JPL Tunable Beam Pyroshock Simulation System

Ali R. Kolaini and Juan P. Fernandez

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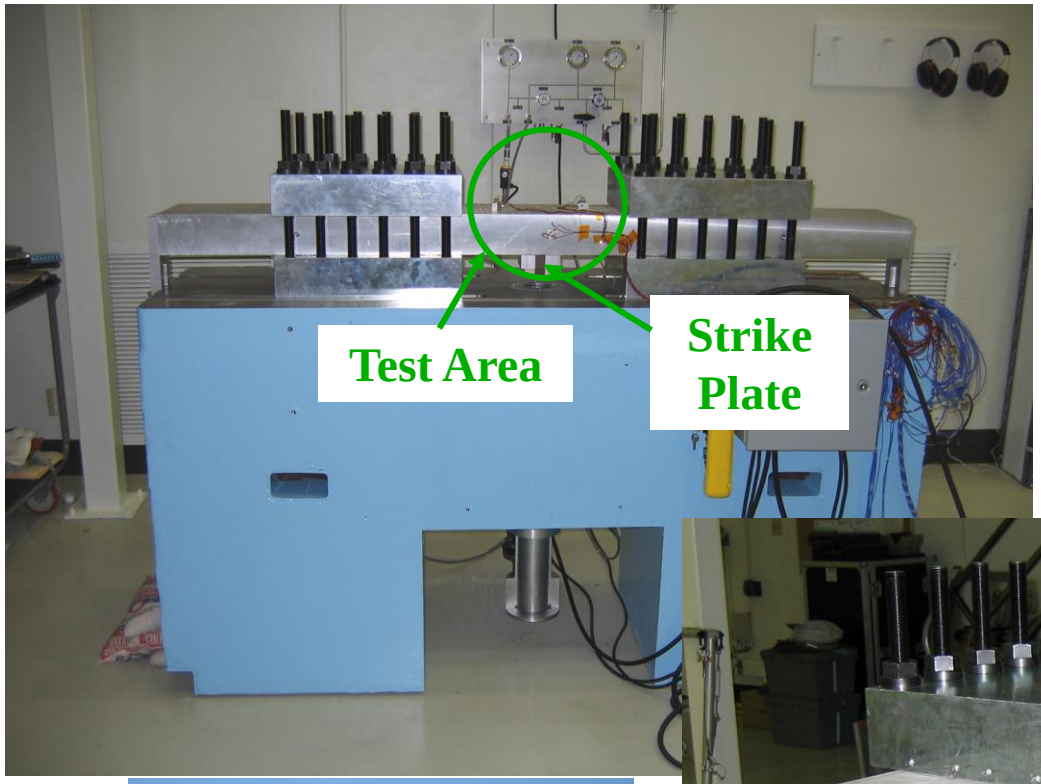
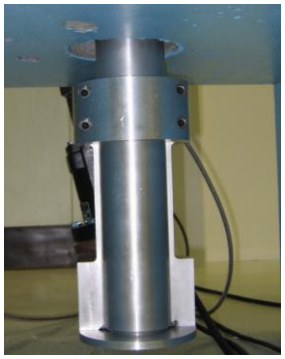
Overview

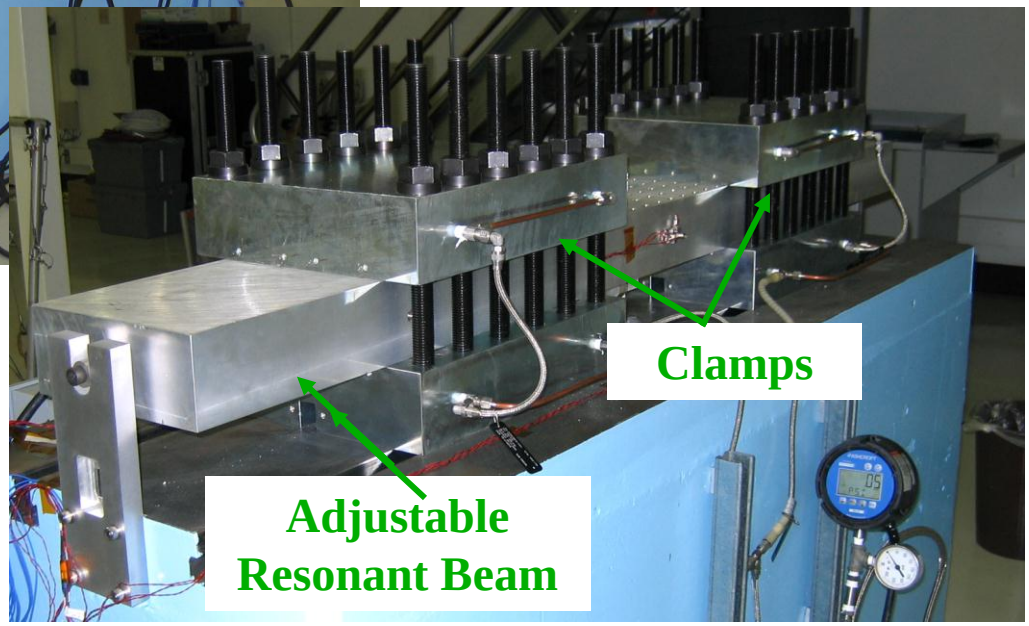
- JPL Resonant Beam
  - Similar to Sandia National Lab design
    - A projectile strikes the beam using air pressure (mass and pressure defines the speed)
    - Knee frequency in SRS specification can be adjusted by varying beam span
    - SRS amplitudes adjusted via air pressure; higher frequency attenuated using pads
      - Sensitive to other parameters such as slug configuration, pads and felt thicknesses, etc.
    - Proper felt thickness to damp out high frequency when the slug strikes the secondary block (reduces metal-to-metal contact related signatures)
- SRS Specifications in Three Orthogonal Axes
  - Tunable beam is being prepared for
    - 1000, 2000, 3000, and 4000 g's with a knee frequency of ~ 1500 Hz
  - These levels will be used for MSL components pyroshock development/flight hardware qualification testing
- Selection of accelerometer locations to obtain desired SRS specification to prevent under or over testing

