

# Is Acoustic Test (Reverberate and DFAT) Adequate Workmanship Screening of Spacecraft/Payloads?



Ali R. Kolaini, Jet Propulsion Laboratory, California Institute of Technology

Spacecraft and Launch Vehicles Dynamic Environments Workshop  
June 26–28, 2018



National Aeronautics and  
Space Administration  
**Jet Propulsion Laboratory**  
**California Institute of  
Technology**

© 2018 California Institute of Technology. Government sponsorship acknowledged.



- Acceptance test
  - To demonstrate that the hardware is acceptable for its intended use.
  - It serves as a quality control screen to detect manufacturing, material, or workmanship defects in the flight build and demonstrate compliance with specified requirements
  - Acoustics tests above 100 Hz are used by many organizations for workmanship screening purposes
- This presentation provides an open technical discussion on the applicability of acoustic test being a workmanship screening test



# Component Workmanship Test

- For components weighing less than 50 kg (110 pounds), the spectrum shown below is used as a minimum vibration test specification (NASA 7001).

Frequency (Hz)	$g^2/\text{Hz}$
20	0.01
20 to 80	+3 dB/Oct
80 to 500	0.04
500 to 2000	-3 dB/Oct
2000	0.01
Overall	6.8

- For sensitive hardware designed to much lower level than 6.8 g these RV levels may be not applicable
- Workmanship should not be a design driver and the table above should be revised on a case-by-case basis**
- There are no stated minimum vibration testing (sine, random, or transient) for hardware with weights more than 50 kg,
  - NASA-STD-7001 recommends a minimum mass attenuated workmanship random vibration test level of 0.01  $g^2/\text{Hz}$  flat from 20 to 2,000 Hz for components whose weight is greater than 200 kg (440 lb).



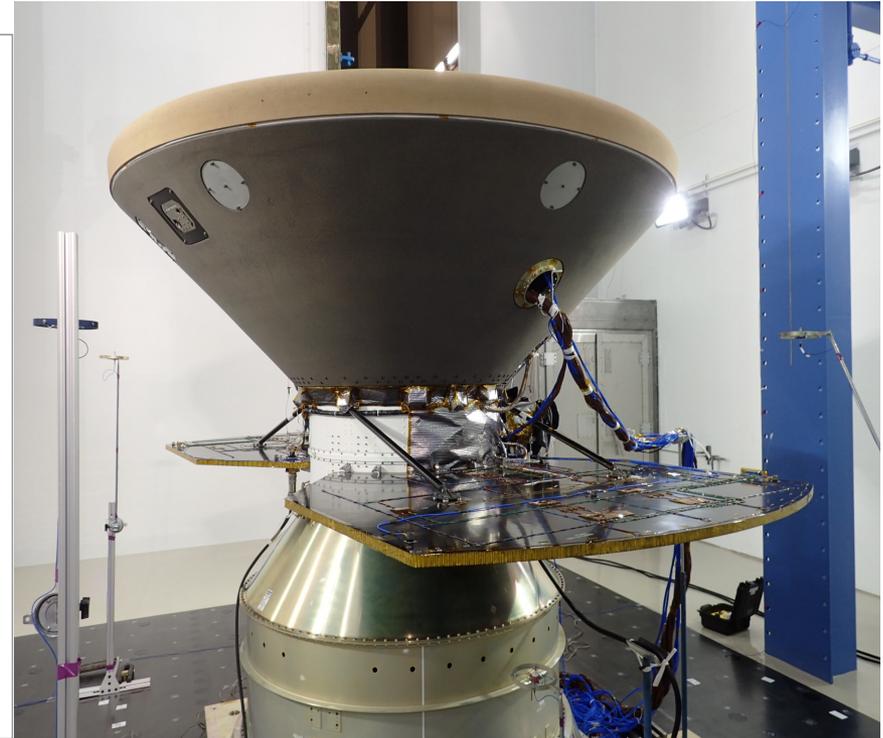
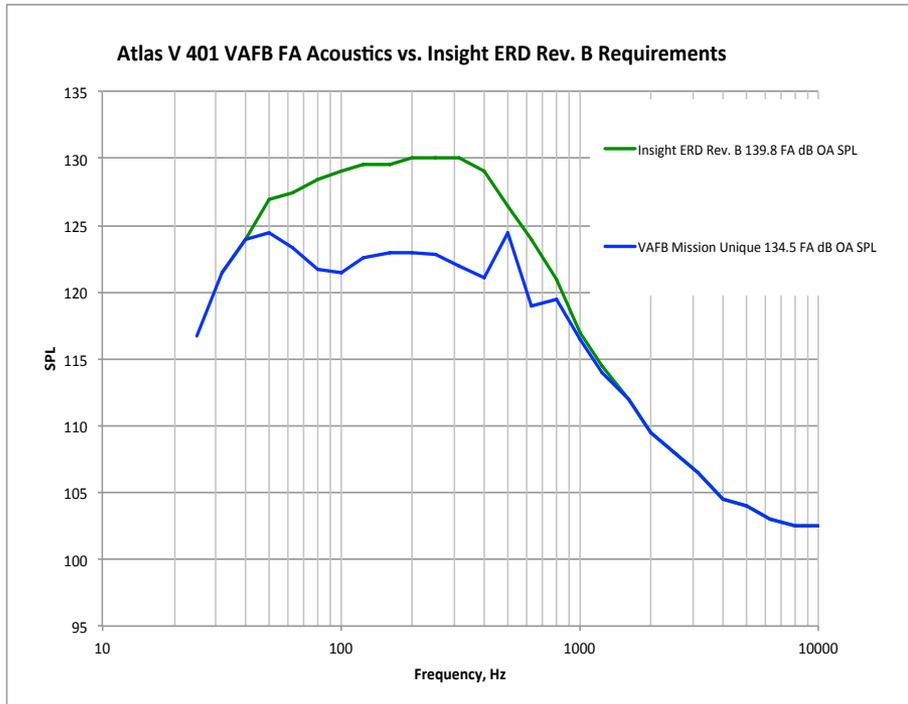
# USAF Minimum Workmanship Acoustic Test Levels

