# Vibro- acoustic predictions: Direct Acoustic vs. Reverberant acoustic fields

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June 7–9, 2011

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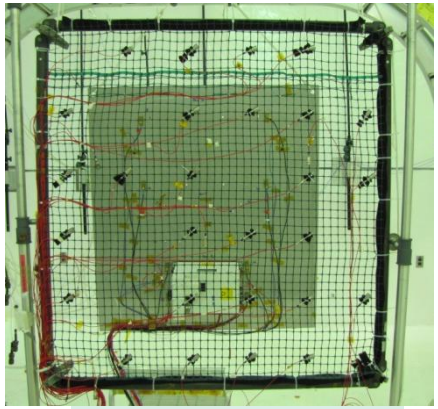
This research *described in this publication* was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. *Government sponsorship acknowledged.*

# Overview

- Direct acoustic field testing method has been used for flight hardware qualification for the last several years
  - The first such testing was reported by Scharton et al. using the QuikSCAT spacecraft,
  - Detailed description later given by Larkin & Walen, 1999
- The structural responses induced by direct acoustic field testing (DFAT) often differ from those of reverberant acoustic testing (RAT), usually at specific frequencies or a range of frequencies
- In ATS-26 (April 2011) a series of papers were presented that discussed this method of testing in some detail
  - J. Rouse, M. Mesh, E. Stasiunas
  - M. Van Dyke and P. Peters
  - K. Yanagase, H. Akagi, S. Ando, Q. Shi
  - N. Saggini, D. Tiani, F. Ribour, N. Poulain, P. Herzog
  - A. Kolaini, D. Kern
- A review of the paper presented at ATS by Kolaini and Kern is given in this presentation
- We concentrate on challenges the DFAT testing provides in vibro-acoustic response predictions and model correlations

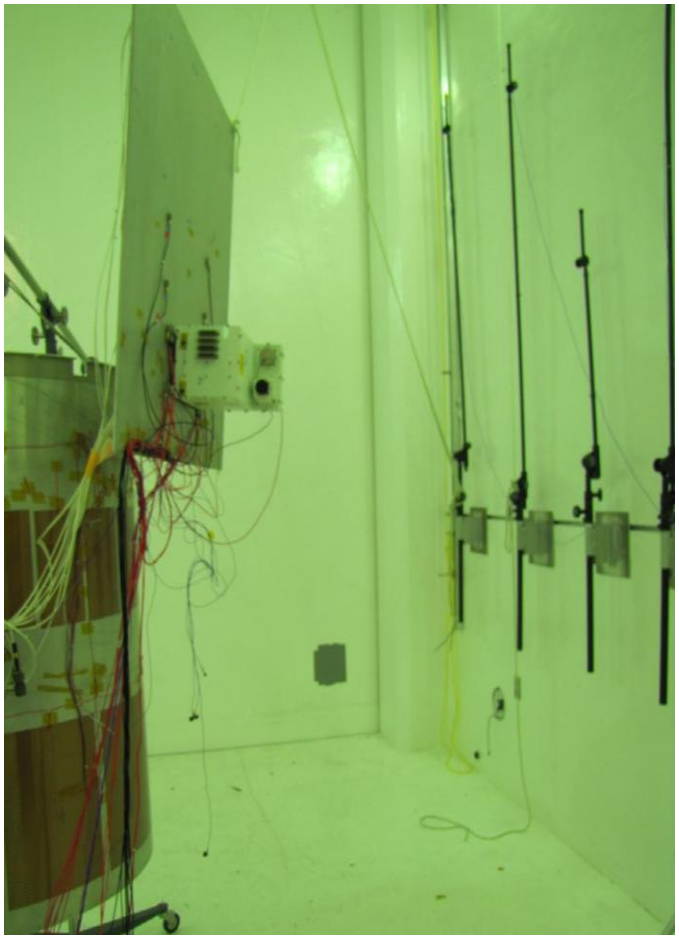
# *DFAT Test Setup*

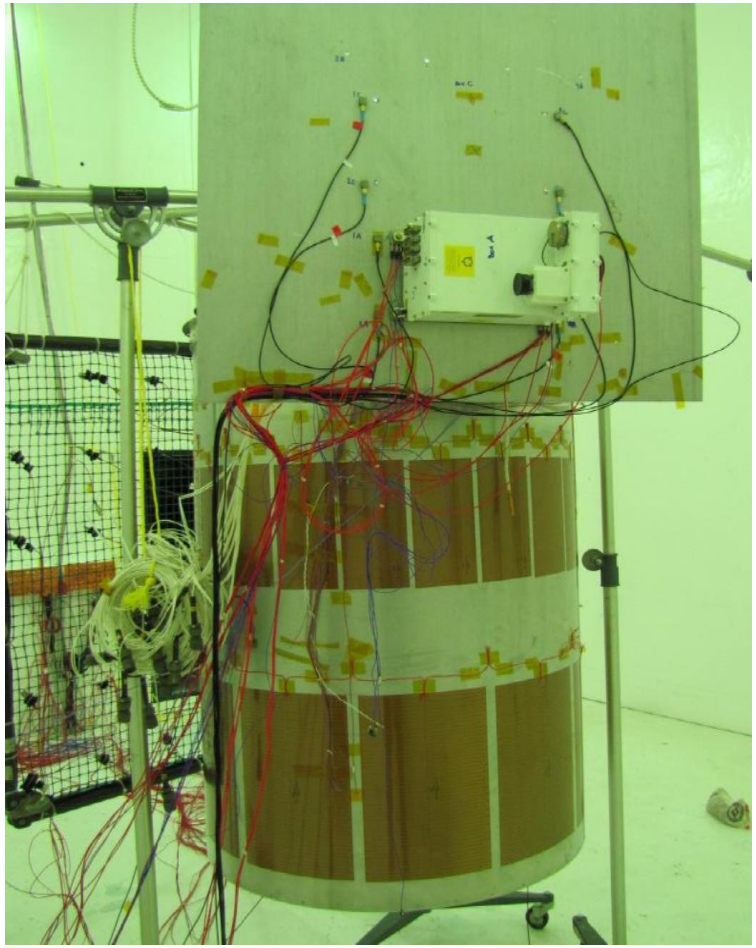
- Speakers and woofers assembled as shown
  - *MSI provided speakers, the MISO control system and conducted the test with the involvement of ETL,*
  - *Data acquired by MSI and ETL*
- Eight control microphones were used in different configurations to control the sound field within the speakers to an overall sound pressure level (OASPL) of up to 145 dB,
- Another 8 microphones were spread within the testing volume to obtain the sound pressure spatial variation,
- An array of 36 microphones was added and positioned in several locations to obtain the detail sound pressure variation within the testing volume.