Tunable Beam Setup



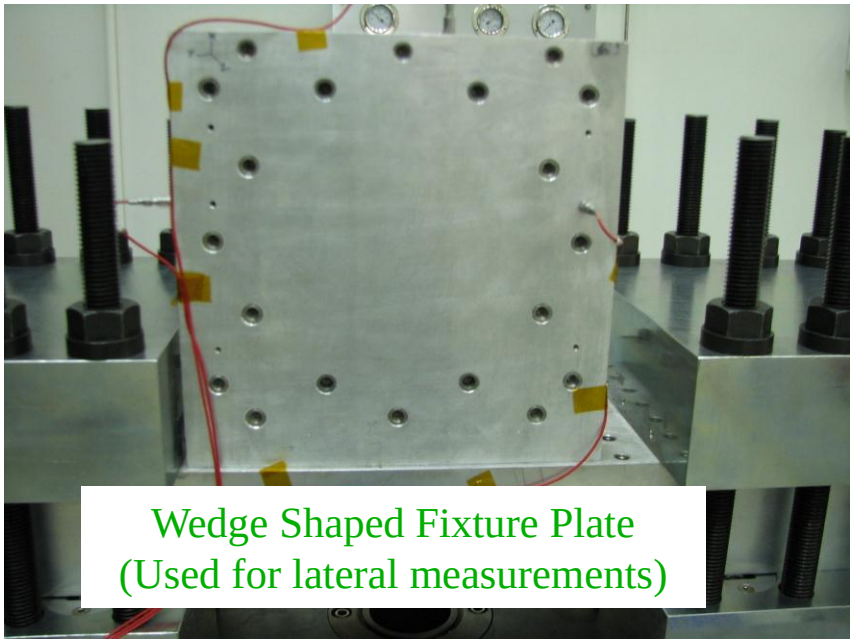


Projectile Tube

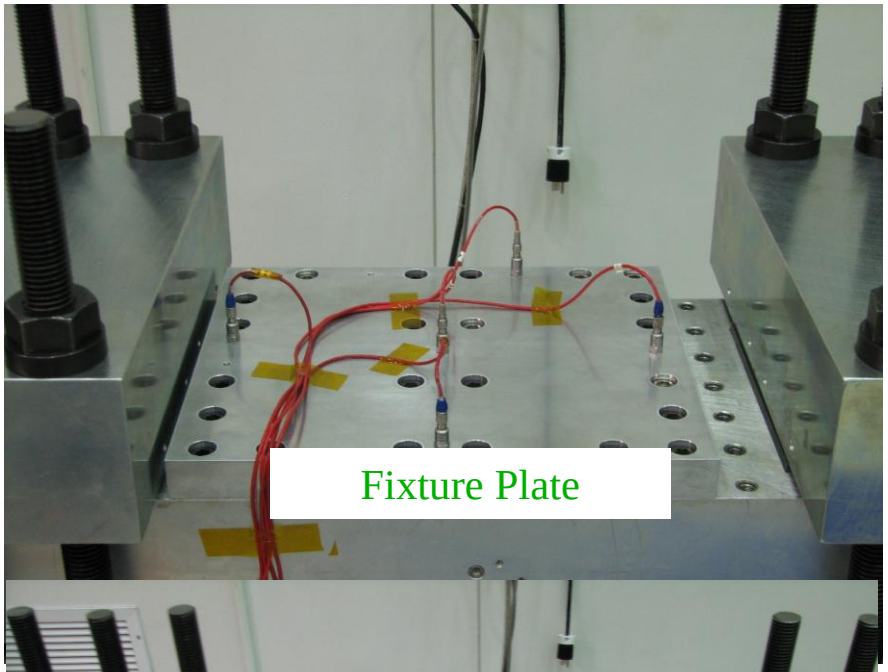


Slugs

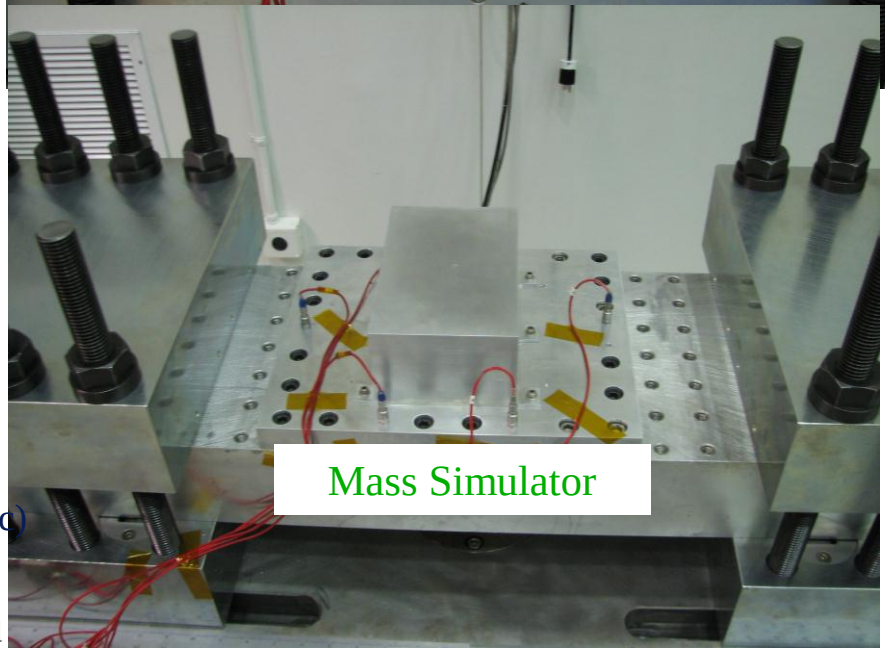
Fixture and adapter plates



Wedge Shaped Fixture Plate
(Used for lateral measurements)



Fixture Plate



Mass Simulator

First Bending Mode

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{E}{12\rho}}\frac{t}{L^2}$$

L=14 inches f_1 =4100 Hz *f1* ~ 1600 Hz (measured)
L = 16 inches f_1 = 3100 Hz *f1* ~ 1400 Hz (Measured)