Units and Vehicles			
1/3 Octave Band Center Frequency, Hz	Minimum Sound Pressure Level, dB	1/3 Octave Band Center Frequency, Hz	Minimum Sound Pressure Level, dB
31	121	630	125
40	122	800	124
50	123	1000	123
63	124	1250	122
80	125	1600	121
100	125.7	2000	120
125	126.5	2500	119
160	126.7	3150	118
200	127	4000	117
250	127	5000	116
315	126.7	6300	115
400	126.5	8000	114
500	125.7	10000	113
Overall 138 dB			

**Important frequency range for workmanship**



# Insight Acoustic Requirements

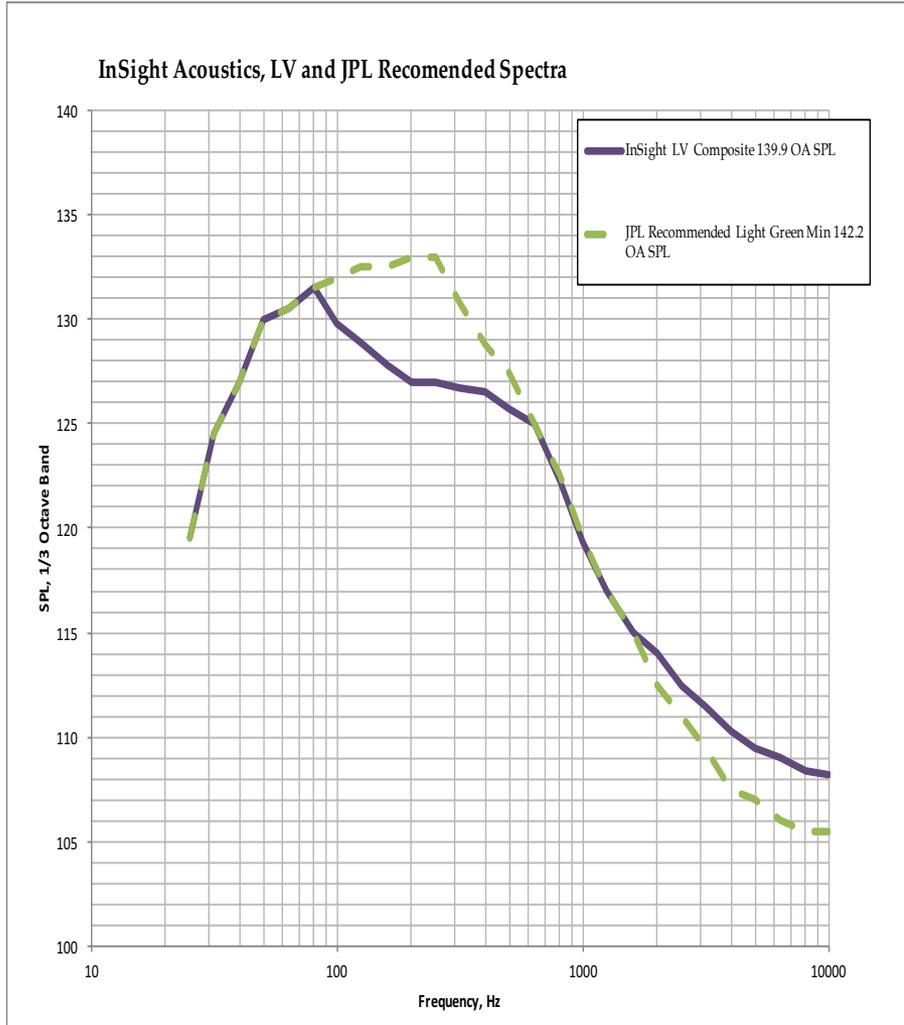


- Revised OASPL Requirement: 134.5 vs 139.8 dB
- Revised acoustic level in mid frequency much lower than the required acoustic workmanship level shown in the previous chart
  - **Workmanship test objectives not achievable with these levels!**



