Fire PRA Maturity and Realism: A Discussion and Suggestions for Improvement

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Topics

- Maturity
  - Indicators
  - Implications
- Realism
  - Quantitative
    - Frequency and probability of fire-induced core damage
    - Relative contributions to total CDF
    - Frequencies of intermediate states
  - Qualitative
- Infrastructure
- Conclusions and Suggestions

Conclusions

- Technical maturity and realism are separate issues.
  - Lack of maturity $\not\Rightarrow$ unrealistic results
  - Maturity $\not\Rightarrow$ realistic results
  - Existence of uncertainties $\not\Rightarrow$ lack of maturity
- Fire PRA is in an intermediate-to-late stage of maturity.

Conclusions (cont.)

- Quantitative results of fire PRAs may be conservative.
  - Degree of potential conservatism is uncertain.
  - Sources include practical modeling choices as well as limitations in current technology and guidance.
- Qualitative results match well with operating experience.
  - Most important fire PRA scenarios appear to have a basis in past precursor events.
  - Most precursor fire sources and induced plant transients are typically included in fire PRAs.
  - Yard fires are a potential realism concern.
  - Not yet addressable: multiple fires, multiple hazards, non-proceduralized recovery actions.
- Work is underway to improve fire PRA technology.

Potential Indicators of Technical Maturity

	Developmental Stage		
	Early (Infancy, Emerging)	**Intermediate (Adolescent, Developing)**	**Late (Mature, Stable)**
Practitioners	• Small research community • Small number of practitioners • Strong personality influences, competing schools of thought	• Larger number of practitioners • Larger number of experienced researchers	• Many well-trained and experienced practitioners • Recognize limits of applicability of methods • Can adapt methods to new situations • Can work with researchers to identify important issues
Research Agenda	• Driven by perceived needs • Problem selection affected by personal choice (e.g., due to ease of formulation or solution)	• New practice-driven research problems • Some consensus positions for some broadly defined problem areas • Some unproductive research lines abandoned • Incomplete coverage of topics	• Most research driven by needs of practice • More abstract research addresses needs clearly identifiable by all concerned
Applications	• Local applications (addressing small parts of larger problems) • No broader framework	• Fast growth • Developing vocabulary • Optimistic views on new methods; limitations not well understood	• Vocabulary has evolved • General framework exists • Little “selling” of area

Does Maturity Assessment Matter?

