Update on HRA Collaborative Efforts

SRM-M061020: HRA Model Differences
SRM-M090204B: Use of US Plant Experience for HRA Method Testing and Data Collection

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Objective and Outline

- Provide an update on NRC/Industry collaborative HRA activities
  - SRM-M061020: HRA Model Differences
  - SRM-M090204B: Use US Plant Experience for HRA Method Testing and Data Collection
- More details on HRA Model Differences
  - Background
  - Technical Approach
  - Current Focus
  - Schedule
- Broad Overview on the Use US Plant Experience for HRA
  - The US Empirical HRA Study
  - An MOU for the use of training simulator data for HRA

SRM-M061020:

HRA Model Differences

Background

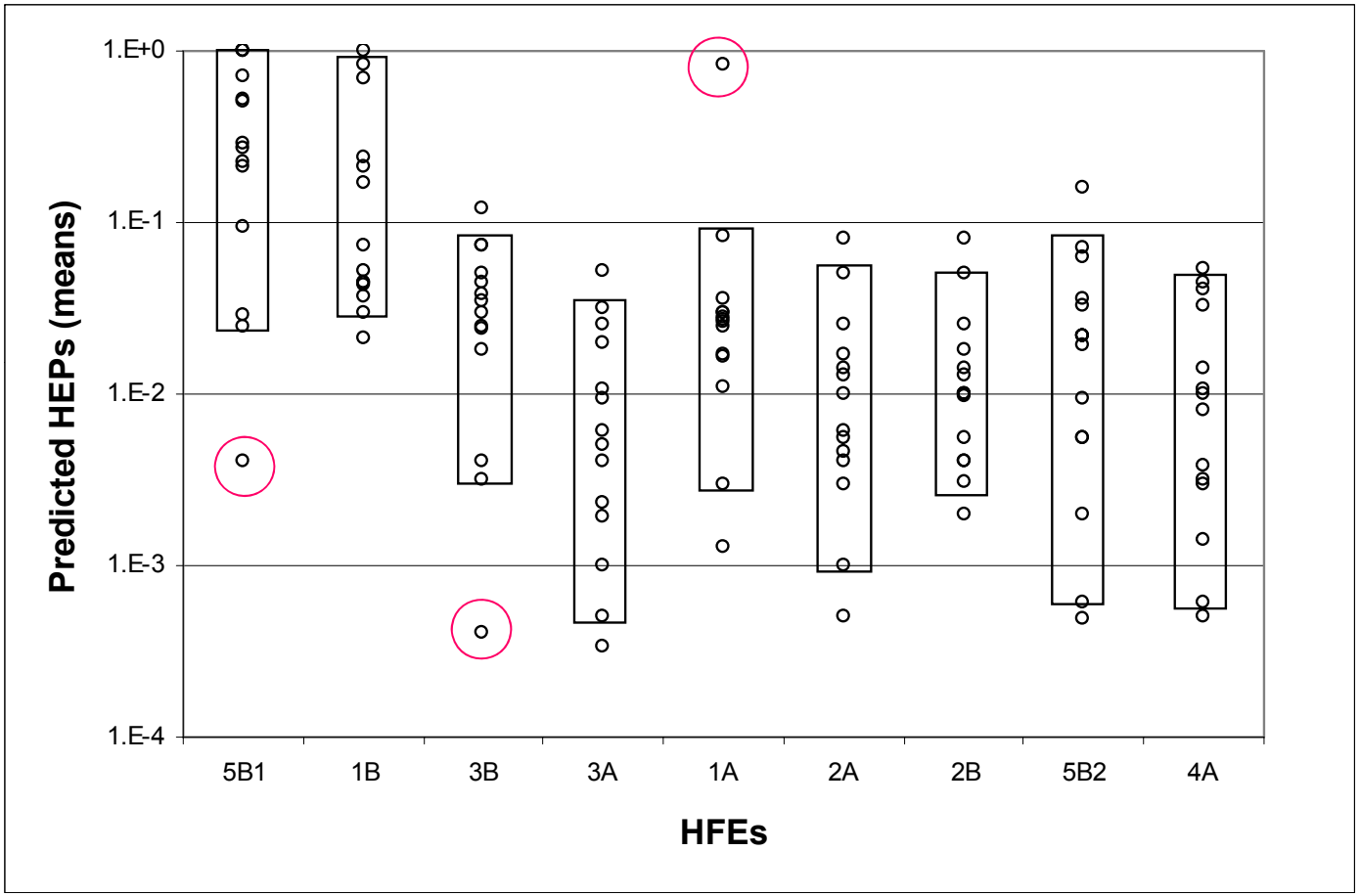
- SRM-M061020 directed the ACRS to "work with the staff and external stakeholders to evaluate the different human reliability models in an effort to propose a single model for the agency to use or guidance on which model(s) should be used in specific circumstances"
- RES has the lead for addressing the SRM
  - Sponsored Organizations: Sandia, Idaho, University of Maryland
- Collaborative with EPRI
- Interdisciplinary Expertise:
  - PRA/HRA, Operational Experience Human factors/cognitive psychology experts
- Periodic meetings with ACRS--input into the work

