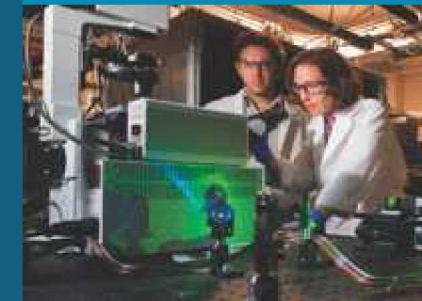


# Quantifying the Effect of Component Inertial Properties on System Level Dynamics



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## Background

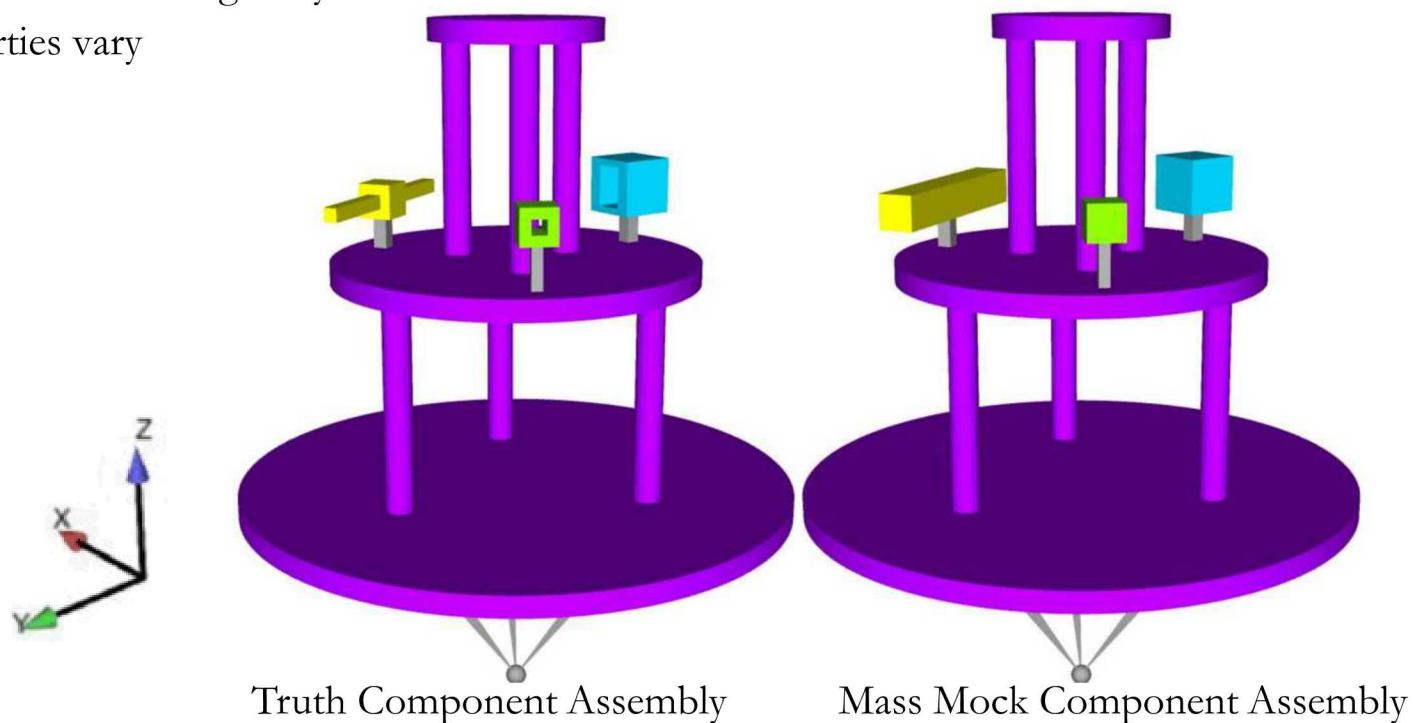
Component level test specifications are often derived from system level field tests

- Early development: Mass mock components utilized in system level models

Analysis uses a simplistic test structure to better understand the effect mass mock components have on the dynamics of an assembly.

Mass mock components:

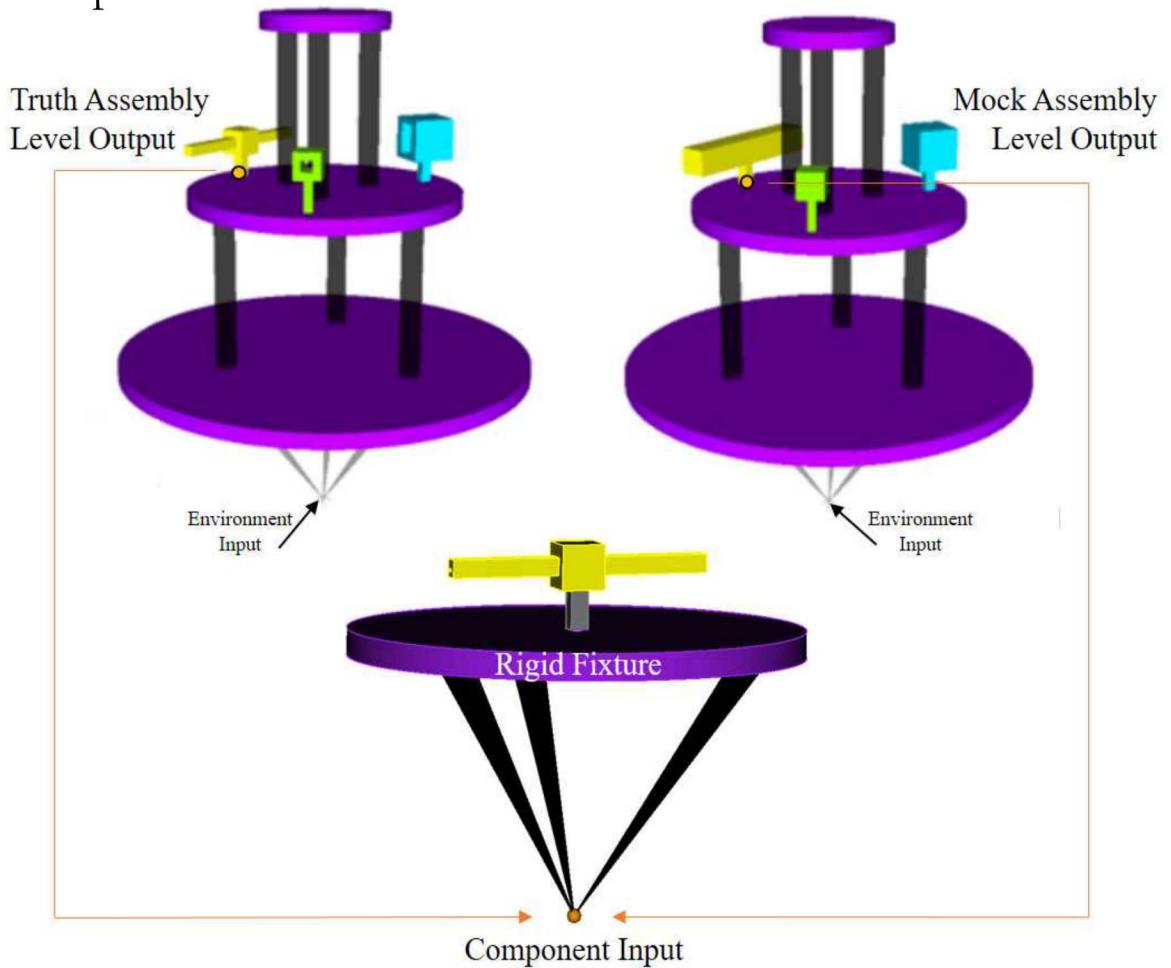
- Maintain mass & center of gravity
- Inertial properties vary



## Analytical Derivation of Component Level Specifications

Base excited environmental input

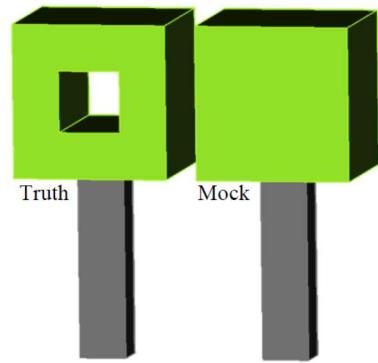
- 6 DOF input
- 1-60 Hz range



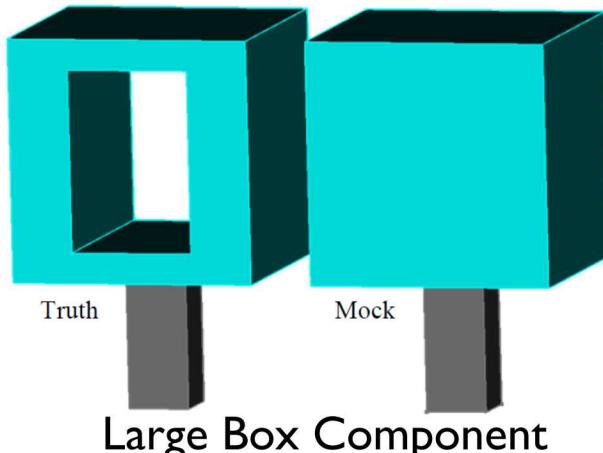
Responses at each component base are used to derive the respective component test input

