HEAF PRA Methodology

Working Group Status Update

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HEAF Public Meeting
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Current HEAF Fire PRA Method

- In the current NUREG/CR-6850 methodology a *one size fits all* approach is used for HEAF consequences:
  - Both the MV and LV Switchgear ZOI is based predominantly on the HEAF event that occurred at SONGs
  - The non-segregated bus duct ZOI is based predominantly on the HEAF event that occurred at Diablo Canyon

  Both events were generator fed HEAFs – the fault was fed by the generator as it coast-down sustaining the arc for a longer duration at higher fault currents than would be expected for switchgear and bus ducts located in other portions of the electrical distribution system
- The current framework does not take into consideration the following elements:
  - Differences in electrical distribution designs and backup electrical protection schemes
  - Insights from operational experience and experimental testing
- These elements may limit the duration of the event and therefore the consequences (ZOI)

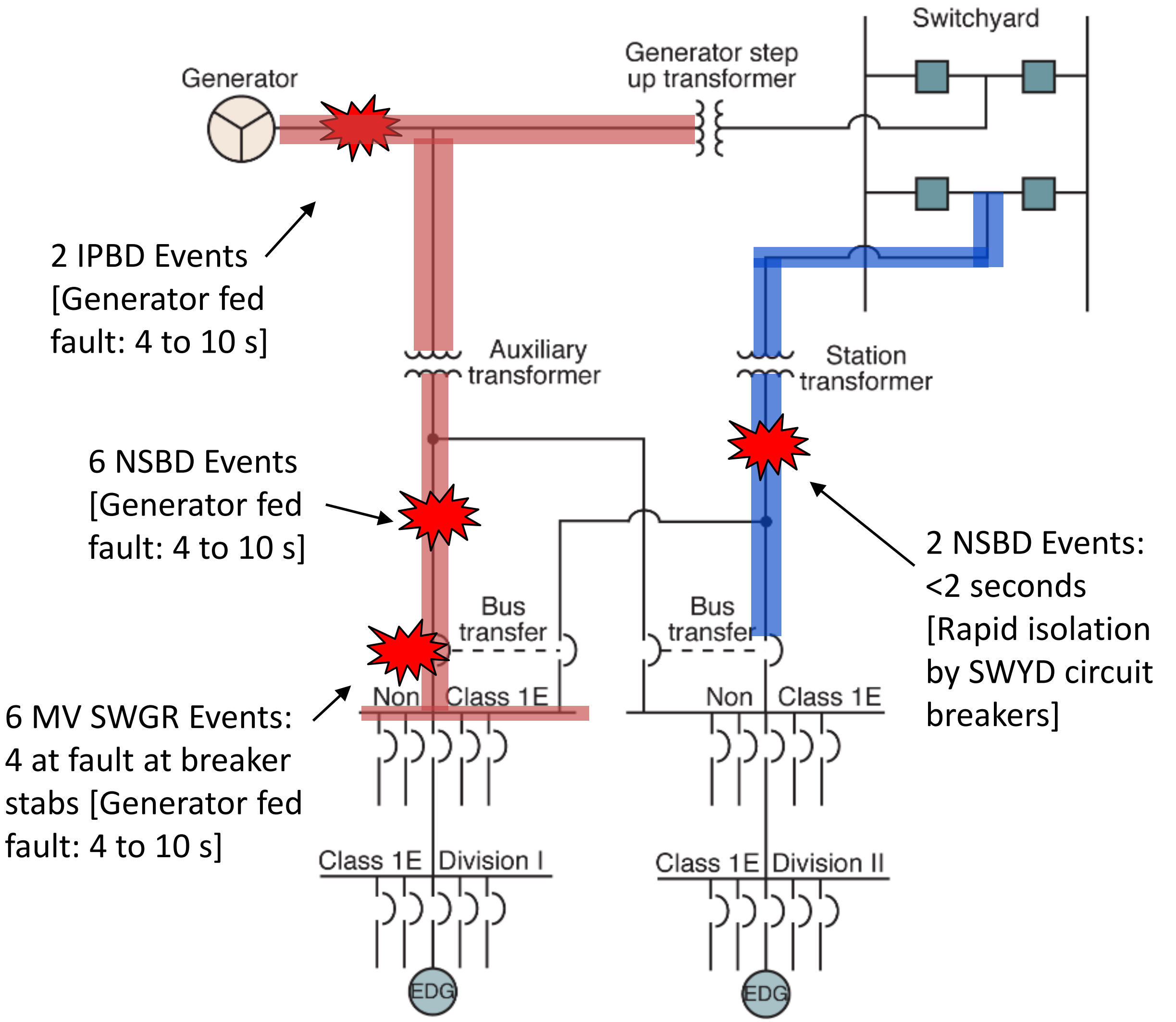
The current NUREG/CR-6850 HEAF framework is not representative of all HEAF events

