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Gemini 2
Telescope Mount Controller

VERSION 1.0

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About this manual

This is a reference manual created by volunteers and is not an official manufacturer publication. Firmware labels and exact menu wording can vary by build date and by controller generation. Always confirm critical operational details against the firmware actually installed on your mount.

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1 Introduction

1.1 Purpose of this manual

Gemini 2 is a computerized telescope mount controller for German equatorial mounts. It continues the Gemini product line but modernizes the user experience with a graphical Hand Controller, direct USB connection, Ethernet networking, a browser-based web interface, removable microSD storage, and expanded software integration.

1.2 What is Gemini 2

Gemini 2 is a stand-alone system with browser control, ST-4 compatible guiding, user-programmable catalogs, firmware upgrades via network or microSD workflows, and compatibility with Losmandy mounts including the GM8, G-11, Titan, Titan 50, Titan HGM, and MI-250, plus custom-mount support through programmable gearing.

At its core, Gemini 2 is a servo-based mount controller that can:

- slew and track a supported equatorial mount
- build and retain pointing models
- guide for imaging
- manage safety limits, parking, and restart modes
- operate stand-alone with no PC attached
- connect to external software over serial, USB, or Ethernet connections.

1.3 Main hardware variants

Gemini 2 exists in two main hardware forms.

1.3.1 Original Gemini 2

The original Gemini 2 controller, also known as the Tall Boy, is the larger first-generation unit. In normal use:

- graphical Hand Controller plugs into **Serial Port 2 / Graphics HC**
- **Serial Port 1** is used for serial computer connections or GPS
- there are two power jacks
- backup battery is a **CR2354** cell

1.3.2 Gemini 2 Mini

The **Gemini 2 Mini** is a smaller, updated version of the Gemini 2 mount controller with a redesigned logic board. Compared to the original unit:

- it has **one power jack** instead of two
- classic Hand Controller jack is removed
- front-panel connectors are rearranged and re-labelled for clarity
- graphics Hand Controller uses the **HC** port
- Serial Port 1 is relabeled **Serial Port / GPS**
- backup battery changes to a more common **CR2450** cell.

Operationally the two versions are similar, but port labels and some cabling assumptions are not interchangeable, so users should pay close attention to the different port names and connector layout when installing cables and accessories.

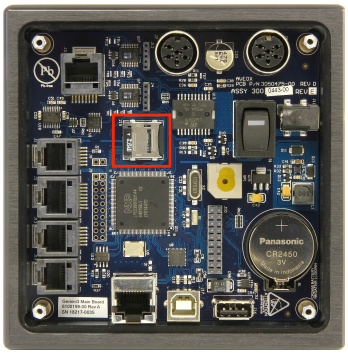
1.3.3 Shared architecture and practical hardware implications

Both Gemini 2 families share the same broad design ideas even when the front-panel labels differ. In day-to-day use, that means:

- main controller and the graphics Hand Controller each use microSD storage
- controller can be maintained over Ethernet, web pages, or SD-card workflows
- **USB-B** is the practical USB connection for a computer-hosted virtual COM workflow
- system is designed for **stand-alone operation**, but becomes much more powerful when its network and storage features are used deliberately
- hardware you physically own still matters, because battery type, Hand Controller compatibility, and some connector assumptions differ between original and Mini units.

1.3.4 Storage media expectations

Removable storage is considered normal operating infrastructure, not a rare service procedure. Gemini 2 owners should therefore keep the following habits:



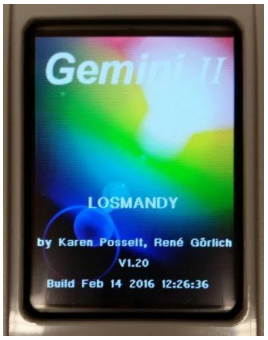
- know how to remove and reseat both microSD cards
- keep a verified backup copy of important files and settings
- format larger cards as **FAT32** when required
- assume that firmware, catalogs, mobile web pages, and recovery files all ultimately depend on correct SD-card contents.

For most systems, cards in the **2 GB** to **32 GB** range are considered optimal, however, since Gemini 2 works under a FAT32 file system when using 4 GB or larger media, the card will need to be formatted to the FAT32 standard.

1.4 Major Gemini 2 capabilities

Gemini 2 inherits the core mount-control behavior of Gemini-1 and adds a more modern control interface and communications stack.

1.4.1 User interface improvements



Gemini 2 adds a color graphical touch-screen Hand Controller with tactile buttons and multi-language support including English, Spanish, French, and German. The touch controller preserves the classic four-direction movement concept while adding dedicated on-screen workflows for startup, catalogs, park, modeling, and system settings.

1.4.2 Networked operation

A major generational change is built-in Ethernet. Through Ethernet, Gemini 2 provides a web interface that mirrors or extends Hand Controller functions. This makes it practical to configure the mount, inspect status, manage models, upload files, and perform firmware operations without being physically at the mount.

1.4.3 Storage and recoverability

The main controller and the Hand Controller both use microSD storage. In practice this means:

- firmware and support files can be updated without replacing ROM parts
- user catalogs can be added
- PEC data and configuration data can be preserved
- SRAM-backed settings can be stored to a configuration file and later restored.

This is one of the most important practical differences from older Gemini generations.

1.4.4 Communications and software control

Gemini 2 can be driven in several ways:

- directly from the Hand Controller
- from a PC using serial
- from a PC using USB
- over Ethernet using a browser
- through ASCOM software
- through command sets compatible with LX200-style control plus Gemini native extensions.

For many imaging users, connecting to the mount via USB or Ethernet, through the Gemini.NET ASCOM driver is the preferred workflow because one connection can carry both mount control and pulse guiding.

1.4.5 Imaging support

Gemini 2 retains the classic Gemini strengths for imaging:

- multiple tracking rates
- Periodic Error Correction (PEC)
- ST-4 compatible guider input
- model-based pointing
- polar alignment tools
- park and restart behavior for repeatability
- external software support for automation and precision guiding.

Gemini 2 includes features intended to support **astronomical imaging** as well as visual observing. These include accurate GoTo operation, pointing-model support, meridian-flip control, safety and overlap limits, and interfaces for computer-based control.

For imaging users, Gemini 2 is designed to work with external software through its serial, USB, Ethernet, and ASCOM-compatible control options. This allows the mount to be integrated into automated or semi-automated imaging systems for target acquisition, tracking, and session control.

1.4.6 Hardware interfaces and service features

Gemini 2 is unusually open as a service and integration platform. Depending on hardware variant and firmware generation, the following features are supported:

- **Ethernet 10/100** networking for browser control and file-transfer/update workflows
- **two serial ports** with practical separation of computer/GPS duties and Hand Controller duties
- **USB-B** as a virtual COM connection for computer software
- **USB-A** as a reserved or future-facing expansion path rather than a general-purpose PC host port
- an **ST-4 compatible guider input**

- **Port E** for end-sensor support
- **Port F / Feature Port** with auxiliary TTL serial and A/D functions for advanced users
- battery, motor, and port-monitor pages in the web interface for diagnostics.

Gemini 2 is not just a keypad attached to a motor box. It is a networked, stateful computer with built-in and customizable web pages for configuration and monitoring.

1.4.7 Mobile and custom web control

A particularly distinctive Gemini 2 capability is that the web interface is itself file-based and extensible. Users can create their own web pages using the published CGI mechanisms. For instance, the utility Mobile Hand Controller (MHC) was created by a user and is optimized for use with phones and tablets through Wi-Fi. For technically inclined owners, this means Gemini 2 can be customized not only through settings, but also through the structure of the file system on the main microSD card.

1.4.8 Internationalization and file-based language support

Gemini 2 has four built-in languages with the option of easily adding extra languages by the user. The built-in languages are English, German, French and Spanish. These are stored in the microSD card along with the firmware, catalogs and web pages, making the user interface partly data-driven and file-driven.

1.5 Conceptual differences from Gemini-1

Users coming from Gemini-1 should pay special attention to the following changes:

1. **Startup choices are broader.** Gemini 2 commonly presents Quick Start, Cold Start, Warm Start, and Warm Restart. These options are only presented if a previous session had at least one alignment/sync performed [video from gemini-2.com]
2. **The graphics Hand Controller matters.** It is not just a prettier display; some workflows, such as touch calibration and graphic menu navigation, are unique to Gemini 2.
3. **The web interface is a first-class control path.** On Gemini-1, the serial link was an accessory path. On Gemini 2, Ethernet and the internal web pages are central to configuration, maintenance, and advanced control.
4. **Configuration persistence is stronger.** Models, PEC, and SRAM-backed settings can be stored or reloaded rather than rebuilt every time.
5. **Hardware variants matter.** Original and Mini units differ in battery type, connectors, and Hand Controller port assignments.

1.6 What's in this manual

The earlier Gemini manual spent a lot of space explaining the underlying astronomy and menu tree. That approach remains useful, but Gemini 2 users most often need help with:

- first power-up and touch-screen calibration
- choosing the correct startup mode
- understanding alignment vs. synchronize
- building east-side and west-side models
- setting limits and park behavior safely
- deciding between serial, USB, and Ethernet
- using the web interface effectively
- protecting settings during firmware updates or battery changes.

1.7 A note on firmware variation

Gemini 2 behavior is firmware-sensitive with different versions (Level 5.x and 6.x) available depending on your hardware. In real use, menu wording and available functions may differ slightly from one build to another. To check the mainboard firmware version on your controller navigate to:

MENU → HC → INFO

When the exact wording on your screen differs from this manual:

- trust the mount's current screen labels
- check the firmware build date
- confirm whether you are using the original Gemini 2 or the Mini
- verify whether a function is implemented in the Hand Controller, the web interface, or both.

1.8 Recommended reading path

For a new owner, the most useful sequence is:

1. Read **Chapter 2** and complete the first-night startup.
2. Read **Chapter 3** for the concepts of Meridian Flips, Safety Limits, Park, and Restart operations
3. Read **Chapter 4** to understand Pointing Models
4. Read **Chapter 5** to learn concepts needed for Imaging, Guiding, and PEC
5. Read **Chapter 6** that covers the Hand Controller and Web Interface
6. Read **Chapter 7** before attaching planetarium or ASCOM software
7. Keep **Chapter 8** nearby for recovery and troubleshooting.

2 Hardware, First Startup, and First Alignment

2.1 First-night goals

Your first session with Gemini 2 should have only five goals:

1. connect the hardware safely
2. power the system with the correct supply
3. calibrate the Hand Controller touch screen (if needed)
4. enter mount, site, time, safety limits and startup information correctly
5. build the first usable pointing model.

Do not begin by chasing every menu and feature. Most early problems come from only a few causes: incorrect startup position, wrong time zone, wrong mount type, incorrect gearing, or limits that were never checked. You can begin to explore other features of Gemini after you have successfully completed the steps in this chapter.

NOTE: 1-4 can be accomplished while setting up indoors or during daylight.

2.2 Before you power on

2.2.1 Confirm the controller variant

Before connecting anything, determine whether you have:

- **original Gemini 2**, or
- **Gemini 2 Mini**.

This matters because the Hand Controller and serial/GPS ports are labeled differently, and because the original unit has two power jacks while the Mini has one. See Appendix A if you are not sure of your model type.

2.2.2 Connect the Hand Controller to the correct port

Normal Hand Controller connections are:

- **Original Gemini 2:** plug the graphical Hand Controller into **Serial Port 2 / Graphics HC**.
- **Gemini 2 Mini:** plug the graphical Hand Controller into **HC**.

If the Hand Controller stays at "Connecting to Gemini," the most basic thing to confirm is that it is in the correct port.

2.2.3 Connect the motor cables correctly

Make sure RA and DEC motor cables are attached to the correct axis and seated completely. Wrong axis cabling is one of the first things to check if the mount slews in the wrong direction or behaves unpredictably during alignment.

2.2.4 Balance the telescope

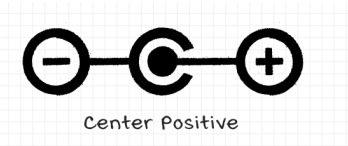
Balance the telescope in both RA and DEC with your real observing or imaging load installed. Gemini 2 can compensate for many things in software, but not for a badly unbalanced mount. Good balance reduces stalls, improves pointing repeatability, and helps the servo system behave predictably.

2.3 Power requirements

Gemini 2 is designed for **12V to 18V DC** operation. If you have a heavy or bulky load on the mount, a power supply capable of greater than 12V (not to exceed 18V!) may help with acceleration/deceleration.

2.3.1 Practical power guidance

Use a power supply that is:



- well regulated
- capable of maintaining voltage during slews
- clean enough to avoid spikes and brownouts
- sized for the mount plus any additional load on the same source
- 12V-18V DC, 3-5A

Skip low-quality power supplies because a mount that appears to have a firmware or logic problem is sometimes only suffering from voltage drop under load.

2.3.2 Connectors

Gemini 2 provides connectors for **power, RA and DEC motors, Hand Controller, serial communications, Ethernet, and accessory connections**. The exact labeling and arrangement depend on whether the controller is the original Gemini 2 or the Gemini 2 Mini, so you should always identify ports by function before connecting equipment.

Before powering the system, verify that each cable is connected to the correct port and is fully seated. Incorrect connections can prevent normal startup, block communication with the Hand Controller or computer, or cause the mount to operate improperly. Careful cable routing is also important to avoid strain, snagging, or interference during slews and meridian flips.

2.3.3 Power discipline in the field

Gemini 2 is happiest when treated like precision electronics rather than like a tolerant accessory. Think about power in four parts:

1. **Voltage headroom** — do not run below 12V
2. **Current reserve** — use a power supply with real overhead rather than a barely adequate rating.
3. **Regulation quality** — poorly regulated power supplies can create strange behavior during slews.
4. **Connector integrity** — intermittent barrel connections create symptoms that look like firmware or model corruption.

The controller is fused at **5A** and is designed for a nominal **12-18V DC** environment, with the main unit capable of supplying substantial motor current during aggressive motion. In practice, a high-quality regulated power supply is more important than squeezing every last volt out of the specification sheet. Higher voltage, such as **16 V DC** can be beneficial to deliver more power to the motors in case of a heavy or bulky load.

2.3.4 Power symptoms that masquerade as software problems

A weak power supply or poor power connection can produce behavior that users often mislabel as software failure: random forced cold starts, incorrect retained settings, motor faults, poor slews, or web/network instability. When troubleshooting a newly acquired used system, treat power verification as part of commissioning, not as a later optimization.

The power connector for Gemini 2 uses barrel connectors with **5.5 mm outer** and **2.1 mm inner** diameter. The Original unit has two power connectors; the Mini has one.

2.4 First Power-up Starting Position: CWD

After you have connected Gemini to a power supply, you are ready to power up Gemini for the first time. But before you power-up, Gemini 2 expects the mount to be in a known physical configuration which is known as the **Counterweight Down (CWD)** position. A mount in the CWD position has:

- the counterweight shaft as nearly vertical and as downward as practical
- optical tube pointing toward the celestial pole for your hemisphere.

In the northern hemisphere this means the optical tube is aimed toward Polaris / the north celestial pole region; in the southern hemisphere the optical tube is aimed toward the south celestial pole region.

Position your mount to this configuration by manually moving the mount (disengage clutches and move the mount). **Do not use Gemini to move the mount to this position for the initial startup.**

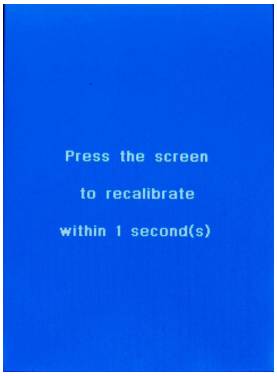
CWD is foundational because Gemini 2 uses the CWD position as the physical baseline for:

- startup initialization
- safety-limit geometry
- alignment logic
- model placement.

- Once your mount has been moved to the CWD position, you are now ready to power on Gemini.

2.5 The Very First Power-up

2.5.1 Hand Controller touch-screen calibration



Upon startup, the Hand Controller briefly presents a screen-alignment step. This alignment step can normally be skipped. The message will disappear after a second or two.

If the touch behavior later becomes erratic, the Hand Controller can be recalibrated using the steps outlined in Section 8.8.1

2.5.2 Startup Modes

After Gemini has booted up, you will be presented with a menu of four choices:

- Quick Start
- Cold Start
- Warm Start
- Warm Restart

Quick Start is recommended for the first-use path as this mode offers a guided setup. Quick Start walks you through the critical setup items—mount type, site, time zone, and date/time. The various other startup modes are described in more detail in Section 2.7. For now, proceed to Section 2.6.

2.6 Setup Parameters: mount type, gearing, site, time and Hand Controller

Now that Gemini is powered up and Quick Start has been selected, you can start to enter information regarding your particular site and mount setup.

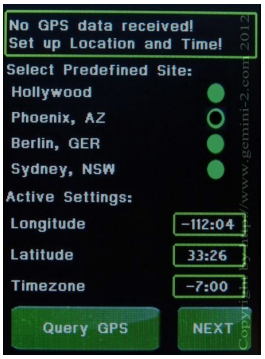
2.6.1 Mount type

Select the correct mount type. Changing mount type later should be followed by a **Cold Start** so the related parameters are fully updated. A mount-type change does not automatically reset previously set safety limits (discussed later). After setting your mount type, tap "Next".

2.6.2 Gearing

If you are using a custom mount, or a modified gearbox arrangement, confirm RA and DEC gearing values. Wrong gearing can make the mount slew or track in the wrong direction or at the wrong speed.

2.6.3 Longitude, latitude, and time zone



Enter your longitude and latitude by tapping the appropriate box and entering your longitude and latitude. After entry, tap the "Ent" box and you will be returned to the previous screen. Make sure you enter the appropriate "+" or "-" in front of your value. A "-" in front of longitude means west of the prime meridian, a "+" is east. A "+" in front of latitude indicates northern hemisphere while a "-" indicates you are in the southern hemisphere. For now, don't worry about the "Timezone" value as that will be set on the next step. Hit "Next".

On this screen, you will enter your Timezone offset. Incorrect **time-zone offset** is one of the most common setup errors. Tap the "Timezone:" box and enter your local time-zone offset and tap "Ent". Gemini 2 expects the site and time zone values to be consistent with the local and UTC time shown on the system.

Next, tap the "Civil Date:" box, enter the date and tap "Ent". Then tap the "Civil Time:" box enter the current time in 24-hour format and tap "Ent". When you return to the "Timezone:" screen, tap "SET". You have now entered the date, time and time-zone offset. These are critical parameters for Gemini to operate correctly.

You should now be on the Hand Controller main screen which has four diamonds as shown in the picture. You can verify the correct date and time from this screen. Date and local time are in the lower right corner. If those values are wrong, alignment and GoTo behavior will act strangely even when the motors and cables are fine.

