



Users Manual

Level 4

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1 Introduction

1.1 General Description

The Gemini Astronomical Positioning System is a professional level computerized device for controlling small to medium German equatorial telescope mounts. It was conceived and designed by René Görlich (working in close collaboration with Scott Losmandy, Norman Diehl and others)¹ as a tool for locating and tracking celestial objects, and for organizing both visual observation and astronomical imaging sessions. Even at its first release as Level 1 (November 2000), it could be used as a completely standalone system, or be controlled from a PC using planetarium software or the Gemini Control Program (GCP) developed by Daniel Görlich. Each subsequent upgrade (Levels 2, 3 and 4) added to its functionality, its convenience of operation, and its remote control capabilities.



The Gemini has many features to help you be efficient and save time in your astronomical observations. Although most should be intuitive, careful reading of this manual will shorten your learning curve and ensure success.

IMPORTANT: Please read the “Quick Start Guide” (section 2.1 of this manual) before attempting to use your Gemini for the first time. It contains important information to help you start using your Gemini system.

One unique feature of Gemini is its ability to perform all of its functions by navigating multiple menus using only five buttons and a single LED readout. While the alternative would be a control panel with multiple specialized controls, the simplicity of the Gemini system allows for almost unlimited upgrade without rendering the basic hardware obsolete. Starting with the Level 4 software, it is possible to add remote hand controller functionality using a PC or PDA. Since this is done using a serial protocol, it is even possible to design a new custom hand controller.

Gemini is available as a retrofit kit, or pre-installed on your telescope mount at the factory. The most recent version of Gemini's software, Level 4, is provided with all new telescope mounts. This level is also available as a simple plug-in upgrade to anyone who already owns Level 1, 2 or 3.

¹ **René Görlich:** Original concept, control electronics, and all software programming, except for the servo subsystem. **Scott Losmandy:** Had developed a servo motor board at Aveox, Inc., developed all the mechanical parts, named the combined/finished device "Gemini," and is the producer. **Norman Diehl:** Co-developed control electronics for the stepper motors (including DSC capabilities), and assisted with development of Gemini's circuitry and board layout. **George Radda and David Palombo:** Developed the servo control, final board layout, and software for the servo processor's manufacture (at Aveox, Inc.). **Wolfgang Steinicke:** Revised NGC/IC catalogue. **Peter Ward:** Southern hemisphere testing. **Many ideas for features and improvements from all.**

1.2 Features

1.2.1 Physical Features

The Gemini Astronomical Positioning System is a professional level computer-to-servo device for controlling a German Equatorial telescopic mount (GEM). It consists of four components: (1) A computer board housed in a flat aluminum panel box to be attached by screws to the pier of your GEM mount; (2) A right ascension servo motor connected mechanically to the mount's RA shaft, and electrically to the Gemini computer via a cable; (3) A declination servo motor (identical to the RA motor) connected mechanically to the mount's Dec shaft, and electrically to the Gemini computer via a cable; and (4) a Hand Controller with buttons, switches, and an 16 character LED display connected to the Gemini computer via a serial cable. A fifth component, though essential, is not provided as part of the Gemini package. It is a 12 to 18 volt D.C. power source that may be either a storage battery or a well-regulated power supply.

1.2.2 Operational Features

The following is a list and brief description of Gemini's operational features:

Setup Features

(a) Hand Controller Setup

The user chooses one of three movement control modes; they are (1) Visual Mode for centering and slewing, (2) Photo Mode for centering and guiding, and (3) All Speeds Mode for centering, slewing, and guiding.

(b) Mount Parameter Setup

The user selects the mount's tracking, slewing, centering, guiding and GoTo speeds, sets a TVC value if any, trains and activates the Periodic Error Control (PEC) function, selects the type of mount being used, sets safety limits for the mount's RA movement, and sets the mount's home position for parking.

(c) Encoder Setup

If accessory RA and Dec axis encoders are installed, the user inputs their resolution, and can test them or turn them on and off. Alternatively, end switches can be connected to the encoder port and configured to physically limit the mounts motions.

(d) Alarm Timer Setup

The user can set a timer for an audible alarm to sound. The alarm can be turned on and off. The buzzer can also be set to be silent.

(e) Date and Time Setup

The user inputs the current UTC date and time. Alternatively, the UTC date and time can be automatically set by a GPS receiver in the Geographic Location Setup described below.

(f) Restore Default Function

The user can restore all setup items to their default Losmandy or Mountain Instruments values.

(g) Brightness of Display Setup

The user can adjust the brightness of the Hand Controller's LED display.

(h) Geographic Location Setup

The user can either input the mount's longitude and latitude manually, or achieve the same thing automatically, including setting the mount's UTC Date/Time and Time Zone via a GPS receiver connected to Gemini's serial port. There are 4 sites available for storing and reloading observing site data.

(i) Communication

The user can determine the equinox of any coordinates sent to Gemini. This selection applies to coordinates transferred to and from planetarium and other telescope control software as well as coordinates entered directly by the user. Either J2000.0 or the Equinox of the Date can be selected. Also, the baud rate of the standard RS232 port, the serial hand controller port and the GPS receiver can be set.

(j) Modeling

Once established, up to 10 telescope pointing models can be stored and reloaded. Also, the last Additional Alignment operation can be undone.

Control Features

(a) Telescope Alignment

Gemini automatically initializes its celestial coordinate system when it is powered in the standard startup position (counterweight shaft down and OTA pointing to the celestial pole). This permits Gemini to GoTo (with reasonable accuracy) a first alignment star to be synchronized. A list of Bright Stars that are currently above the horizon is provided; selecting one of the stars triggers a GoTo operation. Additional star alignments can then be performed in order to develop and refine a computerized pointing model for greater GoTo accuracy. Under certain circumstances (e.g. changing eyepieces, rotating diagonals, etc.), stars found and slewed to by the Gemini are no longer centered in the eyepiece. To adjust for this occurrence, Gemini includes a synchronization feature that allows an object to be re-centered without changing the pointing model. Finally, Gemini includes a polar alignment assistance feature, and a Polar Axis Correction feature; the latter requires that a pointing model first be established.

(b) Telescope Movement

Gemini allows tracking in 6 speeds: Sidereal, Lunar, Solar, Adaptive King Rate, Closed Loop, Comet/User Defined, and Terrestrial (tracking turned off). In addition, the Hand Controller permits the user to move the telescope in both RA and Dec in 3 speeds that are established in the setup menu: Guiding, Centering, and Slewing. The user can also perform GoTo movements of the telescope at a separate speed that is also established in

the setup menu. When a GoTo operation occurs, the telescope moves at GoTo Speed, and then slows down to Centering Speed as it approaches its target. Telescope parking is a separate command that disables tracking and moves the mount to a predetermined Home position – by default, counterweight down with the telescope pointing to Celestial North. Finally, all telescope movement stops and an alarm sounds when the mount slews to either its Eastern or Western safety limit. A warning also sounds when the mount approaches its Western limit while tracking.

(c) Databases

Databases of many well-known celestial objects are permanently stored in the Gemini. These are arranged in eleven descriptive lists and/or astronomical catalogs. The RA and Dec. coordinates in these databases are standardized to epoch J2000.0, and are precessed to the equinox of the day; consequently, once the mount and Gemini are properly aligned, the user can accurately slew to any of these objects. In addition to the permanent databases, Gemini also contains a customizable (user-defined) database where the user can conveniently input and store the names and coordinates of his or her most often-observed celestial objects. This list can be retained or erased at will. Finally, Gemini allows the user to set and return the telescope to marked coordinates called Bookmarks.

(d) Displaying Date, Time, Pointing Coordinates, and Object

If the mount and Gemini are star-aligned, Gemini is able to provide the user with an accurate RA/Dec and Az/El coordinate readout of any position to which the mount is pointing, and is also able to identify (within a level of probability), the most likely celestial object in the field of view, filtered by type of object and magnitude. It can also show the current date and time in UTC, Civil Time, Julian Date, and Local Sidereal Time.

(e) Object Search

Sometimes the user knows the approximate position of a celestial object, but the object is not in the field of view. Gemini can search for the object in two ways: (1) by starting at a known coordinate and scanning in an outward pattern limited to a 5 arc minute to 2 degree FOV, and (2) by moving in a "Z" shape, 5 arc minutes per axis, to help recognize faint objects.

(f) PC Control

Gemini can be controlled by a remote computer via an RS232C serial cable. Such control is most often accomplished with planetarium software using the LX200 protocol, the ASCOM standard or with the Gemini Control Center program available online from Daniel Görlich at <http://www.DocGoerlich.com/GCC>. The serial command set description allows the development of custom software. In addition, Gemini's Feature and Encoder Ports can be used to control user-designed hardware.

