Dr. Annie Kammerer

Seismic Instrumentation
Technology Symposium

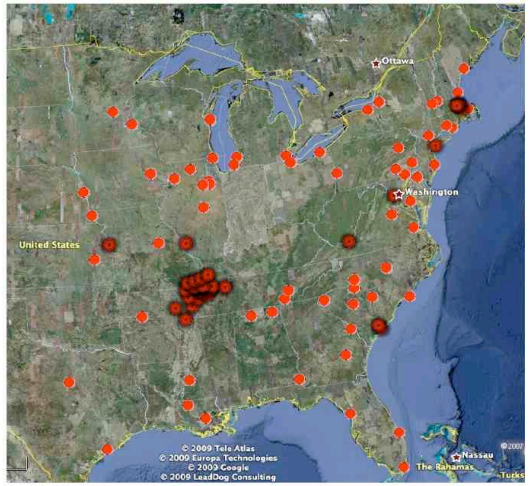
November 2009

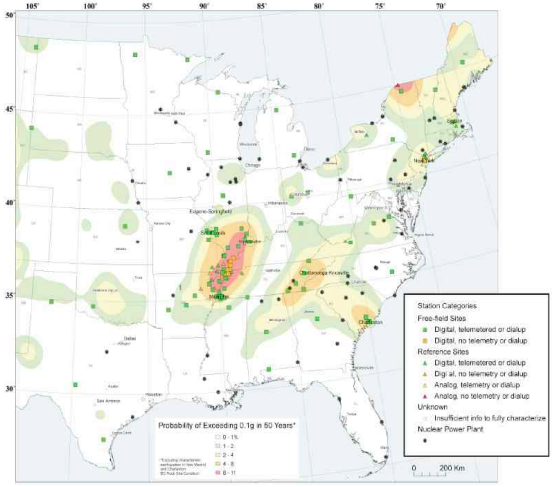
Seismic Instrumentation and Monitoring Needs of US Nuclear Power Plants

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

- 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





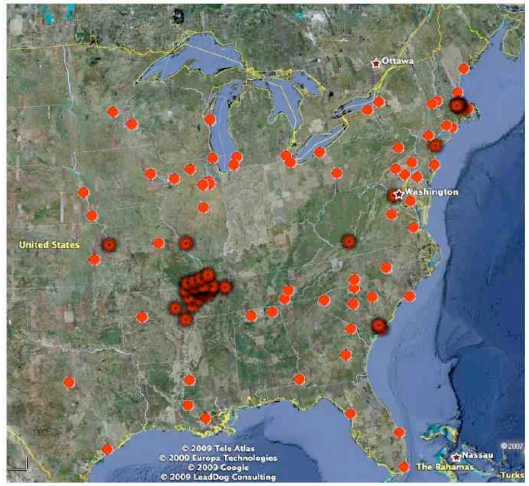
NRC is focused on:

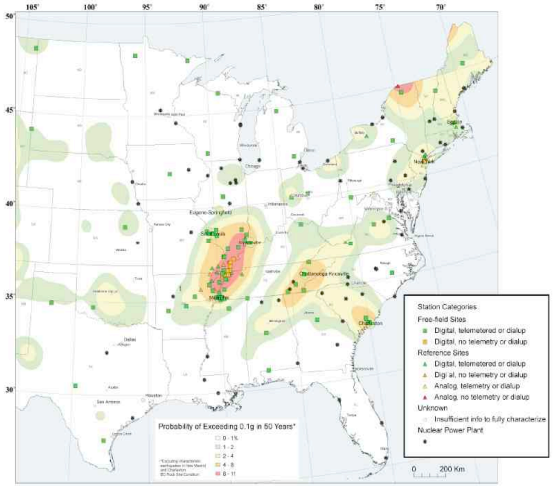
- In-plant instrumentation
- ANSS & regional seismic networks

Instrumentation needed for:

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

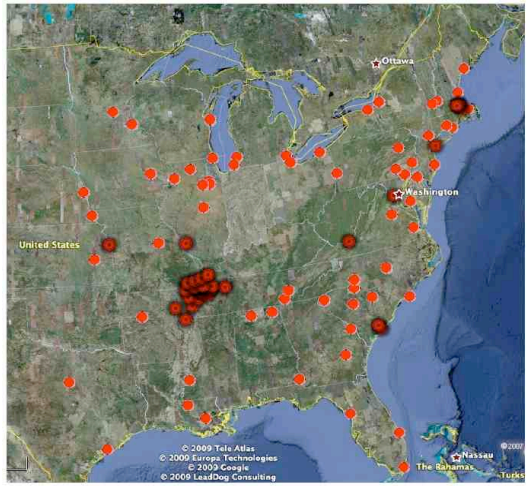
NRC Instrumentation Needs

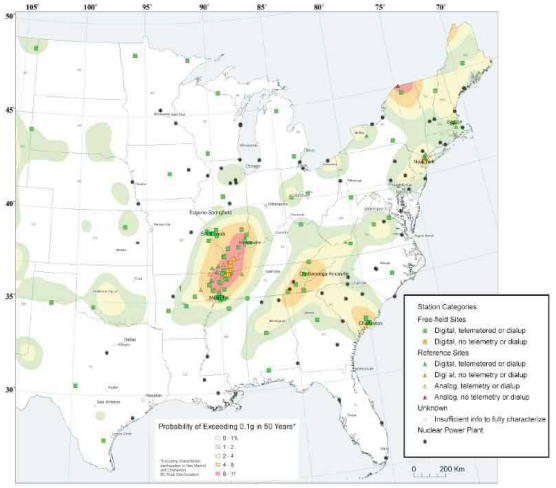


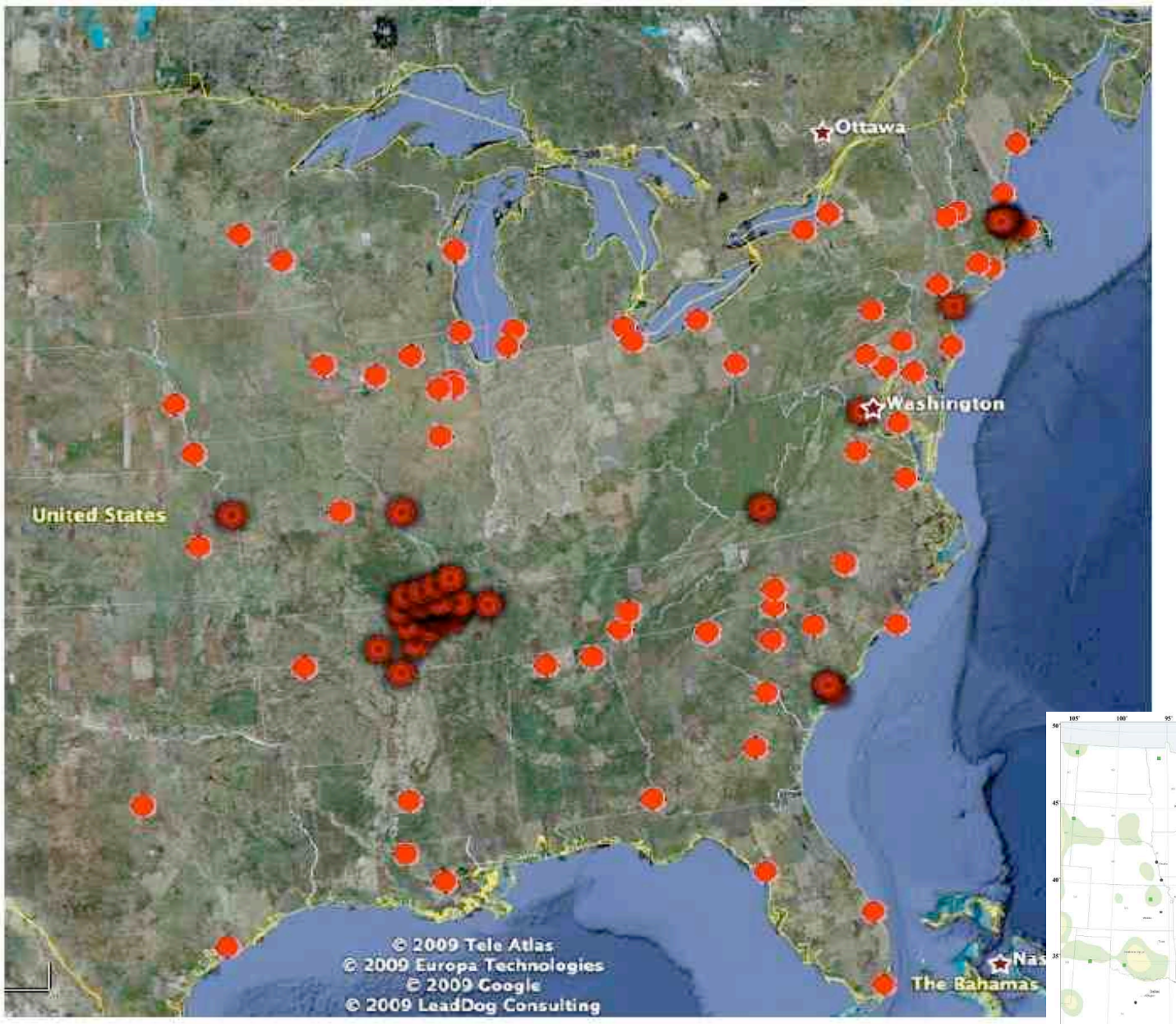


- ANSS/NRC reports on current capabilities and on options for collaboration under development
- Potential for high frequency input motions
- Seismic hazard characterization
  - Depth control
  - Greater coverage for small events
  - Ability to capture a large event
- Interested in research on rotational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

