EMRALD, Dynamic PRA for the Traditional Modeler

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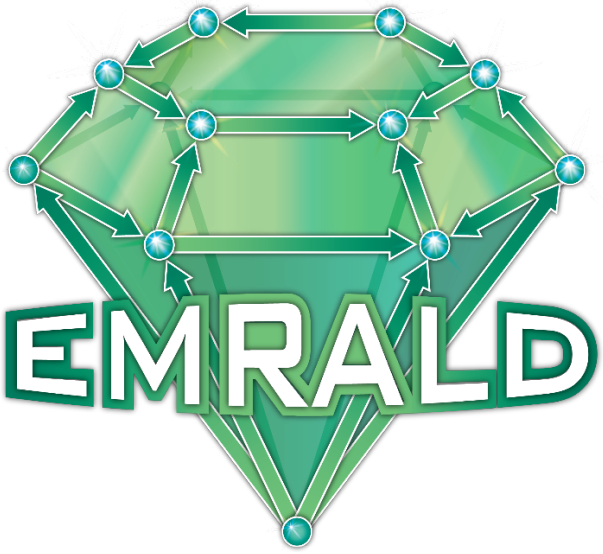

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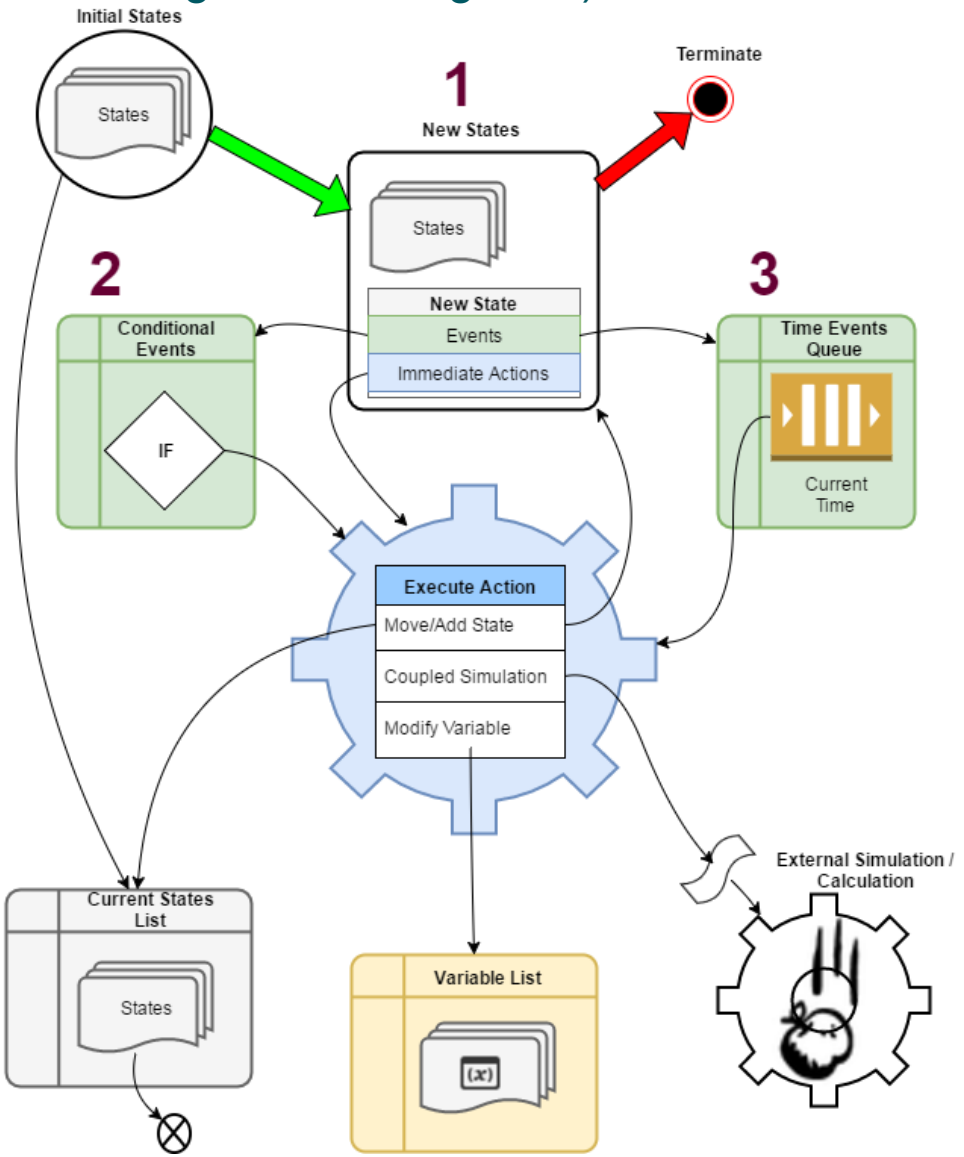
EMRALD

