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Exhibit 1
Design Requirements for the In-Vacuum Mechanical Elements of the Advanced LIGO Seismic Isolation System for the HAM Chamber

A. References (on enclosed CDs, Exhibit 2); note that in case of apparent conflict between a referenced document and this text, this text shall take precedence.

1. LIGO Single-stage HAM Isolation System: Conceptual Design Report (E060229-00-D), Corner configuration notes for the single-stage HAM Isolation System (E060230-00-R), and this requirements document (E030180-02).
2. A zip file containing the SolidWorks files for the conceptual design (D060289-00-D.zip). HAMV2CcenterSpringRightSideUpV3.sldasm is the main assembly drawing.
3. D020525-00, Advanced Seismic Isolation Technology Demonstrator (309 files). This is a HAM-like system with 2 active stages.
4. D047970-A, BSC Advanced LIGO Seismic Isolation System (322 files). This is the system used in the other style of chamber. It has 2 active stages. Many of the parts are to be common to the single-stage HAM design.
5. Chamber SolidWorks files: HAM-Chamber.sldprt, HAM Support Rod.sldprt, HAM Expansion Bellows Assembly.sldasm
6. External Support Parts for HAM (4 files: D972611-G, HAM Expansion Bellows; D972612-G, HAM Crossbeam Weldment; D972613-C, Support Tube Mounting Base; D972614-B, Support Tube Mounting Cap)
7. D961094-04, HAM Assembly
8. D972501-B, HAM Top Assembly
9. D972610-G, HAM Support Tube Weldment
10. Actuator drawings: PSI # 0487-LIGO-D110-050904-SCS
11. Actuator installation tooling (D050343-00, D050344-00, D050345-00, and D050346-00) and instructions (E060226-00, Actuator Installation Instructions) for the BSC design
12. Displacement Sensor drawings: ADE #020536-A02 20 mm sensor
13. Seismometer pod drawings (D0407810-A)
14. Seismometer Lock files: GS-13 folder (63 files)
15. Seismometer drawings: Geotech GS-13
16. Kinematic Lock-locator-limiter devices (D047941-A, part of the BSC system, above). Operation of the Lock-locator-limiter (E060227-00, Locator/Lock Installation Instructions)
17. D000241-C, LIGO II Stiff Active Seismic Isolation System
18. D010120-D, Cable Clamps, 40M
19. D030169-02, ADVLIGO SEI Corner Configuration (This is for a system with 2 active stages.)
20. E960022-07-E, LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures

21. E960050-A, LIGO Vacuum Compatible Materials List
22. E990452-L, SPP-080 Rev. O, Cleaning & Preserving LIGO BSC & HAM Aluminum Weldments and Machined Shims
23. E990453-N, SPP-081 Rev. O, Final Cleaning and Packaging of LIGO S.S. Support Tubes, Leg Elements and Balance Weights
24. E990456-B, SPP-093 Rev. C, FT-IR Test Procedure, BSC Downtube & Support Table Assembly, D972210

B. General:

1. The structure's purpose is to provide a mounting surface for optical components that is stable, well controlled, and isolated from the local floor vibration. The HAM structure will be mounted in a LIGO HAM chamber. The structure consists of two stages, a single active stage (stage 1) and a support stage (stage 0). The stages are interconnected with springs. Stage 0 mounts on existing chamber support elements. It supports Stage 1 with three blade springs and flexures, and has actuators mounted that adjust the position of Stage 1. Stage 1 will have (among other things) seismometers mounted to track its motion, displacement sensors to monitor its position with respect to Stage 0, and an optical table to mount the payload.
2. The conceptual design, described in E060229-00-D, shows the general approach we would like to pursue. That structure is stiff and light, relatively low cost, and has good alignment between sensors, actuators, springs, and flexures. The natural frequencies meet the requirements set forth below. The springs, flexures, sensors and actuators should have a basic 3-fold symmetry. Modeling of this structure shows it will meet the performance requirements for Advanced LIGO. The design is not complete, however. There are several items which require particular attention: detailed design and assembly of the structure to achieve the alignment tolerances, provisions to replace the GS-13 sensor pods in-situ, and provisions to align and replace the actuators and displacement sensors.
   We have also included the design files for the Technology Demonstrator (D020525) which depict a prior design which has many similar features as the subject of this task, but has two active stages; it is included as reference only.
3. Many of the subassemblies used in the BSC isolation platform are to be reused in this design. These include the Kinematic Lock and Locator assemblies, and the basic design for the GS-13 seismometer pods (with modifications described below). In addition, there are several other parts in common, such as the actuators and the displacement sensor, so reuse of assembly tooling and procedures is encouraged.
4. The structures shall be designed to be shipped as assembled modules (except for the pods, which are shipped separately). Custom crating shall be designed and provided, with adequate bracing and packaging to hold the units securely under severe shipping loads.