(g) QuickMenu

This menu duplicates functions found elsewhere in the menu tree, but is convenient to (1) quickly change Gemini's Centering Speed incrementally from 2X to 128X, (2) quickly change Hand Controller Mode to either Visual or Photo, (3) quickly park the mount in the

startup or pre-determined Home position, and (4) initiate a meridian flip if possible. A focusing feature is also available on the QuickMenu, but is only usable when an auxiliary adapter board is connected.

1.3 What's New in Level 4?

1.3.1 Gemini Supports Custom Mounts

In addition to support for Losmandy and Mountain Instruments mounts, Gemini L4 now supports custom mounts. The user can setup the main parameters of his mount: the gear ratios and direction of spur gear and worm gear and the servo motor encoder resolution. The step resolution can reach from 0.1 arcsec per step (servo motor encoder tick) up to 2.5 arcsec/step. Resolutions can be set independently for RA and Dec. axes.

With this new feature, Gemini can be retrofitted to many German Equatorial Mounts, for example mounts with 359:1 Byers gears, Vixen or Astrophysics mounts. Existing servo motor/encoder combinations can often be used, eliminating the need for mechanical adapting the Gemini motor assembly, although custom cables will be necessary.

1.3.2 Supporting the Horizontal Coordinate System

The new Level 4 software supports the usage of Azimuth and Elevation coordinates. These coordinates can be used for queries and GoTo operations over the serial line (see Serial Command Set below) as well as by means of the hand controller. The HC main menu item "RA/DEC Coord." is now called "Coordinates" and contains the additional submenu items "Az/El Display" and "Enter Az/El".

1.3.3 Selectable Serial Port Transmission Rates

Gemini L4 allows you to set several transmission rate values for the serial (RS232) and the serial hand controller ports, from 4800 up to 38400 bit/s, under the Setup→Communication menu item. The default value is 9600 bit/s.

1.3.4 Selectable GPS transmission rate

The GPS speed can be set to 4800 or 9600 bit/s using Setup→Communication→GPS Rx speed menu item. The default value after a reset is the standard NMEA 0183 speed of 4800 bit/s. By setting the GPS receiver transmission rate, Gemini's startup process is accelerated, because the other rate doesn't have to be probed. Also, the query result message display can be interrupted by pushing the menu button.

1.3.5 Reduced Main Menu selection available

After having set up Gemini and aligning the telescope or building a pointing model, some of the menu items are rarely used. The new "Reduced Menu" mode only displays the main menu items normally used while observing: Object Database, Show Information, GoTo, RA/DEC Coordinates and Identify while scrolling downwards (with the DEC- button). Scrolling upwards with DEC+, Align Telescope is additionally included to allow refinement of the pointing model. The other main menu items, Setup, Object Search, Show Date/Time and GuideTo are suppressed. At any time it is possible to switch back to Full Menu Mode using the Quickmenu feature.

1.3.6 Redesigned Quick Menu selection

To accelerate the Quick Menu access and to offer more selections, the Quick Menu feature was redesigned.

1.3.7 Parking the OTA

The telescope can be parked at any "Home Position" by either the hand controller or serial control. The home position defaults to the CWD (Counterweight Down) position. Additional commands have been added to the QuickMenu to provide additional parking options and to stop tracking.

1.3.8 More Alignment Stars

The number of Alignment Stars has been extended to 49. Especially more southern hemisphere objects are now included. The coordinates of these stars are stored with sub-arcsecond precision. Since some bright nearby stars have a significant proper motion these motion values are also stored and included into the calculation to achieve highest alignment accuracy.

1.3.9 Extended Serial Line Protocol

The Level 4 serial command set was extended not only to reflect the additions for new and custom mounts, but also includes commands necessary for dome control and other operations. **:GA#** and **:GZ#** commands are supported to query the azimuthal coordinates. The hour angle the mount is pointing at can be obtained using the new **:GH#** command. The side of the mount the OTA is can be asked for with **:Gm** while **:GS#** now delivers the sidereal time. There are new precision guiding commands, observing sites can be managed (stored, loaded, named), the firmware version information was extended and more. Meridian flips can be initiated by the new **:Mf#** and **:MM#** commands.

1.3.10 Extended Identify interface

The interface to the Identify function within Gemini was extended to remember the results of the latest Identify run. Now the user can decide to use

- "New Selection" to do another Identify run,
- "Previous objects" to observe one of the 10 objects found by the latest run,
- "Continuous Ident" to have the Identify routine running continuously in the background while the telescope is slewed manually or commanded over the serial line, always displaying name and distance of the nearest object matching the search criteria.

1.3.11 Extended Safety Limits Handling

The physical positions of the Safety Limits are automatically derived from the mount settings. For Losmandy mounts, they default to 114 degrees when the telescope is on the east side of the mount and to 123 degrees on the west side, with respect to the startup (CWD) position. To avoid accidentally setting the safety limits, another submenu item "Confirm to Set" was added as a submenu of "Setup→Mount Parameters→Set Safety Limits".

Additionally, a second submenu item "Reset to Defaults" was introduced there to allow you to reset only the Safety Limits to their default values (both east and west) without having to reset all the other Setup values.

Another new submenu, "Set GoTo", allows you to define a point past which Gemini will always GoTo the object so that the telescope tube is on the east side of the mount. Gemini will allow the mount to track past this point, but will not GoTo any object west of this point without a meridian flip, if needed, to put the telescope tube on the east side of the mount. The default value, displayed as 0 degrees, sets the GoTo limit to the western safety limit minus 2.5 degrees, allowing for at least 10 minutes of tracking.

1.3.12 Selectable PC Synchronization Behavior

Gemini accepts two different kinds of Sync commands over the serial line. The LX200 protocol :CM# command shifts the internal coordinate system to reflect the latest position correctly, "Synchronizing" it to an object. On the other hand, the additional ":Cm#" command uses the detected positional difference to enhance the internal pointing model. The software running on a connected computer can choose between either. Since there are still some software packages on the market not supporting the Additional Align feature, Gemini's software now allows you to set the way :CM# and :Cm# commands are interpreted. The Setup→Communication menu item now contains a "Sync or Align" submenu. "Sync Only" selects Gemini's standard behavior as described above, while "Sync→Add. Al." swaps the functionality of both commands, allowing enhancement of the pointing model even with PC software not supporting this explicitly.

1.3.13 Precision Guiding Commands

The serial command protocol has been extended to allow precise movement commands to be sent to Gemini. These commands include:

- Move at guide speed for a specific number of milliseconds
- Move at guide speed for a specific number of steps
- Move at guide speed for a specific number of arcseconds.

2 Getting Started

Now that you've unpacked your Gemini unit, you are no doubt eager to start using it. Please take some time to read through this section of the manual before using your Gemini for the first time. It will guide you through installation and first use of your Gemini, and introduce you to some important concepts for using your German equatorial mount.

2.1 Quick Start Guide

Although it is *highly* recommended that you read through this entire chapter before using Gemini for the first time, this section is provided as a quick start guide to give you an overview of the process, and to use as a reference after you have read the remainder of the chapter.

- Connect motor and power cables. Make sure they are oriented correctly and inserted completely into the socket.
- Position your mount with the polar axis pointing to the celestial pole.
- Position RA and Dec. axes so that the counterweight shaft is pointing down, and the Dec. axis is at 90° (OTA pointing at the celestial pole). This position will be called “Startup Position” or “Counterweight Down” position, abbreviated “CWD”.
- Move power switch to the “on” position.
- After seeing several system messages, select “Cold Start”. Note that Gemini may automatically cold start if its internal memory does not contain valid data.
- Enter date/time, geographic location, and mount type during the cold start sequence. Alternatively, you can use the “Setup” menu to enter this data after the cold start has completed. **Note:** this step assumes that you do not have a GPS connected. Otherwise the date/time and location will be read from the GPS, and Gemini will display “SRAM/RTC updated!”
- Choose 3 to 5 alignment stars from the Alignment Star List (see Appendix 8.3) which are on the same side of the meridian and are well separated in RA.
- Align the mount on the first star using the following sequence:
 - Select “Align Telescope→GoTo Bright Star.” **Note:** Do not confuse this with the Bright Star Catalog. There is a separate menu item under “Align Telescope” called “GoTo Bright Star.”
 - Select your first alignment star from the submenu
 - Mount will slew close to that star
 - Use Hand Controller buttons to center the star in the eyepiece. **Note:** Press and hold a direction button on the hand controller to move the telescope. To move the telescope faster, momentarily press and release the opposite button while continuing to depress the original button. Please see section 2.3.4 below for a complete description of moving the mount manually.
 - Select “Align Telescope→Synchronize”

- Display will confirm the object to which you are pointing
- Press RA+ to complete the initial alignment
- For *each* of your other alignment stars selected in step 7:
 - Select “Align Telescope→GoTo Bright Star”
 - Select the alignment star from the submenu
 - Mount will slew to that star
 - Use Hand Controller buttons to center the star in the eyepiece
 - Select “Align Telescope→Additional Align” **Note:** Do NOT use the “Additional Align” command until you have slewed to the next star using steps a-d above. Doing so will result in the message “Sorry, rejected.”
 - Display will confirm the object to which you are pointing
 - Press RA+ to complete the alignment
 - Gemini will display 2 numbers indicating the calculated offset in arcseconds from the pole in Azimuth (A) and Elevation (E). (e.g. “A:+15 E:-10”)
- Choose an alignment star on the opposite side of the meridian (see Appendix 8.3).
- Perform the same operations as in step 9 to complete an “Additional Align” on that star.
- You should now be ready to observe.

