



**U.S.NRC**

UNITED STATES NUCLEAR REGULATORY COMMISSION

*Protecting People and the Environment*

# **An Overview of NRC Seismic Research Program**

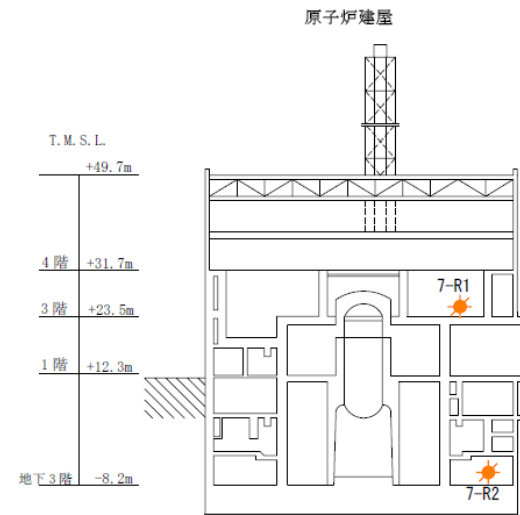
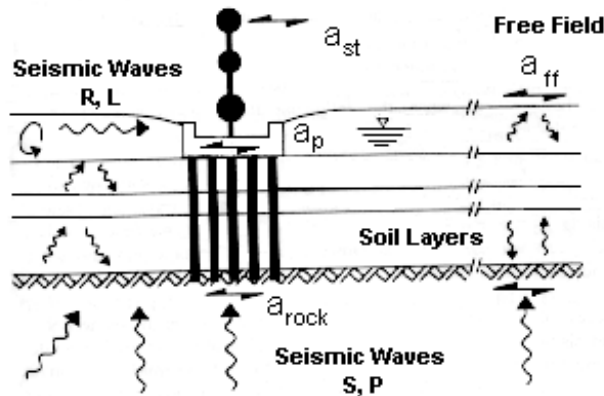
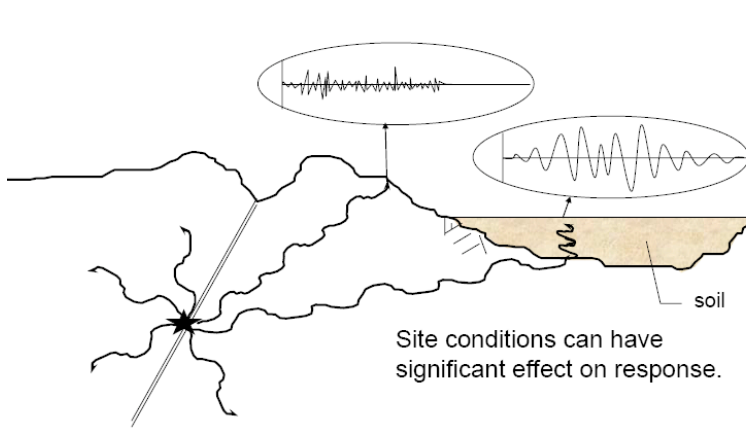
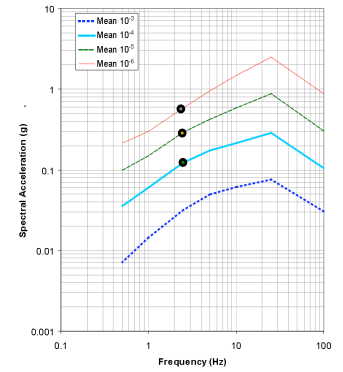
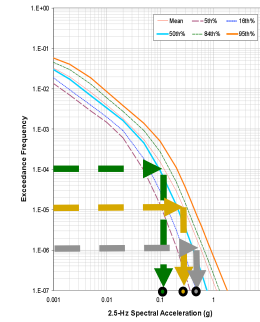
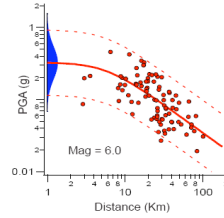
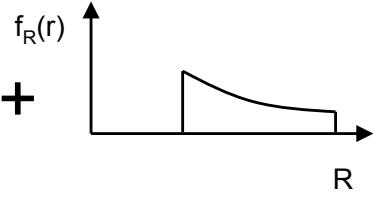
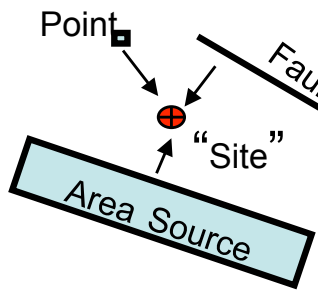
Richard Rivera-Lugo  
October 2009

- 18 Combined (Construction & Operating) License Applications received
- 4 Early Site Permit/Limited Work Authorization granted
- 1 Amended Design Certification Application
  - Westinghouse AP1000 Certification Amendment
- 3 Design Certification Applications
  - General Electric Economic and Simplified Boiling Water Reactor (ESBWR)
  - AREVA Evolutionary Power Reactor (EPR)
  - Mitsubishi U.S. Advanced Pressurized Water Reactor (US APWR)
- 6 Letters of Intent for ESP/LWA/COL Applications over next 2 to 3 years
- 2 Letters of Intent to renew ABWR DC
- Interest in several Advanced Reactor DCs and GenIV

