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Full-Scope Site Level 3 PRA Project

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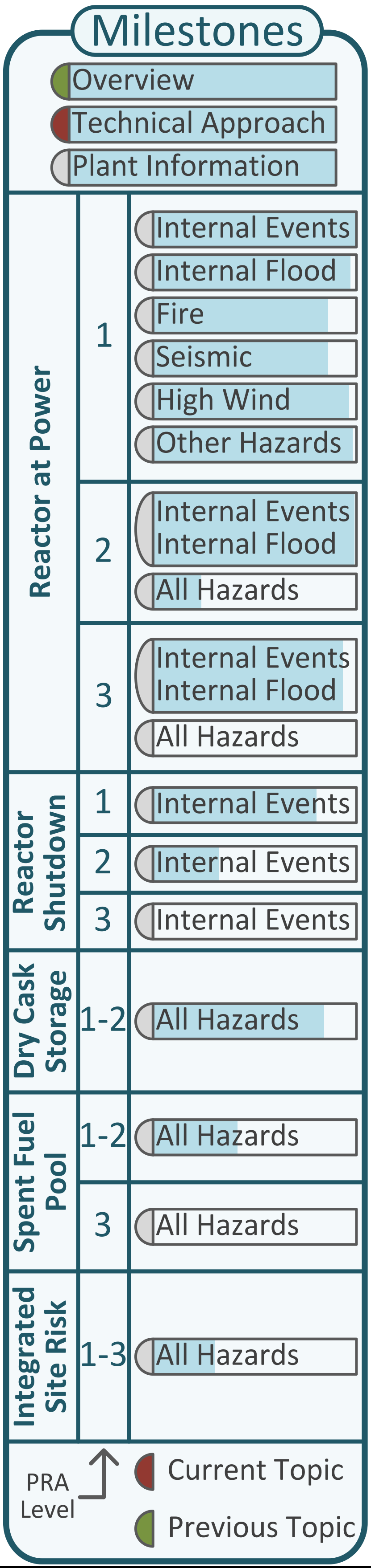
Technical Approach



Topic

This issue addresses the Level 3 Probabilistic Risk Assessment (L3PRA) project technical approach.