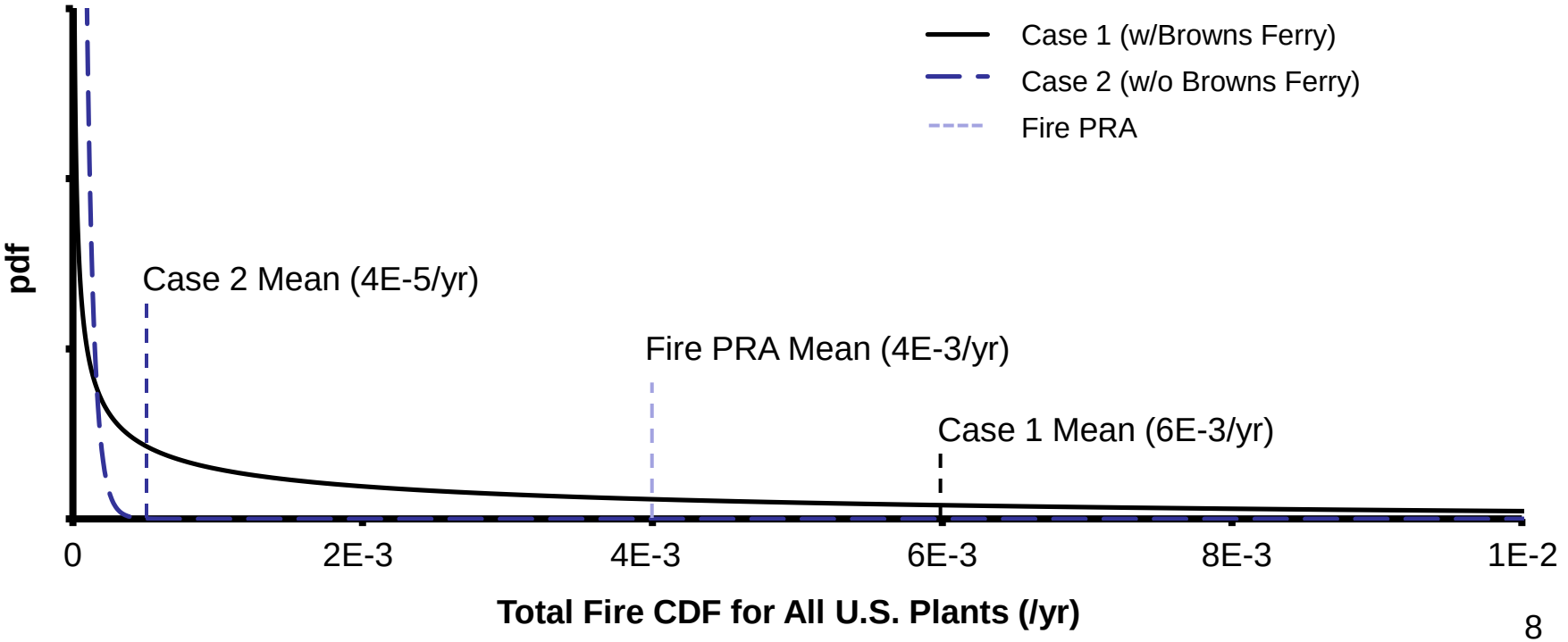
- Largely self-resolving (if continual need, desire, and resources)
- Potential consequences of assessments
  - Discounting of valuable results and insights
  - Use of alternative sources with their own weaknesses
- Potential improvement activities not limited to R&D
  - Applications
  - Other (e.g., training, consensus development)
- Changes will take time

Potential Indicators of Realism

- Quantitative
  - CDF
    - Absolute value
    - Relative contribution
  - Probability of core damage
  - Frequency of intermediate states
- Qualitative
    - Important fire PRA scenarios seen in events?
    - Event features seen in fire PRAs?

Comparing With Historical "Data"

- Data: CCDPs from precursor events
- Fire PRAs: NFPA 805 LARs (2006-2013)
- Metric: Total fire-induced core damage frequency, all plants



