# ALIGO INSTALLATION INSTANCE ACCEPTANCE DOCUMENT

# Title: aLIGO Installation Acceptance Document for LBSC4 (X)

This document covers the technical content for acceptance review of a subset of the Advanced LIGO (aLIGO) installation. See document M1300468 for an overview of the aLIGO acceptance process. Acceptance by Systems Engineering is to be indicated in the metadata for this document in the LIGO Document Control Center (DCC).

## 1 Installation Instance/Subset Definition

*Insert a brief description of the subset of the aLIGO equipment which is covered under this installation acceptance document. Complete the entries in the following table. If elements of the table are not applicable, enter "not applicable".*

This installation covers the BSC chamber LBSC4 and all of the equipment within and attached plus associated electronics racks.

| | |
|---|---|
| **Interferometer** [*L1 or H1*]: | **L1** |
| **Building**(s)/**Room**(s): [*e.g. corner/LVEA*] | **LVEA** |
| **Vacuum Chamber**(s): | **LBSC4 (X ARM)** |
| **Electronics Rack Designation**(s): | L1-VDC-XC1, L1-VDC-XC2, L1-SEI-XC1, L1-SUS-XC1, L1-SUS-XC2, L1-SUS-XR1, L1-ISC-XC1, L1-ISC-XR1, L1-TCS-XC1<br>Note that the Capacitive Position Sensor readout boxes which sit on the cable trays do not have an official designation. |
| **Optics Table(s)/Enclosure(s) Designation**(s), and other equipment/assemblies related to this installation: | ETMX Cryo-Pump Baffle , Optical Lever and Photon Calibrator , ISCTEX Table , STS-2 Ground Seismometer. |

## 2 Procedures

If there are any caveats or explanatory notes regarding the procedure documentation cited in the table below, then add these notes to the table entries.

| | |
|---|---|
| **Baseline or initial Installation Procedure**(s):<br>*[enter linked DCC document #(s); found under E1200023]* | We used https://dcc.ligo.org/E1200344-v4 for our install procedure. Redlined versions are attached to this document in the DCC> |
| **As-Built/Installed Procedure**(s), either:<br>a) Enter hyperlinked DCC number for revised or red-lined baseline install procedure, and/or<br>b) Enter hyperlinked DCC number for separate document with installation notes on | No as-built notes were recorded in document E1200269. However some as-built notes ("red lines") were recorded in the file name BSC4INSTALL.pdf which is filed as an "other file" |

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| deviations, changes in procedure, changes in tooling, etc., and/or<br>c) Enter a list of hyperlinked electronic log entries detailing the experience in applying the baseline installation procedure | with E1200344-v4, the BSC Cartridge installation procedure.<br><br>This installation event (including cartridge weight measurement) was occurred 31 Oct 2013 and was recorded in LLO elog #9459 |
| **Baseline or initial Alignment Procedure**(s):<br>*[enter linked DCC document #(s); found under E1100734]* | E1200956-v5 was the initial procedure |
| **As-Built/Aligned Procedure**(s), either:<br>a) Enter hyperlinked DCC number for revised or red-lined baseline alignment procedure, and/or<br>b) Enter hyperlinked DCC number for separate document with alignment notes on deviations, changes in procedure, changes in tooling, etc., and/or<br>c) Enter a list of hyperlinked electronic log entries detailing the experience in applying the baseline alignment procedure | E1200956-v6 is the as-built alignment procedure, with embedded notes.<br><br>The LBSC4 cartridge alignment was recorded in LLO elog #8990<br>The CMBx installation was recorded in LLO alog #8913, with follow-up work in LLO alog #8956 and #9024.<br>The in-chamber ETMX alignment was recorded in LLO alog #10035. Note that there was a tweak made to the pitch alignment after some initial commissioning. This is recorded in LLO alog #10752.<br>There was also follow up work on TMSx alignment, this was done using green beam. See for example alog #10822.<br>The ETMx ACB installation is recorded in LLO alog #9493. The alignment was not recorded in the LLO alog except for a comment in entry #10035 that it is within tolerance.<br>OptLev alignment: #11145 |

