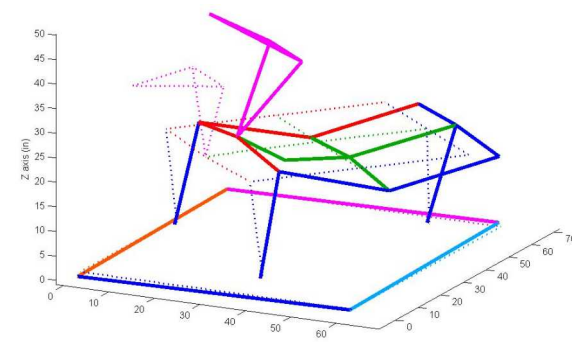
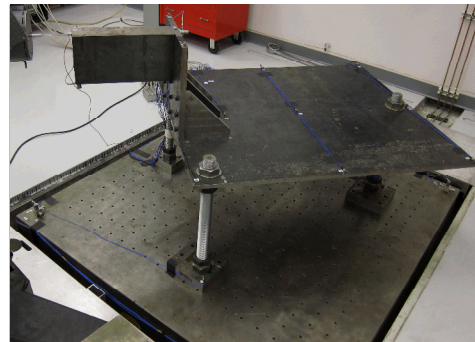
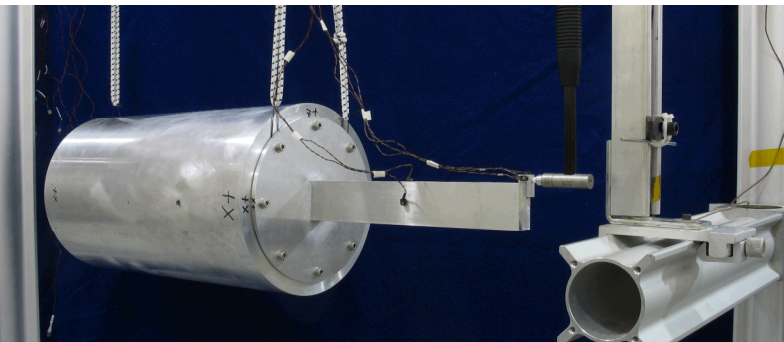


Exceptional service in the national interest



Sandia National Laboratories Experimental Modal Testing Capabilities and Interests

Brandon Zwink

GENERAL OVERVIEW

General Overview: What We Do

- Experimental Modal Analysis
- Modal Parameter Estimation
- Force Reconstruction
- Finite Element Model Calibration
- Substructuring
- Modal Data from Shaker Table
- Experimental Effective Mass
- Nonlinear Joint Identification
- Modal Testing with Laser Vibrometers
- Impedance Model Development

General Overview: Assets

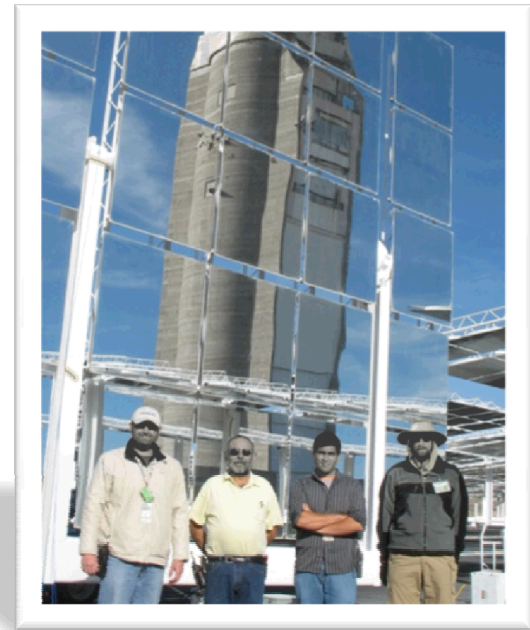
Capabilities

- New 1700 sq ft modal lab
 - 2 overhead bridge cranes
 - 32,000 lbf isolated seismic mass
 - >500 channels of data acquisition
 - 9 data acquisition computers (IDEAS)
- 12 shakers (12-1000 lbf)
- Scanning Laser Vibrometer
- > 1000 Accelerometers
- Strain Gauges – standard and high sensitivity
- Field test capability

