SAND2024-14827C

Dynamic Test Fixtures

"What they do and why we care"

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Current Practices of Developing Test Fixtures

What we ask now

- Will the fixture bolt together with the unit under test and test system (shaker, resonant plate)?
- Will the fixture break?
- (sometimes) Does the fixture physically look like the Next Level of Assembly?

What we should be asking

- Will the component deform the same when built up into the system?

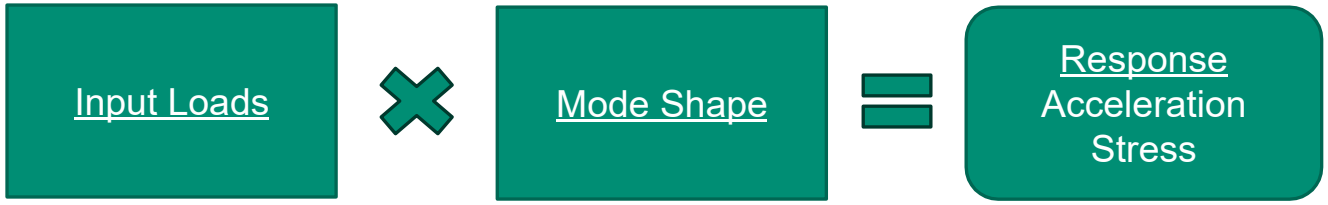
The purpose of this presentation is to provide a brief overview of dynamic test fixtures and recommended practices.

Judging the Effectiveness of a Dynamic Test

There are two parts that define the acceleration/stress state of the Component

- Input loads
- Component mode shapes (full set FRFs)

The loads and shapes have a multiplicative relationship with respect to the acceleration/stress



	Input Load	Mode Shapes	Response
Test Grade	90%	20%	18%
Test Grade	90%	95%	86%

If either the input load **or** the mode shapes of the component are inappropriate, the test will not be effective.

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- Component mode shapes being the same in the test as in the system asse

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The mode shapes are defined by the test fixture!

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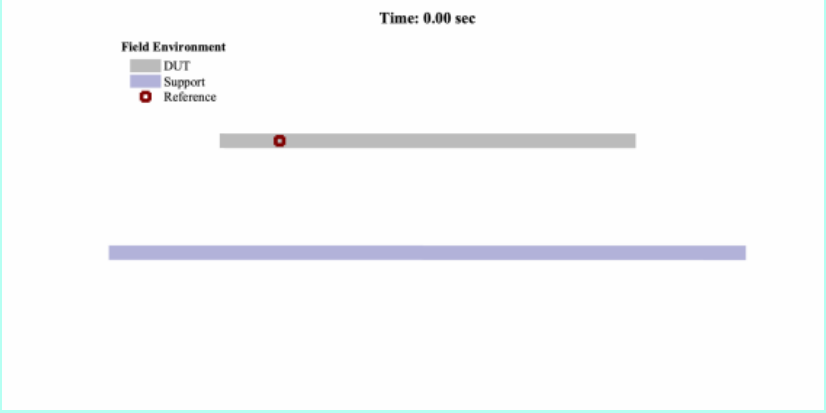
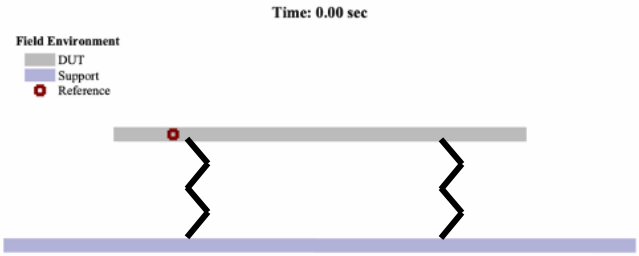
Test Grades	90%	95%	86%

If either the input load **or** the mode shapes of the component are inappropriate, the test will not be effective.

Why is the Test Fixture/Mode Shape Important?

Field Environment Response





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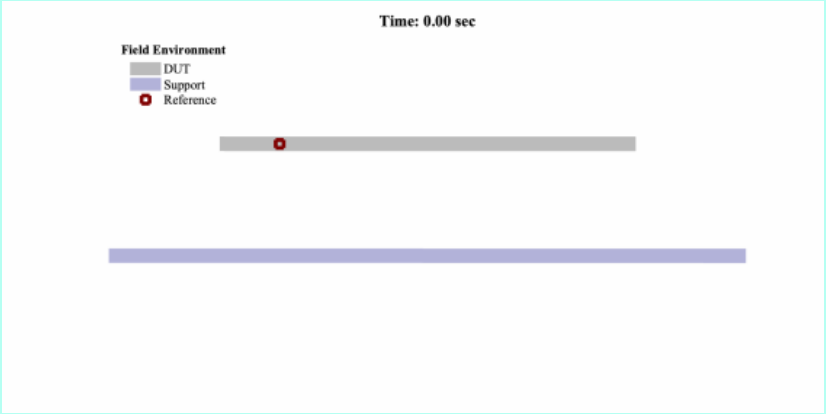
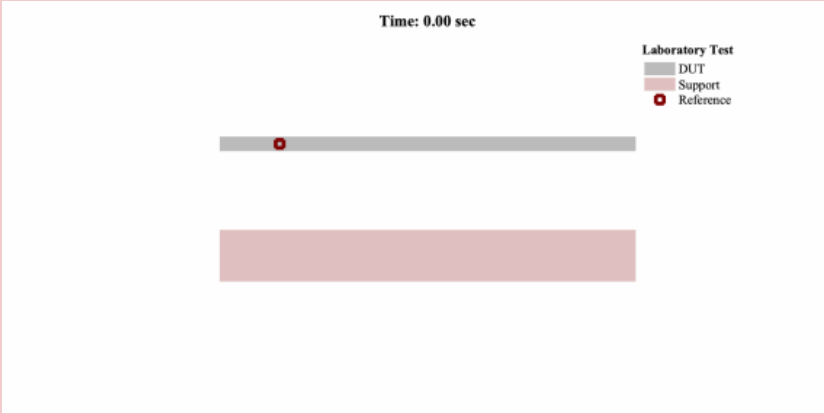


