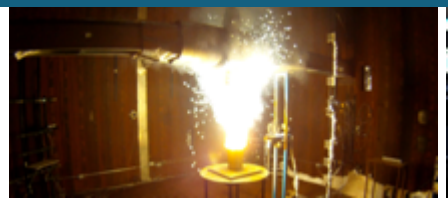
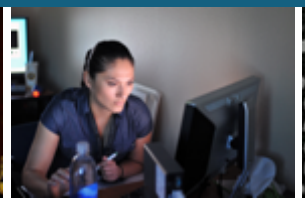
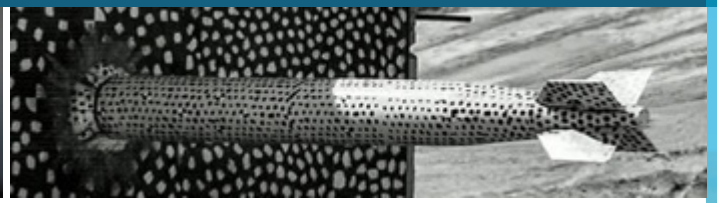
SAND2022-1032C

Sandia National Laboratories

Demonstration 1: Single-input, Single-Output control







IMAC XL MIMO Vibration Short Course

Dan Rohe

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Outline

Why SISO?

Test Specification Generation

SISO Test Setup

SISO Test Demonstration

SISO Test Results

Why SISO?

Single-axis testing is the workhorse for Structural Dynamics

Well-known

- Single-axis tests have been performed for 50+ years.
- Large suite of established tools and practices
- Mature test equipment and facilities

Straightforward

- Bolt test article to shaker table, put control gauges on table, and run the test
- One curve defining the specification - makes test metrics easy to implement

Single axis is likely not going away, even if MIMO takes off.

When can I use SISO testing?

Test article is rigidly mounted to the system to which it attaches
- Fixed-base boundary conditions not a huge departure from reality

Test article has quite a bit of margin to survive the environment
- Can add significant conservatism to ensure the environment is hit, despite the inaccuracies of single-axis testing

Testing a large number of components
- SISO tests are generally easier and faster to run, so economic factors may outweigh accuracy

Thorough understanding of the limitations of the technique
- Modeling or otherwise understanding the effects of the shaker and fixture interactions with the test article
- Understanding the over-testing or under-testing that might occur
- Measuring additional instrumentation channels across the test article to ensure the test meets expectations

