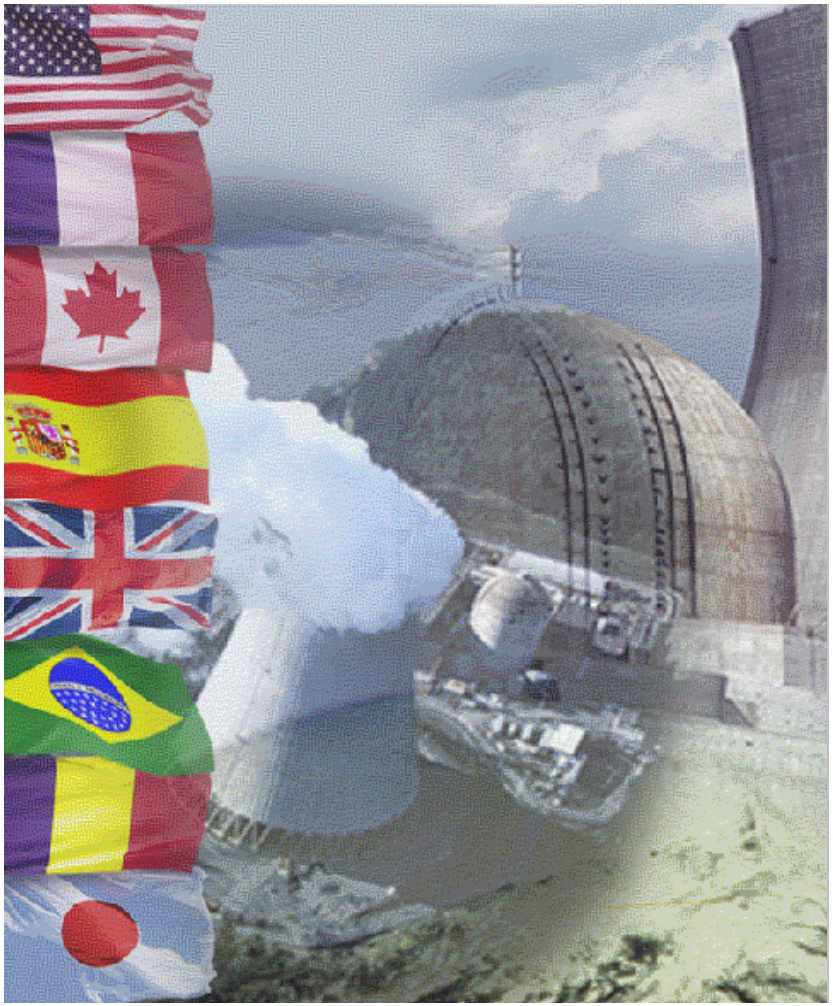


# New Plant Seismic Issues Resolution Program

Presentation to USNRC

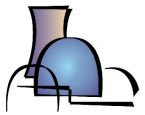
by

EPRI/NEI

October 19-20, 2005

# Industry Goal

- Resolve generic seismic issues in a timeframe to support Administration goals for nuclear power expressed in NP 2010
- Update guidance, where necessary



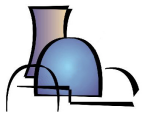


Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Purpose and Objectives of Meeting

- **Discuss:**
  - **Results of update of ground motion hazards for 28 nuclear plant sites and assessment of Industry performance-based method for determining the SSE**
  - **Results of tasks to address high frequency issue**
  - **Updates of progress on other tasks**
- **Objectives:**
  - **Reach common understanding on acceptability of Industry performance-based methodology**
  - **Obtain comments/final direction on HF tasks**
  - **Reach agreement on process for updating regulatory guidance**

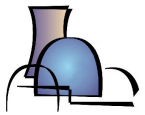




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Topics to be Discussed

- Introduction
- General comments - NRC and NEI
- Industry program status
- Summary of Task G1.1
  - Basis for performance-based method
  - Results of study
  - Discussion
- Summary of Task S2.1 results to date
- Summary of Task S2.2 results to date
- Update on Tasks G1.2, G1.3 and I1.1
- Future plans and schedule