# Program Overview

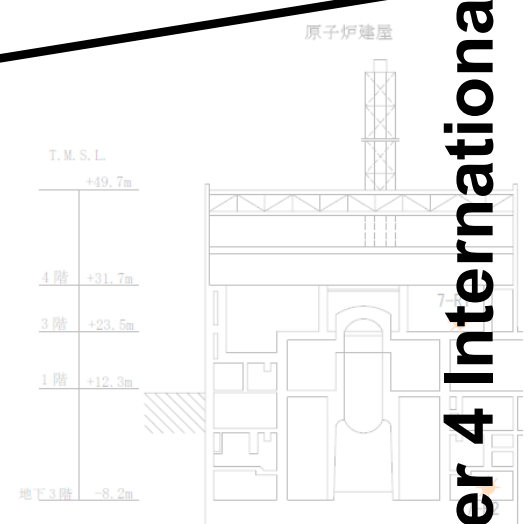
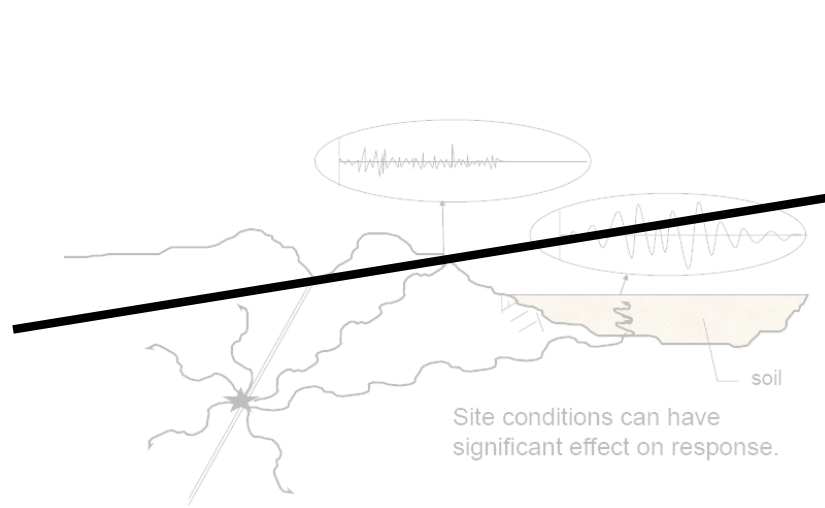
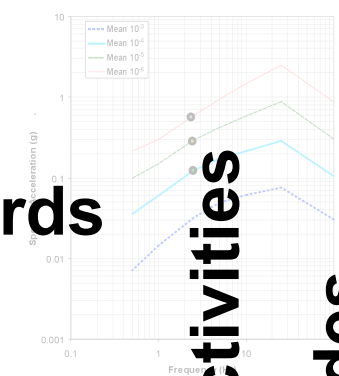
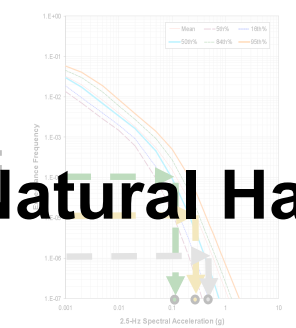
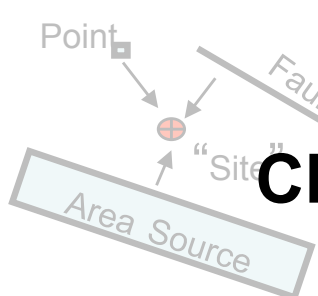
- Publicly available research plan
  - Being updated for 2010 to 2015
- Targeted on regulatory needs
- Strong stakeholder interaction
  - Developed with other NRC offices
  - Cooperation with industry, other national & international agencies, and the technical community
- Developed to advance the science and increase regulatory stability
- Short- and long-term projects

- **Systematic & integrated**
  - Integrated research planning
  - Focused on issues with highest uncertainties
  - Risk informed plan that fills in gaps
- **Cost effective/High Quality**
  - Piggy backing and partnering
  - Universities & Federal Agencies
  - “Next-generation” approaches
- **Emphasis on performance-based & risk-informed approaches**