The Issue

- Evidence that HRA results for a given human action may vary from method-to-method and analyst-to-analyst
- The International HRA Empirical Study provides evidence of variability (November 2006- June 2011)
  - 12 organizations; 15 methods; 14 crews
  - Allowed identification of sources and systematic analysis of variability
  - Insights and lessons learned provided major input for the approach taken to address HRA model differences
- Major contributors to HRA result differences from the Empirical study
  - Differences in qualitative analysis—a major contributor
  - Differences in underlying theoretical frameworks and mathematical models
  - Methods' ability to incorporate issues identified in the qualitative analysis into quantification
  - Analyst ability to appropriately perform HRA and implement a method

Range of predicted mean HEPs for SGTR

Boxes drawn around range, 1 maximum value and 1 minimum value excluded from each range.



- **After exclusion, most ranges span < 2 orders of magnitude.**
- **Many outliers are relatively close to the range.**
- **Exceptions are highlighted.**
- **Exceptions explained in terms of inconsistent assumption and method application.**

The Importance of the Issue

- HRA is the part of PRA for evaluating the human contribution to risk
  - identifying and evaluating human failure events and estimating human error probabilities
- PRA results and insights provide technical basis in decision-making
  - Important to ensure the technical accuracy and robustness of PRA/HRA methodology
- Frequently the human contribution to risk is important
- NRC and industry HRA results for same event do not always match
- The ACRS has identified the importance of addressing outstanding issues in HRA

Focus of SRM-061020

- A single method is the most desirable
- Use of more than one method should be justified
  - Why more than one
  - Which methods should be used for which applications
  - Need for implementation guidance for each particular method and application
- Desirability for convergence of NRC and industry on HRA methods

Process for Addressing the SRM

- Identification of regulatory applications in which HRA plays an important
- Workshops with NRC, national laboratory, and EPRI experts to obtain their views on the path forward (April and June 2009)
- The need to build on existing methods and experience was emphasized
- Outcome:
  - Pursue a single method/structure for HRA
  - HRA desirable attributes to guide the effort

HRA Desirable Attributes

- Validity – content/empirical
- Reliability— the main focus of the project
  - Reproducibility, consistency, inter- and-intra rater reliability
- Traceability/Transparency
- Testability
- Capability for graded analysis
  - Screening, scoping, detailed analysis
- Usability/practicality

