Technical Advisory Committee of the Nuclear Risk Research Center
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November 15, 2018

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SUBJECT: PROPOSED NRRC RESEARCH PLAN FOR FISCAL YEAR 2019

Dear Dr. Apostolakis:

During the tenth meeting of the Technical Advisory Committee (TAC) of the Nuclear Risk Research Center (NRRC), November 5-9, 2018, we met with the NRRC staff to review the proposed research plan for fiscal year 2019. The purpose of our review was to provide comments on the technical merit of the research plan and its relevance for supporting NRRC's current mission.

CONCLUSION AND RECOMMENDATIONS

1. We did not identify any major research gaps that require immediate attention in the plan for fiscal year 2019.

2. The guidance and templates for risk-informed decision-making should start with the decisions that are proposed to be risk-informed. Then for each decision, well-developed examples should clearly describe the issue, the needed decision, the risk-informed thought process, and the supporting information. These activities should be performed with close cooperation from industry stakeholders. The effort to develop the examples should begin in fiscal year 2019.

3. The following recommendations do not directly affect the scope of the research that is planned for fiscal year 2019. However, they should be integrated into the overall research program and plans for subsequent years, beginning in fiscal year 2020.

    - To the extent possible, the probabilistic risk assessments (PRAs) for both Ikata Unit 3 and Kashiwazaki-Kariwa Unit 7 should be used for trial applications of all NRRC guidance and analytical methods. The trial applications should include both the Level 1 and Level 2 elements of each PRA. This will provide the most effective demonstration of how state-of-the-

practice methods are applied to develop high quality fully-integrated plant-specific PRAs.

- The NRRC research program should address methods and guidance for the evaluation of risk during low power and shutdown modes, and the evaluation of risk from events that affect the stored spent fuel.

4. For our future reviews, the presentations for each project should be enhanced. They should describe the technical needs for each research project and how the project supports the NRRC short-, intermediate-, and long-term goals. The objective of each project should describe the specific reason for the activity, and it should explain how each task is needed to support that objective. This will help us to better understand the technical motivation and priorities for the research, its major supporting tasks, and their integration.

BACKGROUND

One of the most important objectives of the research plan is to present the technical context of the research needs, including the rationale, current state of knowledge, and potential contributions and significance of the research to the objectives of the center. Our review of the research plan focused on the objectives of each research project and its supporting tasks, the technical relationships and relative priorities among those activities, and any major needs for additional research. We did not review the technical details of individual research activities or their completion milestones, except as needed to understand how those activities are integrated throughout the plan. We will comment separately on the technical elements of individual research projects in our detailed reviews of those projects.

DISCUSSION

The NRRC staff provided a summary of the scope of a strategic plan and a phased approach for introduction of risk-informed decision-making (RIDM) in the Japanese nuclear industry. Comprehensive plant-specific probabilistic risk assessments (PRAs) of high technical quality provide the risk information and engineering insights that are an essential input for the RIDM process. Therefore, NRRC is conducting research on improved analytical methods, models, and data for the performance of fully-integrated Level 1 and Level 2 PRAs, with extensions to limited-scope Level 3 PRAs. The scope of those research activities covers a wide range of technical issues such as collection and analysis of plant operating experience and data, human reliability analysis, methods for analyzing internal fires and floods, improved modeling of severe accident phenomena, and evaluation of the risk from external hazards such as seismic events, tsunamis, severe winds, and volcanic hazards. In addition to supporting the development of high quality PRAs, the NRRC research team is also developing guidance for the use of PRA as a tool to support the RIDM process.

During this review, we were briefed on several important research projects, the major technical tasks in each project, the current status of each task, known or potential

problem issues, and the estimated schedule for completion of each task. The project timelines and schedules were also useful to illustrate how each activity fits into the overall research scheme and the context of the NRRC short-, intermediate-, and long-term goals.

We did not identify any major research gaps that require immediate attention in the plan for fiscal year 2019.

Recommendations for Selected Research Activities

Based on our discussions with the NRRC research team during this review, we offer the following recommendations for selected elements of the overall research program. Our first recommendation affects planning for work that will begin in fiscal year 2019. The second and third recommendations do not directly affect the scope of the research that is planned for fiscal year 2019. However, they should be integrated into the overall research program and plans for subsequent years, beginning in fiscal year 2020.

(1) Guidance for Risk-Informed Decision-Making

Perhaps the most important goal of the near-term and intermediate-term research is to support Japanese utility implementation of a systematic risk-informed decision-making (RIDM) framework. We understand that this framework will be used for decisions at all levels of day-to-day activities at each nuclear power plant. To help the utilities with their initial efforts to implement this framework, the NRRC researchers have developed draft guidance and a general template that outlines the elements of an RIDM process. We were briefed on the basic structure of the template during this review meeting.

The guidance and templates for risk-informed decision-making should start with the decisions that are proposed to be risk-informed. The final scope and content of those decisions must come from the utility stakeholders who will implement the RIDM process and who need to clearly understand how it will affect their daily activities. Therefore, the NRRC researchers should work closely with their counterparts from the Japanese utilities to develop an initial set of well-defined decisions and associated examples that demonstrate how the overall RIDM template can be applied.

Those examples should cover a wide range of practical situations that will benefit from a systematic consideration of risk. The examples should illustrate the decision process from beginning to end, starting with a clear description of the issue, the associated decision, and the options that are faced by the decision-maker. They should explain the types of risk information that are needed to support that decision and provide examples of how to most effectively combine quantitative and qualitative sources of that information, including their associated uncertainties, to support the most effective option.

The effort to develop the examples should begin in fiscal year 2019.

