Sensitivity Studies for Evaluating SSI Effects for Seismically Base-Isolated NPP Structures. PART 2:Probabilistic SSI Analysis

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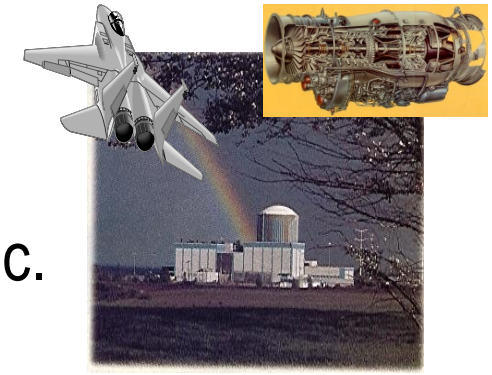


DANS Meeting for ASCE 43 Standard
San Diego, November 5-6, 2015

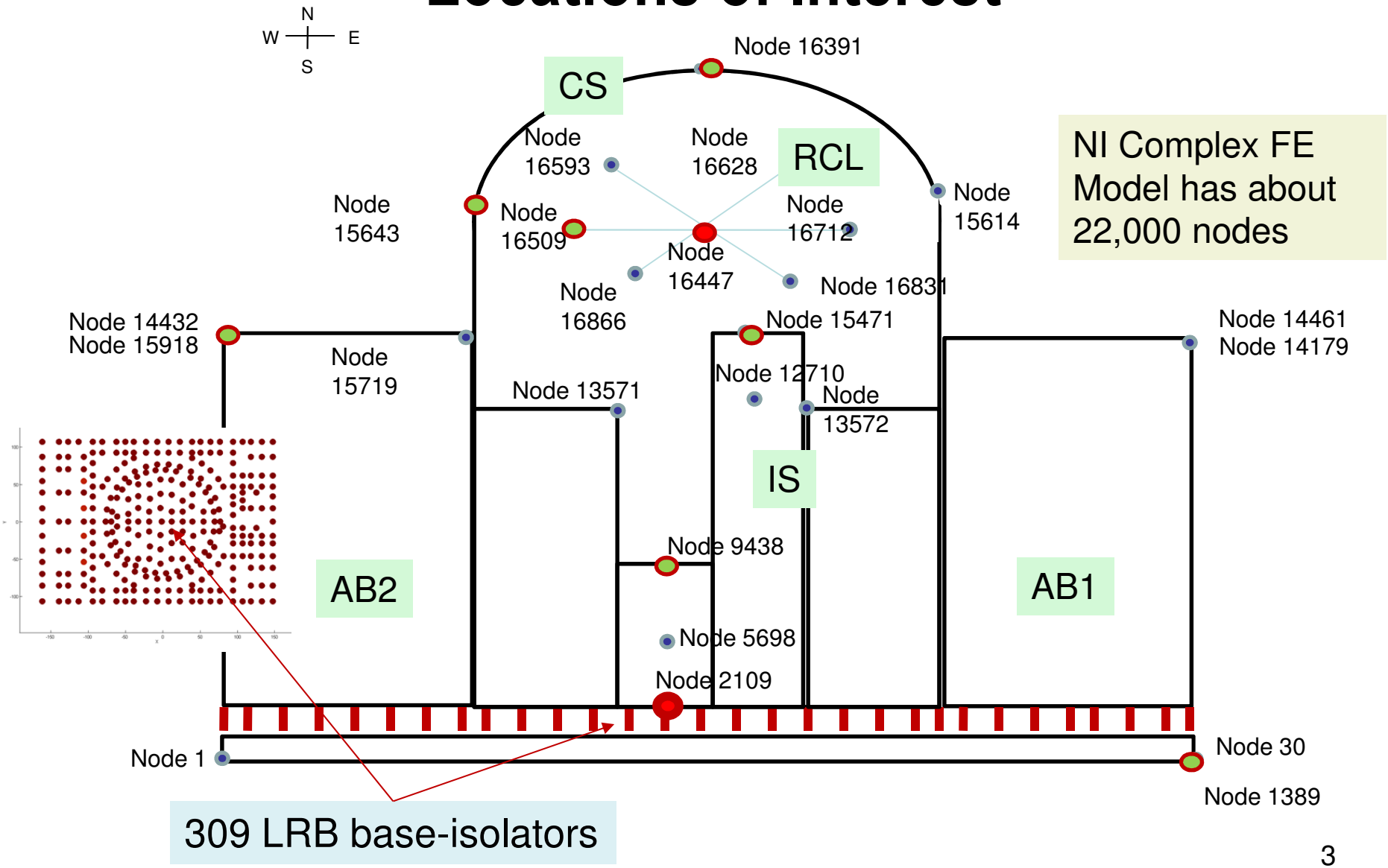
Purpose of This Presentation:

To investigate the effects of base isolation on seismic SSI response of a typical NI complex under coherent and incoherent motions using probabilistic and deterministic SSI analyses.

How will the base-isolation SSI effects for the NI complex differ if we use probabilistic SSI analysis vs. deterministic SSI analysis?

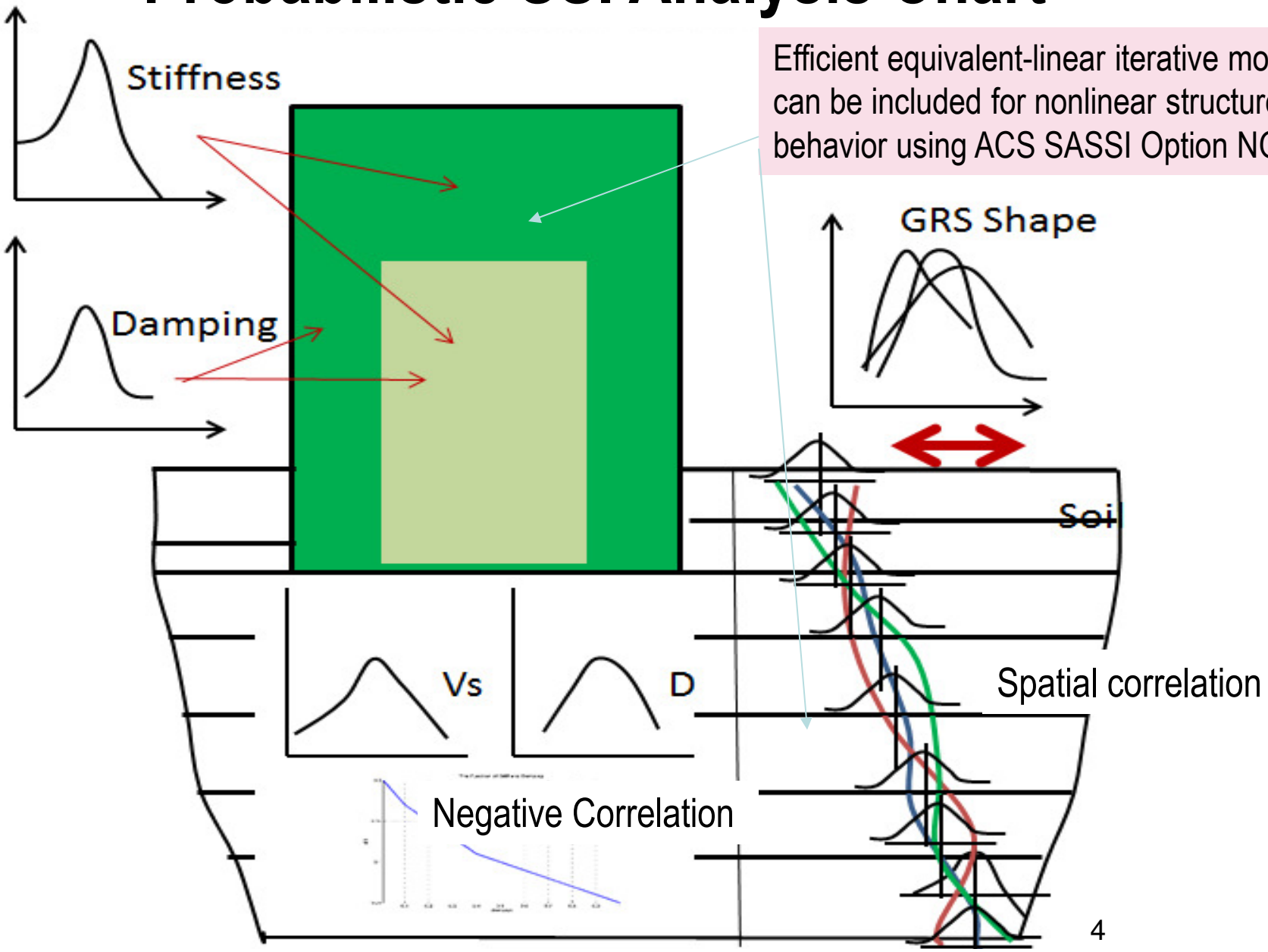
The probabilistic SSI analyses follow the recommendations of the new ASCE 04-2015 standard draft

Typical Nuclear Island Complex Model. Locations of Interest



NI Complex FE Model has about 22,000 nodes

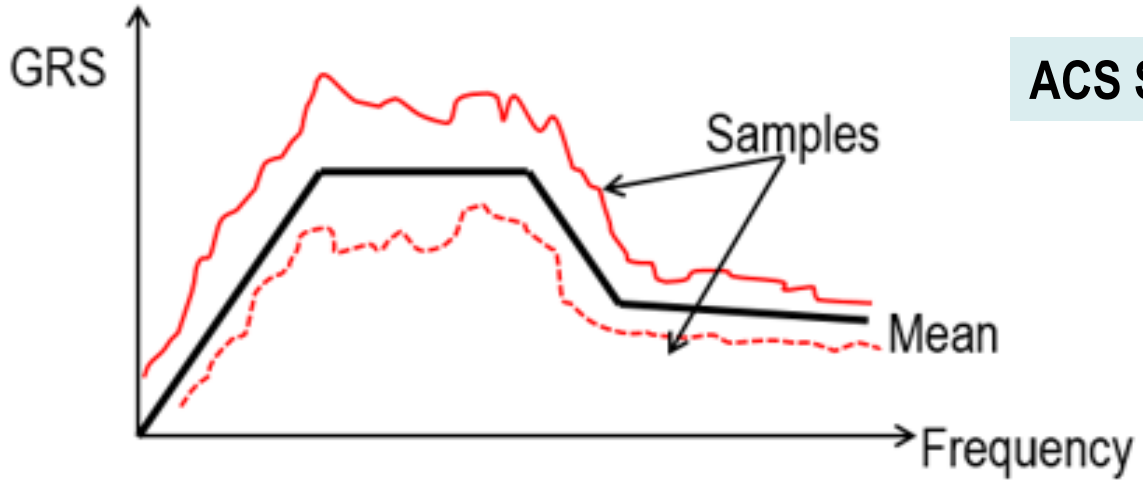
Probabilistic SSI Analysis Chart



Efficient equivalent-linear iterative models can be included for nonlinear structure behavior using ACS SASSI Option NON