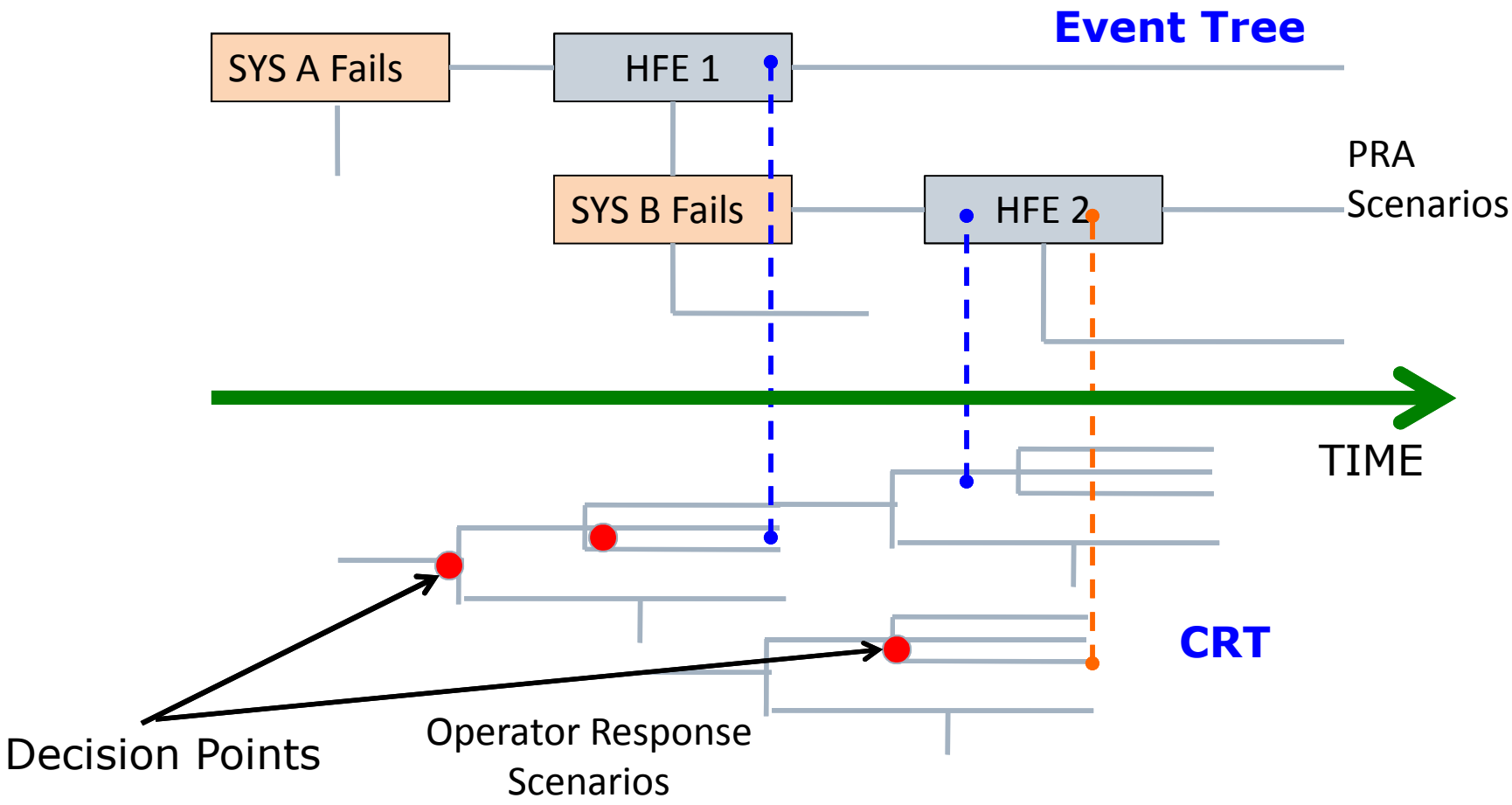
Technical Approach

- Taking advantage of the strengths of existing methods and building on the broader PRA experience, a *hybrid method is being pursued*
- The hybrid is building on the following:
  - ATHEANA for identifying and incorporating contextual aspects associated with human performance
  - Elements of THERP and others regarding task analysis and clear association between human failures and performance-shaping factors (PSFs)
  - The causal structure of the Cause-Based Decision Tree (CBDT) method and other HRA-related structures, such as those in the UMD IDAC approach to quantification

