



Dr. Annie Kammerer

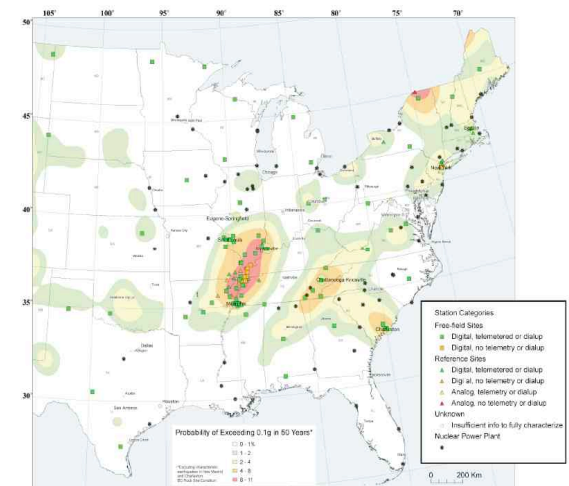
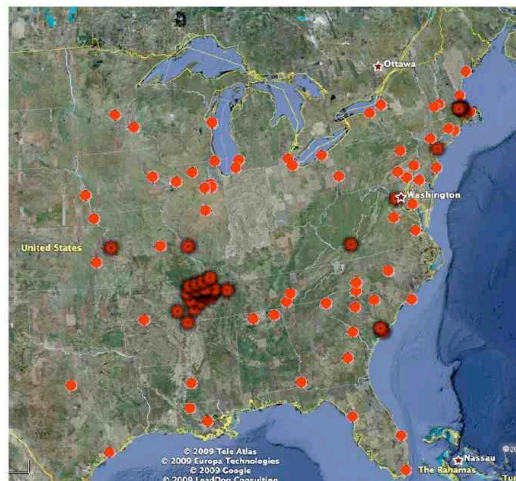
Seismic Instrumentation
Technology Symposium

November 2009

**Seismic Instrumentation and Monitoring
Needs of US Nuclear Power Plants**

- 104 operating reactors in US
- Possibly 35 new reactors in coming years
- Approximately 23 applications in the NRC
 - New plant Combined Operating Licenses
 - Design Certification Documentation
- 3 Early site permits and 1 Certified design

NRC and Nuclear Plants Today



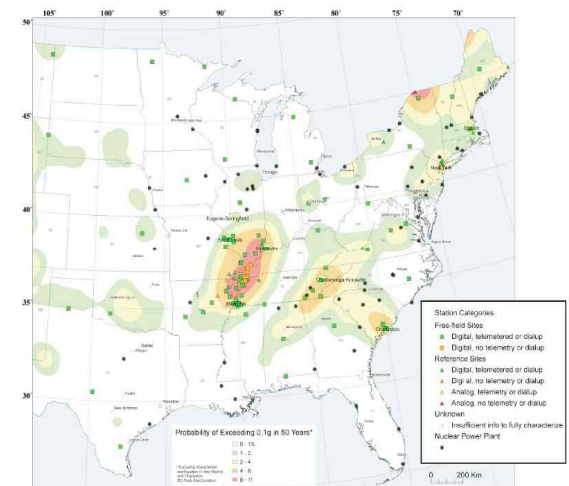
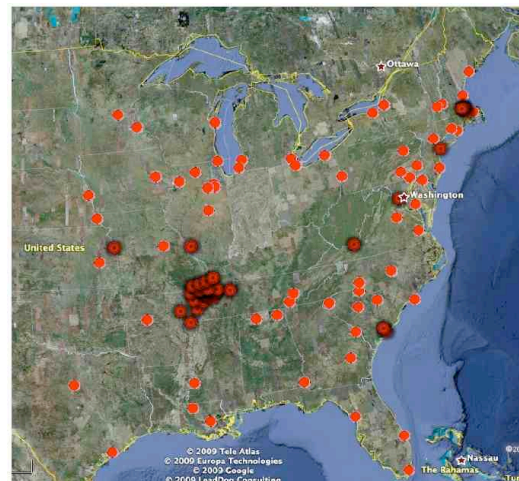
NRC is focused on:

- In-plant instrumentation
- ANSS & regional seismic networks

Instrumentation needed for:

