Uncertainties in SPRA

Sources and Treatment

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U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Uncertainties in SPRA

Sources and Treatment

- Overview of PSHA & interface with ANSI/ANS Standard High Level Requirements (HLRs)
- Areas of uncertainty and treatment in PSHA
- Reevaluation of PSHA
- Site Response overview and uncertainties
- Other hazards and sources of uncertainty
- Engineering sources of uncertainty
- Interface sources of uncertainty

Uncertainties in SPRA

Sources and Treatment

Seismic Load

- Determined by PSHA
- Defined in terms of hazard curves and response spectra
- Uncertainty is explicitly quantified using modern approaches

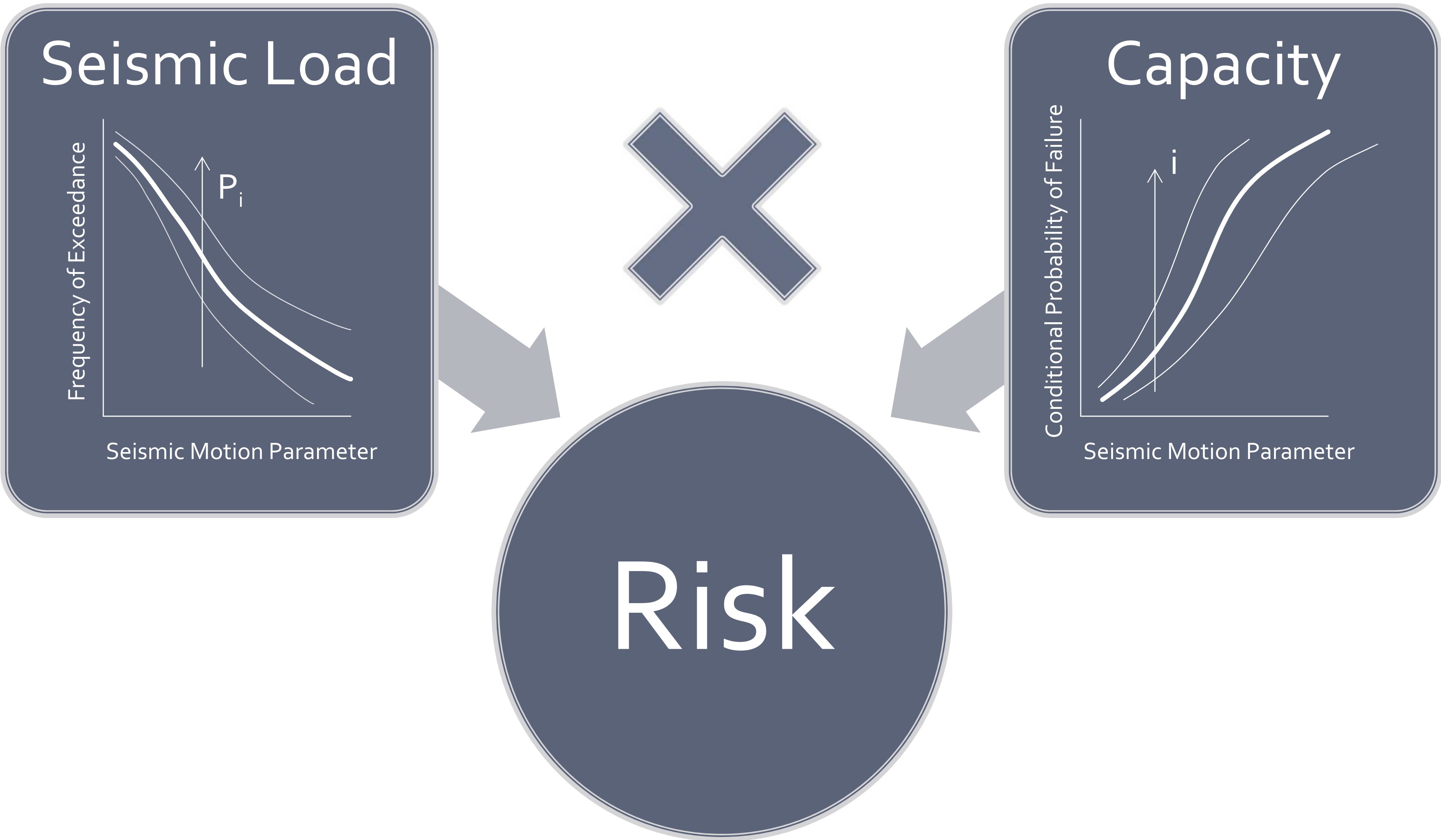
Capacity

- Dependent on systems design and redundancy
- SSC capacity quantified as fragilities
- SSC capacities are frequency dependent and so the shape of the response spectrum is a key input

