SAND2013-3172C

Coupled fluid-structure prediction capability

ESRF External Review
April 23, 2013
by
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Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND Number: 2010-0396P

Overall goal of the effort

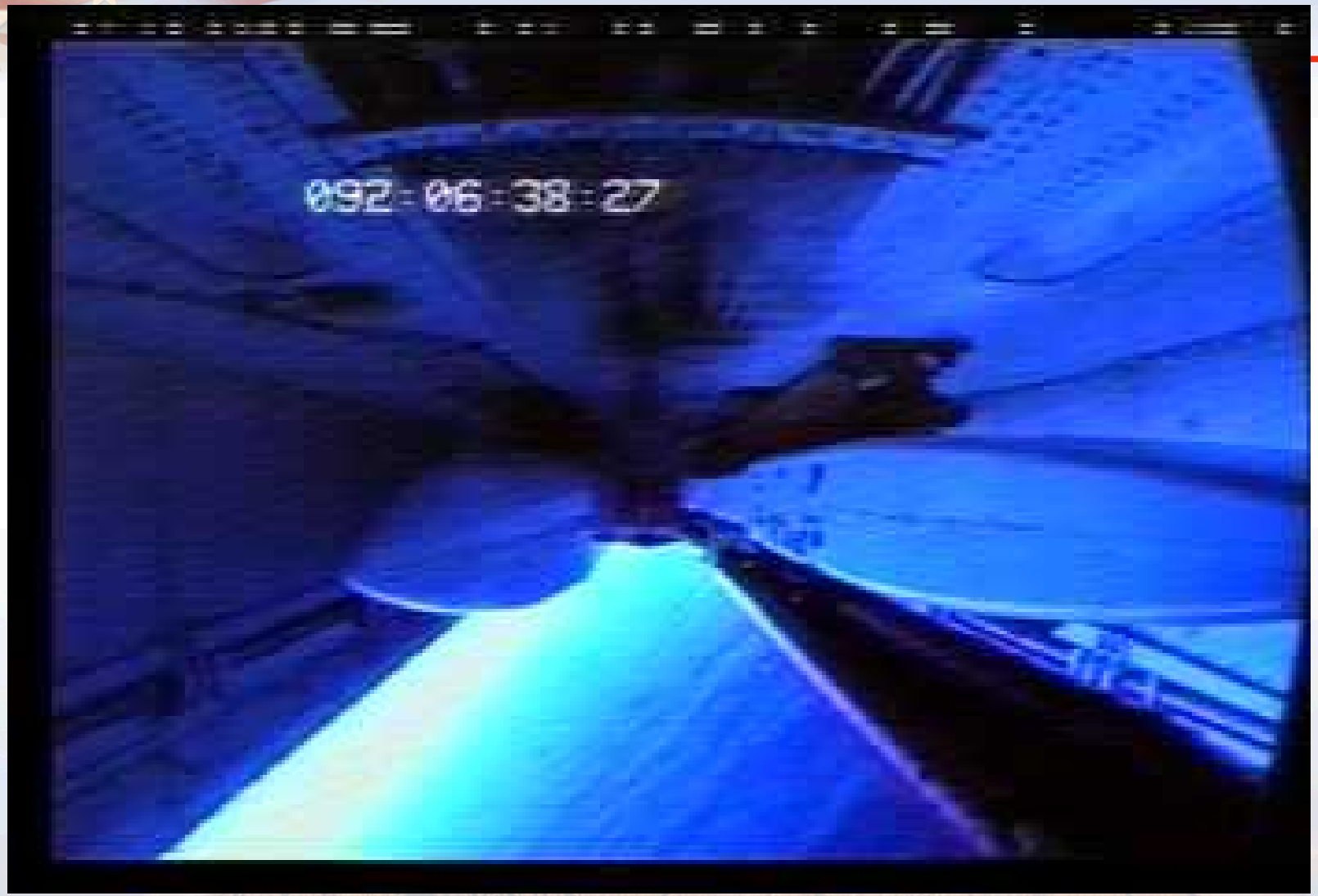
Develop a differentiating capability to predict fluid-structure interaction on complex geometries with quantifiable uncertainties

