



JENSEN HUGHES

Advancing the Science of Safety

BEYOND BASIC EVENTS: MEASURING THE IMPORTANCE OF HIDDEN PRA ITEMS OF INTEREST

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9/26/17**

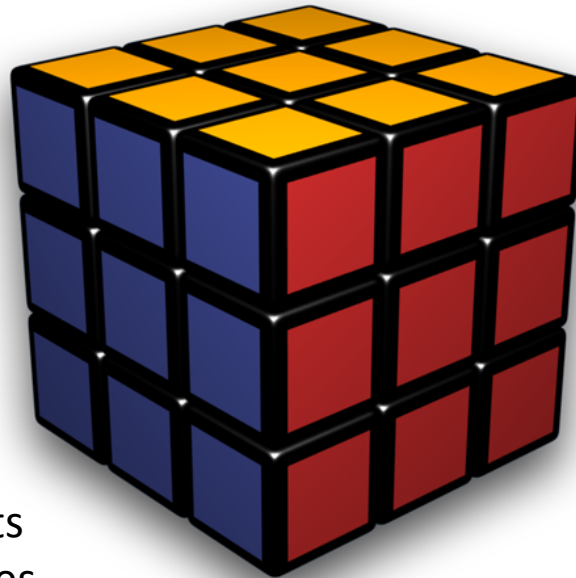
PRA MODELS FROM A NEW PERSPECTIVE

End State Values

- Overall
 - CDF
 - LERF
- Changes
 - Δ CDF
 - Δ LERF

Basic Events

- Initiating Events
- Random Failures
 - Equipment
 - Operator Actions
 - Phenomenological



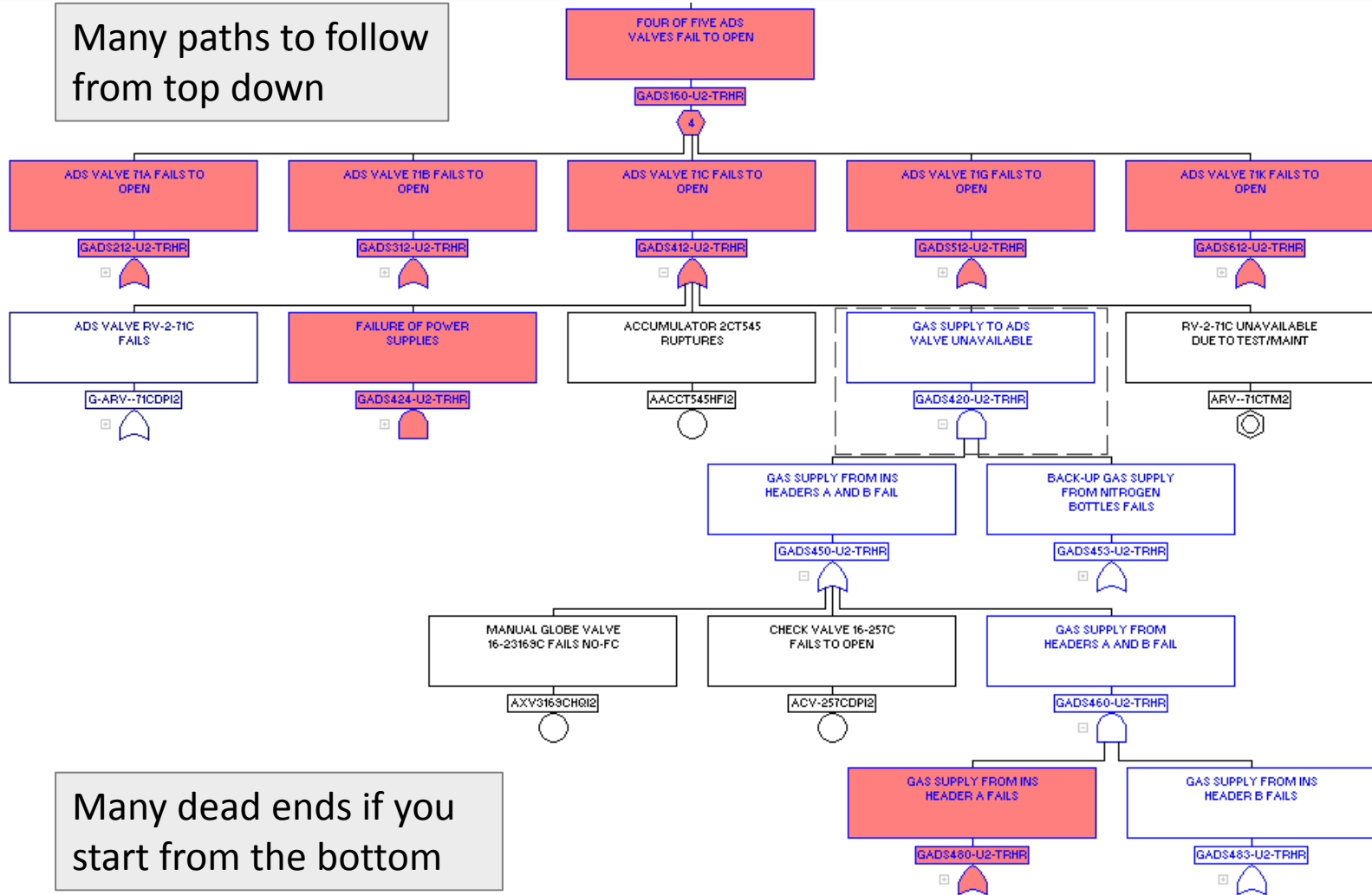
Hidden Items of Interest

- Dependencies
 - Power
 - Cooling
 - Interlocks
 - Instrumentation
- Functional Success Criteria
- Boundary Conditions
 - Plant Configuration
- Spatial Failures
 - Fire Failures
 - Equipment
 - Cables
 - Raceways
 - Flood Failures
 - Equipment



BROWSING MODEL TAKES TIME (AND PATIENCE)

