Evaluation of Human Reliability Analysis Methods Against HRA Good Practices (Draft NUREG-1842)

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Outline

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- Summary of results
- Comparison of Methods on Selected key characteristics
- Implications - What methods should be used when?

Background

- The NRC developed the "PRA Action Plan for Stabilizing PRA Expectations and Requirements," (SECY-04-0118) to address PRA quality issues
- The plan includes the development of guidance for performing/reviewing human reliability analyses (HRAs)
- HRA guidance is developed in two phases:
  - Phase 1: HRA Good Practices--NUREG-1792, 4/05
  - Phase 2: Evaluation of methods against the Good Practices, NUREG-1842, Draft for Public Comment: March 2006
    - Submit to publication: September 2006

Approach for HRA Method Evaluation

- Compared methods, step-by-step with Good Practices
- External review of ATHEANA, SPAR-H, SLIM/FLIM
- Expert meeting to discuss initial evaluation/expert input, Rockville Md., June 2005
- Addressed recommendations
  - Look deeper to underlying technical basis (frameworks, models, data)
  - Discuss methods as intended to be used versus as practiced
- Internal NRC and ACRS review
- Submitted to public review and comment (by 6/15/06): http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1842/sr1842.pdf

HRA Methods Reviewed

- Technique for Human Error Rate Prediction (THERP) (NUREG/CR-1278)
- Accident Sequence Evaluation Program (ASEP) HRA Procedure (NUREG/CR-4772)
- Human Cognitive Reliability (HCR)/Operator Reliability Experiments (ORE) Method (EPRI TR-100259)
- Cause-Based Decision Tree (CBDT) Method (EPRI TR-100259)
- EPRI HRA Calculator
- Standard Plant Analysis Risk HRA (SPAR-H) Method (NUREG/CR-6883)
- A Technique for Human Event Analysis (ATHEANA) (NUREG-1624, Rev. 1)
- Success Likelihood Index Methodology (SLIM) Multi-Attribute Utility Decomposition (MAUD) (e.g., NUREG/CR-3518)
- Failure Likelihood Index Methodology (FLIM)
- A Revised Systematic Human Action Reliability Procedure (SHARP1, EPRI TR-101711)

Summary of Results

- Most HRA methods **are quantification tools** for estimating human error probabilities (HEPs)
  - Provide guidance for obtaining HEPs
  - **Do not deal with the HRA process** and hence do not deal with many of the good practices
  - ATHEANA, and to some extent THERP, address both process and quantification
- SHARP/SHARP1 are HRA guidance documents
- The HRA Calculator is a computerized tool that guides quantification using various methods

Summary of Results

- All HRA methods/tools have strengths and weaknesses
  - Reflect an evolution of our understanding of the role of humans in accidents
  - Different tools address different analyses needs
- Examples of strengths
  - Clear/good technical basis of the underlying model
  - Good step-by-step guidance on how to use the tool
  - Traceable analysis
- Examples of weaknesses
  - Weak technical basis--some methods are not recommended for use in regulatory applications
  - Address a limited set of performance shaping factors (PSFs)
  - Not applied as intended

Comparison of Methods on Selected Key Characteristics

Overall Quantification Approach

- THERP, ASEP, CBDT, SPAR-H--estimate HEPs using a basic/initial HEP subsequently adjusted, and/or tables and curves
- SLIM/FLIM, ATHEANA--estimate HEPs directly based on context & experience/judgment
- HCR/ORE--estimate HEPs based on empirical or judged measures of the timing of the tasks analyzed

Comparison of Methods on Selected Key Characteristics

Dependencies

- THERP uses a model to address dependencies (among subtasks)
- ASEP, SPAR-H and sometimes FLIM use the THERP approach
- ATHEANA, and to some extent SLIM/FLIM, consider dependencies as part of the context and include them in the HEP estimations through expert elicitation
- HCR/ORE, CBDT discuss dependencies but is left to the analysts deal with incorporating the effect of dependencies on the HEP estimates
- SHARP1 provides overall good discussion, but does not address quantification of dependencies

Comparison of Methods on Selected Key Characteristics

Uncertainties

- THERP, ASEP, SPAR-H --state that cover both aleatory and epistemic but cannot be separated
- HCR/ORE, CBD--provide limited guidance
- SLIM, FLIM-- use expert elicitation to create HEP distributions that include uncertainties. Focus primarily on epistemic uncertainty
- ATHEANA--more context specific, largely aleatory because experts are asked to directly consider aleatory influences in obtaining distributions for HEPs.
  - Aspects of epistemic uncertainty may be captured when judges consider HEP estimates for different quantiles.

Comparison of Methods on Selected Key characteristics

Range of Contexts Considered

- THERP, ASEP, CBDT, SPAR-H, SLIM/FLIM--largely consider the "nominal," that is, the expected context in the PRA scenario
- ATHEANA-- investigates the nominal as well as variations (so-called deviation scenarios) that fit within the definition of the PRA scenario
- HCR/ORE.--context is implicitly represented in the simulator runs if performed (identification of range of contexts requires many simulator runs)

Comparison of Methods on Selected Key Characteristics

Range of Specific PSFs Considered

- Most methods cover a relatively small range of PSFs
- THERP – For diagnosis, discusses a wide range of PSFs, but model addresses only a few
- SLIM and ATHEANA do not specify a fixed set, ATHEANA provides range of examples
- Only ATHEANA (and SLIM if modified) considers potential interactions between PSFs

Implications
What Methods Should Be Used When?

It all depends on the issue and decision being made

- HRA process
  - When issue/decision clearly affects just one or very few already identified HFEs with no need to worry about dependencies nor interactions with the rest of the PRA, then detailed identification and modeling processes etc. are not important
  - When issue/decision affects multiple HFEs or requires interactions with the rest of the PRA to be accurate (e.g., need to account for dependencies and the correct component rankings), then following the HRA good practices correctly becomes more important

Implications
What Methods Should Be Used When?

It all depends on the issue and decision being made

- Simpler tools may be used for qualitative and quantitative analysis **if**
  - the overall scope of the PRA is limited (e.g., screening)
  - the risk-related decision being made is not sensitive to the results (determined for instance through screening or sensitivity)
  - based on prior experience, seems likely that the most important influencing factors affecting the human action of interest are easily and directly handled using the less detailed, easier to use method

Implications
What Methods Should Be Used When?

- A simple quantification tool can provide helpful answers as long as
  - the main weaknesses of the tool are avoided
  - the tool is not asked to give answers it cannot provide, for example
    - determine causal influences to a diagnosis error using a simple time correlation curve (TRC)
    - assess the potential effects of communications when "communications" is not addressed directly by the method or easily interpreted as part of another factor that is covered by the method

Implications
What Methods Should Be Used When?

- The quantification tool used needs to be justified as to why it is appropriate for the decision being made
  - The more the decision is sensitive to the probabilistic inputs, the more important it is that the HRA process be rigorously followed and that a more detailed, broader scope quantification tool is used
  - A detailed analysis that considers a reasonably broad range of conditions is needed if, for example
    - A reasonably accurate HEP estimate is needed - whether high or low
    - To understand the drivers for success/failure and what conditions could create problems for the crew is needed (e.g., to identify fixes)

Implications
What tools should be used when?

- Analysts/reviewers/users should avoid selecting a method first and then making the decision/issue *fit* the method
- The HRA process should be the other way around
  - Determine what is needed from the HRA to address the decision/issue
  - Select the appropriate tool(s) accordingly AND justify the selection as well as the assumptions and judgments made in implementing the tool(s)
  - Perform sensitivities to make results even more robust