Interface Control Document (ICD): Output Mode Cleaner (OMC) Suspension (SUS)

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1.1 OMC SUS

This is a chapter of the master Advanced LIGO Detector, Interface Control Document (ICD), E030647.

This ICD covers the interfaces between the sub-systems that produce the hardware that makes up an Output Mode Cleaner Suspension. The sub-systems interfaced to the OMC SUS include, **SUS/UK, ISC, SEI, Systems & AOS.**

1. SUS **System t**hat designs/fabricates the suspension structure, non-suspended items and suspended masses, except the OMC breadboard.
2. The OMC breadboard (or optical bench) is designed/fabricated by the ISC group.
3. The co-located sensor/actuator units, called BOSEMs, for the OMC SUS are designed and fabricated by the SUS/UK group, specifically the University of Birmingham.
4. Cabling of the sensor/actuator units, from the back of the BOSEMs to the top of the OMC SUS structure, are designed and provided by SUS/UK.
5. Cabling from the top of the OMC SUS structure to the chamber feedthrough are designed/provided by the SEI group.
6. The SEI system provides the isolation system to which suspensions are attached.
7. Clamps (called dog clamps) and screws to clamp the OMC SUS structure to the HAM optical table are provided by the SUS group.
8. Front-end electronics for the suspensions controls are provided by SUS/UK.
9. All other electronics are provided by SUS/US. The SUS Work Breakdown Structure (WBS), M030120-00, defines the scope of the SUS efforts and differentiates the US and UK components. In addition, M030162-03 is a detailed statement of the SUS/UK scope.
10. The mass and moments of inertia of the actual optical bench will be provided to SUS/US by the ISC group. Comparison will be made by SUS/US between the dummy bench as tested in the suspension and the actual optical bench as its design matures. If required, additional tests will be carried out by SUS/US with an altered dummy bench matching the actual optical bench's parameters, to check that the resulting behavior still meets requirements.
11. Threaded holes are provided by the SUS/US group on the top mass for cable strain relief from the optical bench.
12. Interface of optics mounted separately to the suspension components should be checked by both ISC and SUS/US. These are the ISC input/output optics that will be mounted on the optics table, inside of the suspension structure, or mounted to the structure itself.

1.1.1 Physical Interfaces

1.1.1.1 Mass Properties

Requirement:

The mass of the OMC breadboard is controlled by the ISC group and is transferred to SUS to be incorporated into the suspension model. See note 10 above. All other masses are defined/controlled by SUS. Total mass of the suspension assembly must comply with the mass budget controlled by the Systems group.

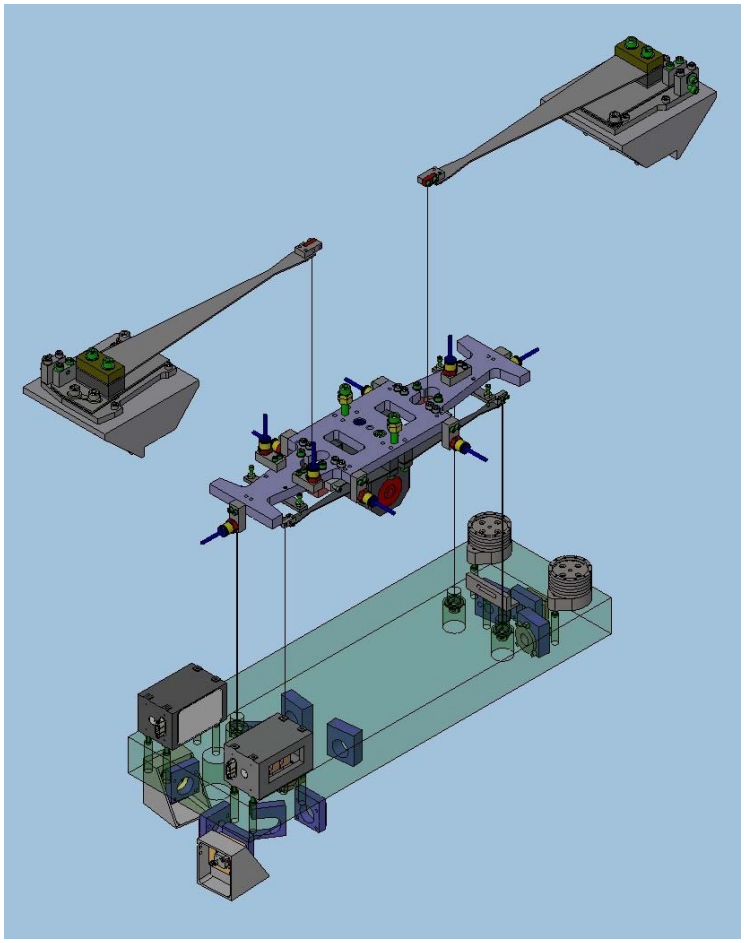
Explanation/description/references:

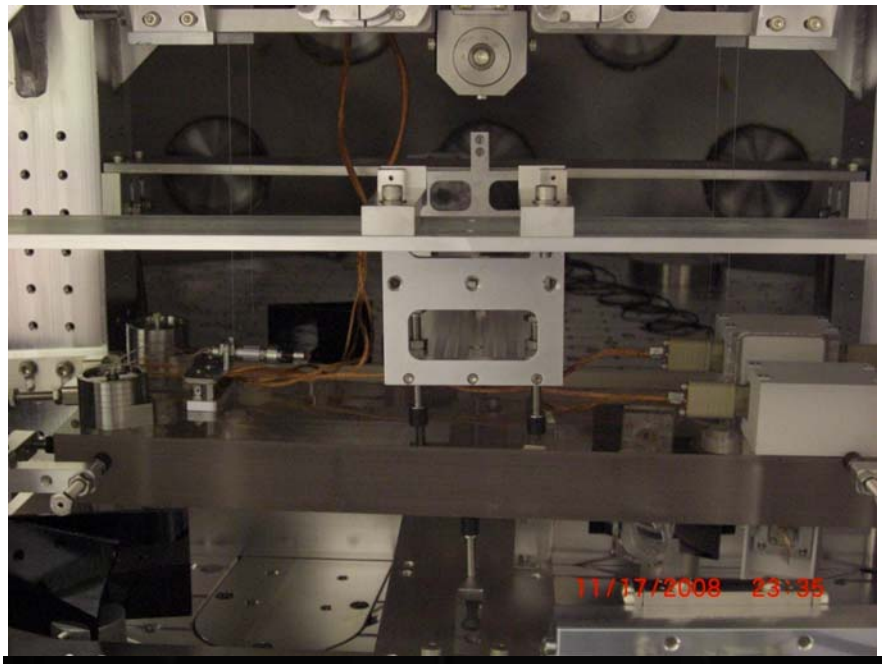
One might expect an interface between SUS suspension mass properties and SEI. However, it is SYS that defines the entire SEI optics table payload complement and maintains the mass properties budget.

Historical Notes:

None

Figure 1:Output Mode Cleaner Suspended Masses

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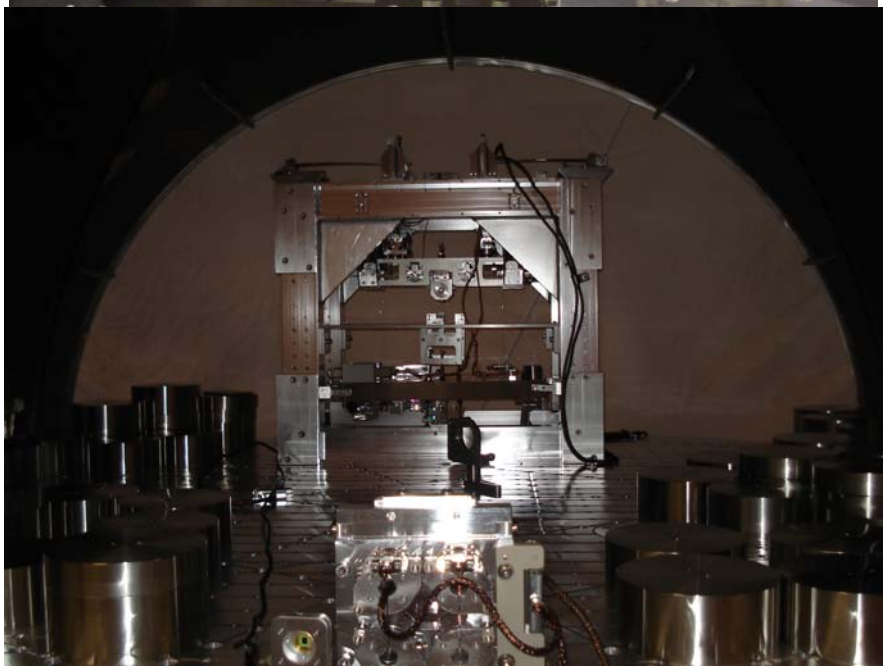

Figure 2: Electronics Block Diagram

1.1.1.2 Envelope

Requirement:
None
Explanation/description/references:
One might expect an interface between SUS suspension envelope and SEI since suspensions must fit on the SEI platform. However, it is SYS that defines where the SEI optics table payload elements are placed and therefore the limits of their envelopes.
Historical Notes:
None

1.1.1.3 Attachment

Requirement:
The OMC suspensions are attached to the SEI/HAM optics tables with dog clamps (provided by SUS/US). The SEI optics table shall have ¼-20 UNC-2B threaded through holes on 2 inch hole spacing over the entire optics table surface. These optics table holes shall have Nitronic 60 inserts The holes shall also have a chamfer to prevent a lip from rising above the nominal optics table surface.
Explanation/description/references:
The hole size and spacing were chosen to achieve a minimum frequency of 150 Hz for the quad suspension vertical bounce mode with the dog clamps & optics table bolts acting as springs retaining the mass of the suspension.
The holes are to have Nitronic 60 inserts o minimize particulate generation (which could rain down on the suspension and COC); see reference T040111-00
Historical Notes:

1.1.1.4 Alignment

Requirement:
The OMC breadboard must sit vertically above the SEI optical table 127mm. This corresponds to the beam at 20mm below the breadboard, as defined in the Design Specifications document, T070189.
Explanation/description/references:
One might expect an alignment interface between SEI and SUS/US since (a) one must align suspensions at the bolted interface to the SEI optics table and (b) the SEI system has the capability to perform low frequency, yaw alignment and length offload. However, it is really ISC/AOS that performs and insures initial (DC) alignment. The yaw and positional offload interface is a digital command interface between SUS/US (which has the scope for all digital SUS controls) and ISC. ISC performs the alignment of the input optics to allow the beam to work in the OMC breadboard.

Historical Notes:
None

1.1.1.5 Optical Table Flatness

Requirement:
The mounting surface of the SEI optics table shall be flat to within 0.010 inch over the entire surface.
Historical Notes:
Same as initial LIGO.

1.1.1.6 Optical Table Levelness

Requirement:
The mounting surface of the SEI optics table shall be capable of being leveled to within 100 microradians.
Note: INS, with IAS/AOS tooling & procedures, is responsible for performing the SEI optics table leveling.
Explanation/description/references:
None
Historical Notes:
None

1.1.1.7 Tooling

Requirement:
The SUS/US will provide all of the assembly tooling/fixtures, including the fixturing required to install the metal dummy bench and the ISC optical bench. SUS/US will also provide the installation tooling to move the OMC SUS from an optical table into the HAM chamber.
Explanation/description/references:
See the SUS/US documents T080117, Suspensions Output Mode Cleaner Assembly and Alignment Procedure and E070217, Output Mode Cleaner Suspension Installation Procedure. See also the ISC assembly/installation document, eLIGO OMC Installation Plan, E080024.
Historical Notes:
None

1.1.2 Electronic/Electrical Interfaces

1.1.2.1 Command Signals

Requirement:
None
Explanation/description/references:
All command signals are between SUS/US and ISC.

