ASTRO-PHYSICS

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State-of-the-Art Instruments for Discriminating Astronomers

"For Mounts shipped starting in July, 2011 and All Previous Mounts"

Mach1GTO

German Equatorial with GTOCP3 Servo Motor Drive

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MACH1GTO GERMAN EQUATORIAL WITH GTOCP3 SERVO MOTOR DRIVE

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ABOUT THIS MANUAL

This version of the *Mach1GTO* Manual was prepared for the production run of mounts that began shipping in July of 2011. Most of the information in this manual is applicable to all *Mach1GTO*'s that have been produced. Some of the information in this manual was simply not available when the first *Mach1GTO*'s left our factory back in 2006. This includes information on newer accessories for the *Mach1GTO* that weren't available for the first production runs. We have also learned a few things through experience and the suggestions of our customers that have improved the information that is available in this manual.

You should also note that this manual is actually one component of a three document system. We have always had two manuals for each mount - one for the individual mount and another manual for the keypad that applied to all mounts. Starting in the summer of 2011, we further divided the mount manuals to allow us to present the GTO Servo Motor Drive System in greater detail. Like the Keypad Manual, the GTO Manual is universal to all mounts that use the Astro-Physics GTO Servo Motor Drive System with the GTOCP3 Servo Control Box. This Mach1GTO Manual, on the other hand, will cover the Mach1GTO's mechanical features and physical operations.

We suggest that all *Mach1GTO* owners adopt this manual along with the current GTO Servo Drive Manual for regular guidance with their mounts. The benefits of the improved information should easily outweigh the minor differences between mounts from earlier production runs and the current one. There will be a few things like the included serial cable and the Precision-Adjust Rotating Pier Base / Hi-Res Azimuth Adjuster that owners of older mounts will not have. These items are available as upgrades. Please see the Web site for details. In a similar fashion, owners of brand new mounts should be aware that some of the photos that were used in this manual are of mounts from earlier production runs. You may therefore see some slight differences whether you have a brand new mount, or a "first run" mount, but none of these were deemed to be of significance, and hopefully, most have been noted in the text or captions. Older versions of the Mach1GTO Manual are available on our Web site.

As always, we highly recommend the Technical Support Section of our Web site for the latest information and for future updated versions of this manual.

A final note and an apology to our friends in the southern hemisphere. Many of the instructions in this manual are written entirely from the point of view of those of us in the northern hemisphere. Since descriptive terms like left and right are meaningless without a defined point of reference, we tend to use east and west to avoid ambiguity. The east and west sides of a German equatorial mount are, of course, reversed in the southern hemisphere. At one point, our thought was to always use phrases like the following: "... on the east side (west side in the southern hemisphere) ..." This quickly became cumbersome and made the text more difficult to read. For simplicity, we decided to leave many of the explanations in their northern hemisphere framework. To our southern hemisphere friends: *We love you no less and apologize for this unintended slight.* We know, however, that you are all smart enough to make the necessary translation to "down under" appropriate instructions. Thank you for your understanding.

PLEASE RECORD THE FOLLOWING INFORMATION FOR FUTURE REFERENCE

Mount Serial Number: ________________________________

Keypad Serial Number: ________________________________

GTOCP3 Serial Number: ________________________________

Purchase Date: ________________________________

Mach1GTO PARTS LIST

1 *Mach1GTO* German Equatorial Head with Servo Drive Motors
1 Stainless counterweight shaft with washer stop and black plastic knob (knob has 1/4" thread)
1 GTO Control Box (Model GTOCP3) with pouch and control box-to-pier adapter (CBAPT)
1 Y cable – R.A. portion is 24.5" long and portion is 40.5" long
1 D.C. power cord (cigarette lighter adapter on one end) - 8' long
1 GTO Keypad controller with 15' coiled cable and Instruction Manual
1 15 foot straight-through serial cable for computer connection (CABSER15)
1 *PulseGuide*™ by Sirius Imaging – remote control utility for Windows™ PC's (CD-ROM)
1 Hex key set

In order to assemble your mount fully, you will need the following items sold separately:

- **Telescope mounting plate:** Many choices to fit your telescope and observing needs. See detailed section later in this manual.
- **Pier or Tripod:**
    - 6" *Eagle* Adjustable Folding Pier (EAGLE6)
    - Astro-Physics 6" Portable Pier – 6 sizes from 24" to 62" tall (6X##PP)
    - Adjustable Wood Tripod (AWT000)
    - Adjustable Aluminum Tripod (SDS400) - not recommended for heavier loads.
    - Adapt to your own custom pier or tripod with our Tripod Adapter (ADATRI)
- **Counterweights:** 6 lb. (6SLCWT) and 9 lb. (9SLCWT) weights are available for the standard 1.125" diameter counterweight shaft. (5, 10 and 18 lb. weights are also available for the optional 1.875" diameter shaft – see below.)
- **DC Power Source:** Portable rechargeable 12 volt battery pack or a power converter to convert your household AC current to DC current of 12 – 16 volts at a minimum of 5 amps. We offer a 13.8 volt 5 amp converter (PS138V5A) and a 15 volt 10 amp converter (PS15V10A). We recommend giving the mount its own power source and powering other devices and accessories from a separate power source or multiple sources. See the GTO Manual for more.

Many of these items will be discussed throughout these instructions. Several additional options are available:

- **Optional Counterweight Shaft:** 10.7" total length x 1.875" diameter counterweight shaft (M1053-A) and safety stop (M12676) for use with 5 lb. (5SCWT), 10 lb. (10SCWT) and 18 lb. (18SCWT) counterweights. Handy for travel or if you already own a 900 or 1200 series mount which also use the 5, 10 and 18 lb. weights.
- **Polar Alignment Scope with Illuminator (PASILL4L):** for quick and easy polar alignment
- **Pier accessory trays:** A flat accessory tray with raised sides (TRAY06), a tray with eyepiece holes (TRAY06H), and two support bar options (TRAYSB or TRAYSB1) are now available to fit the 6" *Eagle* Adjustable Folding Pier, some sizes of the 6" portable pier and both tripods. They are handy and attractive places to keep your eyepieces and other astro-gadgets close at hand!
- **Autoguiding Accessories:** Various imaging and CCD based guiding configurations can take advantage of the *Mach1GTO*'s autoguider port. The autoguider port receptacle (RJ-11-6) uses the industry standard SBIG ST-4 wiring setup. See the GTO Manual for more.
- **PEMPro™:** (Periodic Error Management Professional) is a Windows software application that makes it easy to characterize and reduce periodic error. PEMPro™ will analyze the performance of any mount that is equipped with a CCD camera and compatible camera control software. PEMPro™ gives you powerful tools to program your mount's periodic error correction firmware to achieve the best possible performance for your mount. PEMPro™ dramatically improves guided and unguided imaging resulting in better images and fewer lost exposures. For more information on PEMPro™, see the separate GTO Manual.

Note on Encoders: Mounted encoders can not be used with the *Mach1GTO.* They are not needed since the go-to functions of the mount are so much more accurate. The encoder that is built into the servo motor itself has a resolution of 0.05 arc seconds vs. 324 arc seconds for mounted encoders.

For a complete listing of our *Mach1GTO* accessories, visit our Web site – www.astro-physics.com.

MECHANICAL FEATURES AND SPECIFICATIONS

Construction	All CNC machined aluminum bar stock, stainless steel, brass. Stainless steel fasteners
Worm wheels - R.A. / Dec.	5.9” (150 mm), 225 tooth aluminum
Worm gears - R.A. / Dec.	Brass, 0.705” (17.9 mm) diameter
Axis shafts - R.A. / Dec.	2.36” (60mm) diameter with 2” (51 mm) clear inside diameter
Shaft axis bearings - R.A. / Dec.	3.1” (78 mm) diameter, 2 per axis
Latitude range	0-70 degrees with or without the polar scope attached, engraved scale
Azimuth adjustment	Approximately 13 degrees (+ / - 6.5 degrees from center)
Counterweight shaft	1.125” (29 mm) diameter x 14.5” (368 mm) long [13.625” (346.1 mm) usable length], incl. washer and safety knob. Optional counterweight shaft (M1053-A) available: 1.875” (48 mm) diameter x 10.7” (272 mm) long – 7.7 lbs. (3.5 kg); fits inside Dec. axis for transport and uses 900 / 1200 counterweights
Weight	Total: 32.1 lb. (14.6 kg) R.A. axis / polar fork: 16.5 lb. (7.5 kg) Dec. axis: 11.5 lb. (5.2 kg) Counterweight shaft: 4.1 lb. (1.9 kg)
Capacity	Approximately 45 lb. (20 kg) scope and accessories (not including counterweights), depending on length. Recommended for: Astro-Physics and similar fast refractors up to our 160 mm f7.5 StarFire EDF, 8-11” SCTs and 6-8” Maks. These are only guidelines. Some telescopes are long for their weight or very heavy for their size and will require a larger mount. Remember also that imaging requirements are more rigid than visual observation.
Instrument mounting interface	Please refer to the mounting plate section of the manual starting on page 15
Diameter of base	5.800” (147.32 mm) (portion that is inserted into pier top or ADATRI adapter)

For a complete listing of the servo control, power, and periodic error specifications, please see the GTO Servo Motor Drive System Manual.

INTRODUCTION

The Astro-Physics *Mach1GTO* - Observatory Performance in a Small Package! This is the first, compact, light-weight mounting that was designed for utmost portability while maintaining extreme rigidity and excellent tracking accuracy. No shortcuts were taken to achieve these goals. From the highly accurate fine-pitch gearbox to the precision machine tool bearings, to the innovative worm wheel and clutch design, this mount represents a new approach to this vital part of the overall imaging train.

The advent of modern CCD cameras and telescopes with high-resolution optics has placed greater demands on the ability of mountings to do their part to achieve precision tracking and guiding. At the same time, the mounting should be easy to use with adjustments and setups that are straight-forward and accurate. We have done everything possible to eliminate the frustrations and limitations inherent in a lesser mounting and so put the fun back into the hobby of amateur astronomy.

The Mach1GTO employs the reliable and sophisticated Astro-Physics GTO Servo Motor Drive System. The system uses precise Swiss DC servo motors under the control of the remarkable GTOCP3 Servo Control Box. The GTOCP3 is truly the "brains" of the system taking your wishes as expressed through a command input device like the Astro-Physics GTO Keypad or a computer, and translating them into actions taken by the mount.

The full range of command inputs is available from the included GTO Keypad. This advanced keypad's features allow you to slew automatically to objects in a wide range of databases, as well as any R.A. / Dec. coordinates. A large selection of common names for stars and other objects makes your selection a snap. Keypad operation is simple and intuitive.

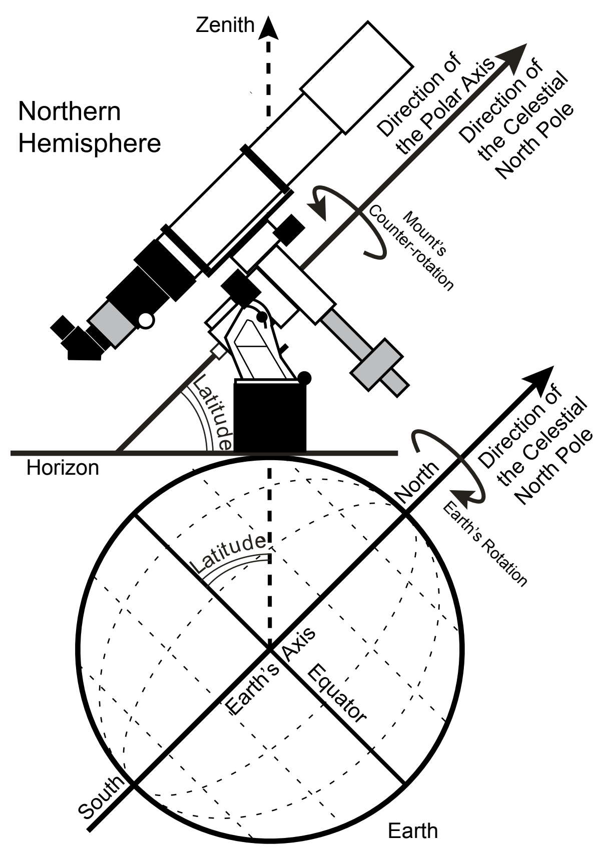
Various additional options such as PulseGuide™ software (included with the mount) and our fully supported V2 ASCOM driver are also available to make the connection between you - the astronomer, and the servo system versatile and straightforward. Details on the servo system and the various options for control software can be found in the separate Astro-Physics GTO Servo Motor Drive System Manual.

The *Mach1GTO* has the strength, rigidity and sophistication to tempt you to permanently place it in a state-of-the-art observatory. However, its portability and ease of setup make it the finest mount of its size for remote use in your favorite dark sky location and even for travel to exotic observing locations around the world. This is the perfect mount for a small to mid-size refractor, Newtonian, Cassegrain or astrograph. Whether you enjoy visual astronomy exclusively or plan an aggressive astrophotography or CCD imaging program, this mount will allow you to maximize your night out under the stars.

In order to fully enjoy your first night out, we recommend that you familiarize yourself with the assembly and basic operation of the mount indoors. The temperature will be comfortable, the mosquitoes at bay, and you'll have enough light to see the illustrations and read the manuals. Please take particular note of counter-balancing, use of the clutches and operation of the keypad controller.