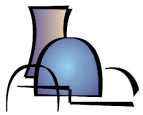


Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Industry Program

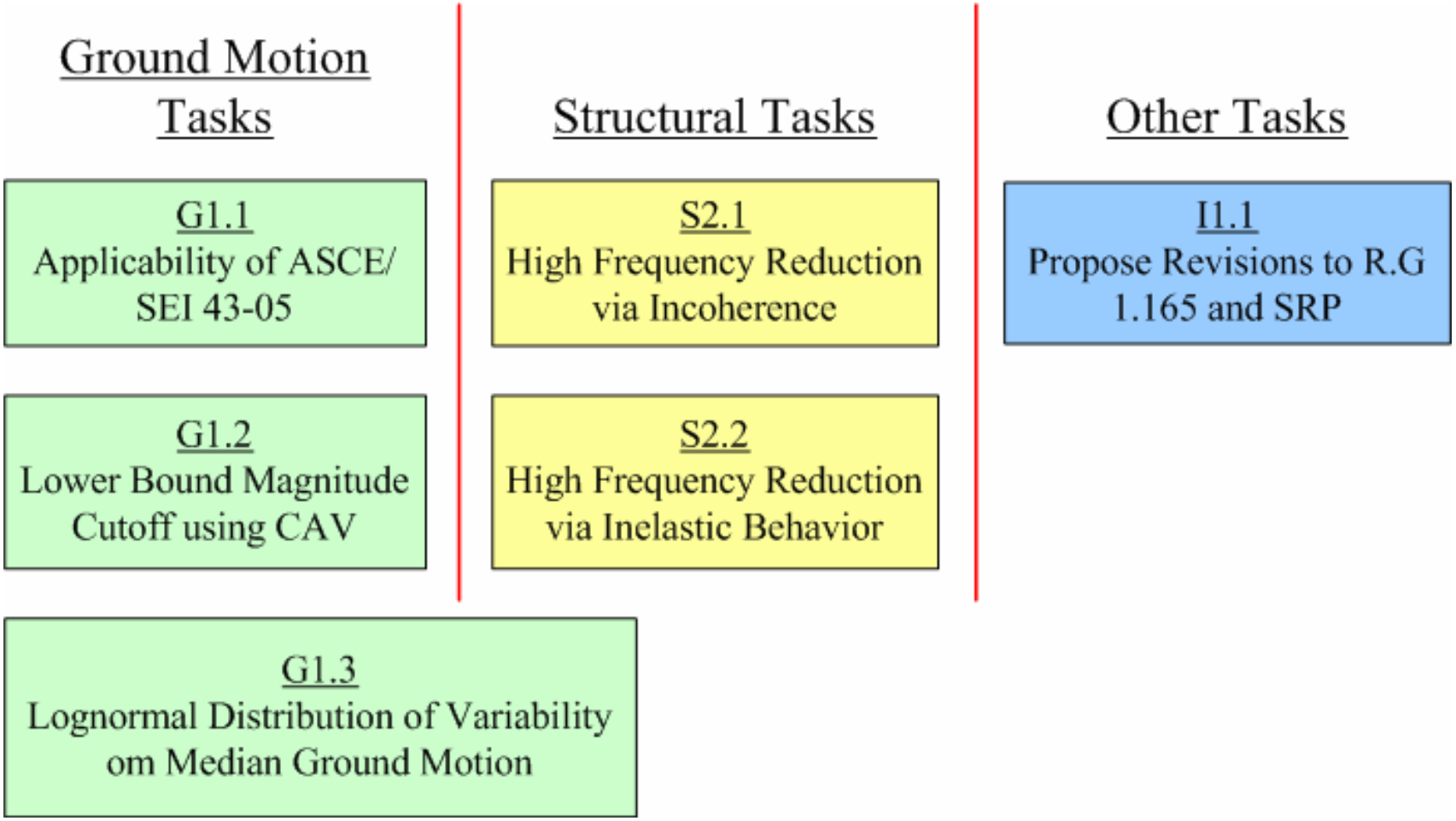
- Demonstrate generic applicability of ASCE/SEI 43-05 - Task G1.1
- Update and improve methods for addressing non-damaging high frequency portion of ground motion spectra – Tasks S2.1, S2.2
- Improve seismic hazard estimation methodology to reflect technology advances - Tasks G1.2, G1.3
- Develop proposed revisions to RG1.165 and NUREG 0800 - Task I1.1