# Mass Mock Components

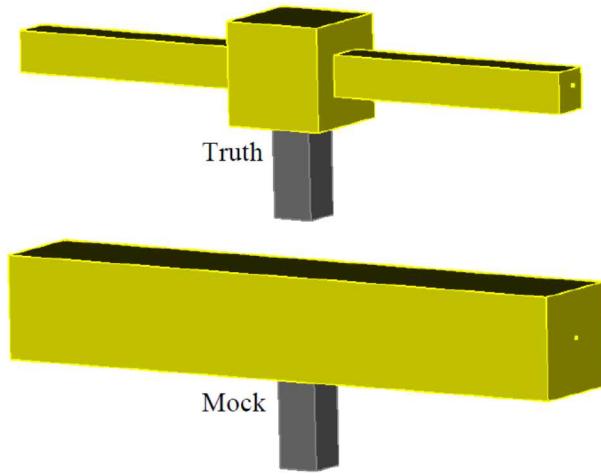
Component	$I_x (kg * mm^2)$		$I_y (kg * mm^2)$		$I_z (kg * mm^2)$		Mass (g)		Volume (cm <sup>3</sup> )	
	<u>Truth</u>	<u>Mock</u>	<u>Truth</u>	<u>Mock</u>	<u>Truth</u>	<u>Mock</u>	<u>Truth</u>	<u>Mock</u>	<u>Truth</u>	<u>Mock</u>
Small Box (Percent Difference)	<b>0.125</b>	<b>0.115</b>	<b>0.134</b>	<b>0.115</b>	<b>0.125</b>	<b>0.115</b>	<b>4.43</b>	<b>4.43</b>	<b>1.64</b>	<b>1.95</b>
	<b>-8.0%</b>		<b>-14.2%</b>		<b>-8.0%</b>		<b>0%</b>		<b>18.9%</b>	
Large Box (Percent Difference)	<b>1.17</b>	<b>0.9</b>	<b>1.07</b>	<b>0.9</b>	<b>1.1</b>	<b>0.9</b>	<b>13.5</b>	<b>13.5</b>	<b>5.0</b>	<b>8.0</b>
	<b>-23.1%</b>		<b>-15.9%</b>		<b>-18.2%</b>		<b>0%</b>		<b>60.0%</b>	
Beam (Percent Difference)	<b>1.92</b>	<b>3.49</b>	<b>0.74</b>	<b>1.33</b>	<b>2.51</b>	<b>4.57</b>	<b>9.49</b>	<b>9.49</b>	<b>3.52</b>	<b>11.70</b>
	<b>81.8%</b>		<b>79.7%</b>		<b>82.1%</b>		<b>0%</b>		<b>232.4%</b>	
Assembly (Percent Difference)	<b>4888</b>	<b>4889</b>	<b>4907</b>	<b>4907</b>	<b>4000</b>	<b>4002</b>	<b>1085</b>	<b>1085</b>	<b>401.7</b>	<b>413.2</b>
	<b>0.03%</b>		<b>0.01%</b>		<b>0.05%</b>		<b>0%</b>		<b>2.86%</b>	



