Finite Element Modeling Requirements

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Advanced LIGO, Seismic Isolation System (SEI)

Structural Design & Fabrication Bidder's Conference

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FEA Requirements
Scope & Definitions

- Contractor must perform finite element analyses to verify compliance with the stiffness requirements (sections C.7 HAM; C.9, BSC)
  - » Earthquake/strength analyses are optional via FEA (not required)
  - » Must include representation of all elements of the structures including:
    - – External support including support tubes, mounting caps and bases, crossbeams, crossbeam attachment plates, crossbeam feet (pointed at 45 deg, toward the chamber center)
    - – Instrumentation pods
    - – Payload (non-suspended)
  - » Models must be delivered to LIGO
  - » Contractor plan for FEA to be reviewed at Kick-off meeting
  - » FEA results must be reviewed and approved by LIGO before committing to fabrication
  - » Must beat requirements in finite element modeling by 10% in frequency (see SOW)

BSC Support Structure
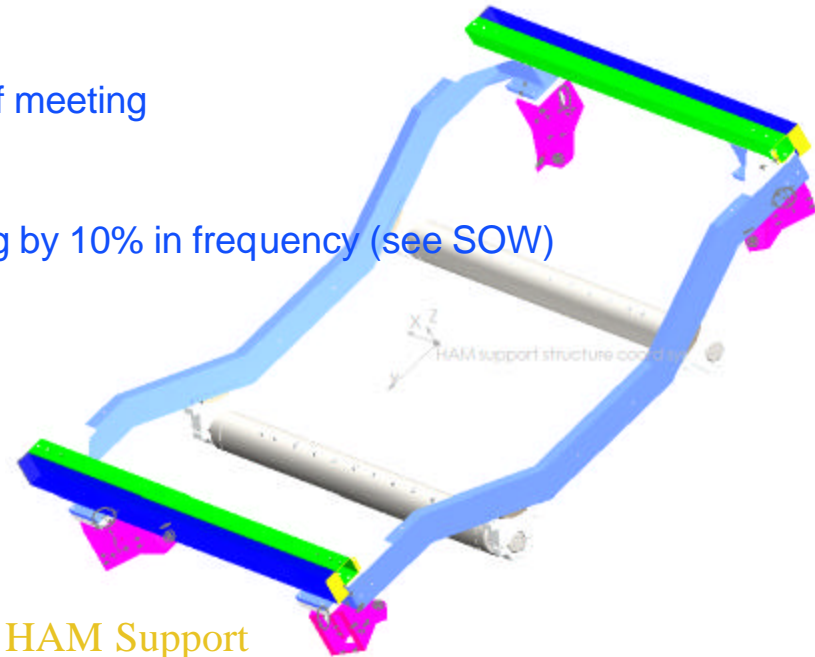
HAM Support Structure

Stiffness/Frequency Requirements

- For common-corner seismometer/actuator and displacement sensor/actuator pairs that share an axis direction on stages 1 and 2: the phase of the transfer function Xsensor/Xactuator shall be greater than -90 degrees for all frequencies below 500 Hz

- For all other pairs of seismometer and actuator, and displacement sensor and actuator on stages 1 and 2: the phase of Xsensor/Xactuator shall be greater than -90 degrees for all frequencies below 150 Hz

- For all pairs of displacement sensor and actuator on stage 0: the phase of Xsensor/Xactuator shall be greater than -90 degrees for all frequencies below 100 Hz
   - » Exception for effect of external structure modes

Example Calculation

- ● Example Structure
  - » Approximate size of the stage 1 BSC system
  - » Has 3 "corners" where actuation and sensing is placed
  - » Includes three beam structures, mid-span along the sides of the stage 1 ring – creates local modes which do not couple well to the global structure modes