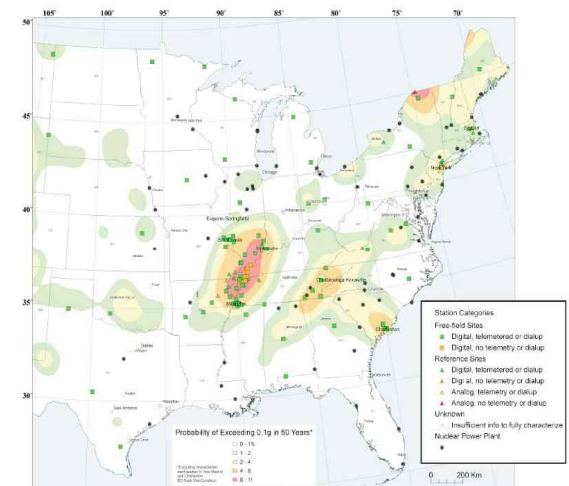
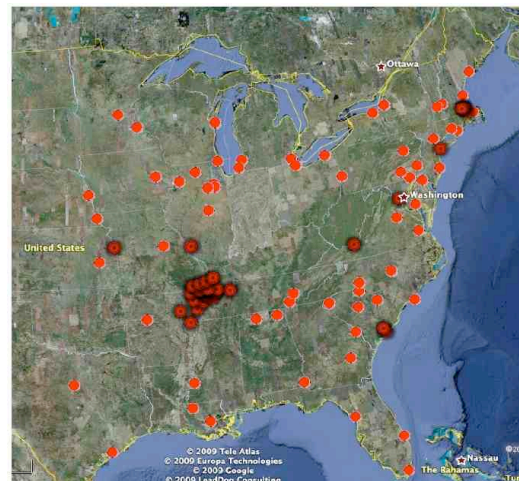
- Seismic hazard characterization
- Earthquake monitoring and post-quake analysis