NRC Instrumentation Needs: ANSS

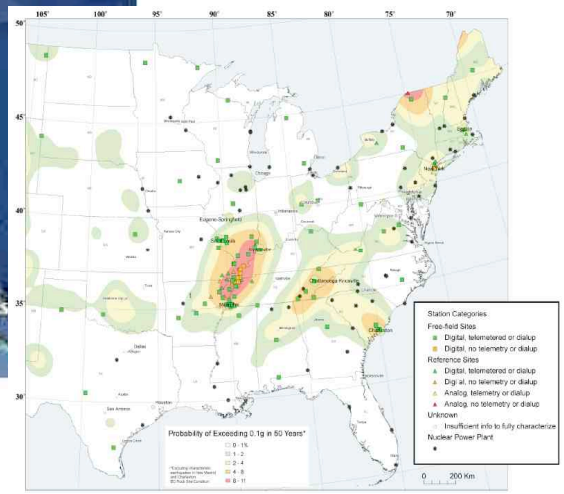






From ANSS report to NRC on current capabilities

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

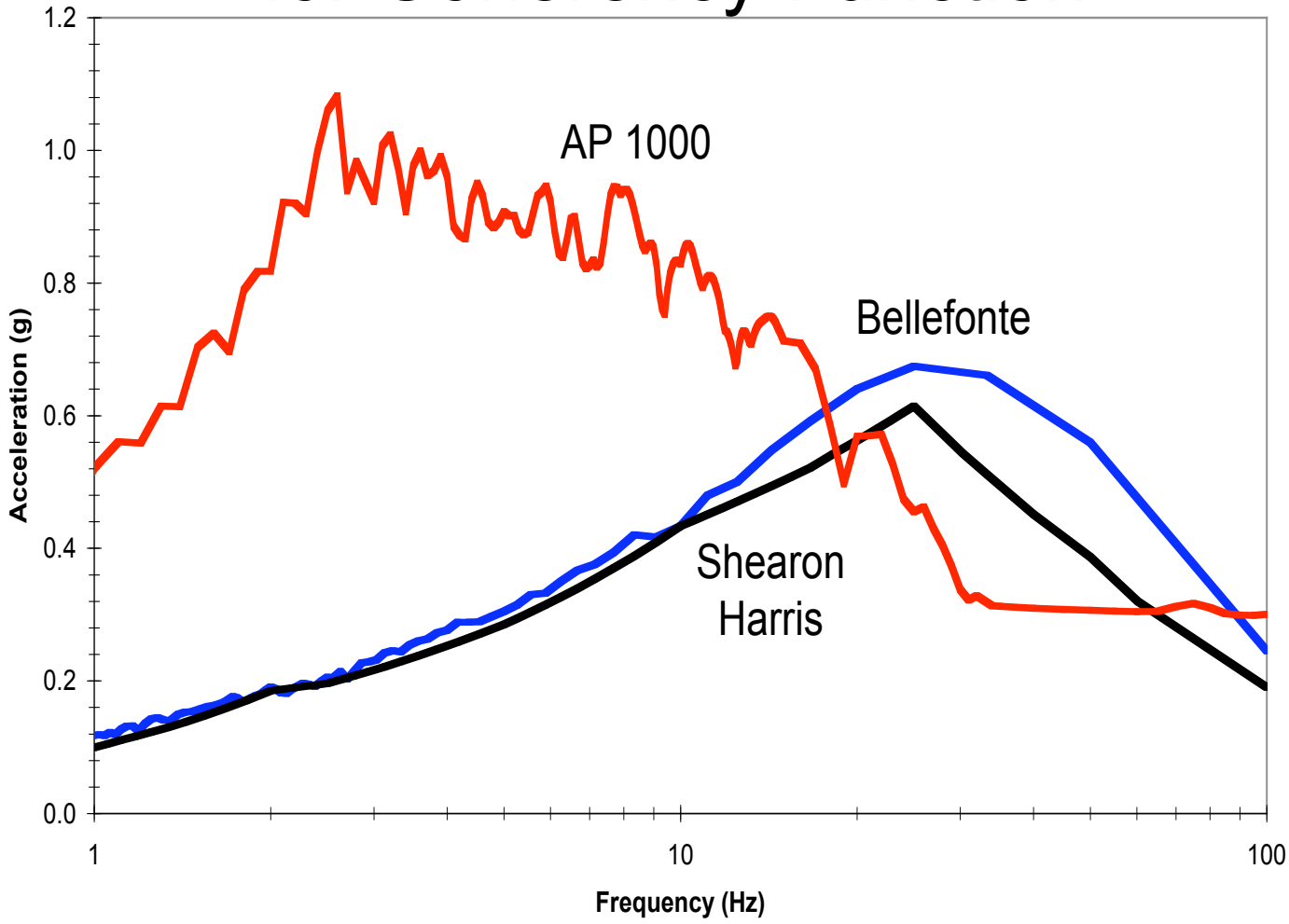
NRC In-Plant Instrumentation Requirements