If you are using a GPS device or if network time is available, refer to section 2.6.10.

You have now configured Gemini to know where you are on planet Earth, the current date and current local time.

More detailed information on the Hand Controller functions can be found in Chapter 6. For now, you will need to be familiar with several functions of the Hand Controller in order to complete the remaining steps in this chapter.

2.6.4 Hand Controller diamond buttons

The Hand Controller contains two sets of diamond-shaped buttons. These buttons are used by Gemini to manually move the mount in RA and DEC. An example might be when centering an object in the FOV.

The mount must be moved using Gemini so Gemini retains its position in the sky. One set of buttons is on the touch screen and the other set are the tactile buttons on the backside of the Hand Controller. Both provide similar functions. Personal preference will dictate which buttons to use when you need to move the mount using Gemini.

2.6.5 Touch Screen Direction Buttons

The direction buttons on the touch screen have two modes of operation. The modes are selected by the Persistent Diamonds setting. When Persistent Diamonds are enabled, sliding you finger off the button the mount will keep moving in the direction of the button until you press it again. If you press and hold, and then release it without sliding your finger off, it will work like a normal button.

Since the graphics screen is not multi-touch, if you use the finger slide off method, and touch the opposite button, the mount will speed up. The speeds are changed in the same order as the speed button (see Sticky Buttons below).

2.6.6 Tactile Direction Buttons

The tactile direction buttons on the back of the Hand Controller work like the original, Gemini-1 Hand Controller buttons: momentarily pushing the opposite button lets the system accelerate to the next higher speed. You can move in both axes simultaneously. If you are moving both axes, both will speed up with the opposite button trick. Ramping up and down in speed occurs independently for both axes.

2.6.7 Hand Controller Speed button

When moving the mount using the diamond buttons, the Speed button determines the speed of the Gemini motors. There are four choices:

- Slew – quickly moves the mount across the sky.
- Move – used to quickly move an object into the FOV
- Center – used to center objects in the FOV
- Guide – used when imaging

Pressing the Speed button once changes the speed selection. The speed choices simply scroll to the next selection with every press of the Speed button. All these speeds can be customized as outlined in Chapter 6.

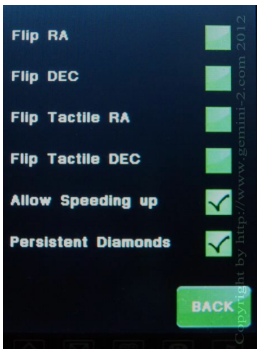
2.6.8 Sticky Buttons

The diamond directional buttons at the main touch screen behave differently than tactile buttons on the back:

If a directional button is pressed, a serial command "Move" is sent immediately and the axis starts moving.

If the button is released, a serial command "Stop" is sent and the movement stops or ramps down.

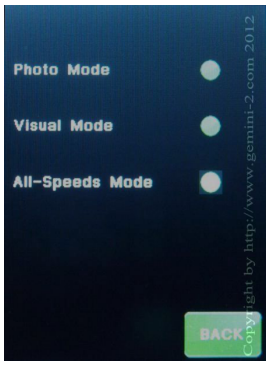
If the touch point is slid away, outside the active area of the button then two possibilities exist:



- HC sends the Stop command once the touch leaves the active area, or
- The pressed button stays active (no Stop command is sent) and the movement continues. Since the screen is single touch only this is the only way to move both axes simultaneously.

This is now selectable via the menu at Menu → HC → Buttons. Select "Persistent Diamonds" if you want to keep the action this way. When this option is left unchecked, the HC will send a Stop command as soon as the touch leaves the active area of the direction button.

2.6.9 Hand Controller Speed Modes



The Hand Controller works in one of three modes: the Visual Mode, the Photo Mode and the All Speeds Mode. You can move both axes simultaneously in all the modes. You select the mode by means of the Menu → HC → Mode screen. Like some other settings, it is remembered permanently and will be in effect even after powering off and on again.

The Visual Mode

In Visual Mode, Guiding Speed is not available. When you press a button, the telescope moves at Centering Speed.

Using touch screen direction buttons: If you push down and slide your finger off the button the mount will keep moving in the direction of the button until you press it again. Pressing the opposite direction button when in this state, the movement will accelerate to manual slewing speed.

Using tactile direction buttons: momentarily pushing the opposite button lets the system accelerate to the manual slewing speed. If you are moving both axes, both will speed up. Ramping up and down in speed occurs independently for both axes.

The Visual Mode is intended for visual observing and for looking up objects. The autoguider port is not active in this mode.

The Photo Mode

In Photo Mode, Guiding Speed is the principal speed, so pressing a Hand Controller directional button moves the telescope at the selected Guiding Speed; Slewing Speed is not available. Acceleration to Centering Speed is available in four stages to allow easy centering of an object in the field of view or on a CCD chip by using the sticky button feature (touch screen) or the opposite button trick (using the tactile buttons) while Gemini is guiding: Pressing the opposite button once changes to 1/8 of Centering Speed to allow fine centering of the target. Then, after about 2 seconds, the speed will increase to ¼ Centering Speed, after another 2 seconds to ½ Centering Speed, and finally to full Centering Speed. Pressing the opposite button twice changes to full Centering Speed immediately.

The All Speeds Mode

In this mode, all speeds are available, from Guiding Speed to Slewing Speed, by using the sticky buttons or the opposite-button trick. You can use this mode, for example, while drift aligning, when you need very fine centering of a star at the crosshairs and a fast move from the meridian to the eastern

or western horizon. However, for normal observing, you'll probably select either the Visual or Photo Mode.

2.6.10 GPS and network time

Gemini 2 can obtain accurate time information from an attached **GPS source** or from a **network time** service when the controller is connected to a network. These methods help reduce setup errors by supplying precise time data automatically, which is important for correct pointing, alignment, and tracking calculations.

When GPS or network time is available, you should still verify that the controller is using the correct **date, time zone, and daylight-saving setting** where applicable. Accurate time input is especially important after startup, firmware changes, or changes in observing location.

2.6.11 UTC is the real clock that matters

Gemini 2 uses **UTC internally** for its calculations. GPS and NTP both deliver UTC. The time zone offset mainly exists so the controller can display sensible local time and date to you. In other words:

- if GPS or NTP provides correct UTC, the sky calculations can still be right even when the displayed local time looks odd
- if the time zone offset is wrong, the local display can be misleading even though the mount still has correct UTC.

This distinction is worth understanding because it explains why some timing problems are only cosmetic while others are operationally serious.

2.6.12 Current versus stored network and time assumptions

On the network side, Gemini 2 distinguishes between **current** settings and **stored** defaults. The same practical mindset is useful for site and time data: confirm what is true **now**, but also confirm what the controller will return to after a reboot, especially if you are moving between DHCP and static-IP environments or between portable and permanent sites.

Gemini 2 can query a GPS receiver on the appropriate serial GPS port. The web interface can also query an NTP time server. Internally, Gemini 2 performs its calculations from UTC, so correct UTC is the priority; local time is derived from UTC plus the configured time zone offset. The GPS receiver sets latitude and longitude of the location and the UTC time. It doesn’t set time zone offset.

2.7 Startup modes explained

Gemini 2 uses four main startup choices. The choice of a startup mode determines how much Gemini 2 trusts retained position, how it interprets CWD or Home, and how safe it is to use previously stored safety limits.

2.7.1 Quick Start

Use Quick Start when you want a guided startup that checks:

- mount type
- location
- time zone
- civil time and date
- related initialization settings.

Quick Start is especially appropriate:

- on the first use
- after transport
- after significant configuration changes, or
- whenever you are unsure that the current settings are correct.
- Quick Start erases any existing pointing model. You can begin building a new model immediately afterward.

2.7.2 Cold Start is "rebuild from geometry" mode

Cold Start should be used when:

- there is no valid model
- you want to clear the current pointing model and rebuild from scratch
- mount has been moved from its prior physical setup, or
- you have changed core mount configuration and want a fully clean start.

A Cold Start requires the mount to begin at CWD.

2.7.3 Warm Start is "reuse the pointing model but realign with the sky"

Warm Start preserves existing pointing models but assumes the mount is starting again from **CWD** as an approximate reference. Use it when the mount itself has not been significantly moved or re-sited, but one or more axes were moved without Gemini powered on.

After selecting Warm Start, the mount will need to be synchronized on a known bright star so Gemini 2 can reposition the pointing model and can correctly locate the safety limits.

2.7.4 Warm Restart is "resume exactly where you left off"

Warm Restart is used when Gemini 2 has been shut down and restarted, but the mount itself has **not been moved** since the previous session. In this mode, Gemini 2 keeps its existing model and restores operation based on the last known mount position.

Warm Restart should be used only when the telescope and both mount axes have remained undisturbed. If the mount has been moved, or if there is any doubt about its actual position, a **Warm Start** or **Cold Start** should be used instead. This helps preserve accurate pointing and prevents incorrect assumptions about the mount's orientation.

2.8 Mount type, gearing, site, and time

Before doing real alignment, verify these items carefully.

Remember to follow these changes by a **Cold Start**.

2.8.1 Longitude, latitude, and time zone

Incorrect **time zone** is one of the most common setup errors. Gemini 2 expects the site and time zone values to be consistent with the local and UTC time shown on the system.
If those values are wrong, alignment and GoTo behavior will often look wildly incorrect even when the motors and cables are fine.

2.8.2 Precision of site entry

A small but important detail: the Hand Controller normally accepts longitude and latitude in **degrees and whole minutes**, while the web interface allows **seconds-level entry**. That does not make the Hand

Controller unusable, but it does mean the web interface is the better place to establish a permanent observatory site precisely.

2.9 Safety Limits

Safety Limits are important because the limits tell the mount how far it can move without crashing into a pier or tripod. The Safety Limits are not automatically set when you select a mount type due to the wide variety of possible equipment variations. Safety limits are set for both east and west sides and are dependent on your hemisphere.

A more detailed discussion on safety limits can be found in Sections 3.1 and 3.2

2.9.1 Safety Limits default values

There are established default limits for Losmandy made mounts and the MI-250 mounts. The default assumes that there is nothing hanging off the focuser end that is below the level of the OTA, such as imaging equipment.

The default limits for Losmandy-made mounts for the northern hemisphere are:

114 degrees for the east (left) side

123 degrees for the west (right) side

Southern hemisphere users:

123 degrees for the east (right) side

114 degrees for the west (left) side

The default limits for MI-250 users for the northern hemisphere are:

92 degrees for the east (left) side

95 degrees for the west (right) side

Southern hemisphere users:

95 degrees for the east (right) side

92 degrees for the west (left) side

Right and left sides refer to a user whose back is to the pole, the telescope is in the CWD position and the user is standing on the pole side of the setup.

2.9.2 How to set Safety Limits

To set the safety limit for your mount from the Hand Controller main screen (four diamonds) choose:

Menu → Mount → Limits

From that screen, tap the "Eastern Position" box, enter the appropriate limit and tap "Ent". Do the same for the "Western Position" box. For now, leave the "Western GoTo Limit" at its default value of "2:30". More information on Safety Limits and how the limits can be customized can be found in Chapter 3.

Your safety limits are now set. The next step is to complete an initial alignment/basic pointing model under the stars as outlined in Section 2.10.

2.10 Initial alignment/basic pointing model procedure

A practical Gemini 2 first-night alignment/basic pointing model looks like this.

2.10.1 Basic manual method

1. Place the mount in **CWD**.
2. Power up (and calibrate the touch screen if needed).
3. Choose **Quick Start** or **Cold Start**.
4. Verify mount type, site, time zone, and civil date/time.
5. Use **Menu → Model → GoTo Bright Star** and select a bright star above the horizon.
6. Let the mount slew, then center the star carefully using the Hand Controller buttons. Make sure the Speed is set to "Move" or "Center".
7. Use **Menu → Model → Alignment** to add the first star.
8. Repeat with another bright star on the same side of the mount.
9. Add further stars to refine the model. A minimum of three (3) stars is a good starting point.
10. Add a flipped-side star later so the opposite-side model can be created. Add at least one (1) star on the opposite side of the meridian.

After you have completed the alignment procedure, test your new pointing model by slewing to a known bright star. Using a medium power eyepiece, if the star is in your field of view, congratulations! You have built a basic pointing model! If not, go back and start over by performing a "Cold Start".

More information on modeling can be found in Chapter 4. Section 4.3 provides some details on terminology and pointing model concepts.

2.10.2 Alignment versus Synchronize terms

Gemini 2 uses two terms regarding pointing model commands. The "**Alignment**" **command always starts a model (if none exists) or adds model points to an existing model.**

The **"Synchronize"** command is different as "Synchronize" uses the existing pointing model. Use **"Synchronize"** when you want to tell Gemini 2 where the mount is now without modifying the existing pointing model.

2.10.3 Building both sides of the pointing model

Gemini 2 maintains separate sky models for each side of the mount. A pointing model built on only one side is incomplete. After you have built a pointing model on one side, select a star that requires the mount to perform a meridian flip and do an additional alignment on that side. Building the two-sided pointing models is essential to good performance after meridian flips.

After building the model on the first side, choose alignment stars on the opposite side and make sure the mount actually **flips** before aligning. If it does not flip, you are still adding points to the first model. A star well away from the meridian is usually the best choice.

Build the second-side model the same way as the first, using several stars spread across the sky. When both sides are modeled, pointing after flips will be much more accurate, and features such as **Polar Axis Correction** will work properly.

2.10.4 Pointing model "Learning"

Gemini 2's modeling feature becomes richer as you add more stars. The first alignments establish the basic index terms. With more stars, the controller begins to "learn" about the mechanical errors of the mount and/or the OTA. In practical language:

- **first alignment(s)** establish the basic positional index terms
- about **3 to 5 stars** are enough for Gemini 2 to estimate polar-axis error terms
- about **6 to 9 stars** allow it to estimate non-perpendicularity and related geometry terms
- **10 or more stars** can bring flexure terms into the model.

2.11 Park commands

At the end of a session, your mount will need to be "parked". Parking the mount moves the mount to a specified position, turns off tracking and provides a starting point for your next session.

2.11.1 Park modes

The Park commands can be accessed from the Hand Controller main screen:

Menu → Mount → Park

Gemini provides for three "Park" modes:

- Park at CWD – this parks the mount in the CWD position
- Park at Home Position – this parks the telescope in a position of your choosing
- Park at Zenith – this is mainly used for taking flats for imaging

The "Park at Home Position" command requires you to set a "Home" position. The "Home" position can be any position you choose at the end of a session. The "Home" position is set by first moving your mount, using Gemini, to the desired position then tapping the "Set Home Position" button. Gemini will then remember this configuration as the "Home" position. Choosing the "Park at Home" command will park the mount in this position.

After you have selected a Park command and the mount parks, you have completed your first session! You can now safely power down Gemini and get ready for your next session.

2.12 A recommended checklist before starting a session

Before you begin normal use, confirm all of the following:

- Hand Controller in the correct port
- RA and DEC cables not swapped
- correct controller variant identified
- high-quality 12–18 V DC power supply attached
- mount balanced
- CWD startup position used
- mount type verified
- gearing verified
- longitude and latitude verified
- time zone verified
- local and UTC time verified
- safety limits checked
- first alignment star centered carefully (if a new pointing model is necessary)
- at least three model points added on one side
- at least one model point added on the opposite side, after a meridian flip

If the above items are correctly configured, most "mystery problems" disappear before they start.

3 Meridian Flips and Safety Limits

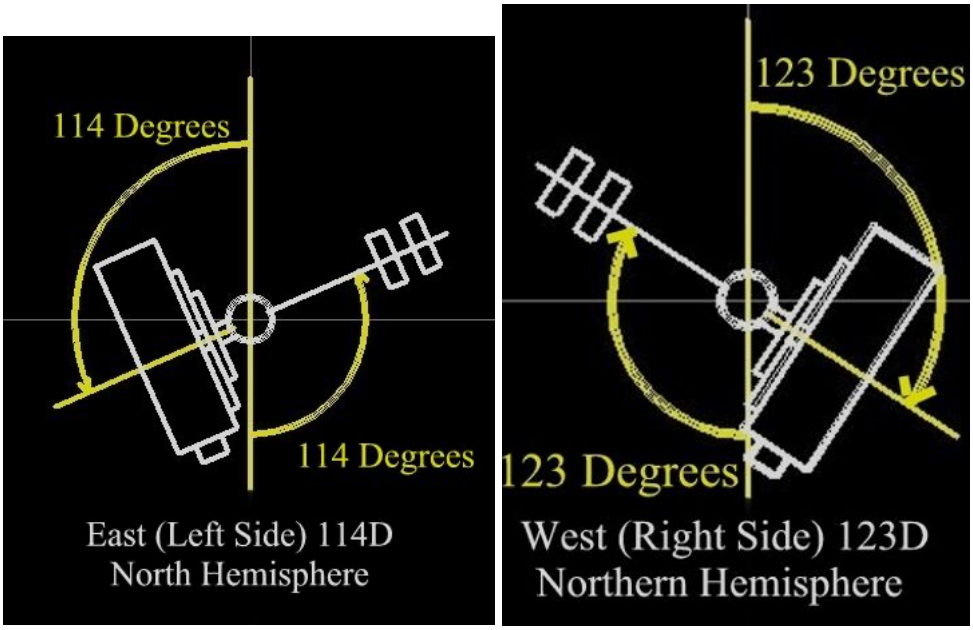
3.1 Meridian flip basics

For users who are new to German equatorial mounts, the **meridian** is one of the most important concepts to understand. The meridian is the imaginary line that runs from due north, through the point directly overhead (the **zenith**), to due south. When an astronomical target is near the meridian, it is at its highest point in the sky, and that usually gives the best imaging conditions of the night.

This matters because the higher a target is, the less atmosphere you are looking through. Less atmosphere means less loss of light, better transparency, and usually sharper images. At the zenith, you are looking through about **1 air mass**, assume that object brightness there is at **100%**. At **30 degrees altitude**, the target is seen through about **2 air masses**, reducing brightness to about **83%** (this is only an estimate, as there other variables involved in calculating relative brightness). Near the horizon, the atmosphere becomes much thicker, rising dramatically to near 38 air masses, and brightness dropping to near **0%**. For that reason, many imagers try to collect most of their data within about **two hours on either side of the meridian**, where image quality and signal-to-noise ratio are usually best.

A German equatorial mount creates a special challenge near the meridian. As the mount tracks an object from the eastern sky toward the west, the telescope tube, camera, or focuser can eventually swing into the pier or tripod. This is called a **pier crash**, and avoiding it is one of the most important safety tasks in mount setup. To continue following the same target safely, the mount must perform a **meridian flip**. During a meridian flip, the telescope moves to the opposite side of the pier but remains pointed at the same object in the sky.