2.2 Installation

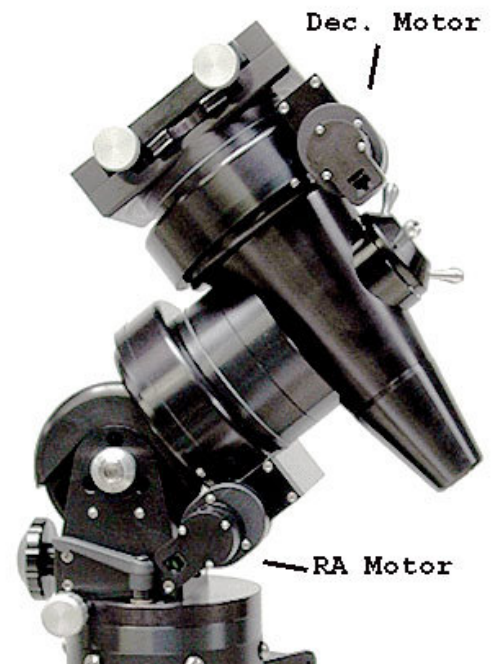
If you bought your mount with Gemini already installed, you can skip the motor installation section. However, you should review the other sections covering cables and power.

2.2.1 Motor Installation

If you bought your Gemini as an add-on to an existing mount, you will first need to replace the existing motors with the Gemini servomotors. Follow the instructions that came with your Gemini kit to remove the existing motors and install the Gemini servomotors.

2.2.2 Cable Installation

You will have one of two different types of motor cables for your Gemini. You may have two flat 8-connector ribbon cables with an RJ-45 connector on each end, or you may have two round cables with 6-pin DIN connectors at each end. These cables are used to connect the drive electronics to the servomotors. Both cables are electrically identical, but one is longer than the other. Plug one end of the shorter cable into the connector on the right ascension motor and the other end into the connector on the drive electronics labeled “RA Servo.” Now take the other cable and plug one end into the connector on the declination motor and the other end into the connector on the drive electronics labeled “DEC Servo.” It is very important that you always plug the RA motor into the RA Servo connector and the Dec. motor into the DEC Servo connector.



2.2.3 Encoders

Gemini can take advantage of optional encoders on your mount. Plug the encoder cable into the 8-pin socket below the HC input. The layout is compatible with the Y-cable of the usual DSCs, like the Losmandy DSC or the NGC Max. The encoder ratios and directions can be set using the “Setup→Encoder” menu item. The default setting is (minus) -4096 for both axes, as used for the G-11 mount. The sign indicates whether the encoder is moved in the same or the opposite direction as the axis to which it is connected. Refer to the table below for other Losmandy mount encoder settings.

Mount	Encoder Tics
GM-8	-4096
G11	-4096
HGM200	+8192

Although Gemini does not require encoders to function, there are some advantages to using them. Encoders allow the system to keep track of the telescope's position even when you are moving the telescope manually with the clutches loosened. Unless you have encoders, you should never loosen the clutches because to do so will cause the system to lose information both about where it is pointing, and about how close the mount is to the safety limits. The system must know where the eastern and western limits are, and when it has to make a meridian flip. Using encoders, the system is informed about manual movements and can take them into account, thereby avoiding exceeding the limits.

The Gemini software is designed to give you the best of both worlds. As long as the position signaled by the encoders is consistent with the motor position within two encoder ticks, the far more accurate motor position is used. But if the encoders signal a change, the system trusts them and corrects its internal address values.

When this happens, you see the characters R (for RA address correction) or D (for Dec. address correction) displayed at the rightmost place of the system's display. This can be an indication of manual movement, mechanical slippage, or a wrong encoder resolution setup.

Even if the encoders are set "Online" (by selecting “Setup→Encoder→Use Encoder”) you can use the system without the encoders being connected. Encoder values are ignored until the first time a position change is signaled (the encoders are auto-detected). On the other hand, you must not connect encoders while the system is running. If you intend to use them only at certain times, you can enable or disable them using the “Setup→Encoders” menu items.

Although Gemini supports encoders, the vast majority of Gemini users do not them. Once you are familiar with slewing using the hand controller, the database, Identify and GoTo functions there is little need to move the telescope manually. Even if you do move it manually it can easily be synchronized again.

2.2.4 Power Requirements

The Gemini System requires 12–18 Volts DC, 3 Amps to operate. You will need to have a battery or **regulated** DC power supply. Your choice of power supply is very important! Many DC power units are not regulated, provide too little current, and too little or too much voltage. This can cause problems with the Gemini. If you plan to run other equipment from the power supply, make sure it has enough additional capacity. **Choose your power supply carefully to meet the requirements mentioned above**, and avoid potential problems such as long power cables. The Losmandy DC power supply (available separately) meets all the above requirements.

2.3 Hand Controller Overview

The Gemini System comes with the **Deluxe Hand Controller**. All functions of the Gemini System are accessible using just the four diamond shaped buttons, and the MENU button. The built-in LED display provides information about all of the Gemini System's features and menus. This simple arrangement gives you complete control with a minimum of effort. Because the Gemini has such a large number of features and options, navigating through the menus can be somewhat overwhelming at first, but after a little practice, you'll find this arrangement quite intuitive and very easy to operate. All of the settings in the Setup menu are stored in non-volatile memory, so you won't have to set them each time. There are also shortcut keystrokes that will give you instant access to some features.

2.3.1 Controls

The Hand Controller has two main functions. It is used to move the telescope in RA and Dec., and to access the Menu. Pressing the MENU button on the Hand Controller toggles between **Telescope Control Mode** and **Menu Mode**. After completing the startup sequence, the Gemini System goes into Menu Mode, offering the main menu item “Align Telescope”. After 15 seconds without any user input it will fall back into Telescope Control Mode.

Telescope Control Mode: The four diamond shaped buttons move the telescope in RA and Dec. The upper diamond button is DEC+, the lower one is DEC–, the right one is RA+ and the left one is RA–. At power-up, the RA and DEC buttons default to these functions. The square RA REV and DEC REV buttons on the bottom can be used to reverse (toggle between) the + and – functions on the respective RA and DEC (diamond) buttons. The functions of the RA and DEC buttons are not marked for this reason.

Unless reversed using RA REV or DEC REV, RA+ moves the mount west in RA while RA- moves the mount east.

DEC+ moves the declination axis of the mount counterclockwise (when viewed from the top), while DEC- moves it clockwise. When



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moving in declination, the direction does NOT change as the mount crosses the celestial pole.

Menu Mode: Press the MENU button and "MENU" is displayed. The DEC+/- buttons scroll through the possible selections, the RA+ button selects items (like a computer's 'enter' key), and the RA- button usually goes back to the previous selection (like a computer's 'back arrow'). Pressing the MENU button again returns Gemini to Telescope Control Mode for guiding, centering, and slewing the telescope.

Note 1: There are some commands in the menu that will switch back to Telescope Control Mode without pressing the MENU button.

Note 2: The RA REV and DEC REV buttons affect the Hand Controller in both Telescope Control Mode and Menu Mode. For example, if you have pressed RA REV, the left-hand RA button now selects items in the menu, and the right-hand RA button is used as a back-arrow key.

Note 3: After about 15 seconds of inactivity at a top-level menu item, the Hand Controller will automatically switch back to Telescope Control Mode.

Display: When in Menu Mode, the display shows the menu items and data for each item. When you enter the Telescope Control Mode, the display will usually show a status message (such as the current tracking rate) for a few seconds and then will go blank. For example, after a GoTo operation, the display will show "FINISHED" for a few seconds, and then go blank. However, selecting some menu items such as "Show Date/Time" and "RA/DEC Display" will display the requested data (date/time or RA/Dec. coordinates), then go into Telescope Control Mode, but will *not* blank the display.

