Toward the Development of a Nuclear Power Enterprise Risk-Analysis Framework

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Risk-Informed Systems Analysis Pathway

Industry equipment reliability and asset management programs are essential to help ensure the safe and economical operation of nuclear power plants. The effectiveness of these programs is addressed in several regulatory and industry-developed programs, such as the U.S. Nuclear Regulatory Commission (NRC) Maintenance Rule 10 CFR 50.65 and the Mitigating Systems Performance Index programs [1]. These programs are labor intensive and expensive; therefore, the goal is to reduce cost and improve operational effectiveness by applying risk-informed based tools and methods. To do this, two work scopes are set: (1) automation of equipment reliability and asset management programs; and (2) development of an integrated computational framework that can reduce plant operational costs while maintaining adequate safety margins and satisfying regulatory requirements

A Framework to be Deployed across the Nuclear Industry

The Risk-Informed Systems Analysis Pathway provides efficient analytical methods and tools to support risk-informed decisions for nuclear power plants equipment reliability and asset management programs. The outcome of this project will be an Enterprise Risk-Analysis Framework, as shown in Figure 4, which can be deployed

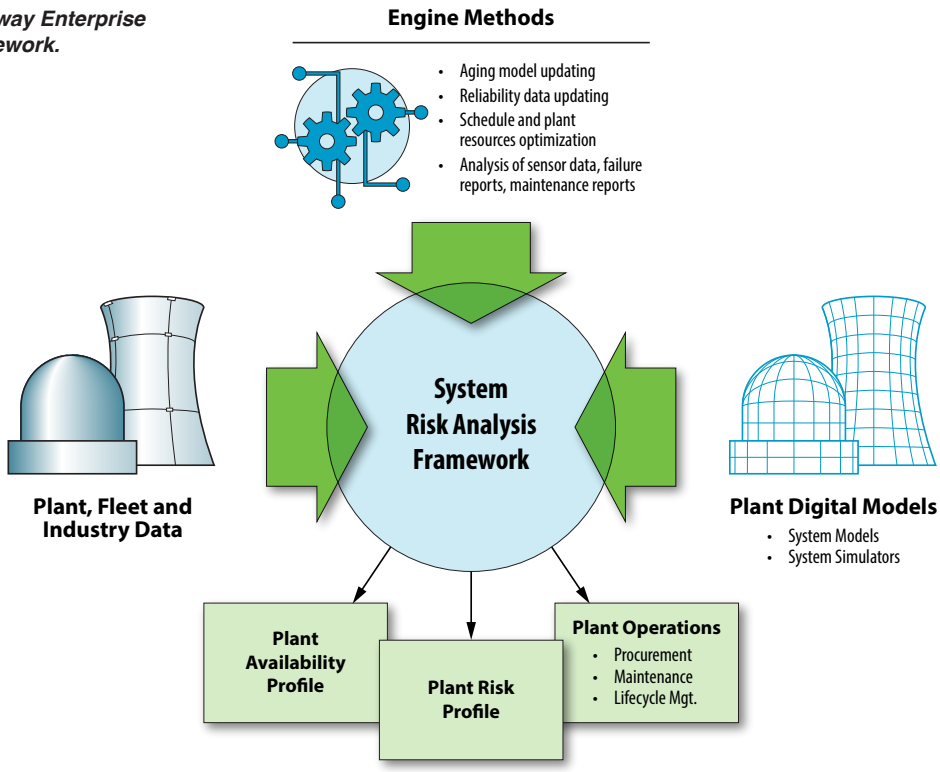

Figure 4. RISA Pathway Enterprise Risk Analysis Framework.

across the nuclear industry. This framework will combine data analytics tools with risk-informed methods to manage plant assets over years of operation—including periods of subsequent license renewal—in a manner that is significantly less labor-intensive and more cost-effective than is currently performed.

Initial work has started using the LWRS Program-developed RAVEN code, which provides advanced capabilities in terms of uncertainty quantification, sensitivity analysis, data mining, and model optimization. These capabilities are used to evaluate the impact of different equipment reliability and asset management strategies—such as different maintenance policies or the deployment of new technologies—from a reliability and economic perspective. The distinguishing feature of this kind of analysis is that it permits the simultaneous evaluation of coupled economic and risk impacts.

As an example, the evaluation of the impact of new maintenance strategies at the system/plant level incorporates maintenance cost and reliability data into a model that describes how they are related when the time between Preventive Maintenance (PM) actions changes. Similarly, the same maintenance model can be used to capture corrective maintenance (CM) costs and identify the optimal interval between PM actions as labeled T_PM in Figure 5, which minimizes maintenance costs while achieving targeted system/plant availability goals.

Another development of the Enterprise Risk-Analysis Framework is targeting a class of optimization methods explicitly designed to address subsequent license renewal issues. Sample questions that can be answered with this system are:

- Which set of projects maximizes the financial return on investment under budget constraints on capital improvements, operations and maintenance, and funding availability?
- What is the best time window to complete each project to maximize the return on investment given aspirations to minimize and smooth expenditures (i.e., small cost variability from year to year), while limiting risk to unexpected costs?

The answers to these and other long-term asset management investment questions can be obtained by applying the methods developed in this research program and using them to optimally schedule component replacement and refurbishment. These methods integrate both risk, reliability, and cost models into a single decision-making tool that helps to address questions at the nexus between safety and economics.

Reference

1. D.A. Dube, C.L. Atwood, S.A. Eide, B.B. Mrowca, R.W. Youngblood, D.P. Zeek, Independent Verification of the Mitigating Systems Performance Index (MSPI) Results for the Pilot Plants, NUREG-1816, February 2005.

Figure 5 Balancing costs and reliability: preventive maintenance use case.