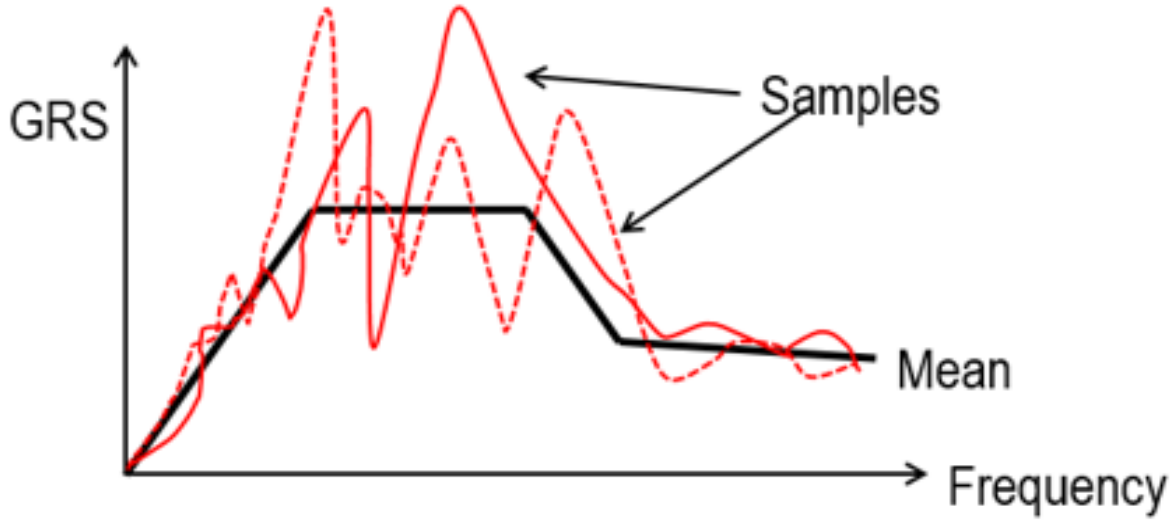
Probabilistic Seismic Input Models

ASCE 04-2015 Method 1

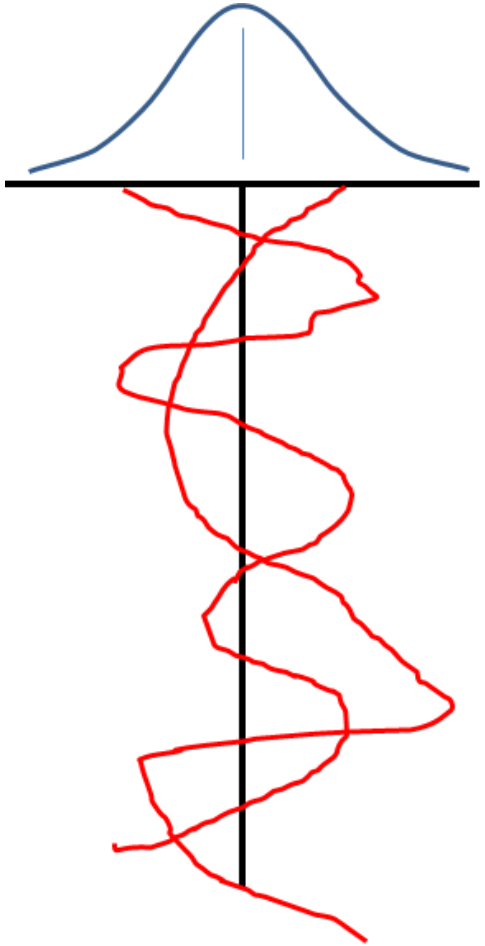


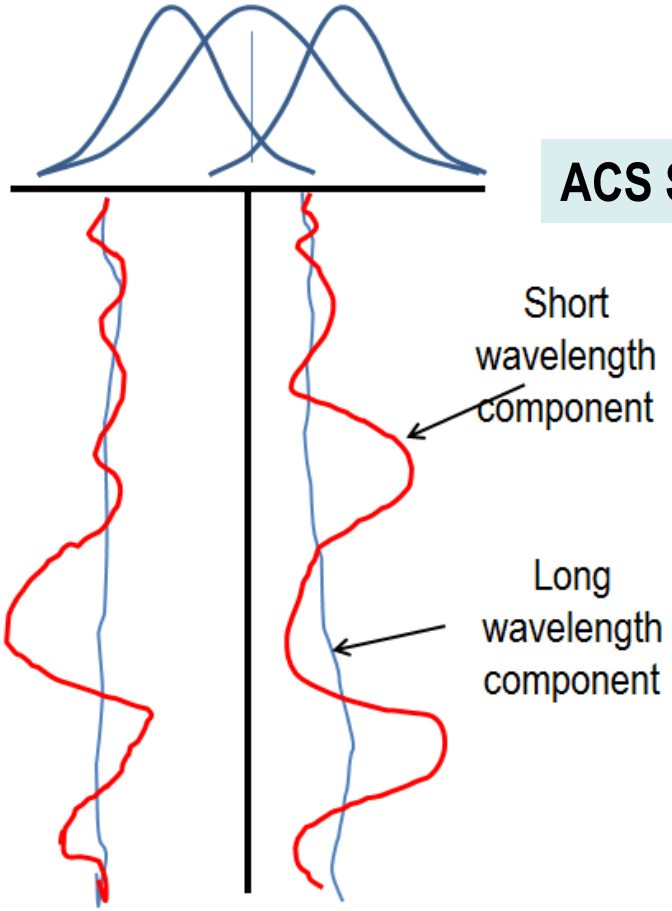
ACS SASSI Option PRO

ASCE 04-2015 Method 2



Vs and D Soil Profile Probabilistic Models. Two Variation Scale Models Based on Field Data



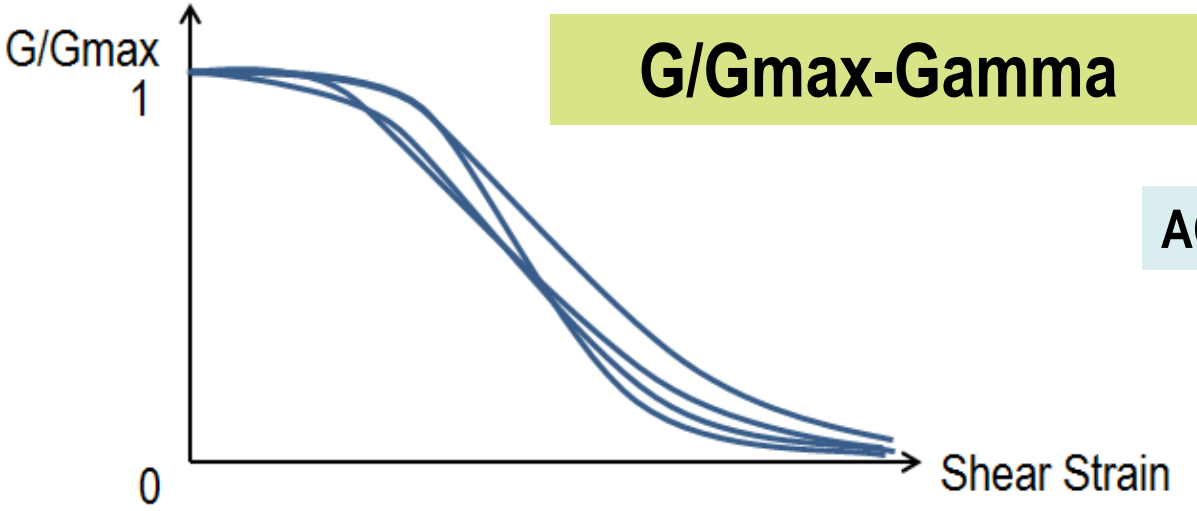


ACS SASSI Option PRO

Model 1 (Simple)

Model 2 (Composite)

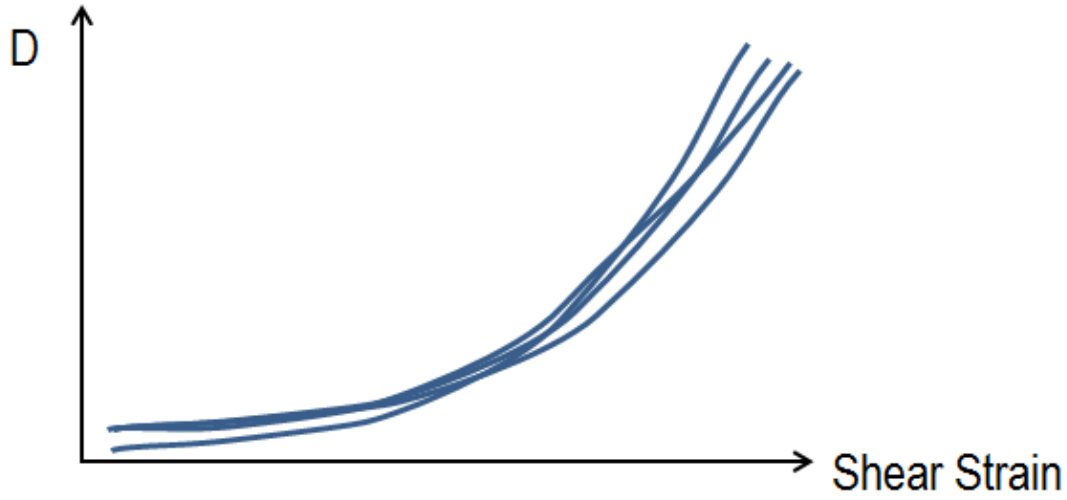
Probabilistic Soil Layer G/Gmax and D Curves



