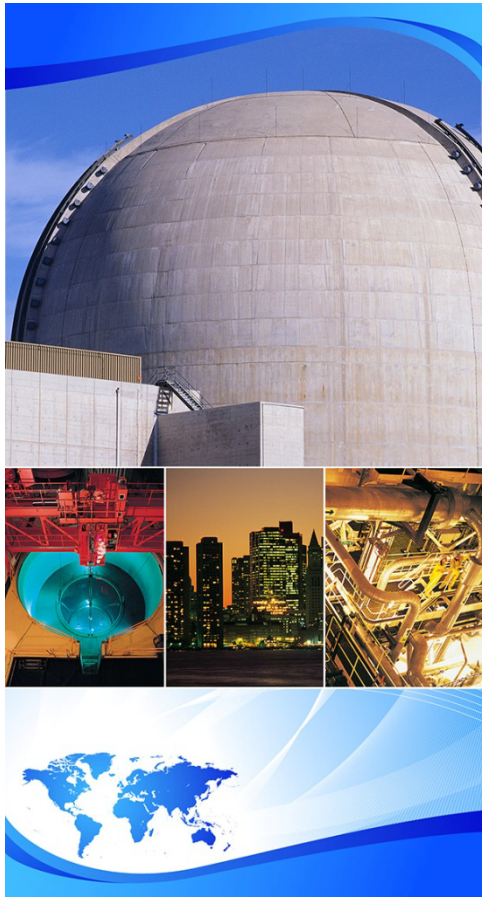

Updates to EPRI/NRC-RES Fire HRA Guidelines

Susan Cooper & Kendra Hill (NRC);
Stuart Lewis (EPRI), John Forester & Stacey Hendrickson (SNL); Jeff Julius, Jan Grobbelaar & Kaydee Kohlhepp (Scientech); Bill Hannaman, & Erin Collins (SAIC); Mary Presley (ARES Corporation)

PSA 2011, Wilmington, NC

March 13-17, 2011

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

Overview of Updates to EPRI/NRC Fire HRA Guidelines (Draft NUREG-1921)

- Background
- Summary of public comments
- Updates to tasks/sections:
  - Overall Fire HRA Process
  - Identification & Definition
  - Qualitative Analysis
  - Quantification: Screening & Scoping
  - Recovery, Dependency, & Uncertainty
  - Appendices (including detailed HRA approaches)
- Project status

Summary of Public Comments

- Four organizations that provided public comments on the draft Fire HRA Guidelines:
  1. Boiling Water Reactor Owner's Group (BWROG)
  2. EPRI's HRA User's Group (HRA UG),
  3. Pressurized Water Reactor Owner's Group (PWROG)
  4. Exelon
- Each comment was tracked by the numbering system used by the commenter.
  - However, for a few cases, a comment was subdivided because multiple issues were raised.
  - Consequently, the total number of public comments to address is two hundred and ninety (290).

Summary of Public Comments (continued)

Summary of public comments for the Joint EPRI/NRC-RES Fire HRA Guidelines (Draft NUREG-1921)	
Commenter	**Number of Comments**
BWROG	89
HRA UG	35
PWROG	102
Exelon	64
Total	290

Updates to Overall Fire HRA Process and "Identification & Definition"

- Fire HRA Process
  - Draft NUREG identified the process independent of Fire PRA tasks
  - Added mapping of Fire HRA tasks to NUREG/CR-6850 tasks
- Identification
  - Poor layout, hard to follow
  - Consolidated the discussion, focusing on 3 types of actions:
    - EOP actions from Internal Events PRA
    - Fire Response actions based on fire procedures
    - Undesired response to spurious
- Definition – better aligned the text to the combined PRA Standard, to define the PRA context before qualitative analysis

Updates to "Qualitative Analysis"

- Major public comment – lots of good information, but……
  1. Need to split-out the guidance from the background
  2. Approach does not fit actual FPRA progression, appears that you have to have detailed information to start and the results will be a Capability Category III Fire HRA

- Restructured the section to better define guidance from "considerations"

- Restructured the section to reflect the iterative nature / successive quantification approach applied during Fire PRA model development

Updates to "Qualitative Analysis"- Feasibility Assessment

- In response to a major public comments - feasibility assessment information from various subsections throughout the document was consolidated into a new section
- Structured section by addressing the major go/no-go factor for deciding feasibility (i.e., sufficient time)
- Other factors were considered (both independent and as input to timing)
  - Sufficient Manpower
  - Primary cues available/sufficient
  - Proceduralized and trained actions
  - Accessible location (incl. environment & travel routes)
  - Equipment/tools available/accessible
  - Relevant components are operable