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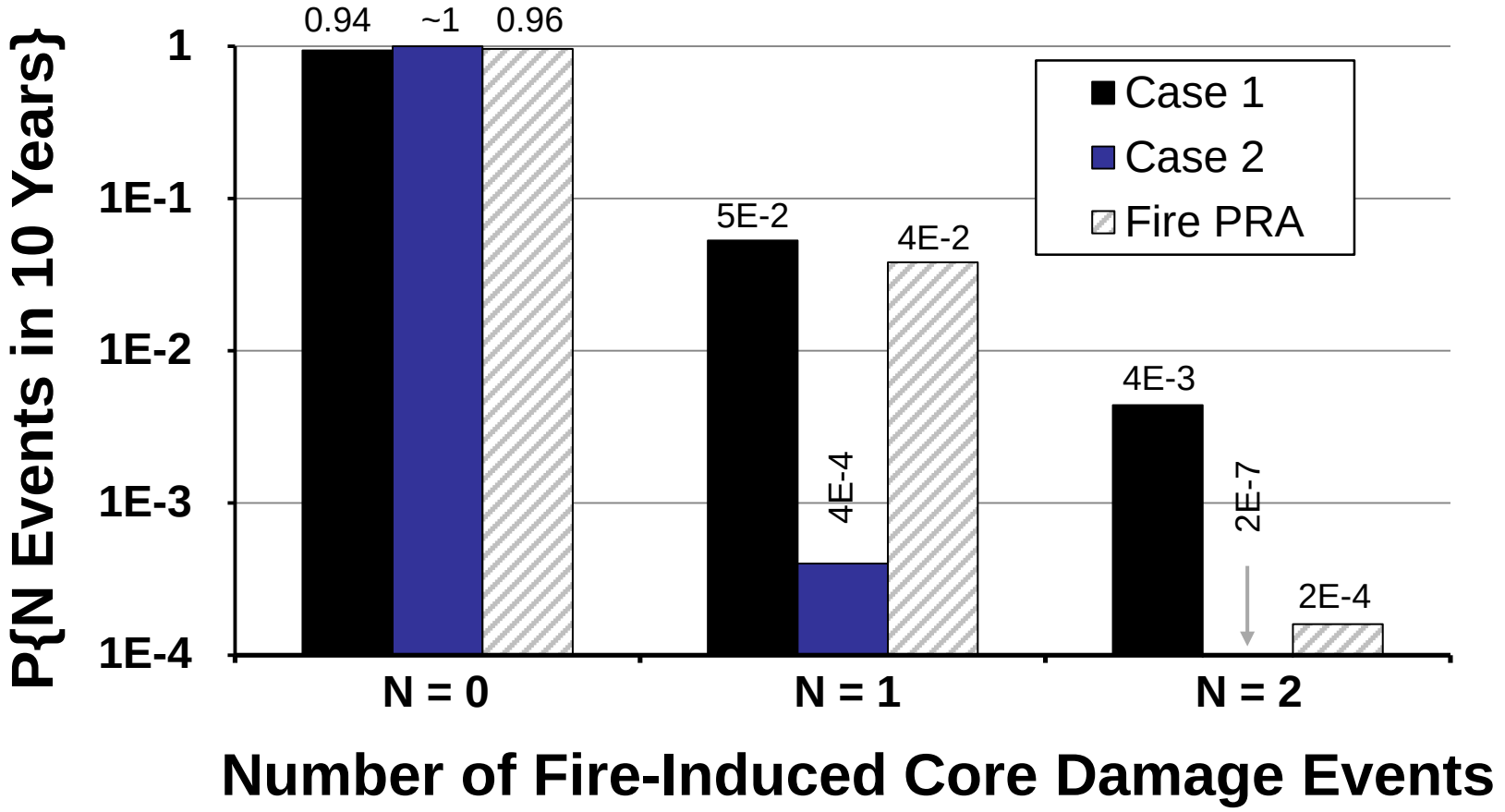

Cautions with Quantitative Analysis

- ***Assumption of exchangeability***
- Also
  - Only CCDPs for initiating event precursors
  - Methods and models for assessing CCDPs have evolved
  - Uses “failure memory” assumption
  - Use of NFPA 805 LAR fire CDFs
    - Representative for remaining plants?
    - Provide post-change CDFs

