The NRC Today

• “Nuclear Renaissance”
  – Tax incentives in 2004 law
  – New streamlined processes with “certified designs”
  – Unknown how many new NPPs (30 to 60?)
  – Re-licensing of existing plants
  – Generic Issue 199

• Rapid growth and turnover of agency
  – 2,600 staff in to 4,000 by 2010
  – 50% of staff eligible for retirement by 2010
  – Adding about 300-400 new staff annually
Certified Plant Design

- Standardization of plant designs
- Use of certified design spectrum
- Site-specific spectrum compared with certified design spectrum
- Floor spectra from SSI used for design of contents
- Geotechnical constraints part of licensing basis
• Code of Federal Regulations
• Regulatory Guidance
  – Guidance on how regulations are interpreted by NRC staff
  – Not required but closely followed by industry (de facto regulations)
• Standard Review Plan
  – Checklist that regulators use during reviews
• NUREG and NUREG/CR
  – Reports that provide technical basis
Existing NPPs

Note: There are no commercial reactors in Alaska or Hawaii.
<table>
<thead>
<tr>
<th>Company</th>
<th>Design Type</th>
<th>Site Under Consideration</th>
<th>State</th>
<th>Existing Plants</th>
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<tr>
<td><strong>2007 Applications</strong></td>
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<tr>
<td>Duke</td>
<td>AP1000</td>
<td>William Lee Nuclear Station (2 units)</td>
<td>SC</td>
<td>N</td>
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<td>NuStart Energy</td>
<td>AP1000</td>
<td>Bellefonte (2 units)</td>
<td>AL</td>
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<td>Harris (2 units)</td>
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<td>ESBWR</td>
<td>North Anna (1 unit)</td>
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<td>South Carolina Electric &amp; Gas</td>
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<td><strong>2008 Applications</strong></td>
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<td>UniSTAR</td>
<td>EPR</td>
<td>Calvert Cliffs (1 unit)</td>
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<td>Y</td>
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<td>AmerenUE</td>
<td>EPR</td>
<td>Callaway (1 unit)</td>
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<td>Detroit Edison</td>
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<td>EPR</td>
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<td>UNK</td>
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<td>Bruneau (1 unit)</td>
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<td><strong>2009 Applications</strong></td>
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<td><strong>2007 – 2009 Total Number of Applications = 21</strong></td>
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<tr>
<td><strong>Total Number of Units = 32</strong></td>
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</table>
Geotechnical Constraints

• All Work (including Research) Focused on Regulatory Mission
  – Applications require independent review by NRC licensing staff
  – Research internal support to licensing staff
  – No liquefaction
  – No slope instability
  – No soft soils
  – Geotechnical elements compliant with certified design requirements for each plant type
  – Appropriate performance assessment tools
Geotechnical Constraints

• Key issues
  – Seismic issues
  – Integration into performance based earthquake engineering (PBEE)
  – Integration into probabilistic risk assessments (PRA)
  – Non-vertical loads and 2-D loading effects
  – Soil behavior under extreme loads
  – Probabilistic liquefaction assessments
  – Improvement and development of site response tools
  – Updates of regulatory guides
For each spectral frequency

STEP 1
Seismogenic Zone Model

STEP 2
Recurrence Model

STEP 3
Ground Motion Attenuation

STEP 4
Ground Motion Hazard

Site conditions can have significant effect on response.
Chapter 2 Earth Science & Natural Hazards

Chapter 3 Earthquake Engineering

Chapter 4 International Activities

Chapter 5 Regulatory Guides
Integrated Planning for Multidisciplinary work
For each spectral frequency:

- 2.3
- 2.8
- 2.10
- 2.6
- 2.7
- 3.1
- 3.2
- 3.9
- 3.10
- 3.12
- 3.11
- 3.13

**Long-Term Planning of current and future projects**

- Active (07)
- Upcoming (08)
- Monitoring (09+)
- Awaiting NGA (09+)
- Long term (09+)
2.2 Mmax (‘07)
Key Seismic Zone Updates (‘08)
Sensitivity & uncertainty study to address issues and prioritize research needs (‘08)

2.3 Next Generation Attenuation (NGA-East) (‘07)

2.4 Application of SSHAC Guidelines (‘07)
2.5  Seismic instrumentation (ANSS)
2.10 CAV filtering effect on seismic hazard curve (industry results)
2.8  NUREG/CR-6728 Update
2.9  Minimum response spectra at foundation
2.6  Multi-dimensional loading of soils and sites
2.7  Extreme ground motions on soil response
3.1 Random Vibration Theory
3.2 Implementation of new site response methods

- Multiple methods allowed in NUREG 6728
  - Theoretical framework but few details
  - methods 2A, 3 and 4
  - Only recently used
  - Implementation details differ between practitioners (including document authors)
  - Not clear how similar results are

- Multiple modeling tools currently in use
  - Non-linear methods
  - equivalent-linear (SHAKE)
  - Random Vibration Theory (RVT)

Active Projects
3.3 Deaggregation frequencies
3.4 High frequency coherency
3.5 Development of time-histories as inputs to analyses

Upcoming Projects & Monitored Projects
New Regulatory Guide 1.208

• “A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion”
• Safe Shutdown Earthquake Ground Motion (SSE)
  – 10,000 year probabilistic motion with design factors
  – Targets frequency of onset of inelastic behavior
• Operating-Basis Earthquake Ground Motion (OBE)
  – Half of SSE loading
  – plant must be closed and inspected
• Soil-Structure-Interaction Guidance under development
Integrated PSHA & Site Response

Find effects of all possible earthquakes, weight each by the likelihood will actually happen in a given year, combine the events
Integrated PSHA & Site Response