1.1.2.2 Data Signals

Requirement:
None
Explanation/description/references:
All data signal interfaces are in the digital realm (SUS/US scope).

1.1.2.3 Interface Cabling/Connectors

Requirement: Jay this is all from the SEI and SUS/UK ICD – hopefully, you can change it for OMC SUS?

N.B.: This requirement will be fleshed out in support of the SUS Electronics PDR Review, Jul 12, 2005.

The SEI system shall provide #TBD female, connectors, each 50 pin, D-type (Accuglass part number TBD). These connectors shall be terminated in a bracket mounted to the optics table with the mating plane of the connector within a distance of 6 inches (150 mm) from the perimeter of the suspension and a distance of 4 inches (100 mm) from the table surface. The SEI system shall route these cables across its isolation stages and to an electrical vacuum feedthrough (also provided by the SEI group).

The SEI cable shall be twisted pair, overall shielded (25 conductors) with TBD gauge and a cross-coupling of < -85 dB at 1 kHz and increasing proportionally with frequency. The cable shield shall not be grounded.

The pin-out assignments of the cables shall be as indicated in the following Table.

Table 1: SEI D25 Female Connector Pin-Outs

Pairing is 1-14, 2-15, 3-16, … etc. TBR

Pin	Signal Name	Description	Pin	Signal Name	Description
1		TBD	14		TBD
2		TBD	15		TBD
3		TBD	16		TBD
4		TBD	17		TBD
5		TBD	18		TBD
6		TBD	19		TBD
7		TBD	20		TBD
8		TBD	21		TBD
9		TBD	22		TBD
10		TBD	23		TBD
11		TBD	24		TBD
12		TBD	25		TBD
13		TBD			

Note: The exo-vacuum cabling interface is between SEI and SUS/US since SUS/US provides all in-air cabling.

Explanation/description/references:

1.1.3 Software

Requirement:

None

Explanation/description/references:

All software interfaces are between SEI and SUS/US. Jay?

1.1.4 Environmental

1.1.4.1 Seismic Loads

Requirement:
The SEI system shall maintain active isolation operation through all seismic events in the 95th percentile based on total displacement rms at LLO (as defined in P040015-00), without shutting down or hitting the SEI mechanical limit stops.
Explanation/description/references:
The SUS system is required to maintain operation through at least the 95th percentile based on total displacement rms at LLO (as defined in P040015-00). In order to do so, the SEI system must continue to function (provide some level of isolation, albeit at a reduced level) and not hit its mechanical stops (which will impart an impulse into the SUS).

1.1.4.2 Elastic Mode Frequencies

Requirement:
The requirements with regard to first elastic mode resonances for OMC structure sections with all mass, including non-structural mass, and assuming a perfectly rigid support (i.e. rigid optics table and no coupled dynamics):

- > 150 Hz structure

The above must be achieved with realistic attachment compliance included. No specific requirements or provisions are made for damping in these modes (so just intrinsic structural damping in these metallic structures, or Q ~ 100). The above requirement should be confirmed initially by finite element analysis with a 15% safety margin. Later confirmation is via modal testing on a prototype. This was confirmed by the structural testing done in spring 2007. The lowest mode is about 140 Hz, and was found to be acceptable to the Systems group.

Explanation/description/references:
See E050159, SEI and SUS/UK ICD, for more information on elastic mode frequency requirements.

Historical Notes:
None

1.1.4.3 Thermal

1.1.5 Safety

Requirement:
E0900042, Hazard Analysis for OMC SUS.
Explanation/description/references:
SUS/US and ISC will abide by all observatory safety plans and procedures.
Historical Notes:
None