EPRI/NRC Fire HRA Guidelines: Introduction to Fire HRA Scoping Quantification

Stacey Hendrickson & John Forester, SNL

Susan Cooper & Kendra Hill, US NRC

Jeff Julius, Jan Grobbelaar, & Kaydee Kohlhepp, Scientech

Bill Hannaman, Erin Collins, & Bijan Najafi, SAIC

PSAM 10

June 7 - 11, 2010

Seattle, WA

Presented by

John Forester

Purpose of Scoping Approach

- Useful in identifying risk significant events that will require detailed analysis
- Provide less conservative HEPs for HFEs surviving screening, but more conservative than a full detailed analysis
  - Straightforward approach without requiring detailed analysis
  - Intent is to provide HEPs that are more realistic, and therefore, some detailed analysis is required
- Relies on assessment of feasibility of actions and a time margin to account for many of the uncertainties associated with fire scenarios
- Requires simple judgments about PSFs

Categories of Actions Addressed in Scoping Flowcharts

- New and existing main control room (MCR) actions
- New and existing ex-control room actions
- MCR abandonment actions
- Recovery of Errors of Commission (EOCs) or Errors of Omission (EOOs) due to spurious instrumentation
  - Supports addressing spurious instrument effects as described in Part 3 (Internal Fires) of ASME/ANS Combined PRA Standard (HLR-ES-C1 and C2)

Steps for Using Scoping Fire HRA Approach

1. Ensure minimum criteria are met
2. Assess feasibility of operator actions
3. Calculate time margin
4. Assess key conditions and PSFs
5. Use flowcharts to quantify - Selection Scheme directs to one of the following:
   - INCR – in MCR actions
   - EXCR – ex-CR actions
   - CRAB – MCR abandonment
   - SPI – errors due to spurious instrumentation

Minimum Criteria

- Procedures
  - Plant procedures covering each operator action being modeled
  - Support both diagnosis & execution of the action
  - Exceptions:
    - Execution of skill-of-the-craft actions
    - Recovery of EOO or EOC in some cases
- Training – on the procedures and the actions
- Availability and Accessibility of Equipment

Assessment of Feasibility

- Show that a given action or set of actions for a particular HFE can be diagnosed and performed within the time available

  time available > time required

- The time required for operator performance should consider 3 aspects:
  - Time at which the cue occurs relative to the initiating event
  - Time it takes the operators to formulate a response (detect, diagnose, decide)
  - Time to execute the response (including travel time, if necessary)

Determining Time Required for an Action for Assessment of Feasibility

- Talk-through with operators and/or trainers
- Walk-through of action and/or procedures
- Simulation
- Job performance measures (JPMs)
- Demonstration through training exercises
- Appendix R feasibility demonstration
- Assessment of feasibility to meet criteria in NUREG-1852
- Assessment of feasibility of similar action