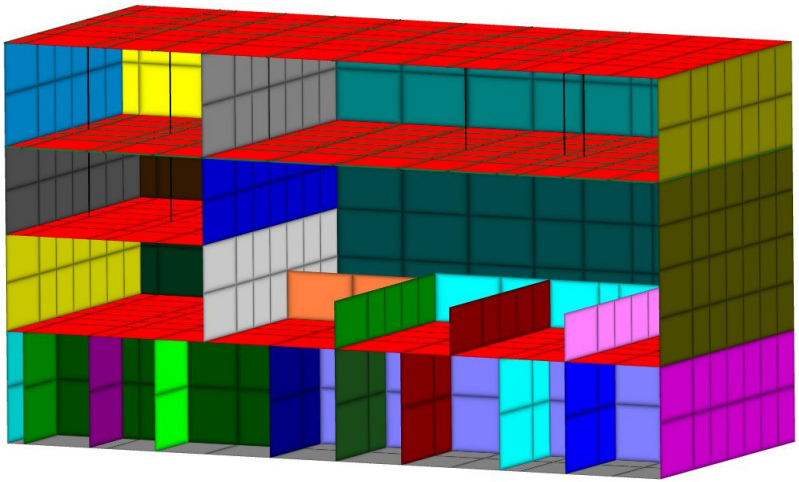
G/Gmax-Gamma

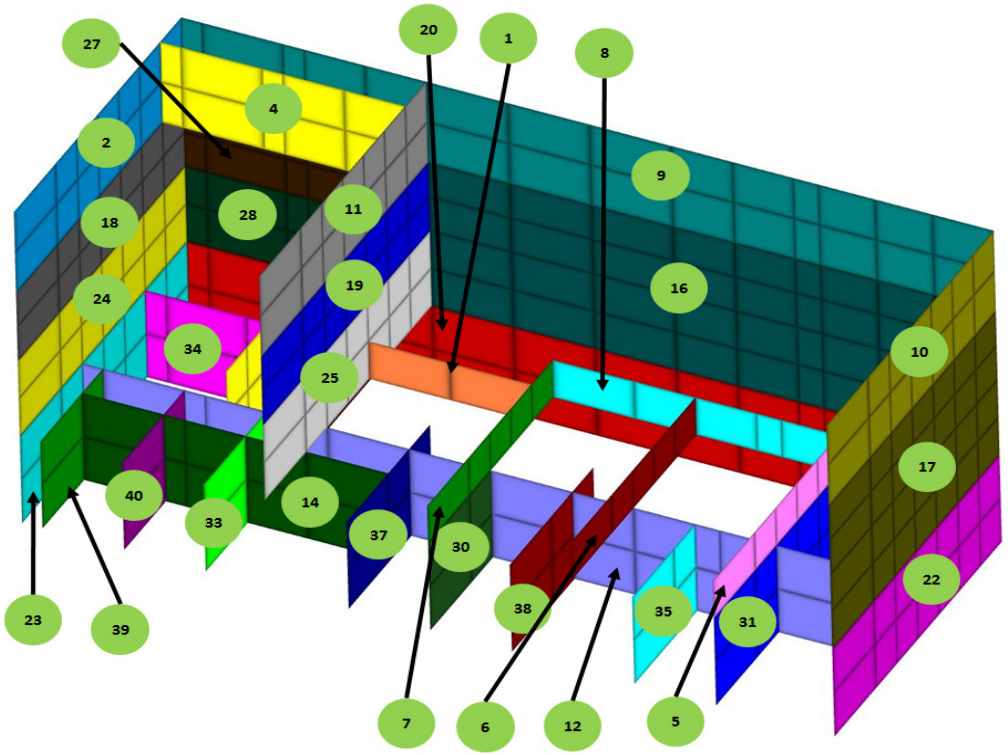
ACS SASSI Option PRO

D-Gamma



Probabilistic Effective Stiffness K and Damping D





Combining ACS SASSI PRO and NON provides more accurate values for the effective K and D for each wall panel and for each SSI input simulation.

Nonlinear concrete behavior NEGLECTED!

Probabilistic SRA and SSIA Comutational Steps

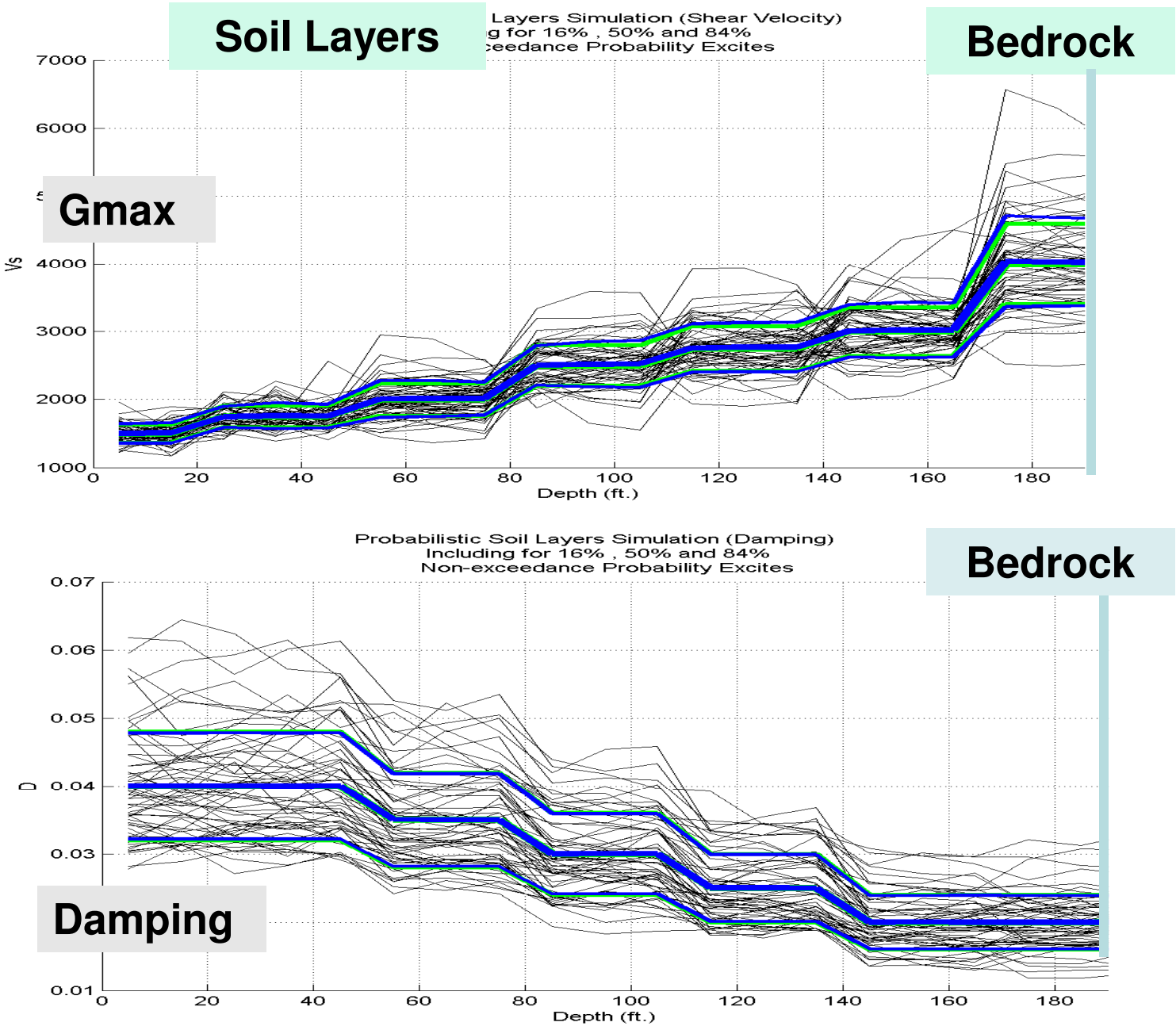
For a full probabilistic analysis three steps need to be completed:

1) ***PREPARE SSI INPUTS:*** Using *ACS SASSI PRO preprocessing modules,* generate statistical ensembles for probabilistic input simulations for Probabilistic SRA and/or Probabilistic SSI analysis *(ProEQUAKE, ProSITE, ProSOIL, ProHOUSE, ProMOTION and ProSTRESS)*

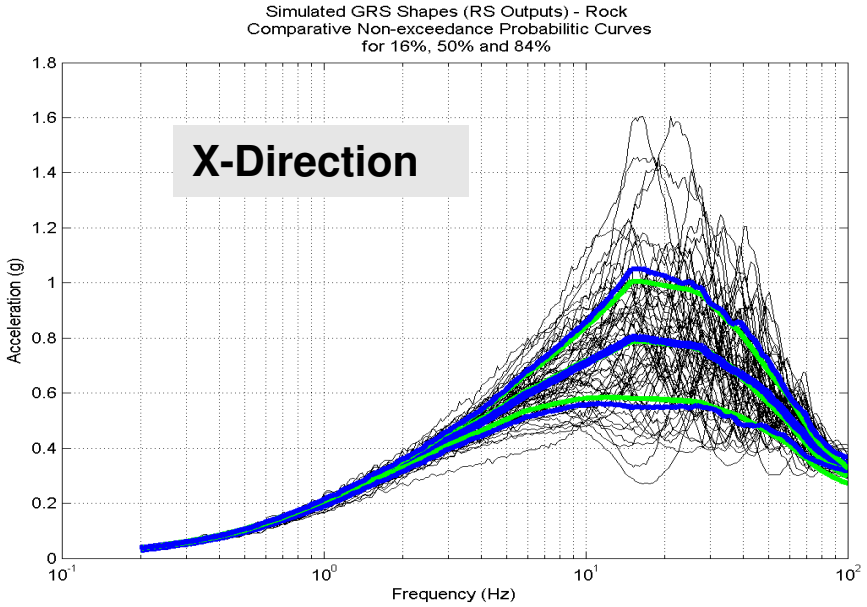
2) ***EXECUTE SSI ANALYSIS:*** Using *ACS SASSI deterministic modules,* run simulated input files to compute the SSI response simulations (SITE, SOIL, HOUSE, ANALYS, MOTION, RELDISP, STRESS).

