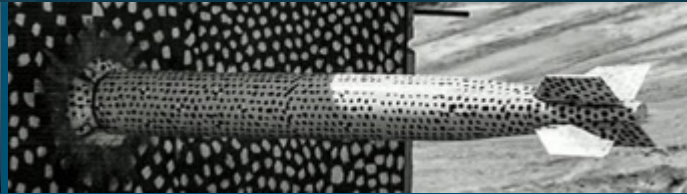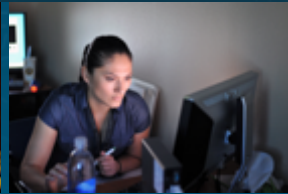Sandia National Laboratories

SAND2020-14243C

Mechanical Environment Test Specifications Derived from Equivalent Energy in Fixed Base Modes, with Frequency Shifts from Unit-to-Unit Variability

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Outline

Motivation

Test Hardware and Loads

Modal Test of RC on 6 DOF Test Fixture

Analysis
- Develop One Specification Accounting for Unit-to-Unit Variability
- Develop Independently Tailored Test Specifications for Unit-to-Unit Variability

Motivation

Motivation

Design qualification requires laboratory mechanical environments testing

Test specifications traditionally are developed with too few sensors at the wrong locations

Elastic motion, rotations, and off-axis motions at the interface are often ignored resulting in poor representations of the input

Considered conservative, but this is not quantified

We develop 6 DOF base excitation that reproduces the test article responses measured in the assembly under environment loads
- Address Unit-to-Unit Variability
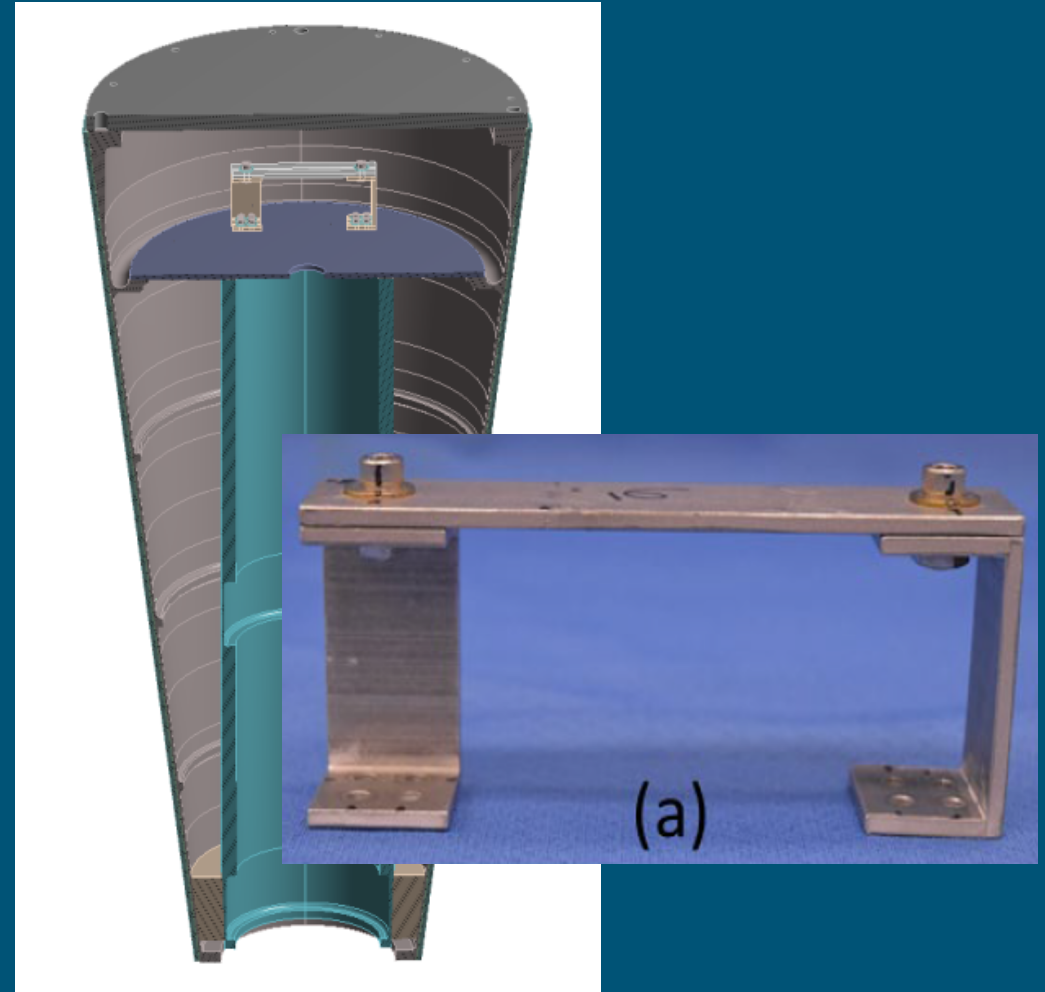
Test Hardware and Loads

