



WHAM3

AUTHOR(S)	DATE	Document Change Notice, Release or Approval
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Instructions on the use of this document:

- 1) Use, and complete, this document on a cleanroom compatible computer while the work is proceeding. This procedure, and all of the applicable documents, must be available at all times during the procedure.
- 2) Use this procedure as a check list for preparation and during the installation; As each step is completed, enter the name of the person completing the work (or approving or checking the step), as well as the date and any comments or notes. In particular, note any discrepancies or deviations and augment with any missing definition. **ALL NOTES MUST BE RECORDED IN THE COMPLETED VERSION OF THIS DOCUMENT (NOT IN OTHER NOTEBOOKS OR FILES).** If the additional notes are too cumbersome to include within the body of this completed procedure, then electronically attach them to the completed procedure.
- 3) Once completed, file the document in the LIGO Document Control Center (DCC) as the next highest version of the procedure and add a note that this is a completed/finished procedure.
- 4) File any significant notes or data from the completed procedure in the electronic logbook (such as any deviations); as a minimum note in the electronic logbook that the installation was completed in accordance with this procedure (cite document number and revision).

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1 SCOPE

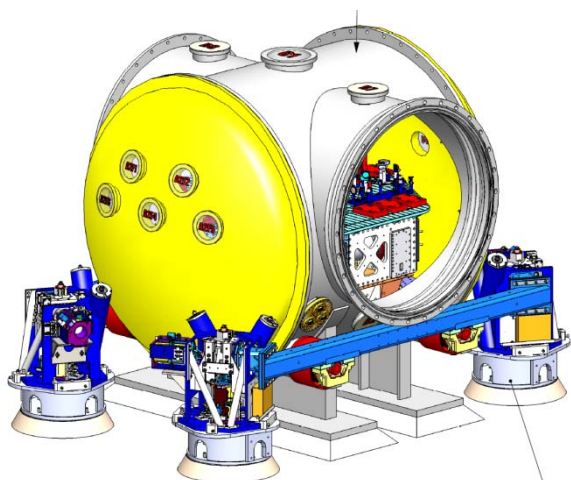
The scope of this procedure is installation of in-chamber components and assemblies in the WHAM3 chamber (see Figure 1), which are defined in the following documents:

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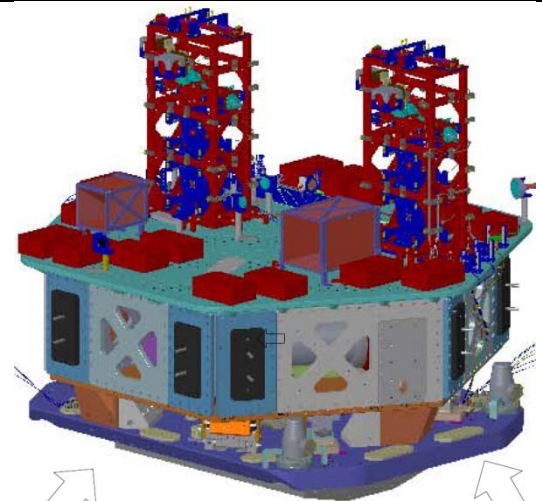
- LIGO-D0901094: [AdvLIGO Systems, HAM3-H1 Top Level Chamber Assembly](#)
- LIGO-D0901094: [HAM3-H1 Top Level Chamber Assembly BOM](#)
- LIGO-E1000183: [AdvLIGO Detailed Mass Properties-CG Report HAM Tables LHO](#)
- LIGO-F1100030: [aLIGO Systems HAM2/3 Related Documents](#)
- LIGO-D0901095: [AdvLIGO VE HAM3-H1, Vacuum Equipment Assembly](#)
- LIGO-D0901096: [AdvLIGO SEI HAM3-H1, XYZ Local CS for ISO Table](#)
- LIGO-D0901097: [AdvLIGO SUS HAM3-H1, Fully Detailed & Envelope for HSTS \(PR2, MC2\)](#)
- LIGO-D1001805: [AdvLIGO SEI HAM3-H1, XYZ Local CS for ISC Components](#)
- LIGO-D1002171: [AdvLIGO SEI HAM3-H1, XYZ Local CS for IO Optic Mounts Components](#)
- LIGO-D1002874: [Flange Layout - H1 Horizontal Access Module 3 \(HAM 3\)](#)
- LIGO-D1000514: [HEPI ASSEMBLY, HAM, aLIGO SEI](#)
- LIGO-D1000554: [AdvLIGO ZEMAX Laser Beam Rays & Optics, H1](#)
- LIGO-D1000907: [AdvLIGO HAM3-H1 ISI Table, Payload & Suspended Mass Assembly](#)
- LIGO-D1101463: [CABLE HARNESS ROUTING CONFIGURATION, HAM 3](#)
- LIGO-D1101296: [ALIGO, AOS, HAM Chamber, Optical Table, Hole Tabulation](#)
- LIGO-D1101775: [ALIGO, ELECTRICAL FEEDTHROUGH TYPES, TYPICAL SUBFLANGES, AND PORT CONFIGURATIONS](#)
- LIGO-D1200573: [AdvLIGO SUS HAM3-H1, XYZ Local CS for MC2 and PR2 Scraper Baffles](#)
- LIGO-D1200574: [AdvLIGO SEI HAM3-H1, XYZ Local CS for OptLev DLC Components](#)
- LIGO-D0901098: [AdvLIGO SUS HAM3-H1, XYZ Local CS for HSTS \(PR2\) Sub-Assy](#)
- LIGO-D0901099: [AdvLIGO SUS HAM3-H1, XYZ Local CS for HSTS \(MC2\) Sub-Assy](#)
- LIGO-D0901096: [AdvLIGO SEI HAM3-H1, XYZ Local CS for ISO Table](#)
- LIGO-D1101249: [ALIGO IO L1 HAM3 INSTALLATION PLATE LAYOUT*](#)

