

# **COE CST Second Annual Technical Meeting: Non-Linear Structural Models**

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# Overview

- Program Goal
- Large System Models
- Program Plan
- Numerical Experimentation
- Modal Testing
- FEA and Physical Test Data



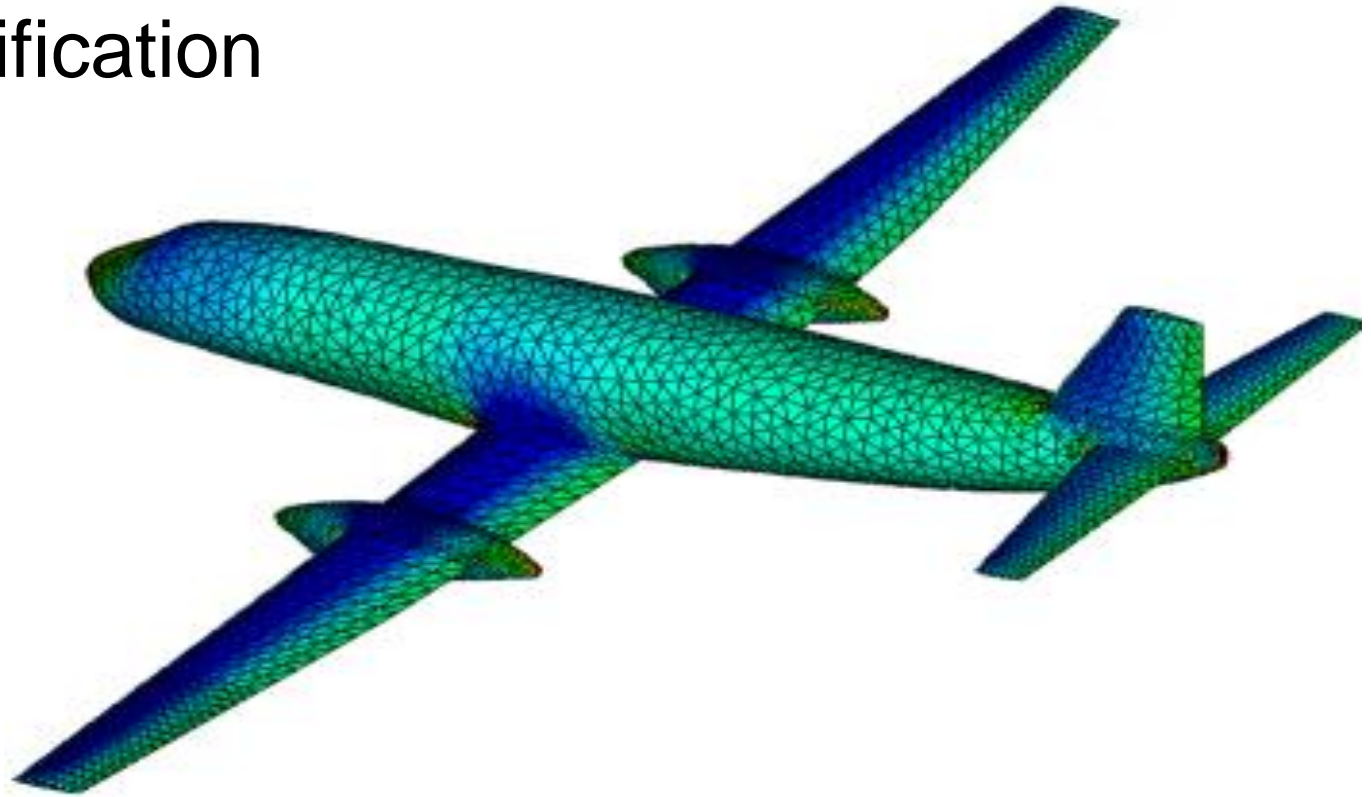
# Program Goal

- The objective is to develop computational tools that improve the capability of estimating the performance and safety margins of commercial space vehicles. The focus is to be able to construct non-linear system level models. The models will be derived from reduced order non-linear finite element models and also directly from structural test data.



