WarpDrive User Manual

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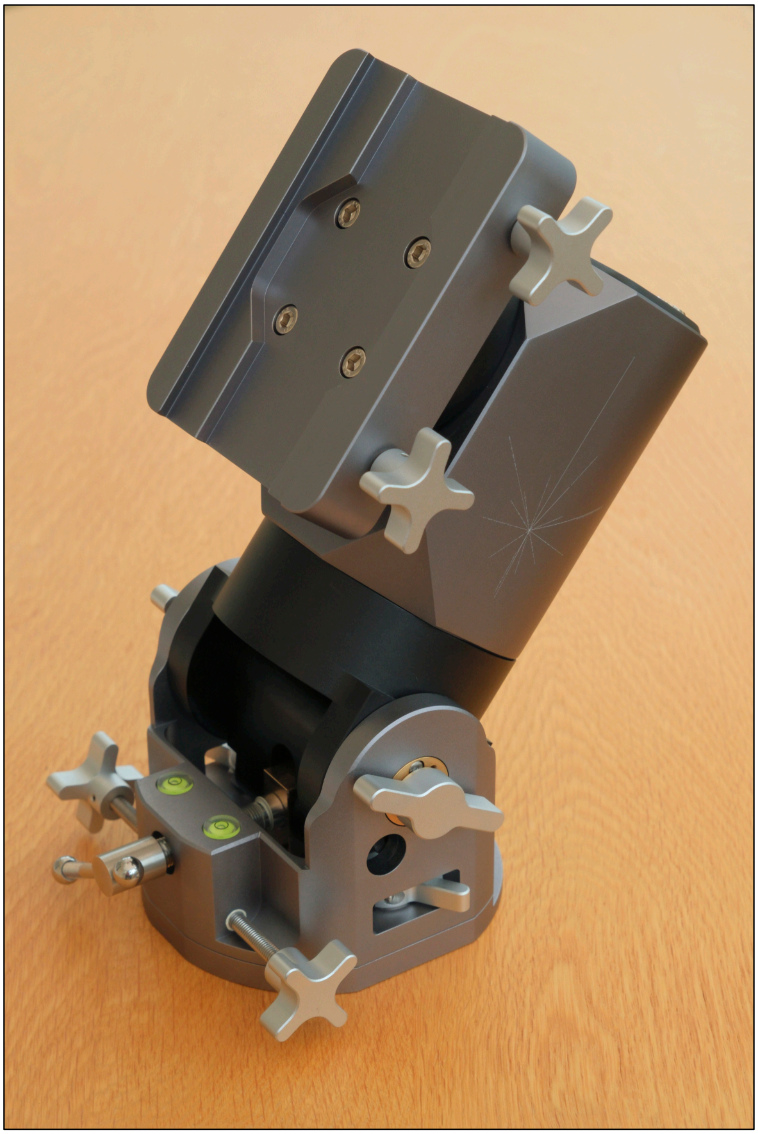

Disclaimer

This manual is compiled by Chris Woodhouse and is written in good faith, with contributions from himself, online resources and several other users. I have no connection with WarpAstron other than buying one of their mounts.

This is not a commercial product, but it is free to distribute, modify and add to. The content therein should be used with due care, however, as there is no implied warranty or liability in its use. This is especially true about tracking and slewing into obstructions.

The entire work is Work in Progress. It will be refined and updated as required until the product and software are established. Like my four books on astrophotography, I conduct careful research before writing and test popular myths. I try to recommend settings that are universal in nature rather than just work for the few.

Revision History

- 22 Nov initial draft layout, rough contents
- 1 Dec early days, starting on tripods
- 10 Dec early drafts of controls, guiding etc.
- 12 Dec details on mobile apps and imaging
- 14 Dec AEB notes, Android and USB updates
- 17 Dec picture updates, imaging
- 21 Dec updates to imaging setups
- 29 Dec AsiAir, polar alignment, firmware
- 30 Dec Mount Tool updates etc.
- 1 Jan Updates and corrections
- 6 Jan Minor updates
- 9 Jan Meridian flips
- 12 Jan PHD2 update
- 13 Jan Guiding updates
- 17 Jan Guider RMS explanation
- 19 Jan WD17 homing reset, meridian flips
- 9 Feb Small updates
- 12 Feb Update on Side of Pier HC setting
- 21 Feb Updated meridian limits under pole
- 8 Nov Added support for WD20P

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Mechanical Setup

Tripods and Piers

Supports

Like other harmonic drive mounts (a.k.a. strain-wave motors), the WD series of mounts is compact, lightweight, and energy-efficient, with an extremely high torque. The high torque enables this class of mounts to work without counterweights, though, as we discuss later, working without counterweights is not always best practice.

The motors at the core of harmonic drive mounts are either stepper or servo motors. The WD mounts have a servo motor on both axes, with a direct-coupled drive. For the servo motors to know where they are, each has an encoder and a home sensor. These are motor encoders, before the reduction drive, not axes encoders.

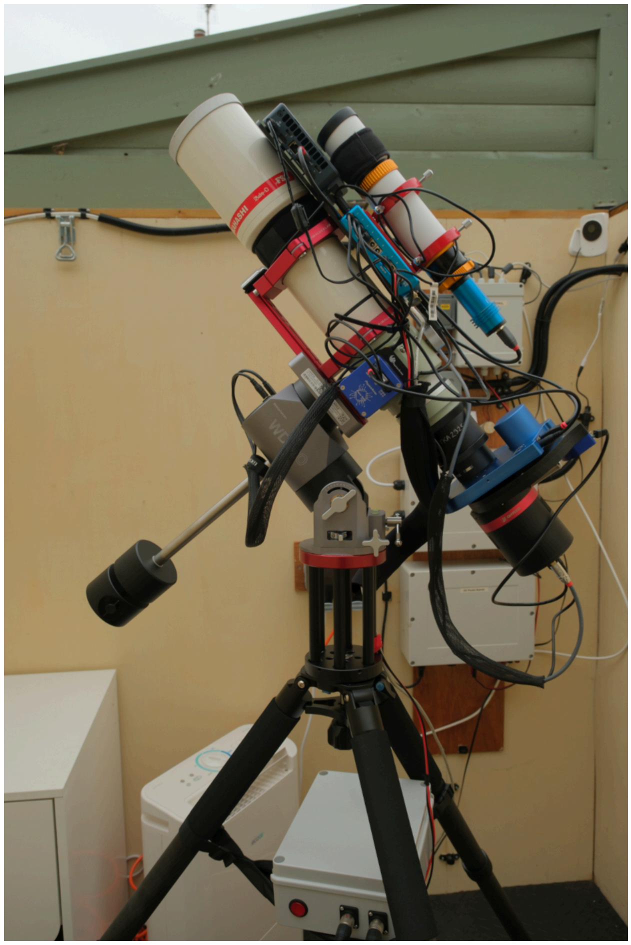
The mechanical engineering of the WD mounts is exemplary. For their size, their rigidity is excellent, with an excellent dual Vixen/Losmandy clamp and great ergonomics. The Alt/Az adjustment is well implemented and the clamps work well. There is a limit to this rigidity, however, simply as a result of the mount's compact size and, as we consider here, its support.

Tripods

Following the lightweight theme, tripods, especially carbon fibre tripods, are a game changer for travel and occasional use. There are several considerations when choosing any tripod:

Stability and Rigidity

If a mount is to be used without counterweights, the mount will be operating without balance, and there is an increased risk of the mount and tripod toppling over at certain orientations or, less obviously, the uneven load will cause bending moments or cause uneven settling on a soft surface, ruining polar alignment. While traditional photographic tripods may be used, it is worth noting that their legs may not splay out at a particularly wide angle (typically 25 degrees) and they usually have more than two leg sections, which are normally thin. Those designed for astronomy typically have a wider splay (about 30 degrees), thicker-section legs, and just one leg extension. For visual use, the height has to be sufficient for comfortable use, whereas for imaging, there is a compromise between a smaller leg ex-



My current temporary setup, awaiting a slim pier of only 110 mm diameter. This is the Pegasus NYX carbon fiber tripod, with an adapted Pegasus pier extension. The counterweights are for stability and to give a rough balance. I intend to use dual refractors and guide scope, close to 20 Kg weight.

tension, for stability, and the feet being sufficiently far apart for overall system balance.

The downside of using a physically small mount on a tripod, and especially with a long telescope, is the risk of leg clashes. Here, when pointing close to the meridian and especially at higher altitudes, the back end of the telescope, camera, or filter wheel, hits the splayed-out tripod leg. The high torque motors cause real damage; my Rainbow mount sheered off a focuser tensioner bolt against the leg of an Avalon TPod. The partial solution is to use a pier extension on the tripod, to reduce the obstruction diameter of the support. Pier extensions, however, introduce another two mechanical interfaces with added flexure and, since they are made of metal, significant additional weight.

Flexure is a consideration for pointing accuracy but less so if one is using plate solving and rapidly guiding a mount during imaging. Things only flex if they are put under stress and a mount with say, a 12 Kg load and no counterweights, applies substantial changing stresses to the support as it moves about. For that reason, and to improve the general stability of the tripod support, I choose to reduce flexure by using a 400-mm long counterweight bar with about half the load weight at its end. The distances between the centre of gravity of the load and the weights to the RA axis are about 2:1, so it achieves approximate balance. The brake on the WD20 RA axis avoids the imaging system from crashing down when power is turned off and the fore-aft position in the dovetail is set so its center of gravity is roughly in-between the two saddle clamping knobs.

WarpAstron recommend a *slight* overall forward balance, to endure consistent engagement of the altitude adjustment system at all orientations. This degree of nose-heaviness varies with the latitude setting, as it alters the center of gravity of the load with respect to the centerline of the altitude pivot axis.

Piers

Observatory-class mounts are often mounted on piers, many of which are substantial, with wide diameters that may incur back-end collisions with imaging systems on a tiny mount. I eventually found a slim steel pier for my observatory, with a 110 mm diameter and 200 mm diameter top plate, which is easily modified with three 6-mm holes for attaching to the WD20. I also have a light, fold-up portable pier, with leveling feet, that is sold under several brand names. Its long, largely unsupported, central column was sufficiently stable for light loads on a Rainbow mount, but I judge it to be too flexible to perform well with a WD20 and an unbalanced 20Kg load.

Slim piers are available; this one is 110 mm diameter, with 200 mm top and bottom plates. It appears to be a common steel pipe size and is considerably more rigid than the carbon fiber tripod / pier extension.

Levelling?

There is often a debate on whether one should level a support if it is going to be used with an equatorial mount. I choose to accurately level the mount support. Why not? In that way, one can transfer the mount from pier to tripod (both leveled) and only have to worry about a minor azimuth adjustment to align. It also means that the load on the pier or tripod is more evenly applied. With an accurate bubble level (±0.03 degrees) it takes just a few minutes. It is also useful for calibrating the home position.

The widely available tri-pier has leveling feet. It works well with small mounts though I would recommend counterbalancing a heavy load on account of the long central column.

Home Calibration

Homing the mount slews both axes to find the home sensor on each. The mount should overshoot and converge on the position (i.e. hover). In this position, the saddle should be pointing directly at the celestial pole and a counterweight bar would be pointing straight down. The saddle plate, however, is simply attached with four bolts and the position of the sensors (WD20) is also subject to the usual manufacturing tolerances. The result may cause the declination value after a slew to have a noticeable pointing error.

This is easily improved; after carefully leveling the tripod/pier, attach the mount without any load or counterweight and carefully remove the altitude range setting bolt (see below). Loosen the altitude locking levers and swivel the mount so that the saddle is pointing directly upwards to the zenith. Carefully home the mount, ensuring it has hovered to find the sensors and then loosen the four bolts, place a level across the saddle (E-W) and carefully tighten the four bolts so that it is exactly level. On my mount, this improved the initial pointing accuracy for DEC by some margin. When you tighten the four bolts, do it progressively in turn and be careful to avoid accidentally twisting the DEC axis motor.

Stability

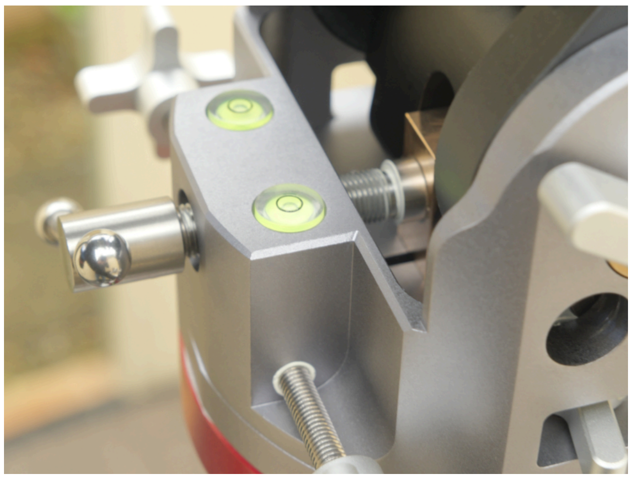
If using a tripod, it is best to have spiked feet on a hard surface. On a lawn, it is useful to hammer three long coach bolts into the earth and place the tripod feet into an indentation on the top of each. That sets up a consistent and stable platform for the tripod. It is best to avoid soft earth and decking, which are prone to subsidence and vibration.

Since the azimuth adjustment of the mount is internal, it is more difficult to reproduce an exact alignment during assembly to a pier or tripod. Assembly consistency improves if one uses countersunk M6 bolts to attach to the top plate, as the countersinking helps to centralize the bolt positions.

Assembly

Lubrication

This mount (like many others) are delivered without any lubrication on its altitude or azimuth adjusting bolts. I usually apply a little lithium grease to the bolt threads. This makes the altitude adjustment smoother under load and also reduces wear in the soft aluminum tapped thread.



It is useful to apply a little lithium grease to the adjustment bolts. It reduces wear on the aluminum and makes it smoother.

Setting Altitude Range

The WD mount's altitude adjuster is thoughtfully placed on the axis centerline. This helps minimize twisting moments that cause the azimuth to alter with altitude adjustments. The fine adjuster has a range of ±15 degrees and the coarse adjuster has positions every 30 degrees. It may be necessary to change the coarse adjuster to suit your latitude. With the mount installed on the tripod or pier, and without any load or counterweight, turn the fine adjustment screw until the hex bolt head is completely within the view of the circular hole on the side of the mount. Carefully loosen the altitude locking knobs and, while supporting the mount body, gently remove the bolt with a 4 mm hex wrench. It should come out easily but the tolerances are tight and it may be necessary to wiggle the mount body to allow it to come out without catching. Once it is removed, manually move the mount body to the approximate latitude position and then put the bolt back into its new threaded hole. Again, it may need a little wiggling and adjustment for the bolt to go back fully without being trapped on the sides of the casing.