Matched Laboratory Test Response



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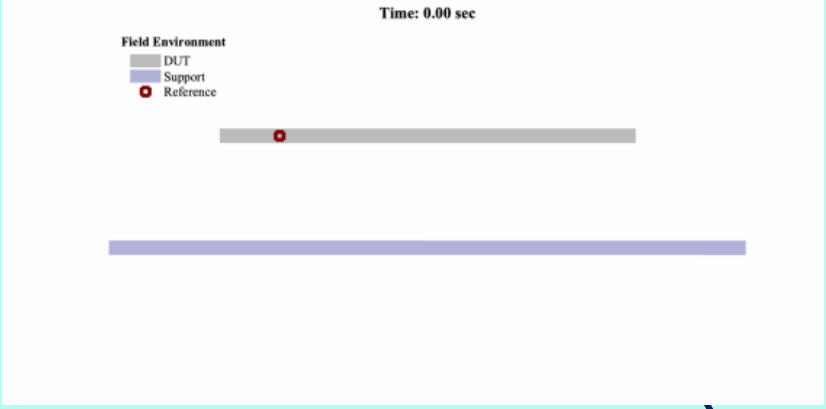

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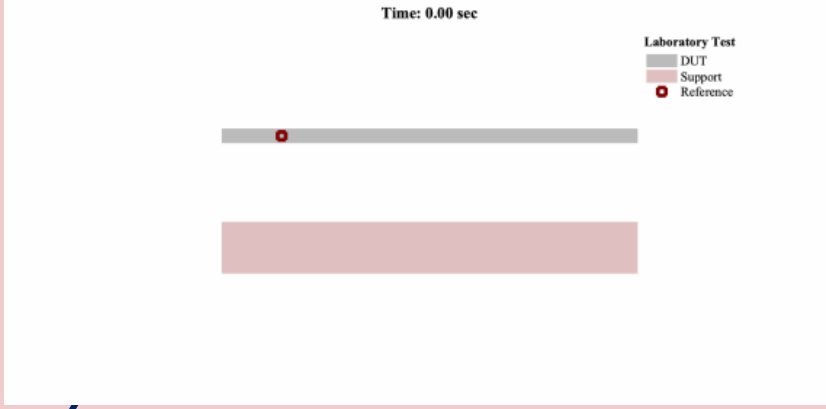
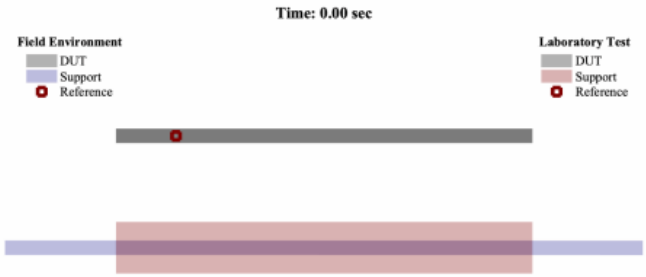


Stress state of the two components are different from each other.



UUT Response Matches at Control Accelerometer Only

Animations by B. Zwink

Why is the Test Fixture/Mode Shape Important?

Field Er

t Response

Every system and component needs to be aware of the following:

- Where are my connection degrees of freedom?
  - Connection DOFs are where you touch the NLA.

Current environment definition assumes no rotation

nt
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definition assumes no relative motion between connections to NLA

DUT Response Matches at Control Accelerometer Only

Animations by B. Zwink

Why is the Test Fixture/Mode Shape Important?

Field Er

t Response

Every system and component needs to be aware of the following:

- Where are my connection degrees of freedom?
  - Connection DOFs are where you touch the NLA.
- Do my connection points have relative motion with respect to each other?
  - Rigid fixture is perfect for hardware with 0 relative motion w.r.t connection degrees of freedom.

Current environment definition assumes no rotation

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DUT Response Matches at Control Accelerometer Only