Risk

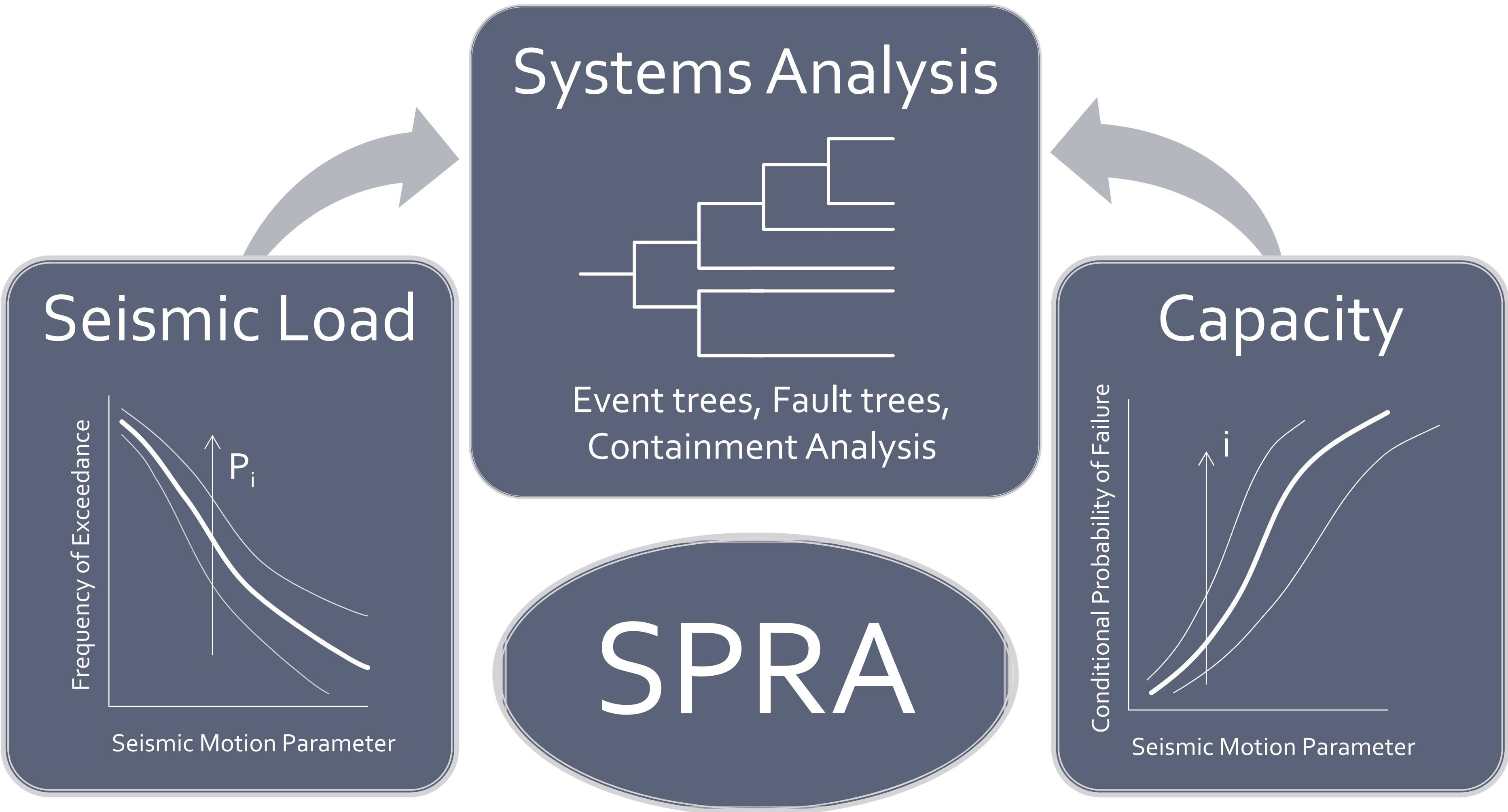
Uncertainties in SPRA

Sources and Treatment



Uncertainties in SPRA

Sources and Treatment



Probabilistic Seismic Hazard Analysis (PSHA)

- Seismic load is determined through PSHA.
- Objective to determine the best estimate (and uncertainty) of ground motion levels at a particular location over times periods of interest.
- PSHA considers all possible earthquakes from all seismic sources that may impact a site, and accounts for the likelihood of any particular earthquake.

Uncertainties in SPRA

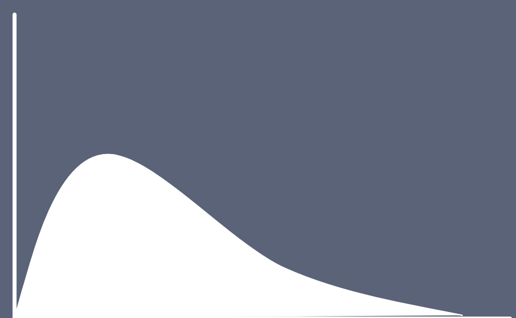
Sources and Treatment

Uncertainty

Aleatory	Epistemic
Natural variability	Modeling or knowledge uncertainty
Not reducible	Reducible with more information
Addressed through integration over parameter distributions	Addressed through use of a logic tree