Test Hardware and Loads

System: Modal Analysis Test Vehicle (MATV)
- Developed by Atomic Weapons Establishment (AWE)
- ~ 1 m tall and 47 kg
- Composite conical shell
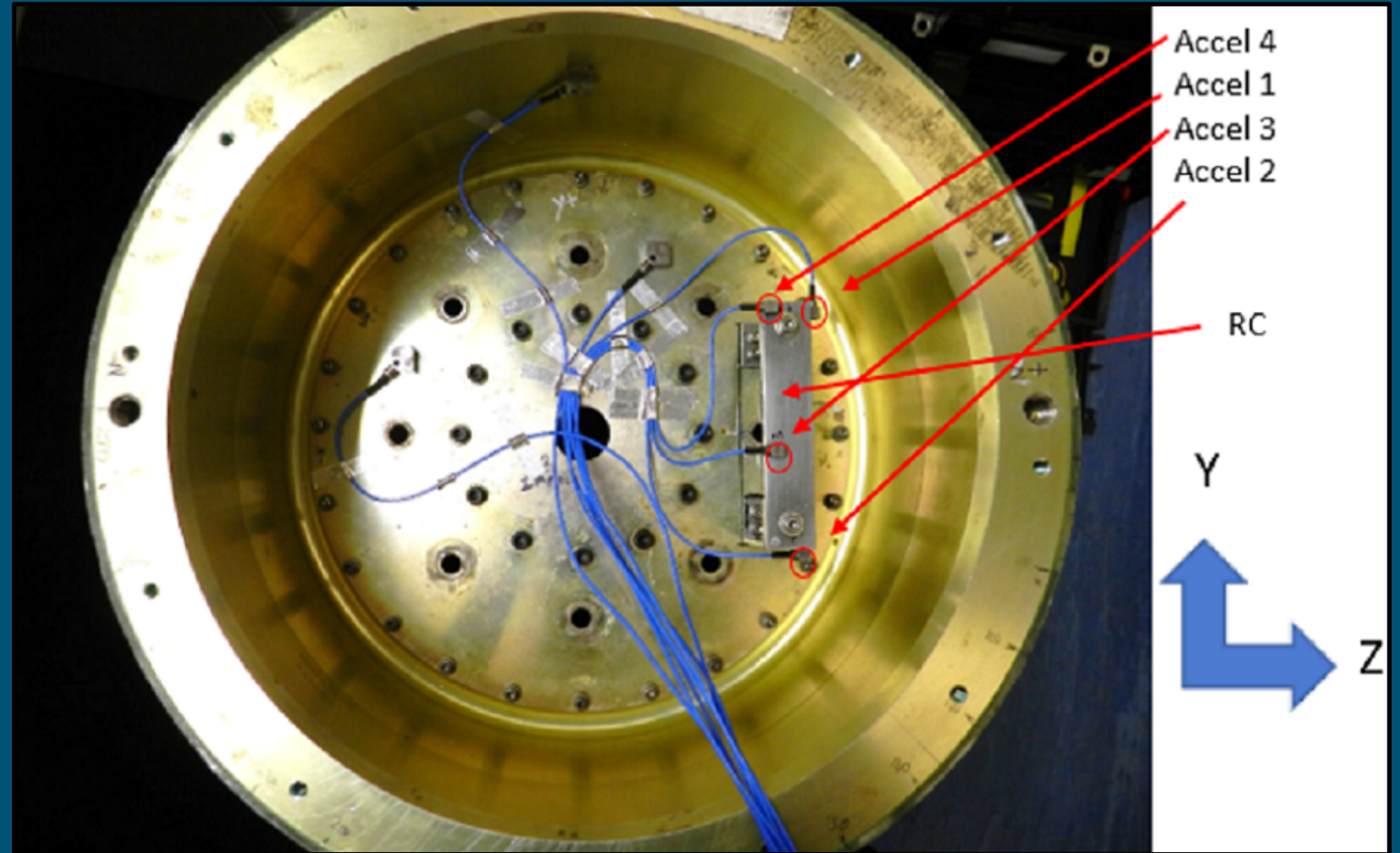- Aluminum shell substrate, cover plate, and internal component plate
- Steel pipe

Removable Component (RC)
- Part of the Box Assembly with Removable Component (BARC) from the Boundary Condition Challenge Problem
- ~ 2" tall, 5" wide
- 2 oriented "C" channel sections connected by a beam on the top

(a)