*352G Dynamics Environments*

# Proposed Insight S/C Acoustic Test



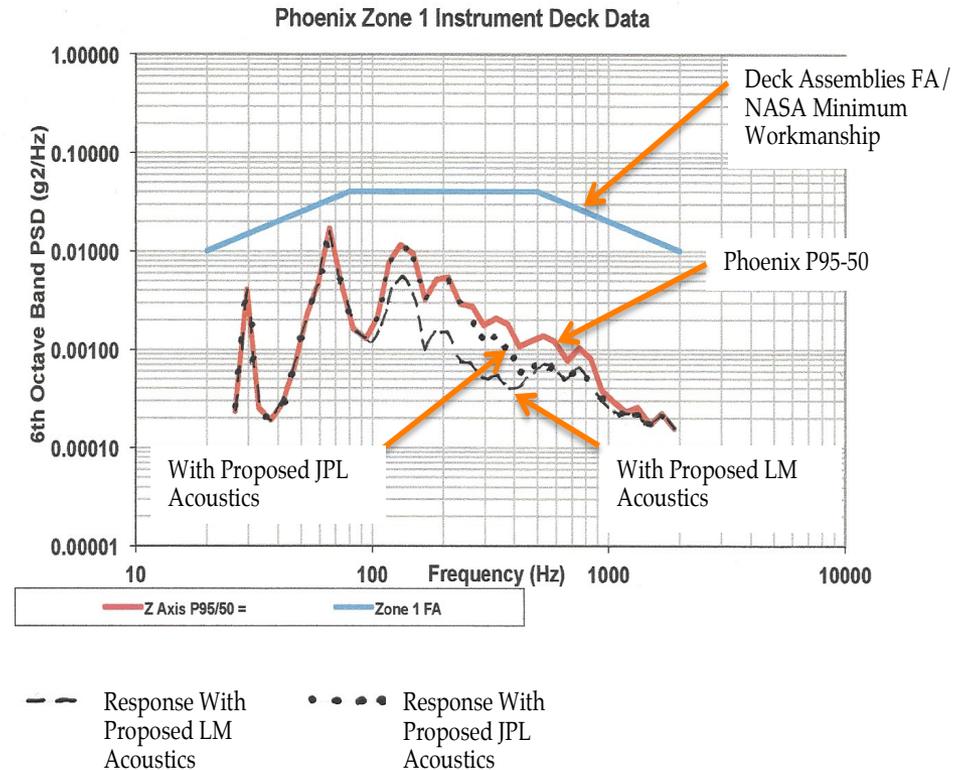
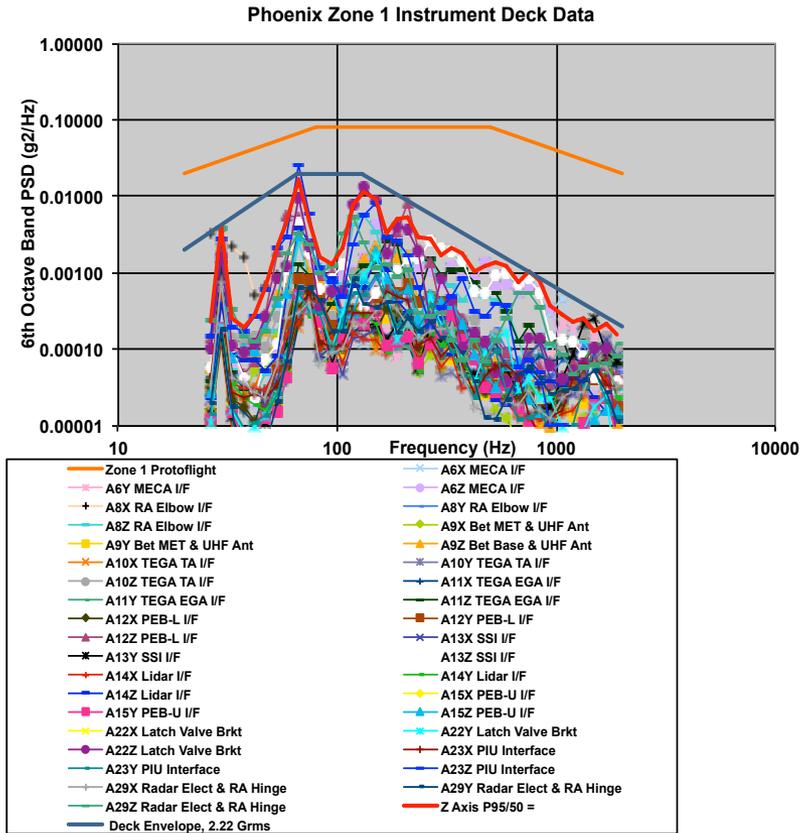
A new acoustic spectrum was negotiated with project based on the following:

1. The S/C is similar built as Phoenix, which was qualified to original acoustic level
2. Critical components interface responses from Phoenix acoustic test were scaled to the proposed levels (next chart)
3. A notch of 3 dB in real-time was introduced into the acoustic spectrum to protect the cruise stage solar arrays per launch vehicle contractor's request.