Why Polar Alignment is Important

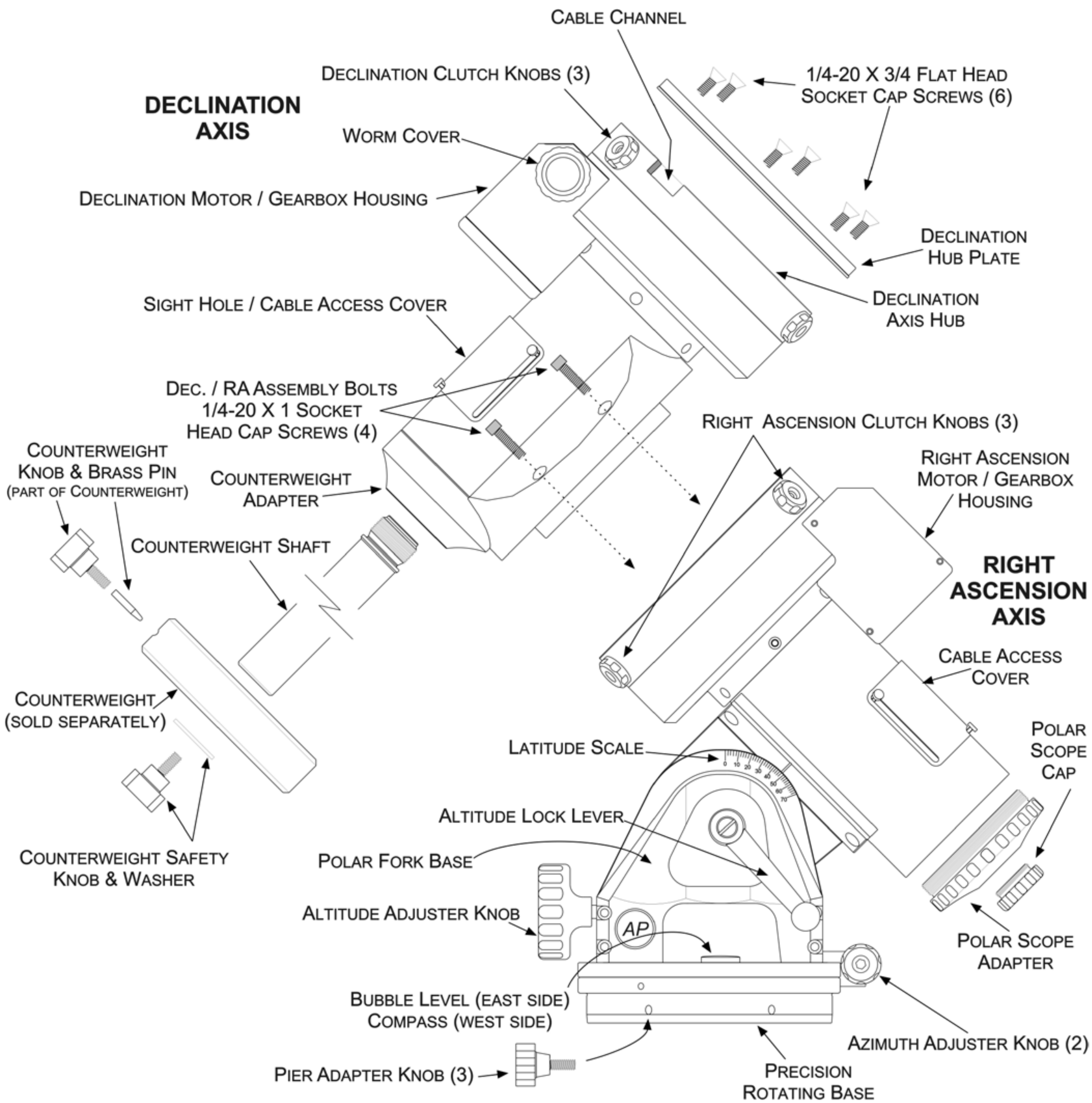
Polar alignment compensates for the Earth's rotation. If you were to take a long exposure photograph with Polaris (often called the North Star) in the center of the field, you would discover that all stars seem to revolve around Polaris. This effect is due to the rotation of the earth on its axis. Motor driven equatorial mounts were designed to compensate for the earth's rotation by moving the telescope at the same rate and opposite to the earth's rotation. When the polar axis of the telescope is pointed at the celestial pole (polar aligned) as shown in the diagram, the mount will follow (track) the motions of the sun, moon, planets and stars. As a result, the object that you are observing will appear motionless as you observe through the eyepiece or take astrophotos.



ASSEMBLY INSTRUCTIONS

Please read all instructions before attempting to set up your *Mach1GTO* mount. The *Mach1GTO* is very rugged, however like any precision instrument, it can be damaged by improper use and handling. Please refer to the following illustrations. The parts are labeled so that we can establish common terminology.

NOTE: The following terms and abbreviations are used interchangeably in these instructions:
polar axis = right ascension axis = R.A. axis = R.A. housing = R.A.
declination axis = Dec. axis = Dec. housing = Dec.



Before You Leave Home

Since most of us must set up our instruments in the dark, in the cold or while battling mosquitoes, a bit of preplanning and organization is important. There are a few simple things that can be accomplished in the comfort of your home before heading outside.   We would advise anyone to do a complete practice run from start to finish before venturing out into the field.   This is especially important for those of you who may be new to German Equatorial Mounts.

Assembling and Disassembling the Two Axes

Because of its compact size and light weight, the *Mach1GTO* does not need to be disassembled for normal transport to and from an observing site.   There will rarely be a need to disassemble the two axes. However, those of you who do disassemble your *Mach1GTO* for transport will need to be familiar with how the two axes are assembled and disassembled.   When re-assembling your mount, we recommend that you fasten the R.A. axis onto your pier or tripod first. That way, you have a solid platform firmly holding on to your R.A. axis while you bolt the declination axis in place.   The pier becomes your “extra set of hands.”

The two axes assemble quite easily with the four 1/4-20 X 1” socket head cap screws shown in the Assembly Diagram on page 7.   To properly line up the two axes, the R.A. axis must be positioned with the two pairs of screw holes on the east (2) and west (2) rather than on the north and south.   In addition, the clutch knobs of the R.A. axis should be at 10 o’clock, 2 o’clock and 6 o’clock as shown in the photo.   The four bolt holes will not line up in any other position. To turn the R.A. axis to this position, loosen the three clutch knobs and turn the axis.   When in the proper position, retighten the clutch knobs for safety.

The declination axis is placed into its position in the R.A. axis with the counterweight adapter down, and the declination hub plate up as in the assembly diagram.   Unlike the bigger 900GTO and 1200GTO mounts, the Dec. axis of the *Mach1GTO* must be straight and square to the R.A. mating surface when mounted.   Don’t try to tilt it into place as you would with the larger dovetailed mounts.   Keep a hand on the declination axis to keep it from falling off until you have at least one of the screws loosely fastened.   With the declination axis in place, insert and tighten the four 1/4-20 X 1” socket head cap screws.

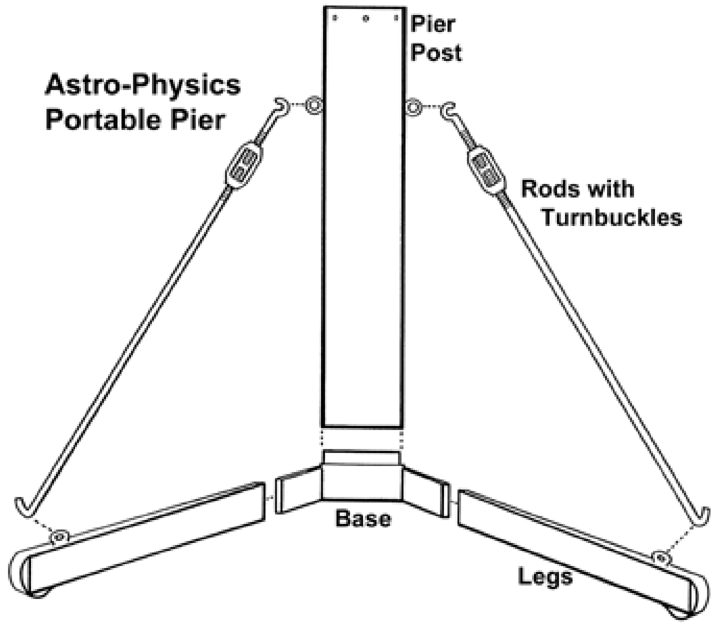
Gross Latitude Adjustment

Unlike its bigger brothers, the 900GTO and 1200GTO, the *Mach1GTO* does not have latitude ranges that should be preset before venturing out into the field.   However, you may still wish to give yourself a head start before heading out into the dark.   Each side of the *Mach1GTO*’s polar fork base is clearly marked with a latitude scale.   You can preset the mount to your latitude before leaving the house, if you wish.   At this point, just get the setting close using the scale. You may want to jump ahead to page 13 to see how to use the Altitude Locking Lever and the Altitude Adjuster to make this adjustment.

Assemble Pier or Tripod

(purchased separately)

NOTE: Starting in 2008, the *Mach1GTO* has six attachment holes in its pier adapter to better facilitate the different pier tops. Older mounts having three attachment holes may be limited in terms of the tripod or pier leg orientations that can be chosen. You will use three of the provided holes with the three pier adapter knobs when you secure the mount to the pier or tripod.



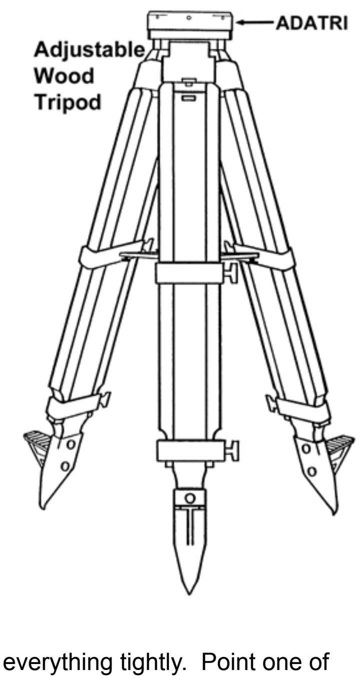
Astro-Physics Portable Pier

Begin by assembling the portable pier at the desired observing location. With six attachment holes in the *Mach1GTO*'s base, you can now orient the pier with a leg to the north or south as you prefer.

1. Slide the three legs onto the nubs of the base and rotate the assembly so that one of the legs points toward the north or south. You can use either orientation in either hemisphere. Most people prefer to have one leg point toward the pole.

2. Place the pier post on the base orienting the three eyebolts directly above the legs.

3. Attach the tension rods. The turnbuckles should be drawn tight until the whole assembly is stiff enough to support your weight without movement. This is another of those instances where you want to tighten in graduated steps. Start by making all three turnbuckles barely snug. Then, make all three barely tight, then half tight and finally all three can be brought to their final tightness.



Adjustable Wood Tripod (AWT000)

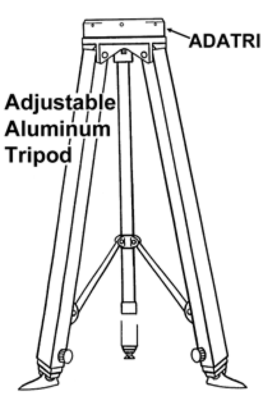
Open the legs of the tripod at the desired observing location. Note which direction is north (south if you are below the equator).

1. Position the tripod with one of the legs pointing roughly toward or away from your pole.

2. Attach the shelf to each of the three legs with the knobs provided.

3. Adjust legs to the desired height and spread them fully.

4. Lock in position with the hand knobs and make sure that leg clamps are tight.
   NOTE: Your tripod must be equipped with the Tripod Adapter (ADATRI) to mount the *Mach1GTO*. If you purchased your tripod from Astro-Physics, it came with this adapter already installed.



Adjustable Aluminum Tripod (SDS400)

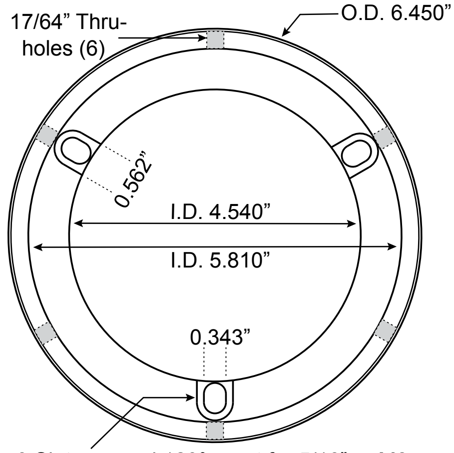
Loosen the clamp on the support and spread the legs to the desired position. Extend the legs to the desired height and clamp everything tightly. Point one of the legs toward the north (or south) pole.

NOTE: The Adjustable Aluminum Tripod is not suitable for the heavier loads that the *Mach1GTO* can carry. It is usable for setups with total instrument weight of less than 20 lbs. or if portability is of critical importance. Also, see the note above under Adjustable Wood Tripod regarding the required Tripod Adapter (ADATRI).

6” Eagle Adjustable Folding Pier (EAGLE6)

Assembly instructions for the 6” *Eagle* Adjustable Folding Pier are included with the pier. Please refer to those instructions for assembly, adjustment and leveling procedures. Your *Mach1GTO* will fit into the 6” *Eagle* Adjustable Folding Pier without any additional adapters. Simply set the mount into the open top of the pier and attach with the three pier adapter knobs included with the mount.

ADATRI Tripod Adapter for 400, 600 & Mach1GTO



3 Slots spaced 120° apart for 5/16” or M8 Socket Cap Screws on a 5.110” bolt circle.
(Circle can range from a minimum diameter of 4.980” to a maximum diameter of 5.240”.

Tripod Adapter (ADATRI)

If you have your own custom pier or tripod with a flat surface on top, you can use our Tripod Adapter (ADATRI) for mounting the *Mach1GTO*. Current versions of the 900 Standard Pier Adapter (900SPA) will also accept this adapter to use the Mach1GTO with 8” Astro-Physics and ATS piers.

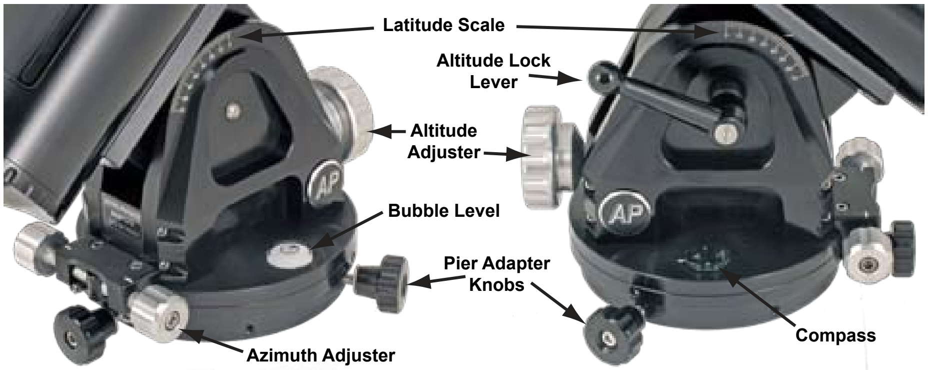
We also offer a separate adapter that can be used in conjunction with this Tripod Adapter to attach to a Losmandy Heavy Duty Tripod or a Losmandy Meade Tripod Adapter (LT2APM). See the Web site for details.

Attach the Mount to the Pier Post or Tripod

The pier adapter is already attached to your *Mach1GTO*. Starting in 2008, there are six attachment holes in the pier adapter base for positioning flexibility. You will use three of them (one every 120°) with the three provided pier adapter knobs. Simply set the mount into the pier post on your 6” *Eagle* Adjustable Folding pier, your Astro-Physics Portable Pier, or the adapter of your Adjustable Wood Tripod. Line up the through-holes on the pier or tripod with the tapped holes in the mount’s pier adapter. Fasten with the three pier adapter knobs. If you are attaching the Control Box Adapter (CBAPT) or a Tray Support Bar (TRAYSB or TRAYSB1) at the top of your pier or tripod, do that now.