RC shown inside MATV
with the aft cover removed

4 Triaxial Accelerometers

Test Hardware and Loads

Suspended MATV in front of an acoustic horn
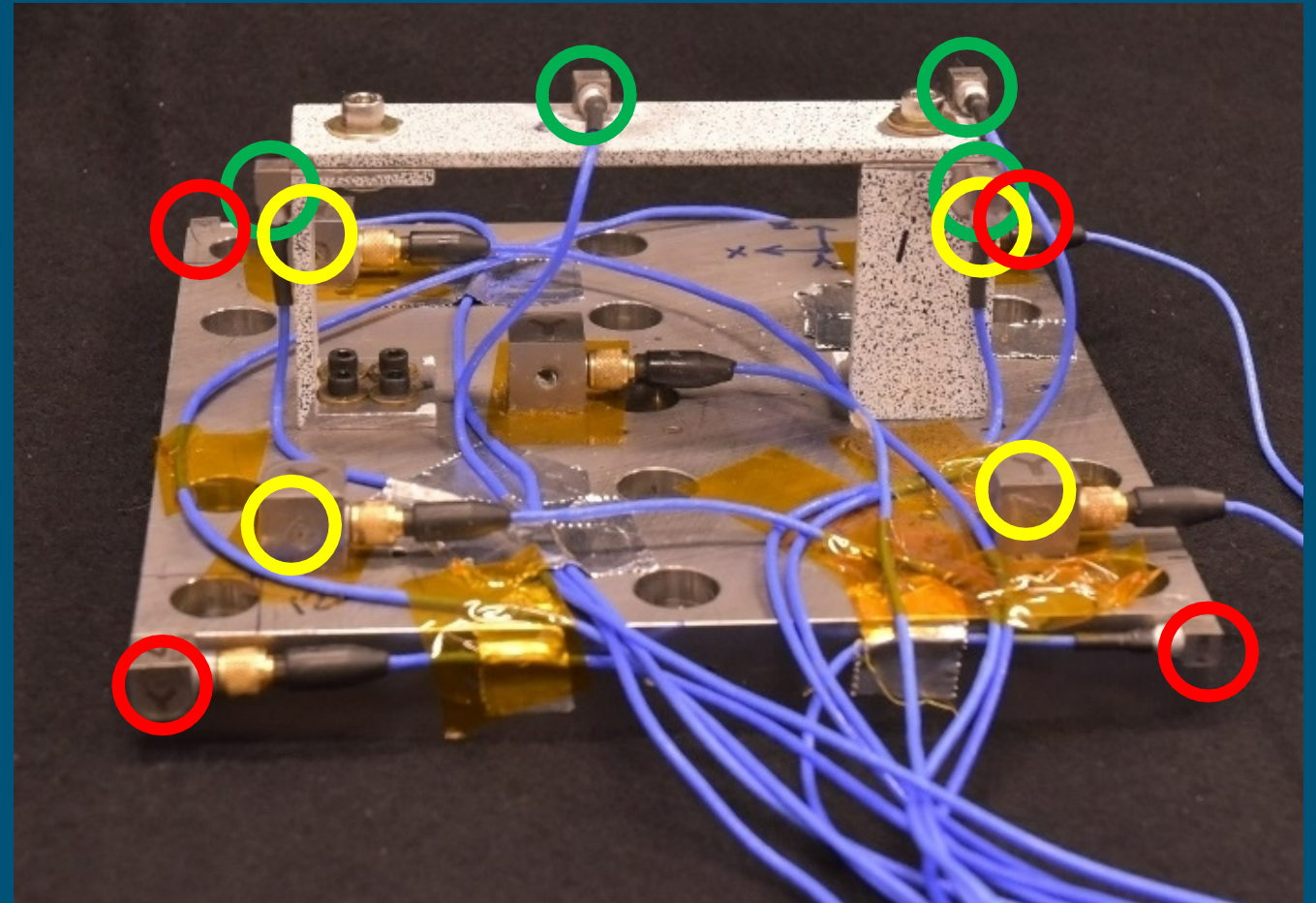
147 dB sound pressure level

Modal Test

Modal Test of RC on 6 DOF Test Fixture

RC installed on the plate test fixture
- Same sensor location on RC as seen in MATV
- Sensors on plate for modal characterization
- Sensors on plate for 6DOF base control

Modal Test of RC on 6 DOF Test Fixture

Fixed Base Elastic Mode	Modal Frequency (Hz)	Modal Damping (%)
1	389.8	0.19
2	1044	0.49
3	1140	0.83
4	1648	0.97
5	1827	0.33
6	2013	0.16

Analysis

Develop One Specification Accounting for Unit-to-Unit Variability

Analysis: Develop One Specification Accounting for Unit-to-Unit Variability

Generate 20 "units"
- ◦ Perturb each fixed base modal frequency of the RC by as much as 5%

Determine the 6 DOF rigid input for each that generates responses that match MATV acoustic test