Small Box Component



Large Box Component



Beam Component

## Assembly Structure

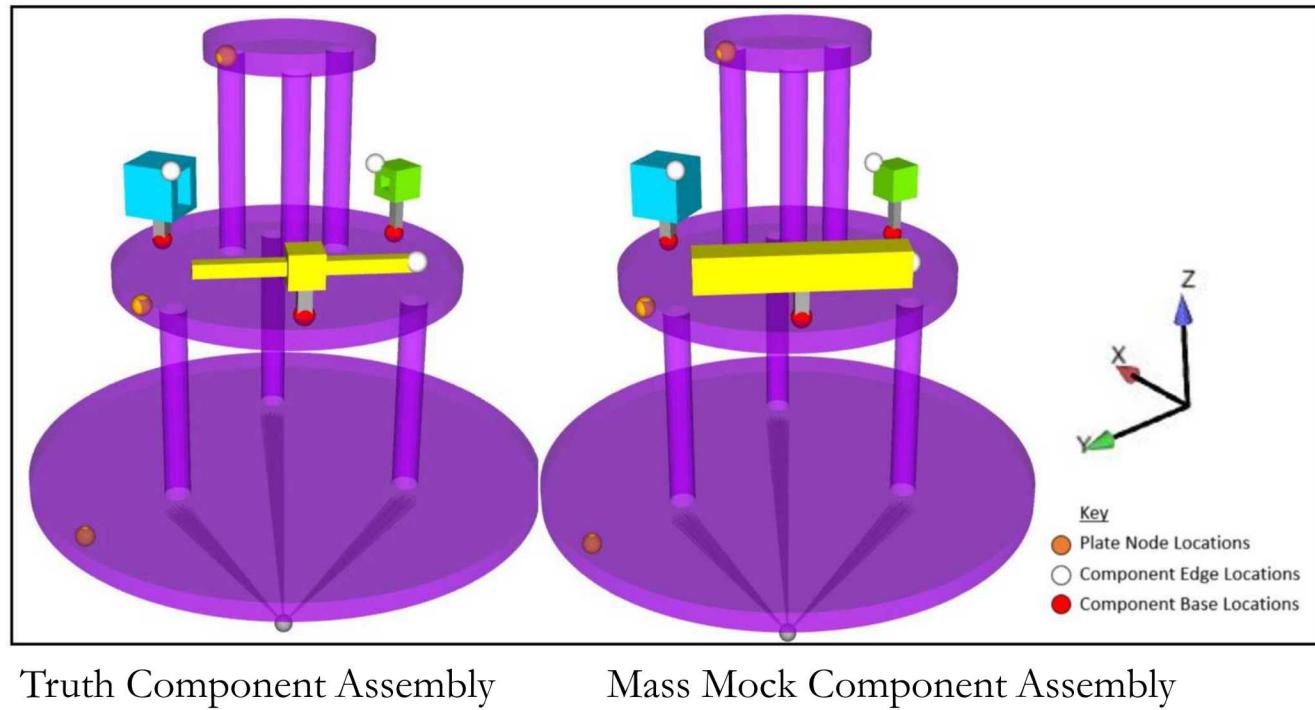


Three tiered structure with symmetrically mounted components

- Consistent node locations used for response comparison

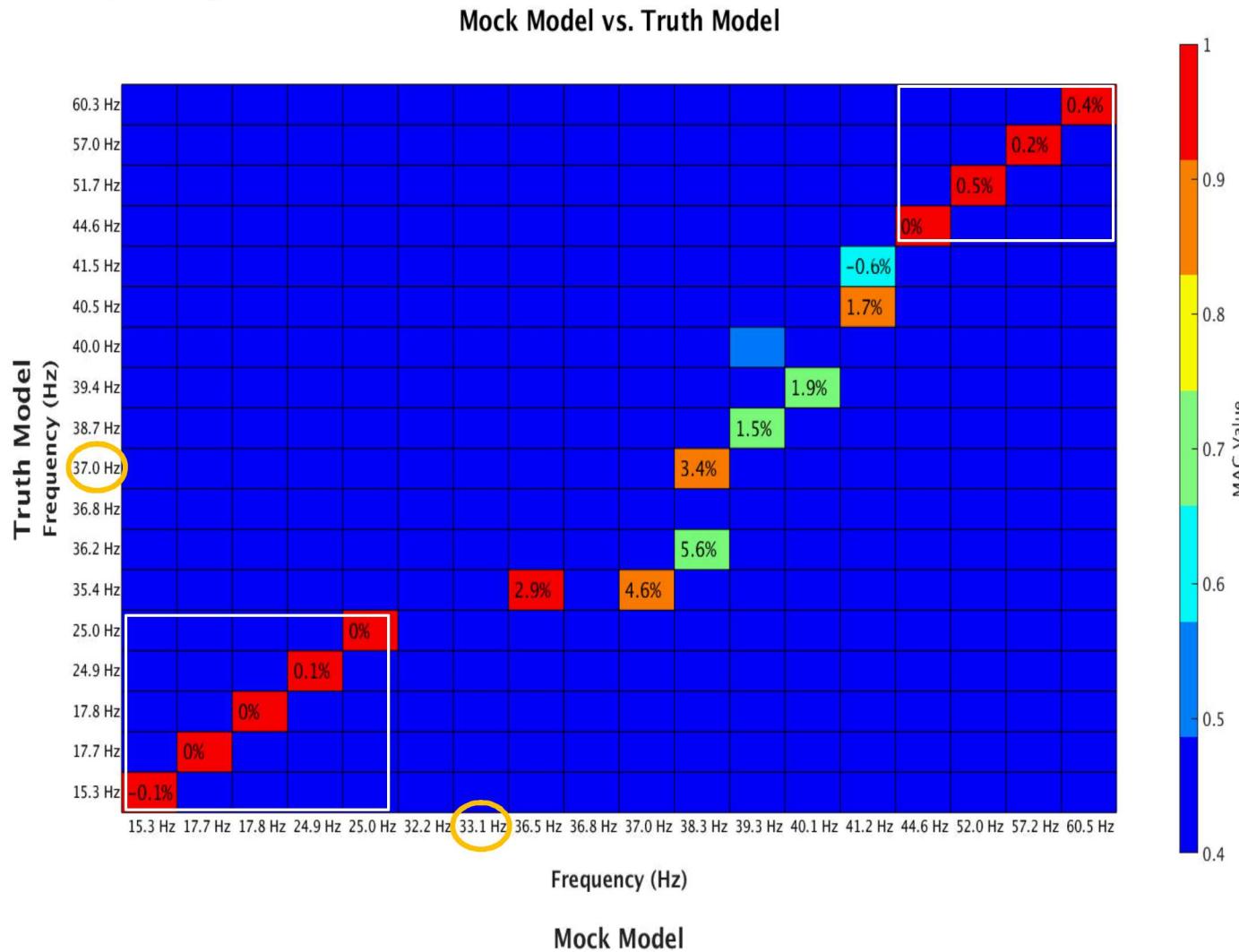
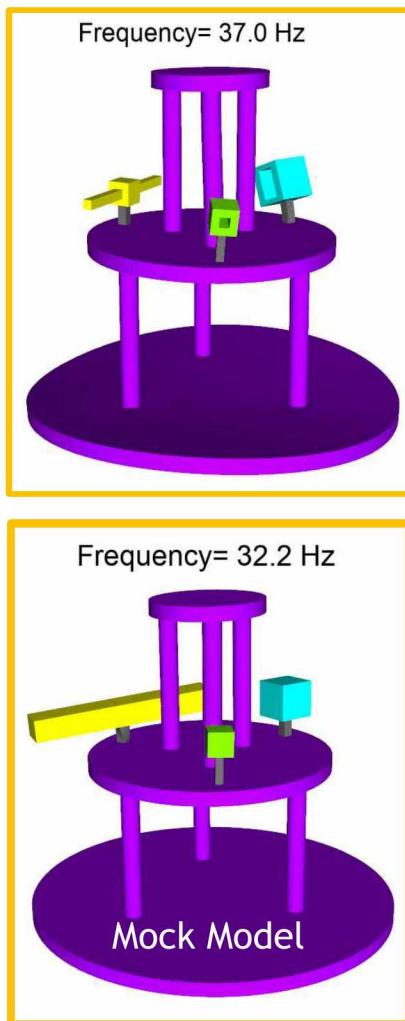
Primary means of comparison

- Modal Data
- Environmental Responses
- Specifications derived for Component Tests



# Modal Correlation

Modal correlation between truth and mass mock assemblies only vary in modes predominantly dictated by component behavior.

