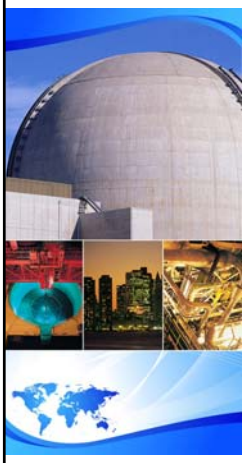

EPRI/NRC-RES FIRE PRA METHODOLOGY

Integration, Lessons Learned and Insights

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Joint EPRI/RES Fire PRA Course
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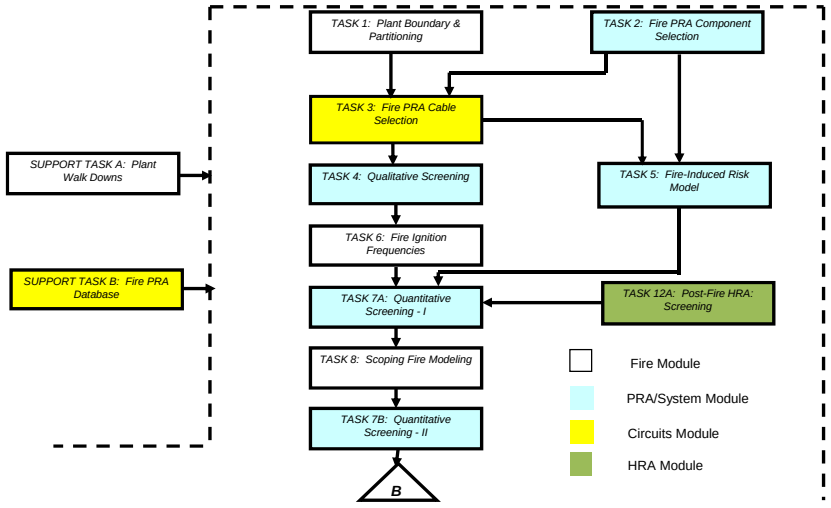
A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

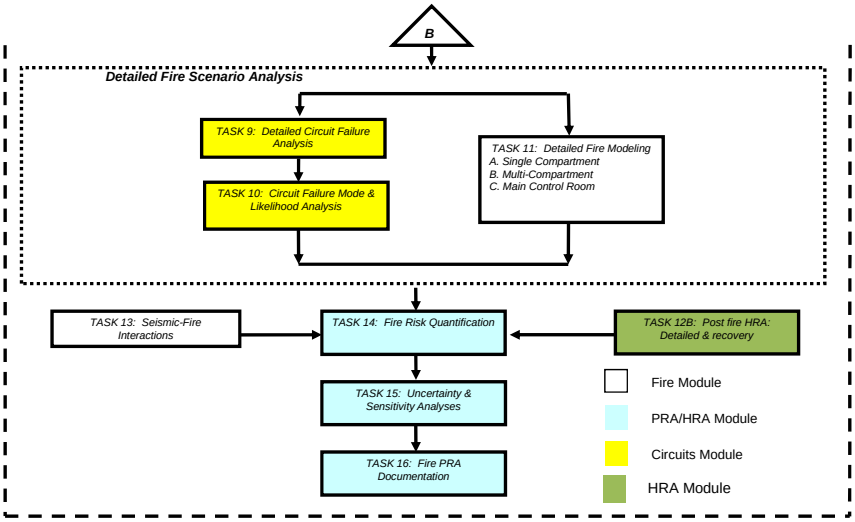
PART I

Integration

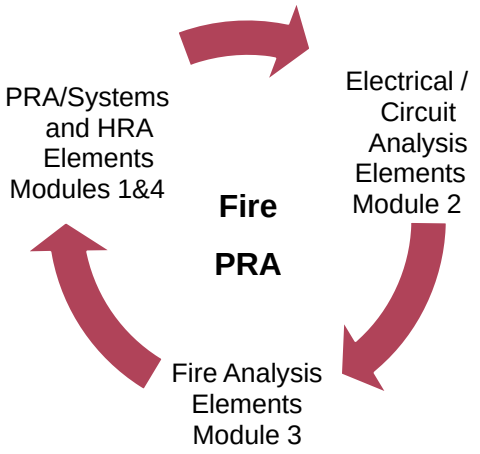
Remember the Fire PRA Process and Module Structure flow chart we showed the first day…



Fire PRA Process and Module Structure (2)

