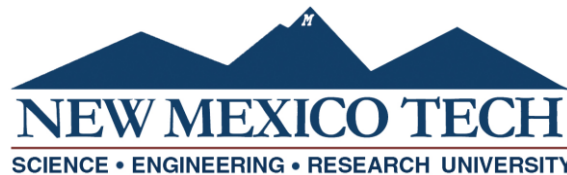# COE CST Fourth Annual Technical Meeting

Task 293
Nonlinear Structural Models

Dr. A. Keith Miller,
Dr. Warren Ostergren,
And Mr. Lance Hernandez

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Washington, DC

NEW MEXICO TECH
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Agenda

- Team Members

- Task Description

- Schedule

- Goals

- Results

- Conclusions and Future Work

Team Members

- **Principal Investigators**
  - Dr. A Keith Miller, Adjunct Research Professor of Mechanical Engineering, NMT
  - Dr. Warren Ostergren, Associate Professor of Mechanical Engineering and Vice President of Academic Affairs, NMT
- **Students**
  - Mr. Lance Hernandez, BS MENG (Dec. 2014)
  - Mr. Joshua Mendoza, MS MENG (May 2013)
- **FAA Technical Monitor:** Mr. Nickolas Demidovich
- **Research Partners:** Sandia National Laboratories
- **Industry Partners:** United Launch Alliance, Ball Aerospace

Task Description

The purpose of this task is to develop computational tools that improve the capability to determine the performance and safety margins of commercial space vehicles. The focus is to construct non-linear system-level models. The models are constructed by computationally combining reduced-order finite element models of substructure components directly with experimentally-derived modal substructure components.

Schedule

- **Spring 2014**
  - Developed Matlab code to extract modal parameters from simulated FEA model of complex beam structures

- **Fall 2014**
  - Current physical testing of beam structure has validated the modal extraction codes

- **Spring 2015**
  - Test modal parameters of second, identical beam structure and begin sub-structuring process