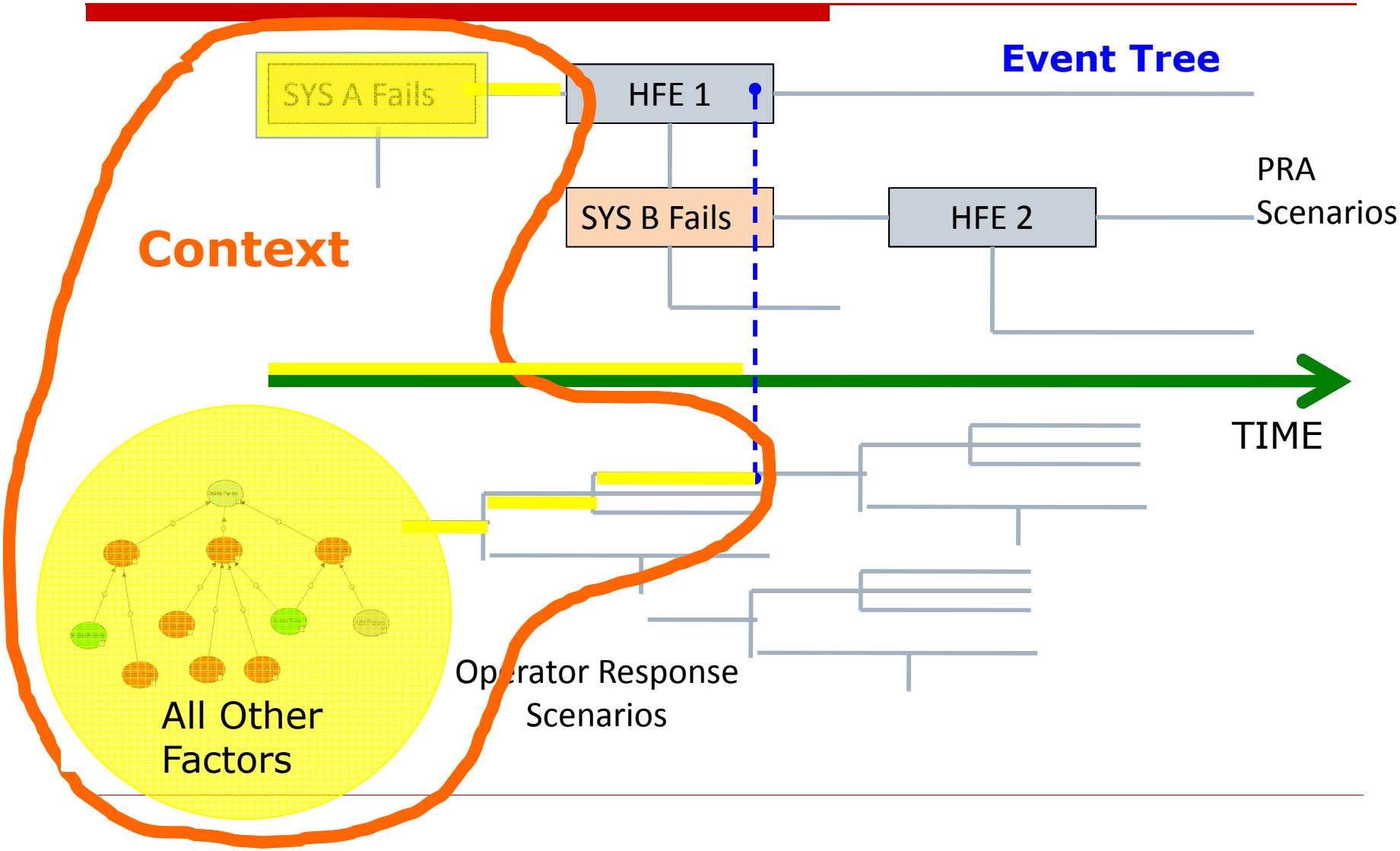
The Hybrid Model

- Qualitative Analysis Model
  - Use of PRA-type logic structure to identify failures paths in a scenario
    - aid transparency and traceability
  - Use causal human performance model (called IDA) to delineate human failure events in a consistent and reproducible manner
  - Establish links between PRA scenarios context, operator psychological processes, and resulting performance incorporating current understanding of human behavior in accident conditions
    - Cognitive and behavioral literature
    - Operating experience
- Quantitative Model
  - Adopt a causal-type quantification model capable to reflect the results of the qualitative analysis
  - CBTD is been expanded/modified
    - Shows the relationships between HEP derivation and the contextual issues and drivers identified

Logic structures being pursued
Crew Response Tree (CRT)



