JENSEN HUGHES

Advancing the Science of Safety

LESSONS LEARNED IN FIRE PRA HUMAN RELIABILITY ANALYSIS

Pierre Macheret, Nick Lovelace

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BACKGROUND AND SCOPE

HUMAN RELIABILITY ANALYSIS (HRA) IN FIRE PRA

- Knowledge on Fire PRA HRA has improved over the last 10 years
- Modeling guidance available on specific topics, e.g., NUREG-1921
- This presentation focuses on 2 lessons learned:
  - Potential for non-conservatisms in MCR abandonment by loss of control
  - Potential for excessive conservatism in modeling of human failure events, when hot short duration plays a significant role.

MCR ABANDONMENT IN FIRE PRA

- MCR abandonment due to the fire models two phenomena:
  - Abandonment by loss of habitability
  - Abandonment by loss of control

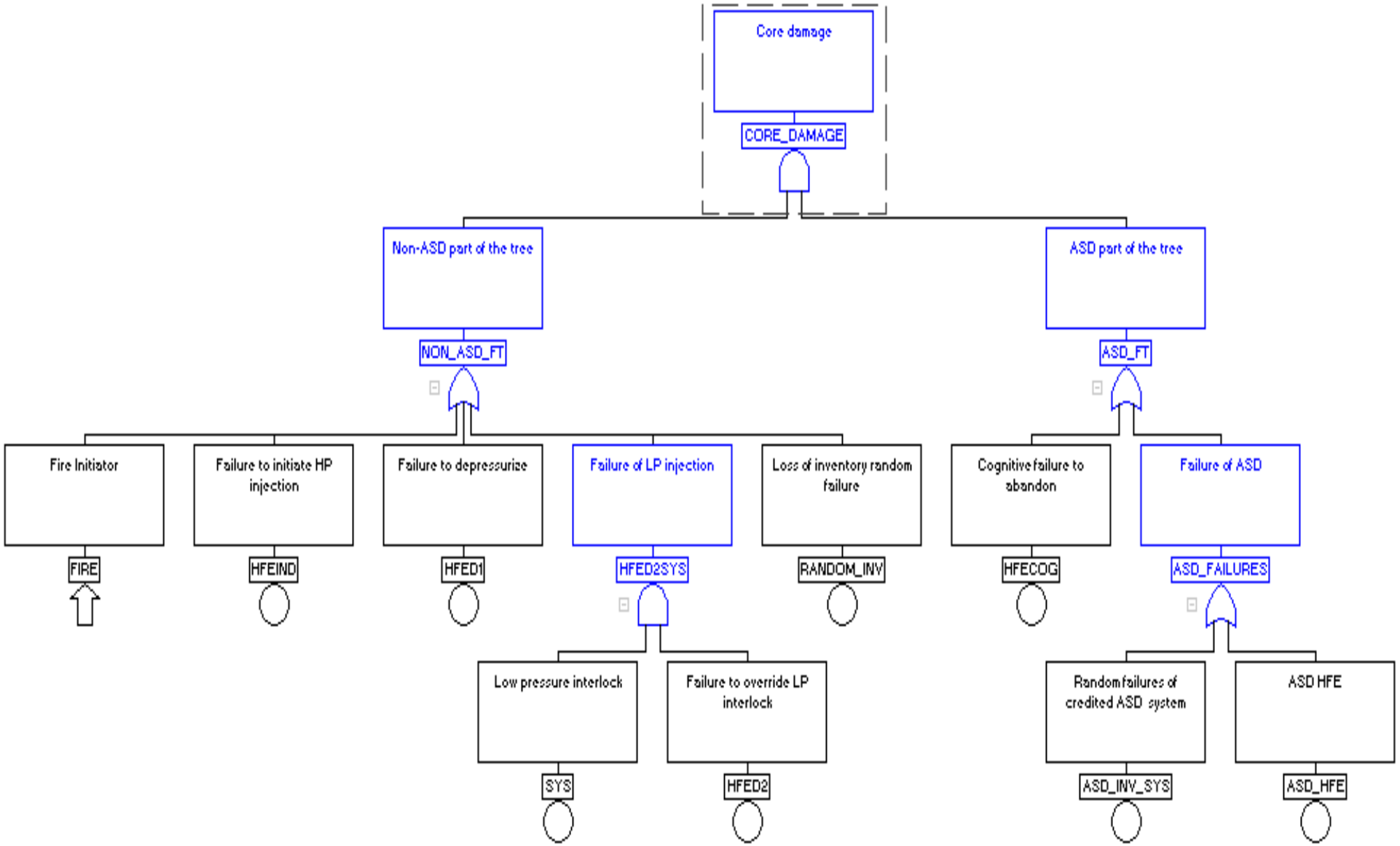
- Alternate Shutdown (ASD) in fault tree typically limited to:
  - Modeling of credited success path in associated fire procedure
  - Random failures of SSCs of the success path (normally there is no fire-induced failure)
  - Human failure events (HFEs) associated with abandonment (alignment of vital auxiliaries, inventory control, decay heat removal).

