Probabilistic Hazard Assessment Approaches: Transferable Methods from Seismic Hazard

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Quantitative assessment of all natural hazards share common attributes and challenges. These include the need to determine the best estimate and uncertainty of the hazard levels, limited data, high levels of uncertainty, and the need to include expert judgment in the assessment process. Over the last several decades, approaches for assessing seismic hazard have matured and current approaches are transferable to other types of hazard. While the level of uncertainty in seismic hazard remains high, particularly in low to moderate seismicity regions, highly structured methods of expert interaction and model development have been developed and applied with success. In 1997, the Senior Seismic Hazard Analysis Committee (SSHAC) developed a structured, multilevel assessment framework and process (the "SSHAC process"), described in NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," that has since been used for numerous natural hazard studies since its publication. In 2012, the NRC published NUREG-2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," after studying the experience and knowledge gained in the application of the original guidance over the last 15 years. NUREG-2117 provides more detailed guidelines consistent with the original framework described in NUREG/CR-6372, which is more general and high level in nature. NUREG-2117 provides an extensive discussion of the Level 3 process, which is well suited to the assessment of other natural hazards.

When seismic hazard assessments are conducted for critical facilities such as nuclear power plants, the judgments of multiple experts are required to capture the complete distribution of technically defensible interpretations (TDIs) of the available earth science data. The SSHAC process provides a transparent method of structured expert interaction entirely focused on capturing the center, body, and range (CBR) of the full suite of TDIs of the available data. The goal is not to determine the single best interpretation; rather, it is to develop and integrate all TDIs into a logic tree framework wherein the weights of the various branches are consistent with the level to which the data and information available supports the interpretation. This approach leads to greater assurance that the "true" hazard at a site is captured within the breadth of the probabilistic seismic hazard assessment (PSHA) results.

To achieve this, a study following in the SSHAC process goes through a series of steps that can be separated into evaluation and integration phases. The fundamental goal of the SSHAC Level 3 process is to properly carry out and completely document the activities of evaluation and integration, defined as follows:

> Evaluation: The consideration of the complete set of data, models, and methods proposed by the larger technical community that are relevant to the hazard analysis.

Integration: Representing the CBR of TDIs in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods).

As discussed in detail in NUREG 2117, the process includes a number of well-defined roles for participants, as well as three required workshops, each with a specific objective. The evaluation process starts by the Technical Integrator (TI) team identifying (with input from resource and proponent experts) the available body of hazard-relevant data, models, and methods—including all those previously produced by the technical community—to the extent possible. This body of existing knowledge is supplemented by new data gathered for the study. The first workshop is focused on with the identification of hazard-relevant data, models, and methods. The TI team then evaluates these data, models, and methods and documents both the process by which this evaluation was undertaken and the technical bases for all decisions made regarding the quality and usefulness of these data, models, and methods. This evaluation process explicitly includes interaction with, and among, members of the technical community. The expert interaction includes subjecting data, models, and methods to technical challenge and defense. Workshop #2 provides a forum for proponents of alternative viewpoints to debate the merits of their models. The successful execution of the evaluation is confirmed by the concurrence of the Participatory Peer Review Panel (PPRP) that the TI team has provided adequate technical bases for its conclusions about the quality and usefulness of the data, models, and methods, and has adhered to the SSHAC assessment process. The PPRP will also provide guidance on meeting the objective of considering all of the views and models existing in the technical community.

Informed by this evaluation process, the TI team then performs an integration process that may include incorporating existing models and methods, developing new methods, and building new models. The objective of this integration process is to capture the CBR of TDIs of the available data, models, and methods. The technical bases for the weights on different models in the final distribution, as well as the exclusion of any models and methods proposed by the technical community, need to be justified in the documentation. Workshop #3 provides an opportunity for the experts to review hazard-related feedback on their preliminary models and to receive comments on their models from the PPRP. To conclude the project satisfactorily, the PPRP will also need to confirm that the SSHAC assessment process was adhered to throughout and that all technical assessments were sufficiently justified and documented.

References:

U.S. Nuclear Regulatory Commission, “Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts,” NUREG/CR-6372, Washington, DC, 1997.

U.S. Nuclear Regulatory Commission, “A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion,” Regulatory Guide 1.208, Washington, DC, March 2007.

U.S. Nuclear Regulatory Commission, “Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies,” NUREG-2117, Washington, DC, 2012.