LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1100570-v5 *Advanced LIGO* Date: 29-Jan-15

Thermal Compensation System (TCS): CO2 Laser Projection System (CO2P): Final Design Document

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1 Introduction

The purpose of this document is to provide a guided overview of the final design of the TCS CO_2 laser projection system (CO2P) for Advanced LIGO (aLIGO), making reference to external documents where necessary. With this document, the final design review (FDR) committee is to determine whether:

1. The CO2P satisfies requirements for TCS actuation on the compensator plate while performing with minimal noise
2. The procurement plan CO2P equipment is adequate
3. Installation of the CO2P can be achieved within the aLIGO Project schedule
4. Sufficiently mature plans exist to ensure continuous reliable operation of the CO2P
5. Costing has been reconciled with the baseline budget
6. Safety concerns have been addressed
7. Interfaces have been defined

All the links presented here are also accessible from the DCC entry for this document.

2 Priority Issues identified for consideration

This section presents unresolved issues up front.

2.1 Outstanding issues

- **Modeling**:
    - Analytical validation of electrical and mechanical noise, for all of the actual components, has not been completed.

2.2 Risk reduction proposals

- Ongoing modeling of interferometer and signal recycling cavity. This modeling will serve to help us understand the operation of TCS and may feedback to requirements on the laser projection system to improve ease of use. [Operations and beyond]
- Use of raster scanning to reduce the effects of changing beam shape. This is difficult to implement due to noise couplings and potentially may suffer from up-conversion. [Operations and beyond]

2.3 Early approval

We request that the FDR committee approve the following items ASAP:

- One possible way to supply adequate power to the RF driver for the laser is to assembly standard 24V supplies in series. Alternatively, a vendor for a custom (linear) supply with >28V and 28A must be identified as soon as possible. In this alternative case, support from Project Systems (SYS) and Controls (CDS) is requested. A candidate switching supply (model 6684A, from Agilent) has been identified by the CDS group; the TCS group would like to purchase and evaluate one in the lab at Caltech as early as possible. However, this implementation requires approval from the aLIGO SYStems group.

- Designs for two unique steering mirror assemblies (D1101013-v1 and D1101851-v1) required for guiding the CO2 laser onto compensation plates within BSC's 1, 2 and 3, serving H1 and L1, are on the critical path to meeting need-by dates at LLO. (Note that the hard-gold-coated copper mirror, D1101014-v4, for the SM1 assembly D1101013-v1 has been received from the manufacturer in December 2011; the associated machined parts have been cost-estimated, but not procured. Detailed drawings of the parts belonging to assembly D1101851-v1 are currently being completed; associated cost estimations have not yet been sought.)

3 CO2P Requirements

This section summarizes requirements for the laser projection system and references documents that provide more detail.

3.1 Conceptual Design Requirements

Top-level requirements are described in detail in T000092 where the primary requirements for TCS are derived from the LIGO principal science requirements. A list of these top-level requirements is given in

Table 1.

Table 1: Top level requirements (interferometer level)

Parameter	Required performance
Sideband extraction through SR cavity	>95% of nominal value (equivalent to phase error of 0.08 radians, or a round trip SR cavity loss of <0.1%)
TCS compensation profile	>112mm centered on optic
CP motion noise	< (2**finesse*/π) times the technical noise spectrum for test mass shown in Figure 1.

No requirement is set for the CO2P beam centering on the CP since the phase profile of the CP will be measured directly allowing for fine alignment after installation.

A detailed description of couplings between noise in the CO2P and the interferometer can be found in T060224, along with the resulting requirements for the CO2P system. We list these requirements in this section for convenience.

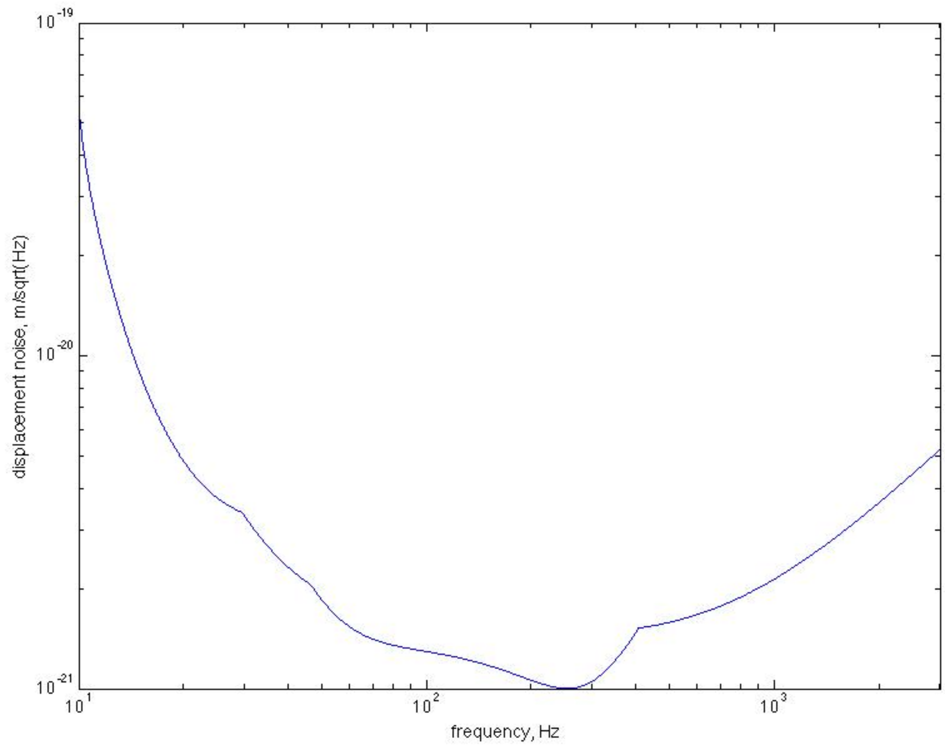


Figure 1: Maximum allowable technical displacement noise of the aLIGO test mass.

3.1.1 Amplitude noise requirement

Figure 1 shows the maximum allowable motion of the HR surface of the test mass. Since the CP is in the recycling cavity the surface motion requirement is relaxed by a factor of 2**finesse*/π, where *finesse* is the finesse of the arm cavity.

The amplitude noise of the CO2P system couples to the displacement noise of the CP by two primary mechanisms – thermorefractive and thermoelastic coupling. In practice the thermorefractive effect is approximately 10 times larger than the thermoelastic coupling. There are other coupling mechanisms (flexure, elasto-optic) that have been shown to be negligible.

Calculation of the effects of absorption of a fluctuating power source with an annular spatial distribution are given in Section 5 and 6 of T060224. This calculation includes the effects of both thermorefractive and thermoelastic coupling. Using this to calculate the amplitude noise spectrum requirement for the CO2P gives the curve in Figure 2.

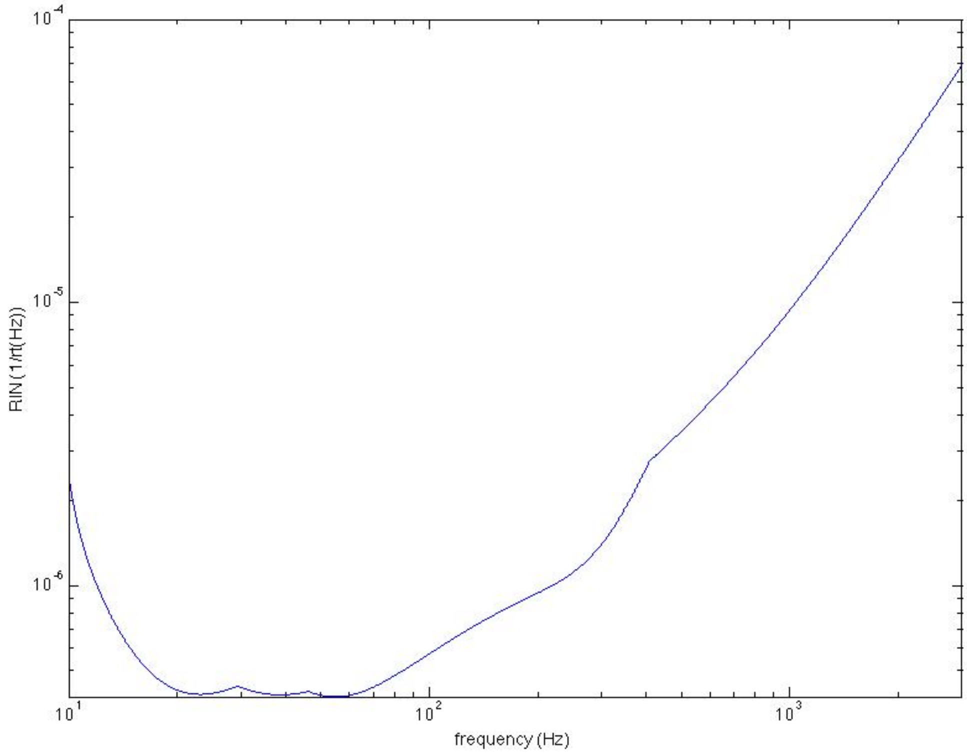


Figure 2: Amplitude noise requirement for the CO2P

To meet this requirement the laser will be followed by an intensity stabilization servo similar to that used in eLIGO, using an IntraAction AOM to modulate the amplitude.

Calculations given in T060224 show it should be possible to achieve a RIN of less than 2×10^{-7} across this frequency range, based on the use of the same type of VIGO systems HgCdTe diodes used in eLIGO. Again a preamp of IF3602 FET followed by an LT1128, is proposed.

The RIN of the unstabilized Access laser has been measured and shown to be slightly lower than that of the Synrad shown in Figure 5 of T060224.

3.1.2 Jitter noise requirement

Two possible jitter mechanisms are identified in T060224, these being angle of incidence of the CO2P on the CP and displacement of the CO2P beam relative to the IFO beam. However for any given angular variation in the incident beam, due to the long projection distance, the effect on displacement of the beam is a far larger effect.

The effect of displacement jitter is strongly dependent on the alignment of the TCS beam. If aligned perfectly there is no coupling to first order. The displacement requirement derived in T060224 is for a displacement of the TCS beam by 1mm, and is shown in Figure 3. The noise requirement must be reduced linearly with increasing offset (ie if the offset is 2mm then the requirement becomes twice as stringent).

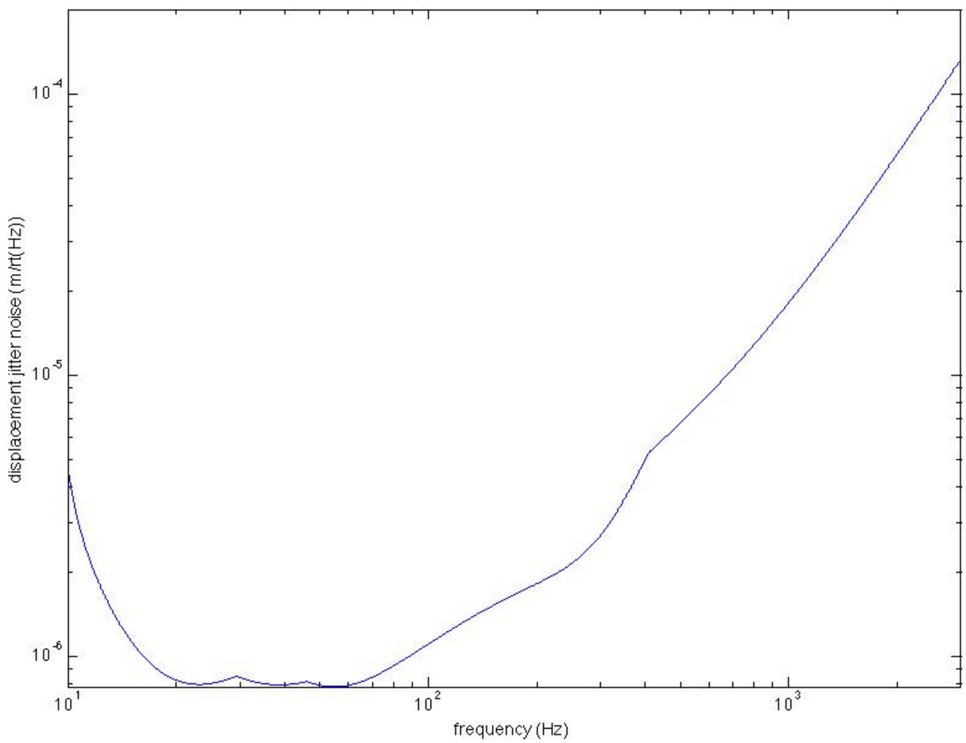


Figure 3: Jitter noise requirement for variations in overlap of TCS and IFO beams

With a significant projection distance, we convert this into an angular jitter requirement for the CO2P. For H2 with a projection distance of approximately 30m, this becomes a requirement of 1×10^{-7}m at 10Hz.

Please note that the baseline final design contains no active jitter control system.

The jitter noise can however be nulled by aligning the input beam using a shaker on the TCS table and moving the alignment until the peak is no longer visible in DARM. This method has been previously used in eLIGO. Any drift in alignment from the laser or AOM will be removed on with the pico-motor and QPD system periodically when the detector is not in science mode.

The measured angular resolution for steering the beam reflected of the picomotor mirrors is 400 nano-radians. When the picomotor mirrors are placed approximately 800mm away from the mask, the smallest beam motion on the mask is approximately 300nm which is approximately 2000x finer resolution necessary than the maximum tolerable 0.6mm beam-mask displacement. Therefore, the picomotor have sufficient resolution to optimize the beam position on the mask.

The jitter noise for the aLIGO CO2 lasers was measured and was determined to be smaller than the minimum acceptable level across the entire audio band, as illustrated in Figure 4. Therefore, no active jitter control system is needed for baseline aLIGO TCS.

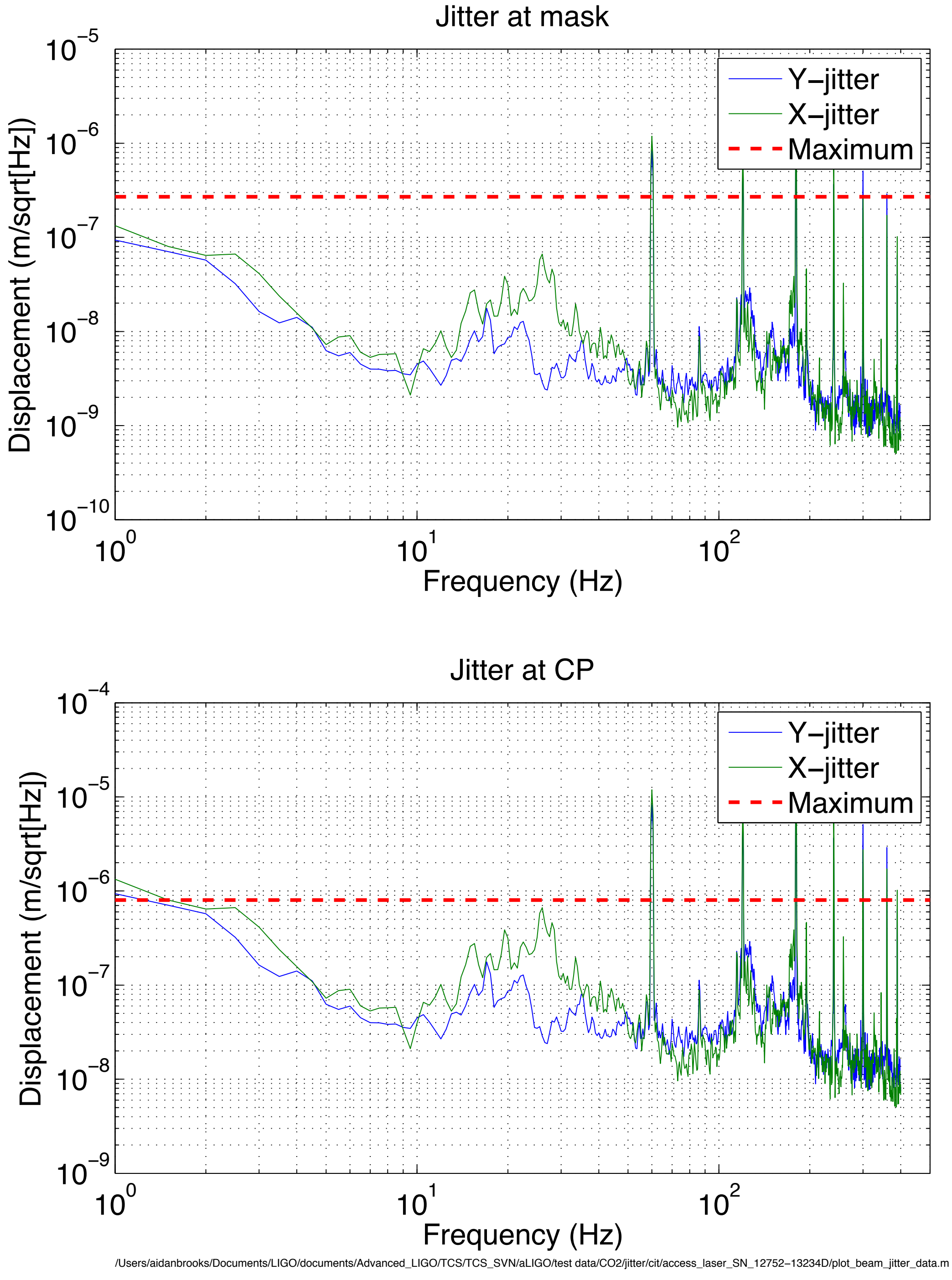


Figure 4: Measured beam jitter from Access Laser SN 12752-13234D

3.2 Requirements for the optical design

There are no substantive changes to the requirements for the optical design described in Section 4.2 of the T0900304 - aLIGO Thermal Compensation System Preliminary Design.

Those requirements are summarized here:

- The amount of TCS power delivered to the Compensation Plate required for optimal compensation of 0.5 ppm absorption at full power is 7.5W; with the factor of two excess capacity specified in the Design Requirements, this rises to 15W.
- The projector must be capable of producing an annular heating pattern that produces a thermal lens that, when combined with the thermal lens from the ring heater, results in a residual optical path distortion that scatters less than 0.1% of the Gaussian TEM00 mode from itself on one round trip through the ITM+CP. The idealized heating pattern is described in Section 4.1.2 of T060083 - Auxiliary Optics Support System Conceptual Design Document, Vol. 1: Thermal Compensation System.

3.2.1 DC requirements

3.2.1.1 Power resolution

The power projected onto the compensator plate by the CO2P is measured using two power meters, one in each beam shaping path. The total power must correct the thermal lens of the ITM+CP such that the residual optical distortion meets the 0.1% scatter in one round trip requirement, as described above. Figure 5 shows results of modeling of scattered power as a function of CO2P power for the case of an ideal correction pattern requiring 5W of annular heating power[1]. From this we see that the power must be set to better than ±1.5%. The power meters that are planned for use in the CO2P are Thorlabs S302C 2W units with a manufacturer specified resolution of 1μW. This resolution is reduced when viewing the power on the controller, however the analogue output of the PM100D gives a direct amplified signal from the power meter head. In practice the resolution will be limited by our ADC to around 0.6mW, though further amplification and subtraction of offsets would reduce this. The resolution required for a measured power of 2W is ±30mW.

[1] The ideal pattern was created by subtracting the thermal lens from 0.4W of self-absorption from a flat wavefront. It was then assumed that 5.0W of annular power were required to create that ideal pattern. This ideal pattern was then scaled accordingly to determine its size at different annular power levels.

