LONG-TERM RESEARCH PROGRAM
FISCAL YEAR (FY) 2012 THROUGH FY 2017 PROJECT STATUS

FY 2012 Project

Smart Grid Impacts on Nuclear Power Plants (NPPs) (OPEN)

The purpose of this project was to perform a literature review to assess industry's efforts to develop and deploy smart grid technology. The outcome will aid in verifying that industry's efforts will not result in unsafe or unintended consequences affecting NPPs and will determine if new regulatory tools are necessary to deal with any potential problems identified. For instance, if smart grid technology creates offsite electrical supply reliability problems for NPPs, a suitable tool will be needed to evaluate that impact.

In-house activities for this project started in FY 2013. However, the project was deferred because necessary resources were allocated to support other higher priority projects. Funding for the project began again in the third quarter of FY 2014, and additional funding was included in FY 2015. The research for this project has been completed. The results of literature review provided a summary of the potential safety and regulatory issues relating to the development of smart grid technology. Insights from this project will be used by staff members who participate in the industry smart grid interoperability panel, which oversees standards development for the smart grid. The draft report of the literature review is under review by the staff. In addition, because of the Federal Energy Regulatory Commission's (FERC's) regulatory responsibility and oversight of grid reliability, the project team consulted with FERC staff and who are also reviewing the draft report. The final report will be issued in March 2016.

FY 2013 Project

Evaluating Remaining Service Life of Nuclear Power Plant Concrete Structures (OPEN)

The purpose of this project is to perform a feasibility study on developing an assessment method for predicting the remaining service life of concrete structures based on their current condition. Safety-significant concrete structures in NPPs are subjected to high temperatures, elevated radiation, and other environmental conditions (e.g., moisture and salts) that can degrade performance over the structures' service life. These structures can be tested to determine if they have retained sufficient properties to ensure adequate performance under design-basis scenarios. However, this testing yields little or no predictive information about how long the structure will continue to maintain their properties as the exposures continues.

No existing standardized method is available for estimating the remaining service life of a concrete structure based on its existing condition. The U.S. Nuclear Regulatory Commission's (NRC's) current research activities in this area focus on (1) understanding the causal factors that contribute to degradation and (2) evaluating aged and ex-plant materials to assess their design margin as a function of degradation.

In 2014, the Office of Nuclear Regulatory Research (RES) awarded a 3-year grant to Northwestern University to study the service life of concrete structures independent of the Long-Term Research Program (LTRP). The study is ongoing, and the results of this grant are expected to be available in August 2017. Knowledge and understanding gained from this study

will be used for a follow-on scoping study, namely the identification of viable destructive and nondestructive techniques that can provide the basis for predicting remaining service life.

FY 2014 Projects

Quantitative Methods for Assessing Cybersecurity Posture (OPEN)

The purpose of this project is to determine the feasibility of quantifying the effects of cybersecurity activities. Government and industry are making large investments to improve cybersecurity. However, an objective way to measure the causal relationship between those investments and improved cybersecurity posture[1] has yet to be established. Quantitatively measuring cybersecurity posture is a key challenge across the nuclear sector as well as other critical related infrastructure sectors, such as the power grid upon which NPP operations depend. Some general research has attempted to quantify cybersecurity posture, but no research has addressed the cybersecurity posture within the context of the NRC regulatory framework. This activity could provide means to assess the aggregate impact of design changes, system upgrades, or programmatic changes on the cybersecurity posture at a nuclear facility. This activity also could assist with informing rulemaking activities and revising NRC guidance (e.g., Regulatory Guidance 5.71, “Cyber Security Programs for Nuclear Facilities”).

The project was delayed from its expected FY 2014 start due to budget and priority decisions. The project will begin in FY 2016 and is expected to be completed in FY 2017.