When the bolt is fully home, it should be possible to turn the altitude adjuster and for the bolt head to disappear from view. If it is not fully home, the head will catch on the sides of the hole. The approximate latitude is indicated on the other side of the mount.

Polar Alignment (PA)

When adjusting the altitude for polar alignment, apply partial tension on the two altitude locking knobs but have the azimuth locking levers in their lock position, to reduce flexure. When locking the altitude position, there is less chance of further unintentional movement if one twist locks both at the same time, one in each hand.

For azimuth adjustment, it helps to reduce the locking tension on both the azimuth locking clamps before applying the adjustment by first unscrewing and then screwing in the respective adjustments, before applying the full clamping force on the two levers. In practice, the azimuth and altitude adjustments have very little interaction and there is seldom a need to go back for a second round of finer adjustments.

PA Methods

There are 101 ways to polar align a mount. They fall into three main approaches:

The altitude range adjustment bolt, outlined in red, needs to be exactly in the middle of the aperture to be removed.

- find the celestial pole by rotating the mount in RA and "plate-solving" e.g. PoleMaster, SharpCap Pro, NINA and polar scope
- drift alignment e.g. PHD2, visual and others
- multiple point/sync analysis and modeling e.g. hand controller, TPoint

The "periodic error" of a harmonic drive limits the precision of multiple point analysis and drift alignment methods (unless the telescope is only set up to evaluate drift along the DEC axis). Rotate/solve systems are unaffected (but require sight of the polar region) and, for those with imaging equipment attached, NINA's or SharpCapPro's polar alignment routines are excellent starting points. Another favorite electronic means is PoleMaster, but the mount does not have a convenient attachment and requires a little ingenuity to fix the camera in place. Keep things in perspective; the drift rate from poor PA will be a fraction of the dynamic tracking error rate from periodic error.

Loading and Balance

A mount's load capacity is quoted as a mass, but it is more correctly defined as a torque limit. Torque units are force x distance and this explains the thorough analysis graphs supplied by WarpAstron. (For example, the WD20 capacity is 22 Kg at 25 cm from the RA axis.)

A large-diameter SCT and a slim refractor of the same mass have different effective loads. The SCT's center of gravity is further from the RA axis than the refractor's and it takes more effort to move. The effort reduces if counterweights are used, within a practical limit on the total mass. Keeping the center of gravity low and using counterweights are the two strategies to make the most of this mount's capacity. It also helps to use a modest slew speed.

The altitude locking mechanism on these small mounts has a little play. It helps to roughly balance the telescope for/aft in the dovetail clamp with a slight forward balance and to make the final PA altitude adjustment against gravity (e.g. for a 50° latitude, the final altitude adjustment raises the telescope).

To Counterweight or Not

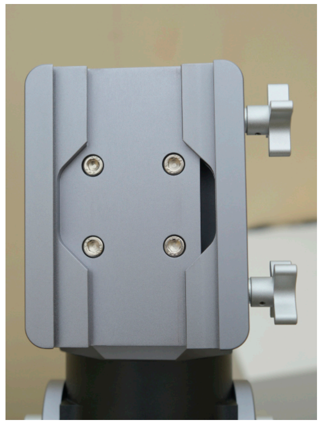
Counterweighting was briefly discussed earlier. If one estimates and applies counterweights, it places less stress on the drive system and improves the stability of the support. Without a clutch mechanism or motor current measurement, it is impossible to accurately balance the mount. There are some who propose an unbalanced system tracks better than a balanced one; it requires direct evidence, however, to make the argument. The counterweight bar should have a 20-mm diameter and an M12 thread on its end. This is a common specification across a variety of small telescope mount manufacturers.

If system weight is of more importance, e.g. for air travel, then take care to work within the load limit and pay attention to the stability of the tripod.

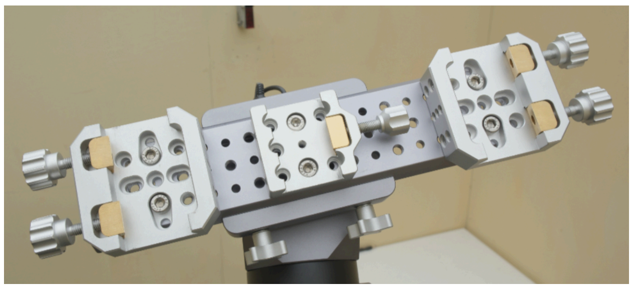
Dual Scope Setups

It is relatively straightforward to rotate the saddle by 90 degrees on its four fixing bolts and use either a Vixen- or Los-

By removing the four bolts on a 38-mm spacing and rotating the clamp by 90 degrees, it is possible to arrange two medium telescopes side-by-side, perhaps with a central guide-scope.



In either orientation, it is useful to level the dovetail clamp when it is homed, powered and in an Alt/Az orientation. This improves the accuracy of the initial slew. The digital level has a resolution of 0.1° but the bubble level is more sensitive, down to 0.03° (2′).



Here a slim Losmandy plate, with multiple M8 threaded holes on a 35-mm pitch works with a variety of clamps as well as directly with some Takahashi telescope mounting rings.

Neither the mount's USB or power cables lock in place and, as the connections are on the rotating part of the mount, it is possible for intermittent connections to occur during slewing and tracking. Here, they are sleeved in nylon braid to reduce the chance of catching on protrusions and are secured to the counterweight bar (or an M12 bolt) with a Velcro tie.™

mandy-based side-by-side arrangement. This arrangement will lift the entire assembly slightly, and increase the torque requirement. It works well with two medium refractors and a central guide-scope. It is useful to make sure that both the saddle-plates are perfectly parallel by aligning them to a straight edge, and that the mount's saddle is perfectly horizontal when in the home position (as described elsewhere).

In this dual-scope setup, the counterweights are an approximate offset for the load. The individual scopes are mounted at their approximate balance point and similarly, the balance point on the cross beam (with the two scopes mounted) was pre-determined on a bench. In this way, there is no high torque around the DEC axis in the unpowered state.

Cable Management

Loose cables have a habit of catching and causing hiccups during guiding. Where cables are connected between moving parts of the system, it is a good idea to secure them near the pivot point and use sleeving to minimize the risk of catching on knobs (e.g. azimuth knobs). Similarly, if cables require connecting from moving parts to the below the mount, sleeve them and support them at the top of the pier or tripod, to form a loop that has sufficient slack to work in all telescope orientations. If you have a single power cable from ground level up to the electronics use a large gauge multicore copper cable in a soft flexible silicone sleeve for minimum drag.

Power

WarpAstron specify a regulated 12V ±0.5 supply. This is not the same as a lead-acid cell or LiPo battery, whose nominal "12V" output maybe as high as 13.8V.

Many use a single high-quality switched mode power supply set to 12–12.5 volts and with a 6–12 A rating. In practice, a single, cooled camera system will, on average, take about 3.5 A. To make it safe, the power supply must be shielded from moisture, preferably in an IP65 box, with sealed cable glands for the mains cable (not a connector) and use high quality connectors for the power output. These power supplies often have an efficiency exceeding 85%. They only become mildly warm, and they should not overheat in a sealed box. It is not a good idea for the voltage to dip below 12 volts; NUC computers, in particular, shut down if their voltage dips below 12V (even temporarily). With this closer-than-normal tolerance power requirement, either use a dedicated power source for the mount, or trim the power supply carefully and use low resistance power cables. For example, 2.5m of 12AWG gauge copper wire may drop about 0.3 volts with typical operating currents.

Operation Basics

OnStep

OnStep was initially designed by Howard Dutton as a general purpose system for controlling a variety of telescope mount hardware to create a computerized goto mount. It runs on an Arduino micro-controller boards and is generously made open source. The project covers the microelectronics and software that reside in the mount and connect to the motors and sensors, as well as the design for a hand controller, observatory control, planetarium and web-server interfaces. There is a broad community of enthusiasts including self-builders and users. The OnStep project supports a wide range of control hosts including a hand controller, iOS/Android apps, web page, ASCOM (Windows), INDI (Linux), and I assume Alpaca (cross platform) over wired and wireless connections. Like many mounts from small companies, OnStep is compatible with the classic Meade LX200 protocol, which is found on many mobile apps and some computer ones too. Rainbow and Pegasus also use this protocol (hint).

In addition to a groups.io community, GitHub resources, and a Wiki, Howard's website is found here and includes a page for the latest ASCOM driver (which, unlike the controller code, is not currently open source):

http://stellarjourney.com/main/software-onstep-telescope-control/

The WarpAstron mount explicitly uses OnStep for its computerized control. Other commercial mounts also use this software as the basis of their products, but are less transparent. The WD mounts use what appears to be the standard OnStep hand controller arrangement and ASCOM driver, but the firmware is (as all implementations ultimately are) customized for their particular hardware. With suitable diligence and respect, and for the good of the wider community, Howard is receptive to new ideas and addresses operating concerns.

The handset is dinky and the top line of the display, from left to right, shows:

- Slew rate, as a factor of the sidereal tracking rate, or as a ratio of the max slew rate
- Guide rate, as fraction of the sidereal rate
- Mount status, including side of pier, tracking, park, home, and error status

Remember - *OnStep* hardware/software is slow. It takes a second or two to respond to any keypress and you need to be patient when tapping away on the hand controller.

Setting up for Visual

Before Use (specific Alt/Az configurations have their own chapter)

This mount, like many others, does not have a battery and it has no sense of time or orientation when it turns on. While it does have GPS, it may take several minutes to register, or not at all, depending on reception and interference (typically from USB3 cables). The last longitude and latitude are stored in memory and will be recalled and potentially updated by GPS. **Without knowing the essentials of time and place, however, the mount will not move.**

There is no explicit indicator of GPS activity on the mount or handset, but pressing the **H** button twice will bring up the currently assumed time. It will change to the correct time when the GPS signal is decoded. Alternatively, you can either use the settings menu, described in the following pages, to manually set the date and time, or use a USB connection and commands via a device driver using something like INDI or ASCOM standards to set the time and place. It is not advised to use the time sync function from the Android or iOS apps as it delays the connection.

The *OnStep* system assumes it is pointing at polar North when it powers up, which may be coincident with the home position. Once time and place have been confirmed, Unpark, turn tracking on and goto the Home position, either with the handset, remote app or attached computer. The mount now knows where to point, and safely (assuming you have set slew limits).

HOMING !!

Whether or not you are doing visual or imaging, if the mount is more than about 85 degrees away from the home position at turn-on, it may be necessary to Home the mount a second time (after turning on tracking for a few seconds) to ensure the mount slews past and back to accurately find the home sensors (WD20/P). This restriction reduces the likelihood of accidental slews into obstacles. (Setting the park position to Az 5, Alt 6, avoids this issue.)

Smart Hand Controller Instructions (SHC)

Based on source (https://onstep.groups.io/g/main/wiki/28605)

Starting Up

When the SHC is powered up an "OnStep w/Teen Astro" splash screen will appear for a few seconds then it'll tell you it's trying to connect. After a couple of seconds, if successful, the SHC will start displaying the status information across the top line (guide rate, pulse-guide rate, and a series of icons as described below) and the RA and Dec below that. If the connection is interrupted for any reason the SHC will automatically attempt to start the connection again. Not all USB C cables work with the hand controller. We collect charging cables with every purchase and some transmit power but there are no communications.

Button Functions

- **N** when tracking or Scroll Up while in Menu's
- **E** when tracking or Back while in Menu's
- **H** Short Press = Scroll Information screen,
  Long Press = Main Menu,
  Double Click = Feature Menu
- **W** when tracking or select current option while in menu's
- **S** when tracking or Scroll Down while in Menu's
- **F1** Decrease currently selected Feature
- **F2** Increase currently selected Feature

Key functions:

- When at the main info display page, pressing **N**, **S**, **E**, or **W** slews in that direction at the rate selected (see below).
- When at the main info display page, a click on **H** cycles through the display of RA/Dec, and Alt/Az, Time.
- When doing an align, a click of the **H** key instead accepts the align star once you've centered it using **N**, **S**, **E**, or **W**
- When at the main info display page, a double click on **H** brings up the Feature key selection menu, where you can change slew rate, guide rate with **N** and **S** keys. Pressing the **W** key at this point makes the selected menu item the Active Feature.
- Pressing the **F1** (decrease) or **F2** (increase) keys then adjusts the selected feature
- When doing an align, a double click of the **H** key instead allows selecting a different align star (after the goto to the prior align star completes). Also, during an align, the **F1** and **F2** keys work only for slew rate selection.
- A long press on **H** brings up the menus
- The **N**, **S** keys then move up/down the menu selections.
- The **W** key selects a menu item.
- The **E** key navigates back to the prior level.

Mount Status Icons

The small icon in the far top right of the hand controller display shows a variety of status:

Alignment Star #1

Alignment Star #2 (#3 thru #8 not shown)

Alignment Star #9 (last possible)

Telescope is at home position. Tracking is OFF

Unknown error. Tracking has stopped

Telescope position exceeds user defined Meridian limit. Tracking has stopped

Telescope position exceeds user defined RA limits "Under Pole". Tracking has stopped

Telescope position exceeds user defined Azimuth limits. Tracking has stopped

Telescope position exceeds user defined Declination limit. Tracking has stopped

Telescope limit sensed. Tracking has stopped

Telescope position exceeds user defined Horizon or Overhead limit. Tracking has stopped

Motor fault. Tracking has stopped

East side of pier. Declination is between 90 and -90

West side of pier. Declination is between 180 and 90 or -90 and -180

(PEC) - assume this is not supported on WD-20

Telescope is slewing

Lunar Tracking rate is selected

Solar Tracking rate is selected

King Tracking rate is selected

Sidereal Tracking rate is selected

Sidereal Tracking, refraction compensated, RA-axis only - not sure if this is implemented

Sidereal Tracking, refraction compensated (Dual-axis)

Sidereal Tracking, refraction and pointing model compensated (Full)

Sidereal Tracking, refraction and pointing model compensated (Full, Dual-axis)

Tracking is OFF

Telescope is guiding

Park failure

Telescope is slewing to park position

Telescope is parked

Menu Structure

The following is a map of the menu structure of the HC as of version 3.x.

- *Words that are in a italic font appear on the screen exactly that way (in the English-localized configuration).*
- Anything in square brackets provides information that does not appear on the screen and is an interpretation of what the function means.
- The indentation level is intended to reflect the sub-menu nesting.

