LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Action Item Progress for the HLTS

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1 Introduction

This document describes the progress on the action items listed in the HLTS (HAM Large Triple Suspension) Final Design Review committee's report (M1000126-v3). Some action items are short-term (July 2010), while others are longer term (September 2010 and beyond). As the action items are resolved, this document will be revised.

2 Action Item Descriptions and Current Progress

The following is the complete list of paraphrased action items from M1000126-v3 and the current progress on each item. The subsections correspond to the number of the action item on the list (i.e. Subsection 2.1.3 describes Action Item 1, Point c.).

2.1 Mechanical Design/Drawing Changes

2.1.1 Correction of d-value

The d-values for the prototype Upper Mass were incorrect and had to be altered using angled lower blade clamps and additional mass. To resolve this, the lower blade clamps (see D0900681-v2) have been lengthened as part of the overall Upper Mass redesign. Assuming straight, level lower blades, the lower breakoff of the Upper Wire is now positioned 2 mm above the upper breakoff of the Intermediate Wires. The final step of the Upper Mass redesign (estimated to be complete by July 2) is to position the center of mass of the Upper Mass equidistant from the wire breakoffs, resulting in d0 = d1 = 1 mm. The OSEM flags will also be repositioned so that the force from the side (as opposed to top) OSEMs passes through the center of mass of the Upper Mass, decoupling linear motion from rotational motion.

2.1.2 Elimination of Self-Clinching Nuts from Structure

The self-clinching nuts have been eliminated from the HLTS structure in favor of threaded holes. This has been completed in the SolidWorks model. Other changes must also be made to the SolidWorks model of the structure, and then all changes must be incorporated on the structure drawing. This is estimated to be complete by July 9.

2.1.3 "Invisible" Earthquake Stops in Coil Holder

The coil holder has some earthquake stops that cannot be viewed. Viewing holes will be added to the coil holder during its redesign, which includes moving the holes for the side OSEM flags. This is estimated to be complete by July 16.

2.1.4 Consider Alternatives for Earthquake Stops

We have been asked to consider split or sprung bolts or lock nuts, instead of a jam nut, to prevent movement of the earthquake stops. We believe that jam nuts are acceptable. Alternatively, if jam nuts are used, we have been asked to consider designing a tool that holds the earthquake stop in place while the jam nut is tightened. This type of tool has been designed, but multiple lengths may be required to cover all situations.

2.1.5 Chamfer and Deburr HLTS Structure Base Plate

The base plate of the HLTS structure should be chamfered and deburred. This has been completed in the SolidWorks model. Other changes must also be made to the SolidWorks model of the structure, and then all changes must be incorporated on the structure drawing. This is estimated to be complete by July 9.

2.1.6 Consider Alternatives for Mounting Additional Mass

The additional removable masses on the Upper Mass and Intermediate Mass should be mounted in a different way to prevent them from coming loose. The redesigned Upper and Intermediate Masses will be designed to use self-locking helicoils (assuming they are approved for in-vacuum use). The self-locking helicoils will prevent the additional mass from coming loose. In addition, vent grooves have been added to the additional mass disks.

2.1.7 Redesign Coil Holder Mounts

The mounting of the coil holder to the prototype HLTS structure required ¼" shims. To solve this issue, the coil holder will be mounted using L-shaped brackets instead of S-shaped brackets, which will allow for adjustment in the direction that previously required shims. This redesign is estimated to be complete by July 16.

2.1.8 Plexiglass OSEM Alignment Targets

Plexiglass alignment targets should be used to align the OSEMs to their flags. Since this is a tooling issue, a resolution will be delayed until after the HLTS structure and machined parts have entered procurement.

2.1.9 Change Trim Masses

In order to increase the precision of the adjustment of the Upper Mass trim masses, the sliding masses should be replaced with threaded trim masses, as in the HSTS. The Upper Mass pitch trim mass will be changed from a sliding plate to a sliding cylinder with a threaded insert. This is estimated to be complete by July 2.

2.2 Drawing Review

Calum Torrie is to review the final production drawings to ensure that all adjustment and alignment features of the HSTS are present in the HLTS, and to check all key suspension parameters. All drawings up to the Suspension Assembly (all suspended masses and wires) are estimated to be submitted to Calum by July 2.

2.3 Adjustment Range and Precision Measurements

The range of each adjustment and the precision of most adjustments on the HLTS have been measured; see E1000232. A summary of these measurements is presented below.

2.3.1 Intermediate Mass – Vertical Adjustment from Additional Mass

The height of the Intermediate Mass can be adjusted by adding mass; the relation is roughly linear. An additional mass of 750 grams decreased the height by 3.969 mm for a relation of 0.00529 mm per gram. With the smallest additional mass disk having a mass of 10 grams, the height of the Intermediate Mass can be controlled to within 0.0529 mm using additional mass.

2.3.2 Upper Mass – Vertical Adjustment from Additional Mass

The height of the Upper Mass can be adjusted by adding mass; the relation is roughly linear. An additional mass of 1000 grams decreased the height by 3.175 mm for a relation of 0.00318 mm per gram. With the smallest additional mass disk having a mass of 10 grams, the height of the Intermediate Mass can be controlled to within 0.0318 mm using additional mass.

