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**Installation and Adjustment Procedure for the Portable Pier and
PlaneWave CDK 17 Telescope**

Judson LaMoure Shattuck, III

Vincent A Schmidt, PhD

Pawlos Campbell

**Warfighter Interface Division
Battlespace Visualization Branch**

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711 HUMAN PERFORMANCE WING,
HUMAN EFFECTIVENESS DIRECTORATE,
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433
AIR FORCE MATERIEL COMMAND
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//signed//
JUDSON L SHATTUCK, III
Battlespace Visualization Branch

//signed//
JEFFREY L CRAIG
Chief, Battlespace Visualization Branch
Decision Making Division

//signed//
MICHAEL A STROPKI
Chief, Decision Making Division
Human Effectiveness Directorate

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1. SUMMARY

The purpose of this document is to highlight the initial steps necessary to mechanically set up and configure the PlaneWave CDK-17 in preparation for operational use.

PlaneWave (www.planewave.com) acted as systems integrator during the specification, manufacture, and shipment of the telescope. The system was delivered on 23 September 2011 in three (3) crates, containing the 12" x 48" portable pier by Advanced Telescope Systems, the MI-500 mount and MI-750 fork arms by Mathis Instruments, and the CDK-17 optical tube by PlaneWave. Eyepieces, cabling, and control electronics were divided between the crate containing the optical tube and the crate containing the mount.

The construction and setup steps illustrated in this manual are primarily executed by Dr. Vince Schmidt, Mr. Judson "Skip" Shattuck (Human Effectiveness Directorate, US Air Force Research Laboratory) and Mr. Pawlos Campbell (Consortium Fellows Research Program).

These instructions outline the mechanical assembly, setup, and orientation of the portable pier (PPR), the Mathis fork arms, and the PlaneWave optical tube assembly (OTA).

2. BACKGROUND

The Battle Space Visualization Branch requires a diverse collection of ground-based satellite images for research involving space situational awareness (SSA) and visualization. The objective of this research is to develop and demonstrate a native (in-house) capability to directly collect, process, analyze, and display ground-based images of satellites and space phenomena. These data will be utilized as inputs into branch SSA and visualization research activities. The research involves the selection and installation of an appropriate collection of imaging hardware, software, and computational components that will make up a research image collection and processing testbed.

In addition to providing timely and applicable research data, the Battle Space Visualization Branch will have improved ability to demonstrate the nature of the research cycle, from initial data collection, through processing and analysis, and into the SSA and visualization research products.

3. SPECIFICATION CONSIDERATIONS

The PlaneWave telescope system is installed in an existing observatory at Wright Patterson AFB in Dayton, OH. The entire telescope assembly was specified to sit on a 10' circular platform and is raised, by a Pentalift scissor lift, 9' up into a shuttered 2.5m ObservaDome dome for observing. (For reference, several of the photographs in this guide depict the platform and the dome.) This is a recognizably unique configuration with distinct challenges in equipment sizing:

- The legs on the portable pier extend through an area $d=5'$ on the floor of the ($d=7'$) platform
- The pier height was selected with minimal optical clearance (at the bottom of the OTA) when observing horizontally through the shuttered dome
- The optical path of the PlaneWave telescope clears the fully opened shutters by just over 5" on each side of the path, when centered in the shutters; physical telescope and pier positioning allows only approximately 3" mechanical clearance between the OTA and the inside of the dome when the OTA points in certain directions.
- Standard 110V grounded electrical outlets must be available on the lift platform.

4. PORTABLE PIER INSTALLATION

The portable pier is manufactured by Advanced Telescope Systems (www.advancedtelescope.com) and was specified to properly support the weight and size of the Mathis fork mount and PlaneWave optical tube. The pier is a tripod with a center support column at 12"OD x 48" tall.

- a. Open the three PPR legs and secure stabilization struts as shown in Figures 4.1, 4.2 and 4.3.



Figure 4.1 Opening stabilization strut



Figure 4.2 Positioning stabilization strut onto PPR leg



Figure 4.3 Stabilization strut onto PPR leg complete

- b. Position the PPR on the hydraulic platform as shown in Figures 4.4. (This figure also shows the mount affixed to the top of the pier; don't install the mount yet!)



Figure 4.4 PPR on the hydraulic platform, location is approximate

- c. Adjust the PPR position using the north side and south side alignment marks on the underside of the ObservaDome as references shown in Figures 4.5 and 4.6 respectively.
 - i. Note this is only an approximate position the exact positioning will be performed later.



