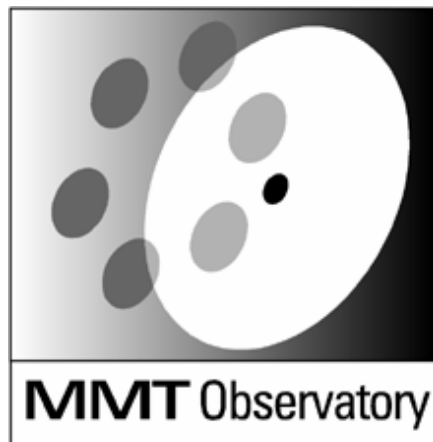


## **MMT Conversion Internal Technical Memorandum #95-2**



Smithsonian Institution &  
The University of Arizona®

### **Procedure for Metrology and Mounting of Force Actuators and Static Supports in the MMTO/6.5-m Primary Mirror Cell**

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## **Procedure for Metrology and Mounting of Force Actuators and Static Supports in the MMTO/6.5-m Primary Mirror Cell**

This procedure outlines requirements and provides a sequence of major steps to survey and mount force actuators and static supports into the mirror cell, as received from TIW, for the 6.5-m MMT. The principal X, Y, and Z coordinates, including elevation axis, were established to tight machine tolerances during precision machining of axes, bores, and flanges at Votaw during fall 1994. These coordinates are centerline references for this procedure. We adopt some of the metrology and fixing techniques developed by SOML during the metrology and installation of loadspreader pucks and frames on the primary mirror, and mounting of single Z axis force actuators and static supports on the 6.5-m polishing cell.

### **Tolerances**

Overall positioning/mounting tolerances for the two-axis actuators are summarized here based on 9/21/95 discussions with Steve West and John Hill. Theta Z is not a critical parameter for single-axis actuators.

X is the cross-lateral direction, Y is along elevation, and Z parallel to the optic axis.

The angles are rotations about the axis, so  $\Phi X$  is a rotation about the cross-lateral axis (i.e., motion in the plane of the dual-axis actuators).

$$X = Y = \pm 0.5 \text{ mm}$$

$$Z = \pm 0.5 \text{ mm}$$

$$\Phi X = \pm 0.07^\circ$$

$$\Phi Y = \pm 0.3^\circ$$

$$\Phi Z = \pm 0.4^\circ$$

It is both reasonable and practical to perform metrology to achieve repeatable measurements 2 to 5 times tighter than these stated tolerances.

### **Requisite Conditions**

The mirror cell/trunnion assembly (25' diameter x 9' deep, weight 27 tons) is supported (85% wt.) on two elevation bearing trunnion stands, nadir-pointing stabilized on a concrete floor. The aft flange is at the top; the trunnion/vacuum flange is at the bottom, 42" above the floor. The X ( $\Phi Y$ ) axis is leveled/plumb to better than  $0.001^\circ$  (1:66,000) on short trunnion stands, measured separately by K&E and WILD optical levels. The Y axis ( $\Phi X$ ) is leveled and stabilized using two self-locking mechanical jacks which support ~15% of the cell's weight.

Precision mechanical bubble levels references will be established on a selected flat surface for  $\Delta$  tilt monitoring during the procedure.

Note: With cell height choice of 42" above the floor, the top plate is 117" and the aft flange is 152" high.

## **Metrology**

### ***Actuators***

The primary metrology for accurately locating the force actuators to better than the alignment tolerances given below is to transfer an X and Y matrix of cross-hair intersections (11x18 or 11x20) on the machined aft flange (top) to the actuator mounting plane using optical plumbs (vertical theodolites). Resolution of measurements on cross-hairs at each level is  $\pm 0.002''$ . Overall X and Y accuracy is expected to be limited by thermal variations (CTE) and by the repeatability of measurements of the matrix cross-hair to the Y axis and X axis centerline references using long verniers, inside micrometers, and Invar tapes, as required.

Independent verification metrology will use theodolites and micrometers to measure each actuator location by triangulation.

X, Y, and Z fiducial centerline marks were machine drilled on the cell and trunnion perimeter surfaces referenced to the elevation bearing axis to  $\pm 0.002''$  across the cell diameter, using the Votaw machine table 1024 pole encoders. Accuracies of the X and Y axes were verified to be parallel and perpendicular to the elevation axis to better than  $\pm 0.003''$  on TIW's leveled trunnion stands at horizon pointing (zenith angle =  $90.00^\circ$ ).

### Steps:

I. Survey the actuator support L bracket height with respect to the corrector cell Z reference, using optical level and plumb precision scale. Determine the average plane and the extrema. Review results of survey and determine acceptable actuator mounting plane Z dimension. Use the lowest practical Z measurement to set the minimum shim thickness (this insures that all mounting plates will have positive shim thickness and that none have to be ground off). Record nominal Z and contours for sag compensation, referred to corrector flange Z reference A.

II. Set X and Y intersections of  $0.009''$  diameter music wire cross-hairs on the aft flange (top) to the nominal coordinates of the actuators (lines of actuator with equal X or Y dimension) and measure the wire center to the mirror cell centerline reference to  $\pm 0.004''$ . Use long verniers, inside-micrometers, or tensioned Invar tapes from the center line and read the music wire centerline dimension using an optical plumb (theodolite) translated below the cell.