Main Menu [H long press]

Goto

- *Stars*
- *Deep Sky*
- *Solar System*
- *User*
- *Filter*

Coordinates
Spiral
Last
Home

A Note on Homing:

[This will prompt for confirmation of model clearance. Use **N/S** to toggle Yes and No ('Yes' clears the model and returns to the home position, 'No' aborts the Goto Home command). If you do not want to lose the model because the telescope will not be moved since the last alignment you should use the 'Park' function.]

Sync

Stars
Deep Sky
Solar System
Here

['Stars', 'Deep Sky' and 'Solar System' will sync the telescope to the coordinates of the object selected without moving the telescope. You are expected to have centered the object already]

Align

1..n-Star Align
Resume Align
Show Model
Clear Model
Reset Home

[The WD17 mount does not have home sensors, but remembers the mount position when it is switched off. If this is corrupted, manually put the mount in the home position and use the Reset Home command to align it once more.]

Refine PA

Parking

Park

[move telescope to park position (default is home position) and save the alignment model in preparation for power down]

Un-Park

[when powered up at park position following use of Park command in previous session, restores the alignment model and starts tracking]

Set-Park

[used to define a custom park position to the current axis locations]

Tracking

Start / Stop
Sidereal
Solar
Lunar

[The following five 'Comp' selections are not available for Alt/Az mounts]

Comp Full

[compensate for atmospheric refraction and polar alignment inaccuracies]

Comp Refr

[compensate for atmospheric refraction only]

Comp Off

[turn off all compensation]

Comp Sngl Ax

[apply selected compensation only to R.A. axis]

Comp Dual Ax

[apply compensation to both R.A. and Dec axis]

Rate Reset

[Reset tracking rate to a standard rate]

[use the following to adjust tiny tracking rate errors due to gearing parameter inaccuracies]

Rate +0.02Hz
Rate -0.02Hz

Settings

Date/Time

[Set local date and time. Questions are asked about whether the time was AM or PM (if the SHC was configured with DISPLAY_24HR_TIME OFF) and whether the time was a DST-adjusted time]

Site

Select Site

[Select one of 4 user-defined sites. If the controller gets site data from a GPS, when received it is always stored in 'Site 1' with the name of 'GPS']

Latitude
Longitude
UTC Offset

[this is the inverse of your timezone offset, e.g. +5 for North American Eastern which is defined as -5 as a time zone. Do not adjust this for Daylight/summer time... the stars don't care about that]

Display

Buzzer

Meridian Flip

Now!

[If a meridian flip is possible at the current coordinates, do it now]

Automatic

[Should OnStep do meridian flips automatically when hitting the meridian limit when tracking from east to west?]

Pause at home

[When meridian flips go via the home position, should OnStep pause the telescope at the home position to allow the user to verify that no cabling is about to snag? If off, an error is thrown and tracking stopped when the Meridian West Limit is reached. Requires a button press to continue]

Configuration

Goto Speed

[Sets the Goto speed to 2x, 1.5x, 1x, .75x or .5x of the configured SLEW_RATE_BASE_DESIRED, respectively]

Fastest, Faster, Default Speed, Slower, Slowest

Backlash

[sets gear backlash for axis 1 and 2]

Axis1 RA/Az, Axis2 Dec/Alt

Limits

Horizon Limit

[Sets number of degrees telescope is allowed to point below the horizon while tracking or slewing]

Overhead Limit

[Sets number of degrees above the horizon that the telescope is allowed to point while tracking or slewing. This is important for Alt/Az telescopes especially because of the 'Dobson hole'. For others it prevents crashing the bottom of an OTA into a pier or tripod.]

Meridn Limit E/Meridn Limit W

[For GEM or FORK mounts, sets how close the telescope is allowed to track to the meridian before a meridian flip is required (tracking stops if meridian flip is not automatic)]

Pier Side

Best, East, West

Firmware Ver

Feature Key menu

[**H** button double tap. Select desired Feature **N**, **S** to scroll, **W** to accept then press **F1** or **F2** button to alter selected feature.]

Guide Rate (i.e. Slew Rate)

[Select guide rate between 2x and Max slew speed]

Pulse Guide Rate (i.e. Guide Rate)

[Select pulse guide rate between 1/4x and 1x]

Reticle

Handset Alignment Utility

The OnStep alignment facility on the HC gives the opportunity to slew to up to 9 stars and, having centered/aligned each star, updates a simple pointing model, which includes compensation for polar misalignment, cone angle and time errors. From the OnStep source code, it appears that after the first star alignment, subsequent goto/syncs do the same thing. I have asked the question on the OnStep group if this can be automated through the imaging application (e.g. NINA).

Handset Tracking Modes

The HC provides several tracking modes to accommodate solar system objects, Moon, stars, and King rate, which estimates atmospheric refraction.

Refraction Modeling

It appears that a basic refraction model, using typical environmental parameters, is used to compensate for atmospheric refraction, progressively altering the tracking rate at decreasing altitudes.

Wireless Control/Mobile Apps

The OnStep project has many options for wireless operation, not all of which are implemented in the WarpDrive mounts. Bluetooth is not enabled by default and requires the WarpAstron Mount Tool (wireless tab) to tool to turn it on (**note: iOS devices do not work with the OnStep Bluetooth serial protocol**).

The Mount Configure Tool (currently Windows only) is found on the tools page of the support tab on the WarpAstron website and points to a file on a Google drive:

https://drive.google.com/drive/folders/1o8hxf-BKK5Cdg1NX4vE8eR0GrUwJqgQBP

The OnStep Smart Web Server is not implemented within the mount, but there are plans for a mobile app to set up the mount. Currently, there is an Android app, OnStep Controller 2, available on Google play, which offers control over the generic mount settings but not wireless or limit settings (see below).

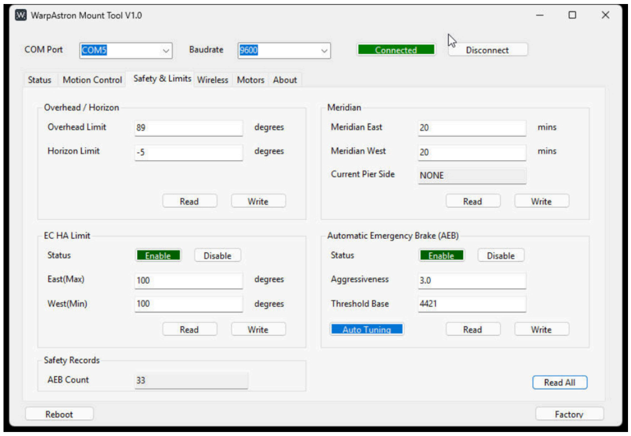
Direct Wireless Control

WiFi and Bluetooth are convenient ways of doing visual astronomy on the WD mounts. The lack of cables is not only useful for outreach events, but the capabilities of mobile devices far outstrip the meagre resources in the mount and its handset in regard to catalogs and user interface. The mount's default setting is WiFi. This is changed to Bluetooth using the WarpAstron Mount Tool utility **(for WD20 only)**. At present, Android users have a better overall experience and do not require the hand controller (iOS users still require the hand controller to initialize the mount before use). In general, the Bluetooth connection works well on Android and is recommended.

In each case, the mount is connected wirelessly to the mobile device and controlled with an app. In the case of WiFi, the SSID is *WARPDRIVE_24D04*, or similar, and its password is initially *12345678*.

iOS (iPhone/iPad)

For iOS, SkySafari, Stellarium, and Luminos are three favorite interactive planetariums featuring scope control. Sky Safari can connect to OnStep over WiFi using the Settings/Telescope/Presets menu.



The WarpAstron Mount Tool (Windows utility) allows one to set up some of the internal mount parameters **(WD20 only)**, including limits and braking. Some of these also appear in the ASCOM setup too, or are available as ASCOM commands. This is the place where you can change the wireless from WiFi to Bluetooth for mobile device operation.

- Scope Type: Meade LX-200 Classic (or Pegasus NYX).
- Mount Type, etc. should match up with your configuration.
- Disable 'Set Time & Location': as it causes long connection delays.
- For WiFi you will need the IP Address and the port (192.168.0.1 and port 9998 or 9999 are typically used.)

Luminos and Stellarium Mobile *Plus* have equivalent configuration requirements:

For example, in Luminos, the connection settings are in its Observe/Remote Control/Configure menu. In each case, first connect your iOS device to the WiFi being broadcast from the mount and, once you have the right settings in the app, connect to it. If the mount has not successfully found a GPS signal, it may be necessary to use the handset to set up the time and/or home the mount.

Android (Phones and Tablets)

On the Android platform Stellarium Mobile and SkySafari are favored by many. Android users also have a Controller App written for OnStep in which the user may usefully Configure, Initialize & Align the mount, Park, as well as find and slew to celestial objects. These include the Solar System, NGC/IC, Herschel 400, Messier, and bright star objects. WarpAstron plan to do a mobile app in the future.

Indirect Wireless Control

It is also possible to control the mount wirelessly via a local network (e.g. home router), where the mount is physically connected to a computer on the local network as well as the mobile device. In this case, this introduces a number of alternative connection protocols, depending on the physically connected computer (Linux - INDI, Windows - Alpaca/ASCOM).

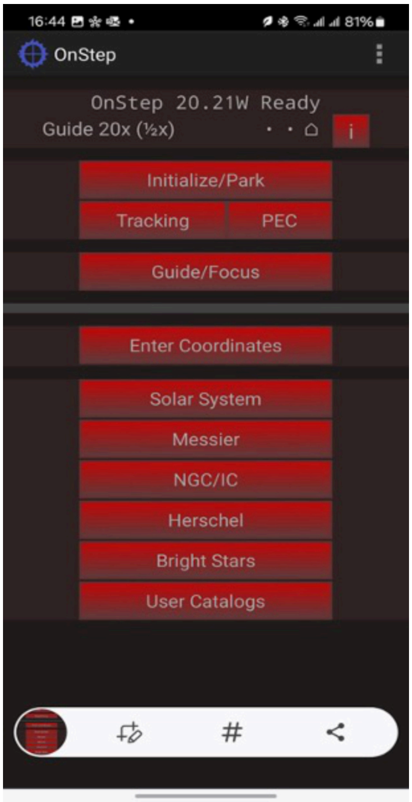
For users of Windows Pro or Enterprise, Microsoft remote desktop works equally well on Pcs, Macs, iOS and Android devices.

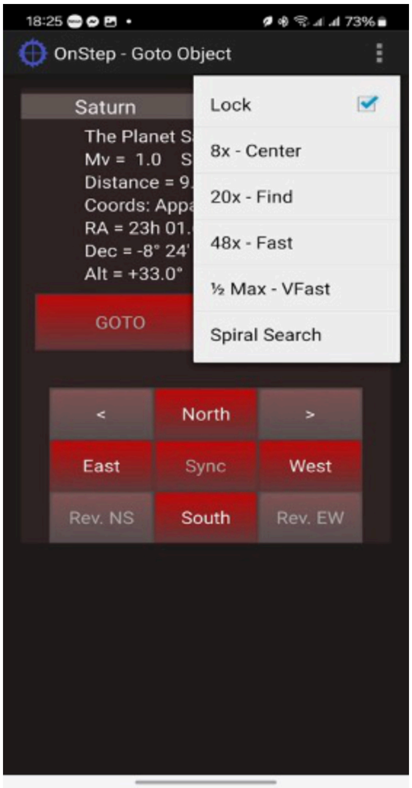
Initialization Gotcha

The WD mounts use the classic Meade LX200 protocol for wireless communications (which is also used by Rainbow and Pegasus). On the first connection, the QR code on the side of the saddle is scanned, which sets up the WiFi connection. The applications require an IP address and a Port number. This is usually 192.168.0.1 and 9998 respectively, and is also displayed in the ASCOM properties page. Although we have already established that an OnStep mount will not move until it knows the location, date and time. It is recommended to not turn on the 'Set Time and Location' or equivalent in the application telescope settings, as it causes connection difficulties. This requires a separate means of initialization; via the handset, OnStep app (Android) wait for the GPS to update, or through a USB connection.

HOMING !! (repeat)

Whether or not you are doing visual or imaging, if the mount is more than about 85 degrees away from the home position at turn-on, it may be necessary to home the mount a second time (after turning on tracking for a few seconds) to ensure the mount slews past and back to accurately find the home sensors (WD20). This restriction reduces the likelihood of accidental slews into obstacles. (Setting the park position to Az 5, Alt 6, avoids this issue.)





OnStep Controller2 (OSC2)

Android users benefit over those on iOS mobile devices from the OnStep controller 2 app, created by Howard Dutton, the author of OnStep. This is targeted at visual users but is also useful for those using mobile imaging devices, such as ASiair, which do not have access to some of the mount initiation settings (time, location, homing). This application works with WiFi and Bluetooth. Bluetooth is preferred, however, since the connection is more reliable and automatic after the first pairing. At the same time, it also frees up the mobile devices Internet connection. It appears the low-power settings put Bluetooth to sleep after a period of inactivity, but it wakes up soon enough with a second press of a button.

The mount does not work with WiFi and Bluetooth at the same time and its default state is WiFi. To change the wireless mode to BlueTooth, requires one to download the WarpAstron Mount tool (windows only) and change the mode (*Set BT Mode* and *Reboot* see dialog above). The mode is remembered when the mount is switched off. This appears to be the only way to make the switch.

Download OSC2 from the Google Play Store and install it on your Android device. You need to pair the device first then select the address your connection will be with; in the device's bluetooth section, press scan and click Warpdrive or similar. Accept the bluetooth pairing request and it should confirm connection. Exit, and open OSC2. The first time you connect, in the top menu (top right 3 dots) choose *Connection*, *Warpdrive,* and *Accept*. At the same time enable *Keep Screen On* in the top menu. The app will now reconnect upon opening the app.

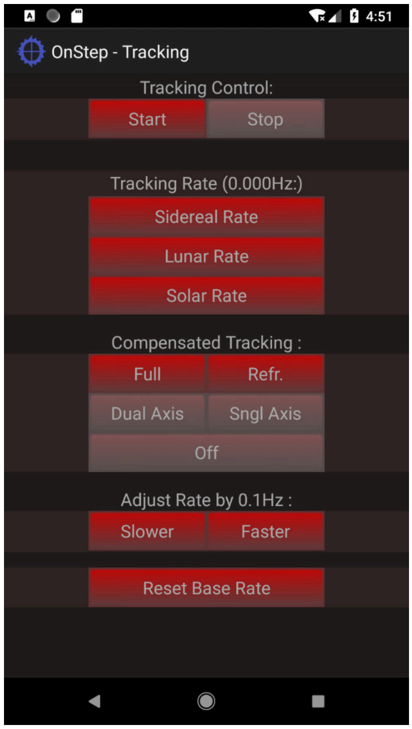
The app will reconnect upon opening; initially, the screen will show no connection, up to 15 seconds or so, after which it will report ready. If you do not use the app for a while and the device powers off, the connection is lost. Opening the app will reconnect automatically.

