
An Open Source, Parallel, and Distributed Web-Based Probabilistic Risk Assessment Platform to Support Real Time Nuclear Power Plant Risk-Informed Operational Decisions

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Program: RC-7: Risk-Informed
Systems Analysis R&D Pathway

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ABSTRACT:

The development and use of probabilistic risk assessments (PRAs) in the nuclear industry have revolutionized our approach to reliability and safety. Since the release of WASH-1400 in 1975 and NUREG-1150 in 1990, the PRA applications have diversified and become more computationally demanding, nevertheless the tools that we use to perform such assessments have not kept up with the technological advancements in high-performance computing and computer science applications. The legacy PRA tools, although still perform well on internal events PRA models that have reasonable sizes, suffer greatly, both in terms of speed and memory requirements, when challenged by more sophisticated models such as single hazard PRAs, and especially multi-hazard PRAs. Therefore, a major redesign of the PRA tools is necessary starting from the computational engine capabilities, backend services to handle large PRA models, and a user-friendly PRA frontend that can automatically generate results and documentation necessary to inform non-PRA experts.

The main objective of the proposed work is to develop, demonstrate, and evaluate a probabilistic risk assessment (PRA) software platform needed to address the major challenges of the current legacy PRA tools, such as better quantification speed, integration of multi-hazard models into traditional PRAs, and model modification simplification and documentation automation. To achieve the main objective, we will first perform benchmarking and profiling of current PRA tools, such as SCRAM and SAPHIRE, to investigate the current bottlenecks in the quantification speed and memory requirements. Secondly, we will design, implement, and benchmark a PRA software platform based on a web-based stack using the latest technologies available to overcome the mentioned challenges. Finally, we will evaluate the performance gains of this framework by modeling and quantifying large PRA models that would have been too expensive to run using the legacy PRA tools.

Quantification speed, accuracy, the credibility of the results, and documentation affect all aspects of risk-informed operational decisions. When PRA models require a long time to be developed and quantified, they delay decisions and create bottlenecks in the process of extracting valuable risk insights. Thus, this research will be a great benefit to the nuclear industry in particular, but also to the PRA community at large given the open-source nature of the research and development effort.

The major deliverables of this project will include the open-source, parallel, and distributed web-based PRA platform and guidelines and best practices on model structures and their impact on quantification times and memory requirements for use by PRA practitioners.

The project will be carried out by a strong collaboration among a diverse team of researchers from NCSU and INL who have already shown a track record of applications and advancements in probabilistic risk assessment and software development of end-to-end products.