Developing HEAF Methodology: Purpose

- Develop a framework that captures the different types of NPP electrical designs, fault locations, electrical protection, and fault durations that may impact the ZOI of a HEAF event
  - Not limited to equipment with aluminum
  - Use insights gained from EPRI survey and US OE
- Developed by a HEAF Working Group
  - Members from the NRC-RES/Sandia, EPRI and the industry
  - Establishing a more refined method for implementation, and the understanding of influencing factors affecting the energetic phase of a HEAF

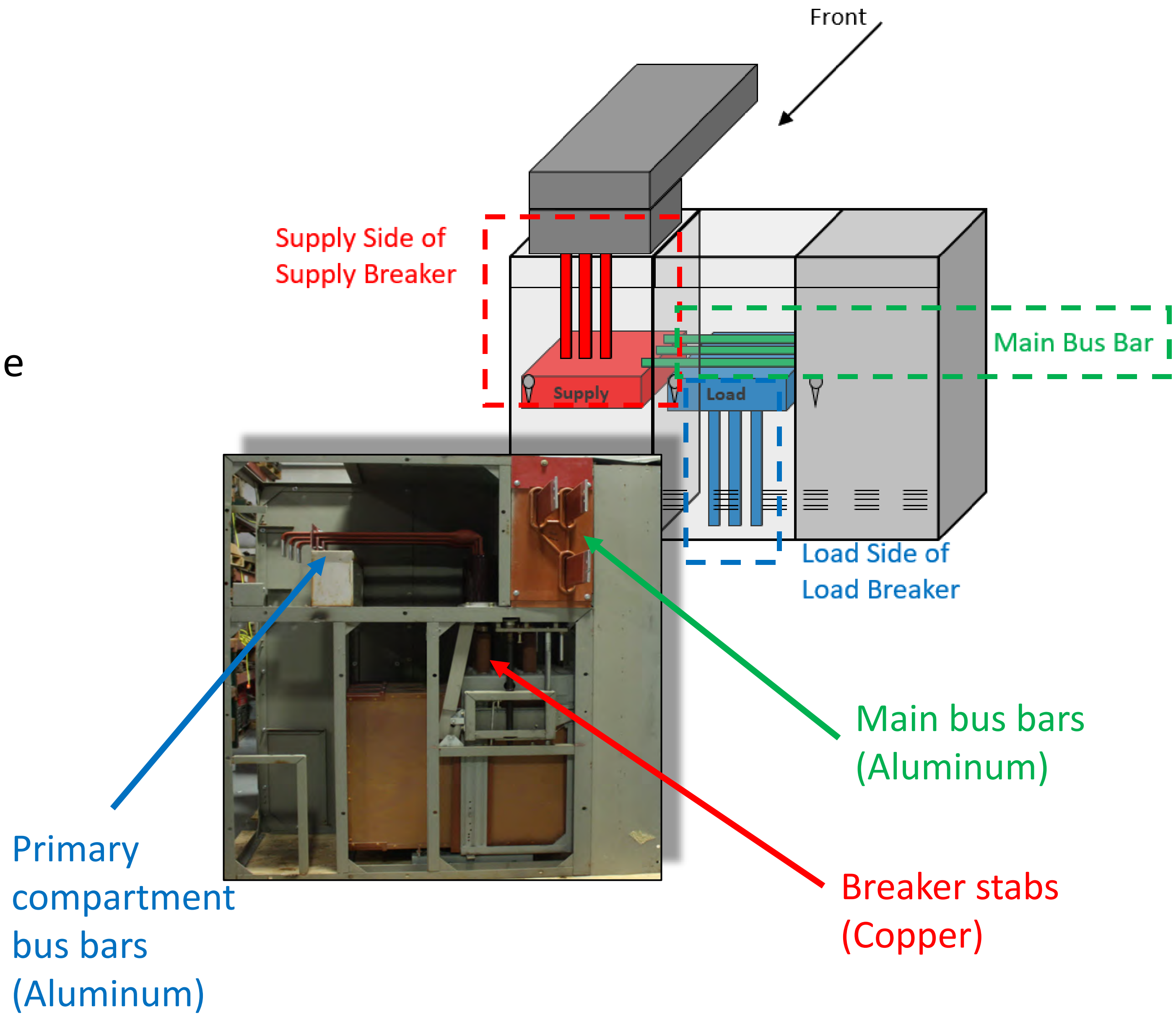
Key variables defining and differentiating HEAFs