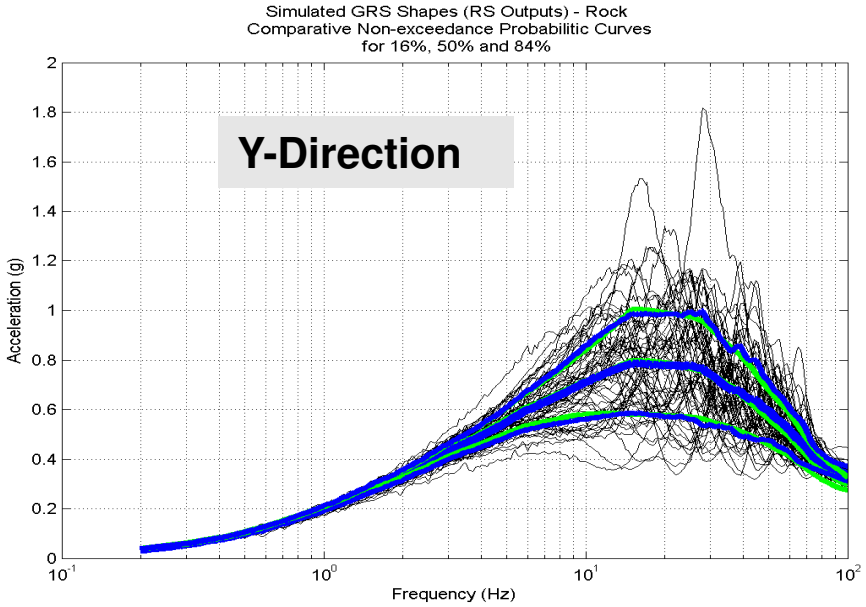
3) ***POSTPROCESS SSI RESPONSES:*** Using *ACS SASSI PRO postprocessing modules*, post-process statistical ensembles of the SSI responses *(ProSRSS and ProRESPONSE)*

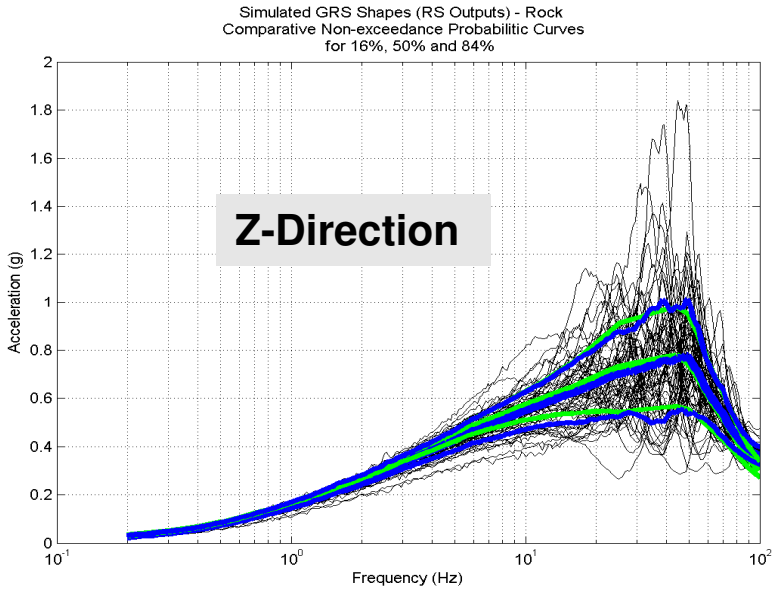
Probabilistic Simulations for Soil Layering



PSRA Simulations for UHRS Input at Bedrock

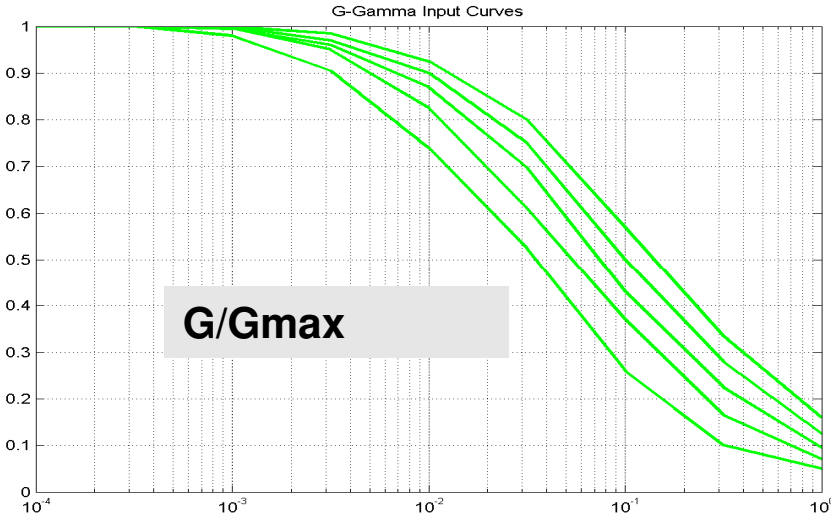


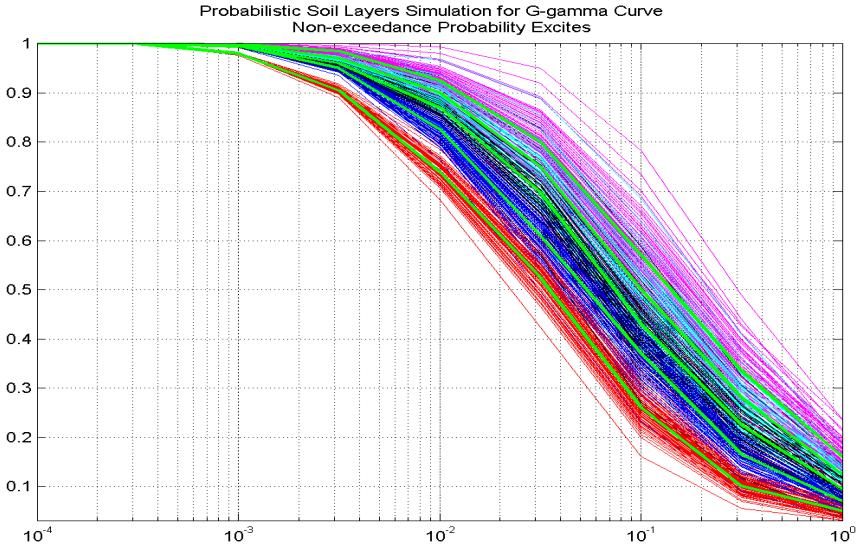


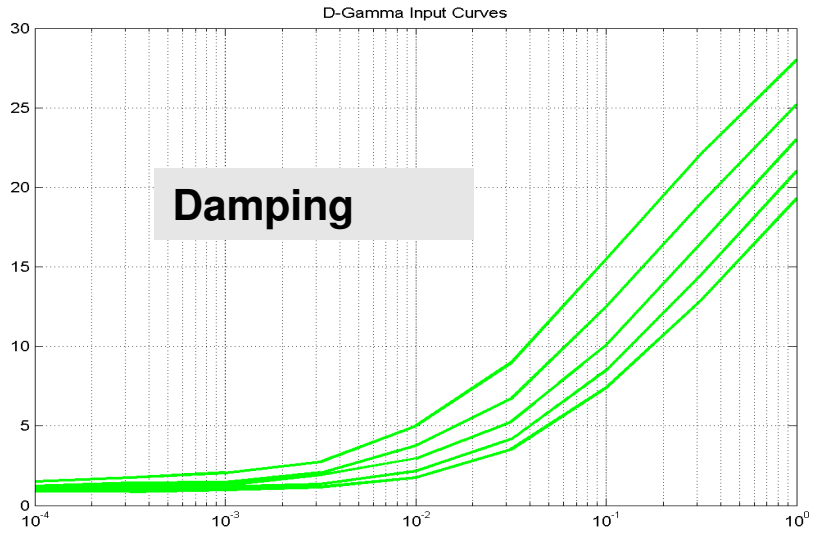


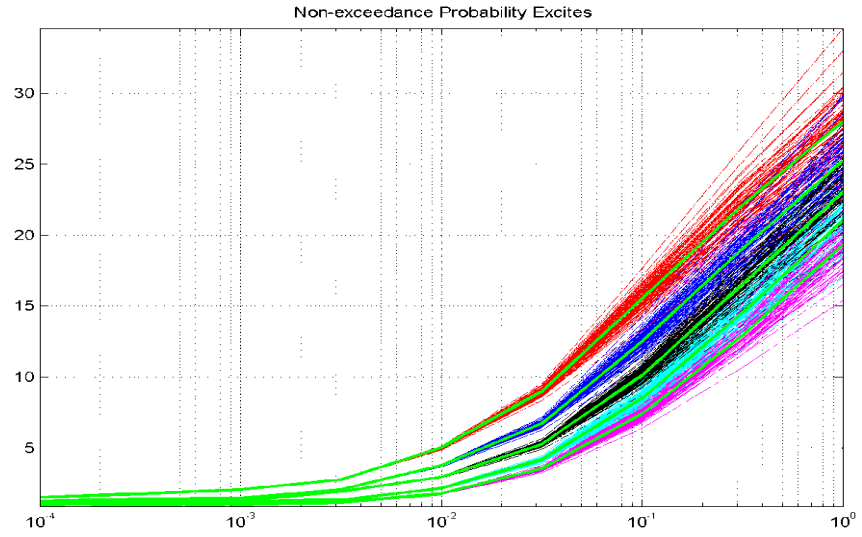
2007 EPRI/Abrahamson Incoherency Model for ***Rock Sites*** (less incoherency than for Soil Sites shown before)