Updates to "Qualitative Analysis"- Feasibility Assessment (continued)

- Information provided to the reader regarding where this fits into the Fire HRA
  - NUREG/CR-6850 tasks
  - ASME/ANS standard requirements
  - Fire HRA Guidelines tasks
    - Linked to Identification & Definition and initial Qualitative Analysis
    - But is a continuous process based on the knowledge base at each step
- Discussion of feasibility vs. reliability (transition between qualitative and quantitative)
- Comparison and contrast between EOP actions and fire response actions and the implications for feasibility of EOP actions

Updates to "Quantitative Analysis: Screening"

- Modified guidance to allow use of human error probabilities (HEPs) from internal events PRA for events that are demanded late (after the fire is out)

- Addressed availability of information for screening phase analysis & use of estimates in evaluating aspects such as spurious effects (in place of fire modeling & cable tracing results)

- Provided a new, simpler table that summarizes screening criteria

Updates to "Quantitative Analysis: Scoping Approach"

Overall, five major categories of modifications have been made:

1. Revised scoping approach to reduce complexity & resource demand, & to provide additional guidance
   - Now allows use of talk-throughs to obtain feasibility-related timing information
   - Provides guidance on how to perform talk-throughs
   - Provides guidance on how to use other available information in assessing feasibility, e.g.,
     - Job Performance Measures, demos from training exercises, Appendix R or NUREG-1852 feasibility demos, assessments of similar actions
2. Addressed how scoping approach fits into Capability Categories
   - Added discussion on use of scoping approach to identify risk-significant human failure events (HFEs) in meeting CC II, as defined in ASME/ANS Requirement HR-G2

Updates to "Quantitative Analysis: Scoping Approach" (continued)

3. Reduced conservatism in HEPs assigned via scoping approach
   - Reduced potential over-conservatism in some HEPs from scoping flowcharts by:
     - Reducing size of required time margins (i.e., none are > 100% now)
     - Eliminating potential effects of double-counting some influences
   - Modified to allow use of less conservative estimate of fire suppression times when fire type is known (per 99% percentile timing estimates for fire suppression supplied in FAQ-08-0050)
4. Improved guidance for using scoping approach
   - Provided a more straightforward selection scheme for determing which flowcharts to use for quantifying different kinds of human actions
   - Clarified that timelines should represent realistic, <u>average</u> times (not worst-case)
   - Moved some discussion on feasibility assessment to "Qualitative Analysis" section
5. Added an example of how to use scoping approach

Updates to "Recovery, Dependency, & Uncertainty"

- For "Recovery" & "Dependency":
  - Per public comments, realized that many of the issues were the same as other portions of the Fire HRA
  - Streamlined down to only a few paragraphs with definitions and pointers to Feasibility Assessment and Quantification
  - Now planning to combine three sections into a new section/chapter, titled, "Recovery, Dependency & Uncertainty"

- Resolution of public comments on "Uncertainty Analysis" section:
  - In progress
  - Major re-write to this section

Updates to "Appendices"

- Deleted Appendix B (Fire Event Review) & re-ordered Appendices
- Appendix A – Fire PRA Standard & Fire HRA Guidance
  - Added information from 2009 version of the standard, including fire-specific requirements
  - Paraphrased SRs from Internal Events HRA, Fire HRA and other areas indicating requirements for HRA task
  - Correlated standard SRs to Fire HRA Guidelines chapters/topics
- Appendix B (formerly "C") – Detailed Quantification Using EPRI HRA Approach
  - Changed guidance on Stress
- Appendix C (formerly "D" – Detailed Quantification Using ATHEANA
  - Added example using ATHEANA
  - Added tips for using ATHEANA
  - Added additional discussion on how to use ATHEANA

Updates to "Appendices" (continued)

- Appendix D (formerly "E") – Definition of Terms (some additions/revisions)

- Appendix E (formerly "F") – Summary of Testing & Peer Review
  - Revised title & content to reflect resolution of public comments

- Appendix F (formerly "G") – HRA Associated with Fire-Related Electric Bus Clearing….
  - Minor changes to address public comments

- Appendix G (formerly "H") – Justification for Scoping Approach
  - Updated consistent with main body of report

Fire HRA Project Status

- Project initiated: 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 & NRO: April 2009
- ACRS sub-committee information presentation: June 2009
- Piloting by PWR Owner's Group: Summer 2009
- Issued for public comment: December 2009
- Joint EPRI/NRC-RES as part of NUREG/CR-6850 Fire PRA Training Course: June/October 2009 (for information only)
- Public comment period ended: March 2010