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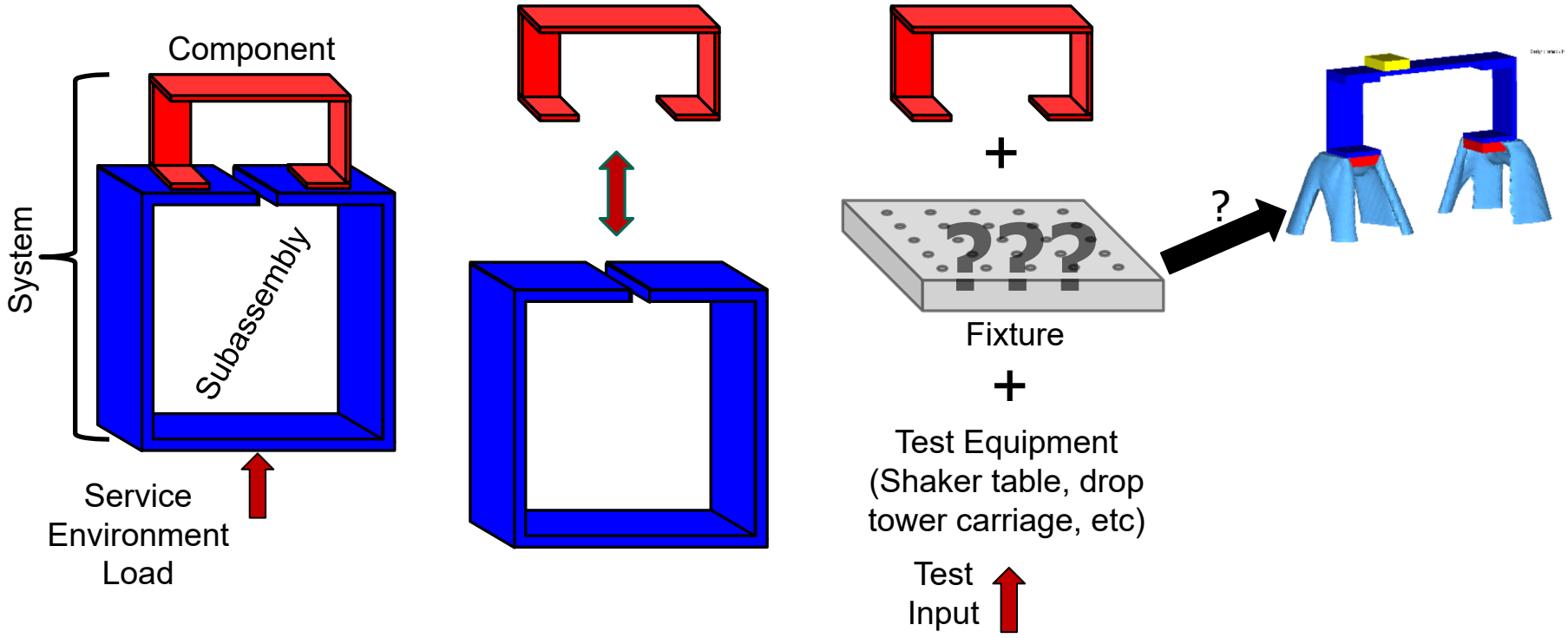
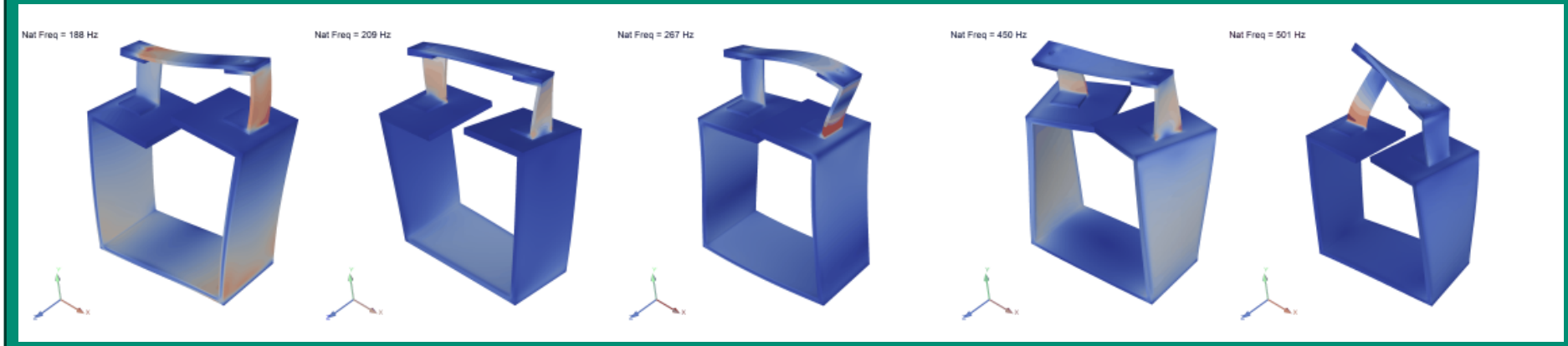
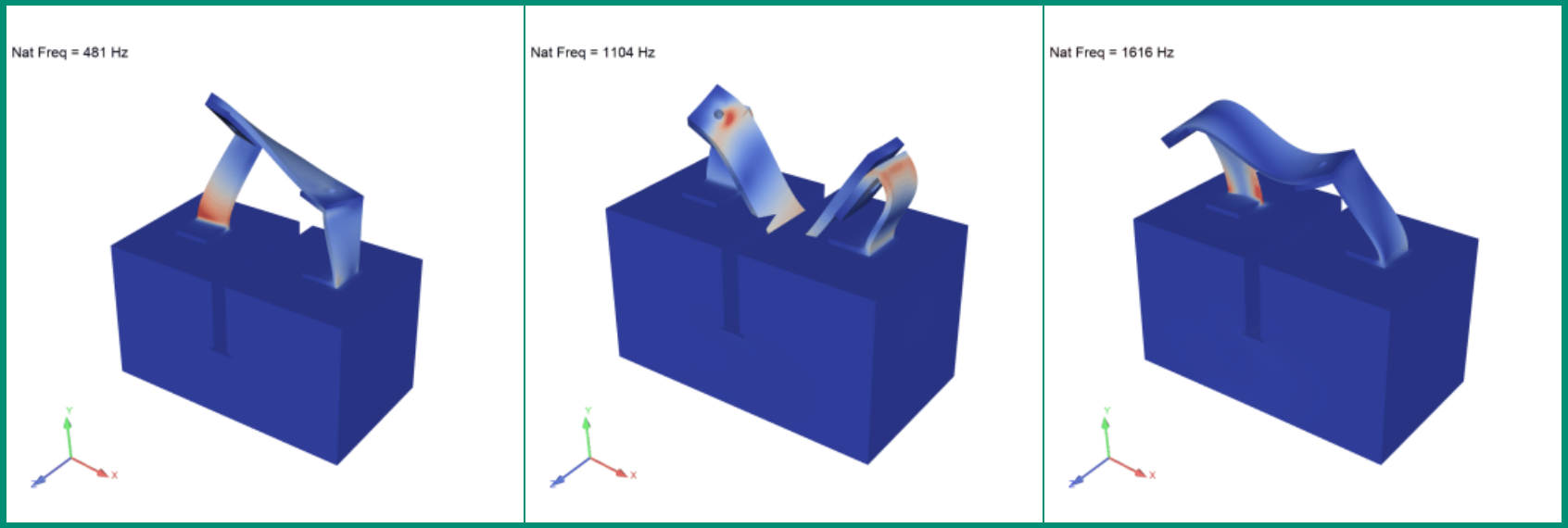
The Fixture Problem Exemplar