Many paths to follow from top down

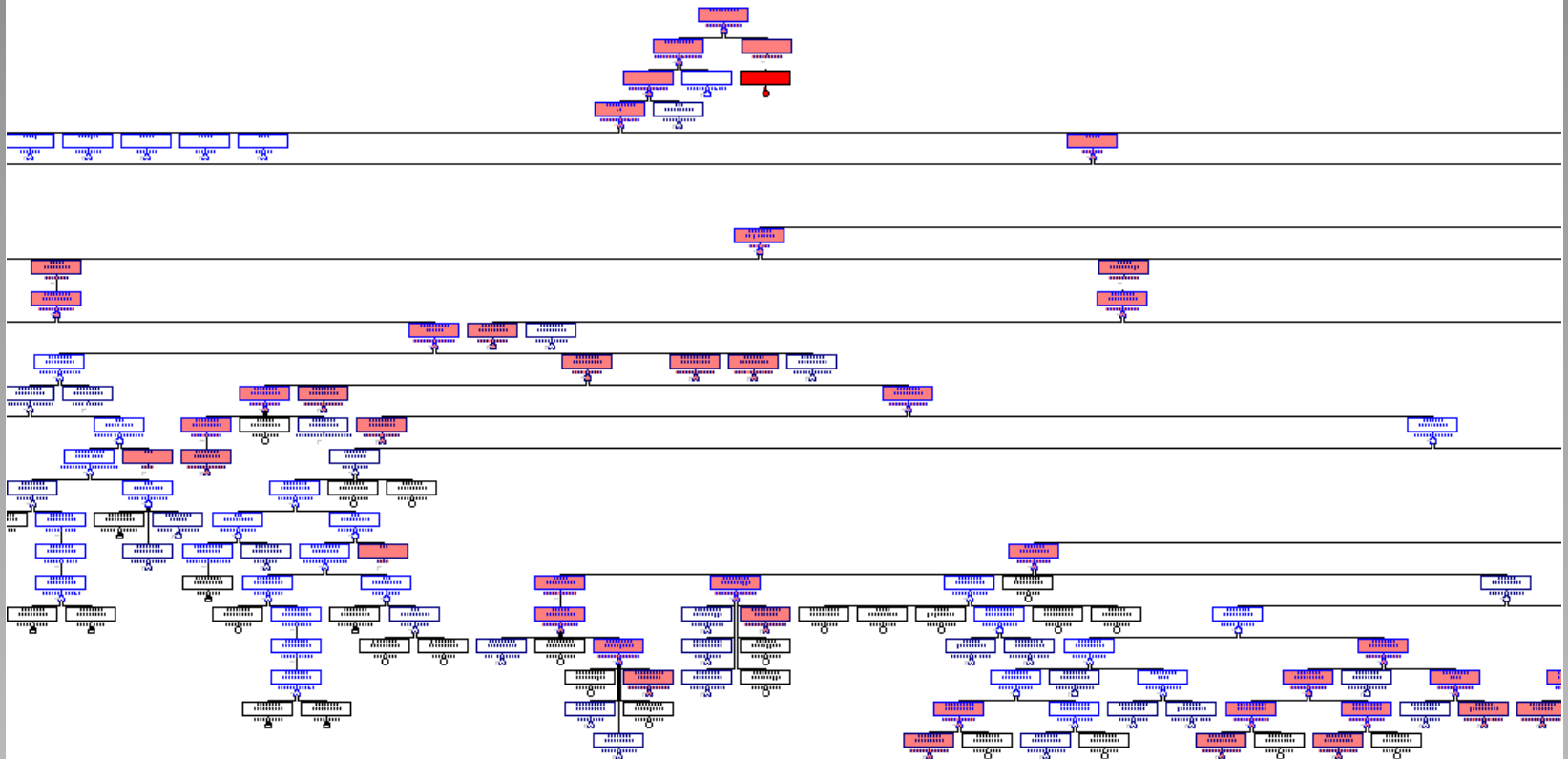


Many dead ends if you start from the bottom



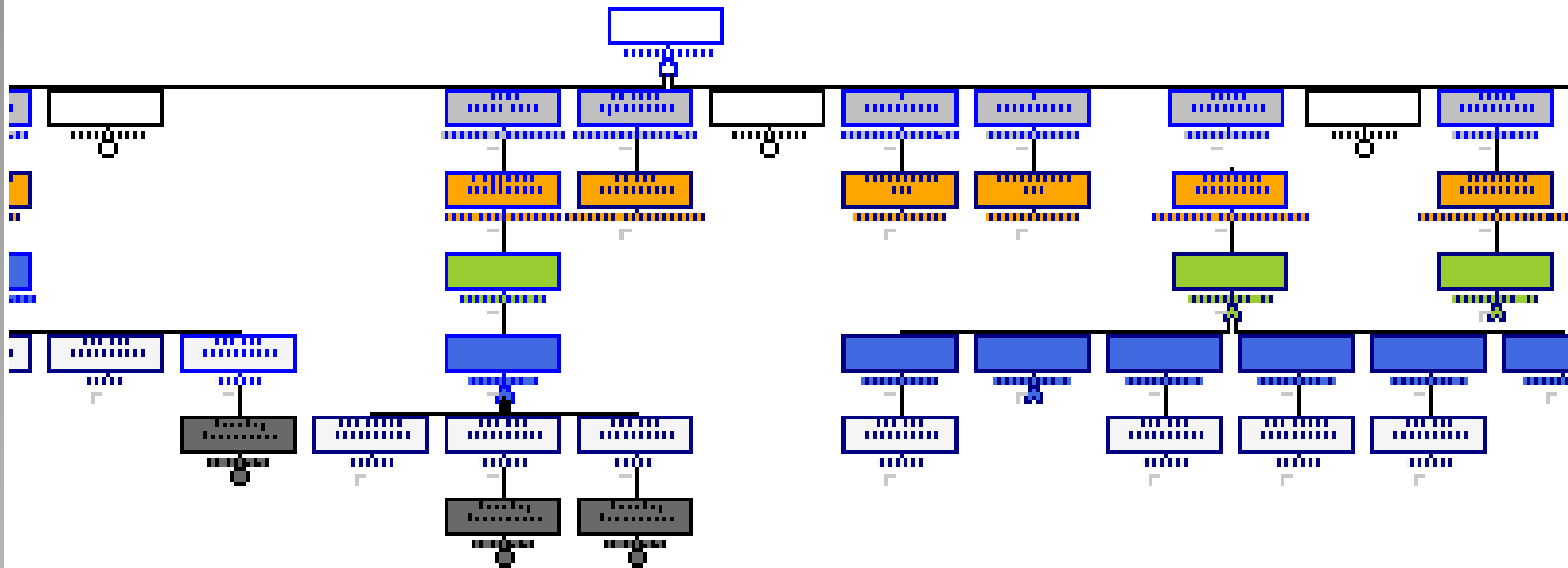
CURRENT BROWSING

- ◆ Cutset events set to TRUE
- ◆ Logical status propagated up through gates
- ◆ Navigate through the entire tree