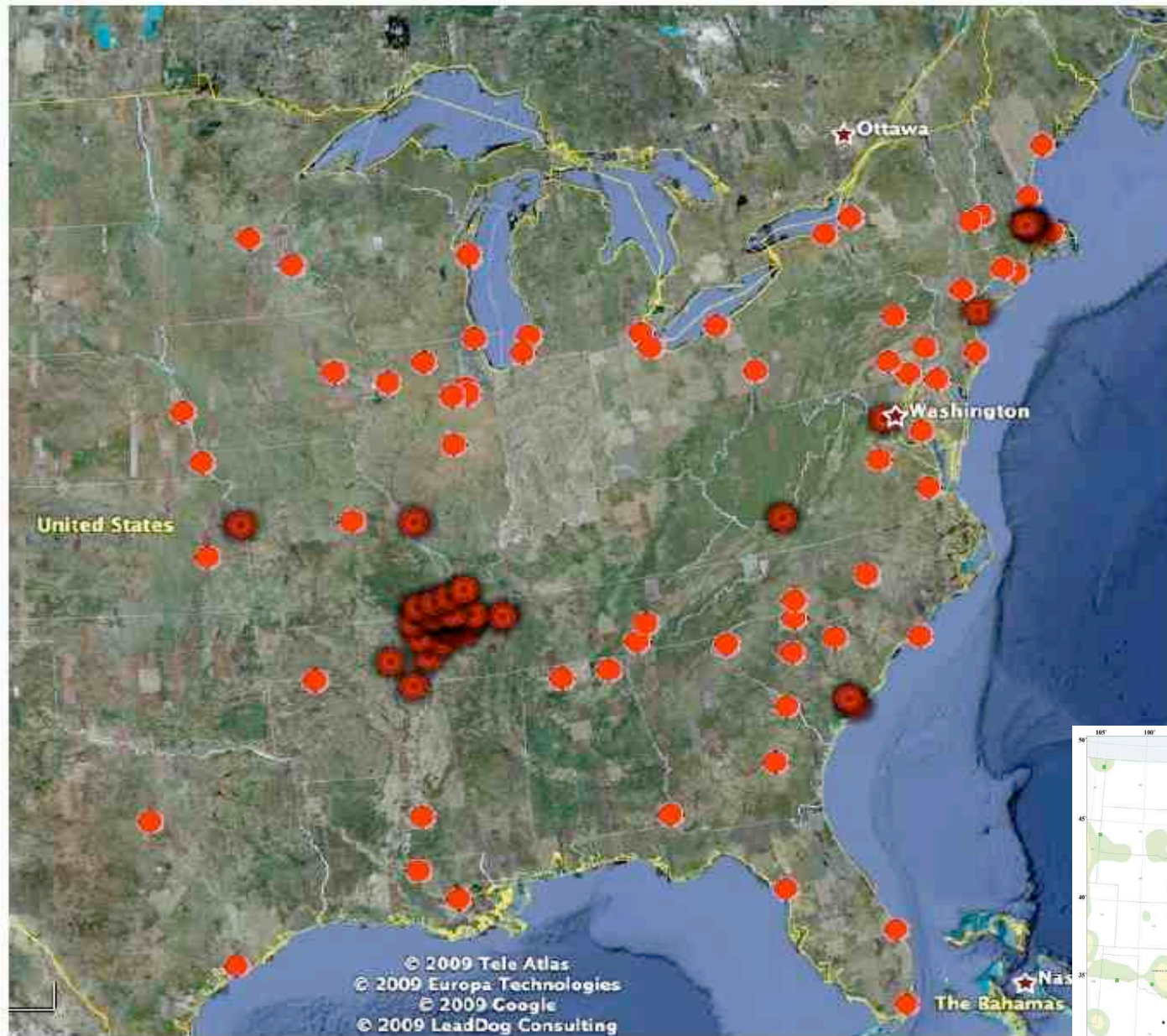
NRC Instrumentation Needs



- ANSS/NRC reports on current capabilities and on options for collaboration under development
- Potential for high frequency input motions
- Seismic hazard characterization
 - Depth control
 - Greater coverage for small events
 - Ability to capture a large event
- Interested in research on rotational seismographs