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## 3 Drawings

*Enter hyperlinked DCC document number(s) for each drawing in the table below. If elements of the table are not applicable, enter "not applicable". All chamber-level, assembly drawings can be found listed at E1200562 and found linked under D0901491.*

| | |
|---|---|
| Applicable Building/Room Top-Level Drawing(s): | D0901465 aLIGO Systems Layout LLO X-End Station |
| Top-Level Chamber Assembly Drawing(s): | D0900471 aLIGO Systems, LBSC4-L1 Top Level Chamber Assembly |
| Electronics Rack Drawing(s): | All drawings for the racks can be found by navigating through G1001032. |
| ETM Optical Lever Drawing(s): | G1000701 Floor Occupancy, Optical Levers, LLO X-End Station. |
| Cryopump Manifold Baffle Dwg(s): | D1003181 Manifold_Cryo_Baffle_Assembly, ETMX |
| PCAL Video CAM Periscope | D1200174: aLIGO, PCAL-VIDEO CAM, PERISCOPE |
| Photon Calibrator Transmission Pier Assembly | D1000676: aLIGO AOS Photon Calibrator Transmission Pier Assembly |
| ISCTEX | ISC Table containing ALS optics etc. The drawing is D1201448, an annotated version will be attached as a related file. |

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## 4 Serial Number Records

*Serial numbers are used to track a subset of the parts, particularly active elements (see M1000051) and electronics (with S-numbered documents; see T0900520). Enter the hyperlinked DCC document number(s), and name(s) for the highest level assembly(ies) covered by this installation acceptance document in the table below. Also enter the hyperlink to the ICS entry for the instance of this assembly in the Inventory Control System (ICS). If elements of the table are not applicable, enter "not applicable". If elements of the table are not available/missing, then enter "not available".*

| Assembly DCC D-Number | Assembly Name | ICS entry |
|---|---|---|
| D0900471 | aLIGO Systems, LBSC4-L1 Top Level Chamber Assembly | https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D0900471-NA |
| D1000513 | HEPI | N/A (assembly and install done in 2004, before ICS) |

## 5 Testing

*All post-installation, stand-alone, in situ, checkout/testing (phases 2 and 3 per M1000211) must be completed, be successful and be documented:*

- *phase 2: pre-installed, post-storage, test results for the assembly (testable item)*
- *phase 3: stand-alone, in situ test results for the assembly (testable item)*

*Note that integrated testing (phase 4 testing per M1000211) is covered under the system acceptance review, not this installation acceptance review. In the table below, enter hyperlinked DCC document number(s) for all of the relevant testing for the major subassemblies/subsystems covered within this installation instance/subset. If elements of the table are not applicable, enter "not applicable". If elements of the table are not available/missing, then enter "not available".*

| Subsystem | Testable Item | DCC document numbers | |
|---|---|---|---|
| | | Phase 2 | Phase 3 |
| SEI | BSC-ISI | LIGO-E1100858 | |
| SEI | HEPI | N/A | E1300932 |
| SUS | BSC3 Suspension (under *Test Results*) | E1400080 | E1400080 |
| AOS/SLC/Viewports | Leak and pressure testing. | E1200445 Leak and pressure testing was completed, refer to above link. All viewports were tagged at time of inspection and testing. | Visual inspection in-situ not completed, refer to bug list. |