As mentioned earlier, the OnStep module in the mount needs to be initialized before it will move, irrespective of the control source. The recommended method is to home the mount before doing any slewing to targets. In the top menu, in *Goto Speed*, choose *Default Speed* (5°/sec). Back in the main menu, press the *Initialize/Park* button and, in this sub menu, press *Set Date/Time* and then press the *Return Home*. After agreeing, the mount homes and stops tracking. It is best practice to home the mount every time you switch it on; even if your park and home positions are the same and the mount is parked before powering off, it is possible for the DEC axis to move while unpowered, as it has no brake. I have noticed that the homing issue (homing accurately over 90 degrees) also applies to the OnStep app. If the mount does not hover around the home position, turn tracking on and then home again.

For visual use, it is useful to do a star alignment with up to 9 stars. Reduce the slew rate (in the menu) to something manageable and, after a rough polar alignment (say, with a compass and a digital level), choose the number of stars you want to align with in the *Initialize/Park* menu. **You must *Return Home* the mount first** before pressing *Start Align,* picking a star, hitting *GOTO* and centering with the *North, South, East, or West* buttons. Press and hold the *Align* button and accept the alignment point. Continue this for the remaining stars. More stars improve the pointing model to account for different errors e.g. polar alignment, cone angle, etc. Three stars are sufficient, providing they are selected from both sides of the meridian and are not too close to either the celestial pole or the meridian.

After doing the star alignment, the mount has an idea of where things are and it is possible to do polar alignment. In the main menu, slew to a bright star near the celestial pole and with a declination of 50–80º. In the *Initialize/Park* menu, press *Refine PA* and then *OK*. The mount will move to where the star should be if it was polar aligned. Now center the star with the mount's Alt/Az adjusters to polar align. It may be necessary to do another multiple star alignment afterwards.

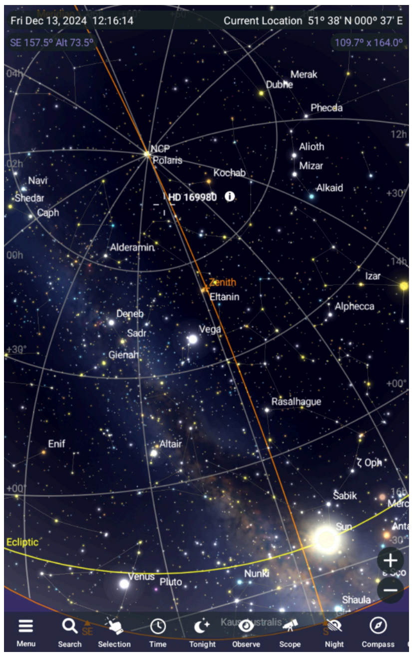
At high magnifications, say to locate a planet, the spiral mode is really useful. To find it in the eyepiece, in the top menu set the *Goto Speed* to *20x-Find*, and press *Spiral Search*. The scope will spiral from inward to outward at the speed you selected, when you find your object, a press of one of the control button stops further slews. Some of the other features of the app are duplicated in other utilities and wired protocols.



There are numerous tracking modes, both in OSC2 and the Hand Controller. More investigation is needed to find out if the compensated tracking is active in the WarpAstron implementation.

SkySafari

The OnStep application has a selection of Goto celestial objects, presented in list form, which may suffice. A more interactive experience uses a planetarium, such as SkySafari. To set up a telescope connection in SkySafari Plus or Pro; in Settings/Telescope/Presets choose Add Preset, Other Connection select Meade LX200 Classic (or Pegasus NYX-101), Next, Equatorial GoTo (German) - or Alt/Az GoTo, if that is your setup, Next, Connect via Bluetooth, Select Device, WARPDRIVE, Set Time & Location, Next, Save Preset. On the main screen tap the telescope icon and click Connect. (The Bluetooth connection to the WD mounts works just as swiftly with Set Time & Location enabled, as disabled.)



SkySafari (and Stellarium) work on iOS, Mac and Android.

Stellarium

In its various guises, Stellarium works over WiFi, USB and Bluetooth. Like SkySafari, it lacks home and parking commands. When connecting via ASCOM (either with USB or WiFi) a workaround is to connect to the OnStep ASCOM driver via the ASCOM device hub (installed with the ASCOM platform). The device hub has a park button (but presently, no home button). If you are linking via WiFi…..

Setting Limits

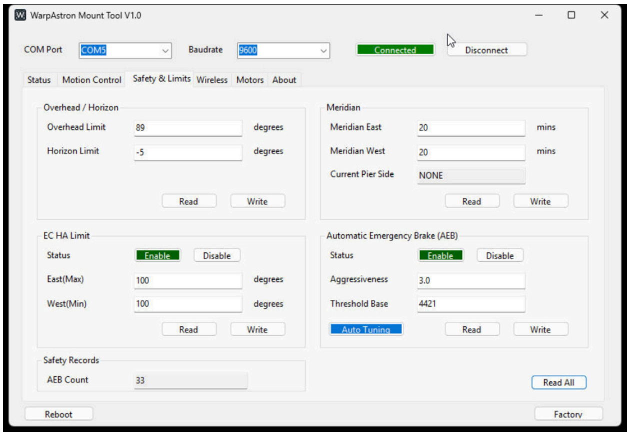
Limits are designed to prevent the mount slewing or tracking too far and causing a collision between the telescope and the mount support. The risk areas typically occur when the mount is pointing straight up, with the counterweight bar (or imaginary one) near horizontal. There are several different limits. The standard ones assume the mount knows where it is (i.e., it has been homed, synchronized with time and location, and the power has not been interrupted). These consist of Horizon, Overhead, Meridian E, and Meridian W settings. The Horizon setting prevents the telescope pointing into the ground. A negative value is below the horizon. A small value is useful for parking the mount with a low profile. The Overhead value prevents slews close to the zenith, which is another direction that has potential for leg clashes. (also see discussion on meridian flips)

Meridian East/West

The Meridian E/W settings are for when the telescope tracks past the meridian and counterweight bar starts to point upwards. There is usually no benefit going past the meridian too far and a +5 degree setting (equivalent to 20 minutes) in both cases is sufficient to manage imaging systems. The mount automatically flips when it tracks to the limit. If the OnStep meridian limits were set to +5 degrees, the meridian flip settings in an app, such as NINA, might be 4 and 12 minutes. This means NINA flips between 4 and 12 minutes past the meridian, corresponding to 1 and 3 degrees, and before it hit the OnStep meridian E/W limit. **The OnStep ASCOM properties also have meridian E/W settings and update the mount upon connection.**

EC HA Limit (WD20)

It is possible that the mount may lose its orientation for any number of reasons and there is a new safety limit introduced in the latest 20.21 firmware. It is not settable in the ASCOM properties but it is enabled and set up in the WarpAstron Mount tool. This is called the EC HA limit East (max) / West (min) in degrees. It works, irrespective of time and location settings (which may be incorrect) and takes priority over the other software limits. It requires the mount to be homed and then uses the motor encoder on the RA axis to work out how far it has rotated E/W from the home position. It should be set a little beyond the meridian limits, e.g. another 2°. For example, if the meridian limits



The WarpAstron Mount Tool is the only place to set the EC HA Limit and Automatic Emergency Brake (AEB) feature.

are set to +5 degrees, the HC limits should be set to; 90+5+2 = 97°. If 2° is too fine, move it out a little further to say, 5° and set EC HA limit to 100° (above).

Automatic Emergency Brake (WD20)

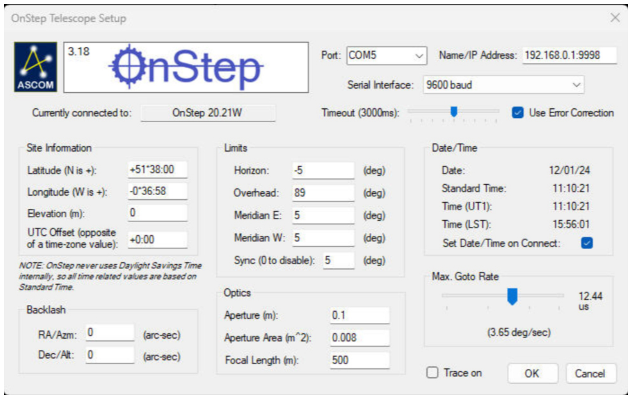
There is also a new safety feature called Autonomous Emergency Braking (AEB) that is set in the WarpAstron Mount tool (Windows). It effectively monitors the RA motor current and detects a stall condition caused by an obstruction. This current threshold varies with load and velocity. Please note, this feature does not prevent collisions but, with the right sensitivity, may detect a collision and stop slewing/tracking and move in the reverse direction to reduce potential damage. This should *not* be considered as a substitute for setting the software limits, it is more of an insurance policy.

The default AEB parameters may require modification for your system; they may be too sensitive and cause unintentional braking/reversing or not sensitive enough to quickly trigger AEB to protect your property in a real collision. Both these factors should be considered for any AEB changes in the tuning process (which is now largely superseded by the automatic tuning process in the latest version of the tool):

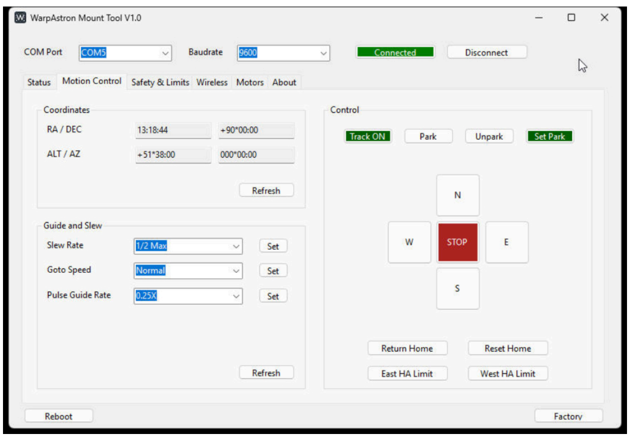
- You can always choose Disable AEB if you are having difficulties.
- The maximum slew speed affects the trigger. Although the WD-20 can reach up to 10°/sec with the latest firmware, a faster speed will more easily trigger AEB, and require a larger threshold.

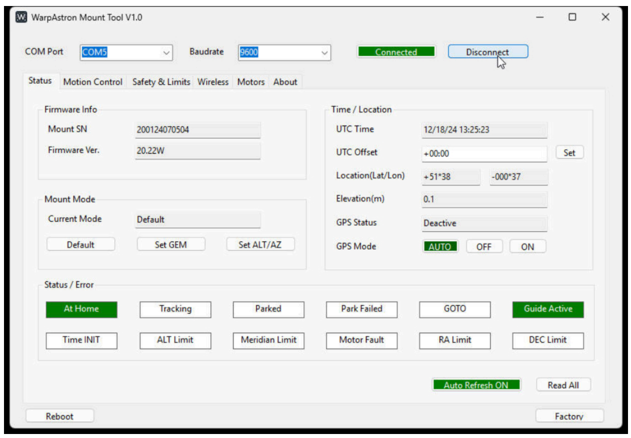
- Unless there is real need for fast slews, a slower rate of 5º/sec is recommended, set up in the hand controller, Android OnStep app, WarpAstron Mount Tool (described earlier) or some imaging apps.
- To test the AEB setting, first home the mount and then choose your normal Guide/Slewing speed.
- Manually slew the mount so that a counterweight bar would be horizontal. Ensure you have at least 10degrees safety distance between your system and the mount support (e.g. tripod, pier) in case an inadvertent reverse causes a collision.
- Home the mount, using Return Home on hand controller or home button on mount.
- If an AEB triggers, the mount stops and reverses, in which case increase the Aggressiveness value by 1 in the PC Mount Tool, and repeat the test.
- Repeat until there is no trigger event.
- The AEB Count is recorded in the Mount PC Tool and shows the history of AEB triggers. If this count is large or increases when nothing collides, it implies false triggers are occurring from an Aggressiveness value that is too low.

If the load significantly changes, or you change counterweights, the Aggressiveness will require tuning. **The Auto Tuning feature in the latest Mount Tool utility calculates the threshold for your system and updates the mount. It should be run each time there is a change in the load or counterweights.** An alternative is to tune, using your heaviest load, and those settings will work with lighter duties.



The various mount settings are confusingly partially duplicated and scattered across the hand controller, ASCOM driver (setup), WarpAstron Mount tool (Windows) and OnStep App (Android). The ASCOM driver setup allow one to set up the various software limits, slew rate, site information and instruct the driver to sync the mount time to the PC time when it connects. The guide rate is set up in the hand controller or via an ASCOM command. The IP address and port number, shown on the top right are used for mobile apps. The hand controller, OnStep App and a direct ASCOM command can set the park position to the current orientation.





The WarpAstron Mount Tool has expanded greatly with the latest version (Windows only at present). This now has parking, homing, and various slew and safety limits in one place.

Setting up for Imaging

Imaging is, in many ways, easier to do than visual use. It is entirely possible to do the full mount setup and initialization from a computer. There are few set-once-and-forget settings that are missing in the driver properties that require the hand controller, or a small utility.

Imaging is a big topic and as far as this manual is concerned, it will first take a look at setting up a physical connection on multiple platforms, before looking at mount-specific items of interest in the imaging applications. If you want an in-depth guide to astrophotography, I can obviously recommend one of my books: *https://www.digitalastrophotography.co.uk*.

The OnStep system that WarpAstron have adopted is based on open source code that runs on one of several Arduino boards. These boards, and the OnStep firmware, variously support USB, Bluetooth, and WiFi operation. These are not high-powered computers and their response times are not . For imaging, reliability is essential for sustained operation without drama; for that reason, a USB connection is preferred over WiFi. This also permits the host computer to use its WiFi for broadband connection and/or remote control. Small imaging computers are popular on portable rigs; Primaluce Lab and ZWO, for example, combine a small computer with integrated power and USB outputs on Windows and Linux platforms respectively. For the purposes of this manual, a USB connection is assumed.

These miniature computers work headless (without monitor, keyboard or mouse) and are typically monitored/controlled via WiFi or cable by another computer or mobile device. Others uses a combination of a small brick computer (e.g. NUC) and an intelligent imaging hub (e.g. Pegasus PowerBox), which is more flexible arrangement in the long term. Remote control is either by a general purpose (e.g. Microsoft Remote Desktop) or dedicated application, running on a PC, Mac, or tablet. One benefit of these small computers is that they run on 12 or 5 Volts.