Figure 4.5 ObservaDome north side marker



Figure 4.6 ObservaDome south side marker

5. ORIENTATION OF OBSERVADOME TO MAGNETIC NORTH TO SOUTH

- a. Paying attention to all operating and safety instructions, fully raise the hydraulic platform as shown in Figure 5.1.



Figure 5.1 Trained operator safely raising hydraulic platform to completely extended position

- b. Rotate in the dome in azimuth so the shutter opening is pointing “approximately” south as shown in Figure 5.2.
 - i. Note that in order to use a magnetic compass it is necessary to stand on the roof top away for any metal interference. Approximately 60’ away from the ObservaDome should be sufficient.



Figure 5.2 The ObservaDome is rotated so the shutter door is pointing approximately south.

- c. Attach mason's string to the north side of the ObservaDome as shown in Figure 5.3.
 - i. Note that the mason's string is tied approximately 10" up on a carpenter's square which is perpendicular to the ObservaDome base.

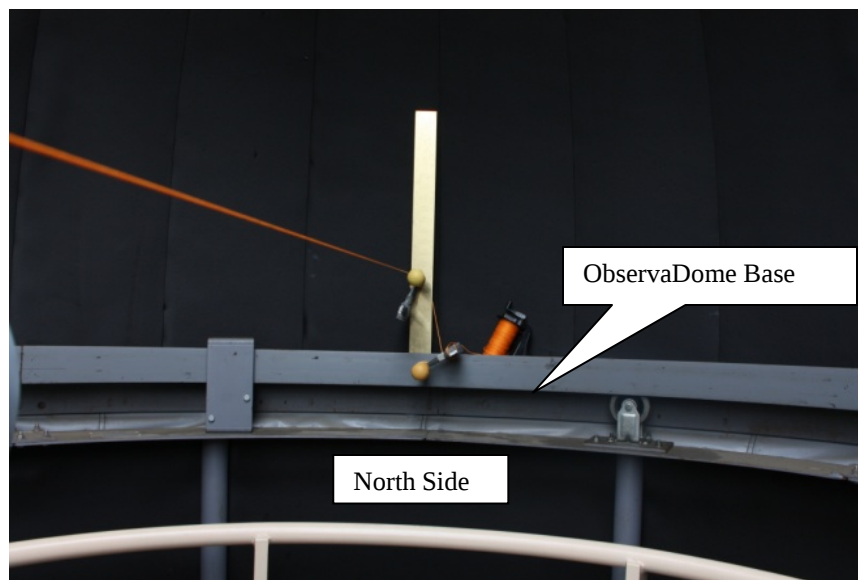


Figure 5.3 Mason's string to the north side of the ObservaDome approximately 10" up on a carpenter's square which is perpendicular to the ObservaDome base

- d. The mason's string is tied above the ObservaDome base so the string will pass through the shutter opening without interfering with the shutter hinge assembly as shown in Figure 5.4



Figure 5.4 Mason's string passing from north side of the ObservaDome through the south facing shutter opening

- e. Tie the south end of the mason's string to a magnetic compass as shown in Figure 5.5.



Figure 5.5 Mason's string tied to magnetic compass

- f. Stretch the mason's string approximately 60' south of the ObservaDome.
 - i. The string should be tight enough that it is straight and not sagging or bending if the wind is blowing.
- g. Holding the compass level, move left or right until the string is parallel with the north markings on the magnetic compass.
 - i. If necessary, rotate the ObservaDome shutter opening clockwise or counter clockwise until the string is centered inside the opening.
 - ii. The north side of the mason's string may need to be shifted clockwise or counter clockwise in order to keep 180 degree separation between them and center the mason's string in the shutter opening.
- h. Scribe a mark perpendicular to the mason's string on both the north and south side of the ObservaDome as shown in Figures 5.6 and 5.7 respectively.
 - i. Note that these marks will be used to orient the PPR north to south.

