SAND2019-2419C

New Mexico Research Spotlight Forum

3/5/2019 Engineering Mechanics & Dynamics

Experimental Structural Dynamics: Test and Analysis Collaboration

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Experimental Structural Dynamics

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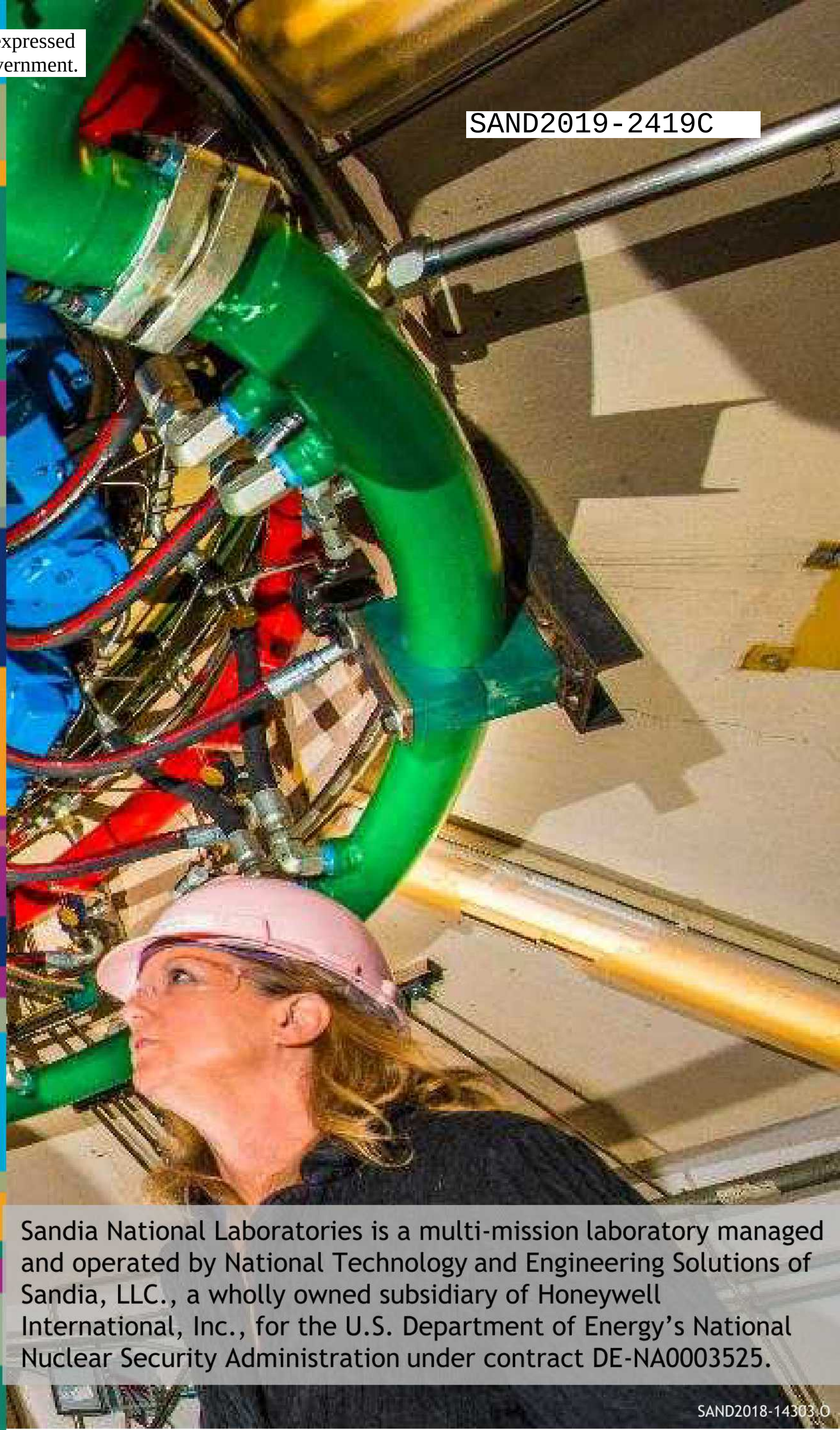
Capability Overview

Sandia National Laboratories | THE UNIVERSITY OF NEW MEXICO | NM STATE UNIVERSITY | NEW MEXICO TECH