Windows

If the mount is connected to a Windows PC, it will require the ASCOM platform and the OnStep ASCOM driver. Like many devices that have simple control protocols, the WD mount uses a Virtual Com Port for its USB connection. First, load the CP2102 USB-serial driver, (from the manufacture'r website or from WarpAstron's support page) and then connect the mount via a USB cable (USBC–C or USBC–USB2/3). In the Windows Device manager, locate the serial port and in the advanced properties, assign a static COM port number for the connection. This prevents Windows changing the port number and causing the mount ASCOM connection to fail. At the same time, for imaging use in general, disable all power saving and sleep features in the Windows advanced power management setups.

Update the imaging computer to the latest ASCOM platform (now 7.02) and then install the OnStep ASCOM device driver, now at 1.0.43. The latest version and revision history is on the OnStep author's website (see resources). The baud rate is fixed at a sloth-like 9,600 baud into a USB-C connection or, if the mount has its WiFi enabled, connect to the mount via WiFi (using a USB WiFi adaptor).

The first connection to the ASCOM driver requires an initial setup, to select the COM port and essential settings. These include software tracking and slewing limits, slew rate (called Goto Rate) **and the enable the *Set Date/Time on Connect* to synchronize the computer clocks.** Computer clocks are notoriously inaccurate; they often rely on an Internet connection to update each week. A regular time synchronization with an NTP server is more accurate. The free utility Dimension 4 is a favorite. Some imaging applications compare the mount's time and location with the computer's and offer options to synchronize one way or the other, or go their separate ways. Having the same (accurate) timebase improves pointing accuracy and reduces the chance of side-of-pier ambiguity when it is pointing close to the meridian.

The ASCOM homing and parking commands appear in many imaging and planetarium applications. **If the mount is further than about 85° from the home position, when it is powered on, a *FindHome()* command, issued by the application (or homing from the handset) will NOT guarantee that it accurately finds the home sensors (WD20). The mount will incorrectly report it is homed, and it will affect subsequent Slews (and Parks).** The work-around is to home a second time, after turning on tracking for a few seconds. Since the mount is already close to the home position, it will hover and find the sensors (WD20). Homing twice has no detrimental effect. (This is also the case for homing via the hand controller or the OnStep Android app.)

ASCOM7

ASCOM 7 was released in late 2024 after an extensive consultation period. It introduced a number of new asynchronous commands to the standard commands. These are intended to allow software to get on with other things rather than wait for something to complete (like a slew or a focuser moving). Included in these are a number of telescope mount commands, typically around slews, homing and parking. The ASCOM standards now have both legacy and new commands for the same movements, to support older and new drivers. There are a few remaining gremlins and it will take a little while for the imaging applications and ASCOM device rivers to settle down. One of those gremlins caught out the OnStep ASCOM driver and it required an update in December to fix it.

INDI

INDI provides a standardized astronomy application-specific interface which then passes the traffic to OnStep across USB (Serial), IP (WiFi or Ethernet) or Bluetooth (Serial). Linux is a very efficient OS and the Raspberry Pi (RPi) operating system. The beauty of the RPi ecosystem is that you can get a complete system, with OS and apps, as a single download and run from an SD card. It is a bit too slow for astrophotography use and there are Linux distributions that run on Intel and AMD hardware. On the Intel NUCs, I have a small M2 SSD drive with Linux on and another with Win11Pro and it is simple to switch between them.

The OnStep INDI driver is built-into the INDI Library, which is part of the standard load. Apps such as KStars, Ekos, CCDCiel, and others connect to physical devices through INDI server. OnStep uses the LX200 protocol. Kstars/Ekos make it easy to select the driver and connect. Other apps, such as CCDCiel or Cartes du Ciel (CdC) may require INDI starter, to set up system profiles and kick off the INDI server.

For support for OnStep INDI, check the OnStep topic on the INDI forum. INDI can control OnStep over USB Serial or WiFi using port 9998 and the LX200 protocol.

This is a common command set used to talk to OnStep across WiFi/Ethernet or USB/Serial or Bluetooth/Serial.)

INDIGO

As you might be able to decipher from the name, INDIGO is a development of INDI, which purports to be more efficient (useful on the meagre RPi.) version of INDI. It has native support for INDI, but I have not had a chance to try it in anger for reporting out.

Remote Operation

Remote operation has many benefits including; it deprives mosquitos of lunch, allows small and/or low-power computers to reside and connect to equipment, to run different operating systems for client and host computers and manage multiple systems from one computer. Remote operation requires a protocol; Microsoft Remote Desktop is popular, free and runs on multiple platforms. StellarMate comes with noVNC, which permits any browser to operate its system (running headless), either by an automatic adhoc wireless or a router connection.

INDI, INDIGO and Alpaca also permit a distributed computer system. This allows the heavyweight apps (imaging, planetariums) to operate on the user's machine and the low power RPi of similar, to connect to the astro devices. There are too many alternative architectures to explain here but, fortunately, there are plenty of online resources to explain how to do this. I generally prefer Macs over PCs but use PCs for astrophotography. I have done astrophotography with Linux but have no compelling reason to switch, as the best of the free Linux applications are also available for Intel architectures. Kinda the devil you know!

Imaging Application Setups

Imaging applications typically connect through either ASCOM (Windows), Alpaca, or INDI/INDIGO (Linux). Most of the generic connection processes have been discussed and, for the popular imaging applications, the information below solely highlights unique aspects relating to the mount and assumes the user already has a working knowledge of the application.

Meridian Flips (general)

Meridian flip settings are confusing; there are meridian flip settings in the mount, ASCOM properties and in the imaging application, all of which interact with mount safety limits. A meridian flip occurs when the telescope tracks **East-<>West,** either pointing **North or South**. The mount does a 180° slew in both RA and DEC, so it is pointing at the same target, but flipped over, allowing it to continue to track without the rear end of the imaging system colliding with the tripod/pier.

For imagers, you need to consider:

- Mount EC HA limit (Warp Astron Mount Tool, in degrees)
- Mount meridian East/West settings (Warp Astron Mount Tool, in minutes) and …
- same equivalent values (in degrees) in the OnStep ASCOM properties' meridian E/W settings
- imaging app's meridian flip settings
- and.... importantly, your mount's safe operating zone
- Mount Pause at Home setting in the OnStep HC (this pauses a meridian flip at the home position and prevents automatic carry on through).
- Side of Pier setting in Settings/Configuration menu in Hand Controller must be set to *best*.

Note: The OnStep ASCOM limits override those set by the WarpAstron Mount tool. When passing under the pole, OnStep stops on the meridian and does not flip (i.e. a high declination target going from West to East in the Northern Hemisphere). There is another limit setting but at present, it is not available to Warp users.

These various setting values must occur in a certain order for the system to work: EC HA Limit > Mount E/W setting > imaging App's meridian flip settings.

Best Practices:

- Avoid putting meridian flip settings on the meridian itself. It is an ambiguous position and often causes confusion when different parts of the imaging system have a different side of pier status.
- Flipping needs to consider the flip to position. There is no point flipping early, only to cause a crash on the other side. For that reason, it is often best to have similar settings for East and West.
- There is little benefit of going a long way past the meridian before flipping. A flip limit just longer than your longest exposure time is often best.
- Note the unit of the flip/limit setting. 1 degree = 4 minutes (time)
- Check out your worse-case setting value by manually slewing to the RA position and then slewing in Dec to ensure the back end of the telescope/camera/filterwheel does not collide with anything. Do this for the worse case filter wheel orientation too.

Suggestion: (assuming NINA/ASCOM)

- Mount EC HA limit (100 degrees, i.e. 10 degrees past meridian)
- ASCOM meridian E/W setting (5°) - equivalent to 20 minutes in the Mount tool
- Imaging app flip point e.g. NINA max mins after meridian (10 minutes i.e. 2.5°)
- Imaging app flip point e.g. NINA mins after meridian (5 mins, i.e. 1.25°)
- Disable *Pause at Home* setting in Hand Controller
- Disable *Pause before meridian* in NINA options

A note on Nina's Pause before meridian setting

For some setups, the equipment may touch the tripod or pier a while before passing the meridian. This pause setting enables the mount to disable tracking for the defined minutes prior to reaching meridian. Once this time and the defined minutes after meridian are passed, the flip will occur normally. Only set a pause time, when your equipment cannot pass the meridian safely. If your equipment can safely track until the meridian flip time keep this setting at 0!

If these limits are safe for your setup, in this NINA example:

- Nina will image up to and past the horizon. It will not start an exposure if it cannot complete before 10 minutes past the meridian, so, if an exposure ends 6 minutes past the horizon, it will flip, centre and carry on.
- These limits come into play before the mount's automatic flip point of 20 minutes past the meridian and well before the 10° fall back of the EC HA limit.

Note: In the later versions of NINA, the imaging sequence requires an explicit meridian flip instruction using the meridian flip trigger.

- The NINA settings above do not pause imaging if the exposure duration is less than 300 second.
- For telescopes with moving mirrors, you may additionally ask the Nina to automatically center/focus after a flip.
- If you have a more restricted system, which cannot image close to the meridian without a potential collision, change the mount settings and additionally instruct the imaging application to pause for a period of time until it is safe to flip over to the other side.
- It is best to attend any setting trial for potential intervention in the case of an incorrect setting! This can be done in daylight with a dummy sequence.

If in doubt, refer to the Meridian Flip settings in the Advance Topics tab of the official NINA documentation (P138):

https://nighttime-imaging.eu/docs/develop/site/pdf/Manual.pdf

Working with Apps

NINA (Windows)

NINA uses both ASCOM and its own drivers (typically for cameras) to connect devices. It uses ASCOM for mount connections and its mount controls include homing, parking, slewing and setpark. Its advanced sequencer offers the ability to embed a double homing command into an instruction sequence and overcome the potential OnStep's Homing Achilles' heel. Here is an outline of an observatory initialization instruction sequence:

connect mount
connect roof
open roof
unpark mount (likely redundant, but does no harm)
tracking on (likely redundant, but does no harm)
home mount
tracking on
wait 5 seconds
home mount
park mount
wait for dusk

There was a bug in an earlier version of the OnStep ASCOM driver which caused the latest NINA nightlies to believe the mount had homed while the mount was still finding the sensors (WD20), and in so doing, potentially corrupting alignment. That has been fixed in the latest OnStep ASCOM drivers on the author's website. The current version on the WarpAstron support page is not the latest.

APT (Windows)

APT supports ASCOM, INDI and INDIGO. It supports Parking, set Park and Homing. The latter two are accessed with a *shift-click* and *ctrl-click* of the *Park* button in the telescope tab.

Sequence Generator Pro (Windows)

SGP uses ASCOM for its device connections. Its telescope control panel has a park command, but no home command. A solution is to also connect a planetarium, such as CdC or C2a, which have more comprehensive control panels with homing, parking etc.

TheSkyX (Windows / Linux / OSX)

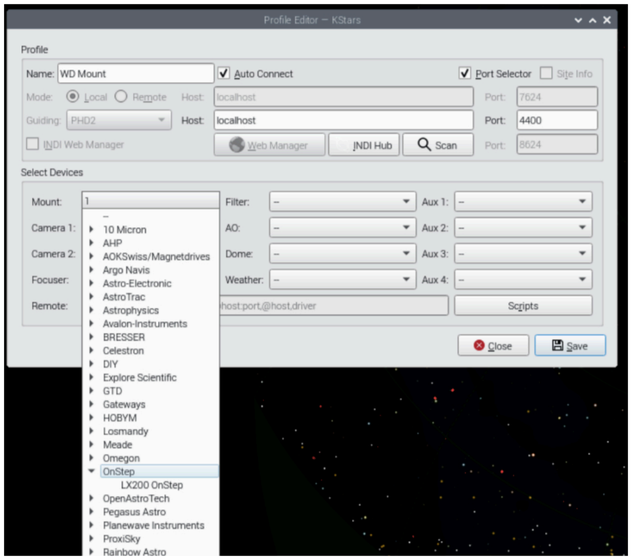
TheSkyX uses ASCOM and its own proprietary X2 protocol for device connection. A link to the OnStep X2 driver is in the resources, which now works with the WarpAstron mount. TheSkyX is optimized for their own mounts, and there are no homing or parking buttons in the telescope panel when other mounts are connected. The OnStep X2 driver overcomes this limitation by putting parking and homing functions in its driver setup page. If you want to use an external imaging application (e.g. NINA), TheSkyX imposes several limitations. Currently any external homing and parking commands, via TheSkyX's X2 ASCOM adaptor, are ignored and raise an exception, as are guiding commands from PHD2. This is annoying; one cannot automatically connect and initialize the mount via TheSkyX and make use of its TPoint capability. One partial workaround is to call the VBS script, listed in the resources, within NINA's advanced sequencer before connecting to the mount using the TheSkyX ASCOM X2 driver. This overcomes the homing problem, but requires a workaround to automatically park during bad weather and Software Bisque to implement external guiding commands in their API for non-Paramounts. (Don't hold your breath.)

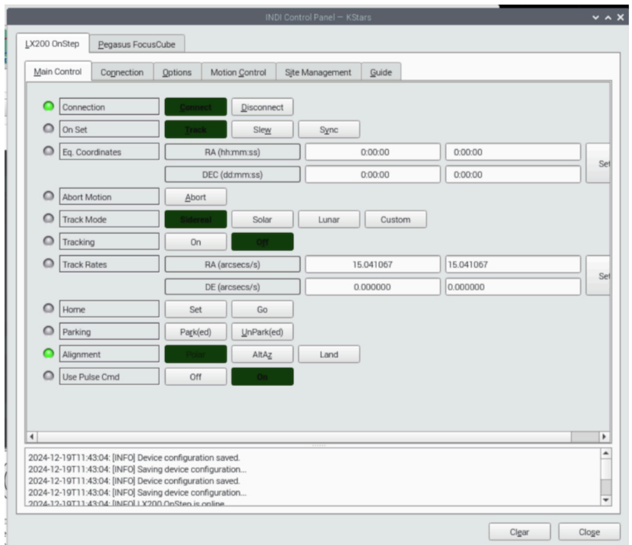
SharpCap Pro (Windows)

The Pro version of SharpCap has a very useful Polar Alignment utility. Compared to using PoleMaster, it is faster, works earlier in the evening and is slightly more accurate. SharpCap uses a mixture of its own drivers and ASCOM for cameras and mounts. The polar alignment routine takes an image of the polar region through a telescope/guide scope, plate solves it and then plate solves again after it has rotated 90°. My utility application sets this up automatically; it homes first and then moves -45°. A second button moves +45°. Press twice in succession for SharpCapPro and press once for PoleMaster and again, for the third reading.