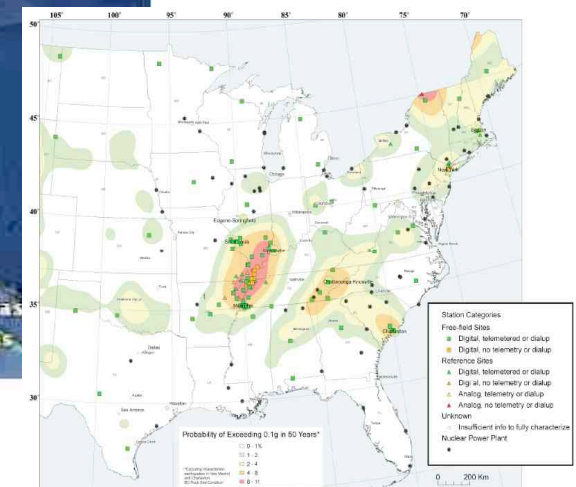
NRC Instrumentation Needs: ANSS





From ANSS
 report to NRC
 on current
 capabilities

Map of Strong
 motion stations
 and NPPs



NRC Instrumentation Needs

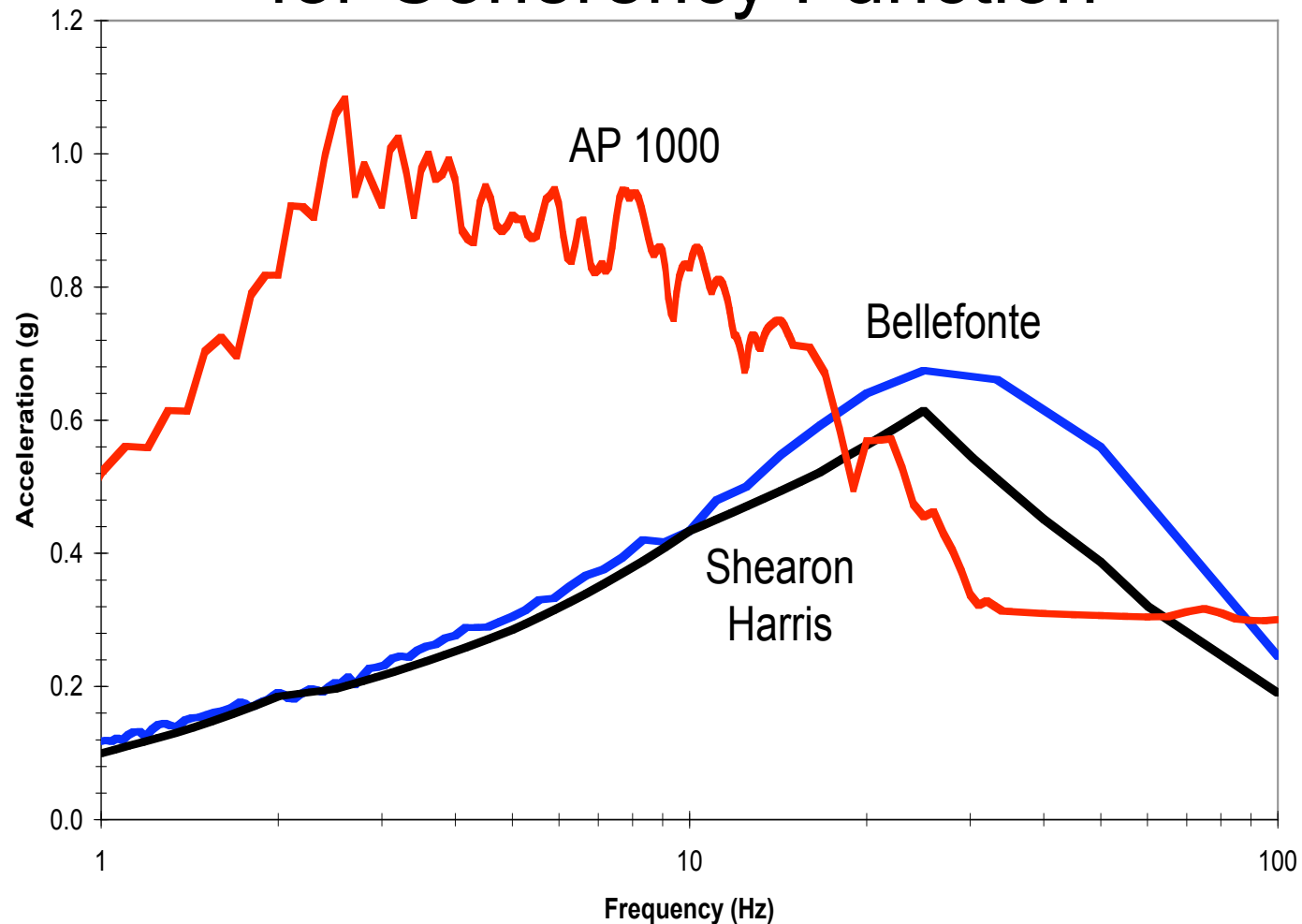
- Code of federal regulations requires instruments
- Regulatory Guide 1.12 describes instrumentation
 - Revision 3 under development
 - Undertaken in coordination with ANS standard update
 - Placement in free field, foundation and structure
 - Frequency range under discussion (in-structure needs differ from free field)
- Licensing basis spells out legal operating requirements for each plant
 - CEUS plants do not have automatic SCRAM
 - Instruments are not safety-related equipment
 - NRC is discussing ways to allow equipment upgrades

NRC In-Plant Instrumentation Requirements

- Operating Basis Earthquake (OBE) is legally defined in Licensing Basis
 - Typically $\frac{1}{2}$ to $\frac{1}{3}$ of Safe Shutdown Earthquake (SSE)
 - If both OBE motions and CAV criteria are exceeded the plant must shutdown within 4 hours
- Regulatory Guide 1.66 describes recommended criteria for shutdown if equipment is unavailable
 - Greater than MMI VI or greater within 5 km of plant
 - Earthquake was felt within the plant and was of magnitude 6 or greater
 - Magnitude 5 or greater within 200 km of the plant
 - Used as guidelines for NRC staff for request to plant

NRC In-Plant Instrumentation Requirements

High Frequency Issues and Motivation for Coherency Function



Comparisons are between certified design spectra and 10^{-4} site specific spectra