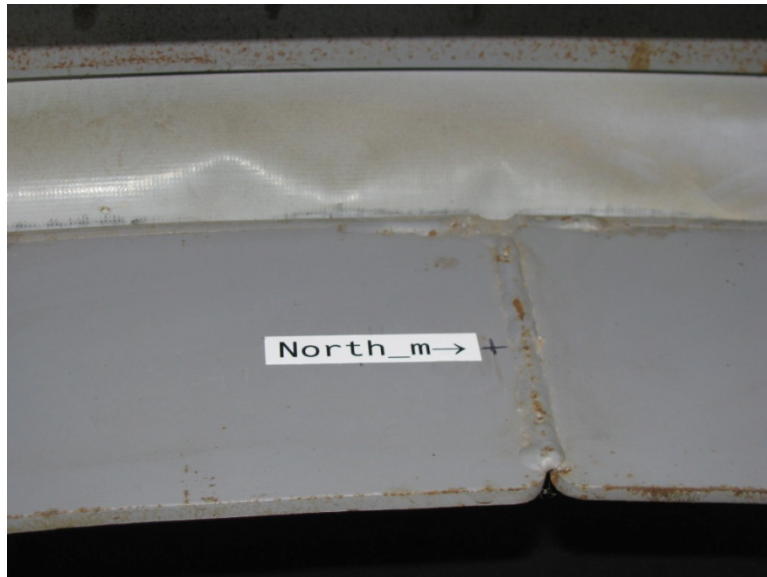


Figure 5.6 Magnetic north marker



Figure 5.7 Magnetic south marker

6. INITIAL ALIGNMENT OF PPR TOWARDS TRUE NORTH

- i. Remove both the Push Block and the Shoulder Bolt, shown in Figure 6.1, from the base plate with a ¼" Allen driver. Note that the Push Block and the Shoulder Bolt are aligned with the north and south sides of the room respectively.

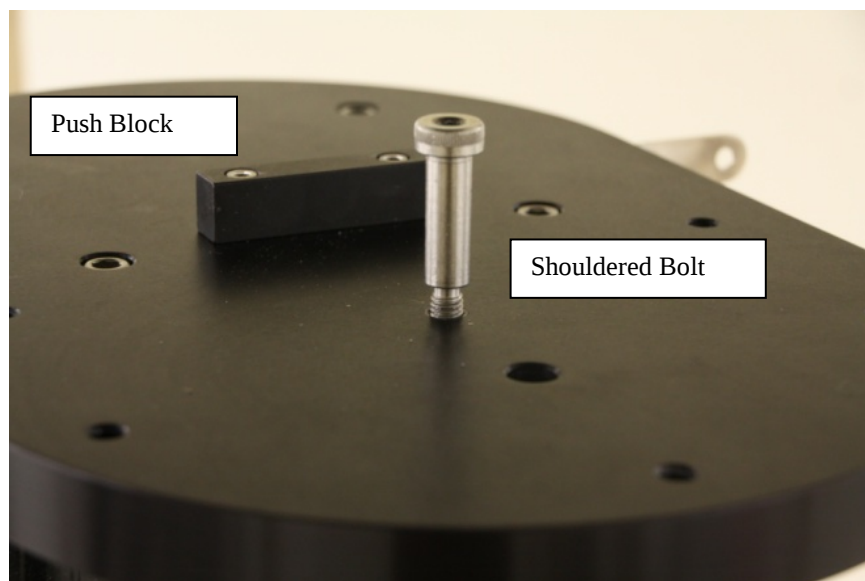


Figure 6.1 Base plate the Push Block and the Shoulder Bolt are aligned with the north and south sides of the room respectively

- j. Find and annotate the centerline (C_L) of the base plate on the PPR as shown in Figure 6.2.

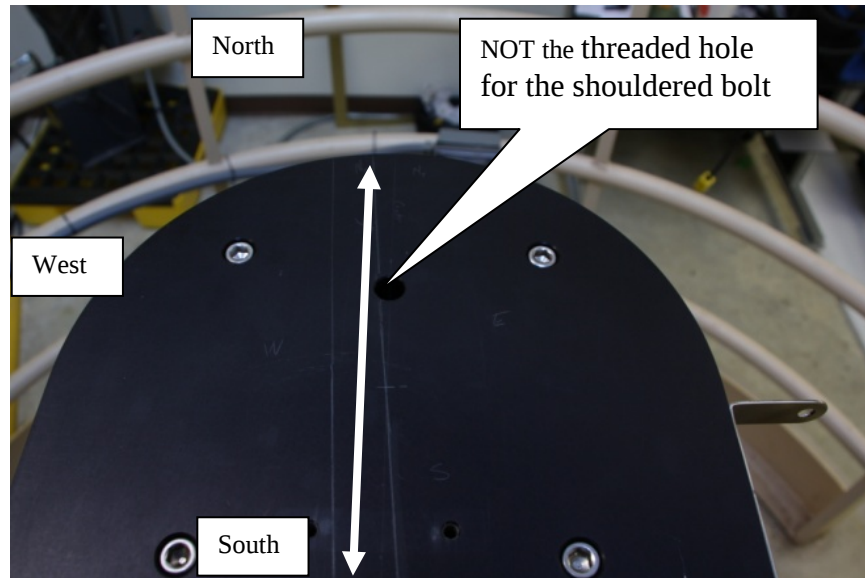


Figure 6.2 C_L of the base plate will be used as an alignment aid to position the PPR along the north-south axis