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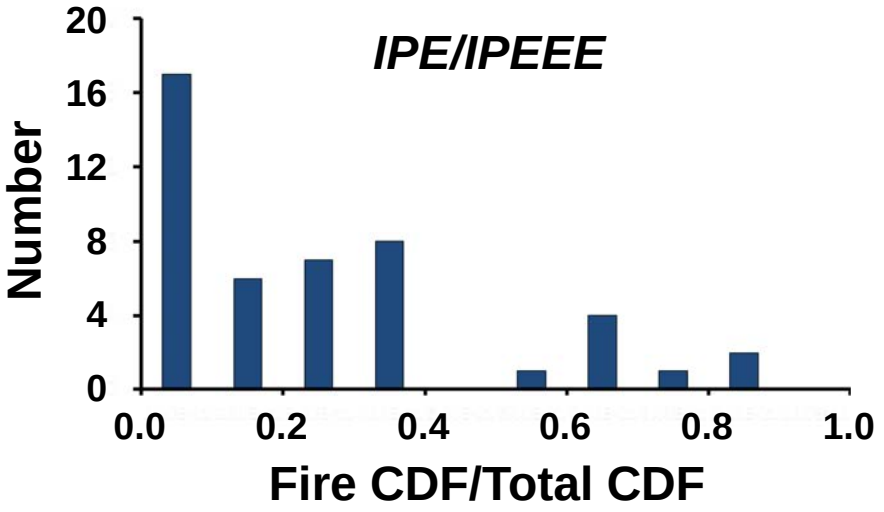
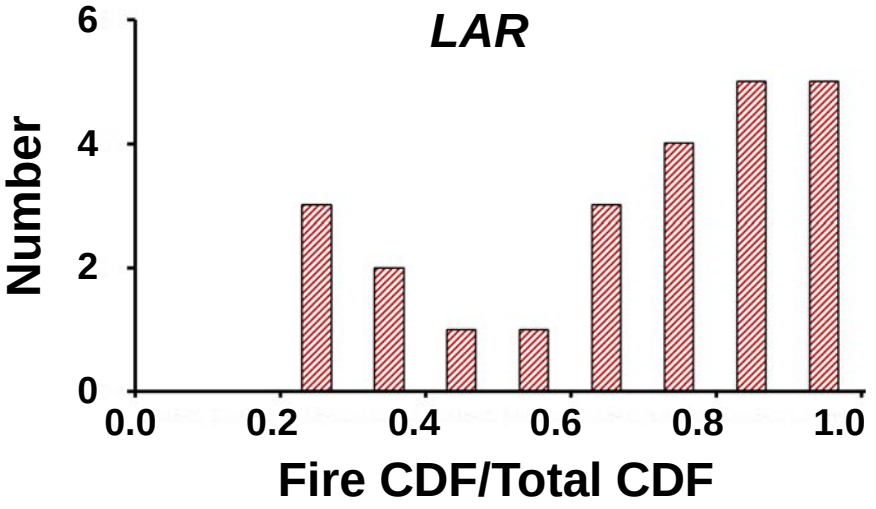
Changes: Relative Contribution





Frequency of Intermediate States

- Canavan et al. (2010)
  - Fire frequencies and severities
  - Frequency of spurious operations
  - Frequency of events with high CCDPs
  - Cumulative effects of multiple modeling conservatisms
- Observations
  - Similar results for fire-induced trips and LOOP
  - Ongoing work has addressed some issues
  - Effort to improve realism may not always be cost-beneficial
  - Conservatisms can be in CCDPs as well as in frequencies

Qualitative Scenario Comparisons

- Risk = $\{s_i, C_i, p_i\}$ (qualitative as well as quantitative)
- Consider IPEEEs as well as current fire PRAs (represented by SPAR-AHZ)
- Results
  - Most important fire PRA areas (e.g., MCR, CSR, switchgear rooms, turbine buildings) and scenarios (e.g., transients, fire-induced failures) seen in major historical events. Yard fires?
  - Historical events involve sources and transients typically included in fire PRAs. Overcooling?
  - Not addressed: multiple fires, multiple hazards, fires as consequences, non-proceduralized recovery actions…
- NUREG/CR-6738 still relevant

Cautions with Qualitative Analysis

- Use of SPAR-AHZ models as representing the broader set of current fire PRAs
- Sparse data for severe events
- Old events (pre-date many improvements)
- PRA does not “predict”
  - Identifies possibilities
  - Even low-likelihood events can occur

Fire PRA Infrastructure Elements

- Research and development
- Standards and guidance
- Staff
  - Training
  - Attitudes and beliefs

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Suggestions

- Structured consideration of indicators of maturity (if maturation acceleration is desired).
- Continue technology development.
  - Operational experience reviews to help identify and prioritize remaining gaps.
  - Emphasize work on enabling efficient analysis of situations where current, qualitative results appear to be inconsistent with operating experience.