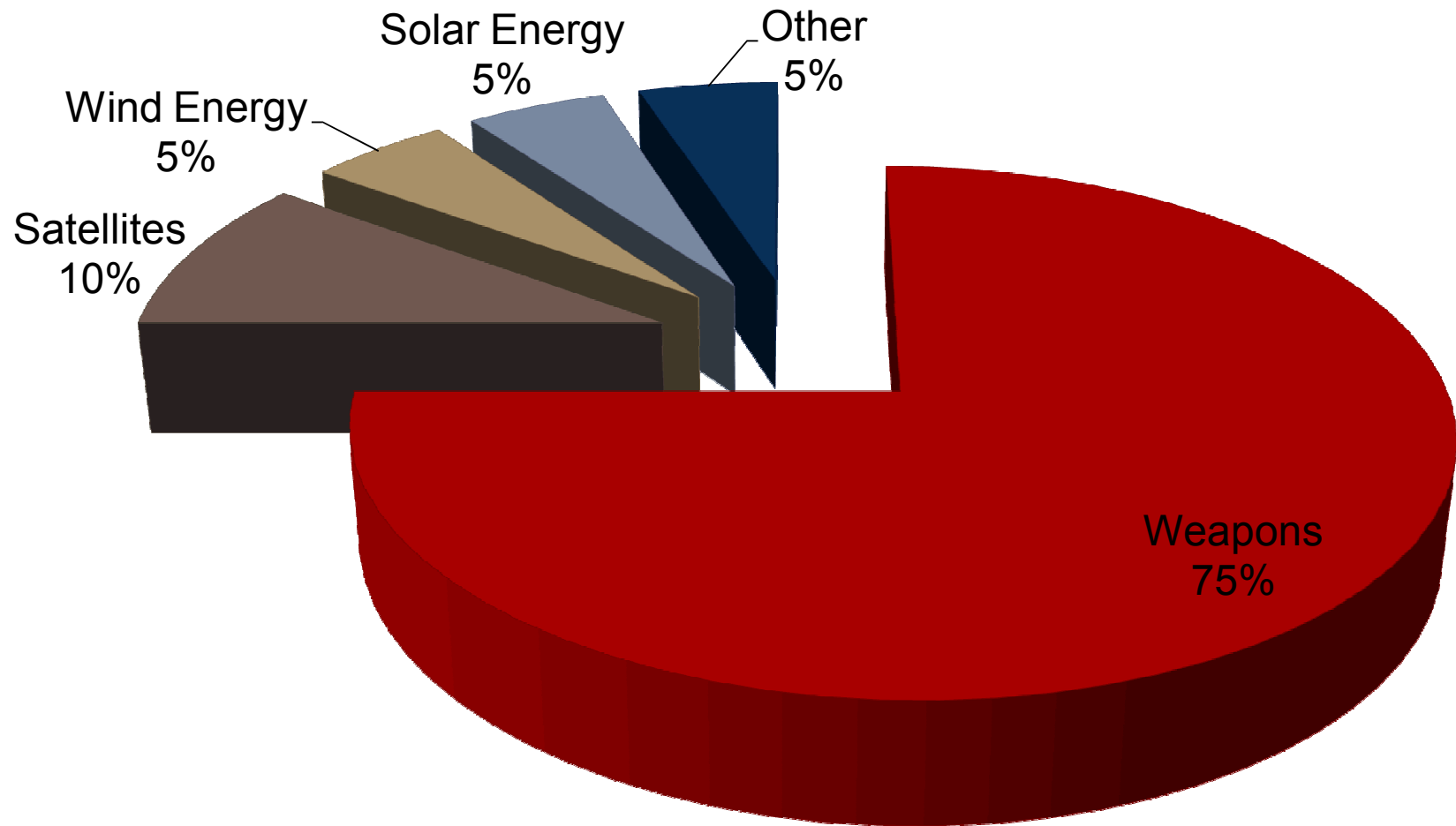


General Overview: Activities

- Field instrumentation for blast, impulse, shock, and vibration testing
- Troubleshooting
- U.S. and international collaborations
- Developed state-of-the-art algorithms for:
 - Force reconstruction
 - Modal parameter estimation
 - Converting driven base to fixed base tests