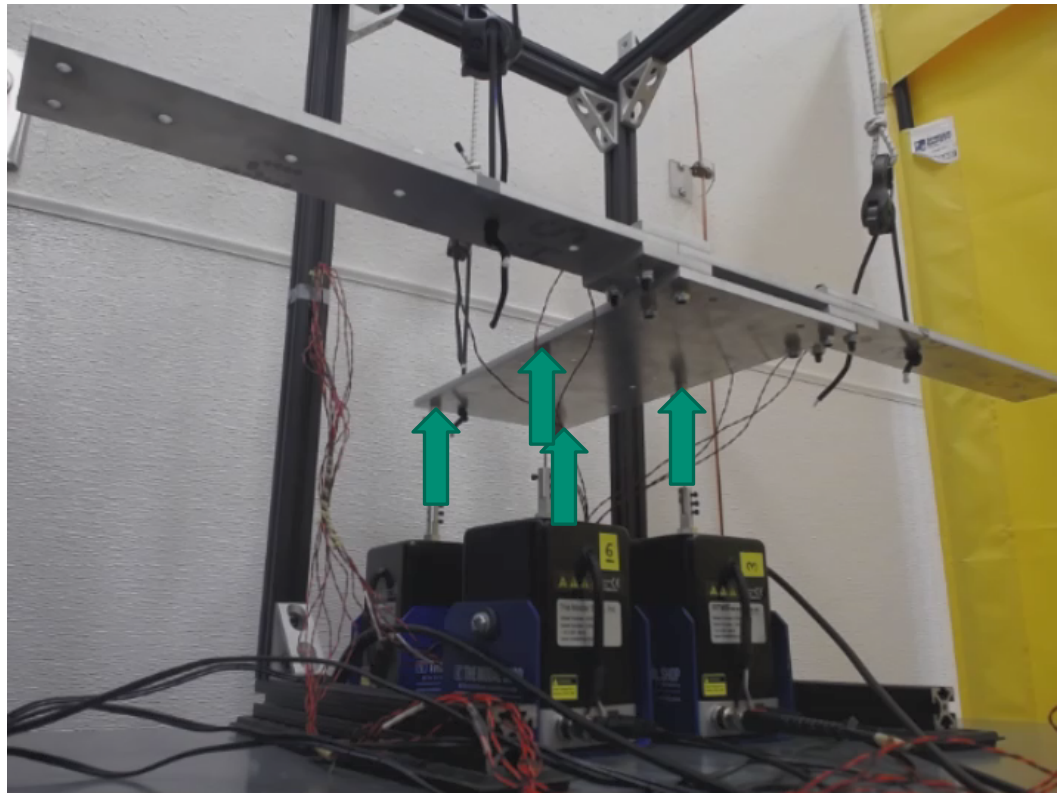
Test Specification Generation

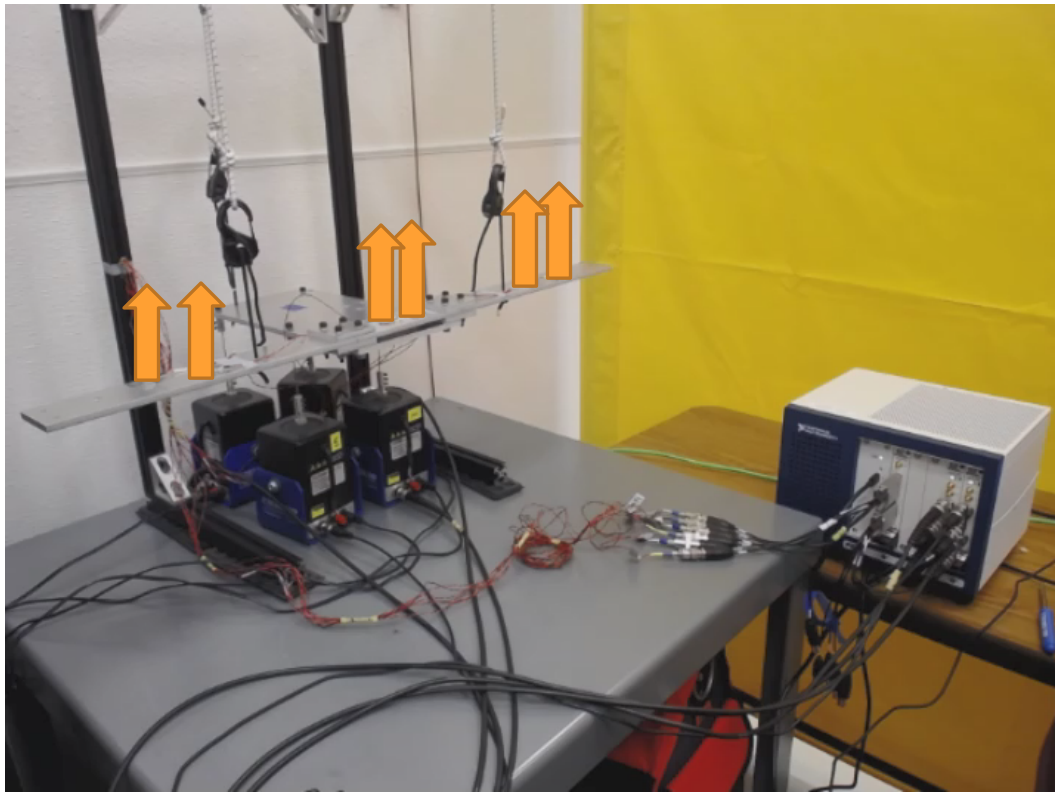
Specification Derived from “Field” Test Data

