Exhibit IV

Final Design

for

Seismic Isolation (SEI) Mechanical Structure Prototype

LIGO-C010406-00-R

Final Design for Advanced LIGO SEI Mechanical Structure Prototype

Approved:

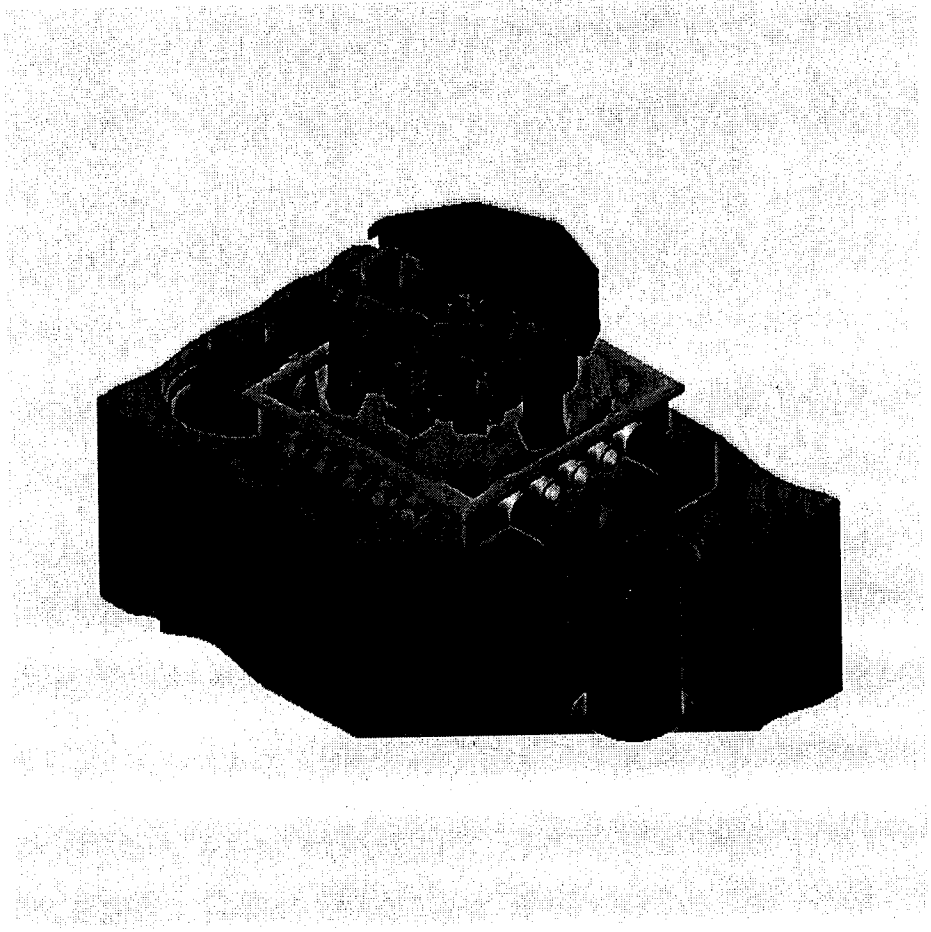
Dennis Coyne 8/27/01
D. Coyne Date
LIGO Chief Engineer

8/31/01
G. Stapfer Date
Engineering Lead for Advanced LIGO
SEI Mechanical Structure Prototype