| | | | |
|---|---|---|---|
| AOS/OpLev | OpLev Impulse Hammer Modal Testing at CIT. | T1100152 | Not Completed |
| AOS/ACB | Photodiode continuity testing.<br>In-situ operation. | E1300375<br>Not envisioned at start. Diodes used for alignment of beam thus confirmed working. | |
| AOS/ACB | Impulse Hammer Modal Testing | One instance of testing completed, refer to LHO e-log entry 8656. | |
| AOS/CMB | Impulse Hammer Modal Testing | | aLOG #9024 |
| AOS/TCS/RHx | Collection, refer to link. | N/R | T1300495 and G1400018<br>Install Recorded in LLO aLOG #8478<br>Small Tweak in aLOG #10117 |
| TMSx | Transfer Functions<br>B&K Hammer Test | Phase 3a in #10862<br>Phase 2a in #9243 | Phase 3b in #11354<br>No in-chamber tests. |
| ESD | ESD install/testing for the quads | (E1300848) | #12018, #12145 and #12160 for LBSC4 |

## 6 Installation Completeness

*If/as applicable, provide a hyperlink reference to a list of remaining tasks to be completed before the installation is finished (i.e. a 'punch' list).*

| | |
|---|---|
| Installation tasks remaining to be completed: | **All items are installed.** |
| ICS Assembly Record needs to be updated | There are some issues with ICS which are affecting this task. Some TCS and SLC records have been added but do not appear. Still need to add viewports, Oplev periscope and perhaps misc. other items to the ICS records. |

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## 7 Installation/Integration Issues and ECRs

*If/as applicable, provide a hyperlinked list of integration issues and Engineering Change Requests (ECRs) encountered during installation and which are relevant to the installation subset/instance covered by this acceptance document. See M1300323 for a description of the Integration Issue and ECR Tracker.*

| Tracker # *[hyperlinked]* | Title/description |
|---|---|
| | |
| #3 closed | Unintentional ground connection at GS-13 pods |
| #26 closed | LLO End Station Rack layout missing ISC rack |
| #27 closed | Improve robustness of electrical connections for TCS UHV Temperature Sensing |
| #30 closed | Change Locating Dimensions of Pcal Transmitter and Oplev/Pcal Receiver Installations in all End VEAs |
| #31 closed | ECR: Modifications to Photon Calibrator Periscope Structures |
| #34 closed | ECR: Add PEM, timing chassis to end-station TCS Remote racks |
| #35 closed | ECR: Add Beckhoff, Dolphin equipment to end-station DAQ racks |
| #44 closed | Removal of ETM HWS secondary beam |
| #49 closed | Changes to TMS post LLO initial build |
| #55 closed | Modifications to Photon Calibrator Periscope Structures (duplicate of #31) |
| #61 closed | ECR - Pcal Periscope Mirror Alignment Pin |
| #63 closed | ECR: Dog Clamps for SLC suspended baffles |
| #67 closed | ECR – Manifold/Cryopump Baffle Suspension Flexure has inadequate strength |
| #78 closed | SUS Electronics Missing/Incomplete/Out-of-date Drawings |
| #80 | Possibility of damage to ESD pattern on ERMs and CPs due to arcing |
| #81 | add vacuum hardware to TM chambers for future instruments without venting |
| #92 closed | ports misidentified on End 2 EtherCAT chassis |
| #97 | Add direct wire connection between RT and EtherCAT systems |
| #105 closed | Remake Manifold Cryopump Turnbuckle Handle |