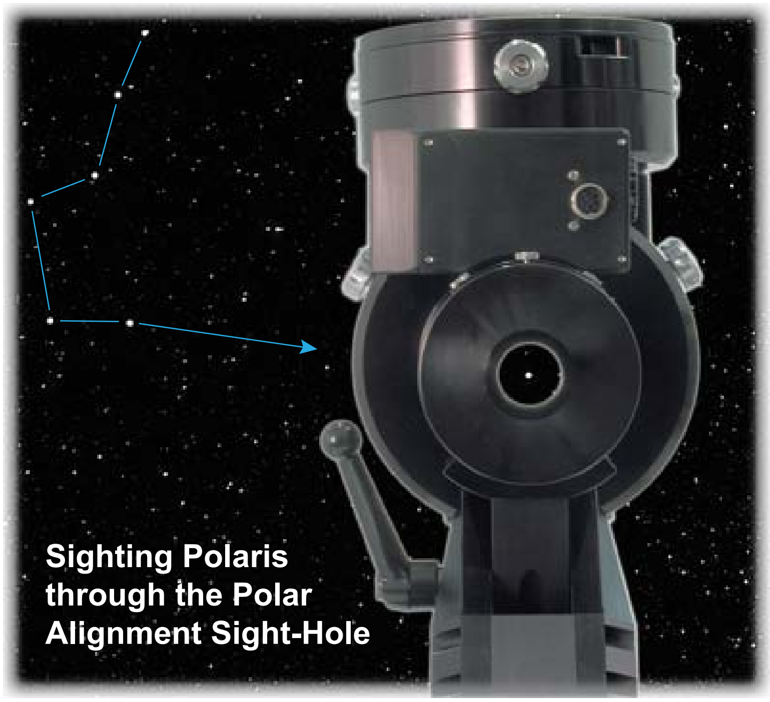
Altitude and Azimuth Adjustments - Rough polar alignment

For rough polar alignment, your goal is to sight the celestial pole when looking through the polar alignment sight hole in the center of the polar axis. You will need to make altitude (up / down) and azimuth (side-to-side) adjustments to the position of the mount.



Before beginning, make sure that the mount is pointing roughly north using the built-in compass, and that your pier or tripod is level using the mount's built-in bubble level. (Refer to note below.)

Remember that magnetic north is not the same as true north and varies both with time and with your location. In the summer of 2011, on the northeast tip of Maine, for example, magnetic north is west of true north by a whopping 18 degrees! On Mauna Kea in Hawaii, by contrast, magnetic north is about 9 1/2 degrees east of true north. Observers along the Mississippi River are lucky and are nearly dead on.



These values change by several arcminutes every year. With experience at a particular site, however, you will soon learn to use the compass to find true north. (You will know just how far off magnetic north is for your location.) In addition, there is an excellent Web site funded by our U.S. tax dollars that will compute the declination of magnetic north relative to true north for any location that you input. The link is as follows: http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp

Note on Bubble Levels: It is possible to achieve perfect polar alignment without having the pier level, but it is slightly more difficult. With a pier that is not level, each adjustment in azimuth also causes a minor shift in altitude and vice versa. This is why we have included the bubble level on the *Mach1GTO*. However, don't waste time obsessing about having a level pier. This is, after all, NOT an Alt / Az mount! Devote the time to the actual polar alignment instead. If you are reasonably close to level, you will not be able to notice a difference. Keep in mind that unless you are a serious astrophotographer or imager, "perfect" polar alignment is not critical.

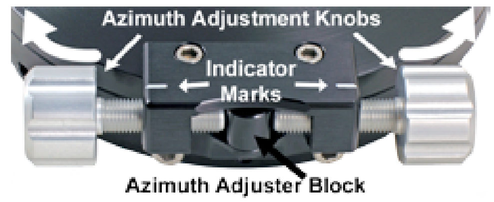
We recommend that you do your rough polar alignment with the mount only since you will be making major adjustments to the position of the mount at this time. The remainder of the equipment: telescope, finder, camera or eyepiece and counterweights will add considerable weight and require more hand effort to make the adjustments. Later, you will do your final polar alignment with the telescope and counterweights attached, but the adjustments will be small.

NOTE: The illustrations that follow show only the R.A. axis. You will, of course, be doing your rough alignment with the mount assembled.

1. If the polar scope (PASILL4L or earlier model) is installed, you may remove it to complete these steps.
2. Remove the polar scope cap (unless a polar scope was installed). If you examine the polar axis assembly, you will see that the center of the R.A. shaft is hollow. Additionally, if you look at the Dec. axis, you will see that it has a sliding cover (the sight-hole / cable access cover). By sliding this cover to the "open" position, you open a sight line through the R.A. axis and out into the sky. For your rough alignment, you will peer through this sight tube and attempt to center Polaris.

3. **Azimuth adjustments:** To begin, move or turn the entire pier or tripod east or west until the mount is oriented approximately toward the pole (an imaginary line drawn through the hollow shaft). If you are using the 6” Eagle Adjustable Folding Pier, you can take advantage of the azimuth adjustment slots for your rough polar alignment. The compass on the west side of the polar fork base will help you. Also, if you want the mount to be level, check the bubble level again after moving everything. (Remember, mount leveling is not critical for most observers.)

Starting in 2011, we began shipping Mach1GTO mounts with an integrated Precision Adjust Rotating Pier Base and a rear-mounted, Hi-Res Azimuth Adjuster. The adjuster is labelled at right. Owners of earlier mounts that have not been fitted with this upgrade should refer to the instructions in an earlier manual.



The Precision Adjust Rotating Pier Base does NOT use lock knobs for the Azimuth, so there is no resulting shifting. The two plates are precisely machined for a perfect fit with no tilt or shift. Adjustment is precise and absolute. The Azimuth Adjustment Knobs effectively become the azimuth locking devices. Tension adjustment between the two plates is possible with two tension set screws on the front of the base (photo at right). However, this tension has been set to the ideal level at the factory. Do not adjust these set screws unless you are absolutely certain that adjustment is required. DO NOT over tighten under any circumstances!

To make azimuth adjustments, use the two fine azimuth adjuster knobs, one on each side of the mount, to make adjustments. You must back off the opposing azimuth knob in order to move the other knob in that direction. Please refer to the photos below. These photos also illustrate the 13 degrees of azimuth adjustment possible with this mount. Get into the habit at this point, even for rough alignment, of using the following approach to azimuth adjustments:

a) Start by backing off the non-adjusting knob by the amount you wish to adjust. Don’t just unscrew it willy-nilly! Try to determine how far you will need to move, and only loosen by that amount.

b) Turn the adjusting knob until it tightens against the azimuth adjuster block. Note that the Azimuth Adjuster Block remains fixed. Each knob turns the mount as shown by the fat arrows in the top photo above. In the northern hemisphere, the right knob rotates the mount to the west, and the left to the east.

c) Repeat as needed, always turning the adjusting knob into a tightened position.

<u>One full turn of the Azimuth Adjuster Knob is approximately 0.70 degrees (42 arc minutes)</u>

Mach1GTO Azimuth Adjustment Range
13 degrees (+/- 6.5 deg. from center)

Azimuth adjusted to the east

Mount centered in azimuth

Azimuth adjusted to the west

4. **Altitude (latitude) adjustments:** The altitude adjustment mechanism on the *Mach1GTO* has two components. There is a large altitude adjustment knob on the front (north) side of the mount for making the adjustments. The second part is the innovative tool-free altitude locking lever on the west side of the polar fork base. This lever has a spring-loaded, ratchet-type action that allowed us to use a longer handle for leverage than would otherwise have been possible. Pulling the handle out away from the base (pull it to the west) will disengage the handle so that it will turn freely in either direction. Using this feature, you simply ratchet it tight when your altitude is set, or ratchet it loose if you need to make a major adjustment.

The shaft of this locking lever is the pivot axis for the altitude adjustments. Turning the altitude adjuster rotates or pivots the mount, up or down, around this axis. Latitudes below about 46 degrees will always have the total system weight north, or in front of this pivot axis, and will therefore have gravity pulling everything down toward the front. At these latitudes, make your approach to the pole from below so that gravity keeps the adjustment system fully engaged from below.

At latitudes above about 54 degrees, the system weight is behind the altitude pivot axis, so you will want to approach the pole from above. At these higher latitudes, gravity will assist in keeping the adjuster fully engaged from above. At latitudes between about 46 and 54, the mount is pretty well balanced over the altitude pivot. More detail for these latitudes is forthcoming in the section on fine polar alignment starting on page 23.

To start your altitude adjustment, loosen the altitude locking lever. If you have preset your latitude using the scale as suggested on page 8, you do not need to loosen very much because you will not be moving too far. Move the polar axis up or down with the large altitude adjustment knob located in the front of the polar axis assembly.

<u>One turn of the Altitude Adjustment Knob is approximately 1.04 degrees (62 arc minutes).</u>

Mach1GTO Latitude Adjustment Range
0 degrees to 70 degrees

0 degrees latitude | 35 degrees latitude | 70 degrees latitude

5. Continue your azimuth and altitude adjustments until you can sight Polaris in the polar alignment sight hole. Try to center it roughly in the sight hole. A very dim red light may help you see enough of the hollow shaft to help you with centering without obscuring Polaris. At this point, you have achieved a rough polar alignment, which may be sufficient for casual visual observations, if you are not planning to slew to target objects with the keypad. When the R.A. motor is engaged (the power is plugged in), it will compensate for the rotation of the earth and keep the target object within the eyepiece field-of-view. Your target object will slowly drift since polar alignment at this stage is only approximate. However, you can make corrections with the N-S-E-W buttons of your keypad controller.

6. When your altitude is pretty well adjusted, grab hold of the end of the counterweight shaft with your left hand. You will be able to feel a small amount of play in an up-down direction by lifting and then pushing down on the end of the counterweight shaft. This is normal. Now, gradually tighten the altitude lock lever until you no longer feel any play at the end of the counterweight shaft. You ***DO NOT*** need to tighten the lock lever any further than this.

7. Make sure that both of the azimuth adjustment knobs are tight against the azimuth adjuster block.

Running Cables Through Your Mount - Preview

If you plan to route cables through your mount, this is the point in your work flow where you will want to do so. Please refer to the later section of this manual entitled “Cable Management” for a full discussion of your options. See page 28. We mention it here because cables that will be routed through the cable channels on the declination axis hub will need to be installed before the mounting plate is attached. The servo Y-cable can be installed with the mounting plate attached.

For your first setup with the mount, we do not recommend that you worry about the through-the-mount cabling options. Start simple with the basics. Doing a complete cable installation takes some detailed planning. Get some experience with the mount first.

Attach Mounting Plate

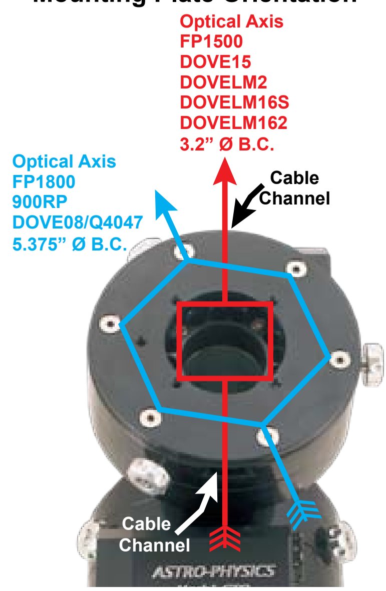
(purchased separately)

Several mounting plates (also called cradle or saddle plates) are available for the *Mach1GTO* mount. If you own more than one instrument, you may need more than one plate, or you may wish to use one of the dovetail mounting plate options with more than one male dovetail sliding bar. Attach your mounting plate with the screws provided with the plate. It is important to use the proper screws, please refer to the information sheet entitled "Mounting Plate Fastener Chart." This chart is available at the end of this manual, on page 38, and in the Technical Support section of our Web site.

Notes on Attaching the Mounting Plates:

Three of the components listed below have six mounting holes that match the six screw holes that hold the declination hub plate onto the hub of the *Mach1GTO*'s Dec. axis. (FP1800, 900RP and Q4047) For ease of assembly, we recommend that you use only four of these holes to mount your plate. Remove four of the screws that hold the declination hub plate in place. They will be replaced by the four screws that hold the mounting plate down. The remaining two can then still hold the declination hub plate in place on the Declination Axis hub while the mounting plate is being attached. The four remaining holes are more than adequate to hold the plate securely on the mount. It really doesn't matter which four you choose, but the two screws left to hold the declination hub plate in place should probably be opposite each other. You may also remove the declination hub plate if you wish for the FP1800 or Q4047, but you will slightly reduce the size of the cable channels.

Mounting Plate Orientation



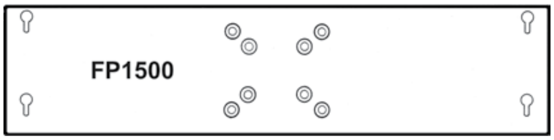
You will also notice that in addition to the four holes that make up the inside pattern on the declination hub plate, there is an extra hole that matches an extra hole found in two of the Losmandy style plates (DOVELM2 and DOVELM16S). This fifth hole is not used if the four regular holes are in use. However, if you lose a mounting screw, it can be used in place of the two normal holes on that end of the plate to make a very solid 3 point attachment (turned 90° from the shown optical axis position).

While there is no required orientation of the mounting plate, we have found the two orientations in the photo at right to work very well. The advantage to the pictured orientations is primarily in the ease of working the clutch knobs, and in providing the easiest routing for cables. Note that your declination hub plate may not be oriented properly for this arrangement. If not, simply remove and rotate it into this position with respect to the clutch knobs and cable channels. As pictured, the two cable channels are at 12 o'clock and 6 o'clock. The clutch knobs are at 3, 7 and 11 o'clock. (The extra hole mentioned above is at 9 o'clock.) The optical axis for a plate with the four-hole pattern is directly over the cable channels. Plates with the six-hole pattern are rotated a bit to allow the attachment bolts to clear the cable channels.

Fixed Mounting Plate Options

15" Flat Mounting Plate (FP1500)

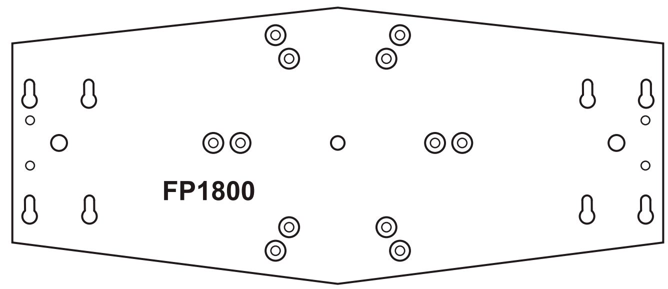
This plate is 15" long by 4.6" wide by 0.5" thick. Two pairs of keyhole slots that measure 3.2" between centers are provided for the instrument mounting rings. The pairs are 13.75" apart. You can drill additional holes to suit your needs. This plate also fits the 400, 600E, 900 and 1200 German Equatorial mounts.



The 15" Flat Mounting Plate's mounting ring hole spacing of 13.75" allows the use of the 15" Dovetail Plate (DOVE15) on top of your instrument as an accessory plate.

Attach this plate with four 1/4-20 x 5/8" socket head cap screws

18” Flat Mounting Plate (FP1800)



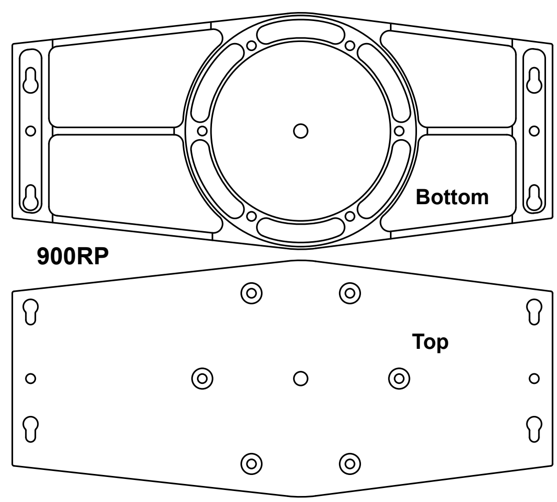
This plate is 18” long and 7.5” at its widest point in the center. The width of the plate tapers to 5.5” at each end. Four pairs of keyhole slots that measure 3.2” between centers are provided. The two inner pairs are 13.75” apart and the outer two pairs are 17” apart. You can drill additional holes to suit your needs. This plate also fits the 900 and 1200 German Equatorials.