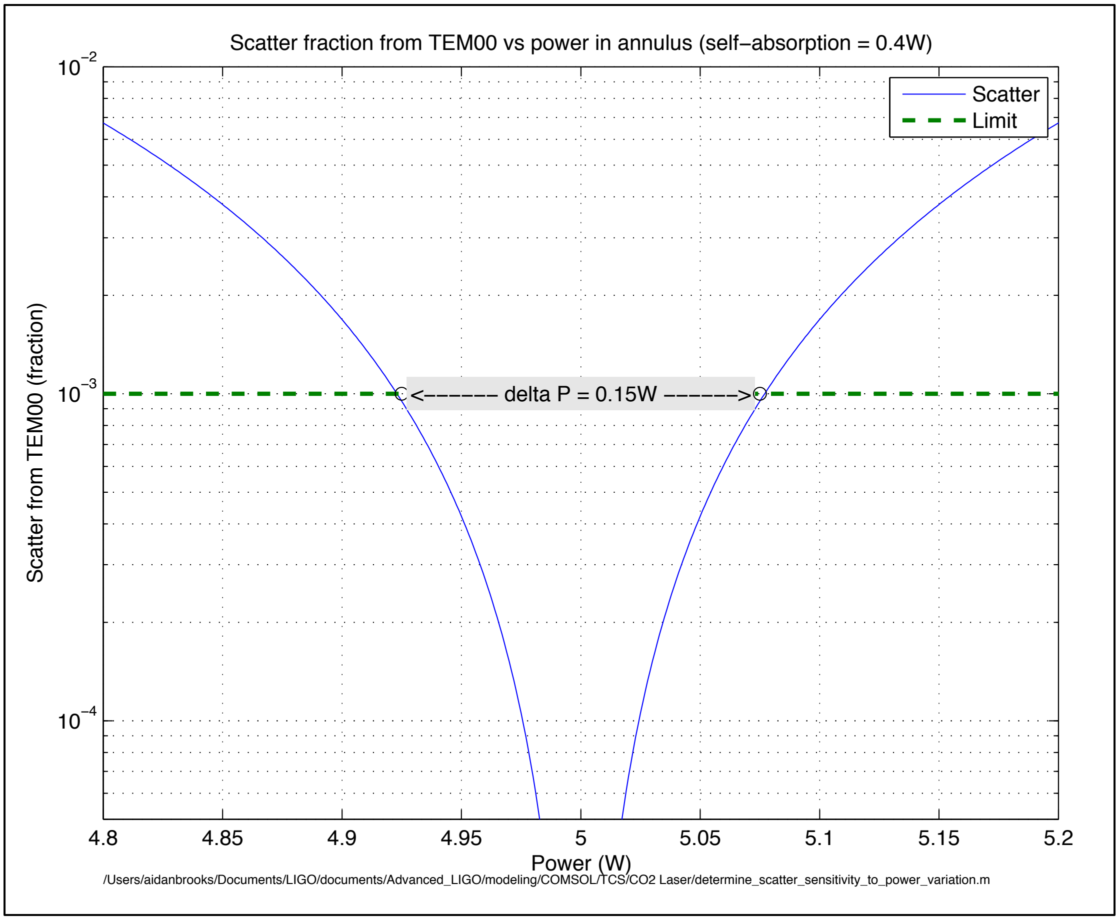


Figure 5: Scatter from TEM00 mode vs power in ideal annulus

3.2.1.2 Beam centering

As specified in Section 3.1.4.1 in T000092-v2 Auxiliary Optics Support System Design Requirements Document, Vol. 1: Thermal Compensation System, "the compensated phase profile can then be sensed and used to improve the CO2 laser projector profile and alignment. For this reason, no requirement on the CO2 laser projector centering is specified".

To expand on this:

- The picomotor mirrors on the upper periscope mirror have an angular resolution of approximately 220nrad and this corresponds to 440nrad resolution for the reflected beam.
- With the 12m projection onto the CP, this corresponds to a alignment resolution of 5 μm. This is much smaller than the necessary spatial resolution ~0.5mm and is therefore an acceptable level of correction
- The alignment to the center of the IFO beam can be achieved in a two stage process
    - First by aligning the center of the test mass as determined by the HWS (with an uncertainty of 2 or 3mm).
    - Secondly, by actuating with TCS and measuring the induced DC tilt in the main IFO beam with the ASC system.
    - This signal is sufficient to realign the TCS system to zero the DC induced tilt (as it must be sufficient for operation of the ASC system).

3.2.1.3 Annular beam diameter and width

We used a COMSOL model to determine the required spatial resolution of a CO2 laser beam profiler. We began by first applying a Gaussian annulus to a compensation plate (CP) and determining the optical path distortion (OPD). The Gaussian annulus is described by the following equation:

$$I(r) = \frac{P_{annulus}}{C_{normalization}} \exp\left(-2\left(\frac{r - r_{ann}}{w_{ann}}\right)^2\right),$$

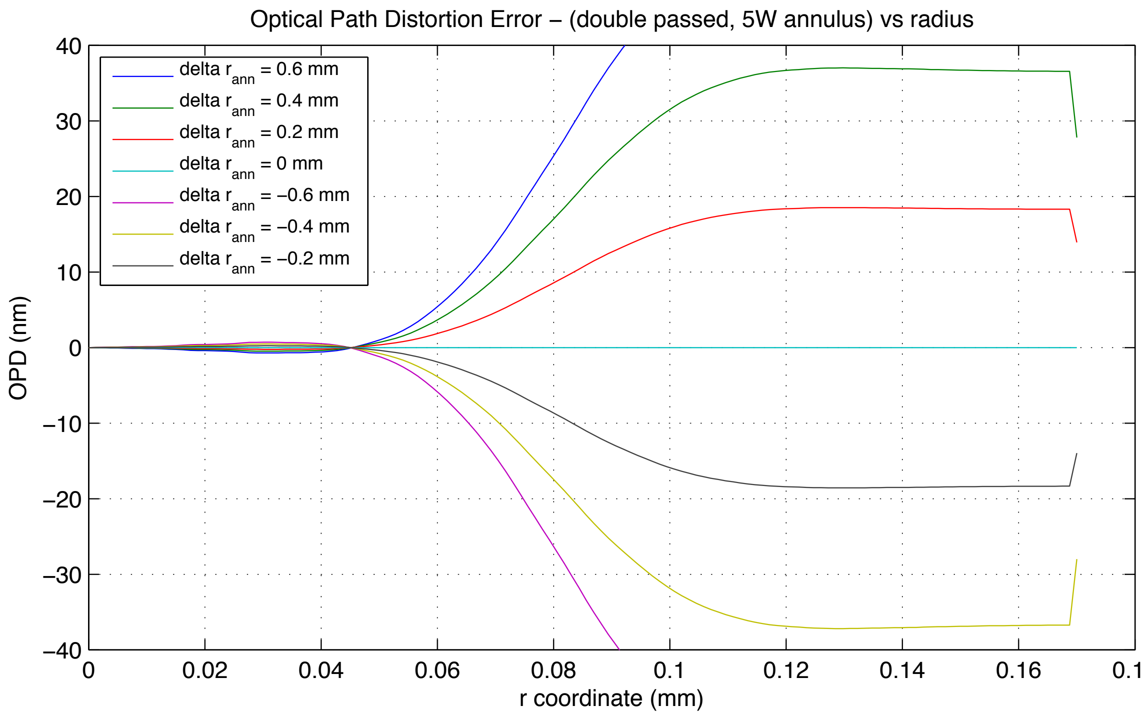
where the nominal parameters are r_{ann} = 81mm, w_{ann} = 37.5mm and $P_{annulus}$ = 5.0W.

We assumed that this OPD, which is close to the ideal correction pattern, was, in fact, the ideal correction pattern[2]. That is, we assumed that this correction plus the 0.4W self-absorption of the interferometer resulted in a flat OPD (wavefront error) on the interferometer beam.

Next, we perturbed the diameter (2 r_{ann}) and diameter (2 w_{ann}) parameters of the annulus from the nominal values and determined the difference in the wavefront error between the two cases (for a beam that is double passed through the ITM+CP). This difference represented the residual wavefront error left on the interferometer beam. Finally, we worked out the scatter from the interferometer TEM00 mode given this wavefront error. The residual OPDs (double-passed through the optic) and the corresponding scatter for the two cases are plotted in Figure 6 and Figure 7.

The results show that the resolution of the beam profiler is limited by the radial variations in the annulus and we need a spatial resolution of better than 0.6 mm at the ITM.

[2] In fact, this annular pattern in the gold-barreled compensation plate will yield 2% scatter from the TEM00 on one round-trip through the residual distortion. Scatter = 2%*($P_{absorbed}$/0.4W)^2.



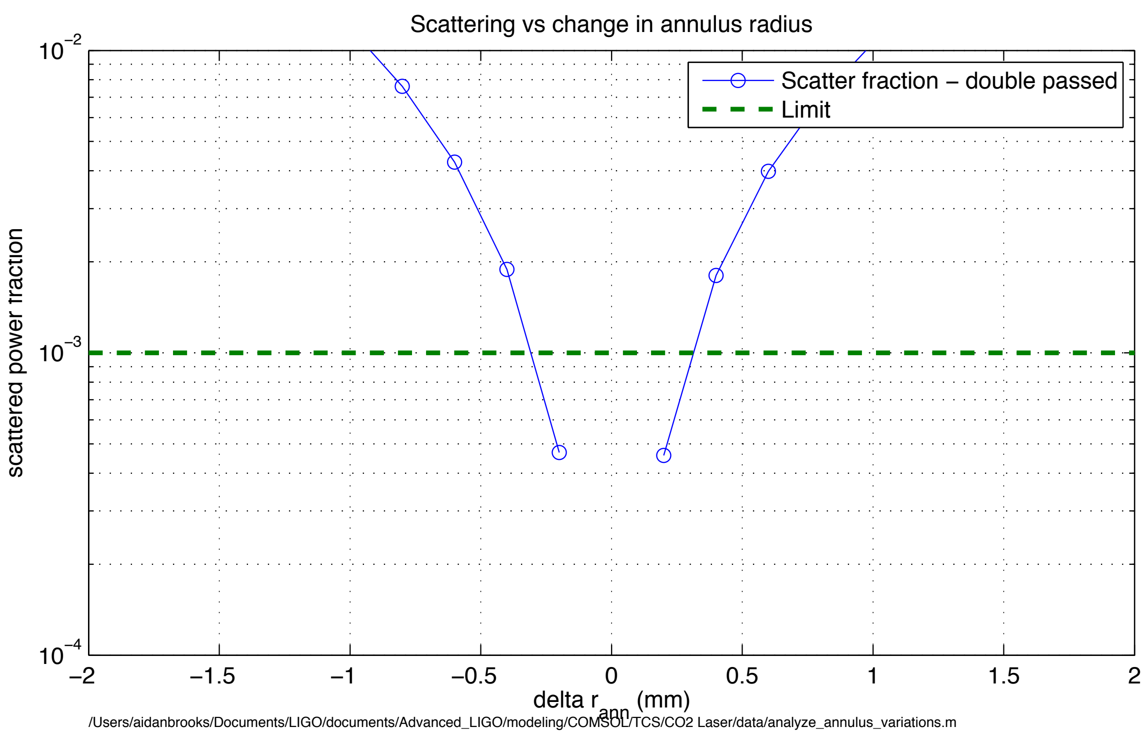
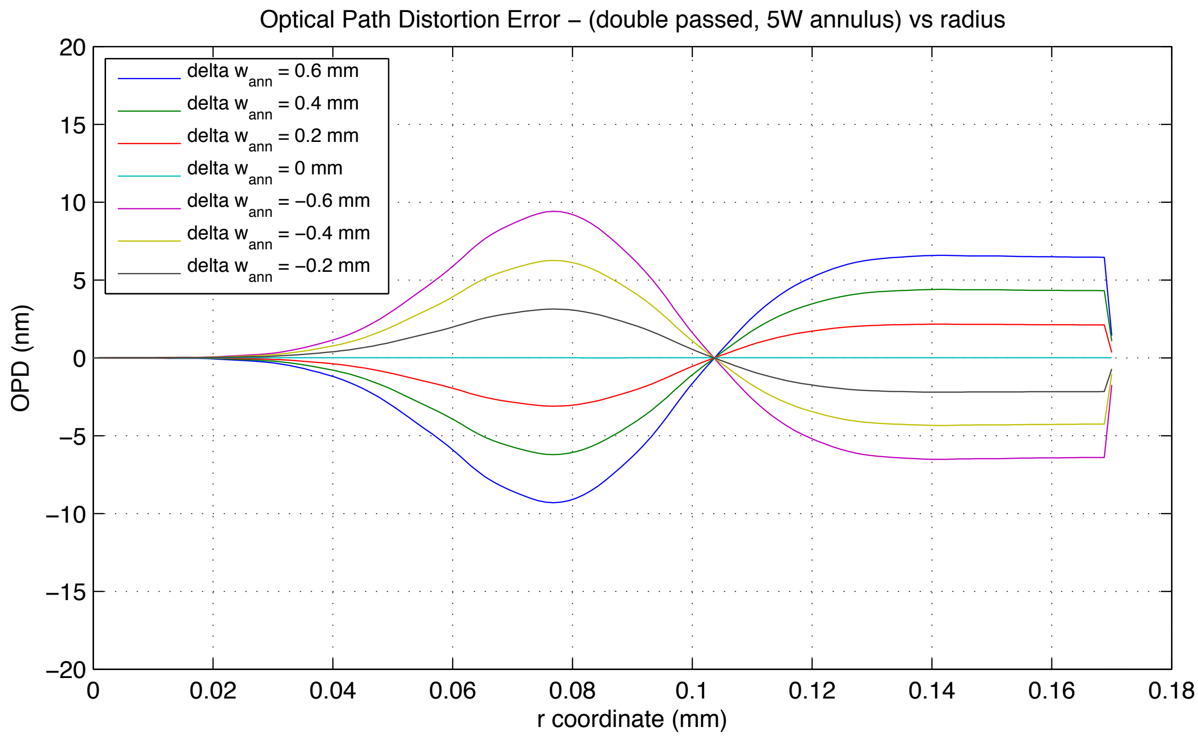


Figure 6: (top) Variation in OPD (wavefront error) as the annulus *radius* is varied, (bottom) scatter from TEM00 mode due to residual OPD.



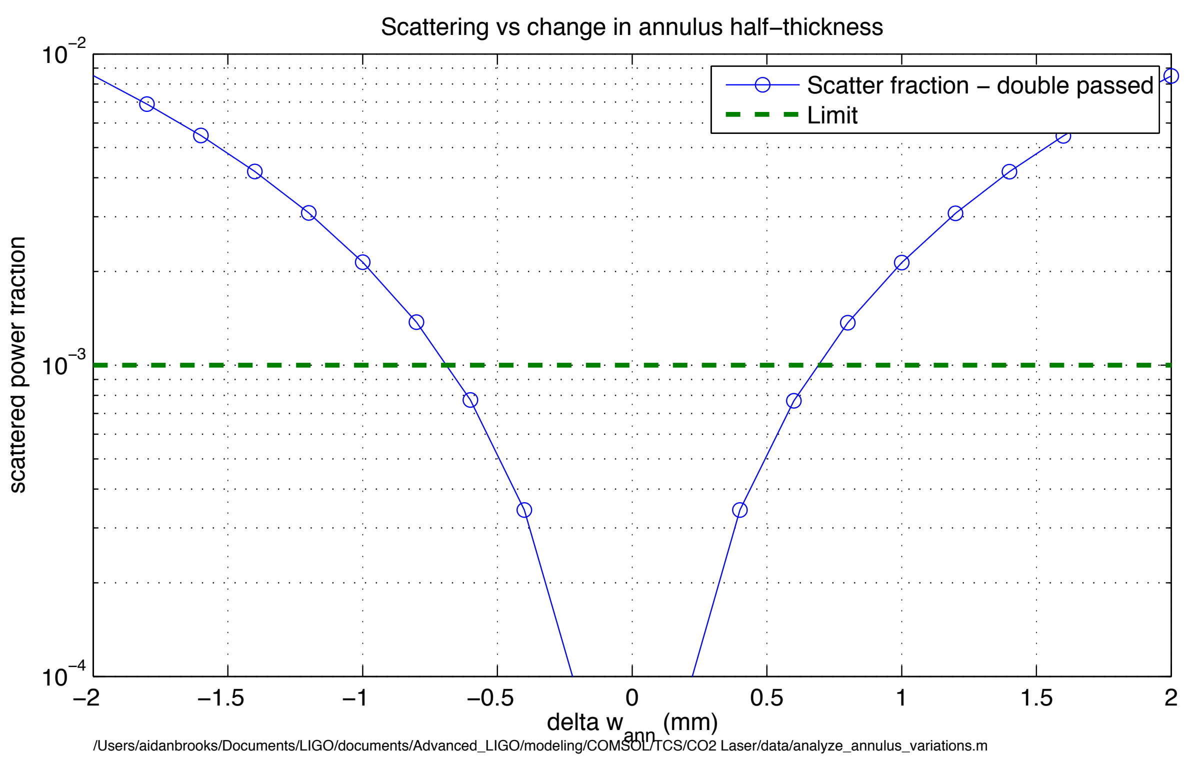


Figure 7: (top) Variation in OPD (wavefront error) as the annulus *half-thickness* is varied, (bottom) scatter from TEM00 mode due to residual OPD.

3.2.2 Requirements to prevent degradation of aLIGO performance

3.2.2.1 Reliability

The reliability of the TCS laser can be inferred from the Availability Requirements for Advanced LIGO that are specified in Section 2.3 of T010075 - Advanced LIGO Systems Design:

- Single interferometer operation: 90% availability (annually integrated), minimum lock duration of 40 hours

From this requirement, we can set a limit on the reliability of each projector such that they require no more than 1 hour of maintenance/downtime every 400 hours (roughly 2 weeks).

3.2.2.2 Beam pointing

A beam pointing drift correction may will require ~30 minutes to tune the alignment of the projector system using the signals from the Hartmann sensor (due to the long thermal time constant of the fused silica CP). Therefore, this should not be required more frequently than 1 correction every 200 hours (roughly once per week).

3.2.2.3 Glitches/mode-hops

The dynamical optical requirements for the CO2 laser were specified in E1000065-v6 - TCS CO2 Laser Specification. Requirement 3.4.1 states:

- After initial warm-up and selection of operating point, laser emission shall maintain a single longitudinal mode over time, with not more than one mode hop per 24 hours, averaged over at least 100 hours.

Based on observation of glitches in the TCS lasers in eLIGO, a mode-hop in the laser results in 10-20s of contaminated data at the output of the GW interferometer but does not, typically, cause a lock-loss. This requirement translates to a reduction on ~0.02% in the availability of the interferometer.

4 Architecture of the CO2 Laser Projection System

A comprehensive description of the CO2P architecture can be found in T0900217. Figure 1 provides key details of the system, which are explained in sections below.

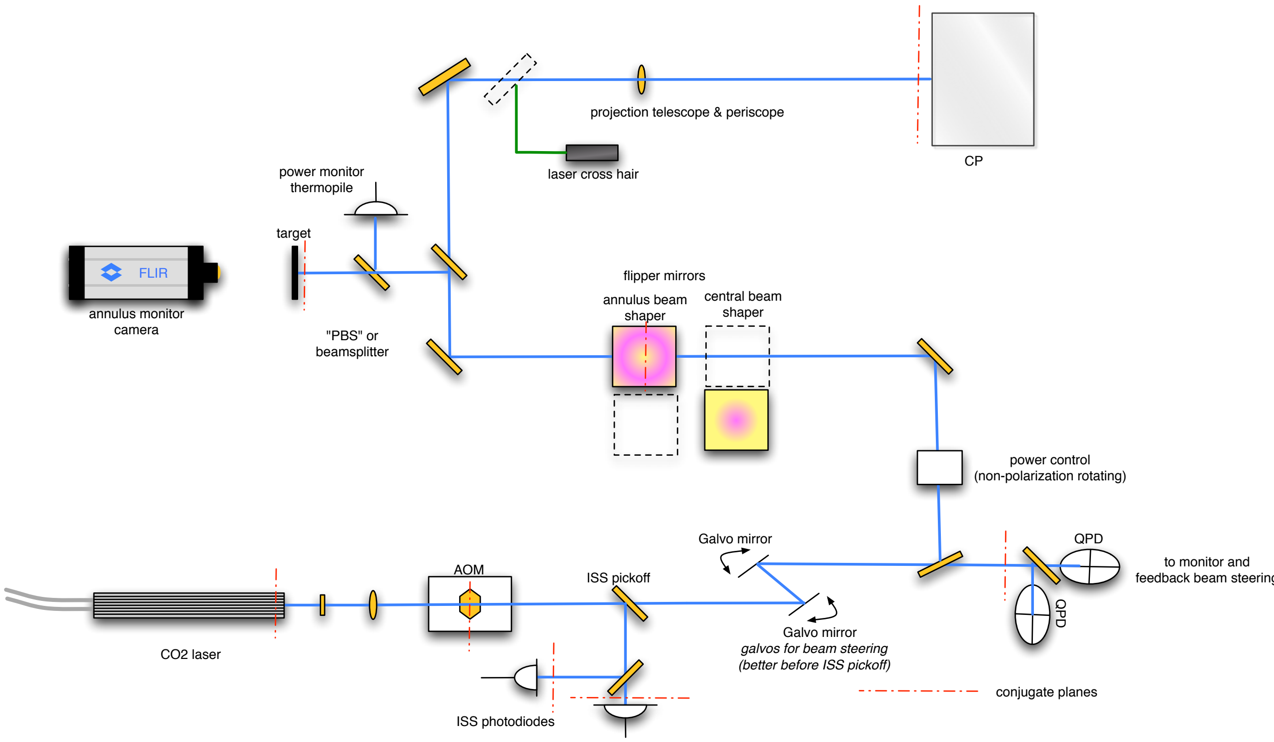


Figure 8: Schematic of main features of CO2P system (AdvLIGO TCS tables.graffle)

4.1 Power stabilized 50W CO_2 laser

The laser chosen to actuate on the compensation plate is a power stabilized CO_2 laser by Access. Power is stabilized at the output of the laser using a pickoff beam on a thermopile. The cavity length is controlled using a piezo mounted mirror, and the cavity length is effectively offset locked. Stability has been measured at ±0.5% over 12 days with no mode hops seen.