Because of this, **safety limits** in Gemini 2 are extremely important. These limits define how far the telescope may move before a flip must occur or before motion must stop. These settings are not universal. They depend on your exact equipment: mount type, telescope length, camera size, focuser, accessories, and available clearance. You should never copy another user's limit values without testing them on your own system.



A practical way to configure the **allowed range** is to begin by setting the **eastern limit**. First, slew the telescope physically to the farthest safe position on the east side of the mount. Then go to **Setting Limits** in the Gemini 2 interface and store that position.

For this example, assume the Western Safety Limit is set at 100°, measured from CWD. Because the meridian is at 90°, a 100° western limit lets the mount track to 10° past the meridian before reaching the safety limit and stopping. The same example is used through the rest of this section.

The Western GoTo Limit (WGL) sets the **start** of the flip-allowed range — the band just inside the Western Safety Limit, in which any GoTo will trigger a meridian flip. It is measured back from the Western Safety Limit:

flip point = Western Safety Limit − WGL

The default WGL is 2.5° (entered as 2:30); this example uses a deliberately larger 9° so the range is easy to see. With a 100° western limit: 100° − 9° = 91°, which is 1° past the meridian. The flip-allowed range therefore runs from **91° (1° past the meridian) to 100° (the safety limit, 10° past the meridian)**. Any GoTo to a target inside that band causes Gemini 2 to flip — which is how some automation software triggers a flip: it waits until the target falls inside the range, then issues a GoTo to the target's coordinates.

Coordinating with imaging software. Configuring Gemini 2 is only half the job; the imaging application must request its flip inside that same range. Programs such as NINA, Sequence Generator Pro, and Ekos usually express the flip point in minutes past the meridian rather than in degrees, using the conversion **1° of sky = 4 minutes of clock time**. Applying that to the example above:

- 91° (start of the range, 1° past the meridian) = **4 minutes** past the meridian
- 100° (safety limit, 10° past the meridian) = **40 minutes** past the meridian

So a 9° WGL gives a flip-allowed range of **4 to 40 minutes past the meridian** — a window **36 minutes wide** (9° × 4 min). Do not wait until the far end of it. Set the imaging application to request the flip earlier — for example at 10 or 15 minutes past the meridian — so it stays well inside Gemini 2's range and leaves margin for tracking and guiding error.

The main rule for software coordination is simple: the imaging application's requested flip range must always be **well inside** the Gemini 2 allowed range. The mount's safety limit is the outer boundary. The imaging program should request the flip sooner, not later.

A few practical points are also worth remembering:

- The **Hand Controller** can be used to navigate these settings through the modeling and limit-related menus
- Remote users can manage limits and network settings through the internal web pages
- Windows users can also configure these settings through the **Gemini ASCOM Driver**

NOTE: after setting any limits, always perform a **careful manual slew test** to confirm that the telescope stops safely and cannot strike the mount.

3.2 Safety limits before real observing

Set limits early to avoid costly unexpected accidents!

3.2.1 Why limits matter

Limits protect the mount and telescope from:

- mechanical collisions
- over-travel
- unsafe meridian behavior
- accidental commands from software or remote users.

3.2.2 Key rule

Set limits only after the controller has a reliable idea of CWD. If you try to set limits after an invalid restart assumption, the geometry may be wrong.

3.2.3 East/West versus Left/Right

The Hand Controller generally describes safety limits as **East** and **West**. The web interface often uses **Left** and **Right**. They refer to the same concept, but through different user-interface language.

3.2.4 Western GoTo limit

The **Western GoTo Limit** setting allows you to specify an angle prior to the Safety Limit position which will affect meridian flips during a GoTo operation. A GoTo command to any object that is west of this angle will cause Gemini to do a meridian flip, if needed, to ensure that the telescope tube is on the east side of the mount when pointing to the object.

NOTE: Use caution when setting the GoTo limit at positions before or at the meridian. Such values would indicate points east of the meridian and would mean that Gemini would try to point to objects between the GoTo limit (now in the eastern hemisphere) and the meridian with the telescope tube on the east side of the mount. It is possible that such objects would be unreachable without violating the eastern safety limit. Attempts to GoTo such objects in this situation would result in the telescope not moving.

3.2.5 Meridian Flip Points (introduced in Level 6)

Flip points are the more advanced version of the older **Western GoTo Limit (WGL)** concept, intended for automated imaging workflows. They control when a **GoTo** command should force a **meridian flip**. If a target lies past the configured flip point, Gemini 2 will try to perform the GoTo to the opposite side of the mount, as long as the target is reachable safely after the flip.

Flip points are designed for **predictable automated imaging**. In earlier Gemini systems, the Western GoTo Limit was flexible and sometimes allowed Gemini to avoid a flip if the destination was close enough to the current position and still before the safety limit. That behavior was helpful for visual observing, where avoiding unnecessary flips could be convenient, but sometimes resulted in unpredictable behavior when using automation software.

Flip points work differently:

- They are set relative to the **meridian**, not the safety limit.
- They can be defined on **both sides of the mount**, east and west.
- They are intended to **force a flip during a GoTo** whenever the target lies past the flip point and can be reached from the other side.

Since both WGL and Flip Points are supported by Gemini 2, it's your choice which of the early meridian-flip mechanisms you prefer to use. For automated imaging, Flip Points are more predictable, while for visual observing, Western GoTo Limit might be more convenient.

3.2.6 Practical limit-setting sequence

When you set limits, Gemini 2 expects you to behave mechanically first and electronically second. The safest sequence is:

1. start from a trustworthy CWD-based geometry
2. switch tracking to **Terrestrial** so the axes stay put while you work
3. physically confirm that the telescope can rotate in DEC without hitting the mount
4. set the **East** limit first, then the **West** limit
5. power-cycle if necessary so the new limits are unquestionably active.

Limits may not take effect until after power cycling. In field use, the conservative approach wins: after changing limits, reboot and retest deliberately.

3.2.7 Software limits versus end sensors

Gemini 2 can work with more than one layer of protection. Software limits define where motion should stop or where flips should be triggered. End-sensor support provides a separate hardware-related protection that will appeal especially to those imaging remotely.

3.3 Meridian behavior and safety logic

3.3.1 The mount does not flip only because the target crossed the meridian

Gemini 2's side selection depends on geometry and limits, not just a simplistic "target crossed the meridian" rule. Crossing the meridian alone does not switch models unless the declination geometry also crosses the pole in the way associated with a real side change.

3.3.2 Force flip when needed

Sometimes Gemini 2 will slew to a target on the opposite side of the meridian **without** changing to the other pointing model, because the target is still reachable safely from the current side. When you need to be sure the mount changes sides, use **Force Flip** on the GoTo command. This is especially useful when building the model on the second side of the mount.

A good rule is to first choose a target well away from the meridian, since that usually causes a normal flip by itself. If the mount still goes to the target without flipping, repeat the GoTo and enable **Force Flip**. Gemini 2 will only perform the flip when it is safe to do so.

Use this feature when you need to guarantee that alignments or imaging operations occur on the **other side of the mount**, rather than continuing to add points to the current-side model.

3.3.3 Why the Western GoTo limit matters more than many users expect

The Western GoTo limit is not just an abstract number. It defines the practical line beyond which Gemini 2 will choose a meridian flip for a new target. The governing relationship is:

flip point = Western Safety Limit - Western GoTo Limit

That formula is worth memorizing because it explains several otherwise confusing behaviors: why a target slightly past the meridian may or may not flip, why changing safety limits changes flip behavior, and why portable users should re-check limits after changing mount geometry or payload shape.

If a target can be reached safely from either side, you may need to force a flip deliberately so that the telescope ends up on the desired side for imaging time, cable management, or collision avoidance.

Both the Hand Controller and web catalog workflows provide ways to request or force a flip when it is safe to do so.

3.4 Limits, park, and restart as one system

These three ideas are related:

- **limits** define where motion must stop or change behavior
- **park** defines how the mount enters a safe inactive state
- **restart mode** defines how the mount wakes back up.

A reliable Gemini 2 system is one where all three have been thought through together.

3.4.1 Park at CWD versus custom Home

Parking at CWD is simple and easy to reason about. A custom Home position can be more convenient for a permanent installation, but only if you also understand the implications for Warm Restart.

3.4.2 Restarting from Home

Once a Home position is defined and used consistently, you can park there and restart from there with Warm Restart, provided the physical assumptions remain true.

4 Modeling and Polar Alignment

4.1 Why Gemini 2 needs a pointing model

In order for a GoTo mount to actually go to a selected target, the mount controller must know where the mount is currently pointing in relation to the celestial sphere and where the mount must move to get to the selected target. In a perfect mount with perfect polar alignment and with a perfectly constructed telescope, building a model would not be necessary. As long as correct site parameters have been entered and the mount has been aligned with one star, slewing to a target requires no correction. Select the target, command the mount to move and the mount moves to the object.

Unfortunately, no such telescope exists. Inaccuracies in mount mechanics, polar alignment and certain telescope types would cause these GoTo slews to not be accurate. Gemini can account for these inherent inaccuracies by creating a "pointing model". Creating a pointing model allows Gemini to learn about these inaccuracies and account for these imperfections when Gemini is commanded to perform a slew to a selected target.

Gemini uses a pointing model so that it can compensate for the real-world differences between:

- where the mount thinks it is pointing
- where the telescope is actually pointing
- how that relationship changes on each side of the mount.

In practice, the pointing model improves GoTo accuracy and makes the controller more tolerant of small setup imperfections. Gemini uses optical encoders attached to the motors to keep track of the physical coordinates where it is pointing at any given time. A pointing models adjusts these physical coordinates to correct for mount inaccuracies, and to produce a more precise sky position of where the telescope is really pointing.

4.2 What modeling does and does not do

4.2.1 What it helps

Modeling helps with:

- GoTo accuracy
- side-to-side repeatability
- understanding mount geometry
- workflows such as Polar Axis Correction that rely on a meaningful model.

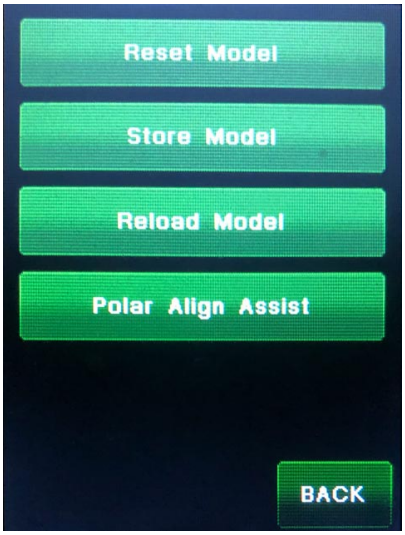
4.2.2 What it does not replace or do

Modeling does **not** replace:

- correct startup position
- correct site and time information
- safety limits
- stable mechanical balance
- good polar alignment for long-exposure imaging
- An accurate pointing model **does not** improve tracking. Tracking quality still depends on polar alignment, mount mechanics, periodic error, and guiding method.

4.3 Core terms to know

The Gemini system uses specific terms that are critical for you to know and understand. You cannot automatically assume you know what these terms mean to Gemini. Assumptions can lead to wrong configurations and erratic behavior. Please take a moment and read through the definitions of these core terms.



4.3.1 CWD

CWD means Counterweight Down. It is the physical reference position used for Cold Start and Warm Start workflows. See Section 2.4.

4.3.2 Meridian flip

A meridian flip is the move that repositions the optical tube to the opposite side of the mount so tracking can continue safely beyond the meridian.

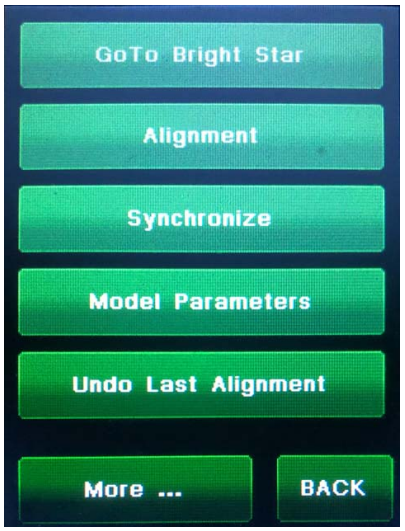
4.3.3 East/West Model side

Gemini uses two independent pointing models in order to successfully point to an object anywhere in the sky. Separate models allow better compensation for side-dependent effects. The mount geometry, non-perpendicularity, balance behavior, backlash take-up, drive loading, flexure and optical train characteristics might not be identical on both sides of the mount.

To accomplish this, Gemini utilizes an "East" pointing model and a "West" pointing model. The "East" pointing model and "West" pointing model are built independently. Looking at the Hand Controller, the "East" button builds the east model (Model 1) and the "West" button builds the west pointing model (Model 0). The "semi-automatic" feature preselects target stars used to build the pointing model. Pressing the "East" button selects stars in the east for the east pointing model and pressing the "West" button selects stars in the west for the west pointing model. The display shows the hour angle (HA) of the target star and the current elevation (El).

4.4 Hand Controller "Model" button

When you press the Model button from the HC, these two menus are available. The menu displayed below is normally hidden and will be displayed by tapping the More... button from the top menu. Below is a brief description of the function of these commands:



Goto Bright Star: Displays a list of bright stars visible from your location that are currently above the horizon. These stars aid in building a pointing model because they are easy to recognize. This is the same as the GOTO Bright Star from the GOTO menu off the main screen.

Alignment: Manually adds a star to the current model. This button expects that you have already centered the star. A cross-hair eyepiece or precise centering on a sensor is recommended for best results. You can use Alignment to add the first, or any subsequent stars to the current model

Synchronize: Synchronizes the mount to a star. This does not add the star to the model. This button expects that you have already centered the star. This command is normally used after a warm start, but can be useful at any time to resynch the mount when **GoTo** commands start to navigate to positions where the target object is not properly centered.

Model Parameters: View model parameter values for the East and/or West model.

Undo Last Alignment: Removes the last star modeled from the pointing model.

Reset Model: Completely resets all model parameters to zero for the selected model. To reset both sides of the pointing model, Reset Model will have to be used twice, once for Model 0 and once for Model 1.

Store Model: Stores a current model on the microSD card. This stores both the East and West models.

Reload Model: Reload a stored model from the microSD card. This reloads both the East and West models.

Polar Align Assist: Perform a polar alignment if no model is stored.
Polar Axis Correction: Perform a fine polar alignment only if pointing model(s) have already been built with a sufficient number of stars for this feature to become active.

4.5 Tips on how to build a Pointing Model

4.5.1 Start with stars that are easy to identify

The best first stars are not just bright - they are unmistakable. A mistaken alignment point will result in an inaccurate pointing model leading to inaccurate **GoTo**'s.

4.5.2 Build one side first

Use two or more stars on the starting side to get the pointing model working. Do not worry about perfection at this stage. The goal is to achieve a stable and reasonably accurate pointing model on that side.

4.5.3 Then build the opposite side

Once the first side works, choose a target that forces a meridian flip or otherwise transitions to the other side pointing model. Add at least one well-centered star there. For the most accurate overall pointing model covering the whole sky, both sides should have a pointing model established.

4.5.4 Keep adding points when needed

Gemini 2 lets you add stars later as conditions change or you just want to improve the accuracy of the pointing model. This makes the pointing model an operational tool, not just a one-time setup task. After changing mount geometry, or site, start a new model.

4.5.5 How to build a pointing model using the Semi-automatic function

This feature automatically selects a star above the horizon on either the east or west side of the sky.

Use the model number to confirm which side you are building:

- **Model 1 = East**
- **Model 0 = West**

Press **East** to build the east model, or **West** to build the west model. If the suggested star is blocked or unsuitable, press the same button again to select another star.

Build the First Side of the Model

1. **Open the Modeling screen:**
   From the Hand Controller main screen, select **Menu → Funct → Modeling**

2. **Choose the side of the sky:**
   Press **East** or **West**, depending on which side of the pointing model you want to build.
3. **Review the selected target star:**
   Make sure the star is visible from your location and is not obstructed.

For best results, the first two stars should be separated by at least 4 hours in right ascension. You may want to choose the first star near the zenith to make it easier for the second star to meet this separation.

If the selected star is not acceptable, press **East** or **West** again, depending on which side you are building, until a suitable star appears.

4. **Slew to the star:**
   When an acceptable star is selected, press **GOTO**.
5. **Center the star:**
   Let Gemini slew to the selected star. Using a medium-power eyepiece, center the star in the field of view.
   NOTE: Use only the **Center** or **Guide** speed to center the star**.** Using the **Slew** speed will take you out of the Modeling function and return you to normal **GoTo** mode.
6. **Add the star to the model:**
   Once the star is centered, press **Model**. On the next screen, press **Align**.
7. **Return to the star-selection screen:**
   Now press **Back**. You should return to the screen with the **East** and **West** buttons.
8. **Select the next target star:**
   A new target star will appear. The second star should be at least 4 hours away from the first star. After that, additional stars can be added between them.

Do not simply accept stars in the order they appear, since they may be too close together. If the suggested star is not acceptable, press the same side button again until a better target appears.

9. **Repeat the process.**
   Press **GOTO**, then repeat the centering, **Model**, **Align**, and **Back** steps for each additional star.

A minimum of **three stars** is recommended when building the first side of the pointing model.

Build the Opposite Side of the Model

10. **Switch to the opposite side.**
    After completing one side, press the opposite button: **East** or **West**.
11. **Select a target star on the opposite side.**
    Gemini will suggest a star for the other side of the pointing model.

If the star is acceptable, press **GOTO**. If not, press the same side button again until a suitable star is selected, then press **GOTO**.

12. **Confirm the meridian flip.**
    The mount must perform a meridian flip at this point. If the mount does not flip, you are not building the opposite-side model. Select another target star that requires the mount to perform a meridian flip.
13. **Build the opposite-side model.**
    After the meridian flip, center the star and add it to the model using the same process:
    GOTO → center the star → Model → Align → Back

Only one star is required on the opposite side, but adding more stars will improve pointing accuracy.

14. When both sides of the pointing model are complete, press **Back** twice to return to the Hand Controller main screen with the four diamonds
15. If, when building the model, a mistake has been made and you need to start over, press the "**Reset**" button on the "**Telescope Model Builder**" screen. This will clear whatever model you are building.

NOTE: When building the opposite-side pointing model, make sure the mount performs a **meridian flip**. Because of the safety limit settings, Gemini may decide it can safely reach the selected star without flipping. If the mount does not perform a meridian flip, you are still adding to the current-side model, not the opposite-side model.

In that case, choose a different star. The selected star must require a meridian flip before it can be added to the opposite-side pointing model.

