NEUP Nuclear Energy University Program
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Economic Risk-Informed Maintenance Planning and Asset Management

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Program: RC-9.2: Risk-Informed Life Cycle Management and Maintenance Optimization

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ABSTRACT:

The proposed work will provide a holistic framework for cost-minimizing risk-informed maintenance planning, including inspection, in light water reactors (LWRs). Optimized maintenance planning has the potential to provide improvements in both safety and economics. Many advanced tools have already been developed and are available to maintenance planners and crew managers that provide valuable information about risk metrics and probability of failure (POF) of components/equipment. However, translating such, often dynamically changing, information into action is not trivial. Maintenance planners and crew managers currently lack a formal approach to adequately account for all dynamically changing risk considerations and translate them into cost-effective maintenance schedule plans. Such a task is particularly difficult as there are many different types of components whose degradation rates may change over time and their maintenance at different stages may require various sets of skills and efforts. Taking a holistic approach to maintenance scheduling provides an opportunity to devise risk-informed, cost-effective maintenance plans during normal plant operations. Importantly, such an approach has the potential to facilitate opportunistic maintenance actions and further account for uncertainty in the duration of maintenance activities.

Specifically, we develop a two-tier framework that

- coarsely minimizes the total maintenance cost during the remaining normal operating cycle of the plant prior to the next scheduled outage (long-term), subject to safety requirements, and
- uses the outputs of the first model to develop a secondary optimization model to finely schedule maintenance activities to maximize the financial impact of these activities in the next week (short-term), subject to uncertainty.

The framework can be executed on a weekly basis, given the updated inputs, such as the remaining length of the planning horizon and point estimates for POFs, to provide the detailed weekly schedule of maintenance activities. This will be made possible through the careful integration of the optimization model, implemented in Python-based optimization modeling language, PYOMO, and the Risk Analysis and Virtual Environment (RAVEN) framework, which allows for interaction with python codes. In addition, the frame-work can be used to investigate the impact of major capital refurbishment and replacement of systems, structures, and components (SCCs) on the plant economics and safety.