The laser cooling water will be actuated on to give low frequency stability using a similar system to that used in eLIGO. By measuring the voltage applied to the piezo the water temperature will be used to keep the piezo in the middle of its range. This will be done with a loop in the real-time system.

4.2 Intensity stabilization

The laser intensity will be further stabilized using an AOM and in-loop and out-of-loop HgCdTe photodiodes. These photodiodes will be the same VIGO Systems type used in eLIGO. A servo based on the same LT1128 opamp and Interfet IF3602 input stage used in eLIGO is planned. A detailed analysis of this servo can be found in T070224.

4.3 Beam pointing control

Consisting of two pico-motor controlled mirrors, followed by near and far-field quadrant photodiodes. The pico-motors will operate at frequencies below 1Hz and the pointing can be corrected using the realtime system. In practice there are likely to be glitches in the picomotor motion that will require this alignment to be done out of science mode. For this reason we do not intend to servo this alignment while in science mode.

4.4 Power control

Relative heating power for center and edge heading will be controlled using a motorized (Newport URS-50) half-wave plate and polarizer. The total heating power is controlled using a separate half-wave plate and polarizer. Since a small amount of power will be transmitted through the polarizer when it is set to zero power, there will also be flipper mirrors to direct the residual beam onto a beam dump to give a true zero intensity.

4.5 Heat management, temperature control

Cooling of the laser projector system will be handled by a separate chiller for each laser bench. The specification derived for this chiller is given in E1101107. A tool to help calculate pipe diameters and design manifolds has been developed but not yet implemented. The chiller will be used to cool the laser, the laser RF driver, the AOM, the AOM driver and two beam dumps.

The temperature of the cooling water will be actuated on to keep the laser piezo in the center of its range and reduce the likelihood that the laser will mode hop.

Since the length of tubing used in the cooling system affects the unity gain of the servo, it is planned that a test be done at Caltech using similar pipe length to those planned for the sites in order to verify that the servo has sufficient gain.

4.6 Beam shaping

There is a single beam shaping path that contains two masks in individual flipper mirror mounts. The masks can be individually inserted into the beam to shape the resulting output. The initial masks will be a central heating mask and a simple annular heating mask.

4.6.1 Optimum beam profile using a mask

When a binary mask is used to correct for thermal lensing, that mask will be constructed by laser drilling a sheet of AISI 316 Stainless Steel, see D1400006 Mask for aLIGO TCS CO2P Central Heating for example.

The optimum mask design to correct for a thermal lens is found using code that iterates through mask designs in COMSOL to converge to a model that provides the appropriate level of correction. The Beam Shape Servo (BeSS), T1200103[3], that accomplishes this is illustrated in Figure 9. The code to run this mask design program resides on the TCS SVN:

`svn.ligo.caltech.edu/TCS_Components/aLIGO/modeling/models/BeSS`

COMSOL modeling with this system finds that:

- at full IFO power with 0.5ppm absorption in the ITM HR surface,
- optimum RH correction for surface effects,
- annular correction with the CO2 laser beam and,

[3] "TCS beam shaping: optimum and achievable beam profiles for correcting thermo-refractive lensing (not thermo-elastic surface deformation)"

- annular mask designed with BeSS,

the residual thermal lens is around 2nm RMS double passed vs a maximum allowed residual of 3.8nm RMS (G1201041). Therefore, the BeSS mask can correct for nominal distortion at full IFO power.

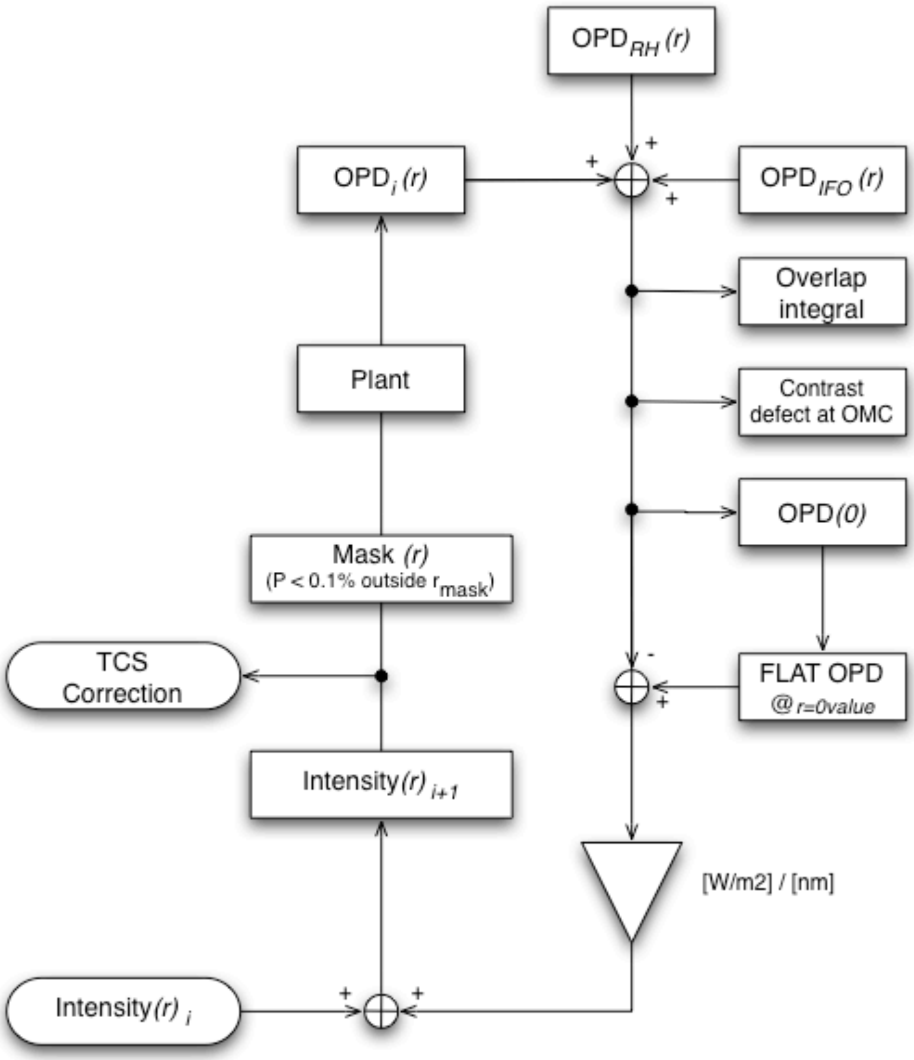


Figure 9: Beam Shape Servo for designing masks. LIGO-T1200103-v2

The calculated optimum mask + Gaussian beam to correct for maximum thermal lensing from 0.5ppm uniform absorption in the ITM HR surface at full power and RH actuation is shown in Figure 10. The residual OPD after this heat pattern has been applied is ~2.1nm RMS which is lower than the required 3.8nm RMS distortion and is illustrated in Figure 11.

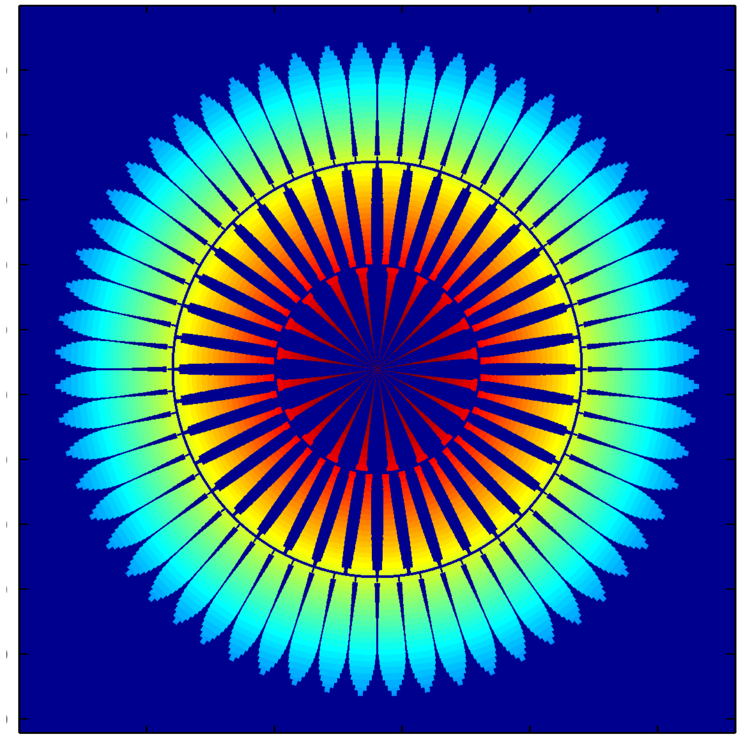


Figure 10: Illuminated optimum mask (P= 4.7W) to compensate for residual optical path distortion after 0.4W of self induced thermal lensing and RH applied to correct thermo-elastic effects.

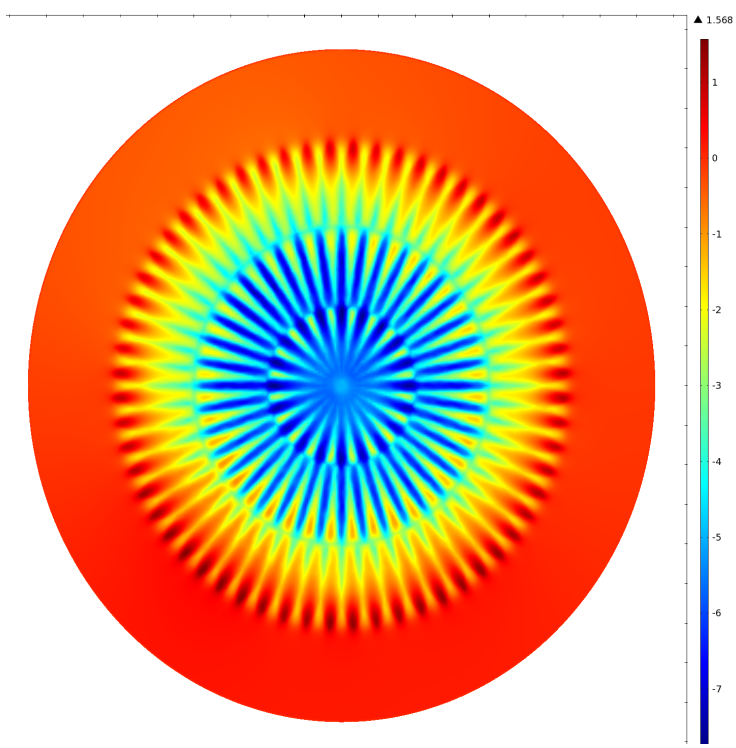


Figure 11: Residual OPD after self-absorption, RH and CO_2 laser applied. RMS = 2.1nm vs maximum of 3.8nm.

4.7 Beam imaging

The annular mask is placed at a conjugate plane of the ITM with a magnification factor of approximately 23x. The central heating mask is placed as close to this plane as practical (about 1.5" away).

4.8 Beam quality monitoring

A pick-off after the masks will be imaged using a camera/beam imager. The image from the beam imager will give continuous monitoring of the projected beam. In eLIGO this was not possible and the annular beam shape could only be checked periodically. Drift in the system was found to cause uneven heat distributions. For aLIGO we will continuously monitor the projected beam shape and the applied phase front changes using the HWS to give more complete information about the system. The data from this system can also be used to track long term drifts.

4.9 Imaging optics and periscope

A final telescope is used to image the beam onto the compensator plate. The beam then passes through a periscope containing pico-motor controlled mirrors to allow for remote beam steering onto the CP.

4.10 Interlocks and control loops

The following control loops will be used

- Laser internal control loop – runs through a LIGO real-time front end model.
- Water temperature – uses error signal from laser internal control loop. Low frequency loop that can be run using frontend system. Also LIGO real-time front end model.
- Intensity stabilization servo – An analog control servo. Alastair looking into this

The laser projector will have its own dedicated interlock board to protect the laser against low water flow rates, and to shut off the laser if its internal temperature rises above a setpoint. This interlock will integrate with the site interlock to shut down the TCS laser in the event that a site kill switch is activated. In addition there will be a clearly labeled TCS laser only kill switch located on the outside of each laser enclose.

4.11 Visible alignment lasers

There is a visible alignment lasers in the CO2 projector optical layout.

The laser is a cross-hairs coupled into the final stage of the projection system using a mirror that is temporarily inserted to align the visible laser to a pair of irises that are aligned to the optical axis. The purpose of this laser is to provide an initial alignment of the optical axis to the compensation plate.

5 Optical Design

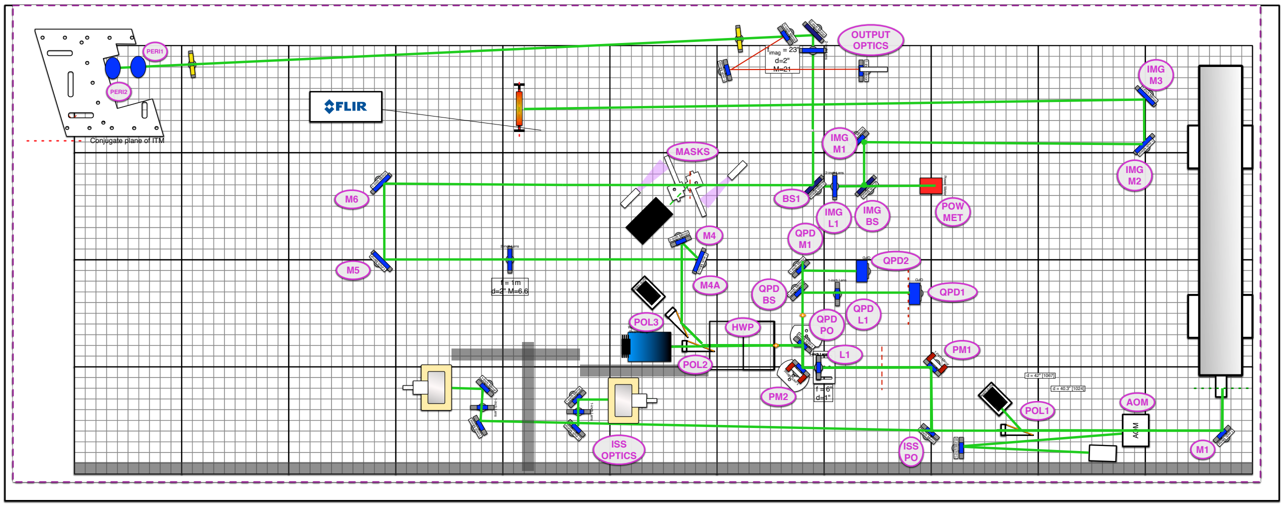
The optical layout consists of in-vacuum mirrors, an in-air periscope containing pico-motor controlled mirrors, and an enclosed optical table. The top-level systems diagram for all aLIGO TCS elements is given by D1001227. Version 3 (-v3) of this document isolates only the CO2P components. Sheet 1 of this drawing illustrates H1 and L1 configurations.

The optical layout is drawn in T1200007.

The ABCD calculation reflecting this layout is described in T1500034.

5.1 Table layout, in air

Figure 5 shows the planned table layout for the CO2P.



T1200007-v13 - TCS CO2 laser table

Figure 12: Optical layout T1200007-v13 for CO2P on a 1" grid.

5.2 In vacuum steering

5.2.1 H1 and L1

As stated in Section 2 (above), designs for two unique steering mirror assemblies (D1101013-v1 and D1101851-v1) required for guiding the CO2 laser onto compensation plates within BSC's 1, 2 and 3, serving H1 and L1, have not yet been reviewed. However, the hard-gold-coated copper mirror for the SM1 assembly (D1101013-v1) has been received from the manufacturer in December 2011.

Two packages documenting the detailed analysis of each of these assemblies are given by G1101230-v3 (for SM1 in BSC's 1 and 3) and G1200016-v1 (for SM2 in BSC 2). Note that the hard-gold-coated copper mirror (D1101014-v4) for the SM1 assembly (D1101013-v1) has been received from the manufacturer in December 2011.

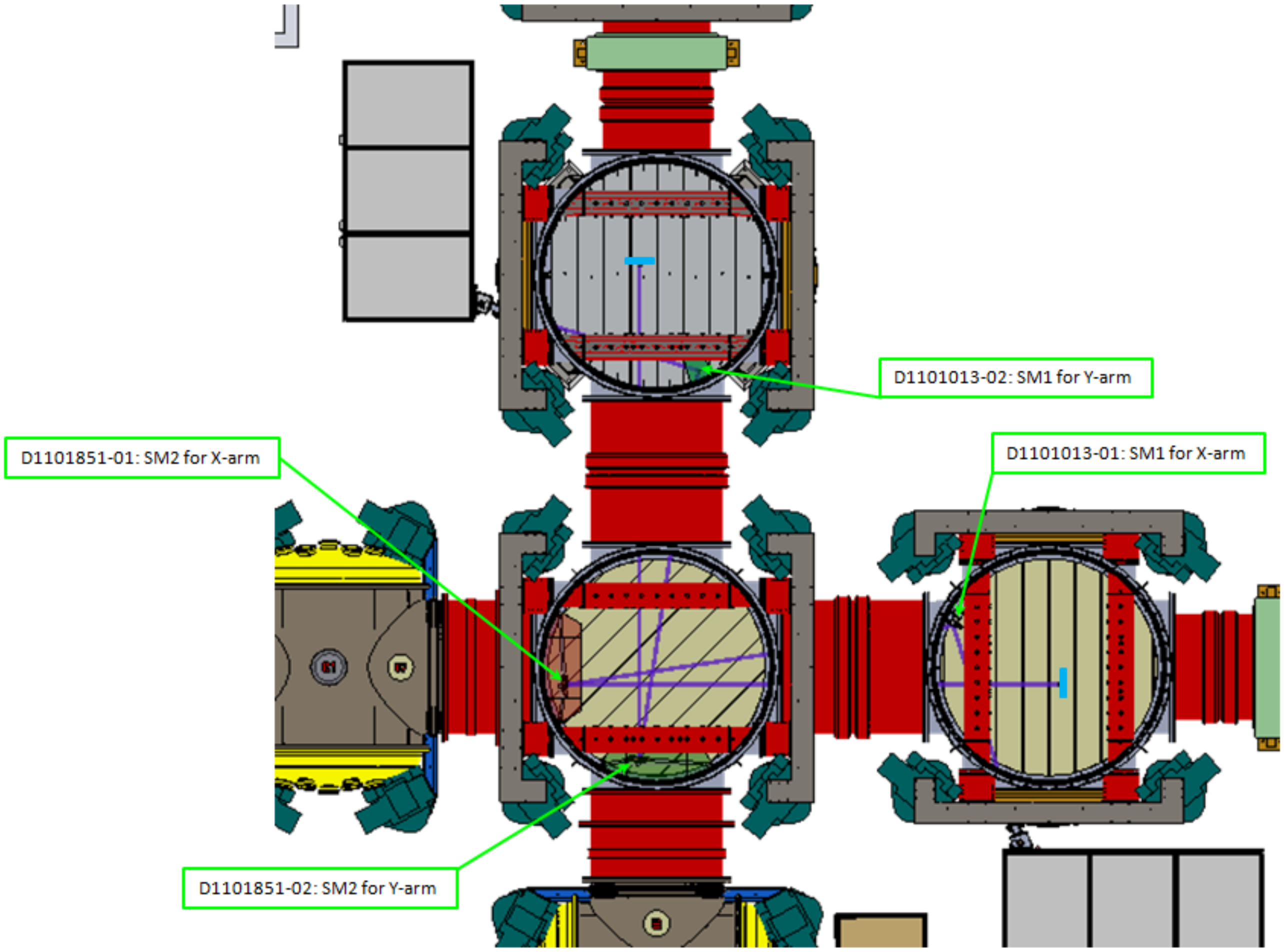


Figure 13: View of injection path for H1 or L1 CO2P beam.

Precise angular projections of beams, in vacuum, are illustrated on Sheet 1 of D1001227-v3.

5.3 Custom Optics and opto-mechanics

We describe here only the custom optics and opto-mechanics. Section 13.2 contains a more complete list of optics to be purchased.

5.3.1 Periscope and mirrors

A custom designed periscope is used to take the beam from the table up to the ZnSe viewport where it is injected into the vacuum system. The periscope has two 4" mirrors, mounted in SL series Newport mirror mounts that have been customized to accommodate pico-motor control. This gives remote beam steering for the final alignment of the beam onto the CP. Implementation of this periscope is most difficult for H2, due to location of the table. This is illustrated in the following figure.

The mirrors used are silicon substrate with a dielectric coating of ZnSe/ThF4. The reflectivity of this coating has been measured at Caltech to be 99% for an S-polarized 10.6um beam.

5.3.2 Optical table

The optics used on the optical table are all standard parts that will be purchased. Some partially transmitting mirrors are required at points for photodiodes and beam monitoring, and for larger numbers of optics it will be more cost effective to have these coated specially.