Acoustic Array

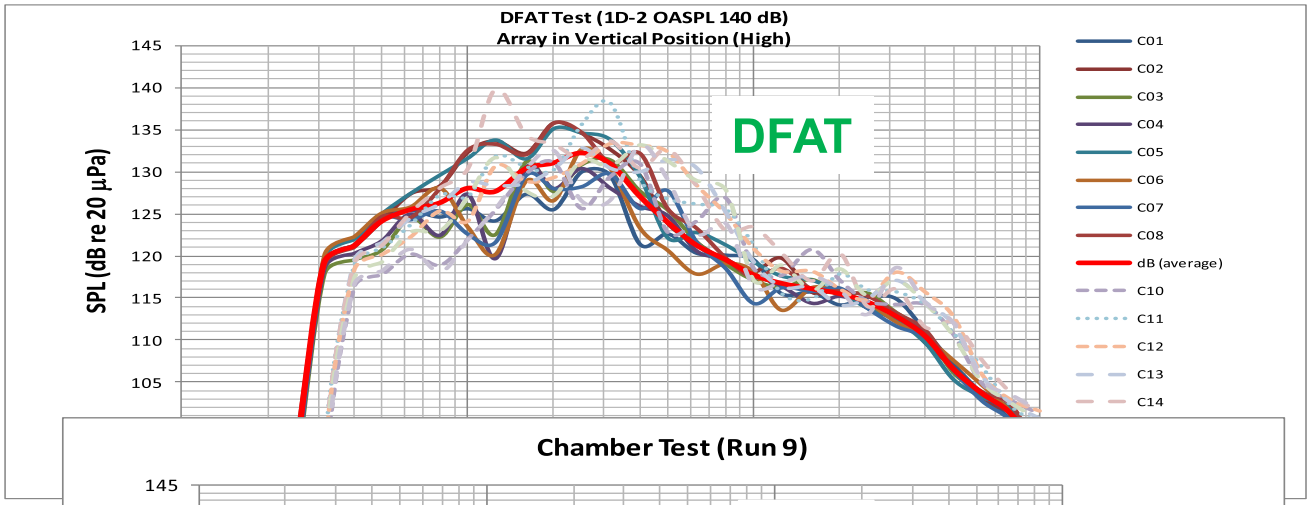
# *Test Articles (RAT setup)*

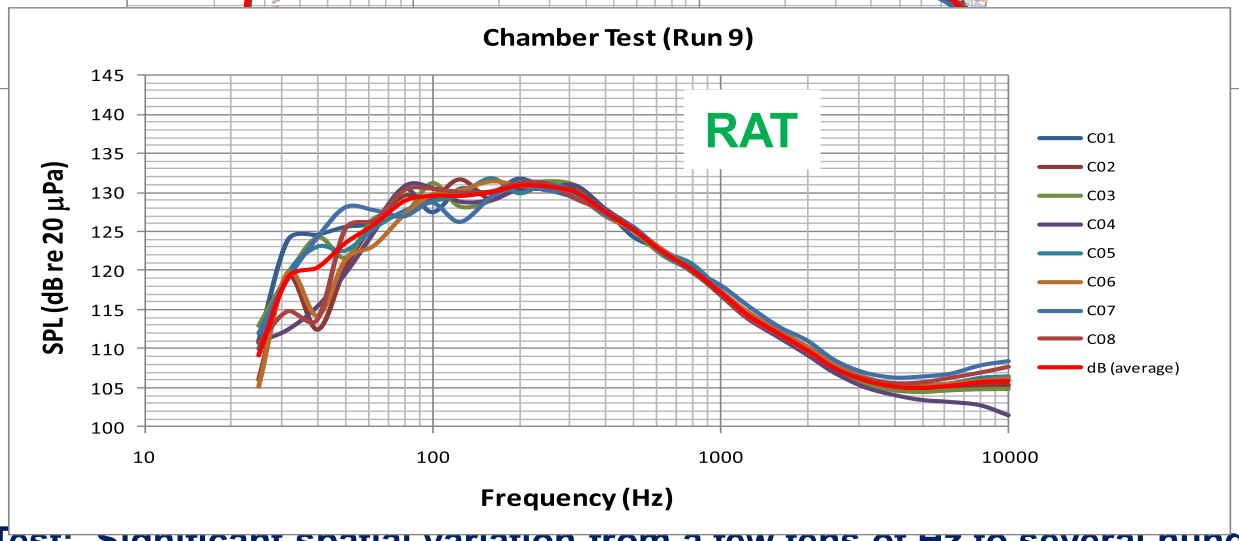




**Similar test articles and set up, microphone array, force gages used in the chamber**

# ACOUSTIC FIELDS: DFAT VS. RAT
## Control Microphones SPLs



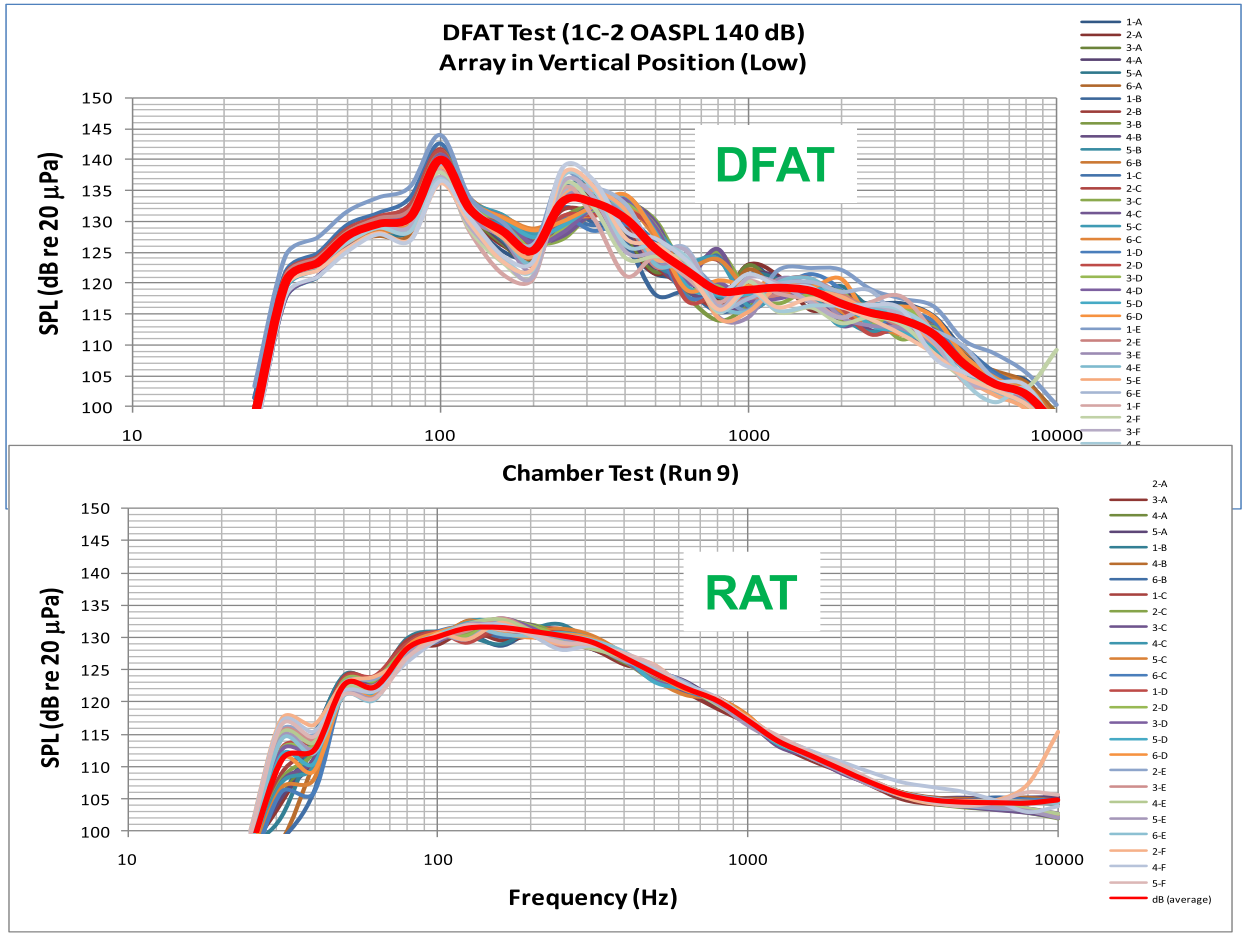




**DFAT Test: Significant spatial variation from a few tens of Hz to several hundred of Hz (acoustic standing waves and wave interferences)**

**RAT Test: Spatial variation from a few tens of Hz to several tens of Hz (Acoustic standing waves; above ~ 130 Hz the chamber is diffuse)**