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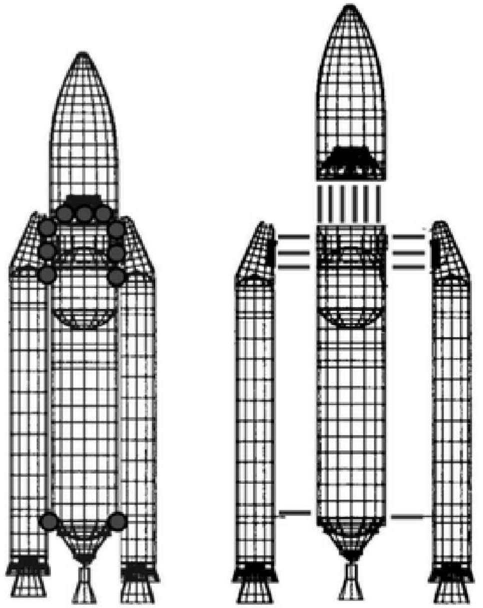
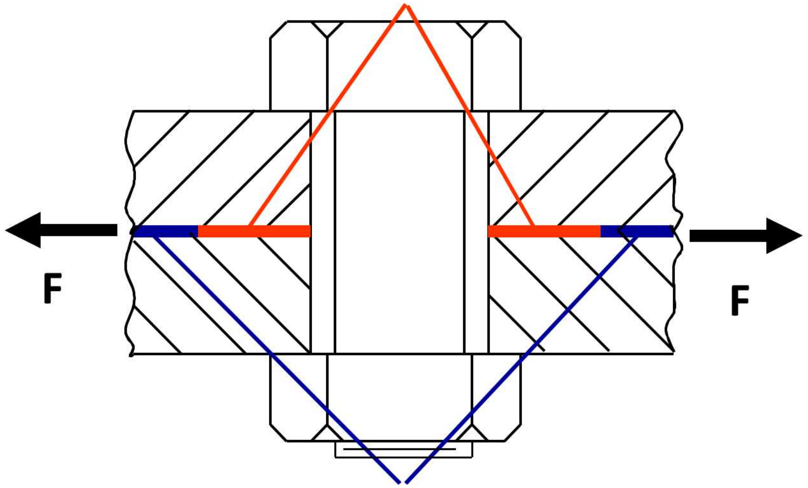
ABOUT YOURSELF

- **2007-2013:** Control Systems and Dynamics Engineer at General Electric – Aircraft Engines
  - Engineering Edison Development Program
  - Rotated through, design, analysis and test on the same engine program
- **2016**: PhD in Engineering Mechanics from University of Wisconsin-Madison
  - "Experimental Dynamic Substructuring Using Nonlinear Modal Joint Models"
  - Funded through Sandia National Labs
- **2017**: Joined Sandia National Laboratories as Post Doctoral Appointee
  - Studied experimental-hybrid substructuring, nonlinear joint dynamics and hardware-in-the-loop substructuring
- **2018**: Converted to a full-time Senior Member of Technical Staff at Sandia National Labs
- Current research areas:
  - Experimental-Analytical Dynamic Substructuring: synthesis of experimental and numerical models
  - Nonlinear Experimental Dynamics: measurement techniques and identification processes

Keywords:
Structural dynamics; test-analysis correlation; nonlinear experimental dynamics; experimental-analytical substructuring



[1]



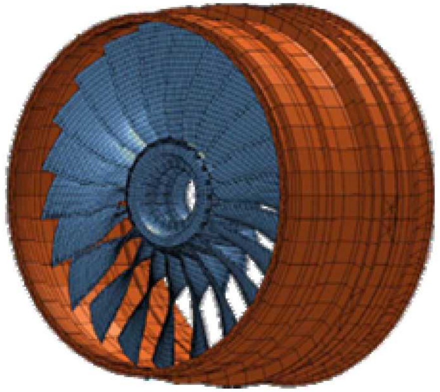
[1] Craig, Roy R., and Andrew J. Kurdila. *Fundamentals of structural dynamics.* John Wiley & Sons, 2006, Ch 17, Figure 17.1.