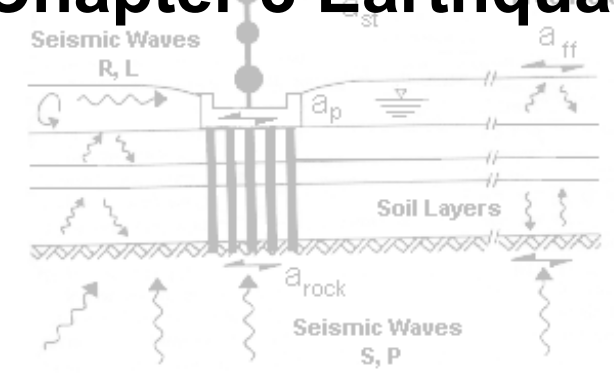


Structures,  
Systems &  
Components

# Chapter 2 Earth Science & Natural Hazards



# Chapter 3 Earthquake Engineering

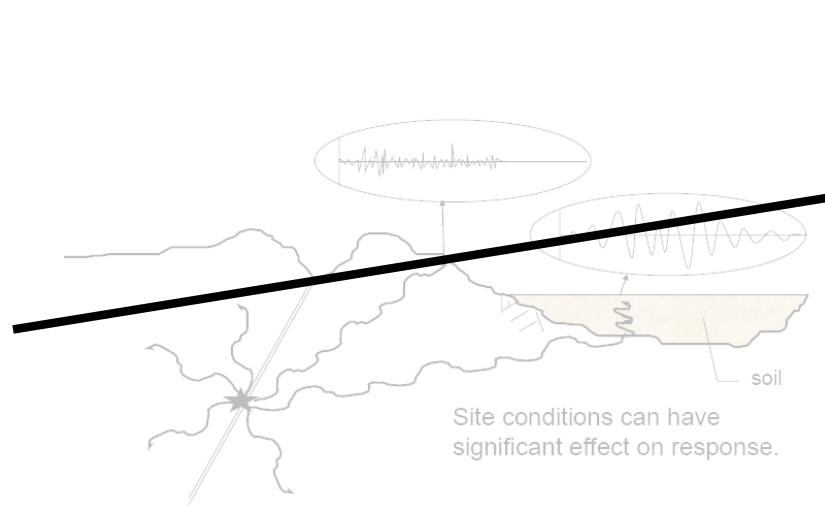
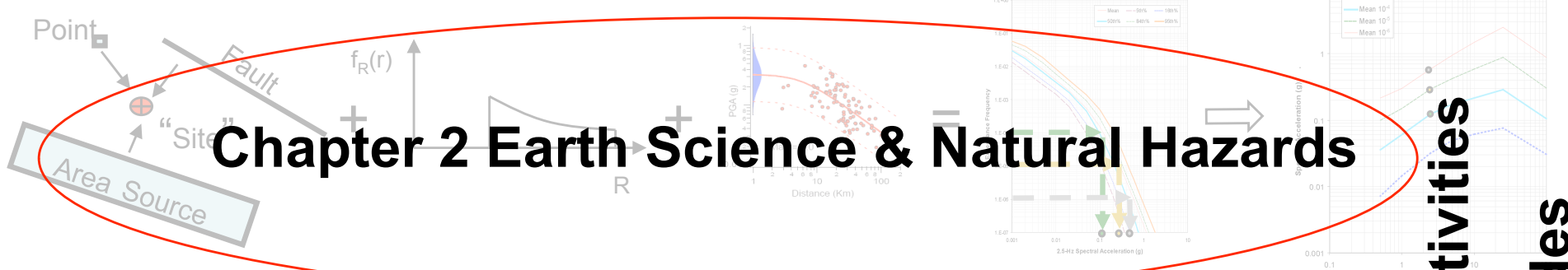


SSCs

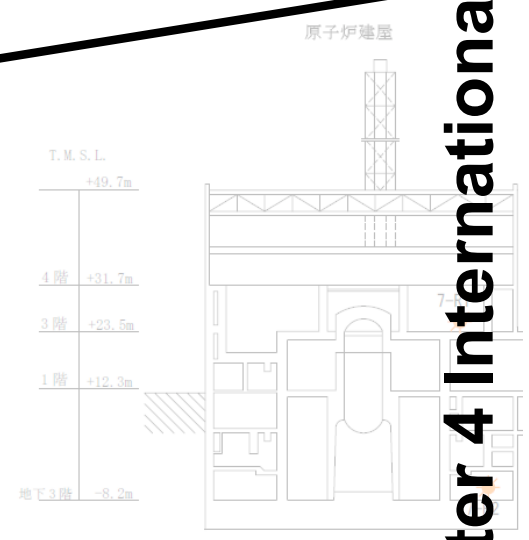
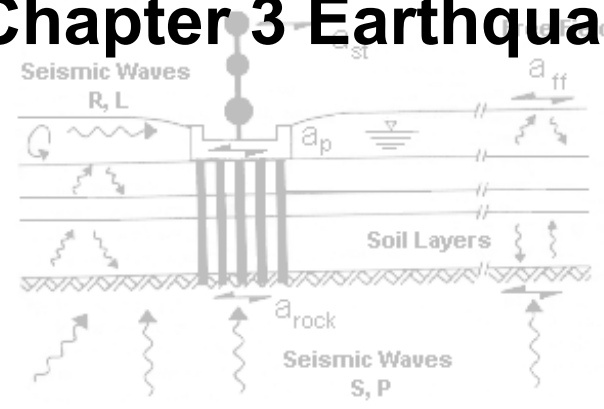
Chapter 4 International Activities

Chapter 5 Regulatory Guides

# Chapter 2 Earth Science & Natural Hazards



# Chapter 3 Earthquake Engineering



SSCs

Chapter 4 International Activities

Chapter 5 Regulatory Guides

# New US NRC Projects to Assess Seismic Hazard in CEUS

Source  
Characterization →

Central and Eastern US Seismic Source Characterization project for Nuclear Facilities (CEUS SSC)

Ground motion  
prediction equations →

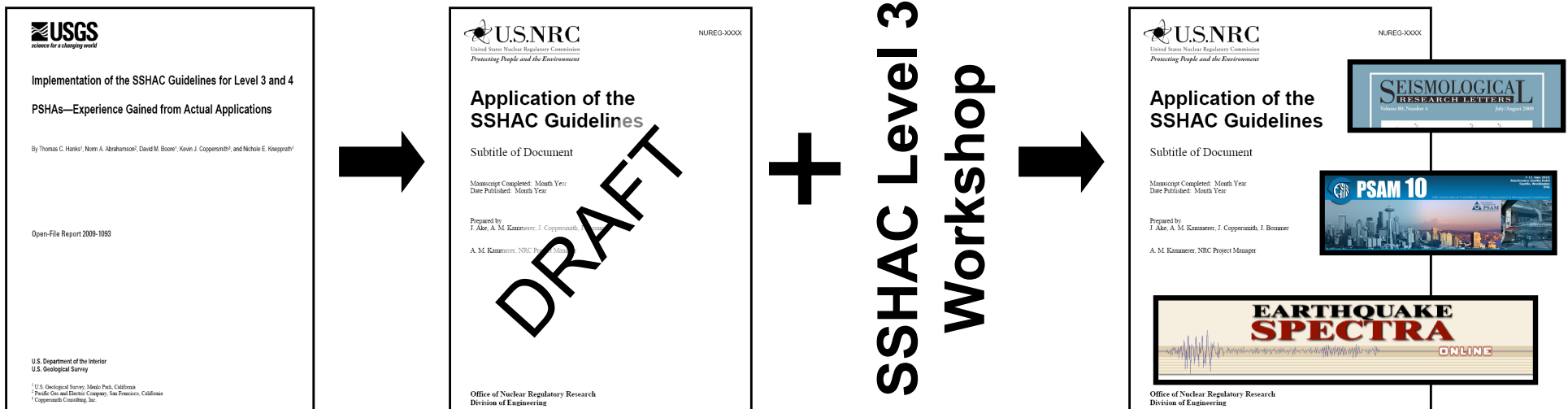
Next Generation Attenuation Relationships for the Central and Eastern (NGA-East)