2.3.3 Angled Upper and Lower Blade Clamps

The Upper and Lower Blade Clamps are produced in multiple versions with varying angles to angle the blade tips up or down. The Upper Blade Clamps (see D0900665) are produced with angles from 0 degrees to 3.5 degrees in increments of 0.5 degrees. With a distance of 250 mm from the blade clamp to the blade tip, the tips of the Upper Blades can be adjusted to +/-15.26 mm from the horizontal, with a precision of approximately 2.18 mm. The Lower Blade Clamps (see D0900681) are produced with angles from 0 degrees to 3.5 degrees in increments of 0.5 degrees. With a distance of 120 mm from the blade clamp to the blade tip, the tips of the Upper Blades can be adjusted to +/-7.33 mm from the horizontal, with a precision of approximately 1.05 mm.

2.3.4 Upper Mass – Roll Adjustment from Sliding Mass

The roll attitude of the Upper Mass can be adjusted by moving a sliding plate in the y-direction; see D030139. For the prototype, the position of the sliding plate for a level Upper Mass was 60.5 mm off-center in the +y-direction, which is very close to maximum adjustment. From symmetry, the total adjustment range of the sliding plate is 121 mm, which corresponds to a roll range of 88.5 mrad. The measured sensitivity of the roll adjustment is 0.5 mm in movement of the sliding plate (the smallest division of the ruler used), which corresponds to 1.1 mrad in roll. It is estimated that the sliding plate can be adjusted by hand to within approximately 0.25 mm, which would correspond to a roll adjustment of approximately 0.5 mrad.

2.3.5 Upper Mass – Pitch Adjustment from Upper Wire Position

The pitch attitude of the Upper Mass can be adjusted by moving the connection of the Upper Wire to the Upper Mass in the x-direction. The total range of this adjustment, from the position where the Upper Wire touches the front of the slot in the Upper Mass (see D020605 for the location and size of the slot) to the position where the Upper Wire touches the back of the slot in the Upper Mass, is 33.8 mrad.

2.3.6 Upper Mass - Pitch Adjustment from Sliding Mass

The pitch attitude of the Upper Mass can be adjusted by moving a sliding plate in the x-direction; see D020608. For the prototype, the position of the sliding plate for a level Upper Mass was 2.5 mm off-center in the +x-direction. The total adjustment range of the sliding plate is +/-21 mm (for a total of 42 mm of adjustment), which corresponds to a pitch range of 44 mrad. The measured sensitivity of the pitch adjustment is 0.5 mm in movement of the sliding plate (the smallest division of the ruler used), which corresponds to 4.4 mrad in pitch. It is estimated that the sliding plate can be adjusted by hand to within approximately 0.25 mm, which would correspond to a pitch adjustment of approximately 2.2 mrad.

2.3.7 Upper Blades – Yaw Adjustment from Rotational Adjuster

The yaw attitude of the entire suspension can be adjusted using the Rotational Adjuster. The total yaw adjustment available is 33.1 mrad (+25.8 mrad and -7.3 mrad from the balanced position). The yaw in the negative direction is limited by an interference in the push/pull screws.

2.3.8 Upper Blade Clamp Shims

The height of the entire suspension can be adjusted through the use of 1 mm shims (see D070331) in the Upper Blade Clamps. In the prototype, the nominal arrangement included one of these shims on each Upper Blade. In production, the nominal arrangement will not include the shims, so that the optic height can be increased 1 mm by adding these shims.

2.4 Software Implementation

A separate review of the software implementation in Simulink and MEDM screens should be undertaken. The timing of this review should be determined by Jay Heefner in concert with others.

2.5 Optic/Prism Bonding Testing

Testing of the procedure for bonding sapphire wire prism breakoff to an actual optic must be accomplished early enough to refine the procedure and tooling in advance of installation on the L1 interferometer. This testing is planned for an HSTS-type optic, which is the more difficult of the two HAM suspensions, and should be complete by the end of September.

2.6 Wire Diameter

Suspensions will explore the possibility of purchasing wire with a more closely controlled diameter, so that the vertical bounce frequencies can be better matched. This may be done through a custom order, or by selecting certain wire segments from a spool or spools. This should be complete by September.

2.7 Alignment Procedure

A checklist-type alignment procedure must be developed to reduce the difficulty in aligning the HLTS. Qualitative measures should be replaced by quantitative ones. This should be complete by September in preparation for the first assembly in April 2011.

2.8 Actions for Systems/Facilities

We are awaiting a timeline from Systems for these items.

2.8.1 Damping Struts or Tuned Mass Dampers

Either damping struts or tuned mass dampers will be used with the HAM suspensions.

2.8.2 Structural Bracing

Will adjacent HLTS and HSTS structures be joined across their tops for stiffening and potential damping?

2.8.3 Clamping Suspensions to Optics Tables

The clamping arrangement (number and types of clamps) must be determined for each HLTS.

2.8.4 HAM Suspension Installation Tooling

Complete the design of the HAM suspension installation tooling.