Envelope the auto-spectra for all 20 units
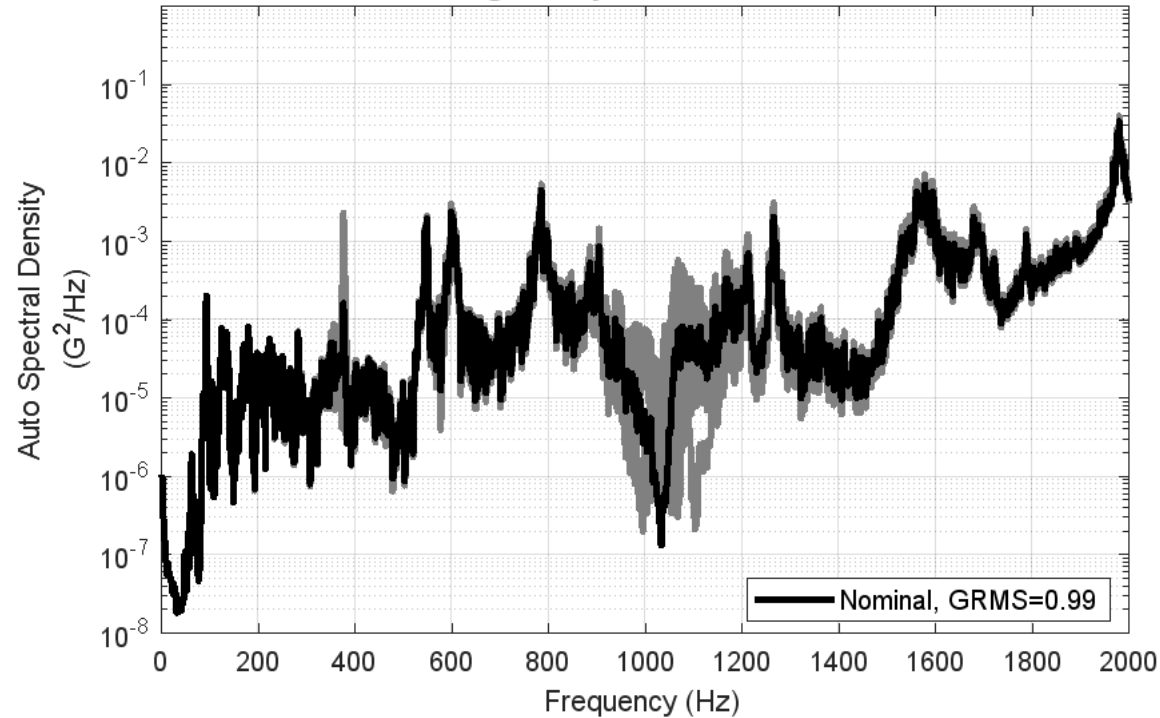
Apply the auto-spectra to a test unit
- ◦ Use the phase and coherence from that unit to fill in the 6 DOF cross spectra
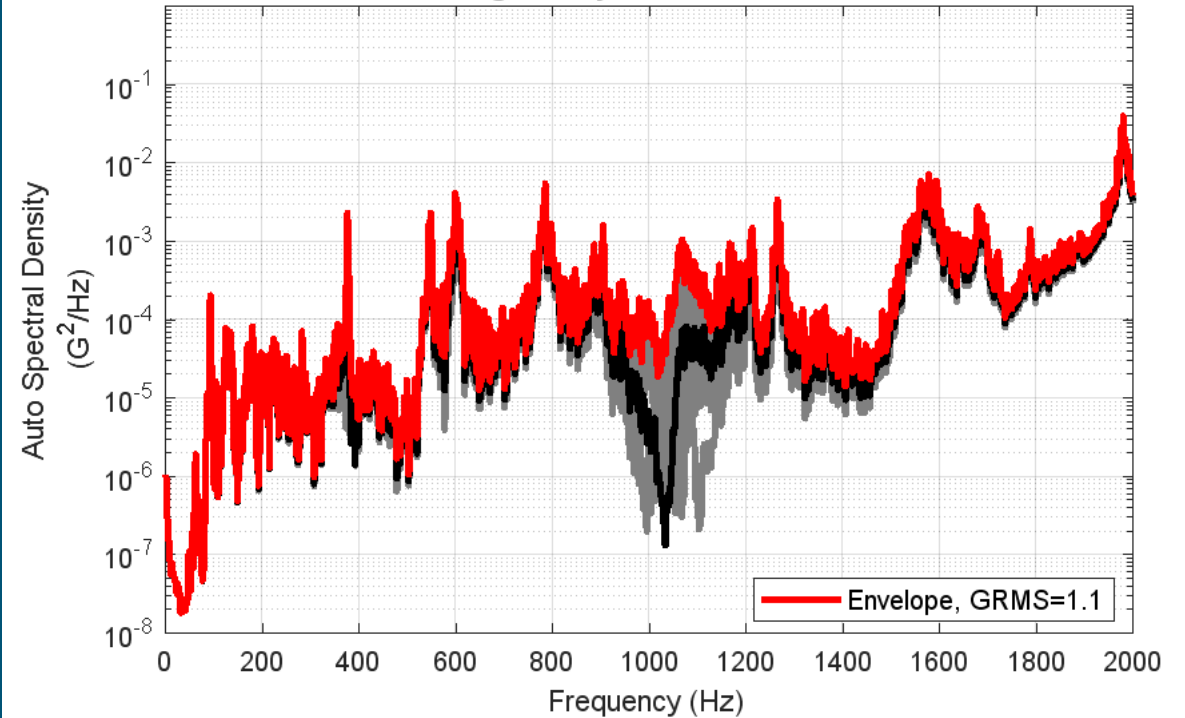
Evaluate Responses