Attach this plate with four 1/4-20 x 1 1/4” flat head socket cap screws. Leave two screws in the Dec. hub’s top plate. (see note at end of this section)

Using the 18” Flat Mounting Plate’s available mounting ring hole spacing of 13.75” allows the use of the 15” Dovetail Plate (DOVE15) on top of your instrument as an accessory plate.

NOTE: This is a very large plate for the *Mach1GTO*. If your instrument requires such a large plate, it may be too large for this mount.

15” Ribbed Mounting Plate (900RP)



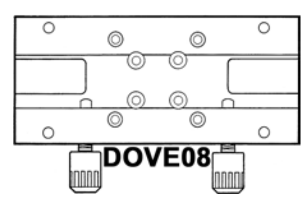
The finished plate is 0.75” thick, 15” long and 6.5” at its widest point. The width of the plate tapers to 4.75”. A pair of keyhole slots that measure 3.2” between centers are provided at each end. The distance between these pairs of holes is 13.75”. Due to the ribbed structure, you may not be able to drill additional holes to suit your mounting rings. The plate weighs 2.3 lbs.

Attach this plate with four 1/4-20 x 1 1/4” flat head socket cap screws. Leave two screws in the Dec. hub’s top plate. (see below) Note that the plate is asymmetrical. In most cases, orient the plate so that the long end points toward the sky. You can also turn the plate in the other direction to balance your scope.

Like the plates above, the 900RP’s mounting ring hole spacing of 13.75” allows the use of the 15” Dovetail Plate (DOVE15) on top of your instrument as an accessory plate.

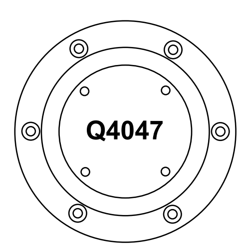
Astro-Physics Dovetail Options

8” Astro-Physics Dovetail Saddle Plate (DOVE08) with Q4047 Adapter



This versatile plate is suited for the 105 f6 Traveler and faster 130 refractors and other short instruments. (We prefer the 15” Dovetail Saddle Plate for most applications of the 130 f8 StarFire EDT) The knob assembly features a brass pin with a tapered end to hold your sliding bar firmly without marring the aluminum. Use with the 7” or 10” Sliding Bars (SB0800 or SB1000), which are sold separately. Repositioning the sliding bar allows you to adjust the balance of your instrument.

NOTE #1: This plate requires the use of the Q4047 adapter with the *Mach1GTO* mount to provide clearance for the knobs.



NOTE #2: This is NOT a Vixen or “V” style Dovetail. The newer Vixen specification is slightly wider than our long established Astro-Physics 8” specification and has a much less angled bevel to the dovetail. A Vixen style plate (sliding bar) will not fit into this dovetail saddle. If you have a Vixen or “V” style dovetail plate on your instrument, please refer to the “12” Vixen Dovetail Converter (SBD2V)” on page 18.

As an accessory plate - Attach to the top of our Astro-Physics mounting rings (tube diameters 5”-8”) or rings from Parallax Instruments that have the Astro-Physics hole pattern (you can request it). You must also use a sliding bar on the bottom of the rings with the same distance (6.3” from center to center), i.e. the SB0800, SB1000, SBD12 or SBD16.

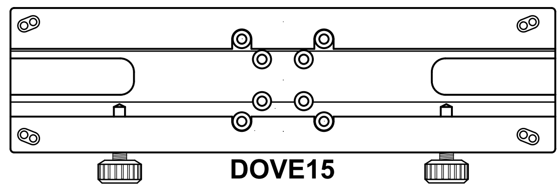
Attach the Q4047 to the mount using four of the six outside holes and four 1/4-20 x 1" flat head socket cap screws. Attach the DOVE08 to the Q4047 with four 1/4-20 x 5/8" socket head cap screws.

15" Astro-Physics Dovetail Saddle Plate (DOVE15) for 15" Sliding Bar (SB1500)

The 15" version of our dovetail plate is suited for the 130 f8 StarFire EDT, 155 f7 StarFire EDFS, Takahashi scopes and other instruments of similar size. The two knob assemblies each feature a brass pin with a tapered end to hold your sliding bar firmly without marring the aluminum. Use with the 15" Sliding Bar (SB1500), which is sold separately. Also makes a great accessory plate when used with either the 900RP, the FP1500, the FP1800 (with rings mounted to inside holes), the SBD16 or another DOVE15.

Note: This plate will not accept Vixen style plates (sliding bars) like the Losmandy V-series. The newer Vixen specification is slightly narrower than our long established Astro-Physics 15 " specification and has a much less angled bevel to the dovetail. This dovetail saddle will not adequately clamp onto the smaller Vixen style plate (sliding bar). If you have a Vixen or "V" style dovetail plate on your instrument, please refer to the "12" Vixen Dovetail Converter (SBD2V)" on page 18.

Attach with four 1/4-20 x 1/2" flat head socket cap screws.

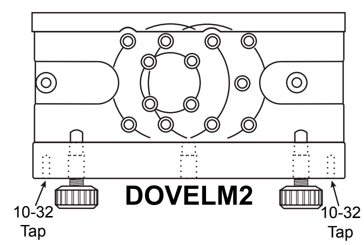


Losmandy D-Series Compatible Saddle Plates

The following dovetail saddle plates are for the Losmandy D series of dovetail plates (sliding bars). Along with the standard dovetail plates made by Losmandy, additional D Series options are now available. These include two sliding bars made by Astro-Physics: (SBD12 and SBD16), and two Astro-Physics side-by-side bars: (SBD13SS and SBD16SS). For those of you who have scopes with the Vixen style or V Series sliding bars, we now also produce the aforementioned D to V series adapter (SBD2V). Please see "12" Vixen Dovetail Converter (SBD2V)" on page 18 and visit the Web site for more details.

8.5" Dovetail Saddle Plate for Losmandy D Series Plates (DOVELM2)

This Astro-Physics plate attaches to the 400, 600E, 900, 1200 and *Mach1GTO* mounts. If you already own one of the Losmandy DAP series (fits Astro-Physics refractors), DC series (for Celestron 8" 9.25" or 11" SCTs) or DM series (for Meade 8" and 10" SCTs) plates, you should consider this plate or the longer DOVELM162. For larger size SCTs we recommend the Easy-Balance DOVELM162 – see below. This is also the perfect saddle plate for our SBD12 Dovetail Sliding Bar.



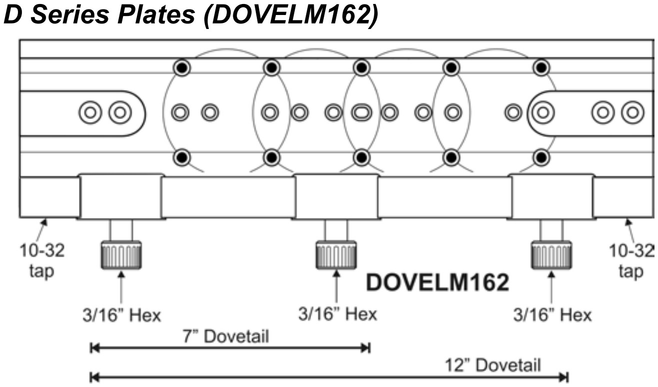
Note that the two larger bolt-hole patterns are offset from the center. This allows you to position the plate either forward or backward depending on the balance point of your telescope. Attach this plate with four 1/4-20 x 5/8" socket head cap screws.

Additional features include a center position knob-hole for use with short D series plates, a ribbed structure underneath to reduce weight and tapped 10-32 holes in the side for cable attachment.

16" Easy-Balance Dovetail Saddle Plate for Losmandy D Series Plates (DOVELM162)

This Astro-Physics plate was introduced in February, 2009, and in mid-2010 we added the center clamp for even greater versatility. The DOVELM162 provides a multitude of mount attachment options, and was specifically designed to meet the balancing demands of "back-end-heavy" instruments like SCTs and Richey-Chrétiens, especially those with heavy imaging gear hanging off the back!

This plate has small knobs to avoid interference with the declination hub, but the knobs have cap screws in the ends that accept a 3/16 hex wrench for extremely secure clamping of your instrument. Additional features include

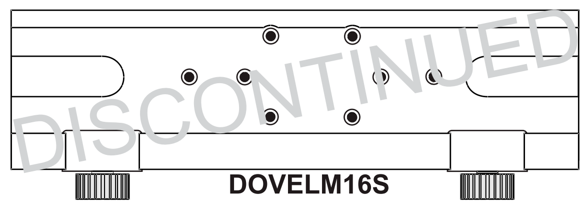


ribbed structure underneath to reduce weight and tapped 10-32 holes in the side for cable attachment.

Note that the bolt-hole patterns are marked with scribe cuts. Attach this plate with four 1/4-20 x 1” socket head cap screws. Holes along the center-line of the saddle plate are for use with the larger 900 and 1200 series of mounts and are not used with the *Mach1GTO*.

16” Dovetail Saddle Plate for Losmandy D Series Plates (DOVELM16S)

This Astro-Physics plate is no longer produced and has been replaced by the DOVELM162 above. If you already own one of these plates, and use a 17.25” or longer Losmandy DAP series (fits 6” and larger Astro-Physics refractors) plate, this mounting plate will work fine. SCTs, RCs and other instruments that are challenging to balance should use the DOVELM162 as shown above.



Note that the bolt-hole pattern is offset from the center. This allows you to position the plate either slightly forward or backward depending on the balance point of your telescope. Attach this plate with four 1/4-20 x 7/8” socket head cap screws. NOTE: As of this writing, this plate is no longer available for purchase. It has been phased out in favor of the DOVELM162 (above). It is included here for those who already own one.

Side-by-Side, Vixen Style and Other Plate Options

In general, we recommend side-by-side configurations more often for our larger mounts. However, the Mach1GTO can handle a pair of smaller instruments in a side-by-side configuration. A nice pairing for a versatile visual setup might be a small wide field refractor along with a smaller-sized Maksutov Cassegrain for high-power viewing. We never recommend using a side-by-side mounting as a guidescope / imaging scope setup due to the possibility of differential flexure.

13” and 16” Side-by-Side D Series Plates (SBD13SS & SSBD16SS)

These plates will fit into any of the three D-series compatible plates listed above and will accept either the DOVELM2 or the DOVELM162 as the instrument saddle plates for each scope. The 13” plate allows optical axes to be placed on 9.5” (250 mm) centers, and the 16” plate allows instruments on 12.5” (318 mm) optical centers.

12” Vixen Dovetail Converter (SBD2V)

This 12” plate fills the void for those customers whose telescopes use the Vixen-style mounting plate including the Losmandy V-Series. Now there is no need to replace your existing Vixen-style bar, rings, or clamshell to accommodate your Astro-Physics mount.

The top portion is a female plate that accepts Vixen-style bars. In order to retain the tilt-in feature of the dovetail, the sliding bars must have an approximate width (at the widest point) between 1.65” (42 mm) and 1.8” (45 mm) and they must have have a 75 degree bevel on each side. The bottom portion is a standard D-series dovetail that will fit into any of our D-Series compatible saddle plates.

Please note that we are not great fans of the Vixen style design. It is our belief that the 75 degree bevel does not provide an adequate safety margin for the clamps. We have not tested all plates that are currently available on the market. We recommend you check your plate for a good fit in this saddle without an instrument attached! Also, note that the top portion of this plate is NOT designed to be used with our SB0800, SB1000 or SB1500 sliding bars.

Other Mounting Plate Options

Additional mounting plate options including custom plates may be available from other sources. The hole patterns for the declination hub are shown on the illustration on page 15.

Assemble Counterweight Shaft

IMPORTANT: Always attach the counterweights before mounting the telescope to the cradle plate to prevent sudden movement of an unbalanced tube assembly, which may cause damage or injury. Remember counterweights are heavy and will hurt if they fall on your foot.

1. Thread the counterweight shaft onto the Dec. axis. Be careful to NOT cross-thread the shaft in the adapter!

2. Remove the counterweight safety knob and washer (or the one-piece Safety Stop (M12676) if you are using the 1.875" diameter shaft) from the base of the counterweight shaft. Add sufficient counterweights (purchased separately) to the counterweight shaft to balance the telescope you intend to use. Loosen the counterweight knob and hold the counterweight with the knob pointing downward so that the brass pin will move from the center opening allowing the counterweight to slide into position. Always use two hands to attach or move the counterweights on the shaft. It is advisable to have the counterweight knob pointing down toward the pier. This will minimize the chance of accidentally loosening the counterweight during the observing session.

3. **FOR YOUR SAFETY: Reattach the counterweight safety knob and washer to the end of the counterweight shaft**. This will help to prevent injury if someone accidentally loosens the counterweight knob.

NOTE: A firm tightening of the counterweight knob will not damage the surface of the counterweight shaft. The pin that tightens against the stainless counterweight shaft is constructed of brass. Likewise, the bronze sleeve that has been press fitted into the center of the counterweight will prevent marring of the shaft as you move the counterweights up and down.

Optional 10.7" x 1.875" Counterweight Shaft

The optional 10.7" total length x 1.875" diameter counterweight shaft offers some additional capabilities and considerations. The shaft installs in the same way as the standard shaft, but instead of a safety knob and washer, this shaft uses the one-piece washerless Safety Stop (M12676) at the end of the shaft. For safety, you MUST use this safety stop! There are two main reasons why a person might choose the optional counterweight shaft over the standard 14.5" x 1.125" shaft:

1. Owners of 900 or 1200 series mounts might prefer to purchase the optional shaft because it uses the same 10 lb. (10SCWT) and 18 lb. (18SCWT) counterweights that those bigger mounts use. These counterweights have larger 1.875" diameter center holes. Please note that this shaft weighs in at a hefty 7.7 lbs. including the safety stop. To facilitate lighter instruments, we have added a 5 lb. counterweight (5SCWT) to the product line to join the other two weights with the larger center holes.

2. Owners who plan to use their *Mach1GTO* for long-distance travel may wish to purchase this shaft for a more compact fit in a travel case. The 10.7" shaft was specifically designed to fit inside the hollow declination shaft and screw into the counterweight adapter from the back side. When fully screwed into the adapter, and with the Safety Stop in place, the whole thing only protrudes about 3/4" from the face of the declination hub plate. To prevent you from accidentally getting the shaft stuck inside the Dec. axis, we added a socket head screw to the end of the shaft. Simply use your 1/4" hex key to break it loose if needed.