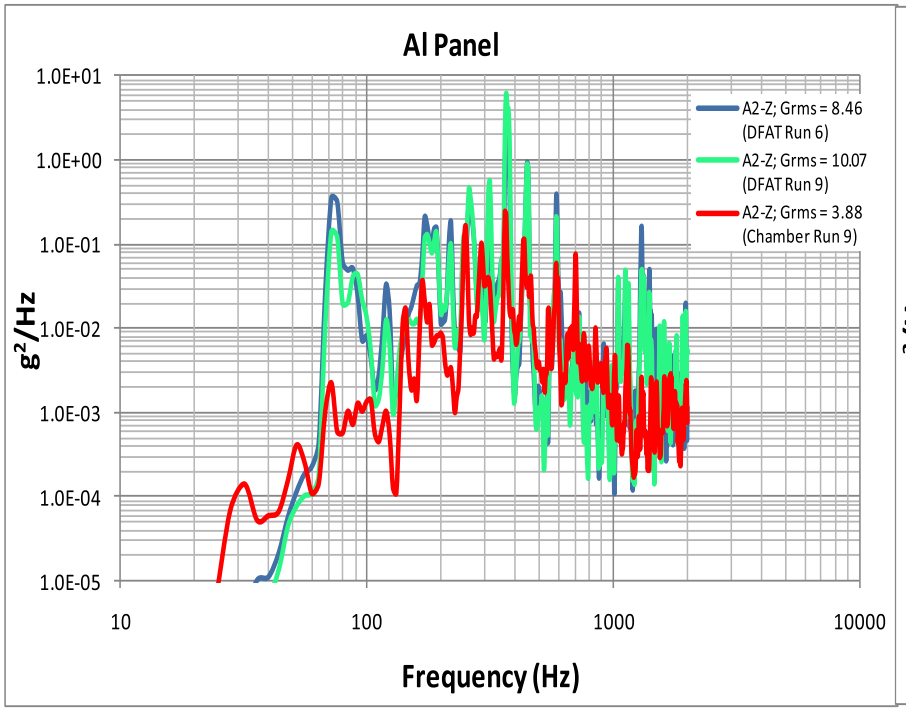
# ACOUSTIC FIELDS: DFAT VS. RAT

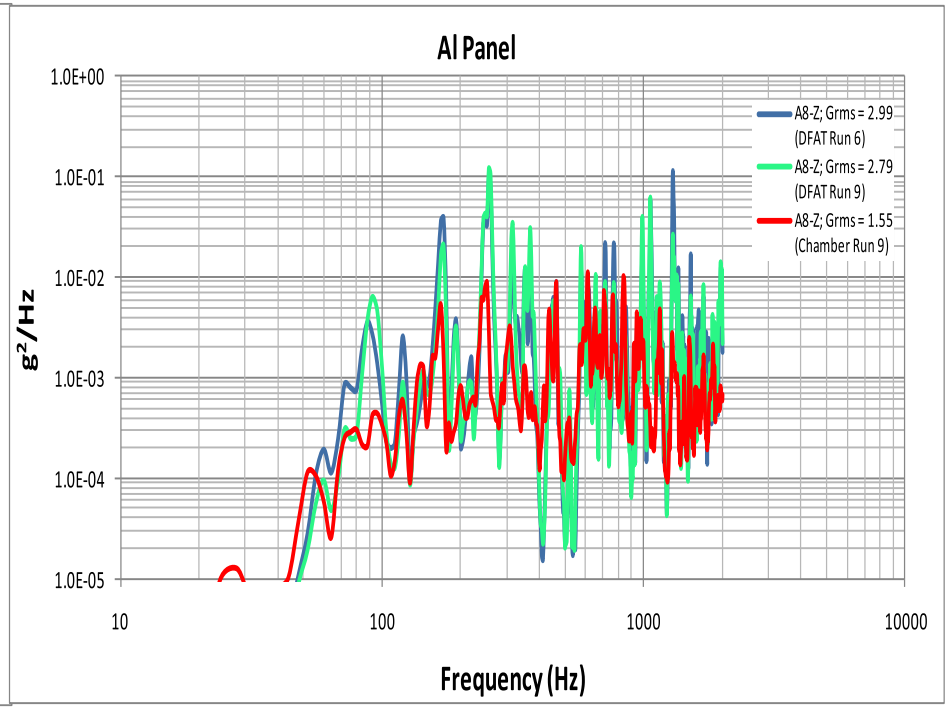
## Microphone Array SPLs




**The sound pressure spectra of microphone array**

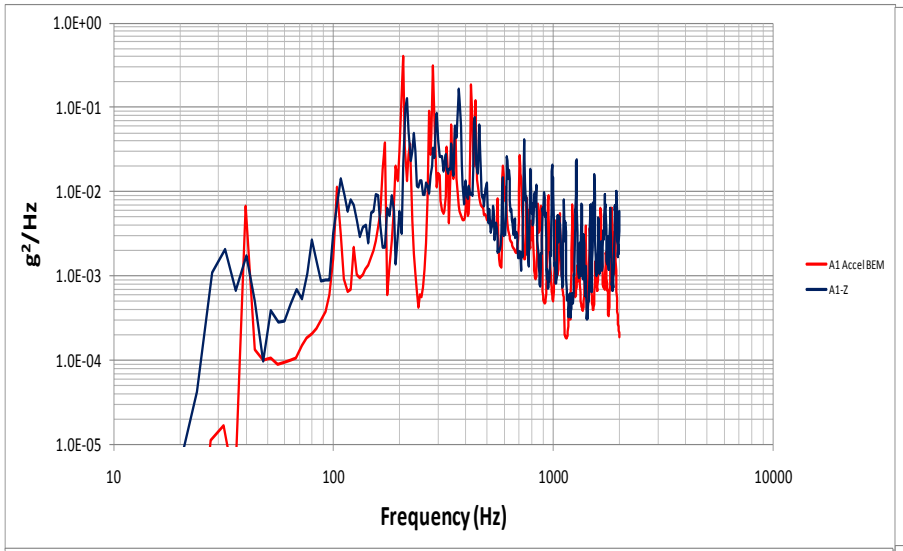
## STRUCUTRAL RESPONSES: DFAT VS. RAT

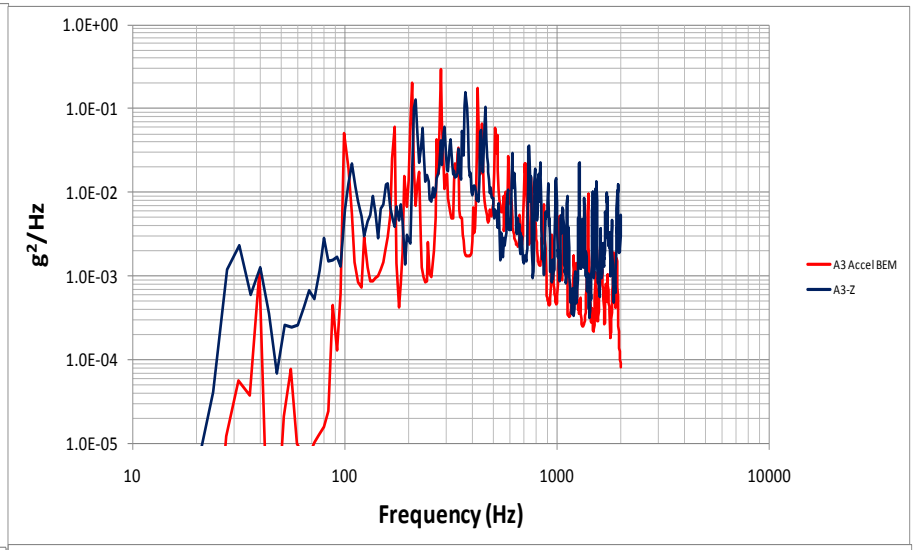