There are a number of custom opto-mechanical parts required. These include:

- Laser mount (for rigidity of base): D1201510
- Periscope from laser to bench (rotates output polarization from P to S): D1200953
- Mounts for the HgCdTe photodiodes (for high frequency stability): D1201065
- Rotation stage (URS-50) mount for the half-wave plate: D1000791

Documentation of analysis for the design for the custom mount of the rotation stage can be found in G1100567-v2, which is also referenced by the Input Optics (IO) layout. The associated modal test data can be found in T1100348-v1.

6 Enclosures / VEA Layout

6.1 Floor plan

The corner station floor plan [D1001227-v3: aLIGO TCS Envelopes, Corner Station, LLO, LHO] shows the size and locations of the tables. Table locations in this document can be related to rack and cable tray layouts in the Systems (SYS) layout given by documents related to D1003142.

6.2 Table enclosures

Enclosures for tables adjacent to BSC's 1 and 3 have been designed so that the periscope is completely enclosed, and the viewport enclosure is integral to the design of one wall. Detailed mechanical drawings are being prepared; the top-level bill of materials is given in the Appendix.

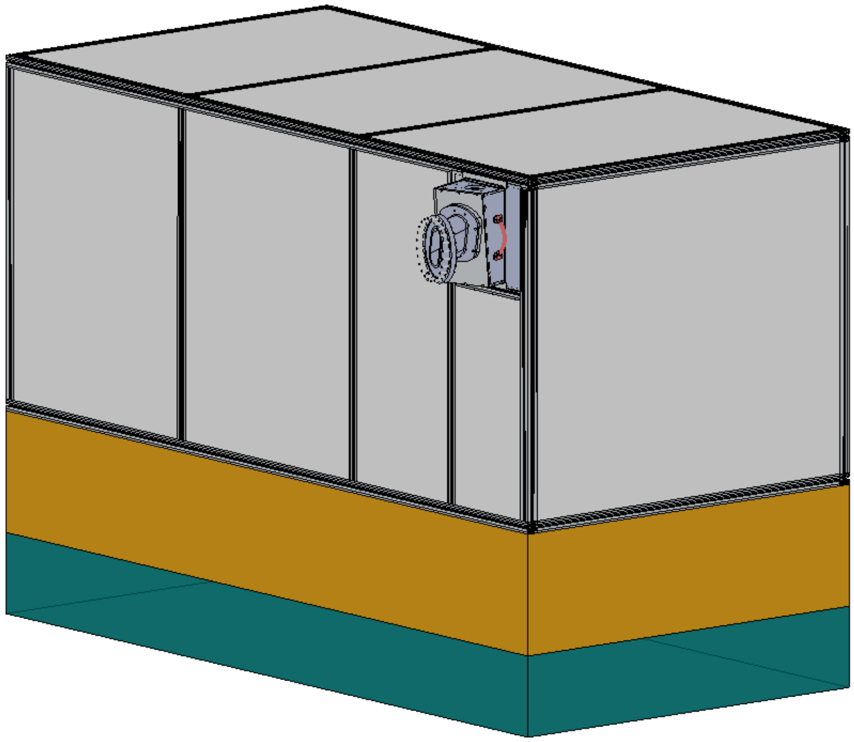


Figure 14: Isometric view of the top level Table assembly for H1 and L1; the viewport enclosure (D1101627-v1) is integral to one panel of the table enclosure.

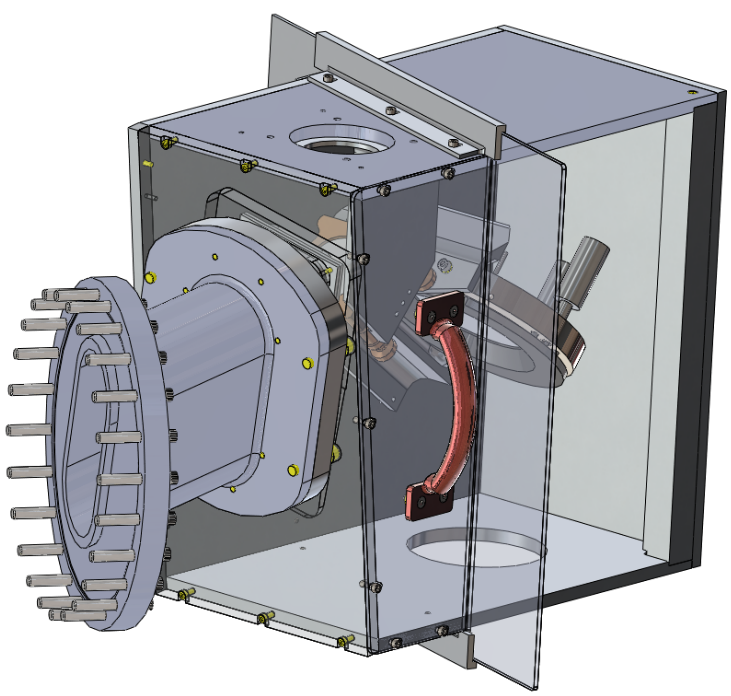


Figure 15: Isometric view of the H1-L1 viewport enclosure D1101627-v1, Type -01.

6.3 Viewport enclosures

For H1 and L1, assembly D1101627-v1 has types -01 and -02 for the X- and Y-arm injections into BSC's 3 and 1, respectively. Detailed mechanical drawings are being prepared; the top-level bill of materials is given in the Appendix.

One element of this enclosure is the Primary Flange Viewport Assembly, D1101630-v1, which incorporates one part (D1003209-v2, a Clamping Flange)

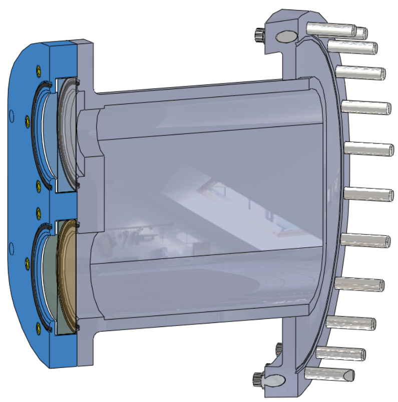


Figure 16: Common use of a *Clamping Flange* (D1003209-v2) for Primary Viewport Assembly in H1-L1

There are two primary viewports, at the vacuum interface, for alignments using a visible camera as well as for injection of the CO2 laser beam. The designs for these ZnSe viewports are the same for both the H1-L1 assemblies. As part of the hazard analysis for TCS, overall, an analysis of ZnSe viewport operating stresses, under vacuum, has been performed. An unapproved report associated with this analysis is given by E1100379-v3.

There are also two secondary viewports, half the thickness of the primary viewports, which are common to the H1-L1. IR sensors are incorporated into the designs. The sensors monitor stray IR light and are a key part of the equipment safety interlock circuitry.

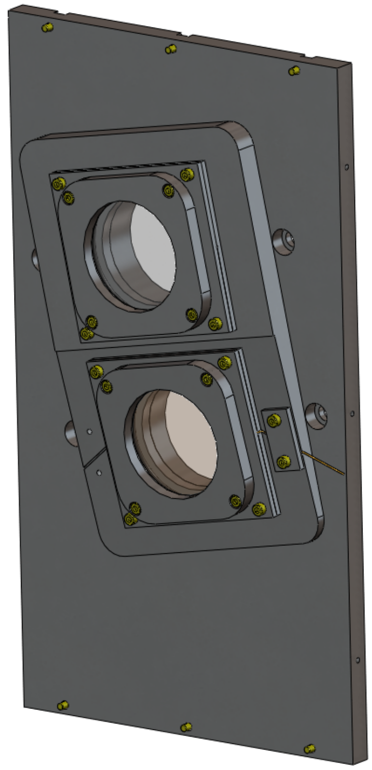


Figure 17: Common use of secondary viewports with temperature sensing for the H1-L1, in sub-assembly D1101631-v1.

7 Electronics

Corner station block diagrams for each of the three major elements of TCS (CO2 laser projection, Ring Heaters and Hartmann Sensors) are given on separate sheets in the document E1100892.

7.1 Overview - Block Diagram

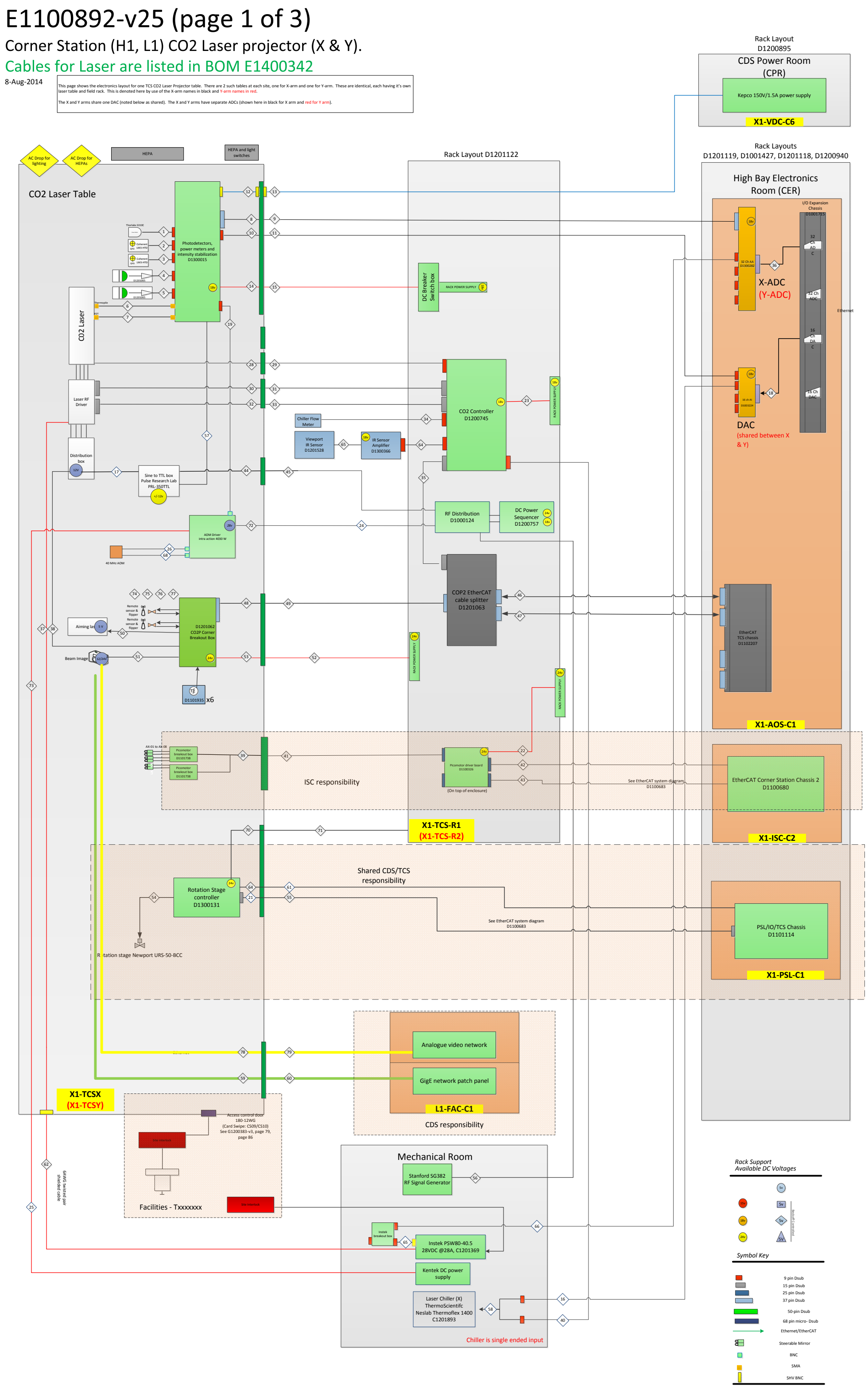


Figure 18: Block diagram of electronics for TCS CO2P system, Sheet 1 of E1100892-v26

7.2 EtherCAT control

The Beckhoff EtherCAT system described in G1100098 will be used for slow control and measurement. Currently we plan to use this for flipper mirrors and temperature sensors.

7.3 Custom electronics

7.3.1 aLIGO TCS ISS SERVO DRIVER [ACTS ON AOM]

The aLIGO TCS ISS servo is show in D1300015. This interfaces with the ISS photodiodes, D1201065.

7.3.2 aLIGO TCS CO2P QPD [D1300650]

The buffer circuitry for the QPDs is on D1300650, aLIGO TCS ISS Interface Board.

7.3.3 aLIGO TCS CO2P CHILLER FLOWMETER SENSING & INTERLOCK CIRCUITRY [D1200745]

The local interlock for the TCS CO_2 laser has been designed, D1200745. It is used to protect the laser against low water flow, or if the internal temperature of the laser increases. The action of the interlock is to trip a relay that disables the enable input of the RF driver of the laser. This interlock is still to be integrated into the LIGO site interlock, however the use of relays in this circuit allows another interlock signal to be routed through the device. The optical table also has its own limited access system that will be integrated with this interlock. IR sensors on the ZnSe viewports are be integrated into this .

The interlock has analogue outputs for flow rate and temperature. It also has digital outputs to give information on latched status.

7.3.3.1 aLIGO TCS CO2P LASER TEMP. SENSING CIRCUITRY

The temperature sensing of the laser is done using an RTD device built into the laser. The readout for this is done in the interlock circuit since this temperature is used to protect the laser. An analogue output from the interlock allows the temperature to be recorded using the EtherCAT system.

7.3.3.2 aLIGO TCS CO2P LASER ENABLE ON/OFF

The laser is turned on and off using an enable input that must be set high to give continuous wave operation. This will be done using a small control box mounted next to the laser on the bench. The laser power can be reduced for alignment procedures by modulating this input with a square wave. The Synrad power controllers used for eLIGO can be used to control the Access laser for this purpose. The laser controller can be switched into use using the laser enable on/off box.

7.3.4 aLIGO TCS CO2P LASER POWER SUPPLY

The power supply for the Access laser requires 28V at 28A. This can be split by driving the two sides of the RF driver with separate supplies at 28V and 14A. The power supply is an Instek PSW80-40.5.

7.3.5 aLIGO TCS CO2P AOM DRIVER

The AOM driver will remain the same water cooled version of the IntraAction GE-4030 used for eLIGO. It will be powered using a external DC supply at 28V. It is proposed to use the same 40.68MHz clock to drive this as for the Access CO_2 laser. This clock will be synchronized to the site clock.

7.3.6 aLIGO TCS CO2P ROTATION STAGE DRIVER

The rotation stage, URS-50-BCC, is controlled through the Beckhoff system via D1300131.

7.3.7 PICO MOTOR DRIVER BOARD

The pico motor driver board will be Daniel Sigg's design D1100326. It will connect to the driver breakout box D1101738.

7.3.8 aLIGO TCS CO2P FLIPPER MIRROR DRIVER

The flipper mirrors will be driven using a New Focus off the shelf driver. This takes a TTL input to operate the flipper mirror. A separate sensor will be used to monitor the status of the flipper mirror.

7.3.9 aLIGO TCS CO2P THERMAL IMAGING CAMERA [FLIR A325c]

The thermal imaging camera will use GigE for both control and to transmit images to a TCS computer. These images will be stored for off-line analysis of beam shape.

7.3.10 aLIGO TCS CO2P IN-AIR TABLE OPTICAL POWER METER

The power from both paths of the CO2P will be monitored using Thorlabs S302C power meter heads. These can take 2W and give a 1uW resolution. The power meter heads will be connected to Thorlabs PM100D power meters which gives an analogue output as well as a local user display. The analogue output will be connected to EtherCAT to record data.

7.3.11 aLIGO TCS CO2P VIEWPORT IR SENSING CIRCUITRY [D1201528]

The ZnSe viewports will use an IR sensor to look for stray IR reflections (caused by sudden large scattering sources on the viewports, for example, insects settling on the ZnSe). This unit has a setpoint above which the laser interlock will be triggered.

7.3.12 aLIGO TCS CO2P IN-AIR TABLE 3-AXIS ACCEL SENSING CIRCUITRY

A 3-axis accelerometer will be used to measure the acceleration created by the shaker. A sensing circuit for this accelerometer is to either be purchased off the shelf or designed.

PEM is responsible for providing this.

8 Software

Software for the CO2P can be split into subcomponents (yet to be developed). There can be a realtime code model for control. In addition there will be a PC collecting data from the GigE camera link used for beam profiling. There will also be an EtherCAT system, though this will be integrated with the system used for the Hartmann wavefront sensors. There will also be some further scripts required. We discuss requirements for each of these below.

8.1 Realtime code

The realtime model for the CO2P (on the CDS SVN under `userapps/release/tcs/common/models`) will cover the following items:

- Collection of fast channel data from intensity stabilization photodiodes
- Control of the ISS
- Slow data related to the laser (thermopile output, piezo, locking status)
- QPD data
- Picomotor control
- Power control using the half-wave plates
- Power monitoring using power meters
- Servo for controlling the chillers

We intend to combine these functions in one model to reduce interdependencies in the TCS system

8.2 GigE beam imaging cameras

The beam profiler will use GigE for both data transfer and control of the camera. It is likely that the data from these cameras, which will be in image format, will not be recorded in the frames. Instead it will be recorded to a dedicated PC to be stored locally. This data is used for long term beam monitoring, not for any form of real time control.

8.3 Other scripts

RS232 monitoring of the chillers is an optional upgrade but not part of the baseline design.

8.4 Computing hardware/software requirements

In total the CO2P should require two computers per interferometer. One multi-core machine is needed to run the realtime system and scripts; a second machine is needed to collect image data from GigE cameras. This second machine may be shared with the Hartmann Sensor computer.

8.5 DAQ/Storage requirements

The following is a brief summary of the data acquisition storage requirements.

8.5.1 Fast channels

The fast channels to be recorded in the DAQ are listed in taken from the TCS_MASTER.mdl Simulink file.

```
#DAQ Channels

ISS_IN_AC_OUT* 2048
ISS_OUT_AC_OUT* 2048
ISS_CTRL1_OUT 1024
ISS_CTRL2_OUT 1024
PWR_SUPPLY_V_OUT 1024
PWR_SUPPLY_I_OUT 1024
AOM_OUT_GAIN_IN2 1024
PZT_OUT_GAIN_IN2 1024
```

Figure 19: The fast CO2P DAQ channels to be stored

Two CO2 laser projectors per interferometer yield a total of 4 x 2KHz + 12x 1KHz channels per IFO. The data rate is, thus, 10 × 2KHz × 2 Bytes = 40 KB/s.

8.5.2 Slow channels (≤16Hz)

The following is a list of the slow channels required for storage per CO2P.

- Shutters: (2× binary actuators, 2× binary read-backs)
- Power meters: (2× analogue readbacks)
- AOM: (1× DC analogue level set)
- ISS: (2× DC analogue level readback, 1× on/off switch, 1× analogue gain set)
- QPD: (8× analogue level readback)
- Polarizers: (2× angle set value, 2× actual value)
- Pico-motors: (6× set-point change request)
- Aiming lasers: (2× binary on/off actuators)
- Temperature sensors: (4× analogue readbacks)
- Flow meter: (1× analogue readback)

This yields a total of 34 slow channels to store at 16 Hz and 16 bits = 1KB/s. This does not include additional slow channels to be stored for other values such as set-points in PID loops, etc. To allow for plenty of head-room in slow channel storage multiply this by a factor of 3 = 3KB/s per CO2P.

This results in 6KB/s per IFO in slow channel storage.

8.5.3 Images

The method for storing images from the GigE beam imaging cameras has not been determined. The images themselves will be no greater than 640x480 pixels at 16-bit resolution = 600KB. They will not need to be stored very often (the shortest thermal time constant of the test mass is approximately 40s). A rate of 2 per minute will suffice. This yields an average rate of 20KB/s per camera, or 40KB/s per IFO.

9 Interfaces

9.1 Corner Station Mechanical Interfaces

Provided by TCS:

- [D1001227-v3: aLIGO TCS Envelopes, Corner Station, LLO, LHO]

It is known that the optical table supports for each of the TCS tables must allow for easy transportation of each of the tables, away from the vicinity of each of the BSC doors. The supports may be of a custom design, yet to be detailed. Tables are the standard RS4000 series, 18" thick, from Newport. Advertised performance for this type of table is shown below.