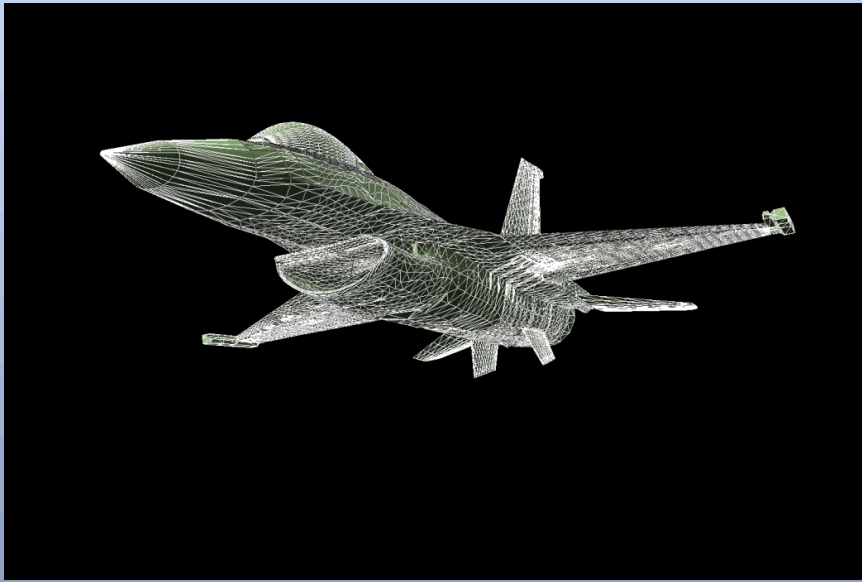
General Overview



FINITE ELEMENT MODEL CALIBRATION

Finite Element Model Calibration

Finite Element Model



Modal Parameters

Experimental Modal Test



Modal Parameters

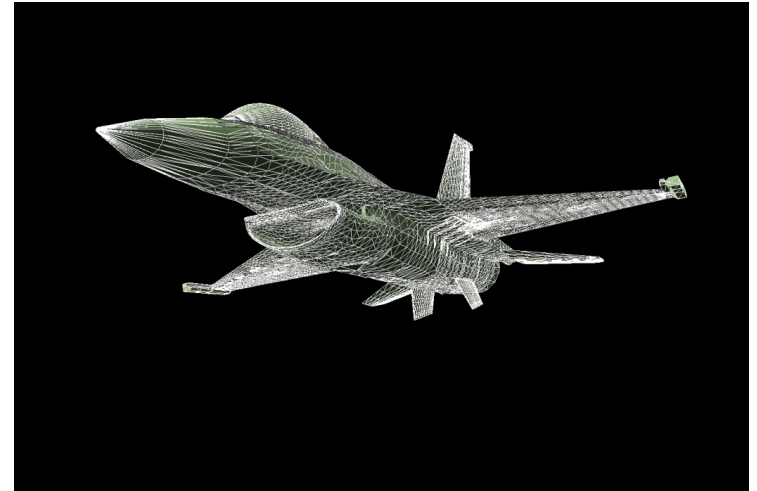


Compare

Finite Element Model Calibration

Why do We Need it?

- Check Assumptions
- Find Errors
- Realistic Elements?
- Linear Model Appropriate?
- Damping Values

