Overview of Interface between Seismic Isolation (SEI) and Suspension (SUS)

Norna Robertson and Dave Ottaway
for SUS group

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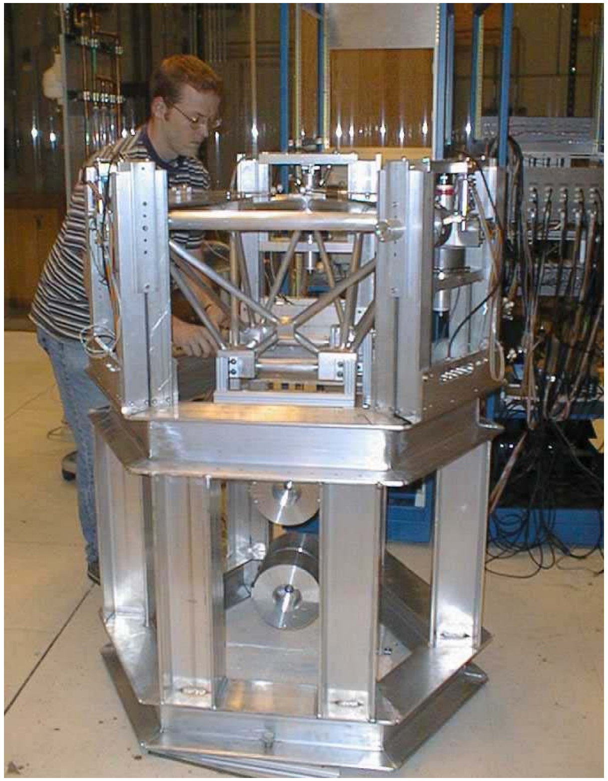
SEI design review, 13th Jan 2005

Topics to be Addressed

- Reminder of key points of combined system and interface issues
- SUS structural resonances: investigations so far
- Installation, physical fit, footprints, etc.
- Mass budget, wiring
- Planned prototype tests at ETF & LASTI to address remaining risks

SUS/SEI combined system

- Seismic isolation for Adv. LIGO achieved by combination of the two systems (+HEPI at low freq)
- The SEI system provides a high impedance mechanical interface to the SUS system: however resonances of SUS support structure w/SEI could impinge on design and performance of SEI control.
- Other interface issues include: installation and fit, mass budget and loading, magnetic interactions, routing of SUS wiring.

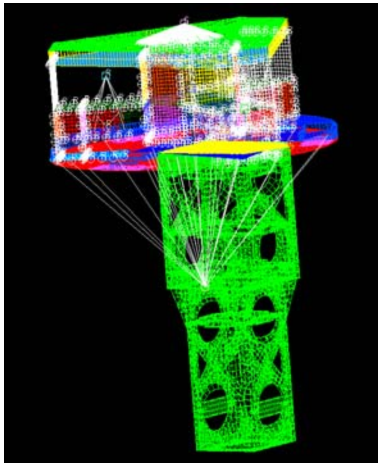


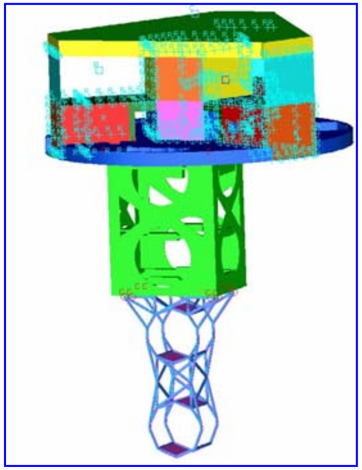
Prototype SEI+SUS at Stanford

Resonance requirements for SUS support structure

- SUS started with a 150 Hz minimum frequency requirement for structural resonances
- To meet this SUS would have to exceed allocated mass budget and envelope.
- SUS then took same requirement that SEI imposed on the dynamics of stage 2 (optics table) structure

  (see section C.8 of E030179-A): basically no phase lag greater than 90^{o} below 150 Hz for non-collocated sensing & actuation points on stage 2)
- Various structure designs were investigated using IDEAS (D Coyne et al.)
- SUS found the requirement not possible to meet for the given mass budget and footprint when exciting with single point actuation. Further work using modal actuation with reasonable cross-coupling into other modes is still to be considered.
- As a working assumption, a revised baseline target was set - see overleaf.





