TITLE

SPECIAL PROCEDURE: OPTICAL ALIGNMENT ADJUSTMENT IN THE VERTEX REGION OF THE HANFORD 4KM INTERFEROMETER

APPROVALS:	DATE	APPROVALS:		DATE
DRAWN:D. Coyne	7/24/01	CHECKED:		
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CHECKED: M. Smith	7/24/01	DCN NO	APPROVED	DATE
CHECKED:		E010142-00	Dennis Coyne	7/24/01

Instructions on the use of this document:
1) This procedure must be available during the installation. If this procedure is needed within a cleanroom, then laminate this procedure (or place it in a plastic sleeve), and clean the plastic with isopropyl alcohol and handle it as a class B tool per M990034). Check off items as the installation proceeds.
2) Use this installation procedure as a check list for preparation and during the installation. Note any discrepancies or deviations and augment with any missing definition. File any significant notes or data from the completed procedure in the electronic logbook (such as any deviations); as a minimum note in the electronic logbook that the installation was completed in accordance with this procedure (cite document number and revision).

1 SCOPE

An incident with the recently installed and only partially commissioned Digital Suspension Controllers (DSC) has caused four of the small optics to apparently loose alignment and may be contacting their stops: MMT1, MMT2, MC2 and MC3. The situation is described in a 7/9/2001 electronic log entry. A vent to examine these optics, determine what is amiss and correct the situation is required.

While vented, we plan to take the opportunity to also perform the following two tasks:

1) Tweak the alignment of the two ITMs and the RM on the 4km interferometer, using the PAMs, so as to zero their biases. The best bias levels for alignment of the ITMs, BS and MMT3 are based on alignment of the X and Y beams at the mid-station (see the 6/20/2001 electronic log entry for details and multiple entries in the week of 6/11 for attempts to align the RM). The BS and MMT3 biases are relatively small and so their PAM magnets will not be adjusted.

2) Adjust the length of the mode cleaner cavity to the correct (theoretical) length. It was initially installed with a slightly incorrect length (using the IO final design report value of 12240 mm instead of the revised value of 12245 mm from E000053-02).

2 APPLICABLE DOCUMENTS

Listed below are all of the applicable and referenced documents for this installation procedure. This list gives the latest revisions of the documents; Within the installation steps, only the document number (and not the revision) is quoted.

M990034-B	Contamination Control Plan

M980133-B	Vent Isolatable Volumes
M980101-B	Procedure for Isolatable Volume Pump Down
E000118-A	Hanford Checklist - Isolatable Volume Pump Down
E000121-A	Hanford Checklist - Spool removal procedure
M980136-A	HAM Chamber Access Door Removal Procedure
E000120-A	Hanford Checklist - BSC Door Removal
M980132-B	O-Ring Installation and Flange Assembly Procedure for HAM and BSC Doors
T970151-C	Initial Alignment Procedures (Reference only: The alignment procedures defined within this procedure supersede the initial alignment procedures defined in T970151.)
M990315-00	Standard Operation Procedure (SOP): COS Infrared Alignment Laser Operation in the LHO LVEA
T990088-01	COS 2km IFO Alignment Procedure Note: Figure 10 in this document shows the alignment layout schematically for chamber WBSC6, but is missing the chamber, optics table, etc.
E000065-04	Chamber Entry/Exit Checklist
T980072-01	COS alignment telescope/autocollimator/projector system
E000116-00	Procedure for Realignment of Large Suspended Optics
D970308-B	Interferometer Optomechanical Layout - Hanford Site
M990297-A	Standard Operating Procedure for LIGO 10-W Laser Operating in the LVEA
M980047-E	Transition to Laser Hazard
M980048-E	Transition to Laser Safe

3 PRE-REQUISITES

- ❑ 1. The optics should have already been positioned and aligned via T970151; This is a remedial alignment procedure.
- ❑ 2. All optics tables should be verified to be level and counterweights adjusted if/as required.
- ❑ 3. Follow all contamination control procedures. In particular cleanrooms must be placed over open chamber doors and the purge air must be flowing into the vented vacuum volume.
- ❑ 4. The Suspension assemblies and control electronics should be confirmed to be operating correctly (per E970154) prior to initiating this procedure.

4 PREPARATION

All preparation must be in accordance with the Contamination Control Plan (M990034).