Framework for large  
PSHA studies →

Recommendations for Application of the SSHAC Guidelines

# SSHAC Guidelines

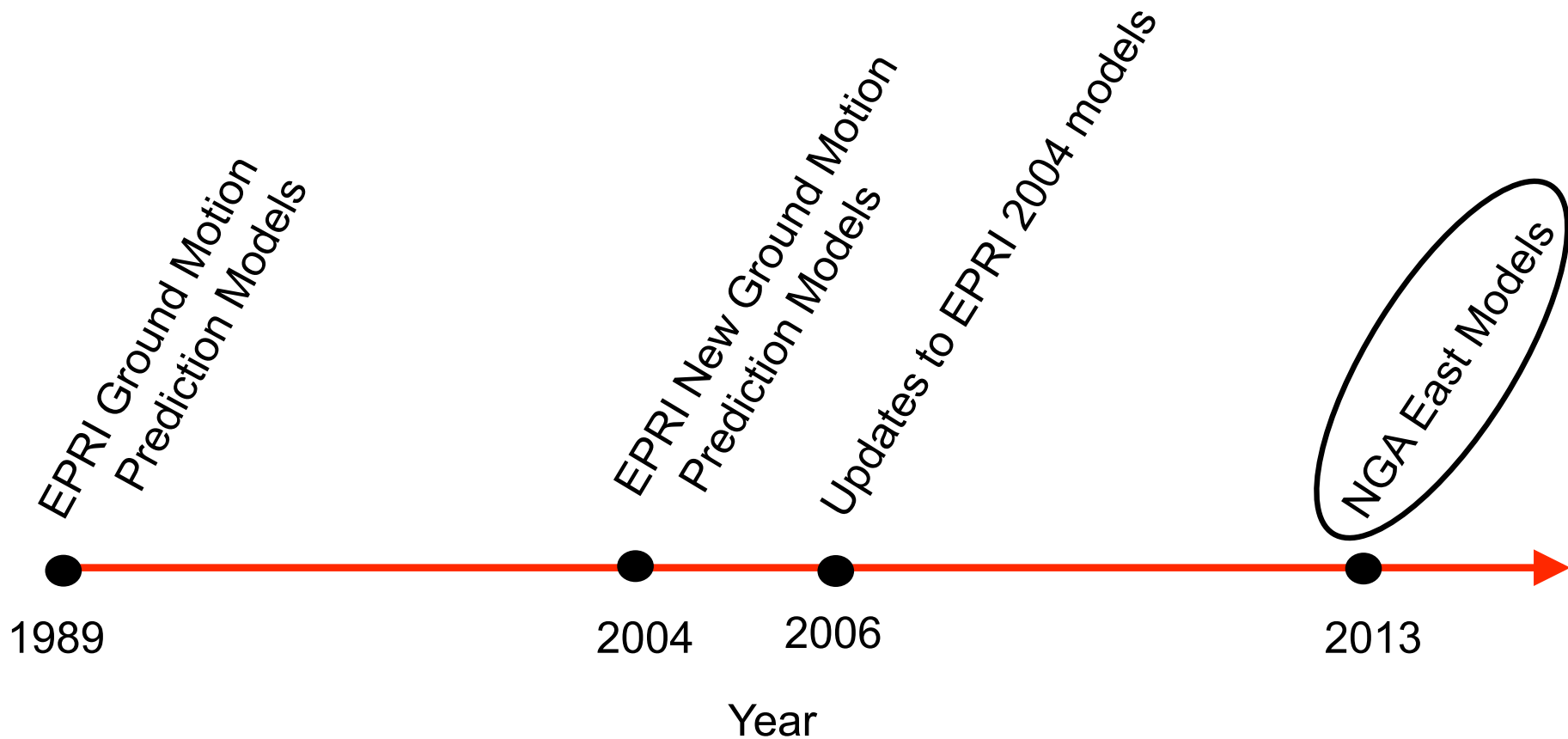
- NUREG/CR 6372 by Senior Seismic Hazard Assessment Committee (SSHAC) describes a process for undertaking PSHA with the use of rigorous approaches for expert interaction and for clear accounting for uncertainty
- The SSHAC guidelines provide a strong framework but have limited practical advice on implementation
- Development of Draft NUREG based on USGS Open File Report (2009-1093), lessons learned in the CEUS SSC Project, and a public workshop focused on level 3 studies