- Fault duration and protection scheme matters
  - For MV switchgear, cabinet breach has been observed around 0.5 sec
  - Most HEAF events have been generator fed events that can persist longer than 4 seconds
    - This is equipment powered by the Unit Auxiliary Transformer (UAT) without a generator circuit breaker
  - The average fault clearing time for the MV SWGR when powered by the SAT is <2 sec for the US fleet (EPRI Survey)
    - Fewer HEAFs on equipment powered by the Station Transformer (SAT)
  - Additional overcurrent protection limits durations of low impedance faults
    - Challenging to see a HEAF below the first switchgear (below the Non-Class 1E in the figure)



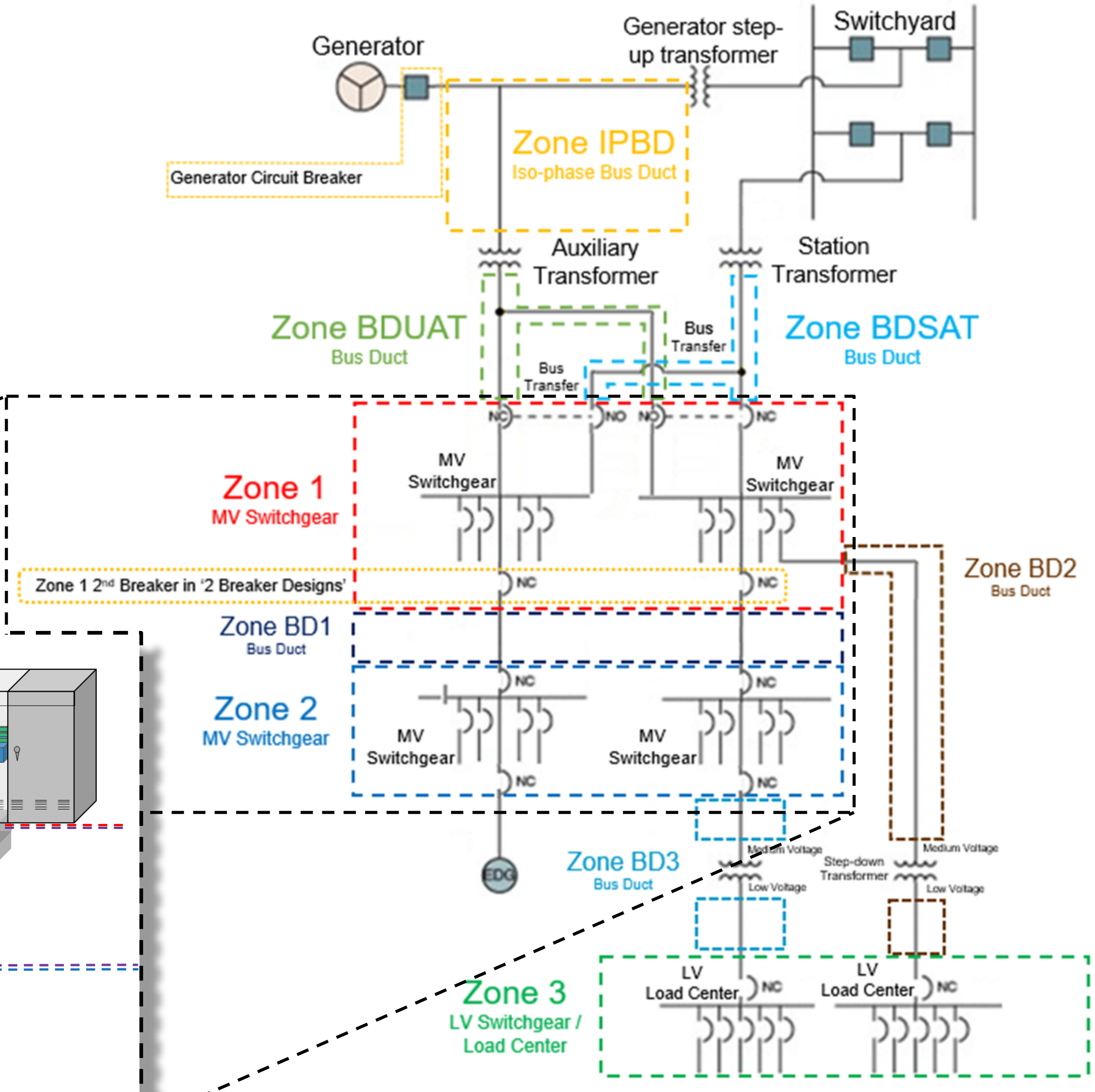
Key variables defining and differentiating HEAFs