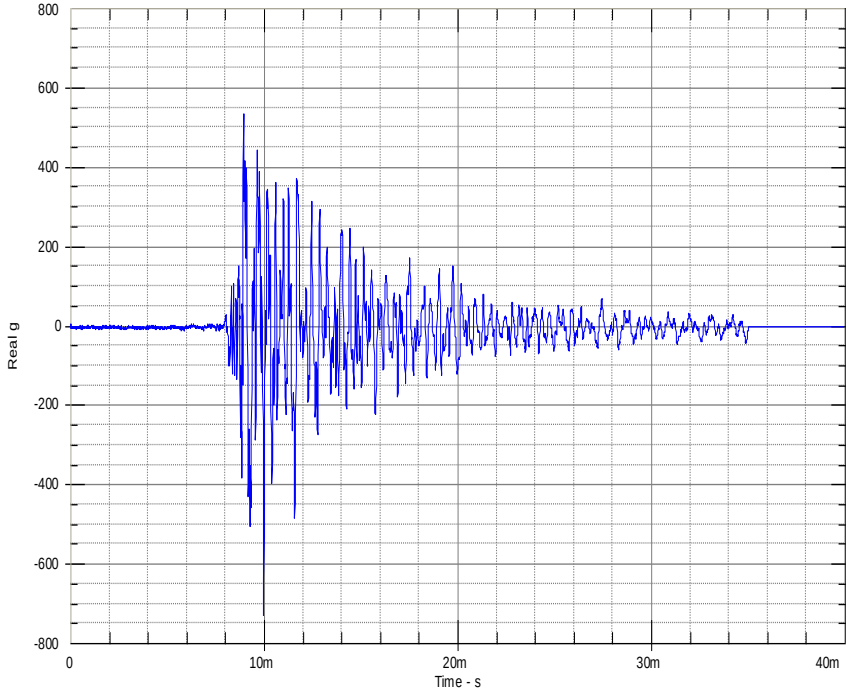
First Longitudinal Mode

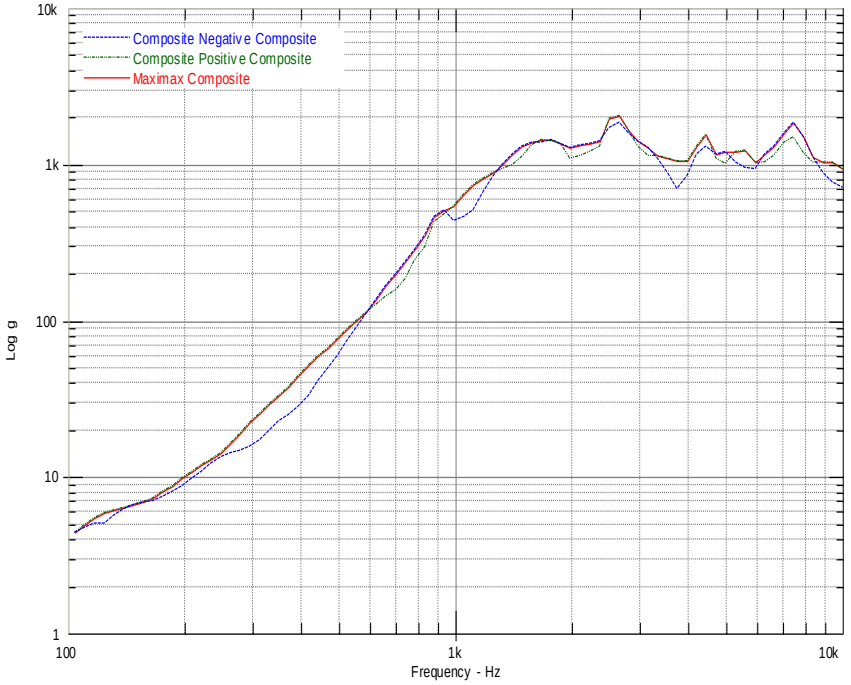
$f_1 = c/2L$

f_1 ~ 5300 Hz (calculated based on measured c ~ 150,000 in/sec)

Shock Signature and SRS in Z-axis (Vertical) Run 39

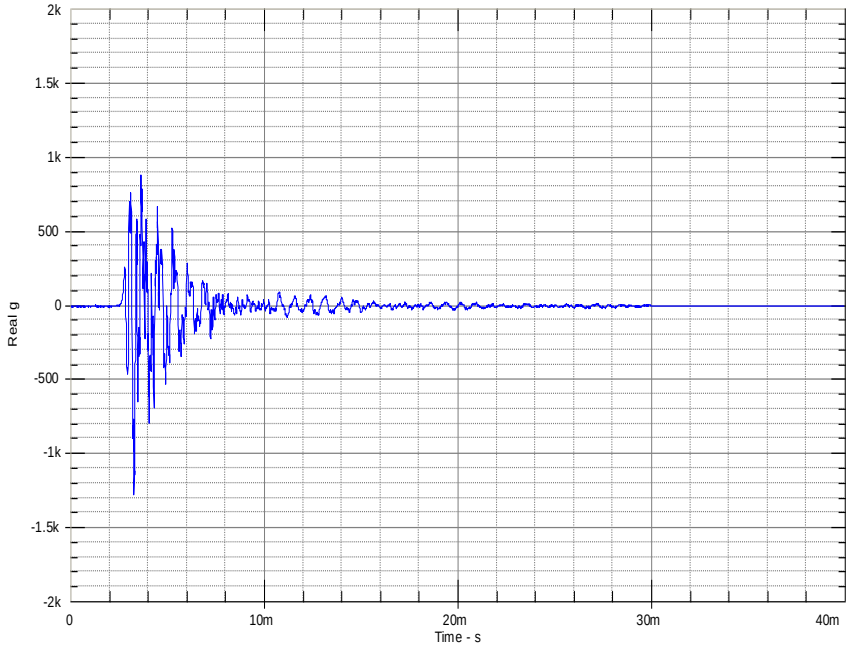
1000 g's

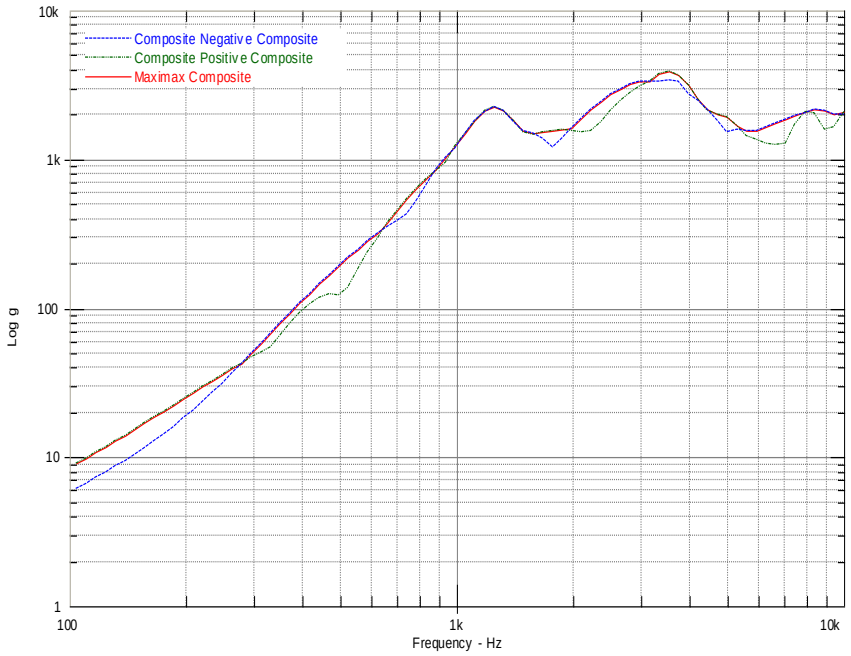




Shock Signature and SRS in Z-axis (Vertical)