Research Challenges: Simulate weapon flight environments and response for a wide range of velocities, attack angles, and environmental conditions

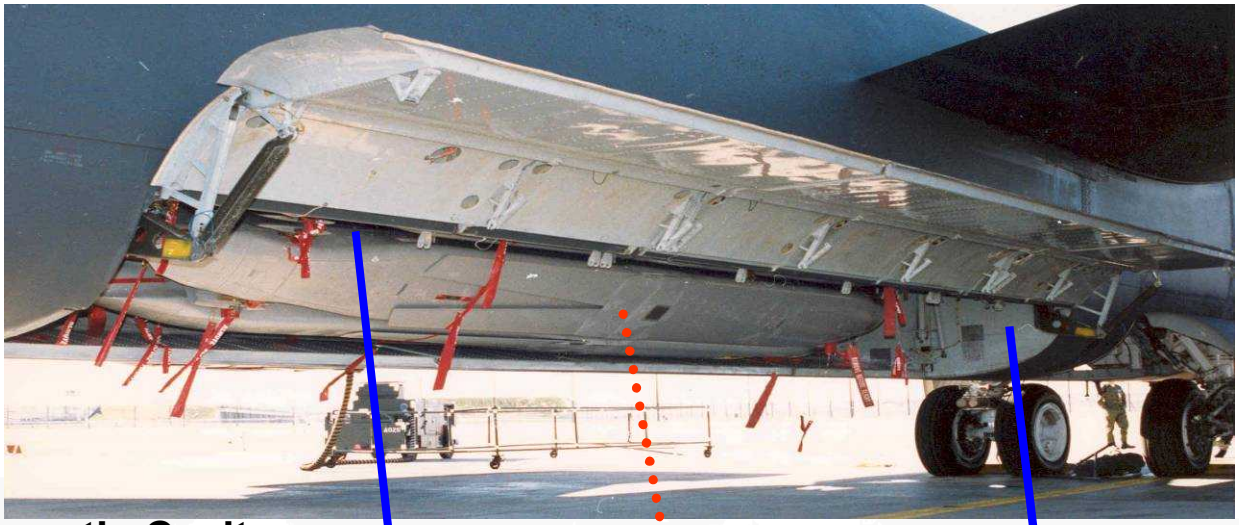
Research Elements

- High performance computing
- Algorithms
- Numerical schemes
- Physical discovery
- Physical models
- Validation
- Uncertainty quantification

Store in F-111 bay



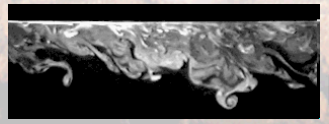
Internal Bay Loadings



Acoustic Cavity Resonances & Broadband Noise

Direct Mechanical

Hydrodynamic Vortical Flows

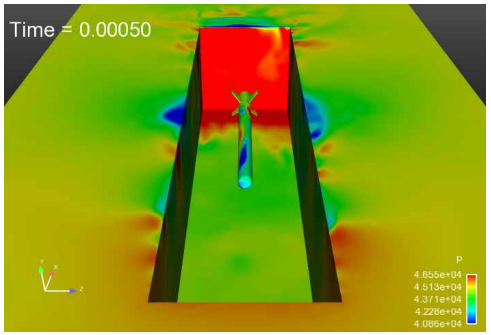


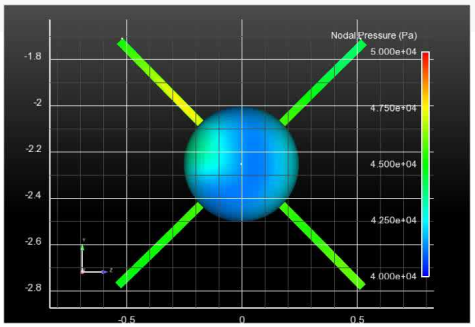
Turbulent Boundary Layer (on B61, direct)