Keep in mind that the combined weight of the equatorial head and shaft will be 36 lbs. not counting the GTOCP3 control box, keypad, cables or the travel case itself. With the mount's two axes separated, and the shaft thus stored, it will all fit neatly into a case that should fit into an overhead luggage compartment, but you still have to be able to lift it up that high! You must also be aware of all rules and regulations regarding weight limits and allowable case sizes, not to mention potential security problems. Please do your homework before trying to take a trip with your valuable astronomical equipment. We have designed the mount to be portable, but we cannot guarantee that you will be allowed to carry it with you.

One final caution: This is a "really cool" feature, but remember, you will need to remove the mounting plate to take advantage of this capability. It will be great for long-distance travel, but you may not want to store the shaft inside the Dec. axis for trips to and from your favorite local dark site.

Attach Mounting Rings

(purchased separately)

Flat and ribbed plates: constructed with keyhole slots at the location where your mounting rings attach. This feature enables you to partially loosen the screws on your rings just enough to insert them into the larger part of the keyhole, then slide the rings to the narrow part and tighten them with a hex key. You can even accomplish this with the rings on the scope, although this maneuver may be difficult to accomplish with a large, heavy instrument.

We prefer this keyhole method to the standard way of completely removing the screws and possibly dropping them in the grass.

Astro-Physics or Losmandy Dovetail Plates: Attach the mounting rings to the male dovetail plate (sliding bar).

CLUTCH KNOBS, BALANCING AND FINE POLAR ALIGNMENT

R.A. and Dec. Clutch Knobs

1. What do they do?
   The three R.A. and three Dec. clutch knobs have the function of connecting the R.A. and Dec. axes to their respective drive worm wheel gears. Their function is progressive, from no tension (axes free to move - as required during correct balancing of the telescope) to a completely "locked up" state. Please note that the clutches have no bearing whatsoever on the worm drive itself. They are simply the mechanism that marries the worm wheel to the axis.

2. How can you find out what they really do?
   As shipped, all *Mach1GTO* mounts have all three R.A. and Dec. clutch knobs firmly hand tightened. This will give you a good idea of the maximum tightness (clutch action) that can be achieved by hand effort alone. At this point, you must bear in mind that for optimum performance all three clutch knobs on each axis (R.A. or Dec.) should be tightened evenly with the same tension (i.e. all three half tight, all three fully tight, etc.).

   In order to feel the effect of the clutch knobs, you may wish to assemble your mount with the mounting plate and counterweight shaft. Do not put scope and counterweights on at this stage. With the above assembly (with the clutch knobs firmly hand tightened - "as shipped"), you can feel the amount of force needed to move each axis by hand. Grab each end of the telescope mounting plate and move it with a backward and forward movement of the Dec. axis. You will feel considerable resistance to this motion. Perform the same operation on the R.A. axis by moving the counterweight shaft backward and forward. With a well-balanced telescope, the above tightness of the clutch knobs will be sufficient for all normal conditions of use.

   Now, mount up and balance your telescope so you can "feel" what this resistance in R.A. and Dec. (movement backwards and forwards) is like when you make these motions from the eyepiece end of your telescope as you would during normal use when slewing (pushing) by hand to acquire an astronomical object within the field of view of your finder or scope.

3. How tight can the clutch be and can you do any damage by over-tightening them?
   These clutches can be tightened as much as needed. There is no danger of over-tightening. You will see that each clutch knob has a 3/16 hex socket for tightening with an Allen key. Using the provided hex key you can lock up the clutches so that only the worm drives are able to move each axis. You should **NOT** attempt to push your scope by hand against this "locked up" resistance, or undue stress will be placed on the worm wheel, worm gear and bearings. Also note that locked up clutches provide no safety factor for your equipment should you hit the pier!

   Most users will never need to use a hex key on their *Mach1GTO*'s clutches, but if you are heavily loaded, if your system is out of balance, or if you are doing critical long exposure astro-photography, you may wish to have the extra clutch tightness. As a general rule, if you have a big scope (6" refractor or 10" SCT) with all the accessories, you will need more clutch tension than a 4" or 5" scope.

4. My clutches don't seem to loosen up the axes as much as my 900 or 1200 mount's clutches when I loosen the knobs. Is this correct?
   The *Mach1GTO* uses a different clutch system, and it also uses a different bearing system for the free rotation of the axes. It will feel stiffer than the 900 or 1200 series mounts.

   You should also be aware that the clutch knobs on the *Mach1GTO* have spring loaded tips that may still be applying pressure to the clutches, even though the clutch knobs feel loose. Back the clutch knobs off by at least two or three full turns to completely disengage the clutches.

WARNING! Be careful when moving the mount with the clutches. It is possible to catch cables or fingers between the clutch knobs and the motor / gearboxes if you are not careful!

Balancing Your Telescope

For proper operation, the telescope must be adequately balanced along both axes. Note that we say: “adequately balanced.” The mount is quite robust. You do not need to obsess with getting things “precisely balanced!” Start by balancing the tube assembly.

First, Balance the Declination Axis

1. Position the mount for balancing. Move the R.A. axis so that the counterweight shaft is pointing down. The declination axis assembly will be in the meridian (this is the classic photographic pose for a German Equatorial). Position the Dec. axis so the telescope tube is horizontal and pointing east.

2. Tighten the 3 R.A. axis clutch knobs.

3. Loosen the 3 Dec. axis clutch knobs (about 2 to 3 full turns) so that the telescope moves freely about the declination axis. NOTE: because of a spring mechanism, you must loosen the knobs past where they begin to feel loose. Be careful because if your telescope is significantly out of balance, it may swing rapidly in the out-of-balance direction!

4. Loosen the tube mounting rings and slide the tube back and forth for balancing. This is best done with the tube in the horizontal position. If you are using a dovetail mounting plate, slightly loosen the hand knobs on the female dovetail receiver plate and slide the male sliding plate (and thus the telescope) to the desired position.

5. The scope is balanced when it stays put (does not move) with the clutches loose and movement back and forth about the declination axis has the same feel in both directions. Be mindful of eyepieces, cameras and other accessories that are yet to be added and compensate accordingly.

6. Re-tighten the telescope mounting rings or mounting plate dovetail clamps!

Second, Balance the Polar Axis

1. Now, tighten the declination clutch knobs and position the mount with the telescope horizontal and the declination axis horizontal. The counterweight shaft is now horizontal with the center of the counterweights the same height as the middle of the tube.

2. Loosen the R.A. clutch knobs (also about 2 to 3 turns). Again, be careful because if your scope is significantly un-balanced, it may swing rapidly in the out-of-balance direction.

3. Move the counterweight(s) up or down to achieve the correct balance in R.A.. Again, movement back and forth about the R.A. axis should have the same feel in both directions.

4. Re-set the tightness of all 6 clutch knobs to the resistance you want making sure that each axis’ 3 clutches are evenly tightened. (See section on clutch knobs above.)

Try to anticipate any balance problems due to the extra weight of diagonals, heavy eyepieces, finders, solar filters, etc. If the scope moves by itself, when the clutches are loose, then the scope is not balanced adequately. You may want to “tweak” by carefully repeating steps 1 – 5 after everything has been attached to the telescope. Be especially careful loosening the Dec. clutch knobs.

NOTE: A small amount of imbalance on the East side of the mount is permissible and even desirable for astrophotography and imaging. This allows gravity to keep the drive train fully engaged while tracking throughout the exposure. If you intentionally create this small imbalance, you must remember to re-adjust the balance whenever you flip from one side of the mount to the other. Forgetting to re-adjust can result in a slight see-saw action in tracking that could spoil your next image.

Fine Polar Alignment

For casual observation, you may skip most of this section and simply start observing. A finder-scope or single power finder may be required to locate objects since GoTo slews with the keypad require good polar alignment for spot-on accuracy. Don't forget to tighten your altitude locking lever and make sure both of your azimuth adjuster knobs are snugged against the azimuth adjusting block Move the telescope manually or by using the N-S-E-W buttons of the keypad.

The keypad and GTO Servo control box will function as soon as they are plugged in. That means that the R.A. axis will be tracking up to the limits of your polar alignment. However, if you plan to use any of the go-to functions of the *Mach1GTO* or do astrophotography, you must perform a more accurate polar alignment. Some methods, procedures and tips are presented below. You will complete this alignment when your scope and other equipment are mounted.

Methods for fine polar alignment

- **Polar Alignment Scope** – Use our optional polar scope [PASILL4L (current), or the PASILL4 or PASILL3 (prior)] models. Earlier polar alignment scopes cannot be used as effectively with the *Mach1GTO* as explained later in this section. This scope will allow you to quickly align your mount on the pole stars. The reticle was designed for use in both the Northern and Southern Hemispheres. Even users of the GTO computerized mounts will find these polar scopes useful, particularly if your telescope is not orthogonal to the mount (please refer to the keypad manual for a discussion of orthogonality). If you have a PASILL4L, PASILL4 or PASILL3, please read the instructions sheets that came with it with the following modification:

  The reason that the *Mach1GTO* requires one of these later model polar scopes is that these models have reticle housings that turn freely in their collars. Unlike the 900, 1200 and earlier mounts that we have produced since the early 1990's, the *Mach1GTO*'s polar axis shaft does not reach all the way to the bottom of the polar axis housing. With these other mounts, the polar scope was actually screwed into the end of the polar axis shaft. If you turned the polar (R.A.) axis, the polar scope turned as well. With the *Mach1GTO*, the polar scope attaches to the polar scope adapter, which is, in turn, attached to the polar axis housing, not the polar shaft. Turning the polar axis does NOT also turn the polar scope. To use the polar scope with your *Mach1GTO*, simply turn the polar scope's reticle housing instead of the R.A. axis as instructed during the final stages of polar alignment. If you started with the reticle properly oriented these will be small movements. DO NOT confuse the reticle housing with the eyepiece, which can also be turned for focusing!

  It is possible to use an older model polar scope (PASILL or PASILL2), but they may be a bit less accurate. To use one of these earlier polar scopes, screw the unit into the adapter, and then back it off to align Polaris' relative position to the pole. Proceed normally turning the polar scope wherever the instructions say to turn the R.A. axis. Since the scope won't be screwed in tight, you may have a bit of sag that will slightly reduce your accuracy. These older polar scopes also have reticles that are outdated with regard to Polaris' position due to the Earth's precession.

  The Polar Alignment Scope will prove adequate for many users. Even imagers who will refine their alignment beyond the polar scope's resolution will find it a great asset in getting close. Start the fine alignment process with the polar scope, and then proceed to one of the more refined and accurate methods below.

- **GTO Keypad** – Please refer to the instruction manual for the GTO Keypad and read the sections from "Getting Started" through "Alternate Polar Calibration Routines & Tips." Also, be sure to read the Keypad Addendum if there is one, as it may contain refinements to the keypad methods. As time goes on, the keypad manuals will be updated. Please refer to the Technical Support section of the Web site for the most recent documentation. Here are summary descriptions of several techniques for polar alignment from the current Keypad Manual and Addendum.

  - The Keypad startup routine provides two methods: The North Polar Calibrate and the Two Star Calibration. These two polar alignment methods were really designed for quick coarse alignment in the field with portable setups. They are most appropriate for visual observers. The Two Star Method is generally the better of the two as it is less affected by orthogonality issues.

- The Daytime Routine (See "Polar Aligning in the Daytime" in the Keypad Manual), is a great trick for daytime setup. In addition, it is the recommended first step in alignment for anyone in the southern hemisphere, and for owners of the 3600GTO. Even those in the south who own our polar scope will find it helpful, since it will generally put the rather difficult-to-spot southern stars into the polar scope's field of view.
- The original GTO Quick Star Drift Method of polar Alignment that takes advantage of the Meridian Delay feature of the Astro-Physics Servo System is also included in considerable detail in the Keypad Manual. A table of suggested stars is found in Appendix I of the manual.
- Saving the best for last, we have also included a second ***Revised*** GTO Quick Star Drift Method that was conceived for use with a finder scope. This method was introduced in the Keypad Version 4.17 Addendum and includes a one-page Quick Reference Sheet to use once you are familiar with the method. By using a finder scope, you are able to remove orthogonality issues from the process, making subsequent alignments much easier.

  For our testing purposes here at Astro-Physics, using one of the first production 3600GTO's, we obtained accurate enough polar alignment for extensive imaging (with a focal length of 3810 mm!) using the Daytime Routine, followed by the Revised GTO Quick Star Drift Method, and did so in less than one half hour! The combination of Daytime Routine followed by the Revised GTO Quick Star Drift Method is our recommended procedure for anyone in the southern hemisphere, or anyone who finds their view of the pole obstructed.

- **Computer Software Solutions** – There are many software packages that include aids to polar alignment. Some work better than others. Many of them have shortcomings, especially if there is any orthogonality error or flexure in your system, or if they rely on pointing model errors to determine alignment. We have seen customers practically tear their hair out trying to get good alignment using software. Do not be fooled into thinking that your alignment is perfect simply because a piece of software told you so. Polar Alignment is, after all, entirely a mechanical issue. With the creation of the Revised GTO Quick Star Drift Method, Roland and other staff members here at Astro-Physics no longer depend on software for polar alignment, although we do still take advantage of some software's capacity to speed up final critical drift alignment. Having said that, here are some of the software options that are available:
  - There is a Polar Alignment Wizard in the Full Version of PEMPro™ 2.x. This wizard is quick and easy and gives excellent results! This method is effectively a traditional drift alignment which is sped up tremendously through the power of digital imaging technology. Details are in the PEMPro™ documentation.
  - We suggest that you refer to detailed instructions in the GTO Keypad manual for a method that utilizes CCDOPS from Santa Barbara Instrument Group (SBIG) for precise polar alignment. This method is basically traditional drift alignment with CCDOPS and your camera precisely measuring the drift for you.
  - There are also other similar alignment procedures, including one in MAXIM DL from Diffraction Limited. Numerous other software solutions are also available.
- **Star Drift method** – Traditionally, this very time-consuming procedure has been regarded as the most accurate method of polar alignment. However, if you are using the old method of drift alignment that employs stars near the eastern or western horizon, you may encounter problems from atmospheric refraction, which will skew your alignment. To obtain more accurate results, choose stars somewhere near the celestial equator due south or slightly east and west, but not below 45 degrees elevation.

  For portable setups, we believe that our two GTO Quick Star Drift Methods (found in the keypad documentation as noted above) are much more practical approaches in terms of providing highly accurate alignment and still leaving enough time to actually get some imaging done. A permanent observatory setup where long unguided exposures are taken may still benefit from a final tweaking using the traditional star drift method (as modified by the 45 degree elevation recommendation above) or from a software enhanced variant like the PEMPro Wizard that allows a CCD to measure and calculate the drift much faster than can be done at the eyepiece.
- **Helpful Advice** – Members of the ap-gto Yahoo group occasionally discuss alternative methods of polar alignment that they have found helpful. We suggest that you participate in this Internet discussion group. Follow the links from the sidebar of our Web site to find the group.

Altitude and Azimuth Adjustments

The mechanics of altitude and azimuth adjustment are relatively straightforward. In the discussion below, we will provide some information and tips that will give you the greatest success with your *Mach1GTO* regardless of the method you choose for determining the amount and direction of each adjustment. We'll leave the choice of method up to you. We list the fine altitude adjustment first because our Revised GTO Quick Star Drift Method begins with altitude. Many texts for the classic star drift method begin with the azimuth adjustments.

