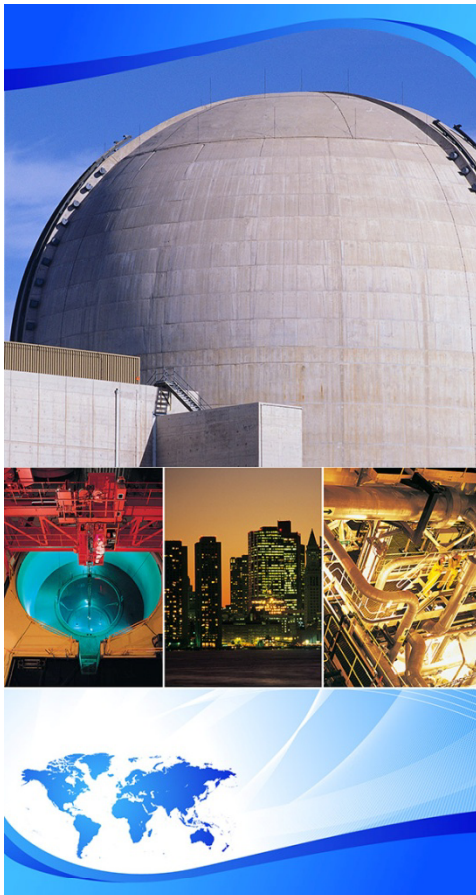




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Towards an Improved HRA Model for Estimation of HEPs

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Overview

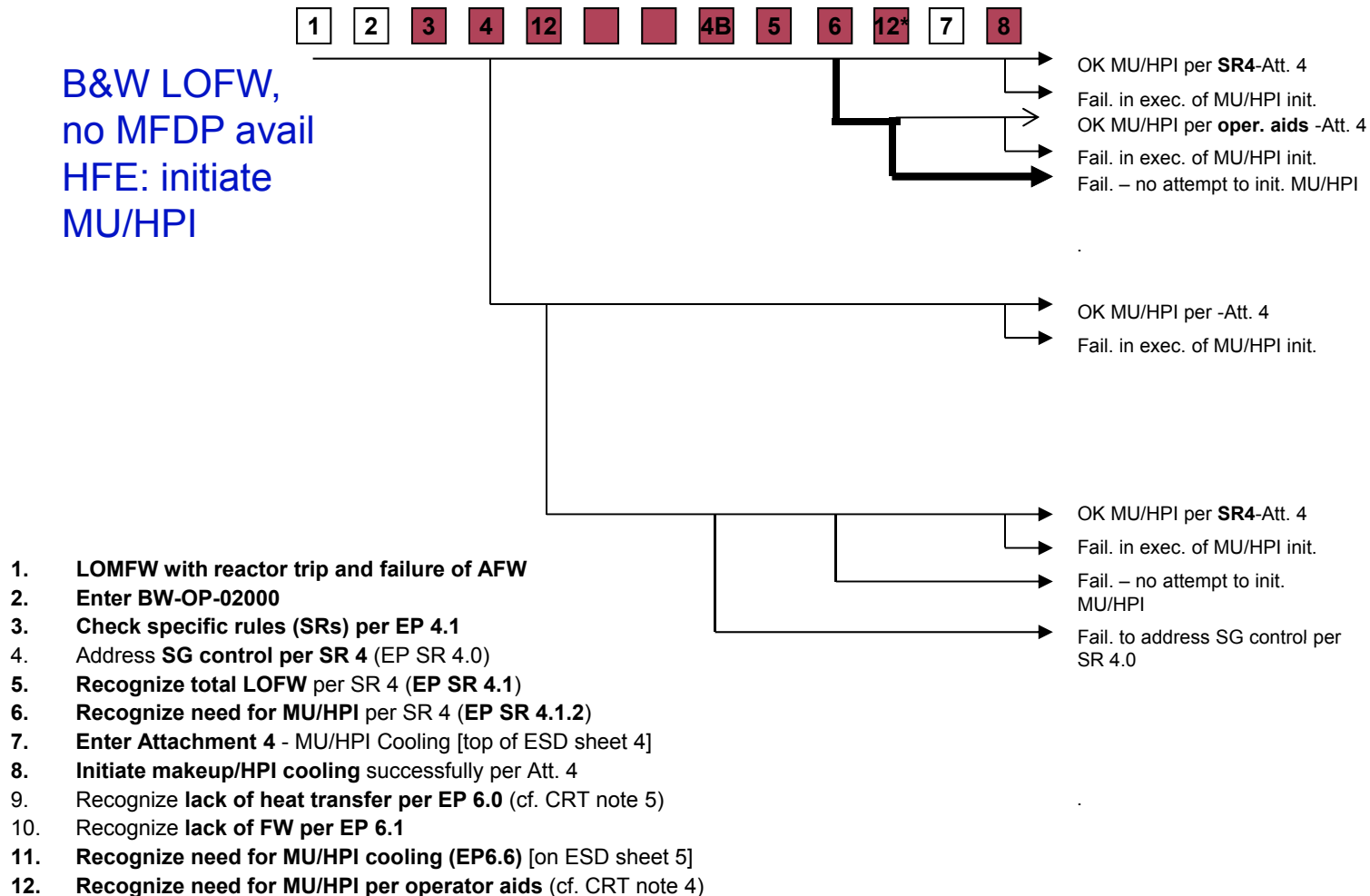
- The objective is to construct a quantification model based on an understanding of the reasons a crew might fail to perform a required function.
 - i.e., it is a causal model based on the state of knowledge concerning human performance and cognitive psychology
 - Psychological mechanisms of human performance
 - Performance influencing factors
- The underlying technical basis derives from an in depth review of the cognitive and behavioral science, psychology and human factors literature

