IN USE: PROBABILISTIC RISK ASSESSMENT FOR SEISMIC EVENTS

ISSUE STATEMENT
Earthquakes have the potential to cause significant damage to nuclear power plants, and therefore constitute a major contributor to the risk of a severe accident. Recent research has increased estimates of the seismic hazard at nuclear power plants. Effective decision-making related to managing risk and addressing safety in the regulatory arena relies on a proper characterization of the risks associated with seismic events. Data refinements and analytical improvements are needed to obtain a more realistic understanding of the risk associated with seismic events.

DRIVERS
Several factors drive the need for more comprehensive and improved methods for seismic probabilistic risk assessments (PRAs).

Regulatory Pressures
Safety authorities in many countries require seismic PRAs to be conducted as part of the process to understand the risks posed by operating nuclear power plants (e.g., as part of periodic safety reviews). In the United States, there are also formal programs in place to apply risk information in a regulatory environment. Based in part on observations from a pilot seismic PRA completed by EPRI, however, current methods appear to fall short of being able to meet requirements of PRA standards in some areas. Also in the United States, regulators have focused on seismic risk evaluations as the tool for evaluating the impact of updated seismic hazards on operating nuclear plants.

More Effective Risk Management
Utilities must make effective use of available resources to address risks. Seismic-related risks are subject to significant uncertainty, and utilities need to have a proper understanding of this uncertainty. An improved capability to evaluate the risk associated with seismic events is important to ensure that available resources are applied in a manner that results in proper decisions regarding operational activities and cost-effective improvements in safety.

Public Perception
Risk assessments performed using data and methods that are not adequately realistic can lead to negative public perceptions. In the United States, inappropriate re-characterizations of the seismic risk for certain sites have already begun to become a public issue. Seismic risk estimates that do not reflect the most appropriate characterization have the potential to lead to public misperceptions that can divert resources from more important issues.

RESULTS IMPLEMENTATION
EPRI will, in conjunction with other stakeholders, refine the data, tools, methods, and guidelines needed to support adequately realistic assessments of the risk associated with seismic events. These efforts will produce a more coherent framework for seismic PRA, and a better and more coordinated set of technical methods. In the short term many of these methods will be used to resolve Fukushima-related issues such as the Near Term Task Force (NTTF) recommendations 2.1 and 2.3. In the longer term, owners of nuclear power plants will employ these methods and tools to develop an appropriate understanding of the contribution of seismic events to risk necessary for risk management and effective risk-informed interactions with regulators. At the same time, the results of this research will aid regulators in developing a better understanding of the risk associated with seismic events to support future risk-informed decisions.

PROJECT PLAN
More effective and realistic assessments of the risk associated with earthquakes require research activities that are coordinated with regulatory agencies and other organizations. Some of these activities have been ongoing for several years. Others are being highlighted or redefined as a result of the pilot seismic PRA completed jointly by EPRI and Dominion in 2010 and by the issuance of the NRC NTTF Recommendations 2.1 and 2.3. The research activities are organized in four areas:

Reassessment of the Seismic Hazard
EPRI is engaged in significant research to better characterize the magnitude of earthquakes as a function of their frequencies of occurrence. These include an overall assessment of the hazard for the Central and Eastern United States, and participation in the resolution of NTTF Recommendations 2.1 and 2.3 and the NRC request for information outlined in the 50.54 (f) letter of March 2012. With regard to better implementation in seismic PRA, EPRI is conducting research to address statistical incoherence, seismic isolation, the effects of high frequency ground motion and the relevance and role of cumulative absolute velocity filtering for earthquakes of certain frequencies.
Improved Characterization of Fragilities

Fragility analysis is the assessment of the conditional probability of failure as a function of the intensity of a hazard. Necessary areas of improvement with respect to fragility analysis for seismic PRA include better coordination of the failure characterization with the response spectra for the site; refinement in fragility estimates to reflect more recent data from tests and actual experience; and better treatment of the impact on plant structures and equipment for soil sites. Additionally, EPRI is undertaking a project to address the high frequency characteristics of the new Central and Eastern U.S. seismic ground motions and their effects on potentially sensitive equipment.

Seismic Risk Modeling and Quantification

Efforts are underway or are being initiated to improve the integration of the seismic hazard, fragility, and plant model to obtain better risk estimates. These improvements include how best to treat the correlation among seismic failure of similar equipment; adaptation of methods for human reliability analysis to reflect the conditions and context of earthquakes; and better methods for quantifying seismic risk, an area in which methods used traditionally for PRA are inadequate. These improvements will be tested through additional pilot studies.

Implementation Activities

To make the most effective use of these research efforts, specific activities must be undertaken to ensure that they are incorporated into various programs. These activities include supporting the revision and refinement of the PRA Standard; interacting with regulators; and providing training to utilities in the performance of seismic PRAs. Intensive efforts are underway to develop guidance to allow effective and timely resolution of seismic issues arising from the Fukushima accident (including those related to the seismic portions of NTTF Recommendations 2.1 and 2.3).

RISKS

The primary impact of not completing the development of a more comprehensive and realistic approach to seismic PRA will be that important safety issues are not identified and addressed. There are no clear risks posed by activities to pursue these research efforts.

RECORD OF REVISION

This record of revision will provide a high level summary of the major changes in the document and identify the Roadmap Owner.

<table>
<thead>
<tr>
<th>REVISION</th>
<th>DESCRIPTION OF CHANGE</th>
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| 0        | Original Issue: August 2011  
Roadmap Owner: Bob Kassawara |
| 1        | Revision Issued: August 2012  
Roadmap Owner: Bob Kassawara  
Changes: Addition of detail on projects for resolution of post Fukushima seismic related issues |
| 2        | Revision Issued: August 2013  
Roadmap Owner: Bob Kassawara  
Changes: Addition of detail on the flow chart on projects for resolution of post Fukushima seismic related issues including the following.  
- Funded task to update the Ground Motion Model (GMM)  
- Funded task to perform High Frequency research  
- Funded task to calculate site-specific seismic hazards and Ground Motion Response Spectra (GMRS)  
Extended the end date for the DOE led New Ground motion Attenuation (NGA) East Project consistent with current expectations. |
| 3        | Revision Issued: January 2014  
Roadmap Owner: Bob Kassawara  
Changes: Rearranged RSM activities into two primary groupings; EPRI Seismic PRA Research Program and Implementation Activities for SPRA. Added specific activities for the following funded tasks:  
- SPRA Structural Modeling Techniques  
- Fragilities from Scenario Earthquakes  
- Fragilities from EQ data  
- Resolution of Walkdown Questions  
- Interactions on ESEP and SPRA Implementation  
- Interaction with NRC and ANS on Regulatory Guides and Standards for restart following an earthquake |