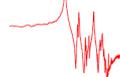
The increase in the acoustic test requirement reduced the mission risk from 'high risk' to 'moderate', as in the original assessment of the system vibration test waiver.



# Insight Components Response Assessment

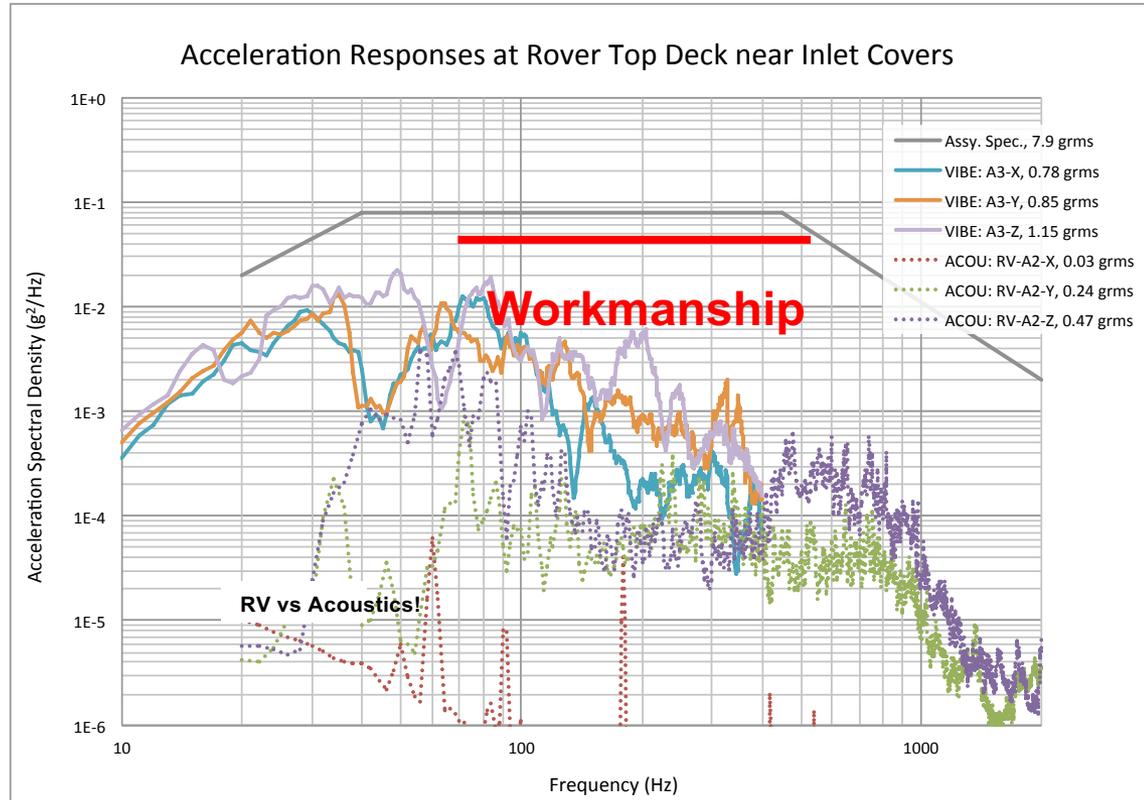


- The Phoenix Science Deck vibration P95/50 plotted (Left figure).
- Phoenix Science Deck vibration was scaled to the new Launch vehicle contractor acoustic spectrum and the JPL proposed acoustic levels.
- The wide difference between the NASA minimum workmanship and the predicted responses on the Science Deck is shown (right figure)
- These were provided as technical reasoning to accept JPL proposed levels