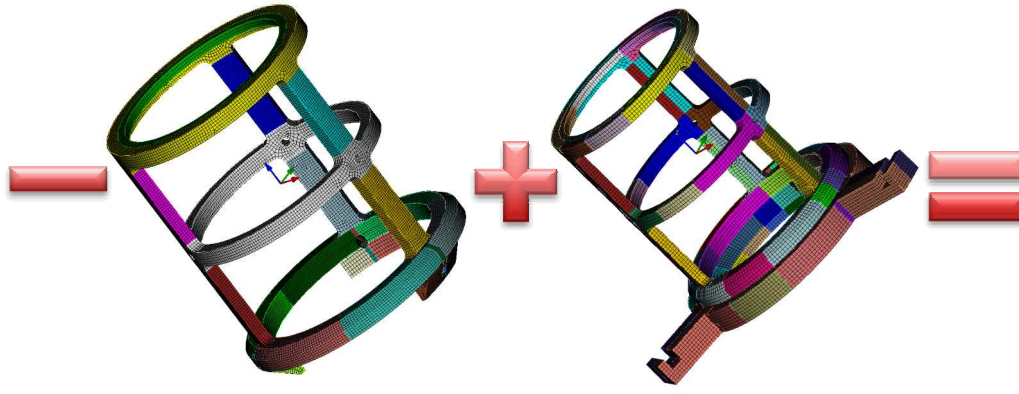


SUBSTRUCTURING

Substructuring

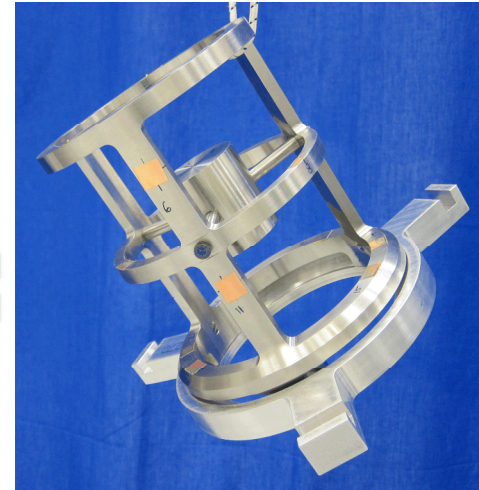


Experimental
Model



Finite Element
Model

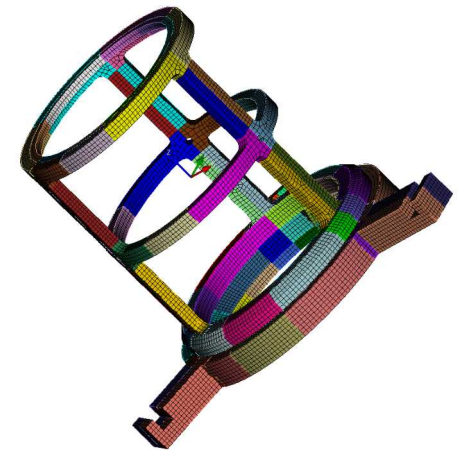
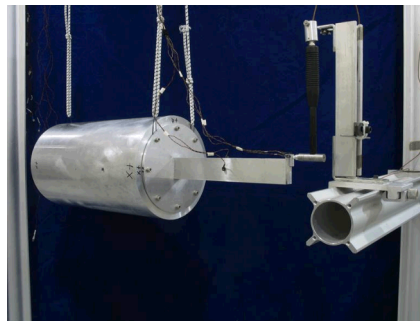
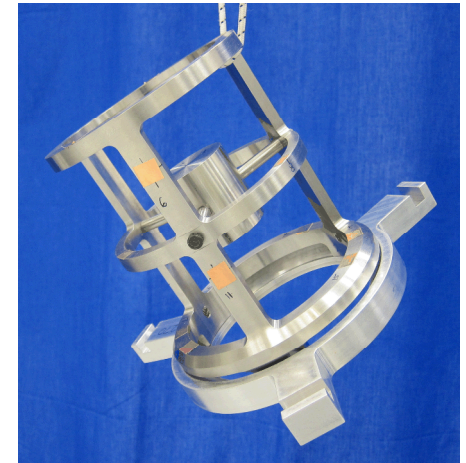
Finite Element
Model



Experimental and
Finite Element
Model

Substructuring

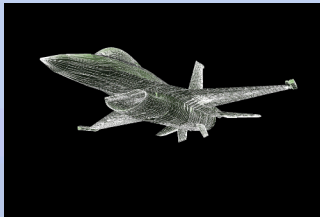
- Combine FEM and Experimental Model
- Advantages of Experimental Model
 - Geometry not required
 - Incorporate nonlinearities
 - Accurate joint representation
 - Faster to develop than FEM
 - Possible large cost savings by not building/tuning FEM