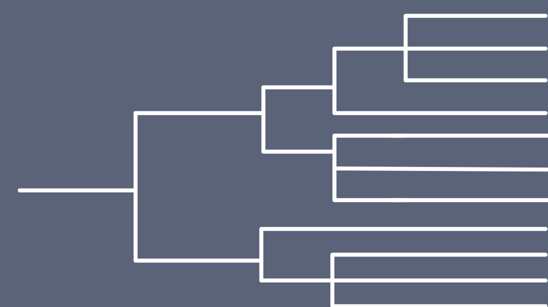
Uncertainty

Aleatory



Integration over distribution of expected parameter values

Epistemic

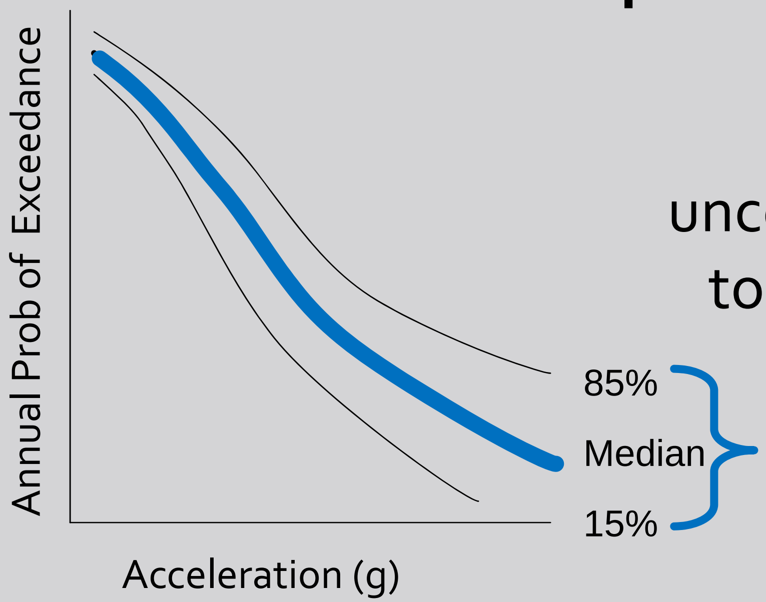


logic tree of technically defensible interpretations

Uncertainty

Aleatory

Aleatory variability gives the curve its shape.