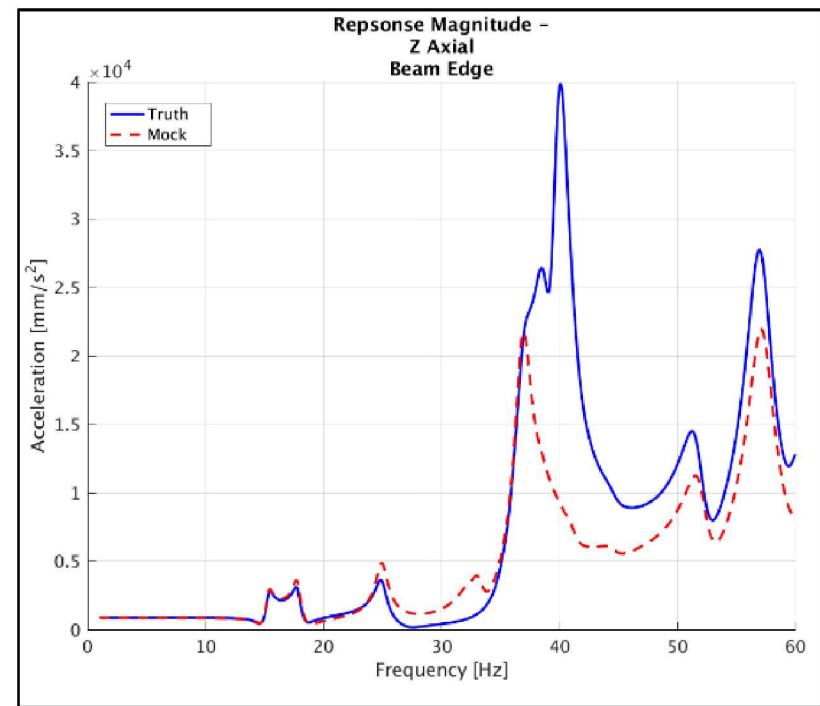
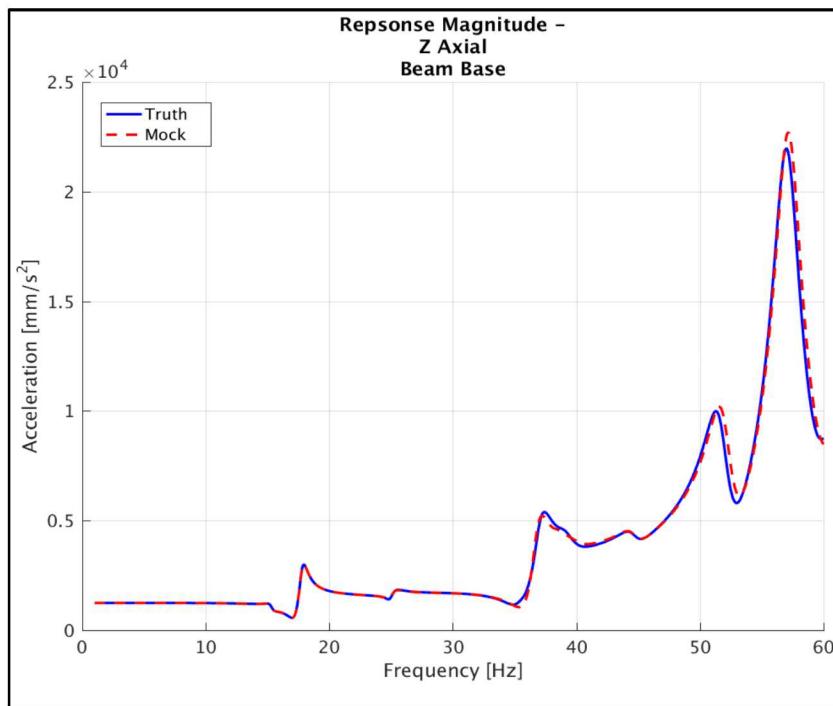
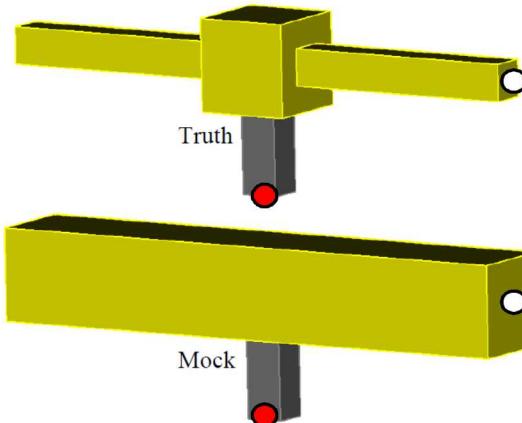