2.3.2 Menu Structure/Navigation

The Gemini menu system is organized as a series of menu items, many of which have sub-menus. A diagram of the full menu structure can be found in Appendix 8.1. You can enter the Menu Mode at any time by pressing the MENU button on the Hand Controller. Once you are in Menu Mode, you can scroll through the menu items using the DEC +/- buttons. To select any displayed menu item, press the RA+ button. If the selected menu item does not have any sub-menu items associated with it, this will immediately execute the selected function. However, if the selected item does have sub-menu items, the Hand Controller will display the first item in the sub-menu. Pressing the DEC +/- buttons will now scroll through the items in the sub-menu. Pressing the RA- button will return you up one sub-menu level.

For some menu items, you will need to enter numeric data. This is easily accomplished using the direction buttons on the Hand Controller. When you come to such a menu item, the far left digit (or sign, if any) of the number will be flashing to indicate that it can be changed. To change the digit, use the DEC+ and DEC- buttons to scroll through the digits 0-9. When the digit you want to enter is displayed, press RA+ to move to the next digit to the right. RA- acts as a back arrow key to move back to the previous digit. When you are finished entering the last digit, press the RA+ button again to enter the keyed-in number.

2.3.3 QuickMenu

If you press and hold the MENU button for at least one second, a selection of useful menu items such as Centering Speeds, Hand Controller Modes, and Telescope Park commands scrolls through the display. The item that is displayed at the moment you release the button is selected. Some QuickMenu items have submenus that will scroll through the display. Pressing the MENU button again selects the current submenu item being displayed. After a QuickMenu item is selected, Gemini returns to the Telescope Control Mode.

2.3.4 Moving the Mount Manually

When you are in Telescope Control Mode, you can move the telescope with the buttons on the Hand Controller. There are three basic movement speeds: Guiding Speed (0.2 to 0.8 of the tracking speed), Centering Speed (up to 255 times the tracking speed), and Slewing Speed, which can be adjusted separately for manual slewing (with the Hand Controller) and slews performed by a GoTo operation. Holding down a button causes the telescope to move. Momentarily pushing down the opposite button while the telescope is moving causes it to accelerate to the next higher movement speed.

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 3 modes. You select the mode by means of the Setup→Hand Controller menu item. 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, the Guiding Speed is not available. When you press a button, the telescope moves at Centering Speed. 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.

This 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 pressing the opposite button 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 1/4

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.

If you want to guide a photograph manually, you may plug a Standard (not Deluxe) Hand Controller into Gemini's autoguider port. This way you are sure that you cannot accidentally move the scope at centering speed while guiding. The LED on the standard Hand Controller will not be illuminated when plugged into the autoguider port.

The All Speeds Mode

In this mode, all speeds are available, from Guiding Speed to Slewing Speed, by using 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.

2.4 Basics of Operation

This section will walk you through getting your Gemini system set up and running for the first time. The steps that we'll follow are:

- Setting up for observing
- Rough Polar alignment
- Putting the telescope in Startup Position (positioning scope with the counterweight down and the OTA pointing north if in the northern hemisphere, or south if in the southern hemisphere).
- Powering on
- Setting parameters (mount type, time/date/location, etc.)
- Aligning mount using alignment stars
- Using the mount

2.4.1 Setting Up for Observing

Once you've completed the Gemini installation and have connected all the cables, you are ready to set up for observing. **IMPORTANT:** As with any telescope mount, make sure your telescope is properly balanced in both RA and Dec. before continuing. Do this with all eyepieces and accessories that you intend to use attached. Refer to the instructions for your mount to help you with this.

2.4.1.1 Rough Polar Alignment

In order to function correctly, your mount must be approximately polar aligned. This means lining up the mount's polar axis with the Earth's rotational axis. You do this by pointing the mount's polar axis toward the celestial pole (north celestial pole in the northern hemisphere, and south celestial pole in the southern hemisphere). For visual use, this alignment need only be within a few degrees since Gemini can compensate for a

fair amount of misalignment in a GoTo operation (using the modeling parameters) and when tracking (using Closed Loop tracking).

There are several methods that you can use to achieve rough polar alignment. The simplest is to use a compass and place your mount so that the polar axis points north (or south in the southern hemisphere). Be sure to account for the magnetic variance of your geographic area. Then, using the latitude scale on your mount (or an inclinometer placed at an appropriate place on the mount), change the elevation of the polar axis to match your latitude. In most cases, you should now be well enough polar aligned for visual use.

At night in the northern hemisphere, you can also sight along (or through) the mount's polar axis and adjust the elevation and azimuth of the mount until it is pointing at Polaris. You can also move the telescope to 90° declination (so that it is parallel with the mount's polar axis) and again adjust the elevation and azimuth of the mount until Polaris is centered in the telescope.

In the southern hemisphere or in the north if you cannot sight Polaris because of trees or buildings, you can use Gemini's Polar Align Assist function for an improved polar alignment after achieving rough alignment using a compass.

Finally, if your mount has a polar alignment scope, follow the instructions that came with it for polar aligning. In general, this will be more accurate than either of the above methods.

After you have completed the remaining steps to get you up and running, you can use Gemini's Polar Axis Correction feature to achieve a very accurate alignment.

2.4.1.2 Startup Position

Your next step after positioning the mount is to position the telescope. When Gemini starts up for the first time or any time after the mount has been moved, it expects the telescope to be in a standard Startup position. In this position the counterweight shaft is pointing down (CWD), and the Dec. axis is at 90° (OTA pointing at the celestial pole). Powering on in this position is necessary so that (1) Gemini will correctly set its movement safety limits, and (2) so that it can initialize to where it is pointing. Failure to power up Gemini with the scope in Startup position will prevent Gemini from being able to use its GoTo capability to find a first alignment star; it could also cause the telescope to collide with the tripod or mount.



2.4.2 Power On and Setup

Now it is finally time to power up the Gemini. After turning on the power switch, you will see a welcome

message scroll across the display (pressing the MENU button terminates the message). When powering up the unit for the first time, or after inserting/changing the internal battery, you may see the words "CMOS reset" appended to the welcome message. This means that during startup, an incorrect checksum was detected and the static memory (SRAM) was reset to its initial values. You should not see this "CMOS reset" again, unless your battery goes low.

Next, Gemini tries to read time and location data from a GPS attached to the serial port. If you have a GPS that supports the NMEA0183 protocol or the Garmin Textout Protocol, you can connect it to Gemini's serial port. Gemini looks for a GPS every time it starts up. After attempting to read the GPS data, Gemini briefly displays a GPS status message. If a GPS is not connected, you will have to set the UTC Date/Time and geographic coordinates manually at the first startup.

After the welcome message and the GPS status message, you will normally be asked to choose a startup mode. This mode determines whether the Gemini uses the modeling data already stored in its SRAM, or resets it and starts with new modeling data. There are 3 options:

- "Cold Start" clears the current modeling data, and should be used whenever the mount has been moved from its polar alignment after a previous observing session. The mount must be in Startup Position during a Cold Start.
- "Warm Start" preserves the modeling data but not the current telescope position data. It should be used if the *mount* has not been moved since the last observing session, but the *telescope* has been moved on the mount. The mount must be in the Startup Position during a Warm Start.
- "Warm Restart" preserves all modeling and position data. This should be used if no movement of the mount or telescope has occurred since the last observing session. This is especially useful for permanent installations, multi-night star parties, and daytime observing if you aligned your mount the night before.

If the CMOS data has been reset, you will not be given a choice, and the system will automatically Cold Start. For this tutorial, if you do see a choice, select "Cold Start."

2.4.2.1 Cold Start Setup Options

Starting with Level 3 version 1.01, you are able to change the UTC Date/Time, Mount type, Longitude, and Latitude immediately after a Cold Start. This is useful if you are traveling with your mount, or using your mount for the first time. After selecting "Cold Start" (or automatically being Cold started after a CMOS reset), the display sequences through the following settings that can be changed one at a time:

- UTC Date/Time
- Mount Type
- Longit.
- Latitude

Each item will be displayed for a few seconds before going to the next one. If you want to change the currently displayed item, press one of the four direction buttons on the Hand Controller. To skip to the next item without waiting, press the MENU button. If you miss setting an item at this time, you can always use the “Setup” menu to make the change after startup is complete (see chapter 5 for details on using the “Setup” menu).

2.4.2.1.1 Setting the UTC Date and Time

The current UTC date and time must be entered into Gemini so that it can make correct calculations for pointing the telescope. If you choose to set the UTC date and time during startup, first note the display, which will show the current value. The format for the date and time is “yymm.dd hh:mm:ss” and must be in Coordinated Universal Time (UTC) – not your local time. Enter each digit of the date and time using the direction buttons on the Hand Controller as described in section 2.2.2 above. The currently selected digit will blink. After selecting the seconds digit, press RA+. Gemini will then return to the startup process and allow you to change the next item.

Note: Remember that the UTC date at certain times of the day may be one day ahead of or behind your local date.