C. Stage Structures:

1. Major structure elements shall be made of aluminum to keep weight to a minimum, while minimizing material costs.
2. The Stage 0 structure shall mount on the eleven bosses of each of the two Support Tubes (D972610) in the HAM Chamber (D972501).
3. The lower surfaces of the HAM structure design may extend as much as 9.9" (25.1 cm) below the plane of the structure mounting interface with the HAM Support Tubes, as long as adequate interference clearance is maintained. This extension "keel" is limited in width to 16.0" (40.6 cm) on either side of the HAM chamber cylinder's centerline.
4. The HAM structure assembly shall have adequate strength to allow a 2-point lift attached to the optical table top at these points: 20.0" (50.8 cm) on either side of the table center, along the centerline which is perpendicular to the HAM Support Tubes (D972610).
5. All portions of the structures shall fit within their respective chambers with a minimum clearance of 0.5" (1.3 cm). Note that Chamber SolidWorks files are provided for convenience in solids modeling; however, information from drawing D961094 is to be used for confirming clearance with the HAM chamber. The two stages of the structure shall fit together with inter-stage clearances of at least 0.2" (0.5 cm), except for parts which bridge the structures: displacement sensor, locks and limiters, actuators, springs and flexures..
6. The support structures shall be designed to survive shipping loads and earthquake shock loads of 1.0 g vertical and 0.5 g horizontal for an assembled module.
7. The structures must be suitably stiff to allow proper functioning of the servo control systems. The criteria stated below for the various structural elements or stages apply to the structure complete with mounted displacement sensors, dummy seismometers, actuators, and a dummy payload on the optical table. The properties of the dummy payload are described in section G, Masses. Finite Element models of the complete design must be constructed to quantitatively predict and document compliance with these requirements.

   It is important that the sensors and actuators move in concert, and that mechanical resonances between them are at a high enough frequency to minimize their impact on the control system. To insure that this is true:
   Assume a sinusoidal excitation, that applies a force, $p(t) = p_0\cos(2*pi*f*t)$, where f = frequency and t = time, along the actuator's nominal force axis, exerted between stage 1, which supports the seismometer and displacement sensor target, and stage 0, to which the other side of the actuator is mounted. On the seismometer's stage, this excitation will cause a sinusoidal displacement at the location of the actuator's center of gravity (CG), $x_a(t)$ and one at the CG of the seismometer or displacement sensor target, $x_s(t)$. These displacements shall be measured along the seismometer's, the displacement sensor's and the actuator's nominal axes. The frequency-domain Fourier coefficient X(f) is defined by x(t) = Re{X(f)*cos(2*pi*f*t)}. X(f) is complex, i.e., X(f) = |X(f)| exp{i phase(X(f))}.

- For common-corner seismometer/actuator pairs that share an axis direction on stage 1: the phase of the transfer function X_s/X_a shall be greater than -90 degrees for all frequencies below 500 Hz.

8. Other than the 6 rigid body modes, the minimum design resonant frequency for Stage 1 shall be 250 Hz (including payload described in section G. Masses).
9. Stage 0 should be stiff. The stage 0 designs shown in the HAM conceptual design, the BSC design (D047970-A), and the Technology Demonstrator (D020525-00) demonstrate adequate stiffness.
10. Kinematic Lock and Locator devices of the design used in the BSC shall be used in this design. The design of the devices is shown in D047941-A, and use of these devices is described in E060227-00. These shall be easy to access and operate.
11. Heavy structure elements shall have lifting provisions to aid in assembly.
12. The radius of gyration of Stage 1 shall give natural frequencies in accordance with the requirements below.