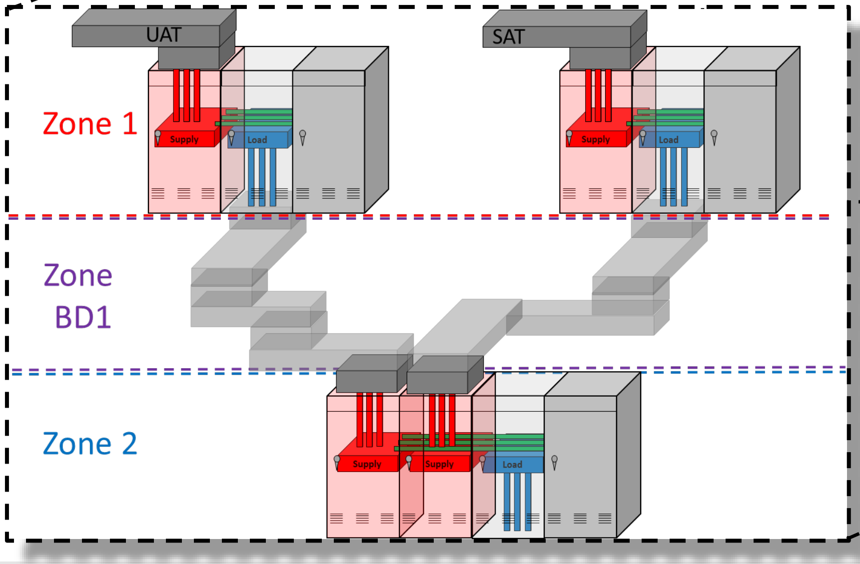
- Fault location matters
  - Most US HEAF events in switchgear have occurred at the breaker stabs
    - The breaker stabs are copper
  - Only one US HEAF event has occurred on the primary compartment bus bar
    - The bus bars (primary compartment and main bus bar may be aluminum)
  - Most US HEAF events in switchgear have occurred in the 'supply' sections
    - Rare for HEAF events to occur in a 'load' vertical section due to the protection provided by the supply breaker