Probabilistic Simulations for Shear Modulus and Damping Soil Curves

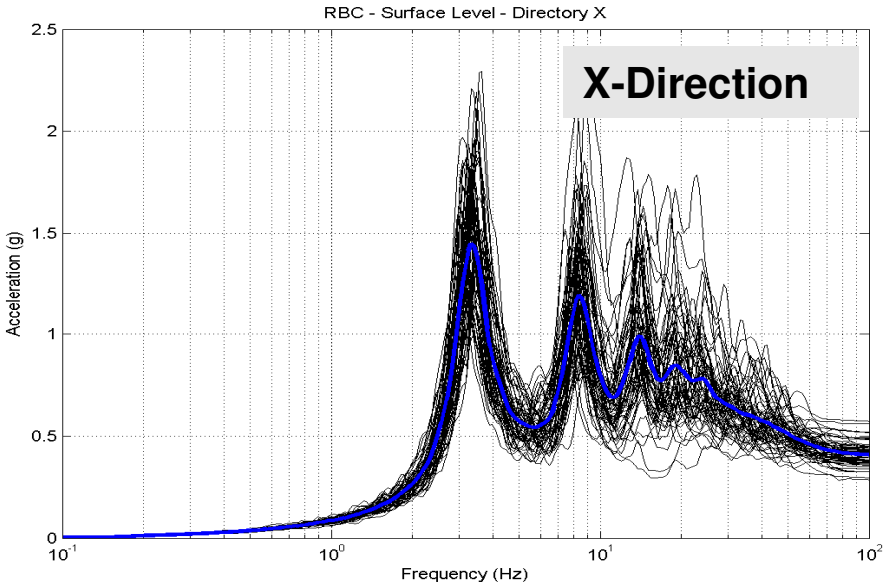


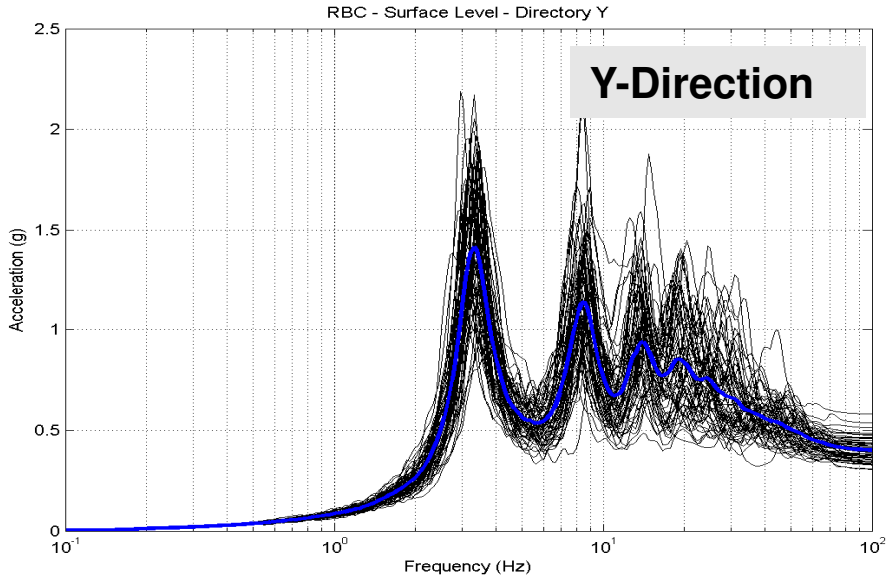


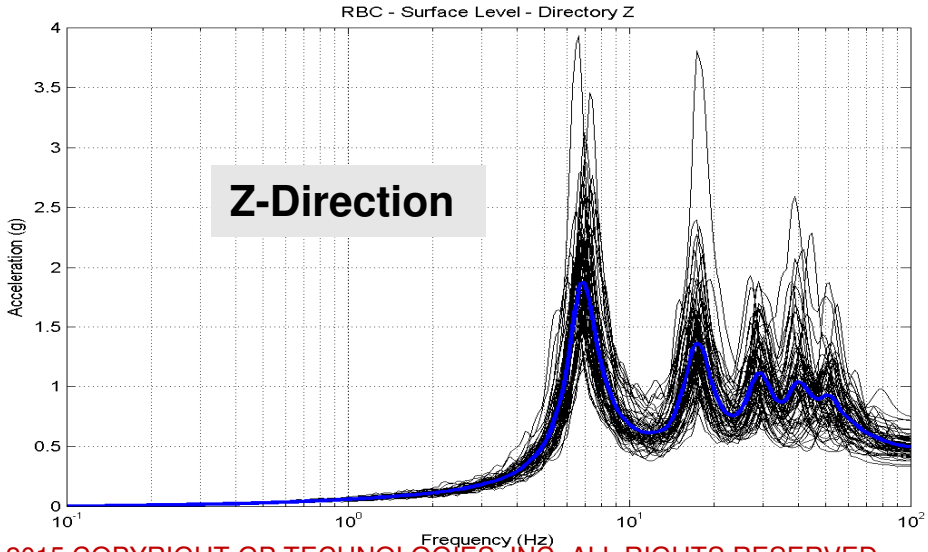




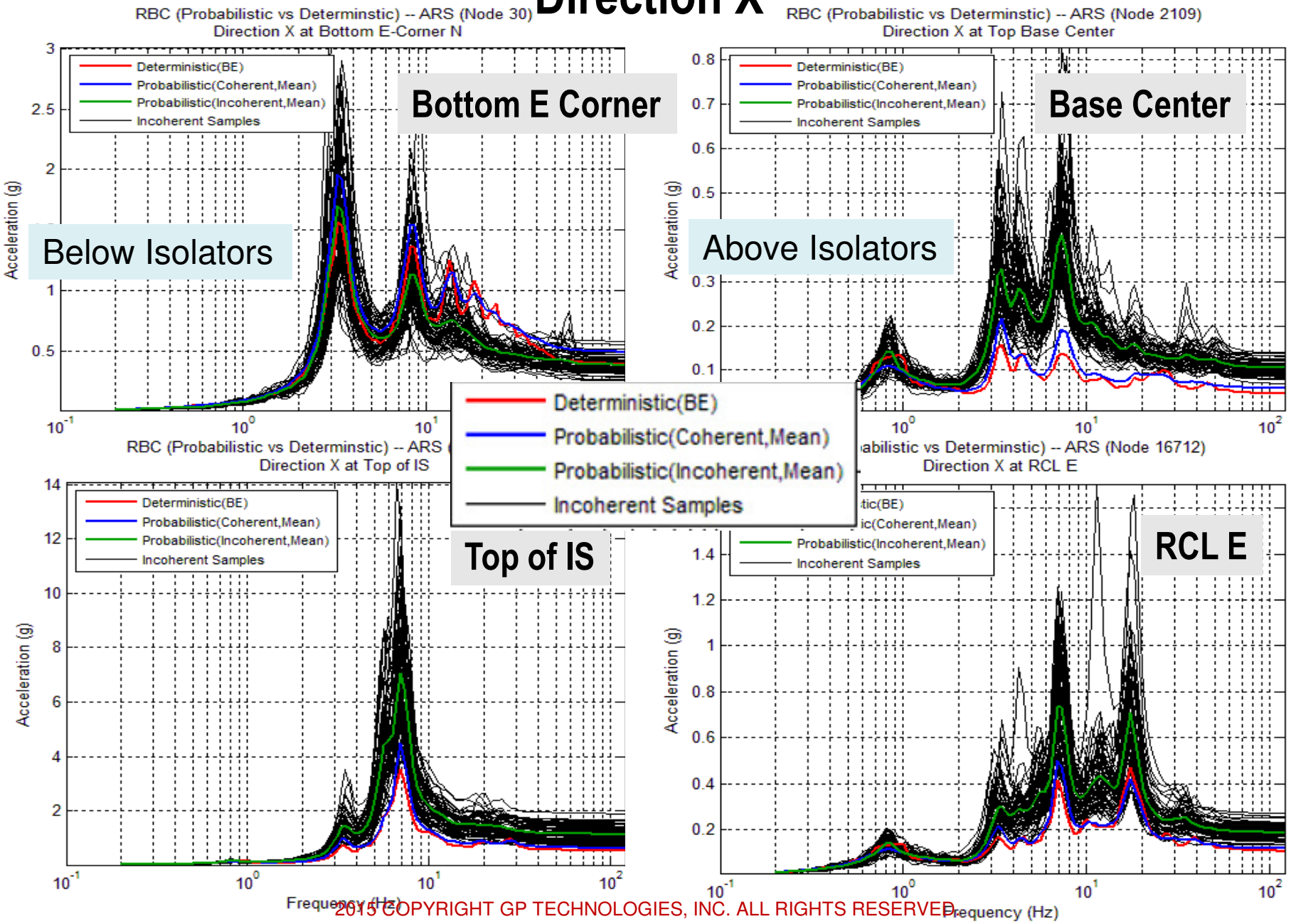
Probabilistic Simulations vs. Deterministic GRS (Probabilistic Mean RS) at Surface