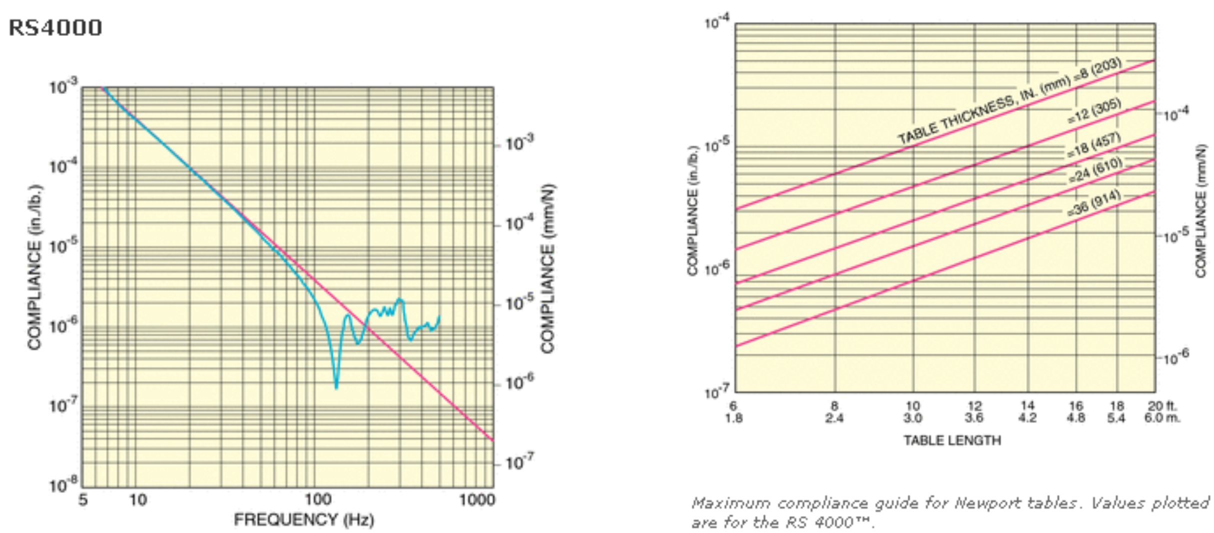


Figure 20: Advertised performance of RS4000 series tables from Newport

9.2 Corner Station Cabling/Plumbing Interfaces

Provided by Systems (SYS):

- [D1002704: Rack and Cable Tray Layout, LVEA, H1& H2]
- [D1003141: Rack and Cable Tray Layout, LVEA, L1]
- [E1000760: Cable Lengths, Corner Station, H1& H2]

10 Verification Testing and Modeling

10.1 Verification Plan

In order to verify expected performance of the laser projection system, a broad collaboration of modeling efforts is necessary. In recognition of this, ad-hoc collaborative modeling discussions have been held in the months leading up to this Final Design Review. In these discussions, it has been acknowledged, by attendants, that the top level modeling tools (for the interferometer) are not yet robust enough for complete correlation of building-block style modeling efforts, using a bottoms-up approach to the verification task. To track the roots of this discussion, visit the wiki page for minutes from the initial meeting.

Acceptance testing of TCS components is described in T1300495, Acceptance Testing of TCS Components.

10.2 Modeling

10.2.1 Requirement on annulus uniformity

Modeling of absorption of an annular beam on the CP has been used to show that phase front can be corrected sufficiently to meet the requirements set in Section 3. One extension of this model that is yet to be investigated is to look at the effect of a non-uniform annulus. The effect of offsetting the annulus has previously been looked at, as have the effects of altering annulus diameter and width. Here we are interested in understanding the effect of having a non-ideal alignment through the mask, which produces an annular beam with a higher power density on one side.

The aim of this modeling is to produce a requirement on beam uniformity that can be used to inform our interpretation of annular beam images that will be coming from the CO2P. This could be used either offline to interpret long term trends, or it could be done in real time to give information on whether the alignment of the system has drifted out with a required range.

10.3 Testing

What follows are descriptions of component tests that can produce data that will be used to verify CO2P once the full interferometer is operational.

10.3.1 Pointing from AOM and Laser

We will measure pointing effects from the laser and AOM using QPDs. Beam steering after the AOM will be used to correct for drifts in pointing.

Alternative AOMs could be tested if beam pointing is an issue from the IntraAction unit.

10.3.2 Investigation of laser stability

As part of the ISS system we will be acting on the laser chiller as well as the AOM. The chiller type and pipe lengths should be setup to closely mimic the situation at the sites. The chiller feedback loop must be setup and analyzed. Due to the latency of such long pipe lengths the unity gain frequency will be low, and the gain limited. It is also possible to improve the temperature stability of the laser using a thermally stabilized enclosure, and this will be considered if sufficient gain cannot be achieved using the chiller alone.

It is possible that the internal intensity stabilization for the laser may also be improved. We will investigate the possibility of implementing our own laser stabilization servo, possibly using photodiodes instead of the internal thermopile to increase bandwidth. We may investigate using separate chillers for the laser and the rest of the heat load.

10.3.3 Quantum efficiency of HgCdTe photodiodes in ISS

We will investigate the effects of spatial variation of the quantum efficiency of the HgCdTe photodiodes on power stability. This QE variation can couple jitter noise to intensity noise.

Approximate measurements of the QE of the HgCdTe photodiodes give 20% variation over mm distances (T0900428), though these values are approximate. The manufacturer does not provide data on QE.

The primary sources of jitter noise in initial LIGO were the laser and AOM. To reach the required ISS level we must have less than 1×10^{-9} m/√Hz of jitter on the photodiode.

10.4 Validity in context of all TCS

In order to validate the architecture of the laser projection system, it is necessary to consider, serially, the expected magnitude of all noise sources within the laser projection system once all components have been completely designed. Outstanding designs are listed in Section 2, above.

Fundamentally, noise associated with operations of the CO2 laser, itself, are to be validated in context of the specification (E1000065-v6). A detailed report of as-delivered performance of the first article *Lasy-50* device obtained from Access Laser Co. is presented in T1100508-v2. The following figures present some data gathered from operations of this device at Caltech.

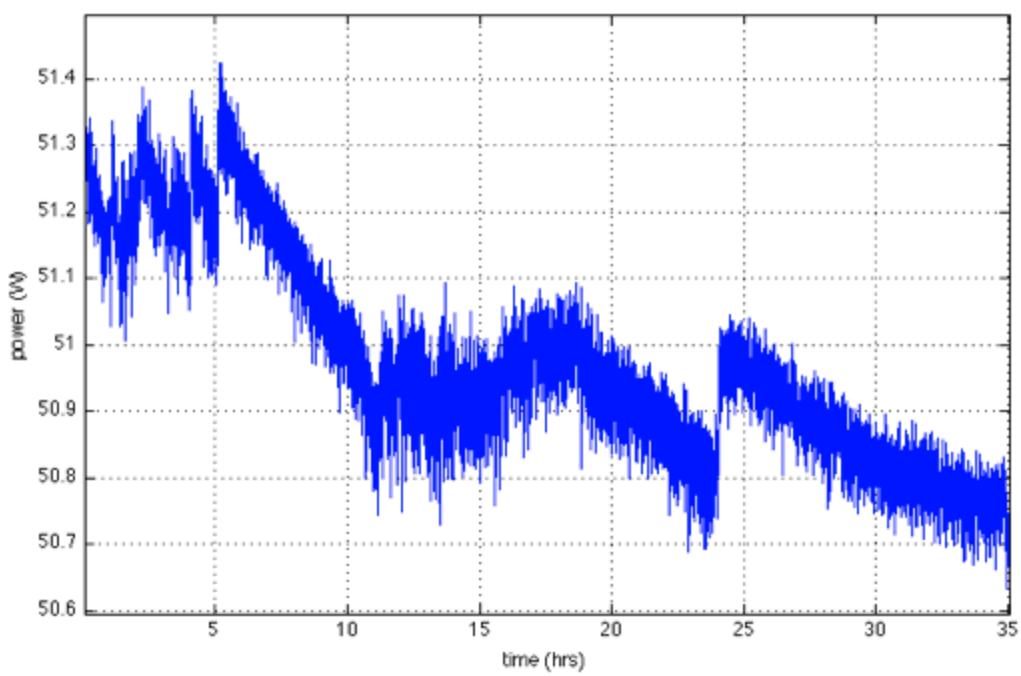


Figure 21: Short term power stability of Access *Lasy-50*

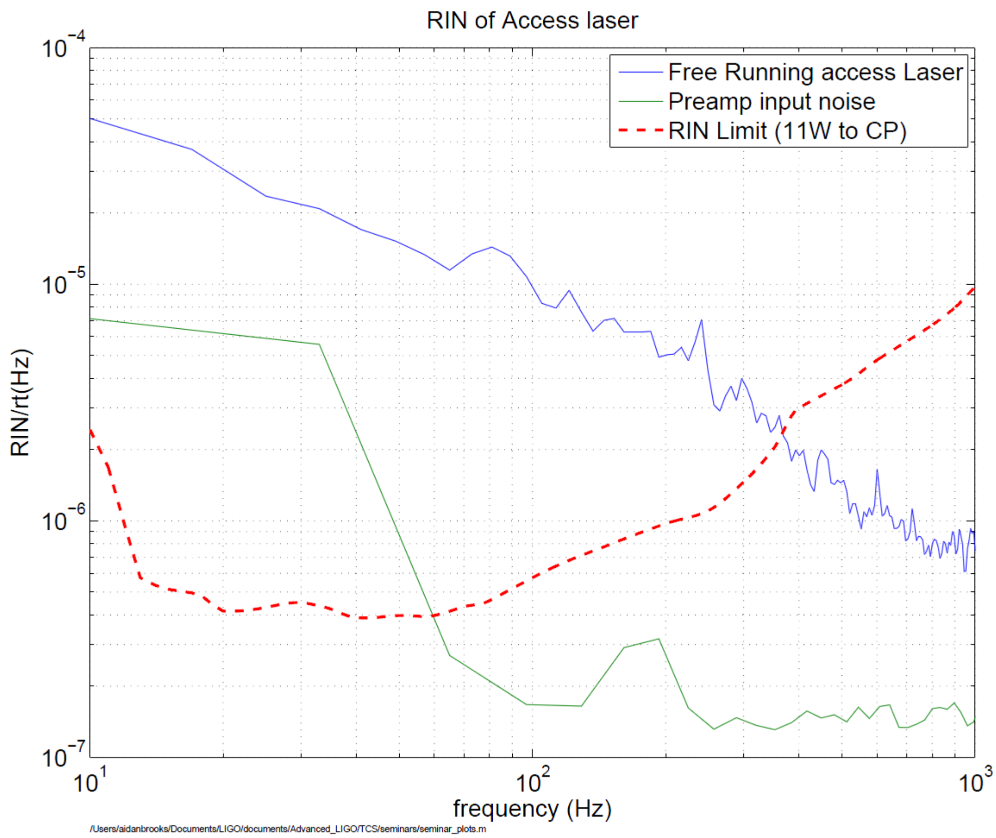


Figure 22: RIN of Access *Lasy-50*

Long term power stability of the laser is being monitored continuously in the Caltech laboratory. 12 days of continuous data are plotted, for example, in Figure 23 below. The laser exhibits a daily variation of approximately ±0.5%. No glitches were observed over the 12-day period.

This easily satisfies the glitch requirement in Section 3.2.2.3.

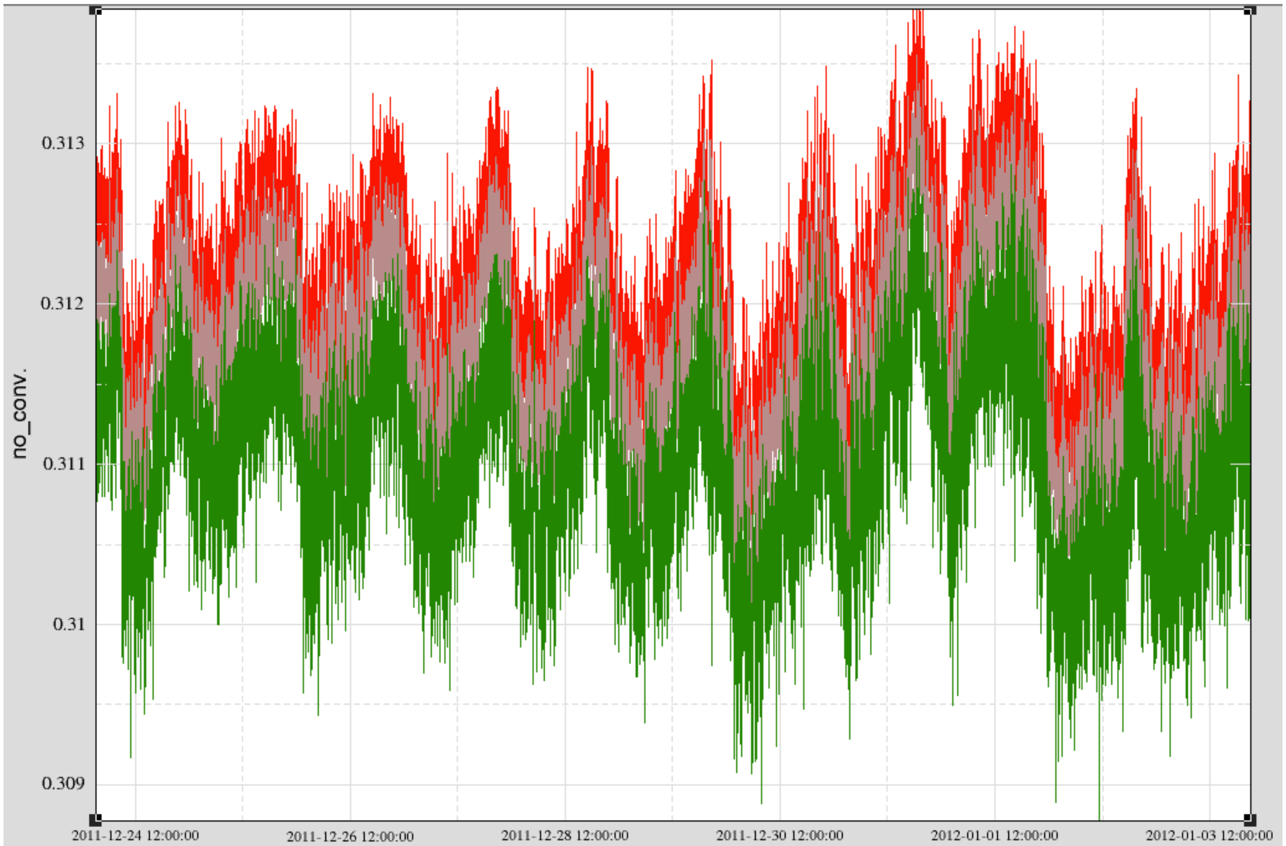


Figure 23: Power of Access laser over 12days, measured with 0.3W pickoff beam. Red trace shows maximum and green curve shows minimum of hourly trend data.

11 Procedures

11.1 Cleaning

The custom ∅4" periscope mirrors described in section 5.3.1 should be cleaned in accordance with the procedure given by T1100596.

The custom ∅12" mirror, installed in vacuum for H2 laser projections onto the compensation plates in BSC's 7 & 8, are to be cleaned in accordance with the approved procedure given by T1100179-v13.

11.2 Alignments

The alignment procedure for the in-vacuum steering mirrors is described in E1400137, Punch List for Re-Aligning aLIGO TCS CO2P-X UHV Steering Mirror #1 (BSC3).

11.3 Operations

The CO2P Operations Manual is on the DCC under E1300233.

12 Safety

The hazards associated with the aLIGO TCS CO2P are discussed in detail in E1000205 - aLIGO TCS Hazard Analysis.

For all activities conducted in the laboratory at Caltech, the approved standard operating procedure (M1000024-V12) must be followed.

As the design of the CO2P for aLIGO is conceptually very similar to the eLIGO design (the peak laser power and thermal power in the system is roughly 2× that of eLIGO), the identification of hazards and mitigation has not changed significantly from that system, the hazard analyses for which are linked below.

- E080206 - LHO ELIGO TCS Hazard Analysis
- E080501 - ELIGO TCS Hazard Analysis, Volume 2

The greatest hazards regarding this subsystem remain the same as eLIGO and are as follows:

1) Class IV radiation directed into an operators eyes [Personnel hazard],
2) Personnel burns (on hands) due to infrared radiation [Personnel hazard],
3) Power supply grounding faults [Equipment hazard];
4) Handling of heavier parts by hand and lifting them under the manifolds (i.e., power supplies, chillers) [Personnel hazard]
5) failure of the ZnSe vacuum viewport window under intense illumination if contaminated by a highly absorbing material. [Equipment hazard]
6) Overheating and damage of equipment that handles high power (electrical or thermal). [Equipment hazard]

More detail on these hazards is briefly summarized in the following two subsections. For full details, see E1000205 - aLIGO TCS Hazard Analysis.

12.1 Equipment Hazards

The following hazards have been identified that may damage equipment:

- **Fire**
  - Fire hazard due to equipment/cable burn through.
- **Heat**.
  - Coolant failure: Should the liquid coolant supply to the TCS table fail, the laser and acousto-optical modulator (Figure 5, Right) could overheat. There is no personnel risk due to this eventuality. Both these devices contain internal fail-safe devices that sense temperature increases and shut themselves down when overheating occurs.
- **Laser**
  - The 50W laser has the potential to damage optics and equipment on the table, including the viewport to the vacuum, if it is improperly used or aligned or if the absorption on a particular optic becomes very high. To alleviate this:
    - gold-coated copper mirrors are used wherever possible for beam steering (the high thermal conductivity makes it next to impossible to damage these with 35W of laser power as repeated damage tests have shown).

        - The optics will be enclosed in HEPA filtered enclosure to help prevent contamination
    - Failure of ZnSe viewports: A viewport cover will prevent contamination of the primary viewport to the vacuum system. This viewport will be temperature interlocked to shutdown the laser in the event that it becomes contaminated and overheats.
- **Misc. hazards**
    - Equipment, especially the laser, can be damaged as it is being transported if it is mishandled.
    - Electronics failure, specifically failure of the laser power supply.

12.2 Personnel hazards

The primary hazard to humans is the Class 4W 50W CO2 laser. This poses both eye and skin hazards. Specifically, there are hazards associated with:

- TCS 30m Laser Alignment: there are unique personnel hazards associated with projecting the laser beam across the LVEA floor.
- Bodily laser burn to personnel: during regular operation and maintenance
- Laser burn to eye: during regular operation and maintenance
- Fire hazard due to equipment burn through
- Electronics failure: failure of the power supply chassis grounding
- Laser power control failure: during alignment

Standard Class 4 laser protocol will be employed when human interference with this laser is required. Due to the safe and continuous operation of the eLIGO lasers and the large similarities between the aLIGO CO2 projector and the eLIGO CO2 projector, the aLIGO standard operating procedure (SOP) will be as close as possible to the eLIGO SOP:

"Standard Operating Procedure Aligning the Thermal Compensation Laser Operating in LVEA," LIGO-M080080-00-W

"Standard Operating Procedure Thermal Compensation Laser Operating in LVEA," LIGO-M080082-00-W

13 Project Planning

13.1 Schedules

Activities associated with the production and installation phases for all elements of aLIGO TCS are linked to formal (INS) activity identifiers in M1200009.

As stated in Section 2.3, above, laser projection system items on the critical path to meeting (INS) need-by dates are the two steering mirror assemblies for BSCs 1, 2 and 3 (D1101013-v1 and D1101851-v1).

13.2 Costs

The most recent costing baseline is documented in M1000349-v2. Since the time of this ACR (#110012), the CO2P bills of materials (BOMs) for all components have been matured and detailed, though not finalized. The Appendix includes detailed BOMs

i. for items installed in air
ii. for electronics
iii. for items to be installed in the vacuum system (or at the vacuum interface)

From these, updating completion estimates can be an on-going activity. The current (unapproved) cost book is given by M1000349-v5.

The CO2 power supply was evaluated using the bid-evaluation matrix in C1201369.

13.3 Procurements

The "notes" column in each of the BOMs includes vendor information. In the case of CO2P, most items to be used for installations in air are readily available from commercial catalogs.

The CO2 laser procurement has been concluded; see procurement activity "AO-214b TCS - CO2 Laser" for details.

Many custom items, for installations in vacuum or at the vacuum interface, have been procured due to early need-by dates and long-lead times. Examples are:

- Assemblies D1002431-v3 and D1001742-v3
- Handling fixture (D1100263-v3) for the ∅12" mirror in each of the above assemblies
- Assembly Type -01 of D1003193-v3
- ZnSe viewports, both primary and secondary (D1100439 and D1100485, respectively)

Custom optics which may have long-lead times but have not been procured include:

- ∅3" optical viewports (see section 6.3)
- ∅10" hard-gold coated copper mirrors for H1-L1 SM2 assemblies (D1101851-v1)
- anamorphic prisms
- ∅4" periscope mirrors (see section 5.3.1)

Associated costs and vendors for each of these have, however, been identified.

Procurement plans associated with custom electronics are not yet mature, due to immature designs.

Beam quality monitoring can be performed by commercially available devices. Several particular vendors and product types have already been investigated, in terms of cost, lead time and technical capabilities. (See, for example, C1107040-v3 and C1107005-v2.) A specification for requirements of these devices in context of operation within the laser projection system, however, have not been fully documented. These requirements will be used to complete systematic rankings of all possible commercial devices.

Similarly, a specification (E1101107-v3) for requirements of a chiller has been drafted. This is to be used to help identify the most optimal chiller for use in conjunction with each laser. To ensure consistent operations *within* any single interferometer (IFO), all chillers should be the same make and model.