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

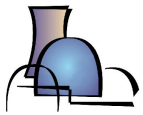
# Industry Program




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Task G1.1 – Performance Based Methods

- Update EPRI hazard results at 28 sites to reflect latest codes, attenuation relationships, updated seismic sources and ground motion model
- Compute performance-based seismic spectra for these sites using ASCE/SEI 43-05
- Demonstrate generic applicability of performance-based methodology

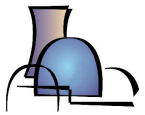




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Tasks S2.1 and S2.2 - Treatment of High Frequency (HF) Motions

- Develop generic methods for accommodating non-damaging HF motions considering
  - Effect of seismic wave incoherence (S2.1) and
  - Effect of limited inelastic behavior on response to HF input motions (S2.2)

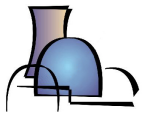




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Tasks to Improve Seismic Hazard Methodology

- Task G1.2 - Use new data and method (CAV) to better define earthquake lower bound magnitude distribution
- Task G1.3 - Define a rational, defendable bound on the lognormal distribution of variability on median ground motion

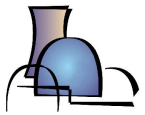




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Task Integration/Re-assessment of Regulatory Guidance

- Task I1.1- Review and integrate results of program tasks and develop proposed revisions to R. G. 1.165 and portions of the SRP, as appropriate



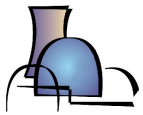


Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Activities Since May 25,05 Industry/NRC Meeting

- Agreement on NRC interactive review process
- June 22-23 Working Group meeting on Tasks G1.2, S2.1, S2.2
- ASCE/SEI Standard 43-05 issued by ASCE
- Final Report on Task G1.1 issued
- August 23-24 Working Group meeting on Tasks G1.2, S2.1, S2.2
- September 16 Working Group meeting on Task G1.3
- Additional supporting data on G1.1 report sent to NRC

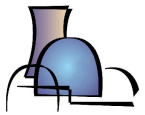




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Industry/NRC Interactions

- NRC representatives participated in Working Group meetings on Tasks G1.2, S2.1 and S2.2
- Meetings were positive and constructive
- No “show stoppers” identified