When you made your rough alignment earlier, you loosened up the altitude lock-lever, got the mount close, and then tightened it back down to the appropriate tightness. Any minor shifting that might have occurred from locking things down tight was of no consequence since it was a rough procedure. Shifting from the azimuth adjustment system has been eliminated by the Precision Adjust Rotating Base and Hi-Res Azimuth Adjuster. Now you are fine-tuning the alignment, so we want to use small steps and keep things tight.

Fine Altitude Adjustment

It is important that you have the altitude lock lever at the proper tension for your final altitude adjustments. This was described in the earlier section on rough alignment, and is basically just tight enough that any up / down or side-to-side play is removed. We will review this procedure here.

a) Loosen the Altitude Lock Lever a small amount. You should NOT need to loosen the lever by more than one-half turn.

b) Grab the end of the counterweight shaft with your left hand and wiggle it up and down to feel the small amount of play or backlash in the system. This is normal with the lever loosened, and is inevitable in an adjustment system that must cover a range of 70 degrees.

c) Gradually tighten the altitude lock lever up to the point where you no longer feel the play. Do not tighten this lever any more than is necessary to hold the mount firmly in position. The goal is to reach the point where the mount is secure and solid, but the final, small adjustments are still possible.

Even with the lever thus tightened, you will be able to make the necessary minor adjustments in altitude to precisely align the mount. You should feel considerable resistance when making these final altitude adjustments, but they are small adjustments, and should not be too difficult. Making these small adjustments with the lever tightened will not hurt the mount.

<u>One turn of the Altitude Adjustment Knob is approximately 1.04 degrees (62 arcminutes). The knob has sixteen scallops and sixteen raised parts on the gripping surface. This divides the knob into thirty-two equal segments corresponding to about 0.033 degrees or 2 arc-minutes each.</u>

1. Be sure that your azimuth is securely locked in place with both adjuster knobs tight against the block before making fine altitude adjustments.

2. We want to use gravity to our benefit. In the earlier section on rough polar alignment, on page 13, we mentioned differing approaches depending on your latitude. These approaches will be elaborated here.

   a) If you are below about 46 degrees in latitude, always make your final approach to the pole from below. If you find yourself pointed above the pole, slightly overshoot your downward adjustment so that you can then make a final tweak upward. If you do need to adjust downward, it helps to push down on the end of the counterweight shaft while making the downward adjustment. Then finish with the upward adjustment.

   b) If you are above about 54 degrees in latitude, make your approach to the pole from above. Your final adjustment should be downward. If you find yourself pointed below the pole, slightly overshoot your upward adjustment so that you can then make a final tweak downward. If you do need to adjust upward, it helps to lift up on the end of the counterweight shaft while making the upward adjustment. Then finish with the downward adjustment.

   c) If you are in the “balanced range” of latitudes - from about 46 to 54 degrees - start by making sure your counterweight shaft is pointing down and northward. Then move a counterweight down the shaft to bring the system slightly out-of-balance with the counterweight side being heavier. Now adjust as if you were below 46 degrees and when finished, remember to rebalance the system.

   d) Why the difference in how you approach the pole from higher latitudes? The reason has to do with the concept of gravitational rest position. When you make your final adjustment, you want to leave the mount in its rest position with regard to the altitude adjuster and gravity. This means that if the lock lever were loosened, the mount would not settle into a lower position because of gravity. You can easily see what this means by performing the following quick experiment with the mount set below 46 degrees latitude:

      i) Loosen the lock lever enough to get play in the system.

      ii) Lift up on the counterweight shaft.

iii) Tighten the lock lever while holding the counterweight shaft up.

iv) Loosen the lock lever and note how the mount shifts down and forward slightly. It has shifted into its rest position. With the mount in its rest position, you can loosen and tighten the lock lever without any significant shifting or movement of the mount.

v) The idea is to have the mount in its rest position with the lock lever simply securing it there instead of having the lock lever holding the mount in position against the force of gravity. This way, all the components that make up the altitude adjustment system are contributing to maintaining the perfect altitude setting.

3. In addition, if you are using an Astro-Physics portable pier, we have found that using the turnbuckle on the north leg of the pier also can make fine altitude adjustments, if used.

Fine Azimuth Adjustment

When designing the Azimuth Adjusters for the *Mach1GTO* mount, we debated using an azimuth adjuster with a single captured threaded rod passing through a stationary azimuth block to avoid the two step process of backing off one side, and then adjusting the other. However, we found that the inevitable backlash in this type of system made adjustment more problematic and less precise.

The first five production runs of these mounts had azimuth adjusters that were built into the front side of the polar fork. The mount base and the pier adapter with its azimuth adjusting pin were held together by a pair of azimuth locking knobs. This system worked pretty well, but as is always the case at Astro-Physics, we were constantly looking for ways to improve things. Starting in 2011, we began fitting the Mach1GTO mounts with a Precision Adjust Rotating Base and Hi-Res Azimuth Adjuster. Users of older mounts who have not purchased the upgrade to this system may wish to consult an older manual for the fine azimuth adjustment procedure since it is a bit different from the one presented here.

The *Mach1GTO*'s Precision-Adjust Rotating Base and Hi-Res Azimuth Adjuster assembly makes for easy and accurate polar alignment in your observatory or in the field, and they combine to eliminate issues of adjustment backlash and lock-down shifting. The Precision Adjust Rotating Base copies the technology used for the 3600GTO and for the 900 and 1200 Precision Adjust Rotating Pier Adapters and brings it home to the Mach1GTO. The Hi-Res Azimuth Adjuster has been relocated to the back of the mount where it is extremely convenient to users of the polar scope. The distance from the center of azimuth rotation to the adjuster was nearly doubled correspondingly doubling the resolution of the adjuster knobs.

With the Precision-Adjust Rotating Base and Hi-Res Azimuth Adjuster, it is the azimuth adjuster knobs that actually lock the azimuth in place. (This is the same as for the larger mounts with the Precision-Adjust Rotating Feature.) Your adjustment technique must not leave the knob you have backed off loose. When finished, both knobs must be tight against the azimuth adjuster block to hold the azimuth angle you have set. If you follow our method below, the act of adjustment will leave both adjusters tight against the azimuth adjuster pin.

Adjustment Method: The natural tendency when making azimuth adjustments is to first back one adjuster knob off a significant amount, then make the required azimuth adjustments with the other knob, and then when finished, to tighten the first knob back up against the azimuth block. This can result in a slight shift as the first knob is tightened against the block.

We recommend that you completely abandon this approach for all of your azimuth adjustment. Instead, start with both knobs tightened against the azimuth adjuster block. Then, back off the first knob ***only by the small amount of the adjustment you plan to make.*** Use the scallops on the knob and the indicator marks on the azimuth adjuster body as reference points to mark your starting and ending points.

One full turn of either Azimuth Adjuster Knob is roughly 0.7 degrees or 42 arcminutes. Each knob has seven scallops and seven raised parts on the gripping surface. This divides the knob into fourteen equal segments corresponding to about 0.05 degrees or 3 arc-minutes each.

Finally, make the actual adjustment by tightening the other knob against the slightly loosened knob thereby making the tiny adjustment you required and eliminating any "lock-down" shift because everything is already tight when you are finished. By using the markings on the knobs, you can easily undo any errors or estimate the magnitude of your next adjustment.

Finally, you will note that the Azimuth Adjuster Knobs have socket cap screws in each end. *These are **NOT** provided to allow extreme tightening of the knobs against the block! Never tighten the knobs beyond hand tight or you may damage the components.* The purpose is to provide even finer resolution for your final small azimuth micro-adjustments. By using hex keys, you can make much smaller incremental moves than is possible with just fingers on the knobs.

Final Note on Altitude and Azimuth Adjustments: Some people love to "tweak" their alignment. Tweaking the azimuth should no longer pose any issues since the Precision Adjust Rotating Base and Hi-Res Azimuth Adjuster do NOT introduce any shifting into the process. If you do make a final altitude tweak, however, DO NOT loosen or further tighten the altitude lock lever. Resist the temptation and leave the altitude lock lever alone!

CABLE MANAGEMENT

Introduction to one of the Mach1GTO's most Innovative Features

In years past, there was no such problem as cable management on astronomical equipment. The only wires or cables would have been for the clock drive motor of the R.A. axis, and maybe one for a drive motor attached to the Dec.'s tangent arm. Today, we have added the cables that accompany film cameras, CCD cameras, autoguiders, multiple dew heaters, motorized focusers, and numerous other electronic accessories. Many modern imaging setups have wires going everywhere, and these wires could be a never ending source of problems and frustrations for the operator. Wires hanging off of cameras can lead to image ruining flexure. Wires can catch and snag as the mount slews, and were especially vulnerable when a German Equatorial Mount was "swapping sides" to point at the other side of the meridian. The problem was that all these wires going to all these different locations had to deal with a mechanical system that was designed to be in motion.

Roland Christen and the design team at Astro-Physics came up with an elegant solution to the "cable nightmare." If cables all around the mount are a problem, then run them ***through*** the mount! The idea seems absurdly simple, but it introduced some significant engineering and design challenges, particularly since this mount is portable and the two axes come apart. Those challenges were met with the *Mach1GTO*. There are four places on the *Mach1GTO* where cables can enter or exit the inside of the mount.

1. The first of these is the hub end of the Dec. axis. Underneath the declination hub plate on the end of the declination axis are two cable channels. Cables passing through the hub get routed through one of these channels and on to their accessory. This is where imaging cables, dew heater cables and motorized focuser cables are most likely to be routed. Starting in 2011, these cable channels were enlarged to better facilitate some of the thicker cables used by some imaging systems.

2. The second point of egress is the sight hole / cable access cover on the Dec. axis. You can run the Dec. leg of your servo drive's Y-cable out through this opening. It is also a very convenient place from which to feed cables.

3. The third place to run cables in and out is the cable access cover on the R.A. axis. This is an especially useful place if you need to do a rough polar alignment each time you set up. It still allows the easy use of the polar scope.

4. Finally, for permanent installations or regular observing spots with marked pier / tripod positions (in other words, observing sites where you don't need the polar scope) the cables can be run out the bottom of the R.A. axis.

Which of these openings you use will depend on your particular situation. All of the openings and internal cable passages have a two inch diameter clearance that will accommodate a DB15 serial plug with relative ease. It is certainly not required that you run any cables through the mount, but many of you will find this feature useful.

Preparation

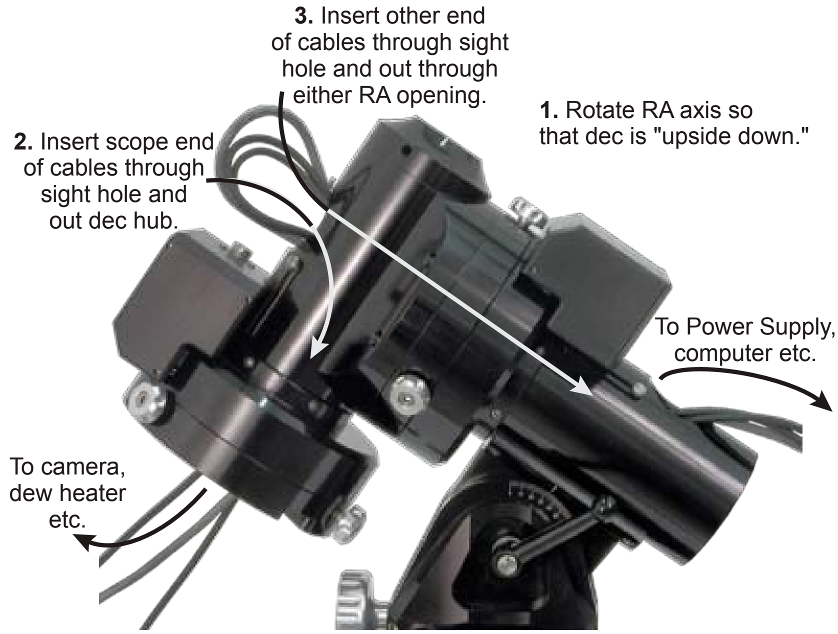
Your approach to cable routing will depend on two main factors: the particular cables you need to run and the degree of portability of your system. These factors lead to a couple of questions: Will the telescope's mounting plate remain attached to the mount between observing sessions? Is the mount often removed from the pier / tripod between sessions? Do you need to rough polar align each time you set up or can you set up and always be close enough to not need a polar scope? Or are you permanently mounted? Since everyone's situation will be a bit different, these instructions are more guidelines rather than specific "follow these to the letter or else" instructions.

If it is practical, you may find it most convenient to first set up your mount following the above instructions and get it pretty well polar aligned. The two axes must be assembled to run your cables. You won't do a final drift alignment yet, but you will want to get close. This is especially the case for those of you who are using a polar alignment scope like our PASILL4L. You do not want to have the polar scope installed when the cables are being run through the inside of the mount or you might scratch the polar scope's objective. However, as you will see, there is a way to use your polar scope with the cables already in place, though this may not be possible in all cases. Do not have your telescope or mounting plate attached yet.

Remove the declination hub plate off of the declination axis hub by removing the six 1/4-20 x 3/4 flat head socket cap screws around its perimeter. Remove the polar scope from the R.A. axis if you are using one. Finally, remove the polar scope adapter (with polar scope cap) and raise the two cable access covers (one on each axis) to the open position. You are now ready to put in your cables. Note: starting with mounts that began shipping in April, 2007, the polar scope adapter is a bit larger and has a knurled grip for easier removal.

Cable Installation – the First Time

Cables can be inserted either from the top (through the declination axis hub) or bottom (through the polar scope end of the R.A. axis), but the simplest way will usually be to insert the cables through the sight-hole / cable access cover on the declination axis. The easiest trick for inserting the cables, if you will be routing cables out through the declination axis hub (as is likely), is to turn the R.A. axis so the counterweight shaft adapter is pointing up and south and let gravity do the work. Always start by running the cables with the largest connectors first. Insert the telescope end of the cable into the sight-hole / cable access cover on the Dec. axis and guide it “down” and out the declination axis hub. Insert the opposite end in the same opening and guide it either out the R.A.’s cable access cover or out the bottom of the R.A. axis. If you are routing out the R.A.’s cable access cover, you can reach in the bottom of the R.A. axis to help you guide the cable end out the access hole.



Mach1GTO **Cable Insertion**

When all the necessary cables have been run through the mount, turn the R.A. axis so that the mount is in its normal position with the counterweight shaft adapter pointing down and north. Adjust the amount of each cable that you will need sticking out through the declination axis hub to adequately reach its electronic device. When determining the length, be sure to run the cable through the cable channel and allow enough slack so that there will be no tension on the cable’s plug. Make sure you allow for focuser travel. Don’t allow too much slack, however, or you will defeat the whole purpose of hiding the cables inside the mount. Be sure that you route each cable through the appropriate cable channel side for the side of the telescope where it will plug in. Also, keep in mind any other places where you may wish to tie your cables like on the end of a mounting plate. Cables for CCD cameras should be tied off to the focuser or the very back of the mounting plate so that the weight of the cables does not pull on the camera causing image shift.