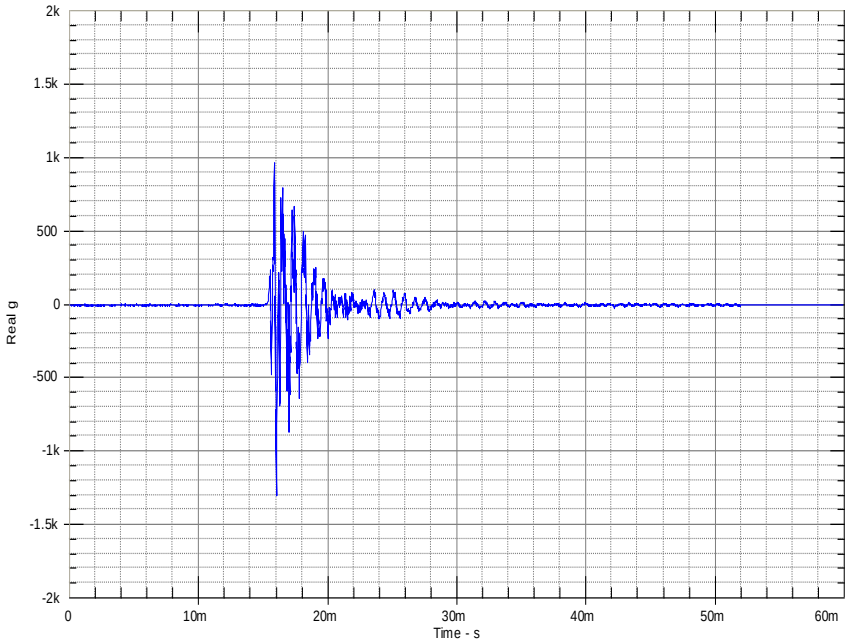
2000 g's

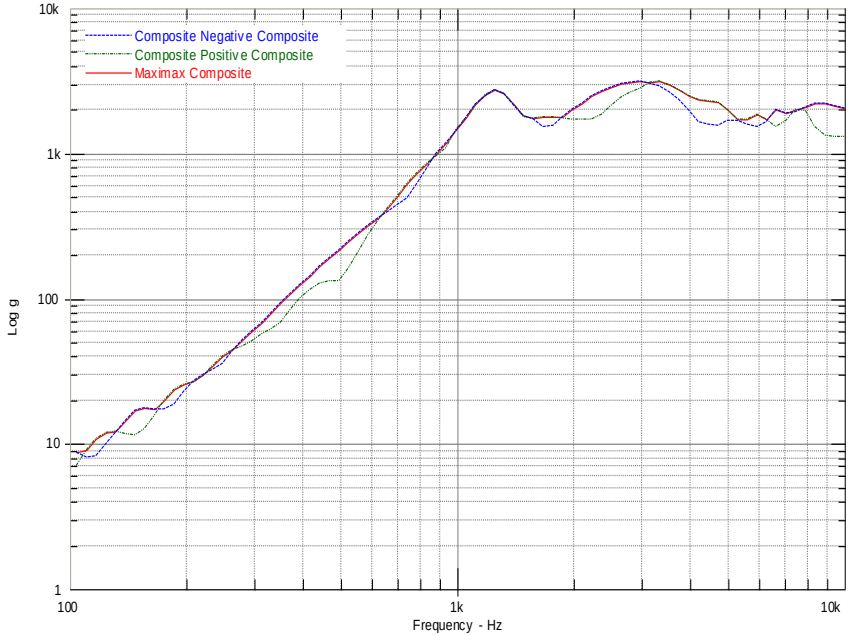




Shock Signature and SRS in Z-axis (Vertical)

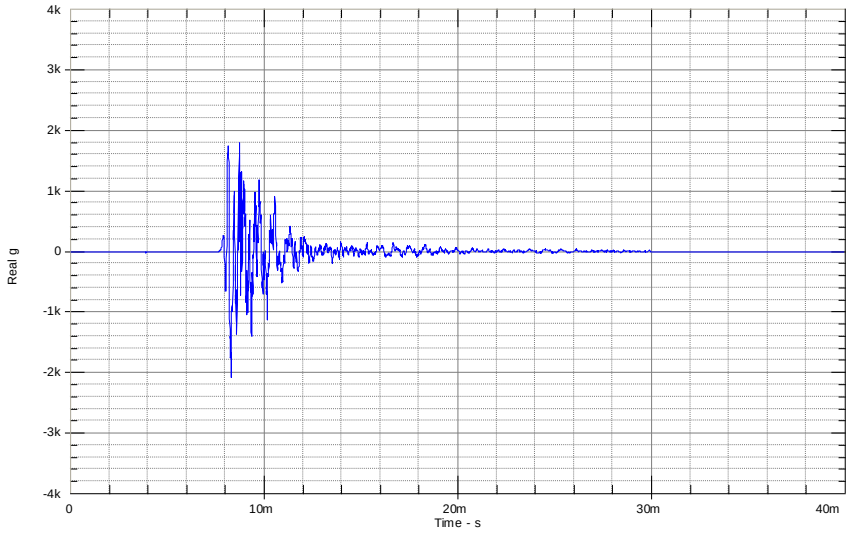
3000 g's

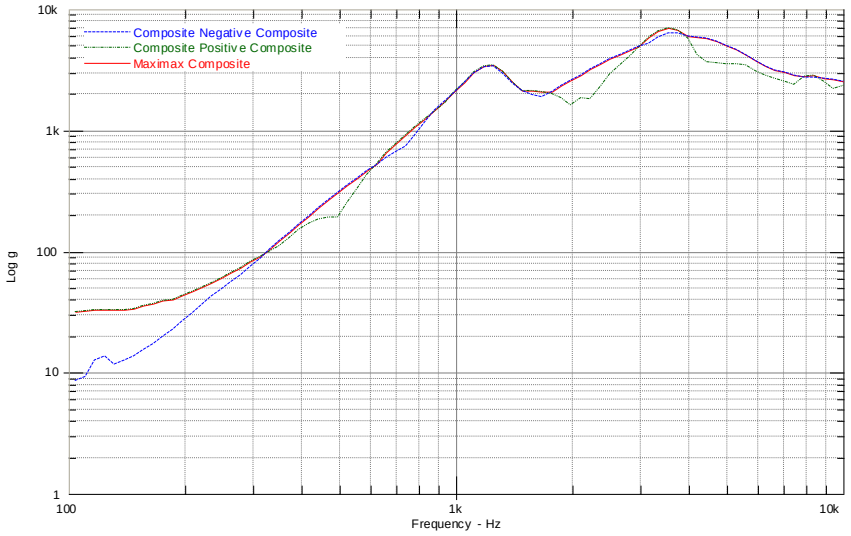




Shock Signature and SRS in Z-axis (Vertical)