D. Springs & Flexures, Actuators, Seismometers, Displacement Sensors:

1. Components shall be provided for as follows (refer to the in-vacuum portion of the conceptual design, and also see D030169):
    a. Springs and flexures:
        i. There shall be 3 each, 1 at each of 3 “corners”.
        ii. The size, stiffness, and location of the springs and flexures shall be such that the 6 rigid body modes of stage 1 (assuming stage 0 is fixed in inertial space) meet the follow conditions:

            Horizontal translation (x and y) modes shall nominally the same. The tip and tilt (rx and ry) modes shall nominally be the same.

MODE	max freq	min freq
horizontal translation (x&y)	1.4 Hz	1.0 Hz
vertical translation (z)	1.9 Hz	1.3 Hz
tip and tilt (rx & ry)	1.1 Hz	0.8 Hz
yaw (rz)	1.2 Hz	0.8 Hz

        iii. The springs shall be made of Maraging 300 steel; springs of trapezoidal pattern and cut by EDM, designed to be planar and horizontal when under operational loading; springs and flexures to be designed for a maximum stress of 35% of yield strength, with a goal of 30%, when operating at the working load and with the flexure laterally offset as much as 1 mm from its nominal location. Springs of a similar design are shown in Technology Demonstrator drawings p00067-029 through –037, with the exception of –033, Flexure Fix; this was incorporated to salvage parts that were warped during age hardening. The springs for this design should be similar, but may have a separate foot, see, for example, the BSC design drawing D047878-B. If other exceptions are desired, they must be made with LIGO's consensus (from the contract technical monitor) and approved prior to final design.

iv. The design shall call out the procurement of material from a single billet of Maraging 300 steel for each set of springs, as well as performing heat treat of each set of springs in a common batch, in order to minimize variation of spring constants within a set.

v. The springs shall nominally be straight when loaded to their final operating condition. The springs shall nominally extend horizontally when loaded to their final operating condition. The flexures shall nominally be vertical in the final operating condition. This is a general design requirement, not a tolerance requirement. Alignment tolerances are determined elsewhere.

vi. Other spring parameters:
Max stiffness: the spring stiffness requirements are set by the mass and the requirements on the natural frequencies.
Max length: 55 cm (from base to center of flexure rod)
Max base width: ½ of length
The radial position of the spring tips and flexures shall result in natural frequencies which meet the frequency requirements.

vii. The flexures shall be designed such that the upper zero moment point of each flexure shall lie within 1 mm of the neutral axis of its spring, and the lower zero moment point will be aligned with the actuators, as defined below.

viii. The springs and flexures shall be located within the structure such that the flexures lie at the corners of an equilateral triangle, which is centered in the structure in the X-Y plane

ix. The zero moment points are defined by the following length from the fillet tangent at each end:

$$z = (1/k) * \tanh(k*L/2)$$

Where k = sqrt{P/(E*I)} and L = flexure length, P = flexure load, E = Young’s modulus, and I = flexure area moment of inertia.

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b. Magnetic Actuators

i. The actuators shall be according to drawing PSI #0487-LIGO-D110-050904-SCS (44 lb_f continuous stall). The LIGO Laboratory will provide the actuators.

ii. There will be 6 each, 2 at each of 3 “corners”, one vertical and one tangential. Note: for this document, the term “tangential” refers to a component which is horizontal, and has its axis perpendicular to the line connecting the center of the structure with the instrument’s axis. The horizontal actuators will be tangential, and the horizontal sensors will be aligned with the actuators.

iii. The plane defined by the actuation centers of the 3 tangential actuators shall be within 1 mm of the plane defined by the lower zero moment points (LZMPs; see definition above) of the 3 flexures at that interface.

iv. These 2 planes shall be parallel to within 1 mrad.

v. Each tangential actuator shall have its axis parallel to the plane defined by the LZMPs to within 1 mrad.

vi. The permanent magnet side of the actuator shall be attached to stage 1, and the "bobbin" (wired) side of the actuators shall be attached to stage 0 to facilitate heat transfer.

c. Capacitive displacement sensors,

i. The capacitive displacement sensors will be ADE Technologies, 20 mm ceramic passive probes and targets. (see drawing ADE #020536-A02). The sensor consists of an active 'probe' which is mounted on one side of the gap to be measured, and a passive target, which is mounted on the other side of the gap to be measured. The probes are commercial devices, and will be supplied by the LIGO project. The design and fabrication of the targets are part of this contract.