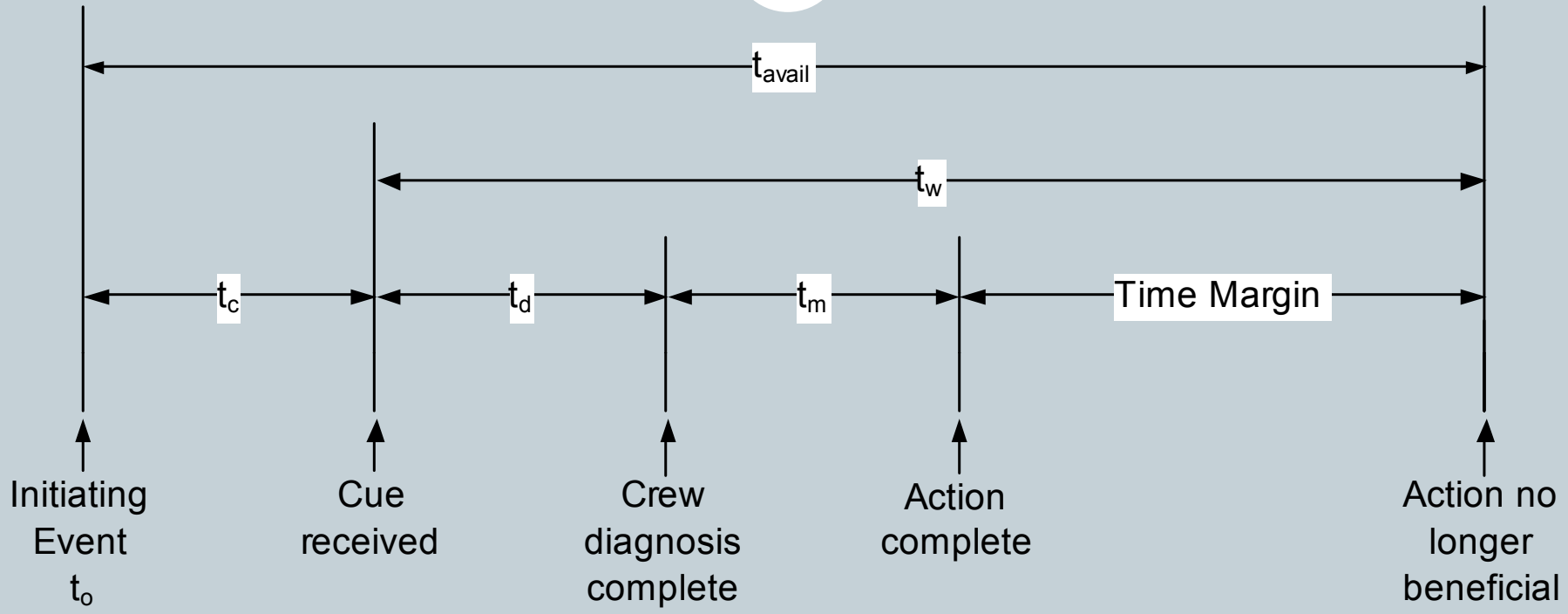
Considerations in Conducting Feasibility Assessment or Demonstration

- Environment
- Available indications and MCR response
- Communications
- Portable equipment
- Personnel protection equipment
- Procedures and training
- Staffing
- Other aspects (e.g., travel path, smoke)

Time Margin

- Extra time included to account for potential unexpected fire effects and variabilities such as:
  - Uncertainties in the demonstrations and conditions unable to be simulated
  - Potential variability in crew response times and individual differences
  - Variations in fire type and related plant conditions
- Within the scoping approach, time margins are required to be calculated for all actions or set of actions.
- Similar to guidance in NUREG-1852

Calculation of Time Margin



$$TM = \frac{t_w - (t_d + t_m)}{(t_d + t_m)} * 100\%$$

Assessing Key Conditions & PSFs within the Scoping Flowcharts

- How well the procedures match the scenario
  - The procedures should be relatively easy to follow given the pattern of indications
  - Serves as a proxy for diagnostic complexity
- Response execution complexity
  - Assessed as high or low
  - Considers number of steps involved in the action, number of crew members necessary, how many locations must be visited, coordination and communication, how many functions are involved, the accessibility of the location or of tools, etc.
- Timing of cues for the action relative to expected fire suppression time
  - Need to assess on-going fire effects
  - Special cases: fires of turbine generators, outdoor transformers, high energy arcing faults, and flammable gas fires

Assessing Key Conditions & PSFs within the Scoping Flowcharts (Cont'd)

- Action time window
  - Time from the occurrence of the cues for action until the action is no longer beneficial
  - Short time window = 30 minutes or less
  - Long time window = greater than 30 minutes
- Level of smoke and other hazardous elements in the action areas
  - Need for special equipment (e.g., SCBA)
  - Impairment of vision or prevention of the execution of the action
- Accessibility
  - Location of action
  - Travel path