13.4 Receiving Inspections

All custom optics used in the laser projection system are going through 100% inspection upon receipt.

Custom machined parts are being inspected with respect to critical dimensions, which are identified on detailed drawings, by vendors' in-house quality assurance departments whenever possible.

Each laser is shipped with data associated with the awarded Statement of Work (C1000270-v7). Upon receipt, data are to be verified on site. In addition, it has been determined that circuit boards internal to each RF driver, which are supplied by Access Laser Co. (together with each CO2 laser), must be tested rigorously to determine robustness in functionality. There have been two failures encountered during operational tests of the first article.

14 Project Planning - Appendix

(i) - Items installed in air

Subsystem:	CO2P System	
Reporter:	Mindy Jacobson	
Date:	7-Jan-12	
	Total No. [MTS] Dwgs =	325
	Aggregate %-complete =	45%

DCN	NOTES	Level	QUANTITY REQ'd	SPARE	TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.]		NAME	TYPE	MODEL STATUS	DWG STATUS	SRC	PDR REV.	delta-PDR REV.	FDR REV.
No.													% COMPLETE					
	EXTERNAL TO VACUUM																	
{}	(QTY 1EA TYPE)X2 IFOs	0	2	0	2	EA		D1000634	-01	-02	**aLIGO TCS CO2P TABLE ASSY, H1/L1**	TopAssy	20	0	MTS	N/A	N/A	v1
	VACUUM INTERFACE	1	2	0	2	EA		D1101627	-01	-02	VIEWPORT ENCLOSURE ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P TABLE, H1/L1	PRT	0	0	OTS	N/A	N/A	
		2	1		1	EA		D1000499			TCS CO2P OPTICS TABLE ENVELOPE	PRT	100	0	MTS	N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P SUPPORTS, H1/L1	PRT	0	0	MTS	N/A	N/A	
		2	1		1	EA		D1000500			TCS CO2P TABLE SUPPORTS ENVELOPE	PRT	100	0	OTS	N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P ENCLOSURE, H1/L1	PRT	0	0	MTS	N/A	N/A	
		2	1		1	EA		D1001168			aLIGO TCS CO2P TABLE ENCLOSURE ENVELOPE	PRT	100	0		N/A	N/A	
		1	1		1	EA		D1001934			aLIGO TCS CO2 LASER, Access Lasy-50	ASSY	100	100	MTS	N/A	N/A	v1
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P MECH OPTICS LAYOUT, H1/L1	ASSY	0	0	MTS	N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P H1/L1 OPTIC_1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P H1/L1 OPTIC_n-1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P H1/L1 OPTIC_n	PRT	0	0		N/A	N/A	
		2	1		1	EA		D1000791			ROTATION STAGE ASSEMBLY	ASSY	100	100	MTS	N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P ISS ELECTRONICS MECH SUPPORT_1	PRT	0	0		N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P ISS ELECTRONICS MECH SUPPORT_n-1	PRT	0	0		N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P ISS ELECTRONICS MECH SUPPORT_n	PRT	0	0		N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P TABLE HARDWARE, H1/L1	HW	0	0	OTS	N/A	N/A	
{}	(QTY 1EA TYPE)X2 IFOs	0	2		2	EA		D1000630	-01	-02	**aLIGO TCS CO2P TABLE ASSY, H2**	TopAssy	25	0	MTS	N/A	N/A	v1
	VACUUM INTERFACE	1	1		1	EA	E1100656	D1003193	-01	-02	aLIGO TCS VIEWPORT ENCLOSURE ASSY, CO2P	ASSY	100	100	OTS	N/A	N/A	v3
		1	1		1	EA		D1100477			TCS VIEWPORTS SPERICAL BEARING PERISCOPE ASSY	ASSY	90	75	MTS	N/A	N/A	v1
		2	1		1	EA		D1100299			PERISCOPE TUBE, CO2P VP ENCLOSURE	PRT	90	75	MTS	N/A	N/A	v1
		2	1		1	EA		D1100416			SPHERICAL BEARING, CO2P VP ENCLOSURE	PRT	90	25	MTS	N/A	N/A	v1
	UC COMPONENTS	2	1		1	EA					SET SCREW	HW	90	0	OTS	N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P TABLE, H2	PRT	0	0	OTS	N/A	N/A	
		2	1		1	EA		D1000499			TCS CO2P OPTICS TABLE ENVELOPE	PRT	100	0	MTS	N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P SUPPORTS, H2	PRT	0	0	MTS	N/A	N/A	
		2	1		1	EA		D1000500			TCS CO2P TABLE SUPPORTS ENVELOPE	PRT	100	0	OTS	N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P ENCLOSURE, H2	PRT	0	0	MTS	N/A	N/A	
		2	1		1	EA		D1001168			aLIGO TCS CO2P TABLE ENCLOSURE ENVELOPE	PRT	100	0		N/A	N/A	
		1	1		1	EA		D1001934			aLIGO TCS CO2 LASER, Access Lasy-50	ASSY	100	100	MTS	N/A	N/A	v1
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P MECH OPTICS LAYOUT, H2	ASSY	0	0	MTS	N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P H2 OPTIC_1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P H2 OPTIC_n-1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P H2 OPTIC_n	PRT	0	0		N/A	N/A	
		2	1		1	EA		D1000791			ROTATION STAGE ASSEMBLY	ASSY	60	60	MTS	N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P ISS ELECTRONICS MECH SUPPORT_1	PRT	0	0		N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P ISS ELECTRONICS MECH SUPPORT_n-1	PRT	0	0		N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P ISS ELECTRONICS MECH SUPPORT_n	PRT	0	0		N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P TABLE HARDWARE, H2	HW	0	0	OTS	N/A	N/A	
																N/A	N/A	
{}	(QTY 1EA TYPE)X2 IFOs	0	2	2	4	EA		DXXXXXXX			**aLIGO TCS CO2P CHILLER INSTALL ASSY, H1/L1**	TopAssy	0	0	MTS	N/A	N/A	
		1	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER, H1/L1	PRT	0	0	OTS	N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMBING, H1/L1	ASSY	0	0	MTS	N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n-1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n	PRT	0	0		N/A	N/A	
		1	1		1	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMBING, H1/L1	ASSY	0	0	MTS	N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n-1	PRT	0	0		N/A	N/A	
		2	?		###	EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n	PRT	0	0		N/A	N/A	
																N/A	N/A	
{}	(QTY 1EA TYPE)X1 IFO	0	1	1	2	EA		DXXXXXXX			**aLIGO TCS CO2P CHILLER INSTALL ASSY, H2**	TopAssy	0	0	MTS	N/A	N/A	
		1	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER, H2	PRT	0	0	OTS	N/A	N/A	
		1	1			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMBING, H2	ASSY	0	0	MTS	N/A	N/A	
		2	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_1	PRT	0	0		N/A	N/A	
		2	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n-1	PRT	0	0		N/A	N/A	
		2	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n	PRT	0	0		N/A	N/A	
		1	1			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMBING, H2	ASSY	0	0	MTS	N/A	N/A	
		2	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_1	PRT	0	0		N/A	N/A	
		2	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n-1	PRT	0	0		N/A	N/A	
		2	?			EA		DXXXXXXX			aLIGO TCS CO2P CHILLER PLUMB ITEM_n	PRT	0	0		N/A	N/A	

(ii)a - Electronics

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN	NOTES	Level	INDENTURE CHART	QUANTITY REQ'd	SPARE	TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.]	NAME	TYPE	MODEL STATUS	DWG STATUS	SRC	PDR REV.	delta-PDR REV.	FDR REV.
No.													% COMPLETE					
	ELECTRONICS																	
{}		0		?			EA				**aLIGO TCS ISS SERVO DRIVER [ACTS ON AOM]**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
									DXXXXXXX		ISS DRIVER ASSY CHASSIS (HARDWARE)	PRT	0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P QPD SENSING CIRCUITRY**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P QPD AMPLIFIER CIRCUITRY**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}	OP'S	0		?			EA				**aLIGO TCS CO2P CHILLER FLOWMETER SENSING & INTERLOCK C**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P CHILLER FLOWMETER SENSING CIRCUITRY**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P LASER TEMP. SENSING CIRCUITRY**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P LASER FORWARD TEMP. CONTROL SERVO**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P LASER ENABLING (INTERLOCK) CIRCUITRY**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P LASER POWER SUPPLY**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
									DXXXXXXX		LASER POWER SUPPLY EMI SHIELDING / CHASSIS (HARDWARE)	PRT	0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P LASER PZT DRIVER [100V SUPPLY]**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
									DXXXXXXX		LASER PZT DRIVER ASSY CHASSIS (HARDWARE)	PRT	0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P AOM DRIVER**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
									DXXXXXXX		CO2P AOM DRIVER ASSY CHASSIS (HARDWARE)	PRT	0	0	MTS	N/A	N/A	
{}		0		?			EA				**aLIGO TCS CO2P AOM FREQUENCY SYNCHRONIZATION CIRCUITR**	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	

(ii)b - Electronics

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN	NOTES	Level	INDENTURE CHART	QUANTITY REQ'd	QUANTITY SPARE	QUANTITY TOT.	QUANTITY UNITS	BOM item no.	DCC No.	TYPE [config.]	NAME	TYPE	MODEL STATUS	DWG STATUS	SRC	PDR REV.	delta-PDR REV.	FDR REV.
No.													% COMPLETE					
{}	SEE ALSO HWS D1101738	0		?			EA				aLIGO TCS CO2P PICO MOTOR DRIVER	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA				WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
	?								D1101739		HWS [IN-AIR] PICO MOTOR B/O BOX FRONT PANEL	PRT	0	0	OTS	N/A	N/A	V2
	?								D1101740		HWS [IN-AIR] PICO MOTOR B/O BOX REAR PANEL	PRT	0	0	MTS	N/A	N/A	V2
{}	NEWPORT	0		?			EA		DXXXXXXX		aLIGO TCS CO2P ROTATION STAGE DRIVER	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}	? SUPPLIED BY NEWPORT	0		?			EA		DXXXXXXX		aLIGO TCS CO2P ROTATION STAGE POWER SUPPLY	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				aLIGO TCS CO2P FLIPPER MIRROR DRIVER	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
									DXXXXXXX		CO2P FLIPPER MIRROR DRIVER ASSY CHASSIS (HARDWARE)	PRT	0	0	MTS	N/A	N/A	
{}	? SUPPLIED BY NEWPORT	0		?			EA		DXXXXXXX		aLIGO TCS CO2P FLIPPER MIRROR POWER SUPPLY	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}	OTS?	0		?			EA				aLIGO TCS CO2P AIMING LASER DIODE DRIVER	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
									DXXXXXXX		CO2P AIMING LASER DIODE DRIVER ASSY CHASSIS (HARDWARE)	PRT	0	0	MTS	N/A	N/A	
{}	OTS ?	0		?			EA				aLIGO TCS CO2P THERMAL IMAGING CAMERA DRIVER	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
	OTS PROFILER ?	0		?			EA				aLIGO TCS BEAM SCANNING CIRCUITRY	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT	HW	0	0	OTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		BEAM SCANNING CIRCUIT CHASSIS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}	OP'S + COMMISSIONING	0		?			EA				aLIGO TCS CO2P IN-AIR TABLE OPTICAL POWER METER	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
	OTS ?								DXXXXXXX		CO2P IN-AIR TABLE POWER METER ASSY HARDWARE	PRT	0	0	MTS	N/A	N/A	
{}	OTS ?	0		?			EA				aLIGO TCS CO2P IN-AIR TABLE SHAKER CIRCUITRY	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}	OTS ?	0		?			EA				aLIGO TCS CO2P IN-AIR TABLE 3-AXIS ACCEL SENSING CIRCUITR	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}	OTS	0		?			EA		DXXXXXXX		aLIGO TCS CO2P DEDICATED PC	ASSY	0	0	OTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	
{}		0		?			EA				aLIGO TCS CO2P VIWEPORT TEMP SENSING CIRCUITRY	ASSY	0	0		N/A	N/A	
		1					EA		DXXXXXXX		BOARD LAYOUT		0	0	MTS	N/A	N/A	
		1					EA				GERBER FILES		0	0	MTS	N/A	N/A	
		1					EA				SCEMATICS		0	0	MTS	N/A	N/A	
		1					EA		DXXXXXXX		WIRING DIAGRAMS		0	0	MTS	N/A	N/A	

(iii)a - Items installed in the vacuum system or at the vacuum interface

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN No.	NOTES	Level	INDENTURE CHART	QUANTITY REQ'd	QUANTITY SPARE	QUANTITY TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.]	NAME	TYPE	MODEL STATUS (% COMPLETE)	DWG STATUS (% COMPLETE)	SRC	PDR REV	delta-PDR REV	FDR REV
INTERNAL TO VACUUM																		
E1101043	**BSC1 = mirror BSC3**	0		2	0	2	EA	E1101044	D1101013	-01 -02	**aLIGO TCS CO2P STEERING MIRROR 1 ASSY, H1/L1**	TopAssy	100	100	MTS	N/A	N/A	
		1		1	0	1	EA		D1001605		CO2P ITMX M1 ASSEMBLY ENVELOPE, BSC1	PRT	100	0	MTS	N/A	N/A	
		1		1	0	1	EA		D1001604		CO2P ITMX M1 ASSEMBLY ENVELOPE, BSC3	PRT	100	0	MTS	N/A	N/A	
E1101043		1		1	0	1	EA		D1102029		aLIGO TCS MIRROR ASSY	ASSY	100	100	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101014		aLIGO TCS CO2P STEERING MIRROR 1, H1-L1	PRT	100	100	MTS	N/A	N/A	v1
	Olander or AirHardware	3		2	2	4	EA		1185-2EN 410		HELICOIL [N60, 8-32 X 2.5D LONG]	HW	0	0	OTS	N/A	N/A	
E1101043		2		1	0	1	EA		D1101295		H1-L1 STEER M1 SUPPORT	PRT	100	100	MTS	N/A	N/A	v1
	Olander or AirHardware	3		2	2	4	EA		1185-2EN 410		HELICOIL [N60, 8-32 X 2.5D LONG]	HW	100	0	OTS	N/A	N/A	
	Olander or AirHardware	3		8	2	10	EA		1185-06EN 345		HELICOIL [N60, 6-32 X 2.5D LONG]	HW	100	0	OTS	N/A	N/A	
E1101043		2		2	0	2	EA		D1101294		H1-L1 STEER M1 AZ BRACKET	PRT	100	100	MTS	N/A	N/A	V1
	Olander or AirHardware	3		1	1	2	EA		1185-2EN164		HELICOIL [N60, 8-32 X 1D LONG]	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		C-607		SHCS 6-32 X .438 LONG, VENTED	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		WF-06-A		FLAT WASHER, #6, Au PLATED	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	2	4	EA		C-824-NA		SHCS 8-32 X 1.5 LONG, Au PLATED	HW	100	0	OTS	N/A	N/A	
	UC Components	2		4	1	5	EA		WF-08		FLAT WASHER, #8	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	2	4	EA		N-832-A		HEX NUT, #8, Au PLATED	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	1	3	EA		SHCV-4423		SHLDR SCREW, 1 IN, HEX HD, 8-32, VENTED, 303 SS	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	1	3	EA		WFV-10		FLAT WASHER, .1875 SHLDR SHANK	HW	100	0	OTS	N/A	N/A	
E1101043		1		1	0	1	EA		D1102078	-01 -02	aLIGO MOUNT ASSY, TCS STEERING MIRROR 1	ASSY	100	100	MTS	N/A	N/A	v1
E1101043		2		1	0	1	EA		D1101292		H1-L1 SM1 AZ SUPPORT BRACKET	PRT	100	100	MTS	N/A	N/A	v1
	Olander or AirHardware	3		1	1	2	EA		1191-3EN 285		HELICOIL [N60, 10-32 X 1.5D LONG]	HW	0	0	OTS	N/A	N/A	
	UC Components	2		1	1	2	EA		SHCV-4436		SHLDR SCREW, 1.5 IN, HEX HD, 10-32, VENTED, 303 SS	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	2	4	EA		C-812		SHCS 8-32 X .75 LONG, VENTED	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	2	4	EA		C-808-N		SHCS 8-32 X .5 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		2	2	4	EA		C-814-N		SHCS 8-32 X .875 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		31	4	35	EA		WF-08-A		FLAT WASHER, #8, Au PLATED	HW	100	0	OTS	N/A	N/A	
E1101043		2		1	0	1	EA		D1101291	-01 -02	H1-L1 STEER M1 BRACKET	PRT	100	100	MTS	N/A	N/A	v1
	Olander or AirHardware	3		12	3	15	EA		1185-4EN 500		HELICOIL [N60, 1/4-20 X 2D LONG]	HW	100	0	OTS	N/A	N/A	
	Olander or AirHardware	3		7	1	8	EA		1185-2EN 500		HELICOIL [N60, 8-32 X 3D LONG]	HW	100	0	OTS	N/A	N/A	
	Olander or AirHardware	3		4	1	5	EA		1185-2EN 410		HELICOIL [N60, 8-32 X 2.5D LONG]	HW	100	0	OTS	N/A	N/A	
	UC Components	2		7	1	8	EA		C-2018-N		SHCS 1/4-20 X 1.125 LONG	HW	100	0	OTS	N/A	N/A	
E1101043		2		2	2	4	EA		D1101395		TCS SM1 H1-L1 INTERFACE DAMPER	PRT	100	100	MTS	N/A	N/A	v1
E1101043		2		2	0	2	EA		D1101287	-01	STANDARD T SECTION, SS 304, 2 X 2 X .25	PRT	100	100	MTS	N/A	N/A	v1
	UC Components	2		14	6	20	EA		C-812-N		SHCS 8-32 X .75 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		11	4	15	EA		N-832		HEX NUT, #8	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		C-2028-N		SHCS 1/4-20 X 1.75 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		N-2520-A		SS NUT, HEX HD, 1/4-20, Au PLTD	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		NJ-2520		SS HEX JAM NUT, 1/4-20	HW	100	0	OTS	N/A	N/A	
	UC Components	2		31	4	35	EA		WF-25-A		FLAT WASHER, .25	HW	100	0	OTS	N/A	N/A	
E1101043		2		1	0	1	EA		D1101437		TCS SM1 H1-L1 STRONG BACK	PRT	100	100	MTS	N/A	N/A	v1
	Olander or AirHardware	3		3	2	5	EA		1185-2EN 410		HELICOIL [N60, 8-32 X 2.5D LONG]	HW	100	0	OTS	N/A	N/A	
E1101043		2		1	0	1	EA		D1101438		STANDARD ANGLE SECTION, SS 316, 1.25 X 1.25 X .25	PRT	100	100	MTS	N/A	N/A	v1
	UC Components	2		7	1	8	EA		C-2012-N		SHCS 1/4-20 X .75 LONG	HW	100	0	OTS	N/A	N/A	
E1101043		1		1	0	1	EA		D1102088	-01 -02	aLIGO WEDGE SUPPORT ASSY, TCS STEER MIRROR 1	ASSY	100	100	MTS	N/A	N/A	v1
E1101043		2		1	0	1	EA		D1101771	-01 -02	WEDGE SUPPORT, H1-L1, aLIGO TCS CO2P SM1	PRT	100	100	MTS	N/A	N/A	v1
	UC Components	2		4	1	5	EA		C-2012-N		SHCS 1/4-20 X .75 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		4	1	5	EA		C-2016-N		SHCS 1/4-20 X 1 LONG	HW	100	0	OTS	N/A	N/A	
E1101043		2		2	0	2	EA		D1101287	-02	STANDARD T SECTION, SS 304, 2 X 2 X .25	PRT	100	100	MTS	N/A	N/A	v1
	UC Components	2		8	2	10	EA		C-812-N		SHCS 8-32 X .75 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		16	4	20	EA		WF-08-A		FLAT WASHER, #8, Au PLTD	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		N-832		HEX NUT, #8	HW	100	0	OTS	N/A	N/A	
	UC Components	2		4	1	5	EA		C-2024-N		SHCS 1/4-20 X 1.5 LONG	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		N-2520-A		SS NUT, HEX HD, 1/4-20, Au PLTD	HW	100	0	OTS	N/A	N/A	
	UC Components	2		8	2	10	EA		NJ-2520		SS HEX JAM NUT, 1/4-20	HW	100	0	OTS	N/A	N/A	
	UC Components	2		12	3	15	EA		WF-25-A		FLAT WASHER, .25	HW	100	0	OTS	N/A	N/A	

