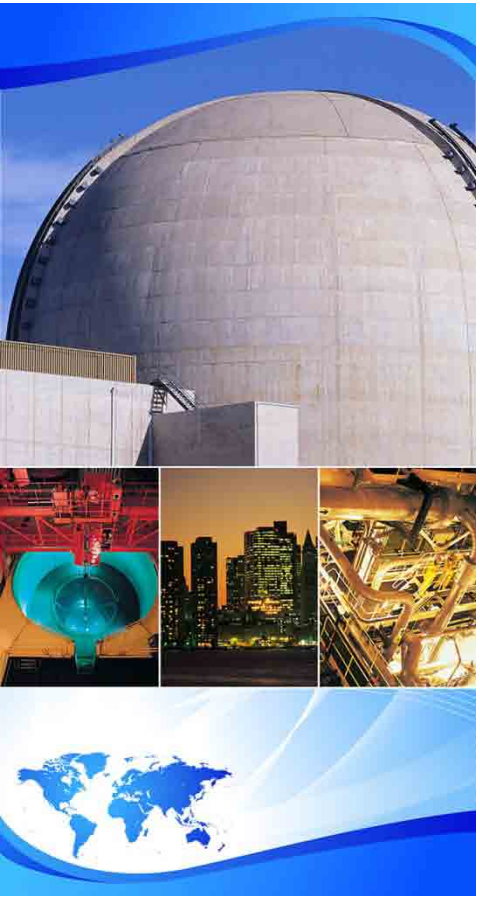


EPRI/NRC-RES FIRE PRA METHODOLOGY: Task 12 – Fire HRA

Fire HRA Training Overview

Joint RES/EPRI Fire PRA Workshop 2012

Bethesda, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Outline of the Presentation

1. **Overview of the EPRI/NRC Fire HRA Guidelines**
2. Identification and definition of fire human failure events
3. Qualitative analysis
4. Quantitative analysis
   a) Screening
   b) Scoping
   c) EPRI approach (detailed)
   d) ATHEANA (detailed)
5. Recovery analysis
6. Dependency analysis
7. Uncertainty analysis

EPRI/NRC Fire HRA Guidelines Overview

- Purpose of the Fire HRA training course module
- Training objectives
- Background on the Fire HRA Guidelines
- Fire HRA development team, approach & timeline
- Fire HRA Guidelines, public review & path forward
- Summary of EPRI/NRC Fire HRA Guidelines scope & contents

EPRI/NRC Fire HRA Guidelines
Purpose of Training Course

- Provide training on guidance from EPRI/NRC Fire HRA Guidelines (NUREG-1921/EPRI 1023001)
- Opportunity for face-to-face, real-time interactions between authors and potential future users
- Opportunity to improve training
  - It is important for us to get student/audience feedback for future presentations

Fire HRA Module Training Objectives

1: Be able to name the **steps in the process** for conducting a Fire HRA.

2: Be able to list the **different categories** of fire HRA human failure events.

3: Demonstrate a knowledge of ASME/ANS PRA Standard **high level requirements** related to HRA**.**

4: Be able to identify **context and performance shaping factors** used in the analysis of fire human failure events.

5: Be able to list the **quantification methods** available for HEPs.

6: Understand the concept and importance of addressing **dependencies** between fire HRA events.