(Event Model Risk Assessment using Linked Diagrams)

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

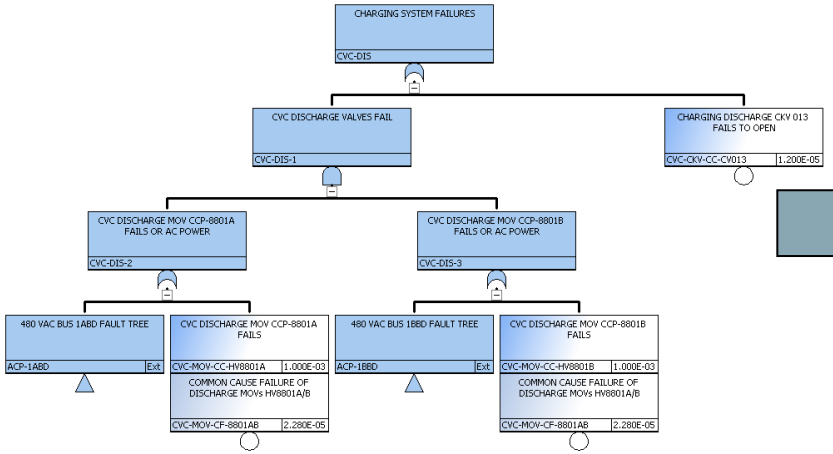
  To begin, add initial start states to Current and New States List.

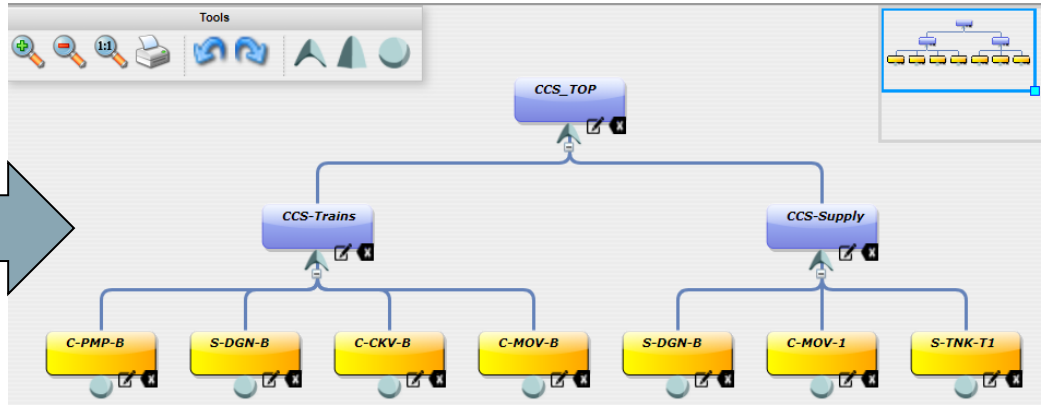
  1. While there are States in the New Sates list, For each State :
     - Add the Events to the Time Queue or Conditional List.
     - Execute any Immediate Actions
  2. If any Conditional Events criteria is met.
     - Execute that events action/s.
     - (Go to Step 1)
  3. Jump to the next chronological event.
     - Process that event's actions.
     - (Go to Step 1)