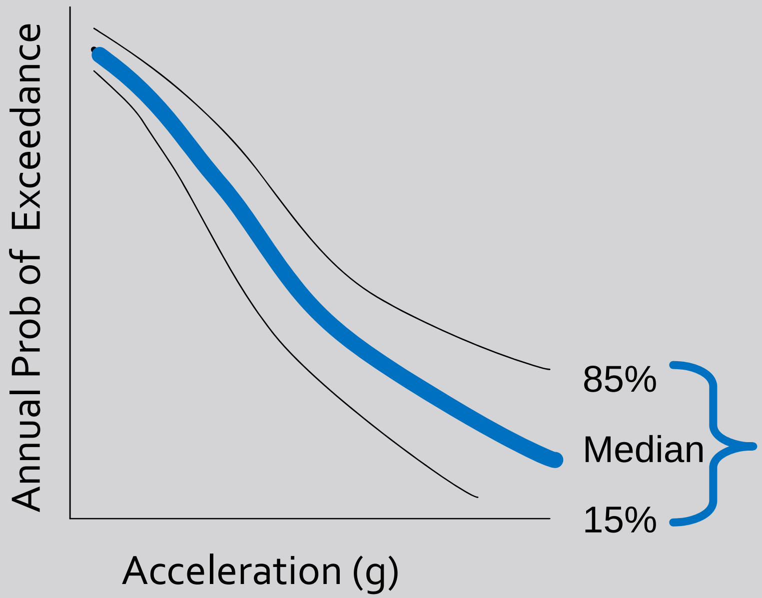


Epistemic

Epistemic uncertainty leads to uncertainty bands

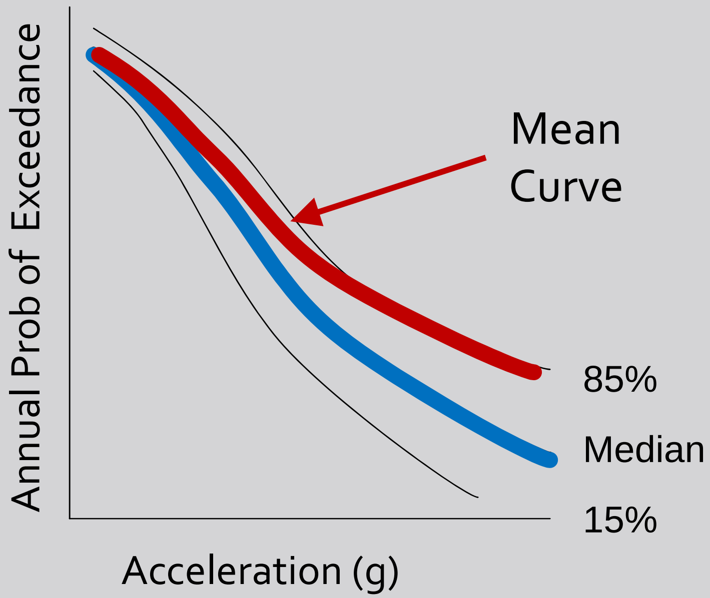
Uncertainty

Median Curve



Uncertainty

Mean Curve

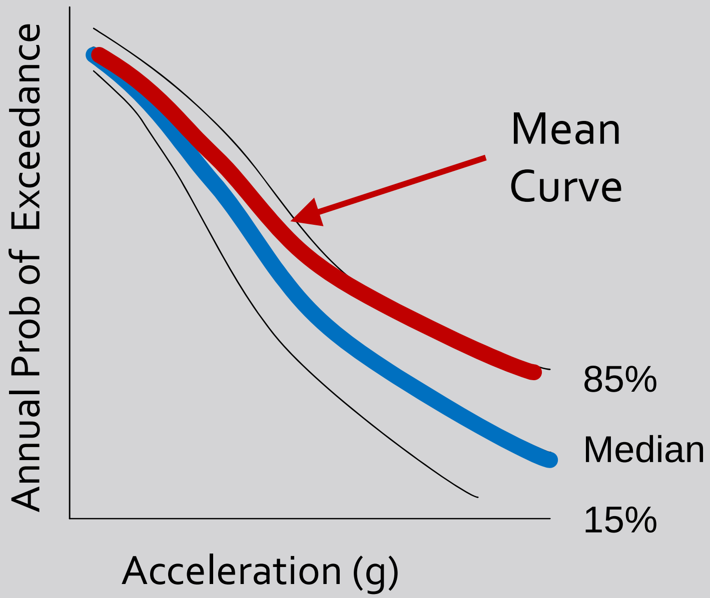


The mean curve is used in risk assessment and design to better account for epistemic uncertainty.

The mean curve exceeds the median due to the log-normal distribution of most parameters

Uncertainty

Mean Curve



Greater epistemic uncertainty due to lack of data leads to a higher mean curve. This leads, in turn, to higher assessments of risk. There is a benefit to accumulating data.

Seismic Source Characterization Model

Provides the characterization for all seismic sources that may impact a site of interest. The SSC model is in the form of a logic tree composed of the full suite of alternative technically defensible interpretations of the earth science data. The logic tree accounts for epistemic uncertainty. Aleatory variability is incorporated for specific parameters as appropriate.

PSHA

Central and Eastern United States Seismic Source Characterization for Nuclear Facilities

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington DC 20555
NUREG-2115

U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585
Report # DOE/NE-0140

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94304
Report # 1021097

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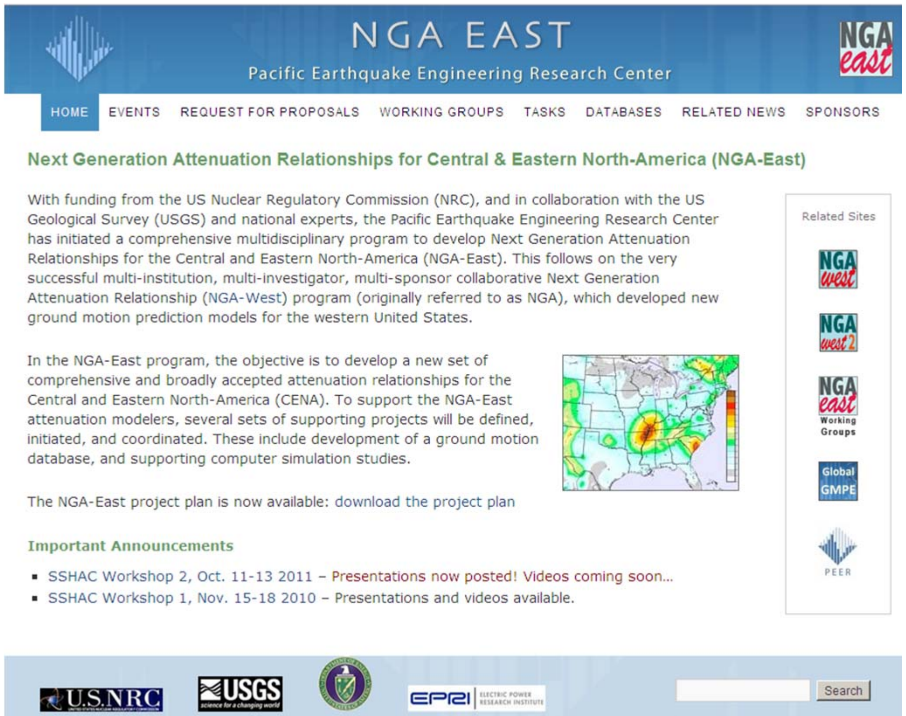
January 2012

Uncertainties in SPRA

Sources and Treatment



NGA EAST

Pacific Earthquake Engineering Research Center

HOME EVENTS REQUEST FOR PROPOSALS WORKING GROUPS TASKS DATABASES RELATED NEWS SPONSORS

Next Generation Attenuation Relationships for Central & Eastern North-America (NGA-East)

With funding from the US Nuclear Regulatory Commission (NRC), and in collaboration with the US Geological Survey (USGS) and national experts, the Pacific Earthquake Engineering Research Center has initiated a comprehensive multidisciplinary program to develop Next Generation Attenuation Relationships for the Central and Eastern North-America (NGA-East). This follows on the very successful multi-institution, multi-investigator, multi-sponsor collaborative Next Generation Attenuation Relationship (NGA-West) program (originally referred to as NGA), which developed new ground motion prediction models for the western United States.

In the NGA-East program, the objective is to develop a new set of comprehensive and broadly accepted attenuation relationships for the Central and Eastern North-America (CENA). To support the NGA-East attenuation modelers, several sets of supporting projects will be defined, initiated, and coordinated. These include development of a ground motion database, and supporting computer simulation studies.

The NGA-East project plan is now available: download the project plan

Important Announcements

- SSHAC Workshop 2, Oct. 11-13 2011 – Presentations now posted! Videos coming soon...
- SSHAC Workshop 1, Nov. 15-18 2010 – Presentations and videos available.