Fire HRA Project Status (continued)

- Resolution of key public comments: June 2010
- Development of a new "track" for fire HRA in EPRI/NRC Fire PRA Course: Summer 2010
- ACRS sub- & full-committee presentations: Fall 2010
- Joint EPRI/NRC-RES NUREG/CR-6850 Fire PRA Training Course:
  - September 27 through October 1, 2010
  - October 25 through October 29, 2010
- Final public comment resolution: Now
- Presentation to NRC's ACRS PRA Sub-Committee: April 2011
- Publication of final report: Summer 2011

Fire HRA Guidelines March 2011 Summary

- Draft Fire HRA Guidelines received 290 public comments
- A major re-write was conducted during the 2010 and early 2011
  - Insights from existing NUREG/CR-6850 Fire PRAs was incorporated
  - All comments were addressed, most resulting in changes to the guidelines
- Additionally, developed and implemented a new “track” for fire HRA in EPRI/NRC Fire PRA Course in 2010
- Updated Fire HRA Guidelines to be presented to ACRS in April 2011
- Publication of final report: Summer 2011

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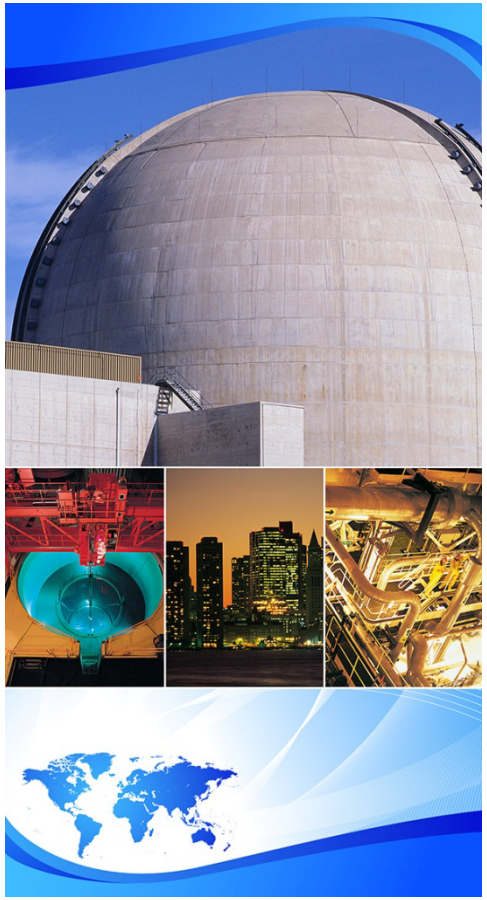
BACK-UP SLIDES



Guidelines for Human Reliability Analysis for Fire PRAs

Stuart Lewis
Program Manager
Risk and Safety Management
Electric Power Research Institute

NEI Fire Protection Information Forum
September 13, 2010

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

Outline

- Background and objectives for the fire HRA guidelines (NUREG-1921/EPRI 1019196)
- Evolution of the guidelines – impact of public review
- Overview of the technical tasks

Background and Objectives

- Human reliability analysis (HRA) is essential to fire PRA, as it is for any PRA
- Potential recognized for unique influences to come into play for operator response during fire scenarios
- Guidance in NUREG/CR-6850 (EPRI 1011989) for PRA provides limited guidance for HRA

Background and Objectives (continued)

NUREG/CR-6850 provides limited guidance for HRA:

- Identification of relevant human actions and definition of human failure events (HFEs) for PRA models
- Method for assigning quantitative screening values
- Initial considerations for more detailed analysis
  - Relevant performance shaping factors (PSFs)
  - Related fire effects

NUREG/CR-6850 does <u>not</u> address:

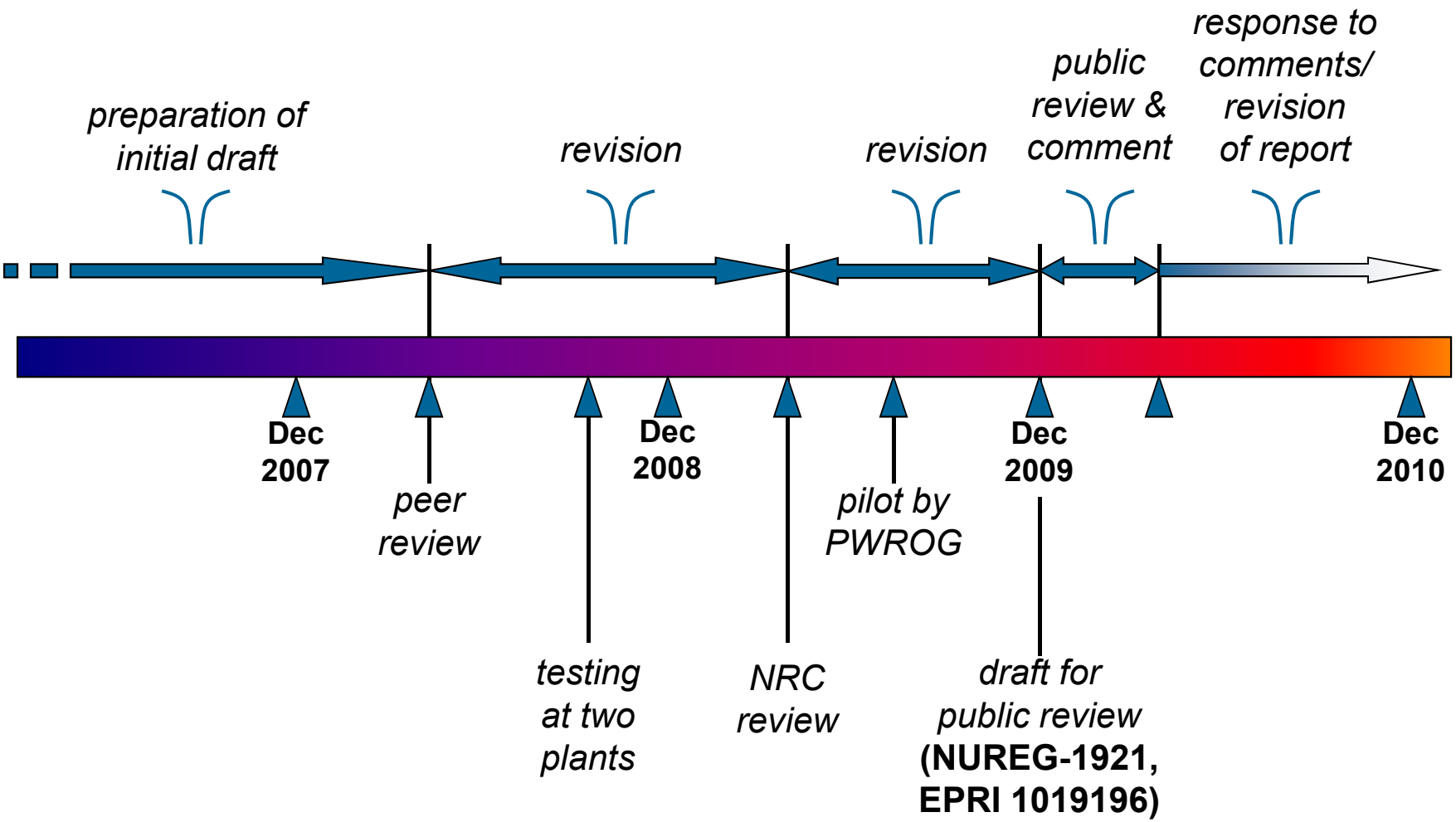
- Specific elements of detailed HRA for fire context
- Elements needed to satisfy Supporting Requirements from ASME/ANS PRA Standard

Background and Objectives (continued)

Objectives for the development of HRA guidance:

- Through joint efforts of NRC and EPRI, address HRA more comprehensively
  - Ensure best-estimate analyses are covered
  - Specify appropriate methods
  - Provide guidance needed to implement methods effectively
- Develop guidance in such a way that it
  - Should meet user needs for effective HRA
  - Properly employed, should produce HRA that meets Category II Supporting Requirements from ASME/ANS PRA Standard

