



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1300878-v4

LIGO

26 November 2013

HAM Tip-Tilt Suspension Acceptance Documentation

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Distribution of this document:
LIGO Scientific Collaboration

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1 Requirements documentation

The design requirements document must be brought up to date, and pointers to background material, analyses, etc. added to the Requirements document. Pointers to prototyping endeavors including testing results if they are not superseded by subsequent testing should be included here.

The design of the HAM Tip-Tilt Suspension (HTTS) has been an iterative process, starting with eLIGO, lessons learned and an initial prototype. This process have been collected and written up in a single document, ‘aLIGO ISC Beam Steering – Tip-Tilt Mirror Design’ ([T1000042](#)).

- a. Design Requirements Document: [T1000042](#), Section 2
- b. aLIGO ISC Beam Steering – Tip-Tilt Mirror Design: [T1000042](#)
- c. Tip-Tilt Mirror Suspension – Beam Steering for the Advanced LIGO Sensing and Control Signals ([P1100090](#))

2 Design overview and detailed design documentation

a) *Final Design Documentation:*

Mechanical

- aLIGO ISC Beam Steering – Tip-Tilt Mirror Design ([T1000042](#))
- aLIGO Tip-Tilt (HTTS) Suspension Blade calculations ([E1300846](#))
- HAM TIP-TILT SUSPENSION Controls Arrangement ([E1400316](#))

[HTTS_COM_with_pitch_screw.png](#) in the ‘Other Files’ of [D1001396](#) the aLIGO Tip-Tilt Mirror Assembly.

Electrical

- aLIGO HAM-A Coil Driver Board Prototype Test Plan ([T1100084](#))
- SUS HAM-A Coil Driver Design Study ([T1200264](#))

ISC Final Design Review (aLIGO Wiki), https://awiki.ligo-wa.caltech.edu/aLIGO/ISC_Final_Design_Review

b) *Review reports:*

- i. Review Report Interferometer Sensing and Control Final Design : [T1000334](#)
- ii. Responses: found on pages 8, 9 and 18 of the above report; all questions were addressed

c) *Supporting design documents:*

Mechanical

- aLIGO HAM Tip-Tilt Suspension Assembly Procedure ([E1100440](#))
- aLIGO Tip-Tilt Assembly Report ([F1100007](#))
- aLIGO HAM Tip-Tilt Suspension Preferred Fasteners List ([E1100442](#))

Electronics

Custom Cable V25N-8-5-8-5-v8 ([D1000228](#))
 aLIGO HAM-A Coil Driver ([D1100117](#))
 aLIGO HTTS Controls Design Description ([T1400030](#))

Modeling

Adding ECD to Matlab/Mathematica SUS models ([G1400012](#))

d) Drawings:

Mechanical

aLIGO Tip-Tilt Mirror Assembly, Top Level Drawing: [D1001396](#)

Electrical

aLIGO Production HAM-A Coil Driver Chassis Top Assembly Drawing - [D1100687](#)

e) Bill(s) of Materials (BOM): cite any collected BOMs. If the BOMs are only to be found on the Assembly and Sub-Assembly drawing sheets, then state so.

Mechanical

The BOM is listed on the top overview drawing, ‘aLIGO Tip-Tilt Mirror Assembly - [D1001396](#)’

Electrical

The BOM for the chassis is listed on top assembly drawing, ‘aLIGO Production HAM-A Coil Driver Chassis Top Assembly Drawing - [D1100687](#)’

The BOM for the coil driver PCB is listed under ‘Other Files’ in the dcc file card ‘aLIGO HAM-A Coil Driver - [D1100117](#)’, labeled ‘Gerber Files and BOM and ODB++’.

f) Interface control: cite any documents (such as RODAs) with interface definition/control and/or cite the relevant sections of the DRD and FDD.

None.

g) Software: cite any software design description documentation. If not applicable, or not available, then state so.

An ‘aLIGO SUS Operators Manual’ has been compiled on the aLIGO wiki, page [https://awiki.ligo-wa.caltech.edu/aLIGO/Suspensions/OpsManual/HTTS, /Screens](https://awiki.ligo-wa.caltech.edu/aLIGO/Suspensions/OpsManual/HTTS,_/Screens) (courtesy of Mark Barton)

h) Design source data:

Mechanical

The mechanical design drawings are in the LIGO Solidworks Vault, under ISC.

Electrical

The electronics Altium Project files are listed under ‘Other Files’ in the dcc file card ‘aLIGO HAM-A Coil Driver - [D1100117](#)’, labeled ‘Altium Project File Rev V2’.

3 Materials and fabrication specification

Any special materials, or treatment of materials including preparation for in-vacuum use; this may be integrated into the Design documentation.

There is a granted ‘Viton Waiver Request’ for the small viton o-rings in the vertical blade assemblies. This is listed under ‘Other Files’ in ‘aLIGO Tip-Tilt Mirror Assembly - [D1001396](#)’, labeled ‘[Viton Waiver Request – Granted.pdf](#)’.

The original shipped suspension wires are replaced by proper LIGO approved wire. This communication is listed under ‘Other Files’ in ‘aLIGO Tip-Tilt Mirror Assembly - [D1001396](#)’, labeled ‘[LHO HTTS Suspension Wire –Replacement Sourced.pdf](#)’.