8/31/01
J. Giaime Date
LSC Lead Scientist for SEI R&D

9/24/01
B. Lantz Date
LSC Design Lead for SEI R&D

LIGO SEI Design Review



High Precision Devices, Inc.
Boulder, CO
1 August 2001

Contents

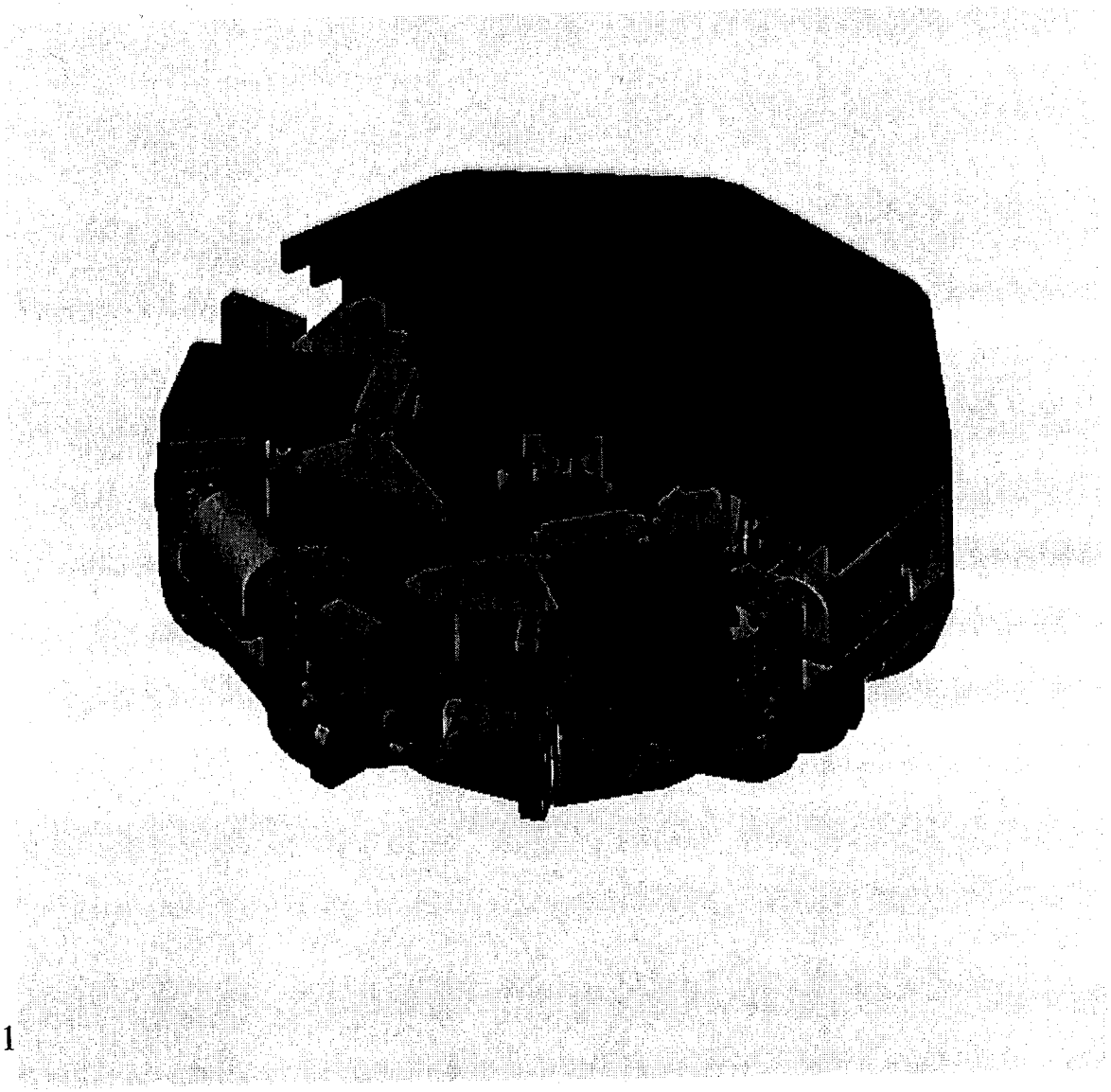
Design summary

- The design of the SEI is essentially complete.
- Original requirements have been verified. Many design requirements were fully defined and/or added during the design process. These have been interactively resolved through collaboration with LIGO scientists and engineers.
- The design work has been done in conjunction with integrated FEA. Parts, sub-systems and full assemblies have been analyzed, with those analyses influencing the final detail design.
- The support structure mounts to concrete pads outside of the ETF chamber. Tubes pass through the ETF walls and support a table with pillars for mounting of springs and sensors.