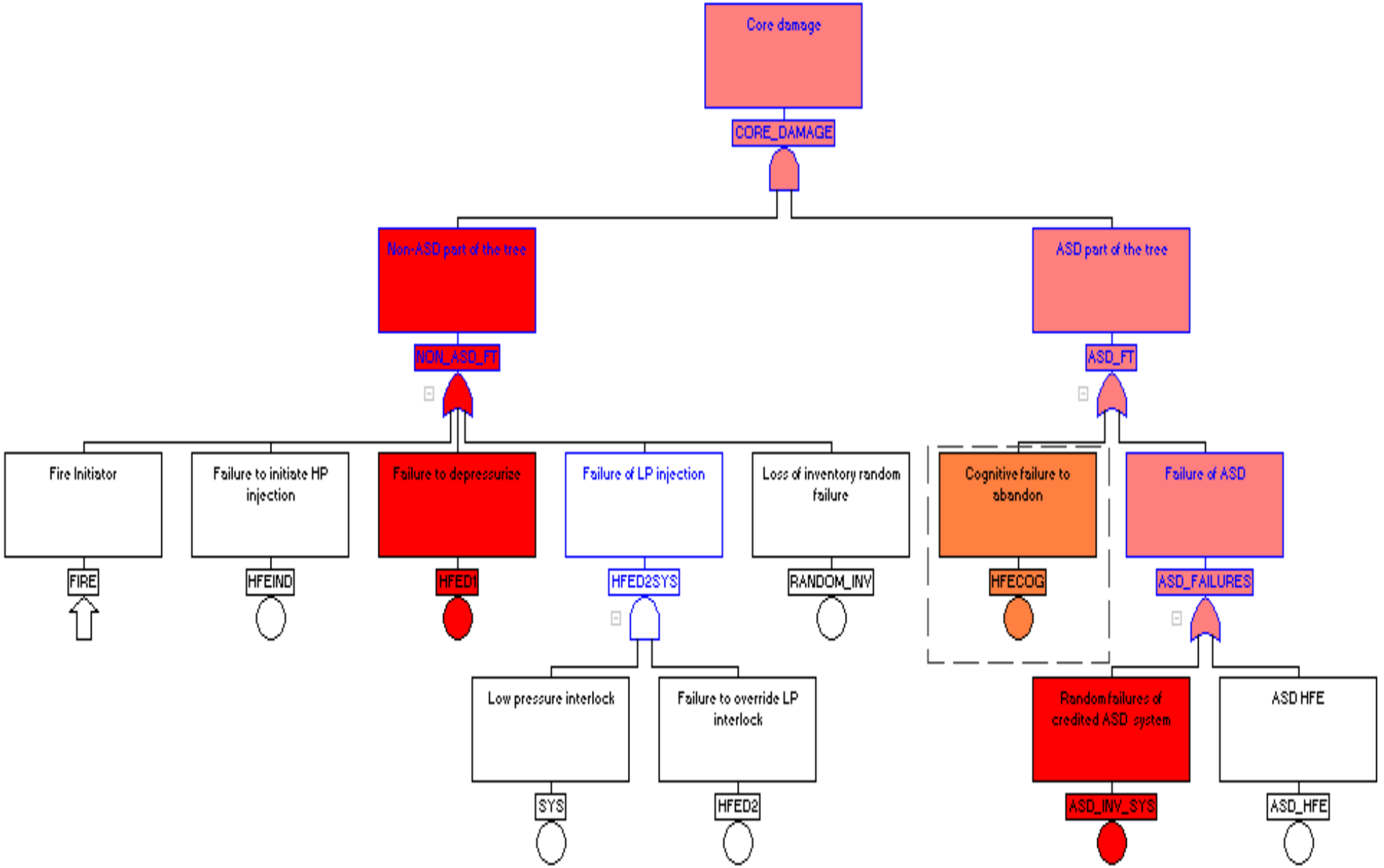
MCR ABANDONMENT BY LOSS OF CONTROL

- Key characteristics:
  - Set of functional criteria for abandonment:
    - Driven by time-critical elements. For example:
      - » Loss of inventory control (BWR)
      - » Loss of DHR (PWR)
  - Cognitive failure to abandon
    - Failure to abandon in time
  - Time window: typically 15 to 45 min