Vortex Shedding, Jet Noise, boundary layer , Still Present But ~ Insignificant

Full scale temporal and spatially correlated loading and response

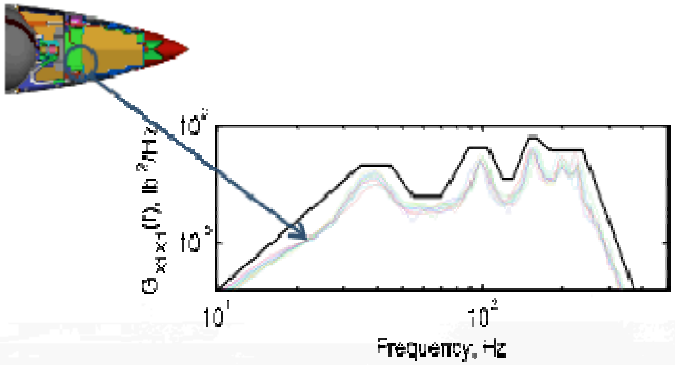
Coupled Fluid Structural simulation



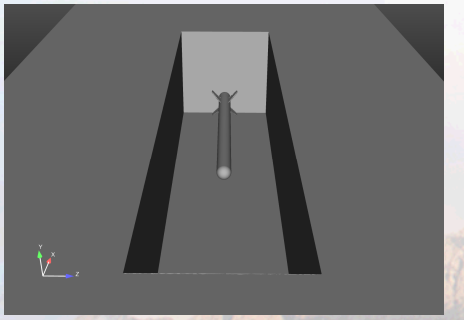


Temporal and spatially resolved loads transferred to B61-12 Structural Dynamics Model

Component response to loading



Hybrid RANS/LES simulation capturing nonlinear acoustic loading



Create mesh (model) of the bay and store

Use experimental discovery and validation to ensure important physics are accurately captured

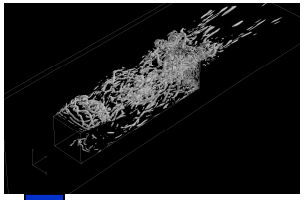
Environmental Specification
- Version 2 Q3 FY14
- Version 3 Q3 FY16

Multi-axis Component response

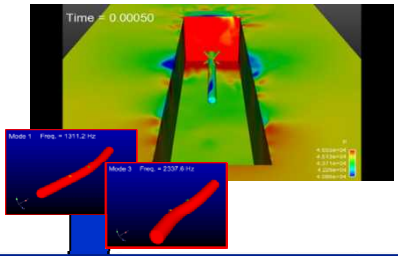
Modeling and Simulation Progression

Modeling,Validation and Applications

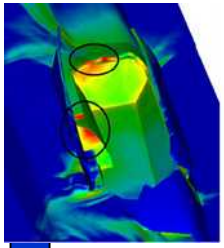
Rectangular Empty Cavity



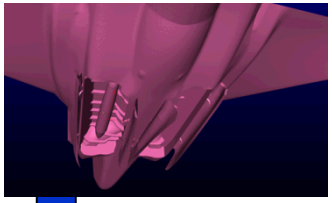
Coupled fluid structured simulation



Complex cavity with/without store



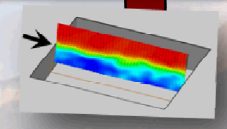
Full system simulation



Gaps

Requirements to predict flow field and loads	Coupling validation and multi-axis structural response	Complex geometry driven interactions: multiple modes and loading directions	Full system validation (if required)

Validation and Discovery



Complex Cavity

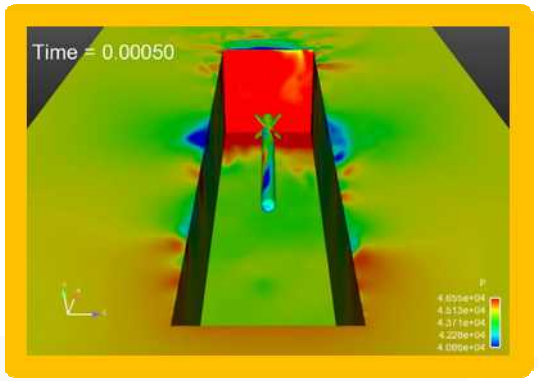
B61-12

B2 Flight Data

Sandia National Laboratories

Full scale temporal and spatially correlated loading and response

Coupled Fluid Structural simulation



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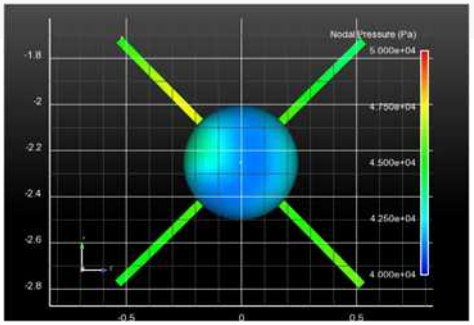