* These documents are not currently available for H1. In the mean time use L1 documents.

All of these documents are provided as “related document” links in the Document Control Center (DCC) entry for the top level chamber assembly drawing, [D0901094](#).



a) WHAM3 with vacuum equipment, HEPI



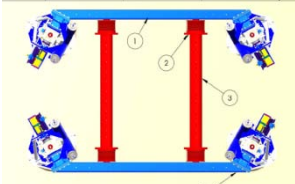
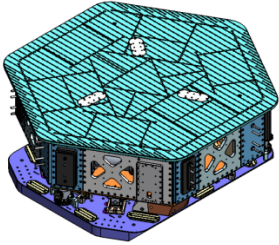

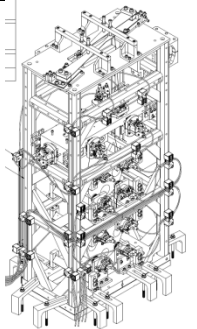
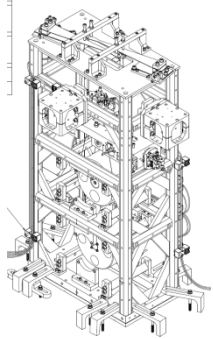
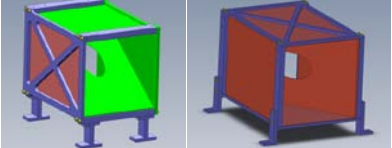
b) WHAM3 without vacuum equipment, HEPI, & ISI support frame

Figure 1 WHAM3 Installation



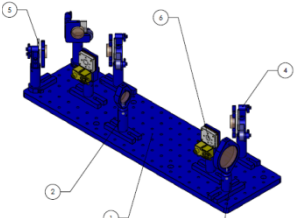
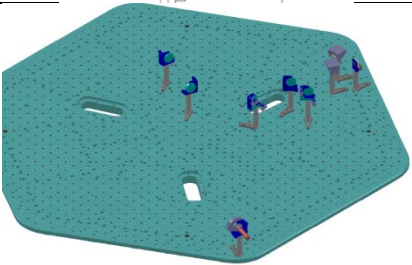

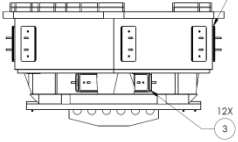
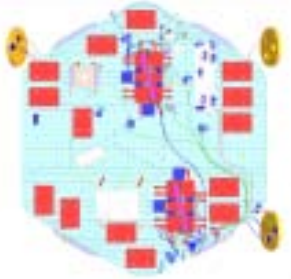
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This installation includes the following principal, sub-system major assemblies:

Subsys.	Assy Dwg	Sub-Assembly Name	Image
INS	D1000514	HEPI HAM Chamber Level Assembly	
SEI	D0901096	WHAM3-ISI assembly Includes: HAM ISI Table (D0900124) HAM ISI Spacer (D1101180)	
SYS	D1101309	Optic Table 1/4-20 LHAM2/LHAM3 Fiducial Kit	
SUS	D0901099	HSTS suspension assembly (MC2) including: HSTS Assembly (D020700) SUS Structure Spacer (D1100037) Vibration Absorbers (D1002424) Optics Cap (D1101143)	
SUS	D0901098	HSTS suspension assembly (PR2) including: HSTS Assembly (D020700) SUS Structure Spacer (D1100038) Vibration Absorbers (D1002424) Optics Cap (D1101143)	
IO	D1200573	IO MC2 Scraper Baffle Assembly Includes: MC2 Scraper Baffle (D1000327) PR2 Scraper Baffle (D1000328)	



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Subsys.	Assy Dwg	Sub-Assembly Name	Image
ISC	D1001805	ISC HAM3 Assembly Including: D1000339 assembly	
IO	D1002171	Optic Mount Components Includes the following 9 sub assemblies: <ol style="list-style-type: none"> D1002085 Rigid Optic Mount LH Assy. D1002075 Rigid Optic Mount RH Assy. (2 each) D1002088 Actuated Optic Mount RH Assy. (2 each) D1100789 aLIGO In-Vac QPD Assy. D1101043 aLIGO IO POP Beams 3" Optic Assy. D1101225 Black Glass Dump Assy. (2 each) 	
AOS/ OptLev	D1200574	DLC Assembly (D1101392)	
SYS	D1000907	WHAM3 ISI Table Balance Masses	
SEI/SYS	D1101775 D1101463	Electrical Feedthrough Types Cable Routing, HAM3	
AOS/SLC	T1100292	Viewport Source List	

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Safety	
E1100094	aLIGO HAM-HEPI switch/install hazard analysis
Drawings	
D0901094	aLIGO Systems, HAM3-H1 Top Level Chamber Assembly
D0901095	aLIGO VE HAM3-H1, Vacuum Equipment Assembly
D0901096	aLIGO SEI HAM3-H1, XYZ Local CS for ISO Table
D0901097	aLIGO SUS HAM3-H1, XYZ Local CS for HSTS (PR2, MC2)
D1000514	HEPI Assembly , HAM aLIGO SEI
D0901098	aLIGO SUS HAM3-H1, XYZ Local CS for HSTS (PR2) Sub-Assy
D0901099	aLIGO SUS HAM3-H1, XYZ Local CS for HSTS (MC2) Sub-Assy
D1200573	aLIGO SUS HAM3-H1, XYZ Local CS for MC2 and PR2 Scraper Baffles
D1000907	aLIGO HAM3-H1 ISI Table, Payload and Suspended Mass Assembly
D1002171	aLIGO SEI HAM3-H1, XYZ Local CS for IO Optic Mount Components
D1001805	aLIGO SEI HAM3-H1, XYZ Local CS for ISC Components
D1101463	Cable Harness Routing Configuration, HAM 3
D1200574	aLIGO HAM3-H1, XYZ Local CS for OptLev DLC Components
D1002874	Flange Layout - H1 Horizontal Access Module 3 (HAM 3)
D1101252	aLIGO IO H1 HAM3 Installation Plate Layout
D1101775	aLIGO, Electrical Feedthrough Types, Typical Subflanges, and Port Configurations
E1000183	aLIGO Detailed Mass Properties-CG Report HAM Tables LHO
F1100030	aLIGO Systems HAM2/3 Related Documents
G1000125	a LIGO BSC and HAM ISI Conventions
D1101296	aLIGO, AOS, HAM Chamber, Optical Table, Hole Tabulation

* These documents are not currently available for H1. In the mean time use L1 documents.

2 REQUIRED EQUIPMENT LIST

Each of the procedures referenced within this overall procedure call out required equipment and parts/assemblies. Below is listed only those parts or assemblies not covered in the subsidiary procedures.

- LIGO-D1101674: [aLIGO, SUS, BSC/HAM INSTALLATION TOOLING](#)
 - for transporting HXTS and OMC structures (sheets 4, 5 & 6)
 - Genie lift adapter plate, D110515

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Note: At LLO they used the old iLIGO lift table as the installation team found it easier.