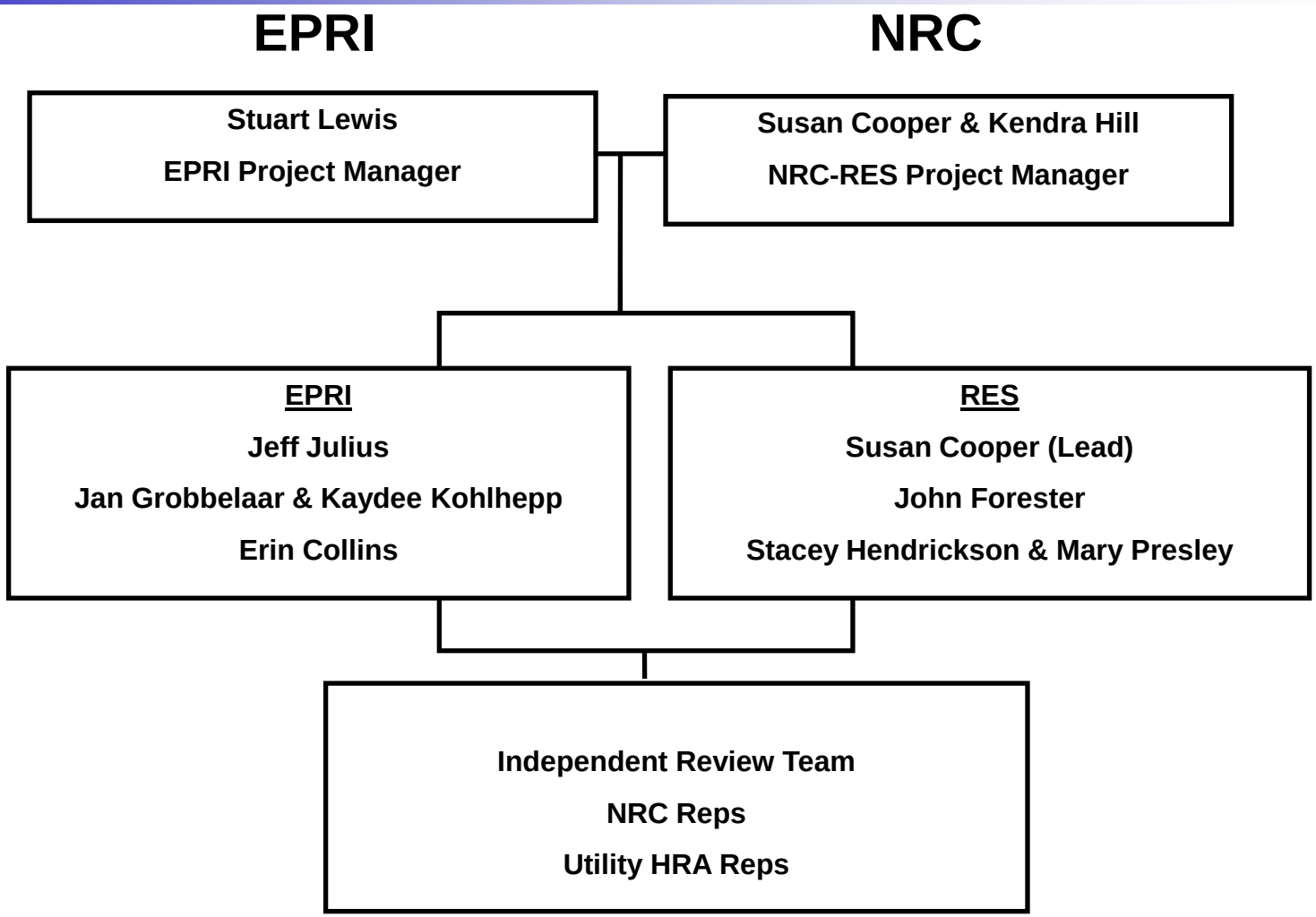
Background on the Issue of Fire HRA

- Almost 50% of USA plants transitioning to NFPA-805
  - Using NUREG/CR-6850 [EPRI 1011989] for the Fire PRA Guidance
- NUREG/CR-6850 [EPRI 1011989] addresses:
  - Identifying human failure events (HFEs)
  - Assigning conservative screening human error probabilities (HEPs)
  - Fire Performance Shaping Factor (PSF) information
- NUREG/CR-6850 [EPRI 1011989] does not:
  - Describe a methodology for developing best-estimate HEPs (given fire related effects)
  - Address the requirements of:
    - ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008, Standard for Level 1 / Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," Chapter 4 for fires
- Consequently, there was a need for fire-specific guidance for best-estimate HRA quantification in fire PRA

EPRI/NRC Fire HRA Guidelines
High Level Objectives

- Through joint NRC and industry efforts, address the need for HRA guidance, especially for best-estimate quantification, for use in fire PRAs
    - Address methodology
    - Address guidance for implementing the methodology
- Develop a joint EPRI/NRC report (similar to NUREG/CR-6850 [EPRI 1011989])
- Consider ASME/ANS PRA Standard requirements and user needs