# Component Level Environment Responses

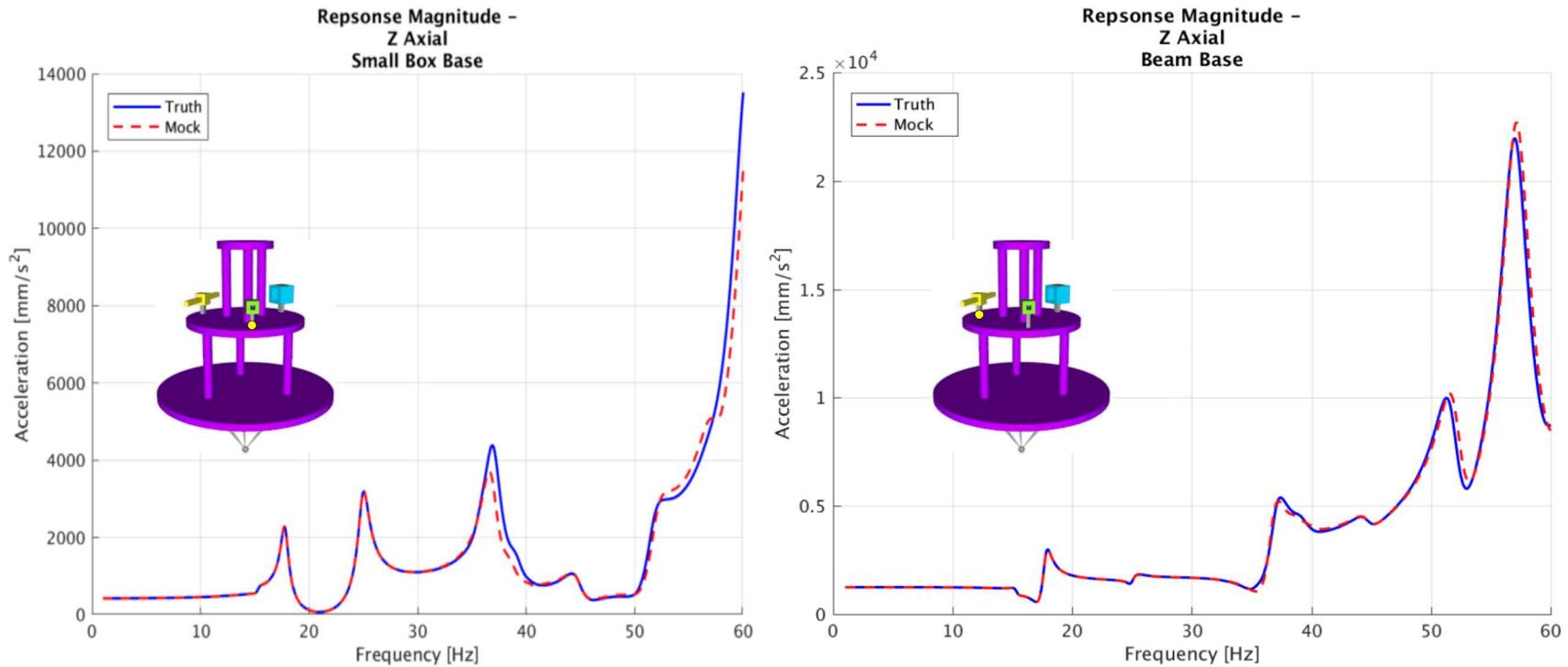
Similar response observed in component base

Larger differences are apparent when evaluated at the component edge

- Inertial properties effect component motion in this region



# System Level Environment Responses

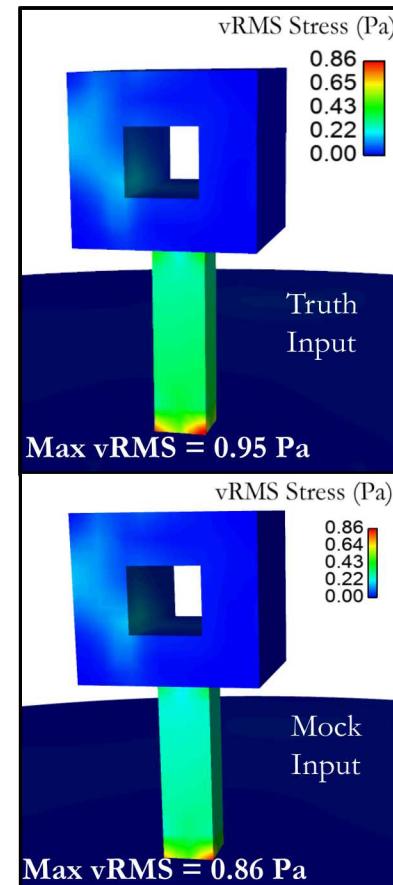
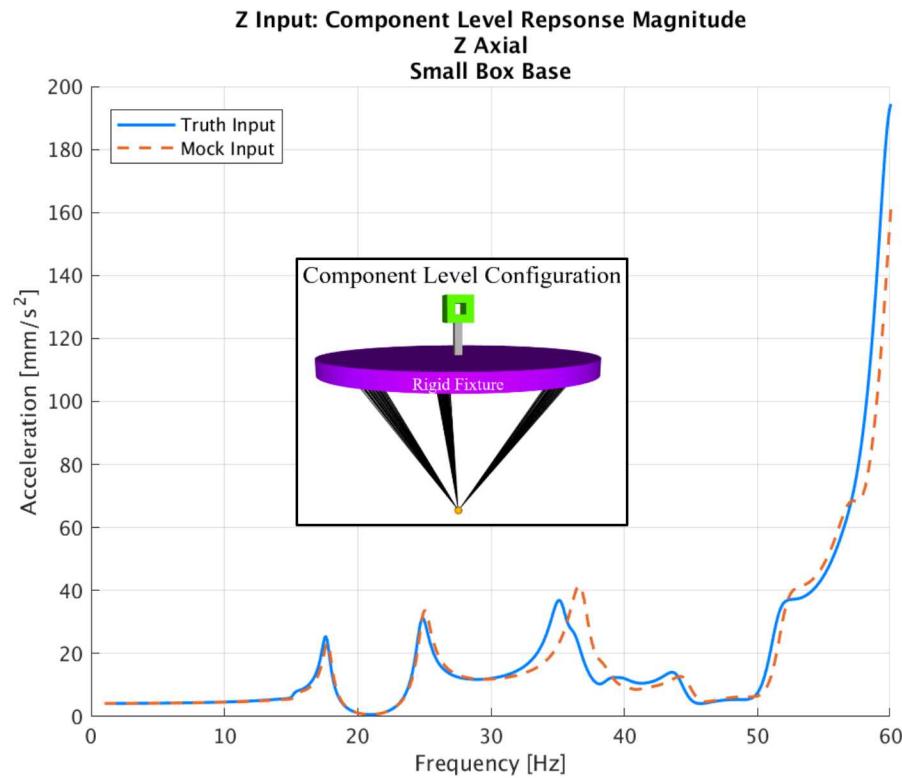