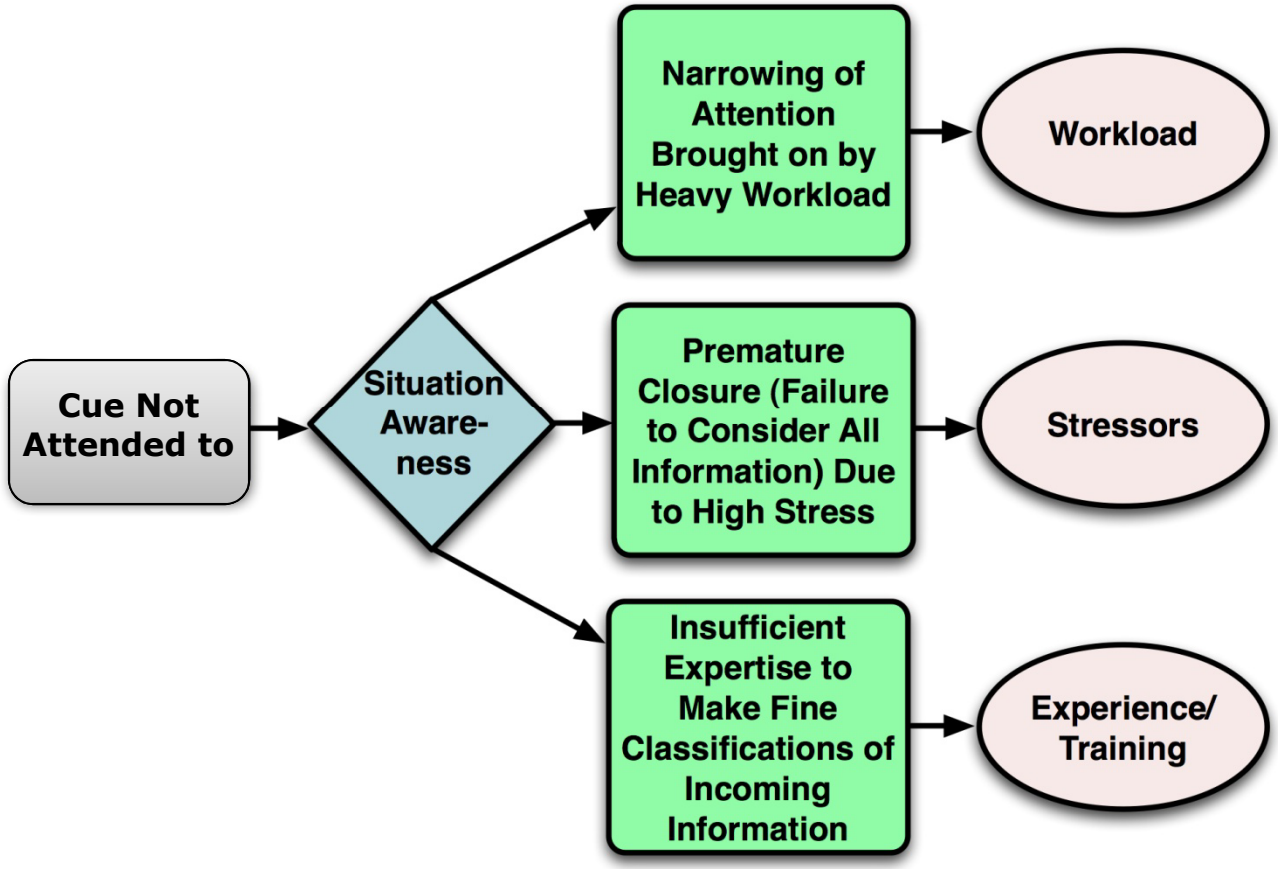
Use of IDA


Event Tree
SYS A Fails
HFE 1
SYS B Fails
HFE 2
PRA
Scenarios
Context
TIME
All Other
Factors
Operator Response
Scenarios

Use of Literature Results in HRA

Proximate Cause (PCs) for The Information part of IDA	Psychological Failure Mechanism	PSFs
Cues not perceived	Suggests that sensory information is held in very short-term memory. If that sensory information is not attended to, it will be lost. (Neisser, 1967)	Inappropriate bias—expectations from training Workload/priorities HMI
Cues not perceived	Broadbent's "filter theory" (1958) explains sensory bottlenecks—the alarm might be missed because humans have a limited ability to take in stimulus inputs and perceive them. It is possible to reach sensory bottlenecks, which can result in sensory overload.	Workload—amount of simultaneous sensory information HMI
Cues not perceived	Failure to perceive the status, attributes, and dynamics of relevant elements in the environment. Endsley, 1995, page 36, 54, 55 (FM identified by Endsley).	Attention-monitoring strategy, HMI Workload—urgency of priorities Inappropriate bias—expectations from training, similarity to a different accident signature Knowledge and experience System response—very slow parameter change