4000 g's



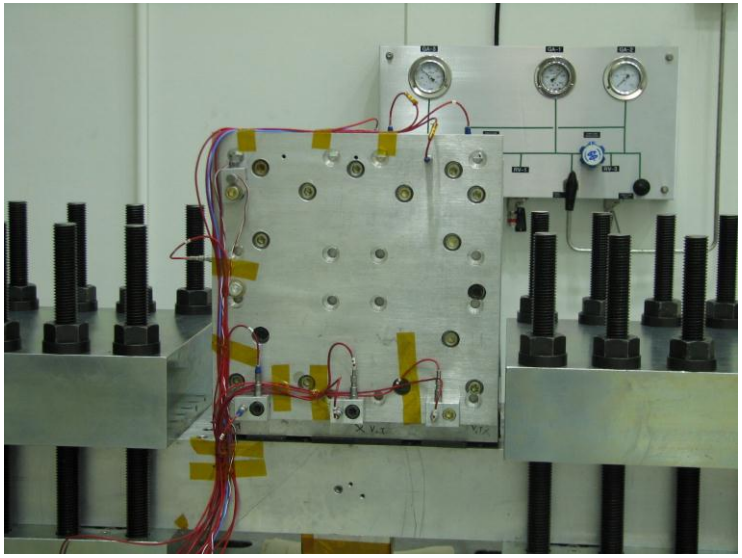


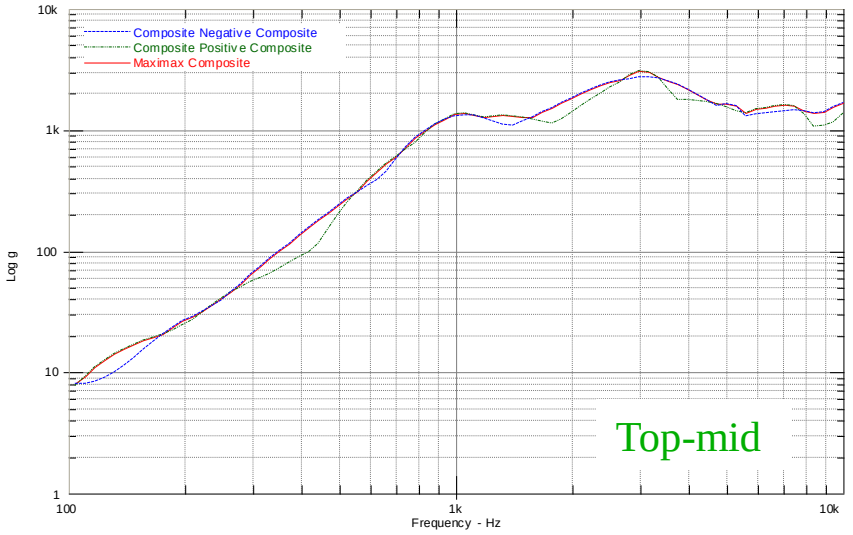
Shock Signatur Repeatability

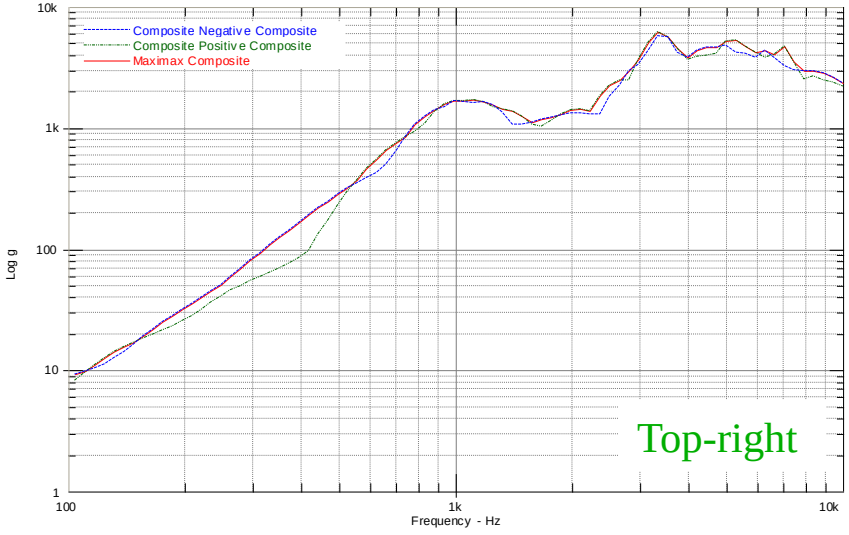
- To achieve the desired and repeatable SRS (knee frequency and levels) and shock signature the following parameters must be controlled:
  - Correct air pressure set and stable projectile/pressure accumulator system (type of valve to release pressure is important)
  - Pads for high frequency attenuation (dorameter, thicknesses)
  - Torque on all bolts
  - Secondary block that slug strikes

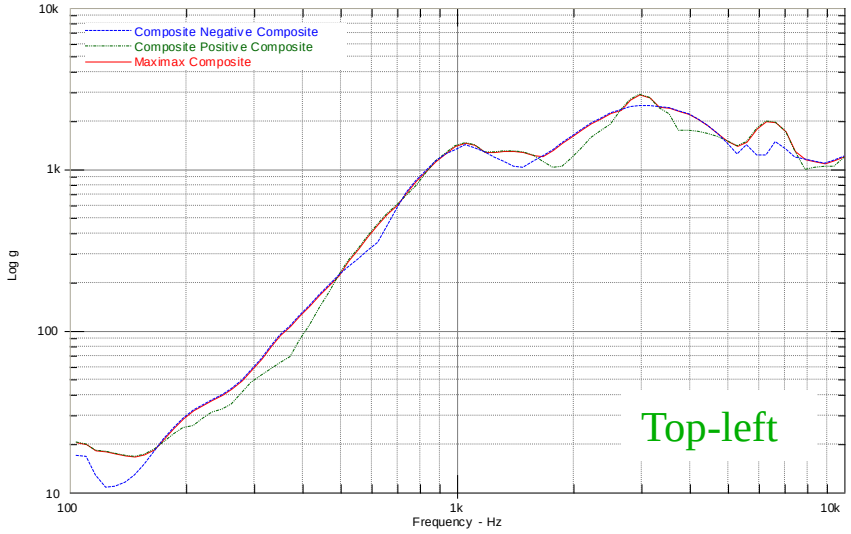
  - Fixture and support plates
  - Location and mouting the control accelerometer(s); potential for over or under testing