Why EMRALD

1. Combination of dynamic with traditional modeling techniques
2. Industry use focus for UI vs. scientific research



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    <Features>x1,x2</Features>
    <SobolOrder>2</SobolOrder>
    <IndexSet>TotalDegree</IndexSet>
    <PolynomialOrder>4</PolynomialOrder>
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       weight='2'>x2</Interpolation>
  </ROM>
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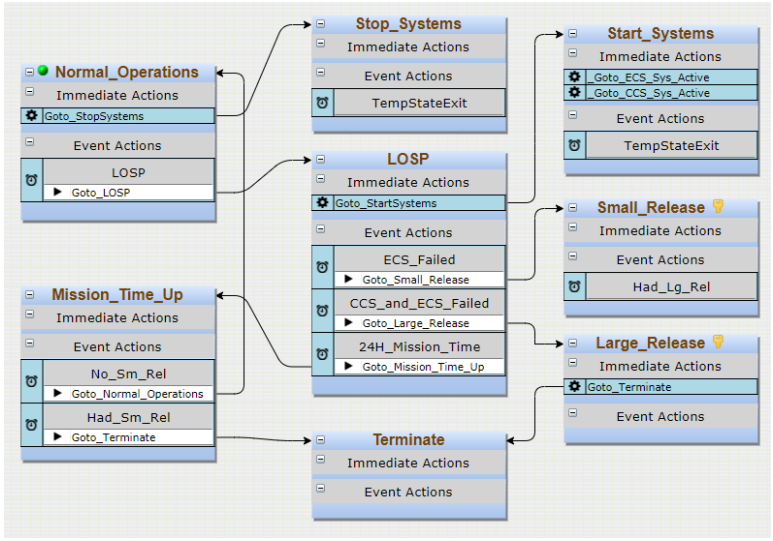
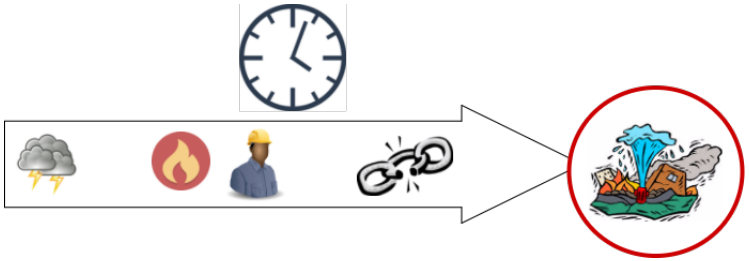
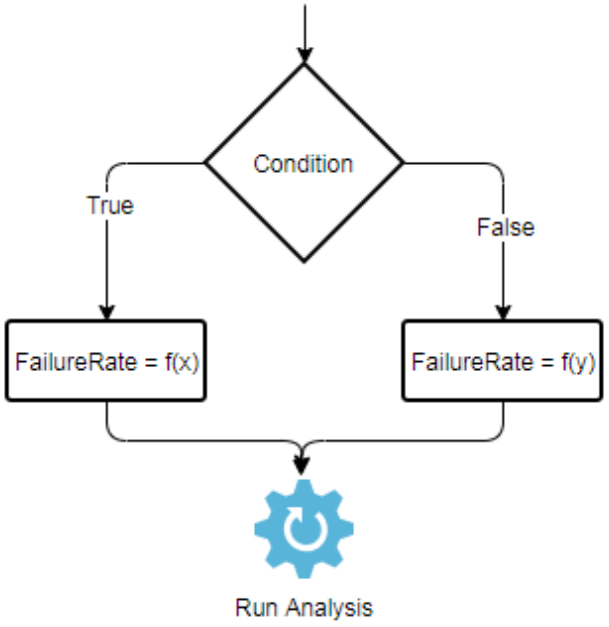
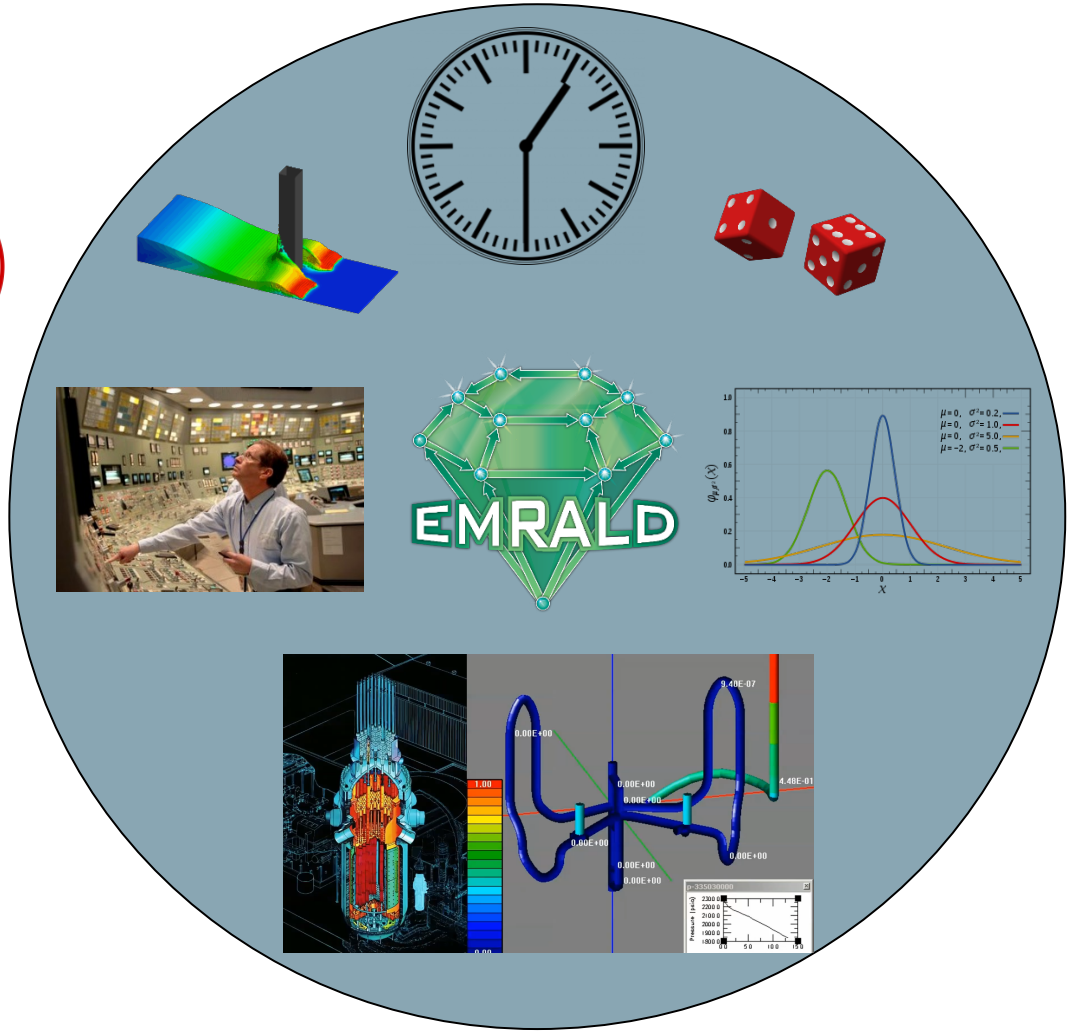