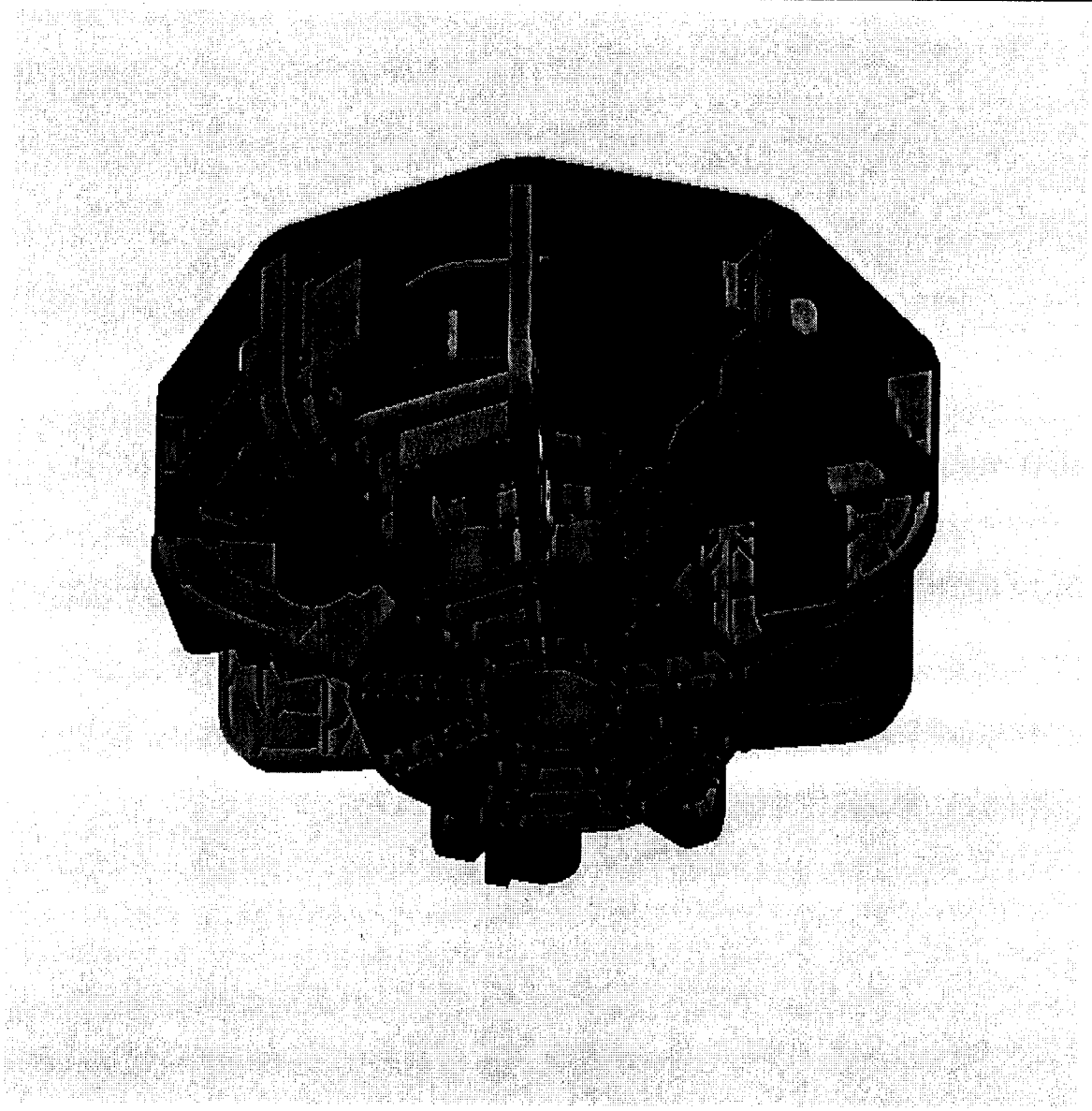
Design summary

- Stage 1 has been designed as a monolithic structure, with mountings for pods, sensors, springs, etc.
- Stage 2 is a complex structure built around a monolithic interstitial stage with ribs, keel and table bolted to it. Mountings are incorporated into the stage for pods, sensors, springs, etc.
- Spring and flexure designs (provided by LIGO) have been analyzed and modified by HPD in collaboration with LIGO staff. A test spring has been fabricated and is being evaluated by LSC scientists.
- Outside vendors have been contacted and have given preliminary quotes on fabrication of major components.