(2) Trial Applications of Guidance and Demonstrations of Methods

During this review, we were briefed on several research projects that have interim milestones for trial applications of the associated methods and guidance. Those trial applications are an essential element of each research project. They demonstrate how the research is applied in a practical risk assessment, and they identify needed refinements before the methods and guidance are issued for general use. Most of these trial applications are not currently scheduled to begin in fiscal year 2019. However, preliminary planning for some applications has already started.

The Japanese industry is actively supporting the development of high quality PRAs for two pilot plants: Ikata Unit 3 and Kashiwazaki-Kariwa Unit 7. These PRAs are very important to the overall goals of the NRRC and the industry. They demonstrate how current state-of-the-practice methods and models are implemented to achieve a comprehensive assessment of the plant-specific risk and its contributors. They also provide important experience and lessons for PRA practitioners at all Japanese utilities, as they update and extend their current models and analyses to achieve the desired level of quality. The scope of each pilot project is currently focused primarily on the development of Level 1 and Level 2 PRA models to evaluate the risk from internal events that occur during full-power operations.

To the extent possible, the integrated Level 1 and Level 2 PRA models for both Ikata Unit 3 and Kashiwazaki-Kariwa Unit 7 should be used for trial applications of all NRRC guidance and analytical methods. Those applications will provide the most effective demonstration of how each state-of-the-practice method is used to develop high quality fully-integrated plant-specific PRAs.

That process will also test the guidance and methods in the context of practical applications for two different reactor designs, different plant-specific internal configurations, different site-specific features, and, perhaps, different details of how the respective PRA models are constructed. This experience is very important to provide confidence that the final guidance and methods can be used effectively throughout the Japanese industry as they are adapted and applied for each plant-specific PRA.

As a final comment, it is important to examine how each improved method is applied for the fully-integrated Level 1 and Level 2 PRA models. Experience has shown that segmented trial applications which test methods separately for the Level 1 and Level 2 portions of the PRA can result in unexpected needs for refinements. For example, lessons learned during the use of some methods for the Level 2 elements of a PRA have required inefficient changes to guidance or practical considerations that affect the Level 1 models and their supporting analyses. To avoid that situation, the trial applications should include both the Level 1 and Level 2 elements of each PRA, or the researchers should demonstrate why a more limited trial application will not affect integrated use of the methods or models in the eventual full-scope PRA.

(3) Risk during Low Power and Shutdown, and Events that Affect Spent Fuel

To date, the NRRC research program and individual research projects have focused almost exclusively on development of methods and guidance for evaluation of the

risk from events that occur during plant power operation. Those methods and models are important, because they provide a fundamental framework for understanding the plant, its systems, its spatial layout and configuration, important features of the site, and how the operators are trained to prevent or mitigate potential accident scenarios.

International experience from full-scope PRAs has shown that events which occur during shutdown modes can be important contributions to overall plant risk. Furthermore, a complete assessment of the plant-specific risk should also examine events that affect cooling or damage to the stored spent fuel. In many technical areas, the methods and models for evaluating these contributions to risk can build from the experience that is gained during development of the full-power PRA models. However, specialized models and analytical techniques are needed to examine and quantify the risk during a variety of plant operating states, system alignments, and maintenance configurations that apply during plant shutdown. The frequency and causes for specific internal initiating events, fires, and floods often vary considerably, depending on the specific system operating alignments and work activities that are conducted during each plant operating state. Evaluation of human performance typically requires special attention, due to the need for more manual intervention when automatic actuation of systems may not be fully available. Integration of the Level 1 and Level 2 PRA models requires careful coordination to account for the containment status during each plant operating state. Activities and system configurations during reactor defueling and refueling operations can also require special models and techniques to evaluate the risk from events that may affect fuel in the reactor vessel and fuel in the storage pools.

To provide consistent guidance and state-of-the-practice methods for development of high quality full-scope PRAs, the NRRC research program beginning in 2020 should address methods and guidance for the evaluation of risk during low power and shutdown modes, and the evaluation of risk from events that affect the spent fuel.

Recommendations for Future Reviews

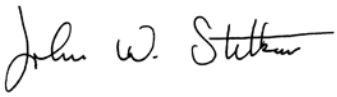
We very much appreciate the NRRC researchers' efforts to organize the overview of the research program and the individual research project summaries in the format that we requested for this review. That format has improved communications and helped us to more efficiently focus on the key technical elements of each research project, discuss potential problems that may warrant special attention, and better understand how each project is integrated into the overall NRRC research plans and schedules.

To help us better understand the technical motivation and priorities for each research project, and how the various research activities are integrated, one topic in the research summaries would benefit from additional attention. For our future reviews, the presentations for each project should be enhanced. They should describe the technical needs for each research project and how the project supports the NRRC short-, intermediate-, and long-term goals. The objective of each project should describe the specific reason for the activity, and it should explain how each task is needed to support that objective. Additionally, if other considerations affect the

scope, priorities, or schedules for specific technical tasks, the summaries should inform us of those influences.

We look forward to our continuing interactions with the NRRC research team to review of the overall research program and individual research projects, and to help the NRRC and the Japanese nuclear industry achieve their goals of comprehensive risk-informed decision-making.

Sincerely,



John W. Stetkar
Chairman

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2. "Fire PRA Guide," Presentation to NRRC Technical Advisory Committee, November 6, 2018, Confidential.

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5. "Development of Phenomenological Relationship Diagram (PRD) Method," Presentation to NRRC Technical Advisory Committee, November 6, 2018, Proprietary.

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7. "Ikata Unit 3 Project Status Update," Presentation to NRRC Technical Advisory Committee, November 7, 2018, Proprietary.

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10. "Template for Operational Risk-Informed Decision Making," Presentation to NRRC Technical Advisory Committee, November 7, 2018, Proprietary.

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