2.4.2.1.2 Setting your Mount Type/Parameters

The Gemini system supports several different mounts, and needs to know which one you are using. Gemini will display the currently selected Mount Type. If you choose to change this item, use the DEC buttons to scroll through the mount types available. When your mount is displayed, press the RA+ button to select it. Gemini will then return to the startup process and allow you to change the next item.

2.4.2.1.3 Setting Your Location

In order to accurately position your mount, Gemini needs to know your position on the Earth in addition to the current date and time. If you had a GPS connected during power-on, Gemini read this data and you can skip the next two steps. The GPS receiver can also be read later using the menu item “Setup→Geogr. Location→Query GPS Rec.”

To set your geographic location manually during startup, press any direction button on the Hand Controller when it displays either the Longitude or Latitude you wish to change.

At the Longitude display, use the Hand Controller buttons to enter your Longitude as previously noted. The longitude is counted from Greenwich, England; eastern longitudes are designated by 'E', and western longitudes (including the American continent) by 'W'. After you have entered the last digit, press the RA+ button again to set the longitude.

The display next shows “Latitude.” Press any direction button to initiate setting your Latitude. Enter your Latitude using the RA and DEC buttons to change digits as you did with Longitude. Northern latitudes are denoted by the “+” sign, while the “-” sign is used for southern latitudes. After you have entered the last digit, press RA+ again to complete the startup procedure.

2.4.2.2 Completing Startup

After the system has completed its startup tasks, it will display the UTC Date/Time, Mount Type, and geographic location. It will then go into Menu Mode and display the “Align Telescope” menu item.

Since the date and time you enter on the Gemini will be UTC, you need to set your time zone for correct conversion to your local time. If the display has gone blank, you will first need to get into Menu Mode by pressing the MENU button. Use the DEC buttons to scroll through the menu choices until you get to "Setup" and then press the RA+ button. You are now in the Setup submenu. Use the DEC buttons to scroll through the menu choices until you come to “Geogr. Location” and press the RA+ button to select it. Such navigation sequences will be abbreviated in this manual by using the names of the submenu items separated by a right arrow “→” symbol. Thus, the menu item you just chose would be depicted “Setup→Geogr. Location.” Finally, use the DEC buttons to scroll through the menu choices until you come to “Timezone” and press the RA+ button to select it.

The display will show the current time zone setting as some number of hours ahead of or behind the time in Greenwich England. For example, the United States west coast is UTC-8 hours or 8 hours behind Greenwich when daylight savings time is not in effect. Press the DEC+ or DEC- buttons to scroll through the time zones. When your time zone is displayed, press the RA+ button to select it.

Having set your location and time zone correctly, you can store them. Up to four different locations can be stored and reloaded. These locations default to Hollywood CA, Colfax CA, Berlin Germany and Sydney, NSW Australia, but can be overwritten by your own settings. Use the “Setup→Geogr. Location→Store Site” command to store the site name, coordinates and time zone. You can find more information about this command in chapter 5.

2.4.2.3 Preferences

Finally, there are some preferences that you can set to tailor Gemini to your liking and to your particular mount. Most of these are optional and can be changed any time. Such items include:

- Hand Controller Mode (Visual, Photo, All Speeds)
- Moving Speeds (Slew, GoTo, Center, Guide). Changing the Slew and GoTo speeds may be needed if a motor keeps stalling during a slew. Often slowing these speeds down helps.
- Brightness of the HC display

Refer to chapter 5 for details about setting these and other options.

IMPORTANT: Changing your geographic location between northern and southern hemispheres will reverse the tracking direction (and because of this, also the Safety Limits). Gemini makes even more internal adjustments when you change the Mount

Type. If you alter either the Mount Type or hemisphere, restart the Gemini after completing the Setup operation. Simply turn Gemini off and then on again to do this.

IMPORTANT: The default safety limits prevent the mount from hitting itself as it moves. However, these safety limits may not be sufficient to prevent your OTA from hitting either parts of the mount or the tripod. You should always check the safety limits and reset them as appropriate for your specific equipment. Please see section 5.3.10.2.6 for information about setting the safety limits.

2.4.3 Refining the Mount's Alignment Model

Let's review where you are at this point: You have assembled the mount and telescope, and have carefully balanced them in both RA and Dec. You have leveled and roughly polar aligned the mount by pointing the mount's polar axis at the celestial pole. You have positioned the mount in the Startup Position with the counterweight down and the telescope pointing north (or south if in the southern hemisphere), and powered Gemini on. Finally, you used Gemini's menus to set the various parameters to make it work. You are now ready to align Gemini's internal modeling parameters.

In order to improve the accuracy pointing to objects in the sky, the Gemini software can learn how the mount is oriented with respect to the celestial pole, what angle the telescope is pointing to in both RA and Dec., the degree of non-orthogonality between the telescope and the mount, etc. All of these parameters form Gemini's "model" of the mount and telescope. These parameters as well as others are built up automatically through a series of alignment operations. Each alignment consists of pointing to a star and telling Gemini when that star is centered. Accurate modeling allows accurate GoTo operations, and the more alignments you perform (up to a point), the better the modeling parameters can be determined. You can read more about the various modeling parameters that Gemini uses in chapter 3.

As mentioned earlier, there are several modes in which Gemini can start up. For the purposes of this section, we will assume that the mount was "Cold Started." Subsequent sections of the manual will explain the modeling and alignment process in greater detail for each of the 3 startup modes.

2.4.3.1 Choosing Alignment Stars

Unless you are perfectly polar aligned and have no mechanical play or misalignment in your mount and your telescope, you will need at least 3 star alignments in order to build an accurate model. These must all be on the same side of the meridian – either east or west. The first 3 alignment stars should be selected from Gemini's "Bright Stars" catalog (database) and must differ in hour angle (distance in RA from the meridian) by at least one or two hours. This means you either need to choose stars that differ in RA by at least a couple hours, or wait a couple hours between alignments so that your next alignment star will differ in hour angle from where your first alignment star was. For example, doing an alignment on Capella and then on Rigel or Bellatrix is not a good idea; the same is true for alignments on Procyon, followed by Castor or Pollux – there are only tiny differences in RA between them.

Make sure that you are certain of the identification of all stars that you use for alignment. If you misidentify a star that is far from the correct star, Gemini will reject the “Additional Alignment.” However, if you align on the wrong star that is close to the correct star, Gemini will accept the erroneous “Additional Alignment,” and errors will be introduced into the pointing model causing inaccurate GoTo operation. You can use the Setup→Mount Parameters→Pointing Model→Undo Last Align command to undo the most recent alignment done.

2.4.3.2 Slewing to and Aligning on your First Star

After you have chosen 3 alignment stars, you are ready to start the alignment process. When you cold started, Gemini assumed that the mount was perfectly polar aligned, level, in the counterweight down position, and that the telescope was pointing north (or south in the southern hemisphere). It then built an initial model based on these assumptions.

Select and GoTo the first of the chosen alignment stars. The easiest way to do this is to select the “Align Telescope→GoTo Bright Star” from the menu. You can then use the DEC buttons to scroll through the list of Bright Stars that are currently above the horizon. When you see the name of the star you want to use, press the RA+ button, and Gemini will slew close to that star. Depending on how well you polar aligned your mount and assuming that your location, date, and time are all accurate, the target star may even be in the field of view of a low power eyepiece. The Hand Controller will now be in Telescope Control Mode, and you should use its buttons (with the aid of a finder scope if necessary) to locate and center the star in your eyepiece. Once the star is centered, press the “Menu” button to enter Menu Mode, and select “Align Telescope→Synchronize.” It will confirm the object you are pointing to. Finally, press RA+ to complete the first step of alignment.

To summarize:

- Choose 3 alignment stars that differ in RA by at least one or two hours
- Select “Align Telescope→GoTo Bright Star”
- Select your first alignment star from the submenu
- Mount will slew close to that star
- Use Hand Controller buttons to center the star in the eyepiece
- Select “Align Telescope→Synchronize”
- Display will confirm the object to which you are pointing
- Press RA+ to complete the alignment

2.4.3.3 Additional Alignments

If you are satisfied with the rough accuracy of a one star alignment, you may skip this section. Otherwise, you should now repeat a similar process with at least 2 more stars on the same side of the meridian. Select “Align Telescope→GoTo Bright Star” from the menu and select your next alignment star from the list of Bright Stars. Press RA+ to GoTo that star, and again use the Hand Controller buttons to center the star in your eyepiece. Now select “Align Telescope→Additional Align.” As before, Gemini will

confirm the object to which you are pointing by displaying its name. Press RA+ to complete this alignment. Repeat the process for the third alignment star on the same side of the meridian. This will establish a basic pointing model. You may continue to refine the model on this side of the meridian by repeating the process with several more stars if desired.