- Operating Basis Earthquake (OBE) is legally defined in Licensing Basis
  - Typically ½ to 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



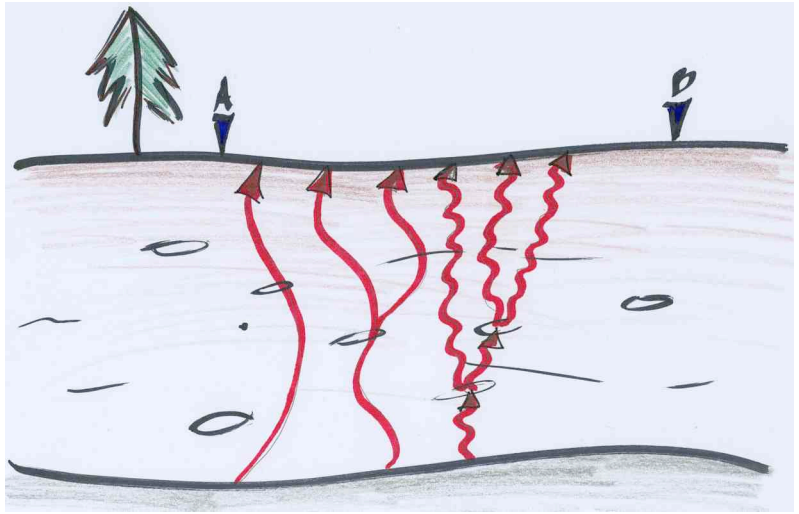
Comparisons are between certified design spectra and 10^{-4} site specific spectra