Once the cables are routed through the mount, and you have the proper amount sticking out the top of the declination axis hub, you are ready to replace the declination hub plate. Be sure that the cables are seated well in the two cable channels and that they are not being pinched by the plate. Put in two screws, one each on opposite sides of the plate and snug them down. Re-check that none of the cables have been pinched and then tighten the two screws firmly. If you are using the FP1800, the RP900 or the Q4047 (with DOVE08) as your telescope mounting plate, install it now using the four provided screws in the remaining four holes. If you will be using one of the other telescope mounting plates (FP1500, DOVE15, DOVELM2 or DOVELM162), first install the remaining four screws from the declination hub plate, and then install the mounting plate with the correct fasteners that were provided.

Where the cables emerge (R.A. cable access hole or bottom of R.A. axis), make sure that nothing will be hanging or pulling on any of the cables. You may wish to bundle the cables together and tie them off to a tripod leg or pier strut to eliminate potential tripping hazards. Run them carefully to wherever they will be plugged in (laptop, heater controller etc.) and try to avoid creating tripping hazards. If you have run the cables out the R.A.’s cable access hole, replace the polar scope adapter and polar scope cap. Do NOT over-tighten the polar scope adapter. You can also partially close the sight-hole / cable access cover on the Dec. axis and the cable access cover on the R.A. axis at this time. They can’t be closed all the way with cables routed through them but they can be closed enough to keep most dirt and dust out.

Disassembly and Subsequent Setups and Polar Alignments

Once you have gone to all this effort, you won't want to undo everything for relatively simple tear-down and set-up situations. And you won't have to! The degree to which you must disassemble the cabling depends on the degree to which you must break down the mount. If you need to disassemble the mount for airline travel, you will unfortunately need to undo everything. If you simply move your entire assembly in and out of the garage on its pier or tripod, you will hardly need to take anything apart. Most of us are somewhere in between. Disassembly steps are basically the reverse of the installation steps above and really don't need further elaboration. The main point is that you will want to avoid complete removal of the cables that involves taking off the declination hub plate if that is possible for your situation.

The real question is: how can subsequent setups be done easily, and how can a person polar align with all those cables in there? Fortunately there are two easy solutions. First, if you regularly need to use your polar scope and you are only running a couple of cables through the mount, just make sure that your cables were run out the R.A.'s cable access hole. If you use this feature, you can insert and use the polar scope without any problem. (You may need to tug lightly at a cable to get it out of the line of sight when aligning.) The cables can simply be left in place and wrapped around the mount for most transport and storage situations. Just take care not to pinch the cables anywhere or to strike a connector on the exterior surfaces of the mount, which could cause a scratch. Then, set up the mount with the cables already in place.

But what about polar alignment if the cables have been run out the bottom of the R.A. axis or if there are very many cables? Simple! Set your mount up on its tripod or pier, but don't tie off or hook up any of the cables from the bottom of the R.A. axis yet. Now, open the sight-hole / cable access cover on the declination axis. Push the cables up from the bottom of the R.A. axis with one hand and hook them with a finger through the sight-hole. Pull the bottom part of the cabling out through the hole and hang the cables out of the way. Insert your polar scope adapter to rough polar align (don't over-tighten), and then put in a polar scope to get a good polar alignment. When you are as close as you can get, pull off the polar scope and adapter, and reinsert your cables through the sight-hole / cable access cover. You are now ready to tie them off, plug them in and go!

A Note on the Mount's Servo Y-Cable

The Y-cable that connects your GTOCP3 control box to the servo motor gearboxes can be run either inside or outside the mount. The *Mach1GTO* doesn't really have anything that will catch the cables, but you still may want to run them inside. This is one cable that will not be run out through the declination axis hub. To insert the Y-cable, put the control box end

Optional "Through the Mount" Servo Y-Cable Installation

1. Feed control box end into Dec. Sight Hole / Cable Access Hole
2. Work control box cable end out through R.A. Cable Access Hole
3. Pull short cable leg through and connect to R.A. Servo Drive
4. Connect long cable leg to Dec. Servo Drive

into the sight-hole / cable access cover on the declination axis. Run it out through the R.A.'s cable access cover, and pull the shorter R.A. leg of the cable all the way through. (Again, if the polar scope adapter is removed, you can easily guide the control box plug out the cable access cover of the R.A. axis.) Only the declination portion will be left inside the mount. Connect all three plugs. When you remove this cable, don't reverse the procedure; simply pull the declination leg on out through the R.A.'s cable access cover.

A Few More Hints and Tricks

- If you need to remove a cable completely from the mount, mark the point where it emerges from the cable channel in the declination access hub. Wrapping the cable at that point with a small piece of colored electrical tape works well. That way you won't need to re-measure to position the cable properly.

- It is often helpful to bundle some of your cables.

- Always tie off cables for CCD cameras to the focuser so that the weight of the cables doesn't cause movement (flexure) in the imaging system over a long exposure.

Please feel free to contribute hints and tricks of your own for future editions of this manual. At Astro-Physics, we know that our customers can be downright brilliant! E-mail your suggestions to support@astro-physics.com.

MOUNT CARE, CLEANING AND MAINTENANCE

Like any fine piece of equipment, your mount's longevity and performance are directly correlated with the quality of the care that you give it. Handle it with respect, keep it as clean and dry as is practical, and perform a few minor maintenance tasks, and your *Mach1GTO* will give you many years of trouble-free service.

Care

Although we build it to be rugged enough for field use, your *Mach1GTO* is a precision instrument with very accurate worm and wheel adjustments. Please be careful if you place the mount on a flat surface, i.e. the ground or trunk of your car. The gear alignment may be affected if the R.A. and Dec. motor / gear box assemblies sustain undue lateral force. This is true of any fine instrument. We suggest that you transport and store the mount in a case or in a well-padded box. ALWAYS remove the mount from your pier or tripod before moving it or transporting it. More damage can be done in a few careless seconds in transit than in many hours of normal operation.

Try to keep your mount protected from dust and moisture when not in use. In warm, humid weather, be aware of the dew that may have formed on the mount while in the field and allow the mount to dry out before packing it away for storage once you get home. On the other hand, if it is cold and dry outside, keep the mount packed up when you bring it into the house until it reaches room temperature to avoid "fogging it up." (The same advice applies to telescopes, eyepieces and other equipment in your Astro-arsenal.)

Cleaning and Touch-up

Wipe your mount clean with a soft dry cloth. If needed, you can use a damp cloth or a cloth that has been sprayed with a mild, non-abrasive cleaner (window or all purpose cleaner – no bleach). Do not spray cleaners directly onto your mount. If you use a cleaning product, follow with a damp cloth to remove the chemicals from the mount.

The anodized surface of your mount is relatively maintenance free and should not require frequent touch up like some painted surfaces.

Mount Maintenance

Under normal operating conditions, minimal maintenance is required. If the R.A. and Dec. axes are attached together for a long time in outside conditions (i.e. in a permanent observatory) then the mating surfaces should be lightly oiled or greased - if you expect to get them apart again after 10 years.

Jostling and vibrations associated with transport to and from observing sites have had the effect of causing screws and fasteners to work their way loose over time. We have worked very hard in both the design and assembly of our mounts to alleviate this problem, but it is still a good idea to periodically (once or twice a year) inspect and if necessary re-tighten any easily accessible fasteners.

The primary maintenance task that you will perform is re-meshing the worm gears to their respective worm wheels. This is a simple and straightforward procedure that is described fully on page 37.

Additional maintenance information can be found below in the troubleshooting section and in the Technical Support Section of our Web site.

TROUBLESHOOTING

Most of the troubleshooting questions and answers are now found in the GTO Servo Motor Drive System Manual. Additional troubleshooting questions are in the GTO Keypad manual. Some of the issues discussed in the keypad manual relate to mount communication issues whether you use the keypad or control the mount with a planetarium program or *PulseGuide*. Please refer to them.

For polar alignment, I am using declination drift technique with stars on east & south. Now, I do not see any drifts in declination on both sides (E & S), so the mount "should be" properly aligned. However, I have still small drift in R.A. which looks like the R.A. motor is a bit faster than earth rotation. This drift is something like 1.5 arcsec during 1 minute or so and is accumulated over time, so it doesn't look like periodic error.

The sidereal tracking rate is exact in the mount (it is crystal controlled and checked here for accuracy). However, the stars do not move at exactly the sidereal rate everywhere in the sky. The only place they move at that rate is straight overhead. As soon as you depart from that point in the sky, the stars will be moving more slowly, especially as you approach the horizons. Thus, it looks like the mount is moving slightly faster than the sidereal rate. Just because you have done a classic drift alignment, does not mean that the stars will now be moving at the sidereal rate everywhere in the sky.

In order to increase the area of sky from the zenith that will give you fairly good tracking, you will need to offset the polar axis by a small amount. The amount will depend on what your latitude is. The other approach is to vary the tracking rate for different parts of the sky. Ray Gralak's *Pulse Guide* will allow you to dial in an exact tracking rate for any part of the sky.

Initially, the mount was working fine. Then, suddenly the mount stopped tracking altogether!

Chances are that the motor was turning properly and driving the worm gear, but that your clutches might have been loose and therefore the scope was not following the motion of the worm gear. The fact that the high slew rate did move the scope does not change this, because Roland has seen this himself where the tracking rate did not overcome the slipping clutches but the slew rate did.

If you are unsure of the motion of the motor, just remove the motor cover plate and look inside. You will see the motor turning. Sometimes when you have the clutches loosely engaged and the counterweights are somewhat out of balance, being heavy in the east, then the clutches might slip at the slow sidereal rate.

In any case, just to set your mind at ease, simply remove the motor cover next time something like this happens and look at the motor shaft. If the motor is not turning, you will have some kind of electrical problem. If it is turning, then it is mechanical.

My R.A. motor has failed, and I need to restore tracking immediately!

Another innovative feature of the *Mach1GTO* is that the declination and right ascension servo motor / gearboxes are interchangeable. In the extremely rare chance that your R.A. drive would fail in the field (at a star party in the middle of nowhere under perfect skies according to Murphy's Law), you can simply swap the two motor / gearboxes and still have the mount's tracking ability. Please note that while the declination motor / gearbox box is on the R.A. axis, you may have a little more periodic error than you are used to, since the fine tuning was done on the R.A.'s original motor / gearbox. Also, since you will be using a different worm gear, your PEM will be different. For imaging, you may need to retrain your PEM. For visual observing, simply turn PEM off while using the declination motor / gearbox on the R.A. axis.

To remove a motor / gearbox, first separate the two axes, and then remove the four small screws on the box that hold the cover with the servo cable connector, and pull the cover off to the side. Its wires will remain attached to the motor. Next, carefully unscrew the two shoulder bolts that hold the motor / gearbox to the axis. Note that there is a spring exerting pressure against these two shoulder bolts, and take note of the spring's position against the shoulder bolts. When they come loose, the spring will push them over. That is fine; don't try to completely remove the bolts. The motor / gearbox will now separate from the axis. To re-install a motor / gearbox, carefully set the box into position making sure that the worm gear settles into the teeth of the worm wheel. Put the two shoulder bolts in place, but only snug down at this point. Make sure that the spring is properly positioned below the ridge in each shoulder bolt. Gently rock the motor / gearbox back and forth, and then center the box in its range of motion. Now fully tighten the shoulder bolts, starting with the bolt on the left. Finally, replace the cover with the four screws and you're ready to go.

There is a detailed instruction sheet entitled "Remeshing the Worm Gear and Wheel" at the end of this manual that will help you get your gear mesh just right. As more detailed information from real life experience becomes available, it will be posted in the Technical Support Section of our Web site.

My GTOCP3 Control Box does not appear to be working properly. Can I use the control box from my other Astro-Physics mount with my *Mach1GTO*?

The answer depends on which model your other Astro-Physics mount is. The GTOCP3 from your *Mach1GTO* can be interchanged with the GTOCP2 or GTOCP3 from most 900GTO or 1200GTO mounts. The interchange works in either direction: the *Mach1GTO* can use the 900GTO or 1200GTO's control box, and the 900GTO or 1200GTO can use the GTOCP3 from the *Mach1GTO*. (Be careful if exchanging with 900GTO and 1200GTO mounts from 2001 and earlier. Motor chatter or buzzing may result. If this happens, do not continue to use the older control box.)

A GTOCP1 cannot be used as it does not have the correct servo cable connection. DO NOT use the control box from a 400GTO, a 600EGTO, a 3600GTO or from a mount purchased from an OEM partner that uses our GTO system. These mounts employ different gearing in their servo drives and therefore use different parameters in the servo controller.

As a final note, if you "borrow" another control box for your mount, you must disable the PEM since the PE curve in the borrowed box will be for a different mount. You can always record a new PEM data set if you wish, and there is no reason to preserve the PEM data set in the borrowed box since it will no longer be valid on its original mount anyway. Any time that you use a different control box on a mount, the PEM data becomes out of phase and will need to be redone. This applies to both the borrowing mount and the lending mount. It is something to consider before trading control boxes, especially if you have achieved a particularly good PEM result with the mount that is to be the "lender."

I am concerned about achieving good balance in the system. My clutches don't seem to loosen up the axes as much as my 900 or 1200 mount's clutches when I loosen the knobs. Is this correct?

The *Mach1GTO* uses a different clutch system, and it also uses a different bearing system for the free rotation of the axes. It will feel stiffer than the 900 or 1200 series mounts, even with the clutches fully disengaged.

You should also be aware that the clutch knobs on the *Mach1GTO* have spring loaded tips that may still be applying pressure to the clutches, even though the clutch knobs feel loose. Back the clutch knobs off by at least three full turns to fully disengage the clutches. Then swing the axis back and forth a time or two before trying to actually measure and adjust the balance.

There is really no need to balance the *Mach1GTO* to any high degree. The motors are quite strong and can handle well over a pound of imbalance in the load. When moving either axis back and forth by hand, even with the clutches not fully loosened, it is quite easy to feel as little as a few ounces of difference.

If you really need to balance for some reason, you can use a small fisherman's scale to pull the axis in one direction, and then the other. When the pull is equal, the axis is basically balanced. Another method is to use an ammeter to measure the current draw. Use the opposing direction buttons at 64x and observe the current being drawn. A balanced load will result in equal current draw in either direction for each axis.

The declination axis does not appear to be moving properly. How can I check it?

Please refer to page 36 for the instruction sheet: "Characterizing the Dec. Axis Motions," which explains how to use Maxim DL software to characterize your mount's performance.

ADDITIONAL SUPPORT

Remember that additional information on the servo drive system is now found in the separate Astro-Physics GTO Servo Motor Drive System manual.

For additional information regarding the *Mach1GTO*, refer to the Technical Support Section of our Web site. We also encourage you to participate in the ap-gto user group. The members of this group are very knowledgeable about the operation of their mounts, CCD imaging and other related issues. The staff of Astro-Physics also participates and you will find a wealth of information in the archives. To find the group, link from User Groups in our Web site's sidebar.