Evolution of the Fire HRA Guidelines

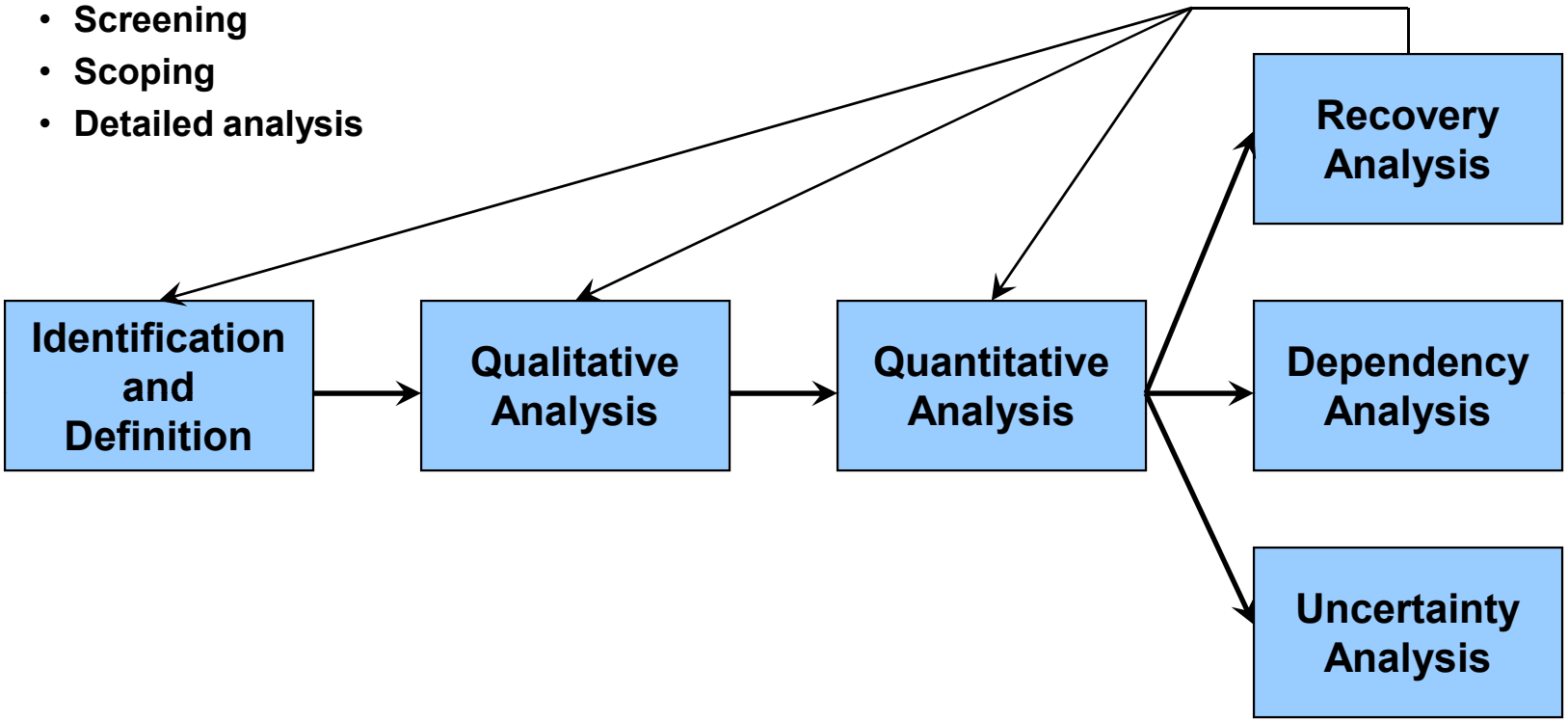


Evolution: Major Comments on Draft

- Better specification needed for elements of qualitative analysis required for screening, scoping, and detailed analysis
- Time margins
  - Unduly pessimistic with regard to use in feasibility assessment and scoping analysis
  - Excessive requirements for demonstration (e.g., walkthroughs when other information available)
- Scoping analysis too complex – effort required commensurate with detailed analysis
- Introduction of “fire stress” – inadequate justification and guidance for application
- Deficiencies in guidelines for uncertainty analysis
- Full piloting of revised guidelines needed

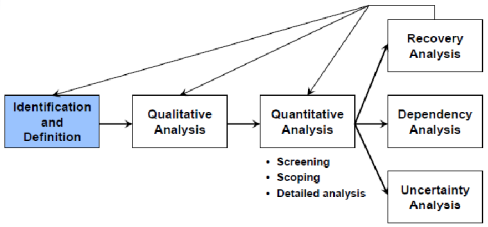
Steps in the Fire HRA Process

- Screening
- Scoping
- Detailed analysis



Identification and Definition

Identification



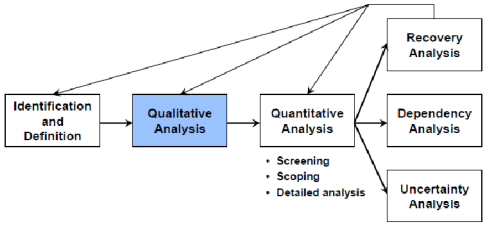
- Determining where there are relevant operator actions
  - From understanding of plant response
  - From PRA models
- Accomplished by
  - Review of plant procedures, operator interviews, etc.
  - Review of PRA models: event trees, fault trees, etc.