(iii)b - Items installed in the vacuum system or at the vacuum interface

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN No.	NOTES	Level	QUANTITY REQ'd	SPARE	TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.]		NAME	TYPE	MODEL STATUS (% COMPLETE)	DWG STATUS (% COMPLETE)	SRC	PDR REV.	delta-PDR REV.	FDR REV.
																N/A	N/A	
E1200002	**BSC2**	0	1	0	1	EA	E1200003	D1101851	-01	-02	**aLIGO TCS CO2P SYS STEERING OPTICS ASSY, H1/L1, BSC2**	TopAssy	100	0	MTS	N/A	N/A	v1
		1	1	0	1	EA		D1001192			CO2P ITMX M2 ASSEMBLY ENVELOPE	PRT	100	0	MTS	N/A	N/A	
		1	1		1	EA		D1001193			CO2P ITMY M2 ASSEMBLY ENVELOPE	PRT	100	0	MTS	N/A	N/A	
	Kugler	1	2		2	EA		D1102171			aLIGO TCS CO2P STEERING MIRROR 2, H1-L1	PRT	100	90	MTS	N/A	N/A	v1
	Olander or AirHardware	2	8	2	10	EA		1185-3EN285			HELICOIL [N60, 10-24 X 1.5D LONG]	HW	0	0	OTS	N/A	N/A	
		1	4	0	4	EA		D1102175			FINE ADJUST PIVOT ROD, CO2P SM2, H1-L1	PRT	100	0	MTS	N/A	N/A	v1
		1	2	0	2	EA		D1102413			ELEVATION SUPPORT PLATE, CO2P SM2, H1-L1	PRT	100	0	MTS	N/A	N/A	v1
	UC Components	2	4	1	5	EA		C-2418-A			SHCS, 10-24 X 1.125 IN LONG, VENTED, Au PLATED	HW	100	0	OTS	N/A	N/A	
	UC Components	2	4	1	5	EA		WF-10			FLAT WASHER, #10	HW	100	0	OTS	N/A	N/A	
		1	1	0	1	EA		D1102176	-01	-02	AZIMUTH SUPPORT PLATE, CO2P SM2, H1-L1	PRT	100	90	MTS	N/A	N/A	v1
	UC Components	2	4	1	5	EA		C-2412-A			SHCS, 10-24 X .75 IN LONG, VENTED, Au PLATED	HW	100	0	OTS	N/A	N/A	
	UC Components	2	4	1	5	EA		WF-10			FLAT WASHER, #10	HW	100	0	OTS	N/A	N/A	
	Olander or AirHardware	2	2	2	4	EA		1191-3EN285			HELICOIL [N60, 10-32 X 1.5D LONG]	HW	0	0	OTS	N/A	N/A	
		1	1	0	1	EA		D1102380	-01	-02	aLIGO TCS CO2P SM2 ASSY SHORT SUPPORT	PRT	100	0	MTS	N/A	N/A	v1
		1	1	0	1	EA		D1102384	-01	-02	aLIGO TCS CO2P SM2 ASSY LONG SUPPORT	PRT	100	0	MTS	N/A	N/A	v1
		1	1	0	1	EA		D1102440	-01	-02	SUPPORT BRACKET, SHORT-SIDE SUSPENSION ARM	PRT	100	0	MTS	N/A	N/A	v1
	Olander or AirHardware	2	1	1	2	EA		1191-3EN285			HELICOIL [N60, 10-32 X 1.5D LONG]	HW	0	0	OTS	N/A	N/A	
		1	1	0	1	EA		D1102441	-01	-02	SUPPORT BRACKET, LONG-SIDE SUSPENSION ARM	PRT	100	0	MTS	N/A	N/A	v1
	Olander or AirHardware	2	1	1	2	EA		1191-3EN285			HELICOIL [N60, 10-32 X 1.5D LONG]	HW	0	0	OTS	N/A	N/A	
	UC COMPONENTS	1	8	2	10	EA		SHCV-4436			VENTED HEX HD 1.5IN SHOULDER SHC #10-32	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	1	12	3	15	EA		C-2016-N			SHCS 1/4-20 X 1 LONG	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	1	32	8	40	EA		WF-25-A			FLAT WASHER, .25	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	1	12	3	15	EA		N-2520-A			SS NUT, HEX HD, 1/4-20, Au PLTD	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	1	12	3	15	EA		NJ-2520			SS HEX JAM NUT, 1/4-20	HW	100	0	OTS	N/A	N/A	

(iii)c - Items installed in the vacuum system or at the vacuum interface

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN	NOTES	Level	INDENTURE CHART	QUANTITY REQ'd	QUANTITY SPARE	QUANTITY TOT.	QUANTITY UNITS	BOM item no.	DCC No.	TYPE [config.]		NAME	TYPE	MODEL STATUS	DWG STATUS	SRC	PDR REV.	delta-PDR REV.	FDR REV.
No.														% COMPLETE					
	(QTY 1EA TYPE)X2 IFOs	0		2	0	2	EA		D1101627	-01	-02	**VIEWPORT ENCLOSURE ASSY, H1-L1 CO2P TCS**	TopAssy	100	0	MTS	N/A	N/A	v1
	IN AIR ASSY	1		1	0	1	EA		D1101628	-01	-02	TOP PERISCOPE ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		SL101.6N-PZA12			MIRROR MOUNT ASSY	ASSY	100	0	MTS	N/A	N/A	
		2		1	0	1	EA		D1100453			ENHANCED ALUMINUM MIRROR, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	
		2		1	0	1	EA		D1101635			TOP PERISCOPE FIXTURE, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		DXXXXXXX			H1-L1 PERISCOPE FIXTURE PIVOT PIN	PRT	100	0	MTS	N/A	N/A	v1
	UC COMPONENTS	2		X		1	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		1	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		1	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		1	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		1	0	1	EA		D1101629	-01	-02	VIEWPORT CAMERA MIRROR ASSEMBLY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		2	0	2	EA		D1101256			ENHANCED ALUMINUM MIRROR, CO2P VP ENCLOSURE	PRT	100	100	OTS	N/A	N/A	
		2		1	0	1	EA		D1101544			H1-L1 VIEWPORT CAMERA MIRROR FIXTURE	PRT	100	0	MTS	N/A	N/A	v1
	NEWPORT	2		1	0	1	EA		U200-AC3K			3-AXIS MIRROR MOUNT, 2 IN	ASSY	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		1	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		1	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	UHV INTERFACE ASSY	1		1	0	1	EA		D1101630	-01	-02	PRIMARY FLANGE VIEWPORT ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
	EBARA CF-10 HW KIT	2		1	0	1	EA		KNP-800-12			PLATE NUTS (24), 12-PT 5-16-24 X 2.25 BOLTS, WASHERS (48)	HW	100	0	OTS	N/A	N/A	
		2		2	2	4	EA		D080631	-	-	ORING, 3 IN VIEWPORTS	PRT	100	100	MTS	N/A	N/A	v3
		2		1	0	1	EA		D1003209			CLAMPING FLANGE, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	
	II-VI	2		1	0	1	EA		D1100439			VP ZnSe WINDOW, .5 IN THK, 60 MIN WEDGE	PRT	100	100	MTS	N/A	N/A	v2
		2		X		###	EA		D1100495			WASHER	PRT	100	100	MTS	N/A	N/A	v2
		2		1	0	1	EA		D1100540			aLIGO TCS .5 IN THK OPTICAL WINDOW	PRT	100	100	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101431	-01	-02	CUSTOM WEDGE VIEWPORT FLANGE WELDMENT, H1-L1 CO2P TCS	PRT	100	90	MTS	N/A	N/A	v1
	UC COMPONENTS	2		X		###	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		1	0	1	EA		D1101631	-01	-02	VP ENCLOSURE FRONT COVER ASSY, H1-L1 CO2P TCS	ASSY	100	0		N/A	N/A	v1
		2		1	0	1	EA		D1100493	-	-	TCS 0.25 IN THICK ZnSe WINDOW CLAM SHELL ASSY	ASSY	100	100	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1100494	-	-	TCS 0.25 IN THICK OPTICAL WINDOW CLAM SHELL ASSY	ASSY	100	100	MTS	N/A	N/A	v2
		2		2	2	4	EA		D080631	-	-	ORING, 3 IN VIEWPORTS	PRT	100	100	MTS	N/A	N/A	v3
		2		2	2	4	EA		D1100413	-	-	STRESS RELIEF BAR	PRT	100	100	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101636	-01	-02	ENCLOSURE FRONT WALL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	
	UC COMPONENTS	2		X		###	EA					SHCS	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		1	0	1	EA		D1101632	-01	-02	VP ENCLOSURE LOWER WALL ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101637	-01	-02	VP ENCLOSURE BOTTOM WALL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	UC COMPONENTS	2		X		###	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		2	0	2	EA		D1101788			VP ENCLOSURE WALL LIP ROD ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101642			VP ENCLOSURE LOWER WALL LIP ROD, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	UC COMPONENTS	2		X		###	EA					CAPTIVE SHCS #8-32	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		1	0	1	EA		D1101633			VP ENCLOSURE SIDE COVER ASSY, H1-L1 CO2P TCS	ASSY	75	0	MTS	N/A	N/A	v1
	UC COMPONENTS	2		X		###	EA					CAPTIVE SHCS 8-32 X .1875 THD X .50 LONG	HW	100	0	OTS	N/A	N/A	
		2		1	0	1	EA		D1101638			VP ENCLOSURE SIDE COVER WALL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	MSC	2		1		1	EA		32845752			6.5 IN x 1.75 IN DOOR PULL, Zn PLATED STEEL	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2				0	EA		FA-810-NA			FH SCREW, 8-32 X .625 LG, Ag PLATED	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2				0	EA					HEX NUT	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2				0	EA					WASHER, FLAT	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		1	0	1	EA		D1101634			VP ENCLOSURE SIDE OPTOMECH ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101639			VP ENCLOSURE SIDE OPTOMECH WALL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	MSC	2		1	0	1	EA					GROMMET, 1 IN ID X 1.75 IN OD, .1875 IN GROVE, MS35489-110	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		###	EA					SHCS	HW	100	0	OTS	N/A	N/A	
	IN AIR COMPONENT	1		1	0	1	EA		D1101641			VP ENCLOSURE MOUNTING ROD, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	IN AIR ASSY	1		1	0	1	EA		D1101787			VP ENCLOSURE REAR PANEL ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101640			VP ENCLOSURE REAR PANEL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	UC COMPONENTS	2		X		###	EA					HARDWARE	HW	100	0	OTS	N/A	N/A	
	IN AIR ASSY	1		1	0	1	EA		D1101746			VP ENCLOSURE SIDE FLANGE WALL ASSY, H1-L1 CO2P TCS	ASSY	100	0	MTS	N/A	N/A	v1
		2		1	0	1	EA		D1101643			VP ENCLOSURE SIDE FLANGE WALL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	MSC	2		1		1	EA		32845752			6.5 IN x 1.75 IN DOOR PULL, Zn PLATED STEEL	HW	100	0	OTS	N/A	N/A	
	UC COMPONENTS	2		X		###	EA					CAPTIVE SHCS #8-32	HW	100	0	OTS	N/A	N/A	
	IN AIR COMPONENT	1				0	EA		D1101644			VP ENCLOSURE TOP WALL, H1-L1 CO2P TCS	PRT	100	0	MTS	N/A	N/A	v1
	UC COMPONENTS	1		X		1	EA					HARDWARE	HW	100	0	0	N/A	N/A	
	UC COMPONENTS	1		X		1	EA					HARDWARE	HW	100	0	0	N/A	N/A	

(iii)d - Items installed in the vacuum system or at the vacuum interface

Subsystem: CO2P System
Reporter: Mindy Jacobson
Date: 7-Jan-12

Total No. [MTS] Dwgs = 325
Aggregate %-complete = 45%

DCN No.	NOTES	Level	INDENTURE CHART	QUANTITY REQ'd	SPARE	TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.]	NAME	TYPE	MODEL STATUS (% COMPLETE)	DWG STATUS (% COMPLETE)	SRC	PDR REV.	delta-PDR REV.	FDR REV.	First Article REV.
E1000883	**BSC7 = mirror of BSC8**	0		1	0	1	EA	E1000884	D1001742		**ALIGO TCS CO2P SYS STEERING OPTICS ASSY, H2, BSC7**	TopAssy	100	100	MTS	N/A	v1	v2	v3
		1		1	0	1	EA		D1001194		CO2P ITMX M1 ASSEMBLY ENVELOPE, BSC7	PRT	100		MTS	N/A			
	KLUGER	1		1	0	1	EA		D1001727		TCS H2IN-VAC MIRROR [Ø12 IN, Au-COATED Cu]	PRT	100	100	MTS	N/A	v2	v2	v3
	HELICOIL	2		8	1	9	EA		TYPE 1185		NITRONIC-60, #8-32, 2-1/2 D, .410 LONG, SIZE 2CN	HW	90		HW	N/A			
		1		2	0	2	EA		D1002313		TCS UHV FINE ADJUST PIVOT ROD	PRT	100	100	MTS	N/A	v1	v2	v2
		1		1	0	1	EA		D1002312		TCS UHV AZ FINE ADJUST PIVOT PLATE, BSC7 [Al-6061]	PRT	100	100	MTS	N/A	v1	v2	v2
	HELICOIL	2		2	1	3	EA		TYPE 1191		NITRONIC-60, #10-32, 2 D, .380 LONG, SIZE 3CN	HW	100		HW	N/A			
	HELICOIL	2		4	1	5	EA		TYPE 1185		NITRONIC-60, #8-32, 1-1/2 D, .371 LONG, SIZE 2CN	HW	0		HW	N/A		N/A	N/A
		1		1	0	1	EA		D1002311		TCS UHV EL FINE ADJUST PIVOT PLATE [Al-6061]	PRT	100	100	MTS	N/A	v1	v2	v2
	HELICOIL	2		1	1	2	EA		TYPE 1191		NITRONIC-60, #10-32, 2 D, .380 LONG, SIZE 3CN	HW	100		HW	N/A			
	UC COMPONENTS	1		4	1	5	EA		C-822-A		VENTED, Ag PLATED SS SHCS #8-32 X 1-3/8 LONG	HW	100		OTS	N/A			
	UC COMPONENTS	1		4	1	5	EA		C-816-A		VENTED, Ag PLATED SS SHCS #8-32 X 1 LONG	HW	100		OTS	N/A			
	UC COMPONENTS	1		8	2	10	EA		WFV-08		VENTED FLAT WASHER #8	HW	100		OTS	N/A			
	UC COMPONENTS	1		5	1	6	EA		SHCV-4436		VENTED HEX HD 1.5IN SHOULDER SHC #10-32	HW	100		OTS	N/A			
	UC COMPONENTS	1		27	3	30	EA		WFV-25		VENTED FLAT WASHER, 0.26 ID	HW	100		OTS	N/A			
		1		1	0	1	EA		D1002287		TCS UHV BRACKET [LONG SIDE], BSC7	PRT	100	100	MTS	N/A	v1	v3	v3
	HELICOIL			1	0	1	EA		TYPE 1191		NITRONIC-60, #10-32, 2-1/2 D, .475 LONG, SIZE 3CN	HW				N/A			
		1		1	0	1	EA		D1002315		TCS UHV BRACKET, SHORT SIDE, BSC7	PRT	100	100	MTS	N/A	v1	v3	v3
	HELICOIL			1	0	1	EA		TYPE 1191		NITRONIC-60, #10-32, 2-1/2 D, .475 LONG, SIZE 3CN	HW				N/A			
		1		1	0	1	EA		D1002317		TCS UHV LONG SUPPORT, BSC7 & BSC8	PRT	100	100	MTS	N/A	v1	v3	v3
		1		1	0	1	EA		D1002327		TCS UHV SHORT SUPPORT, BSC7 & BSC8	PRT	100	100	MTS	N/A	v1	v3	v3
	Viton, SYS procurement	1		2	0	2	EA		D1003328		TCS UHV H2 ASSEMBLY INTERFACE DAMPER [VITON]	PRT			MTS	N/A	N/A	v1	v1
	Viton, SYS procurement	1		4	4	8	EA		D1002502		TCS UHV H2 STRUCTURE BAFFLE STANDOFF [OPTIONAL, VITON]	PRT	100	100	MTS	N/A	v1	N/A	N/A
		1		1	0	1	EA		D1002333		TCS UHV BACK BRACE, BSC7 & BSC8	PRT	100	100	MTS	N/A	v1	v3	v3
		1		1	0	1	EA		D1002334		TCS UHV COARSE ADJUST PIVOT ROD	PRT	100	100	MTS	N/A	v1	v2	v2
	UC COMPONENTS	1		6	1	7	EA		C-2024-N		SS SHCS 1/4-20 x 1.5 LONG	HW	100		OTS	N/A			
	UC COMPONENTS	1		6	1	7	EA		N-2520-A		SS NUT, HEX HD, 1/4-20, SILVER PLATED	HW	100		OTS	N/A			
	UC COMPONENTS	1		6	1	7	EA		NJ-2520		SS HEX JAM NUT, 1/4-20	HW	100		OTS	N/A			
		1		2	1	3	EA		D1002479		TCS UHV SM AZ BAFFLE PLATE [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
	UC COMPONENTS	1		6	1	7	EA		C-808-A		VENTED, Ag PLATED SS SHCS #8-32 X .5 LONG	HW	100		OTS	N/A		N/A	N/A
		1		1	1	2	EA		D1002480		TCS UHV SM EL BAFFLE PLATE [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
		1		3	1	4	EA		D1002482		TCS UHV SM STRUCTURE BAFFLE PLATE [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
		1		3	1	4	EA		D1002484		TCS UHV SM STRUCTURE BAFFLE PLATE, HALF [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
	UC COMPONENTS	1		8	1	9	EA		BU-812-NC		VENTED, MoS2 COATED SS BHSS #8-32 X .75 LONG	HW	100		OTS	N/A		N/A	N/A
	UC COMPONENTS	1		8	1	9	EA		NF-832		SS HEX NUT, #8-32	HW	100		OTS	N/A		N/A	N/A
E1000883	**BSC8 = mirror of BSC7**	0		1	0	1	EA	E1000884	D1002431		**ALIGO TCS CO2P SYS STEERING OPTICS ASSY, H2, BSC8**	TopAssy	100	100	MTS	N/A	v1	v2	v3
		1		1	0	1	EA		D1001198		CO2P ITMY M1 ASSEMBLY ENVELOPE, BSC8	PRT	100		MTS	N/A			
	KLUGER	1		1	0	1	EA		D1001727		TCS H2IN-VAC MIRROR [Ø12 IN, Au-COATED Cu]	PRT	100	100	MTS	N/A	v1	v2	v3
	HELICOIL	2		8	1	9	EA		TYPE 1185		NITRONIC-60, PRIMER-FREE INSERTS, #8-32, 2-1/2 D, .410 LONG, SIZE 2CN	HW	90		HW	N/A			
		1		2	0	2	EA		D1002313		TCS UHV FINE ADJUST PIVOT ROD	PRT	100	100	MTS	N/A	v1	v2	v2
		1		1	0	1	EA		D1002455		TCS UHV AZ FINE ADJUST PIVOT PLATE, BSC8 [Al-6061]	PRT	100	100	MTS	N/A	v1	v2	v2
	HELICOIL	2		2	1	3	EA		TYPE 1191		NITRONIC-60, #10-32, 2 D, .380 LONG, SIZE 3CN	HW	90		HW	N/A			
		1		1	0	1	EA		D1002311		TCS UHV EL FINE ADJUST PIVOT PLATE [Al-6061]	PRT	100	100	MTS	N/A	v1	v2	v2
	HELICOIL	2		1	1	2	EA		TYPE 1191		NITRONIC-60, #10-32, 2 D, .380 LONG, SIZE 3CN	HW	90		HW	N/A			
	UC COMPONENTS	1		4	1	5	EA		C-822-A		VENTED, Ag PLATED SS SHCS #8-32 X 1-3/8 LONG	HW	100		OTS	N/A			
	UC COMPONENTS	1		4	1	5	EA		C-816-A		VENTED, Ag PLATED SS SHCS #8-32 X 1 LONG	HW	100		OTS	N/A			
	UC COMPONENTS	1		22	3	25	EA		WFV-08		VENTED FLAT WASHER #8	HW	100		OTS	N/A			
	UC COMPONENTS	1		5	1	6	EA		SHCV-4436		VENTED HEX HD 1.5IN SHOULDER SHC #10-32	HW	100		OTS	N/A			
	UC COMPONENTS	1		27	3	30	EA		WFV-25		VENTED FLAT WASHER, 0.26 ID	HW	100		OTS	N/A			
		1		1	0	1	EA		D1002454		TCS UHV BRACKET [LONG SIDE], BSC8	PRT	100	100	MTS	N/A	v1	v2	v2
							EA		TYPE 1191		NITRONIC-60, #10-32, 2-1/2 D, .475 LONG, SIZE 3CN	HW				N/A			
		1		1	0	1	EA		D1002453		TCS UHV BRACKET, SHORT SIDE, BSC8	PRT	100	100	MTS	N/A	v1	v2	v2
							EA		TYPE 1191		NITRONIC-60, #10-32, 2-1/2 D, .475 LONG, SIZE 3CN	HW				N/A			
		1		1	0	1	EA		D1002317		TCS UHV LONG SUPPORT, BSC7 & BSC8	PRT	100	100	MTS	N/A	v1	v3	v3
		1		1	0	1	EA		D1002327		TCS UHV SHORT SUPPORT, BSC7 & BSC8	PRT	100	100	MTS	N/A	v1	v3	v3
	Viton, SYS procurement	1		2	0	2	EA		D1003328		TCS UHV H2 ASSEMBLY INTERFACE DAMPER [VITON]	PRT			MTS	N/A	N/A	v1	v1
	Viton, SYS procurement	1		4	4	8	EA		D1002502		TCS UHV H2 STRUCTURE BAFFLE STANDOFF [OPTIONAL, VITON]	PRT	100	100	MTS	N/A	v1	N/A	N/A
		1		1	0	1	EA		D1002333		TCS UHV BACK BRACE, BSC7 & BSC8	PRT	100	100	MTS	N/A	v1	v3	v3
		1		1	0	1	EA		D1002334		TCS UHV COARSE ADJUST PIVOT ROD	PRT	100	100	MTS	N/A	v1	v2	v2
	UC COMPONENTS	1		6	2	8	EA		C-2024-N		SS SHCS 1/4-20 x 1.5 LONG	HW	100		OTS	N/A			
	UC COMPONENTS	1		6	2	8	EA		N-2520-A		SS NUT, HEX HD, 1/4-20, SILVER PLATED	HW	0		OTS	N/A			
	UC COMPONENTS	1		6	2	8	EA		NJ-2520		SS HEX JAM NUT, 1/4-20	HW	100		OTS	N/A			
		1		2	1	3	EA		D1002479		TCS UHV SM AZ BAFFLE PLATE [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
	UC COMPONENTS	1		6	1	7	EA		C-808-A		VENTED, Ag PLATED SS SHCS #8-32 X .5 LONG	HW	100		OTS	N/A		N/A	N/A
		1		1	1	2	EA		D1002480		TCS UHV SM EL BAFFLE PLATE [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
		1		3	1	4	EA		D1002482		TCS UHV SM STRUCTURE BAFFLE PLATE [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
		1		3	1	4	EA		D1002484		TCS UHV SM STRUCTURE BAFFLE PLATE, HALF [WELDER'S GLASS #14]	PRT	100	100	MTS	N/A	v1	N/A	N/A
	UC COMPONENTS	1		8	1	9	EA		BU-812-NC		VENTED, MoS2 COATED SS BHSS #8-32 X .75 LONG	HW	100		OTS	N/A		N/A	N/A
	UC COMPONENTS	1		8	1	9	EA		NF-832		SS HEX NUT, #8-32	HW	100		OTS	N/A		N/A	N/A