Shock Measurement Locations w/ Wedge

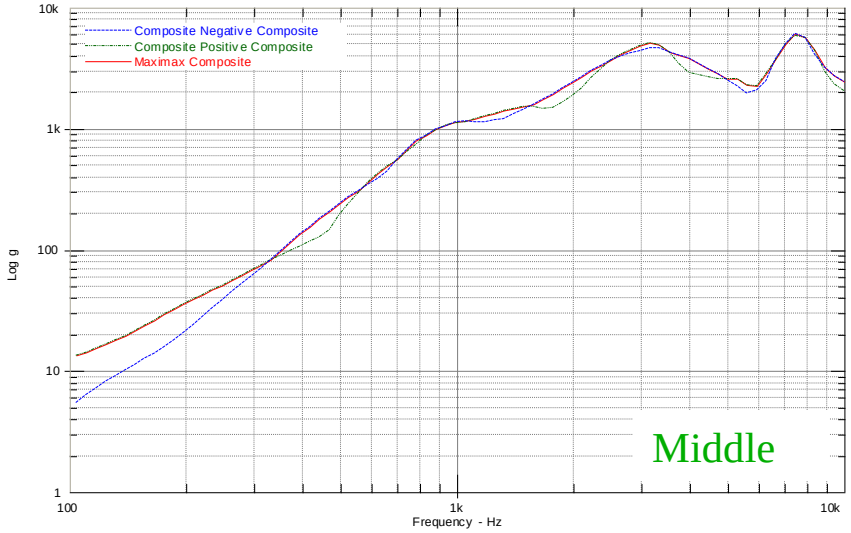


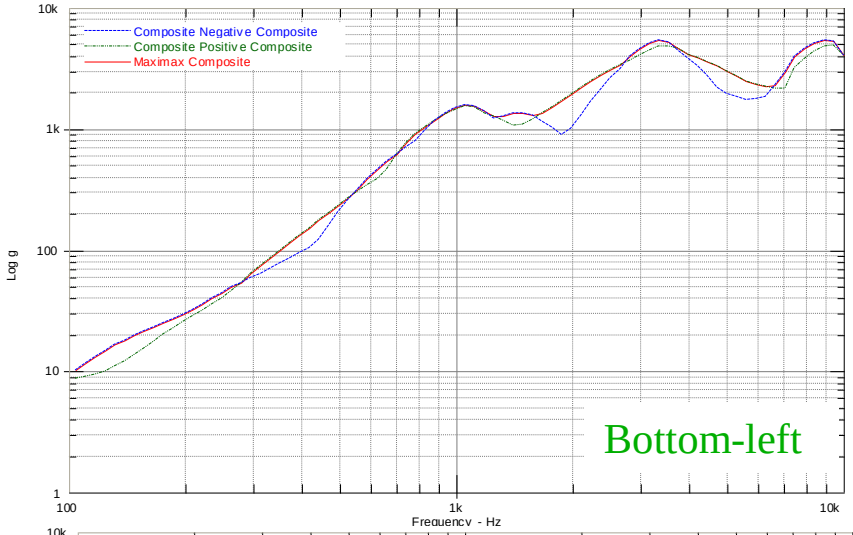


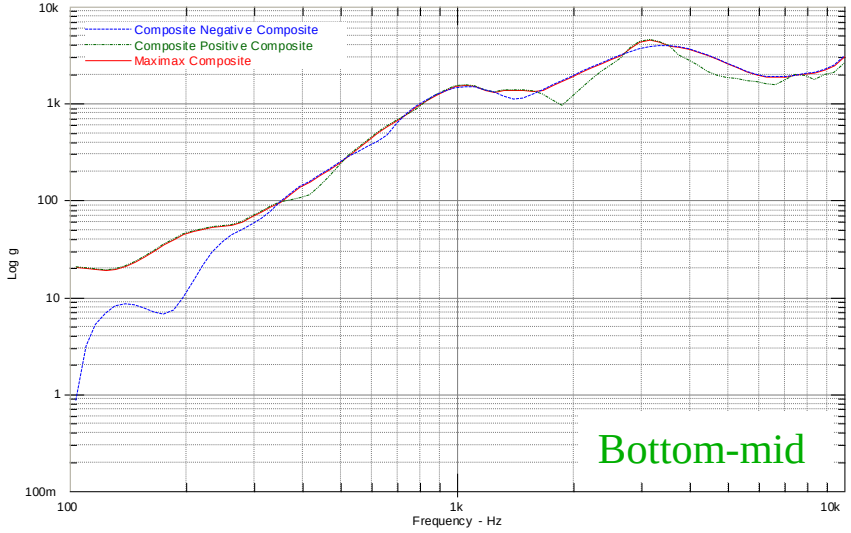


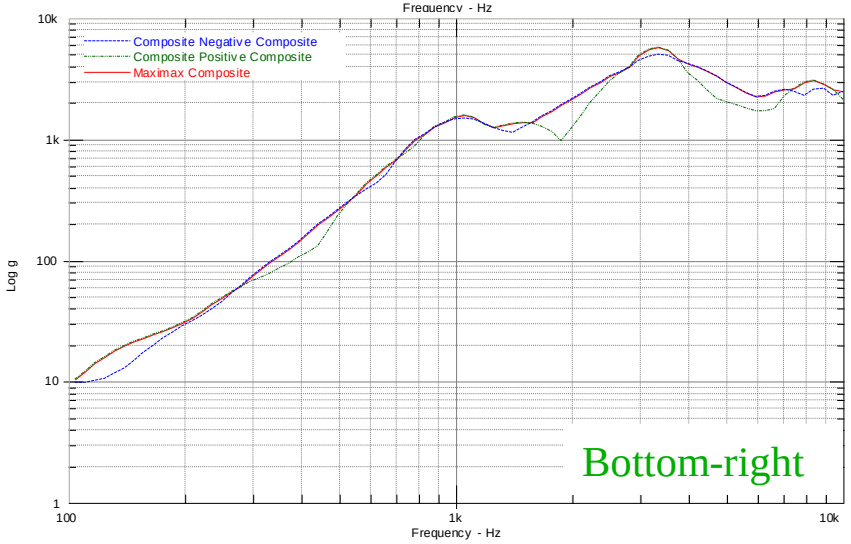


Shock Measurement Locations, cont'd

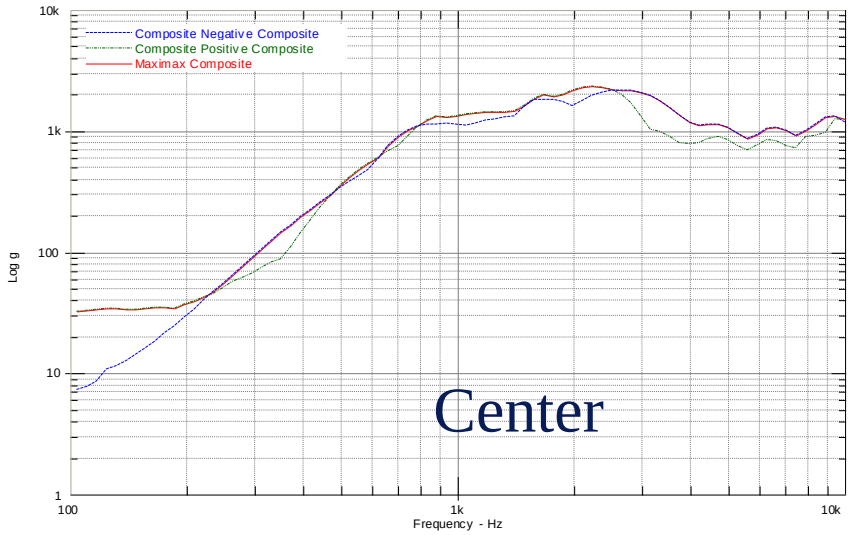




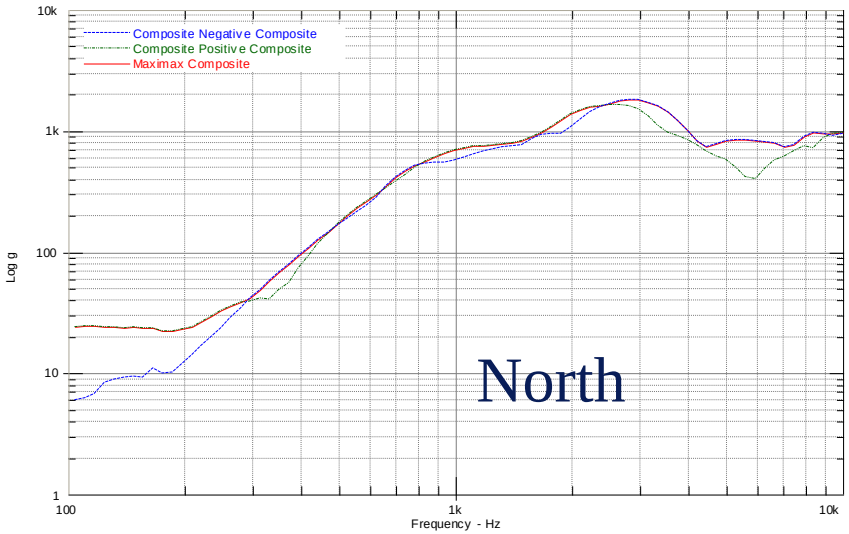


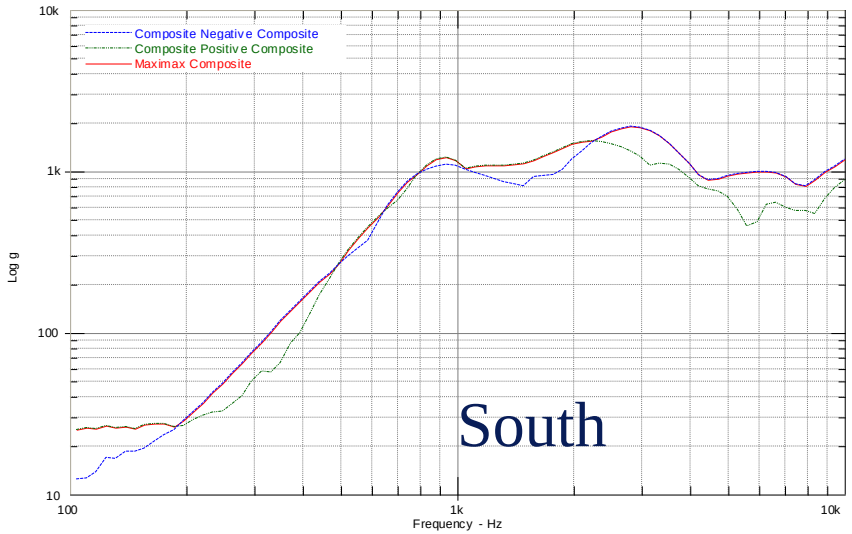


Run 80


Composite Negative Composite
Composite Positive Composite
Maximax Composite
10k
1k
100
10
1
Log g
100
1k
10k
Frequency - Hz
Center

