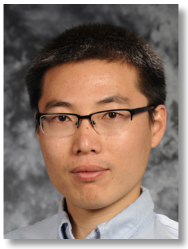
Flexible Enterprise Risk Analysis Framework Software is Free and Open Source





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Risk-Informed Systems Analysis Pathway

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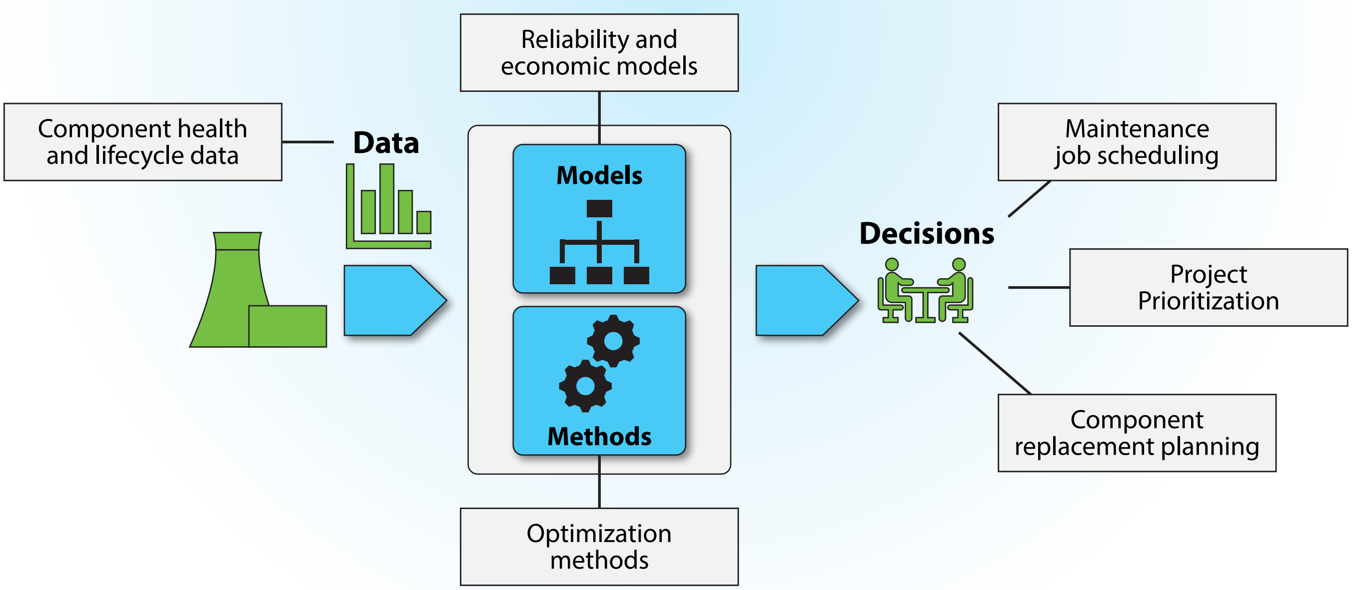
Industry Equipment Reliability (ER) and Asset Management (AM) Programs are essential elements that help ensure the safe and economical operation of nuclear power plants. The effectiveness of these programs is addressed in several industry developed and regulatory programs. For example, all U.S. nuclear power plants have implemented the ER process defined in Institute of Power Operations AP-913 "Equipment Reliability Process Description." Additionally, performance of plant structures, systems, and components (SSCs) is monitored within a regulatory context in the Maintenance Rule 10 CFR 50.65 and the Mitigating Systems Performance Index programs. However, these programs have proven to be labor intensive and expensive. There is an opportunity to significantly enhance the collection, analysis, and use of this information to provide more cost-effective plant operation. Additionally, there is an acute industry need to leverage advanced technology to reduce costs and improve operational effectiveness.

The goal of the RISA Pathway [1] is to provide effective and efficient analytical methods and tools to support risk-informed decisions for the ER and AM programs at nuclear power plants. This is accomplished by creating a direct bridge, see Figure 11, between component health/lifecycle data and decision-making (e.g., maintenance scheduling, project prioritization and actuation planning). Here we are supporting typical system engineering decisions regarding maintenance activity scheduling and component aging management. This is performed in a risk-informed context where herein the term "risk" is

Figure 11. Graphical representation of the enterprise risk-analysis framework: from data to decisions.