ii. There will be 6 each, 2 at each of 3 "corners", one vertical and one tangential.

iii. The probe side shall be mounted to stage 0, and the target mounted to stage 1.

iv. Each pair shall be at least 39" (1 m) from the other two pair at this stage interface.

v. The displacement sensor targets shall be made of 1100 aluminum, at least twice as wide as the 20 mm diameter of the active part of the sensor probe, and centered on the active part of the probe. The targets shall have a surface flatness of 0.0004" (10 micrometer) and a surface finish of 0.000004" (0.1 micrometer). The sensor targets will be large enough to cover the 4 mounting holes of the sensor probe, so that the bolts used to attach the sensor head will touch the sensor target before the probe touches the sensor target, and thus provide an extra safety stop.

vi. The sensor targets shall be within 2 mrad of their nominal design direction (tangential or vertical).

vii. Each sensor head shall be parallel with its target to within 2 mrad. The target standoff for the displacement sensors shall be 2 mm. (Adjustment may be used to meet this requirement.)

viii. The sensors should be near their companion actuator. The sensors should be placed near the outer edge of the structure to improve our ability to measure tilt.

d. Seismometer, Geotech GS-13, in UHV 'pods'

i. The seismometer pods are UHV enclosures for the GS-13 seismometers. The 'dirty' seismometer and a trace gas will be sealed inside the pod, and the outside of the pod shall meet the LIGO vacuum requirements. A design for the pods used in the BSC exists (D047810-A, GS-13 pod assembly). This contact shall:

1) Make slight modifications to the pod design (described below).
2) Provide the pods (including electrical feedthrough), UHV cleaned, leak-checked, and ready for final assembly. (Note, the BSC pods were manufactured on subcontract by Nor-Cal Products, Inc.),
The LIGO Laboratory shall provide:
1) The GS-13 seismometers.
2) The remote locking/ unlocking mechanisms.
3) All cable assemblies.
4) The LIGO Laboratory shall be responsible for assembling the pods and mounting them onto the platform.

ii. The vertical pod from the BSC shall be the starting point for the pods for this design. The only changes shall be to:
1) add a tapped hole to the third mounting pad on the flange, so that all three feet match.
2) add sufficient holes to the rim of the 'pot' to mount a stiff brace or braces to constrain the transverse motions of the pod.
3) The braces are part of this design contract.
4) Provide easy identification to distinguish between the horizontal and vertical pods.

iii. The interface between the stage and the instrument pod will be three 1.0" (2.5 cm) diameter mounting pads on the instrument flange. There shall also be a brace or braces at the other end of the pod to control the pod vibration (see above).

iv. The seismometer pods designed for the BSC described in LIGO D047810-A, GS-13 pod assembly. These are UHV enclosures for the GS-13 seismometers. These pods contain the seismometer, a remote locking and unlocking device, and a trace gas for leak detection. The pods have a 2.75" OD CF-type flange which provides the electrical feedthrough for the seismometer and the locker mechanism.

v. There will be 6 each of the pods, 2 at each of three "corners", 1 vertical and 1 tangential. It is preferred that the pods be near the outer edge of the table to improve our ability to measure tilt.

vi. The instrument pods shall be initially positioned within 1.0 mm of their nominal location, and aligned within 5 mrad of their nominal orientation (vertical or tangential).

vii. The instrument pods will be removable (including when the modules are in their respective chambers) for maintenance. They should be repositionable upon replacement with 1 mrad angular and 1.0 mm positional accuracy.

viii. The vertical Stage 1 pods shall be located (as closely as practical) on-axis with the vertical actuators between Stages 0 and 1, and that the tangential Stage 1 pods be located (as closely as practical) on-axis in the plane of the tangential actuators between Stages 0 and 1. This is in addition to the natural frequency requirements described above.

2. Access shall be provided for installation, adjusting and removal of all pods, actuators, sensors, springs and flexures. This shall include the installation and removal of sensors/ pods and actuators while the system is in the vacuum chamber.