Use of Scoping Flowcharts

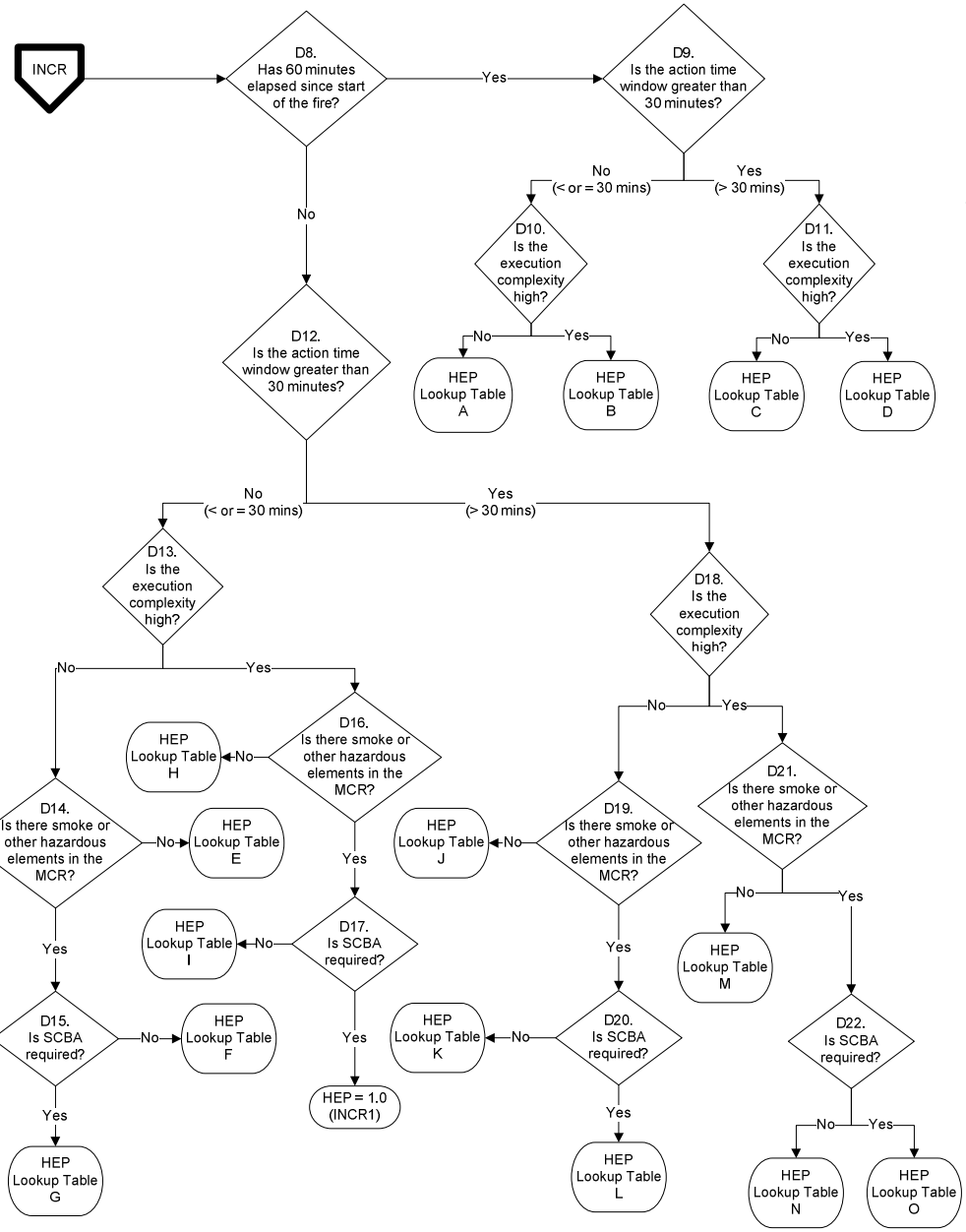
- HFEs quantified based on:
  - Assessment of key PSFs
  - Location of the actions associated with the HFE
  - Condition of relevant instrumentation
- A *Selection Scheme* directs the analyst to the correct flowchart for quantification:
  - In MCR action
  - Ex-CR action
  - MCR abandonment
  - Recovery of error due to spurious instrumentation
- Some HFEs quantified within the Selection Scheme (HEP = 1.0)

Example Flowchart: INCR – In MCR Actions

- Used for the following HFEs:
  - New HFEs identified outside the Internal Events PRA
  - Existing HFEs from the Internal Events that survive quantitative screening
- Addresses diagnosis and execution of the action in the MCR