4.6 How to manually build a pointing model

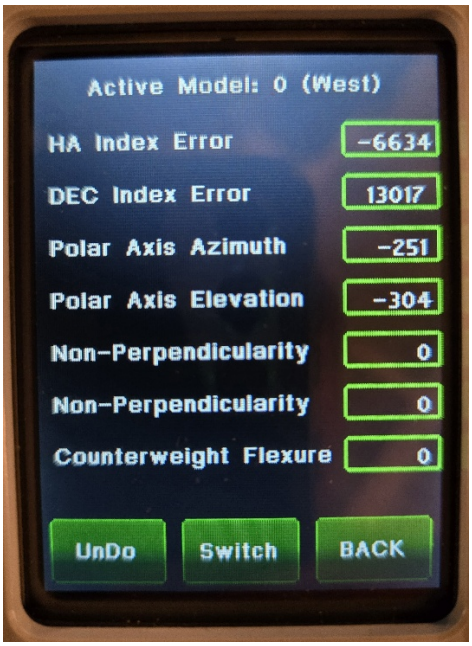
1. From the HC Main menu, select **Menu → Model**
2. Select **Goto Bright Star**
3. **Review the selected target star:**
   Make sure the star is visible from your location and is not obstructed.
4. **Slew to the star:**
   When an acceptable star is selected, press **GOTO**.
5. **Center the star:**
   Let Gemini slew to the selected star. Using a medium-power eyepiece, center the star in the field of view.
6. **Add the star to the model:**
   Once the star is centered, press **Model**. On the next screen, press **Alignment**.
7. Repeat steps 1 through 6 to keep adding stars to the model if needed.

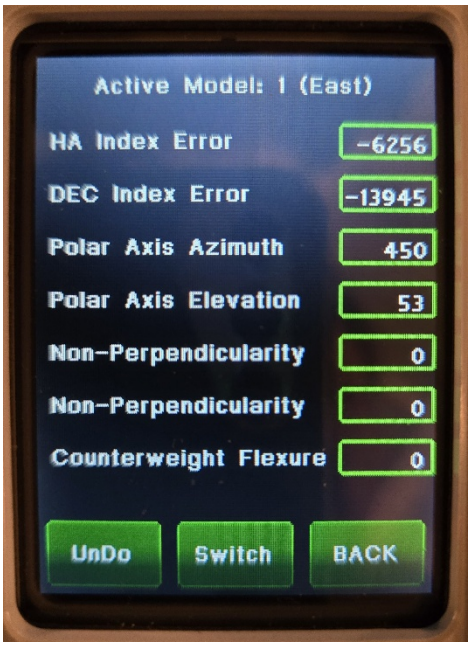
The Hour Angle (HA) and Elevation (El) are shown if you used the GoTo bright star menu above to select your GOTO target. If you want to add stars to the other side model (meridian flip required), just push the DOWN and UP buttons until you get a star offered that is at least 4 hours in HA or more and the meridian flip is almost guaranteed.

4.7 Model parameters definitions

Gemini calculates model parameters that allow the controller to compensate for polar-alignment and mechanical errors during GoTo slews. By compensating for such errors, Gemini can perform very accurate GoTo slews which become more accurate as more points are added to the pointing model. You can view the calculated parameter values from either the Hand Controller or the Webpage.

4.7.1 From the Hand Controller



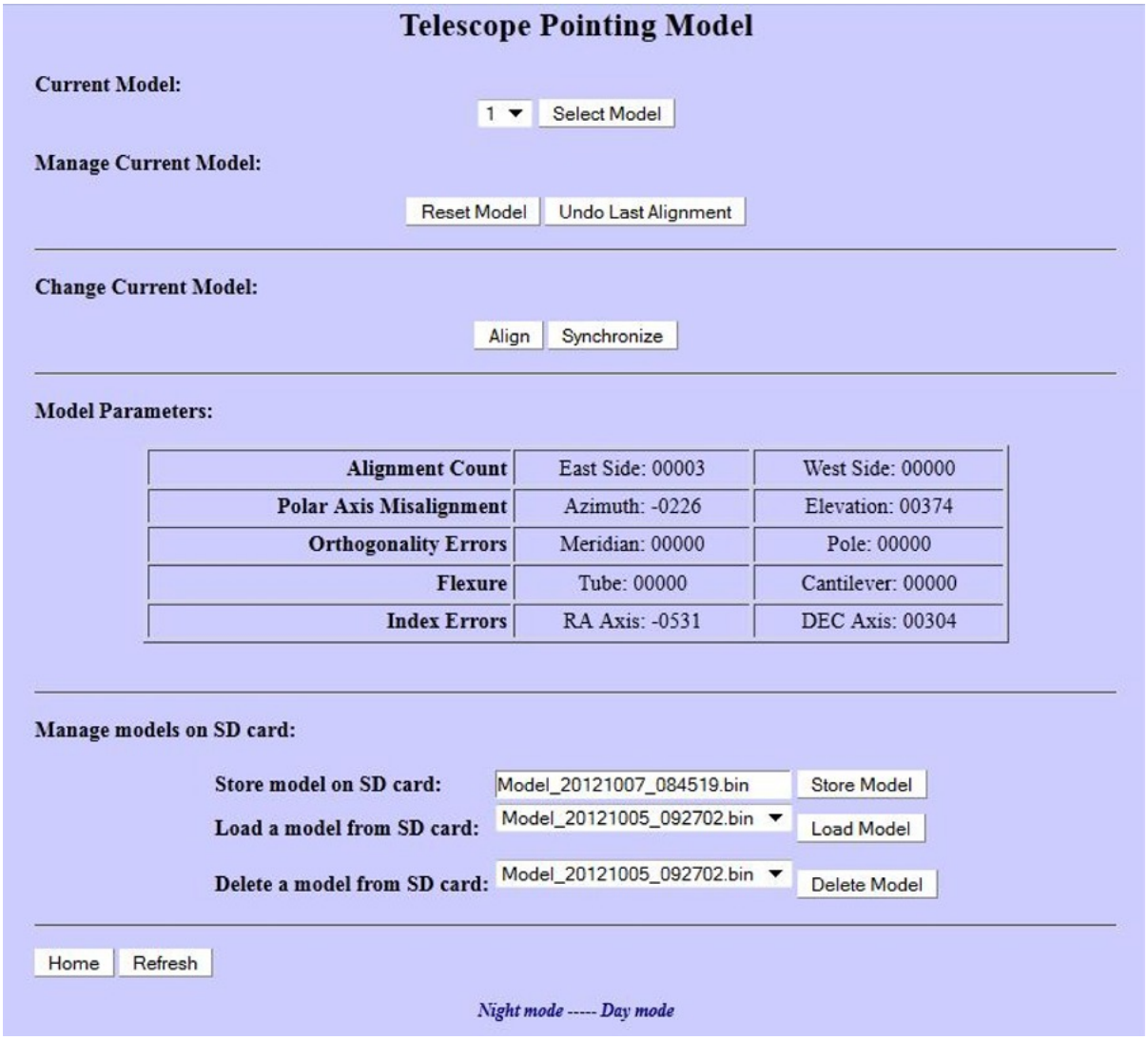


1. From the HC main screen press Menu → Model → Model Parameters. This will display the model parameters for the model as indicated at the top of the page. Selecting the "Switch" button will switch to the other side model parameters. "Undo" will remove the last alignment star from the model.
2. Definitions:

Parameter	**Description**
HA Index Error (IH)	An offset in RA. Synchronize or the first Align operation updates this term.
Dec Index Error (ID)	An offset in DEC. Synchronize or the first Align operation updates this term.
Polar Axis Azimuth (MA)	Amount in arc-seconds the mount is off in azimuth from the pole.
Polar Axis Elevation (ME)	Amount in arc-seconds the mount is off in elevation from the pole.
Non-Perpendicularity (NP)	Non-orthogonality as measured in arc-seconds at the pole.
Non-Perpendicularity (CH)	Non-orthogonality as measured in arc-seconds at the equator.
Mirror Flop (FR)	Mirror flop or gear play in RA, measured in arc-seconds.
Mirror Flop (FD)	Mirror flop or gear play in DEC, measured in arc-seconds.
Flexure in RA (CF)	Counterweight and RA-axis flexure, measured in arc-seconds.
Tube Flexure (TF)	Tube flexure, measured in arc-seconds.

Non-perpendicularity (orthogonality) error is where the telescope is not perfectly aligned perpendicular to the RA Axis. This can be caused by the telescope DEC axis saddle plate not being perpendicular to the RA Axis or the telescope not sitting in the DEC saddle plate parallel to the saddle plate. Other mechanical items can cause this error, but these are the most common.

4.7.2 From the Webpage



1. From the Gemini webpage, navigate to "Telescope Pointing Model".
2. The "Current Model" field will allow you to choose between displaying model parameters for Model 0 (West) or Model 1 (East).

4.7.3 Alignment points required for parameter activation

Gemini requires a certain number of stars in the model to calculate some of these values. The chart below shows how many stars are required for a value to be entered into the indicated parameter. These values are for EACH side of the pointing model.

Parameter	# of Stars
HA/Dec Index Error	1
Polar Axis Azimuth/Elevation	3-5
Non-perpendicularity	6-9
Counterweight Flexure	10+

4.8 Polar alignment tools

Gemini 2 provides two conceptually different polar-alignment aids, Polar Align Assist (PAA) and Polar Axis Correction (PAC). Each method is described below.

4.8.1 Polar Align Assist (PAA)

Use **PAA** before a pointing model exists. PAA is designed to help polar align the mount to within **1 to 2 degrees** of either the north or south pole. This routine will take at least 3 iterations to get as close as a polar scope. PAA is a coarse alignment tool good enough for visual but not a final, precision tool needed for imaging.

NOTE: This routine will not work if a pointing model has already been built!
Use PAA right after doing a Cold Start or clear the current pointing model before proceeding with the routine.

Before powering on Gemini, the mount should be in the CWD position with the DEC axis pointing toward the pole. Starting in this position will improve the accuracy of PAA.

PAA is most useful when:

- you have just set up the mount
- you do not yet have a model
- you want to get close quickly
- you will refine polar alignment later

4.8.2 Polar Align Assist Steps (PAA)

After you have cold started, select **Menu → Model → More… → Polar Align Assist**. Or you can choose **Menu → Funct → Polar Align Assist**. You will now see the menu options **Choose First Star, Choose Second Star,** and **Iterate.** For this alignment process, you'll need to pick two stars.

1. Select **Choose First Star**. The first star selected should be near the celestial equator (Dec. near 0) and above about 20° of the eastern or western horizon (about ±6 hours east or west). Use the DOWN and UP buttons to scroll through the list of stars. Once you find a star that meets the criteria, tap the star name to select that star. Gemini will then return to the **Choose First Star**, **Choose Second Star**, **Iterate** screen.

2. Select **Choose Second Star**. The second star should be near the intersection of the Celestial Equator and the Meridian. Use the DOWN and UP buttons to scroll through the list of stars. Once you find a star that meets the criteria, tap the star name to select that star. Gemini will then return to the **Choose First Star**, **Choose Second Star**, **Iterate** screen.

3. Select the **Iterate** button and the mount will slew to the first star. Once it reaches the star, "Please center object using the Az (azimuth) or El (elevation) knobs!" will appear on the display. If the star is the one near the meridian, center the star only using the mount's AZ adjustment knob (ignore EL). If it is in the western or eastern part of the sky, center the star using only the mount's EL adjustment knob (ignore AZ).

4. Press the **Iterate** button and the telescope will slew to the other star. Center it using the procedure described above. Repeat this about 3 times, each time pressing the **Iterate** button to slew back and forth between the two stars. When you are finished, press the **Back** button to return to the Main Menu.

You can expect to get to within one to two degrees of the pole using this method.

4.8.3 Polar Axis Correction (PAC)

Use **PAC** only after you have built a pointing model, ideally on **both sides of the mount**. PAC is a **fine polar-alignment tool**, not a substitute for the initial alignment process. For coarse alignment before modeling, use **Polar Align Assist** instead.

4.8.4 How to use PAC with an existing pointing model

This method assumes a valid, existing pointing model has already been built.

1. Find a target star that is nearly straight up in the sky and a little south (for northern hemisphere) or north (for southern hemisphere) of straight up.
2. Access the PAC function from the HC main screen by tapping **Menu → Model → More… → PAC**. If the **PAC** button is not visible, either no pointing model exists, or the pointing model was not built with enough stars to enable the **PAC** function.
3. Once you tap **PAC**, Gemini will move the mount away from the object by the amount of polar error calculated when the pointing model was built
4. Physically move the mount in azimuth (Az) and/or elevation (El) to center the target star. DO NOT USE GEMINI TO MOVE THE MOUNT TO THE TARGET STAR!
5. Once the target star is centered, tap **Done** to begin building a new pointing model. After you tap **Done**, the **PAC** function will clear any existing pointing model because the mount has now been physically moved and a new pointing model is required.

4.9 A recommended modeling workflow

For portable visual use:

1. CWD
2. Quick Start or Cold Start
3. PAA if needed
4. first bright-star alignment
5. second and third stars on the first side
6. one star on the opposite side
7. observe

For portable imaging use:

1. CWD

2. Quick Start or Cold Start
3. PAA or polar scope to get close
4. initial east-side or west-side model
5. opposite-side model
6. PAC if needed
7. rebuild the model after PAC
8. begin guiding / imaging

For permanent pier use:

1. establish a precise Home or park position
2. build both sides of the model carefully
3. save models if desired
4. use Warm Restart when the OTA is the same and the mount has not physically moved since last power-up.

4.10 Common misconceptions

"Warm Restart should work even though I moved the axes a little."

No. Warm Restart assumes the same OTA and the mount has not physically moved since last power-up. In this case, Warm Start should be used since the mount was physically moved.

"Modeling will compensate for a fix wrong time zone."

No. Modeling is not a substitute for incorrect setup parameters.

"One side is enough."

Not if you intend to perform a meridian flip, image across the meridian, or use PAC effectively.

"Synchronize and Alignment are basically the same."

Operationally they are different. Synchronize re-aligns the current sky position to the existing pointing model. Alignment adds to the pointing model or starts one if none exists.

4.11 Rules of thumb

- If you changed the physical setup or location, use Cold Start or Quick Start.
- If you kept the **mount site fixed** but lost exact sky position, use Warm Start and then Synchronize.
- If the OTA is the same and the mount has not physically moved since last power-up, Warm Restart is appropriate.
- If PAC was run, you will need to rebuild the model.
- If GoTo is great on one side and bad on the other, the opposite-side model is underdeveloped.

5 Imaging, Guiding, and PEC

5.1 Imaging priorities on Gemini 2

For imaging, Gemini 2 is not just a GoTo controller. Its real strengths are repeatability, multiple tracking modes, PEC, remote control, and support for software-guiding workflows.

In practice, imaging performance depends on four layers working together:

1. Accurate physical setup
2. A decent model on both sides
3. The right guiding method
4. Clean communications from Gemini to your PC and software.

5.2 Polar alignment still matters

Gemini 2 can compensate for many things, but field rotation still punishes long exposures when polar alignment is poor. Use PAA to get close, then PAC or another precision method if you need tighter performance.

For casual or short imaging, a good model plus guiding may be enough. For demanding work, accurate polar alignment is still a separate requirement.

5.3 Tracking rates

Gemini 2 continues the classic Gemini family of tracking modes. There are seven tracking rates:

- **Sidereal** is the default astronomical rate.
- **Lunar** is specialized for the Moon
- **Solar** is specialized for the Sun.
- **Adaptive King** is intended to help with differential refraction when imaging low to the horizon.
- **Closed Loop** can compensate for imperfect polar alignment in some observing scenarios.
- **Comet/User Defined** supports custom rate behavior.
- **Terrestrial** stops tracking.

5.3.1 Sidereal

This is the default rate for stars, galaxies, and most deep-sky observing or imaging.

5.3.2 Lunar and Solar

Use these for lunar or solar observing and imaging rather than deep-sky work.

NOTE: Gemini will automatically switch to the lunar or solar rate when you perform a GoTo command to that celestial body.

5.3.3 Adaptive King

Adaptive King tracking is intended to reduce the effect of atmospheric refraction on tracking. It is most relevant when your target and observing geometry make differential refraction significant, below 30° above the horizon.

The King method (published 1931 by Edward Skinner King) helps to avoid star trailing in photographs caused by differential refraction. Differential refraction may especially affect wide field photographs with long exposures.

King proposed two measures:

- Offsetting the polar axis slightly towards the zenith
- Adjusting the tracking rate.

The values necessary to accomplish this depend on the geographical coordinates of the observing site and the declination of the object being photographed.

Gemini's Adaptive King rate tracking varies the tracking speed to match the required value for the selected object's declination. You will need to offset the elevation of the polar axis yourself.

5.3.4 Closed Loop

For visual observing sessions, there is no need for extremely accurate polar alignment. By selecting Closed Loop tracking, Gemini can accurately track an object even if polar alignment is off several degrees in any direction. Gemini does this by comparing the coordinates of the object being tracked with the actual coordinates of the telescope. If the coordinates do not match, Gemini makes slow corrections in both RA and Dec. axes to point the telescope back at the object. This process of compare and correct is done about 22 times per second.

Although Closed Loop tracking will keep an object centered for a long time, it is not a substitute for a good polar alignment – especially if you intend to photograph extended objects. A misaligned polar axis will lead to field rotation, an effect where objects in the field of view will rotate around the center. However, after having done a good polar alignment, Closed Loop tracking can be used to photograph slow moving objects, such as minor planets or comets. This can work even if the object moves at a varying speed, by repeatedly sending actual coordinates to the Gemini using a computer. Because Gemini uses modeling parameters to calculate coordinates, Closed Loop tracking is only available after a pointing model has been established.

5.3.5 Comet / User Defined

This option is designed for targets that require custom tracking behaviors.

The Comet tracking rate lets you configure Gemini to set separate RA and DEC tracking speeds, ideal for following comets or other solar system bodies with unique movement patterns. There are several ways to achieve this:

- **Training**: Track an object by centering on its starting and ending positions over any time interval.
- **Coordinate Controlled**: Input the RA/Dec positions for both the start and end of a chosen time period.
- **Timer Values**: Calculate and enter RA and DEC timer divisors directly.
- **PC Controlled**: Determine the necessary tracking rates on your computer and upload them to Gemini.

For each method, Gemini computes and loads a new internal timer value to control tracking speed. The timer's range restricts the slowest possible tracking speed; however, faster movement (towards lower RA values) isn't affected by this limitation.

When DEC rates are positive, DEC values increase over time. If the pole is reached, the direction stays the same, but after crossing it, DEC begins to decrease.