Negligible amplitude differences in all three components of the mock and truth system level models (small box and beam component data depicted)

Each of these responses will be used to test the isolated truth component on a rigid fixture

- Translational directions were also explored, see report for more details

# Component Level Environment Responses



Slight input difference near 37 Hz becomes exaggerated in component level test

- Frequency range in which system response excites the small box component

vRMS stress values are relatively small, but have a 9% error in maximum vRMS stress

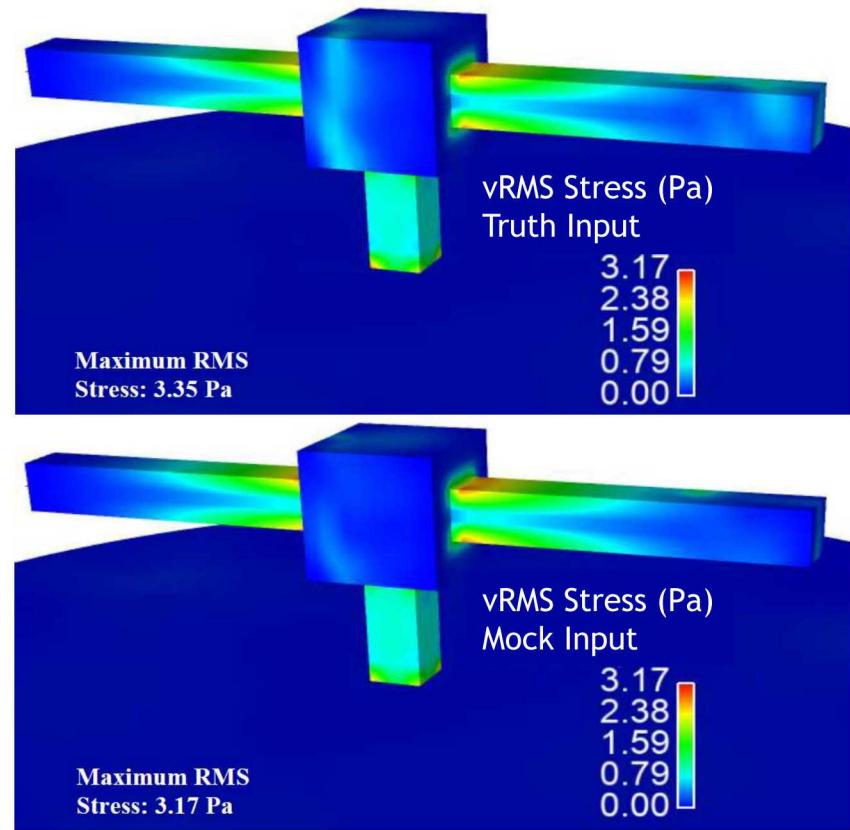
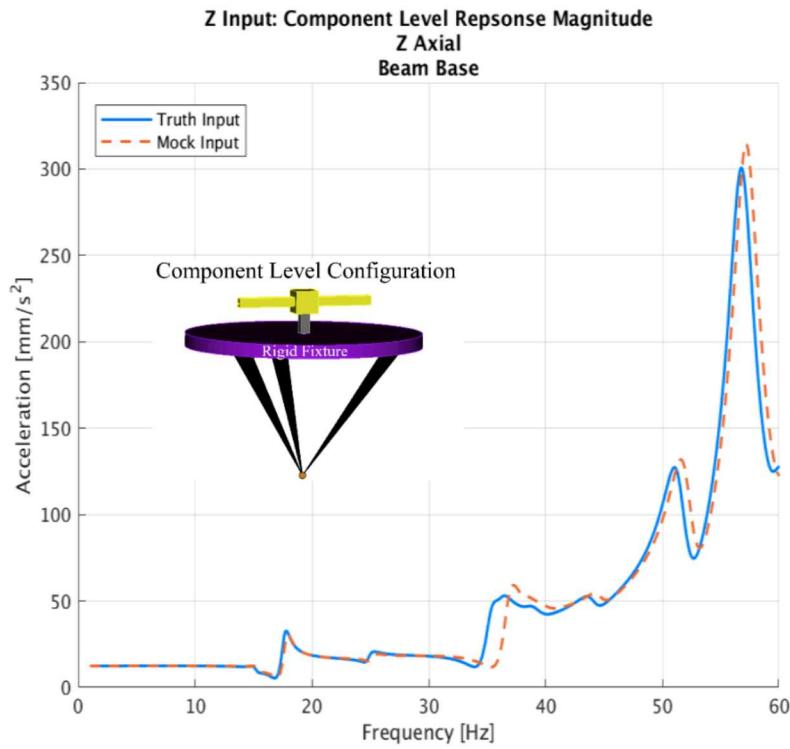
- the truth input results in larger output vRMS stress values