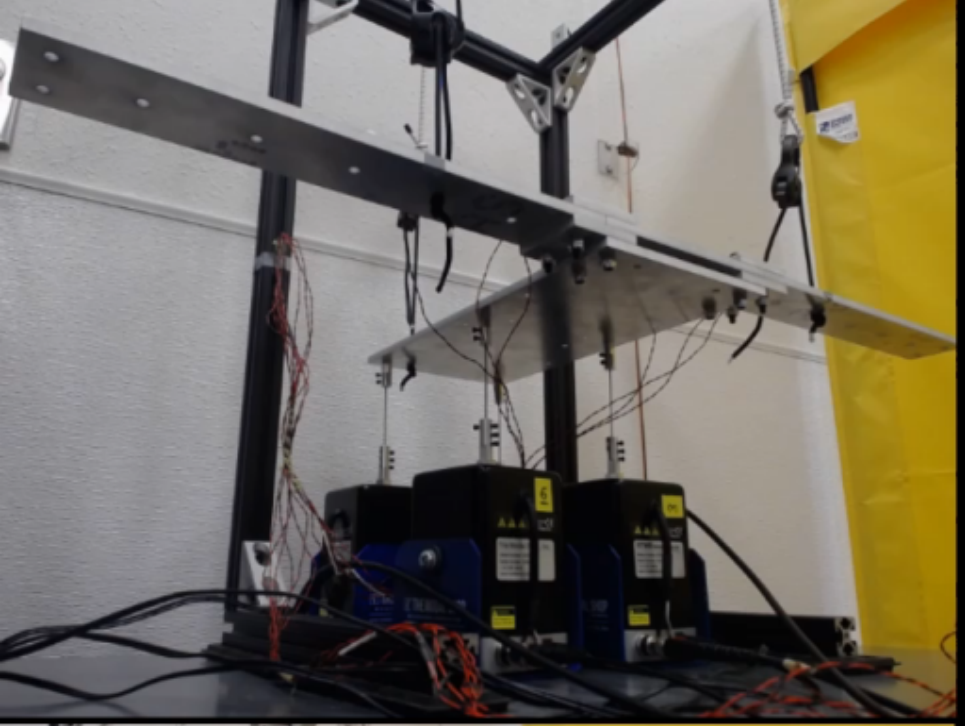
Four shakers applied uncorrelated inputs to the “system” portion of the demo test article

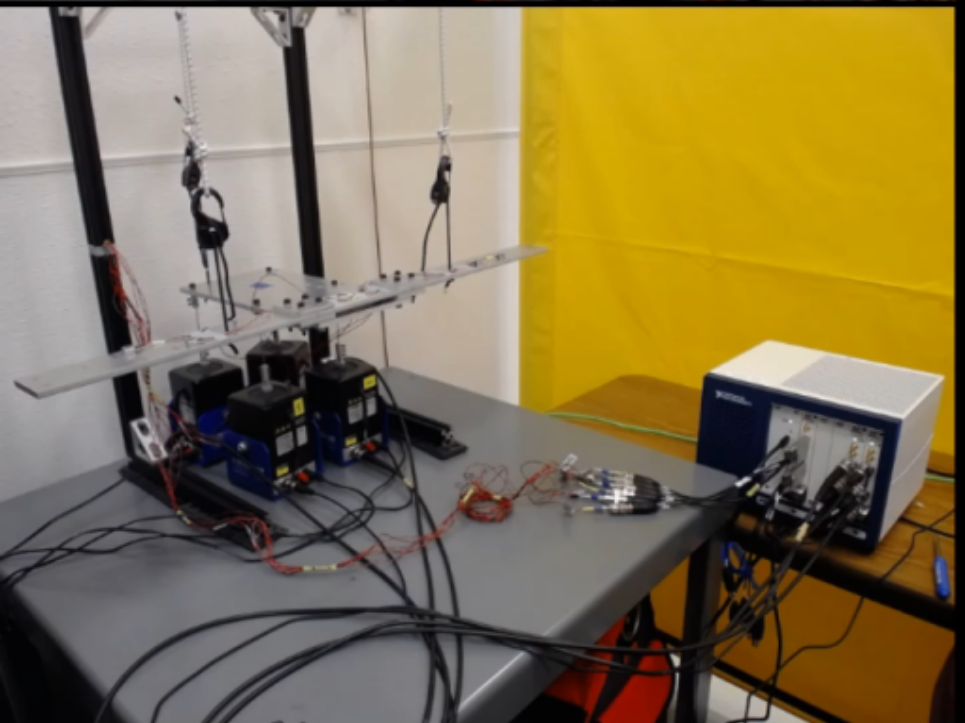
Six accelerometers measured response on the “component” portion of the system.

Test controlled using NI data acquisition system with Rattlesnake software.