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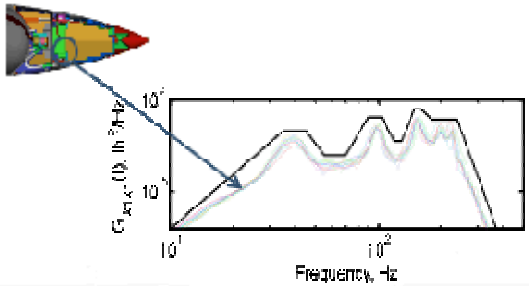


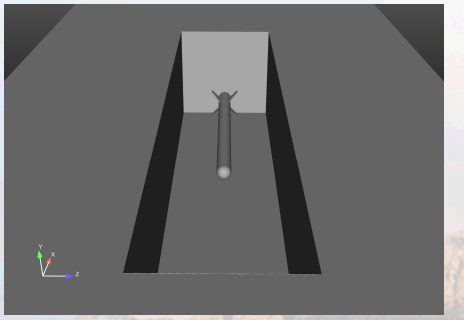
Computational Aerodynamic Loading Prediction

- Code design and Scalable algorithms
- Numerical scheme to resolve the required turbulent scales
- Approach to determining uncertainties

Environmental Specification

- Version 2 Q3 FY14
- Version 3 Q3 FY16

Multi-axis Component response



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Full scale temporal and spatially correlated loading and response

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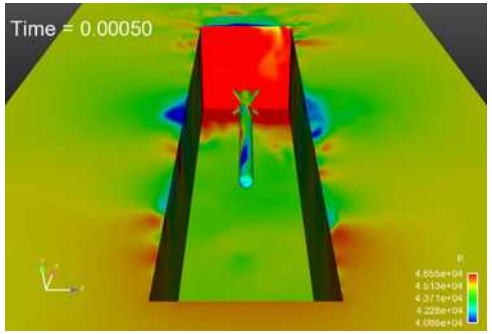

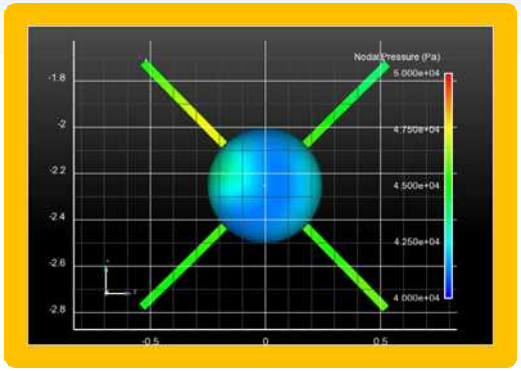

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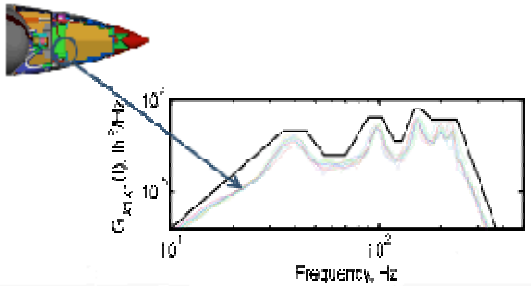

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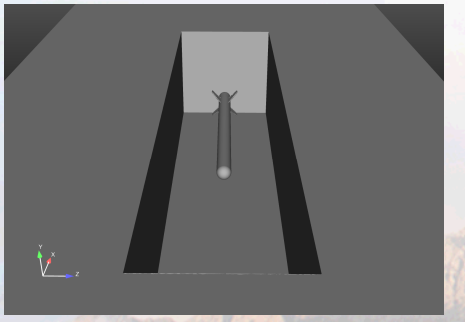