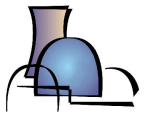


Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

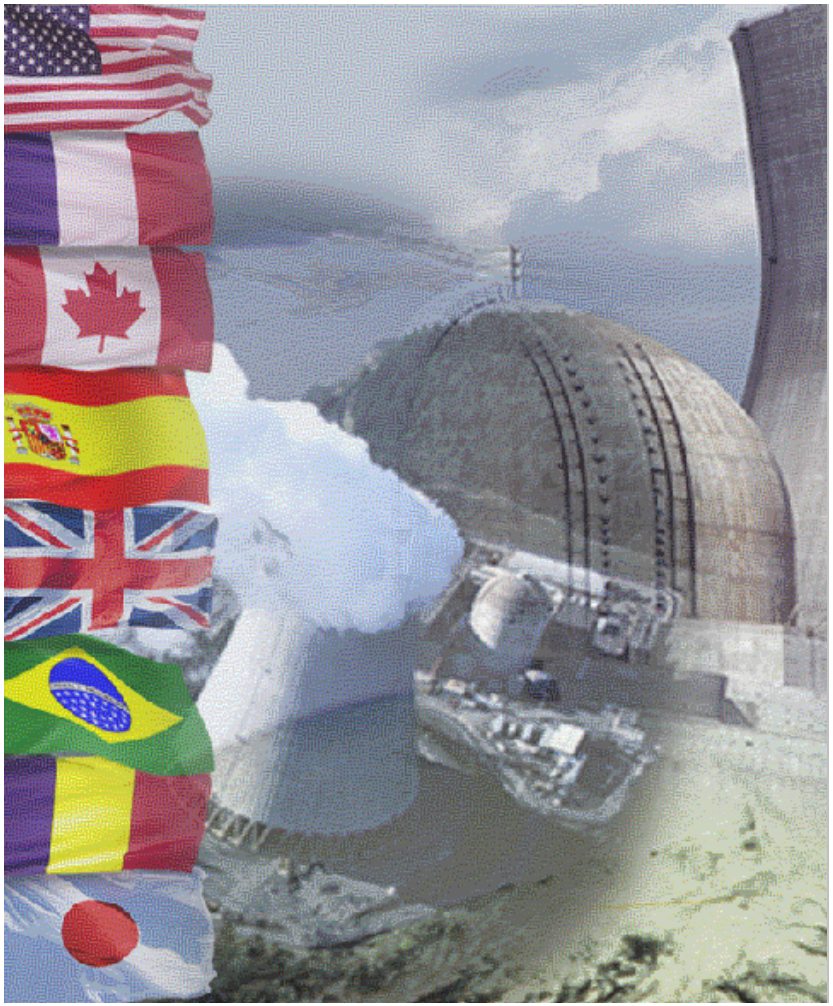
# Future Plans/Schedule

- Final report on Task G1.2 -end of November 05
- Working Group meeting/Final report on G1.3 – January 06
- Final reports on S2.1 and S2.2 – January 06
- Industry/NRC meeting on EPRI 03 Ground Motion Model – early 06
- Industry/NRC meeting (2 days) on G1.2, G1.3, S2.1, S2.2 and I1.1 - late February 06





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

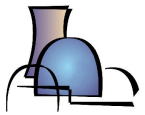


# ASCE Standard 43-05 Risk (Performance-Goal) Based Approach for Establishing the SSE Design Response Spectrum for Future Nuclear Power Plants

Robert P. Kennedy

# Risk Based Approach Used To Establish Design Basis Response Spectrum

- Develops A Risk Consistent Design Response Spectrum (DRS) As Opposed To A Relative Uniform Hazard Response Spectrum (UHRS) Based Upon Median Exceedance Frequency For 29 Sites
- Approach Implements Risk-Informed Regulatory Policy
- Conservatively Aimed At Achieving A Target Performance Goal for Onset of Significant Inelastic Deformation (i.e., Conservative Surrogate for Unacceptable Seismic Performance)





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Four Required Steps – Step #1

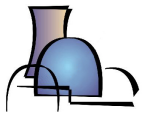
**Define Target Seismic Risk Goal PFT to Be Achieved By Seismic Design Criterion**

**Preferably:** Define in Terms of Mean Annual Frequency of Unacceptable Seismic Performance

**Selected:** $P_{FT}$ = Mean 1x $10^{-5}$/yr Against Onset of Significant Inelastic Behavior for Structures, Systems, or Components (SSCs)

**Basis:**

1. Mean Seismic Core Damage Frequencies Reported For Existing Nuclear Power Plants Average More Than Mean 1x$10^{-5}$/yr
2. Onset of Significant Inelastic Behavior of an SSC Is Generally Far Short of Failure
3. Core Damage Frequency Is Typically Less Than Highest SSC Failure Frequency
4. Therefore, Seismic Induced Core Damage Frequency Is Expected To Be Significantly Less than Mean 1x$10^{-5}$/yr