# SSHAC Guidelines

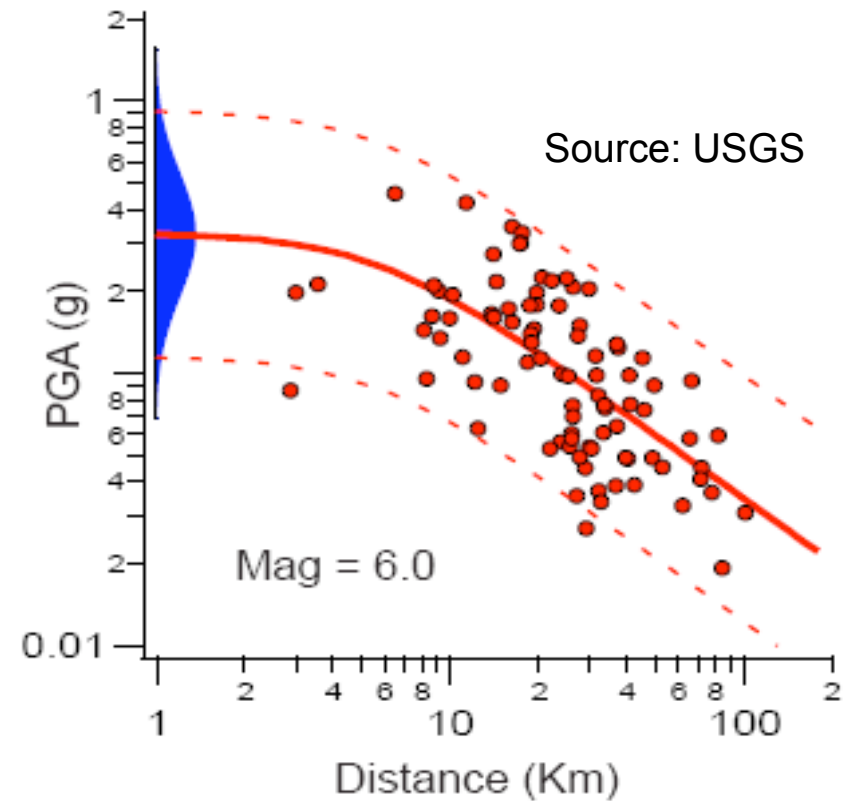
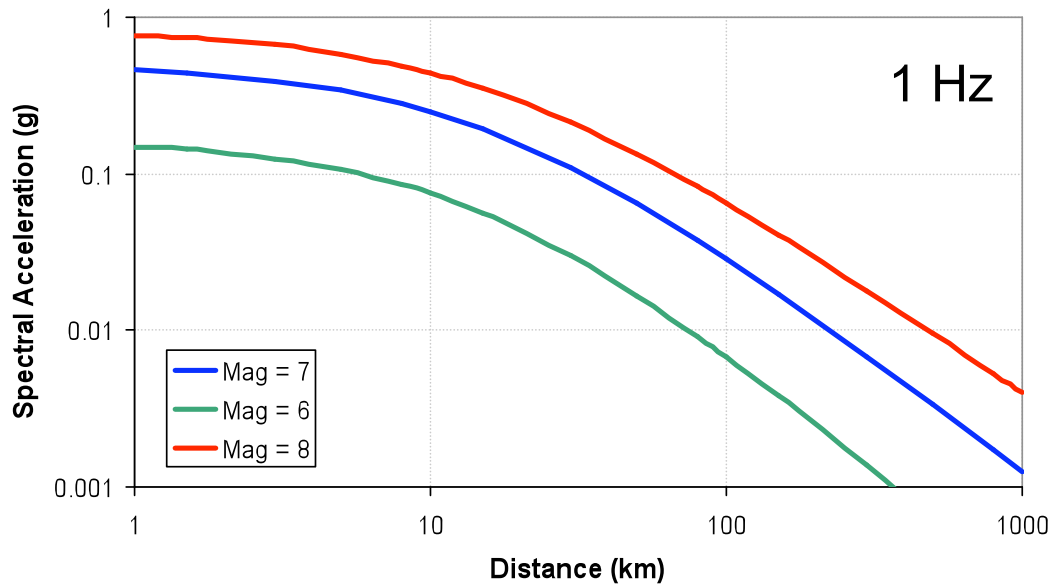
- NUREG will be companion to original SSHAC Guidelines, not a replacement
- NUREG will focus on providing practical approaches for implementing the SSHAC guidelines
- Sections on non-seismic and non-US projects
- Wrap up the project with public outreach and making the guidelines and NUREG more accessible

