Integrating Static PRA Information with RISMC Simulation Methods

PI: Tunc Aldemir, The Ohio State University

Program: Reactor Concepts

Collaborators: Alper Yilmaz -The Ohio State University; Yassin Hassan-Texas A&M University; Diego Mandelli, Andrea Alfonsi - Idaho National Laboratory; Askin Guler Yigitoglu - Oak Ridge National Laboratory

ABSTRACT:

Over the past 30 years, concerns have been raised in the literature regarding the capability of static modeling approaches such as the event-tree/fault-tree (ET/FT) methodology to adequately account for the impact of process/hardware/software/firmware/human interactions on the stochastic system behavior in probabilistic risk assessment (PRA). Work to date has shown that: a) not only the predicted consequences and their likelihoods may significantly change if these interactions are not taken into account, but also the event progression with possible omission of some event sequences , b) accounting for epistemic uncertainties may require regeneration of ET/FT (also due to change in the event progression), and, c) aging of systems, structures and components, as well as maintenance, cannot be properly accounted for with the traditional ET/FT approach.

While numerous methodologies (often referred to as dynamic PRA methodologies or DPRA) have been proposed to address these shortcomings the ET/FT methodology1, the standalone plant level applications of the DPRA methodologies are still difficult (if not impossible) due to their computational requirements. Furthermore, only a small portion of the plant ET/FT may involve the types of interactions or epistemic uncertainties that challenge the ET/FT methodology. The objective of the project is to develop a computationally feasible and user-friendly mechanized process to integrate DPRA and traditional PRA results. The project will benefit from the hybrid approaches that have been proposed in the past that capitalize the advantages of the static and DPRA methodologies while trying to overcome the limitations of both.

The project will use RELAP5-3D and RELAP7 codes, RAVEN driver as DPRA tools and SAPHIRE as the traditional PRA tool to develop the integration process. For the scope of this project, RAVEN will be used to run multiple RELAP5-3D scenarios and manipulate the generated data using both classical and more advanced data-mining techniques. While traditional PRA risk metrics and importances are planned to be used to assess the results (e.g. core damage frequency, risk achievement worth), possible use of new importance techniques designed for DPRA output will be also explored. The integration of the static PRA information from SAPHIRE with RAVEN/RELAP5-3D runs will be illustrated on selected initiating events. Various clustering schemes (e.g. mean shift, K-means) will be considered in the selection of representative scenarios for the integration of RAVEN output into SAPHIRE.

The project will lead to a user-friendly tool that will be able to import subsystem failure data from existing plant static PRA models into DPRA models and also export DPRA model results into existing plant static PRA models to augment them for better representation of process/hardware/software/firmware/ human interactions. The product will also provide added capability to include aging effects in RISMC simulation methods, as well as for the seamless incorporation of internal and external event PRAs. While RAVEN/RELAP and SAPHIRE will be used as example software for dynamic and static PRA tools, the import-export paradigm, as well as the clustering process, will be applicable to other existing dynamic and static PRA tools.