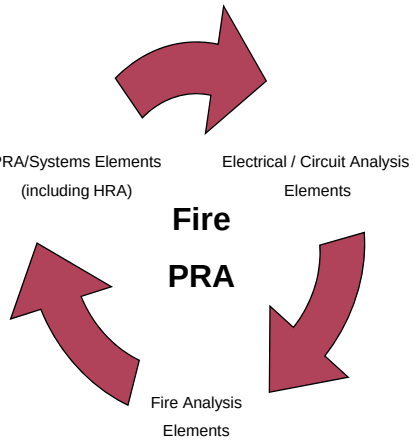


We also look at the fire PRA as comprised of four major parts



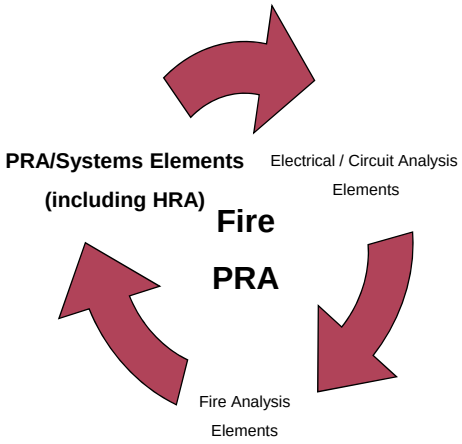
Conducting the fire PRA involves an iterative process that progressively refines these elements

- Objective of refinement process is to:
  - Identify (screen) unimportant contributors
  - Obtain more realistic results for important contributors



The first pass through the analysis generally focuses on the PRA/Systems elements

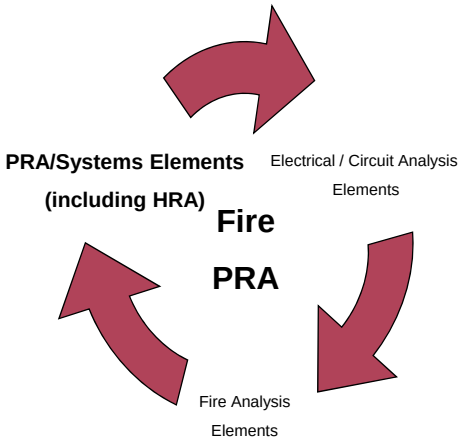
- Building the plant response model is a major focus of the first pass
- A good, solid plant response model is a necessary element of the fire PRA:
  - System/equipment selection (i.e., what will be credited in the fire PRA)
  - Adoption/modification of internal events PRA models e.g.,
    - Incorporating unique fire-induced equipment failure modes and sequences
    - Incorporating fire-specific human actions / human failure events



First pass output: coarse screening values by fire compartment

The first pass through the analysis generally focuses on the PRA/Systems elements (cont.)

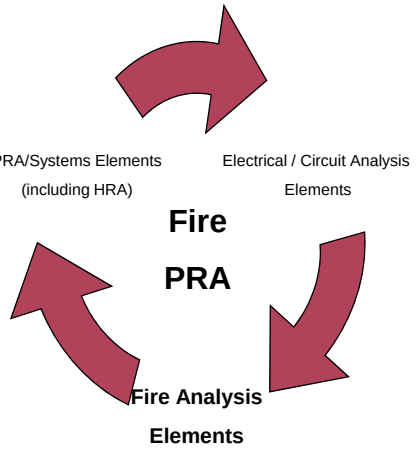
- Fire impacts and fire-induced Electrical faults tend to be treated at a pretty coarse level during the first pass
  - Fire: focus is generally on fire compartments
    - define fire compartments
    - develop compartment fire frequencies
    - map targets to compartments
  - Electrical: utilize existing information as much as possible
    - select and trace cables
    - identify potential component failure modes (fault/function codes) using conservative approaches



First pass output: coarse screening values by fire compartment

The second pass will likely focus on first level refinement of the fire analysis elements

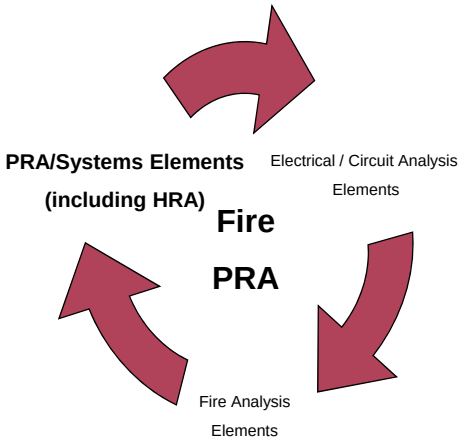
- Develop more specific and localized fire scenarios
  - Screen out non-threatening fire sources (no spread or damage potential)
  - Get past the room-wide damage scenarios for important compartments
    - Wide-spread damage scenarios may be plausible, but are generally low-likelihood events
  - Scenario focus shifts towards more representative fire source – target set combinations
    - Localized damage scenarios represent higher-likelihood events for most compartments and will likely dominate final risk estimates