# Large System Models

- Computationally Intensive
- Time Intensive
- Model Verification



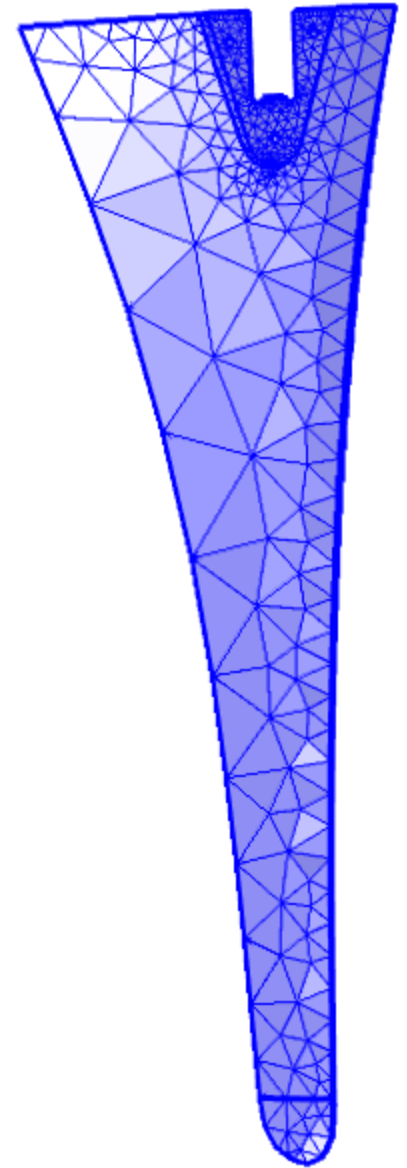
# Program Plan

- Numerical Experimentation
- Modal Testing
- FEA Implementing Physical Test Data



# Numerical Experimentation

- FE Model Basic Concepts
- Eigenvector Extraction
- Matrix Manipulation
- Model Assembly and Analysis
- Code Analysis



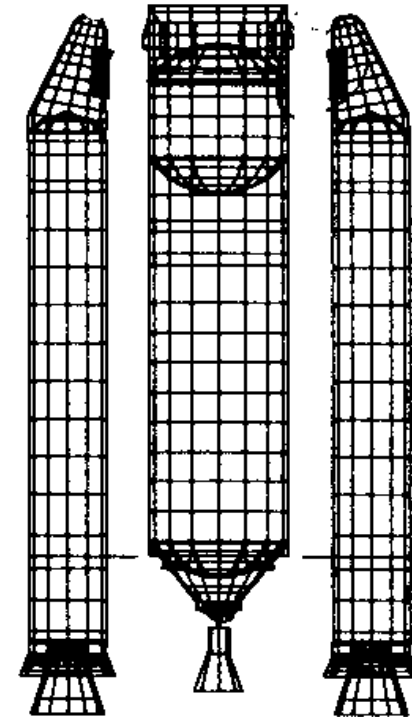
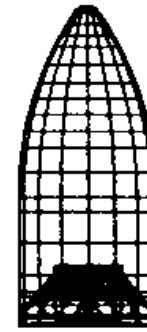
# System Substructuring

$$[M_1] * \{\ddot{x}_1\} + [C_1] * \{\dot{x}_1\} + [K_1] * \{x_1\} = \{F_1(t)\}$$

$$[M_2] * \{\ddot{x}_2\} + [C_2] * \{\dot{x}_2\} + [K_2] * \{x_2\} = \{F_2(t)\}$$

$$[M_3] * \{\ddot{x}_3\} + [C_3] * \{\dot{x}_3\} + [K_3] * \{x_3\} = \{F_3(t)\}$$