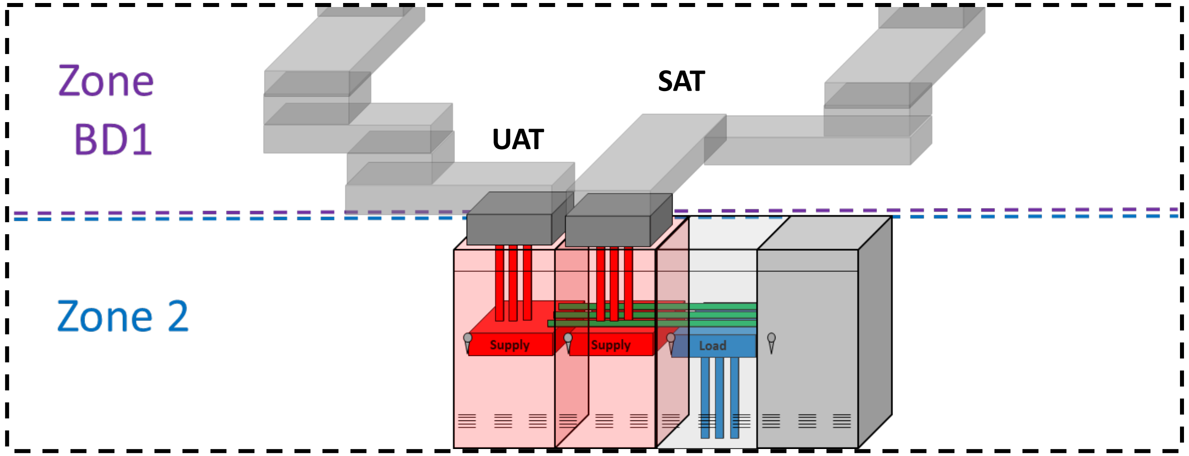
Developing HEAF Methodology: Considerations

- Methodology to consider:
  - Electrical distribution protection schemes
  - Faulting equipment
    - Switchgear (16.a, 16.b)
    - Bus Duct (16.1, 16.2)
  - Fault clearing times (FCT)
  - Fault durations
  - Fault locations
  - Power sources
    - Generator
    - Off-site





Developing HEAF Methodology: Framework



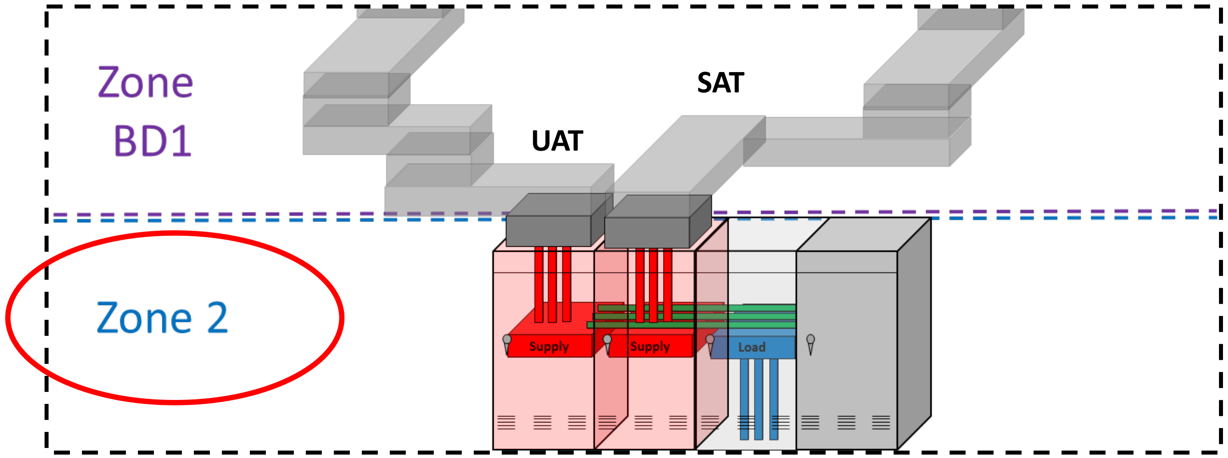
Ignition Frequency	Vertical Section	ZOI	End State Probability	End Sequence
Zone 2 SWGR Frequency	Primary Supply (0.54)	Generator Fed or SWYD FCT (0.06)	0.03	A_2
		Misc. HEAF (0.94)	0.51	B_2
	Secondary Supply (0.32)	Generator Fed or SWYD FCT (0.06)	0.02	C_2
		Misc. HEAF (0.94)	0.30	D_2
	Load & Main Bus Bar (0.14)	Generator Fed or SWYD FCT (0.04)	0.01	E_2
		Misc. HEAF (0.96)	0.13	F_2