Second pass output: more refined screening estimates tied to specific fire scenarios

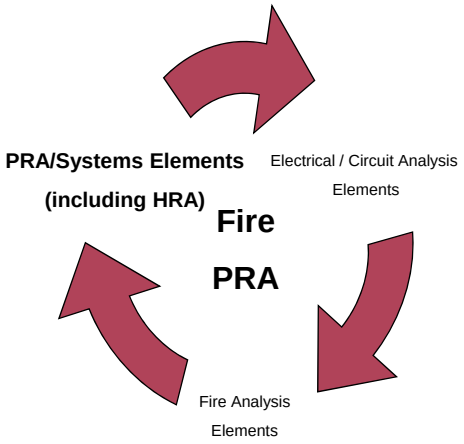
Beyond this point, the analyst must choose where to allocate resources, where to seek further refinement

- One key to success: resource allocation
  - What element should you refine?
  - Where can you get the most "bang for the buck"?
  - Is there something that is easy to do that will improve the answer?
    - "easy" being a relative term here…



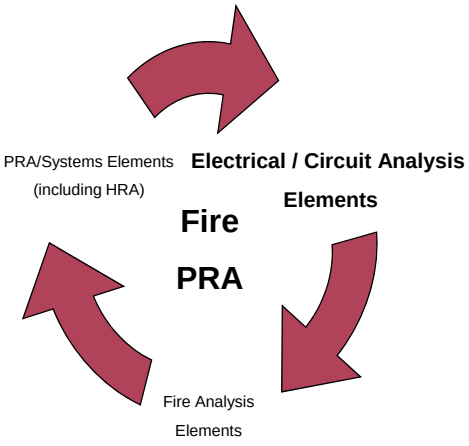
Possible PRA/Systems refinements

- Take credit for additional systems or equipment and add these to the plant response model
- Take credit for additional operator actions
- Refine estimates of existing HEP values
- Refine mitigation/recovery models to reflect changes in your understanding of fire-induced equipment failure modes (requires support from the electrical/circuit element)



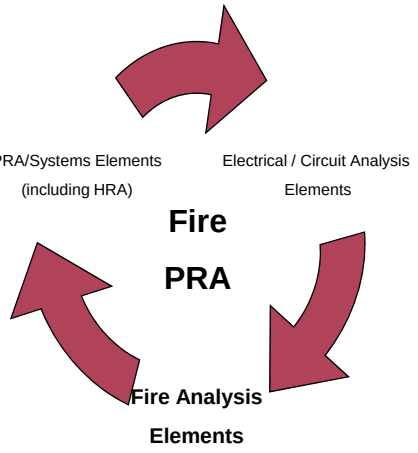
Possible electrical / circuit analysis element refinements

- Refine estimates of the cable/component failure mode likelihoods (e.g., spurious actuation)
- Refine circuit analyses to eliminate cable-to-component failure mode relationships originally assumed but not really plausible (requires input from the PRA/Systems element)
- Refine cable routing/tracing information

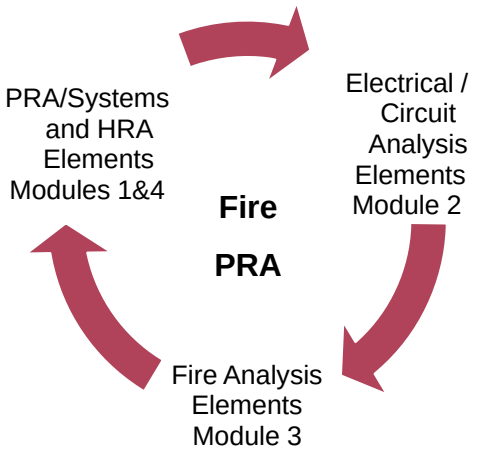


Possible fire analysis element refinements

- Refine fire frequencies
- Refine fire scenarios
  - Break into sub-scenarios to reflect progression of fire damage with time
  - Refine credit given to fire protection systems and features
  - Take credit for fire protection systems and features not previously credited
- Apply fire modeling tools to refine scenario timing (time to target damage)
  - e.g., take advantage of the severity factor approach and distribution on fire peak HRR
- Refine your target sets
  - e.g., incorporate new cable routing/tracing information



Bottom line: you have the option to refine any element of the fire PRA at any time – Choose Wisely!