KStars/Ekos (Windows / Linux / OSX)

Initially designed for Linux, this is the basis of the free AstroBerry Server RPi astrophotography distribution (*https://www.astroberry.io*) and StellarMate(RPi and PCs) (*https://www.stellarmate.com*). The KStars planetarium works best on a big screen and its integrated Ekos imaging module is easy to work out and hides a lot of the command line geekiness that Linux users revel in. The device drivers are al-





The Kstars/Ekos profile editor has a simple menu to select the LX200 OnStep device and additional controls for homing and parking. Here, the app is running on the computer that is USB-connected to the mount. This Linux distribution also permits remote operation with a virtual network.

ready included in the Linux distribution and it is relatively straightforward to connect to your various imaging devices. For example, in the telescope selection tab, select *OnStep- LX200 OnStep* and then press connect.

You can also synchronize date, time and location directly in Ekos settings, select the "INDI" panel, and check the "Kstars updates all devices" option under "Time & Location Update". Also, check the "Time" and "Location" options on the right side.

CCDCiel (Windows / Linux / OSX)

This relatively new imaging application is written by the author of the popular Cartes du Ciel (CdC) planetarium. Its user interface is friendly and easy to navigate on a small screen. It supports ASCOM/INDI/Alpaca device connections on Windows, Linus and OSX platforms. CCDCiel and CdC on Linux also connect via the INDIserver, after INDIstarter is run.

C2a/CdC

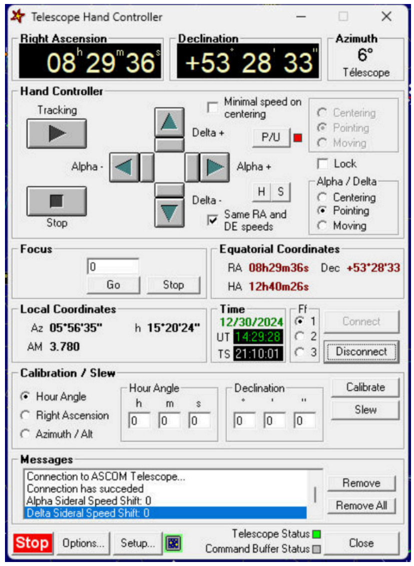
These planetariums are available for Linux and Windows systems. (I'll pass on OSX for now.) While these are not imaging applications, it is often useful to have them connected to the mount at the same time as the imaging app, for instance to position the scope for guider calibration, flats etc. The home and park implementations on these apps are patchy.

Stellarium Plus and SkySafari Plus/Pro draft

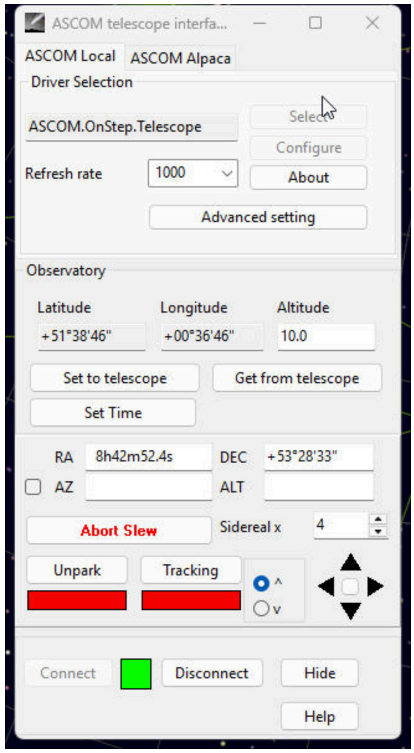
While not directly associated with imaging, it is worth repeating here. These mobile apps work on iOS and Android devices and the paid versions additionally control a telescope mount. As previously discussed, the best experience is a combination of BlueTooth and Android (which, significantly, also supports the OnStep App). iOS devices require a WiFi connection to the mount and is less robust in tests. If you are setting up the mount with a mobile device, it is still possible to control it via USB with an imaging application. The mobile apps typically have slew and goto commands but have no park or homing control. On Android, the OnStep app is ideal for filling this omission.

Working with AsiAir

The AsiAir is a popular portable imaging solution for many setups. WarpAstron have a large user-base using AsiAir with WD mounts. Designed by ZWO, it works best in a ZWO environment but also works with other equipment, including a growing number of telescope mounts using OnStep. There are issues with some AsiAir implementations that may lead to a coordinate system errors causing a wrong target slew, home position, or failure of the mount's limit protection. Some users report that ASI updates since Q1 2024 no longer have issues. The advice is to monitor the operation of the equatorial mount throughout the ASI-AIR operation and take immediate emergency actions such as stopping or powering off when encountering the above issues.



The C2A planetarium telescope control panel has homing and parking buttons, but the homing is not working.



The CdC planetarium telescope control panel has parking controls and also time/location synchronization.

The AsiAir cannot do the mount initialization and once the software is connected, it works best without interruptions from other sources (HC, WiFi, Bluetooth). There are some limitations of the AsiAir system, which are particular to a few mounts, but it is not certain if/when ZWO will address these.

Setting Up AsiAir

The following is a summary of a CN post by MarkusF:

- Choose the 'OnStep Electronics' driver rather than the 'OnStep' driver and control everything exclusively through the AsiAir+, after an initial mount synchronization.
- Enable the Automatic Homing option in ASiAir
- Connect everything (including the AsiAir and the hand controller) and turn on. First, ensure the mount has updated its time and location (GPS, Android App or HC) then *home* the mount with the HC, app or a button press on the mount's front panel.
- From now on, only use ASiAir
- *Sync* via AsiAir.
- Short slew via AsiAir and *home* via AsiAir, then *sync* again.
- Calibrate the guider, by slewing to an object in the East and at low declination and run the calibration routine, using short exposures.

Synchronization

It has been observed that, regardless of the mount type, the AsiAir can forget its position, which ultimately leads to a potential crash. For that reason, it is a good idea to *sync* after performing a goto operation from AsiAir's Sky Atlas or after a homing operation.

AsiAir Polar Alignment (PA)

AsiAir's All Sky Polar works but remember to then home and sync. Perform a home in your ASIAIR mounts control panel first after powering the mount, then enable tracking, use manual control to move the mount a bit, and home again. After that, you can perform the polar alignment without the issue. With a little care, AsiAir's Normal PA also works; if the mount is still moving after the 60° slew, it ruins the first plate-solve. If so, refresh and it should work smoothly, including homing. (Remember to sync in the home position.)

If you encounter issues such as the mount not moving or moving incorrectly during PA, do not cancel or exit the app, but wait for the polar alignment page to report an error. Then, perform the mount homing and restart the polar alignment process.

Guiding

Just Tell Me!

For those impatient to try something out, here is a PHD2 guiding recommendation:

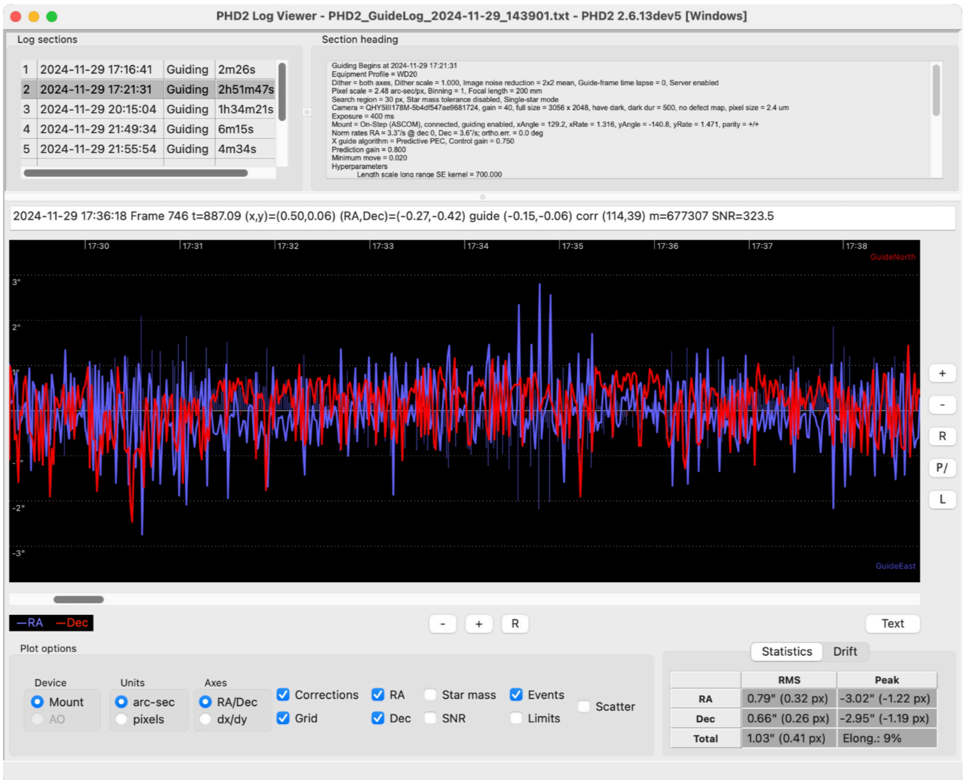
- 50-mm guide scope or better (200mm focal length)
- CMOS guide camera, USB3/C with small pixels ~2.5 µ
- PHD2 settings - single star, subframe on, 0.5 second exposure, pulse-guide (rather than ST4)
- RA algorithm set to PPEC, 80/75 predictive/reactive weight, minimum move set to 0.02, period 359 seconds, auto adjust enabled
- DEC algorithm set to Z-filter, factor 8, min move 0.05 pixels
- Enable reverse DEC after meridian flip

Why? Read on.

Guiding Basics

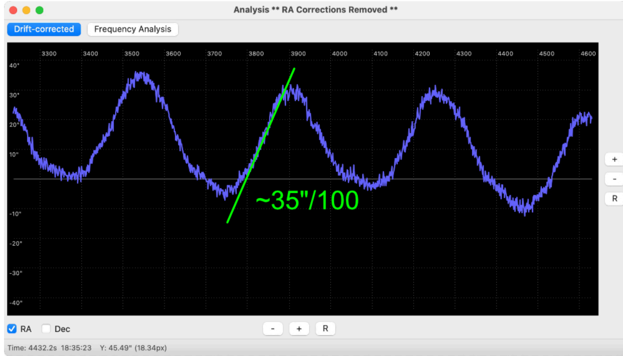
Guiding is requirement for most mounts, even those with encoders on their axes, but it is a necessity with harmonic drives on account of their obvious tracking error. This tracking error has a very definite cyclical nature, very much like classical Periodic Error (PE) on a worm-drive mount, but with some variations over time and with load. Some claim that harmonic drives do not have PE as these variations make classical Periodic Error Correction (PEC) tricky to do well. These variations, however, are a fraction of the principal cycle and for practical purposes, harmonic drives have PE. Some harmonic drive manufacturers have chosen to implement a basic PE to remove a significant proportion of the cyclic error. On a sample WD20 mount, the PE has a period of about 359 seconds and a peak to peak magnitude of about ±20 arc seconds. This is remarkably similar to the performance of other harmonic drive mounts. (In comparison, I have owned several worm drive mounts with PE ranging from ±1"to ±60".)

This amount of PE has interesting consequences. First, if the PE is changing by 40" over 5 minutes, there is less of a compelling reason to accurately polar align to reduce drift! The peak-to-peak magnitude is the headline, but not the whole story. The rate of change of the tracking error is critical, as this is what the guiding system has to



The free utility PHD2 Log Viewer, available from the PHD2 website, is a useful analytical tool, which reads the PHD2 guide log and can highlight key areas of performance.

keep up with. The useful utility PHDLogViewer can display the underlying mount tracking error by analyzing a PHD2 guide log file. This exposes the cyclical error and it is easy to use the cursor to measure two points around the steepest slope (the fastest rate of change) and work out the rate of change. Over a number of days, my WD20 mount measured 0.4–0.5 arc seconds/second. (In comparison, the worse case drift rate from a 5 arc minute polar misalignment is ~0.5 arc seconds / 30 seconds.)



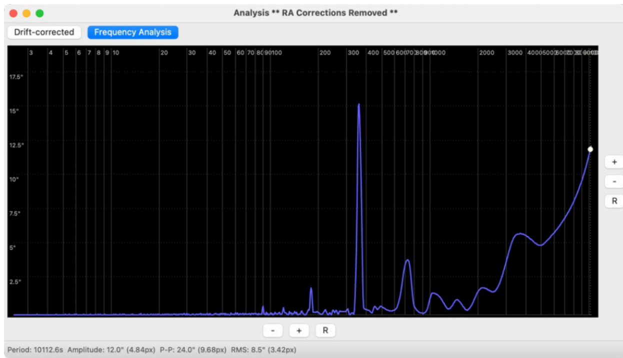
Right clicking in PHD Log viewer shows underlying tracking performance. It is possible to measure the maximum rate of change of the RA tracking error. Here, it is about 0.35 arc seconds per second.

Compromises

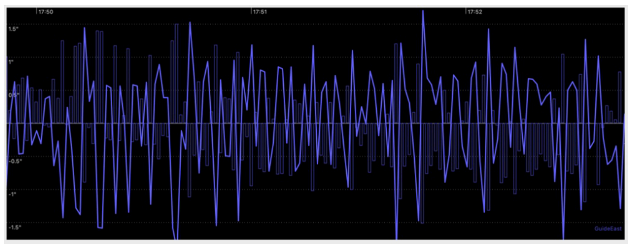
The rate of error change determines the frequency of the guider corrections. Too infrequent, and the guide system is playing catchup, in alternating polarities, for most of a typical 300-second exposure. Extremely rapid guiding is difficult in practice, as it requires a fast camera download, image processing and responsive mechanical correction. The brief exposures additionally require a bright guide star(s) in the field of view to allow accurate centroid calculation in the presence of sensor read noise. Lastly, rapid guiding is at the mercy of atmospheric conditions. If you compare the guide graphs for 0.5-, 3- and 10-second exposures, carried out in quick succession, it is clear to see that the apparent tracking error is worse with short exposures, as a result of atmospheric seeing. The actual underlying tracking error is identical in all three.

The current thinking suggests that guide exposures of 0.3 —1.0 seconds are a good starting point. If the best you can achieve with 1-second exposures still shows evidence of lagging behind, then try 0.5 seconds. The exposure time is one consideration. The others are the choice of guiding algorithm and its settings. This is where these instructions may be contentious to some, but the best recommendation is to give alternative strategies a try for an hour or two and look at your actual images (not just PHD2's RMS value).