Example Flowchart INCR

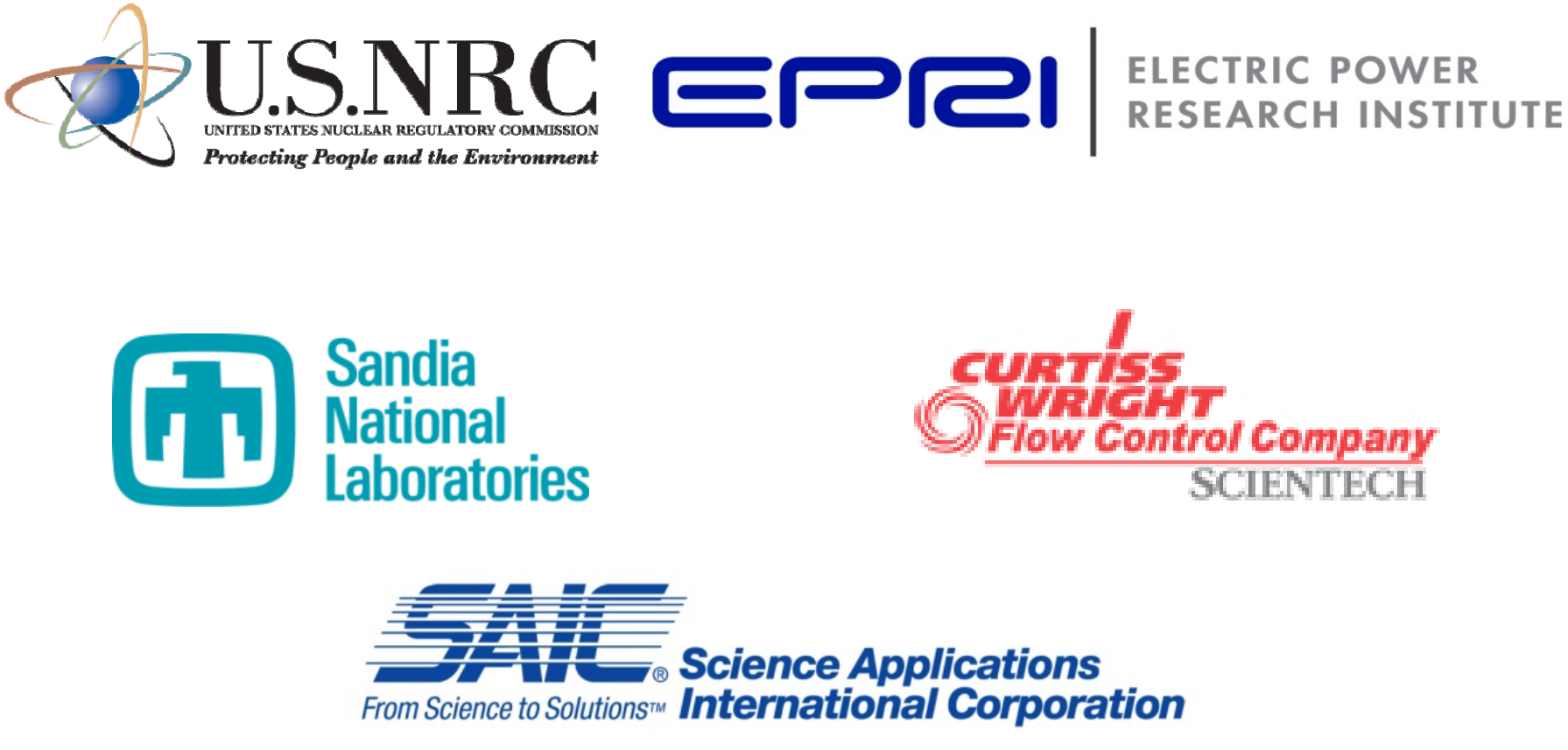
Scoping HRA flowchart for in MCR actions



HEP Values

- Base HEP = 1E-3
- Within a flowchart, HEP values are based on:
  - Timing of the cue for an action relative to start of fire
  - Length of action time window
  - Level of diagnosis complexity
  - Level of execution complexity
  - Level of smoke (area of action & travel path)
  - Accessibility of action site (area of action & travel path)

Questions?