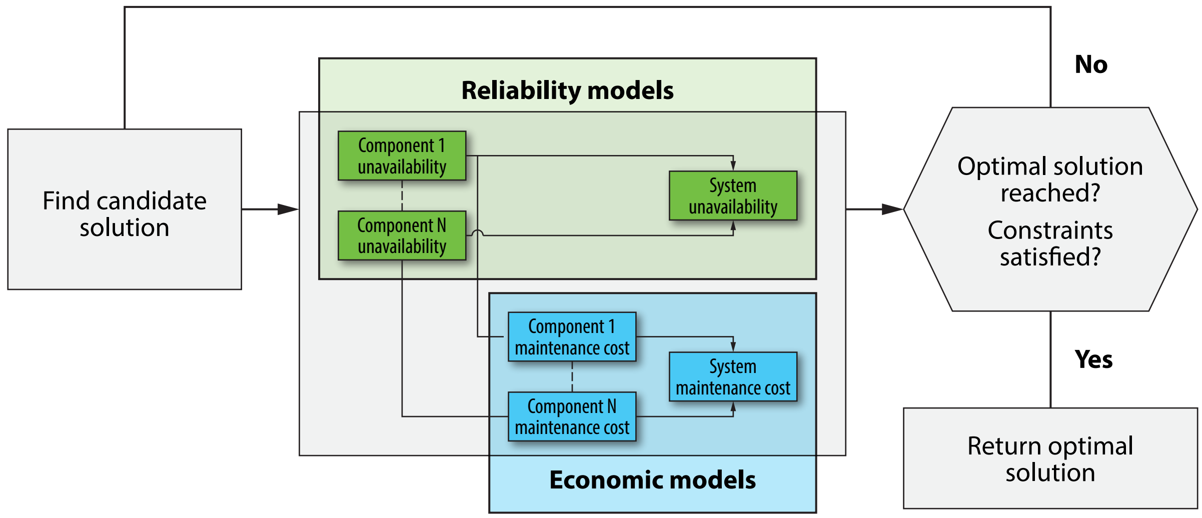


Figure 12. Example of a workflow that integrates economic and reliability models to obtain optimal solution (e.g., optimal component replacement schedule)

broadly constructed to include both plant reliability and economics. The vision is to reduce plant operations and maintenance costs by automating this decision process, by evaluating the reliability and economic impact of different maintenance strategies (i.e., evaluate what-if scenarios), and by identifying the optimal maintenance posture that maximizes system reliability and minimizes operational costs (i.e., maximize the maintenance value given resource constraints).

The final outcome of this project is an enterprise risk-analysis framework, which can be deployed across the nuclear industry. This framework combines data analytics tools to analyze ER data with risk-informed methods designed to support system engineer decisions (e.g., maintenance and replacement schedules, optimal maintenance posture for plant systems) in a customizable workflow. A challenge is that the structure of this workflow strongly depends on the decision that needs to be made, the type of data available, and the constraints that need to be considered. Current methods are designed to provide specific answers to specific problems; however, these methods might prove to be inadequate even when problem settings slightly change (e.g., different types of constraints, additional dependencies between system reliability and economics). We tackled this challenge by designing the framework in a flexible and modular fashion such that the user can assemble and customize his/her own workflow that integrates SSC economic lifecycle models (e.g., maintenance and replacement costs), system reliability models, and optimization methods (see Figure 12).

In January 2021, the first step toward the development of this framework was taken when two software packages, which are an integral part of the enterprise risk-analysis framework, were released with an open source license: LOGOS and SR2ML. SR2ML (https://github.com/idaholab/SR2ML) is a software package that contains a set of reliability models designed to integrate ER data (e.g., aging, testing, maintenance) and perform system-level reliability calculations [2]. LOGOS (https://github.com/idaholab/LOGOS) is a software package that contains a set of discrete optimization algorithms that can be employed to effectively manage plant assets and optimize schedules for plant operations [3]. These software packages are plugins that can be interfaced with the INL-developed RAVEN code (i.e., https://raven.inl.gov/) propagate data uncertainties (e.g., component remaining useful life), and perform data analysis and model optimization (e.g., via genetic algorithm heuristics). In this respect, SR2ML is designed to propagate ER knowledge to the system/plant level in order to identify the components that are most critical to system/plant health. LOGOS uses this information to prioritize and schedule plant operations (e.g., maintenance, testing, replacement) based on budget, reliability, and resource constraints.

References

1. Risk-Informed Systems Analysis website: (https://lwrs.inl.gov/SitePages/Risk-Informed%20Systems%20Analysis.aspx).
2. INL-EXT-20-59928, "Integration of Data Analytics with the Plant System Health Program," Idaho National Laboratory, Rev. 0, September 2020.
3. INL-EXT-20-59942, "Development and Application of a Risk Analysis Toolkit for Plant Resources Optimization," Idaho National Laboratory, Rev. 0, September 2020.