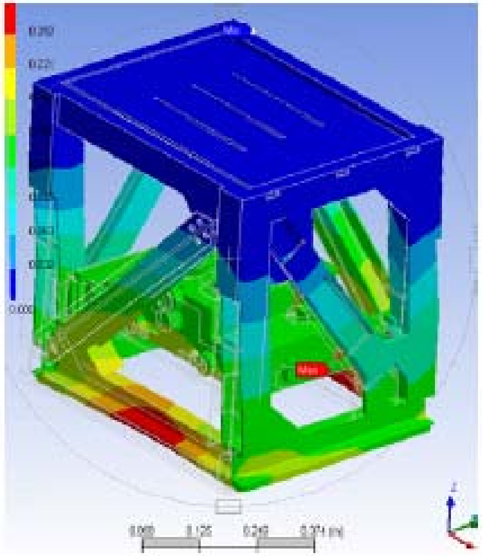
Resonance requirements for SUS support structure contd

Current SUS working baseline assumption/goal:

- The first resonance limits, with all mass, including non-structural mass, and assuming a perfect support (i.e. rigid optics table), not coupled dynamics, are:
  - > 200 Hz first resonance for the upper structure
  - > 100 Hz lower structure
  - > 100 Hz combined upper and lower structure
- Ideally the above would be achieved with realistic attachment compliance included, and no added damping
- The above to be confirmed initially by finite element analysis with a 15% safety margin. Later confirmation is via modal testing on a prototype.

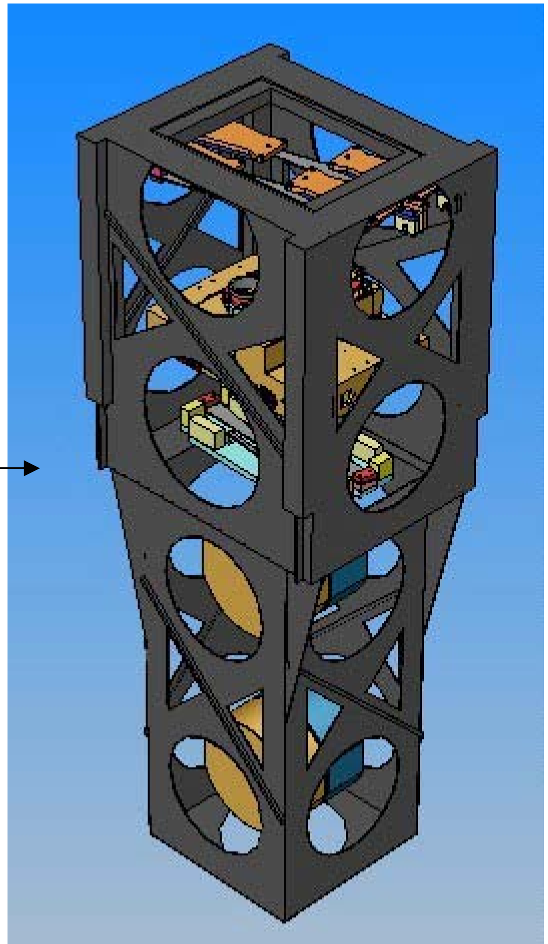
Resonance requirements for SUS support structure contd

- Aim: above conditions will result in a phase lag, between non-collocated SEI stage 2 sensors and actuators, due to quad structure modes that will not exceed 90° below 100 Hz and not exceed 180° below 150 Hz.
- This will be checked by coupled finite element dynamics analysis of quad structure + stage 2 SEI structure
- Further: SUS has incorporated a design requirement to allow (as a backup) for de-coupling the lower structure from the upper structure when installed:
  - Lower structure could be mounted from the upper structure or the "ground" (vacuum chamber structure) or the support tubes (isolated by the HEPI SEI subsystem).
  - Practicality of mounting lower structure to support tubes is not yet established, and not preferred from a layout standpoint (space and C of G considerations)
- FEA of conceptual upper and lower SUS structures already underway, see e.g. T040230 draft (FEA of upper structure, C Torrie et al)



Design of SUS Support Structure

split here



early conceptual design

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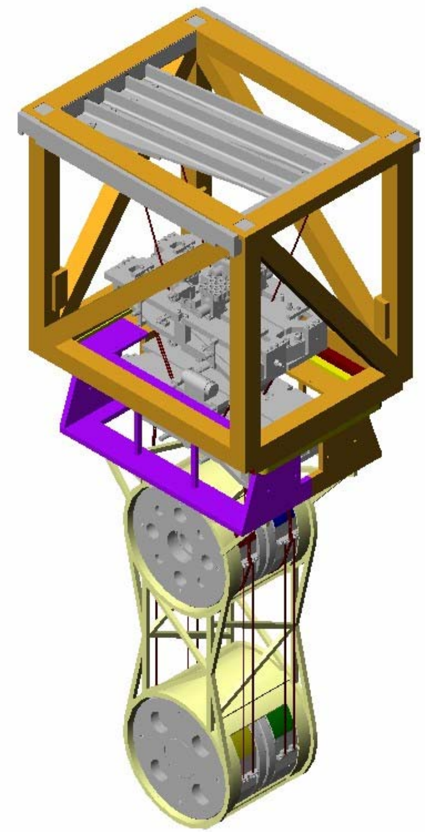