352G Dynamics Environments

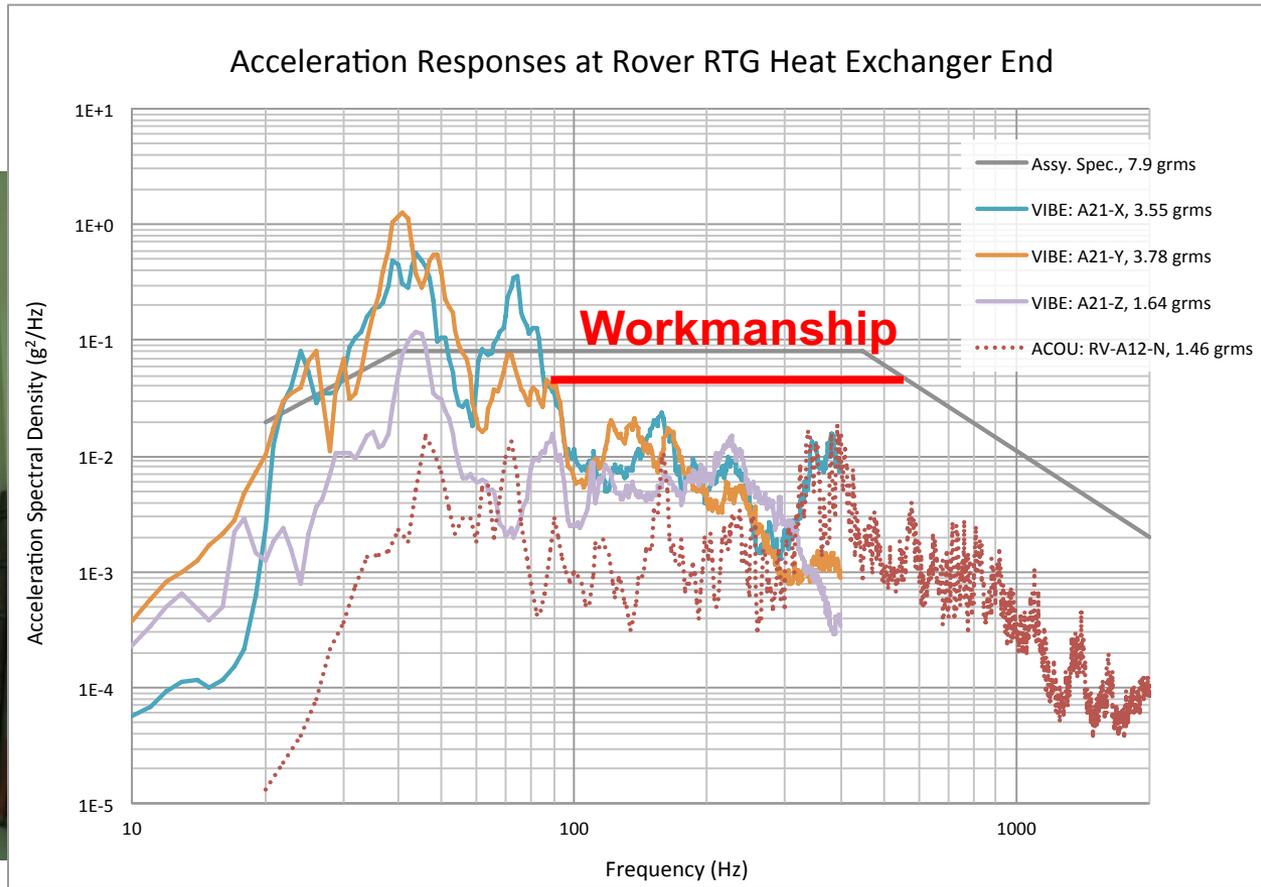
# MSL S/C Acoustic Tests, 1/3



- Rover Top Deck responses inside heat shield yield levels much lower than the workmanship requirement (more than two orders of magnitude)
- Acoustic test not a good workmanship test for this case



