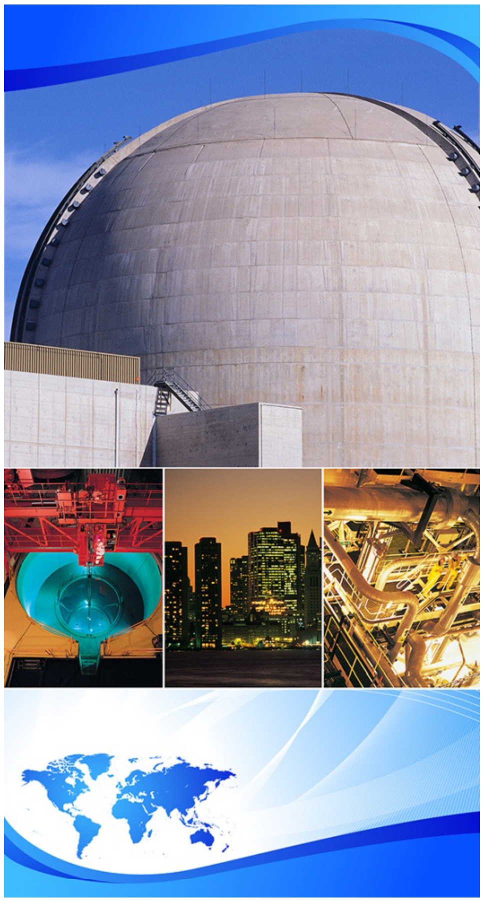

Towards an Improved HRA Method

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

Motivation for a New Method

- Staff Requirements Memorandum (SRM M061020) from US NRC to ACRS, "*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*"
- NRC's Office of Research (RES) and Electric Power Research Institute (EPRI) working together to address the SRM (under an MOU)

Aims of Project

- Provide an HRA method that is:
  - Consistent with the state of knowledge on human performance and cognitive psychology
  - Practical and straightforward to use
  - Produces traceable and reproducible results
  - Comprehensive enough to address a broad scope of applications

Evaluation of Current Methods

- Analyzed needs for HRA and identified useful features and limitations in existing methods
- Determined important features for an HRA method and evaluated current HRA methods against this list

Important Feature	Description
Content Validity	How well the method represents all elements of the construct it claims to measure
Empirical Validity	Does the method have an empirical basis?
Reliability	How consistently the method measures its intended construct
Traceability	The ability to reverse engineer the analyst’s work mathematically and conceptually
Construct Validity	The method measures what it states to be measuring
Adaptability/Scalability	Whether a method can be adapted to different application domains and levels of analysis
Usability	The method provides a practical tool without compromising the technical integrity of the analysis

Integrated Human Event Analysis System (IDHEAS)

Institute (EPRI)

Lessons Learned from Empirical Studies

HRA methods were found to be inadequate in one or more of the following areas:

- Comprehensive underlying theoretical basis of human performance to guide the analysis, particularly with respect to the cognitive activities associated with understanding complex situations and deciding how to respond
- Systematic and thorough guidance for performing a qualitative assessment to support HRA quantification
- Strong connection between the qualitative and quantitative assessments
- Guidance on how to use the information from the qualitative analysis to quantify the HEPs

Path to Address SRM

- Develop new method that integrates many of the good features of existing methods and proposed elements for addressing some of the limitations identified.
  → Conceptually a hybrid of ATHEANA and CBDT HRA methods and IDA information processing model
- IDHEAS = Integrated Decision-tree Human Event Analysis System

Technical Basis of Approach

- Provide a cognitive framework linking operator psychological processes with behavior and performance
  - Literature review of cognitive science, psychology, & human factors
  - Identify performance influencing factors to be used for quantification
- Cognitive functions categorized as:
  - Detecting/noticing
  - Sensemaking/understanding
  - Decision making
  - Action implementation
  - Team coordination

Qualitative Analysis

- Crew Response Tree (CRT)
  - Visual representation of the potential crew failure paths resulting in the HFE
  - Supports performance and documentation of the qualitative analysis
  - Result of a task analysis that defines what has to happen for crew success in performing a function for which an HFE is defined
- Procedural task analysis
  - Examine which procedures are in play
  - Helps identify the critical steps which might lead to the HFE
  - Branches on the CRT represent failures to follow the critical steps in the procedure.

Qualitative Analysis – Cont'd

- Crew Failure Scenario
  - Explanation of why HFE occurred
  - Constructed through qualitative analysis
  - Informed by & consistent with cognitive mechanisms identified in psychological literature review
- Crew Failure Modes (CFMs)
  - Error modes describing initial fault in crew failure scenario
  - A set of 14 have been identified and map to 3 stages of the crew interaction with the plant:

Status Assessment → Response Planning → Action/Execution

Quantitative Analysis -Decision Trees

- Constructed for each CFM
- Represents an integral model of the crew failure scenarios
- Structured approach for quantifying HFEs
- Branch points correspond to the PIFs considered to be most relevant to the cognitive mechanisms that can result in the CFM
- Recovery potential also accounted for
- Human error probability
  - Probability assigned to the end points (complete paths)
  - Represents consensus of experts

Quantification Model

$$\text{HEP(HFE}\mid\text{S)} = \sum_{CRTsequence}\sum_{CFM}\text{Prob}(CFM \mid CRTsequence, S)$$

- Addresses the set of relevant CFMs and different paths through the CRT for a given HFE for a given scenario, S, and associated context
- Outer sum is over the CRT sequences that leads to the HFE, and the inner sum is over the CFMs that are relevant for the CRT sequence.
- The term Prob(*CFM|CRTsequence, S*) is the probability associated with the end point of the path through the DT for the specific CFM that is determined by the assessment of the relevant factors associated with the HFE (and the CRT sequence)

Summary

- IDHEAS proposed in response to challenge presented in SRM
- Improve current state of the art by:
    1. Comprehensive cognitive framework of human failure
    2. Improved qualitative analysis that adequately describes context of HFE and feeds into quantitative analysis
    3. Improved HFE quantification process

QUESTIONS