Identification and Definition (continued)

Definition

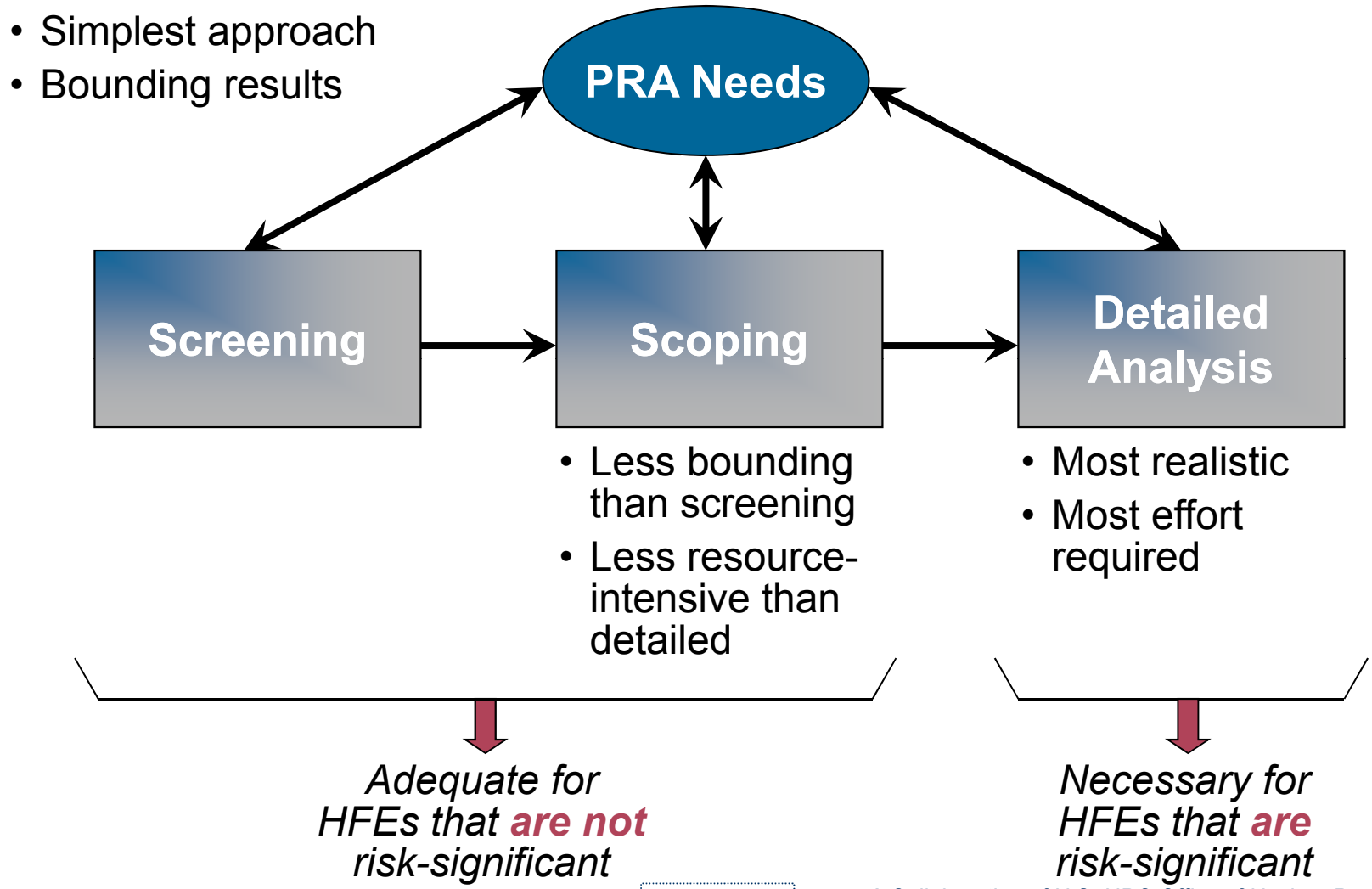
- Supports justification for including human failure event(s) in PRA models
- Provides information needed as inputs to qualitative analysis
  - Procedures available
  - Cues to initiate and confirm action
  - Timing
  - Staff required, including impact due to fire
- Includes initial assessment of feasibility – go/no-go