E. Additional Alignment Requirements:

1. The vertical offset between the LZMP and the cg of the platform shall be less than 10 cm, including the effect of the payload. The payload parameters are described in section G. Masses.
2. An alignment jig shall be provided to align each actuator coil with respect to its magnet such that its close tolerance side gap is balanced, side-to-side, to within 0.004" (0.1 mm) and it is mid-range in the directions of stroke and large tolerance side gap, to within 0.040" (1.0 mm). Actuator mounting feature details shall accommodate this alignment, and the jig design and procedures shall be such that the spacing is maintained upon jig removal. Ideally, this would reuse the tooling developed for the BSC system. The tooling parts are described in D050343-00, D050344-00, D050345-00, and D050346-00, and the BSC installation instructions are given in E060226-00. Alignment bars for the actuators are shown in the BSC system drawings, and should be reused if possible.
3. Misalignment of the flexures and spring attachments could cause the system to suffer horizontal misalignments when released from the 6 DOF kinematic locators. The misalignment of the flexures and spring attachments shall not cause the suspended location of the system to be misaligned by more than 0.004" (0.1 mm) at any location between stage 0 and stage 1.
4. A procedure and fixturing shall be provided for installing the springs and flexures without damage to the spring, the flexure or any other part of the system. Note that the flexure is easily damaged.

F. Optical Table:

1. The HAM structure optical table portion of Stage 1 shall be a nine-sided plate of 6061-T6 aluminum, with side's tangent to a 76.77" (195 cm) dia. circle. One of its sides shall be parallel to the axes of the HAM support tubes. As an alternative, the HAM optical table may be designed as circular, at 76.77" (195 cm) diameter, rather than nonogonal.
2. The optical table shall be centered in the HAM chamber's plan view.
3. The optical table shall contain a matrix of ¼-20 tapped holes containing wire inserts of Nitronic 60 material[*] with minimum depth of 0.5" (1.3 cm) at a spacing of 2.00" (5.08 cm) x 2.00" (5.08 cm), spread over the entire surface. The holes shall have an 82^{o} countersink of 0.390" (0.99 cm) diameter. One axis of the matrix shall be parallel to the axes of the chamber support tubes.
4. The optical table shall be flat within 0.01" (0.25 mm), with a surface finish of 64 rms or better.

[*] for example, part 1185-4EN375 from the Olander Company, Sunnyvale, CA.

5. The top surface of the optical table shall be 78.0 cm (30.71”) above the structure interface with the HAM support tubes. No part of the HAM Structure shall extend above the top surface of the optical table.
6. The local stiffness of the optical table shall be large enough that the small optics suspension frame will not cause large, local deformations, or have low natural frequencies. The suspension frame may be modeled as a right rectangular prism, 40 cm wide, 22 cm deep, and 83 cm tall. The total mass should be 45 kg (100 lbs).

G. Masses:

1. The following masses are defined as part of the HAM Structure; the total of these shall be limited to a maximum of 8876 lb_m (4026 kg); less mass is much preferred.
    i. All Structure elements defined elsewhere in these requirements, except for the Payload described in H.2 below, including structural members, pods, seismometers, actuators, displacement sensors.
    ii. Trim masses, which shall be bolted to Stages 1 in locations and in increments of mass to make each loaded spring flat (correcting the levelness of each stage for variations in spring stiffness) which will level the optical table (to within 0.2 mrad).
    iii. Balance masses, which shall be bolted to Stages 1 in locations and in increments of mass to properly locate the center of gravity (CG) of Stages 1 in accordance with DR H.4, when a Payload (see H.2 below) is installed.
    iv. The mass of the stage 1 structure (which includes sensors and actuators) plus trim plus balance mass should be less than 1500 kg.

2. The following masses are defined as the Payload:
    i. The aggregate of masses of individual nonsuspended optical components mounted on the optical table in a chamber; use 959 lb_m (435 kg) for modeling purposes.
    ii. The aggregate of masses of individual suspended optical components mounted on the optical table in a chamber; use 165 lb_m (75 kg) for modeling purposes.