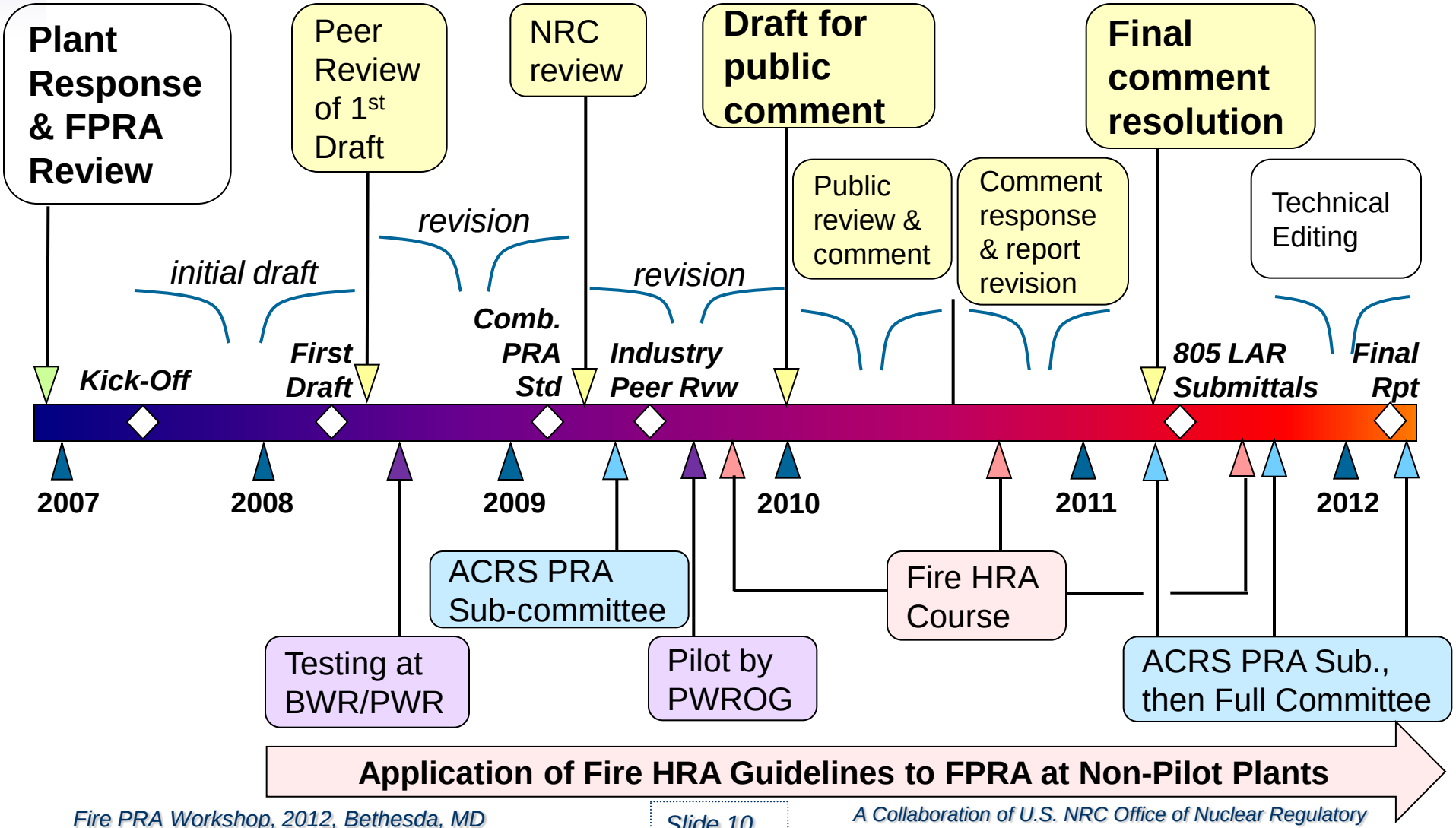
EPRI/NRC Fire HRA Guidelines
Development Team