INTEGRATION WITH REGULAR (NON-ASD) MODEL

- If ASD model is AND-ed with non-ASD model, conditions that would lead to abandonment by loss of control could be realized by human failure events (HFEs).
- There could be situations where the failure to abandon in time is completely dependent on preceding HFEs of the non-ASD model.
- Example
  - Loss of inventory control due to failure of high-pressure injection (lost to the fire) followed by failure to emergency depressurize
  - Complete dependency with failure to abandon can be expected
  - This can lead to non-minimal cutsets


Core damage
CORE_DAMAGE
Non-ASD part of the tree
NON_ASD_FT
ASD part of the tree
ASD_FT
Fire Initiator
FIRE
Failure to initiate HP injection
HFEIND
Failure to depressurize
HFED1
Failure of LP injection
HFED2SYS
Loss of inventory random failure
RANDOM_INV
Cognitive failure to abandon
HFECOG
Failure of ASD
ASD_FAILURES
Low pressure interlock
SYS
Failure to override LP interlock
HFED2
Random failures of credited ASD system
ASD_INV_SYS
ASD HFE
ASD_HFE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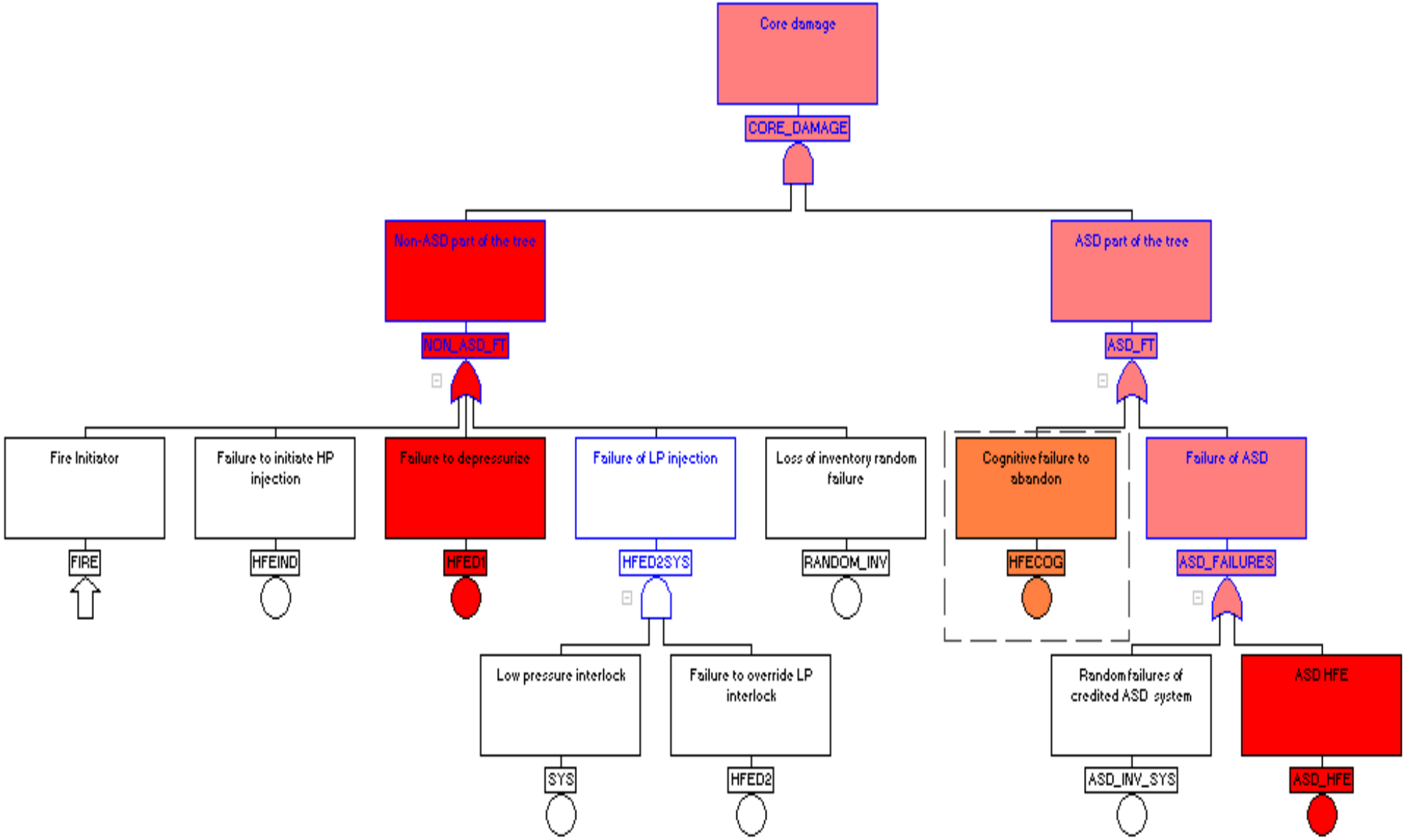
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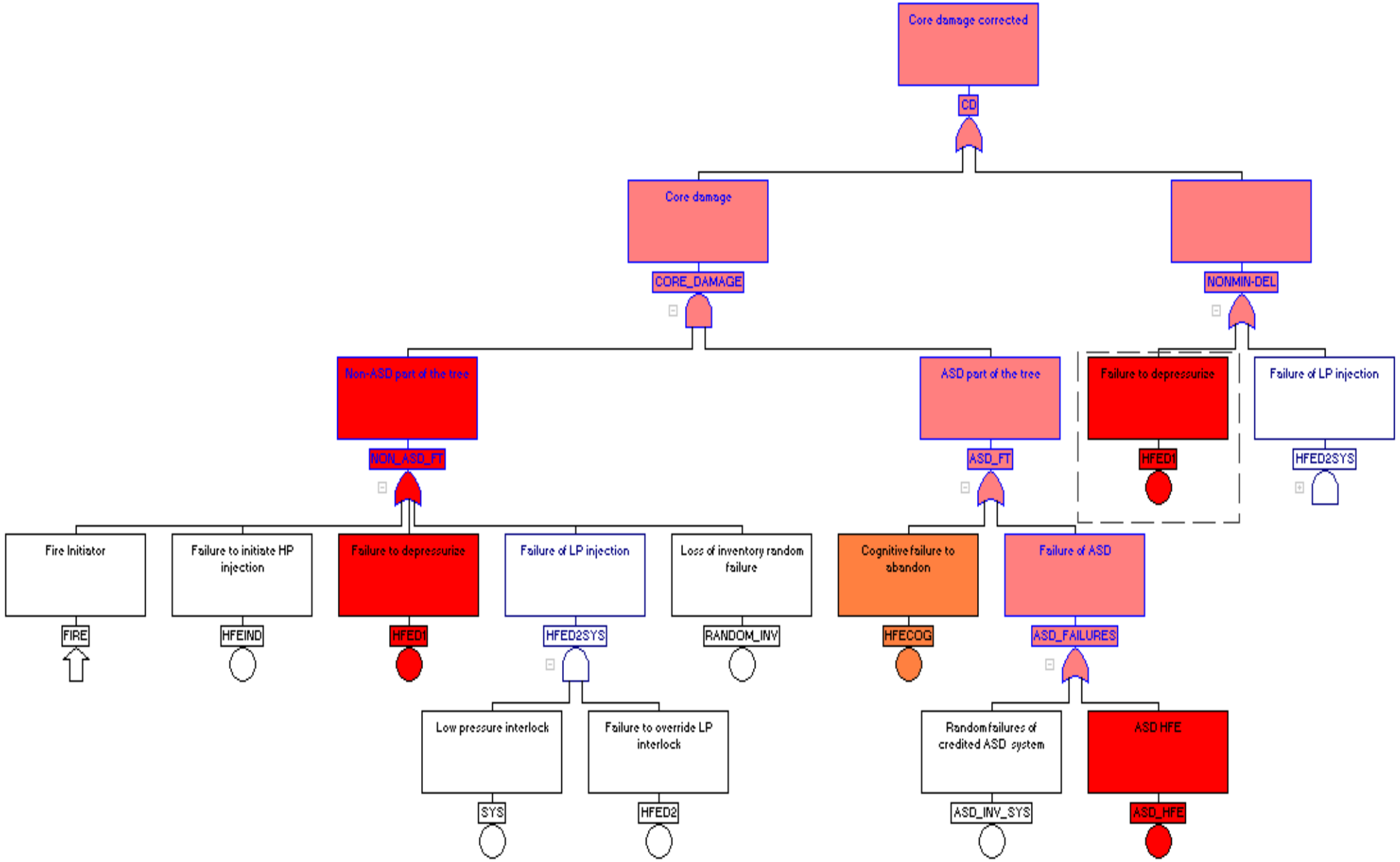
POTENTIAL SOLUTIONS

- Identify in advance which scenarios will be run as ASD by loss of control
  - Use of status panel
- Insert additional logic in fault tree