Why EMRALD (cont.)

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







EMRALD Modeling

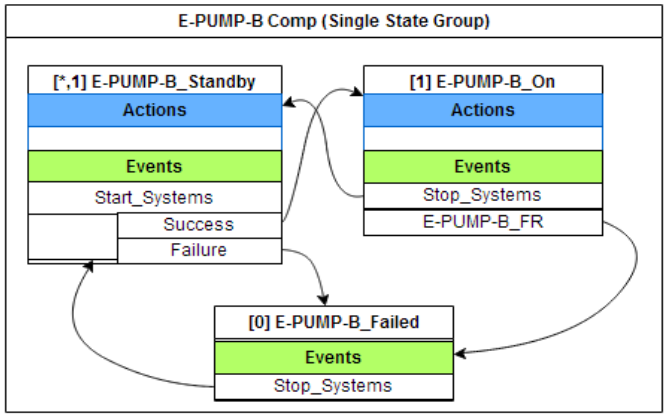
States

- Actions (transition, change variables, run script)
- Events -> Action (sampling, conditions, time, etc.)

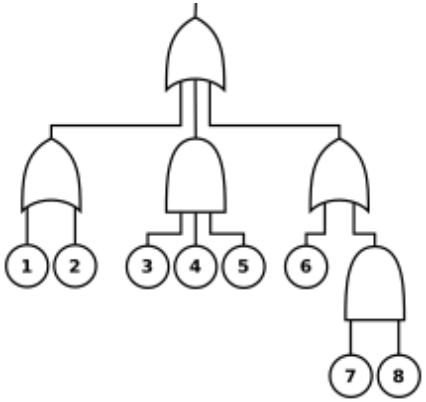
State
Actions
Transition
Change Variable
Run Script
Events
Failure Rate Sampling
Timer
State Change
Logic Tree
Evaluate Variable
External Event