The Problem Visualized



Field Configuration Mode Shapes

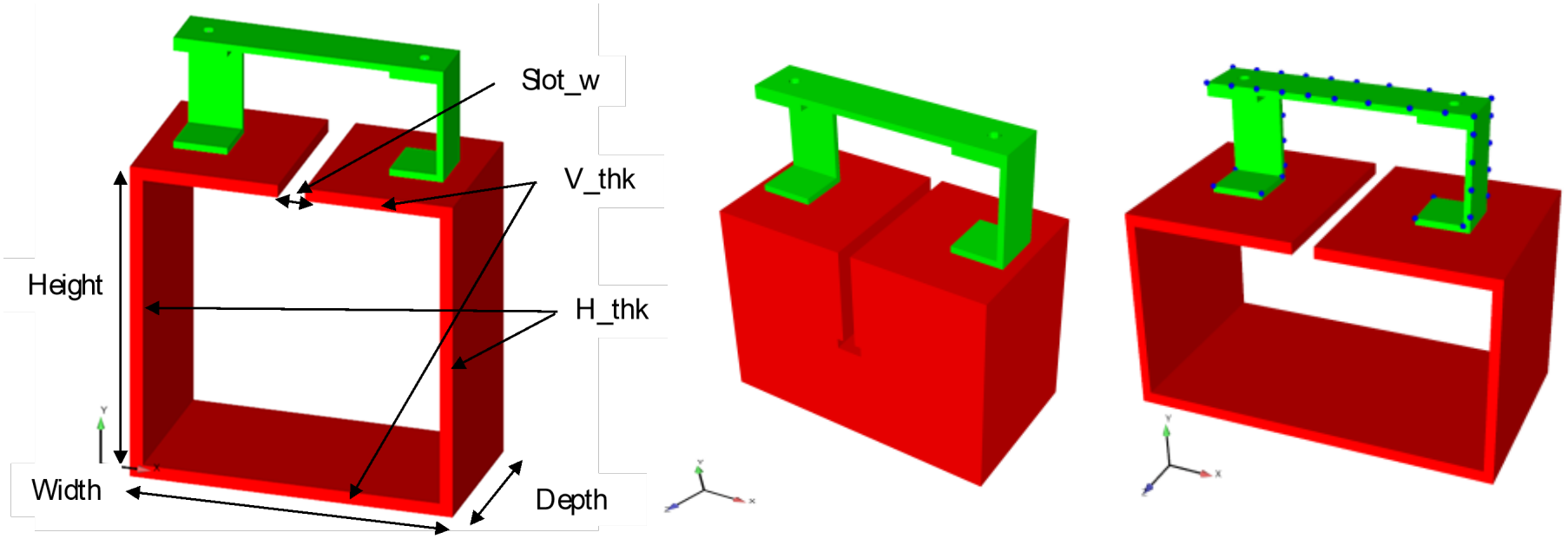


Test Configuration Mode Shapes

Using Optimization to Design the Fixture

	Reference	Initial Cond.	Optimized
H_thk	0.238 in	2.5 in	0.18 in
V_thk	0.238 in	2.5 in	0.23 in
Slot_w	0.5 in	0.25 in	0.41 in
Height	6 in	3 in	3.98 in
Width	6 in	6 in	7.05 in
Depth	3 in	3 in	3.91 in

Fixture was designed to match the first two mode shapes of the component in the system configuration.

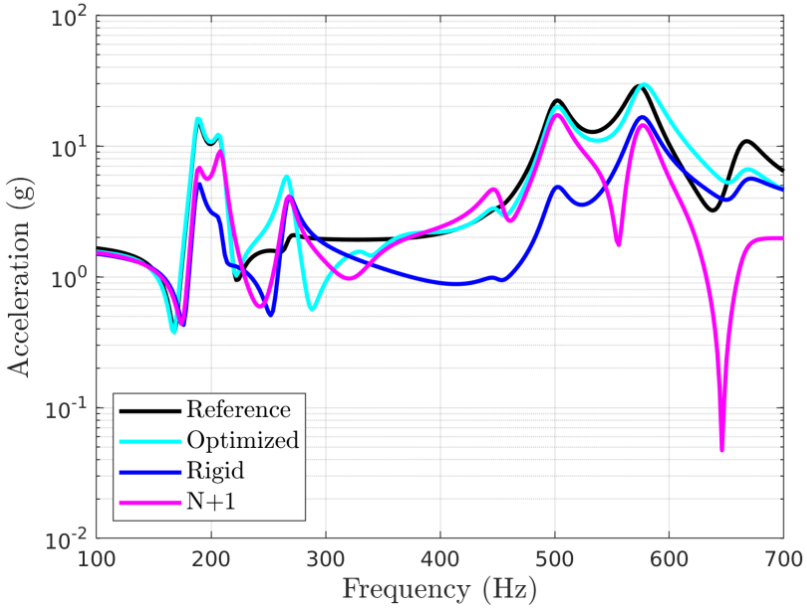


Comparing Component Response using an Optimized Fixture

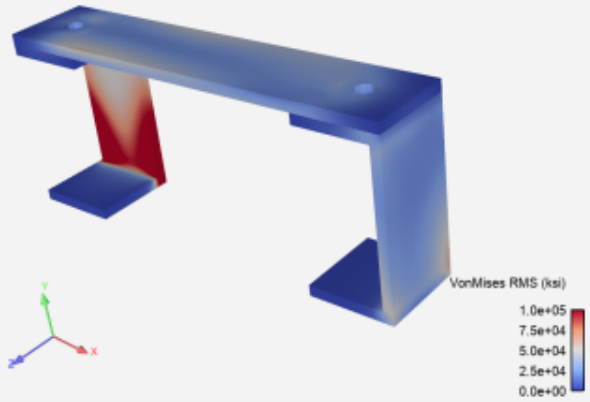
Examination of the response on the component

- Under-test?
- Over-test?