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| #111 closed | Modify Manifold Cryopump Copper Plate (D1100821) to add grooves for o-ring bumper stops. |
| #115 | TOP driver for Quad suspension: DC current range mismatch |
| #118 closed | ECR: HEPI medm screen update |
| #182 closed | ECR: BSC-ISI and HEPI MEDM (Duplicate of #500) |
| #183 closed | Change the CPS biases from the local basis to the calibrated cartesian basis (Duplicate of #205) |
| #186 closed | ECR: Topology Changes to SUS models as a result of ISC Informed Interaction |
| #191 closed | Droopy Quad top mass blades |
| #205 closed | ECR: Add Cartesian bias monitoring and offsets to the ISI models |
| #207 closed | ECR: Model and screens update to allow sensor correction to the ISI using Ground seismometers (STS-2) |
| #215 closed | Purchase additional F1 Mirrors (D1102335) from higher quality vendor. Strip, resurface and recoat mirrors in-house or ship back to vendor.<br>**LLO TMSx was already assembled and did not receive new mirrors (BO'R)** |
| #236 | Addition by welding of Pcal Receiver Mounting Blocks to six Oplev/Pcal Receiver Pylon Weldments. |
| #253 closed | ECR – minor rework/modifications to the Manifold Cryopump Baffle Assembly |
| #261 closed | Issues arising from LLO TMSx primary optic being too thin |
| #283 | CPS Circuit Modification to eliminate a high frequency oscillation |
| #327 | Odd High-frequency behavior from all SUS Top2Top Transfer Functions |
| #355 closed | ECR: Modify HAM-ISI and BSC-ISI simulink control filters to monitor gain for ODC |
| #359 closed | Modifications to TMS tablecloth and cable routing during TMSx build at both LLO and LHO |
| #375 closed | ECR: Migrate the ISI Checker Script functions to the frontend code |
| #385 closed | ECR: create science frame channels for the SEI models |
| #445 closed | ECR: Update the SAFE level for the BSC and HEPI model watchdog |

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| #459 closed | Add XTerm window pop-up for BSC-ISI and HAM-ISI transition command buttons (Duplicate of #650) |
| #482 | ECR: ODC changes in SUS, SEI, HPI and PSL |
| #487 closed | ECR: Remove ISI IPC links which come from SUS offload |
| #489 closed | Duplicate cable number in end station wiring diagram |
| #500 closed | ECR: HEPI MEDM Update |
| #524 closed | 27 out of 30 Silicon Photodiodes have suffered bond wire failure |
| #530 closed | ECR: update to the HEPI master model and related MEDM screens |
| #551 closed | ECR: HEPI script update |
| #556 | TCS End Station EtherCAT chassis design modifications |
| #557 | Lack of Baffle Photo-diode Readback |
| #562 closed | Readbacks for arm cavity baffle photodiodes (Duplicate of #557) |
| #589 | Alignment drift of the ALS return beam in the end station |
| #614 closed | ETM HR coating for green out of spec |
| #629 | CPS Racks Grounding Schemes |
| #630 | CPS cross talk |
| #650 | ECR: ISI model update - Jan 2014 |
| #652 closed | Acquisition of green arm transmitted power |
| #662 | Use of GE FANUC RFM cards on end-station SEI, SUS front-ends |
| #664 | 5V regulator failing on Timing Comparators |
| #668 | DC Switch Breaker Box Install in Pier Pod and TCS ISS Power cords. |
| #696 | Adding auto-alignment for ALS |
| #697 closed | L1 ETMX (QUAD) main chain pitch to vertical cross coupling |
| #713 | AA/AI placement in End Station Remote rack |
| #716 | Add a relay switch for ALS laser noise eater |
| #721 | ECR: Replace the custom cartesian-bias-ramping code with cdsFiltCtrl2 parts |
| #722 | ECR: Adding Independent ASC IPC Paths for Dither Alignment to Most SUS |

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| #724 closed | Updating documentation on ITM and ETM coating specifications |
| #738 | Seismic Responsible Sus cable going directly from Stage 2 to Stage 0 on L1 ETMX |
| #746 | ECR: store suspension mis/alignment values separately in EPICS database |
| #751 | Op Lev Cover for lead bricks |
| #759 closed | Add BLRMS for OpLevs on suspensions |
| #761 | In Situ, Visual Inspections of All Viewport Windows |
| #762 | Increase drive range for the ETM UIM actuators |
| #776 closed | Syncing the CPS Timing to the GPS (Duplicate of #630) |
| #777 | Low signal strength for green PFDs |
| #788 | mechanical problems with the Optical Levers (OptLev) at both sites |
| #822 | LBSC4 (ETMX) Issue Tracker |