Overview (Cont'd)

- The quantification model is that element of the HRA process that provides the HEP for an HFE
- The HFE is defined in terms of the context provided by the PRA scenario in which it appears
 - Plant status
 - Guidance (procedures)
 - Task analysis
- The model is applied to a CRT
 - Result of a task analysis that identifies what the crew has to do and where errors can lead to the HFE
 - Paths through the CRT represent crew successes and failures in essential subtasks

Example CRT

B&W LOFW,
no MFDP avail
HFE: initiate
MU/HPI



Overview of Quantification Model

- Define a set of Crew Failure Modes (CFMs)
 - Tailored to the types of tasks expected for NPP operators
 - Categorized by “phase” of response: plant status assessment, response planning, action (cf. IDA)
- For each CFM construct a decision tree (DT). Branches correspond to:
 - Categories of PIFs that are relevant to that CFM
 - Recovery potential
- The probability associated with each path is determined by expert judgment and is included on the DT – not determined by the user
- The appropriate path through the DT for each HFE is determined by specific characteristics of the PIFs consistent with HFE context

Crew Failure Modes (CFMs)

- Plant Status Assessment
 - Key alarm not attended to
 - Critical data misperceived
 - Critical data misleading or not available
 - Critical data dismissed/discounted
 - Premature termination of collecting critical data
 - Critical data not checked with sufficient frequency
 - Misread or skip step in procedure
 - Wrong data source attended to

Crew Failure Modes (CFMs) – (Cont'd)

- Response Planning
 - Misinterpret procedures
 - Choose inappropriate strategy
 - Delay implementation
- Action
 - Fail to execute action (complete omission)
 - Incorrectly perform response
- Critical data miscommunicated