- LIGO-D1101854: [aLIGO, HAM INSTALLATION ARM USAGE](#)
 - LIGO-D1001994: [aLIGO, HAM INSTALLATION ARM, ASSEMBLY, FLANGE MOUNT](#)
 - LIGO-D1002052: [aLIGO, ASSEMBLY, HAM ARM](#)
 - LIGO-D1001664: [HAM STRUCTURE LIFT ASSEMBLY, aLIGO, SUS](#)
 - LIGO-D1101674: [aLIGO, SUS, BSC/HAM INSTALLATION TOOLING](#)
 - see sheet 11 of D1101674
- LIGO-E1100831: [HAM Installation Arm User Guide](#)
- LIGO-D1001664: [HAM STRUCTURE LIFT ASSEMBLY, aLIGO, SUS](#)
 - HAM vertical lift, D1001667 (sheet 11)- 1 lift at each site (lifting arms, extenders being returned to CIT for rework). 1 spare at CIT

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date:

comments (optional):

3 PREREQUISITES

- Ensure Support Tubes are in nominal position, XYZ. See [T1100194](#), [T1100187](#) & [E1200625](#) leveling them to 0.4mrad
- Install HEPI per [E040011](#) and [E1100094](#). *Leave HEPI actuators disconnected.*
- Vent the vertex vacuum volume and set the purge gas flowing per procedure [M1000360](#). Follow the Lockout-Tagout procedure [M990190](#).

4 ISI INSTALLATION FOR WHAM3

4.1 Prepare the Chamber for ISI Installation

- The oxide layer removed from the interior of the HAM shells, and the HAM chamber certified as “clean”.
- Install the cable tray ([D1002704](#)) around the WHAM3 chamber.
- Install HAM Chamber Cleanrooms around the WHAM3 chamber and clean the chamber exterior and the region around the chamber.



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- Install the dial indicators on the HAM support tube ends
- Remove the WHAM3 Chamber Doors per procedure [M1000362](#)
- Install the electrical feed-throughs listed in [D1101463](#) into WHAM3 per procedure [M990173](#).

Note: The electrical feed-throughs can be installed later in the sequence.

- Install the field cabling from the electrical feed-throughs to the electronics racks. Field-route cables as necessary.

Note: The field cabling can be installed later, but must be done after the cable trays are in place, yet before the ISI is installed. For LLO, the field cabling was required for chamber-side testing but it was not necessary to connect it to the chamber prior to ISI installation. LHO installed cable trays after the ISI as it was found that the cable trays could interfere with the SEI dial indicators. Use caution when working around the SEI dial indicators.

- Install the viewports listed in [T1100292](#) for WHAM3, per procedures [E1100484](#) and [M990173](#)

Note: The viewports can be installed later in the sequence.

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date:

Version numbers of all subsidiary documents followed:

comments (optional, e.g. deviations, exceptions, problems, "punch-list"):

4.2 Install the WHAM3 ISI Assembly

- Install the ISI assembly into the vacuum chamber per [E080012](#).
- Install ISI dummy mass payload.
- Float HEPI.
- Elevate and level ISI table to ± 0.1 mrad as per [E1000403](#) and [E1200470](#).
- Align X, Y, and yaw (about Z) of ISI optical table per [E1200470](#).
- Install HEPI Actuators. Confirm table alignment if motion indicated on dial indicators suggest that may be required.
- Install all SEI in-vacuum cabling, and all other subsystem in-vacuum cabling per [D1101463](#). *During install all cables needs to be quality control checked watching for grounding points noted in [T1200266](#) (this doc is specific to suspensions, but offers good guidance which can be applied to all cables as a heads up on grounding issues.*

**WHAM3**

- Check optical table alignment (level, X, Y, yaw about Z) per [E1200470](#).

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date:

comments (optional):

4.3 Perform final HAM-ISI testing/characterization prior to payload integration

- Perform the phase II testing associated with HAM-ISI installation prior to attaching payload to the optics table, (ie perform Step 6 in [E1100994](#)).
- Lock HEPI.
- Lock ISI.
- Remove Dummy Payload Mass.