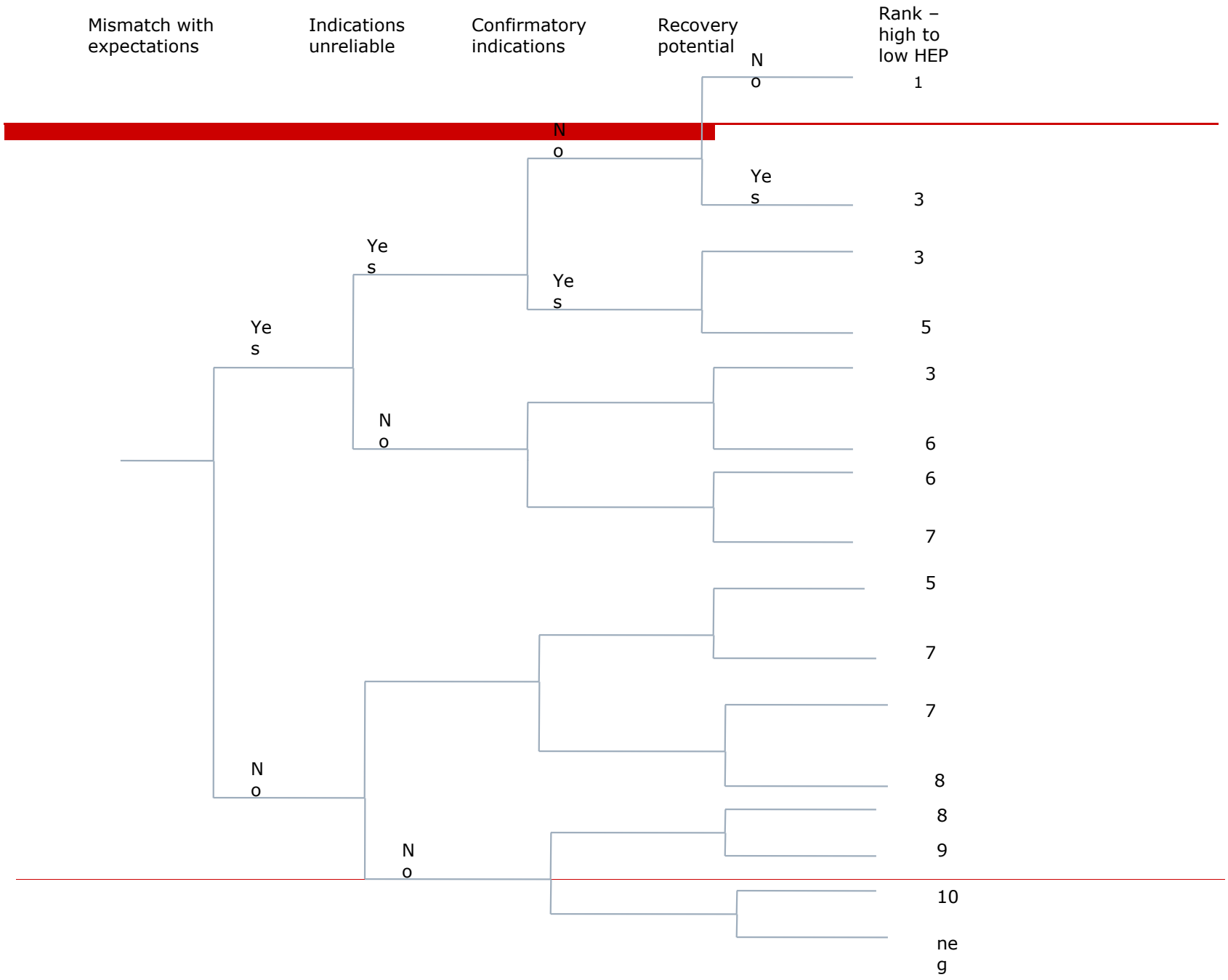
Assignment of PSFs to PCs through Psychological Mechanisms