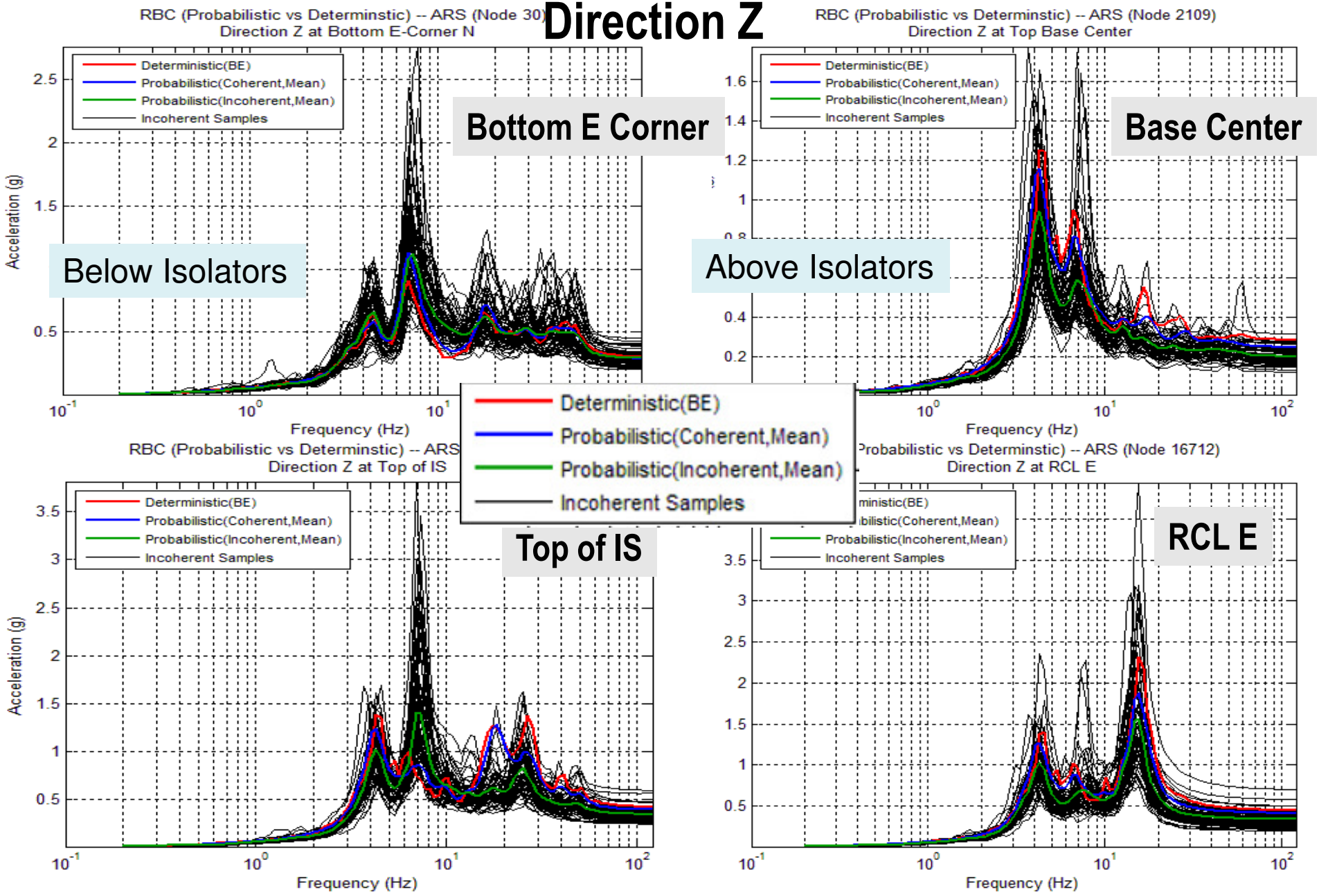




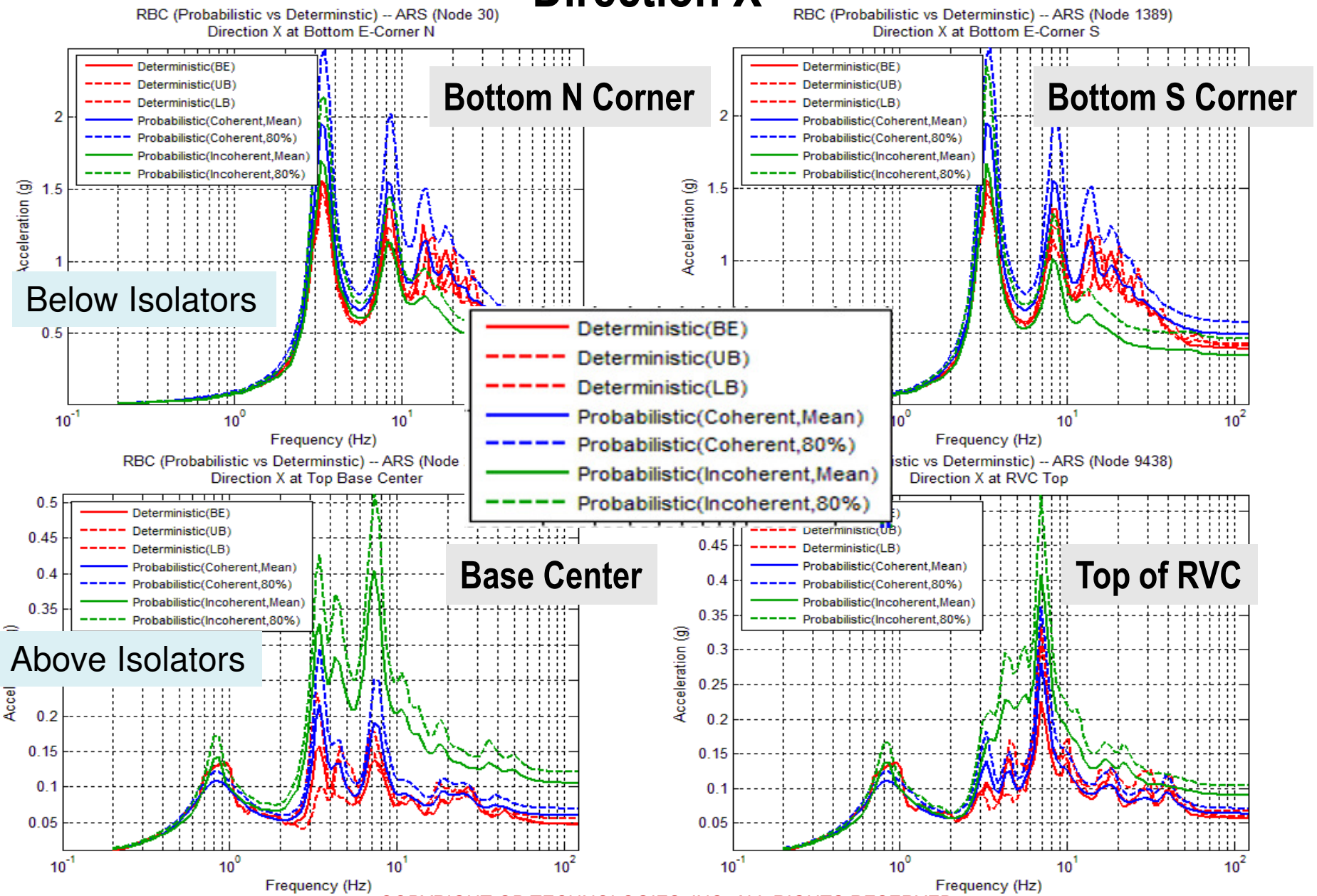
Probabilistic-Deterministic ARS for RB Complex Structure. Direction X



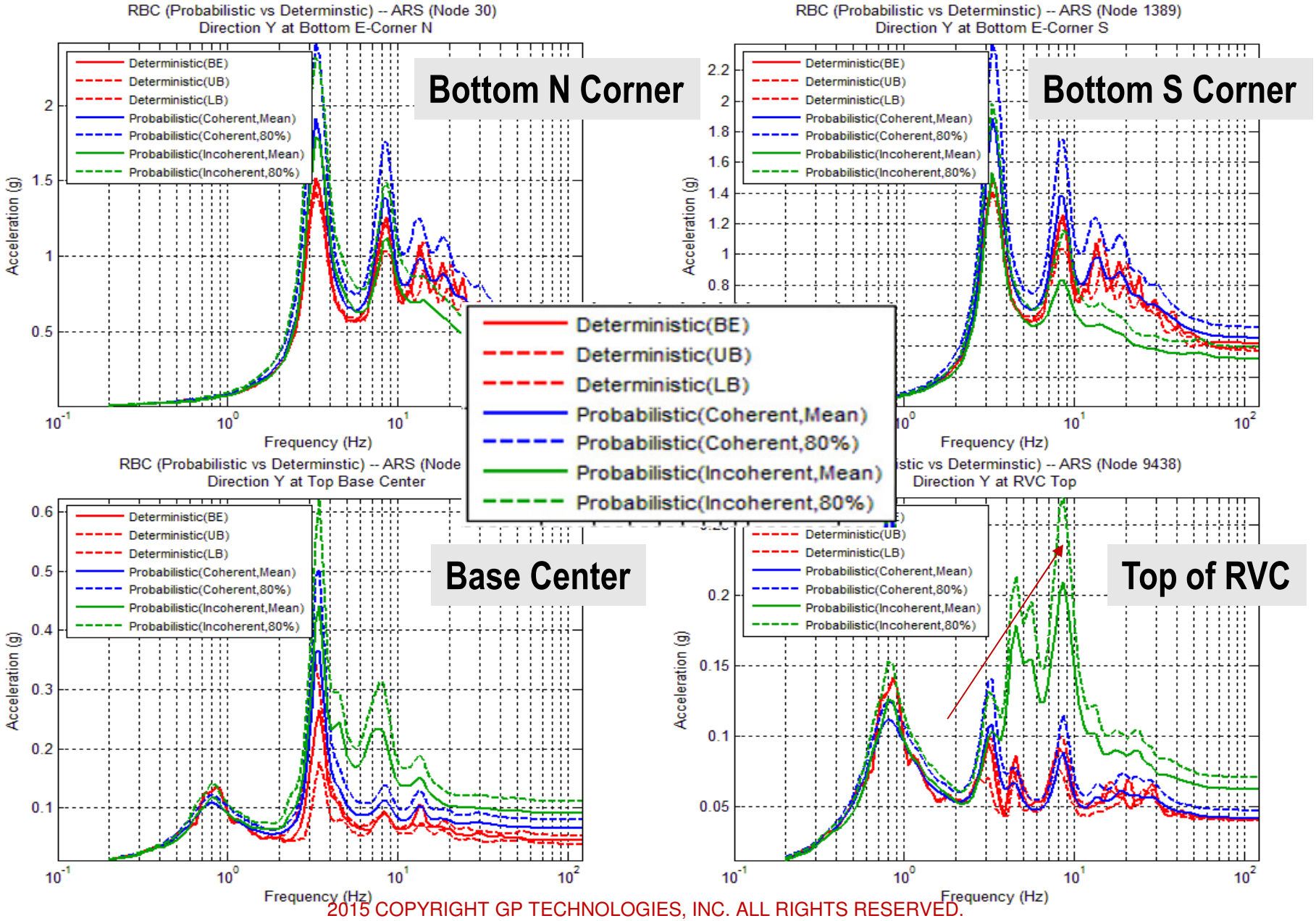
Probabilistic-Deterministic ARS for RB Complex Structure. Direction Z



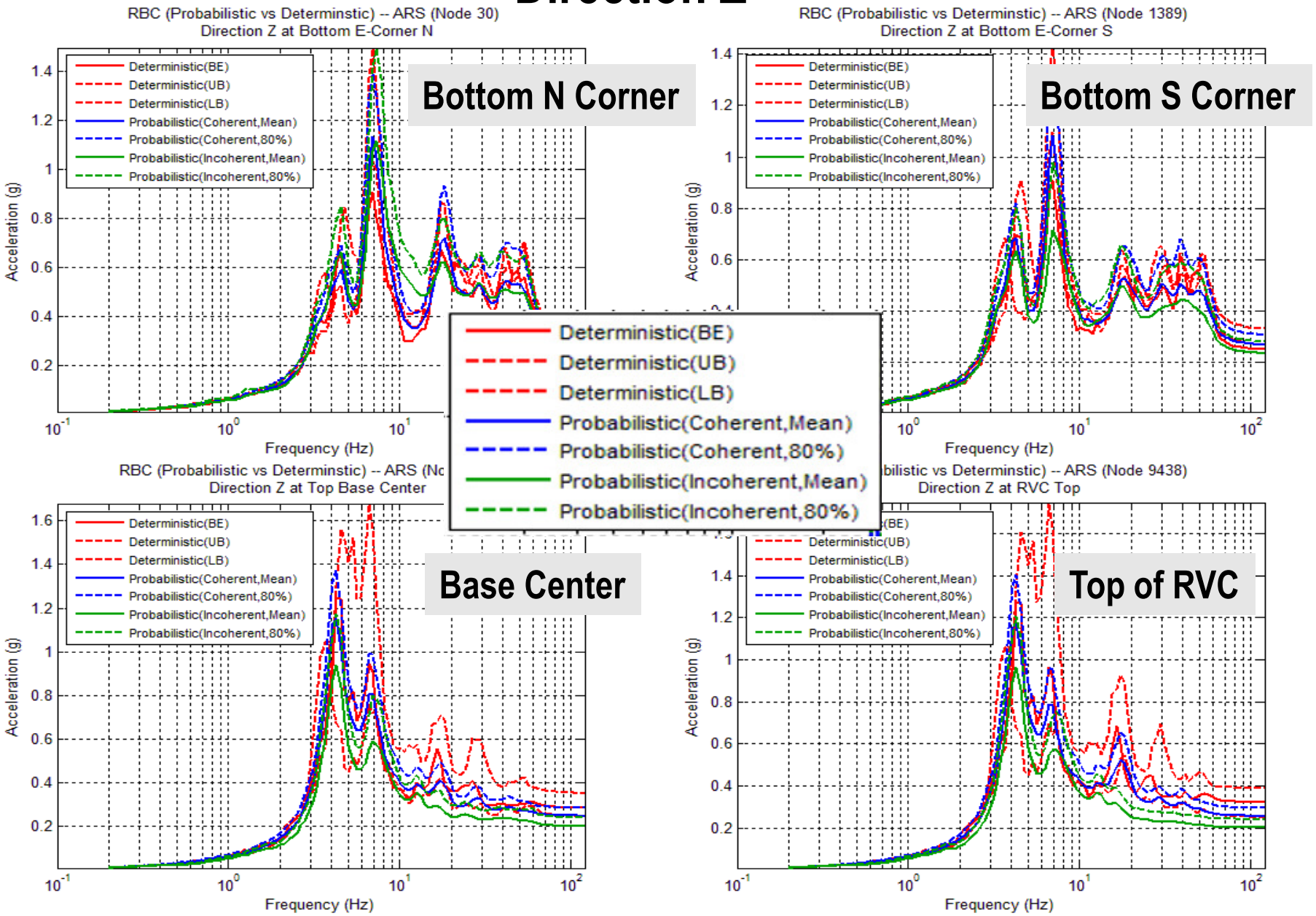
Probabilistic-Deterministic ARS for RB Complex Structure. Direction X