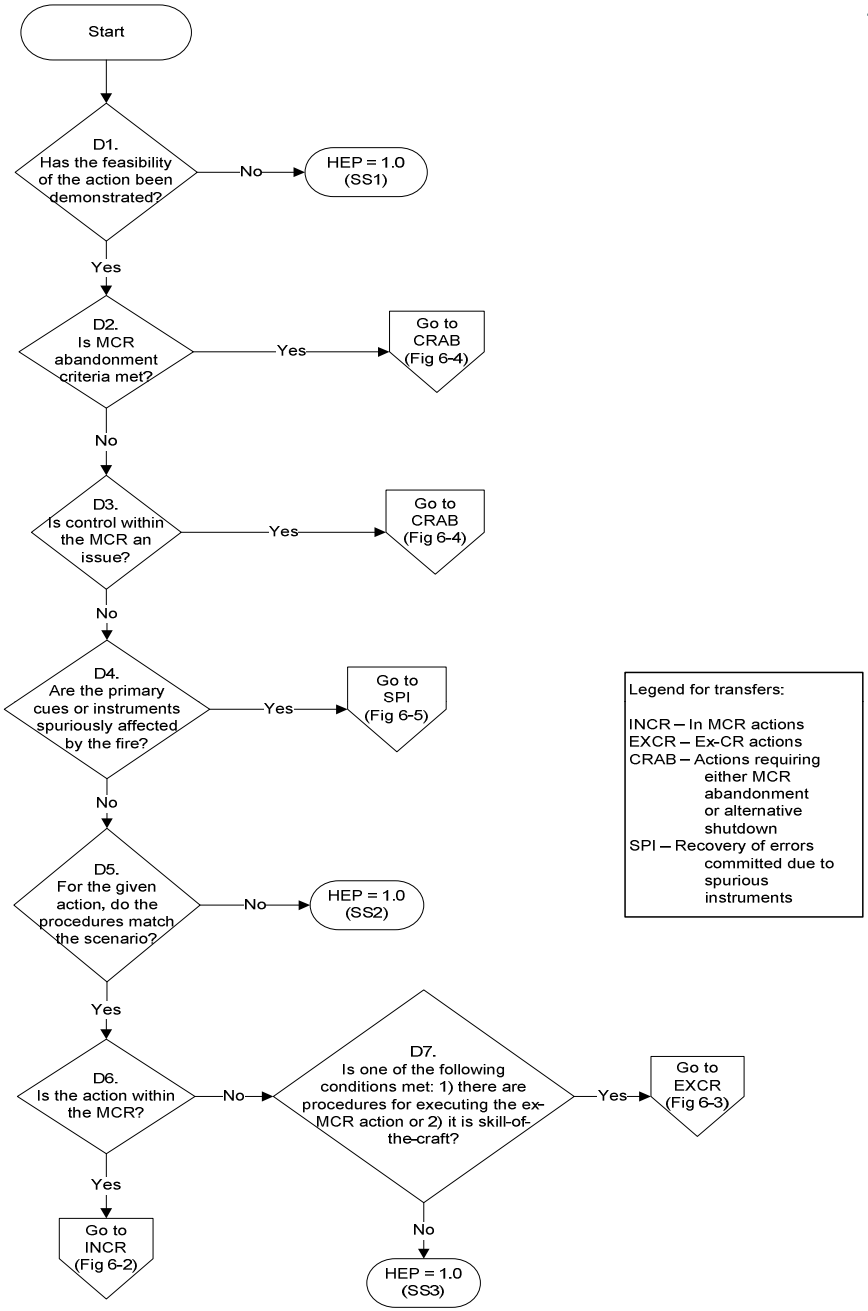

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment
EPRI
ELECTRIC POWER
RESEARCH INSTITUTE
Sandia
National
Laboratories
CURTISS
WRIGHT
Flow Control Company
SCIENTECH
SAIC
From Science to Solutions™
Science Applications
International Corporation

Full Demonstration of Feasibility (if required) DELETE

- Walk-through tasks and simulate conditions as realistically as possible
- If estimates must be made, use a process to ensure that estimates are reasonable and use knowledgeable plant staff
- Use at least one, randomly selected crew in conducting the demonstration (use more crews if able)
- One demonstration may be sufficient to credit other similar actions under similar situations
  - For example, use a bounding case

Selection Scheme

Directs analyst to correct quantification flowchart



Multipliers Applied to HEPs Within Flowchart

Change in PSF	Scoping Approach Multiplier
Fire effects ongoing	10
Action time window ≤ 30 mins	5
High execution complexity	5
Increases in smoke level	2
Decreases in time margin	5

Multipliers Applied to HEPs Across Flowcharts

- EXCR HEP = INCR HEP = slight increase*
- CRAB HEP = EXCR HEP = moderate increase*
- SPI HEP for in MCR = INCR = moderate increase*
- SPI HEP for ex-CR = EXCR = moderate increase*

Multipliers Applied to HEPs Across Flowcharts

HEP in Base Flowchart	Multiplied by	Adjustment Value	Equals	HEP in Scoping Flowchart
INCR	X	2	=	EXCR
EXCR	X	2	=	CRAB
INCR for in MCR actions; EXCR for ex-CR actions	X	5	=	SPI