(iii)e - Items installed in the vacuum system or at the vacuum interface

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN	NOTES	Level	QUANTITY REQ'd	SPARE	TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.] -01	-02	NAME	TYPE	MODEL STATUS (% COMPLETE)	DWG STATUS (% COMPLETE)	SRC	PDR REV.	delta-PDR REV.	FDR REV.	First Article REV.
		0	1		1	EA	E1100656	D1003193	-01	-02	VIEWPORT ENCLOSURE ASSY, H2 CO2P	TopAssy	100	100	MTS	N/A	N/A	v3	
		1	1		1	EA	E1100656	D1003194	-	-	PRIMARY FLANGE VIEWPORT ASSY	ASSY	100	100	MTS	N/A	N/A	v2	
E1100655-v1	Futrell's	2	1		1	EA		D1003209	-	-	CLAMPING FLANGE, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	v2	
		2	2	1	3	EA		D1100495	-	-	WASHER, CLAMP RING [PEEK OR TEFLON]	PRT	100	100	OTS	N/A	N/A	v2	
		2	1		1	EA		D1100439	-	-	ZnSe VIEWPORT, 3 IN OD. 0.5 IN THICK, 60' WEDGE	PRT	100	100	MTS	N/A	N/A	v1	
		2	1		1	EA		D1100540	-	-	aLIGO TCS 0.5 IN THICK OPTICAL WINDOW	PRT	100	100	MTS	N/A	N/A	v1	
E1100983-v1	MDC	2	1		1	EA		D1003196	-	-	aLIGO TCS 10-IN CUSTOM VP FLANGE	PRT	100	100	MTS	N/A	N/A	v2	v2
		2	4	1	5	EA		D080631	-	-	ORING, 3 IN VIEWPORTS	PRT	100	100	MTS	N/A	N/A	v3	
	EBARA CF-10 HW KIT	2	1		1	EA		KNP-800-12	-	-	12-PT BOLT, 5/16-24 UNC-2A X 2.25 +WASHER, QTY 48 +NUTPLATES, QTY 24	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	12	3	15	EA		C-1016-NA	-	-	SHCS 10-32 UNF-2A X 1 IN LONG	HW	100	0	OTS	N/A	N/A		
E1100655-v1		1	1		1	EA	E1100656	D1003204	-01	-02	VP ENCLOSURE FRONT COVER ASSY, CO2P	ASSY	100	100	MTS	N/A	N/A	v3	
E1100655-v1	Futrell's	2	1		1	EA		D1003206	-01	-02	VP ENCLOSURE FRONT WALL, FIXED	PRT	100	100	MTS	N/A	N/A	v3	
	CK FASTNR TORQUE	2	1		1	EA	E1100656	D1100493	-	-	TCS 0.25 IN THICK ZnSe WINDOW CLAM SHELL ASSY	ASSY	100	100	MTS	N/A	N/A	v1	
E1100983-v1		3	1	1	2	EA		D080631	-	-	ORING, 3 IN VIEWPORTS	PRT	100	100	MTS	N/A	N/A	v3	
E1100655-v1	Futrell's	3	1		1	EA		D1003208			MOUNTING PLATE, CO2P VP COVER	PRT	100	100	MTS	N/A	N/A	v1	
E1100655-v1	Futrell's	3	1		1	EA		D1100250			MOUNTING PLATE COVER REAR, CO2P VP COVER	PRT	100	100	MTS	N/A	N/A	v1	
		3	1		1	EA		D1100485			ZnSe VIEWPORT, 3 IN OD. 0.25 IN THICK, 60' WEDGE	PRT	100	100	MTS	N/A	N/A	v1	
E1100983-v1		3	1	1	2	EA		D1100495	-	-	WASHER, CLAMP RING [PEEK OR TEFLON]	PRT	100	100	MTS	N/A	N/A	v2	
		3	1	1	2	EA		D1100496			VIEWPORT THERMOCOUPLE	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	3	4	1	5	EA		C-610-N			SHCS 6-32 UNC-2A X .625 IN LONG	HW	100	0	OTS	N/A	N/A		
	CK FASTNR TORQUE	2	1		1	EA	E1100656	D1100494	-	-	TCS 0.25 IN THICK OPTICAL WINDOW CLAM SHELL ASSY	ASSY	100	100	MTS	N/A	N/A	v2	
		3	1		1	EA		D1100539			aLIGO TCS 0.25 IN THICK OPTICAL WINDOW	PRT	100	100	MTS	N/A	N/A	v2	
E1100983-v1		3	1	1	2	EA		D080631	-	-	ORING, 3 IN VIEWPORTS	PRT	100	100	MTS	N/A	N/A	v3	
E1100655-v1	Futrell's	3	1		1	EA		D1003208			MOUNTING PLATE, CO2P VP COVER	PRT	100	100	MTS	N/A	N/A	v1	
E1100655-v1	Futrell's	3	1		1	EA		D1100250			MOUNTING PLATE COVER REAR, CO2P VP COVER	PRT	100	100	MTS	N/A	N/A	v1	
E1100983-v1		3	1	1	2	EA		D1100495	-	-	WASHER, CLAMP RING [PEEK OR TEFLON]	PRT	100	100	MTS	N/A	N/A	v2	
	UC COMPONENTS	3	4	1	5	EA		C-610-N			SHCS 6-32 UNC-2A X .625 IN LONG	HW	100	0	OTS	N/A	N/A		
E1100983-v1		2	4	1	5	EA		D080631	-	-	ORING, 3 IN VIEWPORTS	PRT	100	100	MTS	N/A	N/A	v3	
E1100655-v1	Futrell's	2	2	2	4	EA		D1100413	-	-	STRESS RELIEF BAR	PRT	100	100	MTS	N/A	N/A	v1	
	UC COMPONENTS	2	16	4	20	EA		C-607-N			SHCS 6-32 UNC-2A X .4375 LONG	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	2	6	EA		C-605-N			SHCS 6-32 UNC-2A X .3125 LONG	HW	100	0	OTS	N/A	N/A		
		2	16	4	20	EA		C-608-N			SHCS 6-32 UNC-2A X .5 LONG	HW	100	0	OTS	N/A	N/A		
		2	8	2	10	EA		C-1824-N			SHCS .3125-18 X 1.5 LONG	HW	100	0	OTS	N/A	N/A		
		1	1		1	EA	E1100656	D1003210	-01	-02	VP ENCLOSURE SIDE OPTOMECH ASSY, CO2P	ASSY	100	100	MTS	N/A	N/A	v2	
E1100655-v1	Futrell's	2	1		1	EA		D1003213	-01	-02	SIDE OPTOMECH WALL, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	v2	
	MSC	2	2	2	4	EA		79311791			GROMMET, 1 IN ID X 1.75 IN OD, .1875 IN GROVE, MS35489-81	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	26	4	30	EA		C-608-N			SHCS 6-32 UNC-2A X .5 LONG	HW	100	0	OTS	N/A	N/A		
E1100655-v1	Futrell's	1	1		1	EA	E1100656	D1003214	-01	-02	VP ENCLOSURE TOP WALL, CO2P	PRT	100	100	MTS	N/A	N/A	v2	
E1100655-v1		1	1		1	EA	E1100656	D1003215	-	-	VP ENCLOSURE SIDE COVER ASSY, CO2P	ASSY	100	100	MTS	N/A	N/A	v1	
E1100655-v1	Futrell's	2	1		1	EA		D1003216	-	-	SIDE COVER WALL, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	v1	
	MSC	2	1		1	EA		32845752			6.5 IN x 1.75 IN DOOR PULL, Zn PLATED STEEL	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	1	5	EA		FA-810-N			FSHCS, 8-32 X .625 LONG	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	1	5	EA		WF-08			FLAT WASHER, 8-32	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	1	5	EA		N-832			HEX NUT, 8-32	HW	100	0	OTS	N/A	N/A		
	MSC	2	12	3	15	EA		41852401			CAPTIVE SHCS 8-32 X .1875 THD X .50 LONG	HW	100	0	OTS	N/A	N/A		
E1100655-v1		1	1		1	EA	E1100656	D1003217	-01	-02	VP ENCLOSURE BACK COVER ASSY, CO2P	ASSY	100	100	MTS	N/A	N/A	v1	
E1100655-v1	Futrell's	2	1		1	EA		D1003218	-	-	BACK WALL, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	v1	
	MSC	2	1		1	EA		32845752			6.5 IN x 1.75 IN DOOR PULL, Zn PLATED STEEL	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	8	2	10	EA		FA-810-N			FSHCS, 8-32 X .625 LONG	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	8	2	10	EA		WF-08			FLAT WASHER, 8-32	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	8	2	10	EA		N-832			HEX NUT, 8-32	HW	100	0	OTS	N/A	N/A		
	MSC	2	16	4	20	EA		41852401			CAPTIVE SHCS 8-32 X .1875 THD X .50 LONG	HW	100	0	OTS	N/A	N/A		
E1100655-v1	Futrell's	1	1		1	EA	E1100656	D1003219	-	-	MOUNTING ROD, SIDE-TO-BACK COVERS	PRT	100	100	MTS	N/A	N/A	v1	
	UC COMPONENTS	1	2	2	4	EA	E1100656	C-608-N			SHCS 6-32 UNC-2A X .5 LONG	HW	100	0	OTS	N/A	N/A		
		1	1		1	EA	E1100656	D1003221	-01	-02	VP ENCLOSURE LOWER WALL ASSY, CO2P	ASSY	100	100	MTS	N/A	N/A	v3	
E1100655-v1	Futrell's	2	1		1	EA		D1003220	-01	-02	BOTTOM WALL, CO2P VP ENCLOSURE	PRT	100	100	MTS	N/A	N/A	v2	
E1100655-v1	Futrell's	2	1		1	EA		D1003222	-	-	PERISCOPE INTERFACE FLANGE, FEMALE	PRT	100	100	MTS	N/A	N/A	v1	
	UC COMPONENTS	2	8	2	10	EA		WF-25			FLAT WASHER, 1/4 IN	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	8	2	10	EA		C-2010-N			SHCS 1/4-20 UNC-2A X .625 LONG	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	2	6	EA		WF-08			FLAT WASHER, 8-32	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	2	6	EA		C-810-N			SHCS 8-32 UNC-2A X .625 LONG	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	2	2	4	EA		C-608-N			SHCS 6-32 UNC-2A X .5 LONG	HW	100	0	OTS	N/A	N/A		
		1	1		1	EA	E1100656	D1101145	-01	-02	TCS H2 CO2P TOP PERISCOPE MOUNT ASSY	ASSY	100	100	MTS	N/A	N/A	v1	
E1100655-v1	Datum Control	2	1		1	EA		D1101144	-01	-02	H2 CO2P TOP PERISCOPE FIXTURE	PRT	100	100	MTS	N/A	N/A	v2	v3
		2	1		1	EA		SL101.6N-PZA12			MIRROR MOUNT ASSY	ASSY	100	100	MTS	N/A	N/A		
	NEWPORT	3	1		1	EA		Q1048496			CUSTOM MIRROR MOUNT, MICROCONTROLLE	PRT	100	100	OTS	N/A	N/A		
E1100983-v1	Edmund Optics	3	1		1	EA		D1100453			ENHANCED ALUMINUM MIRROR, 4 IN DIA	PRT	100	100	MTS	N/A	N/A	v2	
	UC COMPONENTS	2	4	2	6	EA		MC-616-N			SHCS M6 X 16	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	2	6	EA		MLW-06			WASHER, SPLIT LOCK, M6	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	8	2	10	EA		MC-516-N			SHCS M5 X 16	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	8	2	10	EA		MLW-05			WASHER, SPLIT LOCK, M5	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	2	2	4	EA		SHCV-4420			SH SHOULDER 8-32 X .375 LONG	HW	100	0	OTS	N/A	N/A		
		1	1		1	EA	E1100656	D1101235	-	-	H2 VIEWPORT CAMERA MIRROR ASSY	ASSY	100	100	MTS	N/A	N/A	v2	
E1100655-v1	Futrell's	2	1		1	EA		D1101547			H2 VIEWPORT CAMERA MIRROR FIXTURE	PRT	100	100	MTS	N/A	N/A	v1	
		2	1		1	EA		U200-AC3K			3-AXIS MIRROR MOUNT, 2 IN	PRT	100	100	OTS	N/A	N/A		
E1100983-v1	Edmund Optics	2	1		1	EA		D1101256			ENHANCED ALUMINUM MIRROR, 2 IN DIA	PRT	100	100	MTS	N/A	N/A	v2	
	UC COMPONENTS	2	6	2	8	EA		C-806-N			SHCS 8-32 UNC-2A X .375 LONG	HW	100	0	OTS	N/A	N/A		
	UC COMPONENTS	2	4	1	5	EA		C-808-N			SHCS 8-32 UNC-2A X .5 LONG	HW	100	0	OTS	N/A	N/A		
		2	4	1	5	EA		WF-08			FLAT WASHER, 8-32	HW	100	0	OTS	N/A	N/A		

(iii)f - Items installed in the vacuum system or at the vacuum interface

Subsystem:	CO2P System
Reporter:	Mindy Jacobson
Date:	7-Jan-12
Total No. [MTS] Dwgs =	325
Aggregate %-complete =	45%

DCN	NOTES	Level	INDENTURE CHART	QUANTITY REQ'd	SPARE	TOT.	UNITS	BOM item no.	DCC No.	TYPE [config.]	NAME	TYPE	MODEL STATUS	DWG STATUS	SRC	PDR REV.	delta-PDR REV.	FDR REV.	First Article REV.
No.													% COMPLETE						
{}	**possibly not needed**	0		?		###	EA		DXXXXXXX		**aLIGO TCS CO2P OPTICS INSTALL FIXTURE ASSY, H1/L1, BSC1, B**	TopAssy	0	0	MTS	N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
{}	**BSC2**	0		?		###	EA		DXXXXXXX		**aLIGO TCS CO2P OPTICS INSTALL FIXTURE ASSY, H1/L1, BSC2**	TopAssy	0	0	MTS	N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
						0							0	0		N/A	N/A		
E1000883	**BSC7 = BSC8**	0		1		1	EA	E1000884	D1100293		**aLIGO TCS TEMPLATE, H2 UHV CO2P MIRROR ASSY**	TopAssy	100	100	MTS	N/A	N/A	v1	v1
		1		1	0	1	EA		D1100263		aLIGO TCS FIXTURE, H2 UHV MIRROR ASSY	PRT	100	100	MTS	N/A	N/A	v2	v3
		2		1	0	1	EA		D1101272		TCS H2 UHV MIRROR SPLASH COVER	PRT	100	100	MTS	N/A	N/A	N/A	v2
		2		1	0	1	EA		D1100265		aLIGO TCS FIXTURE BASE PLATE, H2 STEERING MIRROR ASSY	PRT	100	100	MTS	N/A	N/A	v2	v2
		2		2	0	2	EA		D1100266		aLIGO TCS FIXTURE TALL SUPPORT GUSSET	PRT	100	100	MTS	N/A	N/A	v4	v5
		2		2	0	2	EA		D1100267		aLIGO TCS FIXTURE SHORT SUPPORT GUSSET	PRT	100	100	MTS	N/A	N/A	v4	v5
		2		4	0	4	EA		D1100285		aLIGO TCS FIXTURE RETAINER	PRT	100	100	OTS	N/A	N/A	v2	v2
E1100356		2		4	0	4	EA		D1101866		SHIM, .125 THICK	PRT	100		MTS	N/A	N/A	N/A	v1
	MSC	2		2	2	4	EA		32845752		6.5 IN x 1.75 IN DOOR PULL, Zn PLATED STEEL	HW	100		OTS	N/A	N/A		
	UC COMPONENTS	3		8	2	10	EA		FA-808-N		FHSCS 8-32 X 1/2 LONG, 18-8 SSTL	HW	100		OTS	N/A	N/A		
	UC COMPONENTS	3		8	2	10	EA		C-806-N		SHCS 8-32 UNC-2A X 3/8 LONG, 18-8 SSTL	HW	100		OTS	N/A	N/A		
	UC COMPONENTS	3		8	2	10	EA		WF-08		FLAT WASHER, #8, NAS 620-C8 OR EQUIVALENT	HW	100		OTS	N/A	N/A		
	UC COMPONENTS	3		8	2	10	EA		FA-812-N		FHSCS 8-32 X 3/4 LONG, 18-8 SSTL	HW	100		OTS	N/A	N/A		
	UC COMPONENTS	3		8	2	10	EA		N-832		HEX NUT, 8-32	HW	100		OTS	N/A	N/A		
	McMASTER-CARR PN	3		8	2	10	EA		96659A103		FLAT WASHER, #8, MS 15795 OR EQUIVALENT	HW	100		OTS	N/A	N/A		
		1		2	0	2	EA		D1100300		aLIGO TCS INTERFACE TEMPLATE	PRT	100	100	MTS	N/A	N/A	v2	v2
		1		1	0	1	EA		D1100297		aLIGO TCS LONG BASE TEMPLATE	PRT	100	100	MTS	N/A	N/A	v2	v2
		1		1	0	1	EA		D1100296		aLIGO TCS SHORT BASE TEMPLATE	PRT	100	100	MTS	N/A	N/A	v2	v2
		1		1	0	1	EA		D1100298		aLIGO TCS TEMPLATE BRACE	PRT	100	100	MTS	N/A	N/A	v1	v1
		1		1	0	1	EA		D1100295		aLIGO TCS FIXTURE TEMPLATE BRACE	PRT	100	100	MTS	N/A	N/A	v2	v2
		1		2	0	2	EA		D1100294		aLIGO TCS FIXTURE TEMPLATE	PRT	100	100	MTS	N/A	N/A	v1	v1
	UC COMPONENTS	2		6	2	8	EA		C-2008-N		SHCS 1/4-20 UNC-2A X 0.5 LONG	HW	100		OTS	N/A	N/A		
	UC COMPONENTS	2		6	2	8	EA		C-2012-N		SHCS 1/4-20 UNC-2A X 0.75 LONG	HW	100		OTS	N/A	N/A		
	MCMASTER P/N	2		12	4	16	EA		96659A106		FLAT WASHER, 1/4 IN, 5/8 OD, MS 15795 OR EQUIV	HW	100		OTS	N/A	N/A		
	MCMASTER P/N	2		4	2	6	EA		97365A170		PULL-OUT DOWEL PIN, 1/4 IN, FLAT VENT, 2.5 IN LONG	HW	100		OTS	N/A	N/A		