Comet/User Defined tracking settings remain saved as long as Gemini stays powered on. If Gemini is powered off while in Comet/User Defined tracking mode, it will restart in Sidereal mode.

5.3.5.1 Training Comet Tracking

To start training, select "Menu → Track → User Define → Train." Unlike PEC training, you only need to keep the object in view—not follow its motion precisely. When finished, center the object and press COMET → STOP. Gemini then computes tracking rates for both RA and DEC axes and the mount will follow the object in both axes.

Training duration depends on the object's motion and observation type. For slow-moving objects, a few minutes is usually enough for visual observing, while photography may require up to half the exposure time. Rapidly changing objects (e.g., near-Earth Asteroids) benefit from shorter, just before the observation, training sessions. Generally, the longer and more accurate your training (up to 45 minutes), the better the tracking performance.

5.3.6 Terrestrial (tracking off)

Terrestrial stops tracking. It can be used for terrestrial observing, or when it is desirable to stop the telescope from moving without powering Gemini off.

5.4 Guiding options

Gemini 2 gives you three practical guiding paths.

5.4.1 Manual guiding from the Hand Controller

Manual corrections are still possible and can be useful for testing, diagnostics, or unusual workflows. The graphics Hand Controller preserves the classic directional logic, and Gemini 2 also supports classic button-style control concepts.

5.4.2 ST-4 / guider-port guiding

Gemini 2 includes an ST-4 compatible autoguider input. This remains a familiar and widely supported option, especially when using dedicated autoguiders or cameras with guider outputs. While it can be an option, pulse guiding using PC autoguider software remains the recommended way if you use a PC.

5.4.3 Pulse guiding through software

Pulse guiding through software lets a PC autoguider send guide corrections directly to Gemini 2 through a mount driver instead of through the ST-4 guider port. In a Windows workflow, this is typically done with the Gemini.NET ASCOM driver, which supports serial, USB, and Ethernet UDP connections.

On systems that use the **INDI** ecosystem, the same general idea applies: the mount is connected through an **INDI driver** that exposes **pulse-guiding** capability to guiding programs, so software such as **PHD2** can send guide corrections without requiring a separate ST-4 cable. PHD2 documentation recommends using **ASCOM or INDI pulse guiding instead of ST-4** when the mount supports it, because it reduces cabling and improves logging and diagnostics. In practical terms, pulse guiding is usually the more reliable method for an imaging setup, while ST-4 remains mainly a compatibility option.

5.4.4 Guider-port operating-mode requirement

The ST-4 compatible guider input is not universally active in every operating mode. The guider-input operation requires the Hand Controller to be in **Photo** mode or **All-Speed** mode. If guider hardware

appears electrically fine but the mount ignores it, verify operating mode before assuming a cable or pinout problem.

The classic four-button Hand Controller can be plugged into the guider port to simulate ST-4 inputs during testing, which is useful for bench verification.

5.5 Why Ethernet guiding is often the best choice

The Gemini 2 is optimized for Ethernet use (for example with ASCOM driver):

- control and guiding can share one connection
- Gemini UDP operation is faster and more reliable than USB in this case
- ASCOM driver supports multiple clients
- synchronous guiding feedback is available.

For a modern imaging rig, this often means:

- fewer cables
- more reliable and faster communications with the mount
- easier software integration
- simpler remote operation.

5.6 PEC on Gemini 2

5.6.1 What PEC does

Periodic Error Correction compensates for the repeatable tracking error introduced by the worm and drive train. PEC does not eliminate all tracking errors, but it can significantly reduce the repetitive, periodic component.

PEC can be especially useful when manually guiding a long exposure image by reducing the amount of guiding correction needed. It is possible to train the PEC during the first few minutes of the exposure, so that after the training is complete, PEC will reduce the number of corrections required for the remainder of the exposure. Using PEC together with an autoguider can also reduce the amount of correction done by the autoguider.

For users who are satisfied with the existing periodic error of their mount, Gemini's PEC function need not be used.

5.6.2 Gemini 2 PEC capabilities

Gemini 2 PEC features:

- PEC training from the controller
- PEC training using a CCD camera and PC software (e.g. PEMPro)
- ability to save and restore PEC curves to microSD storage
- option in recent firmware versions to start PEC automatically with tracking.

5.6.3 Basic PEC training workflow

A typical Hand Controller PEC workflow is:

1. enter the PEC menu
2. start PEC training

3. (auto)guide the star while training is active
4. complete at least one real correction cycle
5. save or reuse the trained curve.

If no actual corrections are made while training is underway, no usable PEC curve will be retained.

5.6.4 When to retrain

Retrain PEC when:

- worm is rotated by hand
- firmware update, reset, or storage changes invalidated prior data, or
- testing shows that the old curve has become counterproductive.

5.6.5 How PEC data is actually created and retained

Gemini 2 only records a PEC curve when real RA corrections are made during training. If you start PEC training and then make no corrections, no usable curve is created. Corrections can come from:

- Hand Controller RA buttons during training, or
- guider input while the PEC training state is active
- pulse guiding commands from PC software during PEC training

Once a curve exists, the Hand Controller menu changes: PEC can be turned on or off, retrained, and configured to start automatically with tracking. PEC data is stored on the Gemini 2's SD-card, so it should be thought of as persistent system data. It can be reused across multiple sessions unless one of the conditions is met from the previous section.

5.6.6 Third-party PEC-building tools

If you build PEC with external software such as tools that drive Gemini through the Gemini.NET stack, confirm where the resulting curve is stored and whether the software has been told to include PEC data explicitly. Do not assume that an external training run has automatically become a persistent on-controller curve.

5.7 TVC and servo motor control

5.7.1 TVC (Time Variable Compensation)

Gemini 2 includes **TVC** in the Mount menu for declination backlash compensation. TVC is a way to compensate for backlash caused by slack before the worm re-engages after a DEC reversal.

Use TVC conservatively. Too much compensation can be as disruptive as too little. It is a tuning tool, not a magic fix.

You can select a value between 0 and 255, which is the number of steps made at high speed whenever the DEC . direction is changed. You should choose a "TVC Value" that results in a short or no delay when changing the guiding direction in DEC. If you see a short jump, you have to decrease the value.

5.7.2 Motor-state and threshold pages as imaging diagnostics

For advanced users, Gemini 2's web pages provide more than just settings. The motor page can expose motor-state and threshold information, and later firmware generations also expose more real-time servo details. These pages are not a substitute for guiding analysis, but they are excellent for answering questions such as:

- is the controller operating near a lag or power threshold
- are motor warnings being triggered too aggressively
- does the mount behave differently under heavy payload or poor balance.

That makes the web motor pages especially helpful when tuning an imaging system that is mechanically sound but operationally inconsistent.

5.8 Portable imaging workflow

For a portable imaging session, a dependable Gemini 2 routine is:

1. set up and balance
2. power with a strong regulated supply
3. CWD and Quick Start
4. establish site/time correctly
5. set limits
6. build the first-side model
7. build the opposite-side model
8. use PAC if necessary
9. rebuild the model after PAC
10. connect imaging software over Ethernet if possible
11. enable or verify PEC if you use it
12. begin guiding and plate-solving workflow.

5.9 Permanent-imaging workflow

For a permanent pier-mounted Gemini 2 system, the emphasis shifts to repeatability:

- define a reliable Home position
- choose and configure a parking strategy
- build and optionally store both models
- keep the network settings stable
- save SRAM before maintenance
- use Warm Restart when valid
- keep firmware and driver versions documented.

5.10 Common imaging mistakes

5.10.1 Relying on guider-port when Ethernet pulse guiding is available

If your software stack supports Gemini.NET and Ethernet, that path is usually cleaner, faster, and more reliable.

5.10.2 Training PEC with poor fundamentals

PEC is not a substitute for good balance, good power, or good polar alignment.

5.10.3 Running PAC and forgetting that the model was invalidated

PAC changes the physical mount alignment. Rebuild the model afterward.

5.10.4 Ignoring side-to-side modeling

If the system images well before a flip and poorly after a flip, the opposite-side model is a prime suspect.

5.11 Practical recommendations

- Use the **guider port** when you need compatibility or simplicity
- Train **PEC** only after mechanical and setup basics are stable
- Use **TVC** only as a tuning aid
- Keep a written record of your guide method, startup mode, and park behavior so you can reproduce success.

6 Hand Controller and Web Interface

6.1 Two user interfaces, one controller

Gemini 2 is operated from two primary interfaces:

1. the **graphical Hand Controller**
2. the **internal web interface** available over Ethernet.

You do not need to use both, but understanding both makes Gemini 2 dramatically easier to operate and maintain.

6.2 Hand-controller fundamentals

6.2.1 Startup screen and calibration

On power-up, the Hand Controller may briefly present the touch-calibration screen. Accurate calibration matters because hidden areas and edge behavior can otherwise produce unintended actions, including language changes.

6.2.2 Main directional screen

The main directional screen preserves the familiar Gemini movement logic:

- four directional controls for RA and DEC movement
- a way to change speed behavior
- a **Menu** path for configuration and status
- a **GOTO** path for target selection and parking.

Physical buttons on the back behave like the earlier Gemini button layout and can be used for movement control.

6.2.3 Speed mode behavior

Gemini 2 uses four manual motion speeds—**Slew, Move, Center, and Guide**—which can be selected from the main screen with the **Speed** button. The chosen speed determines how the direction buttons move the mount, while the actual values for those speeds can be adjusted in the Speed menu. Speed behavior also depends on the selected Hand Controller mode: in **Visual** mode the buttons normally move at **Centering Speed** and can ramp up to manual slewing speed, while in **Photo** mode the buttons start at **Guiding Speed** and can step up through finer centering rates for precise framing. **All Speeds** mode makes the full range from guiding to slewing available, which is useful when both fine centering and large repositioning are needed in the same session.

6.2.4 Classic four-button controller compatibility

Gemini 2 preserves compatibility with the older four-button control concept, but not identically across all hardware. The original Gemini 2 supports the classic Hand Controller, while the Mini omits that traditional jack. For long-time Gemini-1 users this is worth calling out because some troubleshooting and guider-test procedures on the reference site assume access to the classic controller on the original hardware.

Even if you prefer the graphics Hand Controller, the classic controller remains useful as a minimal fallback interface and as a practical tool for testing guider-port behavior.

As with earlier Gemini workflows, direction and speed control are closely related. Pressing opposing keys can increase speed, similar to classic Gemini behavior.

6.3 Main Hand Controller screens

Because menu labels can vary somewhat by firmware, it is better to think in terms of major functional groups.

6.4 Align / Functions screens

This is where you work with the mount's sky model.

Typical items include:

- **Alignment**
- **Synchronize**
- **GoTo Bright Star**
- **Polar Align Assist**
- **Polar Axis Correction**
- **Store Model**
- **Reload Model**
- **Model reset / undo operations**

6.4.1 Alignment

Adds the current centered object to the active model for that side.

6.4.2 Synchronize

Re-establishes position without using the same model-building intent as Alignment.

6.4.3 Polar Align Assist

Polar Align Assist is the coarse polar-alignment tool used before a model exists. Its purpose is to get the mount reasonably close to the pole so that normal alignment and modeling can proceed efficiently.

6.4.4 Polar Axis Correction

Polar Axis Correction method is a tool for tightening the alignment.

Available after a model exists. Intended for precise adjustment using the model. Running it invalidates the model, so plan to rebuild afterward.

6.4.5 Store / Reload Model

Gemini 2 can store the current models to microSD and later reload them. Both east and west models are stored together.

6.5 GOTO Screen

The GOTO Screen is one of the biggest practical differences from Gemini-1. It is designed around target acquisition rather than around a long scrolling single-line menu.

Typical target sources include:

- catalog object selection
- bright stars
- solar-system targets
- coordinate input
- bookmarks
- park commands.

Only catalog objects above the horizon are normally shown.

6.5.1 Bright Star shortcut

A direct bright-star path is provided so you can align quickly without drilling through the full catalog selection every time.

6.5.2 Coordinates

Coordinate input is available from the GOTO side of the interface. Depending on firmware and page, you may also be able to choose between coordinate systems such as J2000 and JNOW when working with certain target-selection flows.

6.5.3 Force flip

For some catalog and web target-selection pages, there is an option to request a meridian-flip if that is the desired safe option for the move.

6.6 Mount Screen

The Mount Screen contains core mount-configuration controls.

- **Type**
- **Gearing**
- **Limits**
- **TVC**
- **PEC**
- **Network**
- **Startup**
- **Balance**

6.6.1 Type

Select the mount type. After changing mount type, do a Cold Start so the whole system is re-initialized consistently.

6.6.2 Gearing

Used for custom or modified mounts. Wrong values here can break basic motion behavior.

6.6.3 Limits

Used to set safety limits and the western GoTo limit. The reference pages emphasize that limits are relative to CWD and should be set only after valid startup geometry exists.

6.6.4 TVC

Adjusts DEC backlash compensation.

6.6.5 PEC

Enter the PEC training and control workflow.

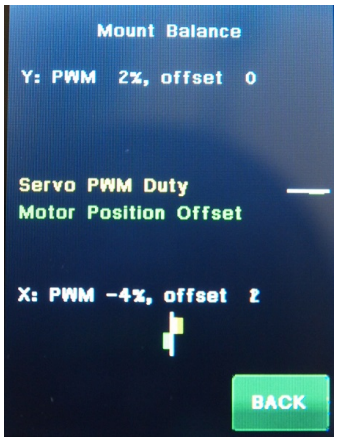
6.6.6 Network

Configure Ethernet behavior.

6.6.7 Startup

Choose the default startup behavior such as Ask if Possible, Cold Start, Warm Start, or Warm Restart.

6.6.8 Balance



The Balance menu provides a real-time view of how much effort the RA and DEC servo motors use to move the mount. The PWM (pulse-width modulation) display shows this effort as a percentage while the mount is tracking.

A higher percentage means the motor is working harder. You can use this screen to check the mount's balance: if the mount is unbalanced, the PWM value will be higher on the affected axis.

Adjust the mount's balance until the PWM percentage is as close to 0% as possible to get a better balance.

NOTE: high PWM numbers can also indicate other mechanical issues, such as worm/gear mesh being too tight, old or missing grease, mount is overloaded, etc. If after adjusting balance the PWM numbers are still high, these other causes may need to be investigated.

6.7 System / Site / Time / Network Screens

6.7.1 STORE, firmware information, and version checks

In Gemini 2, system housekeeping deserves first-class attention. Two especially important habits are:

- use **STORE** when you have created settings worth preserving
- know how to read firmware dates and versions from the Hand Controller or the **Firmware/SRAM** web page.

The version page is not just informational. It is also the place where web-based flashing of NewGem.bin, SRAM reset, and SRAM backup/restore actions are organized. If you are about to update firmware, replace a battery, or diagnose strange retained-state behavior, this page should be part of your routine.

6.7.2 What STORE does and does not replace

STORE is extremely useful, but it is not a substitute for understanding the full SD-card workflow. Models, PEC data, controller files, and language/mobile pages all live in different places. Use STORE to protect configuration state but continue to think of Gemini 2 as a file-backed system overall.

Common functions include:

- site setup
- time setup
- network setup
- store SRAM
- reload SRAM
- reset defaults.

The **STORE** function writes SRAM-backed values to Gemini.cfg in the CONFIG directory on the main unit's microSD card. This is especially useful after you have finalized:

- site
- mount type
- limits
- parking information
- similar operating settings.

6.8 Park menu and park modes

Gemini 2 separates the idea of **where** the mount parks from **how** it wakes up afterward.

6.8.1 Park positions

Common park-related actions include:

- park at CWD
- set and park at Home
- unpark
- stop or restart tracking.

6.8.2 Park modes

The reference Park Modes page describes three wake-up rules.

6.8.2.1 Mode 0 — Every Move

Any move-related command can wake the mount.

6.8.2.2 Mode 1 — GoTo Command

Directional buttons and guider inputs are ignored while parked, but GoTo or unpark commands wake the mount.

6.8.2.3 Mode 2 — Explicit Wakeup

Only an explicit unpark command wakes the mount. Mode 2 is the safest behavior.

6.9 The internal web interface

The web interface is one of Gemini 2's defining features. It is accessed over Ethernet using HTTP, not HTTPS. In many installations you can reach it by IP address, or by the host name gemini if local name resolution is working.

Log in with:

- **user:** admin
- **password:** blank

6.9.1 Main web pages

The main page links to a series of specialized control pages. The reference page lists these as the core set.

6.9.1.1 State

Shows the current state of the mount.

6.9.1.2 Hand Control

A limited browser-based hand-control page for basic movement and operations.

6.9.1.3 Functions

Provides operations such as:

- **GoTo** coordinate input
- park / sleep / wakeup
- reboot and cold reboot
- parking-mode control
- PEC control

- classic Hand Controller mode
- and tracking-speed selection.

6.9.1.4 Catalogs

Provides access to visible catalog objects and **GoTo** functionality. This page can also work with added user catalogs.

6.9.1.5 Mobile Hand Controller

This utility is for use with Android or iOS phone or tablet. This utility requires a Wi-Fi connection for the phone/tablet and the Gemini 2 be connected on the same network. This software was supplied by a user of the Gemini 2 and is an example of what a user can do with the user-extensible web interface.

6.9.1.6 Access / Password

On this web page you can change the password for the Gemini 2 from blank to something else.

If you are not going to access Gemini 2 from the internet (outside of your local network) then you probably do not need to change this.

Also note that if you do change this you will have to totally reprogram the Gemini 2 to get it to revert to having no password. Also note that when the firmware is updated, the Gemini 2 will revert to having no password.

Use only alphanumeric characters (numbers and letters).

6.9.1.7 Battery / Ports

These pages are easy to overlook and valuable to learn. The Battery / Ports page can show backup-battery voltage and live port activity.

6.9.1.8 Servos

This page contains servo-related status values and thresholds.

6.9.1.9 Mount

This page centralizes mount parameters such as:

- mount design / type
- gearing
- move and slew speeds
- centering speeds
- safety limits
- default startup mode.

6.9.1.10 Site / Time

Used to enter:

- local or UTC time
- observing sites
- GPS query functions
- NTP time queries.

6.9.1.11 Modeling

Shows model parameters, lets you switch current model side, align, undo alignments, reset, and store or retrieve models from the microSD card.

6.9.1.12 SD Card

Shows the contents of the microSD card and allows uploads. It is also used for catalogs and some update workflows.

6.9.1.13 Firmware / SRAM

Used to:

- flash firmware files
- store SRAM to Gemini.cfg
- reload SRAM from stored configuration.

6.9.1.14 Network

Controls DHCP/static behavior, stored and current network settings, timeout behavior, and related Ethernet parameters.