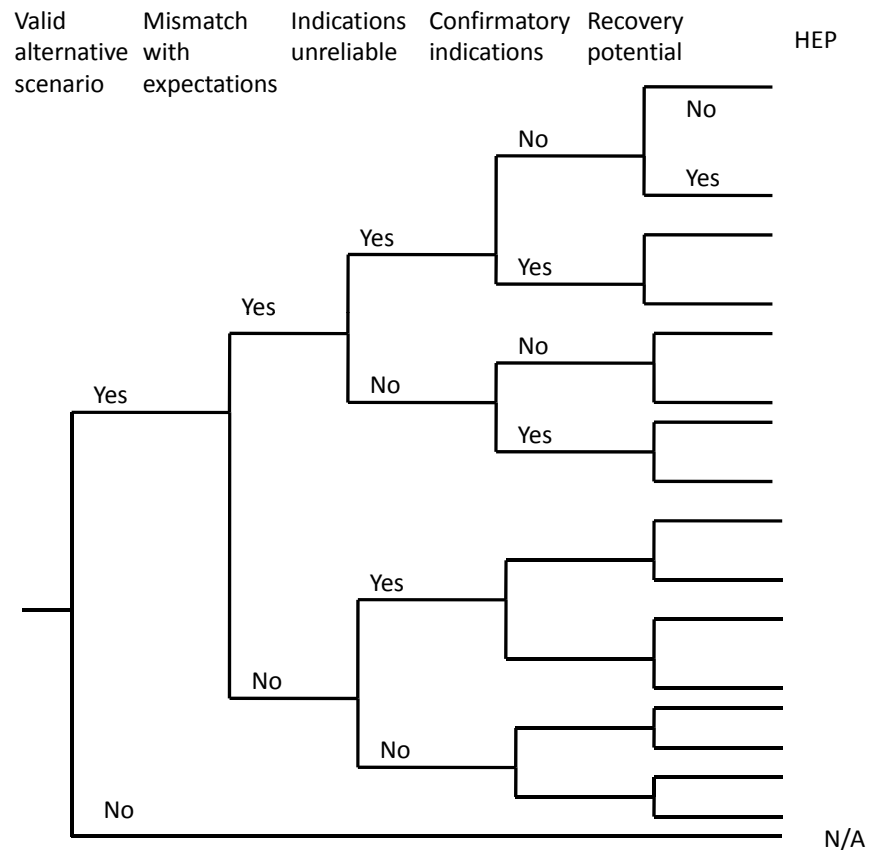
Construction of DTs

- Based on an analysis of the results of the literature survey
 - Cognitive mechanisms and associated PIFs
- Intention is that the complete set of Decision Trees captures the set of crew failure scenarios (explanations of why the HFE can occur)
- The branches of the decision trees address the PIFs that have an effect on the likelihood of the occurrence of the crew failure scenarios
- When applying the DT to a specific HFE, the direction taken at each branch is determined by analyzing the specific characteristics of the PIFs obtained during the qualitative analysis
 - Guidance in the form of questions, and issues to be addressed

Example DT – Critical Data dismissed / discounted

- Definition of CFM: The crew is aware of, and has obtained the correct information (e.g., the value of a key plant parameter, or the status of a piece of equipment), but has decided to discount it from the assessment of the plant status (and therefore represents an incorrect synthesis of the information they have).
- Performance Influencing factors:
 - Valid alternative scenario (a boundary condition)
 - Mismatch with expectations (related to training and experience)
 - Indication unreliable (a detrimental factor)
 - Practice is to confirm indication (a mitigating factor)
- Potential for recovery is included as a branch point on the DT where applicable

Decision tree – Critical data dismissed/discounted



Assessment of Potential for Correction of Initial Error (Recovery)

- Assessed based on an understanding of the plant status evolution following the initial error and the opportunities/prompts for reassessment of plant status
 - Opportunities captured in the nodes following the initial failure on the CRT
- Potential for recovery dependent on a number of issues, e.g.:
 - Nature of the initial error (CFM dependent)
 - The salience of any new evidence that challenges current mental model
 - The availability of a plan or procedural path for correct response given that it leads to a revision to the operators' mental model.
 - The arrival of the new information and its assimilation can happen in sufficient time to allow the correct response to be effective and prevent the HFE.

Implementation of Quantification Approach

- For each sequence on the CRT that leads to the HFE:
 - Analyze the initial node to identify the relevant CFMs
 - Subsequent nodes are used to assess the potential for correcting the initial error in a timely manner
 - For each relevant CFM, assess the contribution to the HEP using its Decision Tree (DT) – one for each CFM
 - DT path for a specific HFE is determined by the characteristics of the PIFs as they relate to that HFE
 - The HEP is the sum over all CFMs for the initial nodes of all CRT sequences that could, if unrecovered, lead to the HFE

Quantification of HFE

- Perform the following summation

$$\text{HEP}(\text{HFE}|\text{S}) = \sum_{\text{CRT Sequence}} \sum_{\text{CFM}} \text{Prob}(\text{DT path}|\text{S})\text{CFM}$$

Summary

- The quantification model consists of a set of decision trees – one for each CFM
- The structure of each tree is based on an analysis of the result of the psychological literature, tailored to the nuclear power plant environment
- Guidance provided for identifying the relevant PIFs at a node in a CRT and for determining the path through the DT
- The paths through each decision tree represent the specific aspects of the context that effect the potential for failure of the associated CFM.
- Each CFM and the PIF characteristics together define a crew failure scenario for the HFE