Diagrams

- Components
- Systems
- Plant response



Logic Trees

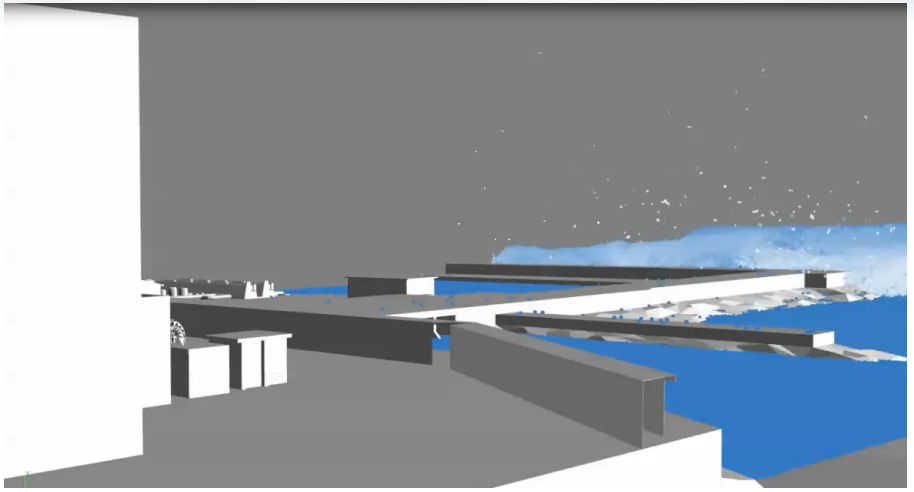


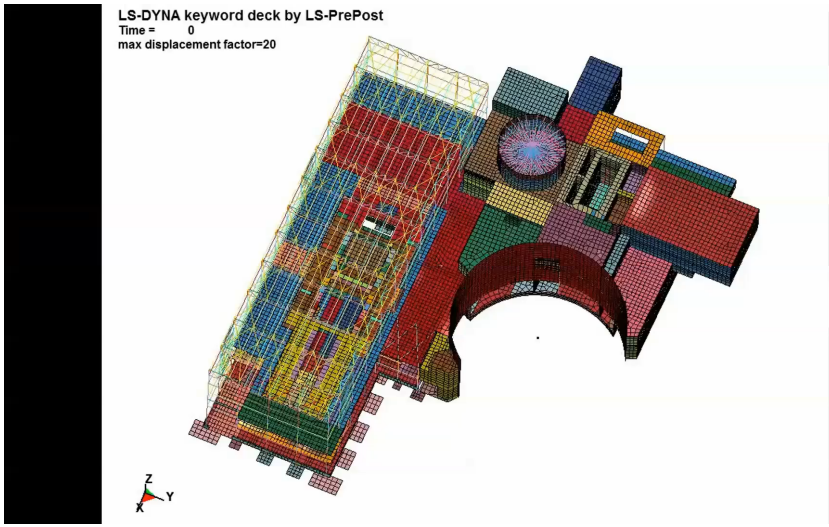
Variables

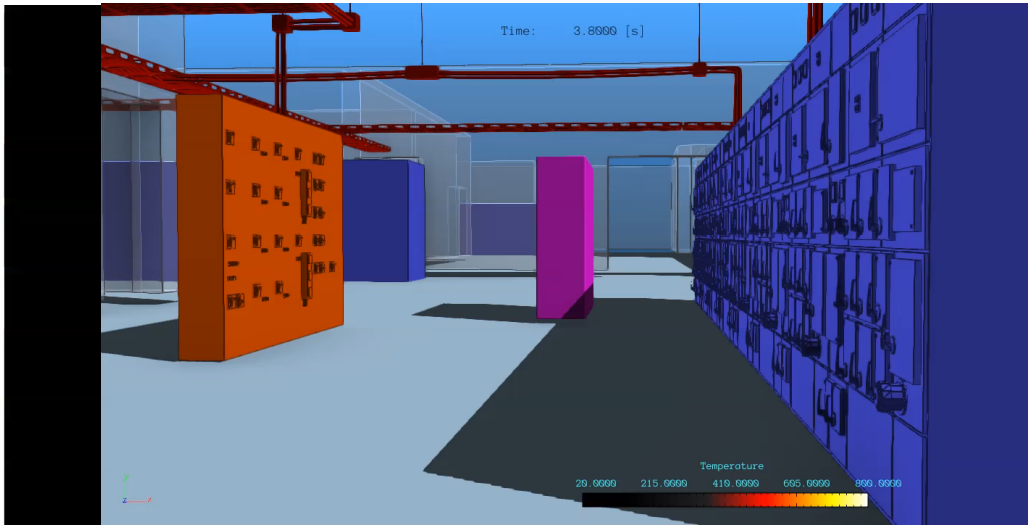
External Links

Current Applications

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







Two way 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

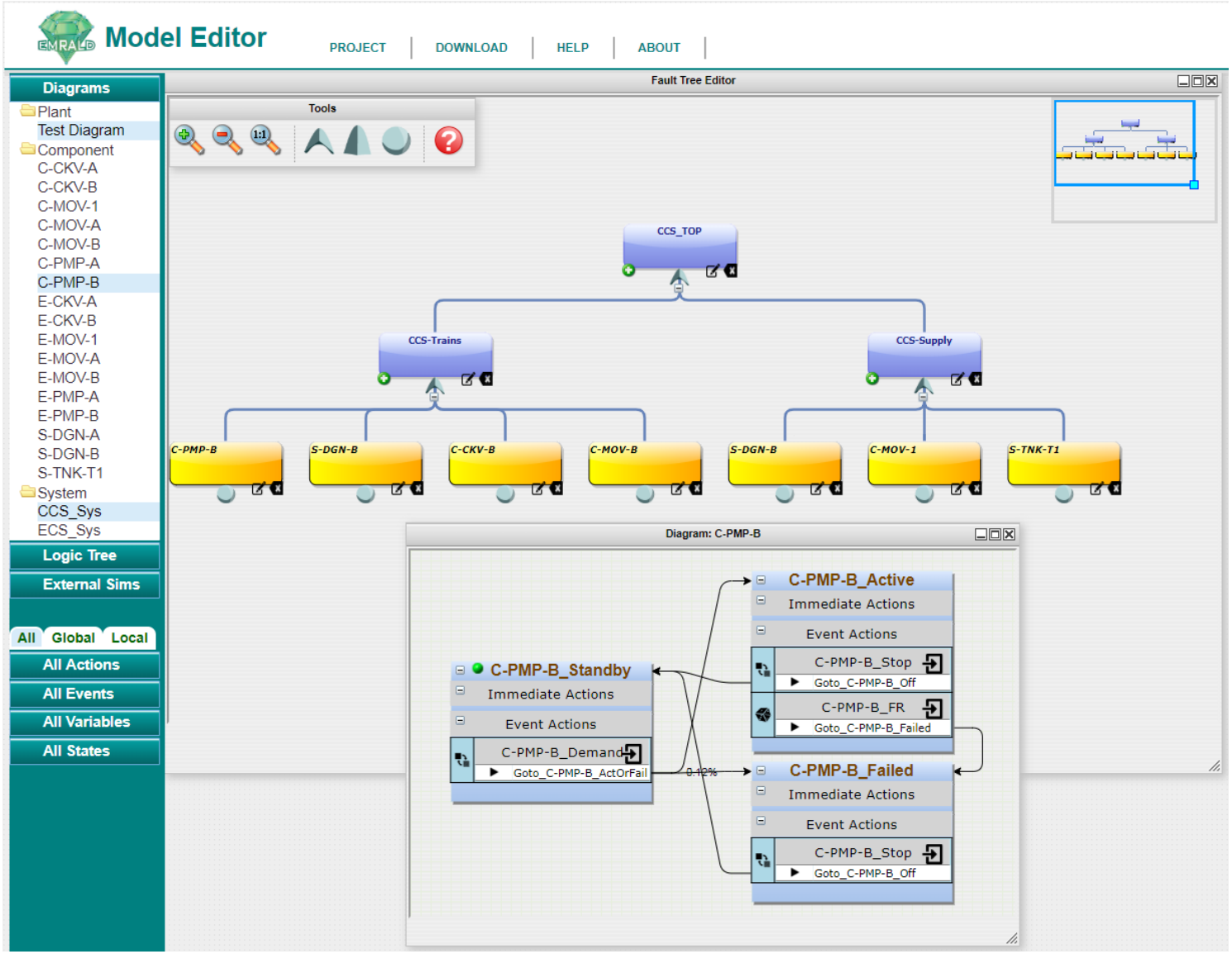
- Example packages
- Beta ready


```
{
  "dispName": "SetFlow",
  "version": "0.1.0",
  "pID": "f028d34e-2111-4857-a911-11d83f8e343f",
  "msgType": "mtSimAction",
  "globalRunTime": "00:00:00",
  "desc": "Adjusting the Flow",
  "simAction": {
    "itemData": {
      "nameId": "Flow",
      "value": "300"
    },
    "actType": "atCompModify",
    "time": "01:05:00"
  }
}
```