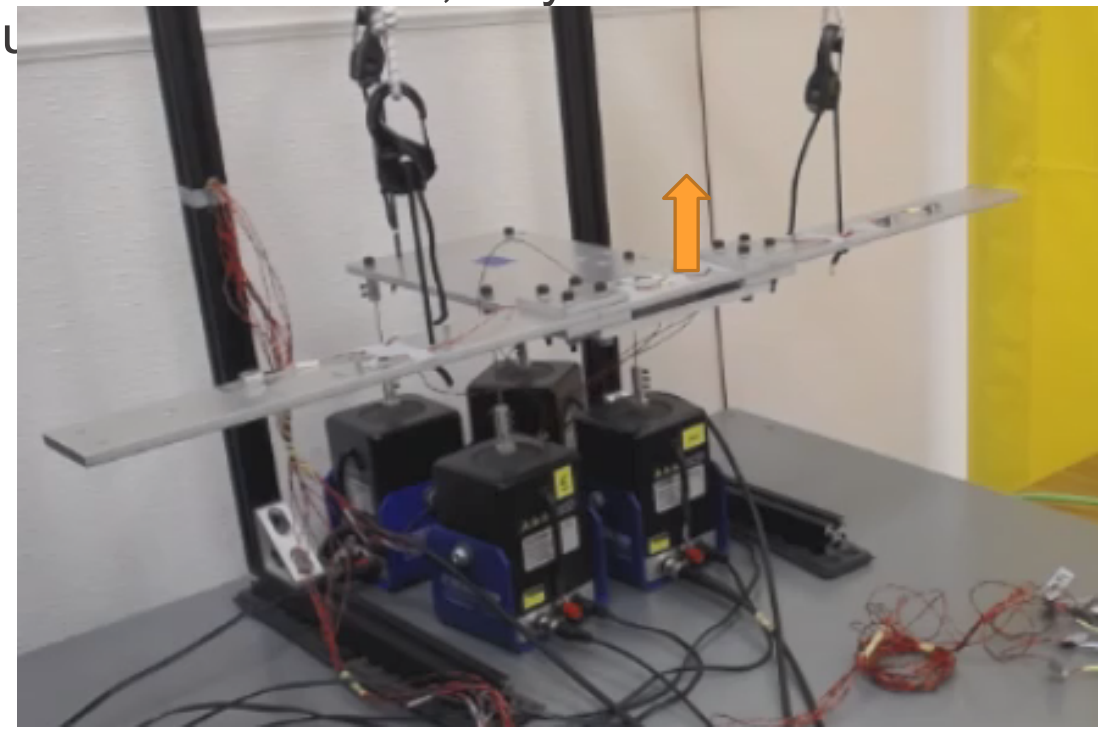


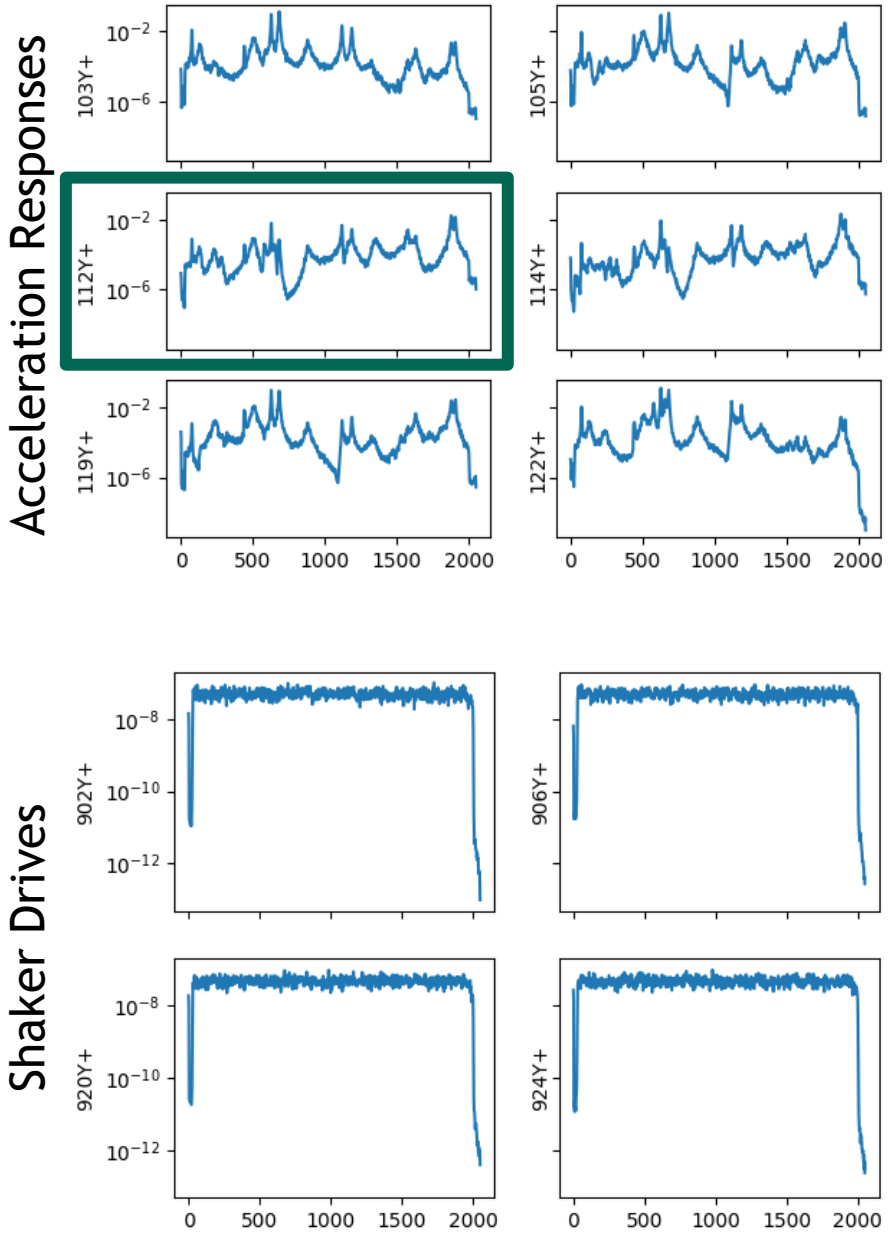
Creating the Specification

CPSD matrices were computed from the time response of the accelerometers and the voltage signals.

Acceleration CPSD matrices are used for the target.

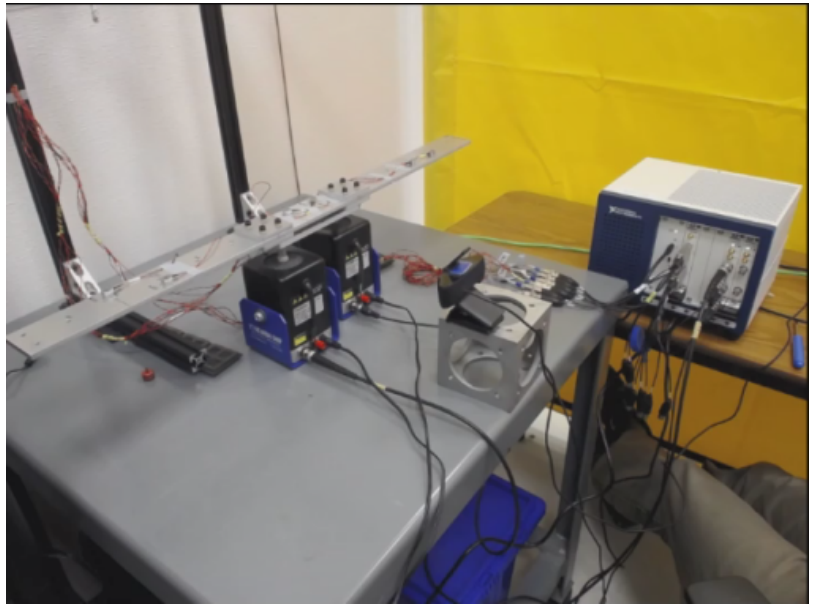
For the SISO case, only accelerometer 112Y+ was u





SISO Test Setup

Goal: Simulate a single-axis shaker table test with modal shakers



A typical shaker table test has the following properties:

- Uniaxial excitation
- Table and/or fixturing constrains rotations
- Table and/or fixture may have unwanted dynamics that is hard to control out

We can't very well bring a T-2000 to IMAC, so we will approximate with modal shakers

