

Can Traditional PRA tools be extended to Beyond-design-basis risk assessment?

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The nuclear industry is continually increasing its reliance on probabilistic risk assessment (PRA) tools for nuclear power plant design, operation, life extension, and regulation. Probabilistic safety assessment (PSA) or probabilistic risk assessment evaluates the risk associated with a specific hazard by a convolution of system fragility and hazard curve. The fragility curve of structures, systems, and components (SSCs) is expressed as the conditional probability of failure for a given hazard. A systems analysis for the propagation of component fragilities is conducted using event and fault trees, which can be fairly large in size for an actual power plant. Historically, this has imposed computational challenges on the propagation of component failure probabilities through the fault and event trees for all the possible accident sequences. Hence, computational efficiency is maintained by employing certain assumptions in event tree and fault tree analysis. These assumptions consider the component failure probabilities to be very small as well as statistically independent. Originally, these assumptions were intended for use in risk assessment of design basis (DB) accident scenarios where these assumptions are valid. However, these assumptions are not necessarily valid for Beyond Design Basis (BDB) scenarios. In fact, several studies have shown that component failure probabilities can be about two orders of magnitude higher for BDB events in most cases.

In this study, we have examined the impact of the key assumptions on the determination of accident sequence probabilities and the critical accident sequence using an illustrative case study. The outcomes using conventional approaches are compared with exact calculations. It is shown that the traditional approaches not only

lead to significant differences in the estimations of failure probabilities but also in accurate identification of critical paths. It is illustrated that traditional PRA tools are not suitable for performing probabilistic risk assessment under the BDB scenarios. Such deficiencies in the traditional PRA tools pose a need for the improvement in the quantification approaches.