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date:

comments (optional):

5 PAYLOAD INSTALLATION IN THE WHAM3 CHAMBER

The WHAM3 assembly is depicted in Figure 3. The major optics assemblies integrated into the WHAM3 assembly are the Power Recycling Mirror 2 (PR2) suspension assembly ([D0901098](#)), and the Mode Cleaner Mirror 2 (MC2) suspension assembly ([D0901099](#)).

WHAM3

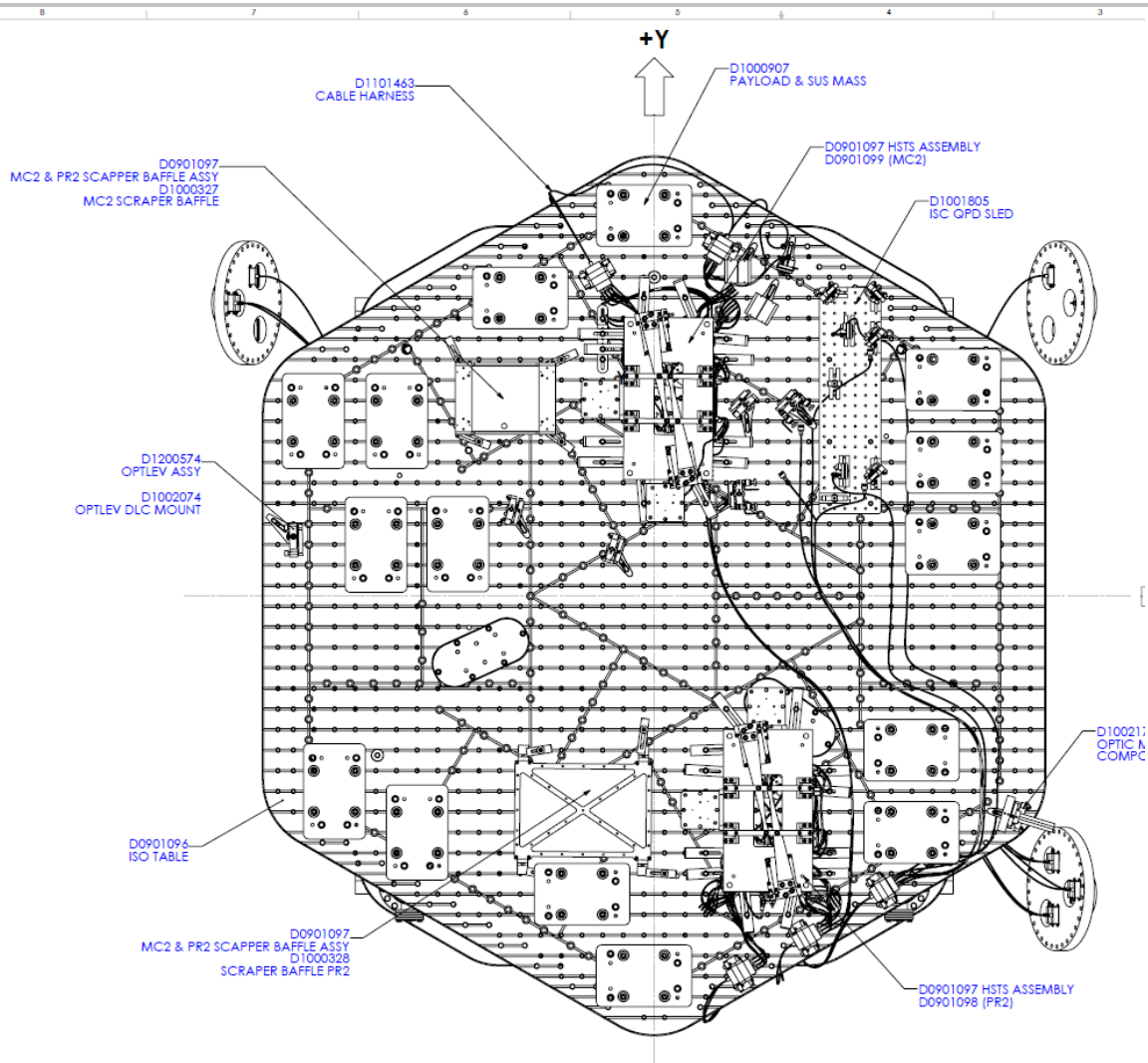


Figure 2 WHAM3 ISI Assembly ([D0901094](#))

5.1 Prerequisites

- Complete Phase 2b testing of SUS.
- Ensure optic has been inspected, cleaned, and protected as per [T1200321](#).
- Install FirstContact peel tab per [E1000079](#).