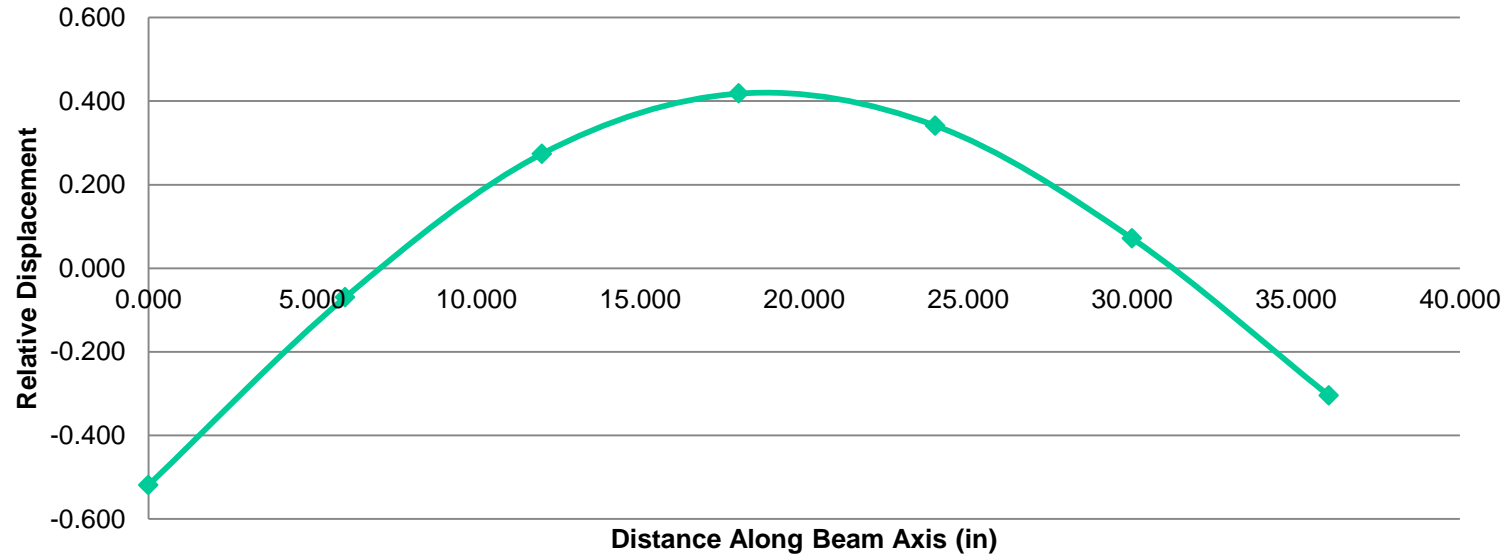
$$[M_4] * \{\ddot{x}_4\} + [C_4] * \{\dot{x}_4\} + [K_4] * \{x_4\} = \{F_4(t)\}$$