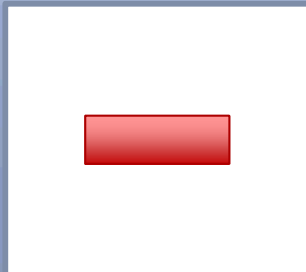
MODAL DATA FROM SHAKER TABLE

Modal Data From Shaker Table

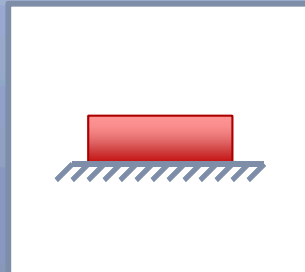
Finite Element Model



Boundary Conditions



Free-Free

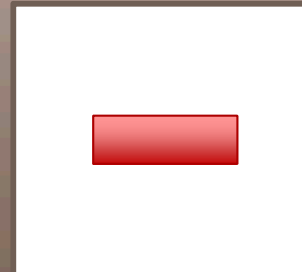


Fixed-Free

Experimental Modal Test



Boundary Conditions



≈Free-Free



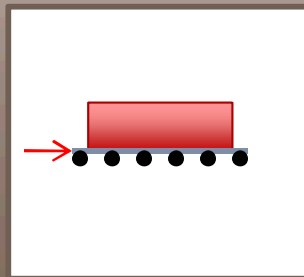
≈ Fixed-Free

Modal Data From Shaker Table

Experimental Modal Test

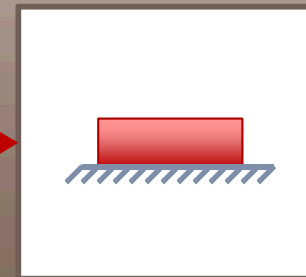


Boundary Conditions



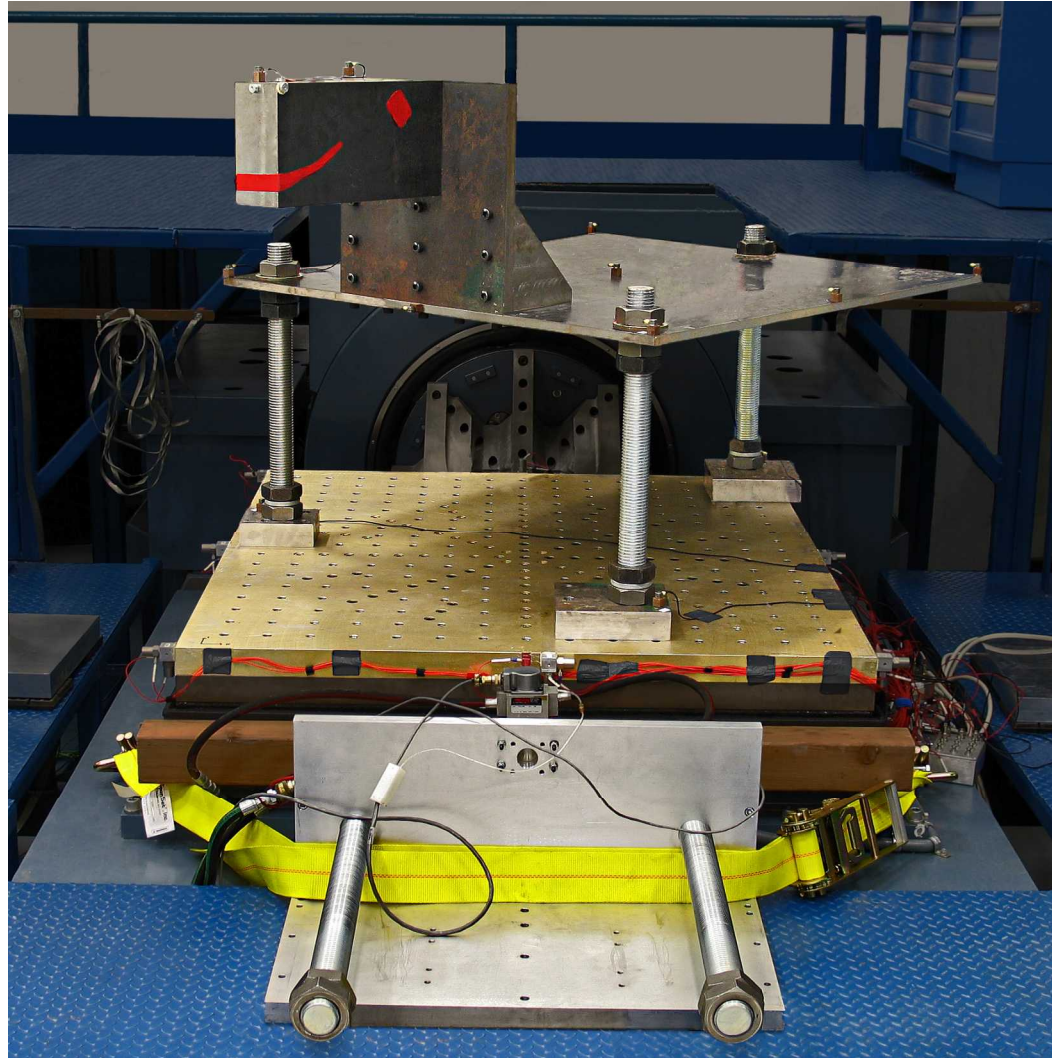
Shaker Table

Convert

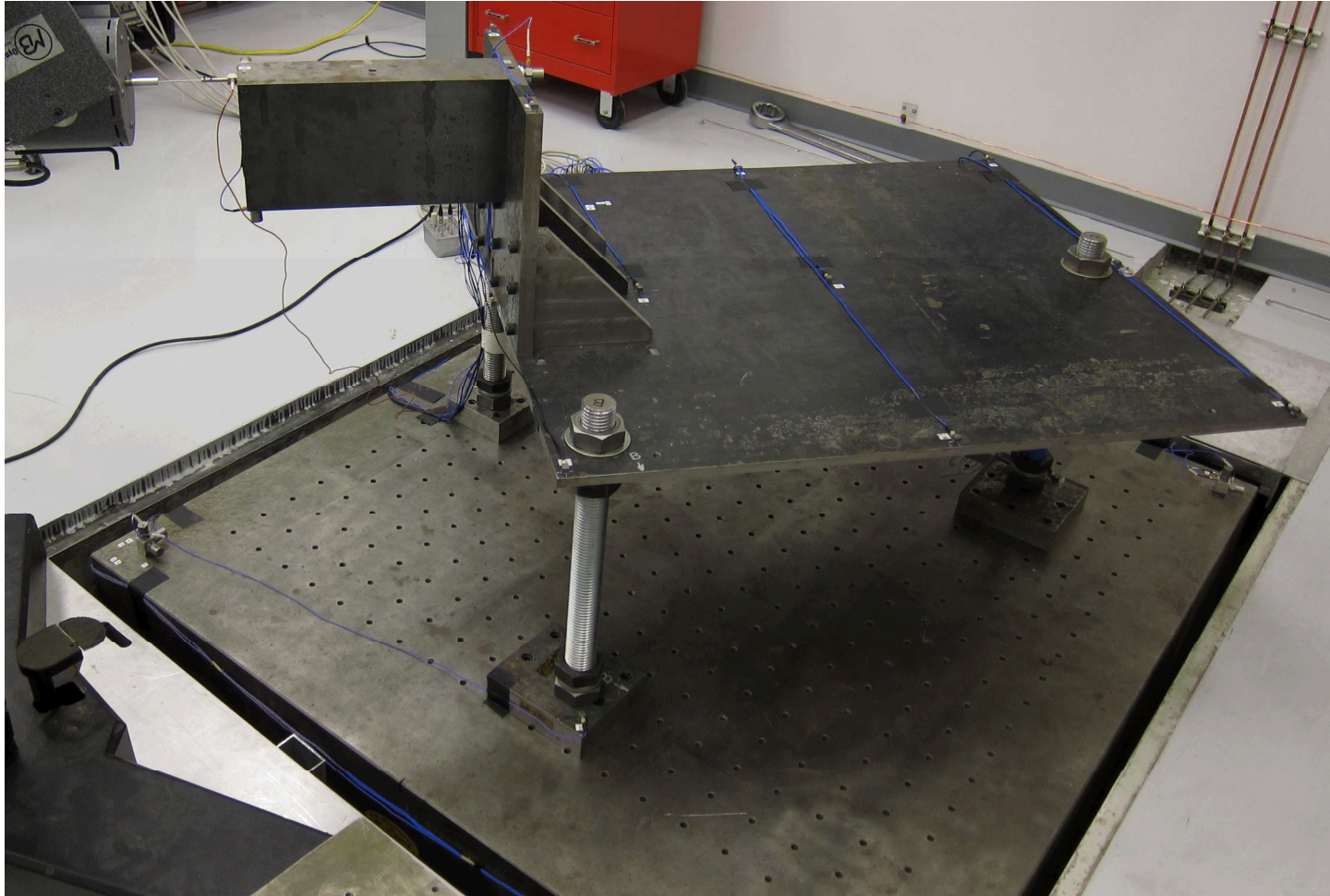


Fixed-Base

Modal Data From Shaker Table



Modal Data From Shaker Table



Modal Data From Shaker Table

	Truth Test	Full System (Constrained)
Mode	Frequency (Hz)	Frequency (Hz)