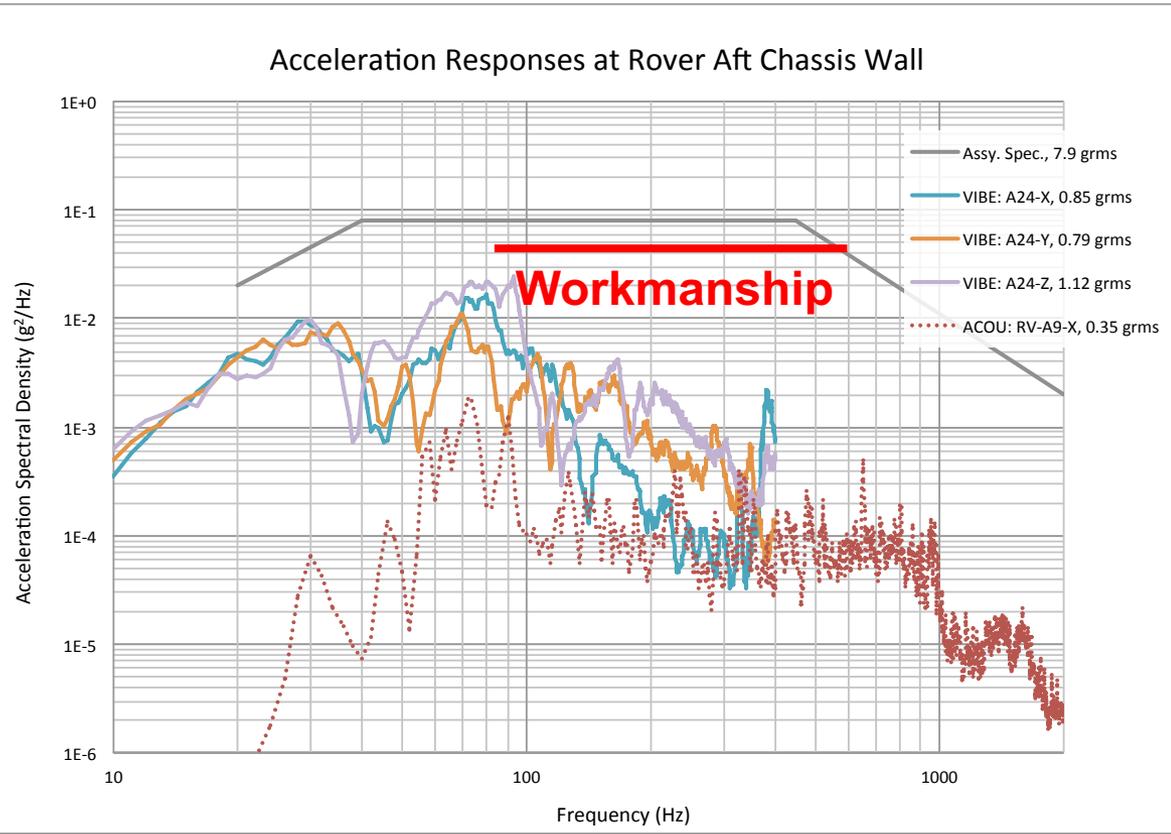
# MSL SC Acoustic, 2/3



- Rover RTG responses inside heat shield yield levels much lower than the workmanship requirement (more than two orders of magnitude between 80 Hz to 350 Hz)
- Acoustic test not a good workmanship test for this case



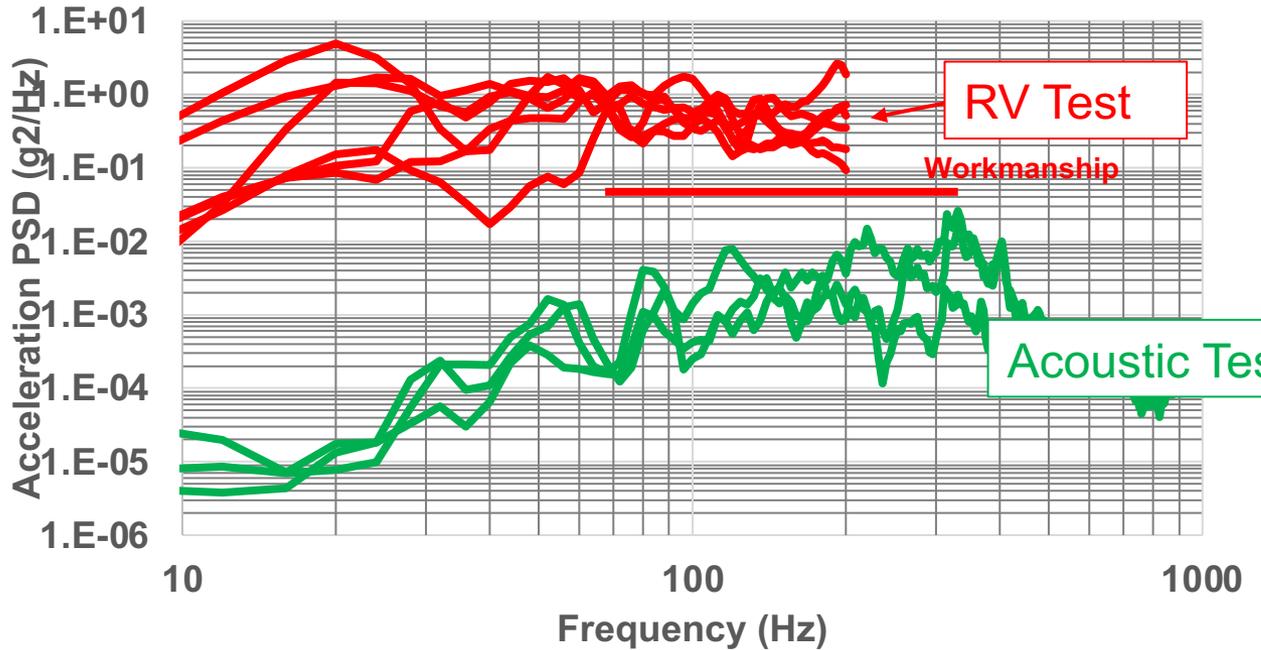
# MSL SC Acoustic 3/3



- Rover Aft Chassis Wall responses inside heat shield yield levels much lower than the workmanship requirement (more than two orders of magnitude)
- Acoustic test not a good workmanship test for this case