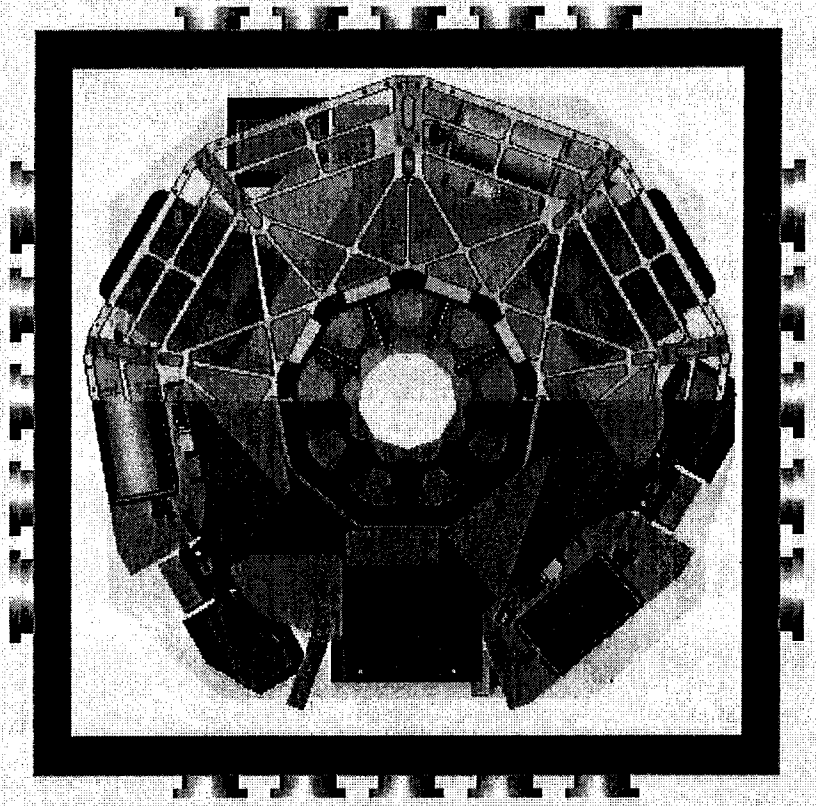
Top ISO view



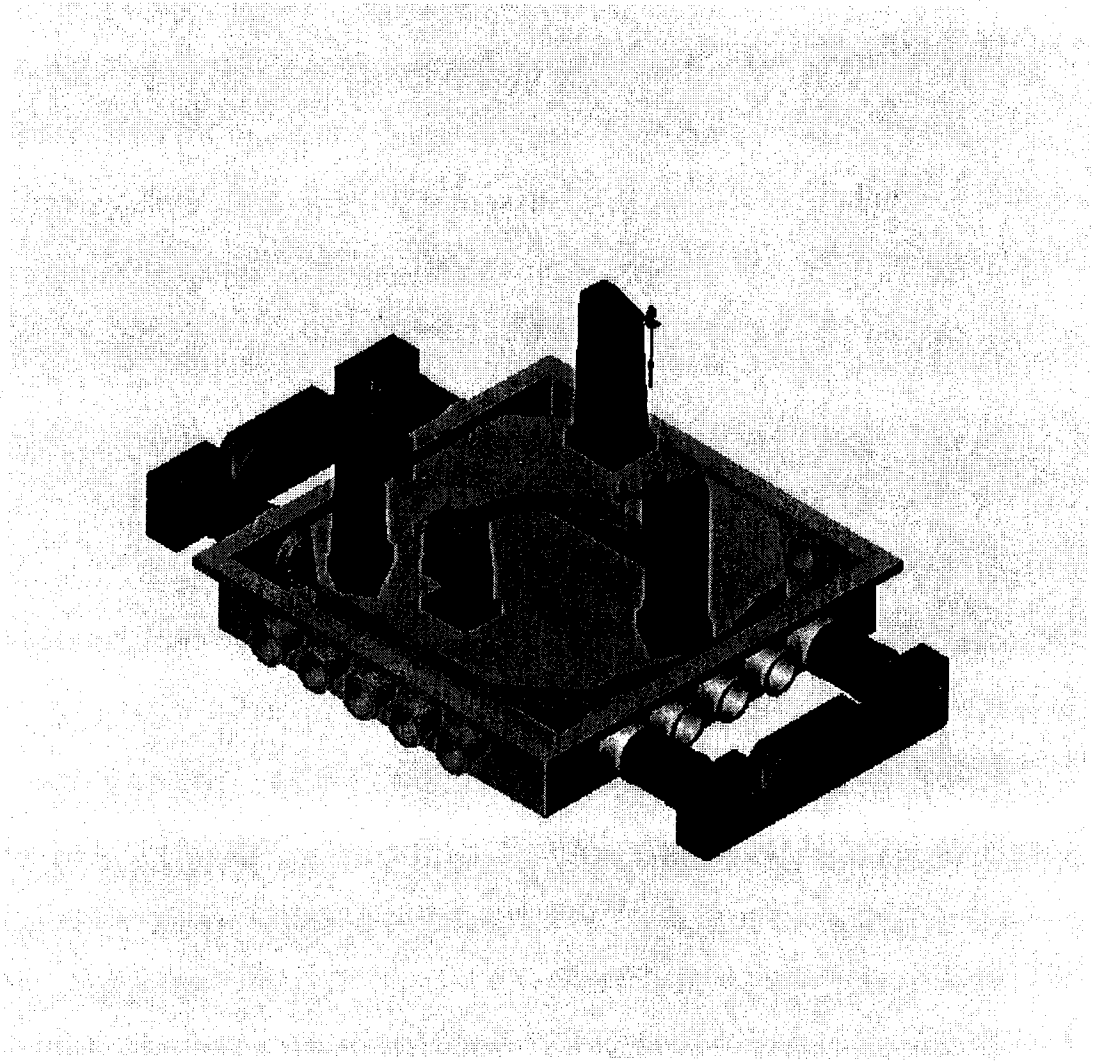
Bottom ISO view



Top view in ETF



Support structure



Support structure

Requirements

- Must provide support and attachment for Stage 1 springs, forcers, position sensors.
- Must have clamp/limit-stops and kinematic positioning to locate Stage 1 relative to the support table.
- Mates with ETF chamber and surrounding pads.
- Must survive earthquake shock (1g vertical; 0.5 g horizontal) (requirement added after original RFP)
- "Window" in frequency domain around 60 Hz (requirement added after original RFP)

Support structure

Design

- Piers to support cross tubes.
- Bellows feedthroughs for cross tubes.
- Support table.
- Pillars for spring supports and horizontal forcers.
- Pillars for vertical forcer and sensor support.
- Clamp/limit-stops with kinematic positioning for Stage 1.

