

June 25, 2014

Mr. John W. Stetkar, Chairman  
Advisory Committee on Reactor Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

SUBJECT: HUMAN RELIABILITY ANALYSIS MODELS

Dear Mr. Stetkar:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter to Chairman Macfarlane, dated May 14, 2014, that summarized the views of the Advisory Committee on Reactor Safeguards (ACRS) regarding research activities for human reliability analysis (HRA) models. These activities are related to the staff's response to the Commission's Staff Requirements Memorandum M061020. The letter summarized the Committee's review of two draft reports developed under the research activity: (1) Draft NUREG-2114, "Building a Psychological Foundation for Human Reliability Analysis," and (2) Draft NRC/EPRI report, "An Integrated Decision-Tree Human Event Analysis System (IDHEAS) Method for NPP Internal At-Power Operation."

The ACRS letter contains a summary of significant accomplishments of research activities. The letter concluded that: (1) "Draft NUREG-2114 contains valuable information to improve understanding of the theoretical basis for human cognitive performance, the causes for human errors, and a structured framework to assess the contributions to errors in the context of an evolving event scenario. It should be published.", and (2) "Elements of the IDHEAS methodology will enhance documentation of the human reliability analysis (HRA) process, reduce analyst-to-analyst variability in its use, and improve traceability of the bases for differing assessments."

The letter also provides detailed recommendations that should be addressed before the IDHEAS methodology is endorsed for use.

We appreciate your support of the HRA research. The staff agrees with the ACRS recommendation that we should publish the draft NUREG-2114. The staff carefully reviewed the ACRS's six major recommendations on the IDHEAS methodology and agreed to address these recommendations. Please see below the staff response to the ACRS recommendations as well as some further information on related HRA research activities.

#### **Recommendation 1**

*"The IDHEAS report should document the rationale for excluding specific cognitive mechanisms and performance influencing factors delineated in draft NUREG-2114 from explicit consideration in the assessment of each crew failure mode."*

Response:

The staff agrees with the recommendation. The draft IDHEAS report did not provide a clear mapping between the cognitive mechanisms and the performance influencing factors in the decision-trees of IDHEAS crew failure modes. Some mechanisms were implicitly assessed through interactions with internal and external stakeholders involved in performance influencing factors, and other mechanisms were excluded either because they are insignificant to the failure modes or because their impacts are mitigated for operational crews well-trained on procedures. The staff will systematically go through the lists of cognitive mechanisms in NUREG-2114 and will perform the mapping between the cognitive mechanisms and the performance influencing factors for every crew failure mode in IDHEAS. For the cognitive mechanisms that were excluded in the assessment of the crew failure modes, the staff will document in the report the rationale for excluding them in this model specifically for internal at-power events.

**Recommendation 2**

*“The qualitative assessment guidance should emphasize the need to develop operational narratives which adequately describe the entire context of the evolving event scenario, how that scenario affects all information and stimuli in the operators' environment, and factors that may influence personnel response in that context, considering the effects on all plant systems and functions, regardless of their inclusion in the probabilistic risk assessment (PRA) models. Examples of good operational narratives should be provided.”*

Response:

The staff agrees that performing qualitative analysis should include developing an operational narrative of the event to describe the entire context of the evolving event scenarios. The qualitative analysis guidance in the draft IDHEAS report was intended to clearly document the context for each action in a hierarchical way. This involved describing the scenario and operational event evolution in (1) human failure event definitions and the associated timelines, (2) the development of the crew response tree, and (3) the assessment of the paths through the decision-trees for the various crew failure modes. This approach has a limitation in identifying qualitative information that affects all cues and stimuli in the operators' environment, such as, for example, the information regarding distraction to operators' response, multitasking, and unfamiliar dynamic evolution of an event. Such information may not become apparent during the development of the crew response tree and the assessment of decision-tree paths. However, this kind of information should be available to analysts and help them to assess decision-tree paths. In addition, the information is needed to analyze the dependency between human failure events in a scenario.