Core damage corrected
CD
Core damage
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ASD part of the tree
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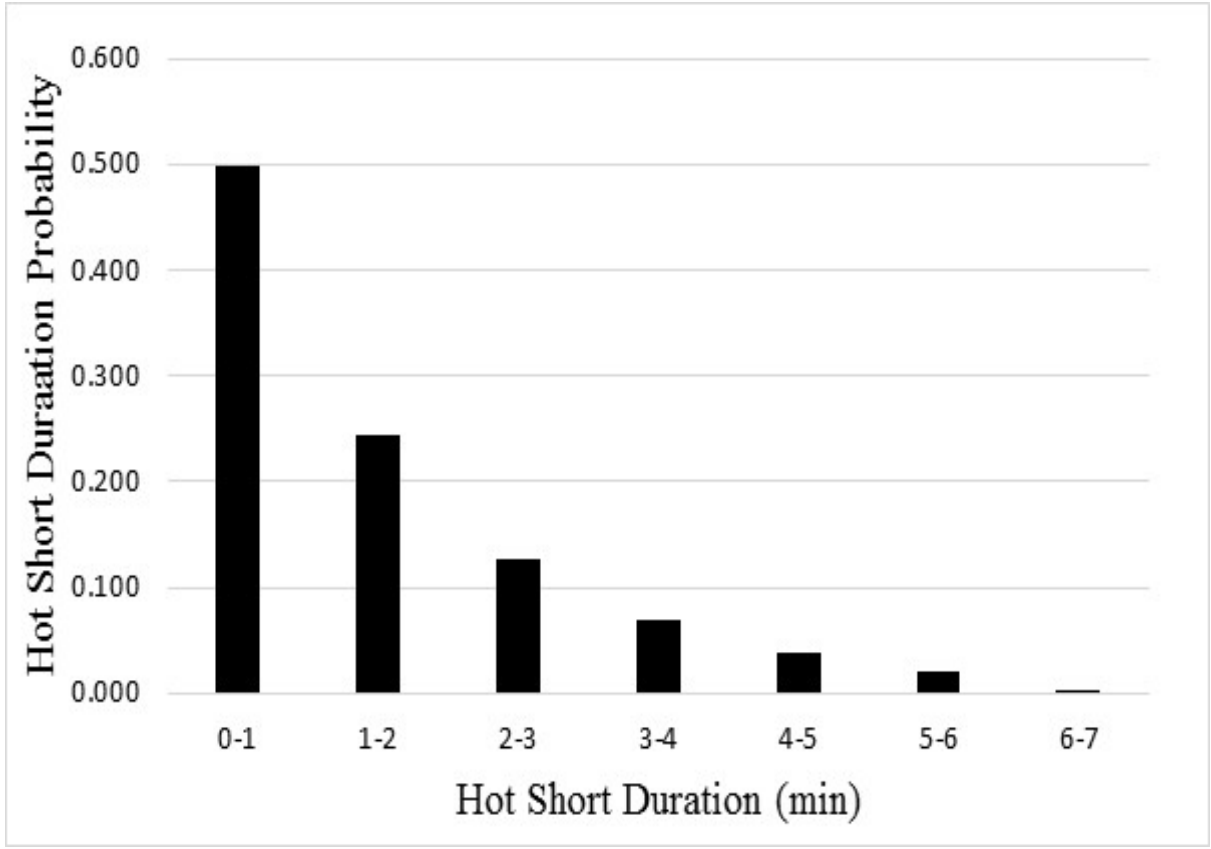
2ND LESSONS LEARNED: POTENTIAL FOR EXCESSIVE CONSERVATISM

- Importance of realistic timing for time-critical actions.
- Thermal hydraulics calculations may used inputs that are too conservative
  - Loss of inventory control due to spurious opening of safety relief valve, or spurious opening of PORV
  - Credit for hot short duration (when possible) can provide a significant benefit on the time window
  - NUREG/CR-7150 has short duration probabilities
  - 2 cases:
    - Hot short duration 7 min or longer, prob ~ .02
    - Hot short duration less than 7 min, prob ~ .98
  - Conditional on a hot short duration less than 7 min, the actual expected duration of the hot short is ~ 2 min.

HOT SHORT DURATION



Hot short duration probability, conditional on hot short lasting no more than 7 min

CONCLUSION

- Two lessons learned presented here intended to improve accuracy and realism of Fire PRA.
- Avoid non-minimal cutsets arising from attempt to unduly recover pre-abandonment actions
- Increase realism by taking advantage of knowledge acquired on hot short duration.

QUESTIONS?

Contact

P. Macheret
pmacheret@jensenhughes.com

For More Information Visit
www.jensenhughes.com

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