EXPERIMENTAL-ANALYTICAL SUBSTRUCTURING

- Often we are tasked with analyzing systems where one or more components are difficult to model analytically
  - Unknown material properties
  - Complicated geometry
  - Difficult to model
  - Produced and designed by an outside vendor

- The dynamics of these parts can have profound impact on the system level performance
- Experimental models are often the optimal choice for characterizing the impact of non modeled hardware it's the system level response

FEM Front Casing

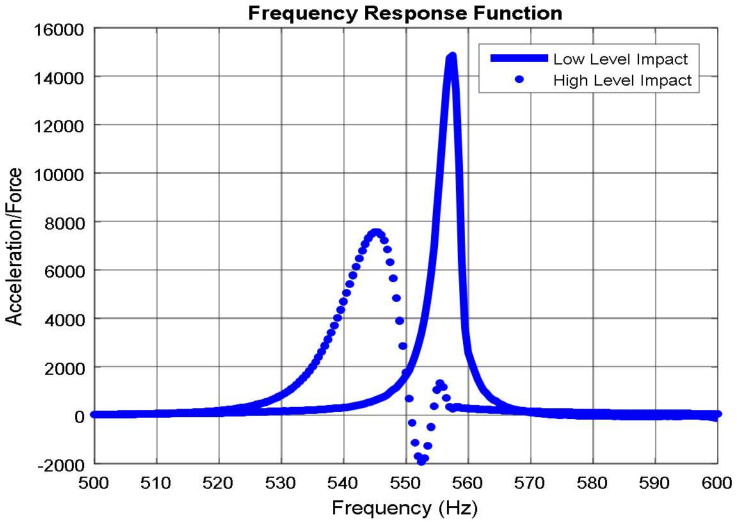


Experimental Model of Casing

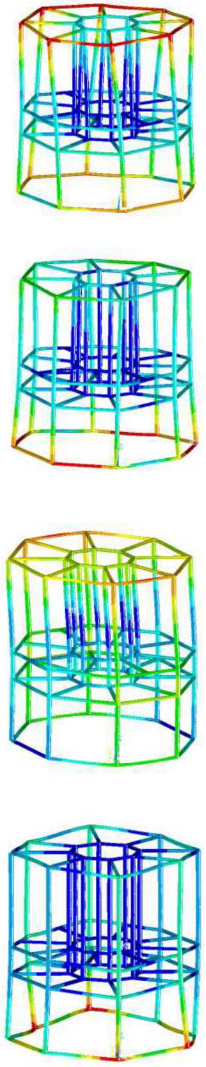
EXPERIMENTAL NONLINEAR MODAL MODEL

- Often we treat a structures dynamic response as linear, which means the response scales with forcing amplitude.

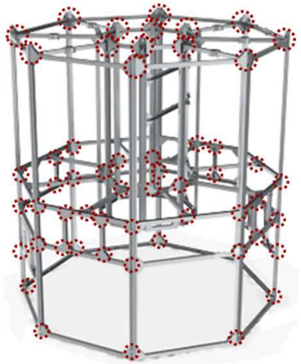
- Many industries rely on bolted joints to connect subcomponents. The frictional interfaces at these joints cause an otherwise linear system to have a nonlinear response, observed as a change in damping and stiffness with response amplitude



- Many constitutive elements have been formed to characterize these responses when the nonlinearity is caused by joints (Iwan[1], Palmov, Smallwood, etc.)



- If we have many joints, it becomes cumbersome to identify the parameters of each joint separately!



$$\begin{Bmatrix} F_S^1, K_T^1, \chi^1, \beta^1 \\ F_S^2, K_T^2, \chi^2, \beta^2 \\ F_S^3, K_T^3, \chi^3, \beta^3 \\ \vdots \end{Bmatrix}$$

- Experimental evidence has shown that many jointed structures can be tested and represented with uncoupled weakly nonlinear modes.

- This comes with two main assumptions
  - Energy transfer between modes remains negligible
  - The mode shapes of the nonlinear system are preserved at all amplitudes

FUNDING SOURCES

NNSA Funded R&D – Managing funding projects in many areas:

- Experimental Nonlinear Structural Dynamics
- Experimental-Analytical Substructuring
- Optical Modal Measurements Techniques

SEM Dynamic Substructuring Black Box Challenge

- New structural dynamics challenge being developed through Sandia and SEM to test state of the are dynamic substructuring techniques

RESEARCH NEEDS AND COLLABORATION

Opportunities for faculty-SNL collaborations through research initiatives

Potential mentorship for graduate students in individual or group settings

Available to pursue new research topics in experimental structural dynamics through joint proposals