Images from presentation given by Dr. Keith Miller

# Eigenvector Extraction

## Mode 1

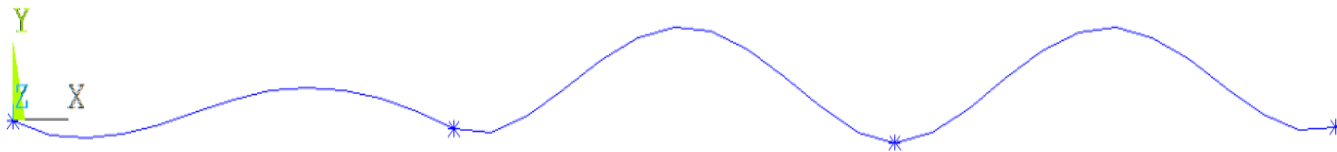
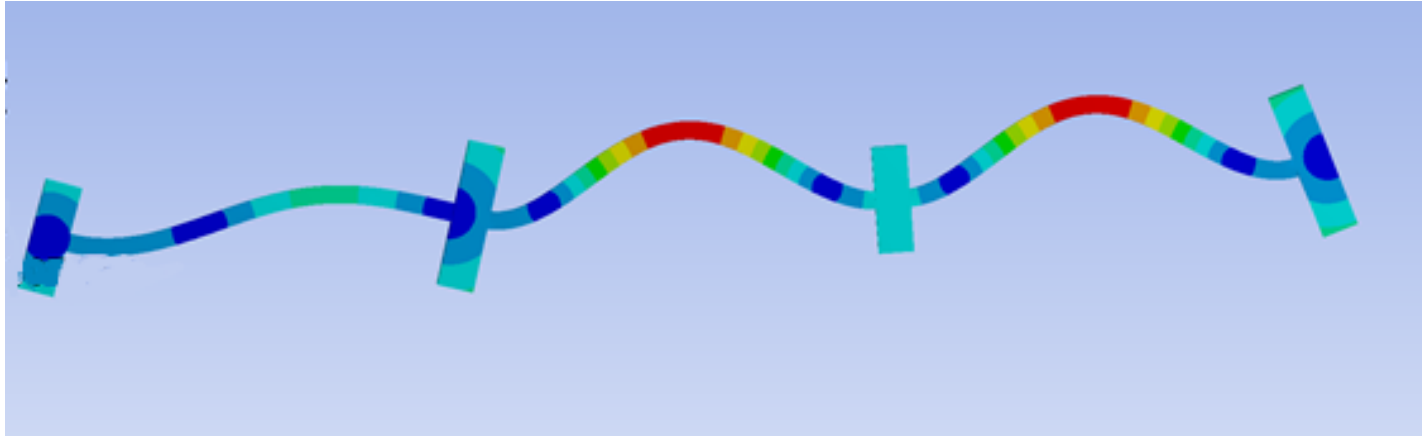


## Eigenvectors

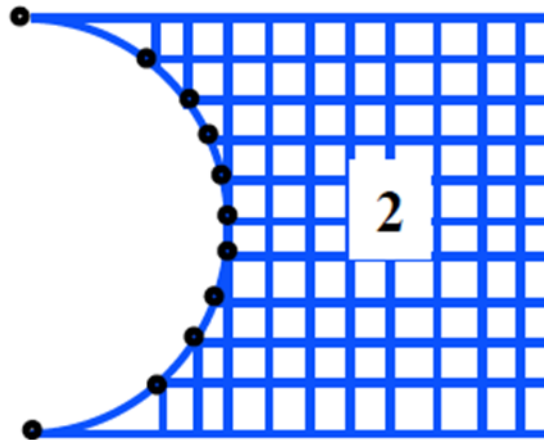
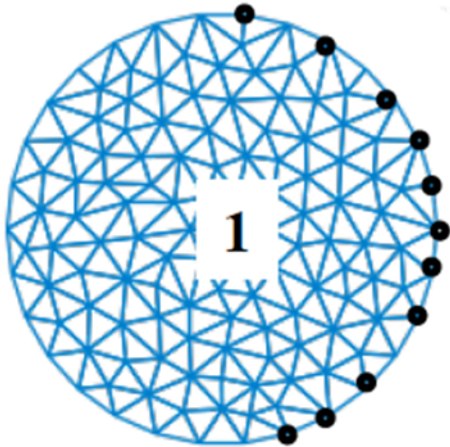
Displacements	X	Y	Z	Rot X	Rot Y	Rot Z
Node 1	0.000	-0.519	0.000	0.000	0.000	3.062
Node 2	0.000	-0.070	0.000	0.000	0.000	2.719
Node 3	0.000	0.274	0.000	0.000	0.000	1.669
Node 4	0.000	0.418	0.000	0.000	0.000	0.215
Node 5	0.000	0.341	0.000	0.000	0.000	-1.202
Node 6	0.000	0.071	0.000	0.000	0.000	-2.230
Node 7	0.000	-0.304	0.000	0.000	0.000	-2.592