- What is the best method?
- When does it matter?
- How do we increase availability of software & knowledge?
NGA-East

• Follows up on “Next Generation Attenuation Relationship” project

• Approach
  – Standard agreed upon assumptions
  – Standard and complete database
  – Development program first to scope project and bring in multiple agencies
  – Cooperative agreement
  – USGS in-kind participation in development project

• Products needed to
  – Update NUREG-6728
  – Develop technical basis to replace RG1.60 standard spectrum used for foundation level check

• Doing preliminary work
  – Technical Basis for assumptions
  – Development of earthquake record database
SSHAC Guidelines

• “Recommendations for PSHA: Guidance on Uncertainty and Use of Experts” NUREG/CR-6372
• Senior Seismic Hazard Analysis Committee (SSHAC) sponsored by NRC, DOE & EPRI
• General framework but limited practical details
• Much has been learned in trying to apply SSHAC
  – Yucca Mountain (two level 4s – seismic and volcano)
  – PEGASOS (level 4)
  – EPRI (level 3)
• Need practical recommendations how to apply and how to update (NUREG)
Northeast (NESZ)
Charleston (CSZ)
New Madrid (NMSZ)
Eastern Tennessee (ETSZ)
Key NRC issues

• Staffing needs (seismic background)
• Research constrained by NRC regulatory requirements and needs
  – Risk-informed, performance-based focus
  – Development of regulatory guidance
  – Development of analysis tools
Workshops/Working Group and “Next Generation” approaches

- NRC started discipline, but it matured in western US
- Seismic research moving from Ad Hoc
  - Different databases, gray literature, proprietary reports, proprietary software
- Moving to workshops, working groups and “next generation” approaches
  - Common databases & inputs, community consensus, documentation of thought processes, outliers & uncertainties better understood
Workshops/Working Group and “Next Generation” approaches

• Same, complete, and agreed upon data sets and information
• All key experts in the research area involved
• “Next Generation” implies fundamental redevelopment of technical tools or approaches
• Both best estimates & estimates of uncertainties
M_{\text{max}} Workshop

- $M_{\text{max}}$ is largest magnitude for a source
- Issue for area sources in CEUS for long return periods (impacts NRC more than others)
- Currently very limited technical basis for decision
- Follows “best practices” for seismic workshops
  - Foundation document compiled & sent to participants before workshop for review. Also downloadable at USGS.
  - All key researchers sponsored, but open to anyone
- Results incorporated into USGS database used for NRC PSHA reviews & used for review of EPRI database.
Next Generation Attenuation

NGA-East

Natural Variability

NGA 2006, SS, M=7, Vs=760

Peak Acceleration (g)

Distance (km)

0.01 0.1 1

Uncertainty in Attenuation
Magnitude

STEP 3
Ground Motion Attenuation

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment
• Went from ad hoc to unified approach
• Mutually agreed databases, technical bases & assumptions
• Epistemic uncertainties reduced and characterized
• Broad community consensus (removed points of
Proposed Coherency Method Validation and Ramifications

Wave Passage Effects

Scattering Effects

• Scattering causes high frequency waves to lose coherency (they become random)

• Building foundations damp out incoherent motions
Proposed Coherency Method Validation and Ramifications

![Graph showing spectral acceleration vs. frequency]

- **5% Damping**
- **Horizontal**
- **Vertical**
- **RG 1.60 Horizontal (ZPA=0.3g)**
- **RG 1.60 Vertical (ZPA=0.3g)**
Proposed Coherency Method Validation and Ramifications

- Reduces translation but increases rocking and torsion
- Not analyzed in time domain SSI model
- Need staff guidance document
3.9 Deeply embedded structures

3.6 Performance-Based design techniques in the design of SCCs (integrated with update of RG 1.122)

Active Projects
Upcoming Projects
Monitored & Long Term Projects

3.7 Service and age related degradation of SCCs (external research on Structural Health Monitoring and foreign lessons)

3.8 Shake table inputs for IEEE Standard updates (discussions with industry on high frequency)

3.10 Lateral earth pressures on deep foundations

3.11 Base-Isolation systems

3.12 Post processor for P-CARES

3.13 Advanced Reactor Designs
2.11 Tsunami

- Continued tsunami source development with USGS
  - Phase 1 report being used by NRC staff and industry
  - Reviewed & referenced by ACRS members

- Continued development of modeling capabilities with USGS and NOAA
  - NRO setting up contracts with USGS Modelers
  - ACRS interested in Canary Islands results (fast tracked)

- RIL requested to support NRO review of South Texas
1.100 Electrical & Mechanical
1.122 Floor Design Spectra/SSI
1.12 Seismic Instruments-Plants
3.17 Seismic Instruments-Waste
1.198 Liquefaction
1.138 Geotechnical Lab testing
1.132 Geotechnical Investigations
1.166 Seismic Emergency Response

- Some revisions limited and some extensive
- Some require development of modern technical bases (e.g. 1.198 & 1.122)
- Long term planning required
International Projects

• IAEA EBP on Seismic Hazard (and/or specific Collaborative Research on Lessons Learned in the K-K Nuclear Power Plant)
  – Best path TBD in December
  – Supports NRO NRR user need coming within the month
• IAEA EBP on Tsunami Hazard
• IAEA Program to Update Hydro-Meteorological Guidance
  – to Include Tsunami and Global Warming
• Collaborative Seismic Research with Japan on Large Scale Testing and Analysis
  – On-going long-term
• Committee on the Safety of Nuclear Installations
  – On-going long-term
• Participation in SMART-2008 Seismic Benchmark
  – On-going start in 2007