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BACKUP SLIDES

Comparing With Historical "Data" (2014 update)

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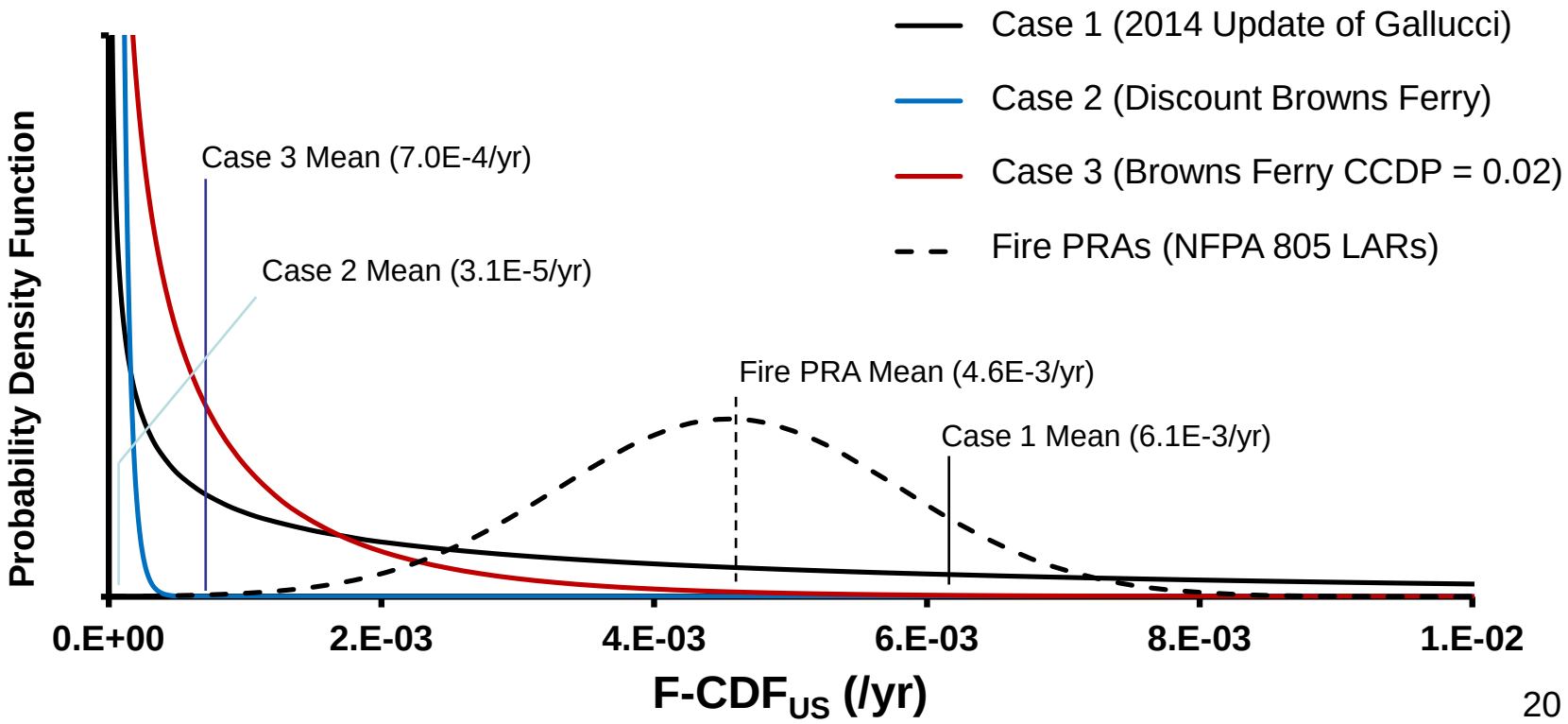

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Changes: Relative Contribution (2014 update)