# Aquarius Acoustic Test

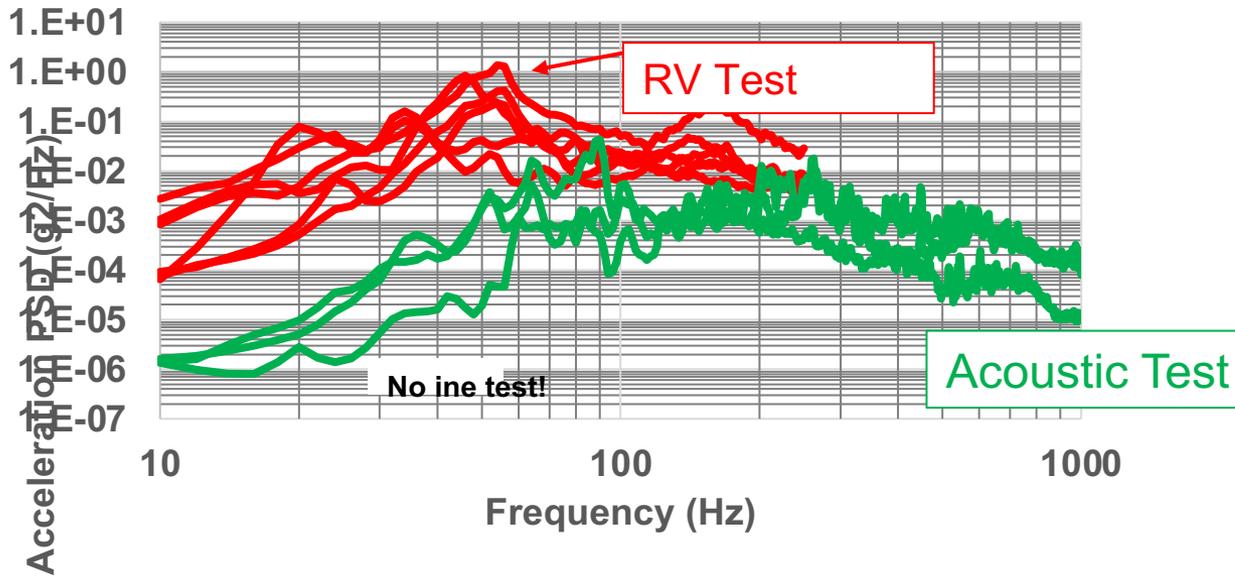


- **AQUARIUS Flight Instrument Response @ Bipod Top +X due to Acoustics Test lower than workmanship requirements**
  - **Mono-ball workmanship flaws uncovered during RV tests not acoustic test**



*352G Dynamics Environments*

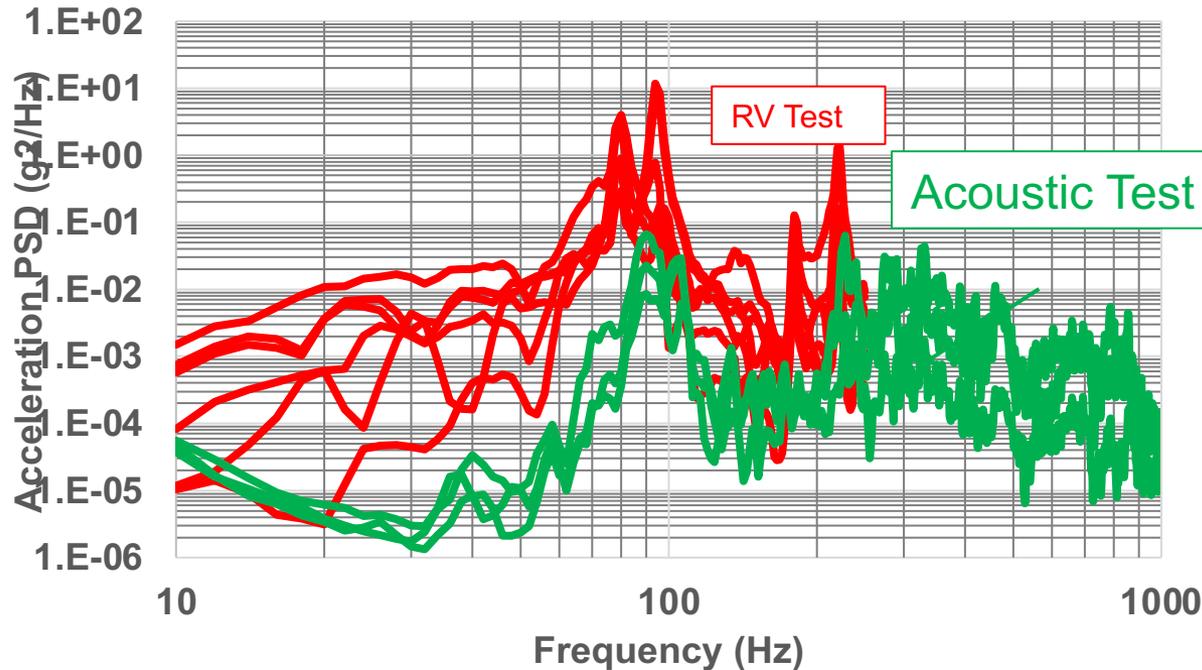
# SMAP Acoustic Tests, 1/2



- **SMAP Flight Instrument Responses @ RBA Reflector Deployment Motor Interface due Acoustics Test; less than workmanship levels (more than an order of magnitude)**
  - **Acoustic test not a good workmanship test for this case**