Seismic Load Effects on Reactor Materials Degradation (OPEN)

The purpose of this project is to perform a scoping study on the potential effects of dynamic and sudden pulse-type high-strain rate loadings, such as those caused by earthquakes, on the degradation rate of passive systems, structures, and components (SSCs). A seismic event could potentially compromise an SSC’s designed stress or temperature limits or margins. The principal objective of this scoping study is to identify possible scenarios in which seismic shock loading could accelerate degradation in passive SSCs. In addition, the activity will assess the feasibility of in-service inspection techniques for detecting potential changes in material resulting from seismic loading. As a result of this research, the NRC may need to conduct an assessment for licensees to re-evaluate the component degradation rate caused by seismic loads in their plants to demonstrate reasonable assurance that continued plant operation will be safe.

This research began in August 2014 under a contract with Argonne National Laboratory. Three of five expected reports have been delivered. The initial scoping study is expected to conclude in September 2016. The outcome will determine the necessity to pursue this work in the future as well as define the technical scope, which may include code-related activities, informing and engaging industry to address the potential cumulative effects of degradation mechanisms.

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[1] Cybersecurity posture is the state of a licensee’s overall cybersecurity program and represents the degree of program effectiveness in protecting critical digital systems and assets against cyber-attack.

Advanced Knowledge Engineering Tools to Support Risk-Informed Decisionmaking (OPEN)

A rapidly emerging field of research is the use of computer-based systems to analyze information collections to identify insights and subtle inter-relationships that would be cost-prohibitive to obtain through manual means. At the NRC, risk-related documentation often occurs in many different forms (e.g., licensee amendments, safety evaluation reports, NUREG reports, inspection reports, and generic communications) and often includes extremely complex information. The purpose of this project is to perform a scoping study to explore the use of advanced knowledge engineering tools and techniques (e.g., natural language questions and answers, text mining, formal modeling) in exploring probabilistic risk assessment (PRA) documents to efficiently identify insights and inter-relationships.

The objective of this scoping study is to use several case studies (known as “use cases”) to determine if these knowledge engineering techniques are sufficiently mature to: (1) efficiently analyze a diverse array of documentation sources within a pre-defined information base and (2) provide flexible tools to query this information base to identify new insights. It is hoped that knowledge engineering technology could enhance the efficiency of NRC reviews of probabilistic risk assessment (PRA) applications and assist the staff in connecting diverse sources of information (e.g., PRA documentation, licensing basis information, operating experience, licensees' submittals) in an integrated manner. This is particularly useful for PRA applications when subtle dependencies and interactions can drive risk results. Moreover, the basic underlying technology could be useful in non-PRA applications that require intelligent mining of large amounts of information.

The Office of Nuclear Regulatory Research (RES) worked with the Office of the Chief Information Officer (OCIO) and their contractors in developing a set of use cases and associated information bases. OCIO has developed a prototype software tool that RES is currently testing on the first use case (a search for and characterization of U.S. operational events involving multiple reactor units). Other use cases that are being investigated include the characterization of licensee PRA results and the development of common cause failure insights from operational events. The staff expects to complete the investigation and document the results of this feasibility study in a final internal report that summarizes the lessons learned. The project is planned to be completed in FY 2016.

FY 2015 Project

Potential Applications for and Assessment of Adaptive Automation in Nuclear Plant Processes (OPEN)

The purpose of this project is to perform a scoping study to address the potential importance of adaptive automation (AA) technology within the nuclear industry. AA technology allows the allocation of functions to adjust dynamically among the user and the automation. The study will evaluate the likelihood of implementing AA within the nuclear industry in both new reactors and currently operating reactors. It will include a literature review of their use in surrogate industries to identify potential areas of concern for regulating AA within nuclear power plants and whether the experience and results of using AA in other industries are applicable to the nuclear industry. The potential benefits of AA are likely to be of particular interest to the NRC, as well as designers and potential owner/operators of small modular reactors. A contract was awarded in July 2015 and was expected to be completed in FY 2016, but due to the limited availability of the contractor, work is now expected to be completed in FY 2017.