- ❑ 1. Clean the LVEA, particularly the floor adjacent to chambers WHAM1, WHAM2, WHAM3 and WBSC3. Particulates and dust should be removed by mopping with clean water.
  Clean the chamber (wipe or mop with clean water) from the stiffening ring above the door down, as well as the floor in the vicinity of the chamber well in advance of the opening of the vacuum system.
- ❑ 2. Arrange for clean room coverage over chambers WHAM1, WHAM2, WHAM3 and WBSC3.
- ❑ 3. Vent the vertex volume per M980133
- ❑ 4. Remove spool WBE-3A1 from between BSC 2 and HAM 3 using ‘C’ bar on crane hook and per E000121-A (supports the MMT3, RM and ITMx alignments)
  Cover the openings with clean rooms and ensure adequate purge air flow.
  Reminder: cover open doors when access is not immediately required!
- ❑ 5. Roll back the ISCT and IOT optics tables from the doors of WHAM1. Remove the E & W doors of WHAM1, the W door of WHAM2 and the E door if WHAM3.
  Cover the openings with clean rooms and ensure adequate purge air flow.
  Reminder: cover open doors when access is not immediately required!

5 RE-ALIGNMENT STEPS

All work must be in accordance with the Contamination Control Plan (M990034).

Sequence: The following steps are in a logical and workable sequence. However some of the steps can be done in parallel and some steps can be done at other points in the sequence.

- ❑ 1. **Examine/repair the problematic small optics.** Examine the MMT1, MMT2, MC2 and MC3 optics in place to see if the cause for their mis-alignment is evident. If necessary remove these suspensions for closer inspection or repair. First mark the position and orientation of the SOS structures on the optics tables (with mechanical stops). Note all observations in the elog.

- ❑ 2. **Replace the problematic small optics.** Once the problem has been remedied, put the MMT1, MMT2, MC2 and MC3 SOS units back into place (if they were removed).

- ❑ 3. **Adjust the Mode Cleaner Length.** Move MMT2 so that the mode cleaner half length is 12245mm (per E000053-02) instead of the initially set 12240 mm.

- ❑ 4. **Re-align the Mode Cleaner (MC).** Re-align the MC in air per (pending written) procedure

- ❑ 5. **Position the Sokkia total station** (with the LDS-1000 laser autocolimator mounted on top) over IAS monument IAM? in the area where spool WBE-3A1 (between WBSC 2 and WHAM 3) normally resides.
  The local coordinates of IAM? are {?, -200} mm
  Set the height so that the center of the COS LAC aperture will be at -498 mm in local coordinates, when it is later substituted for the theodolite and LDS-1000.
  Adjust the Sokkia so that it is pointing as follows:
  Yaw = 0 (pointing +X direction)
  Pitch = 90 deg, 2', 8" (pointing 2' 8" down)

- ❑ 6. **Position the PLX** (Lateral Transfer Hollow Retroreflector) on a clean, stable mount in the spool to the +X side of chamber WBSC3 in front of ITMx,4k optic, oriented horizontally, with one of the apertures approximately centered laterally and vertically with respect to the IMTx,4k optic. Use the LDS-1000 red beam as a guide to position and rotate the PLX until the LDS-1000 beam retroreflects from the ITMx HR surface without clipping.
  First ensure that the proper bias control has been applied to the ITMx,4k optic (pitch bias = -6.0 and yaw bias = -1.7 according to the 6/20/2001 elog entry). Then confirm that the retroreflected beam indicates that the ITMx HR surface is close to the expected orientation from survey (within ~100 microrad).

- ❑ 7. **Mount ITMx Target** onto the ITMx suspension structure.

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❑ 8. **Mount the COS laser autocollimator (LAC)** Replace the Sokkia total station & LDS-1000 with the COS laser autocollimator (LAC) such that it points into the input aperture of the PLX. Use the COS 940 nm wavelength, 4W unit, including an x/y linear stage and tip/tilt adjustment mount.

❑ 9. **Transition to a Laser Hazard Condition** If not presently in a Laser Hazard condition, then transition per the COS Alignment SOP, M990315. Post a list of qualified personnel for LIGO M990315 to the LVEA entrances.

❑ 10. **Autocollimate off of the ITMx,4k** First ensure that the proper bias control has been applied to the ITMx,4k optic (pitch bias = -6.0 and yaw bias = -1.7 according to the 6/20/2001 elog entry). Adjust the position and the orientation of the COS LAC until the beam is centered on the target and autocolimates from the HR surface of the ITMx,4k optic.

❑ 11. **Position the MMT3 target** in WHAM1, with a reference mark indicating the center of MMT3. This target should have a positional accuracy of +/- 2 mm and can be positioned by reference to the MMT3 structure (i.e. does not need to be positioned optically).

❑ 12. **Check the centering of the COS beam at the MMT3 optic.** The center of the COS LAC projected reticle pattern should be well centered (within a 5 mm radius) on the MMT3 target. If it is not, stop and re-check the autocollimation from the ITMx HR surface. If still not well centered, stop the procedure and reconsider.

❑ 13. **Adjust the RM PAMs**, with zero bias control applied to the RM, until a retroreflection from the RM HR surface is centered in the COS LAC to within ~30 microradians (the central spot of the reticle pattern is ~200 microrad in size).
Notes:
a) The ITMx should be on its stops so that its reflection is outside of the field of view of the COS LAC.
b) The RM must be off of its stops (freely hanging) during this step.
b) If a large yaw adjustment appears to be required (greater than ~1 mrad), then stop the procedure and re-check the COS LAC alignment. If this does not remedy the situation, stop the procedure for re-consideration.