Qualitative Analysis



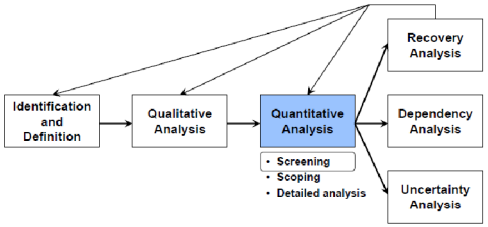
- Involves assembling information needed to support quantitative analysis
  - Understanding of fire-specific context
  - Review of relevant historical experience
  - Review of plant operations
  - Evaluation of feasibility for action
  - Identification and characterization of relevant performance-shaping factors (PSFs)
- Nature of qualitative analysis oriented to quantification approach (i.e., limited for screening, more extensive for detailed analysis)

Three Progressive Options for Quantification



Quantification – Screening Approach

Extension of NUREG/CR-6850

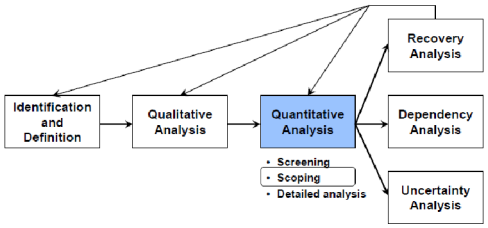


- Relaxation of values, especially for longer time frames (i.e., after fire is suppressed)

- Allows quick assignment of values for
  - HFEs from internal-events PRA, for actions only indirectly affected by fire scenario
  - HFEs from internal-events PRA, with complications from spurious actuations
  - New fire-related HFEs or HFEs significantly from internal-events PRA significantly affected by fire scenario
  - HFEs for actions following evacuation of the main control room

Quantification – Scoping Approach

Intentions for Scoping Approach



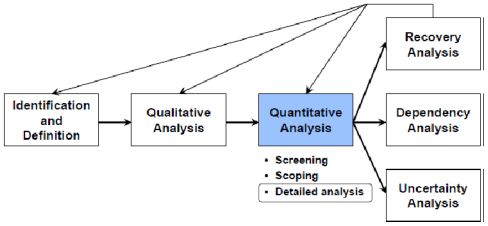
- Results less bounding than from screening approach
- Less resource-intensive than detailed analyses
- Adequate for human failure events that are not risk-significant (to meet Cat. II Supporting Requirements)

Formulation

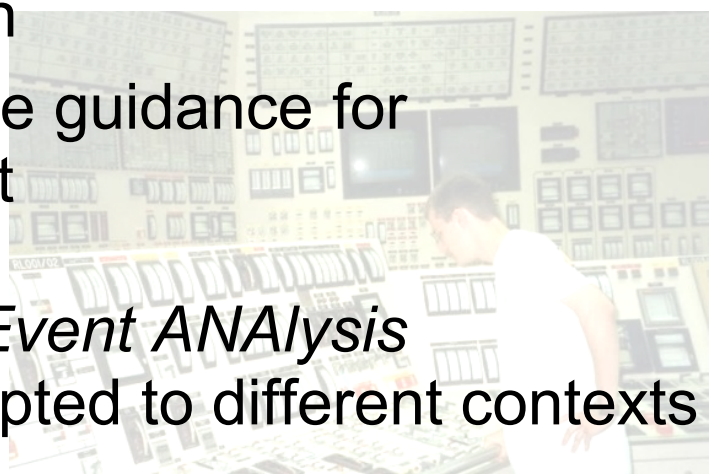
- Series of decision trees (e.g., in-control room vs. local actions; response to spurious indications, etc.)
- Tied to assessment of time margin
- Intended to be applied via simple assessment of performance shaping factors

Quantification – Detailed Approaches

Two options for detailed analyses:

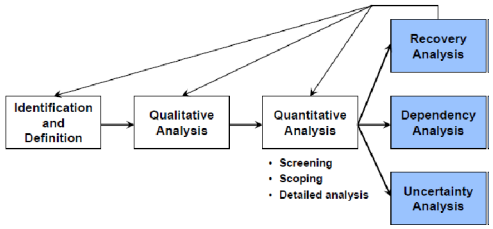


- EPRI methods, (e.g., as implemented in HRA Calculator®)
  - Cause-based decision tree method and/or HCR/ORE time reliability correlation for failure in cognition
  - THERP for failure in execution
  - Limited changes, but extensive guidance for implementation for fire context



- NRC's *A Technique for Human Event ANAlysis* (ATHEANA): designed to be adapted to different contexts

Recovery, Dependency, Uncertainty Analyses



Recovery analysis

- Analogous to process for PRA in general
- Evaluated via qualitative and quantitative methods as for other HFEs