Support structure

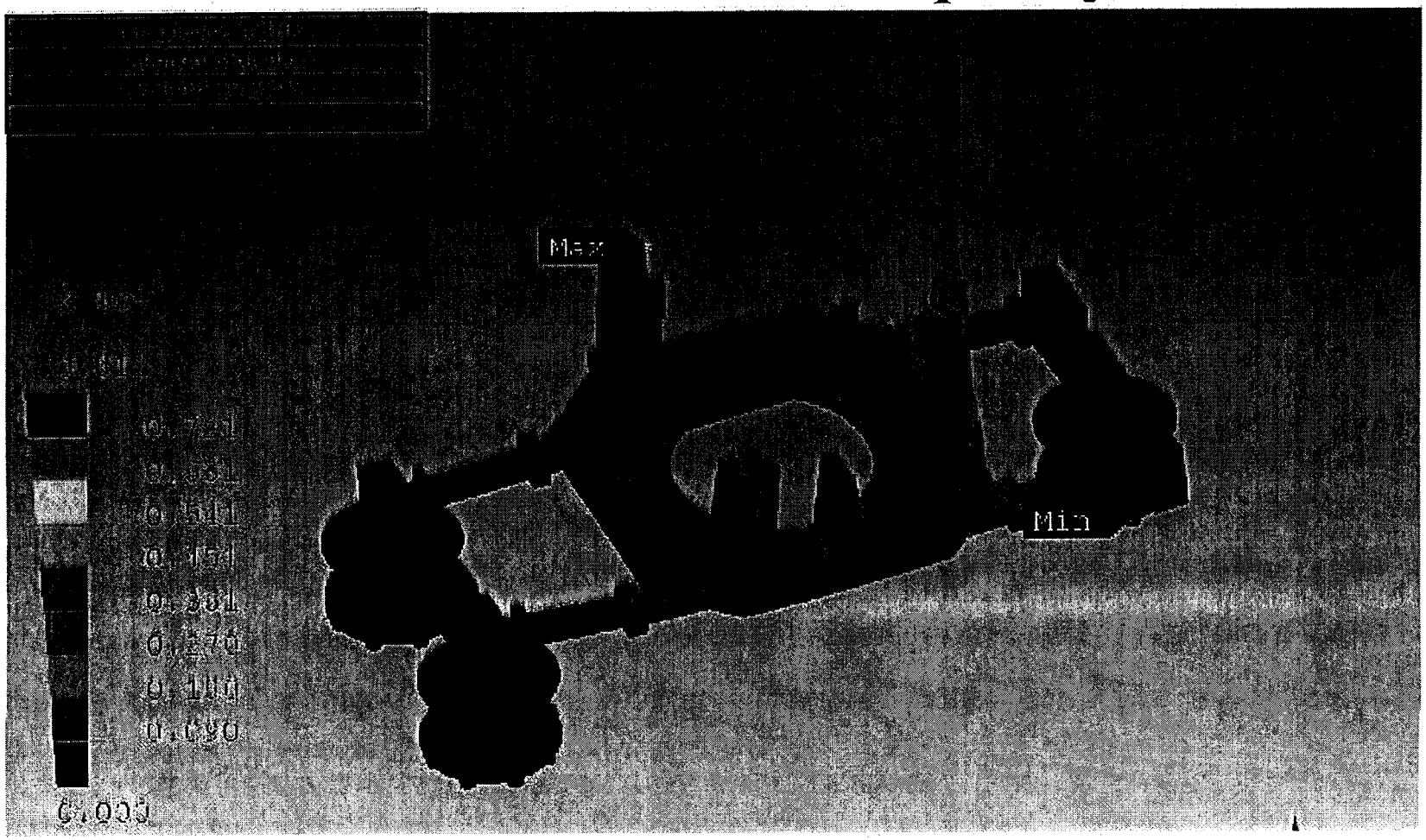
Analysis

The support structure has been designed and analyzed. It has structural resonance modes as shown below:

Assembly: Support Structure	2g vertical; 1g Horizontal
Mode#	Frequency, FEA (Hz)
1	43
2	49
3	59
4	67
5	72
6	81

Support structure

Illustration of the lowest frequency mode



Support structure

Fabrication

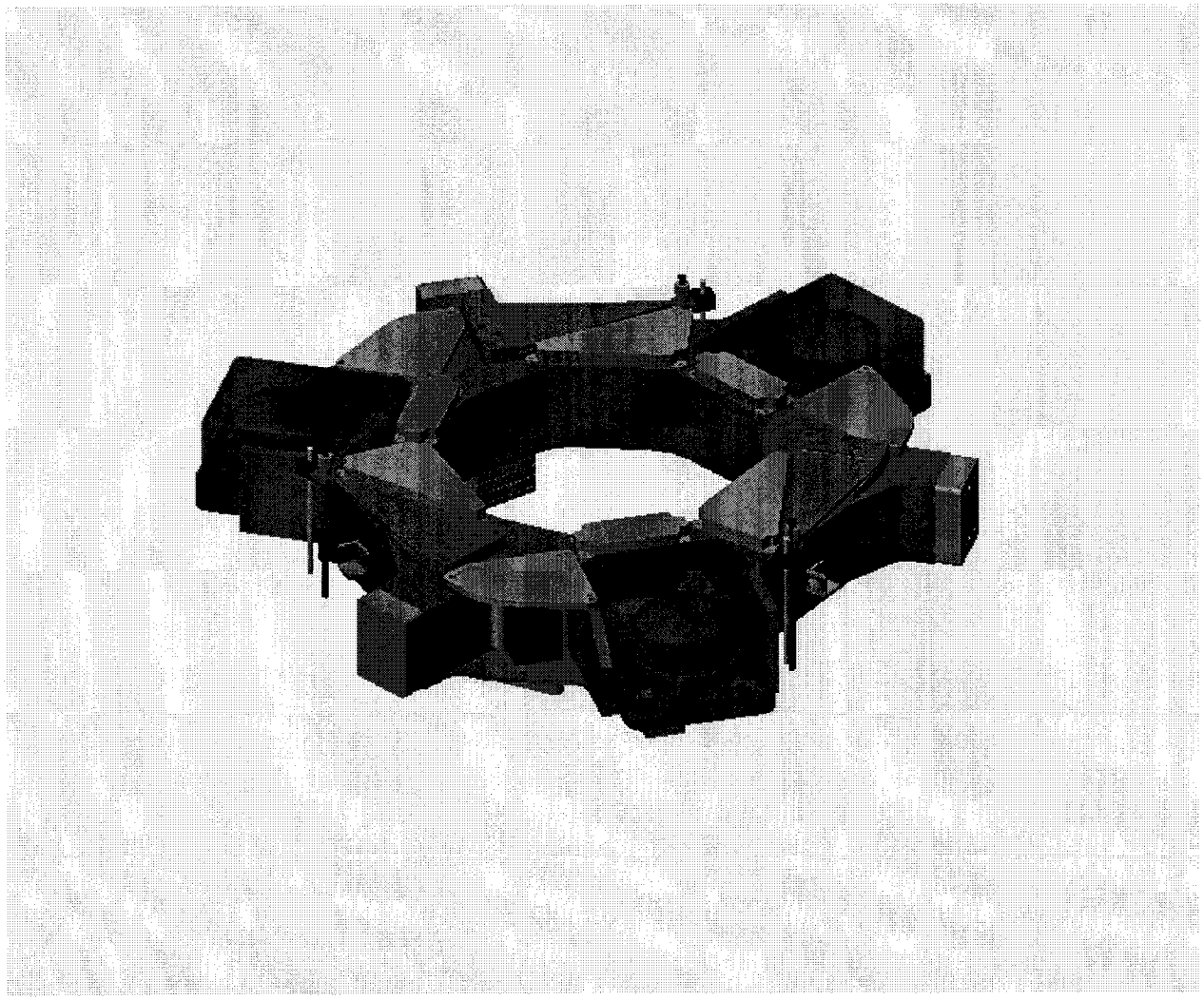
- Fixtures have been designed, built and shipped for pouring concrete pillars at the ETF site.
- Bellows have been ordered (16 week lead time).