Elastic Mode 1	16.09	16.17
Elastic Mode 2	21.35	21.10
Elastic Mode 3	24.78	24.70
Elastic Mode 4	28.19	28.26

Frequency Error 0.3% to 1.2%

	Truth Test	Full System (Constrained)
Mode	Damping Ratio	Damping Ratio
Elastic Mode 1	0.78%	1.75%
Elastic Mode 2	0.71%	1.81%
Elastic Mode 3	0.54%	0.98%
Elastic Mode 4	0.61%	1.54%

Damping Error 81% to 155%

Modal Data From Shaker Table

Advantages

- Single test setup
- Less object movement
- Less time
- Less money

Disadvantages

- Less accurate
- High uncertainty on damping estimates
- Limited bandwidth

EXPERIMENTAL EFFECTIVE MASS

Experimental Effective Mass

Use 1: Satellites

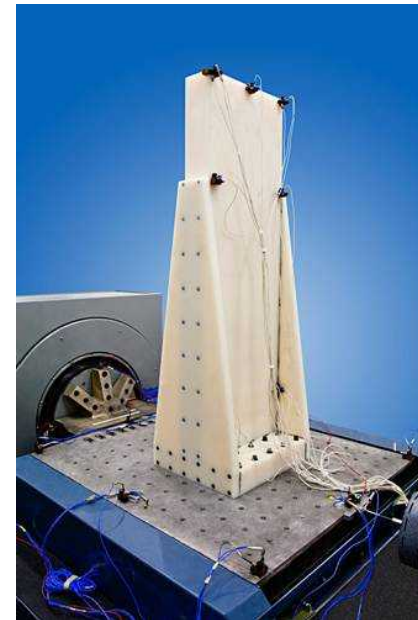
- Validate only modes with 15% effective mass or more
- Effective mass traditionally determined from FEM