Fire HRA Guidelines Development Approach

1) Fire Generic Data Review
   - Existing guidance & literature
   - Historical & experiential plant fire data
2) Fire HRA Methodology & Guidelines Development
   - Examined HRA process & identified how process and tasks would change for the fire environment and accident response scenarios in response to a fire
3) Fire HRA Review & Test
   - NRC and industry peer review team (7 people)
   - Two plants tested Scoping method flowcharts

Evolution of the Fire HRA Guidelines



Fire HRA Guidelines Development Timeline

- Started March 5, 2007
- First integrated draft - May 2008
- Peer review - June 2008
- Testing at 2 plants - Summer/Fall 2008
- Revised draft - April 2009
- Quick review by NRR and NRO – April 2009
- Piloting by PWR Owner's Group – Summer 2009
- Public comment period - December 2009 to March 2010
- ACRS presentations
  - Sub-committee: June 2009; April and September 2011
  - Full committee: April 2012
- Training Courses:
  - 1st presentation in September and October 2010
  - 2nd presentation in August and November 2011
  - 3rd presentation in July and September 2012
- Publication of final report – July 2012

Fire HRA Guidelines Public Review & Comment

- NUREG-1921/EPRI 1019196 issued in November 2009 for public review and comment
- Prior to public review period, obtained comments during presentation to ACRS PRA Subcommittee
- Received 265 public comments (~75 editorial) from:
  - PWROG
  - BWROG
  - EPRI HRA User's Group
  - Exelon
- Final report was revised to address public comments, etc.
  - Approach is not fundamentally different, but
  - Some important changes (e.g., reduced requirements for assessing feasibility of operator actions during screening and scoping analyses)

Fire HRA Guidelines Path Forward

- Final Guidelines document issued in July 2012
- It is anticipated that this guidance will be used by the industry as part of transition to NFPA 805 and possibly in response to other regulatory issues
- This is the first report addressing fire-related HRA for fire PRA that goes beyond the screening level
- As the methodology is applied at a wide variety of plants, the document may benefit from future improvements to better support industry-wide issues being addressed by fire PRA

Fire HRA Guidelines Summary
Objectives and Scope

- Identify/analyze **existing post-initiator** HFEs
  - Changes to previously modeled HFEs due to fire effects
- Identify/analyze **post-initiator fire response** HFEs
  - New category of HFE to be analyzed
    - Procedures, training, cues typically different from existing post-initiator HFEs
  - Includes alternative shutdown (such as MCR abandonment due to habitability or transferring command and control to outside the MCR)
- Identify/analyze **post-initiator HFEs in response to spurious actuations and indications**
  - New category of HFE to be analyzed

Fire HRA Guidelines Summary
Objectives and Scope (continued)

- Implement post-initiator fire HEPs in fire PRA model(s)
  - Initial quantification using screening or scoping approach
  - Identification of risk significant events for later detailed HRA (e.g., to meet ASME/ANS Part 2 supporting requirement HR-G1, Capability Category II)
  - Including dependency analysis

- Out of Scope
  - Pre-initiators (per NUREG/CR-6850 [EPRI 1011989])
  - Fire brigade response (except for impacts on fire PSFs)

Fire HRA Guideline Summary

- Standard HRA **process** used for Fire HRA modeling:
  - Based on other processes and guidance
    - ASME/ANS PRA Standard
    - NUREG-1792
    - Fire Manual Actions, NUREG-1852
    - SHARP1
    - ATHEANA
- Overall, NUREG-1921 [EPRI-1023001] captures the state-of-practice in HRA then advances the state-of-the-art for fire-specific PRA purposes

Fire HRA Process Steps

1. **Identification & definition** of human failure events (HFEs):
   - Substantial guidance provided, including feasibility test
   - Feasibility Evaluation (Go / No-Go) example criteria
     - Sufficient time available to complete action
     - Procedures & cues exist
     - Sufficient manpower
2. **Qualitative analysis**
   - Iterative process that continues throughout quantification steps
   - Discussion includes tips & tools for information collection, & interpretation, addressing important fire-specific topics, etc.
   - Comprehensive discussion of HFE feasibility under fire conditions
   - As fire PRA develops, fire HRA must consider additional fire scenario-specific details that become available