    These payload components are the responsibility of the LIGO project. The contractor is only responsible to emulate the mass properties of the payload for the purpose of testing the assembly in accordance with the Statement of Work requirement c.7. The total of masses of optical components (both non-suspended and suspended masses) shall be 1124 lb_m (510 kg) for a HAM system. The effective first mass moments of the ensemble of payload components shall be:
    - Mx = total Payload mass times the composite center-of-mass x-position (direction parallel to the support tubes, referenced to optical table center) = +/- 0 lb_m-in (+/- 0 kg-m)
    - My = total Payload mass times the composite center-of-mass y-position (direction perpendicular to the support tubes, referenced to table center) = +/- 0 lb_m-in (+/- 0 kg-m)

- Mz = non-suspended mass times the composite center-of-mass z-position (vertical, referenced to optical table surface) = +9720 lb_m-in (+112 kg-m)

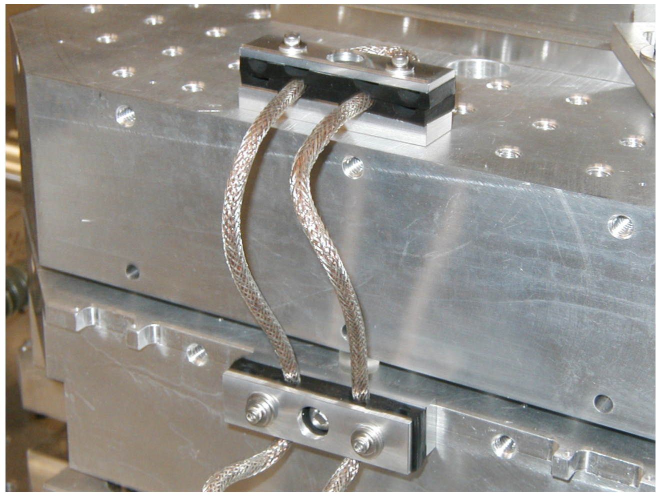
For finite element modeling to determine natural frequencies (both body modes and bending modes) and for the calculation of the stage 1 CG, the non-suspended payload shall be reasonably distributed about the optics table, much that the CG requirements above are met. The suspended mass may be ignored for these calculations.

3. Interpretation (not requirements): given the envelope restrictions, in order to have the CG of stage 1 plus payload be within 10 cm of the LZMP, a number of conditions must be met to avoid very large balance masses forming a ‘keel’ for stage 1. The table top must be relatively thin, and thus ribbing will be required. As the flexure length increases, the LZMP moves down much more rapidly than the CG does, and thus limits the flexure length. A large non-structural mass as a keel will move the CG down, but causes the table bending modes to suffer, and increases the size of the springs. The conceptual design has achieved a reasonable compromise for these parameters.

H. Cabling:

1. Clamping and routing provisions shall be made for the following control system cables, at each of three equally spaced areas around each structure. These cables shall be clamped at each stage that they traverse in sequence of suspension hierarchy, with cables spaced and routed such that they do not touch each other, do not touch any other items between clamps and will not sag over time to a position that causes them to touch. Clamps to be used will be as shown on D010120-D, Cable Clamps, 40M; the assembly is as shown in this photo (following) of a smaller unit. This task provides the mounting provisions for the clamps and cables; clamps and cables are provided by others. The following list is for each of three positions around each structure.

   - GS-13 seismometer, 2 ea, 4 twisted pair of 28 ga conductors per, with shield
   - Capacitive displacement sensor, 2 ea, 1 coax of 28 ga (minimum) conductors per. Note that these cables only run on stage 0.
   - PSI voice coil actuator, 2 ea, 1 twisted pair of 16 ga conductors per, with shield. Note that these cables only run on stage 0.
   - Optical Suspension controls, 5 ea, 12 twisted pair of 28 ga conductors per, with shield



Cable clamp assemblies, 4 cable capacity

I. Vacuum Compatibility:

1. The structures shall be designed for an ultrahigh vacuum environment.
2. All materials exposed to the vacuum environment shall be in accordance with the approved materials list (E960022, E960050). Document E960050 shows two lists: Table 1 for approved materials, and Table 2 for materials that could possibly be provisionally approved, if required and conditions permit. Document E960022 shows the procedure LIGO uses to qualify materials and the cleaning methods used for small parts.
3. All welds shall be made as full penetration welds to eliminate trapped volumes caused by welding.
4. Other trapped volumes (except for pod interiors) shall be provided with holes for venting during pumpdown.
5. All tapped holes shall be made with 0.005” (0.13 mm) oversize taps for minimizing the potential for galling.
6. All nuts used external to the pods shall be retapped with 0.005” (0.13 cm) oversize taps for minimizing the potential for galling.
7. Stainless steel screws shall be used in aluminum tapped holes, and silver-plated stainless steel screws shall be used in stainless steel tapped holes, for minimizing the potential for galling. Silver plated screws shall be made undersize to account for plating thickness, and the plating thickness shall be controlled accordingly.
8. Lubricants (other than silver plating) are not acceptable in the assembled structures.