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Captive Carry Experiments, Discovery and Validation

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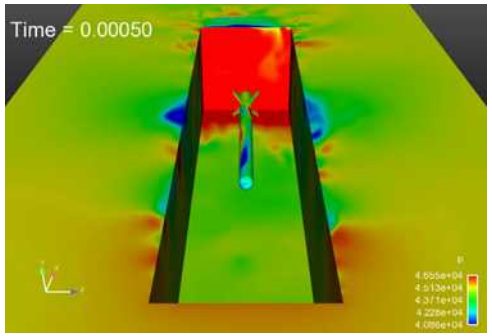

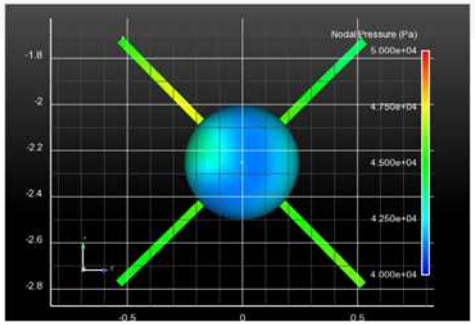

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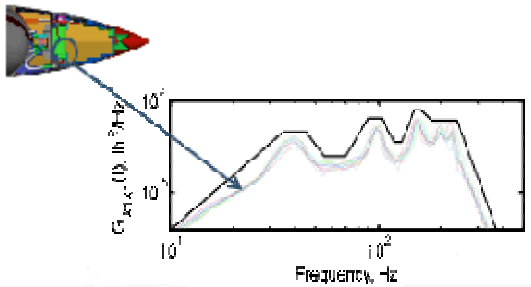

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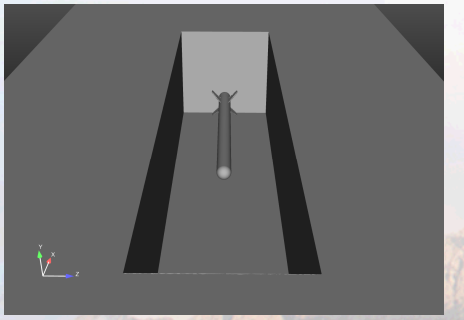

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Structural Response to Captive Carry

- Application of the unsteady pressure loads
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Multi-axis Component response

A software approach to unsteady, turbulent fluid-structure interactions - Steve Bova

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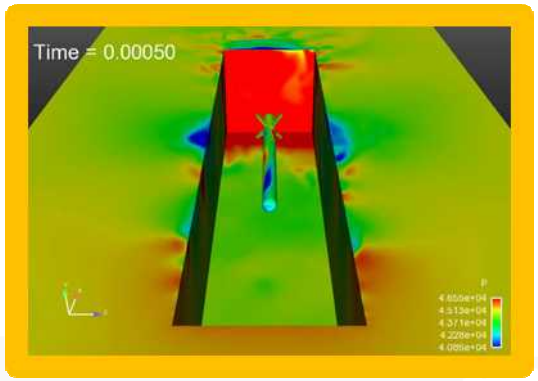

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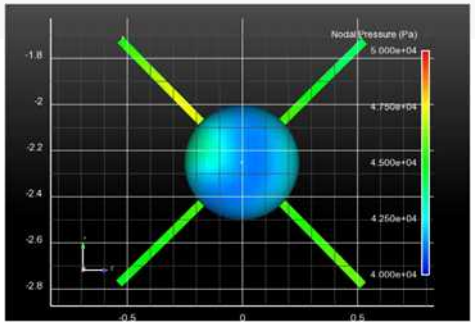

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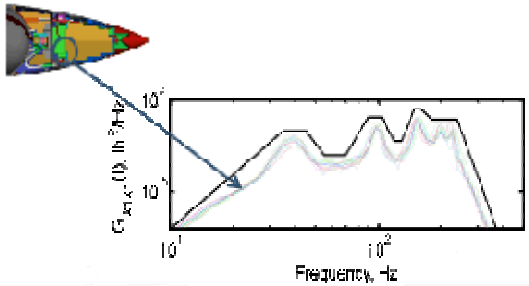