5.2 Weigh the full suspension payloads

- Weigh the full MC2 HSTS suspension, record below
- Weigh the full PR2 HSTS suspension, record below

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- Systems to confirm, or revise, the mass balancing plan ([E1100742](#), “aLIGO Detailed Mass Properties-CG Report HAM Tables (LLO)”) and drawing of the balance mass locations: [D1000907](#), aLIGO HAM3-H1 ISI Table, Balance Masses Assembly

Payload	Mass (Kg)	Comments/caveats
MC2 HSTS Suspension		
PR2 HSTS Suspension		

- completed, approved or checked by:*
date:

comments (optional):

5.3 Install the Fiducials

- Install the WHAM2/3 Fiducial Kit (D1101309) into their designated hole locations using [D1101296](#) as a guide.

5.4 Installed the main suspension payloads

- Install HAM installation arm on Left side of the HAM3 EAST chamber flange.
- With ISI locked, install the HSTS suspension assembly MC2 in WHAM3 per [D0901099](#) and Section 6.2.1 steps 4 a) thru d) of [T1000097](#).
- Install Cable Table Brackets for MC2 as per [D1101463](#) and connect all SUS in-vacuum cables to the ones laced up the ISI in Section 4.2 above.
- Check grounding and fix if any found.
- If Vibration Absorbers have not already been installed on MC2, do so as per [D0901099](#) and remove locker pins.
- With ISI locked, install the HSTS suspension assembly PR2 in WHAM3 per [D0901098](#) and Section 6.2.1 step 4 a) through d) of [T1000097](#).
- Install Cable Table Brackets for PR2 and any other subsystems as per [D1101463](#) and connect all SUS in-vacuum cables ([D1000234](#) quadrapuss) to the ones laced up the ISI in Section 4.2 above.
- Check grounding and fix any found.
- If Vibration Absorbers have not already been installed on PR2, do so as per [D0901098](#) and remove locker pins.
- Remove optic shielding and suspend PR2.



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- Perform SUS Phase 3a Testing of PR2 as per [G1200070](#).
- Perform B&K Hammer Testing of PR2 per [T1000606](#).
- Remove optic shielding and suspend MC2.
- Perform SUS Phase 3a Testing of MC2 as per [G1200070](#).
- Perform B&K Hammer Testing of MC2 per [T1000606](#).
- Lockdown PR2 and MC2 and install optic shielding.
- Deinstall the HAM installation arm.

5.5 Install the IO components, Optical Lever mirrors and balance mass

- Install all WHAM3 IO payload as per Section 6.2.1 steps 6 thru 9 of [T1000097](#).
- Install optical lever mirror components as per [D1200574](#).
- Install the ISI balance masses as per [D1000907](#) and balance table as per XX.
- Perform Step 8-10 of HAM-ISI Phase II Testing [E1100994](#).

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date:

comments (optional):

5.6 Align the Optics

- Align the PR2 SUS per [E1200470](#). *Note: this may require locking both MC2 and PR2 and ISI numerous times.*
- If large errors require significant adjustment in the suspension, recheck TFs as per Phase 2b testing [G1200070](#).
- Align the MC2 SUS per [E1200470](#).
- If large errors require significant adjustment in the suspension, recheck TFs as per Phase 2b testing [G1200070](#).
- Remove any IAS fixturing.
- Adjust the HSTS pitch per [T1100091](#).

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**WHAM3**

comments (optional):

6 Final operations

Check that the following have already been done in prep for closing chamber:

- Perform chamber inspection for tools, loose items, etc. Take final configuration pictures and data (count PEEK components).
- Remove all optic covers.
- Remove any TFE SUS Earthquake stop fixturing.
- Remove locker pins from vibration absorbers.
- Remove FirstContact from optics as per [T1200321](#) and [E1000079](#).
- Inspect optic surfaces and reclean as needed per [T1200321](#).
- Set all SUS Earthquake stop gaps to 0.75mm gap (0.6 turns of screw).
- Lock all SUS Earthquake stop nuts.
- Set witness plates.
- Close doors.
- Perform SEI Phase III Testing and SUS Phase 3b Testing as per [G1200070](#).

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date:

comments (optional):