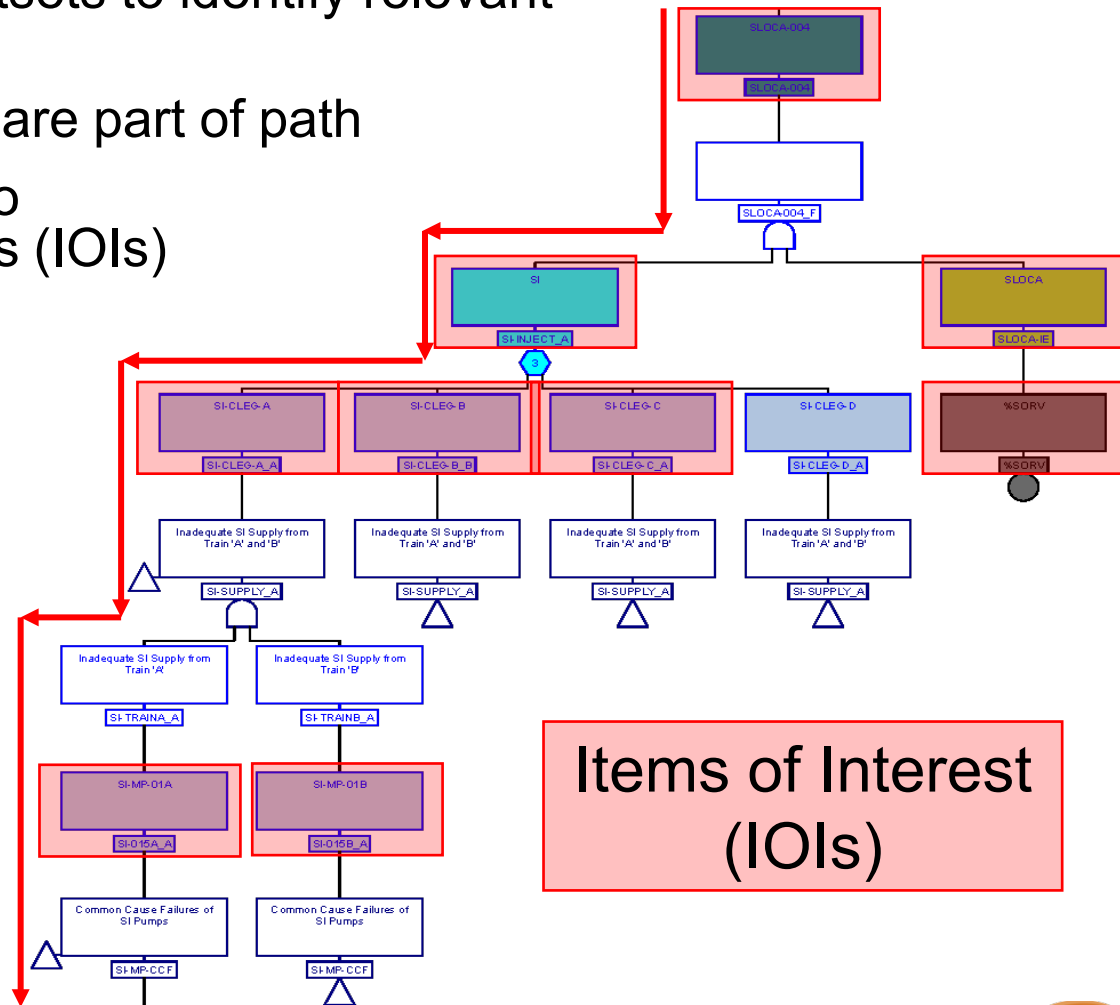
A BETTER WAY TO BROWSE

- ◆ Remove intermediate gates between items of interest
 - Enables more efficient navigation down through the tree
- ◆ Remove the parts of the tree that are not part of the cutset path
 - Allows upward navigation without “dead ends”



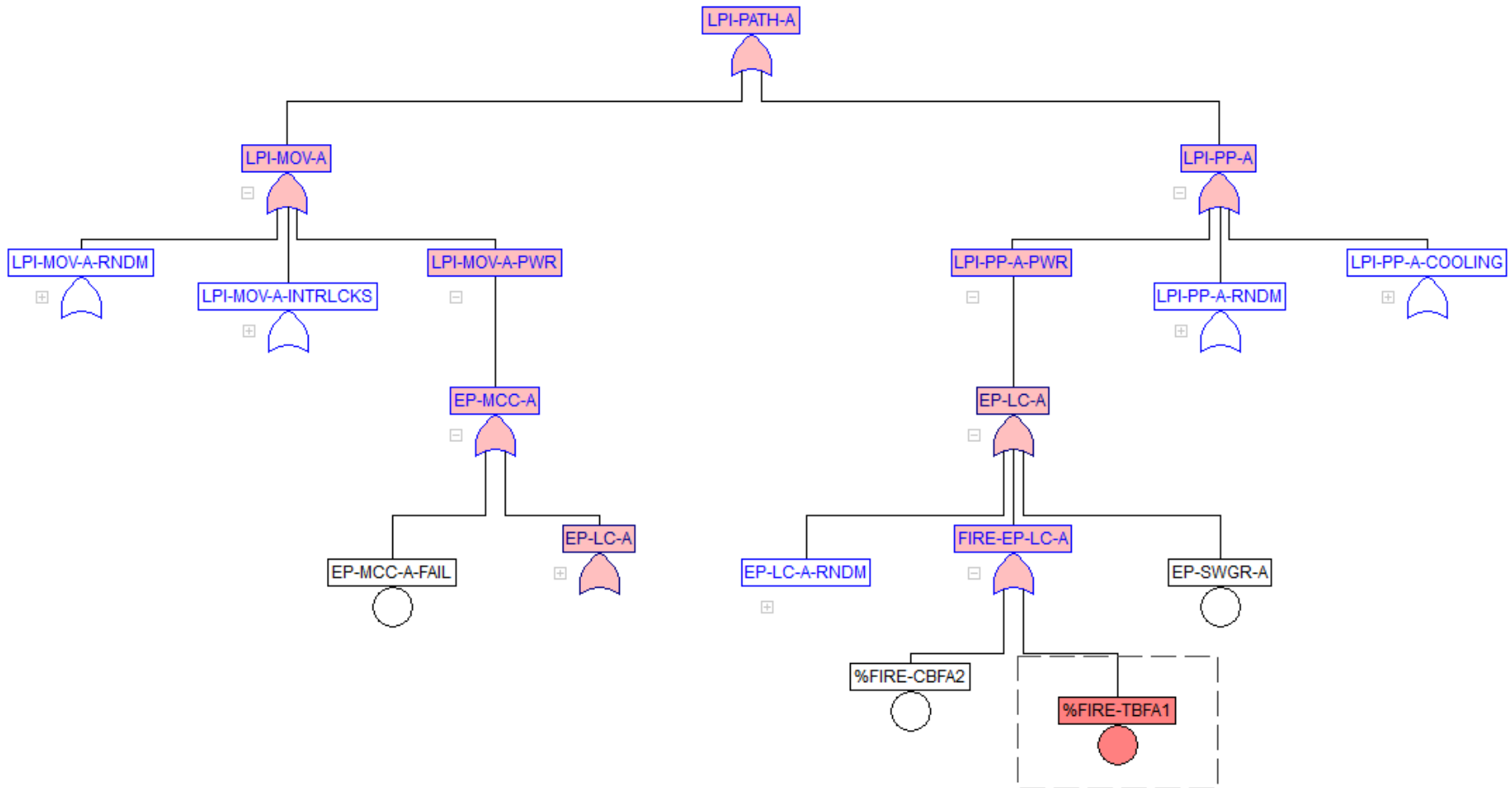
AUTOMATED BROWSING

- ◆ Post-process cutsets to identify relevant fault tree path
- ◆ Store gates that are part of path
- ◆ Gates mapped to Items of Interests (IOIs)