The high torque motors in harmonic drives are highly responsive to guide inputs and, unlike some larger (and often older) worm-drive mounts, have virtually no backlash and can make very small adjustments (i.e, correction durations of less than 20ms). For these reasons, it is tempting to "abuse" them with rapid guiding commands at 100% guide rate and for DEC, in alternating directions too. We have all probably done just this at some point and got ok results. Now, an analogy; if you were driving a car at 100



Another option is to display the frequency plot of the tracking error. Here, the WD20 mount has a dominant PE cycle of about 360 seconds. The harmonics are considerably less, demonstrating that PEC is not only a practical proposition on this mount, but would remove much of the principal tracking error.



An RA trace, with corrections, will show if the mount is lagging behind, or if the corrections are too extreme. Here, the corrections are occurring in both polarities, keeping the tracking error within ±1.5". This suggests that it is largely responding to seeing conditions. The trace will generally shift up or down if it is lagging behind the PE.

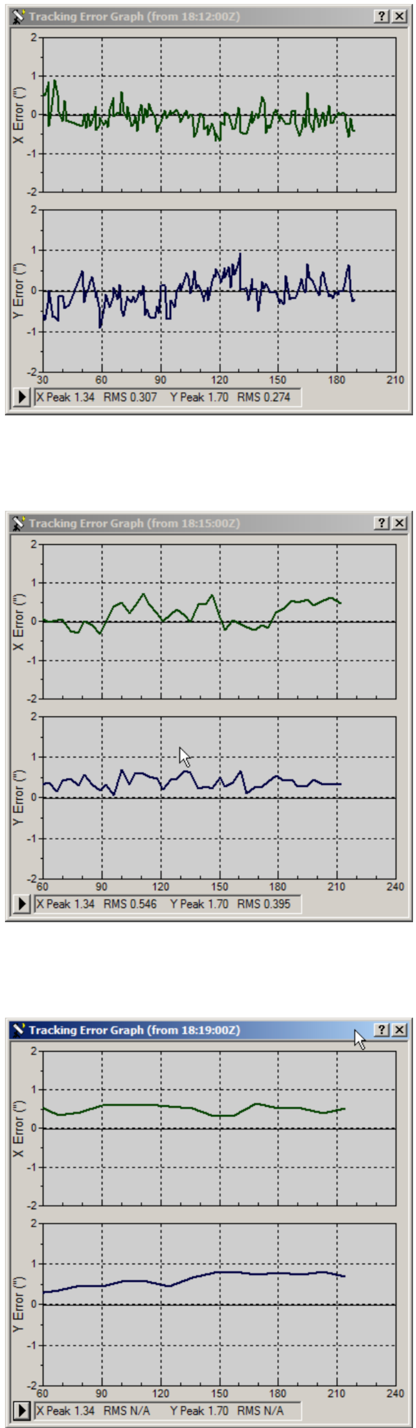
km/h, at half throttle, and wanted to reduce your speed to 50 km/h, would you alternate between hard braking and 100 km/h twice a second... and then, to catch up, a few seconds later, put your foot to the floor? (Please, no jokes about BMW drivers.) This highlights a general principle in dynamics that proposes the best control systems waste the least energy in their mechanical system. The perfect scenario for a telescope mount would be a control system that continuously and smoothly modified the motor speed to counteract the mechanical gear error. Guiding systems, however, are not continuous, they are largely retrospective, discontinuous, and digital in nature. My chapter on guiding in *The Astrophotography Manual* and the WarpAstron forum post by Markus, based on a paper by Chen, have far more detail. In essence, the nearest we can get to a smooth analog adjustment is to set a low guide rate (0.25x, or lower, if it becomes available) such that the corrections almost run into one another (i.e. continuous) and individually have less impact on the instantaneous speed change of the motor. If you have been using 0.75x or 1x guide rates, it is interesting to try 0.25x and reduce the exposure duration to about 0.5 seconds. The RA tracking should improve slightly, and the DEC error should be be much better than before.

Starting Points

If, say, we now have two pieces of the jigsaw puzzle, say 0.5 seconds and 0.25x or 0.5x guide rate (set by the hand controller or via a computer command (e.g. ASCOM or INDI), we still need to calibrate and select the guiding algorithm and settings. In recent years PHD2 has added several new guiding algorithms to its suite. A guiding algorithm is the link between the centroid measurement(s) and the guide output. It is fair to say that different mount architectures favor different algorithms and those that were in favor 10 years ago, with spur-geared worm drives do not work well with direct coupled strain wave motors. Some algorithms are specific to either RA or DEC axis and some are equally viable on either. The DEC and RA axes do not have use the same algorithm and it is important to understand the mount's behavior to home in on the best choice.

For mounts with significant periodic error, the Predictive PEC or PPEC algorithm is particularly useful for RA guiding. Guiding starts with a standard hysteresis algorithm and progressively substitutes individual measured corrections to a predicted correction learned from several motor cycles. The result is, after

The DEC trace, using Z-filter, for a well PA aligned mount. Note that the correction pulses are few and far between, indicating that the guiding commands are only issued when really needed.



Successive traces from an guiding application (in this case, Maxim DL) for an unguided mount, that has excellent PA and low PE, using 0.5-, 3-, and 10-second guide exposures. Short exposure "tracking errors" are mostly an indicator of atmospheric seeing.

10 minutes or so, the corrections are predominantly based on a predictable smooth computed periodic error and are less sensitive to atmospheric seeing on individual measurements. The hysteresis element is never entirely disabled; it remains and mops up residual errors. The contribution aggression of both corrections can exceed 100%, as the hysteresis component is merely looking at a percentage of what remains. The algorithm works best in long term and resets its prediction after a meridian flip or a sustained interruption to tracking.

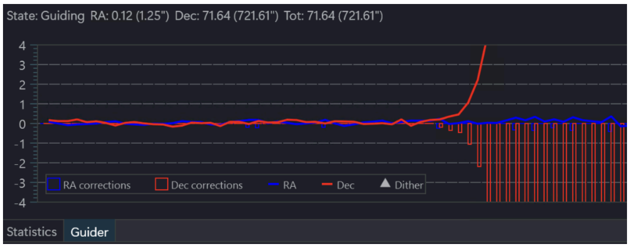
If the RA corrections are clearly not keeping up with the guide error and the guide pulse lengths, shown in PHD2 (or the log viewer), are longer than the exposure duration, increase the guide rate to 0.5x, recalibrate, and try again.

For the DEC guiding algorithm, we can be more contentious. If the mount was perfectly aligned (and there was no atmosphere) there would be no drift or need to guide the DEC axis. If only. In reality, there will be a slow steady drift, and since this mount has negligible backlash, it should only require an occasional guide pulse to keep it steady. The challenge is that the RA axis requires rapid guiding, which makes both RA and DEC star centroid measurements highly sensitive to atmospheric seeing. The standard hysteresis algorithm, in the presence of atmospheric seeing and even with low aggression, will continually issue alternating guide corrections in opposite directions. This is equivalent to our BMW driver keeping stationary by alternating between reverse and 1st gear.

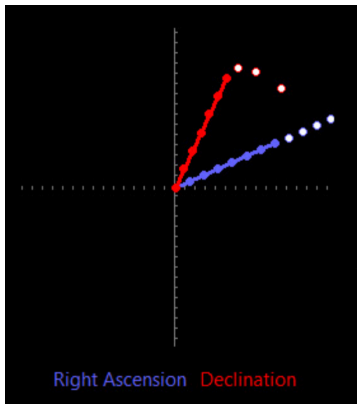
A promising solution is the Z-Filter algorithm. It has the unusual characteristic of potentially issuing guide corrections on each guider cycle, but makes its evaluations over many measurements by looking at trends. To evaluate its effectiveness, take a look at the DEC trace above and, in particular, the corrections, or lack thereof. This algorithm works out trends. Ignore PHD2's RMS readout. One may see a consistent and unchanging positive or negative guide error, with few corrections. As far as the light frame is concerned, the DEC axis is tracking perfectly, with a small (but consistent) image centering error during the exposure.

It is really worth a try. I previously used the hysteresis algorithm on my DEC axis for the Rainbow, Pegasus, and WarpDrive mounts at different guide rates and aggression settings. I often had better results with the RA guide output disabled and in most cases, the guided DEC performance was the same or worse than the RA axis; a clear indicator of something awry.

Multistar guiding usually gives better results than single star/subframes. The latter is much faster; even with a fast, small guide camera, the computation time for multi-star limits the guide frequency to about 1 correction/second on a modest Intel NUC computer with USB3 connection.

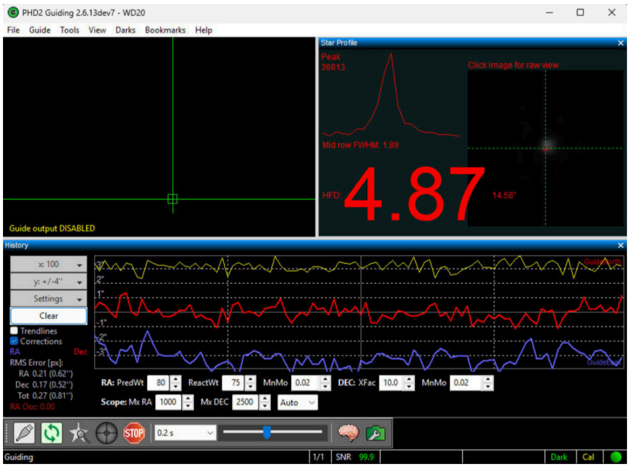


If after a meridian flip, the declination error suddenly goes off the chart, change the 'reverse DEC output after meridian flip' setting.



Guider Calibration

Calibrating a mount with high PE brings its challenges. One of those is that during the DEC guiding calibration, the RA tracking error is rapidly changing. This causes the calibration to have skewed results. The extreme example opposite shows what might happen. The red and blue arms are not orthogonal. This was likely done when the RA tracking error was changing



Without changing anything, the guider outputs were disabled and the old trace cleared out. RA obviously starts to drift, but look at the red DEC trace. **It has hardly changed.**

This proves the RMS figure in both cases is mostly a measure of atmospheric seeing. Other than adaptive optics, no guide algorithm, or mount model is going to make a difference.

You can make the RMS figure look better by guiding at high declination (with DEC compensation disabled), in better seeing conditions, or by using exposures of several seconds.

effects remain the same (in terms of image pixels). If you really wish to compare guiding performance with different settings, the assessments should be done with the same settings: exposure duration, declination, approximate altitude, and with very good, consistent atmospheric conditions.

Another consideration of the effect of declination is how the auto guider algorithm reacts to an RA error at different DEC values. PHD2 has a specific setting *use DEC compensation* for the purpose. This boosts the sensitivity of RA errors in the algorithm at high DEC. This accomplishes the same effect as calibrating PHD2 at the target declination (as the original PHD application always did). At the same time, however, it boosts the sensitivity to apparent RA errors caused by atmospheric seeing. The PHD2 authors suggest leaving this enabled, I do not, as I typically have poor seeing. It is useful to compare guiding performance in both cases (by looking at the light frames) while guiding at a high declination and decide for yourself.

Proof of the Pudding

Remember, the only thing that matters is the quality of the light frame. I have had amazing images with pinpoint stars on a Takahashi FSQ85 when the guider, using 0.3-second exposures, reported RMS figures of 1.2”.

To truly assess tracking, look for star elongation in the middle of the image and its FWHM (or HFD) statistics in the image processing application (e.g. PixInsight). There is no perfect setting, however, and it is usually necessary to adjust settings with a different load, or imaging conditions. SGP and NINA both measure star count and HFD for each light frame and publish on a little graphic. This is very useful, not only to check on focus drift, but also on tracking performance.

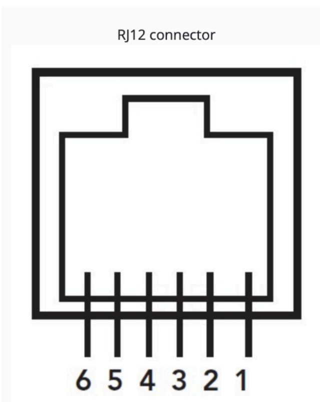


Table 2 ST-4 pin allocation

RJ12 pin number ->	1	2	3	4	5	6
Most manufacturers	NC	Common	RA+	Dec+	Dec-	RA-
Meade, Atik, TIC *(Fig 3)*	NC	Common	RA-	Dec-	Dec+	RA+
SBIG (STV), Takahashi, Paramount.	RA+	Dec+	Dec-	RA-	Common	NC

Notes:

- ‘Most manufacturers’ = QHY, Sky-Watcher, Orion, Atlas, Sirus, Celestron, iOptron, Astro Physics, Losmandy, ZWO, Vixen.
- NC = No Connection
- RA & Dec direction labelling is Northern Hemisphere referenced.
- Early Celestron RJ12 sockets were (incorrectly) numbered in reverse. As such, pin numbering from manuals may not align with the above table.
- Some manufacturers incorrectly label the plug as RJ11 rather than the correct RJ12

The Warp Astron’s ST4 adaptor pinout

Alt-Az Configurations

Alt-Az configurations are typically used for visual use.

Changing Mount Configuration

Mechanical

Adjust the mount base (tripod) to be completely level (the levelness will directly affect the accuracy of the alt-azimuth tracking) Set the azimuth of the equatorial mount to true north and adjust the latitude angle to 90 degrees.

Software

Switch to Alt-Azimuth Mode in HC

- Long-press **H** to enter menu: *Main Menu/Settings/ Configuration/Mount Runtime*
- select "Enabled" and single click **W** for confirmation
- in *Mount Type, s*elect *AltAzm* and single click **W**
- reboot the mount to take effect
- to resume to equatorial mount mode, please select "Default" or "GEM" and reboot

Known Limitations

OnStep

On power-on, OnStep assumes the park position is the same as the home position, and reports Alt (latitude) and Az(0), even if it was parked at a different position before power-off. In this case, even pressing the home button on the mount has no effect unless the time has been updated. The sense of direction updates once the mount is initialized with time and homed. The stored park position is remembered properly from here on. This is possibly behind the rationale of limiting the initial slew to find the home position to ~85 degrees. As mentioned before, to guarantee the home position is found, home once, turn on tracking for a few seconds, and home a second time.