# Component Level Environment Responses

Maximum vRMS stress is 5% higher than mass mock derived input

Frequency shift propagates to responses occurring above 35 Hz in mock input

- The mock input is less conservative than the truth input in terms of resulting vRMS stress
- Environments are generally enveloped to assume more conservatism



## Conclusions

Changing component inertias effected system dynamics and output component vRMS stresses

Maximum vRMS stresses were not large, but component modes were not primarily modes of excitation

This model provided relatively isolated components – increasing interface complexity and coupling should be explored

There are discrepancies assumed when using mass mock components that should be considered in environmental specifications



# Questions?

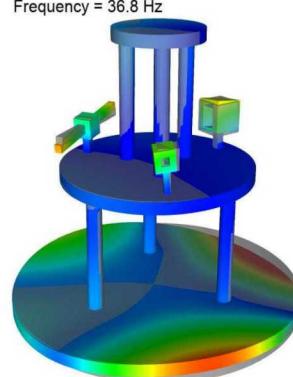
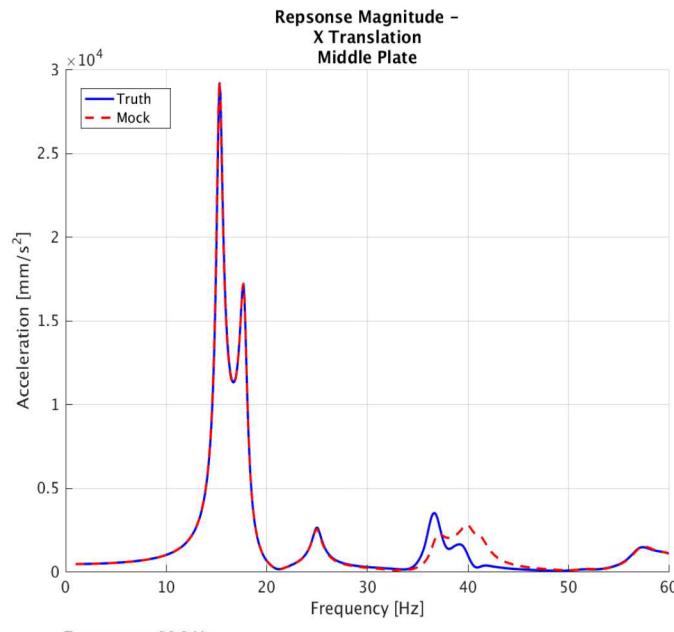


# Extra Slides

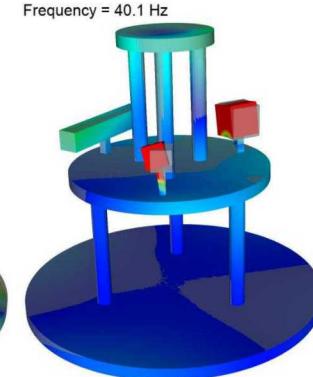
# System Level Environment Responses

Response evaluated in the middle and top tiers of the structure show variance

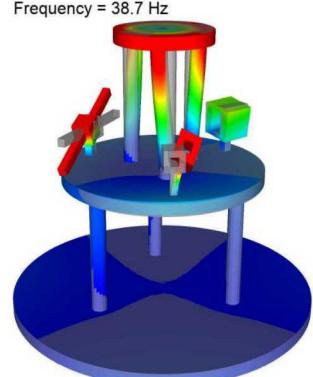
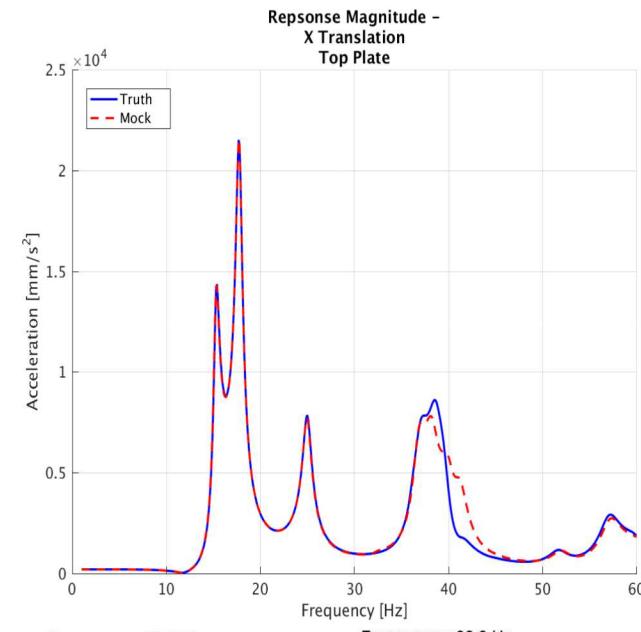
- Component driven modes effect system level response



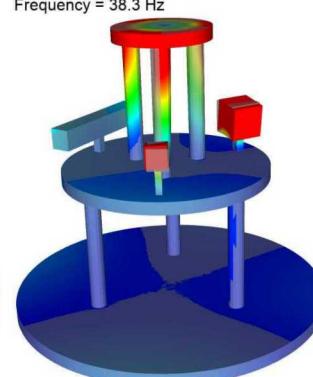
Truth Assembly



Mock Assembly



Truth Assembly



Mock Assembly