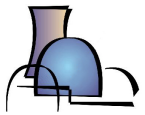
Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Mean Seismic CDF for Plants Performing Seismic PRA from Table 2.2 from NUREG 1742

| Plant | Mean Seismic CDF (EPRI) | Plant | Mean Seismic CDF (EPRI) |
|---|---|---|---|
| South Texas Project 1 & 2 | 1.90E-07 | Beaver Valley 1 | 1.29E-05 |
| Nine Mile Point 2 | 2.50E-07 | Indian Point 2 | 1.30E-05 |
| La Salle 1 & 2 | 7.60E-07 | Point Beach 1 & 2 | 1.40E-05 |
| Hope Creek | 1.06E-06 | Catawba 1 & 2 | 1.60R-05 |
| D.C. Cook 1 & 2 | 3.20E-06 | San Onofre 2 & 3 | 1.70E-05 |
| Salem 1 & 2 | 4.70E-06 | Columbia (Washington Nuclear Project No. 2) | 2.10E-05 |
| Oyster Creek | 4.74E-06 | TMI 1 | 3.21E-05 |
| Surry 1 & 2 | 8.20E-06 | Oconee 1, 2, and 3 | 3.47E-05 |
| Millstone 3 | 9.10E-06 | Diablo Canyon 1 & 2 | 4.20E-05 |
| Beaver Valley 2 | 1.03E-05 | Pilgrim 1 | 5.80E-05 |
| Kewaunee | 1.10E-05 | Indian Point 3 | 5.90E-05 |
| McGuire 1 & 2 | 1.10E-05 | Haddam Neck | 2.30E-04 |
| Seabrook | 1.20E-05 | | |

| | |
|---|---|
| Median of Mean Seismic CDF Value (EPRI Results) | 1.20E-05 |
| Mean of Mean Seismic CDF Value (EPRI Results) | 2.50E-05 |

| | |
|---|---|
| * | CDF Values reported are for EPRI hazard curves. LLNL hazard curves produced substantially higher CDF results |





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Four Required Steps – Step #2

**Establish Seismic Hazard Exceedance Frequency HD At Which Uniform Hazard Response Spectrum UHRS is to be Defined**

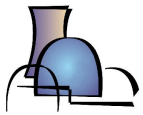
$H_D = R_P * P_{FT}$

$R_P$ = Probability Ratio

**Preferably:** $2 \leq R_P \leq 20$

**Selected:** $R_P = 10$

**Result:** $H_D$ = Mean 1 x $10^{-4}$





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Four Required Steps – Step #3

**Establish the Required Degree of Conservatism of Deterministic Seismic Acceptance Criterion**

**Requirement:** Seismic Acceptance Criterion Defined by NUREG-0800 Standard Review Plan and Reg Guides

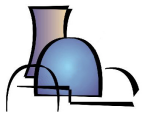
**Premise:** Seismic Demand and Structural Capacity Evaluations Have Sufficient Conservatism to Achieve Both of the Following:

1. Less Than About a 1% Probability of Unacceptable Performance for the Design Basis Earthquake Ground Motion, and
2. Less than About a 10% Probability of Unacceptable Performance for a Ground Motion Equal to 150% of the Design Basis Earthquake Ground Motion

**Justification:**

1. Past Seismic PRA And Seismic Margin Studies Have Shown That SSCs Designed to Standard Review Plan Requirements Achieve at Least These Levels of Conservatism

2. Additional Justifications for Above Premises Are Presented in Reference Documents





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Four Required Steps – Step #4

Define Design Basis Earthquake Response Spectrum DRS

DRS = DF * UHRS

DF = Design Factor

DF Function of:

- Probability Ratio $R_P$ Defined in Step #2
- Seismic Margin Factor $F_P$ Defined in Step #3
- Hazard Curve Slope Ration $A_R$

$A_R$ = Ratio of Ground Motions Corresponding to Ten-Fold Reduction in Exceedance Frequency

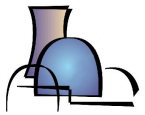
$A_R$ Differs at Each Natural Frequency

$$A_R = \frac{SA_{0.1H_D}}{SA_{H_D}}$$

Recommend:

For $R_P = (H_D/P_{FT}) = 10.0$

DF = Maximum ($DF_1$, $DF_2$)
$DF_1 = 1.0$
$DF_2 = 0.60$ $A_R^{0.8}$





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI

# Four Required Steps – Step #4 (continued)

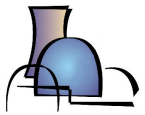
For $H_D$ = Mean $1x10^{-4}$

Calif. Site: $A_R$ = 1.5 to 2.25

EUS Site: $A_R$ = 2.25 to 4.0

Design Factors DF For Various Seismic Hazard Slope Factors AR

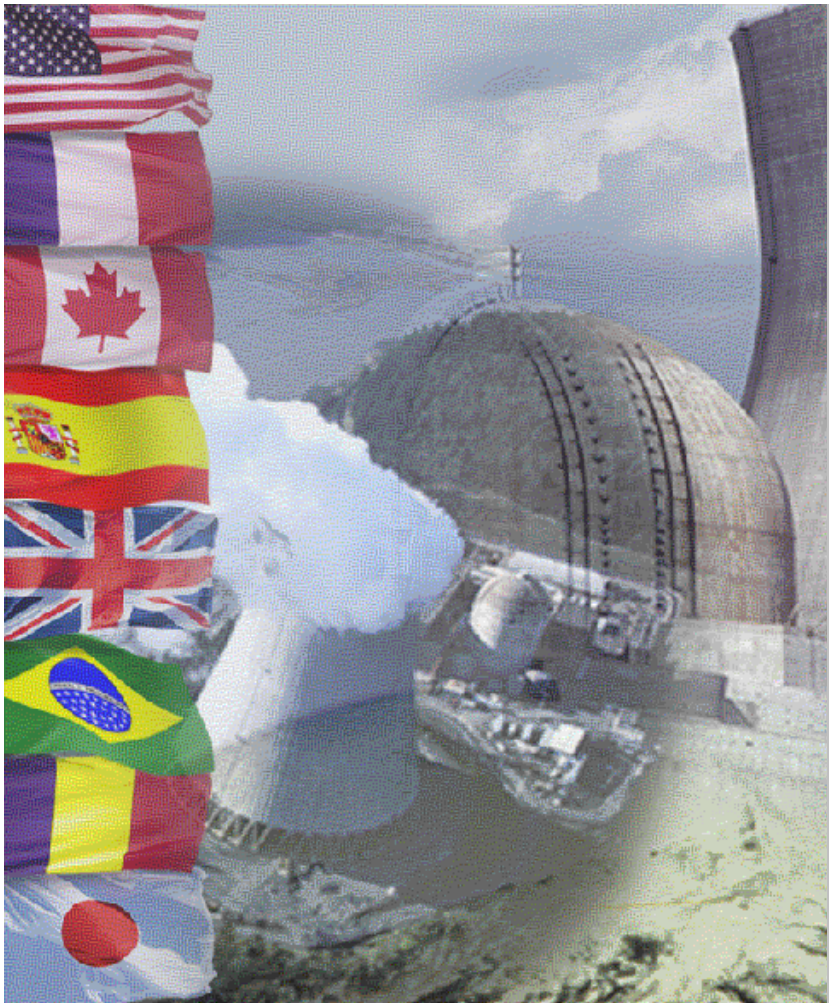
| $A_R$ | DF | Equivalent Hazard Exceedance Level * $1x10^{-4}$/yr |
|---|---|---|
| 1.5 | 1 | 1.00 |
| 1.75 | 1 | 1.00 |
| 2 | 1.04 | 0.88 |
| 2.25 | 1.15 | 0.67 |
| 2.5 | 1.25 | 0.57 |
| 2.75 | 1.35 | 0.51 |
| 3 | 1.44 | 0.47 |
| 3.25 | 1.54 | 0.43 |
| 3.5 | 1.63 | 0.41 |
| 3.75 | 1.73 | 0.38 |
| 4 | 1.82 | 0.37 |
| 4.25 | 1.91 | 0.36 |
| 4.5 | 2 | 0.35 |
| 4.75 | 2.09 | 0.34 |
| 5 | 2.17 | 0.33 |
| 5.25 | 2.26 | 0.32 |
| 5.5 | 2.35 | 0.32 |
| 5.75 | 2.43 | 0.31 |
| 6 | 2.52 | 0.30 |