6.9.1.15 Serial Port / Serial Command pages

These pages expose serial-port settings and the controller's command-reference functionality.

6.10 Hand Controller versus web interface: when to use which

6.10.1 Best uses for the Hand Controller

Use the Hand Controller for:

- first-night setup at the scope
- star centering
- alignment and synchronize actions
- movement while looking through the telescope
- quick park and restart tasks
- operation when no PC is present.

6.10.2 Best uses for the web interface

Use the web interface for:

- mount parameter review
- network configuration
- firmware and SRAM management
- SD-card uploads
- model inspection
- remote status checking
- catalog management
- observatory-style remote workflows.

6.10.3 Night mode, HOME navigation, and custom pages

Most web pages support a **Night mode / Day mode** toggle, and most also provide a **HOME** link back to the main web index. Additional web pages can be created using Gemini 2 CGI mechanism. This is one of the platform's most unusual strengths: the web interface is not just fixed firmware UI, but is user-extensible front end stored on the controller's media.

6.11 Recommended user-interface habits

1. Use the **Hand Controller** for live pointing and centering.

2. Use the **web interface** for persistent configuration and recovery tasks.
3. After major configuration work, use **Store SRAM**.
4. After changing mount type or major geometry, do a **Cold Start**.
5. Treat **limits** and **park behavior** as part of configuration, not as optional extras.

7 Connectivity, Software, and Files

7.1 Control paths available on Gemini 2

Gemini 2 can be operated in four broad ways:

- stand-alone, from the Hand Controller only
- from software over **serial**
- from software over **USB**
- from software and browser tools over **Ethernet**.

Each has a valid use case, but they are not equal in capability.

7.2 Stand-alone operation

Gemini 2 can be used completely stand-alone with no external computer. This is still one of the best ways to learn the mount because it forces you to understand startup mode, alignment, limits, and park behavior before adding software complexity.

7.3 Serial connection

7.3.1 What serial is good for

Use the serial port when:

- you have legacy software that expects COM-style control
- you are integrating through a USB-to-serial adapter
- you are attaching a GPS receiver
- or you want a simple command path without Ethernet.

7.3.2 Port naming

On the original Gemini 2, the serial computer/GPS port is normally **Serial Port 1**. On the Mini it is labeled **Serial Port / GPS**.

7.3.3 Web-interface limitation

The Gemini 2 web interface is available **only through the Ethernet connection**, so it cannot be used unless the controller is reachable on the network. If you cannot connect to the web interface, you also will not be able to use the Gemini.NET ASCOM driver over Ethernet.

7.3.4 Baud-rate discipline and Hand Controller behavior

The graphics Hand Controller is unforgiving about baud rate: it expects **57600 baud**. On the original Gemini 2 it normally belongs on Serial Port 2 / Graphics HC. If you intentionally move it to Serial Port 1 for testing, that port must also be set to 57600. After some firmware-reset scenarios, Serial Port 1 may default back to **9600 baud**, which is one more reason not to treat that port as the normal permanent home for the graphics Hand Controller.

When a Hand Controller seems dead, always consider port selection and baud settings before assuming firmware corruption.

You **cannot access the web interface through the serial port**. Serial accepts Gemini command traffic, not browser traffic.

7.4 USB connection

7.4.1 What USB is good for

USB is useful for computer control when Ethernet is not practical. It can be used with the ASCOM driver.

7.4.2 What USB does not do

Do not think of Gemini 2 as a general-purpose USB host. Common **USB Wi-Fi** or **USB Bluetooth** dongles cannot simply be plugged into Gemini 2 to add wireless capability, because those devices require host-side recognition and driver support that Gemini 2 does not provide. In practical terms, wireless Gemini 2 setups are built around **Ethernet bridges, routers, or external networking gear**, not around generic PC-style USB dongles.

- The web interface is **not** available over USB.
- Windows may require a driver.
- Linux systems are generally better at exposing USB serial devices without extra effort.
- Confirm current macOS USB-driver support for your controller and operating-system version

7.5 Ethernet connection

7.5.1 Why Ethernet is special on Gemini 2

Ethernet is not just another port. It is the path that unlocks:

- web interface
- firmware updates via network workflows
- Gemini.NET ASCOM Ethernet path
- remote status inspection
- convenient multi-client software control.

Caveats: using Gemini 2 over Ethernet, the main cautions are practical rather than functional. The controller's Ethernet port is **10/100 only**, so direct connections to older 10/100 network hardware may require attention to cable type, while most modern Gigabit network ports handle this automatically. If you connect Gemini 2 **directly to a computer**, both the computer and Gemini 2 must be configured with compatible **static IP settings** unless a DHCP router is present. Also remember that the **web interface is available only over Ethernet**, not through USB, even though USB and serial can still be used for Gemini command access and ASCOM connections.

7.5.2 DHCP and static IP

Gemini 2 supports both DHCP and static IP configurations. When DHCP is enabled, the controller tries to obtain an address; if that fails within the configured timeout, it can fall back to the stored address, commonly 192.168.0.111.

7.5.3 Direct connection versus network connection

You can connect Gemini 2 either:

- directly to a computer Ethernet port, or
- through a switch / router.

If you connect directly to a computer, you may need to set the computer's Ethernet interface to a matching static IP range and disable DHCP on Gemini 2.

7.5.4 Web login basics

To access the Gemini 2 web interface, connect to the controller over **Ethernet** and open its network address in a browser, such as `http://gemini` if name resolution works on the local network, or its IP address if needed. When the login prompt appears, the default user name is **admin** and the default password is **blank**.

The web password can be changed from the **Web Access** page if you want to protect the controller on a broader network. If you do set a password, remember it carefully: reverting to no password requires fully reprogramming the Gemini 2, and a firmware update resets the web password back to blank.

7.5.5 Addressing, fallback behavior, and hostnames

The web-network page distinguishes between **current** and **stored** LAN settings. The stored settings matter because they define what Gemini 2 falls back to when no DHCP server is found at startup. The commonly documented default address is **192.168.0.111**.

If your network supports NetBIOS name resolution, the controller may also be reachable as **gemini**, which is why some documentation uses http://gemini rather than a numeric address. This is convenient, but numeric IP access is still the more deterministic troubleshooting method.

7.5.6 Direct cable versus routed network

Gemini 2 can be used with a router-based LAN or in a direct computer-to-controller Ethernet arrangement. On older 10/100 hardware without automatic cable-type detection, a **crossover cable** may be required for some direct connections.

7.5.7 FTP-style file access and network-place workflows

Many update and maintenance procedures assume that the Gemini 2 storage can be reached over the network as a file target, not just as a browser target.

If the web interface does not open, the ASCOM Ethernet workflow will not work either. Confirm browser access first.

7.6 Multiple Gemini 2 controllers on one network

Multiple Gemini 2 controllers on one LAN require more care than simply plugging them in. The controllers can share the same default IP assumptions, and even the same default MAC assumption, so a multi-mount environment should be deliberately re-addressed rather than left to chance.

In practice, give each controller:

- its own static IP
- its own non-conflicting stored fallback address
- a documented identity that your ASCOM and browser workflows can follow reliably.

The Gemini.NET driver can address up to two **mounts per computer at a time**.

If you have more than one Gemini 2 on the same local network, change both the **IP address** and the **MAC address** of the second unit. The default values are:

- default IP: 192.168.0.111
- default MAC: 1e:30:6c:a2:45:5f

Two controllers cannot safely coexist on one network with the same network identity.

7.7 GPS and NTP

A useful operational rule is that **GPS and NTP solve UTC**, while the observer still has to think about presentation and site consistency. GPS can update time and coordinates, but it does not magically repair a poor time zone assumption. NTP can do the same for UTC over the network, provided the NTP server address is configured and reachable.

If you use GPS or NTP routinely, develop the habit of checking both:

- UTC time for correctness
- displayed local time as a sanity check that the time zone offset has not drifted into nonsense.

Gemini 2 can obtain time and site data from:

- a GPS receiver connected to the appropriate serial/GPS port
- an NTP server through the network path.

Internally, Gemini 2 calculates from **UTC**. This means the time zone setting still matters because local display values are derived from UTC plus the time zone offset.

7.8 ASCOM and external software

7.8.1 Gemini.NET ASCOM driver

The maintained Gemini.NET ASCOM driver supports:

- Gemini 1 Level 4
- Gemini 2 Level 5
- Gemini 2 Level 6
- and communications over serial, USB, and Ethernet UDP.

This driver is maintained independently from Losmandy itself.

7.8.2 Why many users prefer Ethernet with Gemini.NET

The Ethernet configuration guide highlights these advantages:

- control and guiding over one cable
- faster UDP communications
- synchronous guiding acknowledgements
- multiple simultaneous ASCOM clients
- reduced need for separate guider cabling.

7.8.3 First-time ASCOM caution

Before connecting ASCOM software for the first time, complete the important Gemini 2 setup inside the controller itself and save those settings. The practical risk is that a poorly initialized driver profile can overwrite mount parameters with incorrect values. A safe sequence is: finish setup in Gemini 2, Store SRAM, confirm the driver profile deliberately, and only then connect external software. If something goes wrong, inspect the ASCOM profile before reconnecting and restore saved settings if necessary.

7.8.4 SkySafari and bridge-style software paths

A workable SkySafari path uses **Gemini.NET** plus **Wi-Fi Scope** as a bridge. SkySafari, when used over Ethernet in this kind of arrangement, may open a new socket for each command and can eventually overload the Gemini 2 Ethernet stack. The same warning says this particular issue does not occur when SkySafari is used over a serial path.

The practical lesson is not “never use SkySafari,” but rather: keep your connection architecture simple, and do not assume every app uses Ethernet in a controller-friendly way.

The first-time ASCOM setup guide warns that if advanced settings are sent to Gemini before the driver profile is initialized correctly, the driver can overwrite mount settings with bad or unknown values. In other words: do the first ASCOM setup carefully.

A practical rule is:

1. finish setup inside Gemini 2 first
2. save or store your settings
3. configure the ASCOM profile deliberately
4. then connect.

7.9 Planetarium, guiding, and automation software

With the correct driver stack, Gemini 2 can be used with:

- planetarium programs
- plate-solving tools
- guiding applications
- capture suites
- observatory automation software.

Software such as TheSkyX, MaximDL, and PHD2, can all be used concurrently with ASCOM-based workflows.

7.10 Catalog workflows

7.10.1 Built-in and Hand Controller catalogs

Gemini 2 includes catalog access from both the Hand Controller and the web interface. The controller shows only horizon-appropriate objects in many target-selection workflows.

7.10.2 Adding user catalogs

User catalogs can be added through SD-card and upload workflows. The web Catalogs/Objects and SD Card pages are the most practical entry points for these tasks.

7.10.3 Hand-controller catalog updates

Hand-controller catalog and logo updates are staged through the main unit’s SD-card structure. Files placed in the HCFirmware directory are uploaded to the Hand Controller on the next Hand Controller power-up. Catalog transfers can also be triggered from the Hand Controller through `HC → SDcard → Upload files`, but that menu path is for catalog transfer only; it should not be confused with a true Hand Controller firmware flash.

7.10.4 SD-card directory map you should know

SD-card directory structure is useful to understand. The most useful directories are:

- **Catalogs** — main star/object catalog files
- **HCFirmware** — files that will be uploaded into the Hand Controller
- **Logs** — protected internal logs
- **MHC** — files for the mobile web interface

- **CONFIG** — configuration backups such as Gemini.cfg
- **PEC** — PEC storage
- **HC** — web-based Hand Controller files
- **EN / DE / ES / FR** — language-specific web content.

Once you understand these directories, firmware updates, catalog updates, mobile UI changes, and recovery procedures become much easier to reason about.

Files placed into the HCFirmware folder are uploaded to the Hand Controller on the next Hand Controller power-up. Catalog and logo file updates follow this transfer mechanism.

7.11 Firmware and storage workflows

7.11.1 Main ideas

There are several legitimate ways to update Gemini 2 firmware:

- place a firmware file at the **root of the main microSD card** and trigger flashing
- use the **web interface** to upload and flash NewGem.bin
- use **file-transfer / FTP-style** access to place update files
- use a **card reader** to work directly with the microSD card, or
- use **GFU** to automate downloading and uploading of bundled update files.

One special case is especially worth remembering: when the root-level file is named HGM_Gem2.bin, Gemini 2 can flash it on next power-up and then rename it to Cur_Gem2.bin. This makes that filename pair part of the recovery vocabulary of the platform.

7.11.2 Gemini Firmware Updater (GFU)

The GFU workflow is mostly automatic:

- downloads the latest combined firmware package
- extracts it locally
- transfers selected files by FTP
- stores settings before flashing
- restores settings afterward.

7.11.3 Store SRAM before risky maintenance

Before firmware work, battery service, SD-card handling, or any maintenance where fast recovery matters, store SRAM first. This creates Gemini.cfg in the `CONFIG` directory and gives you a practical restore point for the controller's operating configuration. It is one of the safest habits a Gemini 2 owner can develop, because even when an update path is designed to restore settings automatically, models and PEC may still need separate attention afterward.

7.11.4 What updates usually preserve and what they may not

The GFU documentation says that when flashing is selected, the tool ordinarily saves and restores settings **except PEC and Models**. That is a very important boundary. Even when a firmware workflow is designed to restore configuration, you should still assume that:

- **configuration** may be recoverable
- **models** may still need to be rebuilt or reloaded
- **PEC** may need to be preserved separately or recreated.

This is why the safest pre-update ritual is: Store SRAM, back up key files, know your firmware versions, and do not update in a hurry.

Use **Store SRAM** before:

- firmware updates
- battery changes
- SD-card work
- or any maintenance where you want a fast recovery path.

This creates Gemini.cfg in the CONFIG directory. You can later reload it.

7.12 Battery-backed settings and recovery

The battery-backed SRAM is central to Gemini 2's retained-state behavior. It is what makes warm restarts, stored site data, retained configuration, and long-lived operational convenience possible. It is also why a tired battery can imitate a software catastrophe.

The web Firmware/SRAM page exists for a reason: use it to store configuration before risky work, to reload it after battery service when appropriate, and to reset SRAM deliberately when a firmware change leaves the controller in an inconsistent state.

Gemini 2 stores important operating values in battery-backed SRAM. That is convenient, but it also means careless battery work can be destructive.

Before changing the battery:

1. store SRAM to file
2. document the current firmware and network settings
3. replace the battery carefully
4. power-up and set time/date immediately
5. reload SRAM if needed.

7.13 Serial command support

7.13.1 Command families

Gemini 2 supports:

- a subset of the **Meade LX200** command set
- additional LX200-style Gemini extensions
- and **Gemini native commands**.

This is what makes the controller compatible with a large ecosystem of telescope-control tools while still exposing Gemini-specific functionality.

7.13.2 Interfaces that use serial commands

Gemini 2 command traffic can be accepted through:

- serial port
- USB virtual COM path
- Ethernet path
- and the graphics Hand Controller command environment.

7.13.3 Useful serial-behavior facts for integrators

The Level 5 and later serial documentation shows that Gemini 2 can report startup state programmatically and can even accept startup-mode selection through the serial protocol. In other words, the controller is not just exposing coordinates and GoTo commands; it exposes meaningful state transitions that software can interrogate.

That matters when writing automation or observatory software, because it means a client can distinguish between:

- initial boot display
- waiting for startup choice
- a Cold Start in progress
- a completed equatorial or Alt/Az startup state.

For advanced integrators, Gemini 2's native command set is where mount-type, end-switch, gearing, park-behavior, and related low-level settings become truly useful.

The full serial command set is too large and firmware-sensitive to reproduce here. For custom software development, always consult the command-set page that matches your installed firmware level.

7.14 Recommended connection choices

7.14.1 Best general choice

If your workflow supports it, choose:

Ethernet + web interface + Gemini.NET ASCOM driver

This gives the broadest functionality with the fewest cables.

7.14.2 Best legacy-compatible choice

Choose:

Serial or USB + ASCOM / planetarium software

when you need compatibility with an older workstation or software environment.

7.14.3 Simplest learning option

Choose:

Hand Controller only for the first few sessions until startup, limits, align, synchronize, and parking all make sense.

8 Troubleshooting, Maintenance, and Recovery

8.1 First troubleshooting rule: suspect the battery

8.1.1 Low-battery symptoms can be unexpected

There is a surprisingly wide range of strange behavior that can be attributed to a weak backup battery in the main unit. Symptoms can include:

- wrong time or date on startup
- forgotten site or mount type
- missing model or PEC state
- erratic GoTo behavior
- repeated forced cold starts
- odd startup behavior
- weird configuration resets
- unexplained controller symptoms
- inconsistent logic behavior.

When the system begins to show some unexplainable strange behavior:

- inspect battery voltage
- make sure battery is properly seated and making contact
- replace the battery if below the documented threshold or if symptoms persist.

It is recommended to replace the backup battery when the monitored voltage is about **2.75 V or lower**. In other words, battery health is not a minor maintenance item on Gemini 2; it is part of core controller reliability.

8.2 Battery replacement warnings

8.2.1 Do not improvise an external battery pack

The battery circuit differs from Gemini-1 in that attaching an external battery pack in place of the internal battery can damage the ARM processor.

8.2.2 Set time and date immediately after replacement

After replacing the battery, power on the controller and set the time and date right away. Failing to do so can cause the battery to discharge quickly in some older versions of Gemini 2 controller.

8.2.3 Save SRAM before battery work

Battery replacement should be treated as a controlled maintenance event, not as a casual hardware swap. Before replacing the backup battery, use the Firmware/SRAM workflow to store the current settings to Gemini.cfg. After replacement, power the controller promptly, correct the time and date, and reload the saved configuration if needed. This preserves site, limits, and other retained settings that might otherwise be lost or scrambled during battery service.

8.3 Mount slews the wrong way

If the mount slews or tracks in the wrong direction, check these in order.

8.3.1 RA and DEC cables

Make sure the RA and DEC cables are not swapped.

8.3.2 Site and time values

Wrong time zone, wrong longitude sign, wrong latitude sign, or inconsistent local/UTC time can all create apparently absurd pointing behavior.

8.3.3 Mount type and gearing

Verify mount type first. Then verify gearing. If the system has modified gearboxes or custom gearing, the worm-ratio signs may need to be changed.

8.3.4 SRAM reset after firmware changes

If the problem appeared right after a firmware upgrade, the troubleshooting page explicitly recommends performing an SRAM reset from the Firmware/SRAM page.

8.4 Hand Controller will not connect

If the Hand Controller remains stuck at “Connecting to Gemini,” check the following.

8.4.1 Correct port

The Hand Controller must be connected to the correct HC port for your hardware variant.