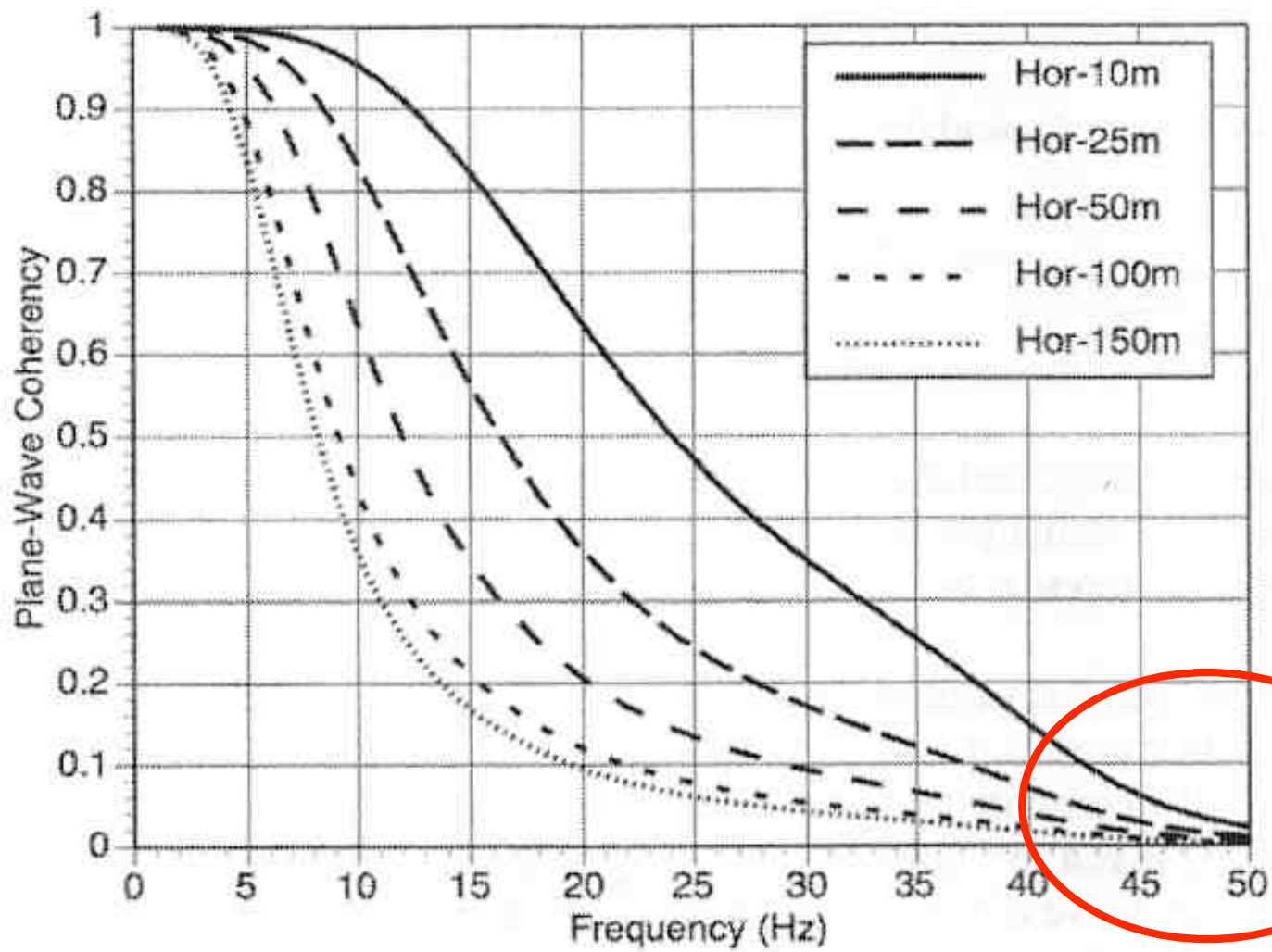
Coherency Function

- EPRI (Abrahamson) relationship accepted in NRC Interim Staff Guidance

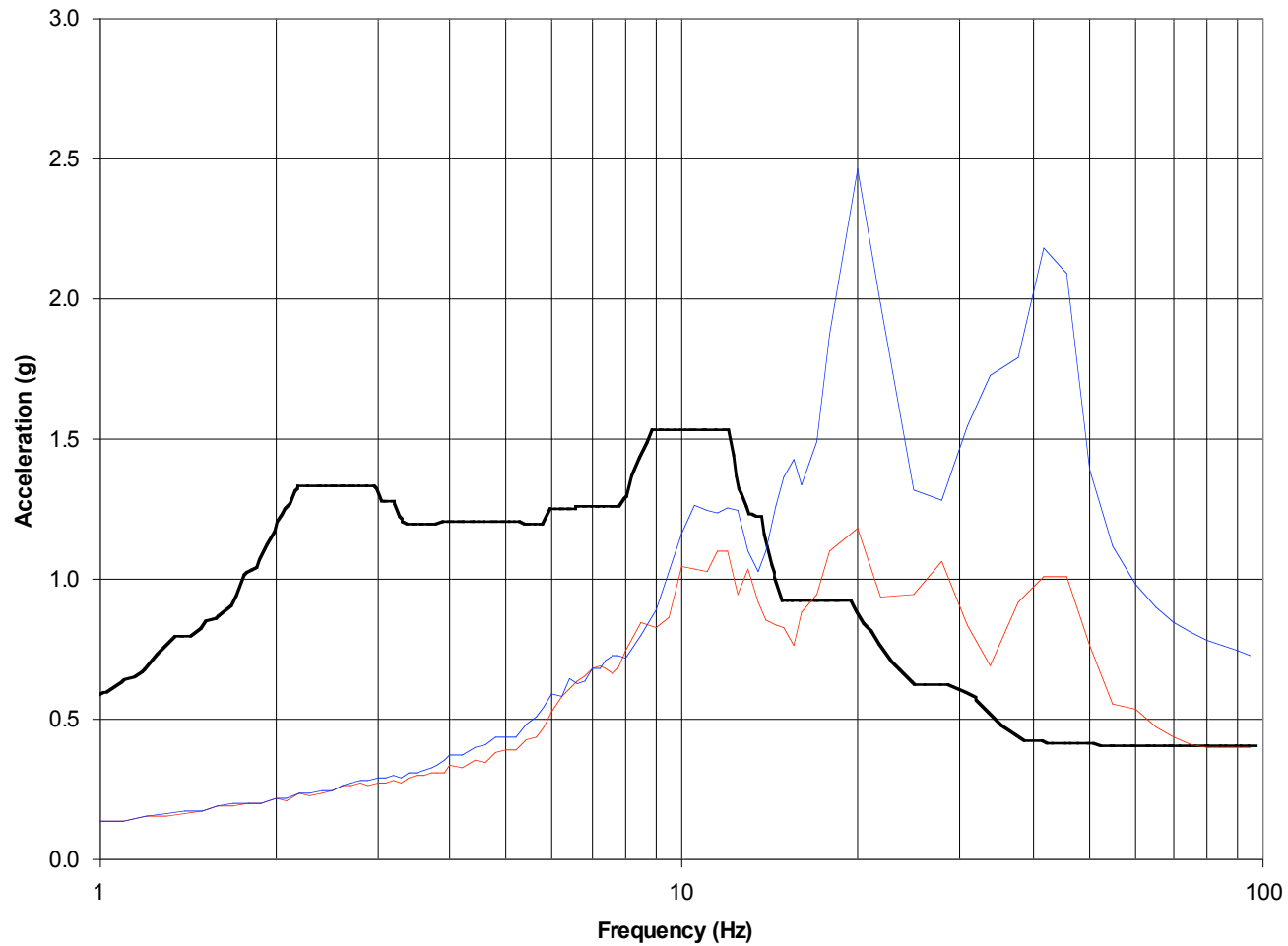
$$\gamma_{pw}(f, \xi) = \left[1 + \left(\frac{f \operatorname{Tanh}(a_3 \xi)}{a_1 f_c(\xi)} \right)^{n_1(\xi)} \right]^{-1/2} \left[1 + \left(\frac{f \operatorname{Tanh}(a_3 \xi)}{a_2} \right)^{n_2} \right]^{-1/2}$$

Coeff	Horiz Coeff
a_1	1.0
a_2	40
a_3	0.4
$n_1(\xi)$	$3.80 - 0.040 * \ln(\xi + 1) + 0.0105 [\ln((\xi + 1) - 3.6)]^2$
n_2	16.4
$f_c(\xi)$	$27.9 - 4.82 * \ln(\xi + 1) + 1.24 [\ln((\xi + 1) - 3.6)]^2$





Motivation for Coherency Function



Comparisons are made within the structure

- NRC is interested in both In-Plant and ANSS networks for multiple reasons including hazard assessment and plant monitoring
- In-Plant instruments typically wouldn't see very high frequencies due to structural response ($\gg 50$ Hz), but free-field instrumentation at high frequencies are needed for understanding loads
- NRC currently revising RG1.12 in conjunction with ANS standard revision.
- NRC staff are interested in finding a way to allow plants to update their instruments without impacting licensing basis

SUMMARY



Thank You

**Seismic Instrumentation and Monitoring
Needs of US Nuclear Power Plants**