Fire HRA Process Steps (continued)

3. Quantification Methods – three levels

- **Screening Quantification**
  - Refinement/relaxation for areas identified in NUREG/CR-6850 [EPRI 1011989] implementation
  - Typically used in NUREG/CR-6850, Task 7 first/screening quantification
- **Scoping Fire HRA** method added (new):
  - Developed to address the majority of HFEs, thereby conserving HRA resources
  - Simplified HRA quantification method with limited set of performance shaping factors (PSFs) to address
  - Decision tree format (enhancing traceability)
  - Typically used during NUREG/CR-6850, Tasks 7 or 8, or early quantification of detailed fire scenarios in Tasks 11/14

Fire HRA Process Steps (continued)

3. Quantification (cont'd, 3rd of 3 methods)

- **Detailed Fire HRA**
  - Uses existing methods
  - Performance shaping factors modified for the fire context:
    - EPRI Cause-Based Decision Tree & HCR/ORE; & THERP
    - NRC's ATHEANA HRA method
  - Typically used in NUREG/CR-6850 [EPRI 1011989] Tasks 11/14 quantification of detailed fire scenarios as needed

Fire HRA Process Steps (continued)

4. Recovery, Dependency, and Uncertainty

- Typically part of NUREG/CR-6850 [EPRI 1011989] Tasks 11/14 quantification of detailed fire scenarios
- In general, these tasks are not different than that for internal events PRA
- NUREG-1921 [EPRI 1023001] discusses fire-specific aspects of these tasks

Fire HRA Process Steps

NUREG/CR-6850 [EPRI 1011989] Task	Fire HRA Process Step
Task 2 – Component Selection	**Identification** of previously existing HFEs & potential response to spurious
Task 5 – Fire-Induced Risk Model	**Identification and Definition** of fire response HFEs
Task 12 – Fire HRA	**Qualitative Analysis -** context & performance shaping factors
Task 7 – First/Screening Quant.	**Quantification –** typically screening or scoping
Task 8 – Scoping Quantification	**Quantification –** typically scoping
Tasks 11/14 – Detailed Scenario Quantification	**Quantification & Dependency** could be screening, scoping or detailed HRA
Task 15 – Uncertainty	**Uncertainty**

Fire HRA Guideline Summary

- NUREG-1921 [EPRI 1023001] also provides some additional tools & discussion that may be helpful to the analysis, e.g.,
  - Section 2.3, Relationship to Other Fire PRA Tasks
    - More detailed discussion of relationship between HRA and fire PRA
    - Table 2-1 relates NUREG/CR-6850 tasks to ASME/ANS PRA Standard elements & HRA tasks
  - Section 2.5, Fire-Induced Cable Failure(s) and Electrical Faults
    - Discussion of how fire PRA treats fire-induced cable failure(s)
    - Table 2-2 relates different types of fire damage to different fire PRA tasks & how this damage is addressed

Fire HRA Guideline Summary

- NUREG-1921 [EPRI 1023001] also provides some additional tools and discussion… (continued)
  - Section 4.3, Feasibility Assessment
    - Feasibility is defined & criteria are identified
    - Discussion of how feasibility assessments can be performed
  - Section 4.6.2, Timing
    - Discussion of timing windows used in NUREG-1921 [EPRI 1023001] quantification methods
    - Discussion of how to develop timing information
  - Section 4.11, Reviews with Plant Operations
    - Discussion on how to conduct talk-throughs & walk-throughs

Fire HRA Technical Overview

- **<u>Fire HRA Process Summary:</u>**
  - Identification and Definition
  - Qualitative Analysis
  - Quantification Methods:
    - Screening
    - Scoping
    - Detailed
  - Recovery, Dependency, & Uncertainty

- Each Fire HRA process step is further described in subsequent presentations

CURTISS WRIGHT Flow Control Company

SCIENTECH

Sandia National Laboratories

SAIC® From Science to Solutions™ Science Applications International Corporation