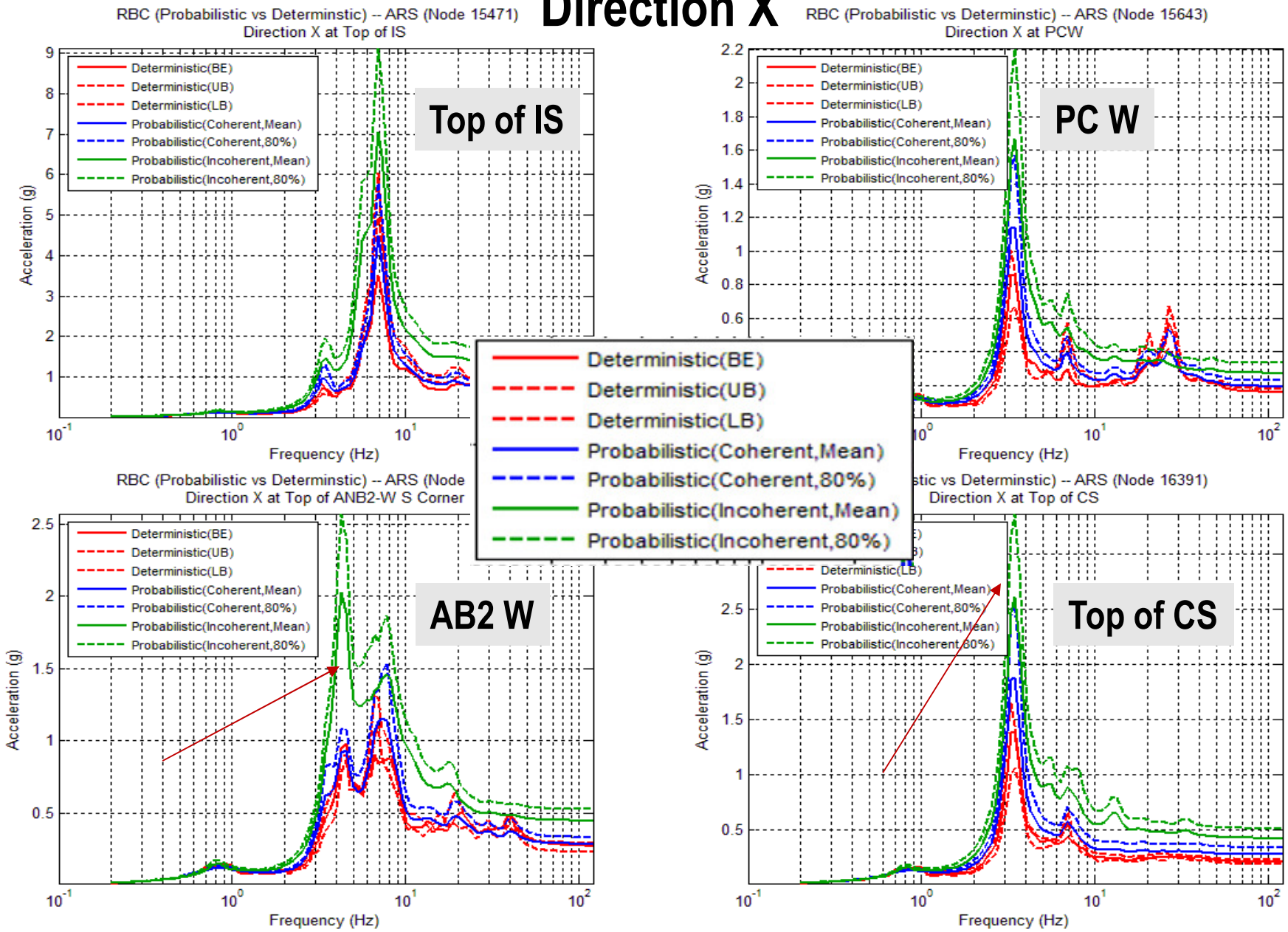
Probabilistic-Deterministic ARS for RB Complex Structure. Direction Y



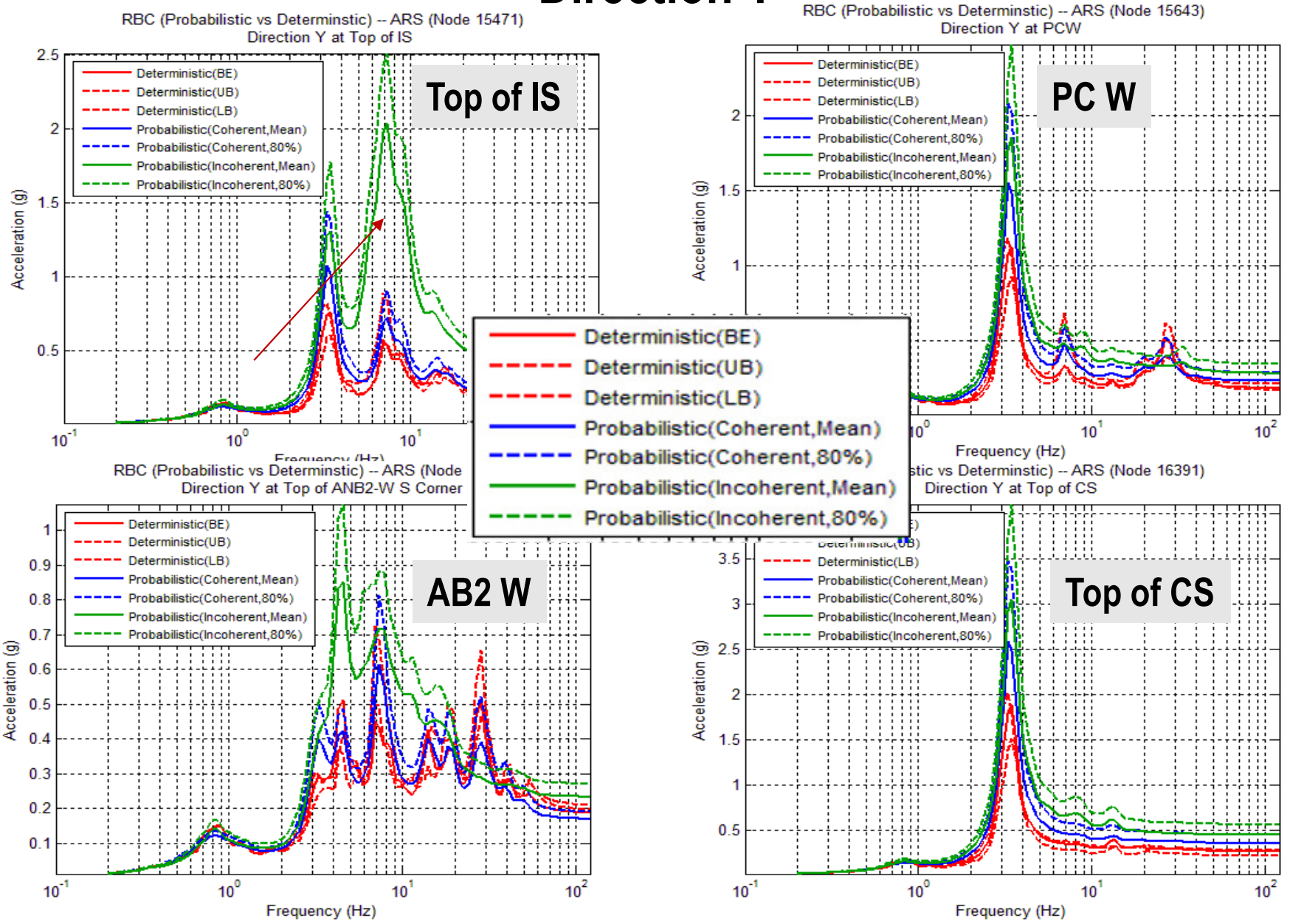
Probabilistic-Deterministic ARS for RB Complex Structure. Direction Z



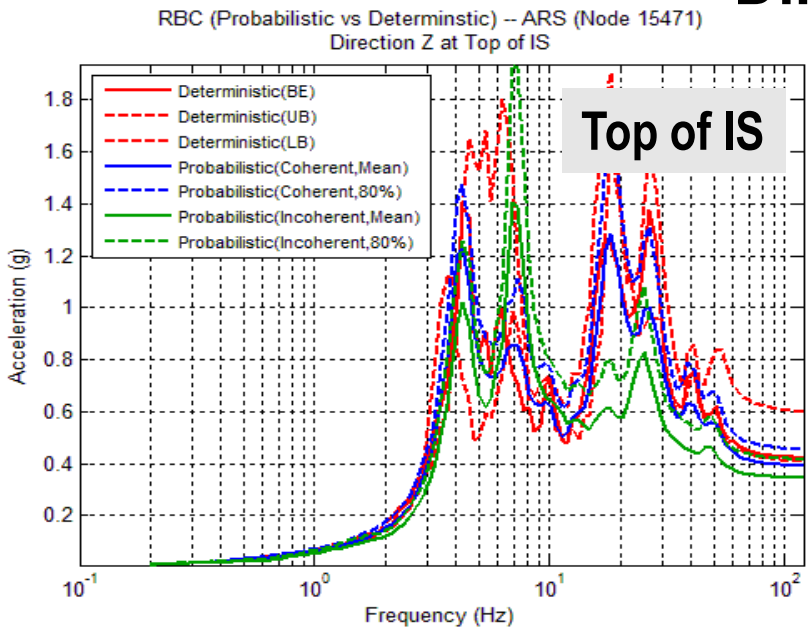
Probabilistic-Deterministic ARS for RB Complex Structure. Direction X