Goals

- **Task Specific Goals**
  - The main goal of this task is to combine reduced-order finite element models of substructure components directly with experimentally derived modal substructure components
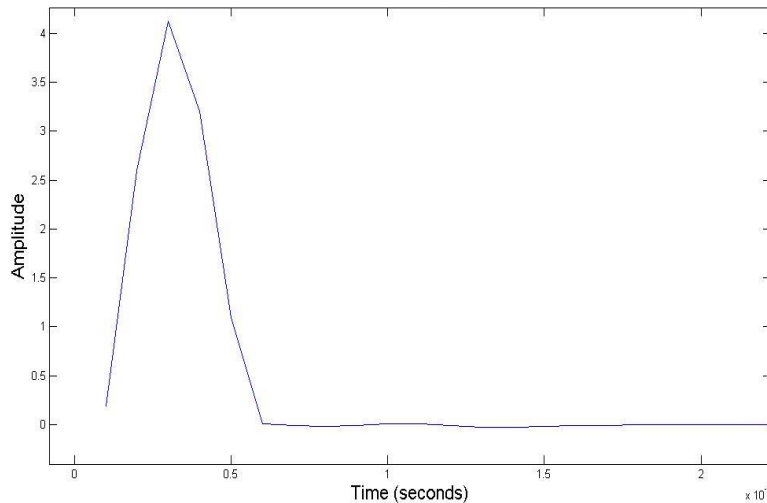
- **Relevance to Commercial Space Industry**
  - This methodology will aid in determining the performance and safety margins of commercial space vehicles
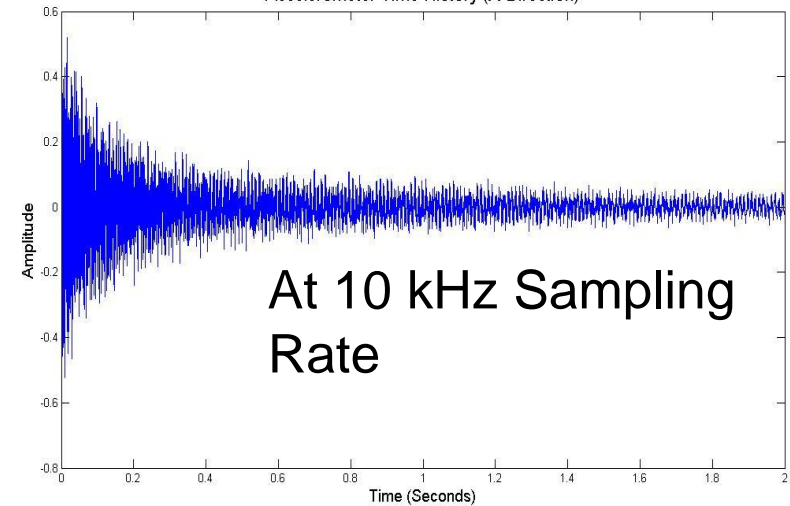
Results (Physical Setup and Time Responses)
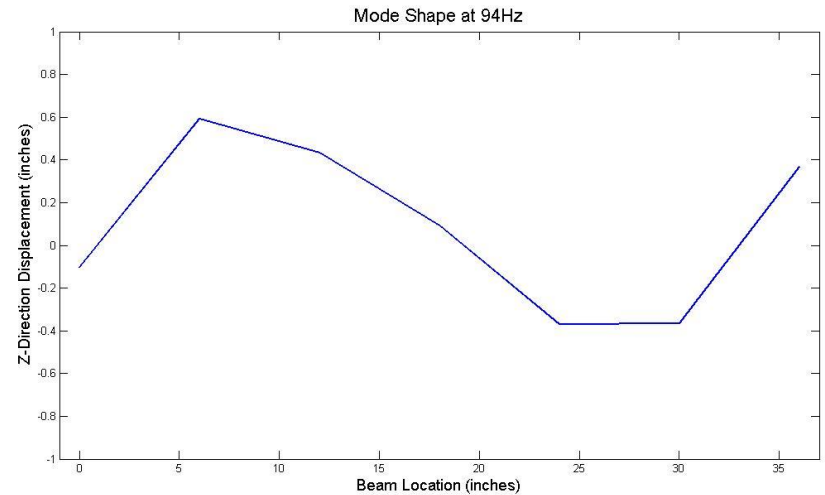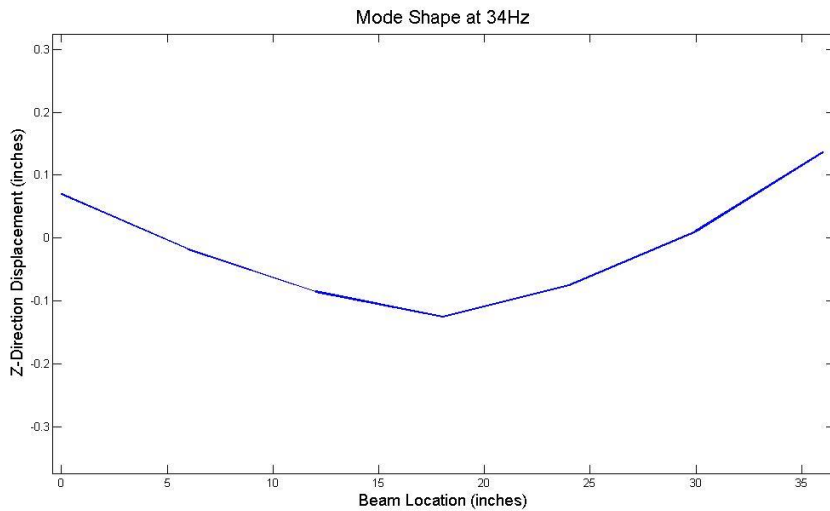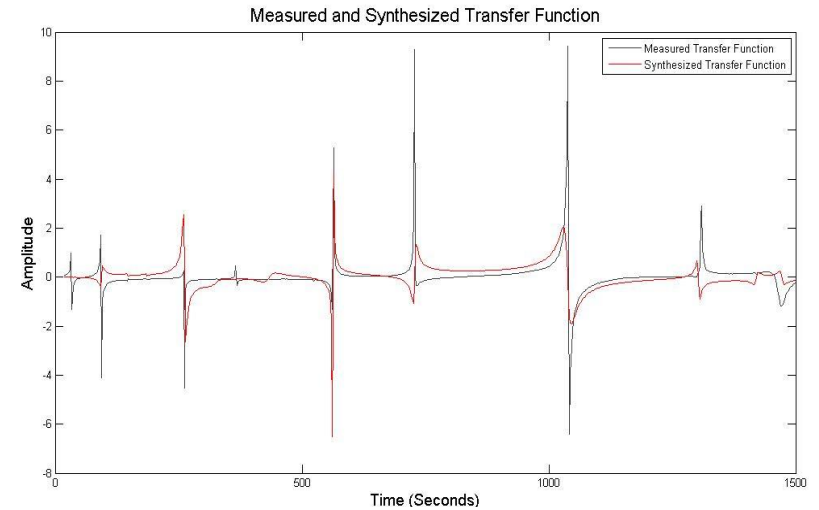