Support structure

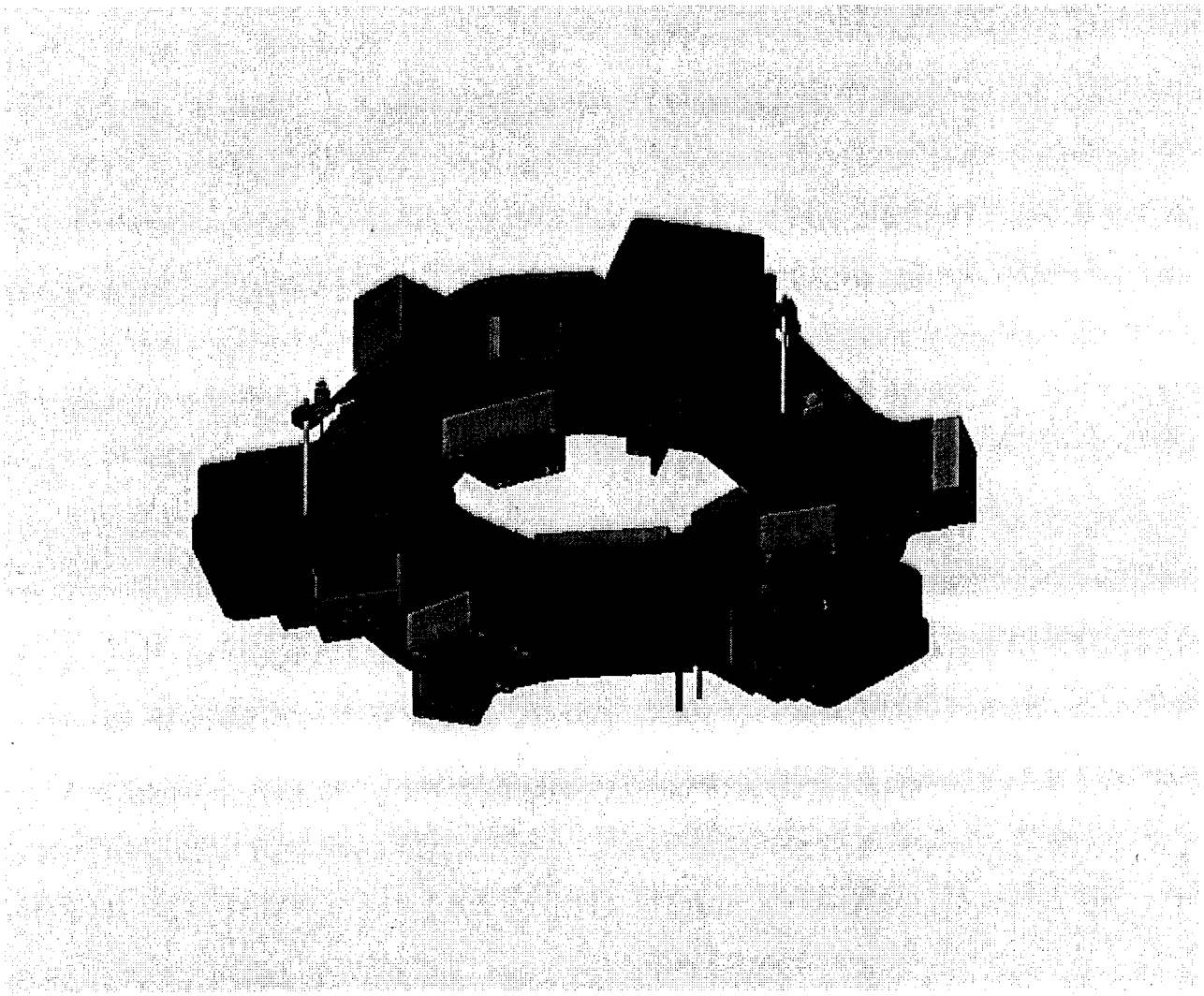
Detail design tasks remaining

- Create a resonant frequency "window" around 60 Hz.
- Mounting for horizontal and vertical Stage 1 forcers.
- Mounting for position sensors.
- Finalize Support Structure to Stage 1 kinematic positioning.
- Finalize Support Structure to Stage 1 lock-downs/limit stops.
- Outer support tube modifications for ease of fabrication.
- Bellows protection shields (requirement added after original RFP)
- Additional holes in support table for mounting masses and for lifting.

Stage 1



Stage 1



Stage 1

Requirements

- Pods for mounting of the STS-2 and L4C seismometers.
- Minimum resonance greater than 150 Hz.
- Mounting for trim masses (225 Kg total).
- Attachment points for Stage 1 flexures.
- Attachment for Stage 2 springs.
- Mounting for Stage 1 and Stage 2 forcers and position sensors.
- Total Stage 1 mass = 850 Kg
- Coaxiality of forcers and sensors.
- Adjustment for vertical position of horizontal forcers.

Stage 1

Design

•Monolithic design.

• Access for assembly and/or adjustment of pods, springs, forcers, position sensors.

•Mounting for trim masses.

•Weight reduction of Stage 1 structure to give a total Stage 1 mass of 850 Kg including 225 Kg of trim mass.

•Consideration given for ease of machining and lowest practical material cost consistent with performance requirements.

Stage 1

Analysis

- Lowest free body resonance at 192 Hz.
- Flexure and spring frequencies agree with predictions.