8.4.2 Hand-controller microSD card contents

A failed Hand Controller update can corrupt or incompletely populate the Hand Controller microSD card. The troubleshooting involves checking for the expected root files and the presence of the full HCFirmware contents. A missing or corrupted file set on the HC card can look like a dead controller when the real issue is simply incomplete media.

The microSD card in Hand Controllers can work loose. Reseating it is a good first recovery step.

8.4.3 Reseat the microSD card

If the Hand Controller will not connect or appears dead, reseating its microSD card is a valid first recovery step. Early Hand Controller cards can work loose, and an incomplete contact can look like a major controller failure when the real issue is only unstable media seating. Power down, remove and reinsert the card carefully, make sure it is fully seated, and then retry startup before moving on to more invasive recovery work.

8.4.4 Why Hand Controller uploads sometimes fail

If you are updating the Hand Controller from files staged in the main unit, remember a subtle but crucial rule is: the **main Gemini 2 unit must have gone through the boot menu and into a startup mode**. If the main unit is still sitting at the boot-choice screen, a file intended as Hand Controller firmware can be interpreted merely as a catalog file.

Also remember the operational difference between the two upload paths:

- power-cycling the Hand Controller can trigger firmware or file upload from staged files, but
- **Upload files** menu on the Hand Controller is intended for catalog uploads, not for a real Hand Controller firmware flash.

8.4.5 Confirm the web interface first

If the browser cannot open the Gemini 2 web interface, the Ethernet ASCOM workflow will not connect either. Always test browser access first.

8.4.6 Check DHCP/static assumptions

A controller set for DHCP but connected directly to a computer often fails to get a usable address. In that case, use a matching static-IP arrangement.

8.4.7 Use HTTP, not HTTPS

The Gemini 2 web interface expects HTTP. Some browsers attempt HTTPS automatically; that will fail.

8.4.8 Multiple-controller conflict

If you have two Gemini 2 units on your network, you are going to have to change the default MAC address for one of them, and to make sure they are both assigned a different IP address.

Make sure only one Gemini 2 is turned on. This will be the one you want to change.

Go into the Web interface using your computer. Select "Network" on the web home page. Then

1. Change the IP address to something different from the other Gemini 2, but on the same subnet (change just the last digit)
2. Change both the Current Setting and stored setting of the MAC address from 1e:30:6c:a2:45:5f to, for example, 1e:30:6c:a2:45:5e
3. Hit the set button. Now this is going to disconnect you from your network. Don't be alarmed. Just use the new IP address in your browser to reconnect.

NOTE: If you have MAC address filtering enabled on your router, then you are going to have to add this new MAC address to your router before your router will see this Gemini 2 on the network

8.5 ASCOM connects but causes bad settings

The first-time ASCOM guide specifically warns that incorrect profile setup can overwrite Gemini settings. If ASCOM connection appears to corrupt configuration:

1. stop using the driver until you inspect its profile settings
2. review mount settings inside Gemini 2 directly
3. restore SRAM if necessary
4. correct the driver profile before reconnecting.

8.6 GoTo is inaccurate or alignment is rejected

8.6.1 Wrong startup mode

This is a top suspect. If the physical state does not match Warm Restart assumptions, the system begins from the wrong sky position.

8.6.2 Not started at CWD for cold-style workflows

Cold Start and Warm Start assume CWD. If you begin from the wrong physical position, the geometry and limits are compromised from the start.

8.6.3 One-sided model only

If GoTo works well before a flip but poorly after a flip, the opposite-side model is probably incomplete.

8.6.4 Wrong bright-star identification

An alignment based on the wrong star can poison the model. Use stars that are unmistakable.

8.7 Limits and park behavior are unsafe or confusing

8.7.1 Limits were set from a bad startup assumption

If limits were set after an invalid Warm Restart or without establishing correct CWD reference, reset them after a correct Cold Start or Warm Start.

8.7.2 Park mode misunderstood

Remember that park **position** and park **wake-up mode** are different settings. A mount that appears "dead" after parking may simply be in Explicit Wakeup mode waiting for a formal unpark command.

8.8 Touchscreen behaves badly or changes language

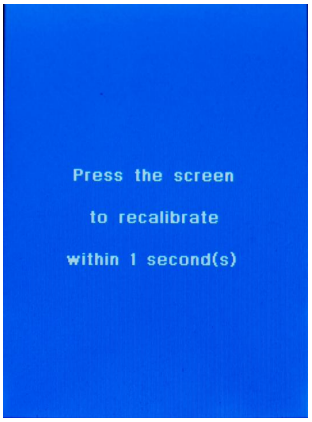
Hidden touch areas exist on the HC. As the result, a poor calibration can contribute to unwanted behavior.

Do this:

1. recalibrate the Hand Controller
2. especially after firmware changes
3. verify the controller firmware update actually completed
4. inspect the Hand Controller microSD card if the behavior persists.

8.8.1 Touchscreen Calibration

NOTE: Screen calibration must be done in non-flipped modes, with the cord coming out of the bottom of the Hand Controller.



Each time the HC is initialized, a screen prompting to "Press the screen to recalibrate" will be presented. Touch the center of the screen within one second to start the recalibration, otherwise the HC will continue its normal initialization process. If you miss it, you can safely unplug the Hand Controller and plug it back in to start over. The HC can be hot connected/disconnected without any risk.

Once the calibration process starts, follow the instructions on the screen. Try to touch the screen as precisely as possible in the areas indicated. Using a touch-screen pen or stylus can make this easier.

8.9 Power-related faults

Use a higher-quality supply if you see:

- motor stalls during slews
- repeated resets
- erratic behavior under load
- or behavior that gets worse when both axes move.

In practice, a supply that is nominally 12V but sags under slew load can create faults that imitate software problems.

8.10 Reset Gemini to Default Settings

When Gemini is behaving strangely and all other troubleshooting steps don't help, it might be time to try a complete settings reset. This will restore original, factory settings and erase any of your changes. Note that this step doesn't restore or change the firmware version, just the settings are cleared:

- make sure you record all your settings before proceeding, especially the network-related ones. All of these will be reset, and your mount will lose connectivity until you restore them
- navigate using the HC to **Menu → System → Reset HGM Defaults**
- turn off Gemini, then turn it back on
- re-enter all the settings

This can help if there is a bad or corrupted setting in the Gemini configuration.

8.11 Firmware-update recovery

8.11.1 Before updating

Always:

- store SRAM
- note current firmware versions
- confirm network connectivity if using GFU or FTP
- avoid casual experimentation during a good operating period.

8.11.2 After updating

Check:

- Hand Controller calibration
- site/time correctness
- mount type
- gearing
- limits
- ability to connect by browser
- and whether the HC now boots fully.

8.11.3 If the HC does not recover

If the Hand Controller does not recover normal operation after a restart or communications interruption, first wait a few seconds to confirm that the controller is not still reconnecting. If it remains unresponsive, check the Hand Controller cable and connector, verify that it is plugged into the correct port, and make sure the Gemini 2 unit itself is still powered and operating normally.

If the HC still does not recover, disconnect and reconnect the Hand Controller, or restart Gemini 2 and allow it to complete startup again. When necessary, use the web interface or another control connection to confirm that Gemini 2 is running correctly and that the problem is limited to the HC connection. If repeated recovery attempts fail, inspect the cable, connector, and HC hardware before returning the system to service.

8.11.4 Rebuild and root-file recovery concepts

When recovery becomes serious, it helps to know the root-file logic of the platform. A properly named HGM_Gem2.bin file can be flashed automatically on power-up and then renamed to the current-file name once successful.

A full Hand Controller update after a main-unit rebuild can take **many minutes**; long wait times are normal.

Treat long firmware writes with patience. Interrupting a slow but healthy update is often more dangerous than letting it finish.

Inspect the Hand Controller microSD card with an external reader and verify the expected files and directories if you are unsure.

8.12 Maintenance habits that prevent trouble

A good Gemini 2 maintenance habit looks like this:

1. Keep a spare battery on hand.
2. Store SRAM after you finish a stable setup.
3. Document your network settings.
4. Document your mount type and custom gearing values.
5. Keep firmware and ASCOM versions noted in your observing log.
6. Recheck limits after any major change in payload or geometry.
7. Use good power.

8.13 Recovery checklist

If Gemini 2 does not start or behave correctly after a firmware change, first verify that the correct firmware file was uploaded to the **root** of the main microSD card. The main firmware file is `NewGem.bin` for normal web flashing, or the same file renamed to `HGM_Gem2.bin` for automatic flashing at power-up. Uploading the file alone does not program the controller until you run the flash process or power-up with the boot-time filename.

A practical recovery sequence is:

- **Store SRAM settings** before major changes whenever possible, so they can be reloaded later from `Gemini.cfg`.
- If the main unit still responds over Ethernet, **reflash the firmware** from the web interface and then reboot.
- If the microSD card appears corrupted, **rebuild or reformat only the main-unit microSD card**, then restore the proper file structure. Formatting is recommended only when corruption is suspected.

- After rebuilding the main microSD card, remember that the controller may return to the default IP address **192.168.0.111**.
- If the Hand Controller also needs recovery, place its files in the **HCFirmware** directory and then **power-cycle** Gemini 2 so the main unit can upload them to the Hand Controller. Do not interrupt power while that update is in progress.

After recovery, confirm that Gemini 2 finishes booting, shows the expected firmware date/version, and then reload saved settings if needed. If a saved configuration is unavailable, you may need to re-enter site, mount, limits, and parking values manually.

8.14 Bench testing and power-fail behavior

Gemini 2 can be bench-tested meaningfully. With appropriate care, motors can be connected off-mount so that direction, response, guider input, and Hand Controller behavior can be verified without risking the telescope. A few details are especially useful:

- RA motor does not normally begin turning until a startup mode has been selected
- motor direction depends on the selected mount type
- guider-input and Hand Controller behaviors can be tested independently if you understand the port roles.

Gemini 2 also includes a brownout / power-fail supervisor. When supply voltage drops far enough, the controller attempts housekeeping, stops motion, and can later report "**Back after power fail**" if power returns. That behavior is helpful, but it should not be treated as a substitute for clean power or for a disciplined park-and-restart routine.

When Gemini 2 behaves strangely, this recovery order is usually the fastest.

1. Check the battery.
2. Check power quality.
3. Check ports and cables.
4. Check mount type and gearing.
5. Check site, time, and time zone.
6. Confirm the startup mode matched reality.
7. Confirm browser access if using Ethernet.
8. Restore SRAM if you had saved it.
9. Do a Cold Start and rebuild the model if the geometry is suspect.

That sequence solves a very large fraction of real-world problems.

9 Frequently Asked Questions

Here are some of the common questions from Gemini 2 users.

9.1 Can I use an external battery pack in place of the internal backup battery?

No. Gemini 2's backup-battery circuit is not the same as Gemini-1's, and substituting an external battery pack can damage the controller. After replacing the internal battery, power-up Gemini 2 and set the time and date immediately. Saving SRAM first, then restoring it after battery replacement, can preserve settings, but time and date still must be set again.

9.2 What is the difference between the original Gemini 2 and Gemini 2 Mini?

The Gemini 2 Mini is smaller, has one power connector instead of two, removes the classic Hand Controller jack, rearranges the front-panel connectors, relabels the serial ports, and uses a CR2450 backup battery instead of the earlier CR2354. It also incorporates a redesigned PCB and improved connector hardware.

9.3 What power supply does Gemini 2 require?

Gemini 2 operates from about 12 to 18 VDC. The original unit has two 5.5 mm outer / 2.1 mm inner barrel connectors; the Mini has one. The controller is fused at 5 amps, and a good-quality regulated supply with adequate current capacity is recommended so voltage does not sag during slews.

9.4 Can I add Wi-Fi or Bluetooth by plugging a USB adapter into Gemini 2?

No. Gemini 2 does not support generic USB Wi-Fi or Bluetooth dongles because it does not provide the host-side drivers and configuration needed to run them.

9.5 Can I use Ethernet without Internet access?

Yes. Gemini 2 can be connected over Ethernet on a local network with no Internet connection. In a direct computer-to-controller setup, static IP addressing is usually required, and the computer and Gemini 2 must be given compatible IP, gateway, and netmask settings.

9.6 What if I have more than one Gemini 2 on the same network?

Each controller must have its own unique IP address, and a unique MAC address. By default, Gemini units ship with the same MAC address. Static addressing is the safest approach. If you use the Gemini.NET ASCOM driver, note that one computer can address up to two Gemini 2 at a time but must be configured to do so.

9.7 Does pointing-model building improve tracking?

No. Modeling improves GoTo accuracy, not basic tracking accuracy. Good tracking depends mainly on accurate polar alignment, along with correct time, time zone, latitude, and longitude.

9.8 Why does Gemini 2 use two separate pointing models?

Gemini 2 keeps separate models for the east and west sides of the mount because a single model across both sides led to larger errors after meridian flips. Two models allow better compensation for geometry changes, flexure, and similar effects.

9.9 What is CWD?

CWD means **Counterweight Down**. In this position, the counterweight shaft points downward and the optical tube points toward the appropriate celestial pole for your hemisphere. This is the standard reference position used for startup and alignment procedures.

9.10 What is required for Southern Hemisphere use?

Only one special setting change is required: latitude must be entered as a negative value. Gemini 2 handles the other hemisphere-dependent behavior automatically. Users must also establish Southern Hemisphere CWD orientation and verify hemisphere-appropriate safety limits.

9.11 What does “Autoguider Error” mean?

This message usually means the autoguider port is receiving invalid guide inputs, such as simultaneous plus and minus signals on the same axis. It can also be caused by camera-interface issues or electrical interference. Power-up order and proper isolation can help prevent it.

9.12 What backup battery does Gemini 2 use?

The original Gemini 2 uses a CR2354 battery. The Gemini 2 Mini uses a CR2450. After battery replacement, power-up the controller and store the correct time and date so the battery is not drained unnecessarily.

9.13 Can SkySafari be used with Gemini 2?

Yes. SkySafari can be used with Gemini 2 through the **ASCOM Gemini.NET driver** together with **Wi-Fi Scope**. Caveat: when used over Ethernet, SkySafari opens a new socket for each command, which can eventually overload the Gemini 2 Ethernet stack; this issue does not occur the same way over a serial connection.

9.14 Can the Hand Controller firmware be updated from the main Gemini 2 unit?

Yes. If the Hand Controller firmware file is placed in the **HCFirmware** directory on the main unit’s microSD card, the Hand Controller can load it on the next Hand Controller power-up. The main Gemini 2 must already have completed its own boot process; otherwise the file may be treated as a catalog file instead of a firmware update.

Catalog files placed in **HCFirmware** are uploaded to the Hand Controller at the next power-up, and the logo file can be transferred the same way. Catalog uploads can also be triggered from the Hand Controller **HC → SDcard → Upload files** menu, but that menu path is for catalog transfer only, not for firmware flashing.

9.15 Why are there several ways to update Gemini 2 firmware?

The basic requirement is simply to place the correct firmware file at the **root** of the main microSD card. Gemini 2 supports several transfer methods—such as web upload, FTP, direct SD-card access, combined ZIP packages, and the GFU Windows utility—because users reach the controller in different ways. `HGM_Gem2.bin` is used for boot-time self-programming, while `NewGem.bin` is flashed through the web interface.

9.16 What are the main SD-card directories used for?

The most important directories as follows: **Catalogs** stores object catalogs, **HCFirmware** is used to transfer files to the Hand Controller, **Logs** stores internal log information, **MHC** contains the mobile web interface, **CONFIG** stores configuration backup data, **PEC** stores periodic error correction data, and **HC** contains the web-based Hand Controller interface. The language directories such as **EN**, **DE**, **ES**, and **FR** hold the localized web-interface files.

9.17 What size microSD cards can Gemini 2 use?

The original supplied cards were typically **2 GB**, but both **SD** and **SDHC** cards are supported. Cards up to **32 GB** with newer firmware have been successfully tested, Cards **4 GB and larger** should be formatted as **FAT32**, not exFAT.

9.18 Is there any special advice for PHD guiding with Gemini 2?

Yes. The guidance from Craig Stark is the fact that very short **DEC guide pulses** may be ignored, although this does not affect RA guiding in the same way. It recommends using a calibration step comfortably above the threshold, avoiding **Lowpass** DEC guiding, and favoring **Resist Switch** or one-direction DEC guiding so small ignored pulses can accumulate into a correction pulse large enough to be accepted. This applies only to the ST-4 guider port. DEC pulses shorter than ~75ms may be missed because that input is timer-sampled; RA is unaffected. Pulse guiding through the ASCOM driver is immune and needs none of these workarounds.

9.19 Why might the Hand Controller suddenly change languages?

This is usually caused by **touchscreen calibration** problems. Hidden screen areas near the bottom of the display can be triggered if the LCD alignment is off, and excessive pressure from the front-cover gasket can contribute as well. Recalibrating the screen is the first step, and if necessary slightly loosening the front-cover screws; recalibration may be needed after firmware updates or large temperature changes.

9.20 What units are used for index error, polar-axis misalignment, orthogonality, and flexure?

All of these values are expressed in **arc-seconds**. Some names differ between the web interface and the Hand Controller—for example, **Orthogonality Error** on the web side corresponds to **Non-Perpendicularity** on the Hand Controller.

9.21 Which catalogs are included in the Hand Controller by default, and how are more added?

These are the default Hand Controller catalogs: **BSL**, **Combined Constellation Stars**, **LBN**, **LDN**, **Messier**, **PN**, **SAO**, **Sh2**, **Southern Constellation Stars**, and **WDS**. Additional catalogs can be added by placing `.guc` files in the **HCFirmware** directory of the main Gemini 2 microSD card, where they will be uploaded to the Hand Controller on the next power-up.

9.22 How can a second Ethernet port be added to a laptop?

A **USB-to-Gigabit Ethernet adapter** can be used to add another Ethernet port to a laptop. This allows one laptop port to connect to Gemini 2 while the other remains connected to the local network.

9.23 Can a pointing model be built using plate solving?

Yes. This can be done manually if the plate-solving software can send a **Sync** command through the **Gemini.NET ASCOM driver**. The driver setting **"Sync performs additional align"** must be enabled so each plate-solve Sync adds another point to the Gemini model.

10 Appendices and Quick References

10.1 Appendix A — Original Gemini 2 (tall boy) vs Gemini 2 Mini

Gemini 2 has been produced in two main hardware forms: the original Gemini 2 controller and the later Gemini 2 Mini.

The original Gemini 2 is the larger first-generation unit. It uses two DC power jacks, supports the original classic four-button Hand Controller through a dedicated jack, and labels its two serial ports as Serial Port 1 and Serial Port 2 / Graphics HC. On that version, the graphical Hand Controller must be connected to Serial Port 2, and Serial Port 1 is the usual port for a computer serial connection or an attached GPS receiver. The original hardware uses a CR2354 backup battery.