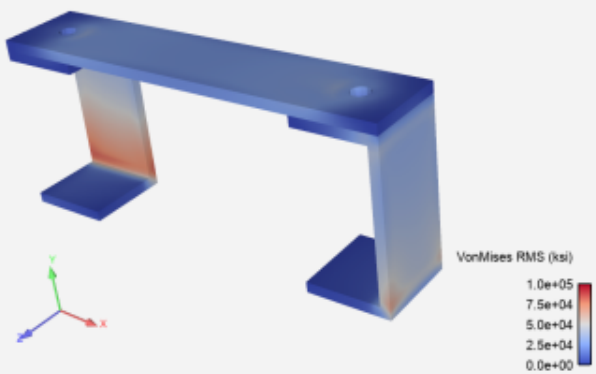
Adjust narrative: Focus on fixture and not just loads.



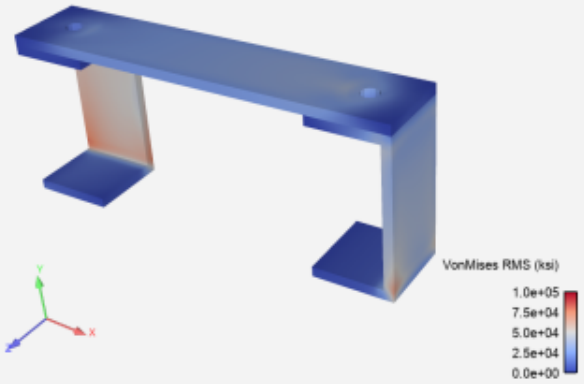
Rigid Fixture RMS stress



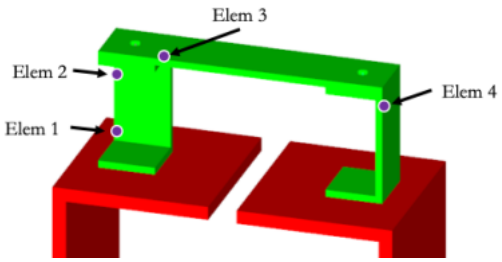
Reference RMS stress

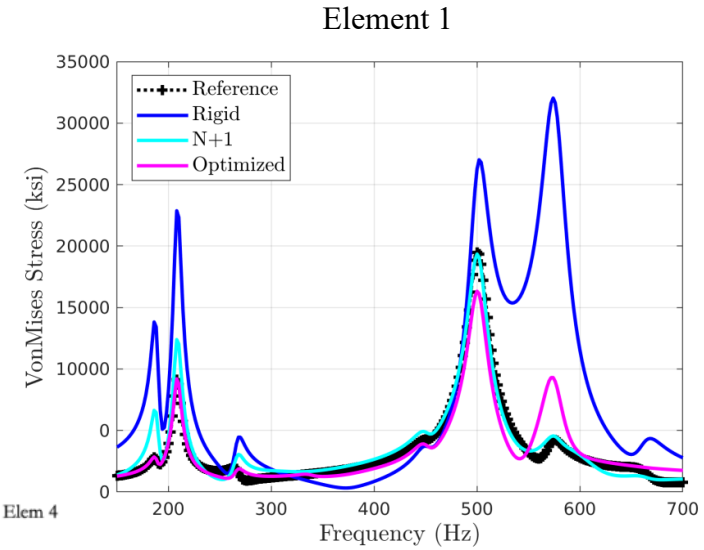


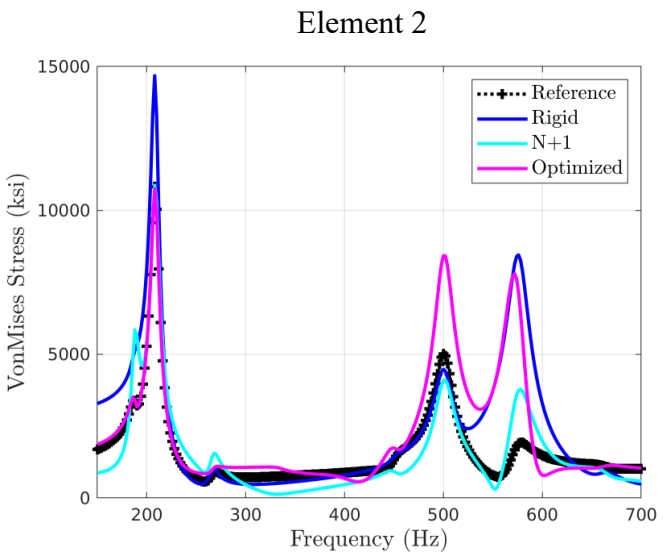
Optimized Fixture RMS stress