Therefore, the staff plans to add a section on guidance for developing operational narratives that explicitly documents the context of the entire evolving event scenario as well as the guidance on using the information in each of the narratives for assessment of decision-tree paths. The guidance section will include two parts - the key elements in an operational narrative and the mapping between these elements and the quantification model.

The staff plans to either apply the guidance in an example demonstrating how the IDHEAS methodology works (Appendix A of the current IDHEAS report) or provide additional examples to demonstrate how to use the operational narrative guidance.

**Recommendation 3**

*“A formal and complete expert elicitation process should be conducted to develop human error probabilities and associated uncertainty distributions for each combination of contextual factors in the final version of every decision tree.”*

Response:

The staff agrees with the recommendation and plans to conduct another expert elicitation to complete the human error probability estimations for each of the branches in all the decision-trees. Further, the staff plans to review the transcripts from the first two elicitation workshops to make necessary refinements to decision trees that have not been quantified. These refinements will ensure that all of the decision-trees are clear and pertinent to internal, at-power operations to facilitate their use.

**Recommendation 4**

*“Uncertainties in the human error probabilities should be derived directly from the expert elicitations.”*

Response:

The staff agrees with the recommendation and plans to address uncertainties in the human error probabilities as recommended. Moreover, the staff plans to systematically address uncertainties in the method. Several key areas contributing to the method uncertainties are time estimation, assessment of decision-tree paths, and human error probabilities estimated for each path. The staff plans to provide guidance on how to take all of these uncertainties into consideration in the integrated analysis.

**Recommendation 5**

*“The guidance for estimation of the available time window and the time required to perform each action should include explicit evaluation of the uncertainties in those times. The probability that an action cannot be completed within the available time window should be included as a contribution to the overall HRA results.”*

Response:

The staff agrees with the recommendation and plans to address the time issue as recommended. In IDHEAS, the time margin for a human action is determined by the difference between the time available to perform an action and the time needed to perform the action. The time issue has two aspects: uncertainties in estimation of time needed for the action and quantification of the effect of time margin on human error probabilities.

The draft report provides guidance on estimating time required for an action by considering a list of factors that could potentially affect the time required. The staff acknowledges that the report did not provide explicit guidance on how to credit the effects of those factors. The time required

for a human action consists of time needed to detect the cues, the cognition time to understand the situation and make decisions, and the time for execution. Typically, analysts estimate the required time through simulator observation and talk-throughs with operational personnel. The estimated time varies due to individual differences in operational personnel, numbers of simulations, scenario designs, and analysts' methods of generalizing inputs from different individuals.

### **Recommendation 6**

*“Formal pilot testing of the IDHEAS methodology should be performed. The testing should be conducted by multiple teams of analysts who have a range of practical experience with evaluating human performance in PRA applications. Teams should include members with expertise in nuclear power plant engineering, operations, and the plant-specific PRA, as well as human performance and HRA. Each team should evaluate the same set of PRA event scenarios that cover a range of human actions and anticipated crew failure modes.”*

#### Response:

The staff agrees with the recommendation and plans to conduct a formal testing of the IDHEAS method. The objectives of the testing are to validate that the method works as intended, evaluate the advantages and disadvantages between the method and other HRA methods currently in use, and make any necessary changes to assure accuracy and usability. The testing will be conducted by multiple teams of analysts who have a range of practical experience with evaluating human performance in PRA applications. Each team will evaluate the same set of scenarios that cover a range of human actions and represent different types of HRA applications (e.g., PRA models, Significance Determination Process event analysis). The staff will work with a group of user representatives to determine explicit criteria for testing.

In summary, the staff appreciates the comments and recommendation provided by the ACRS. The staff looks forward to continuing to work with the ACRS as the staff proceeds with current research efforts, develops final reports, and develops new research initiatives addressing HRA.

Sincerely,

*/RA/*

Mark A. Satorius  
Executive Director  
for Operations

cc: Chairman Macfarlane  
Commissioner Svinicki  
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