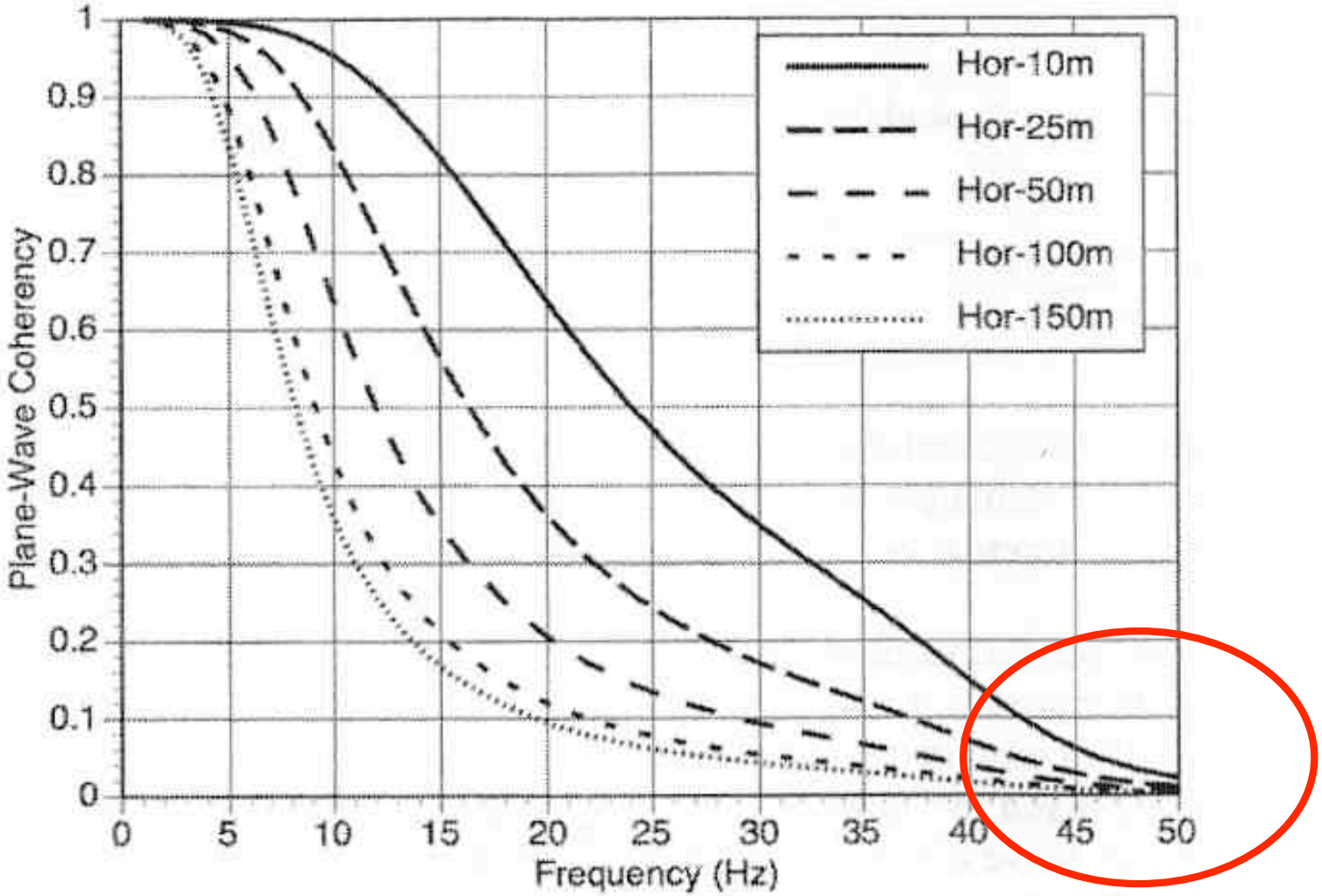
Coherency Function

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

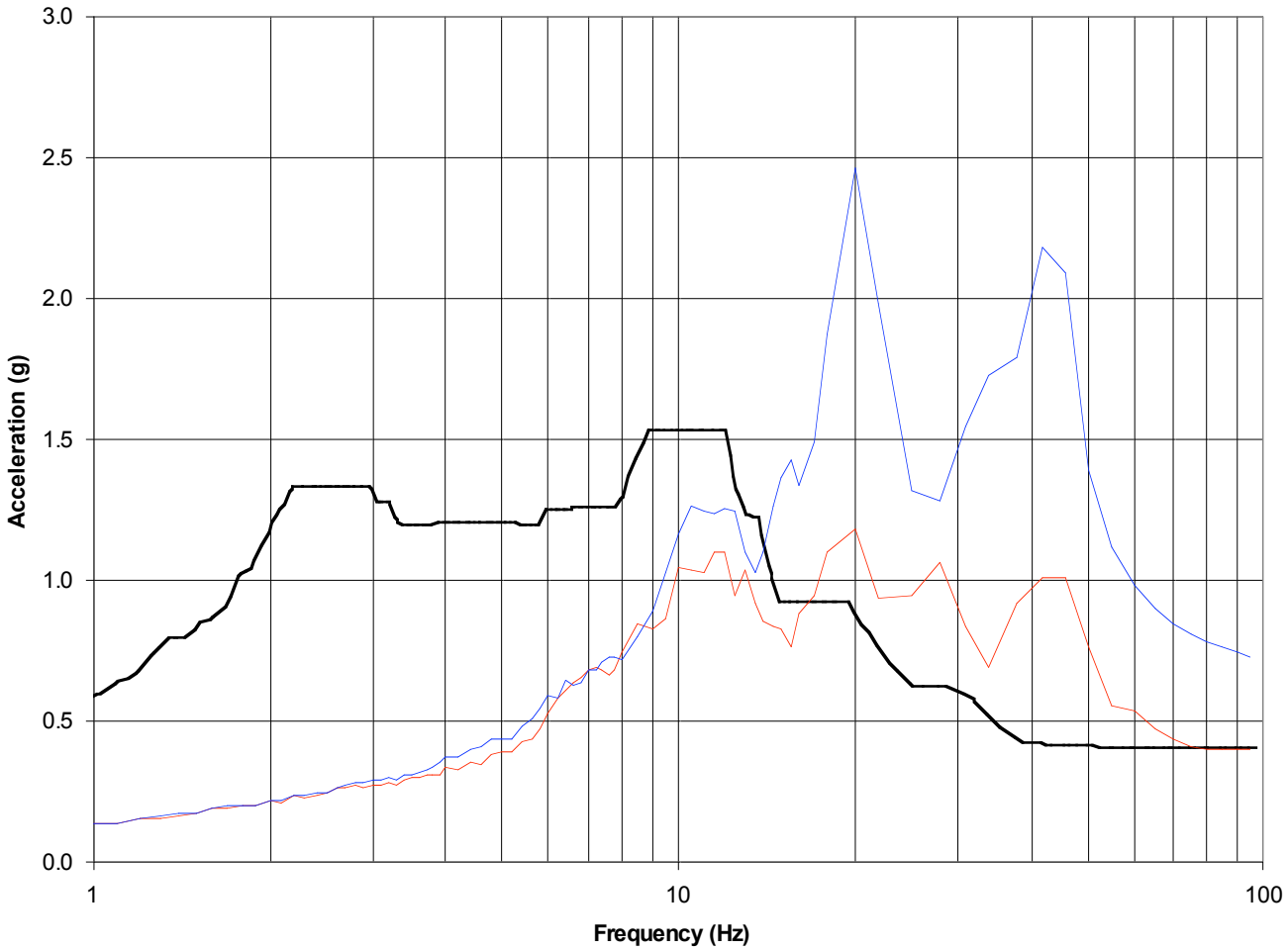
$$\gamma_{pw}(f,\xi)=\left[1+\left(\frac{f\ Tanh(a_3\xi)}{a_1 f_c(\xi)}\right)^{n1(\xi)}\right]^{-1/2}\left[1+\left(\frac{f\ Tanh(a_3\xi)}{a_2}\right)^{n2}\right]^{-1/2}$$

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
$f_c(\xi)$	$27.9-4.82*\ln(\xi+1)+1.24[\ln((\xi+1)-3.6]^2$




Plane-Wave Coherency
Frequency (Hz)
Hor-10m
Hor-25m
Hor-50m
Hor-100m
Hor-150m
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
5
10
15
20
25
30
35
40
45
50

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 (>>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

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