Related Sites

Search

IN PROGRESS
January 2014

Ground Motion Characterization Model

Provides a distribution of predicted ground motions for a particular magnitude distance scenario earthquake. The GMC model is in the form of a logic tree composed of Ground Motion Prediction Equation (GMPEs). The logic tree accounts for epistemic uncertainty. Each GMPE incorporates aleatory variability through "sigma".

PSHA

Uncertainties in SPRA

Sources and Treatment

Seismic Source Characterization Model

HLR-SHA-C

All credible sources of potentially damaging earthquakes

Epistemic & Aleatory

SSHAC Guidelines

Ground Motion Characterization Model

HLR-SHA-D

All credible mechanisms influencing vibratory ground motion

Epistemic & Aleatory

SSHAC Guidelines

PSHA

HLR-SHA-A

requires that the fundamental elements of PSHA are incorporated, including the **composite distribution of the informed technical community**

HLR-SHA-B

requires a comprehensive up-to-date **database** including: geological, geophysical, topographical, geotechnical, historical/instrumental seismicity, & paleoseismicity

HLR-SHA-A

SSHAC Guidelines

HLR-SHA-B

SSHAC Guidelines

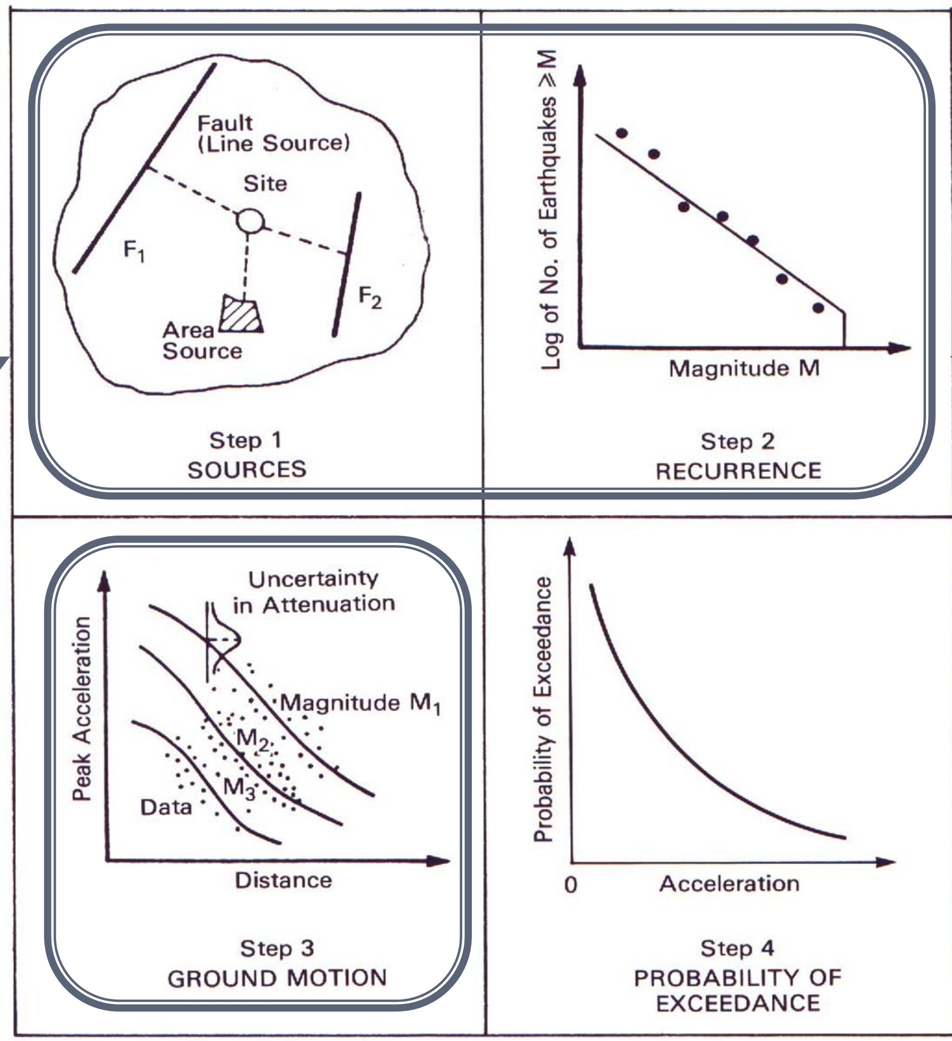
Uncertainties in SPRA
Sources and Treatment

Seismic Source Characterization: SSC Model

Source Geometry

Earthquake Recurrence

Ground Motion Characterization: GMC Model



Base figure from Reiter (1990)

Uncertainties in SPRA

Sources and Treatment

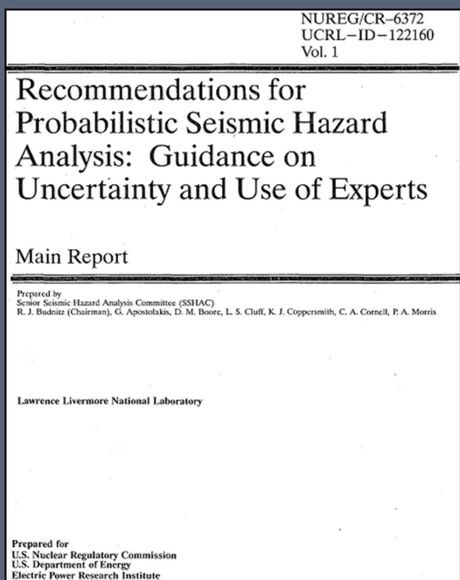
Characterize all seismic sources that could impact the site