Photo from NASA: GPS Satellite

Use 2: Margin Calculations

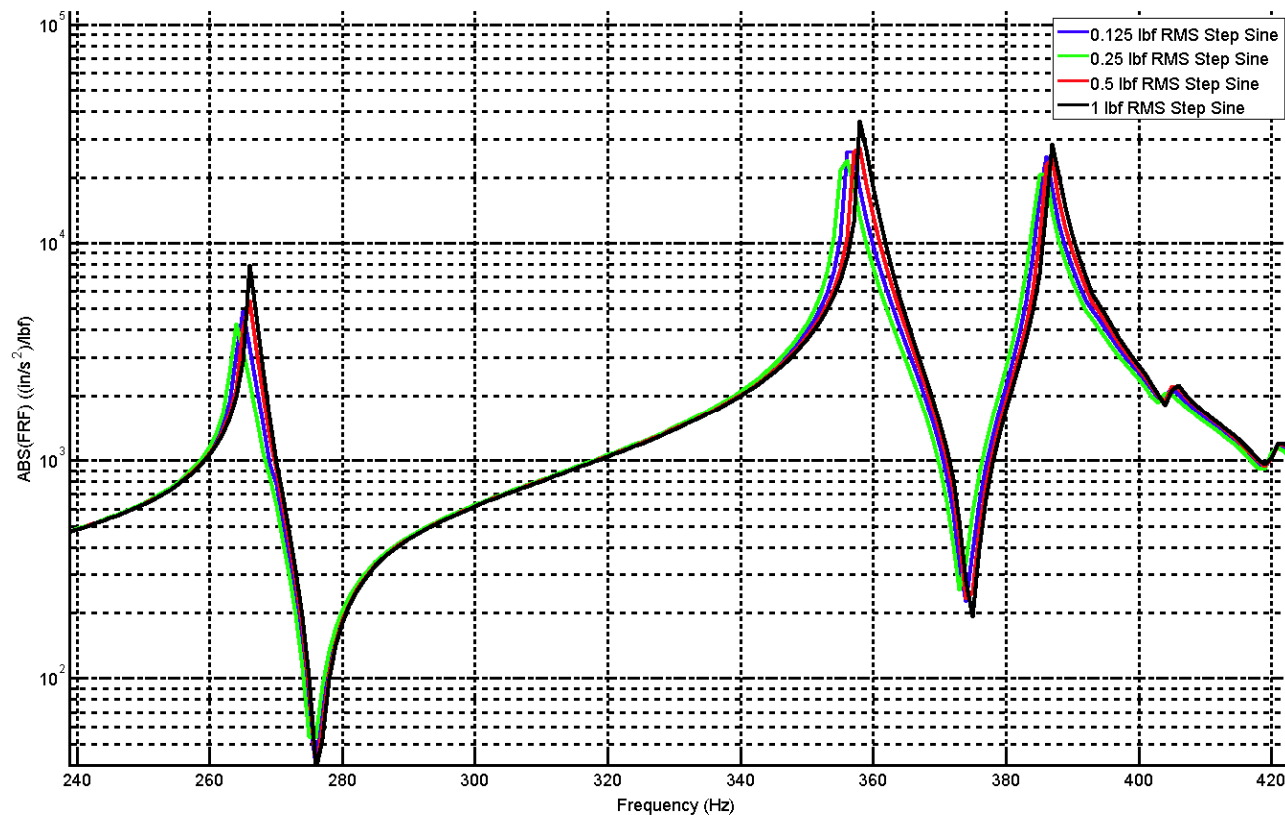
- Energy methods for determining margin require effective mass



NONLINEAR JOINT IDENTIFICATION

Nonlinear Joint Identification

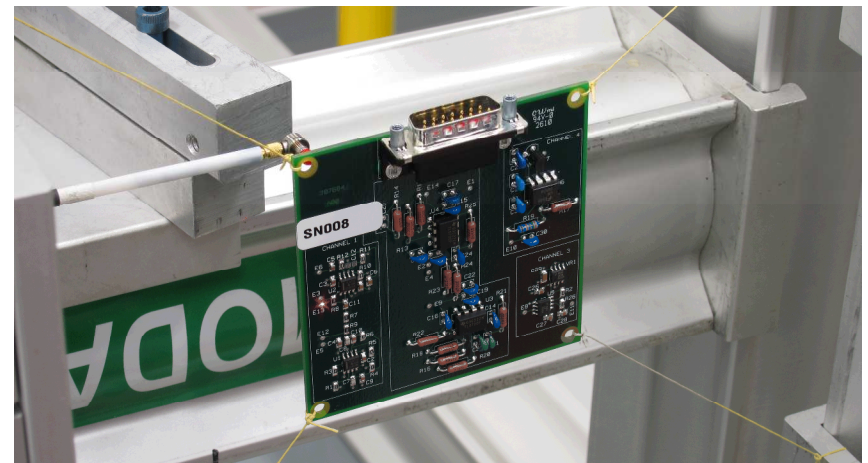
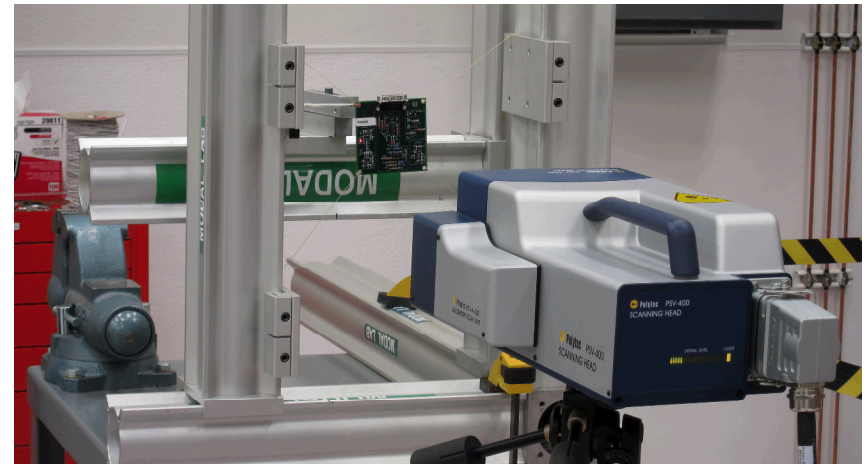
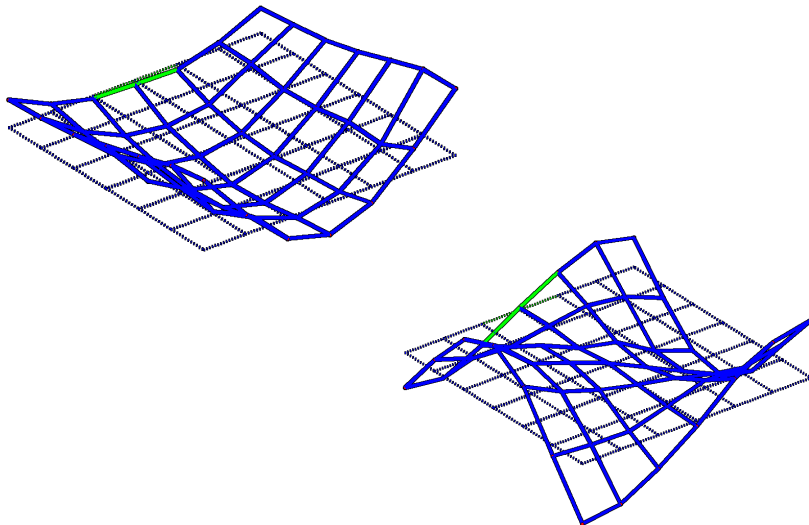
- Identify presence
- Step-sine test to characterize nonlinearity