# Updates to Ground Motion Prediction Models



# Ground Motion Prediction Equations (aka Attenuation Relationships)

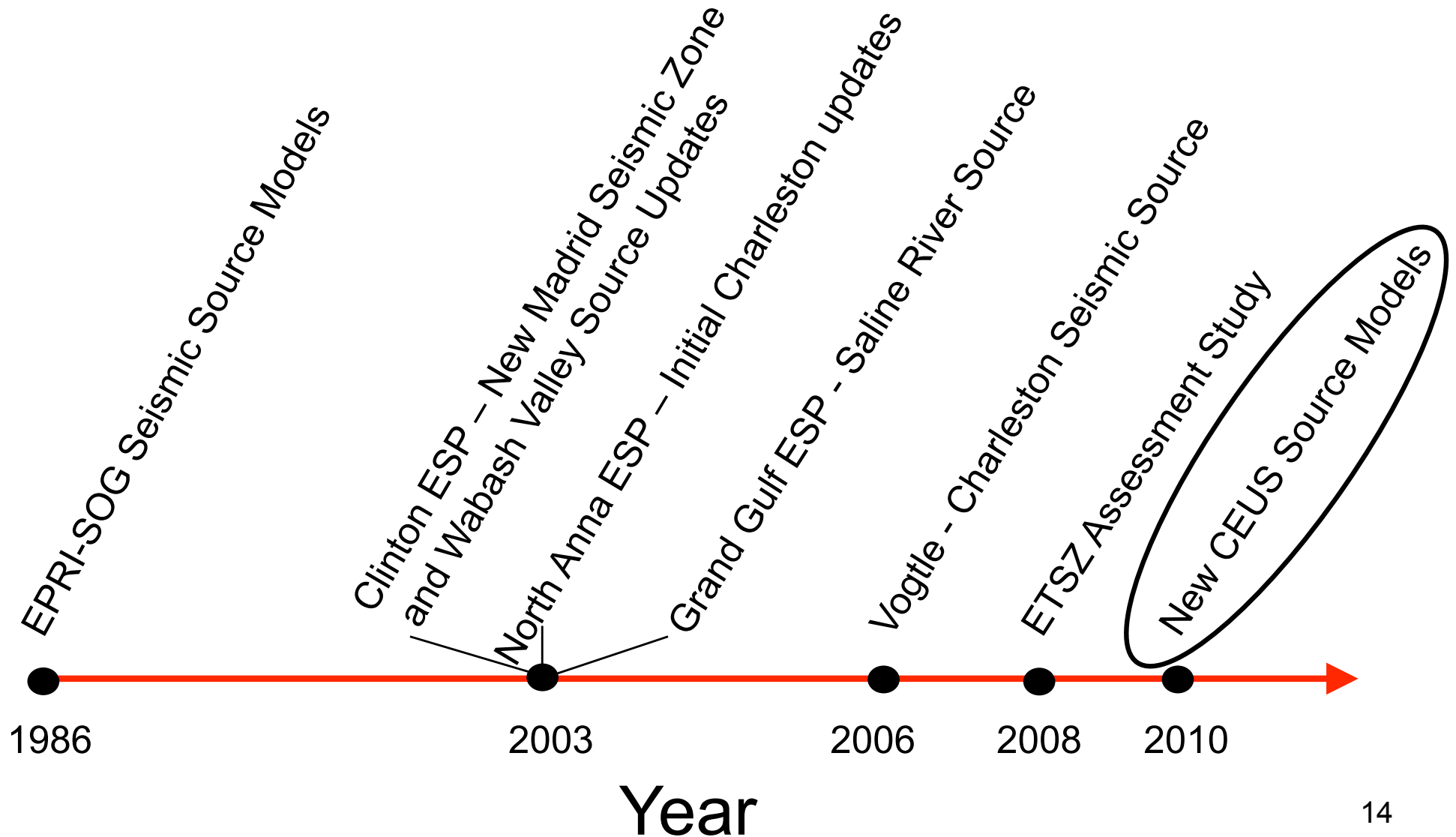
## Ground motion amplitudes based on distance & magnitude



- PEER Providing Project Management
- Cooperative support of NRC, DOE, EPRI, NEHRP, USGS
- 2 Focus areas
  - Ground Motion Prediction Equations (GMPE) development
  - SSHAC level 3 study on implementation of GMPEs for critical facilities
- 4 Working groups
  - Database development
  - Geotechnical Issues
  - Simulation and Modeling
  - GMPE development
- Project Schedule from 2009 to 2014

# Replacement of EPRI-SOG Models

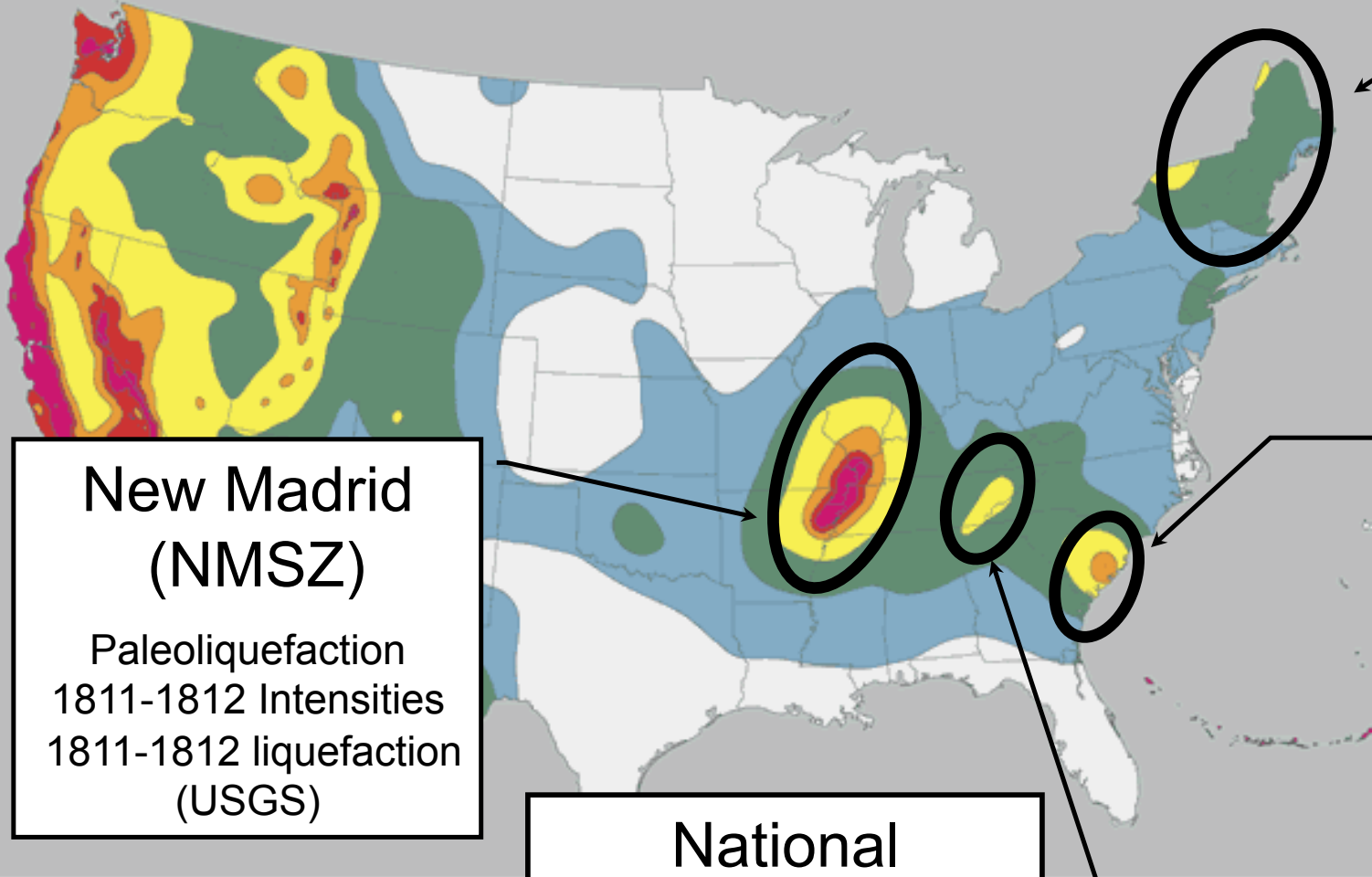
Source models are not static, they require updates as our understanding of the geology/tectonics of these sources improves