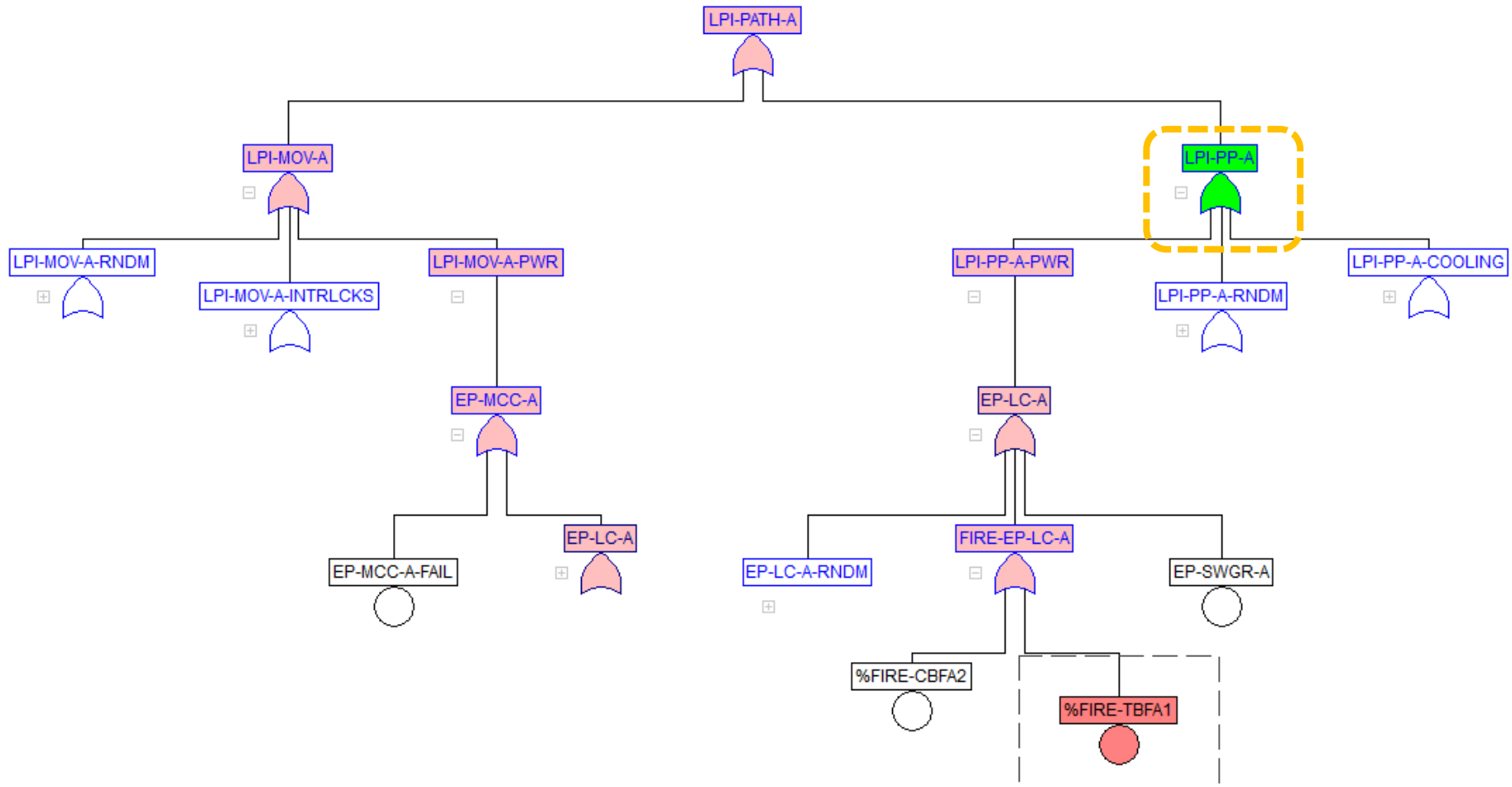
GATE PARTICIPATION ISN'T ALWAYS CRITICAL

- ◆ Participation – Gate is part of cut-set path to top gate
- ◆ Criticality – Changing status of gate changes status of top gate