IMPORTANT: When using the “Additional Align” command, you must already be pointing to the star on which you want to align. The easiest way to do this is to use the “Align Telescope→GoTo Bright Star” command as described above. The “Additional Align” command does not move the telescope. Failure to do this will result in a “Sorry, rejected” message from Gemini.

Next, pick one more alignment star on the side opposite the meridian from the first 3, and repeat the Additional Align process just described. The reason for doing this is that after a meridian flip, you'll experience an offset in RA caused by play in the RA gear (Now the opposite side of the worm and teeth are in contact). Additionally, some parts of the system (such as the main mirror of an SCT) will have flopped to the other side. Adding one more alignment after a meridian flip allows Gemini to know how big the play in the RA gear and the flop are, and take them into account. For best results, choose a star in the middle of the hemisphere, ensuring that the RA gear is in good contact. Refocusing also helps to move the mirror into a stable position after the meridian flip.

To summarize:

- For each of your other 2 alignment stars:
 - Select “Align Telescope→GoTo Bright Star”
 - Select an alignment star from the "Bright Stars" catalog
 - Mount will slew to that star
 - Use Hand Controller buttons to center the star in the eyepiece
 - Select “Align Telescope→Additional Align”
 - Display will confirm the object to which you are pointing
 - Press RA+ to complete the alignment
 - Gemini will display the calculated offset from the pole in arcseconds in azimuth (A) and elevation (E). For example, it might display “A:+15 E:-10” to indicate that your mount is 15 arcseconds from the pole in azimuth and 10 arcseconds from the pole in elevation.
- Choose a star on the opposite side of the meridian
- Perform the above steps for an Additional Align on that star

You should now be ready for normal operation with your Gemini. You can perform more Additional Aligns any time during your observing session to further refine the model. Be sure to read chapter 3 for more information about starting up and aligning Gemini in its different startup modes, and for more details about Gemini’s internal modeling capabilities.

2.4.4 Normal Operation

By now, you are no doubt eager to put Gemini through its paces. You can control your mount using Gemini either from the Hand Controller or via a computer connected through Gemini's serial port. Chapter 5 describes these operations in great detail. The present chapter concludes with a quick guide on how to use the Hand Controller to select and GoTo objects in Gemini's database.

2.4.4.1 Entering an Object of Interest

There are 2 ways to tell Gemini where you want it to go. The most common is to simply select one of the thousands of objects from Gemini's catalogs. However, if you want to GoTo an object that is not in a catalog such as a comet, you can enter its RA and Dec. coordinates manually using the commands in the "Coordinates" menu item.

Catalogs

Gemini has 11 permanently stored catalogs (databases) containing over 40,000 entries. To select an object from a catalog, simply select the "Object Database" menu item. You can then scroll through the catalogs using the DEC buttons; selecting one of the catalogs then allows you to choose an object from that catalog.

Some catalogs such as the "Messier" and "NGC" catalogs require numeric entries to choose an object. Other catalogs such as "Bright Stars" or "Solar System" allow you to scroll through objects and select the object you want. In the case of the "Bright Star" catalog, it is conveniently organized and subdivided according to the first letter of the stars' names. In all cases, once the object you want is displayed, press the RA+ button to select it. A message is displayed, containing the object's distance to the meridian (negative in the east) in minutes of time and the elevation in degrees.

Another way to acquire a catalog or object list is to compose it yourself. Using the optional Gemini Control Center software, you can use your PC to prepare and download your own catalog that can contain up to 4000 objects. This has the advantage of including in your list only objects that will be used for a particular night's observation.

Coordinates

Another method of selecting an object is to enter its RA and Dec. coordinates directly. Select "Coordinates→Enter RA/DEC" from the menu. You will then be shown the mount's current RA/Dec. location and be prompted to change each digit to the desired coordinates. As with all numeric entries in Gemini, use the DEC+ and DEC- buttons to change the flashing digit, the RA+ button to advance to the next digit, and the RA- button to go back to the previous digit. After you have entered the last digit, press the RA+ button again to finish entering the coordinates.

By default, Gemini assumes that any coordinates you enter are for the epoch of the current date. However, you can change Gemini's default epoch to J2000.0 using the

“Setup→Communication→Coordinate Epoch→Epoch J2000.0” menu item. You can find more details on this in chapter 5.

Alternatively, you can enter coordinates of the azimuthal coordinate system using the Coordinates->Enter Az/El submenu.

2.4.4.2 GoTo Operation

After an object has been selected (either from the internal catalogs or by entering its coordinates) a new menu item appears: “GoTo <object>” (where <object> is the currently selected object). Simply select this menu item to cause Gemini to slew to that object. As the telescope approaches the object, it will ramp down from slew speed and finish pointing at centering speed. When the GoTo is complete, the display will show “FINISHED.” If you have correctly built a good pointing model, the object should be within a few arc minutes of the center of the field of view. You can then center it using the Hand Controller, and either Synchronize, or perform an Additional Align if you want to continue to refine the pointing model.

2.4.4.3 Tracking

By default, Gemini will track at the sidereal rate. This should be sufficient for visually observing nearly any object if you are roughly polar aligned, but the tracking can be changed to other rates if desired. It is important to note that continuous tracking will occur while in either the Menu Mode or the Telescope Control Mode.

2.5 Next Steps

The steps outlined above are sufficient to get you started and provide you with many hours of observing pleasure. However, we have only scratched the surface of the Gemini’s many capabilities. Please take some time to read through the rest of the manual for information regarding such topics as:

- Using Gemini to achieve better polar alignment
- Imaging (tracking rates, Periodic Error Control, using an autoguider, etc.)
- Startup modes
- Mount modeling

2.5.1 Gemini Users’ Group

You can exchange information and ideas with other Gemini users on the Gemini Users’ Group forum on Yahoo. You can get more information or join the group at http://groups.yahoo.com/group/Gemini_Users.

3 Important Concepts about Your Mount

In order to get the most from your mount and the Gemini system, you'll need to understand a few important concepts about both astronomy and telescope mounts. This chapter will introduce you to these concepts and show you how to apply them using some of Gemini's advanced features.

3.1 *Astronomical Coordinates*

3.1.1 Right Ascension and Declination

Just as any location on Earth can be described by its latitude and longitude, positions in the sky can be described by a set of coordinates known as Right Ascension (abbreviated RA) and Declination (abbreviated Dec.). RA and Dec. are the celestial equivalents of longitude and latitude, and are actually closely related.

Imagine a globe of the Earth with lines of latitude and longitude drawn on it. Now, extend those lines out from the globe to the imaginary celestial sphere on which are placed all the objects in the sky. Directly above the poles of the Earth are the celestial poles, and directly above the terrestrial equator is the celestial equator. The star Polaris lies very close to the north celestial pole. Declination is easy since it exactly corresponds to latitude, measuring the angle between the celestial equator and the celestial poles. Just as lines of latitude run parallel to the equator and go from 0° at the equator to 90° at the poles, so do lines of declination. Declination values are measured in degrees, minutes and seconds of arc (or decimal minutes) and are positive when north of the equator and are negative when south of the equator. Thus, a star at 46 degrees 12 minutes 42 seconds south of the celestial equator is said to have a Dec. of -46° 12' 42".

Right Ascension is analogous to longitude, measuring angles east and west. And, like longitude, RA needs an arbitrary zero-point. While the zero-point of longitude is Greenwich, England, the zero-point of RA is that location in the sky where the Sun crosses the celestial equator on its way north in the spring (also called the first point of Aries). However, unlike longitude, RA is measured in hours, minutes and seconds (or decimal minutes) from 0h 0m 0s through 23h 59m 59s. RA values increase as you move east of the first point of Aries. Note that because the Earth is rotating to the east on its poles, lines of constant declination remain in constant positions on the sky, but lines of constant RA move from east to west in the sky during the night. We'll look at this in more detail in the next section of this chapter.

So, the coordinates of an object might look like 16h 42.9m +38° 55' 12" which means 16 hours 42.9 minutes east of the first point of Aries and 38 degrees 55 minutes 12 seconds north of the celestial equator. You can use the "Coordinates→Enter RA/DEC" menu item to input the coordinates into Gemini. If you then tell Gemini to GoTo those coordinates, you'll find yourself looking at M13 in Hercules.

Gemini displays RA in hours, minutes, and decimal minutes so that the RA value above would be represented as 16h 42m9. Declination is displayed as degrees, minutes, and seconds, so the above Dec. value would be represented as +38° 55' 12".

3.1.2 Precession

While most stars, galaxies and other deep sky objects do not move relative to each other in any kind of time frame we can notice, their RA and Dec. coordinates do change slowly over the years. This is because the coordinate system is based on the poles and equator of the Earth. In addition to rotating on its axis once a day and orbiting the Sun once a year, the Earth's axis is precessing like a top once every 26,000 years taking the RA and Dec. coordinate system with it.