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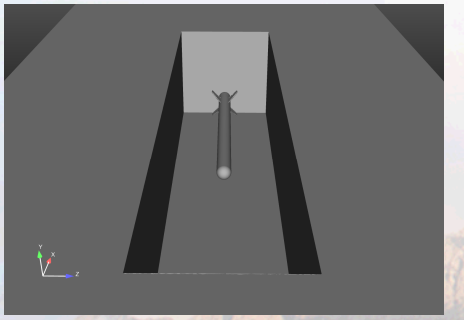


Create mesh (model) of the bay and store

Integrated Research and Development effort

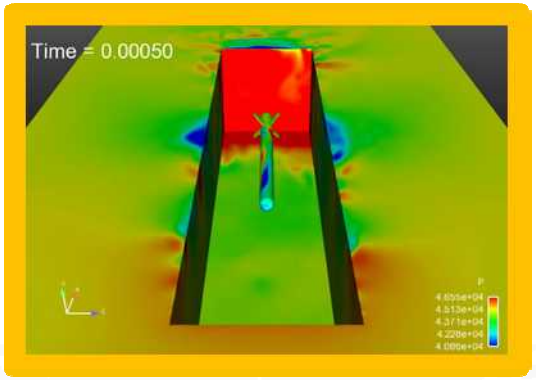
Develop a differentiating capability to predict fluid-structure interaction on complex geometries with quantifiable uncertainties

Current Research Challenge: Predict the environments and component response for a B61-12 in captive carriage

- We have focused on this Challenge for three year
- The principle area we are working to enable the capability
  - Software and Algorithms
  - Numerical schemes and Physical models
  - Physical discovery and Validation
  - Uncertainty quantification
- Resolved future efforts
  - Improved physical discovery and validation enabled by temporal and correlated data
  - Subgrid Model that enables separation and quantification of numerical errors and physical modeling errors

Computational Aerodynamic Loading Prediction for Captive Carriage – Micah Howard

Coupled Fluid Structural simulation



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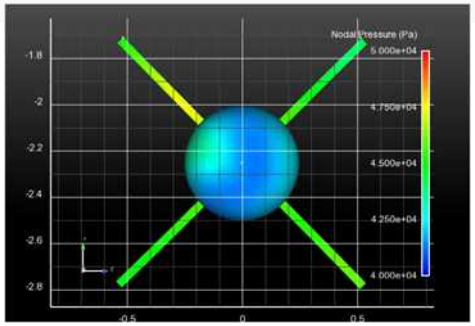

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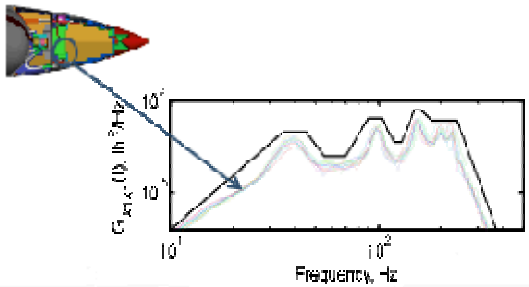

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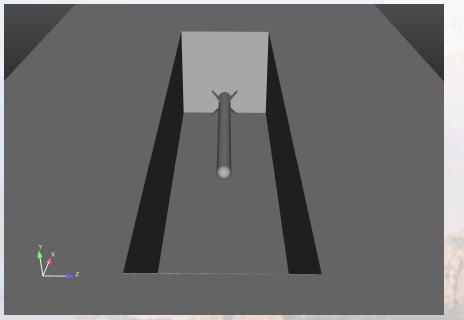

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Multi-axis Component response

Captive Carry Experiments, Discovery and Validation – Justin Wagner

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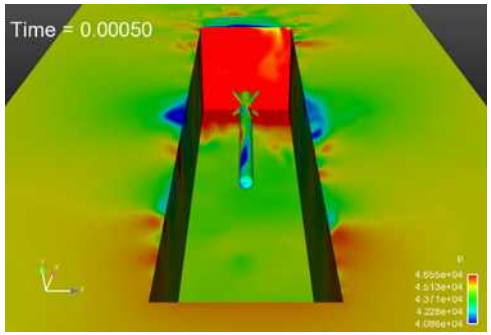