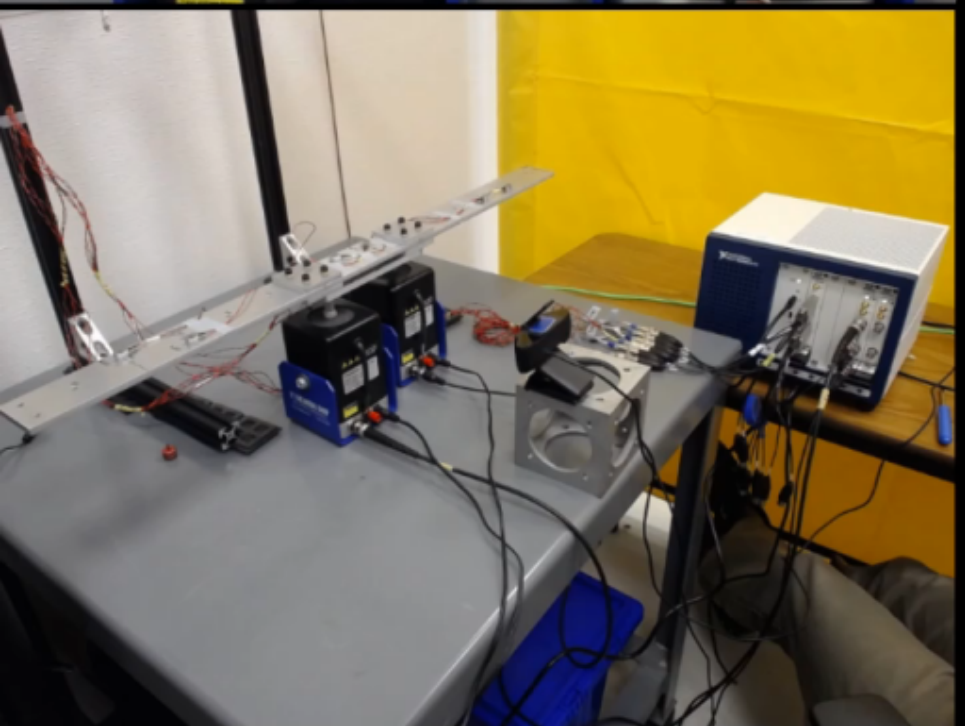
- 2 shakers attached at the middle of the "component"
- Shakers attached with stiff links, not stingers
- Same voltage supplied to both shakers so they are nominally moving together, translating not rotating the part.

Rattlesnake used to control the test with NI Hardware

- Output transformation used to transform one output control signal into two identical physical drive signals

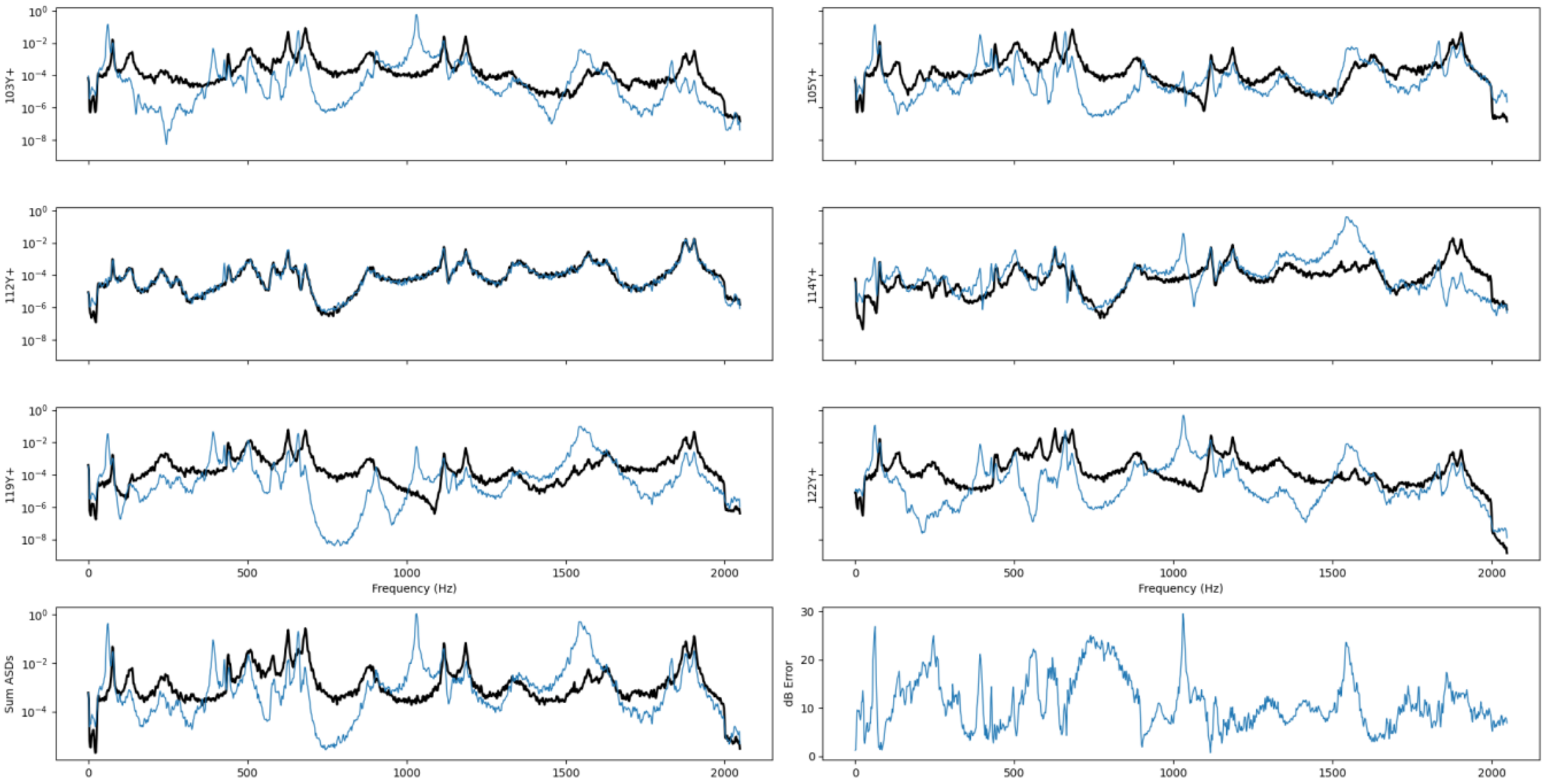
$$To_p = o_c \qquad o_p = T^+ o_c \qquad T = [1 \quad 1]$$