- k. To compensate for the -5° declination in Dayton, Ohio (Appendix A) $+5^\circ$ must be added to the C_L in Figure 6.2.
- l. Align a protractor on the C_L in Figure 5.2 with its origin at the threaded hole for the shouldered bolt shown in Figure 5.1.
- m. Inscribe a mark on the base plate at the -5° (counter-clockwise) location. Draw a line from the threaded hole for the shouldered bolt through the -5° location as shown in Figure 6.3.
 - i. This -5° declination line (D_L) will be used to align the PPR to true north and south.
 - ii. Note that when line D_L is aligned with magnetic north and south, the C_L will be rotated clockwise $+5^\circ$ which compensates for the -5° declination.

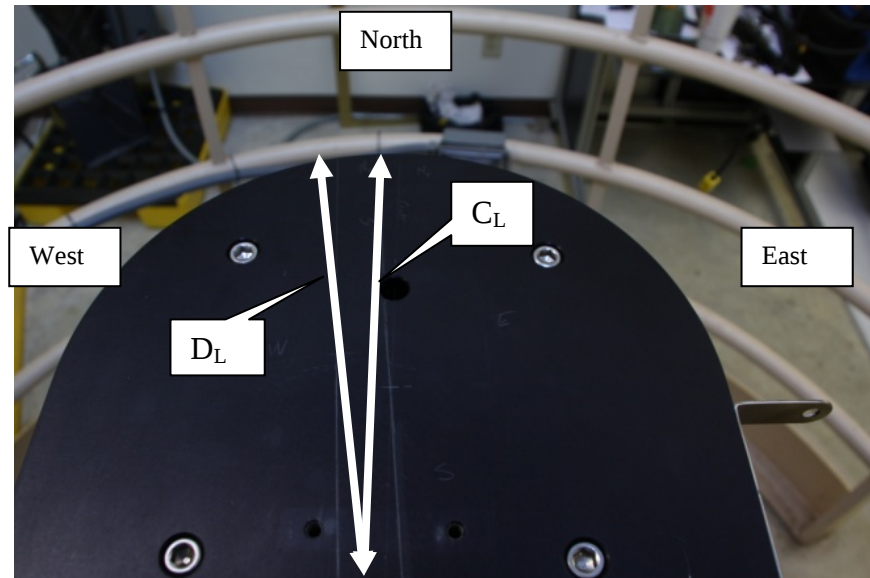


Figure 6.3 C_L of the base plate shown with the -5° declination line (D_L)

- n. Paying attention to all operating and safety instructions, fully raise the hydraulic platform as shown in Figure 5.1.
- o. Attach mason's string to the magnetic north and south markers shown in Figures 5.6 and 4.7.
- p. Using a framers' square or other right angle device align the D_L with the mason's string as shown in Figure 6.4.

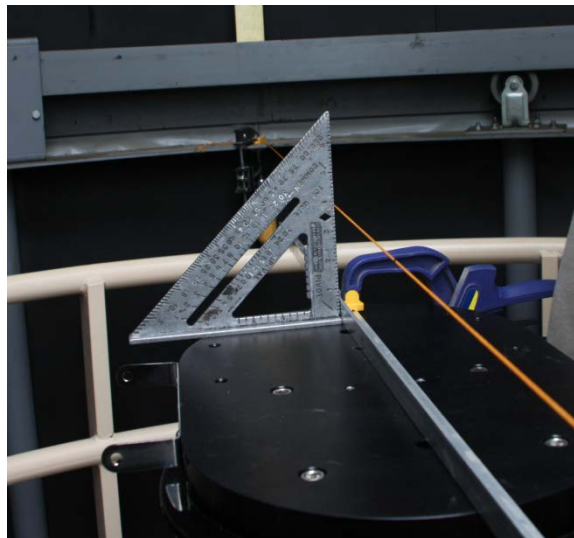


Figure 6.4 Alignment of the base plate with the -5° declination line (D_L)

- q. With the base place, thus PPR, aligned, scribe marks on the legs of the hydraulic platform as shown in Figure 6.5.



Figure 6.5 Annotating the PPR legs after alignment of the base plate with the -5° declination line (D_L)

- r. Reinstall the push block which was removed in Step 5.a. after lubricating the bolt treads with high quality lithium grease (HQLG). A $\frac{1}{4}$ " Allen driver is required and torque is 16 ft-lbs.
- s. In order to prevent the position of the PPR from grossly shifting on the platform as it is raised or lowered, simple brackets with U-bolts were attached (not shown) to connect two (2) of the PPR legs to the rails of the lift.
- t. This concludes the PPR initial alignment procedure. More accurate alignment is performed after the telescope is installed using celestial bodies as navigational points of reference.