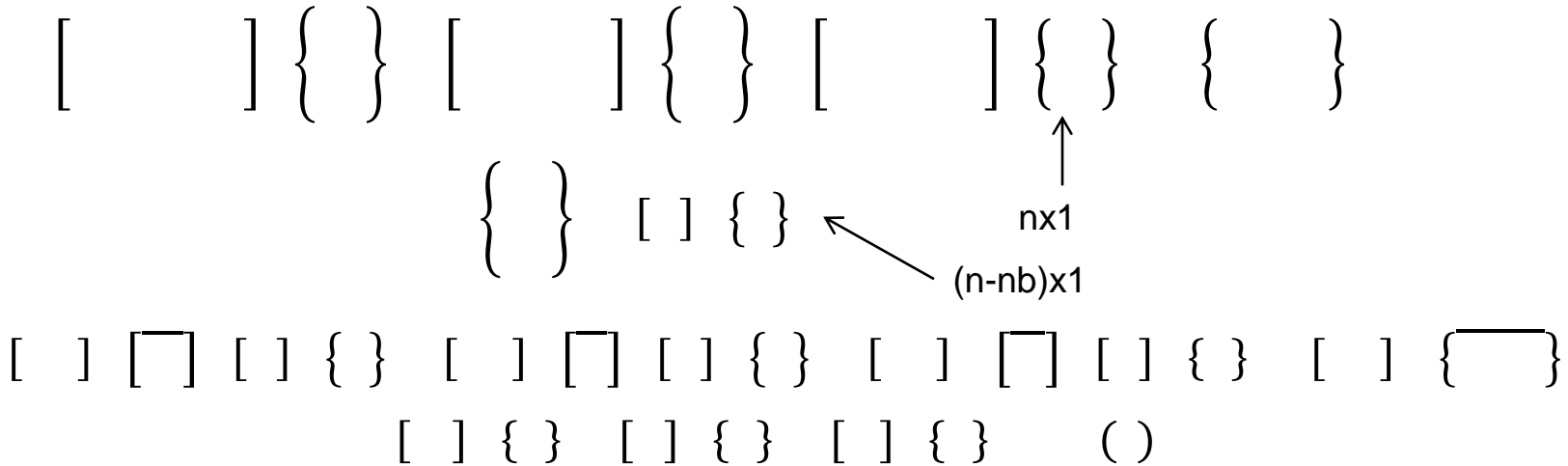
# Model Reduction



# Global System Assembly



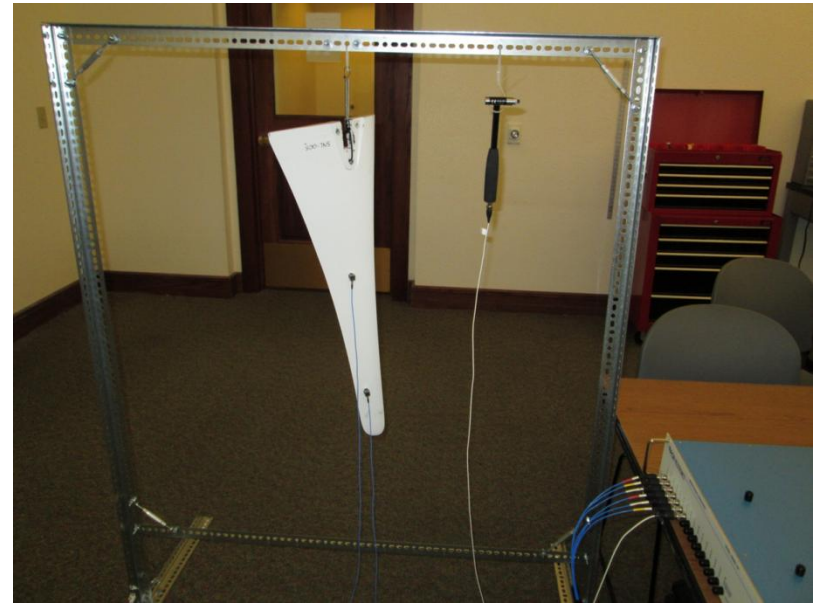
- Boundary nodes



Images from presentation given by Dr. Keith Miller

# Modal Testing

- Modal Testing Procedures
- Modal Data Gathering
- Frequency Response Function
- Extract Eigenvalues & Eigenvectors



# Future Work: Combining FEA and Physical Test Data

- Determine Source of Error in Current FE Models
- Re-Condition Matrices
- Properly Couple Test Data to Model