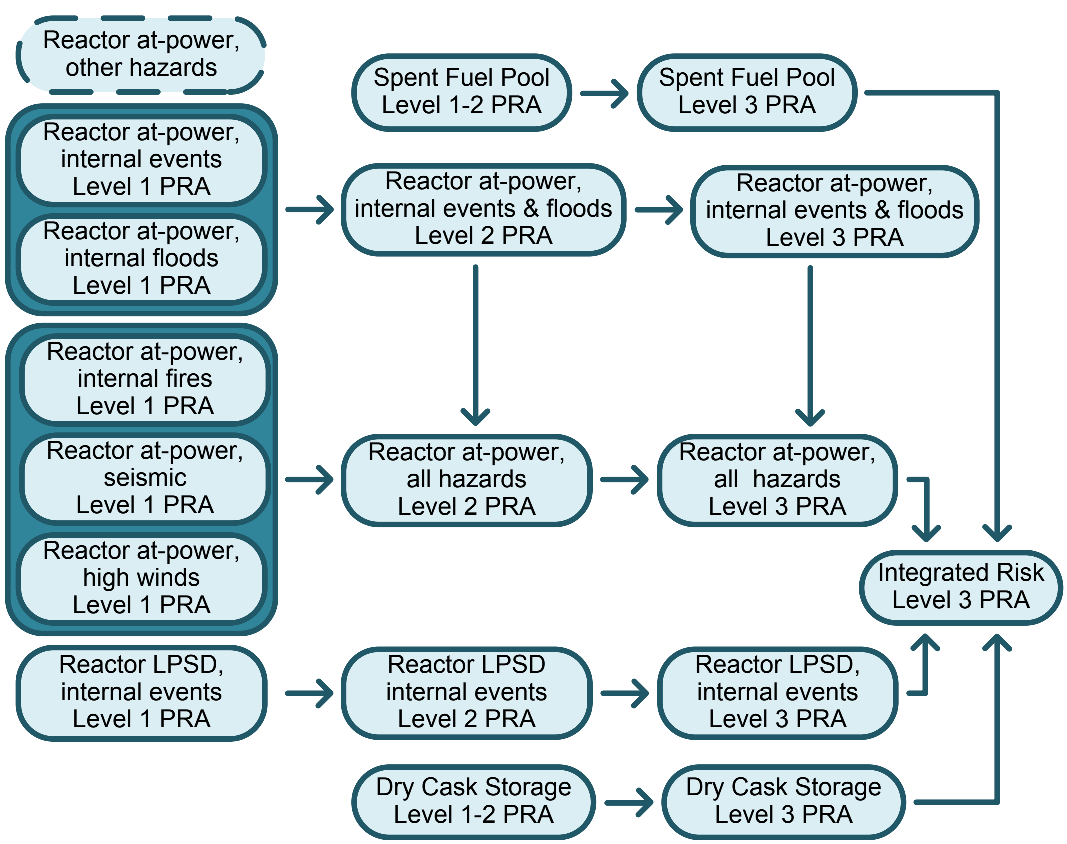
Overall Approach

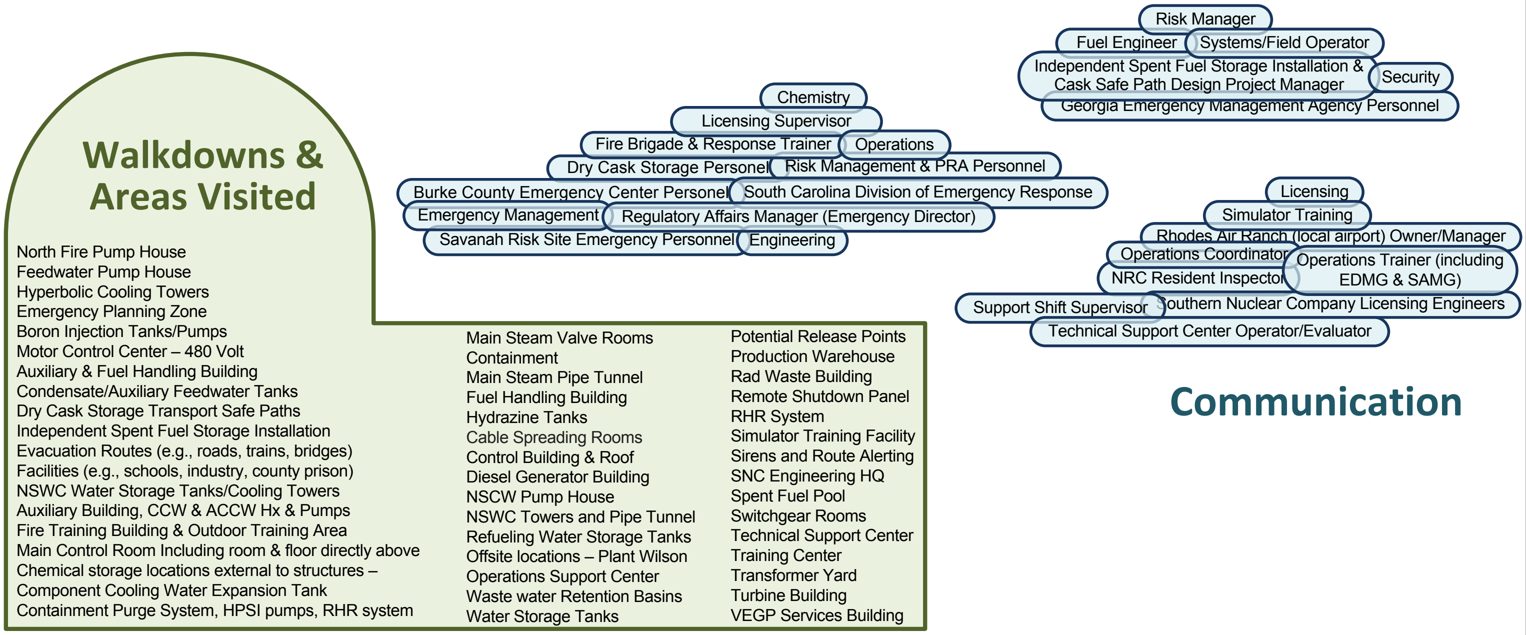
The L3PRA project evaluates the risk from multiple sources, hazards, operating states, and PRA levels for Southern Nuclear Operating Company's (SNC's) Vogtle Electric Generating Plant, Units 1 and 2. For each risk source (i.e., reactor, spent fuel pool, and dry cask storage), separate models are independently constructed. These models are then used to develop an integrated site risk model. Some of the individual PRA models are based on models provided by SNC that have undergone a peer review in accordance with the ASME/ANS PRA standards, and others are developed independently by NRC staff and contractors. For all of these models, NRC staff and contractors conduct plant walkdowns and have extensive interactions with Vogtle site (and SNC headquarters) personnel.