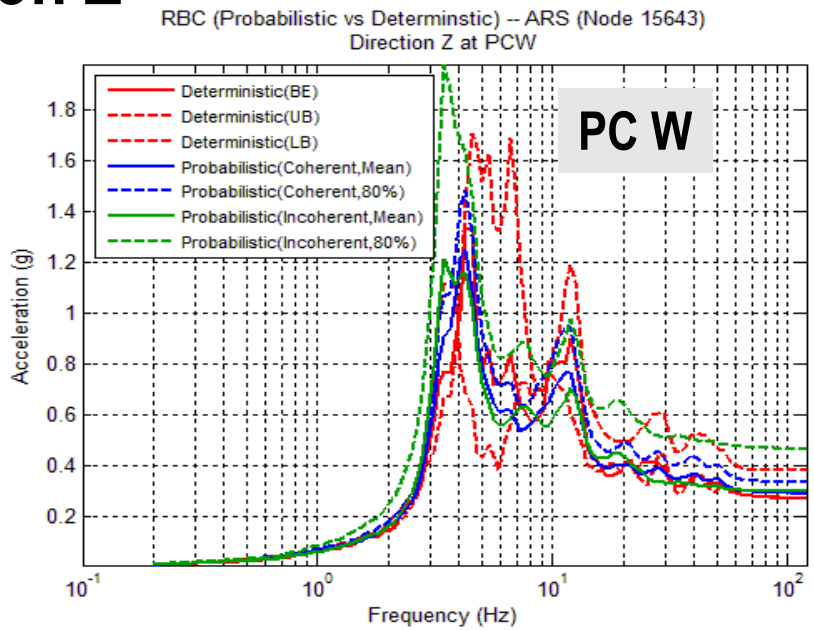


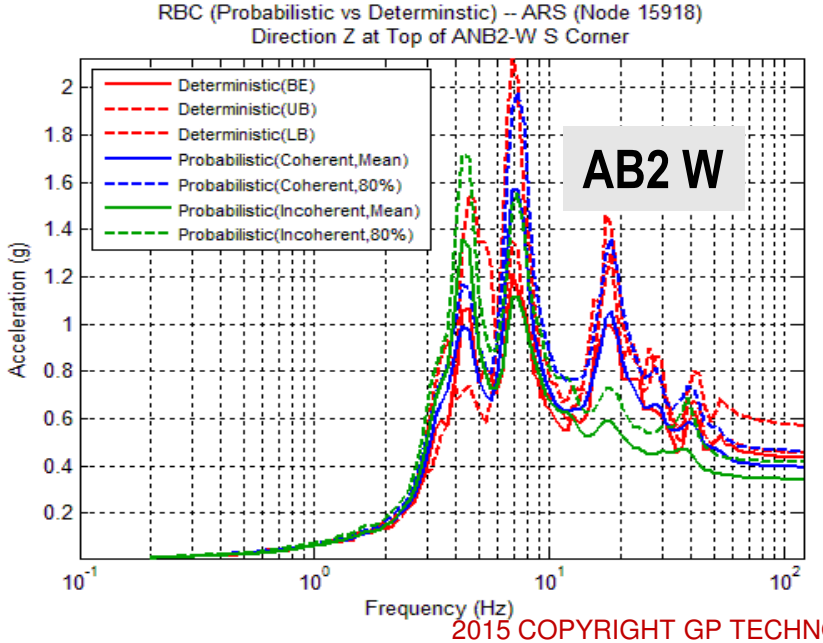
Probabilistic-Deterministic ARS for RB Complex Structure. Direction Y

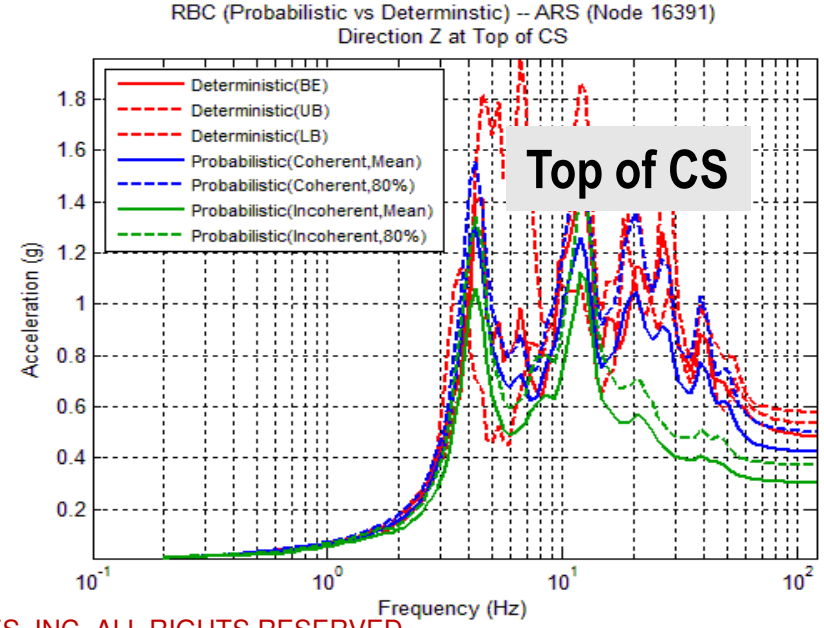


Probabilistic-Deterministic ARS for RB Complex Structure. Direction Z





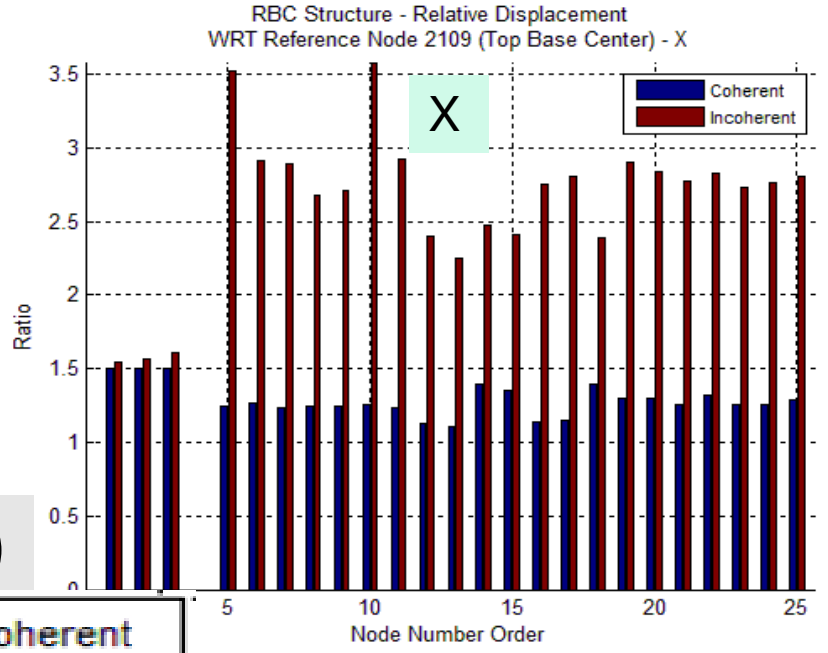


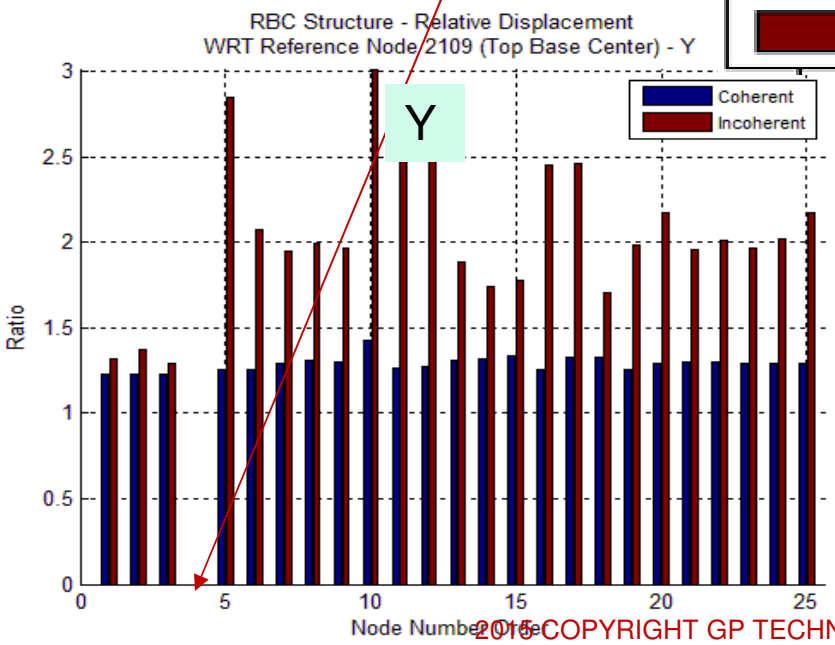


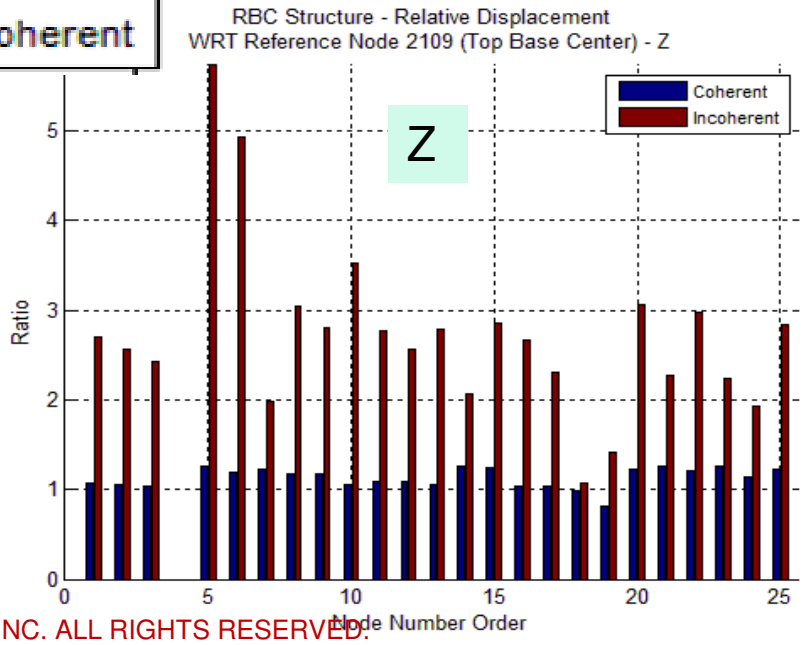
P/D Relative Displacement Ratio = 80% NEP/Max(BE, LB, UB)

Node Order #	Node #	
1	1	Bottom W-Corner N
2	30	Bottom E-Corner N
3	1389	Bottom E-Corner S
4	2109	Top Base Center
5	5698	RVC Bottom
6	9438	RVC Top
7	12710	High Elev. in IS
8	13571	Top of IS SGB W
9	13572	Top of IS SGB E
10	14179	Top of ANB1-E S Corner
11	14432	Top of ANB2-W N Corner
12	14461	Top of ANB1-E N Corner
13	15471	Top of IS
14	15614	PCE
15	15643	PCW
16	15719	Top of ANB2-E S Corner
17	15918	Top of ANB2-W S Corner
18	16391	Top of CS
19	16447	RCL Center
24	16831	RCL SE
25	16866	RCL SW

Reference is Baseslab Center (above)







Conclusions

- Probabilistic SSI analysis results are significantly larger than standard Deterministic SSI analysis results for coherent input. Probabilistic 80% NEP ISRS have peaks that are 2-3 times larger than Deterministic ISRS (envelope of LB, BE and UB soils).
- Probabilistic SSI analysis produces significantly larger ISRS amplifications for higher frequency modes.
- Incoherency increases significantly the relative vertical displacements within the NI complex structures and for the RCL system.
- LRB isolator fragilities under axial forces are largely affected by incoherency.