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

EPRI



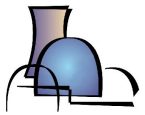
# Industry Activities to Support Updating of Seismic Regulatory Guidance

## Presentation to USNRC
## October 20, 2005

J. Carl Stepp
Consultant
EPRI Advances Nuclear Plants Systems

# Objective

- Develop state of practice technical documents and support NRC actions to update affected sections of seismic regulatory guidance
  - Regulatory Guide 1.165
  - NUREG-0800

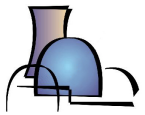




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Approach

- Work with NRC staff and management to establish procedures and a schedule of interactions to implement updates of seismic regulatory guidance
- Prepare industry technical reports supporting the scope of proposed technical updating of the affected sections RG 1.165 and NUREG-0800
- Work interactively with NRC staff in a series of meetings to implement specific updated technical revisions

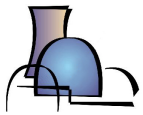




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Planned Industry Technical Reports

- Implementation of performance based method for determining site-specific seismic design basis ground motions - Task G1.1, Submitted for review
- Technical basis for bounding the variability of ground motion about median estimated motions - Task G1.3
- Technical basis for establishing a distribution on lower bound magnitude for seismic hazard integration - Task G1.2
- EPRI 03 Ground Motion Model for the CEUS - Submitted for review
- Technical basis for treatment of high frequency ground motion spectra - Tasks S2.1 & S2.2

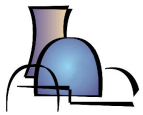




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# NRC Technical Reports for Updating Regulatory Guidance

- NUREG/CR-6728: *Technical basis for revision of regulatory guidance on design ground motions: hazard- and risk-consistent ground motion spectra guidelines, and*
- NUREG/CR-6769: *Technical basis for revision of regulatory guidance on design ground motions: development of hazard- and risk-consistent seismic spectra for two sites*
  - Technical guidance for assessing site-specific hazard- and risk-consistent seismic design spectra
  - Supports updating of affected sections of NUREG-0800 and RG 1.165





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

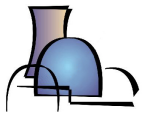
# Proposed NRC-Industry Technical Exchange Meetings

- Mid October 2005
  - Review technical basis for updating RG 1.165 implementing the performance based method for deriving site-specific seismic design basis ground motion

    [this meeting]
  - Review Tasks S2.1 & S2.2 technical results and identify any technical or regulatory closure issues

    [this meeting]
  - Review proposed technical updating of the affected sections of RG 1.165 and NUREG-0800 incorporating technical advances provided by the results of:
    - NUREG/CR-6728
    - NUREG/CR-6769, and
    - EPRI TR-1009684 - the EPRI 03 Ground Motion Model

    [Late February, 2006]