4 Parts and **in-process** spares inventoried

All elements of aLIGO must be recorded in the ICS or in the DCC using the S-number scheme. As-built modifications for parts or assemblies should be found here.

All HTTS’s are in ICS, as assemblies using the assembly drawing number: ASSY-D1001396-SN. There are 29 assembled HTTS’s. Each interferometer uses 5, and 1 designated spare.

In addition, 4 units are used at the 40m prototype, and 1 unit used in outreach at LHO. This leaves a generous number of spares (6).

HTTS D1001396 ICS listing can be found at https://ics-redux.ligo-la.caltech.edu/JIRA/secure/IssueNavigator.jspa?reset=true&&customfield_10250=D1001396

LLO RM1, HAM1, S/N 23: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-23>

LLO RM2, HAM1, S/N 05: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-05>

LLO OM1, HAM6, S/N 10: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-10>

LLO OM2, HAM6, S/N 31: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-31>

LLO OM3, HAM6, S/N 11: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-11>

LLO SPARE-LBR, S/N 03: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-03>

LHO RM1, HAM1, S/N 24: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-24>

LHO RM2, HAM1, S/N 22: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-22>

LHO OM1, HAM6, S/N 02: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-02>

LHO OM2, HAM6, S/N 04: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-04>

LHO OM3, HAM6, S/N 33: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-33>

LHO SPARE-Optics Lab (mezzanine), S/N 09: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-09>

CIT-40m, TT1, S/N 30: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-30>

CIT-40m, TT2, S/N 18: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-18>

CIT-40m, storage, S/N 01: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-01>

CIT-40m, storage, S/N 28: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-28>

In Storage

LHO, STORAGE/mezzanine, S/N 06: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-06>

LHO, STORAGE/mezzanine, S/N 07: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-07>

LHO, STORAGE/mezzanine, S/N 08: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-08>
LHO, STORAGE/mezzanine, S/N 12: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-12>
LHO, STORAGE/mezzanine, S/N 16: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-16>
LHO, STORAGE/mezzanine, S/N 19: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-19>
LHO, STORAGE/mezzanine, S/N 20: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-20>
LHO, STORAGE/mezzanine, S/N 26: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-26>
LHO, 3rd IFO STORAGE/mezzanine, S/N 25: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-25>
LHO, STORAGE/mezzanine, S/N 27: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-27>
LHO, STORAGE, S/N 32: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-32>
LHO, STORAGE, S/N 34: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-34>
LHO, STORAGE, S/N 36: <https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1001396-36>

5 Assembly procedures

All assembly procedures must be in the DCC and annotated or updated for lessons learned. Storage, if used, should be described here along with procedures to maintain the equipment in good condition (e.g., purge frequency). Transportation procedures and cautions must be noted.

aLIGO HAM Tip-Tilt Suspension Assembly Procedure ([E1100440](#)).

6 Installation procedures

All installation procedures must be in the DCC and annotated or updated for lessons learned.

aLIGO HAM Tip-Tilt Suspension Installation Procedure [E1300887-v3](#), section 4.1 In-Chamber Installation.

7 Test documents

Test rationale, plans, and data for each unit must be documented as described in M1000211. That tree structure should be pointed to by the overall tree structure laid out in this Acceptance prescription. The top-level objective is to make clear how the measurements performed, which often will not directly measure a required performance parameter, give confidence that the subsystem will fulfill the requirements.

Phase 3a, In-Chamber Testing Procedure

- aLIGO HAM Tip-Tilt Suspension Test Plan [E1300887-v3](#), section 4.2 Phase 3a – In-Chamber Testing.

Phase 3b – In-Vacuum Testing Procedure

- aLIGO HAM Tip-Tilt Suspension Test Plan [E1300887-v3](#), section 4.3 Phase 3b – In-Vacuum Testing.

Test reports are in E1400218, which has a short summary, while in ‘other files’ the LHO and LLO Report are available and has links to the various aLOG entries.

8 User interface software

User interface software, and the test routines indicating proper functioning of the software, must be described in words and have code under configuration control (SVN). Watchdog and Guardian routines must also be treated in this way.

An ‘aLIGO SUS Operators Manual’ has been compiled on the aLIGO wiki, page <https://awiki.ligo-wa.caltech.edu/aLIGO/Suspensions/OpsManual/HTTS/Screens> (courtesy of Mark Barton)

9 Operation Manual

*A manual appropriate for operators, written in accordance with M1200366, covering setup/initialization, check-out, operating instructions, calibration, maintenance, **operations spares plan**, storage/transport and troubleshooting. It must be accessible from standard user screens.*

An ‘aLIGO SUS Operators Manual’ has been compiled on the aLIGO wiki. The MEDM Screens can be found at <https://awiki.ligo-wa.caltech.edu/aLIGO/Suspensions/OpsManual/HTTS/Screens> (courtesy of Mark Barton)

10 Safety

Safety documentation must be in the DCC for all phases of the subsystem development, including any needed for normal use or foreseen maintenance/repair scenarios.

N/A.