Determine every that earthquake that each source can produce and the likelihood of the earthquake

Assesses the ground motion distribution for each earthquake

Integrates the ground motion over all earthquakes accounting for the likelihood of each scenario

SSHAC Guidelines


NUREG/CR-6372
UCRL–ID–122160
Vol. 1

Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts

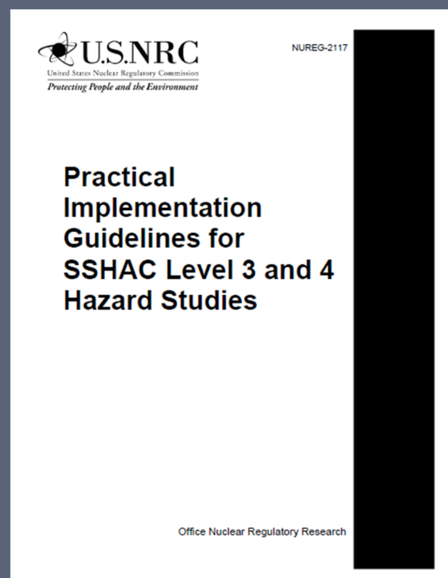
Main Report

Prepared by
Senior Seismic Hazard Analysis Committee (SSHAC)
R. J. Budnitz (Chairman), G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppersmith, C. A. Cornell, P. A. Morris

Lawrence Livermore National Laboratory

Prepared for
U.S. Nuclear Regulatory Commission
U.S. Department of Energy
Electric Power Research Institute

NUREG/CR-6372
(1989)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NUREG-2117

Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies

Office Nuclear Regulatory Research

NUREG 2117
(2012)

Original report provides framework. New report provides details. Both describe how to undertake studies that develop hazard assessment models

Meeting HLR-SHA-A with SSHAC

- Overall SSHAC process is focused on developing the composite distribution (for clarity now called the center, body, and range of the technically defensible interpretations).
- 4 Levels of complexity described: only 3 and 4 allowed for new sites. Level 2 used for site-specific refinement.

Meeting HLR-SHA-B with SSHAC

- Process requires development of a up-to-date database with inclusion of all publically available information
- Workshop 1 is focused on "Data needs and Critical Issues"
- Standard practice is now to create a comprehensive and complete seismicity catalogue and "project GIS" database

Uncertainties in SPRA

Sources and Treatment

HLR-SHA-C, HLR-SHA-D, and HLR-SHA-F with SSHAC

- The process requires a full exploration of all available models, methods, and interpretations, Including in workshop 2 “alternate interpretations”
- Full documentation of the process is required, including justification of leaving any technically defensible interpretations out of the final models
- Both the aleatory and epistemic uncertainties are transparently documented and tracked.

Uncertainties

Overall PSHA Approaches

- The SSHAC process provides a robust approach to many of the requirements (A-D, F)
- The PSHA captures the uncertainty in a new Level 3 and 4 study
- Computational uncertainty is second order

Uncertainties

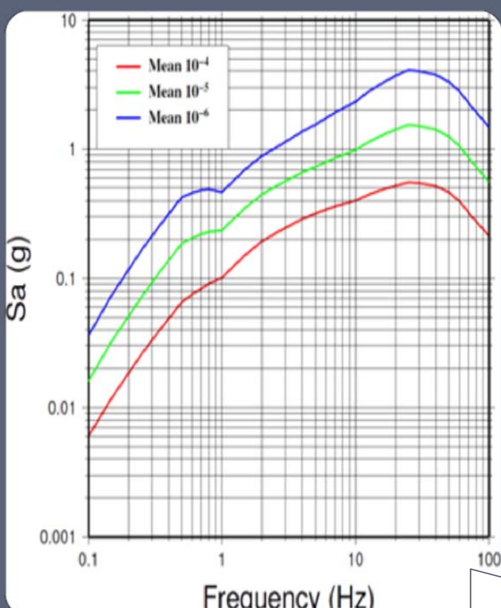
GMC & SSC Models

- A host of specific technical questions related to GMC and SSC models are a matter of discussion. Uncertainty is captured in the model by the SSHAC process, even if large.
- There is a new CEUS SSC model. A new GMC model is under development and the current model is generally hampered by a lack of data available for development at the time. This is an area of uncertainty currently
- GMC models tend to be the driver in the uncertainty in PSHA analyses

