1 Related Documents

1. Quad Pusher
http://www.ligo.caltech.edu/docs/D/D060052-A.pdf

2. Quad Movers
http://www.ligo.caltech.edu/docs/D/D060053-A.pdf

3. Thrust/~~Ball~~ Screw - Part ~~#TST-0510-X-3-SB~~ D960499
~~Fairlane Products www.fairlaneproducts.com or Fixtureworks www.fixtureworks.net~~

4. AdvLIGO Quad Suspension Controls Prototype Suspension and Adjustment Method
http://www.ligo.caltech.edu/docs/T/T060039-00.pdf

5. Metal Quad Noise Prototype Balancing and Alignment Procedure
http://www.ligo.caltech.edu/docs/T/T080165-00.pdf

6. Holo-Krome Bolt Torque Data Sheet

URL:
http://www.holo-krome.com/pdf/techbk34-40.pdf

7. QUAD MOVER SPACER D1100536
8. USING A QUAD POSITIONER & MOVER ASSEMBLY LIGO-D1100018.

2 Introduction

This document is a note on the use of the quadruple pendulum structure pushers. They were originally designed for use with the quad controls prototype, but proved equally useful for the noise prototype. They are intended for fine tuning the centering and aligning of the pendulum structure and optic on the ISI optics table. At LASTI these pushers were used to improve the yaw precision of the dummy test mass to within ±1 mRad.

The documentation for the three different parts to these pushers are found in Section 1 above under documents 1, 2, and 3. The thrust screw, listed as document 3, is not a LIGO part. It is obtained from Fairlane Prodcuts or Fixtureworks, which is a Fairlane Products company.

3 Class B Tooling

Safety cables.

Ken Mailand's 5 axis table on it's wheeled cart.

The quad's lower structure assembly tooling. OR EQUIV. BS SET FOR BS.

$\frac{1}{4}$ inch allen wrench.

$\frac{5}{16}$ torque wrench capable of up to 400 in-lb (33 ft-lbs, 45 Nm).

Quad pushers D060052-A.

Quad movers D060053-A. (SEE D1100018)

D960499 3 inch $\frac{1}{2}$-13 thrust screw with ~~steel ball~~ FLUOREL OR TEFLON tip.

D1100536 SPACER FOR QUAD MOVER (SEE D1100018)

A tool for measuring the position and/or rotation of the quad structure.

4 Using the Pusher

IF 8 MOVERS (2 PER SIDE) ARE USED SAFETY CABLES ARE NOT REQUIRED. CIT.

Safety is the primary concern here, and there are a few measures to take simultaneously. Safety cables should be used to tie the structure to the table. The cables should be tied so as to prevent the structure from rotating in the dog clamps once they are loose. Additionally, the quad movers in document 3 are meant to augment the dog clamps. These movers have a slippery teflon tip, so they can be used in a similar way to the dog clamps while still allowing the structure to turn. They should be placed around the structure in line with some of the dog clamps.

SPACER AND A

OR SIMILAR PLATFORM

THIS TECHNIQUE ALSO WORKS FOR BS, WITH THE LOWER BS STRUCTURE TOOLING SUBSTITUTING FOR THE LOWER QUAD TOOLING. CIT.

The 5 axis table should be placed under the quad for added safety, see Figure 1. Using the 5 axis table requires installing the lower structure tooling around the lower structure of the quad, and removal of the sleeve if it is in place. The bottom of the lower structure tooling can be clamped to the 5 axis table with dog clamps, however this may make turning the structure more difficult. It should suffice to simply touch the 5 axis table up to the bottom of the lower structure. Note: The 5 axis table cannot take the full weight of the quad anyway because the lower structure was not designed to take the full weight of the upper structure (testing shows that it can take the static weight, but there is a small risk of deforming the structure). The 5 axis table has two safety purposes here. First, two help the safety cables stabilize the position of the structure in loose dog clamps; and second, to catch the structure in the event that all previous safety measures fail.