Analysis: Develop One Specification Accounting for Unit-to-Unit Variability

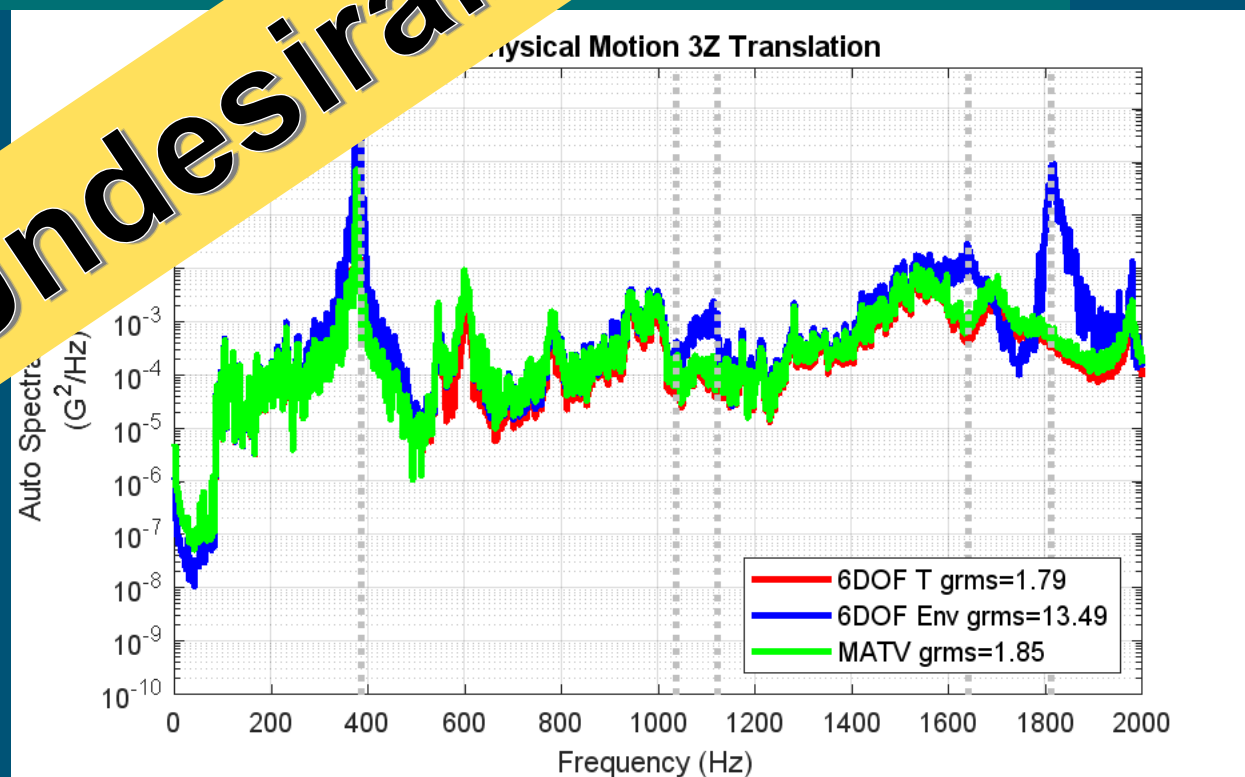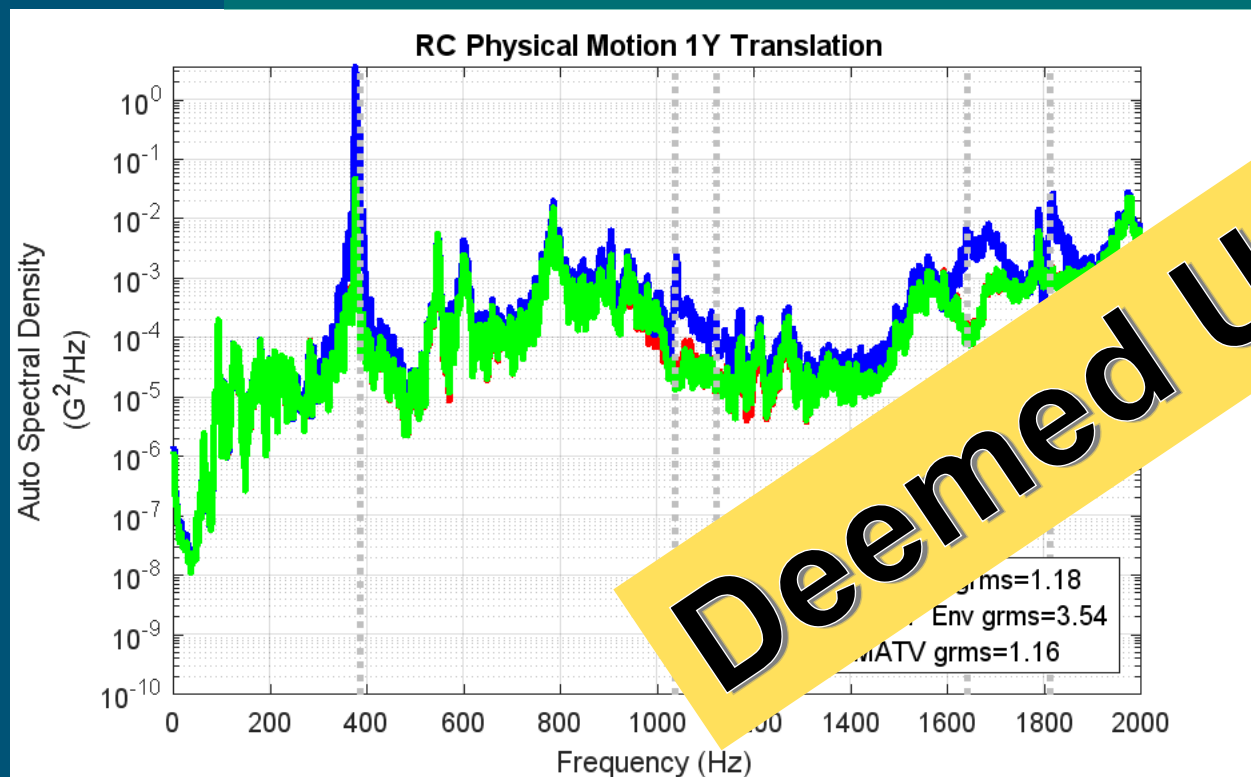# Example Auto Spectra Inputs and Envelope