7. INSTALLATION AND ASSEMBLY OF THE MI-500 MOUNT ONTO THE PPR

- u. Position the rocker base onto the PPR base plate and align the shouldered bolt, removed in Step 5.a., as shown in Figure 7.1.
- v. The azimuth adjusting screws will align with the push block shown in Figure 6.1 and may need to be loosened to fit properly as seen in Figure 7.1.
- w. Note the north orientation of the rocker base.
 - i. Lubricate the shouldered bolt treads with HQLG. A $\frac{1}{4}$ " Allen driver is required and torque is 16 ft-lbs.

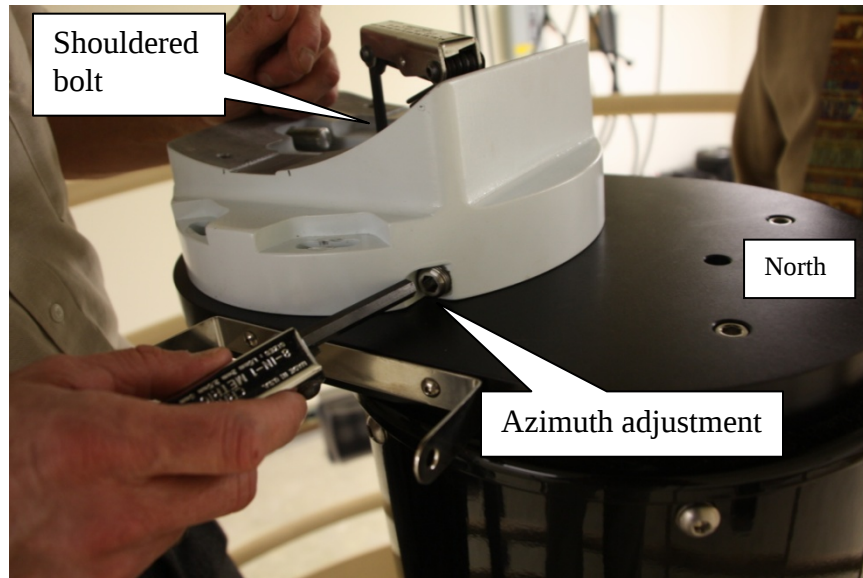


Figure 7.1 Alignment of the Rocker Base onto base plate

- x. Install the five stainless steel bolts which secure the rocker base to the base plate as shown in Figure 7.2.
 - i. Lubricate the bolt treads with HQLG. A 3/8" wrench or socket is required and torque is 54 ft-lbs.
 - ii. Note that these bolts will be loosened during final alignment.

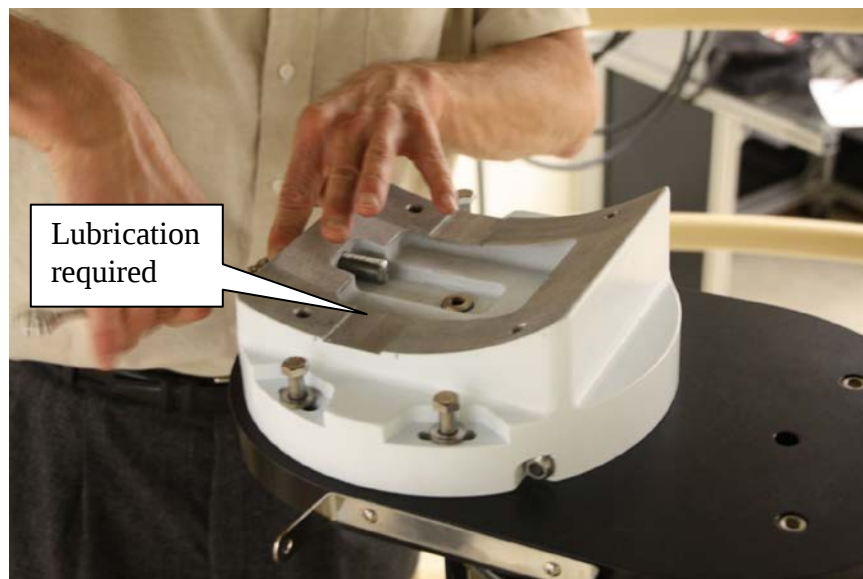


Figure 7.2 Securing the rocker base to the base plate

- y. Lubricate the machined surface of the rocker base with a HQLG.
- z. Install the polar assembly and the four stainless steel bolts which secure it to the rocker base as shown in Figure 7.3.