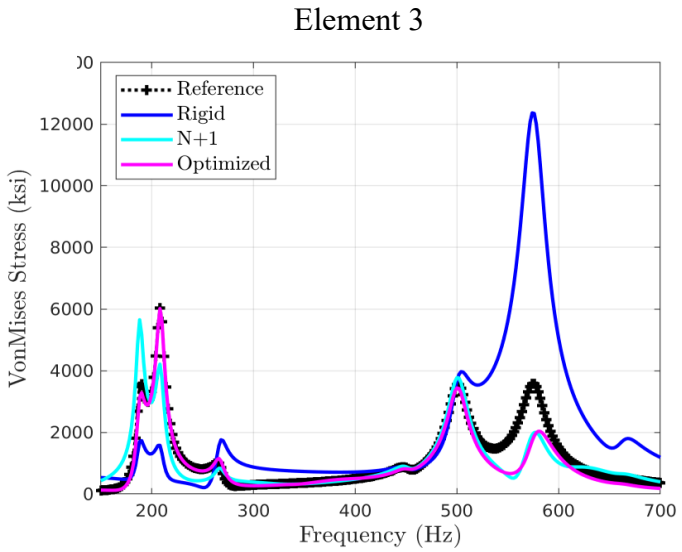


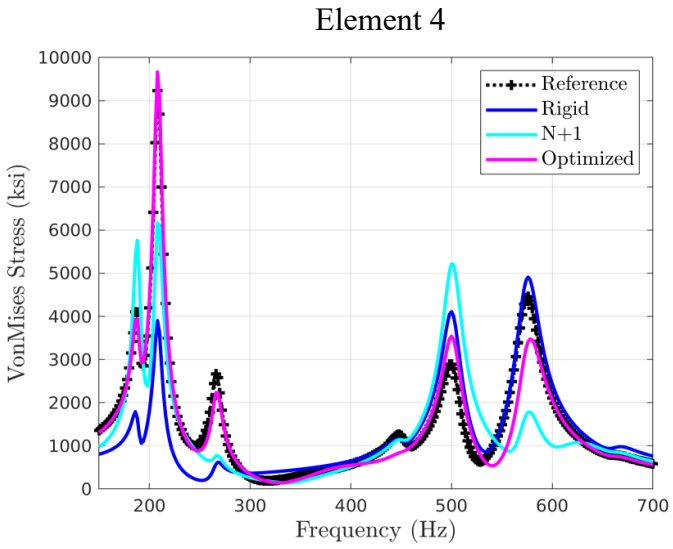
Case Study – Non-Trivial Optimization on Modal Projection Error the BARC Assembly



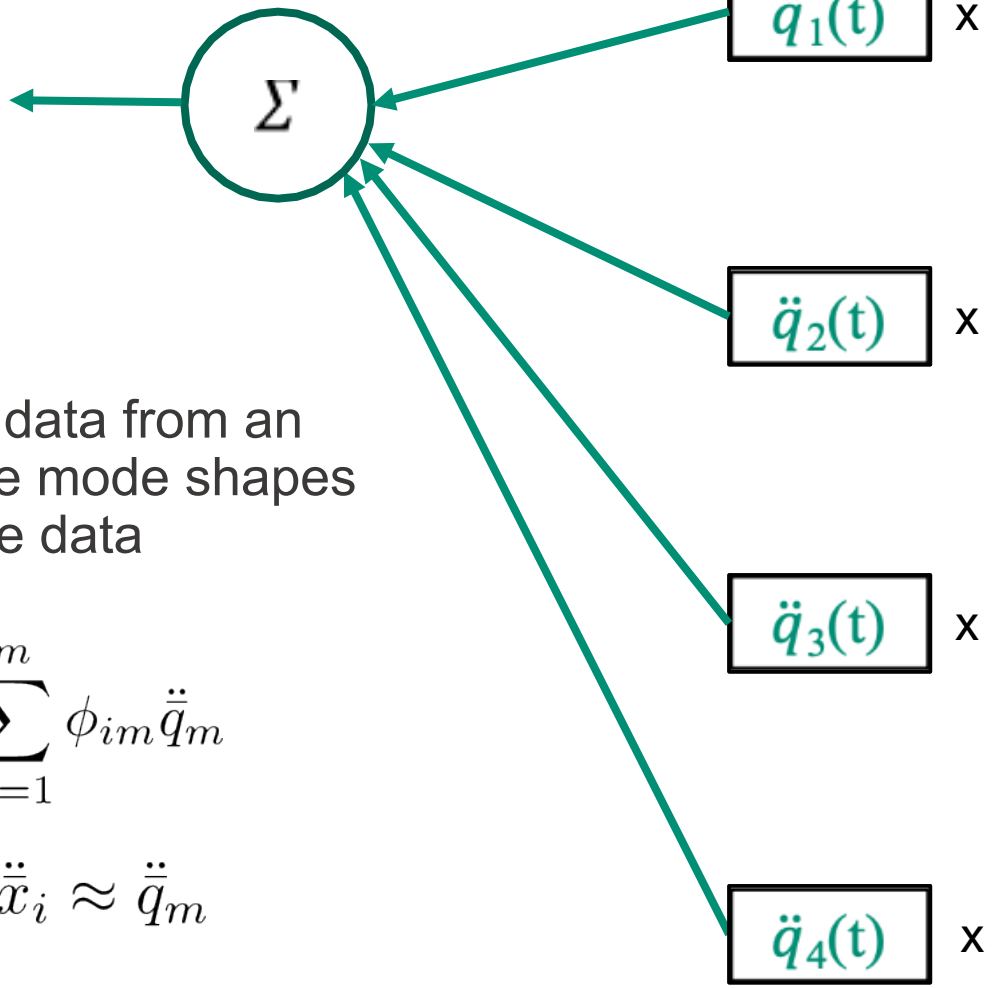


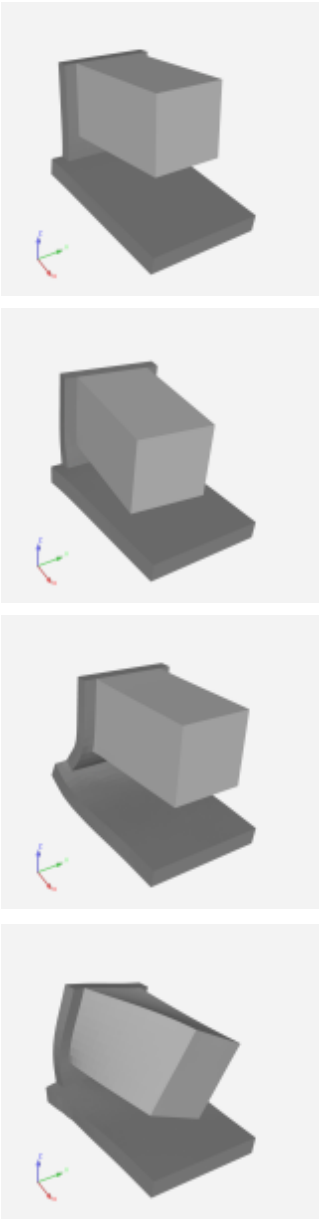






Modal Accelerations and Modal Filters





Given measured data from an environment, take mode shapes and fit them to the data

