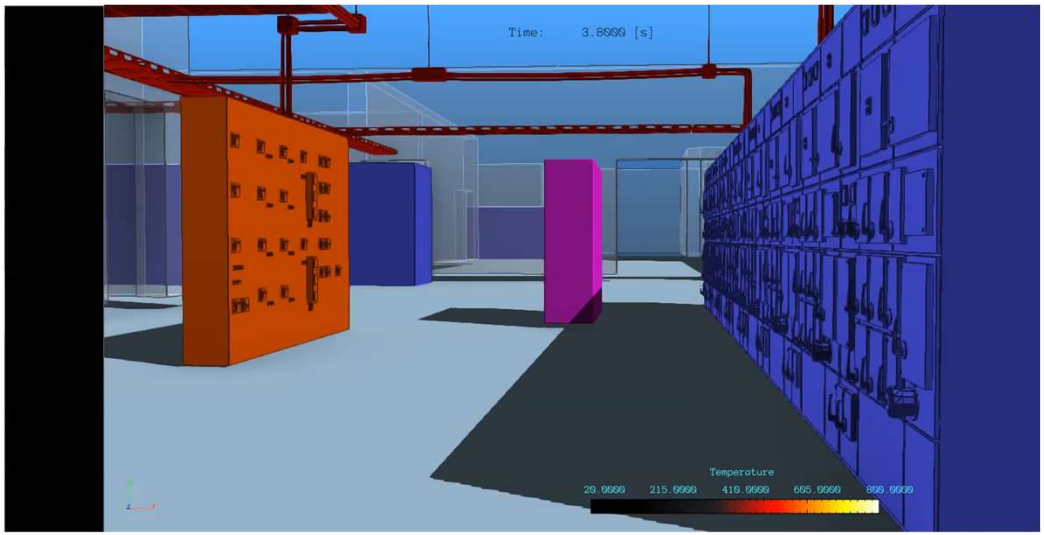


Current Applications

1. External flooding
2. Multi hazard evaluation (seismic, internal flooding, thermal hydraulics)
3. Operator procedures with fire simulation (preliminary work)







TCF Task - Coupling Protocol

Platform – XMPP (originally Jabber)

- Message-oriented middleware based on XML
- Near real-time
- Cross-Platform, Cross-Network
- Numerous language packages
- Open source

Message Protocol

- JSON - JavaScript Object Notation
- Open & expandable
- Schema validation

Status

- Example packages
- Beta ready

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  }
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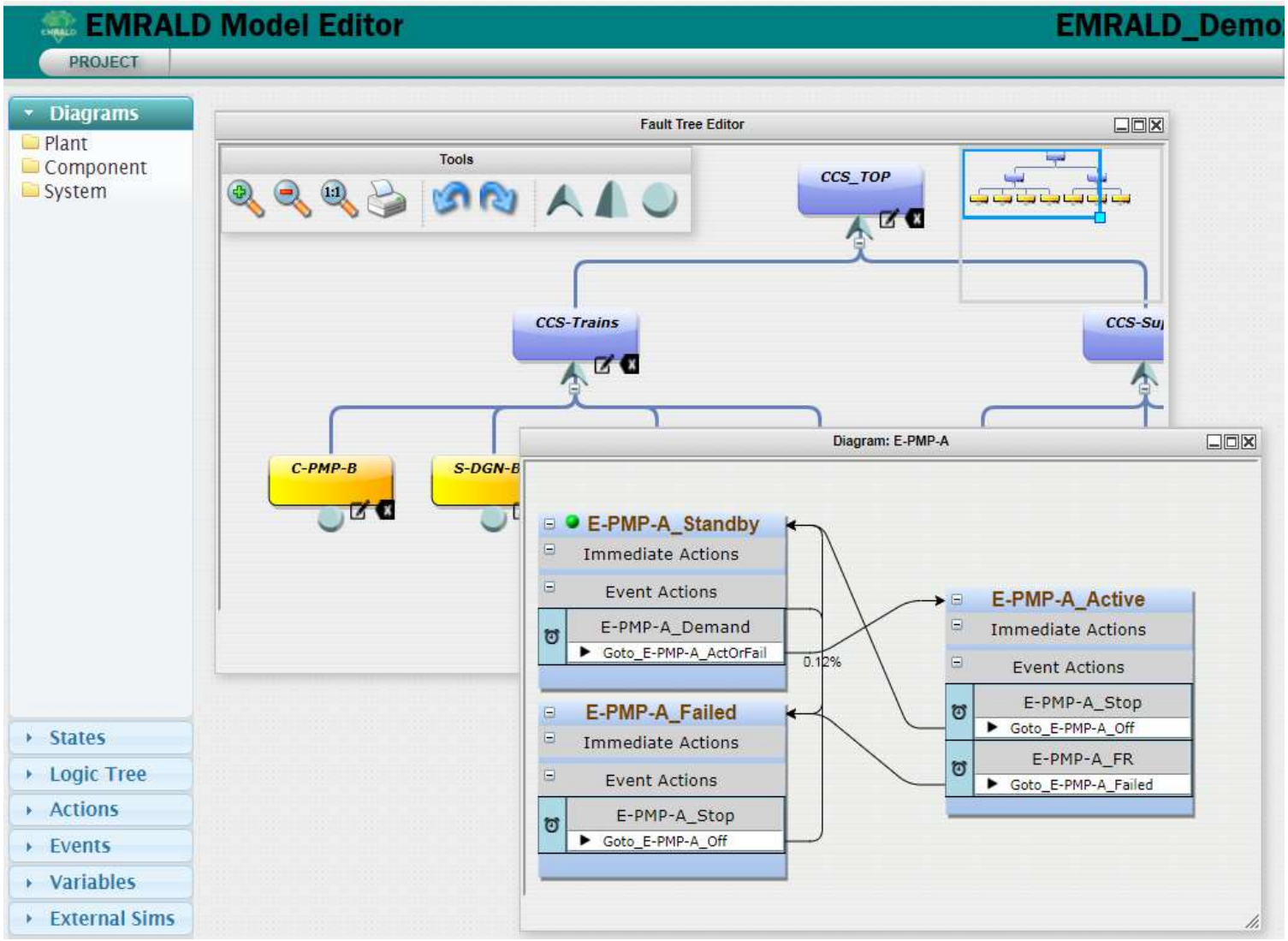
TCF Task - User Interface

Interface

- Web based
- Open Source Packages
- Customizable

Status

- ~80%



Current Commercialization Work

Small Business Innovation Research (SBIR)

- 3 requests

Grid Reliability

- Investigating a combined proposal with University of Idaho, Siemens.
- Funding Opportunity Announcement (FOA)

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Coupling features

- XMPP cross platform, open JSON protocol
- Time Step simulations
- Other discrete event simulations
- Formula Solvers
- Static Input Deck

Input Deck	
Event	**Time**
Power Failure	3:36.40
Battery Exhausted	4:50.22
...