# CEUS Seismic Source Characterization project for Nuclear Facilities

- Participation from NRC, DOE, EPRI, USGS, and other US specialists
- SSHAC level-3 study
- Developing a new seismic source database for the CEUS to be used as a regional model
- NPP applications will still study local sources
- “International Observers Program” allowed international specialists to observe the US project firsthand

# Key Seismic Source Zone Updates



## New Madrid (NMSZ)

Paleoliquefaction  
1811-1812 Intensities  
1811-1812 liquefaction  
(USGS)

## Northeast (NESZ)

## Charleston (CSZ)

Seismic reflection  
reprocessing  
(Virginia Tech)

## National

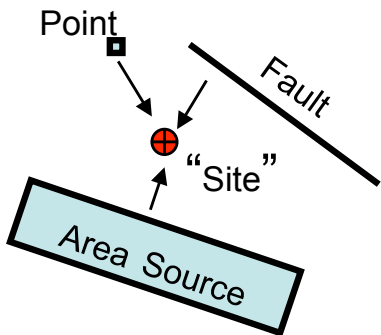
Advanced National  
Seismic System (USGS)

Paleoliquefaction  
guidelines (USGS)

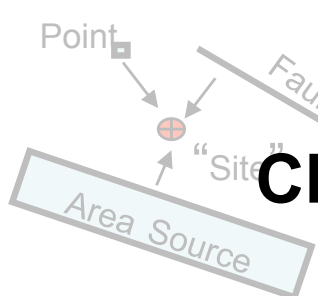
Intensity/Magnitude  
correlations (USGS)

## Eastern Tennessee (ETSZ)

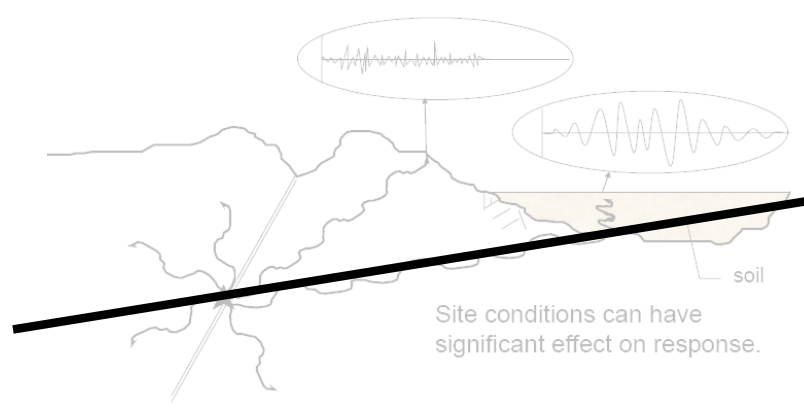
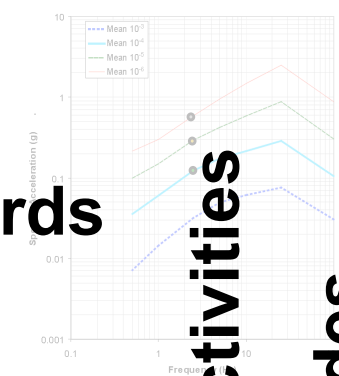
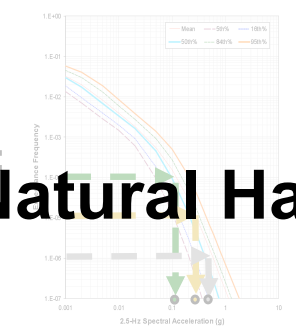
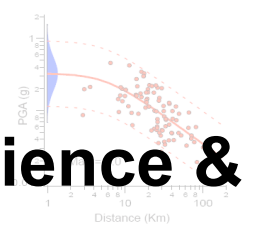
Paleoliquefaction (Univ. of Tenn)  
Seismites (speleothems) (USGS)