III. Place and course-adjust alignment/drill jig plate and clamp (adjacent to push set-screws) to L brackets.

IV. Position the optical plumb below actuator location and center the optical axis on the actuator reference cross-hair to  $\pm 0.004''$ .

V. Adjust jig plate in X and Y to center jig cross-hair on the actuator reference cross-hair (aft flange) to  $\pm 0.010''$  using optical plumb. Adjust jig  $\Phi Z$  to Y axis reference (ball screws) to  $\pm 0.010''$  end-to-end. Snug axial clamps and add lateral clamps or blocks with adjusting push screws.

Using #4 and #5 center-drills, drill 12 mounting plate hold-down holes through jig plate guide holes; remove jig and enlarge holes for 0.04 clearance of 3/8-16 bolts and 1/4-28 screws.

VI. Attach a 1'' wide strip of aluminum foil sealing tape to the inside edge of each aluminum actuator mounting plate (for easier sealing later). Position and secure aluminum actuator mounting plates to a certified actuator alignment/drilling/casting jig fixture. Coarse adjust push set-screw(s) heights to the calculated shim thickness  $\pm 0.010''$  for a given set of L brackets, based on above actuator plane Z dimension.

Install mounting plates hold-down screws and backing nut plates, and tighten to snug. Install 3/8'' bolts with spring washers just snug to secure jig, but allowing fine adjustments of jig, with backing nut plate assembly, in six axes.

VII. Verify position of reference cross-hair and optical plumb. Refine alignment of jig plate center X and Y cross-hair to actuator location alignment cross-hair to  $\pm 0.005''$  with optical plumb, compensating for any known alignment or CTE offsets. Record metal and air temperature. Iterate with adjustment of  $\Phi Z$  to  $\pm 0.010''$  ( $0.1^\circ$ ) end-to-end, parallel to Y axis reference.

VIII. Re-adjust plate Z (and tilt) to nominal actuator height (include any sag factor) to  $\pm 0.005''$  using plumb scale and optical level. Refine  $\Phi X$  to  $\pm 0.02^\circ$  and  $\Phi Y$  to  $\pm 0.1^\circ$  using precision machinist levels.

IX. Re-check references X, Y, and Z and tolerances of all 6 axes; repeat step as required. Iterate X, Y, Z,  $\Phi X$ ,  $\Phi Y$ , and  $\Phi Z$  adjustments until all tolerances are met with hold-down screws and push set-screws moderately tight, and only spring washer force on the 3/8'' mounting bolts.

X. Verify aluminum actuator mounting plates are flat and contacting jig plate with less than 0.003'' gap.

XI. Seal edges of shim space with aluminum foil tape; provide 1/16'' relief at each corner. Insert sealing sleeve, and/or close holes as needed for castable shim.

XII. Re-verify tolerances of all 6 axes. Record metal and air temperature. Verify above metrology using independent and direct X-Y triangulation measurements where practical.

XIII. Mix castable shim material (2-part epoxy) per manufacturer's directions, and immediately inject under actuator mounting plates using expendable grease gun pump(s). Connect 1/8'' NPT

hose with bullet or union fittings, avoiding disturbance, to the aligned jig. Inject shim at moderate rates to avoid hydraulic lifting of jig plate.

XIV. Check for any motion or disturbance. Re-verify tolerances, and refine adjustments as required. Record measurements.

XV. Clean re-usable epoxy-handling parts promptly.

### ***Static Supports***

The static supports (cupped engine mounts) will be positioned in X, Y, and Z in much the same way as on the polishing cell, using the SOML static support positioning fixture, adapted to the actuator alignment jigs. Shims will be used to adjust Z based on variations in the top plate plane at static support locations, plus any desired sag compensation.

A map of static support location heights will be made using optical level and scale measurements. The top plate to actuator L bracket Z dimensions are fabricated to insure shim space for both actuator and static supports (the PVC cups have extra length to be machined off).

#### Tolerances:

The final tolerances for X, Y, and Z positioning of the static supports are still being considered (see West, Callahan, *et al.* Sept. 1995) owing to the problem of matching rubber engine mount compliance with uniformity of force distribution with maximum stress in the mirror. It is likely that metrology will place the supports to  $\pm 0.005''$  of the mapped mirror loadspreader coordinates, X, Y, and Z.

#### Steps:

I. Using a plumb precision graduated scale and optical level, survey each static support location for Z (and any local tilt) with respect to Z reference A corrector cell flange and actuator mounting flange plane to  $\pm 0.003''$ .

II. Using the results of the static support height map, shim the engine mount cups to the calculated nominal height with respect to corrector cell Z datum, with correction for any sag factor. Adjust shims to position static support height to  $\pm 0.003''$ .

III. Each static support is positioned in X and Y with a fixture attached to 2 adjacent actuator mounting jigs. The adapted SOML static support positioning fixture(s) position alignment plugs which fit into each engine mount clearance sleeve. The X - Y position of the PVC mounting cup is adjusted by counter-rotating the eccentric cup in its eccentric mounting ring until the clearance sleeve is centered on the alignment plug;  $\pm 0.005''$  alignment is expected. Tighten 6 clamping screws. Record metal and air temperature.

IV. The static support mounting assembly is locked in position, pending further refinements after the mirror/loadspreader shoulder bolts are lowered onto the static supports for a more exact fit-up and exact centering for a given metal temperature.