Run 80


Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
North


Composite Negative Composite
Composite Positive Composite
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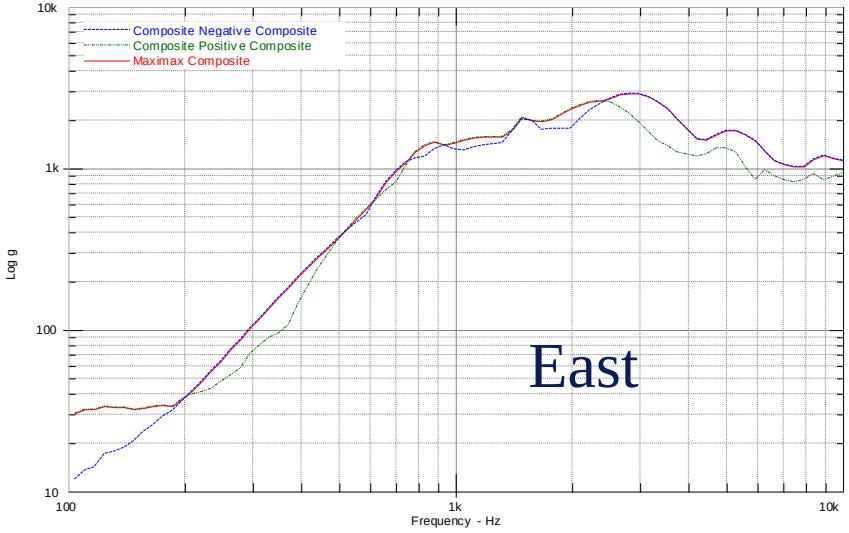
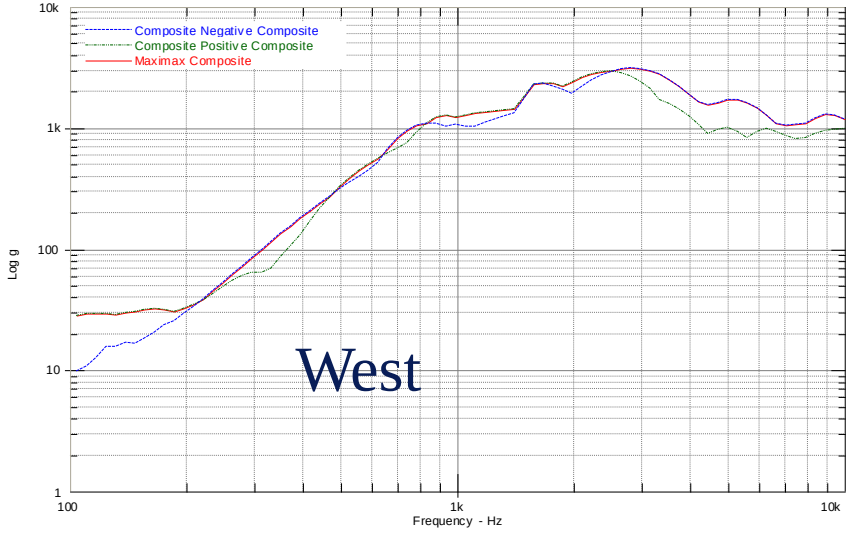
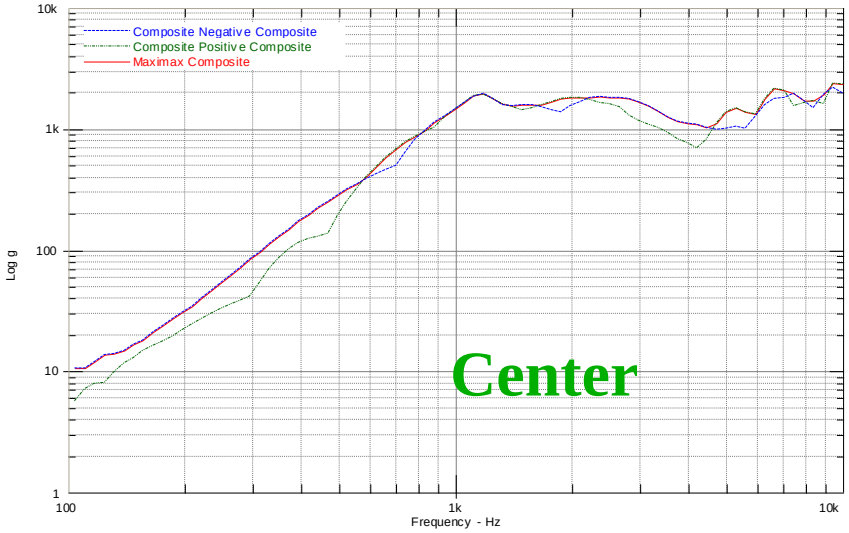
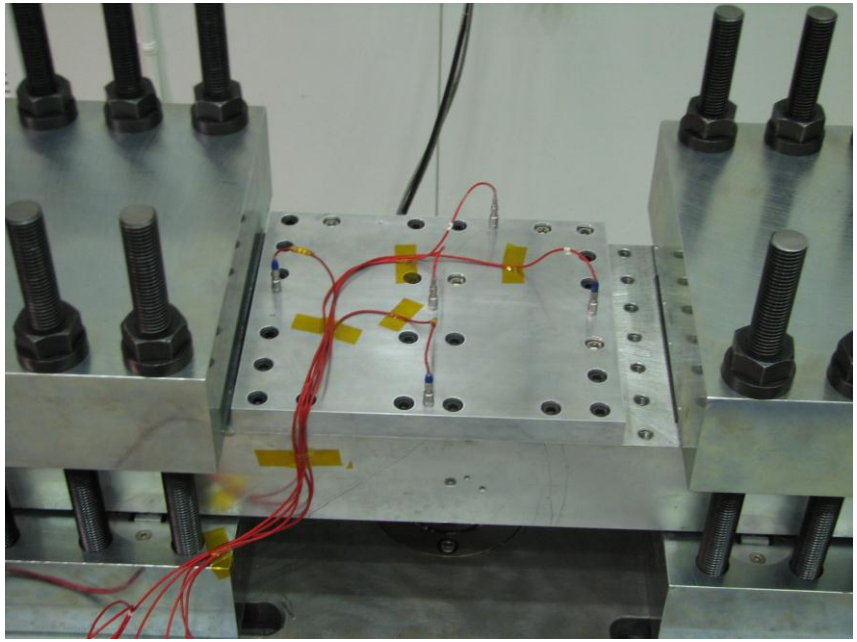
Log g
Frequency - Hz
South