- i. CAUTION: Polar assembly weights approximately 250 lbs.
- ii. Lubricate the bolt treads with HQLG. A 3/8" hex wrench or socket is required and torque is 54 ft-lbs.
- iii. Note that these bolts will be loosened during final alignment.

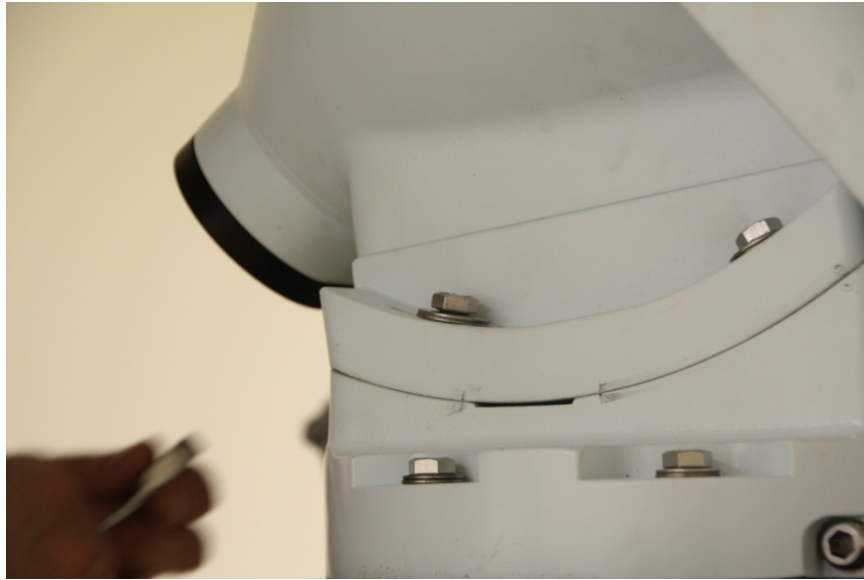


Figure 7.3 Securing polar assembly to the rocker base

8. INSTALLATION OF THE MI-750 EQUATORIAL FORK ONTO THE POLAR ASSEMBLY

- a. Install the stainless steel threaded pin into the center of the polar axis as shown in Figure 8.1. This is used to locate and support the equatorial fork during assembly until the six stainless steel fork bolts are installed.
 - i. Lubricate the pin treads with HQLG. No torque is required although the pin must thread into the polar axis approximately 1½".

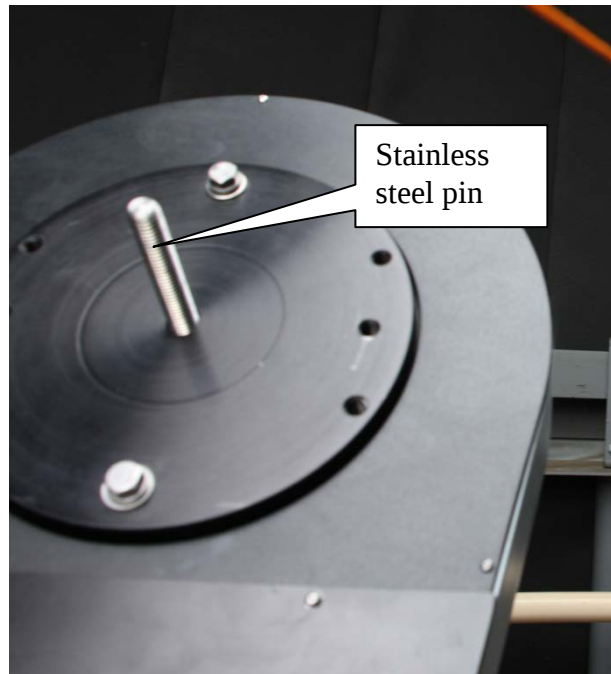


Figure 8.1 Stainless steel threaded pin installed in the center of the polar axis

- b. Carefully lift the equatorial fork onto the polar axis as shown in Figure 8.2.
 - i. CAUTION: The equatorial fork is bulky and weighs approximately 120 lbs.
- c. The equatorial fork is symmetric so orientation not important.



Figure 8.2 Carefully lifting the 120 lb equatorial fork onto the 100 lb polar assembly

- d. Secure equatorial fork by installing the flat washer and hex-nut on the stainless steel pin with hand pressure as shown in Figure 8.3.

- i. Note that the Stainless steel pin is an initial alignment mechanism and the equatorial fork must be manually stabilized until the six stainless steel Allen headed bolts are installed.