ASCOM

The OnStep ASCOM settings dialog does not expose the guide rate setting. This is not something that is regularly changed and is accessed by the hand controller, an application that is able to send the appropriate ASCOM command or the INDI equivalent. The latest WarpAstron Mount Control tool also sets the guide and slew rates. For wireless users, initialize via WiFi or Bluetooth with the Android OnStep app. In addition, OnStep only supports 0.25, 0.5 and 1.0x guide rates and the same for both axes. Individual rates are on the development list for OnStep.

X2 (TheSkyX)

The X2 driver interface (API) does not support parking and homing. The X2 driver plugin, written by Rodolphe Pineau is donate-ware and has a home and park capability within the driver settings. These are not exposed to the outside world and if you want use TPoint with NINA, you must home the mount (e.g. with a VBS script (using OnStep ASCOM commands), before disconnecting and then connecting to TheSkyX through its ASCOM X2 adaptor driver. Parking the mount requires a disconnection of TheSkyX and another VBS script. Software Bisque have been aware of this limitation for some time and it is unlikely they will improve the mount control options for non-Paramount owners.

Firmware

The firmware (20.21) introduced a new feature (AEB) which monitors the RA motor current and reverses the motor direction if it suddenly increases (i.e. the telescope hits an obstruction). The sensitivity of this varies with load and speed. Some users have had issues with this feature, which has required WarpAstron intervention to fix. Firmware 20.22W and version 1.0 of the Warp Astron Mount Tool utility introduce a new feature that measure the system dynamics and calculate the AEB settings. If the system load or balance is changed, run the AEB tuning routine again.

Other

The OnStep microcontroller board has both WiFi and Bluetooth. Only one can be enabled at a time. The Bluetooth serial implementation is not compatible with iOS devices. With the added issue that WiFi connections appear to be less robust in practice on either mobile platform, an Android-based tablet using Bluetooth is currently the most reliable wireless option.

Firmware Upgrades

It is not the intention to duplicate and possibly incorrectly advise on firmware upgrades. That said, the following notes hopefully will guide the user to the right links and instructions.

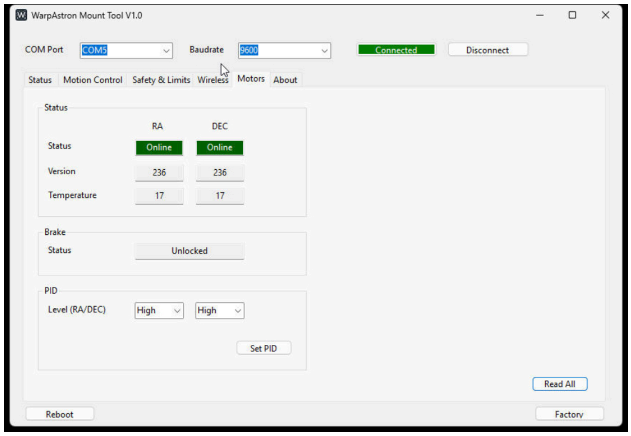
There are several separate circuit boards in the mount, each with their own firmware. Like most Arduino boards, they have two modes (programing and operation) triggered by external hardware and software protocols. It is sometimes necessary to update the boards in a certain order and the instructions vary depending on the existing firmware version. There is also a special service firmware update for the motor boards. Used incorrectly, it can leave the motor boards into the wrong mode and they will not operate until reset to normal. This will be increasingly unlikely with time that it will be needed for the latest production units.

Stop! Take Note

Most of the firmware-related issues on the forum appear to process related, rather than a hardware issue. There are extensive instructions about how to update the firmware, with flow charts and forum advice. It takes a while to work through the resources and decide what is required. I found a few anomalies but after erring on the side of caution and not attempting to update the motor boards, the mount firmware update went without a hitch. It would be useful if these resources were all put in one place (I'm not attempting it). Suffice to say, read carefully and if in doubt, consult the Warp team, armed with the serial number and firmware version information. In the case one reaches a dead end, WarpAstron have the ability to use remote desktop software.

What is my Firmware Version?

The mount firmware version is displayed in the hand controller (*Settings/Firmware Ver*), the ASCOM driver properties and also in the WarpAstron Mount Tool. The latest Mount Tool also reports the motor firmware version. The current issues of upgrading from much older firmware will gradually diminish over time and firmware updates will become less onerous.



With the latest firmware and Mount Tool, the motor status is now correctly read.

Firmware Resources

WarpAstron webpage: *https://www.warpastron.com/index.php/software/*

Official Forum: *https://bbs.warpastron.com/c/firmware/7*

Resources

Links

OnStep: *http://stellarjourney.com/main/software-onstep-telescope-control/*
Latest ASCOM driver : *http://stellarjourney.com/main/onstep-ascom-driver-software/*
Warp official forum: *https://bbs.warpastron.com*
Warp support software page: for drivers, tools and mobile apps: *https://www.warpastron.com/index.php/software/*
PHD2: *https://openphdguiding.org/downloads/*
PHD2 Log Viewer: *http://adgsoftware.com/phd2utils/*
OnStep X2 plugin (for The Sky X) : *https://rti-zone.org/software_x2mount_plugins.php*
OnStep Android controller app: *https://play.google.com/store/apps/details?id=com.onstepcontroller2&hl=en-US*
Shameless plug: *https://www.digitalastrophotography.co.uk*
ModelCreator: *https://www.astromi.ch/Files/ModelCreator2/ModelCreator_2_Setup_2.6.8.0.zip*
CCDCiel: *https://ap-i.net/ccdciel//en/start*
CdC: *https://www.ap-i.net/skychart/en/start*
StellarMate: *https://www.stellarmate.com/products/stellarmate-os/stellarmate-os-detail.html*
INDIstarter: *https://sourceforge.net/projects/indistarter/files/indistarter-2.4.1/*

Contributors

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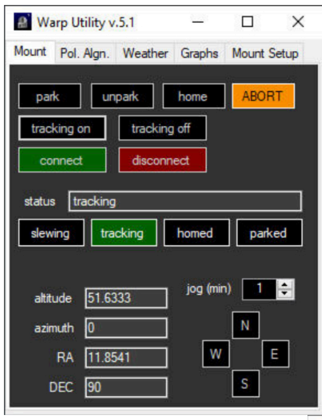
Utilities

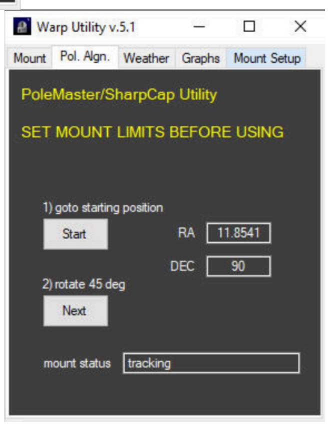
Mount Utility (using ASCOM)

On a PC, it is useful to be able to home and park a mount outside of the imaging applications. While it is possible to do this in an advanced sequence within NINA, I wrote a small Windows App to do basic telescope initialization and control. This same app also monitors an observing conditions device and displays trends of the sensor data. It also features a useful utility which sets up a mount very quickly and rotates in RA efficiently to fixed positions, which is required by PoleMaster and SharpCap Pro when polar aligning. The apps homing function overcomes the issue of the park and home position being more than about 80° apart, by homing twice.

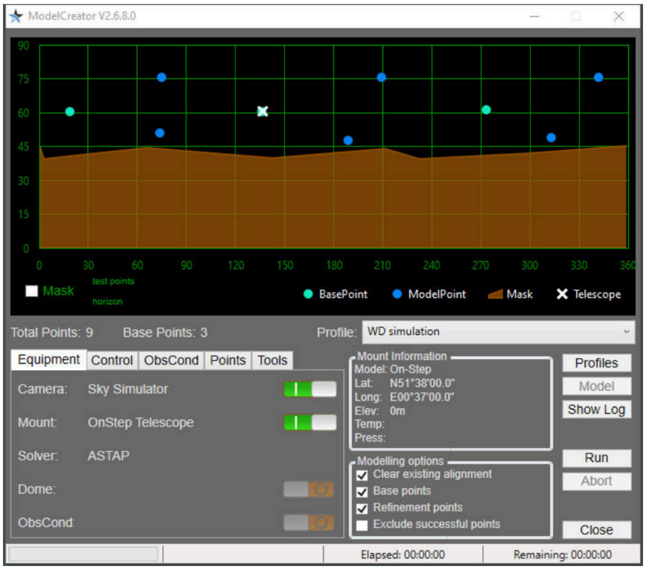
The latest version is in the DropBox folder with this manual. The source code is published on GitHub: *https://github.com/chris125577/MountControl*



This small utility does basic mount initialization, including homing, parking, jogging, updating location, guide rates, and time. It also makes it easy to do the polar alignment RA moves. It is shared with no implied warranty or liability.



Pointing Models



ModelCreator

For visual users, the multi-star alignment utility in the handset or Android app is useful enough. For imagers, however, if you wish to improve your initial slew accuracy, an automated pointing model is more convenient.

Using TheSkyX and TPoint is one possibility, but there is also a free utility, ModelCreator, kindly provided by Astromi.ch, (who make environmental sensor modules for telescope mounts) that should automate a simple pointing model, using the sync functions within ASCOM. It permits connection to a camera, mount, sensors, dome etc. and automatically slews to your selected points, exposes, plate-solves, and syncs with the mount. The sync points, horizon and settings can be stored and recalled as profiles, making it quick and easy to use.

The model should remain in the mount until you home it next. (*This seems to work with a sky simulator but as yet untested in the field.*)

Sync and Align Accept

These two functions on the handset do not quite do the same thing. From the OnStep Wiki:

"The one star alignment is implemented to correct RA/Dec offset. Two or more star alignment measure/corrects for polar axis misalignment (relative to the celestial pole,) cone error, etc. More stars removes ambiguity and increases likelihood of good performance. The results are saved when Set park is called and maintained when Parking/UnParking the mount. The sync. equatorial coordinates command refines the model for a local area of the sky, this refinement is lost when the power is cycled unless another Set park is called."

From the OnStep source code, while Align and Sync are separate commands and do different things, if an align process has been started, the *Sync* command acts as an *Align* accept until the alignment routine is completed. In this way, it might be possible to start a 9 star alignment and use the handset to center/align the first star (when viewing an image loop in your imaging application and then apply ModelCreator to quickly do the rest. There is a post on the OnStep user group that requests if there is a way to do this entirely through ASCOM commands, say, in a NINA sequence.

Scripts

A sample VBS script to home and center a mount, using an ASCOM connection. This homes twice, overcoming a potential issue of the initial slew to home being >90 degrees. This is saved with a VBS file extension and a copy is in the Dropbox folder with this manual.

In NINA, it is called with a script instruction: path/cscript.exe path/WDHomeAndPark.vbs

```
dim x
' Create telescope object
set Scope = CreateObject("ASCOM.OnStep.Telescope")
' Connect to the object
if not scope.Connected then
		scope.connected = true
		if not scope.connected then
				wscript.echo "Failed to connect the scope."
				Quit
		end if
		wscript.sleep 2000
		scope.unpark
		WScript.sleep 2000
		scope.tracking = true
		WScript.Sleep 3000
end if
if not scope.canfindhome then
		wscript.echo "check ASCOM settings"
Quit
end if
x = 0
Scope.Findhome
' wait for mount to home
do Until (Scope.AtHome OR x > 30)
x = x + 1
WScript.Sleep 2000
loop
WScript.Sleep 1500
' second time, to account for swings of more than 90 degrees to home
scope.tracking = true
WScript.Sleep 5000
x = 0
Scope.Findhome

' wait for mount to home
do Until (Scope.AtHome OR x > 30)
x = x + 1
WScript.Sleep 2000
loop
WScript.Sleep 1500

if not Scope.athome then
		wscript.echo "failed to home"
Quit
end if
' Park scope after homing
Scope.park
scope.connected = false
if scope.connected then
    wscript.echo "Failed to disconnect the scope"
    Quit
end if
```

WD20P (draft)

This is taken from the WarpAstron website and clearly shows the new USB-C power and power+data port.

Mechanical Differences

The WD20P addresses several limitations on the WD20P, yet retaining the same essential drive mechanism. While the obvious addition is the internal support of 150 W of power and data pass through its two USB-C ports in the saddle, the restricted voltage input range of the original WD20 (12–13 V) has been radically upgraded to accept 12–28 V input. The motors are unchanged, according to the website, but the product description suggests the RA motor is drawing more power and delivering more torque, even though the load capacity remains unchanged.

Power Delivery

USB standards are constantly evolving and for many years has had the dual purpose of transmitting data and power. USB and, especially USB-C ports are routinely found on rechargeable items, with no need for data transmission. The original (pre power-delivery) USB standard was used 5V, in varying currents from 100 mA to 1.5 A (USB3) and up to 3A with USB c.

Power delivery (USB-PD) started with USB type A and B connectors, where the cable permits the device to request a certain electrical power up to 5 A and 20 V. The standard changed with the introduction of USB-C connections, allowing 5, 8, 15 and 20 V, from 0.5–100W, and has been further extended to permit fast charging of laptops. A USB-C cable that supports more than 60 W is electronically marked. It is also possible to get special programmed cables, designed for a particular voltage. The cable has a small embedded circuit and communicates the required voltage, for instance, a DC USB cable inserted into a power-bank with a programmable output of say 20V.

WD20P

There are two USB-C ports on the WD20 saddle. Both deliver power (a total of up to 150 W) and one additionally is a data link to the mount (via a USB Type-C to Type A cable). The power output status (voltage and power) is available on the hand controller. For the higher output voltages, it requires a higher input voltage. The mount data port on the right does the same job as the PC connection on the plastic facia. The option permits a tidier cable interface that does not flex with declination rotations. It can also deliver power at the same time, say to a mini PC, providing it can instruct the mount to supply the desired voltage and the input voltage on the mount is sufficient.

If the WD20P is supplied with just 12 V, the saddle power output is limited to 12 V, 3 A (36 W). If you want to exceed 60 W, you need supply the mount with a stabilized 20–24 V DC supply.

WD20 Owners

It is not possible to upgrade to the WD20P but there are alternatives to its powered saddle.

For instance, my system has a Pegasus UltimatePowerBox V3 (UPBV3), which sits on the refractor, with a NUC unit on top. A power and USB cable flex down to the mount's connectors. This is overkill for many setups but, in this case, it is required to support a complex dual refractor/filterwheel/rotator/focuser/camera system.

For a simpler setup, the PegasusAstro Saddle Powerbox is an interesting alternative. It has a controllable 4-way 12 V distribution, two dew heater ports and a powered 4-way USB3.1/2.0 hub. It also has temperature and humidity sensing and hence can automate dew heater power. The AM5 puck adaptor has the required 38-mm spacing.