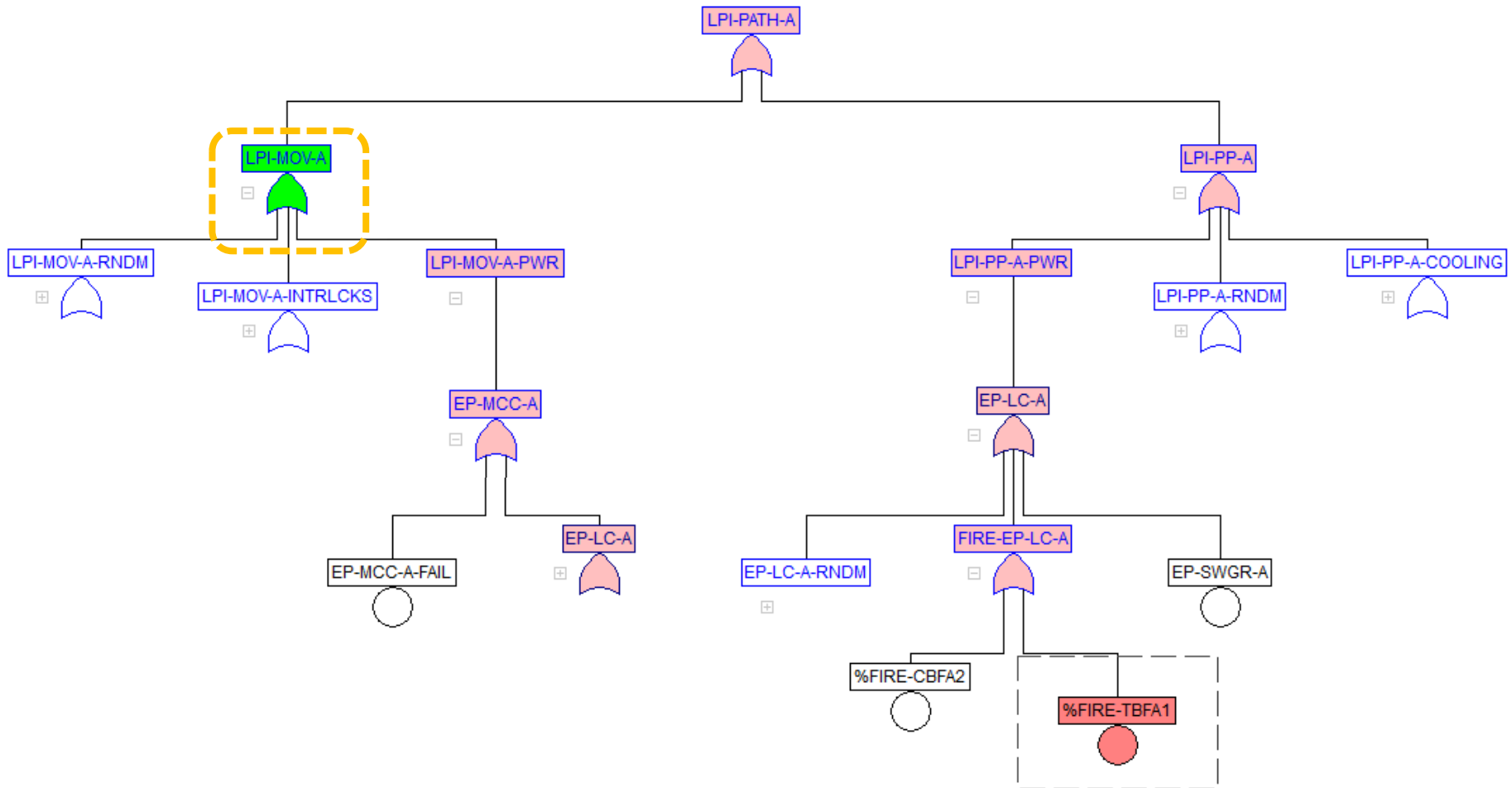
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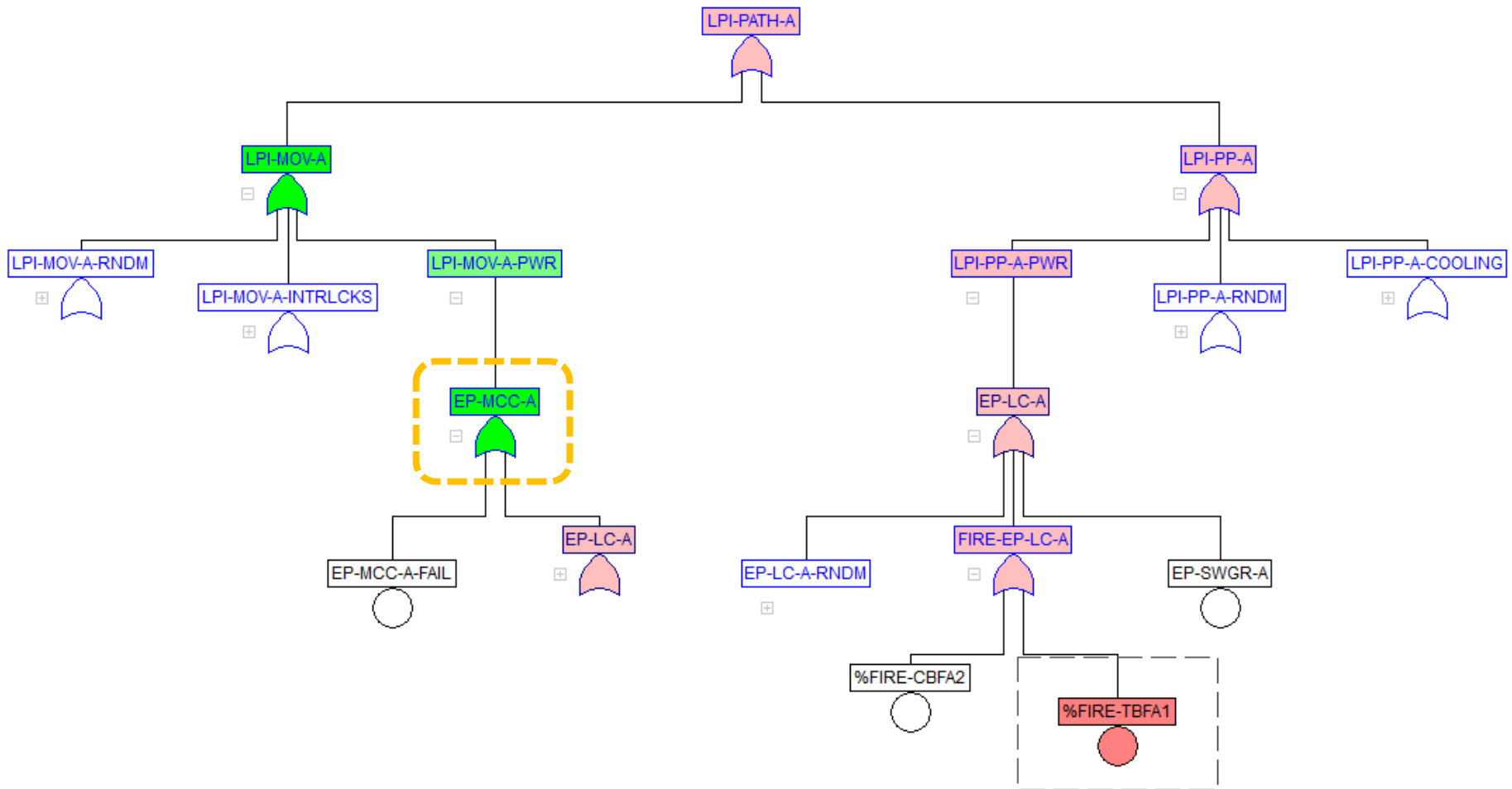
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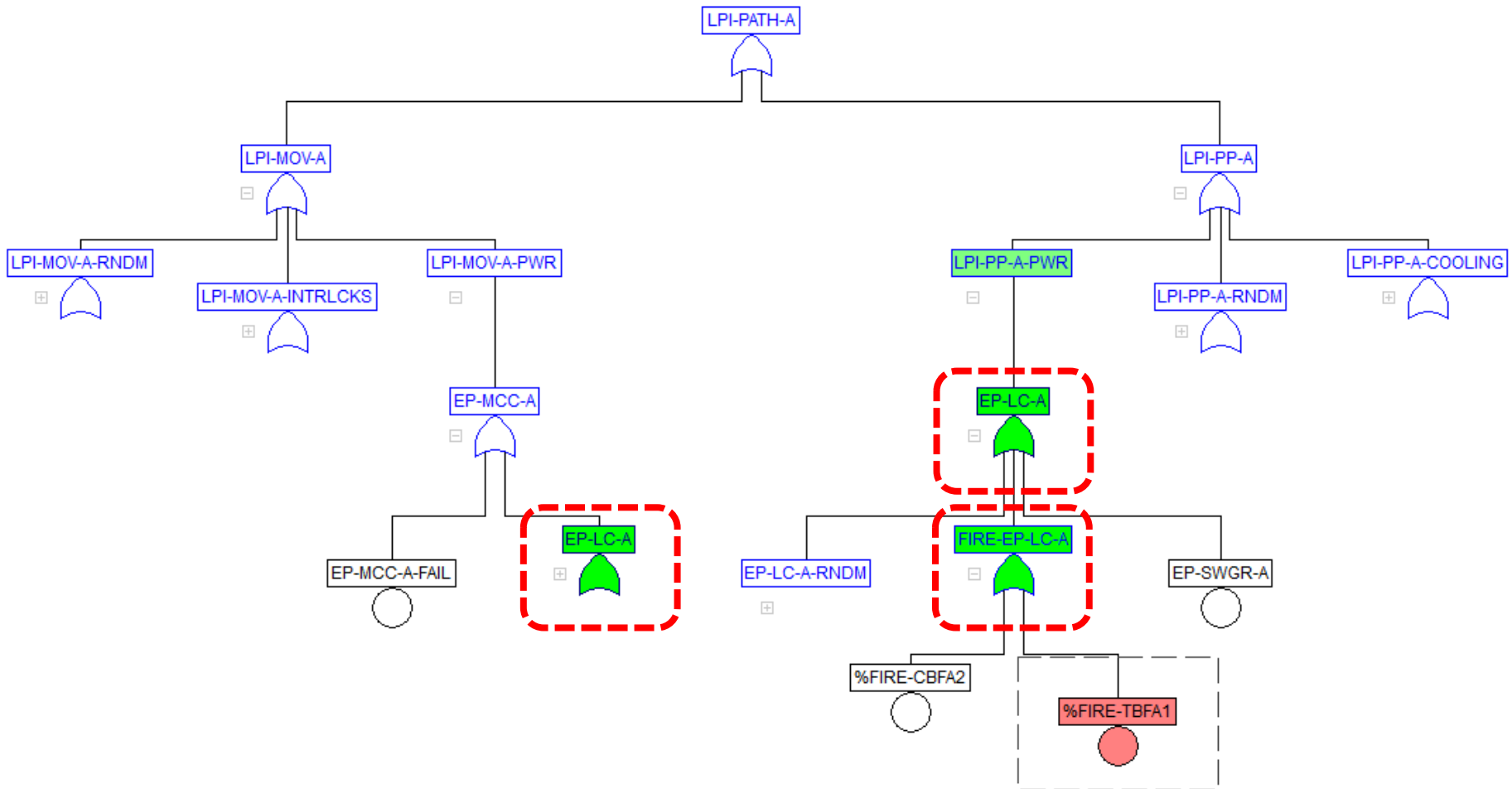
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IOI IMPORTANCE MEASURES

