Sandia National Laboratories

Energy, Climate & Infrastructure Security

Probabilistic Risk Assessments

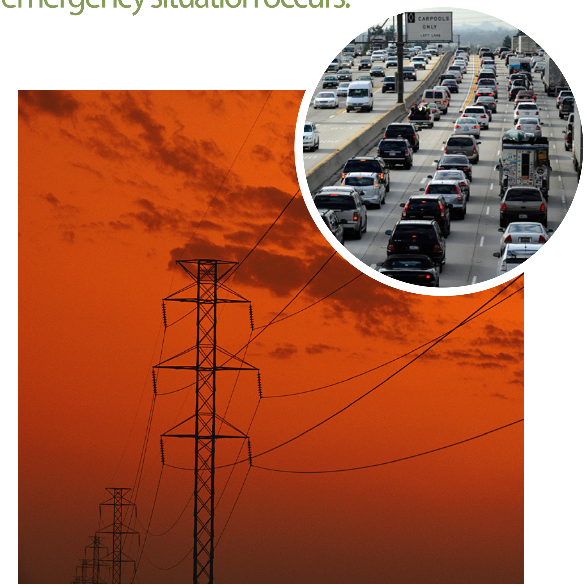
Used as a systematic process to identify potential accidents and threats at facilities such as nuclear power plants, PRAs highlight possible points of vulnerability within a complex system before an incident or emergency situation occurs.

A New Age of Risk Assessment

A probabilistic risk assessment (PRA), which is sometimes referred to as probabilistic safety assessment (PSA), is a systematic, logical analysis process. This powerful tool helps ensure the safe design and operation of complex engineered systems that have the potential for significant failure consequences. Sandia National Laboratories is a leader in the development and application of PRA methods in both civilian nuclear power and defense applications.

PRA helps assure nuclear power plant safety

In the past, PRAs provided largely qualitative results, but with increasingly accurate modeling and data analysis techniques, PRAs now provide much more quantitative risk assessments. Many opportunities exist for the application of Sandia PRA research and analysis expertise including national infrastructure, transportation, health care, agriculture, and, of course, nuclear power and national defense.



PRA analyses can be used to evaluate a variety of industries including infrastructure and transportation systems

Characterizing Risk

In simple terms, risk represents the product of the likelihood of an adverse event and the consequences of that event occurring. Sandia researchers use an array of analysis techniques including event and fault trees, influence diagrams, decision trees, and network diagrams,combined with deep systems knowledge and substantial professional expertise to produce realistic risk estimates for complex systems. The resulting analyses explore the often subtle and non-intuitive interactions among initiating events, hardware failures, human errors, and operational and organizational factors that influence the risk profile for a system. Insights obtained from PRA analyses play valuable roles throughout the system life cycle varying from design and licensing, to construction, operation, decommissioning, and regulation.

Application to Civilian Nuclear Energy

Sandia has over 30 years of experience developing and applying PRA methods to civilian nuclear power applications, dating from the Three Mile Island event in 1979. This history coincides with the development of the modern risk-informed, performance-based regulatory framework employed by the U.S. Nuclear Regulatory commission today. Sandia played a central role in many of the seminal works which form the basis of the U.S. nuclear regulatory structure, and continues serving as an active contributor in the development of industry standards which provide

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guidance for the correct application of these techniques in an industrial setting. Sandia's staff includes many original developers of current PRA methods as well as a new generation of researchers capable of continuing the development of this important methodology into the future.

There are many compelling challenges in the area of civilian nuclear power risk analysis which will need to be addressed in the coming decades. Some of the challenges are associated with emerging nuclear reactor designs including small modular reactors, as well as next generation light water reactors and advanced gas and metal cooled reactors. Sandia researchers are already exploring solutions to the risk analysis challenges presented by new technology incorporated into these designs including digital instrumentation and control and passive safety features. For example, Bayesian belief networks allow analysis of systems with limited operational data, and dynamic risk analysis techniques are valuable where system performance depends on event progression. Sandia continues to extend current PRA methods and conduct empirical studies providing system and component performance data upon which future risk analyses will depend.

However, the challenges posed by analysis of the current aging U.S. and international fleet of third generation reactor designs are no less important than those posed by new designs. The impact of aging on the performance of existing reactor systems and components is of particular importance, and will require new empirical and analytical studies. In support of these needs, Sandia researchers are developing new data and methods to improve current understanding of the risk profile for existing designs and extending PRA analysis into operating states that are currently poorly characterized.

Sandia-Originated Methods and Tools

As a leader in PRA methodology development since the 1970s, Sandia has established a best-in-class reputation in several specific technology areas relevant to PRA analysis of civilian nuclear power. In particular, Sandia is an active force in establishing the state-of-the-art in human reliability analysis and fire risk analysis, as well as computational modeling of severe accident progression and off-site health consequences. The methods and empirical data developed at Sandia inform both regulatory guidance and industrial standards used throughout the U.S. civilian nuclear energy industry. The MELCOR and MACCS2 computational analysis tools incorporate physical models for severe accident phenomenology including radionuclide transport and release based on more than 30 years of U.S. and international experimental data. Maintained and under continuous development at Sandia, these tools represent a repository of the best models of physical processes involved in severe reactor accidents and their off-site health consequences.

Risk-Informed Decision-Making

By identifying potential risks and safety vulnerabilities in complex, high-consequence, engineered systems, PRAs ultimately support risk-informed decision-making. While assumptions and inferences may seem logical in certain circumstances, PRAs provide the scientific rigor and support needed to establish and justify regulations, industry standards, and decisions. With more information available, better decisions are made optimizing facility function, avoiding incidents, and promoting public safety.

Human reliability analyses are a key component of assessing risk at nuclear power plants

Publications

(1991). Severe accident risks: An assessment for five U. S. nuclear power plants (NUREG-1150). Washington, DC: U. S. Nuclear Regulatory Commission.

Cook. J. R., & Sprung, J. L. (2000). Reexamination of spent fuel shipment risk estimates (NUREG/CR-6672). Washington, DC: U. S. Nuclear Regulatory Commission.

(2005). Fire PRA methodology for nuclear power facilities (NUREG/CR-6850). Washington, DC: U. S. Nuclear Regulatory Commission.

(2005). Good practices for implementing human reliability analysis (NUREG-1792). Washington, DC: U. S. Nuclear Regulatory Commission.

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