This is why RA and Dec. coordinates always have a date associated with them, called the Epoch or Equinox of the coordinates. Most sources now use Epoch 2000 coordinates (abbreviated J2000.0), meaning that the RA and Dec. values were correct on Jan 1, 2000. In order to accurately point a telescope at an object whose J2000.0 coordinates are given, a precession calculation must be applied to determine the RA and Dec. values for the current date.

By default, Gemini assumes that any coordinates you enter are for the epoch of the current date. You can change Gemini's default epoch to J2000.0 using the "Setup→Communication→Coordinate Epoch→Epoch J2000.0" menu item, allowing you to enter (or transfer from a connected PC) J2000.0 coordinates and letting Gemini perform the needed precession calculation.

3.1.3 Azimuthal Coordinate System

Although the equatorial coordinate system (RA/Dec.) is best suited for most astronomical objects, some applications require pointing to a given azimuth and altitude (Alt/Az). One example is pointing to satellites in geostationary orbits. Gemini supports the azimuthal coordinate system by allowing you to display the current altitude and azimuth as well as allowing you to enter Alt/Az coordinates from both the hand controller or over the serial line.

While the altitude of an object can be easily defined as the distance from the horizon, azimuth needs an arbitrary zero-point and an orientation. There are two common systems: one starting in the north, the other in the south. Gemini's zero point in azimuth is in the north, increasing to the east (90°), south (180°) and west (270°).

In order to fit the display, the precision of Alt/Az coordinates is limited to minutes in Visual mode. In Photo mode, azimuth and altitude are alternately displayed with an accuracy of (arc)seconds.

3.2 How the Sky Moves

If you have spent any length of time outdoors looking at the stars, you've probably noticed that everything in the sky shifts position over time during the night. Of course this is due to the fact that the Earth is rotating on its polar axis. Recall that the celestial poles in the sky lie directly above the Earth's poles, so just as the Earth rotates around its poles, the entire sky appears to rotate around the celestial poles, completing one revolution in about 24 hours. Objects that lie close to the poles make small circles around the pole, while objects further from the pole make larger circles, taking them below the horizon for periods of time during their revolution. So, although an object's RA and Dec. don't change significantly during the course of a night, a fixed telescope aimed directly at a point on the meridian (the imaginary line passing directly overhead from north to south) would see stars drift through it from east to west as increasing RA values cross the meridian. It is important to understand that a fixed telescope points to a constant Dec. value, but a changing RA value. This also explains why RA is measured in hours.

There is another coordinate system – one that does not move with the rotation of the Earth. Because it does not move relative to the Earth, it can be used to describe a telescope's position relative to the Earth. It uses the same Dec. value as does the rotating system to measure angles north and south of the poles. But instead of RA, the so-called "Hour Angle" is used to measure angles east and west. It too is measured in hours, minutes and seconds (or sometimes just minutes), but uses the meridian as its zero point. An object in the east has a negative hour angle. This value is interpreted as the number of hours it will take for the object to arrive at the meridian. If it is due east, its Hour Angle (abbreviated HA) will be -6h, meaning it will need 6 hours to arrive at the meridian. Objects in the west have a positive hour angle, indicating the number of hours the object is past the meridian. Gemini displays the hour angle of an object (in minutes, together with the current elevation) at the time you select it from one of the databases.

3.3 Tracking

One of the jobs of a telescope mount and control system is to move the telescope to compensate for this constant change in RA of the sky. In order to stay pointing at a constant RA value, the mount must move at the same rate that objects in the sky appear to move. This is called tracking. If your mount is polar aligned, then its polar (or RA) axis is parallel with the Earth's axis, and tracking should involve simply driving the mount in RA at the same rate the Earth is turning. While this is a very close approximation for stars, there are a few complications that need to be addressed.

3.3.1 Rates

Gemini can drive the telescope at several different tracking rates depending on the object you are observing and how close your mount is to being polar aligned. The currently active tracking mode is displayed briefly whenever you press the MENU button to enter Telescope Control Mode.

3.3.1.1 Predefined Rates

Two predefined tracking rates drive the RA axis at a constant speed to compensate for the Earth's rotation.

Sidereal

Sidereal rate is simply the rate that compensates for the Earth's motion relative to the celestial sphere. It keeps the mount pointed at a constant RA and Dec. coordinate in the sky and will probably be the rate that you use the vast majority of the time. With sidereal tracking selected, the telescope makes one revolution per sidereal day (86164.0905 seconds). **Note:** The sidereal rate assumes that your mount is accurately polar aligned.

None/Terrestrial

This rate turns tracking off completely and allows you to observe stationary objects such as points on land, or geosynchronous satellites. It is also useful for keeping the telescope from exceeding its safety limits when the Gemini must be left on for extended periods of time between observations.

3.3.1.2 Computed Tracking Rates

In addition to the Earth's rotation, the computed tracking rates take many additional factors into account such as the Earth's orbit around the Sun, the Moon's orbit around the Earth, and an object's position relative to the horizon.

Lunar and Solar

Neither the lunar nor solar tracking rates is constant. Since the orbits of Earth and Moon are slightly elliptical, the apparent speed of Moon and Sun will change. When you select the lunar or solar tracking rates, the tracking speed will be calculated based on the actual position and the position one hour later.

Because the Moon orbits the Earth, its RA and Dec. change during the course of the night. The lunar tracking rate compensates for the RA component of that change; there is no compensation for the changes in Dec. While sidereal rate can certainly be used for visual lunar observing, the lunar rate will do a better job keeping the Moon centered in the telescope's field of view. Since the Moon is relatively near the Earth, even the location on Earth where you are observing must be taken into account. The lunar tracking rate therefore takes the parallax into account by calculating topocentric instead of geocentric positions.

Gemini computes the tracking rates by calculating the current position of the Sun or Moon and the position one hour later. While the tracking rate for the (distant) Sun will not change much during an observing session, the tracking rate for the Moon might vary significantly as its parallax changes moving from the horizon to higher elevations and

vice-versa. You can reselect the lunar tracking rate periodically throughout the observing session to allow Gemini to recalculate the correct rate as needed.

Because the Earth is orbiting the Sun, the Sun's RA and Dec. do change during the course of the day, but much more slowly than the Moon's. The solar tracking rate again compensates for the RA component of that change, but not for the Dec. Since the difference between solar and sidereal rate is only about 4 minutes a day, you will see little difference between the two over a short period of time.

Adaptive King

In the absence of the Earth's atmosphere, sidereal rate tracking would be all that is needed to accurately track objects with fixed RA and Dec. coordinates (any object outside the solar system). However, because the Earth's atmosphere refracts (bends) light, it complicates the situation. The light from an object close to the horizon must pass through more atmosphere than an object higher in the sky. It is therefore subject to more refraction, causing the object to appear to be slightly higher in the sky than it actually is. This is called refraction. As the object climbs higher in the sky, it is subject to less and less refraction, and catches up with its refracted image. This means that objects appear to move at a rate slightly slower than sidereal rate when they are close to the horizon. Several methods have been devised to compensate for this effect called "differential refraction."

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, and
- 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. The user must offset the elevation of the polar axis himself.

Closed Loop

The preceding discussion of tracking rates assumes that the mount is accurately polar aligned, allowing tracking to be accomplished using only the RA motor. However, 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.

Comet/User Defined

The Comet tracking rate allows you to program Gemini to set independent RA and Dec. tracking rates to follow comets and other solar system objects that follow unique trajectories. There are several methods you can use to achieve this:

- **Training** - Train the tracking by centering on the initial and the end position of an object over an arbitrary interval of time
- **Coordinate Controlled** - Enter the RA/Dec. positions at the start and at the end of an interval of time
- **Timer Values** – RA and Dec. timer divisors can be calculated and entered directly.
- **PC Controlled** - Calculate the necessary tracking rates at a PC and download them to the Gemini.

For each of these methods, a new tracking value for Gemini's internal timer that controls the tracking speed will be calculated and loaded. The available timer range limits the lowest possible speed. Faster tracking (moving towards smaller RA values) does not have this limitation.

Positive Dec. rates mean that the Dec. values are getting higher with time. Upon reaching the pole, the direction will not be changed. After crossing the pole, Dec. will decrease.

The Comet/User Defined tracking values are preserved as long as the Gemini is not powered down. The programmed rate can be activated again (after another tracking rate was used) with the "Setup→Mount Parameter→Tracking Speed→Comet Tracking→Activate" menu item. If the Gemini was powered down while in Comet/User Defined tracking mode, it will start up in Sidereal mode.

Training Comet Tracking

When you select “Setup→Mount Parameter→Tracking Speed→Comet Tracking→Train Tracking,” a training phase is started. Unlike training PEC, you don't have to follow the motions exactly. Just keep the object in the eyepiece for a sufficient amount of time. Finally, center it and press the MENU button to end the training phase. Gemini calculates the necessary tracking rates in RA as well as in Dec. and the mount will follow the object in both axes.