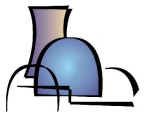




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

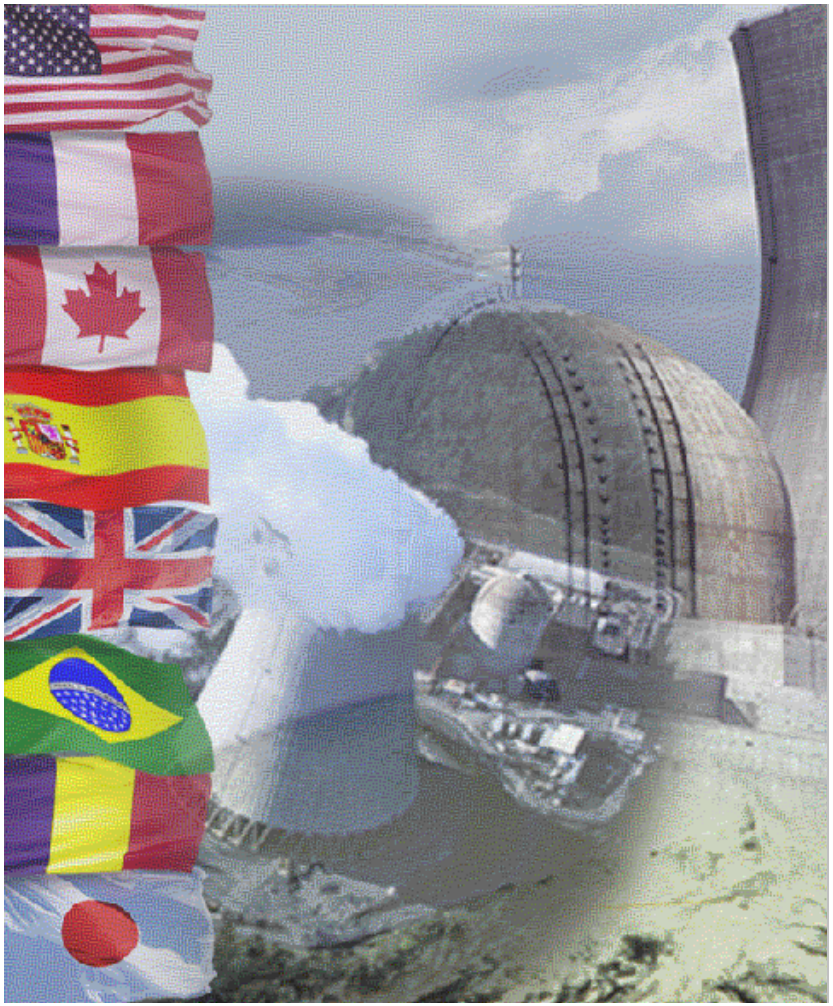
# Proposed NRC-Industry Technical Exchange Meetings, cont'd

- Late February 2006
  - Review proposed technical updates of affected sections of RG 1.165 and NUREG-0800 based on technical advances:
    - quantifying the variability of ground motion about median estimated motions - Task G1.3 results
    - establishing a distribution on lower bound magnitude for seismic hazard integration - Task G1.2 results
    - treatment of high frequency ground motion spectra - Tasks S2.1 & S2.2 results
    - EPRI 03 Ground Motion Model
    - NUREG/CR-6728 & NUREG/CR-6769





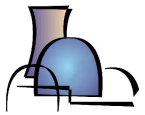
Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.



# Shock and Vibration Test Standards

# Military Shock Test - Mil-S-901D

- Types- Lightweight <550# equipment, Medium Weight <7400#, Heavy weight >7400#
- Test Procedure
  - Lightweight: 400# hammer, 3 blows at each of 1,3 and 5 ft., all three directions
  - Medium weight: 3000# hammer, 6 blows, 2 each at 3 drop heights from 0.75 to 5.5 ft.
  - Heavy weight: Explosion (not applicable)
- Acceptance
  - Grade A: Operability, no damage
  - Grade B: No loose parts, leakage, fire

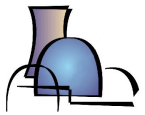




Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.

# Vibration Test Standard - Mil-Std-167

- Types: Internal vibration (rotating equipment) and external vibration
- Test Procedure
  - Internal: Operation of equipment only
  - External: Shaker or table, exploratory tests to determine resonances (4 to 50 Hz, amp's 30 to 3 mils) followed by 2 hr. endurance test at worst resonances and amplitudes
- Acceptance
  - Internal: Specified vibration limits (<1.2 to0.1 mils)
  - External: Operability, no damage





Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.