OR FLAT BLADE SCREWDRIVE

The pusher itself consists of 2 main parts, the thrust screw mount shown in document 1 above, and the $\frac{1}{2}$-13 thrust screw istelf in document 3. The screw mount also requires a $\frac{1}{2}$-13 nitronic-60 helicoil. The thrust screw requires a $\frac{1}{4}$ inch Allen wrench. Figure 2 shows the pusher assembly mounted to the optics table ready to push on the quad structure for alignment.

The use of the pusher is very simple and straight forward. Simply mount the pusher onto the optics table near the quad structure where it needs to be pushed or turned. If you use the rear through hole of the thrust screw mount to bolt the pusher assembly to the table as shown in the figure then it will be necessary to remove the thrust screw before the assembly is mounted to the table, since it gets in the way. Once the assembly is on the table, turn the thrust screw until the ~~ball~~ TIP at the end of the screw is up against the structure.

OR SCREWDRIVER

The dog clamps should now be loosened just enough to remove the friction of the structure against the optical table. This may mean a tiny gap is necesarry. The quad movers should pick up some of the quad's weight to take advantage of the teflon tip. Then, to push on the structure simply use the $\frac{1}{4}$ inch Allen wrench to tighten the thrust screw. Using multiple pushers simultaneously around the structure in strategic locations will make it easier to translate and rotate the structure by precise amounts.

Retighten the dog clamps when the structure is well located. The $\frac{3}{8}$ in dog clamp bolts should be torqued to at least 330 in-lb (27.5 ft-lbs, 37.3 Nm). Lastly, remove the safety equipment and tooling. Please note that retightening the dog clamps is likely to shift the

position of the structure slightly. The experience at LASTI was that about 1 mRad of yaw precision was lost when torquing the dog clamps. However, in this case the structure was not perfectly constrained by the pushers since we only had 2 available. Using 3 or more to 'lock' the structure while tightening the clamps may help improve on this issue.

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Quad Pendulum Structure Pushers