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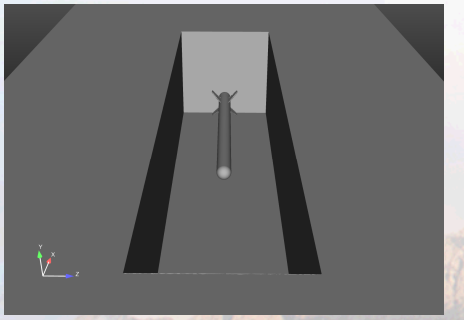

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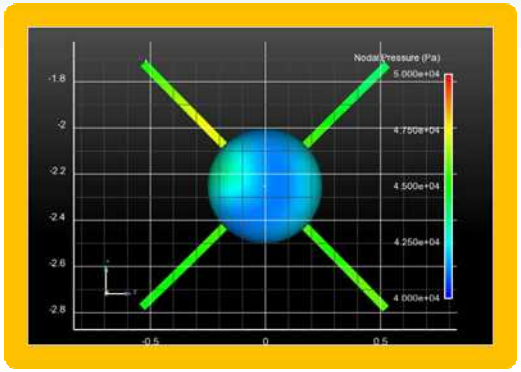

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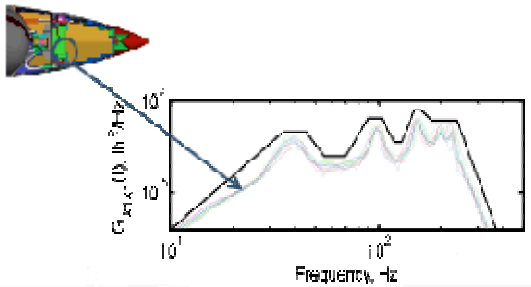

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Structural Response to Captive Carry – Mike Ross

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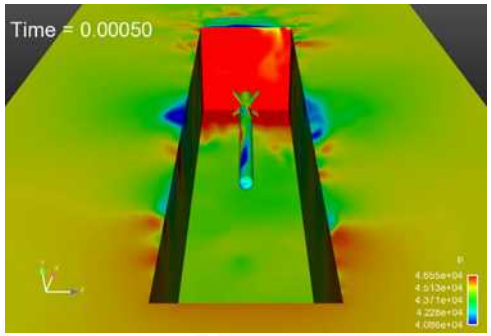

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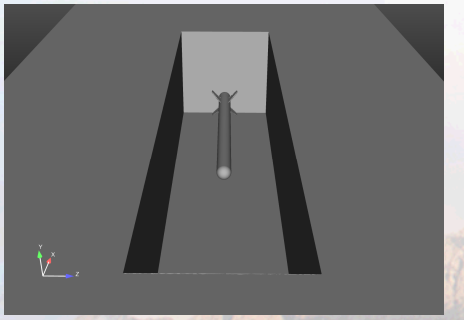

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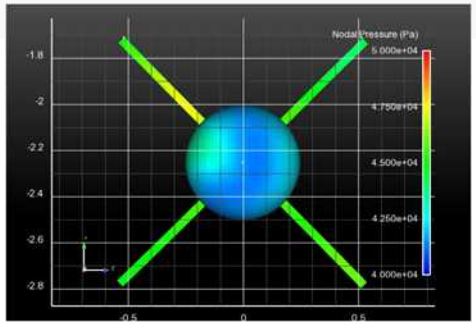

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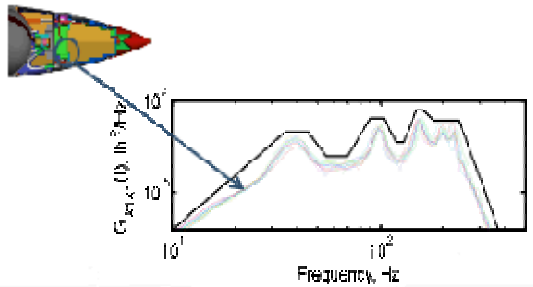

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