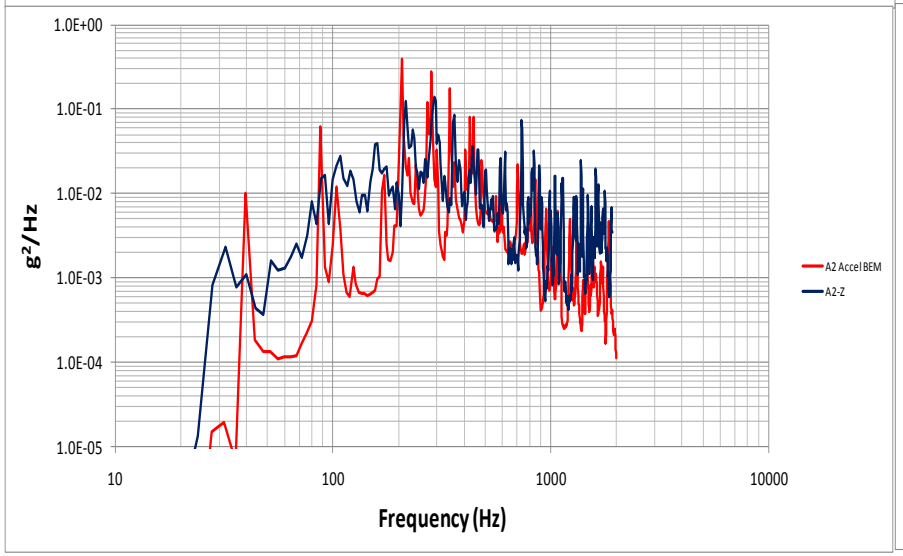



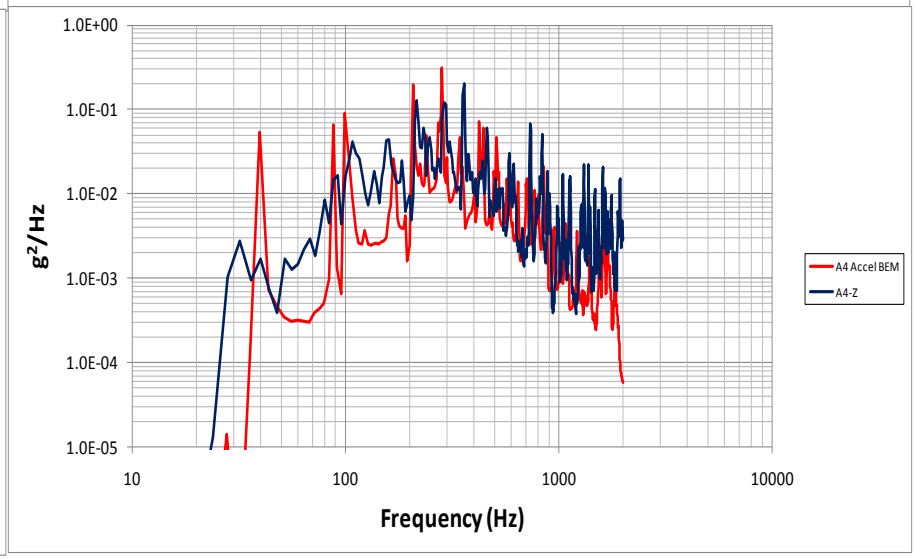

**Acceleration responses of the Al panel measured at two locations using reverberant (red lines) and speakers tests (green and blue lines). The differences between two methods of testing for the same conditions are very clear.**