$$\ddot{\bar{x}}_i \approx \sum_{n=1}^{m} \phi_{im} \ddot{\bar{q}}_m$$

$$\phi^{+}_{i \times m} \ddot{\bar{x}}_i \approx \ddot{\bar{q}}_m$$

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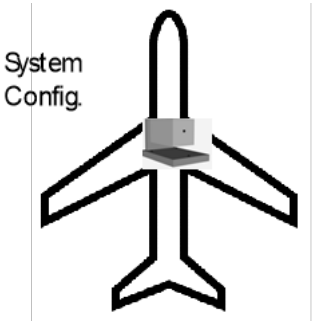
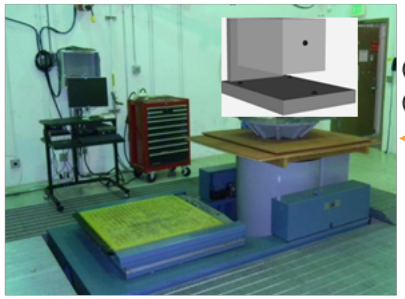
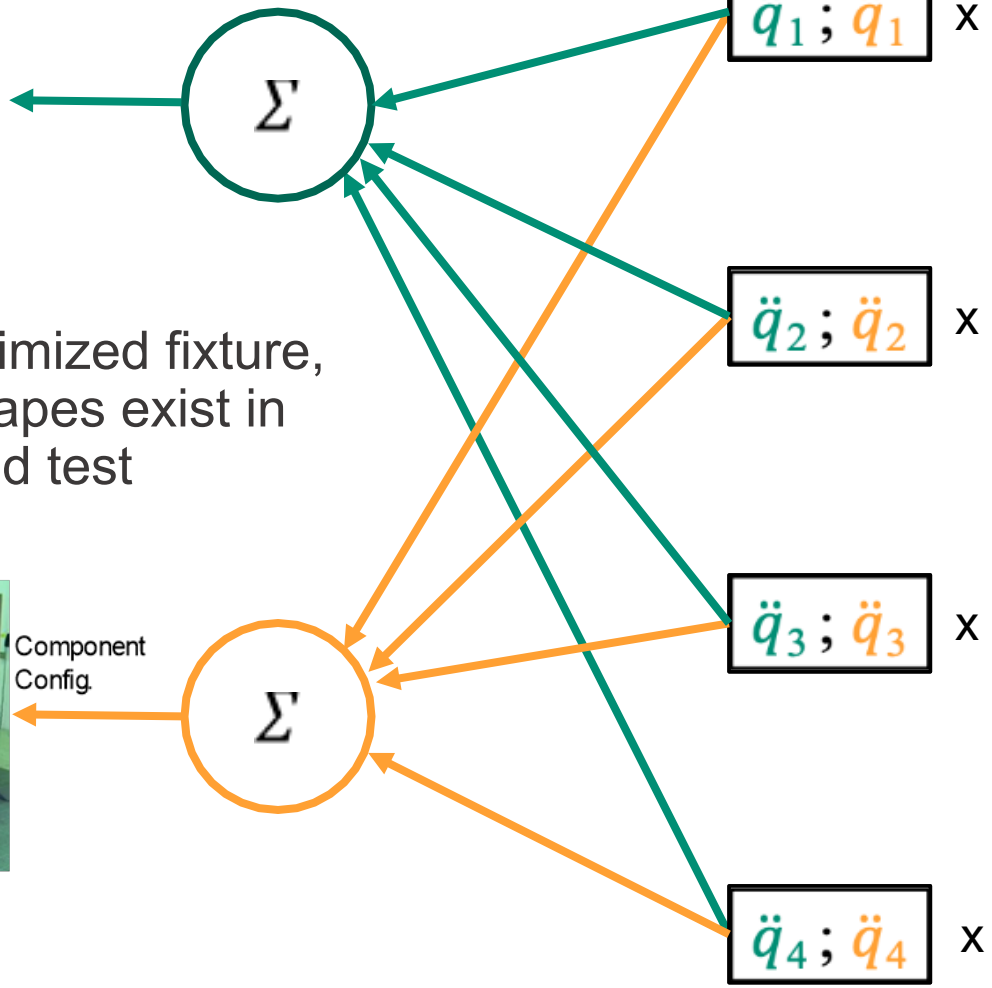
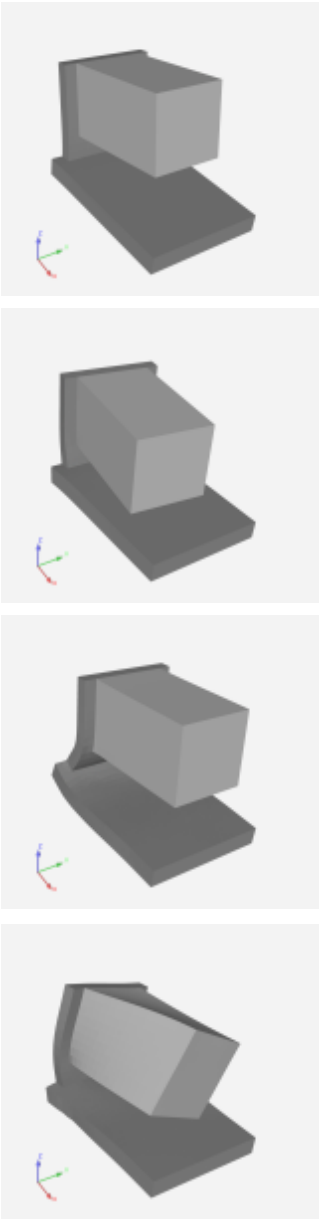