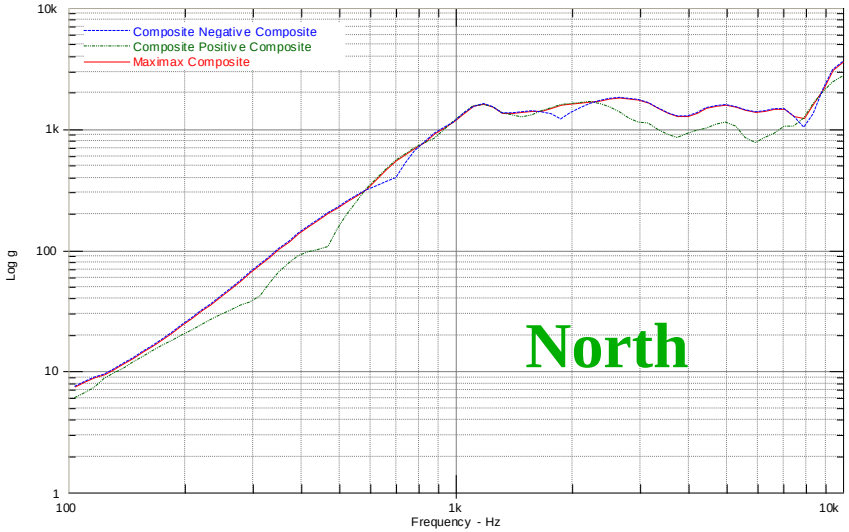

Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
East

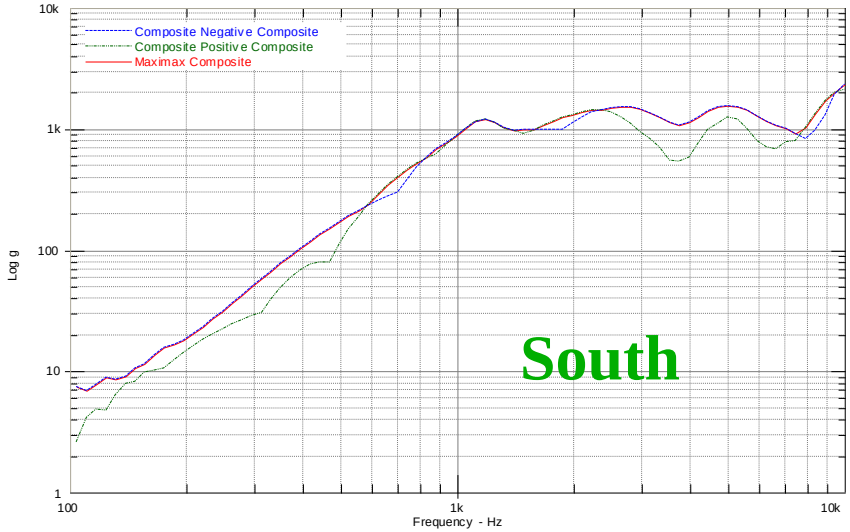

Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
West

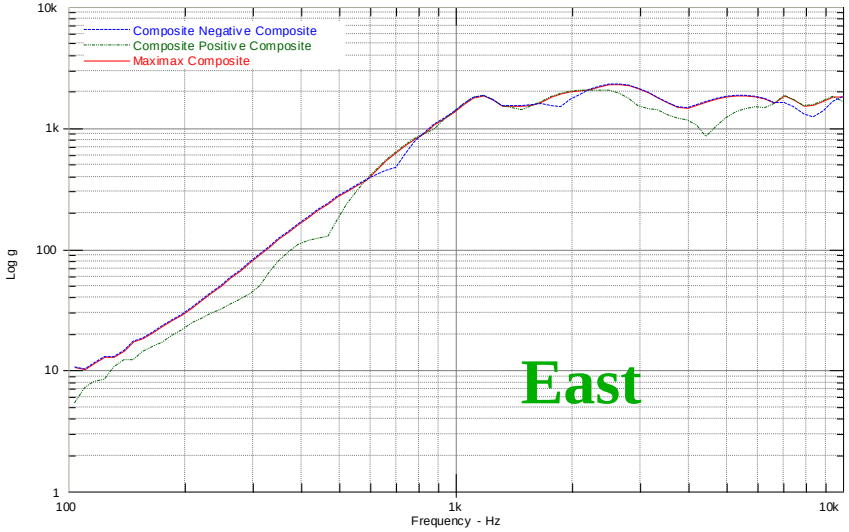
Run 86

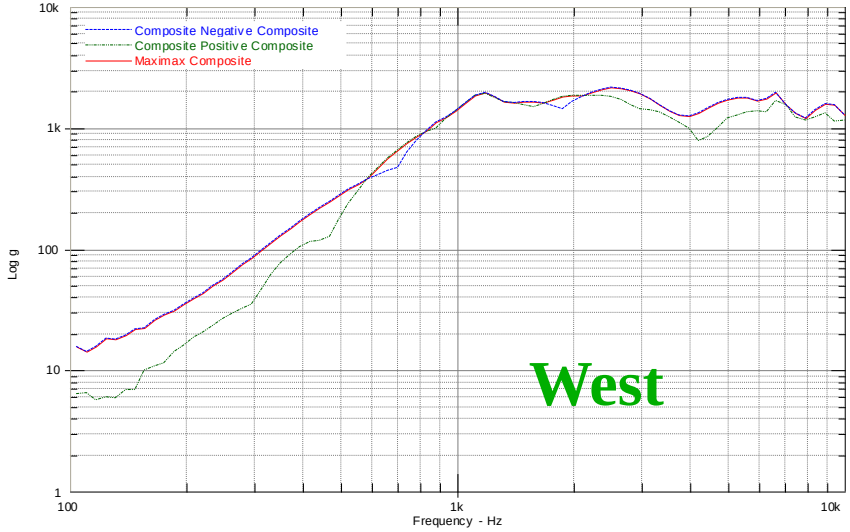

Composite Negative Composite
Composite Positive Composite
Maximax Composite
10k
1k
100
10
1
Log g
100
1k
10k
Frequency - Hz
Center




Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
10k
1k
100
10
1
100
1k
10k
North


Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
10k
1k
100
10
1
100
1k
10k
South


Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
10k
1k
100
10
1
100
1k
10k
East


Composite Negative Composite
Composite Positive Composite
Maximax Composite
Log g
Frequency - Hz
10k
1k
100
10
1
100
1k
10k
West

Summary

- Current Tunable beam setup provides four shock levels in preparation for MSL components flight/none-flight hardware shock testing
  - The system is ready to be certified for flight hardware
  - Fixture plate and control accelerometer locations to achieve the desired shock levels are to be determined on a case-by-case basis
  - To achieve correct shock specification for a test hardware a stringent procedure must be followed
  - Shock levels may be extended to below 1000 and above 4000 g's
- Current system has limited foot prints, therefore, is applied for limited test hardware
  - An adapter plate is being designed to broaden this limitation and achieve multiple axes shock with a single slug strike
- Tunable beam will be used for multi-mission shock testing