If any problems occur, please don't hesitate to contact Astro-Physics for assistance.

We encourage you to submit your technical support questions directly to Astro-Physics by phone or e-mail: support@astro-physics.com.

We may add additional troubleshooting tips to future versions of this manual or in a separate technical document. In such an instance, we would add this information to the Technical Support section of our Web site as well.

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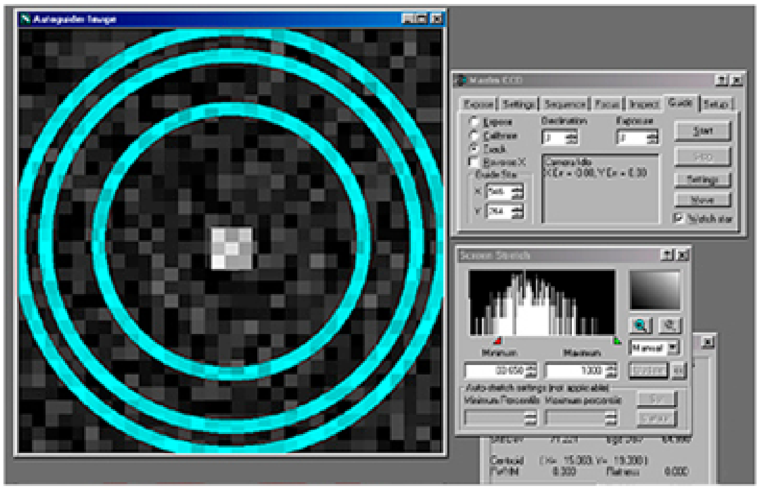
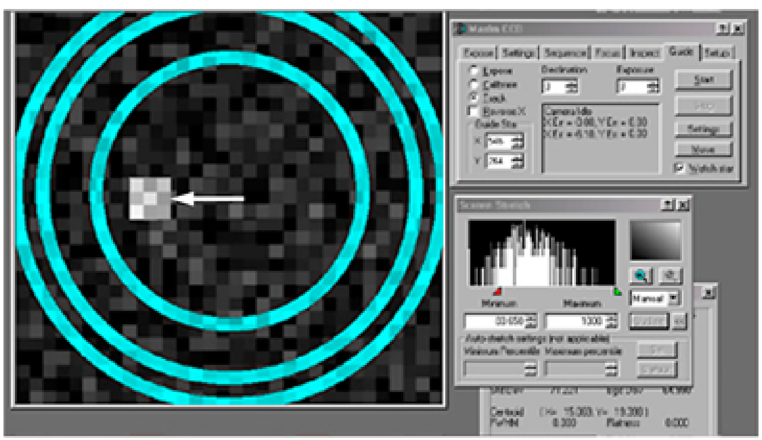
CHARACTERIZING THE DEC. AXIS MOTIONS

These instructions explain how to use Maxim DL software as a tool for characterizing any problems with the Declination axis movements of your mount. However, Ray Gralak's PulseGuide software offers an easier and more extensive evaluation procedure. PulseGuide is available as a free download through our website.



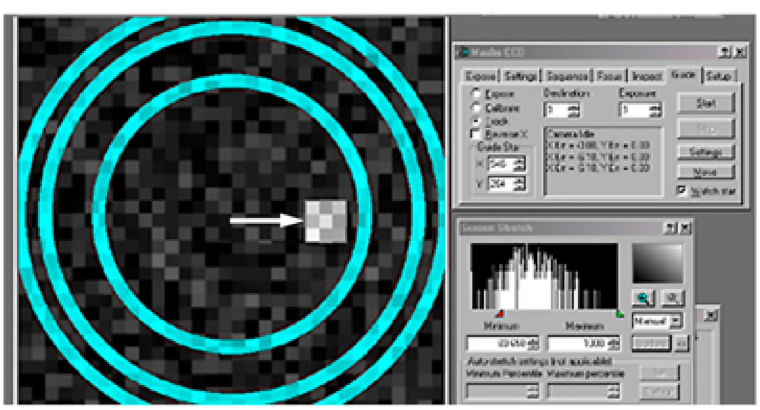
Step 1

Acquire a reasonably bright guide star and begin guiding in RA only - turn off Dec guiding (note X and Y are switched on the Maxim parameter page, as of v3.07). Use a 1 second or faster refresh rate so you can see the motion of the guide star as you begin to move it around. Magnify the screen to 1600x and place the cursor in the middle as shown. Check to make sure that the mount is guiding adequately in RA, and that the guide star is not bouncing around due to poor seeing. Best results will be achieved when the RA guiding is 0.5 pixels average in RA.



Step 2

Put the keypad button rate at 0.5x. Press the keypad North button until the guide star has moved approximately 6 pixels from the center. Now press the South button in very short pulses and note which direction the star moves. It should move back toward the middle after a few button presses. It might move slightly up or down, or it might continue to move further away from the middle, or any combination. Please note exactly how far, and in which direction, the guide star moves (pixel position is displayed in the guide box at right in Maxim). Please allow a moment for the star to settle down after each button press.



Step 3

Press the South keypad button until the star has moved 6 pixels off the center in the opposite direction. Repeat Step 2 and note exactly the motion of the guide star as you move it with the pulsed motion at 0.5x.

You may wish to enable Track Log to record the numbers for further study. Please note on the log what you did at what time so the results will be useful later.

You have now characterized the Dec axis.

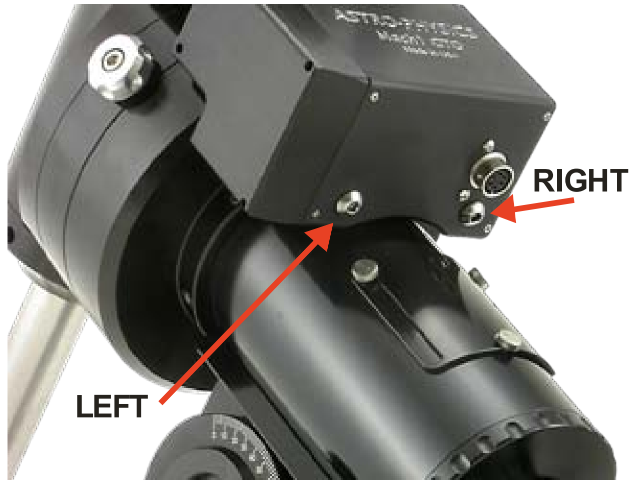
09-15-03

RE-MESHING THE WORM GEAR AND WHEEL

The revolutionary design of the Mach1GTO motor / gearbox makes re-meshing the worm gear into the worm wheel a simple process. The instructions apply equally to either axis.

1. On the face of the motor / gearbox that has the cable connection are two 1/4-20x5/16 Button Head Cap Screws. These are by far the two largest screw heads on that surface, and will be located on either side at the bottom of the box. (See the photo at right.) These screws are merely place holders to fill the holes that give access to the mounting bolts underneath. They do not hold anything. Simply remove them using a 5/32" Allen (hex) wrench and set them aside.

2. Insert the long end of the same 5/32" Allen wrench into the RIGHT hole (under the cable connection) and engage the socket of the attachment shoulder bolt that is inside. The bolt and the hole are lined up, so only minimal "fishing around" should be required. Loosen this bolt between 1/4 and 1/2 turn. DO NOT loosen any further or remove the bolt!



1/4-20x5/16" Button Head
Use 5/32" Allen Wrench

3. Repeat step 2 with the LEFT hole. As you loosen the second bolt you will feel the motor / gearbox come loose on the axis.

4. Gently rock the motor / gearbox from side to side and from front to back to be sure that the worm is fully seated in the wheel.

5. Tighten the LEFT shoulder bolt first. It is critical for proper worm mesh to tighten the LEFT bolt first. Tighten the bolt in small increments. As you tighten, wiggle the box slightly so that it finds its center as the bolt is gradually tightened. Once the bolt has made full contact, tighten about another 1/8 turn.

6. When the LEFT bolt is tight, tighten up the RIGHT bolt, also about 1/8 turn past the point of full contact. When you have the RIGHT bolt properly tightened, check the LEFT bolt to be sure that it still feels tight.

7. Once the attachment bolts are both tight, replace the two button head screws to close the access holes back up, and the re-meshing is complete.

NOTE: These are not lug nuts that hold the wheel onto your car. If you are unsure how tight to make the attachment bolts, I would suggest that you err on the side of caution and don't risk over tightening. It is easier to do this whole process over making everything a bit tighter the second time around than it is to undue the damage from too heavy a hand on the wrench. We have found that a good practice is to have the long end of the wrench in the hole, so that you only have the short end for leverage. Make it as tight as you can with this short lever, and then reverse the wrench and tweak the tightness by no more than 10 additional degrees.

7-24-08

ASTRO-PHYSICS MOUNTING PLATE FASTENER CHART

A-P Part #	Description	Ships with:
FP1500	15" Flat Plate	(4) 1/4-20x5/8" SHCS [for mounting to 400, 900 or Mach1GTO] (4) M6-1.0x20mm SHCS [for mounting to 600E] (4) 1/4-20x3/4" SHCS [for mounting to 1200]
FP1800	18" Flat Plate	(6) 1/4-20x1" FHSCS [for mounting to 900 or 1200] (4) 1/4-20x1-1/4" FHSCS [Mach1GTO]
DOVE08	8" Dovetail Plate	(4) 1/4-20x1/2" SHCS [for mounting to 400] (4) M6-1.0x16mm FHSCS [for mounting to 600E] (4) 1/4-20x5/8" SHCS [for mounting to 900 or Mach1GTO, requires Q4047] [or to attach to SBD13SS or SBD16SS] (4) 10-32x3/4" SHCS [for mounting as Accessory Plate onto A-P rings]
DOVE15	15" Dovetail Plate	(4) 1/4-20x1/2" FHSCS [for mounting to 400 or Mach1GTO] (4) M6-1.0x16mm FHSCS [for mounting to 600E] (4) 1/4-20x5/8" FHSCS [for mouting to 900 or 1200] (4) 10-32x3/4" SHCS [for mounting as Accessory Plate onto A-P rings]
DOVELM2	8.5" Dovetail Plate for Losmandy D Series Plate	(4) 1/4-20x5/8" SHCS [for mounting 400 or Mach1GTO] (4) M6-1.0x20mm SHCS [for mounting 600E] (2) 1/4-20x5/8" FHSCS [for mounting to 1200] ** (4) 1/4-20x3/4" SHCS [for mounting to 900 or 1200] ** [or to attach to SBD13SS or SBD16SS]
DOVELM16/S	16" Dovetail Plate for Losmandy D Series Plate for 1200GTO - "S" version for 900 or Mach1GTO	(6) 1/4-20x1" SHCS [for mounting to 900 or 1200] (4) 1/4-20x7/8" SHCS [for Mach1GTO]
DOVELM162	16" Dovetail Plate for Losmandy D Series Plate for 900, 1200, Mach1GTO. Also for 3600GTO w/ SB3622 or SB3627 Can also be mounted on AP ring tops with blocks	(6) 1/4-20x1" SHCS [for mounting to 900, 1200 or Mach1GTO (uses 4)] [or to attach to SBD13SS or SBD16SS] (1) 1/4-20x3/4" FHSCS [opt. 900 or 1200 for end positions] (4) 1/4-20x3/4" SHCS [for SB3622 in side-by-side configuration and for attachment to blocks for ring-top mounting]
900RP	15" Ribbed Plate for 900 or Mach1GTO	(6) 1/4-20x1" FHSCS [for mounting to 900] (4) 1/4-20x1-1/4" FHSCS [for mounting Mach1GTO]
1200RP15	15" Ribbed Plate for 1200	(6) 1/4-20x3/4" SHCS [for mouting to 1200]
1200RP	24" Ribbed Plate for 1200	(6) 1/4-20x1" SHCS [for mounting to 1200]
Q4047	900/Mach1GTO Adapter for use with DOVE08	(6) 1/4-20x5/8" FHSCS [for mounting to 900] (4) 1/4-20x1" FHSCS [for mounting to Mach1GTO]
SB0800 *OR* **SB1000** *OR* **SB1500**	7" and 10" Sliding Bars for DOVE08 or ACPLTR and 15" Sliding Bar for DOVE15	(2) 1/4-20X1/2" SHCS (2) Acorn Nuts (2) 1/4-20 Nuts (2) 1/4-20x3/8" SHCS (1) 10-32x5/8" FHSCS (1) 10-32 Nut
SBD12	12" Sliding Bar for the Losmandy D-Series Dovetail Saddle Plates	(4) 1/4-20x1" low profile SHCS [for attaching the SBDAPB or LMAPBLOCKS] (4) 1/4-20x1-1/4" FHCS [for attaching directly to AP Rings] (4) 1/4-20x1/2" low profile SHCS (3) 1/4-20x3/8" SHCS [2 for Stowaway - 1 for Safety Stop] (2) 1/4-20x7/8" SHCS [Stowaway with SB0550 as spacer]
SBD16	16" x 5" Wide Sliding Bar for the Losmandy D-Series Dovetail Saddle Plates	(4) 1/4-20x3/4" SHCS [for attaching the SBDAPB or LMAPBLOCKS] (4) 1/4-20x1-1/4" FHCS [for attaching directly to AP Rings] (1) 1/4-20x3/8" SHCS [for Safety Stop]
SBDAPB	AP Riser / Spacer Blocks	(4) #10-32 x 1/2" SHCS [for attaching to mounting ring tops]
SBDTB	Adapter Blocks for large Taks - Mewlon, BRC & FRC	(4) M10 x 20 mm SHCS [for attaching to SBD16]
SBD13SS *OR* **SBD16SS**	13" or 16" Side-by-side Dovetail Plate for Losmandy D-Series Dovetail Saddle Plates	(2) 1/4-20x3/8" SHCS [for Safety Stops -required at both ends]
SBD2V	12" Losmandy D-Series Male to Vixen Style (Losmandy V-Series) Female Adapter / Sliding Bar	(1) 1/4-20x1/4" low profile SHCS [to replace Safety Stop on V plate] (1) 1/4-20x1/4" SHCS [Safety Stop for SBD2V]
LT2APM	Losmandy Tripod to Astro-Physics Mount Adapter Plate	(3) 5/16-18x5/8" SHCS (4) 1/4-20x5/8" SHCS (4) 1/4-20x1" SHCS (3) 3/8-16x3/4 SHCS
CBAPT, **TRAYSB &** **TRAYSB1**	Control Box Adapter, Bi-Level Support Bar & Single Level Support Bar	(1) 1/4-20X3/4" FHSCS (1) 1/4-20X1" FHSCS (1) 5/16-18X1" BHSCS (2) 5/16-18X3/4" BHSCS
DOVEPW	16.5" Dovetail Saddle for Planewave 7.652" dovetail on AP 1200 and 3600GTO	(6) 3/8-16x1" SHCS
DOVE3622	22" Dovetail Saddle Plate for 3600GTO	(6) 3/8-16x1" SHCS (4) 3/8-16x1-1/2" SHCS
SB3622 *OR* **SB3627**	Dovetail Sliding Bar for DOVE3622	(2) 3/8-16x1/2" low profile SHCS (4) 1/4-20x7/8" SHCS for lock-down