A single proximate cause is explained by different facets of a cognitive model with corresponding different PSFs

The Quantification Model

- Based on the CBDT Framework
  - Under Development--EPRI has the lead
- Underlying structure the IDA framework
- Uses proximate causes for human failure in the NPP environment
- Links Proximate causes to PSFs thru cognitive mechanisms
- Use expert judgment to associate an HEP with each path through the tree
- Use Expert Judgment for quantification


Mismatch with expectations
Indications unreliable
Confirmatory indications
Recovery potential
Rank – high to low HEP
Yes
No
Yes
No
No
Yes
No
Yes
No
No
Yes
1
3
3
5
3
6
6
7
5
7
7
8
8
9
10
neg

Focus

- Current focus
  - Start with addressing the issue for a detailed internal event/at power PRA/HRA
  - Converge with EPRI on use of a single or set of methods
- Future
  - Expand to other scenarios
  - Modify for screening/scoping analyses

Schedule

- Quarterly working meetings with the ACRS subcommittee
  - Next in April 22, 2011
- Technical Basis for public review—12/2011
- User's Guide for public comment—December 2011
- Application on event evaluation for public review— 12/2011
- Piloting/Testing: September 2012
- Final report—2013
- Computerized capability—TBD

Anticipated Uses

- The tools developed should support NRC staff risk-informed activities
  - Event evaluations (significant risk determination)
  - Guidance for staff review of risk-informed licensee requests
    - Current plants—e.g., risk-informed licensing changes
    - Future plants—reviews of PRAs/HRAs for new plant operation licensing and practices
  - New PRAs and especially the Level 3 PRA planned by the staff for the next few years
- Industry applications in the same areas

SRM-M090204B

Use of US Plant Experience for HRA Method Testing and Data Collection

Motivation

- The International HRA Empirical Study was based on the use of Halden Reactor Project simulator facilities and European crews
- Commission concern on the applicability of the study's findings on USA
  - Ensure that findings and lessons are suitable to US applications
- The study involved mainly method-to-data comparisons
  - Need to address analyst-to-analyst variability
- Recognized benefit from additional empirical studies

Motivation (cont)

- SRM-M090204B – February 2009
  - Pursue testing U.S. nuclear plant operating crews' performance in a variety of situations
  - Keep the Commission informed on the HRA database and benchmarking projects

- Two Separate activities:
  - NRC MOU with a US Plant to Use its simulators for performing simulator experiments—September 2009
    - The US HRA Empirical Study

  - NRC MOU to collect licensed operator simulator training data for HRA –expected to be signed in January , 2011

Objectives of the US HRA Empirical Study

- Address open issues identified in the International HRA Empirical Study
- Address issues related to the need and amount of plant specific information
  - How could we optimize the process
- Address analyst-to-analyst variability
  - Have more than one team per method
  - Better understanding of how analysts apply methods
- Develop tools as needed to improve the robustness of HRA

Who is involved?

- Collaborative effort
  - Sandia National Labs has the lead
  - Halden supports the data collection/interpretation
  - Idaho National Lab
  - HRA teams comprised by national lab, commercial contractors and NRC staff
  - EPRI participation in performing analyses and reviewing submittals
  - University of Mexico
  - Finland and Czech Republic
- Methods to be applied
  - ATHEANA—3 teams
  - EPRI's calculator/CBTD— 3 teams
  - SPAR-H—two teams
  - THERP/ASEP- 3 teams?

Status of the US HRA Empirical study

- Experimental design completed—October 2009
- Simulator runs performed, January 2009
- HRA teams received information and visited the plant, Summer 2010
- HRA Teams submitted analyses, September 2010
- Simulator data interpreted, August 2010
- Comparisons of HRA predictions to data, May 2011
- Draft Documentation of results/publication, Sept 2011
- Final NUREG, June 2012

MOU on collecting licensed operator simulator training and exam data for HRA

- Sign MOU with a licensee in January 2011
  - No interference to the licensee's training program
  - Minor increase in the information to be collected
- Data to be collected by the licensee's trainers and transmitted to NRC
  - No observers from NRC during data production stage
- Objective of the data collection
  - Improve understanding of operating crew behavior in responding to malfunction(s)
  - Improve capability to estimate HEPs