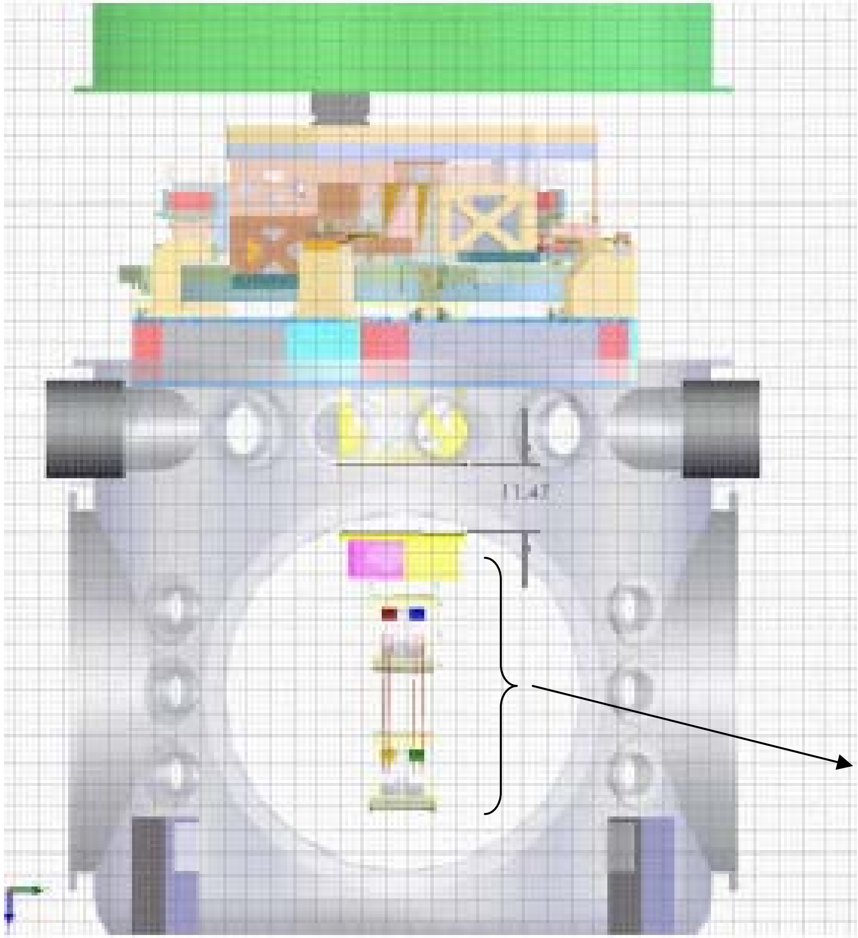
recent conceptual design:
work in progress

Diagrams from SUS group

Installation, Physical Fit, Footprints etc

- Current installation plan at LIGO sites: assemble SEI+SUS outside tank and install as one from above: “cartridge installation”
- SUS design incorporates a split structure (“3+1”) to give facility of removing and replacing lower part (3) without removal of the SEI and upper part (1) of the SUS.
- LASTI installation: not possible (with current size specifications) to do as single unit due to restricted headroom (see L Jones D030715-00-D). The lower SUS structure will be installed through door - see next slide.

SEI and SUS in LASTI tank



Lower section of suspension and support structure installed through door

Mass Budget, Wiring

- Detailed mass budget and C of G calculation for quad ETM was prepared by SUS group for use by SEI - seeT030137-05: “ETM controls prototype: Mass estimate of an ETM suspension layout” C Torrie et al (latest revision July 2004).
  - Design of support structure working to the limits given in this document
  - Current ETM mass estimate: 418 kg (no contingency on suspended mass)
- Initial mass estimates for other chambers/suspensions also carried out - see E040136-00 “Seismic isolation payload properties”, D Coyne March 2004.
- Wiring: SEI requires to carry wiring from SUS to vacuum chamber feedthroughs (example - ETM quad may have up to 136 wires). Work on how to incorporate the wiring for LASTI tests (use of harness etc.) has already been carried out, and most cabling and all feedthroughs ordered (L Jones).

Planned prototype tests

- ETF plus structures
  - Examples of upper and lower SUS support structures will be provided by Caltech for measurement of coupled resonances and control behaviour on Stanford ETF.
- LASTI tests - see next slides.

LASTI Response to ASI Issues

- Testing of Suspensions Controls Prototype to continue as planned
  - Solid Spacer to support Quad within BSC envelope currently being designed
  - Use HEPI as 6 DOF Shake table
- Reallocation of manpower resources to SEI BSC assembly and testing (K Mason, D Ottaway, M McInnis)

New LASTI Schedule

Controls Prototype

- Jan ’05 Design and fabricate Solid Spacer for BSC
- Jun ’05 Assembled Quad arrives and external shakedown begins
- July ’05 Cartridge Installed into Vacuum
- Oct ’05 Preliminary Locking tests begin
- Jan ’06 Removed from Vacuum

BSC Seismic Development

- Mar – Jul ’05 Procure parts
- Aug ’05 Dirty Assembly
- Sept ’05 Modal Testing
- Sept ’05 Dissemble
- Oct ’05 Clean Parts
- Nov ’05 Clean Assembly
- Jan ’06 Pre- Installation Test
- Mar ’06 Vacuum Installation
- April ’06 Removal from Vacuum

May ’06 Combine Quad and BSC Extra-Vacuum

Jun ’06 Cartridge Install