PRELIMINARY

Fault Progression Trees drafted to identify the probability of potential HEAF consequences based on:

- Equipment (bin)
- Power source
- Fault location
- Electrical distribution protection schemes and fault clearing time
- Operating experience

Developing HEAF Methodology: Framework



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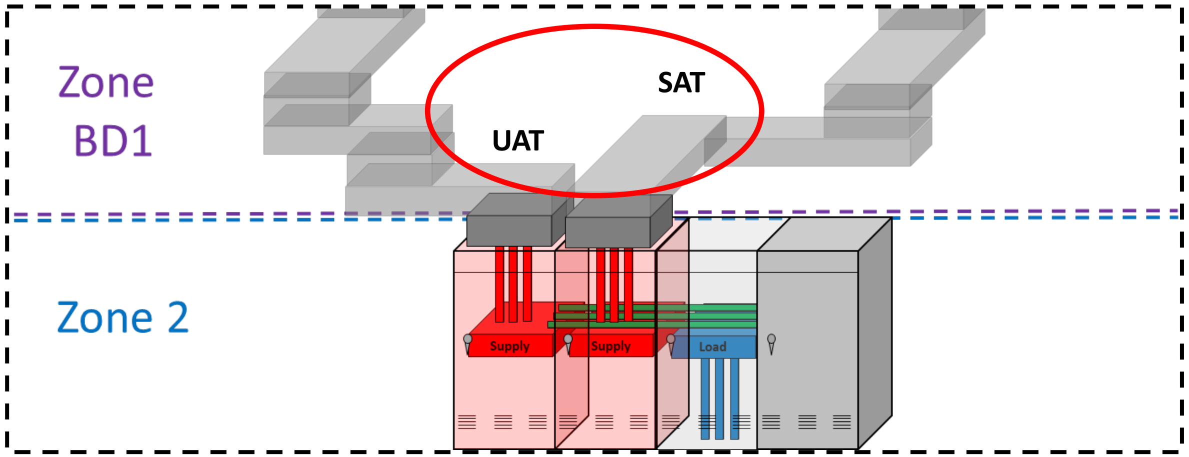
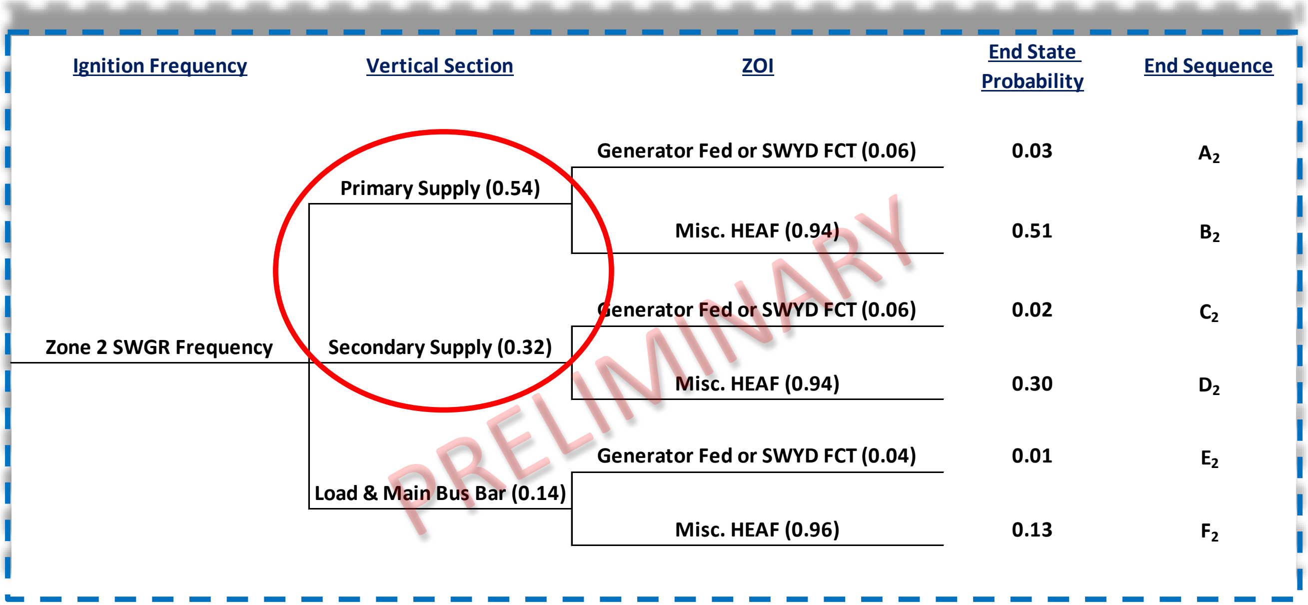
Fault Progression Trees drafted to identify the probability of potential HEAF consequences based on:

- Equipment (bin): The generic ignition frequencies are updated through 2017
- Power source
- Fault location
- Electrical distribution protection schemes and fault clearing time
- Operating experience

Developing HEAF Methodology: Framework

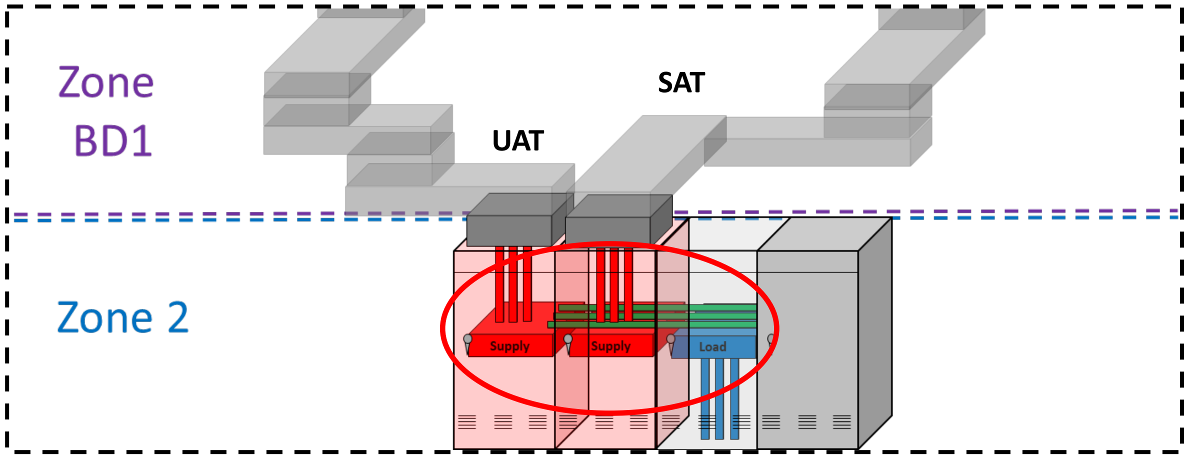




Fault Progression Trees drafted to identify the probability of potential HEAF consequences based on:

- Equipment (bin)
- Power source: OE and testing shows the power source impacts the HEAF consequence through the possible fault durations
- Fault location
- Electrical distribution protection schemes and fault clearing time
- Operating experience

Developing HEAF Methodology: Framework



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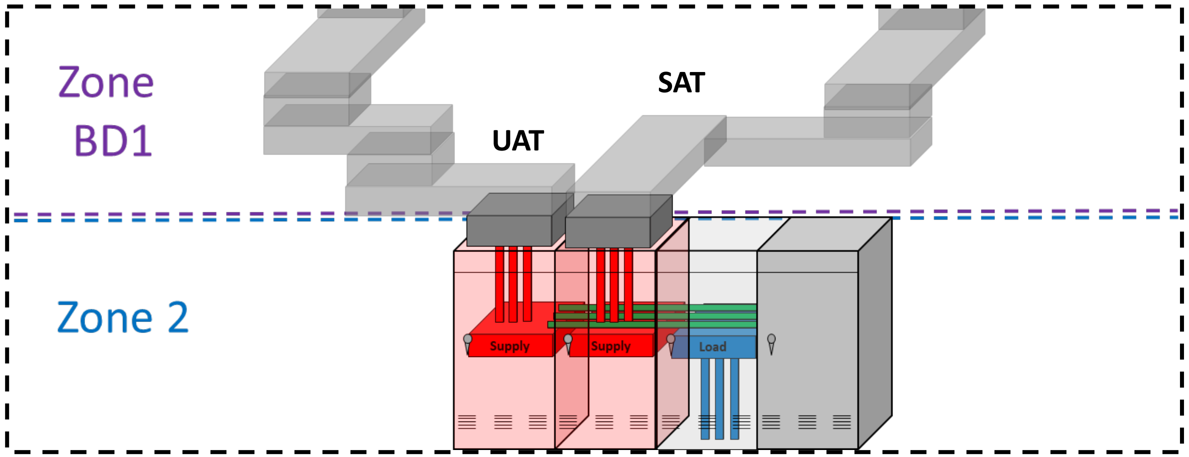
PRELIMINARY