FY 2016 Project

Strategic Approach for Obtaining Material and Component Aging Information from Decommissioning Nuclear Power Plants (OPEN)

The purpose of this project was to perform a scoping study to understand and manage material and component degradation that is critical for ensuring the continued safe and reliable operation of NPPs. Research efforts can sometimes be enhanced through the use of prototypically aged components and materials from decommissioned NPPs. The SSCs used in an NPP must be able to withstand very harsh conditions that could include extended time at high temperatures, neutron irradiation, elevated stress, and corrosive environments.

The study will develop a long-range agency strategy (roadmap) for identifying and addressing information gaps for the use of materials and components from decommissioning plants. The roadmap will be developed in separate phases. The first phase will survey NRC staff from various technical disciplines to identify and rank information gaps that could be addressed through evaluation of decommissioned plant materials. The second phase will consist of a number of public workshops with the industry to determine the best approach for obtaining and studying these materials. The roadmap will be finalized based on the outcome from the first and second phases.

The resulting roadmap will be used to guide future NRC research and NRC interactions with industry in identifying specific SSCs that are determined to have high safety importance. The data obtained through the acquisition of prototypical plant materials and components (either by industry or the NRC) could be used for safety assessments in various regulatory-related products such as topical reports and updated regulations. Moreover, the data will support the evaluation of aging management programs for potential subsequent license renewal applications and a range of other future licensee submittals during the extended period of operation such as relief requests and related rulemakings relating to the American Society of Mechanical Engineers Code.

This staff began this contract in July 2015 and plans to complete the project in FY 2017. The project is ongoing with three reports scheduled to be delivered in 2016 and 2017. This initial scoping study focuses on a literature review of data needs and a strategic plan for capturing important information for harvesting opportunities.

FY 2017 Projects

Nanotechnology (Planned to start FY 2017)

The purpose of this project is to perform a scoping study to (1) assess the state of nanotechnology, (2) determine its possible use in nuclear applications over the next 5 to 10 years, (3) identify current industrial products or ongoing research that will likely be used for future nuclear applications, and (4) identify any knowledge gaps or potential safety issues that may require additional research before granting regulatory approval for any such applications as well as any existing regulatory gaps that need to be addressed to provide an acceptable decision making framework.

Use of nanotechnology has significantly increased over the last 10 years. Development of advanced production techniques and the use of economies of scale have driven an increased

use in many industries. Currently, nanotechnology is used in such diverse applications as fabric, materials, sensors, fuels, medicine, electronics, remediation and cleanup, and food. Use of nanotechnology in nuclear applications is anticipated in the coming years. For example, Argonne National Laboratory has developed a nanofluid with increased thermal conductivity that is now available for commercial use. Adaptation of commercial products is the most likely path for its use in nuclear applications. It is important that NRC evaluates the technical basis of the potential use of nanotechnology to confirm the safety of proposed nuclear applications.

Advanced Fuel Designs (Planned to start FY 2017)

The purpose of the project is to develop a scoping study to identify any regulatory gaps in the NRC's current regulatory criteria and guidance to address emerging technologies in advanced fuel designs. The project will develop recommendations regarding whether future technical work is needed to address the regulatory gaps identified including what work is needed, who should perform this work, and on what timescale.

The scoping study will review the NRC's regulations and guidance relevant to fuel designs to determine their applicability to advanced fuel designs. Specific fuel designs could include high-enriched uranium nitride fuel and/or tri-isotropic coated particle fuel (TRISO) and fuel with accident tolerant cladding. The study also will assess the fuel characteristics to identify any differences with the technical basis for current regulations. Staff will monitor advances by the U.S. Department of Energy before selecting a specific fuel design.

The scope of the work will include the entire fuel cycle for which the NRC has regulatory responsibilities. A report will be generated to summarize the limitations and applicability for these regulations and guidance for advanced fuel designs. The report also will include case studies for two to three unique advanced fuel designs. The specific design would be evaluated against current regulations and guidance to identify gaps.