Sandia National Laboratories

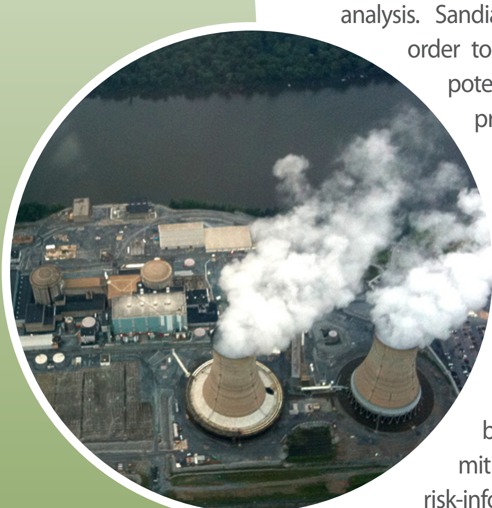
Energy, Climate & Infrastructure Security

Human Reliability Assessment

Researchers at Sandia National Laboratories use human reliability assessments as a structured approach to identify potential human errors and systematically estimate the probability of those errors occurring as a step toward estimating a system's total risk.

Quantifying the Human Dimension of Risk

Humans form an integral part of many complex engineered systems with the potential for significant failure consequences. From nuclear energy to the chemical process industry, and from health care to infrastructure, human reliability assessments (HRAs) are important elements of any comprehensive risk analysis. Sandia applies HRAs to these systems in order to generate statistical likelihoods of potential human failure events. HRAs provide a structured approach to identify potential human actions that can lead to system failure, and systematically estimate the probability of those errors occurring to calculate potential risk. By better-understanding the human contributions to a system's total risk, measures can be implemented to eliminate or mitigate potential errors and support risk-informed regulations and decisions.



Three-mile Island Nuclear Power Plant

A Balanced Disciplinary Approach

At its core, human reliability is comprised of two primary components: knowledge of the system and human behavior. The interplay between these two disciplines requires a balanced interdisciplinary approach leveraging elements of industrial ergonomics and cognitive psychology with knowledge-based analysis of the engineered system. Investigating various phases of human information processing including detection, assessment, response planning, and response execution, Sandia researchers identify and quantify the ways that human actions selectively initiate, propagate, or terminate fault and accident sequences.

HRAs represent a difficult task since researchers need to understand all elements of the situational context ranging from hardware functions to operator responses during accident progression. Due to this complex nature, successful HRAs use inputs from many technical disciplines to generate a systems-based assessment of total risk. Inputs from probabilistic risk assessments, systems engineering, plant design, human factors engineering, cognitive and behavioral science, and ergonomics are only a few of the diverse areas that are drawn upon as input for HRA analysis. While other institutions may specialize within a contributing discipline, Sandia maintains an exceptionally balanced multidisciplinary team with experts spanning all relevant disciplines. This balanced team of psychologists, engineers, and mathematicians provide a sensible and synergistic blend of disciplines.

Sandia HRA has applications broader than nuclear power plants including assessment of health care and U.S. Naval training systems.

A Founder in HRA

The origins of HRA trace back to Sandia's development of the first-ever HRA methodology for the U.S. Nuclear Regulatory Commission (NRC). Sandia developed the Technique for Human Error Rate Prediction (THERP) to evaluate the probability of human failure events occurring at a nuclear power plant. Serving as foundation of HRA methodology and practice, THERP is capable of modeling dependent relations between actions and errors in a way unlike any other technique. It is an extensively documented and widely used HRA technique throughout the U.S. and the international community.

For more information please contact:

Shawn P. Burns
E-mail: spburns@sandia.gov
Phone: (505) 844-6200
Website: ne.sandia.gov

U.S. DEPARTMENT OF ENERGY

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Humans as Part of the Nuclear Complex

Whether transporting radioactive material to a disposal site or operating a nuclear power plant, industry and regulatory agencies strive to ensure the safe and secure operation of the nuclear industry. Recognizing the complex nature of these situations, it is increasingly important to assess risk--not only risk attributable to equipment and processes, but risk attributable to the human element, as well. As illustrated in the 1979 Three Mile Island accident, human factors can be the root cause of serious problems.

Sandia researchers are extending the state of the art in HRA through method development and empirical data collection and analysis. The resulting body of work not only enhances the understanding of the risks associated with the operation of current civilian nuclear power reactors, but supports the licensing and regulation of new reactor designs. In addition, Sandia researchers are developing new methods and techniques applicable to the analysis of current and future designs. For example, Bayesian analysis methods are of particular interest in this area given the often limited data available for human performance in operational and accident contexts. Sandia researchers also develop and study models of human cognition to provide insights into situational awareness and learning. These efforts represent a portion of a broader Sandia program in advanced probabilistic risk assessment which has supported civilian nuclear energy regulatory rule making since the late 1970s.

An example of a nuclear power plant control room

Gaining Insight into Risk

Since HRAs are used to estimate the likelihood and importance of human failure events and unsafe actions, they easily provide input to probabilistic risk assessments for all types of systems. This allows researchers to identify error-forcing contexts, mitigation strategies, and opportunities for system improvements. Identifying vulnerabilities of high consequence industrial systems and their operations, this methodology ultimately supports risk-informed decision-making by providing the scientific rigor and support needed to justify regulations, standards, and decisions. With increasingly accurate and reliable risk-informed information available, better decisions are made to optimize facility function, avoid incidents, and keep people safe.

Human behaviour is a critical element of safety in a nuclear power plant control room

Publications

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