Fault Progression Trees drafted to identify the probability of potential HEAF consequences based on:

- Equipment (bin)
- Power source
- Fault location: OE highlights where HEAF events are more likely to occur within equipment
- Electrical distribution protection schemes and fault clearing time
- Operating experience

Developing HEAF Methodology: Framework



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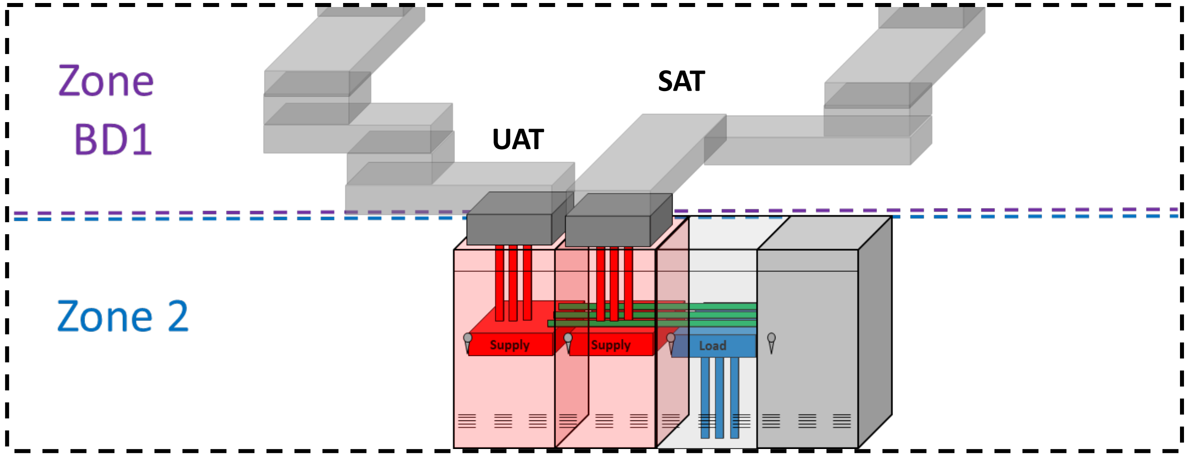
PRELIMINARY

Fault Progression Trees drafted to identify the probability of potential HEAF consequences based on:

- Equipment (bin)
- Power source
- Fault location
- Electrical distribution protection schemes and fault clearing time: The duration of a fault impacts the hazard (i.e. ZOI)
- Operating experience

Developing HEAF Methodology: Framework



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PRELIMINARY

Fault Progression Trees drafted to identify the probability of potential HEAF consequences based on:

- Equipment (bin)
- Power source
- Fault location
- Electrical distribution protection schemes and fault clearing time
- Operating experience: Split fractions developed by working group through expert judgement based on operating experience, typical plant alignments, and switching considerations

Key Takeaways

- The current NUREG/CR-6850 HEAF framework is not representative of all HEAF events
- Working Group of experts –NRC-RES/Sandia, EPRI and the industry– is establishing a refined methodology for incorporating the influencing factors affecting the energetic phase of HEAFs and practical implementation in fire PRA
- The draft framework captures the different types of NPP electrical designs, fault locations, electrical protection, and fault durations that may impact the HEAF ZOI
- New framework will provide a more accurate reflection of realism for the modeling of HEAF

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