User Interface

Interface

- Web based
- Open Source Packages
- Customizable

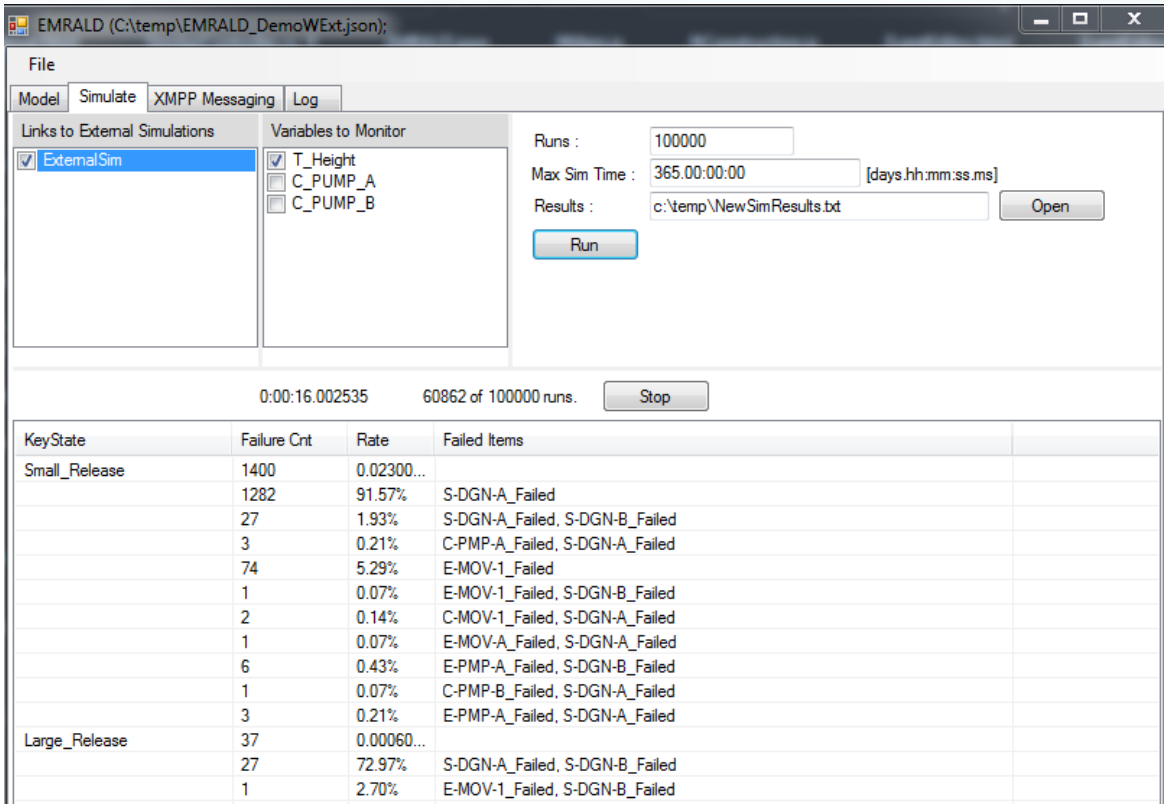


EMRALD Solve Engine & Results

Features

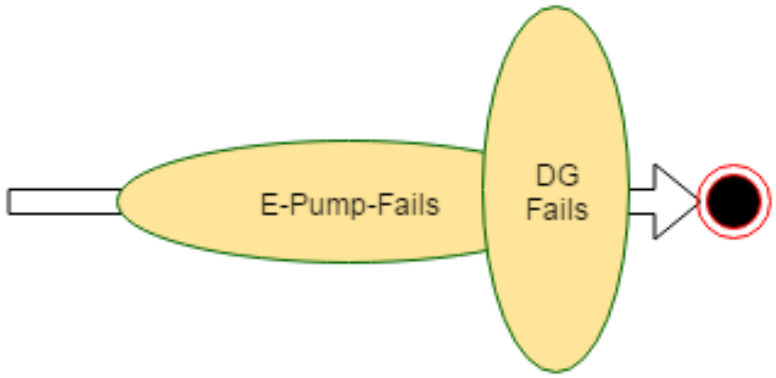
- Decoupled from modeling UI
- Command line or UI
- Monitor progress
- Monitor coupled communication

Results include timing and events for component failures.



KeyState	Failure Cnt	Rate	Failed Items
Small_Release	1400	0.02300...	
	1282	91.57%	S-DGN-A_Failed
	27	1.93%	S-DGN-A_Failed, S-DGN-B_Failed
	3	0.21%	C-PMP-A_Failed, S-DGN-A_Failed
	74	5.29%	E-MOV-1_Failed
	1	0.07%	E-MOV-1_Failed, S-DGN-B_Failed
	2	0.14%	C-MOV-1_Failed, S-DGN-A_Failed
	1	0.07%	E-MOV-A_Failed, S-DGN-A_Failed
	6	0.43%	E-PMP-A_Failed, S-DGN-B_Failed
	1	0.07%	C-PMP-B_Failed, S-DGN-A_Failed
	3	0.21%	E-PMP-A_Failed, S-DGN-A_Failed
Large_Release	37	0.00060...	
	27	72.97%	S-DGN-A_Failed, S-DGN-B_Failed
	1	2.70%	E-MOV-1_Failed, S-DGN-B_Failed

Need to develop visualization for clustering failure contributors.



IA2 Test Results.

- Coupled calculations by **EMRALD**: combine seismic, flooding, BEPU and PRA

Sequence Case	Thermal Hydraulics reduction in conservatism
Seq 2-02-05 (LOOP)	-7.30%
Seq 2-16-03-10 (SBO)	-34%

3D component	Failure Cnt	%
LC 480V 1	30320	97.0768%
UPS 1 B	209	0.6692%
125VDC PNL 1	515	1.6489%
SWGR 4KV 1	160	0.5123%
LC 480V 2	27	0.0864%
UPS 1 A	2	0.0064%

Sequence Case	CDF No Pipe Failure, [SAPHIRE]	CDF Increase With Pipe Failure [SAPHIRE Conservative]	CDF Increase With Pipe Failure [EMRALD coupled]
Seq 2-02-05 (LOOP)	6.19E-07	+7.4%	+1.380%
Seq 2-15 (LOOP)	8.76E-06	+17.4%	+0.040%
Seq 2-16-03-10 (SBO)	2.82E-06	+36.3%	+0.052%
Seq 2-16-45 (SBO)	1.81E-05	+24.1%	+0.003%

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Application - www.safety.inl.gov/emrald
Info – www.emrald.inl.gov