- ● Frequency Response Analysis
  - » Modal analysis performed with Algor and I-DEAS
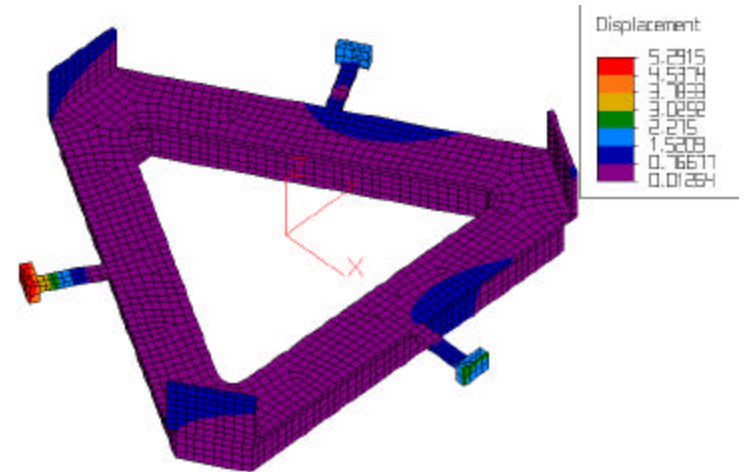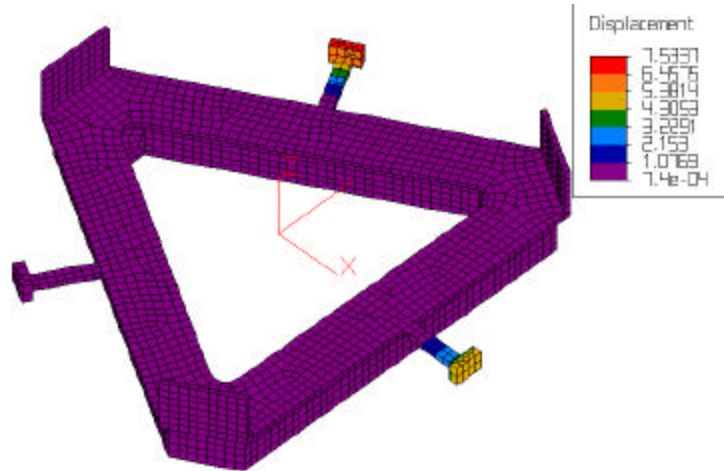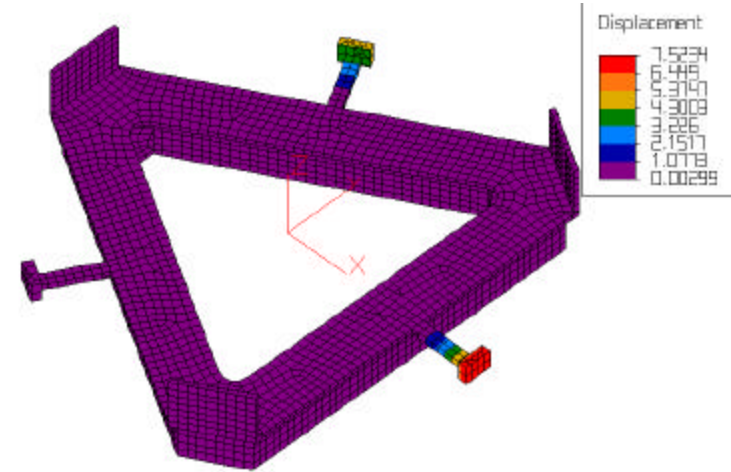 - » Displacement Transfer Functions calculated with I-DEAS

(96.00)

(83.14)

(10.00)