# BEM Predictions: Acceleration Responses of Bare AL Panel @ Box B IFs (Correlated w/ measured data, RAT results)

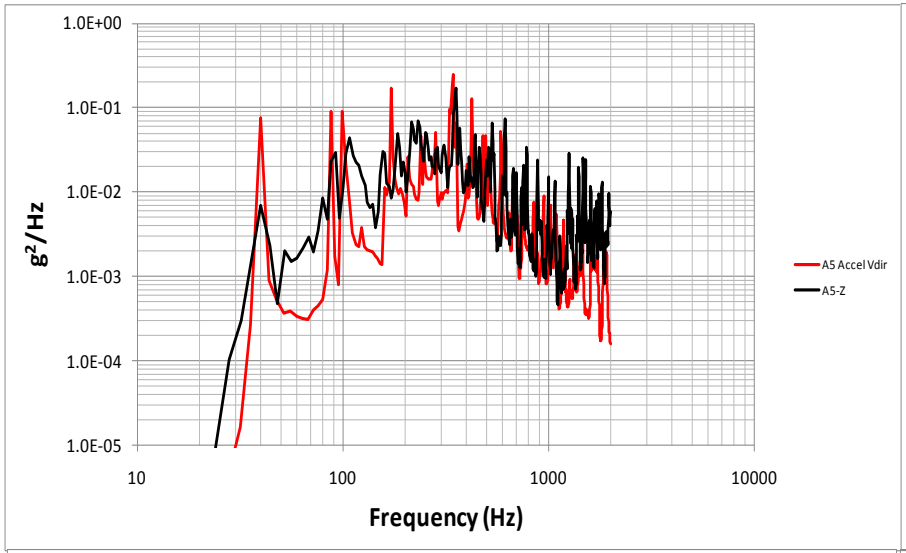


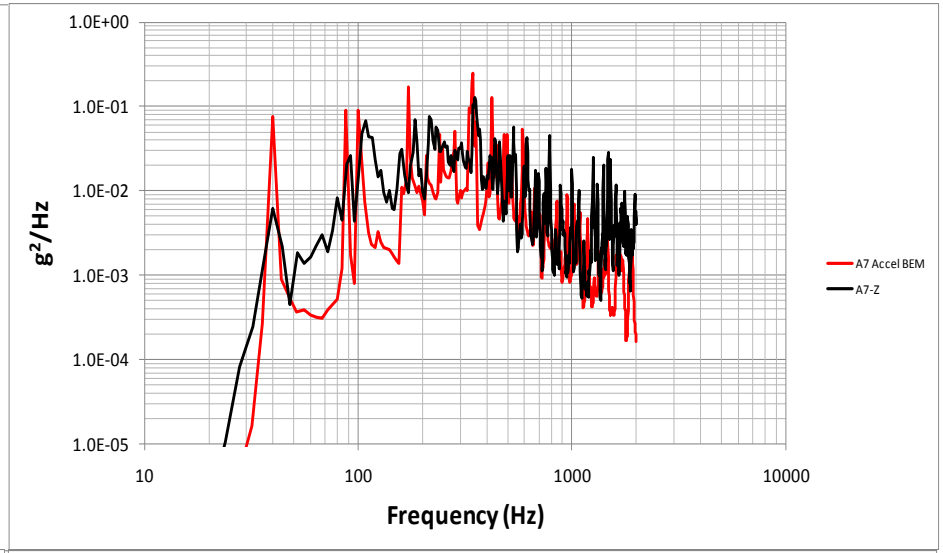



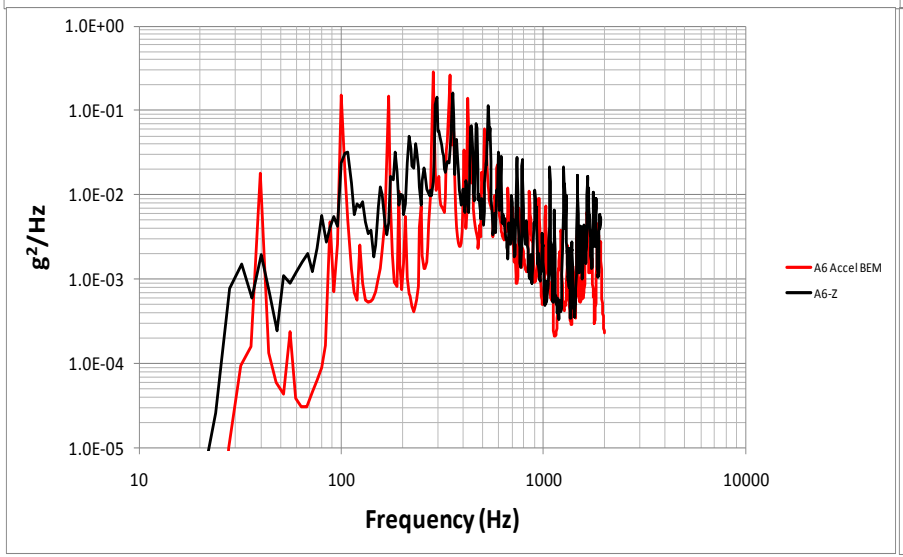



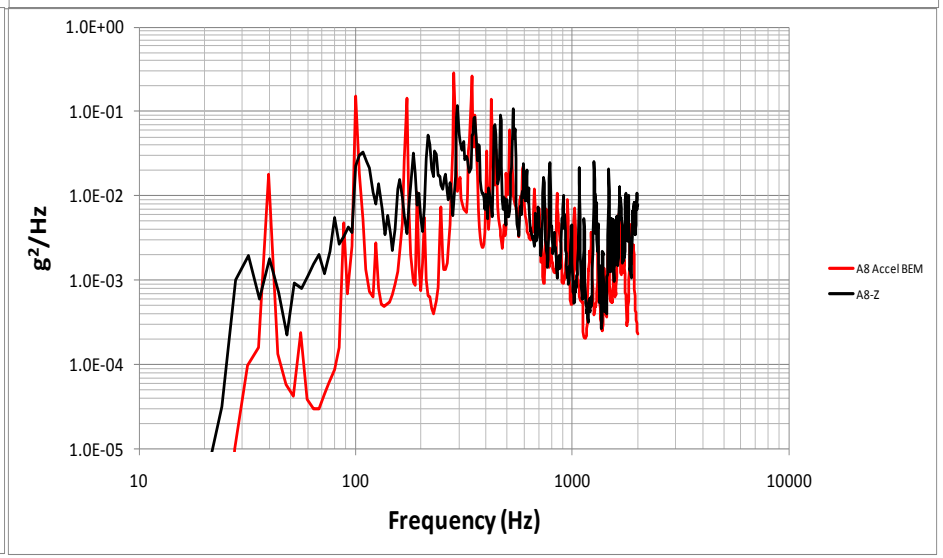



# BEM predictions: Acceleration Responses of Al Bare Panel @ Box A IFs (Correlated w/ measured data, RAT Results)

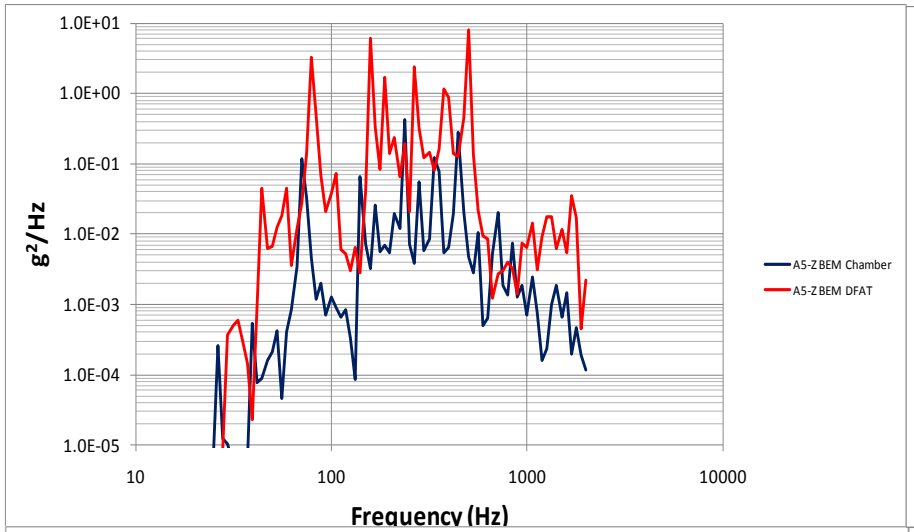


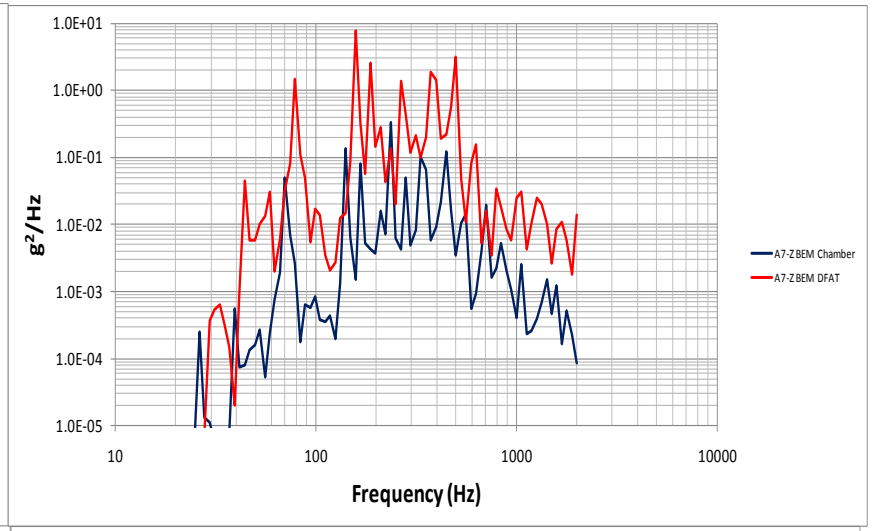



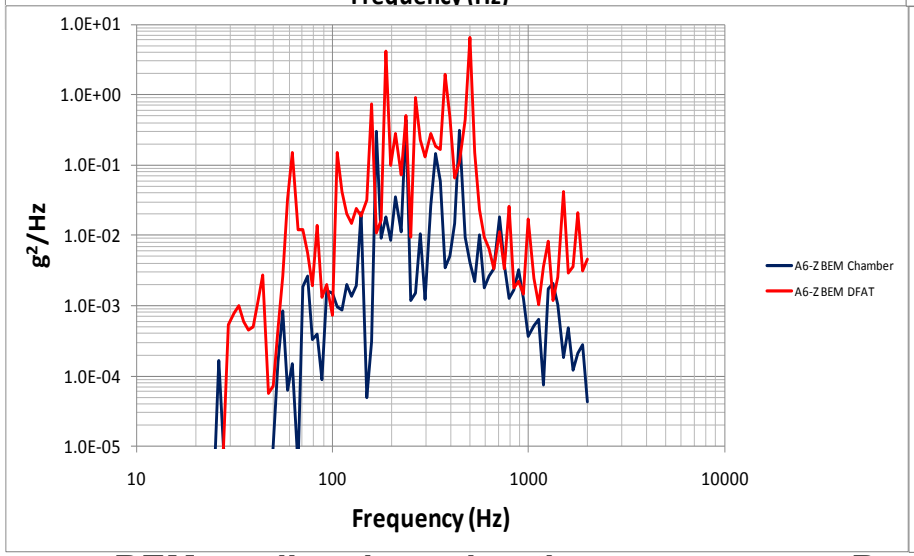



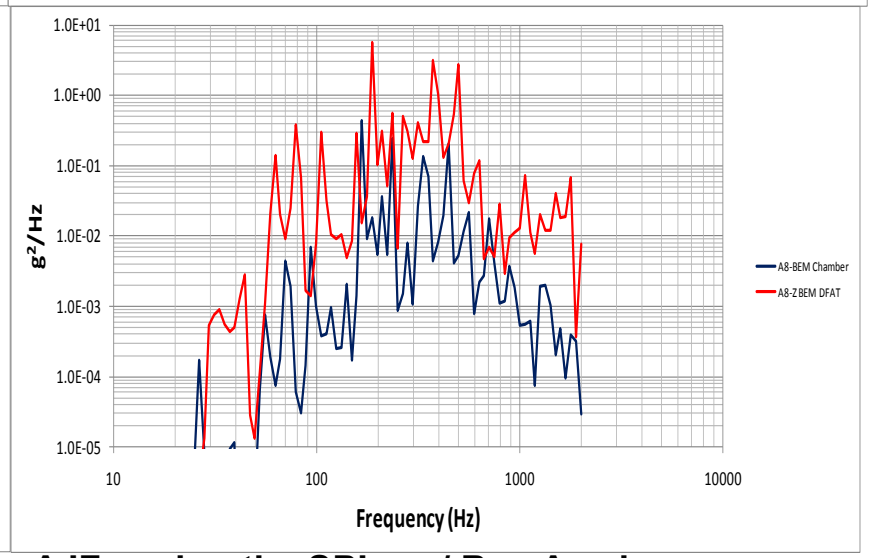



# BEM Predicted Results: DFAT and Reverberant Comparisons



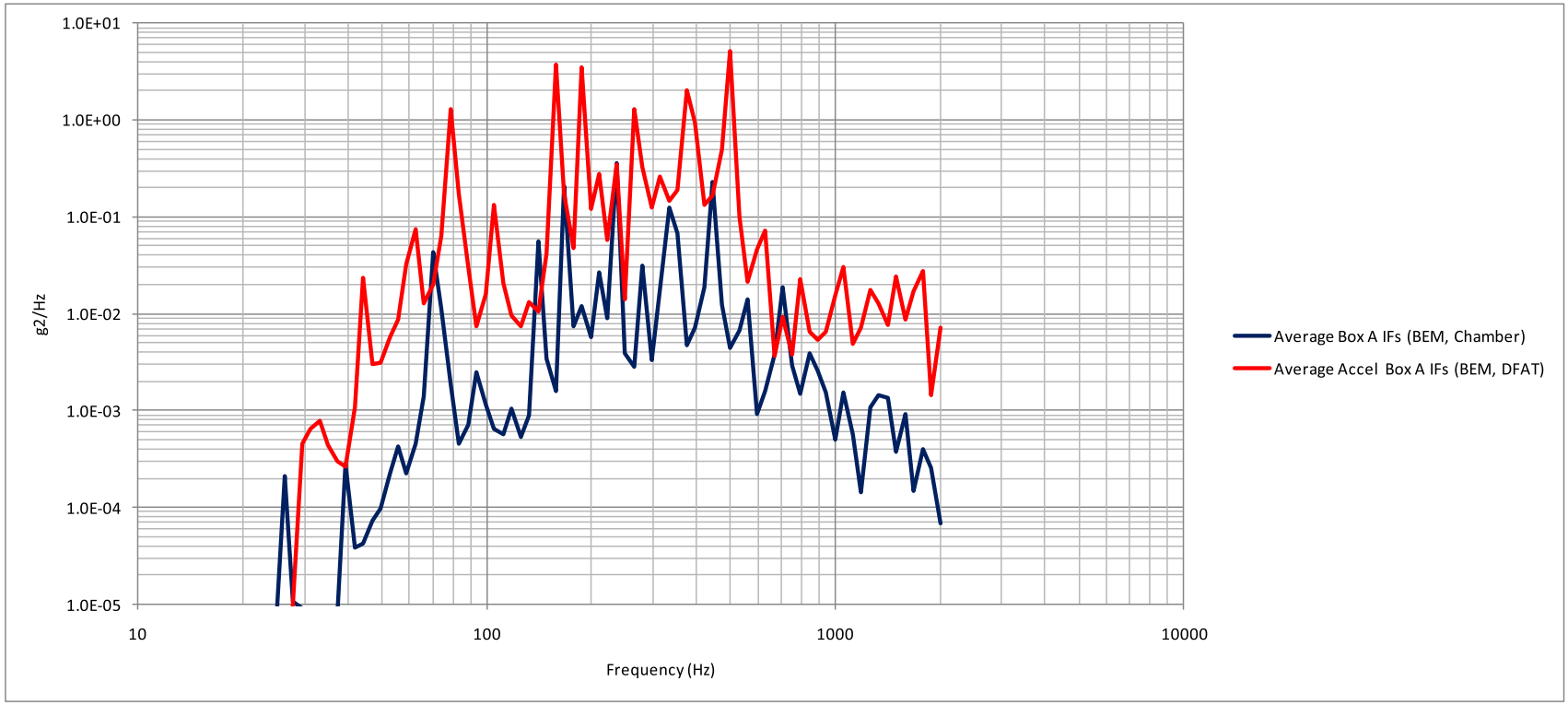