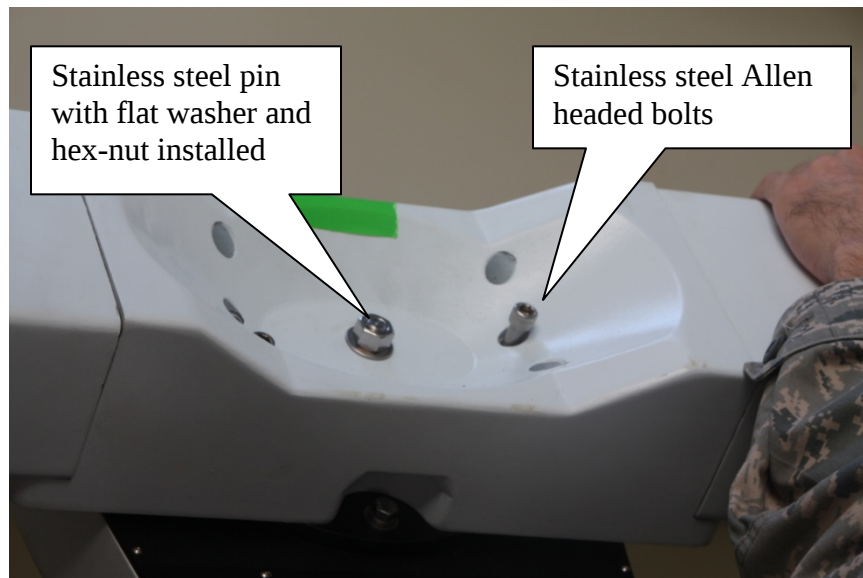


Figure 8.3 Securing the equatorial fork onto the polar assembly

- e. Install the six stainless steel Allen headed bolts as shown in Figure 8.4.
 - i. Note the equatorial fork may need to be rotated clockwise or counter clockwise for alignment purposes.
 - ii. Lubricate the bolt threads with HQLG. A 3/8" Allen driver is required and torque is 54 ft-lbs.



Figure 8.4 Securing the equatorial fork onto the polar assembly

- f. Tighten the hex-nut on the stainless steel pin.
 - i. A 13/16" hex wrench or socket is required and torque is 75 ft-lbs though it is not critical, only used for initial alignment.

9. INSTALLATION OF THE PLANEWAVE CDK17 OTA ONTO THE MI-750 EQUATORIAL FORK

- a. Loosen the adjusting bolts on both the dove tailed rails of the equatorial fork.
 - ii. A 1/4" Allen tool is required
- b. Carefully slide the PlaneWave CDK17 into the dovetail clamps, with final configuration shown in Figures 9.1 and 9.2.
 - iii. Pay special attention to orientation of the rails and the optical tube. The rails must be rotated to position the "long" part to the North (back) side of the assembly, which also ensures the removable dovetail is at the top of the rails. This orientation allows proper optical tube balance to be performed, and promotes an additional level of safety, since the optical tube will generally rest on the fixed portion of the dovetail. DO NOT lubricate the friction-based dovetail joints!