Assembly: Stage1	Mass: 766 Kg			
Mode #	Frequency, FEA (Hz)	Frequency, Calculated by Hand (Hz)	Mode	Component
1	1.4	1.75	Translation	Flexure
2	1.4	1.75	Translation	Flexure
3	4.7	2	Torsional	Flexure
4	7.1	7.8	Vertical	Spring
5	10.1	9.7	Tilt	Spring
6	10.3	9.7	Tilt	Spring
7	192	-	-	Stage1 Assembly

Stage 1

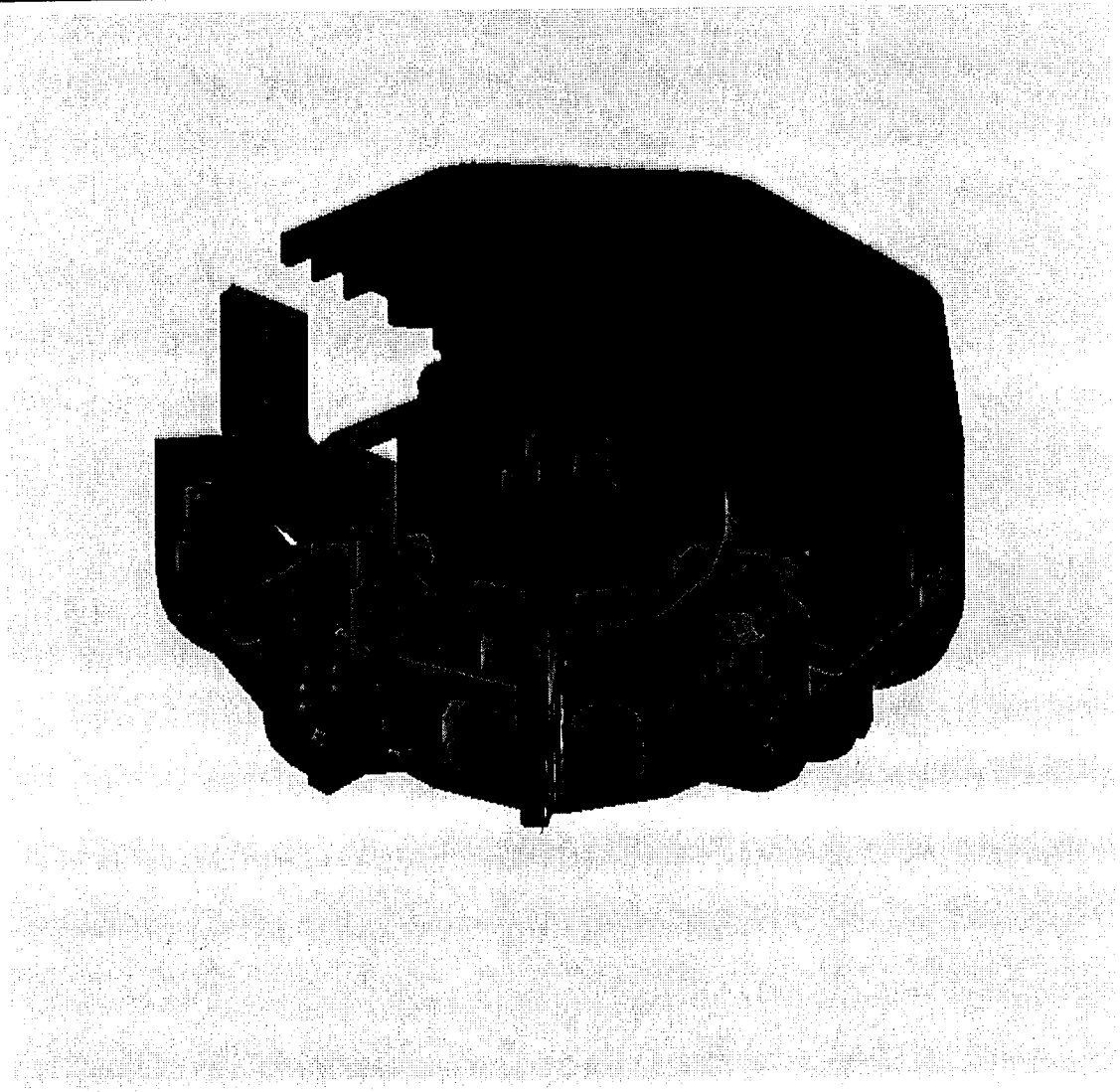
Analysis

Stage 1

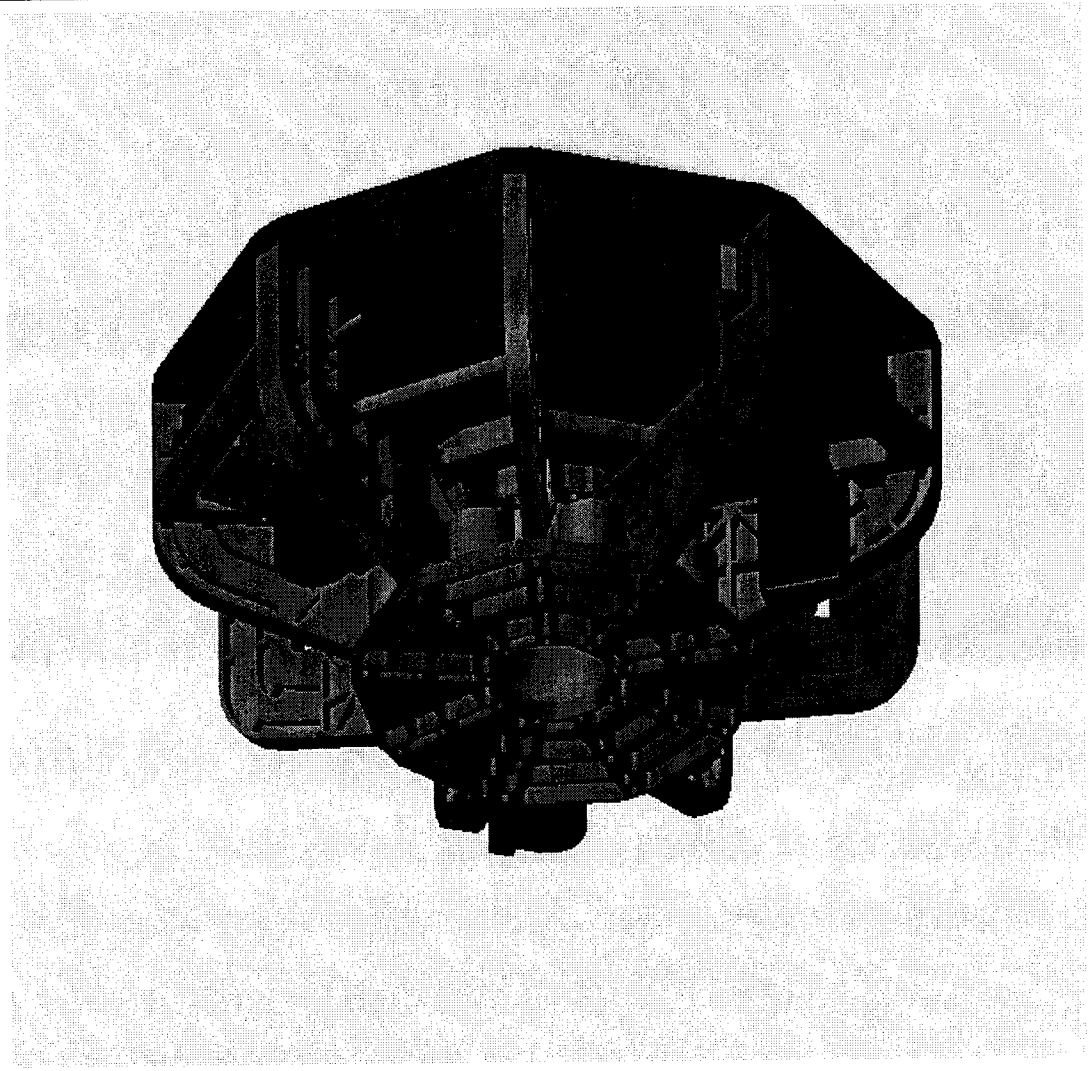
Remaining detail design tasks

- Analyze the Stage 1/pod connection.
- Raise and confirm the lowest Stage 1 body mode resonance to give 50% safety factor over 150 Hz requirement.
- Stiffen the horizontal forcer mount.
- Remove mass from Stage 1 to meet target 850 Kg total.
- Finalize design and location of trim masses (225 Kg).
- Mount Stage 1 and Stage 2 position sensors.
- Finalize Stage 2 forcer mounting.
- Add provision for lifting rings.

Stage 2



Stage 2



Stage 2

Requirements

- Mounting for GS-13 pods (horizontal and vertical).
- Center of gravity of stage within 8 cm of lower zero-moment point of flexure in vertical axis (requirement added after original RFP).
- Coaxiality of forcers and sensors.
- Adjustment for vertical position of horizontal forcers.
- Stage 2 radius of gyration to be 60 cm +/- 10%. Spring tips and flexures to be within that range. (requirement added after original RFP).
- Minimum resonance greater than 150 Hz.

Stage 2