   In addition, to prepare parts for UHV use, the following is also required:

9. Processing: all parts shall be processed in a manner similar to that detailed in procedures listed in E990452, E990453 and E990456, which include the general processes listed below:
   - Cleaning: after visual contamination is removed, brushes and wipes are used with lacquer thinner, acetone, alcohol, phosphoric acid, detergent and hot, deionized water for a thorough cleaning. A visual “water break” test is made

to confirm the absence of a hydrocarbon film on the parts, and the parts are drained and blown dried with filtered N_2 or $C0_2$. Care is taken to not recontaminate by handling equipment or personnel throughout this and subsequent steps. Precautions are taken to assure safety in working with acid and combustible vapors.

- Sampling: the surfaces of each cleaned part are flushed with ultra high purity isopropyl alcohol (<1 ppm residue after evaporation), which is collected in a ultra clean bottle and shipped to the following laboratory for FTIR (Fourier Transform Infra Red) testing, a measurement of hydrocarbon content: Fitzsimmons & Associates, Inc., 1860 Arthur Drive, West Chicago, IL 60185 (telephone: 630 231-0680). Control samples of the alcohol are also taken and analyzed to confirm control of the sampling process. The results are reported to LIGO; if not approved; cleaning, sampling and baking are repeated until acceptable results are achieved.
- Bake out: all parts are baked in a clean environment to temperatures of 120C for aluminum parts and 200C for stainless steel parts, with bake temperatures held for 48 hours.
- Assembly: once sampling results have been approved and the parts have been baked, the structure is assembled in a clean room, with cleanliness maintained. Pods are not part of the assembled module.
- Packaging: ultrahigh vacuum clean aluminum foil with fold lap seams and Class 100 “Strato-Gray” plastic sheeting (double bagged) with tie wire (inner bag) and heat sealed seams (outer bag) used to package the structure, following an explicit wrapping plan.
- Labeling: the outer bag is labeled to identify the assembly (part name, number/revision, serial number), date baked and the statement, “Cleaned and Baked for Ultrahigh Vacuum Service”
- Crating: the part is then crated with securing fixtures and pads, taking care to prevent puncturing the packaging. The crate is properly labeled and kept protected from precipitation.

J. Drawing Notes:

The following notes shall be added to all shop drawings, as appropriate:

1. All dimensions in inches.
2. Dimensions and tolerancing per ASME Y14.5M-1994.
3. Surface texture per ANSI/ASME B46.1-1985.
4. Remove all burrs and break sharp edges to a maximum of 0.015”.
5. All inside corners to be 0.015” radius max.
6. Countersink 82 degrees all tapped holes to major diameter.
7. Countersink 82 degrees approximately 0.015 deep all drilled holes.
8. Parts to be thoroughly cleaned to remove all oil, grease, dirt and chips.
9. All aluminum welding done by a GTAW process using 2% thoriated tungsten welding electrodes and ER4043 filler material.
10. All stainless steel welding done by a GTAW process using 2% thoriated tungsten welding electrodes and ER308L filler material.

11. All machining fluids shall be water soluble and free of sulfur, chlorine and silicone, such as Cincinnati Milacron's Cimtech 410 (stainless steel).
12. The coordinate system in the CAD assembly drawing for the structures shall be such that +z is up. X=0 and Y=0 shall be aligned with the center of the stage 1 structure. Z=0 shall be at some sensible place (e.g. the surface of the optical table).
13. Etch or stamp the drawing part number on noted surface of the part and then a three digit serial number. Serial numbers start at 001 for the first part and proceed consecutively. Use 0.125" high characters, larger if appropriate for large parts. Example: D010165-A 001