PART II

Lessons Learned and Insights to-date

on Use of

EPRI 1011989, NUREG/CR-6850

Use of the Fire PRA Method Since its Publication

- Completed
  - First application by the NFPA-805 pilot plants at Harris and Oconee
    - Both PWRs
  - Results from these studies raised questions regarding their potential conservatism
- A number of technical improvements and clarification to the method completed
  - FAQs
- Vast majority of the Fire PRAs are in development and will be submitted as part of transition to 805
  - Due six (6) months after SER issued for the Oconee LAR, although some may submit sooner
  - Peer Review against Section 4 of the ASME/ANS combined PRA standard RA-Sa-2009 and RG 1.200, Rev. 2 has been completed for less than half of these Fire PRAs
  - Early results of these studies have continued the discussion over potential conservatism
- Short and long term improvement projects are in progress and planned

General

- Planning and schedule
  - Plan for model validation (troubleshooting)
    - Such as cutset review, similar to internal events but with a whole new dimension
  - Plan for model refinements
    - Carefully assess use of conservative assumptions early on
  - Increasing complexity of Fire PRA models are challenging resources and schedule
- Understand the objectives of the Fire PRA and its possible implication on the model
- Automation
  - Plan for an integrated Fire PRA by specifying proper tools and plant data that eventually will communicate with each other
    - Interfaces between different modules; PRA, HRA, electrical and fire analyses
- Fire PRA Standard
  - Self-assessment is easier to do as each task is completed
  - Traceable documentation
- Evolution of methods
  - Stay informed and get involved

Fire Analysis

- Develop a clear consistent process to be followed by the analysis team focused on integrated approach for quantification and simplify documentation process
  - This will be helpful as the method evolves and refinements are implemented
- Consistency between fire modeling and the cable/raceway database
- Walkdowns
  - Keep them targeted: Identify the information needed throughout the Fire PRA and schedule them appropriately
  - Avoid collecting unnecessary information
  - Avoid duplicate walkdown efforts
- Data quality
  - Ignition sources and targets should be identified with the proper ID's
- Tasks 1, 6, 8, and Appendix P will set you up to perform detailed quantification when properly structured
- Main control room analysis method is more robust and tends to yield less conservative results, than single and multi-compartment method
  - This was not the case in the previous, e.g., IPEEE, methods

Electrical Analysis

- Develop a clear consistent process to be followed by the analysis team focused on integrated approach for quantification and simplify documentation process
- Plant specific decisions on where to store/maintain the circuit analysis information
  - Separate database, expanded capability for the cable and raceway database, etc.
- Cable selection and detailed circuit analysis may/should be combined in one task
  - Many cables can be selected and analyzed at the same time
  - Need a well structured database to store and maintain all the information
- Scope and complexity of circuit dependencies may change significantly as the scope of the systems and components are expanded to gain more realistic results
  - Breaker coordination requirements

PRA/Systems Analysis

- Fire PRA component selection
  - Each component in the list needs a story
    - Where it comes from (Internal events, Appendix R, MSO expert panel, HFE cues/indication review, etc.)
    - How should it be reflected in the model
  - Single most important input to electrical analysis
- Plan for the MSO expert panel
  - Input for the Fire PRA equipment list and the logic model
  - Recognize the application, probabilistic vs. deterministic
- Fire PRA Model
  - There is significant link that begins early on between component selection, fire-risk model and fire HRA.
    - Identification and modeling of operator actions; fire response actions and responses to erroneous alarms/instruments due to spurious actuations
    - Identification and modeling of alarms and instruments
  - Proper reflection of fire procedures in the fire-risk model can become both cumbersome and critical

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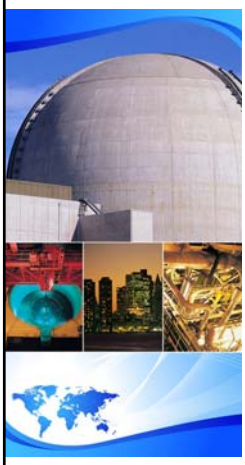

EPRI/NRC-RES FIRE PRA METHODOLOGY

Module III-2: Perspective

R.P. Kassawara - EPRI
J.S. Hyslop - RES
Joint EPRI/RES Fire PRA Course
September and October 2010

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

On The Requantification Project

- A consensus methodology for Fire PRA that is facilitating implementation of risk-informed fire protection
- Continues to provide effective tools and approaches for performing fire PRAs
- Refinements to methodology made in many fire PRA areas via NFPA 805 FAQ program.
- Other fire PRA related research planned or underway

Continued Cooperation

- We established a framework for future research cooperation
- The cooperation under the MOU is continuing
  - Fire Model Application Guide
  - Fire Human Reliability Analysis (HRA)
  - D. C. Circuits Testing
  - Expert Elicitation of Spurious Actuation Probabilities
  - Fire Events Database Improvement
  - Other Projects….