# SMAP RV Acoustic Test, 2/2



- **SMAP Flight Instrument Response @ Low Gain Antenna due to PF Acoustics Test; two order of magnitude less than workmanship levels**
  - **Acoustic test not a good workmanship test for this case**

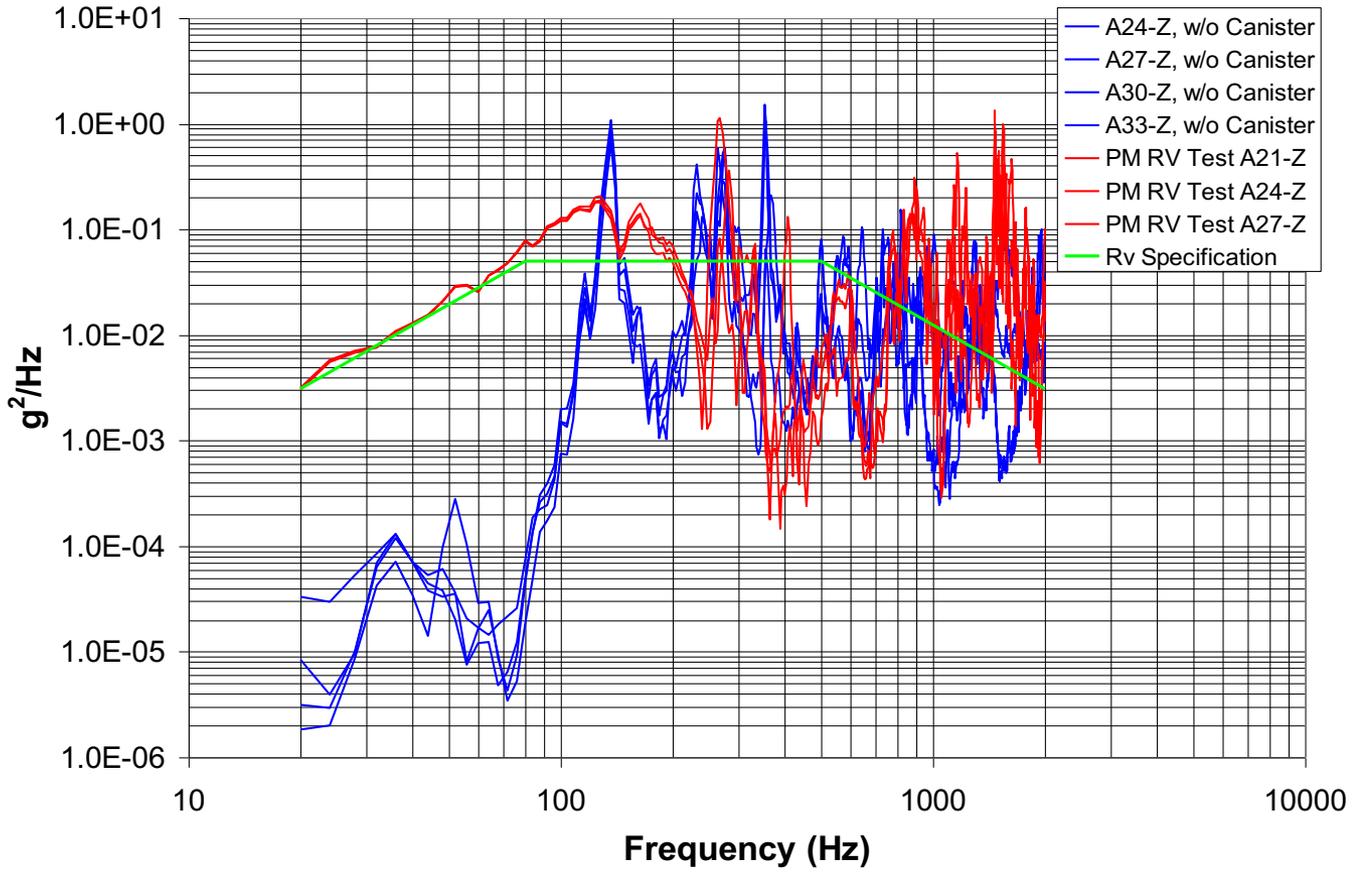


# Summary

- This presentation is an attempt to draw the community's attention to acoustic test as a workmanship screening (Reverberant and DFAT)
- Serves as an introduction to the special session at this workshop discussing acoustic test
- Acoustic test is not a complete workmanship test above ~100 Hz
  - Structures that are not acoustically responsive will not provide adequate workmanship screening test
  - Structures inside an enclosure that attenuate sounds will not go thru adequate workmanship test
- Acoustic pressure limits should not be part of acoustic tests using Reverberant and DFAT methods
  - There are discussions on limiting responses (i.e. pressure levels) during acoustic tests; no technical justification exists for this



# One more topic .... (Reflector Acoustic and RV Tests Responses)



**Acoustic test not a substitute for component RV qualification test**



# Thank you



National Aeronautics and  
Space Administration  
**Jet Propulsion Laboratory**  
**California Institute of  
Technology**