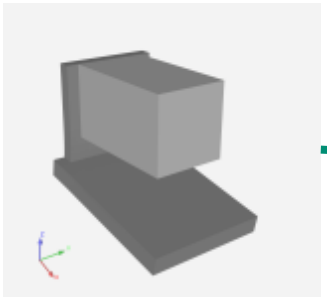
Because of the optimized fixture, the same mode shapes exist in both the system and test configurations

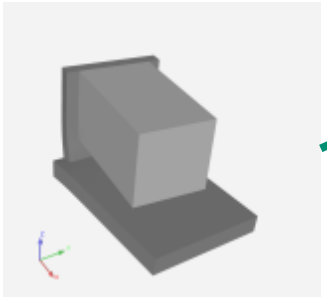


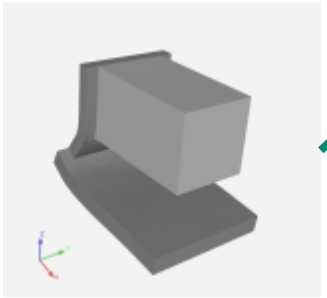


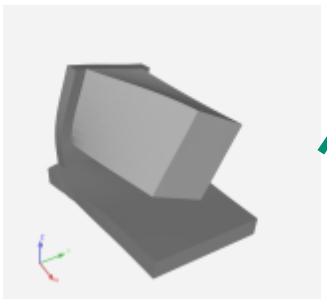


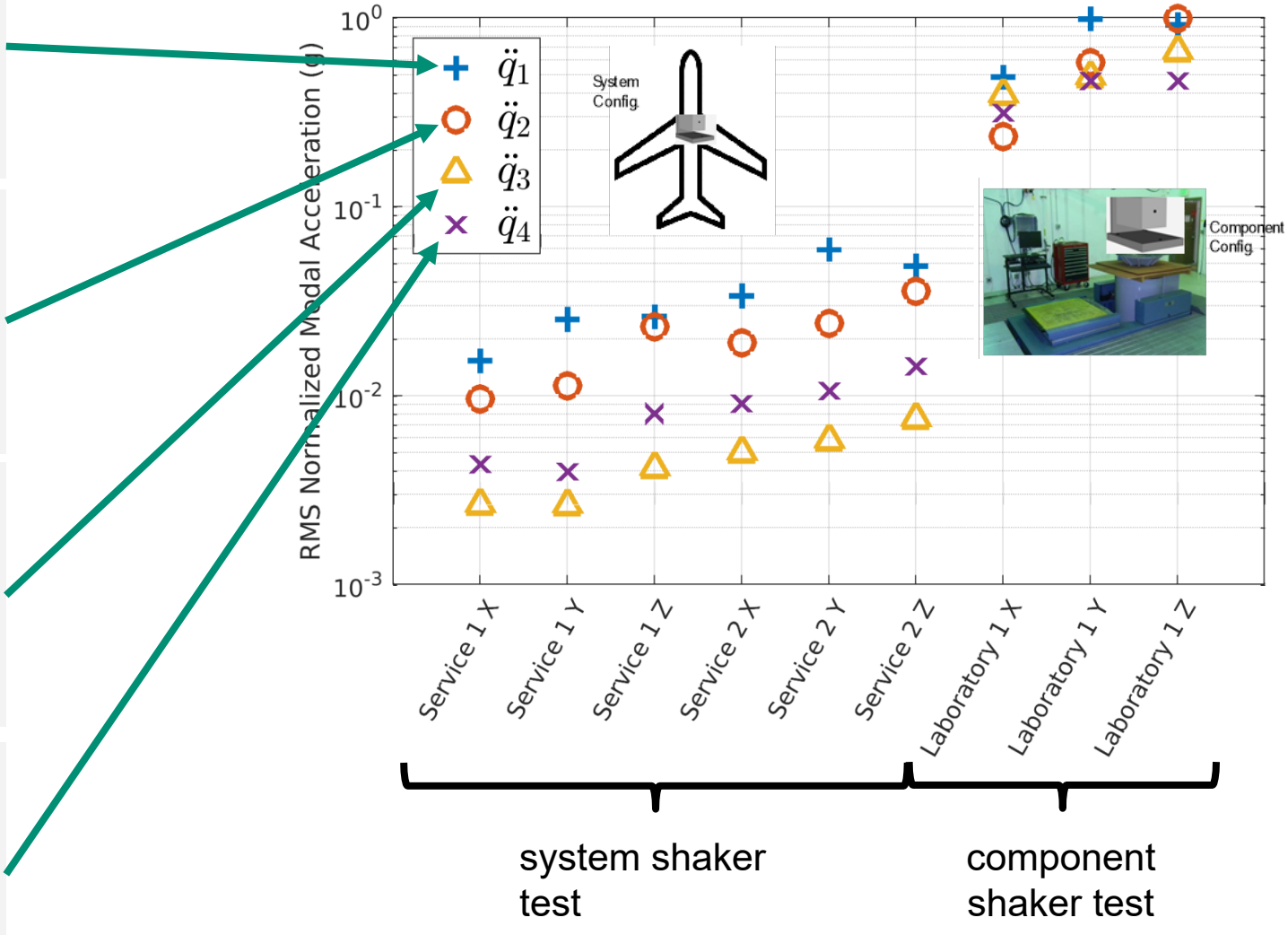
Comparing Modal Accelerations











Summary

- Your test fixture for dynamic tests dictates the possible deformation your component will experience.
- Without a satisfactory test fixture, the probability of false failures and false successes are high.
- Having similar modes between the operational and laboratory configurations allows for comparison of modal amplitudes and an improved means of comparing full-field environment responses.