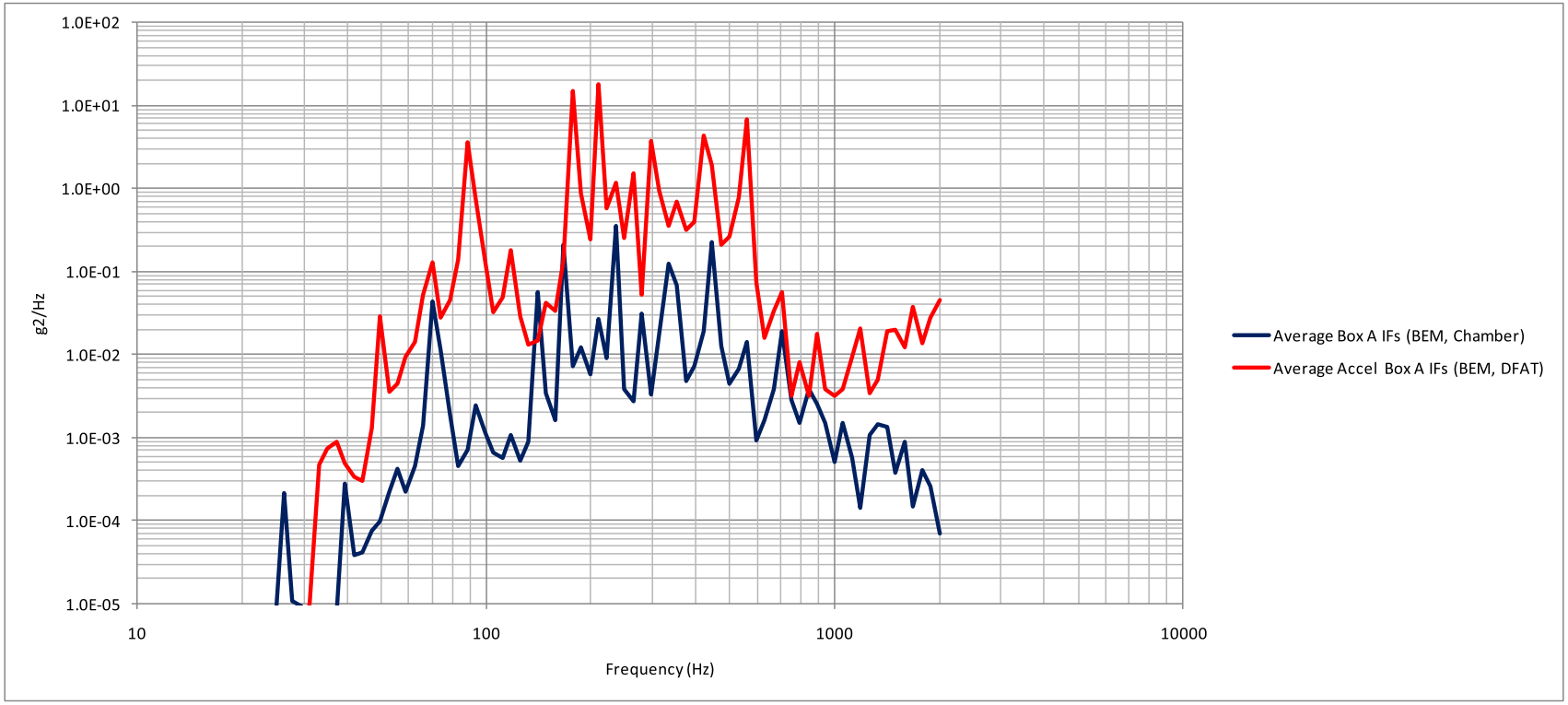

**BEM predicted acceleration responses at Box A IFs using the SPLs w/ Box A using DFAT and FAT measured SPLs**

# BEM Predicted Results: DFAT and RAT Comparisons
# Bare AL Panel @ Box A Ifs (Average)



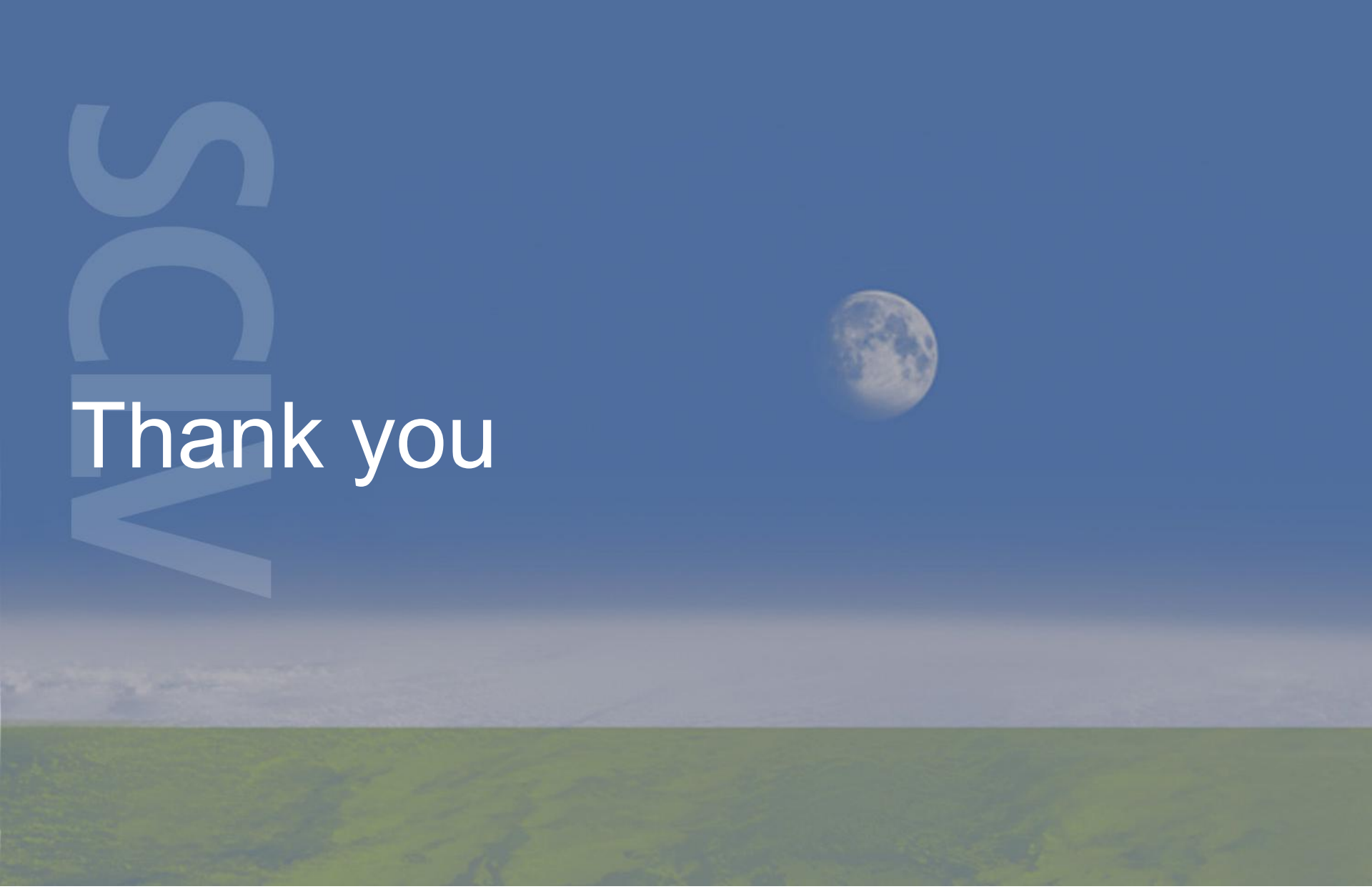

Average BEM predicted acceleration responses at Box A IFs of the AL panel w/o the Box using the SPLs obtained from DFAT and FAT tests

# BEM predicted Results: DFAT and RAT Comparisons
# AL Panel+Box A @ Box A Ifs




Average BEM predicted acceleration responses at Box A IFs using the SPLs obtained from DFAT and FAT tests

# Summary

- Even though more than 100 flight acoustic qualification tests have so far been performed within the last several years using various speakers testing set ups, the knowledge of our understanding of the kind of acoustic field produced by this method has been minimal
- The speakers' tests performed at JPL with the involvement of several institutions provided an opportunity to examine the sound fields in a more detail but limited manner using multi-input-single-output speakers control scheme
- The chief concern with this method of testing with current state-of-the-art is producing acoustic fields with significant spatial variability that impact the structural qualification in a significant way
  - *Existence of acoustic standing waves and acoustic wave interferences*
- This kind of variability provides a challenge in vibro-acoustic model correlations; important for design and pre-qualification predicted responses
  - *Lack of the accurate characterization of the DFAT acoustic field may lead to questionable model correlation with post test acoustic results,*
  - *The existing vibro-acoustic tools may not be adequate for structural response predictions for DFAT acoustic environments (acoustic field is neither diffuse nor is direct!),*
  - *More rigorous mathematical tools need to be developed to account for all the standing waves, wave interferences, etc. in DFAT testing.*
- Much more needs to be done before DFAT becomes a reliable and safe method of acoustic flight hardware testing

# Thank you