❑ 14. **Transition to a Laser Hazard Condition** If not presently in a Laser Hazard condition, then transition per the SOP, M990297 for the PSL. Post a list of qualified personnel for LIGO M990297 to the LVEA entrances.

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❑ 15. **Align the MMT to the Recycling Cavity (RC)**
Note: Do not adjust the MMT3 bias controls. Assure that the bias settings are per the 6/20/2001 elog entry (pitch bias = -1.945 and yaw bias = -0.882).
a) Check that the LOS projected reticle pattern is centered on a target in front of MMT2 to within a 2 mm radius. If it is not centered, stop the procedure for re-consideration.
b) Adjust MMT1 bias controls to center the PSL beam on the center of a target in front of MMT2
c) Adjust MMT2 bias controls to center the PSL beam to the same position that the COS LAC reticle pattern hits the target in front of MMT3
d) Verify that the PSL beam retro-reflects from the RM HR surface.

❑ 16. **Transition to a Laser Safe Condition**
per the SOP, M980048 for the PSL and the COS LAC.

❑ 17. **Close the HAM doors** Perform exit checks per E000065 and close the HAM chambers.

❑ 18. **Re-position the ISC & IOT Optics tables**

❑ 19. **Set up the Sokkia and LDS-1000** Replace the COS LAC with the Sokkia total station and the LDS-1000 in the spool between WHAM3 and WBSC2. Make sure that the ITMx has the proper bias values applied (pitch bias = -6.0 and yaw bias = -1.7 according to the 6/20/2001 elog entry). Adjust the orientation of the LDS-1000 mount until the instrument reads zero (+/- 10 microradians). Make sure that the LDS-1000 mount is stable and does not drift on the timescale required for ITM PAM adjustment (~20 minutes).

❑ 20. **Adjust the ITMx PAM magnets** Zero the applied bias to ITMx. Note the change in pitch and yaw as measured by the LDS-1000 LAC. Adjust the PAM magnets until the LDS-1000 again reads zero (+/- 10 microradians).
CAUTIONS:
a) IT IS ABSOLUTELY ESSENTIAL THAT THE LDS-1000 LAC AND ITS MOUNT ARE NOT DISTURBED FOR THE DURATION OF THIS ADJUSTMENT. ALL TRAFFIC AROUND THE CHAMBER SHALL BE RESTRICTED!
b) The adjustment should be completed as quickly as practical and safe so that alignment drift is not a concern.

❑ 21. **Remove the Sokkia and LDS-1000** and their mount from the spool area between WHAM3 and WBSC2.

❑ 22. **Replace the spool** between WHAM3 and WBSC2 per procedure E000121.

❑ 23. **Open the BSC1 S door**

❑ 24. **Place a Precision Flat** on a tripod in the spool to the +Y side of ITMy (BSC1). Use a non-dielectric coated mirror (i.e. one with high reflectivity for all angles). The optical flat should be positioned at the same height as the center of the ITM and oriented so that the LDS-1000 LAC can be used with it to retro-reflect from the HR surface of the ITMy.

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- ❑ 25. **Set up the LDS-1000** on a tripod at the height of the ITMy just outside the S door of chamber BSC1 so that it retroreflects off of the HR surface of ITMy using the precision flat. Make sure that the ITMy has the proper bias values applied (pitch bias = -3.75 and yaw bias = +0.2 according to the 6/20/2001 elog entry). Adjust the orientation of the LDS-1000 mount until the instrument reads zero (+/- 10 microradians). Make sure that the LDS-1000 mount is stable and does not drift on the timescale required for ITM PAM adjustment (~20 minutes).

- ❑ 26. **Adjust the ITMy PAM magnets** Zero the applied bias to ITMx. Note the change in pitch and yaw as measured by the LDS-1000 LAC. Adjust the PAM magnets until the LDS-1000 again reads zero (+/- 10 microradians).
  CAUTIONS:
  a) IT IS ABSOLUTELY ESSENTIAL THAT THE PRECISION FLAT, THE LDS-1000 LAC AND ITS MOUNT ARE NOT DISTURBED FOR THE DURATION OF THIS ADJUSTMENT. ALL TRAFFIC AROUND THE CHAMBER SHALL BE RESTRICTED!
  b) The adjustment should be completed as quickly as practical and safe so that alignment drift is not a concern.

- ❑ 27. **Remove the Precision Flat** from BSC1.

- ❑ 28. **Close the BSC1 S door.** Perform exit checks per E000065 and close the BSC1 door.

- ❑ 29. **Pump down** per procedure M980101