Model Construction

The reactor, at-power, Level 1 PRA models for internal events and internal floods are constructed by taking the corresponding Vogtle models developed by SNC and converting them to the NRC's SAPHIRE PRA computer software. These models are then further modified to incorporate various aspects of the existing Standardized Plant Analysis Risk (SPAR) model for Vogtle, as well as other NRC-initiated changes.

The L3PRA Level 1 PRA models for internal events and internal floods are combined to serve as the input for the at-power Level 2 PRA model. The Level 2 model extends the Level 1





model to include the status of containment systems, uses the MELCOR code to model accident progression (which is represented in a containment event tree) and characterize the resultant radiological source terms, and bins the accident sequences into release categories. The Level 1 and Level 2 accident sequences are directly linked in the SAPHIRE code, enabling parameter uncertainty to be propagated through to the release categories.

The Level 3 PRA model takes the source term information obtained from the Level 2 PRA, as well as other information, such as site atmospheric conditions, demographic data, protective measures, and economic considerations, and inputs it into the MACCS code to estimate the consequences of an accident. This consequence information is then combined with the release category frequencies to characterize plant risk.

Separate at-power Level 1 PRA models are constructed for internal fires, seismic events, and high winds. For internal fires, the several thousand fire sequences from SNC's peer-reviewed fire PRA for Vogtle are mapped to a manageable number of fire scenarios for inclusion as separate event trees in the L3PRA SAPHIRE-based model. Due primarily to limitations in resources and plant access, the work performed by SNC to develop the fire scenarios (e.g., identification of fire ignition sources, analysis of fire growth and spread, and assessment of fire damage), is used directly in the L3PRA fire PRA (i.e., SNC's analyses are reviewed for acceptability, but no reanalysis is performed). For seismic events, a plant response model is developed based on the L3PRA internal event model and using seismic hazard and fragility information provided by SNC. Since no high wind PRA model exists for Vogtle, this model is developed using the results of a plant walkdown and surrogate wind hazard and fragility information. The fire, seismic, and high wind Level 1 PRA models serve as the input to the respective at-power Level 2 and Level 3 models. These models are developed using the same approach as for internal events and internal floods, but account for hazard-specific impacts.

For all other hazards (i.e., those beyond internal events, internal floods, internal fires, seismic events, and high winds), a screening analysis is performed to determine if it is necessary to develop a PRA model.

For low power and shutdown (LPSD) plant operating states (POSs), only an internal events PRA model is constructed for Level 1, Level 2, and Level 3. Consequently, a quantitative, integrated PRA model among all reactor operating modes and hazards is not developed. For the LPSD PRA, a systematic approach is used to focus the analysis on the POS and initiating event combinations believed to be most risk significant. Boil-off calculations are used to determine allowable times for operator actions to maintain or restore fuel cooling, whose failures are generally the most significant contributors to LPSD risk.

For the spent fuel pool, a single integrated Level 1 and Level 2 PRA model is constructed that addresses the risk-significant hazards. Potential initiating events/ hazards are prioritized into different tiers, primarily based on expected time to fuel uncovery or habitability concerns. The MELCOR code is used to model accident progression and characterize the resultant radiological source terms. The integrated Level 1 and Level 2 model serves as the input to construct the Level 3 PRA model for the spent fuel pool, which uses the MACCS code to estimate accident consequences.

The dry cask storage PRA adopts the methodology from the NRC's previous dry cask storage PRA, as documented in NUREG-1864, with additional input from a previous EPRI dry cask storage PRA. An extensive literature search and a hazard and operability study are used to determine if any additional initiating events/hazards should be modeled. Additional (new) analyses are performed to assess human reliability, structural and thermal response, and consequences. An event tree approach is used to estimate the frequency of release, the MELCOR code is used to characterize radiological source terms, and the MACCS code is used to estimate accident consequences.

The integrated site PRA focuses on accident scenarios involving more than one site radiological source (reactors, spent fuel pools, and dry cask storage). A key assumption in the technical approach to developing the integrated site PRA model is that important multi-source accident scenarios can be identified and modeled by (1) logically combining important accident scenarios from individual single-source PRA models and (2) accounting for the impact of dependencies between sources on accident scenario frequencies or consequences. However, to provide assurance that potentially important multi-source accident scenarios are not missed, this approach is coupled with the use of systematic techniques to search for and prioritize potential multi-source accident scenarios that may not be captured by relying only on results and insights from individual single-source PRA models.

For More information

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