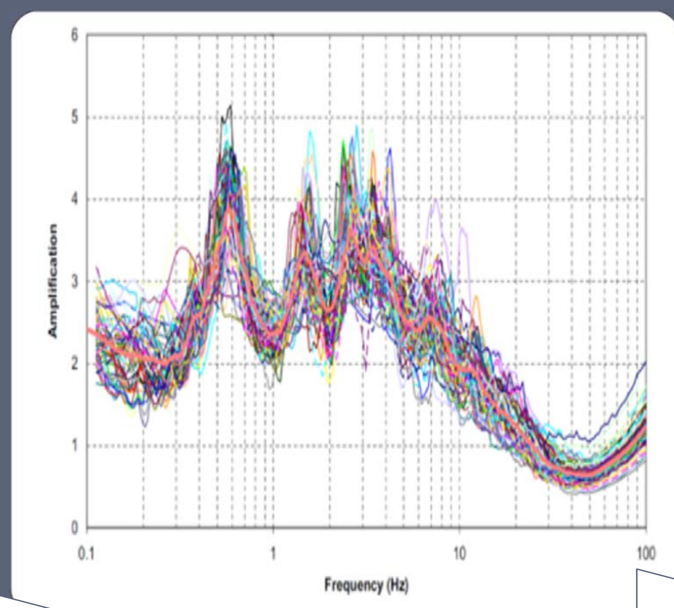
Site Response

HLR-SHA-E

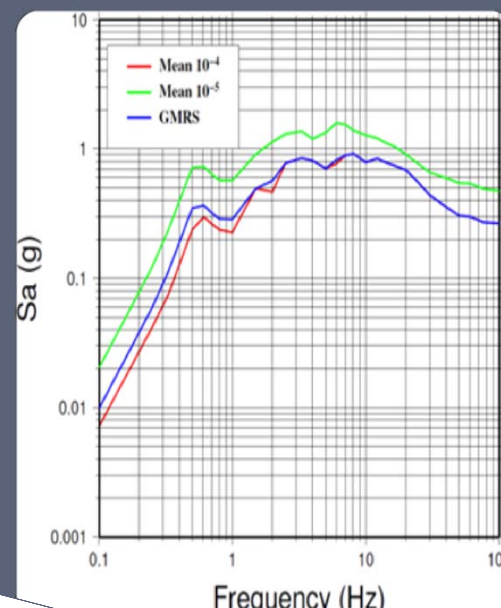
Base Rock UHS



Site Response – 60 profiles



Surface UHS & GMRS



Uncertainties

Site Response

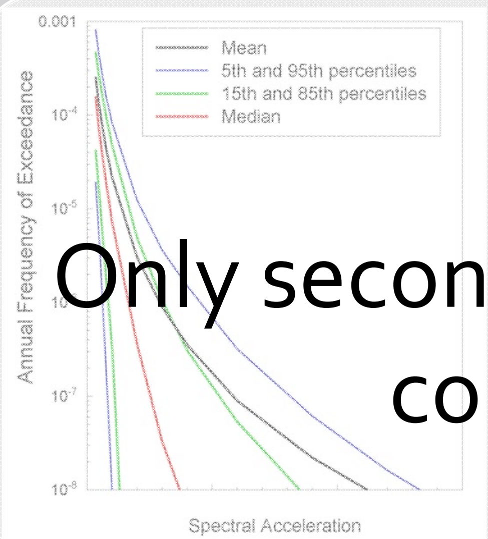
- Site response (E) has significant uncertainty and a potentially large effect on the hazard results
- Many operating plants lack geotechnical information from modern equipment
- Site response techniques are not as standardized as hoped. Simplifying assumptions (1-D propagation) do not always apply and other tools are not well developed.

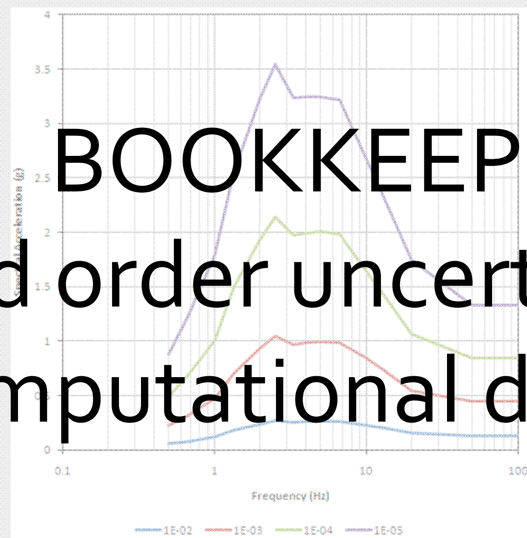
Uncertainties

Site Response

- Spatial and material variability is not always well captured and randomization approaches and tools are limited
- There is known double counting of some uncertainties with the GMPE models
- Ground motion selection and modification not well developed for site response

HLR-SHA-F





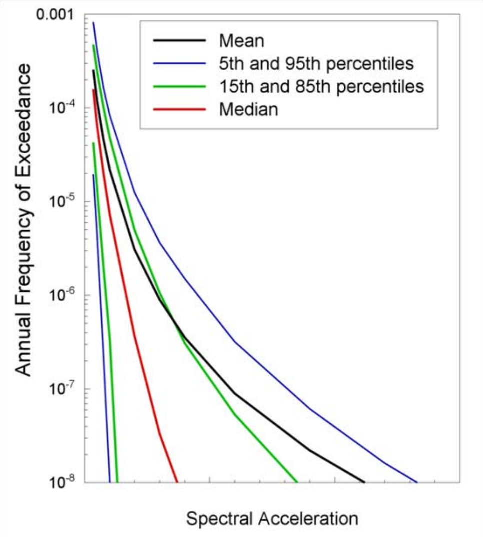
BOOKKEEPING.
Only second order uncertainties related to computational decisions.