Dependency analysis

- Qualitative level of dependence among post-initiators assessed (based on timing, same crew, cues, etc.)
- Quantitative interpretation of qualitative levels

Uncertainty analysis

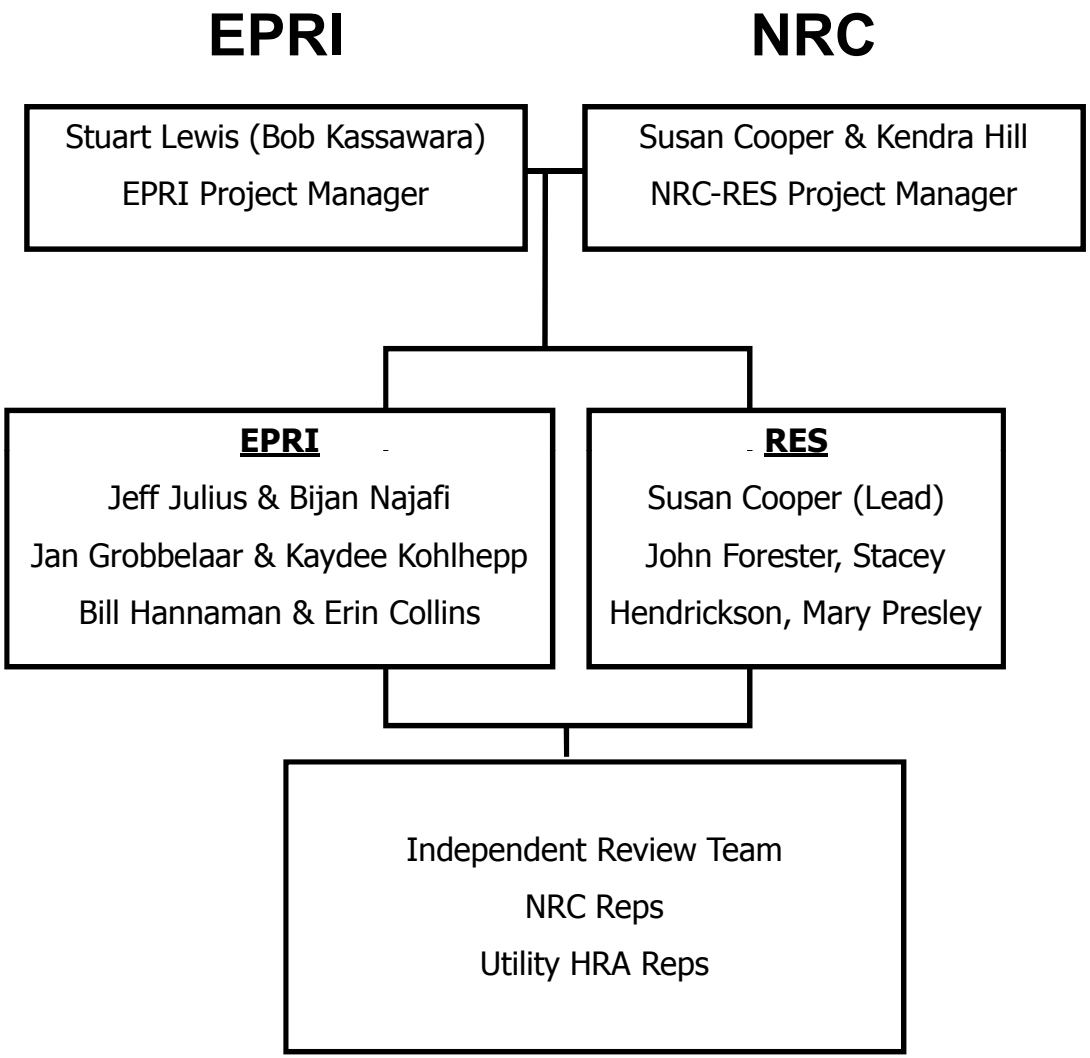
- Guidance consistent with joint NRC/EPRI treatments of uncertainty (NUREG-1855, EPRI 1016737)
- Focus on identifying, characterizing impact of sources of uncertainty

Summary – Fire HRA Guidelines

- Intended to be systematic approach, with detailed guidance for address fire-specific context
- Methods generally follow existing approaches for HRA, with emphasis on qualitative understanding of impacts of fire scenarios
- Scoping analysis is “new” approach, allowing analysis to go beyond screening values without detailed analysis

Together…Shaping the Future of Electricity

EPRI/NRC Fire HRA Guidelines: Development Team



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