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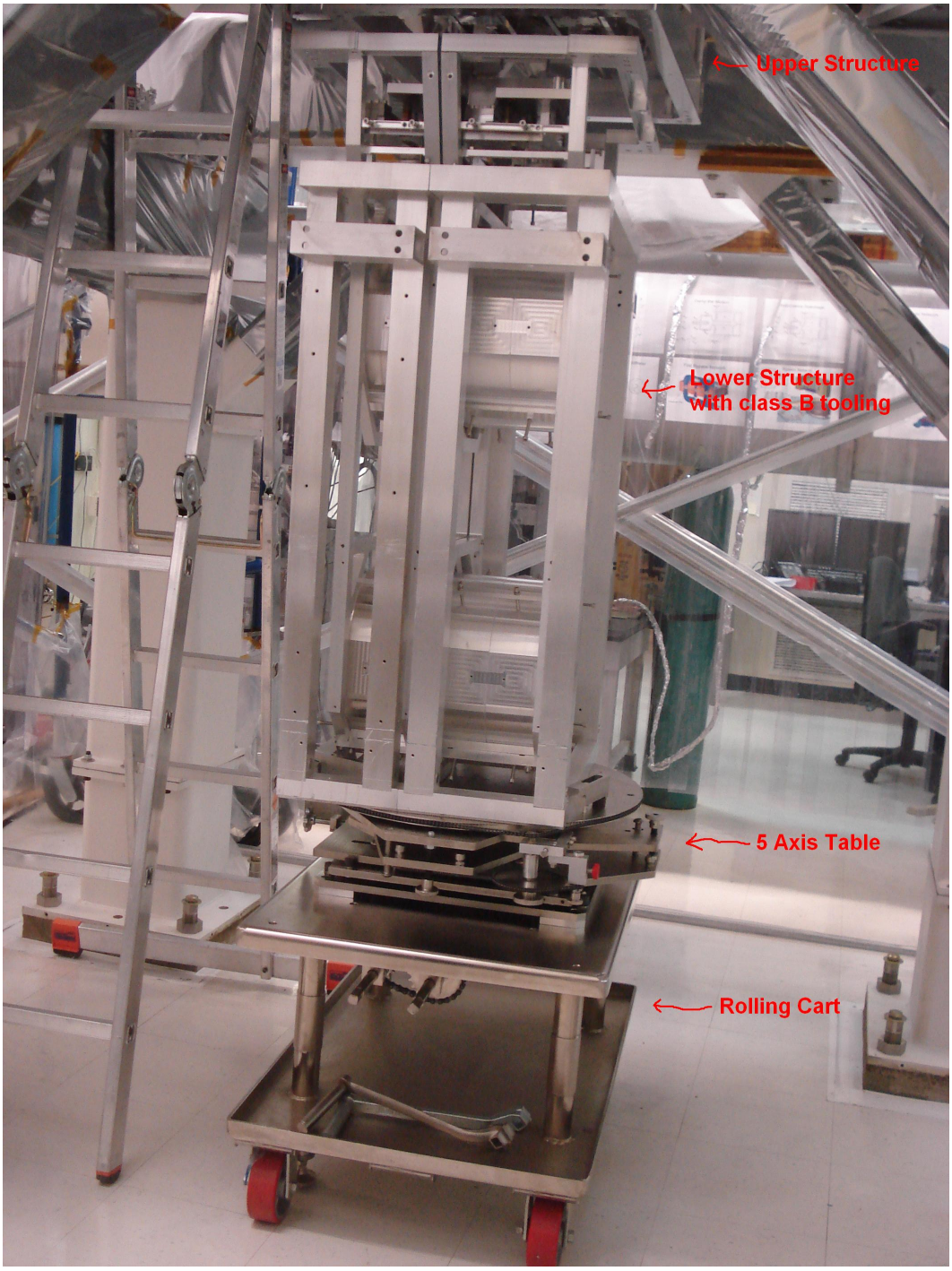

Figure 1: The 5 axis table, its wheeled cart, the lower structure, and the lower structure assembly tooling are all visible here. The red arrows point to these various components. At the top of the picture, part of the upper structure is visible and is shown to be seperated from the lower, which is irrelevant to the discussion in this document. While the upper structure can be turned with the lower disconnected, fine tuning the structure position usually requires referencing the optic.