Analysis: Develop One Specification Accounting for Unit-to-Unit Variability

Vertical lines drawn at fixed base elastic modes of the test arti...

Note the high responses are all connected to exciting the ... the wrong inputs

Deemed Undesirable

Example Physical Responses on RC

Analysis

Develop Independent Test Specifications for Unit-to-Unit Variability

Analysis: Develop Independent Test Specifications for Unit-to-Unit Variability

Decided to investigate independently tailored 6 DOF rigid body inputs for each test article

Install test article on the 6DOF shaker with the same response sensors from MATV test
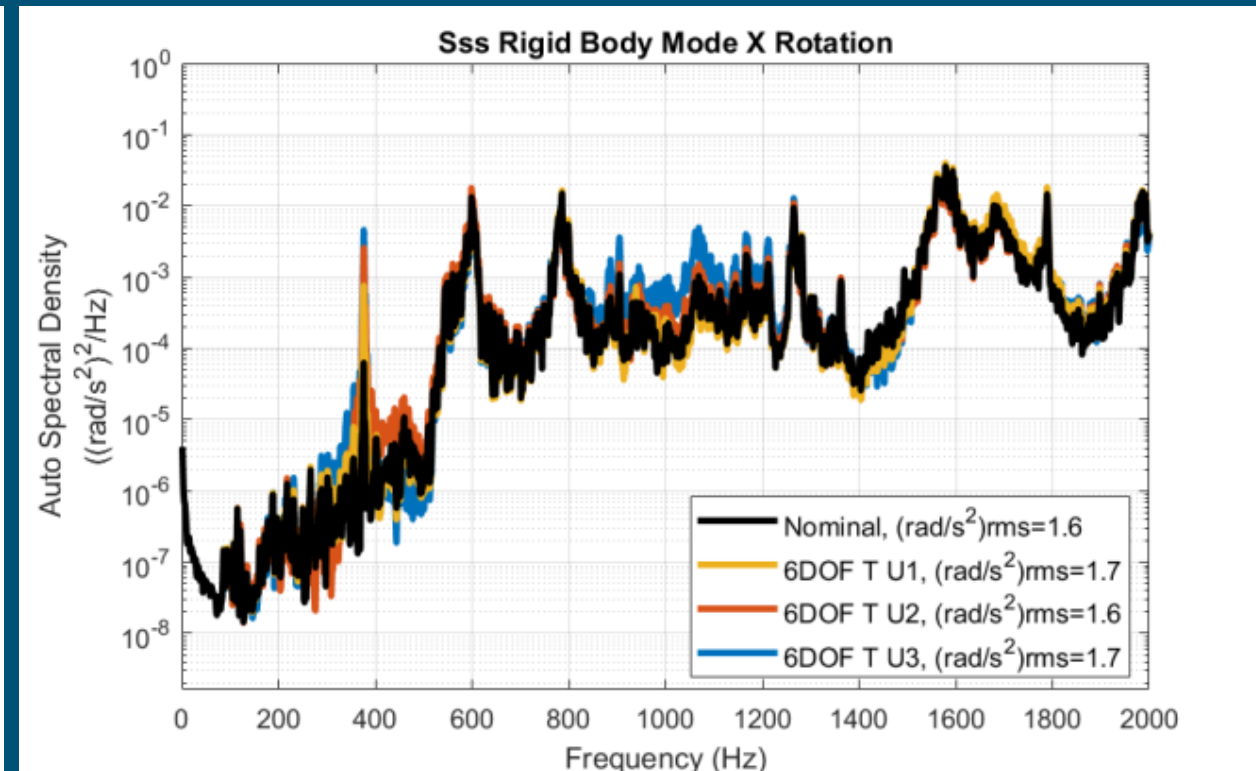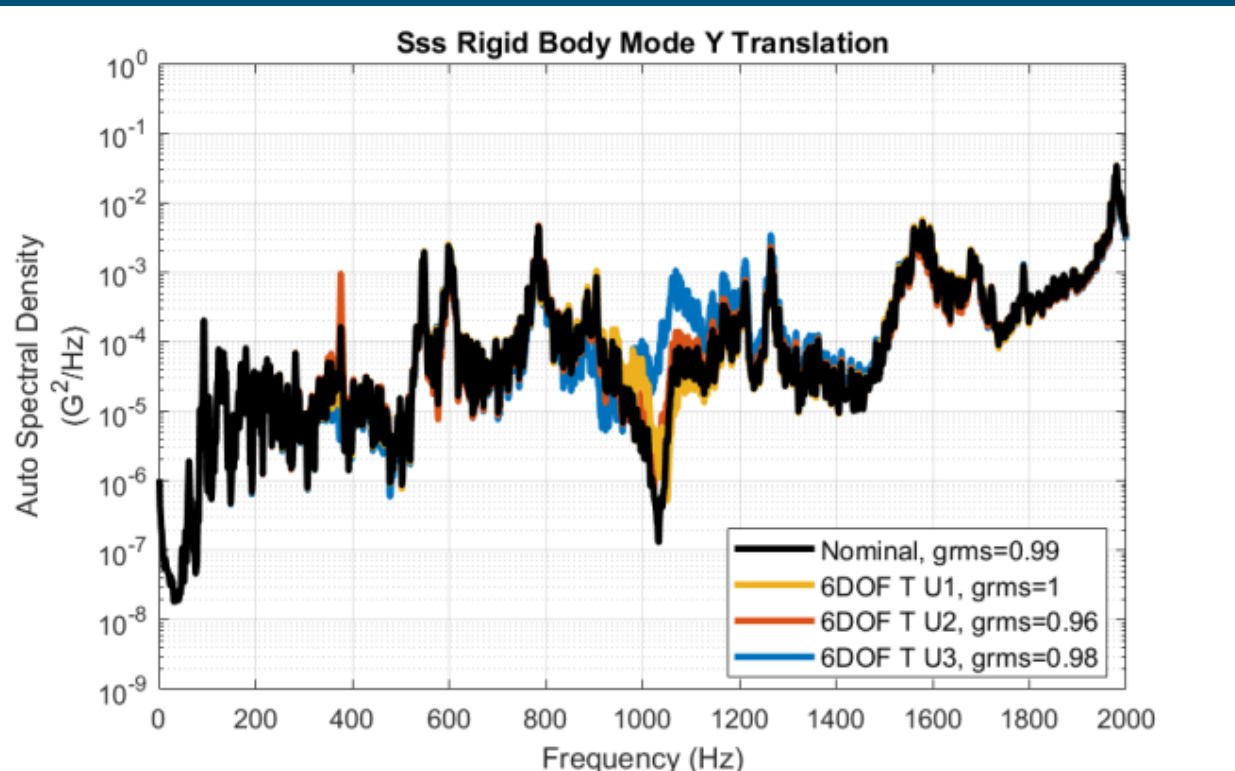
Perform a standard low-level control loop (buzz) test to determine dynamics of the test article