MODAL TESTING WITH LASER VIBROMETERS

Modal Testing with Laser Vibrometers

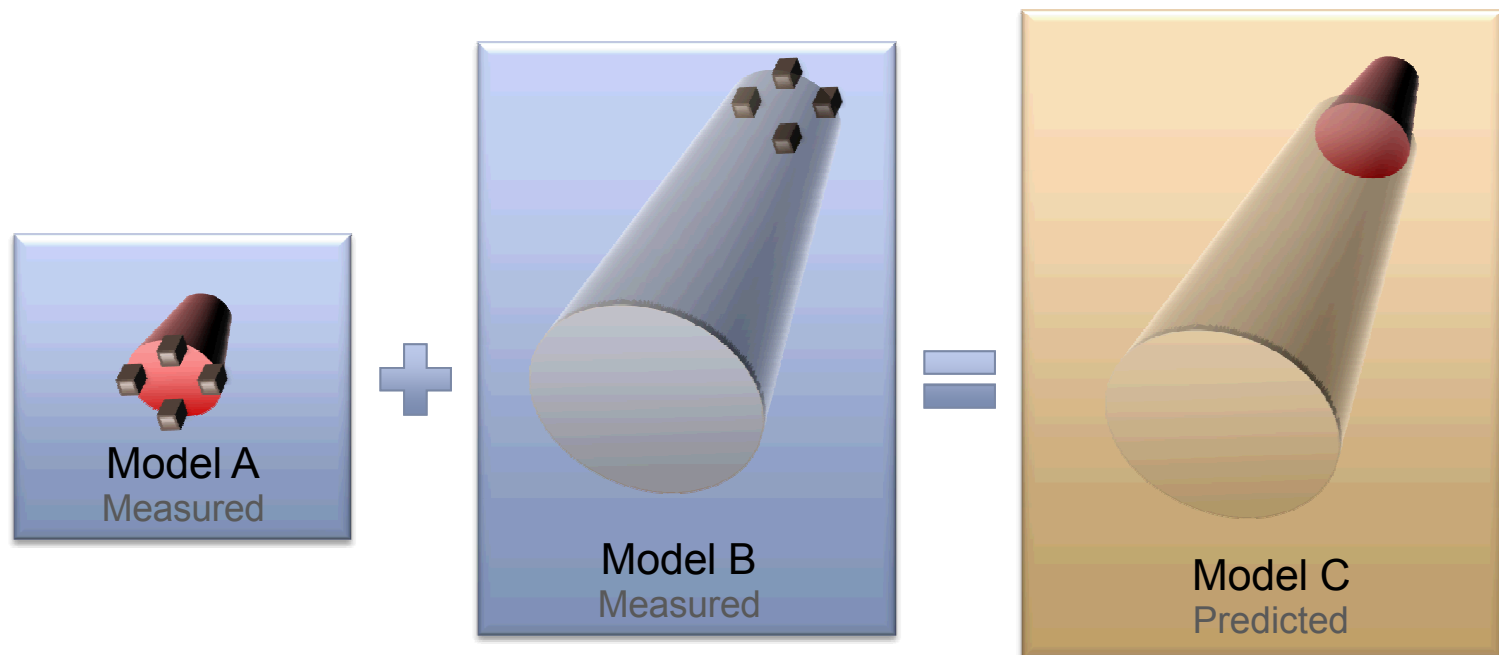
- Non-contact
- Minimal mass-loading
- Dense spatial resolution
- Low instrumentation time



IMPEDANCE MODEL DEVELOPMENT

Impedance Model Development

- Experimentally derived model
- Allows response of a system to be predicted on any fixture



QUESTIONS



Modal Team

David Epp - Manager

Randy Mayes

Mike Arviso

Tyler Schoenherr

Brandon Zwink

Patrick Hunter

Anthony Gomez

James Wade (Rokwel)