The Gemini 2 Mini is a physically smaller redesign of the controller. Its front panel was rearranged, the RA and DEC motor connectors were rotated to improve cable clearance, the PCB was redesigned, and the classic Hand Controller jack was removed. On the Mini, the former Serial Port 1 is relabeled **Serial/GPS**, and the former Serial Port 2 is relabeled **HC**. The Mini also has only one power connector, and its backup battery was changed to a CR2450 cell in a more accessible holder.

10.2 Appendix B — Startup mode quick reference

Gemini 2 supports several startup modes so the controller can match how much of the previous state is still trustworthy. The correct choice depends on whether the mount has been moved, whether a valid pointing model already exists, and whether the controller still knows the telescope's physical starting position. Selecting the correct startup mode is important because Gemini 2 uses that choice to determine how it initializes sky position, pointing model use, and safety limits.

Ask if Possible

Ask if Possible is the most flexible default setting. When selected, Gemini 2 prompts you to choose among the available startup modes unless it has already determined that a Cold Start is mandatory.

Quick Start is the guided startup path intended for first use or for sessions where you want Gemini 2 to walk you through the basic configuration items. Functionally, it also performs a Cold Start, so it should be treated as a fresh initialization rather than as a resume mode. Use Quick Start when the controller is new to you, when setup values need review, or when you want the safest guided path back to a known baseline.

Cold Start is the correct choice when you must rebuild the session from scratch. A Cold Start clears stored modeling information and requires the mount to begin from the **CWD** position: counterweight shaft down and the optical tube aimed toward the celestial pole appropriate to your hemisphere.

Warm Start is similar to a Cold Start, but it keeps the existing model and remembered settings. It still requires the mount to be physically returned to the CWD position before startup.

Warm Restart is the true resume mode. It preserves the model and settings and assumes that neither the RA axis, the DEC axis, nor the mount's installed position has been moved since the previous valid session state.

Selecting the right start mode

Use **Quick Start** for first-time setup and guided re-entry, **Cold Start** when the controller needs a fully fresh beginning, **Warm Start** when the mount must be returned to CWD but an existing model should be retained, and **Warm Restart** only when the mount has truly not moved and the last known state is still valid. A good rule is simple: the less certain you are about the telescope's exact physical position, the more conservative your startup choice should be.

Relation to park and home positions

CWD is the standard reference position for Cold Start and Warm Start. Once you define a Home position and park the mount there, Gemini 2 can later be restarted from that known parked state with Warm Restart, provided the mount has not been disturbed. In that case, no additional synchronize step is normally required because the controller is resuming from a trusted saved position.

10.3 Appendix C — Alignment quick reference

1. Start in CWD.
2. Choose Quick Start or Cold Start.
3. Verify mount, site, and time values.
4. GoTo a bright star.
5. Center it.
6. Use **Alignment**.
7. Repeat on another star.
8. Add one or more stars on the opposite side later.

10.4 Appendix D — Polar alignment quick reference

Fast field method

- Use PAA before a model exists.
- Expect coarse alignment, roughly within 1–2 degrees.

Precision method with Gemini 2

- Build both sides of the model.
- Run PAC.
- Rebuild the model afterward.

10.5 Appendix E — Park and restart quick reference

If you park at CWD

- safest to reason about
- ideal for Cold Start and Warm Start
- easy for portable setups.

If you park at Home

- useful for permanent installations
- best when Warm Restart assumptions remain true
- requires discipline and repeatability.

Park modes

- **Mode 0:** any move wakes the mount
- **Mode 1:** GoTo / unpark wakes the mount
- **Mode 2:** only explicit unpark wakes the mount

Mode 2 is the safest mode for unattended or software-driven systems.

10.6 Appendix F — Web pages worth learning first

Learn these pages first:

1. **State** — current mount state
2. **Mount** — type, gearing, limits, startup mode
3. **Site/Time** — time, site, GPS, NTP
4. **Modeling** — inspect and manage models
5. **Functions** — park, wakeup, tracking, PEC-related actions
6. **Firmware/SRAM** — store and restore settings
7. **SD Card** — upload catalogs or support files
8. **Network** — DHCP/static configuration

10.7 Appendix G — First-night safety checklist

Before issuing long slews or leaving the mount unattended:

- verify correct mount type
- verify correct gearing
- verify RA/DEC cables
- verify CWD start if using Cold or Warm Start
- verify limits
- verify site and time values
- verify that you understand the current park mode
- verify a good power supply is in use.

10.8 Appendix H — Maintenance checklist

After a stable setup session:

- Store SRAM.
- Note firmware versions.
- Note network settings.
- Save or store models if that is part of your workflow.
- Save PEC if you use it.

Before a firmware update or battery change:

- Store SRAM.
- Verify you know which controller variant you have.
- Verify you have the right battery type.
- Plan to re-enter or confirm time/date after power-up.

10.9 Appendix I — Gemini Level 5 vs Level 6

Gemini Level 6 was first released in June 2023. It came out with a two main components, the Level 6 firmware itself and the servo PIC controller firmware, v3.

The following are the main differences between Level 5 and Level 6:

- New servo motor PIC firmware to support 4x encoder resolution and improved runaway protection
- Support for fast satellite tracking in both axes
- Added Meridian Flip Points function
- Improved PEC management
  NOTE: Level 6.02 released in 2024 added significant improvements to PEC after some issues were discovered in Level 6.0
- Better DHCP/network management
- Much more…

As of the July 2026, Level 6.12 is the officially released version and Level 6.13 is being tested and should be released soon. Please check Gemini-2.com website for the up-to-date list of firmware versions.

10.10 Appendix J — Ports and interfaces quick reference

10.10.1 Power

- Original Gemini 2: two barrel-jack power connections.
- Gemini 2 Mini: one barrel-jack power connection.
- Common working assumption: 12-18V DC, well regulated, with healthy current reserve.

10.10.2 Hand-controller and serial ports

- Graphics Hand Controller normally belongs on the dedicated HC / Serial Port 2 connection.
- Graphics HC requires 57600 baud.
- Serial Port 1 is commonly used for computer serial or GPS duties.

10.10.3 USB

- USB-B is the practical PC connection and behaves like a virtual COM path.
- USB-A is not a general-purpose host port for arbitrary USB accessories.

10.10.4 Ethernet

- Central connection method for browser control, GFU workflows, and many ASCOM setups.
- Common documented fallback IP: 192.168.0.111.
- NetBIOS hostname may be gemini where the network supports it.

10.10.5 Guiding and expansion

- ST-4 compatible guider input.
- Port E for end-sensor support.
- Port F / Feature Port for advanced accessory and low-level integration roles.

10.11 Appendix K — SD-card directory quick reference

10.11.1 Main unit

- Catalogs — object and star catalogs.
- HCFirmware — files staged for transfer into the Hand Controller.
- CONFIG — configuration backup such as Gemini.cfg.
- PEC — PEC storage.
- MHC — mobile web interface files.

- HC — web-based Hand Controller files.
- EN/DE/ES/FR — language-specific web pages.
- Logs — internal logs; do not treat this as ordinary user storage.

10.11.2 Hand Controller

- root firmware file state matters (gemhc.bin versus post-flash/current naming)
- catalog files are optional
- HCFirmware directory contents are operationally important
- a partially seated card can look like a controller failure.

10.12 Appendix L — Firmware and retained-state quick reference

10.12.1 Check versions

Use the Hand Controller or the Firmware/SRAM web page to read firmware date/version information. Remember that the Hand Controller firmware version may not display until the controller has completed a real startup mode.

10.12.2 Before updating

1. Read and note current firmware dates.
2. Store SRAM.
3. Preserve model and PEC expectations separately.
4. Confirm network access and correct target IP.
5. Avoid updating in poor power conditions.

10.12.3 After updating

1. Confirm firmware versions again.
2. Confirm mount type, gearing, site, and time.
3. Confirm limits and startup defaults.
4. Reload or rebuild models as needed.
5. Re-enable PEC and verify its persistence if required.

10.13 Appendix M – Connect to PC over Ethernet

10.13.1 Important Port Warning

- **Do not** plug the Ethernet cable into **Port E** (top) — it's not an Ethernet port.
- **Do not** use **Port F** for Ethernet.
- Use the **dedicated Ethernet port** on the Gemini 2 unit.

10.13.2 Summary

Method	Pros	Requirements
Router (DHCP)	Easiest, automatic IP, can be wireless	DHCP router, correct IP subnet
Direct (Static IP)	Independent from home network	Manual IP setup, proper cable, matching subnets

10.13.3 Why Use Ethernet

Using Ethernet gives you full access to Gemini 2's built-in web interface and offers several advantages over USB or serial:

- **Full Web Control:** Access through any web browser (desktop, tablet, or phone) to:
  - Slew to targets and build models
  - Move the telescope and adjust settings
  - Monitor port status, power, battery, and servo performance
- **File Management:** Upload firmware, catalogs, and Hand Controller updates to the microSD card. Use FTP to back up or restore models, PEC data, and settings.
- **Networking Benefits:**
  - Longer cable lengths and higher speeds than USB/serial
  - Easily made wireless via a Wi-Fi bridge (e.g., Netgear WNCE2001, D-Link DAP-1350)
  - More reliable and cost-effective cabling; fewer cables to Gemini 2
  - Control from any computer on your LAN
  - Compatible with Gemini.NET ASCOM driver for mount control and pulse guiding
  - Some ground loop isolation, unlike USB

10.13.4 Network Compatibility

The Gemini 2 Ethernet port supports **10/100 Mbps** and does **not** auto-detect cable type. One end of the connection (computer, router, or switch) must be **auto-detecting** or support **Gigabit (10/100/1000 Mbps)** to handle standard patch cables.

- If *both* devices are only 10/100 Mbps and lack auto-MDI/MDIX, use a **crossover cable**.
- Most modern laptops, routers, and switches support auto-detection (Gigabit), so standard patch cables work.

10.13.5 Connection Methods

10.13.5.1 Using a Router (DHCP) — Recommended

1. Connect Gemini 2 to a router, switch, or wireless adapter.
2. Power on Gemini **after** connecting the cable so it can obtain an IP from the DHCP server.
3. Ensure your computer also uses DHCP or has a static IP on the same subnet.
4. Access the interface using a browser:
   - http://gemini (via NetBIOS), or
   - Gemini's assigned IP, e.g., http://192.168.0.111
5. Login credentials:
   - Username: admin
   - Password: *(blank)*

6. If http://gemini doesn't work but the IP does, enable **NetBIOS over TCP/IP** on your computer.
7. Optionally, reserve a fixed DHCP lease for Gemini in your router so the IP stays the same.

NOTE: Gemini does **not** support HTTPS. Always use http:// (not https://) in the browser.

10.13.5.2 Router IP Alignment:

- Gemini defaults to 192.168.0.111 (Gateway 192.168.0.1).
- If your router uses 192.168.1.x (common for Netgear), update Gemini's IP address to 192.168.1.111, for example, and gateway to 192.168.1.1 via the Hand Controller.

10.13.5.3 Direct Connection (No Router)

1. Use a **crossover cable** if your NIC is 10/100 Mbps only. If your NIC is Gigabit (10/100/1000), either crossover or standard cable works. A Gigabit switch can also be inserted so standard cables may be used.
2. Assign **static IP addresses** on both ends:
   - **Computer:** e.g., 192.168.0.2, subnet mask 255.255.255.0, gateway 192.168.0.1
   - **Gemini:** 192.168.0.111 (default)
   - Ensure no other device uses the same IP.
3. If your network base is different (e.g., 192.168.1.x), adjust both sides to that scheme.
4. Verify gateway and interface details with ipconfig /all in a Windows Command Prompt.
5. Power on Gemini and browse to http://gemini or its IP address.

If IPs don't match, either change the computer's IP to match Gemini, or change Gemini's IP with the Hand Controller (*Menu → Mount → Network Options*).

10.13.5.4 Testing the Connection

- Open a browser and go to http://gemini or http://192.168.0.111 (or whatever IP you assigned).
- If the login prompt doesn't appear, check:
  - Cable type (standard vs crossover)
  - NIC speed and auto-detect capabilities
  - IP addressing (same subnet, unique addresses)
  - NetBIOS settings if using the hostname

11 Glossary

This glossary collects astronomy-related terms, uncommon technical terms, and abbreviations used throughout this manual.

Adaptive King — A tracking method intended to reduce tracking error caused by atmospheric refraction, especially for targets low in the sky.

Air mass — A measure of how much atmosphere light from an object passes through before reaching the observer; higher air mass usually means lower image quality.

Alignment — In Gemini 2, the command that starts a pointing model or adds a star to an existing model after the object has been centered.

Alt/Az — Short for altitude-azimuth, a coordinate system based on height above the horizon and compass direction.

Arc-second — A very small angular unit used in astronomy and pointing-model error reporting; 3,600 arc-seconds equal one degree.

ASCOM — A standard Windows software framework that lets astronomy programs communicate with telescope mounts, cameras, focusers, and other devices.

Autoguider — A guiding system that sends small correction commands to the mount to keep a guide star centered during imaging.

Backlash — Slack or play in a mechanical drive system that causes a delay before motion begins after a direction change.

Brownout — A drop in supply voltage low enough to disrupt correct controller behavior or force a reset.

CGI — Common Gateway Interface; in this context, the mechanism used by Gemini 2 web pages to interact with controller functions.

Closed Loop — A Gemini 2 tracking mode that uses model information in an attempt to maintain tracking despite imperfect alignment.

COM / COM port — A communications port designation used by Windows for serial-style device connections, including virtual serial connections over USB.

CR2354 / CR2450 — Coin-cell backup batteries used by different Gemini 2 hardware variants to preserve SRAM-backed settings.

CWD — Counterweight Down; the standard reference position in which the counterweight shaft points downward and the optical tube points toward the celestial pole.

DEC — DEC lination; the celestial coordinate equivalent of latitude, used together with right ascension to locate objects in the sky.

DHCP — Dynamic Host Configuration Protocol; a network service that automatically assigns IP settings to devices.

Differential refraction — A change in apparent star position caused by Earth's atmosphere, often more noticeable at low altitude and across wide fields.

End sensor — A hardware position sensor used as an additional motion-limit or safety input.

Equatorial mount — A telescope mount whose right ascension axis is aligned with Earth's rotation axis so it can track the sky with motion in one primary axis.

Ethernet — A wired network connection used by Gemini 2 for browser control, file transfer, and some software-guiding workflows.

FAT32 — A file-system format commonly required for Gemini 2 SD-card compatibility, especially on larger cards.

Field rotation — Apparent rotation of the image field during tracking, usually caused by imperfect polar alignment.

Flexure — Small physical bending or shifting in the mount or optical system that changes pointing accuracy.

Force Flip — A GoTo option that explicitly requests a meridian flip when a target could otherwise be reached from the current side of the mount.

FTP — File Transfer Protocol; a network method for moving files between systems, used in some Gemini 2 update and maintenance workflows.

GFU — Gemini Firmware Updater; a utility used to transfer and install Gemini 2 firmware files.

GoTo — A mount-control command that slews the telescope automatically to a selected object or coordinate.

GPS — Global Positioning System; used by Gemini 2 to obtain accurate time and, in some cases, location data.

Guide pulse — A short correction command sent to the mount during guiding to adjust tracking in RA or DEC.

Guiding — The process of making continual small mount corrections to keep a target centered during long exposures.

HA — Hour Angle; the angular distance of an object east or west of the local meridian.

Home position — A user-defined parked position used as a repeatable reference for restart and operation.

HTTP — Hypertext Transfer Protocol; the web protocol used by the Gemini 2 browser interface.

Index error — An offset between where an axis is assumed to be at its reference position and where it physically points, commonly modeled in RA and DEC.

IP address — A network address used to identify a device, such as Gemini 2, on an Ethernet network.

LX200 — A telescope control command set widely supported by astronomy software and partly implemented by Gemini 2.

Meridian — The imaginary north-to-south line that passes through the zenith; objects near it are near their highest point in the sky.

Meridian flip — A repositioning move that places the telescope on the opposite side of the mount so tracking can continue safely past the meridian.

MHC — Mobile Hand Controller; a browser-based control interface optimized for phones and tablets.

Model 0 / Model 1 — Gemini 2's separate pointing models for the west and east sides of the mount, respectively.

NTP — Network Time Protocol; a network-based method for synchronizing accurate time.

Orthogonality / Non-perpendicularity — A geometric error in which axes or attached components are not perfectly square to one another.

OTA — Optical Tube Assembly; the telescope tube and its optical components, excluding the mount.

PAA — Polar Align Assist; Gemini 2's coarse polar-alignment routine used before a pointing model exists.

PAC — Polar Axis Correction; Gemini 2's fine polar-alignment function that uses an existing pointing model.

PEC — Periodic Error Correction; a method of compensating for repeatable tracking error caused by the worm and drive system.

Pier crash — A collision risk in which the telescope or accessories strike the mount pier or tripod during tracking or slewing.

Plate solving — A software process that identifies the telescope's exact sky position by analyzing an image of the star field.

Pointing model — A mathematical model built from alignment stars that helps Gemini 2 compensate for mechanical and geometric errors to improve GoTo accuracy.

Polar alignment — The process of aligning the mount's polar axis with the celestial pole.

Polar axis — The mount axis intended to be aligned with Earth's axis of rotation.

RA — Right Ascension; the celestial coordinate equivalent of longitude, used together with declination.

RA axis — The right ascension axis of an equatorial mount, intended to track Earth's rotation.

SD / microSD card — Removable flash storage used by Gemini 2 and the Hand Controller for firmware, configuration files, catalogs, and related data.

Sidereal rate — The standard astronomical tracking rate used to follow the apparent motion of the stars.

SRAM — Battery-backed memory used by Gemini 2 to retain settings such as site, configuration, and other controller state between sessions.

ST-4 — A common autoguider connection standard that sends simple directional guide corrections to the mount.

Synchronize — A Gemini 2 command that updates the mount's current sky position reference without serving the same purpose as adding a new model point.

Terrestrial — A tracking mode in which sidereal tracking is turned off.

TVC — Time Variable Compensation; Gemini 2's declination backlash-compensation feature.

UTC — Coordinated Universal Time; the time standard Gemini 2 uses internally for calculations.

Virtual COM port — A USB or software-generated connection that behaves like a traditional serial port.

Warm Restart — A startup mode that resumes operation assuming the mount has not been moved since the previous session.

Warm Start — A startup mode that preserves the model but assumes the mount has been returned to CWD and needs sky-position re-establishment.

WGL — Western GoTo Limit; a setting that helps determine when Gemini 2 should choose a meridian flip for a GoTo command.

Zenith — The point in the sky directly overhead.

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