Generate 6DOF shaker inputs to drive the test article responses to match MATV responses
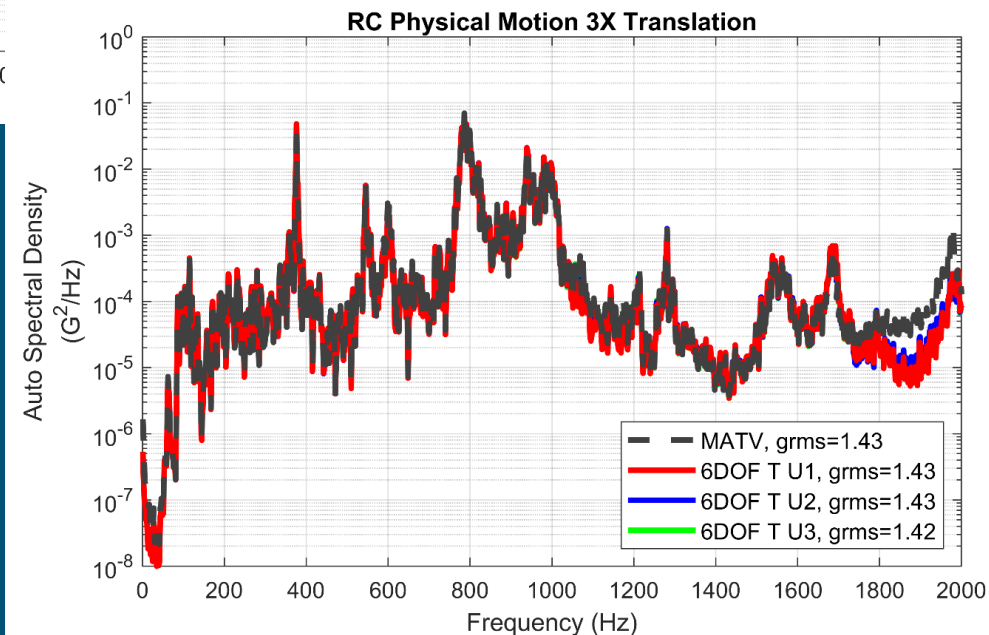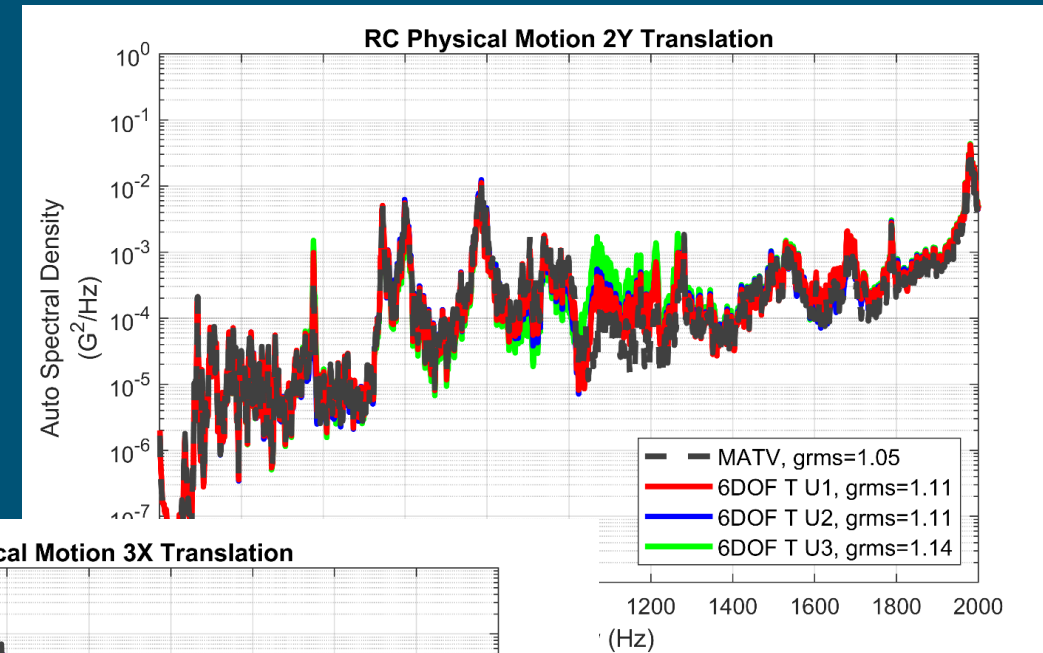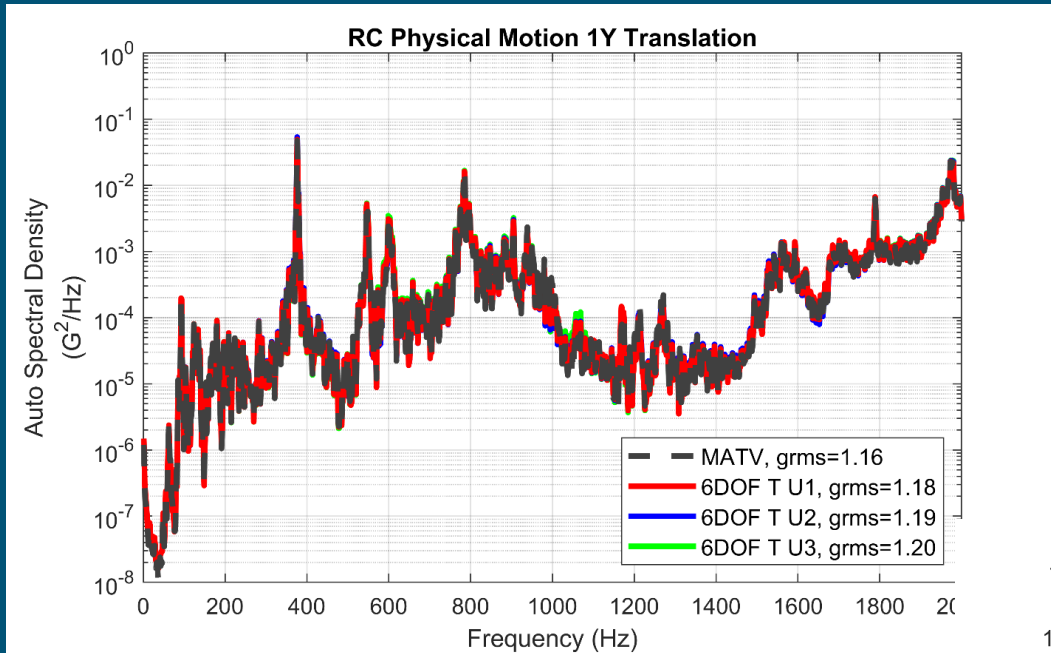
Apply inputs to the test article

Analysis: Develop Independent Test Specifications for Unit-to-Unit Variability

Example Auto Spectra Inputs

Analysis: Develop Independent Test Specifications for Unit-to-Unit Variability

Example Physical Responses

Conclusions

First tried to develop 6 DOF inputs as an envelope of the inputs needed to drive several unique test articles to match the MATV responses which have shifted in frequency from the original nominal test article

- The envelope turned out to be incorrect inputs driving very high responses at the fixed base elastic modes of the test article

Improved method: develop a unique set of inputs for each unit to match the desired responses

- Controllable responses
- Can add quantifiable conservatism
- Need to investigate conservatism in stress/strain states given the matched acceleration responses