



BNL-NUREG-75683-2006-CP

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for Regulatory Reviews***

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Presented at the
American Nuclear Society Annual Meeting

Reno, Nevada

June 4-8, 2006

Energy Sciences and Technology Department

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Advances in HFE Methods and Their Implications for Regulatory Reviews

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INTRODUCTION

There is renewed interest in the United States (U.S.) to construct new Generation III and III+ reactors within the next decade and Generation IV reactors in the future. Licensing by the U.S. Nuclear Regulatory Commission (NRC) is a significant consideration and these new plants may pose new challenges. One such challenge is the advances in human factors engineering (HFE) methods that are used. These methods are used to design and evaluate the HFE aspects of a plant, such as the human-system interface (HSI). These methods are important because NRC HFE reviews are design process oriented, thus, the criteria are mostly technology neutral with regard to reactor design.[1] However, the HFE review criteria are not neutral with respect to the HFE methods that are used as part of the design process. This will be important for new reactor reviews because the diversity of reactor types, HSIs, and operational concepts will increase, especially for Generation III+ and IV plants. Thus the NRC is conducting research to identify advances in HFE methods and to develop additional guidance to address their review.

METHODOLOGY

Trends and issues in emerging HFE methods were identified in the nuclear industry and in related industries and the military arena through a review of the literature and discussions with subject matter experts. The methods were then organized into the following categories: Analysis, Design, and Test and Evaluation. Each is discussed below.

RESULTS

Analysis methods are used to develop information and requirements used as inputs to HFE design activities. While there is general agreement on the importance of beginning HFE activities early in the design process, there is a need for more formal and structured approaches to support them. Examples of where such guidance is needed includes: operating experience analysis and the development of lessons learned, function allocation, human reliability analysis (HRA), and the development and application of knowledge engineering techniques.

To use HRA as an example, current methods may not be applicable to new designs which incorporate increased automation, alternative concepts of operations, and intelligent agents and HSIs. HRA will be further constrained by the lack of data to support human error probability estimates. Guidance to address this gap is needed.

On the other hand, one area that has been evolving rapidly is task analysis. Recent advances in work analysis, cognitive task analysis, and cognitive engineering are especially applicable to supervisory control tasks. However, there is a lack of guidance on the appropriate application of such methods; thus guidance for their review is needed.

Design methods are used to translate requirements into detailed designs. Advanced methods are evolving to develop designs in far less time and with more user input. Using techniques such as rapid prototyping, designs quickly evolve through a number of iterations with users to obtain feedback and make HSI modifications. The cycle is repeated until the design is completed. A potential safety concern relates to the technical basis on which such HSIs are developed.

Future HSIs are also likely to provide information at much higher levels than exist in today's plants. Lower-level information will be integrated and processed to provide more immediately meaningful information to operators. While this type of information display may be a promising advance, there are no well-defined processes for conducting the analyses needed to specify them or to review the process at the design stage.

A key issue regarding *test and evaluation methods* is evaluating the effects of advanced and intelligent systems. Evaluations are becoming more performance-based, thus performance measurement and criteria are important considerations. Measures that reflect integrated system performance are needed for which criteria for system acceptability can be established. Further, since personnel work as teams, modeling and measurement of effective team performance is an important consideration.

In a performance-base approach, validation of integrated systems is a key activity and many aspects of its methodology are being impacted by technology. For example, one significant component is the testbed, such as a full-mission simulator. New technologies are being developed that provide alternatives to traditional testbeds, e.g., virtual reality (VR). An important question that needs to be addressed is the validation of VR models and

the methodology for their use. In general, clearly defined methodological criteria are needed to review licensee validation submittals.

While the above issues relate to measuring actual personnel performance, current trends are to obtain "performance data" from human performance models, such as task network models and discrete event simulation. Since operator availability is limited and the means to collect data can be expensive, models are an attractive alternative. As modeling improves, its application will be extended to more complex design and evaluation situations. Regulatory reviews will have to consider the validity of the modeling and its results will have to be assured.

CONCLUSIONS

HFE methods are rapidly evolving leading to new approaches to designing the HFE aspects of plants. Important aspects of the HFE methods were discussed in terms of analysis, design, and test and evaluation. Thus, improvements to the review methods and criteria are necessary to keep pace with the advances that are coming.

ACKNOWLEDGEMENTS

This paper is based on research that is sponsored by the U. S. Nuclear Regulatory Commission. The views presented in this paper represent those of the authors alone and not necessarily those of the NRC.

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