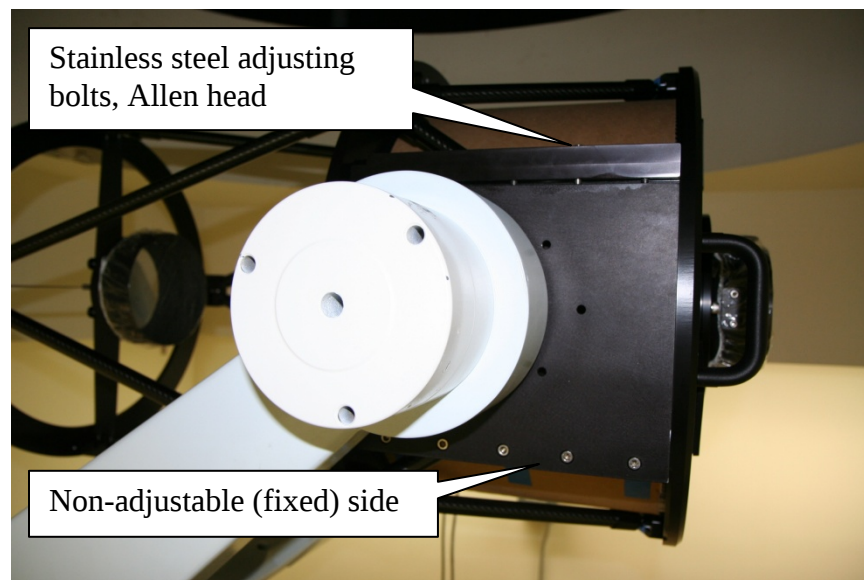


Figure 9.1 Securing PlaneWave CDK17 OTA onto the equatorial fork

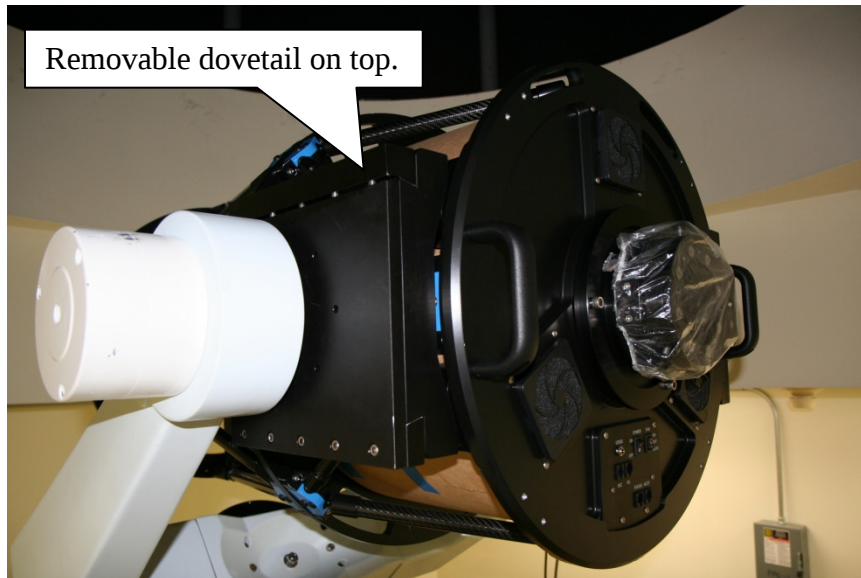


Figure 9.2 Correct orientation of PlaneWave CDK17 OTA onto the equatorial fork

- c. After initial installation the PlaneWave CDK17 can be pushed forward or pulled backward to achieve front-to-back balance as shown in Figure 9.3. (The equatorial fork's clutch bolts must be loosened to perform balance testing; re-tighten the clutch bolts once balance is obtained.)



Figure 9.3 When properly balanced the PlaneWave CDK17 OTA will remain level on the equatorial fork

- d. Tighten the adjusting bolts on both the dove tailed rails of the equatorial fork.
 - iv. A 1/4" Allen tool is required and torque is 16 ft-lbs.

10. CONCLUSION

Proper mechanical setup critically impacts usability and effectiveness of the telescope system. The steps outlined in this guide are intended as an outline of the process used for the RHCV telescope system installation, and should be applied in addition to understanding and following the manufacturers' installation instructions for each individual component.

Mechanical configuration is only one part of the overall system installation. Other installation processes include electrical and software system configuration, and support hardware/software system (i.e. dome controller) integration. Installation and configuration of these subsystems is documented elsewhere.

Appendices

Appendix A. Magnetic Declination

Magnetic declination is the angle between magnetic north (the direction the north end of a [compass](#) needle points) and [true north](#). The declination is positive when the magnetic north is east of true north.

Declination in Ohio is always west of true north. (Ohio Topographic Maps by Michael C. Hansen)

The declination for Dayton, Ohio is

Latitude: 39° 45' 32" N

Longitude: 84° 11' 30" W

Magnetic declination: 5° 52' WEST

Declination is NEGATIVE

BEARING is the direct compass number or angle in degrees (path) to follow to get from point A to B.

HEADING is the direction of actually travel due to obstacles between a straight line between points A and B.

Simple example: Assume the current declination value is -12° (therefore 12° westerly), and the desired bearing is $+72^\circ$. A magnetic compass indicates you are traveling with a bearing of $+72^\circ$ from magnetic north. Knowing the declination value the actual heading is $+72^\circ + (-12^\circ) = +60^\circ$.

In order to have the heading equal to the bearing the declination must be compensated for. Therefore $+12^\circ$ must be added to the magnetic compass heading of $+72^\circ$ from magnetic north which equates to $+72^\circ + 12^\circ = 84^\circ$.

Appendix B. List of Acronyms, Abbreviations, and Symbols

CCW.....	Counter-Clockwise
C _L	Centerline
CW	Clockwise
D _L	Declination line
HQLG.....	High Quality Lithium Grease
OD	Outside Diameter
OTA	Optical Tube Assembly
PPR.....	Portable Pier