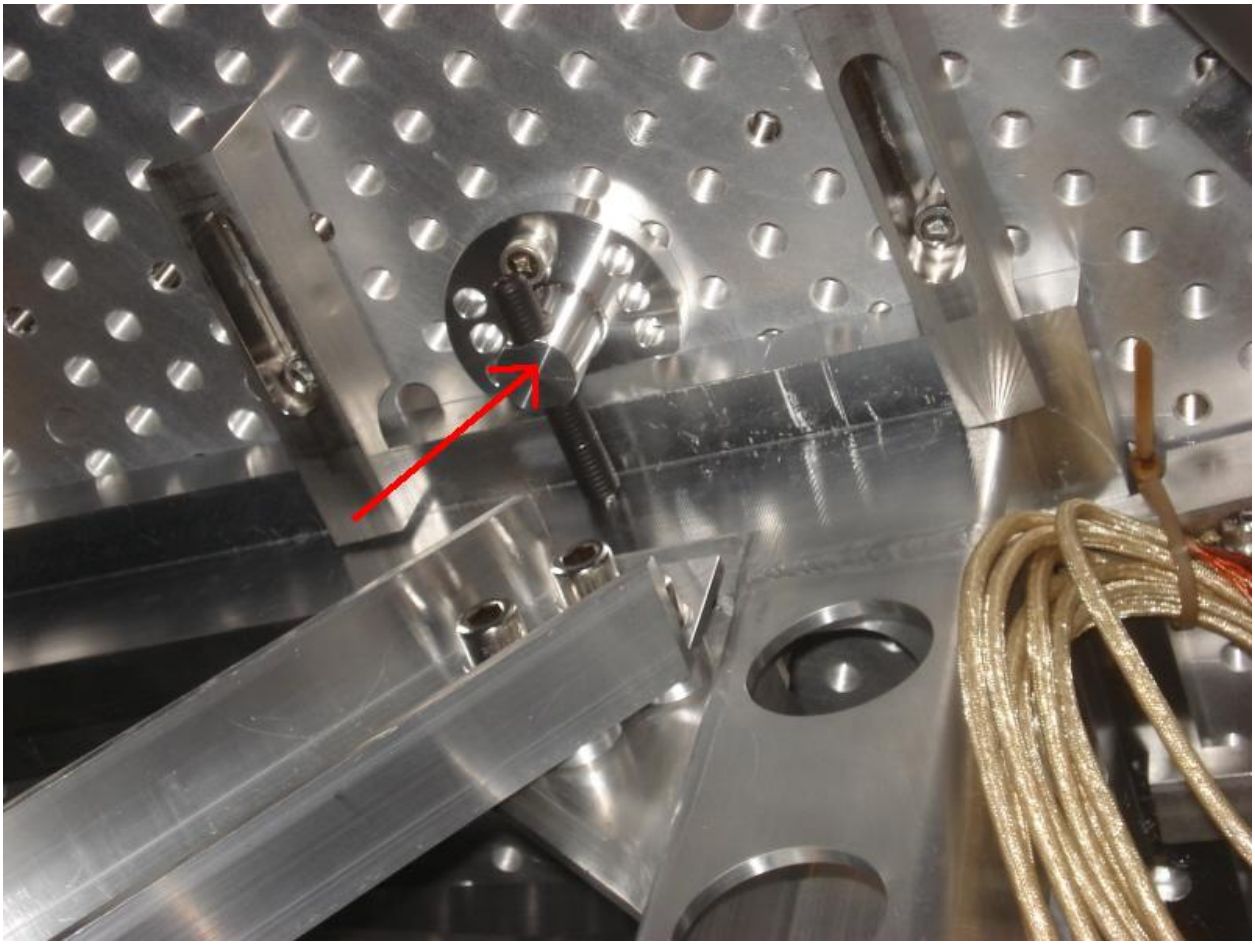

Figure 2: The red arrow points to the quad structure pusher assembly. Visible are both the screw mount on the optics table and the black thrust screw that pushes on the structure.

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We design, manufacture and stock a wide range of workholding and positioning components, as well as rollers and bumpers for materials handling, assembly and manufacturing. The workholding and positioning components provide for faster speeds and feeds, and their modular and economical replaceable wear surfaces extend the life of expensive jigs, fixtures, jaws and clamping mechanisms.

Our line includes serrated grippers, low-profile edge grippers, single point and straight serration grippers, as well as Swivots® -swivel-action modular component workholding system incorporating a serrated or smooth contact area that rotates and pivots for holding and positioning of irregular contour surfaces. And Accu-Thrust™ thrust screws that allow straight-line static thrust loads without transmitting torsional or radial forces on an object or work piece. We also design, manufacture and stock a line of rollers and bumpers used in materials handling, assembly and manufacturing applications. The rollers and bumpers come in a variety of durometers, materials, styles and mounts while the bumpers can be custom cut to meet specific applications.

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- **11/23/09** Fairlane Products introduces line of diamond coated grippers, providing non-slip gripping with minimal force.
- **10/12/09** Fairlane Products introduces new Sof-Top™ Urethane Grippers, providing secure holding plus surface protection.
- **02/22/09** Fairlane Products now offering a complete line of metric quick release ball lock pins.
- **01/16/09** Fairlane Products adds full stainless steel line of quick release ball lock pins.

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