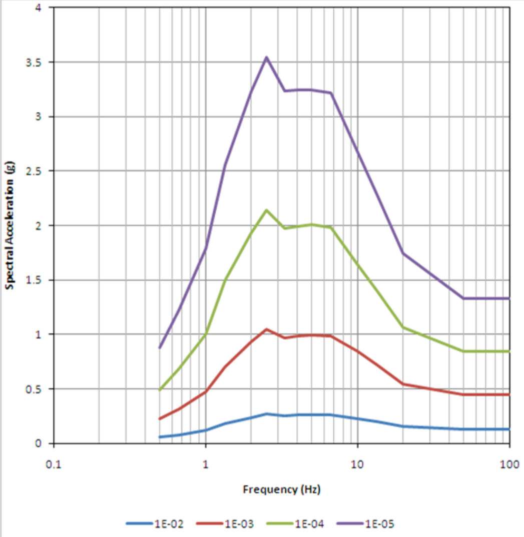
Specifies the reporting criteria. Also specifies that uncertainties propagated and displayed in final quantification

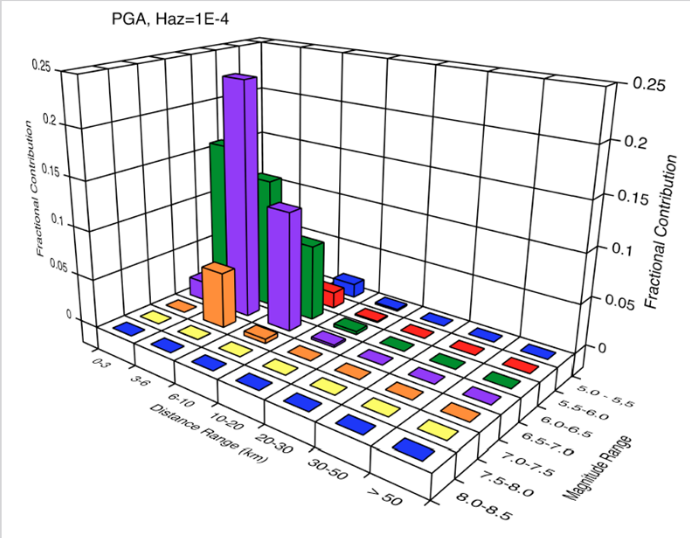
Uncertainties in SPRA

Sources and Treatment

HLR-SHA-G







Spectral shapes must be appropriate. Can be based on deaggregation or on uniform hazard spectrum

Uncertainties

Spectral Shape

- Uncertainty in shape arises from both the GMPEs and the use of scenario earthquake or uniform hazard response spectra
- Different approaches lead to different answers
- Use of uniform hazard is conservative for design and SPRA

HLR-SHA-H

Table 6-1. Recommendations Regarding Updating Hazard Assessments for Nuclear Facilities

Existing Study	Condition of Existing Study	Hazard Assessment Needed	Recommendation	Study Level for New Study
No study, or previous studies conducted at lower SSHAC Levels (2 or 1), or non-SSHAC studies	Not adequate for nuclear/critical facilities	Regional and/or site-specific	Conduct new study	3 or 4
Regional or site-specific	Not viable** and hazard results expected to be significantly different	Regional and/or site-specific	Replace existing study	3 or 4
Regional or site-specific	Not viable but hazard results not expected to be significantly different	Regional and/or site-specific	Revise existing study	2, 3, or 4
Regional or site-specific	Viable	Site-specific	Refine regional study locally consistent with RG 1.208 and ANSI/ANC-2.27 / 2.29 2008	2, 3, or 4
Site-specific (one or more sites), no regional	Viable	Regional	Use site-specific studies to assist development of regional models	3 or 4
Site-specific (one or more sites), no regional	Not Viable	Regional	Conduct new study	3 or 4

** "Viable" is defined as: (1) based on a consideration of data, models, and methods in the larger technical community, and (2) representative of the center, body, and range of technically defensible interpretations.

NUREG 2117
Table 6-1

Specific guidance (based on guidance in the ANSE/ANS standard) is provided on situations in which an update should undertaken. However, the quality and ongoing viability of the technical basis of a study is often a subjective decision.

Uncertainties

Updating

- There is uncertainty in the quality or viability of older studies and engineering judgment often plays a role.
- Anchoring to old study is an issue when it is being updated, rather than replaced.

Uncertainties

Interface

- There may be interface issues between seismic hazard approaches and fragility curve development. CAV filtering creates an area of uncertainty.
- Soil-structure-interaction modeling is not well integrated with PSHA or SPRA in terms of carrying through probabilistic loading

Uncertainties

Interface

- Seismically-induced fire and flooding are not well developed or integrated in SPRA, both in terms of initiation and ability to respond
- Human factors are not well characterized and may be very site specific

Uncertainties

Fragility Curves

- I’m assuming that Greg and Ravi are covering these…(correlations, generic curves, screening levels, etc.)

Other Hazards

HLR-SHA-I

- Approaches to analysis of other natural hazards are generally less well developed, with the exception of liquefaction and seiche
- PTHA is quickly becoming well developed and state-of-practice on the west coast. Landslide-induced tsunami are still an issue

Other Hazards

HLR-SHA-I

- Multiple approaches for landslides exist and they can be used to estimate epistemic uncertainties