Requirements (continued)

- Total Stage 2 mass of 1450 Kg.
- Attachment points for Stage 2 flexures.
- Mounting for Stage 2 position sensors.
- Mounting for Stage 2 forcers (horizontal and vertical).
- Mounting for trim and ballast masses.
- Table at correct height when mounted in ETF and HAM chambers (requirement added after original RFP).

Stage 2

Design

- Design utilizes monolithic interstitial plate, for mounting ribs, keel and table, etc.
- Weight reduction of Stage 2 structure to give a total Stage 2 mass of 1450 Kg, including 600 Kg payload (400 Kg on the table; 200 Kg in the keel and keel masses) and including 145 Kg trim masses.
- Consideration given for ease of machining and lowest practical material cost consistent with performance requirements.

Stage 2

Design (continued)

- Keel plate for mounting of ballast masses, lowering the center-of-gravity to meet added requirement.
- Access for assembly and/or adjustment of pods, springs, forcers, position sensors.

Stage 2

Analysis

- Lowest free-body resonance at 236 Hz.
- Flexure and spring frequencies agree with predictions.

Assembly: Stage2	Mass: 1643 Kg			
Mode#	Frequency, FEA (Hz)	Frequency, Calculated by Hand (Hz)	Mode	Component
1	0.9	1.5	Translation	Flexure
2	0.9	1.5	Translation	Flexure
3	2.2	1.9	Torsional	Flexure
4	3.2	2.9	Vertical	Spring
5	3.4	3.3	Tilt	Spring
6	3.4	3.3	Tilt	Spring
7	236			Stage2 Assembly