SISO Test Demonstration



SISO Results

SISO Test Results

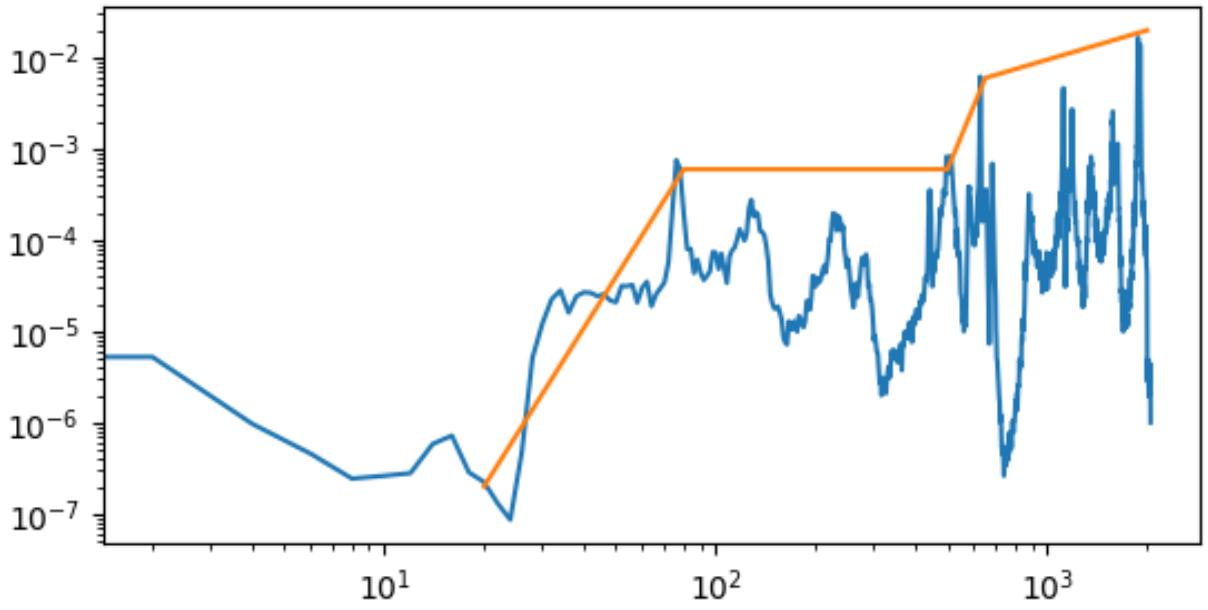


What about Straight-Lining the Specification?