Co-located Actuator and Sensor

Non co-located Sensor

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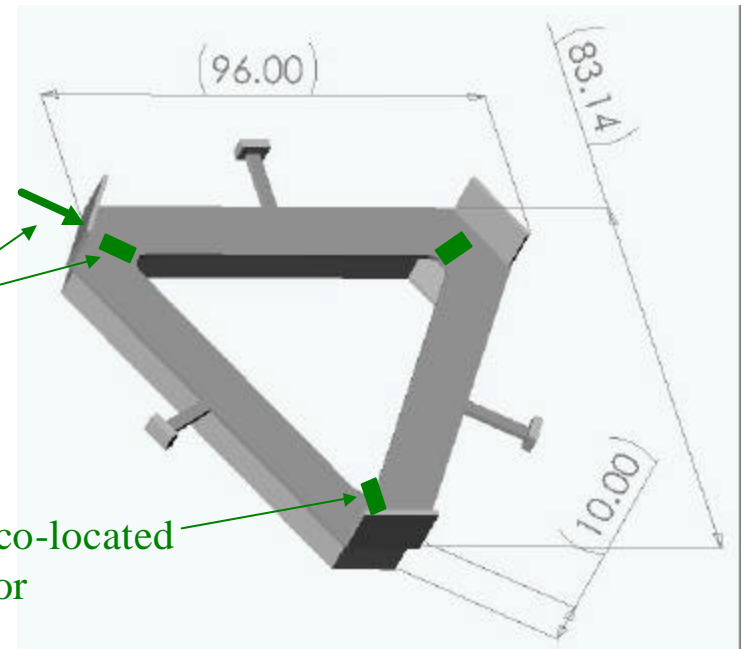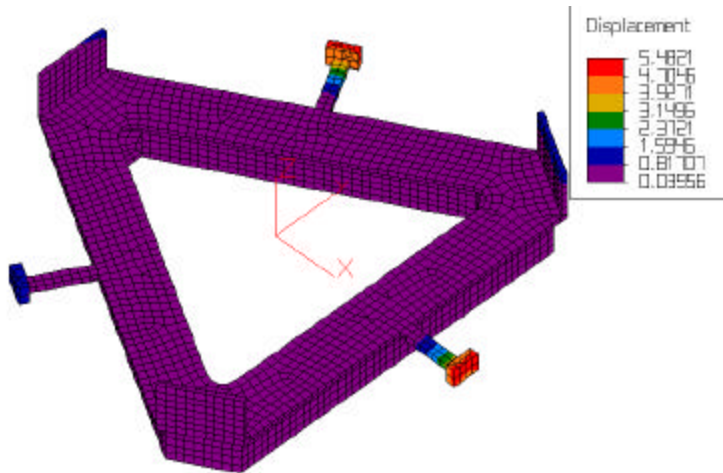
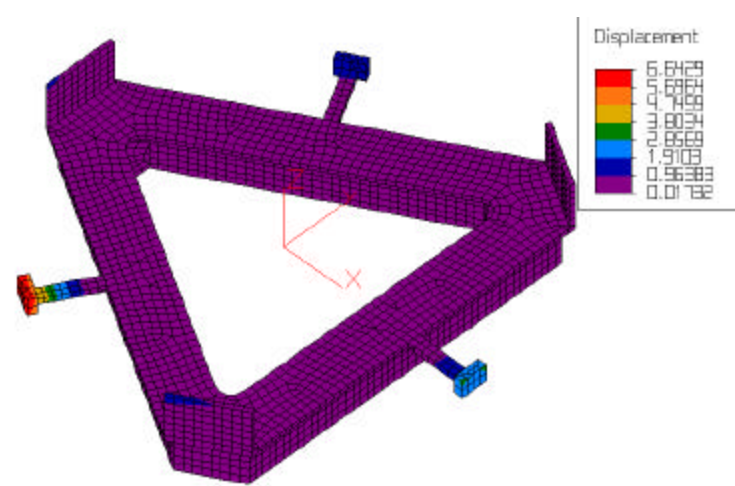# FEA Requirements
Example Calculation
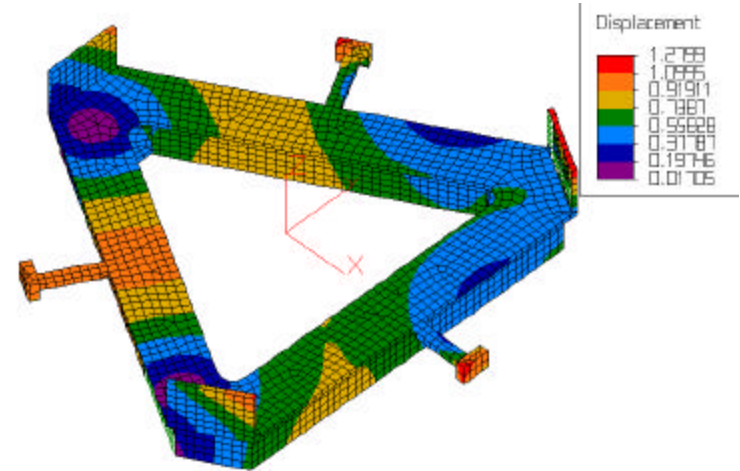
82 Hz