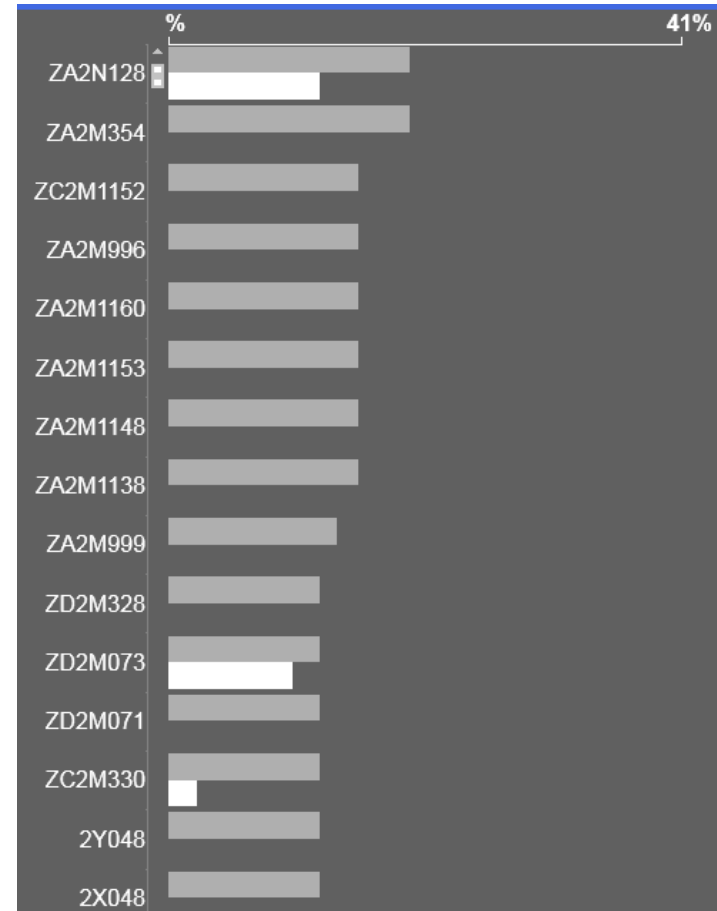
$$\text{Participation Index} = \frac{(CS_{ALL} - CS_{NP})}{CS_{ALL}}$$

$$\text{Criticality Index} = \frac{(CS_{ALL} - CS_{NC})}{CS_{ALL}}$$

CS_{ALL} = ES Value of All Cutsets

CS_{NP} = ES Value of Cutsets Where Gate is NOT Participating

CS_{NC} = ES Value of Cutsets Where Gate is NOT Critical



FIRE PRAS PRESENT UNIQUE CHALLENGE

Thousands of Scenarios and Cutsets

Hundreds of Fire Failures per Scenario

COREDAMAGE-U2 = 2.21E-05 (3164 cutsets)			
1:	9.22E-07	%F06S-5J_E224_B	EHU2AD03DXIO-FRA-J
2:	5.08E-07	%F02-75_T_C	EHU2AD03DXIO-FRA-J
3:	4.95E-07	%F36_2BD003_Y	ECB-E212HOI2-AGG
4:	4.17E-07	%F36_2BD003_Y	ECB-E212HOI2-AGG
5:	3.15E-07	%F36_2BD003_Y	ECB-E212HOI2-AGG
6:	2.69E-07	%F36_2BD003_Y	ECB-E212HOI2-AGG
7:	2.39E-07	%F32_30A1701_H_R	WPM0AP57TM0
8:	2.09E-07	%F32_30A1702_H_R	WPM0AP57TM0
9:	1.97E-07	%F36_2DD003_Y1	ECB-E212HOI2-AGG
10:	1.78E-07	%F36_2BD003_Y	ECB-E212HOI2-AGG
11:	1.78E-07	%F06S-5P_2R4-R-B_A_Y	AHU--CADDXD2-F
12:	1.66E-07	%F36_2DD003_Y1	ECB-E212HOI2-AGG
13:	1.54E-07	%F36_2BD003_Y	ECB-E212HOI2-AGG
14:	1.49E-07	%F39_20A1508_H_Y	ECBDGE13HQI3-AGG
15:	1.30E-07	%F06S-5J_E124_B	ZTU--HRCWI2
16:	1.30E-07	%F06S-5J_E224_B	ZTU--HRCWI2
17:	1.28E-07	%F17_PAU	AHUBTL-RDXI2-F
18:	1.26E-07	%F36_2DD003_Y1	ECB-E212HOI2-AGG
19:	1.12E-07	%F39_20A1508_H_Y	ECBDGE13HQI3-AGG
20:	1.10E-07	%F37_20A1601_H_Y	ECBDGE23HQI3-AGG
21:	1.07E-07	%F36_2DD003_Y1	ECB-E212HOI2-AGG
22:	1.07E-07	%F25-78H_2AC836_Y1	1-SEQ-MCR-031
23:	9.79E-08	%F25-78H_2AC836_Y1	1-SEQ-MCR-015
24:	9.28E-08	%F36_2BD003_Y	ECB-E212HOI2-AGG
25:	9.26E-08	%F06S-5P_2R4-R-B_A_Y	HMV--15SX12-SSD-AGG
26:	9.26E-08	%F06S-5P_2R4-R-B_A_Y	HMV--15SX12-SSD-AGG
27:	9.04E-08	%F37_00A20_Y	EBSCHN3CTM3
28:	8.70E-08	%F25-78H_2AC836_Y1	1-SEQ-MCR-031
29:	8.51E-08	%F25-78H_20C722B_Y	1-SEQ-MCR-031
30:	8.28E-08	%F37_20A1601_H_Y	ECBDGE23HQI3-AGG
31:	7.91E-08	%F02-75_2PS4-W_A_W	EHU2AD03DXIO-FRA-J
32:	7.91E-08	%F02-75_4PS4-W_A_W	EHU2AD03DXIO-FRA-J
33:	7.69E-08	%F25-78H_2AC836_Y1	1-SEQ-MCR-031
34:	7.61E-08	%F25-108_20C03-01	1-SEQ-MCR-031
35:	7.53E-08	%F25-78H_20C722B_Y	1-SEQ-MCR-031
36:	7.10E-08	%F36_2DD003_Y1	ECB-E212HOI2-AGG
37:	6.95E-08	%F25-78H_20C722B_Y	1-SEQ-MCR-031
38:	6.95E-08	%F25-78H_20C722B_Y	1-SEQ-MCR-031
39:	6.34E-08	%F39_20A1508_H_Y	ECBDGE13HQI3-AGG
40:	6.14E-08	%F36_2DD003_Y1	ECB-E212HOI2-AGG
41:	6.14E-08	%F25-78H_20C722B_Y	1-SEQ-MCR-031
42:	6.00E-08	%F25-108_20C03-03	1-SEQ-MCR-031
43:	5.61E-08	%F06S-5P_2R4-R-B_A_Y	HMV--15SX12-SSD-AGG
44:	5.50E-08	%F38_20A1701_H_Y	EHU2DD03DXIO-FRA
45:	5.50E-08	%F38_20A1702_H_Y	EHU2DD03DXIO-FRA
46:	5.49E-08	%F39_20A1508_H_Y	ECBDGE13HQI3-AGG
47:	5.37E-08	%F50-78B_TGH-185_B	BALAP039XXI2
48:	5.37E-08	%F50-78B_TGH-185_B	BALBP039XXI2
49:	5.37E-08	%F50-78B_TGH-185_B	DMVLOOPBTM2
50:	5.37E-08	%F50-78B_TGH-185_B	DMVLOOPBTM2
51:	5.20E-08	%F38_20A1703_H_Y	EHU2DD03DXIO-FRA
52:	5.20E-08	%F38_20A1704_H_Y	EHU2DD03DXIO-FRA
53:	5.20E-08	%F38_20A1705_H_Y	EHU2DD03DXIO-FRA