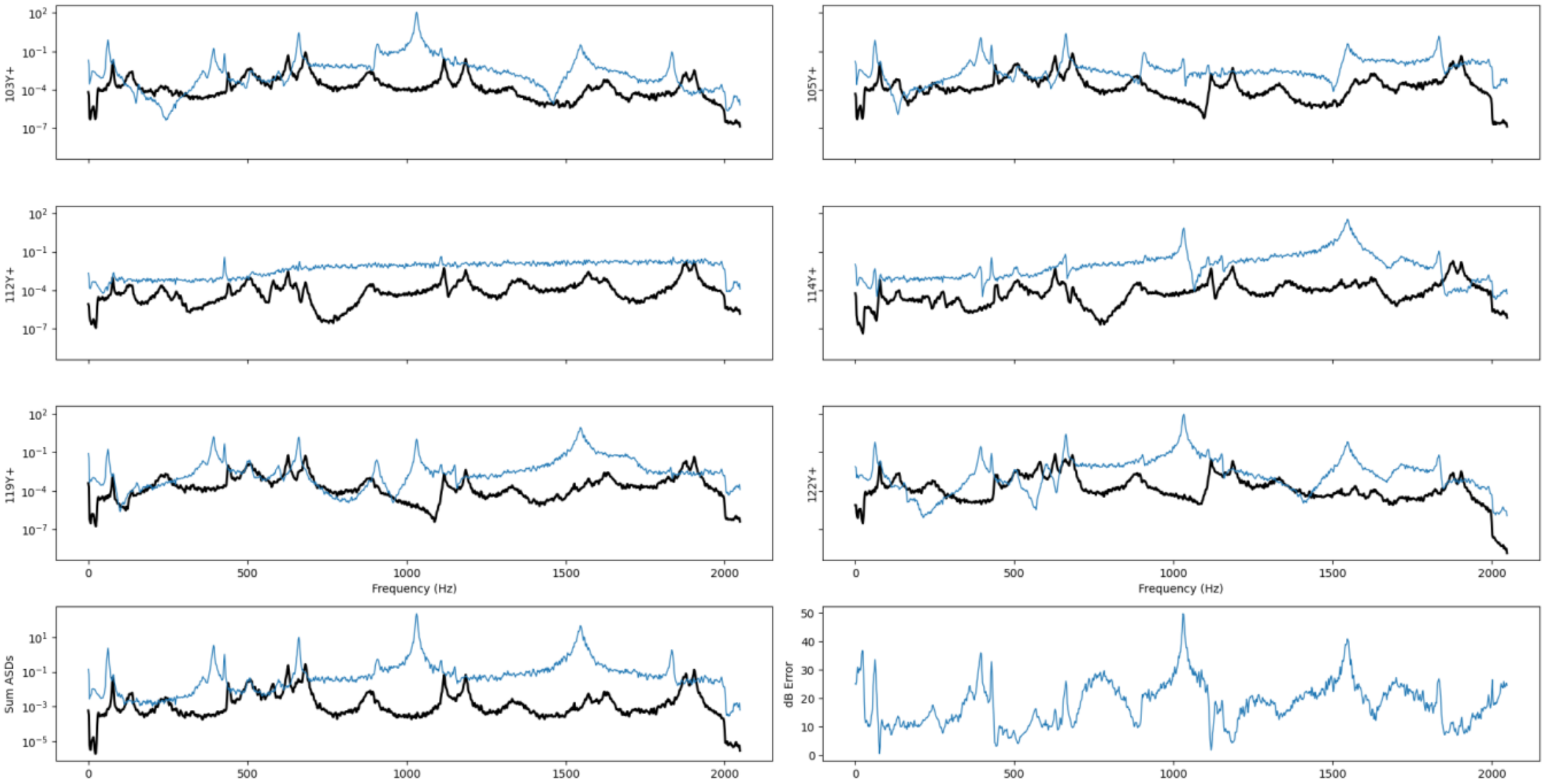
Controlling directly to the flight response resulted in some over- and some undertesting at different frequencies.

Ideally, you'd like your test to be at least conservative if not accurate.

We often "ensure conservatism" by straight-lining the specification; by enveloping the flight response, we make sure that the laboratory test is conservative, right?



SISO Test Results with Straight-light Specification



Conclusions

Conclusions

SISO testing can be limited:

- No control over the shape of the response
- Depending on the dynamics of the part, you could be significantly over-testing or even under-testing your test article

We hope to improve these results with MIMO testing

- Adjust the shape of the responses so they match over more of the structure
- Reduce under-testing and over-testing of the part

After lunch we will run the MIMO version of this test to see if we can do better!