Excitation Impulse

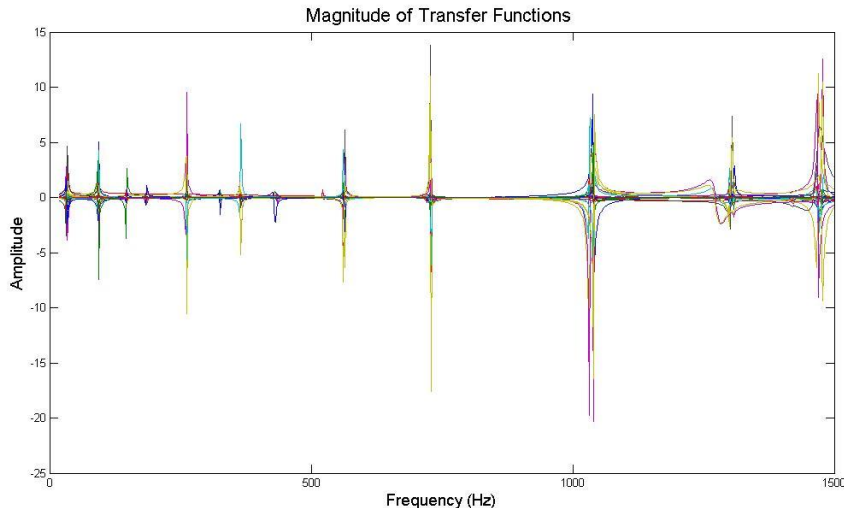
Accelerometer Time History (X-Direction)

At 10 kHz Sampling Rate

Results (Transfer Functions and Mode Shapes)

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Conclusions and Future Work

- The physical testing has successfully validated the modal extraction codes.

- More physical testing will take place with increased damping on the beam structure to further validate our results.

- Next step is to begin testing second beam structure and begin the sub-structuring phase of the project.

TASK 293 Nonlinear Structural Models

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PROJECT AT-A-GLANCE
- **UNIVERSITY**: New Mexico Tech
- **PRINCIPAL INVESTIGATORS**: Dr. A. Keith Miller, Dr. Warren Ostergren
- **STUDENTS:** Mr. Lance Hernandez
- **FAA TECHNICAL MONITOR:** Mr. Nickolas Demidovich

RELEVANCE TO COMMERCIAL SPACE INDUSTRY
- The structural integrity of commercial launch platforms must be assessed for each mission, i.e. safety certification or recertification. A significant amount of structural response data must be collected in order to state confidence bounds on the computed safety margins. Experimental data will very likely need to be supplemented with data generated by numerical simulations of the structural response of the launch platforms to the anticipated flight environments. Efficient, cost-effective methods for generating non-linear structural models of CST platforms will result from this effort.

STATEMENT OF WORK
- Solicit Industrial Working Group feedback to guide implementation of system computational assembly methods.
- Generate non-proprietary code to extract relevant structural features from experimental test data i.e. modal extraction software using rational fractional polynominals (RFP)
- Provide Matlab™ scripts for combining finite element modelled components with experimentally defined (modal) components in structural assemblies.
- Provide help to commercial companies desiring to use modal extraction an assembly codes.

Modal Extraction Process
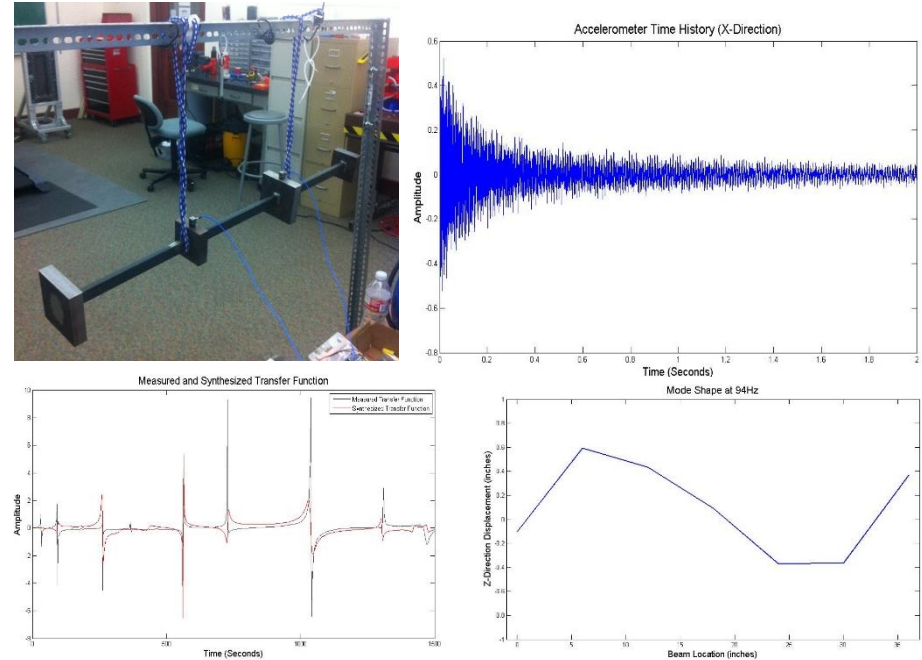
STATUS
- Modal extraction codes have been validated by physical testing of beam structure.

FUTURE WORK
- More physical testing will take place with increased damping on the beam structure to further validate our results.
- Next step is to begin testing second beam structure and begin the sub-structuring phase of the project.