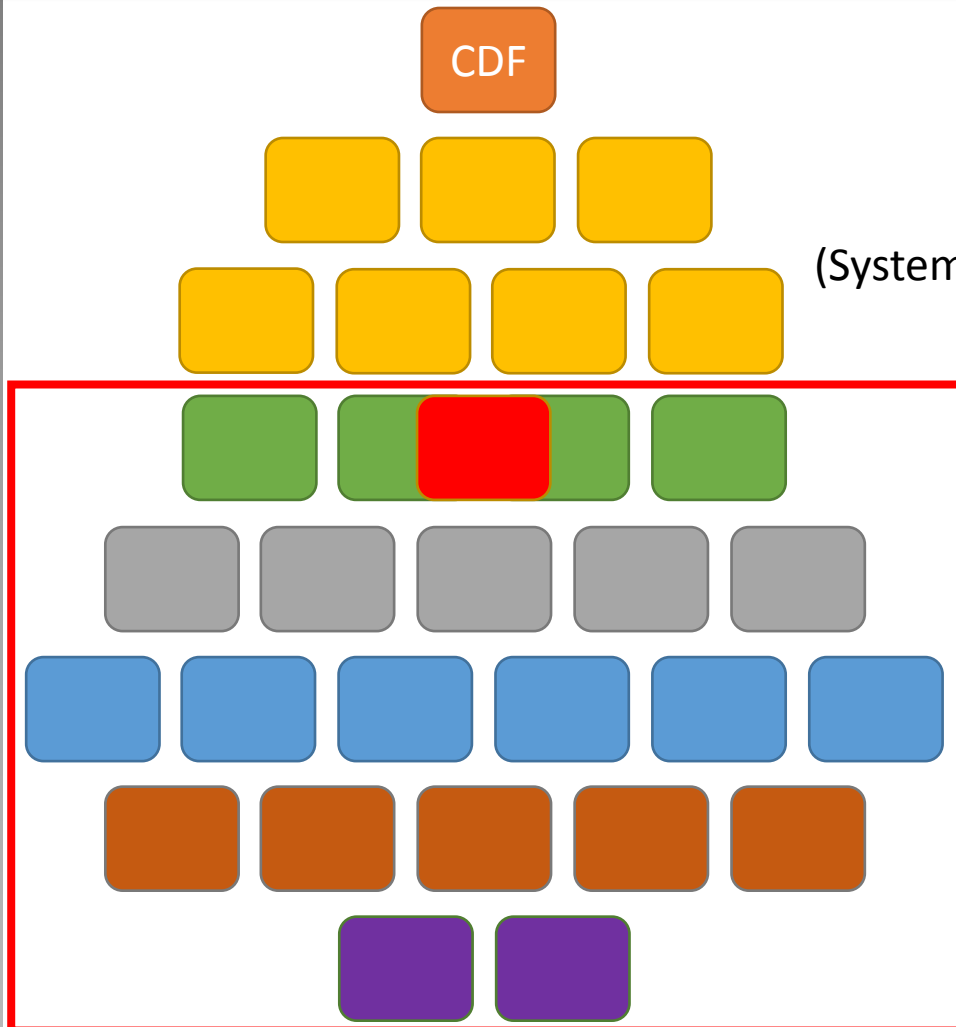
Fire Scenario Failures

403	Zone
2SL420	Raceway
2Q1102E	Cable
SV2-02-17:FTRD	Component
ASV1A-17HOI2-HS-AGG	Basic Event
2Q1102G	Cable
SV2-02-18:FTRD	Component
ASV1A-18HOI2-HS-AGG	Basic Event
ZA2M354	Raceway
ZA2B1021A	Cable
MCC00B53	Component
EMC124DAHWI2	Basic Event
ZA2N128	Raceway
ZA2B1014A	Cable
MCC20B59	Component
EMC124TBHWI2	Basic Event
ZD2M071	Raceway
ZD2B1322A	Cable
MCC00B50	Component
EMC424TBHWI2	Basic Event
ZD2M071	Raceway
ZD2B1322A	Cable
MCC00B50	Component
EMC424TBHWI2	Basic Event
ZD2M073	Raceway
ZD2B1313A	Cable
MCC20B39	Component
EMC424WAHWI2	Basic Event
20B1113_EP	Raceway
ZB2B1113A	Cable
MCC20B37	Component
EMC224RBHWI2	Basic Event

Cutset#1 Prob: 9.22E-07 Old Prob: 2.25E-04 G



FIRE PRA FAULT TREE



Quantified Top Gate

Traditional PRA Logic IOIs
(Systems, Components, Functions, etc.)

