
Extending PRA and HRA legacy methods and tools with a cause-based model for comprehensive treatment of human error dependency

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ABSTRACT:

Probabilistic risk assessments (PRAs) of nuclear power plants have greatly contributed to the safe operation of the U.S. reactor fleet. Yet, legacy PRA tools and methods present limitations that can hinder their application, among those the assessment of dependency between human actions. Dependency accounts for the escalation of error rates when a human error occurs, i.e., one error may increase the chances of subsequent errors. When present, dependency can significantly drive overall plant risk. Dependency is a long-discussed topic in Human Reliability Analysis (HRA), but its modeling and quantification are still unsolved challenges. Recent efforts on addressing these challenges, for example through the development of Bayesian Networks (BN) causal models and quantification through dynamic BNs, have been constrained to standalone HRA models. This project aims at developing a solution to HRA dependency assessment in PRA from methodological and practical /computational perspectives within legacy PRA tools and methods. Requirements for HRA dependency assessment based on PRA methods and tools, including CAFTA and SAPHIRE, and on state-of-the-art HRA research and practice will be developed. Those will be an input to the methodology development, which will comprise an algorithm for HRA dependency assessment through BNs and its implementation, procedures for extending currently used HRA methods for integrating the dependency method, and procedures and computation plugin for integrating the method into PRA tools. The methodology will be demonstrated through case studies and benchmarked against current methods used in PRA tools. The project outcomes are a solution for the long-term challenge of how to model and quantify HRA dependency in PRA, through a causal BN approach, and the necessary algorithms and efficient plugin for integrating the BN-based methodology into legacy/static/ and dynamic PRA tools. The objectives will be achieved given the team members' extensive experience in HRA, PRA, BNs, HRA dependency modeling and quantification, and development of PRA computational capabilities. The complementary expertise of the team regarding HRA research and practice, organizational factors, human performance modeling, experiments design and data collection, and PRA will ensure that the solutions will reflect the state-of-the-art of both HRA and PRA through a practicable, usable method and tool. As PRA supports the safe operation of U.S. Nuclear Plants, this project will provide needed improvements to PRA methods/tools to enhance the long-term viability and competitiveness of the existing U.S. reactor fleet.