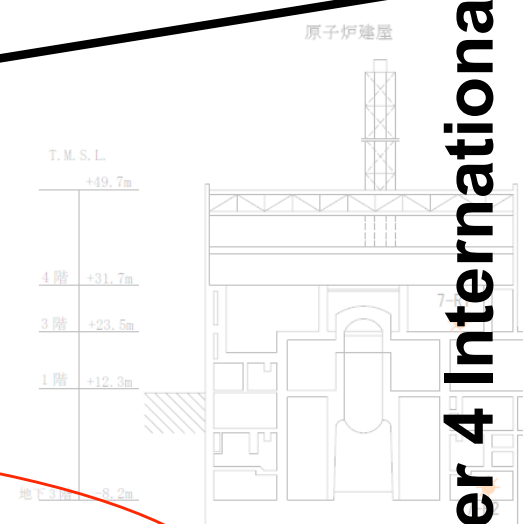
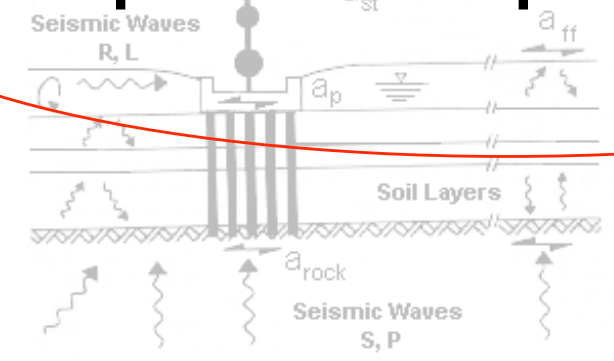
# Chapter 2 Earth Science & Natural Hazards



$$f_R(r)$$



# Chapter 3 Earthquake Engineering

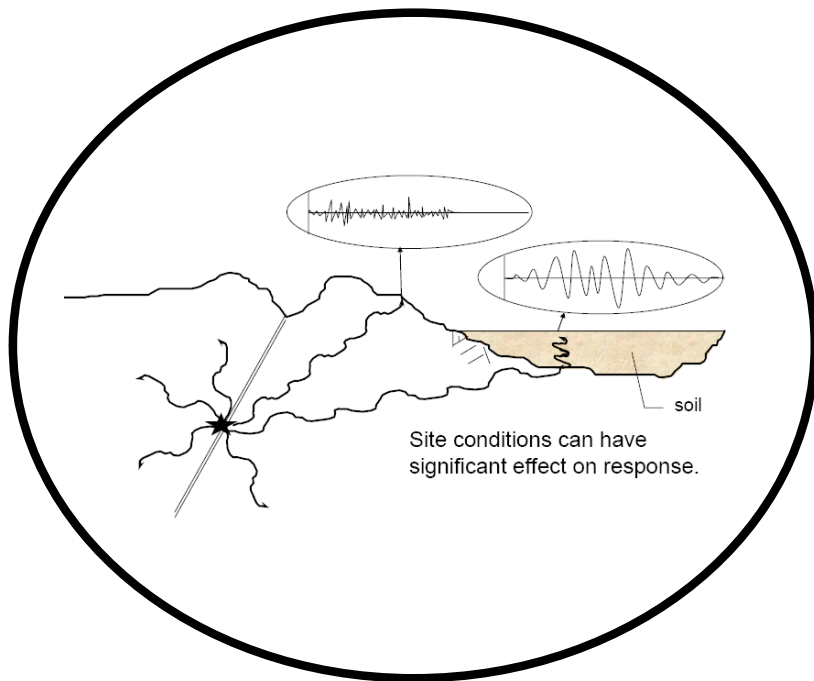


SSCs

Chapter 4 International Activities

Chapter 5 Regulatory Guides

# Random Vibration Theory & Site response methods



- Multiple methods described in NUREG 6728
  - Theoretical framework for integration of site response in PSHA, but few details
  - Only recently used and implementation differs
  - Focus on better understanding
- Multiple modeling tools currently in use
  - Non-linear, SHAKE, and RVT
  - Comparison of methods
  - Developing RVT software

# Seismic Engineering

- Development of Technology Neutral Performance-based, Risk-informed framework (with LBNL)
  - RG 1.208, ASCE 43-05
- Targeted research to improve application of seismic probabilistic risk assessments
- Complex Load Effects in Input & Response
  - Non-vertically propagating waves
  - High frequency & incoherent waves
  - 3-Dimensional effects in structures and soil

# Seismic Engineering

- **Advanced Reactor Designs**
  - Base isolation technologies (currently underway at LBNL, Berkeley, and SUNY Buffalo)
  - Aging and degradation of materials under new operating conditions
  - Deep foundations and lateral earth pressures
  - New construction techniques (e.g. modular construction)

# Seismic Engineering

- International Projects
  - Joint program with Japan on testing and numerical modeling
  - Kashiwazaki-Kariwa structure and component modeling project with IAEA
  - International Cooperation through the new IAEA International Seismic Safety Centre
  - International regulatory guidance

# Summary

- Seismic Research Plan publicly available
- Key drivers are both the advancement of state of practice AND greater regulatory stability
- Integrated risk-informed approach
- Both short- and long-term planning
- Focus on consensus products
  - Community-wide consensus
  - Multiple stakeholders & sponsors