Fire Scenario Initiator

Impacted Equipment

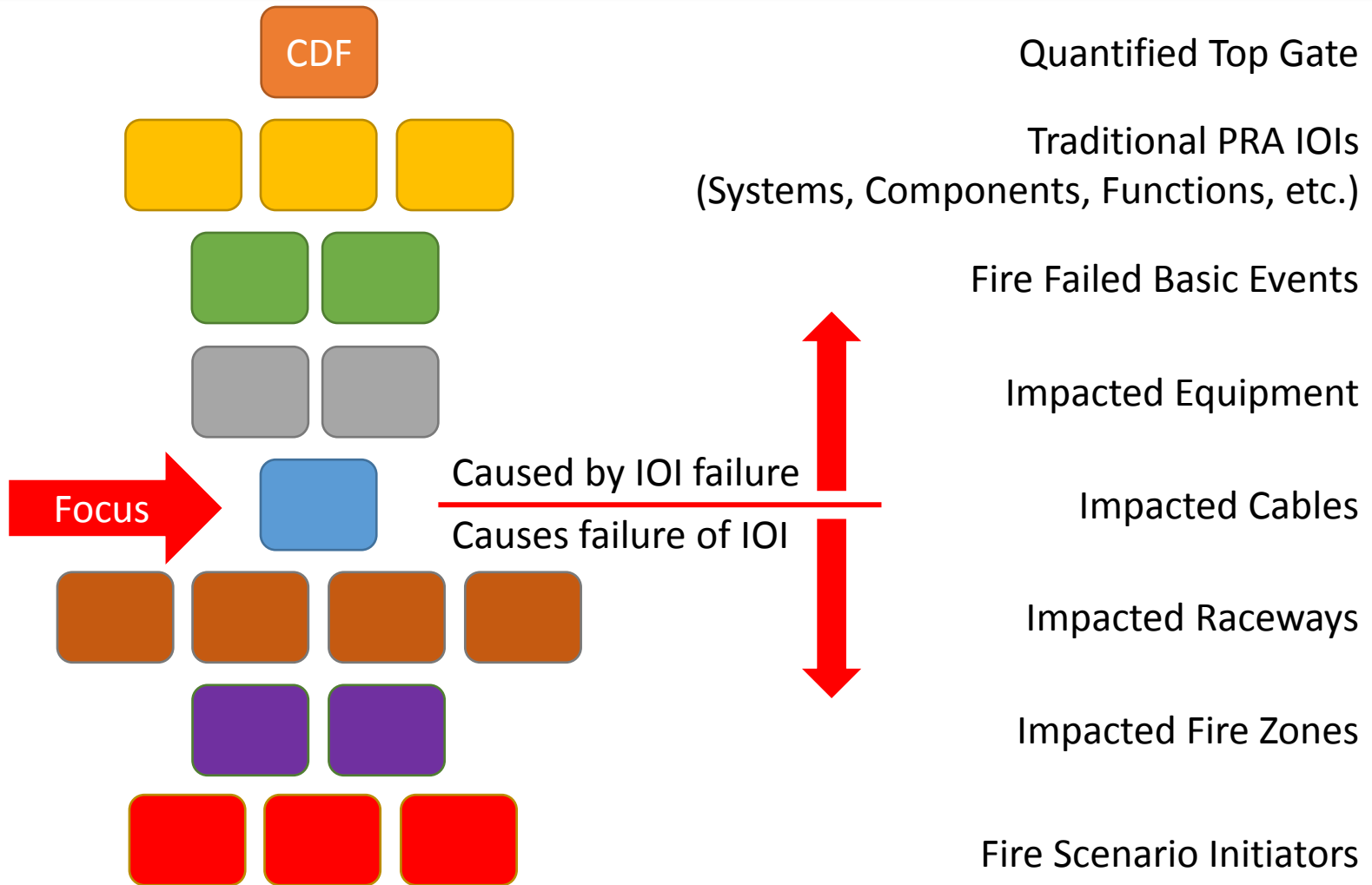
Impacted Cables

Impacted Raceways

Impacted Fire Zones



FOCUS ON A PARTICULAR IOI



REVEALS OPPORTUNITIES FOR RISK REDUCTION

Dashboard

F-Equipment

Non-Mutually Exclusive Results

Name	Base	Above	Below
2E51-F063 (FE)	<input type="text"/>	<input type="text"/>	<input type="text"/>
ODG009 (FE)	<input type="text"/>	<input type="text"/>	<input type="text"/>
ODG01K (FE)	<input type="text"/>	<input type="text"/>	<input type="text"/>
ODG01P (FE)	<input type="text"/>	<input type="text"/>	<input type="text"/>
ODG02JA (FE)	<input type="text"/>	<input type="text"/>	<input type="text"/>
ODG02JB (FE)	<input type="text"/>	<input type="text"/>	<input type="text"/>

F-Cable | F-Equipment | F-BasicEvent | BE

Non-Mutually Exclusive Results

Name	Base	Above	Below
U2-455F (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-456F (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-453F (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-454F (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-AR14 (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-R173 (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-435B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-434B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-436B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
437B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
R172 (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-419B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
445B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>
U2-420B (FR)	<input type="text"/>	<input type="text"/>	<input type="text"/>

Browser

Focused IOI

2RI041 (FC)

Category: F-Cable

Description:

Unfocus

Locate

2RI041 (FC) 1 / 1

Currently Viewing

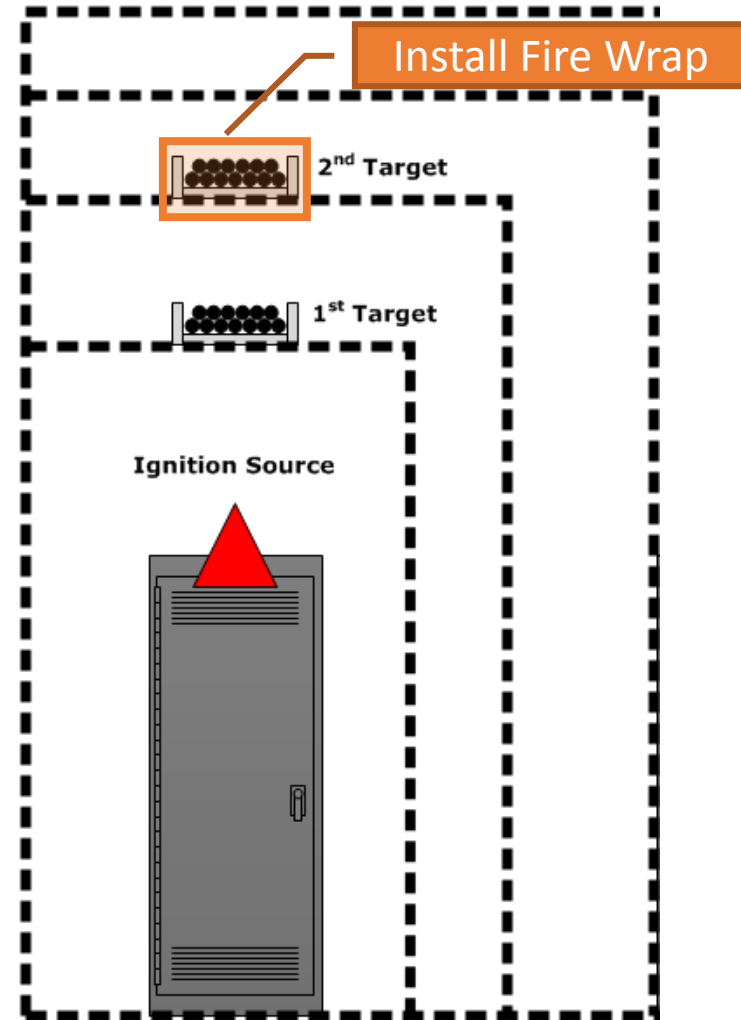
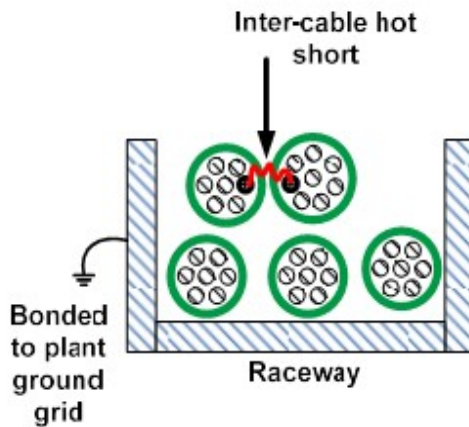
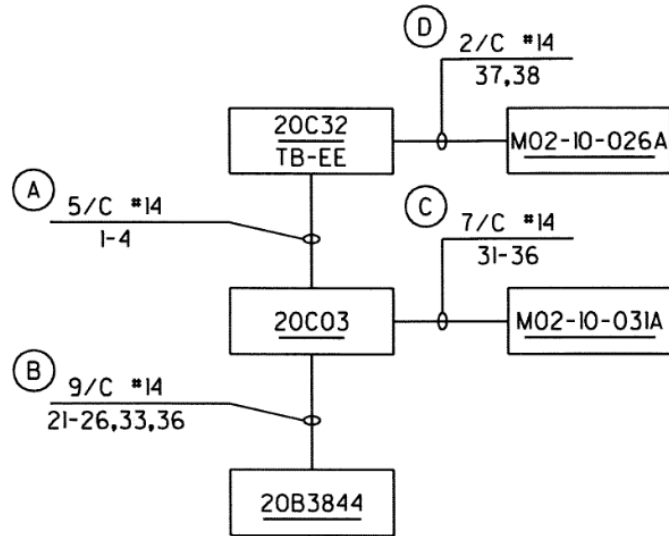
B,E. Cutset

%F_4E4-2_2AP06E_H_R	RCVCL-1D	RCVSEQ-GTR-006	2RHHURHRF92A-H--
2HCPM2E22C001A--			

All

8 2.4E-06	%F_4E4-2/4E4-1_2AP06E_H_M	RCVCL-1A	RCVSEQ-GTR-058
2HCPM2E22C001A--			
9 2.3E-06	%F_4E4-2_2AP06E_H_R	RCVCL-1D	RCVSEQ-GTR-006
2RHHURHRF92A-H--			
10 2.3E-06	%F_4E4-2/4E3-1_2AP02E_H_M	RCVCL-1A	RCVSEQ-GTR-058
2HCPM2E22C001A--			

UTILIZING THE RESULTS TO IMPROVE MODEL/PLANT



QUESTIONS?

Contact

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