84 Hz

85 Hz

166 Hz
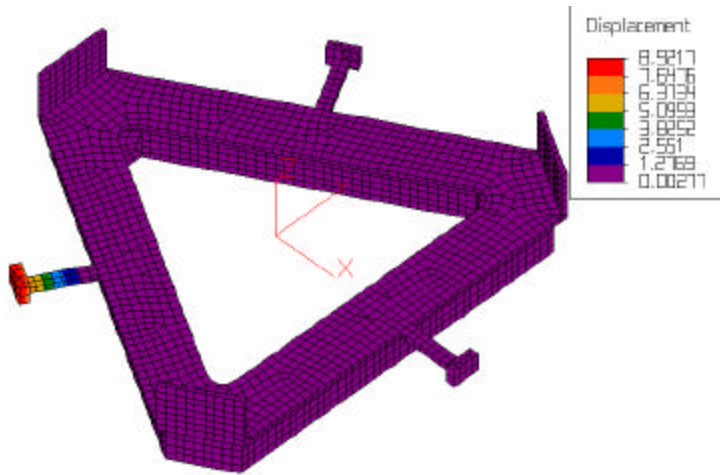
FEA Requirements
Example Calculation

169 Hz

171 Hz

177 Hz

179 Hz

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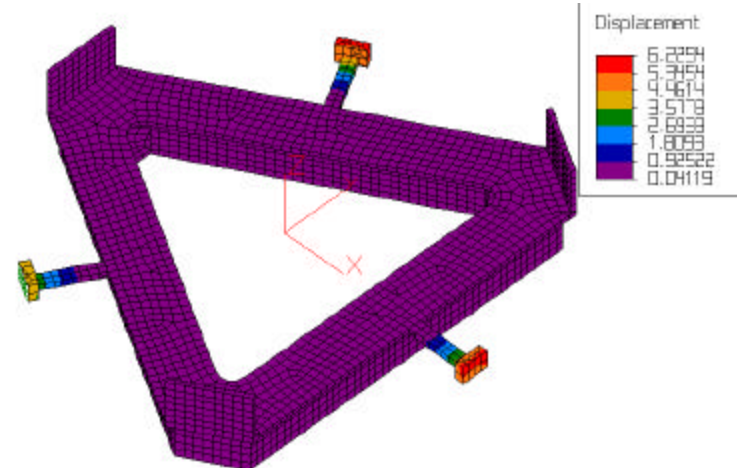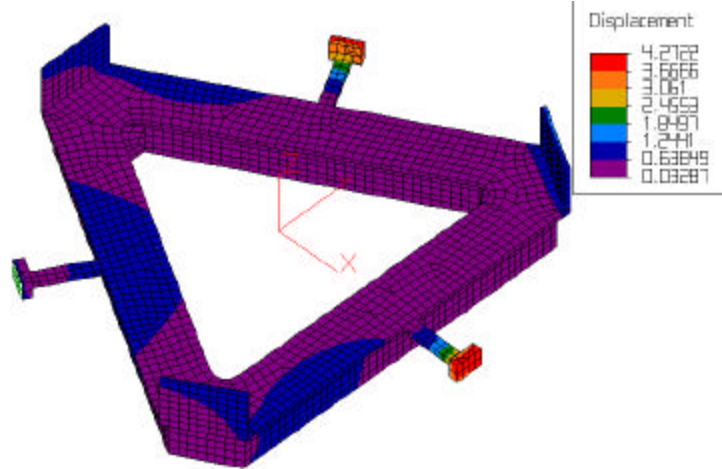
FEA Requirements
Example Calculation

216 Hz

218 Hz

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FEA Requirements
Example Calculation

Spectrum

Non-colocated sensor (at another "corner")

Colocated sensor (same "corner" as actuator)