The amount of time needed for training will vary with the object and the type of observation. For an object with a relatively slow and constant motion, a few minutes of training should be sufficient for visual observing. For photography, you may want to consider training for up to half of the intended exposure time. For an object that changes speed fairly quickly (such as a Near Earth Asteroid), shorter training sessions just before the observation will work best. In general however, for an object with relatively constant speed, the longer the training (up to 45 minutes) and the more exactly the object is centered at the beginning and end of training, the better the tracking will be.

After the training, “Show Information” displays the number of steps done and timer values calculated. If the training reveals an RA motion too slow to follow within the RA timer's range, an RA timer value of 65535 (the maximum value) will be displayed and used instead.

Coordinate Controlled Tracking

Calculating the tracking rate using coordinates is useful if you want to track an object for which you have an ephemeris. Knowing 2 different positions of the object at different times, Gemini can calculate the speed required to track the object. You can use the “Setup→Mount Parameter→Tracking Speed→Comet Tracking→Calculate Rates” menu item to enter coordinates from an ephemeris for the object you want to observe. Gemini asks for three pieces of data: two sets of object coordinates, and the amount of elapsed time (in hours) between them. The coordinate difference is used to calculate the necessary tracking rates in both RA and Dec. Since only the difference is used, the coordinates need not reflect the exact location of the object at the current time. If the RA value is outside the possible range, the input will be rejected.

If the coordinates change very slowly, you can multiply all values (RA, Dec. differences and the time interval) by a constant to input them with increased accuracy.

Timer Values

Comet Tracking allows you to manually enter rates for both RA and Dec. In both cases, these are divisor values that are used to divide the timer frequency to calculate the rate at which the motors are driven.

RA Rate

Gemini uses a 1.5 MHz timer to regulate the tracking rate in RA. The number that you enter as the RA rate divisor will be divided into 1,500,000 to determine the number of steps per second made by the RA motor. Increasing the RA timer value slows the tracking down, while decreasing the timer value speeds up the tracking. Note that for some mounts, such as the GM-8, CI-700, and Titan, the 1.5 MHz clock is pre-scaled by a factor of 2.

To determine the correct divisor for sidereal tracking for your mount, use the following equation:

$$RA_{Divisor} = \frac{1,500,000 / prescaler}{StepsPerRev / WormPeriod}$$

where *prescaler* is a mount-dependant scaling value, *StepsPerRev* is the number of motor steps per revolution of the worm, and *WormPeriod* is the period of the worm in seconds. The table below lists the values for *prescaler*, *StepsPerRev*, and *WormPeriod* for various mounts:

Mount	Prescaler	StepsPerRev	WormPeriod
G-11, HGM-200, MI-250	1	6400	239.344658 sec.
Losmandy Titan	2	6400	319.1262611 sec.
GM-8, CI-700	2	6400	478.68939 sec.
Losmandy Titan 50:1	1	12800	319.1262611 sec.

For example, to find the correct RA rate divisor for sidereal rate on a G-11, we get:

$$\frac{1,500,000 / 1}{6400 / 239.344658} = 56096$$

Dec Rate

The divisor for Dec. movement is calculated in a similar manner. For moving in Dec., an internal timer of 22.8881835938 Hz frequency is used. As with the RA divisor, the Dec. divisor value is divided into the timer frequency to determine the number of steps per second that the Dec. motor will make. A value of zero disables tracking in Dec., while a value of 1 would select the maximum speed of approx 22.9 steps per second. Higher values will slow Dec. movement down. The direction of the Dec. movement depends on the sign specified and the side of the meridian the telescope points to.

PC Controlled Tracking

In addition to programming to track visible objects, serial line command capability has been provided to allow the user to set his or her own RA/Dec. tracking rates. This "User

Defined Tracking" (to be used instead of a training phase) is useful for tracking minor planets and comets by setting the necessary rates using a computer program. For more information on how computer software can produce these commands, see Appendix 8.4 - Serial Line Protocol.

Comet tracking produces the same undesirable field rotation as Closed Loop tracking if the mount is not adequately polar aligned. With the tracking rate set correctly for a moving object, that object will be imaged as a point, but other objects that are moving at a different speed will be trailed on the image.

3.3.2 Meridian Flip

One of the characteristics of a German Equatorial Mount is that it cannot continuously track an object from the eastern horizon to the western horizon. At some point after the object has crossed the meridian, the telescope must be flipped to the other side of the mount to avoid tracking into the mount or tripod. This is called a "meridian flip." While this is not a great concern for visual observing, it must be taken into account when planning a long exposure photograph. You'll need to plan ahead so that you don't face the need to do a meridian flip after 15 minutes of a planned one-hour exposure. The hour angle displayed (in minutes) when you select an object from the database can help you to plan your exposure. For example, if the HA is minus 10 minutes, you know that the object will cross the meridian in 10 minutes. It would be best to position the telescope on the east side of the mount (if safety limits allow), or wait to begin your exposure until the object has moved so that you *can* position the telescope on the east side.

3.3.3 RA Safety Limits

Whether you are imaging or observing visually, you do need to be concerned about the east and west limits of the mount. The system will never make a complete turn in RA. There are default limits set for how far the RA axis can be turned to the east and to the west: 122 degrees to the west (telescope on the west side of mount) and 114 degrees to the east (telescope on the east side of the mount). The limits for the Mountain Instruments MI-250 are 92 degrees to the east, and 95 degrees to the west. These angles are measured from the CWD position. During a GoTo operation, if the mount cannot reach its target on the current side of the meridian, it will make a meridian flip.

Note: The "east" and "west" defaults given above are for the northern hemisphere. They are swapped for the southern hemisphere.

To change the safety limits, use the Hand Controller to move the scope to where you want the new limit to be set, and select the "Setup→Mount Parameter→Set Safety Limit" menu item. You have to start up the system accurately in Startup Position and slew to the position you want to set as the new limit. While this is no problem if you are narrowing down the allowed range, going beyond the old limits is a bit tricky. About 10 degrees before you reach the current limit, the system will softly ramp down the speed until the motor stops near to the real limit. Carefully continue moving with centering speed or slewing slowly until the system stops the motor and you hear the buzzer. You are now

outside the allowed range. Use the Hand Controller to carefully move beyond the old limit to the new limit position, and select the Set Safety Limit command. The buzzer won't stop until you go back inside the allowed range or set the new limit with this menu item.

Alternatively, if you already know the values of the Safety Limit angles to be set, you can use the Set Safety Limits submenus “Set East” and “Set West” to store them without having to move the mount.

IMPORTANT: The limits are stored in CMOS SRAM. Whenever the "CMOS reset" message is displayed during startup, all values are reset to the factory default. If you need different limits to be set, you will have to set them again!

While tracking, an audible warning (a short beep about every 20 seconds) sounds some minutes before the western safety limit is reached. This gives you an opportunity to close the camera shutter or take whatever other action is necessary. If you want to continue your observation of this object, you'll need to perform a meridian flip. This can easily be done using the “Meridian Flip” command in the QuickMenu.

3.3.4 GoTo Commands and Meridian Flips

By default, if you attempt to GoTo an object (using either the menus on the hand controller or a command transmitted via the serial port), Gemini will attempt to point to the object without doing a meridian flip if the safety limits allow it. If the telescope is on the east side of the mount and the object can be reached without moving past the east safety limit, Gemini will point without a meridian flip. Similarly, if the telescope is on the west side of the mount and the object can be reached without getting closer than 2.5 degrees from the western safety limit, it will point without a meridian flip. In all other cases, the mount will do a meridian flip before pointing to the object.

For example, if the western safety limit is set to the default value of 122 degrees from the CWD position, a GoTo command to any object from the eastern horizon to 29.5 ($122 - 90 - 2.5 = 29.5$) degrees west of the meridian will not cause a meridian flip. This could be a problem if you want to start imaging an object that is, say, 25 degrees west of the meridian. If the telescope is on the west side of the mount, a GoTo command will not cause a meridian flip since the object can be safely reached without it. However, you probably *want* to perform the meridian flip before you GoTo this object to give you more time to image before reaching the western safety limit. If you are controlling the telescope manually, you can use the QuickMenu “Meridian Flip” command to force a flip. Alternatively, if you are using telescope control software that understands Gemini's serial commands, it could check which side of the meridian the mount is on, and issue a meridian flip command. However, this does not work with most control software that uses only the Meade command set without Gemini's extensions. For these programs, the only solution is to GoTo an object that is past the western safety limit to force the meridian flip, and then go back to the object of interest.

To solve this problem, Gemini now allows you to set a “GoTo Limit” to define a point past which Gemini will always GoTo the object so that the telescope tube is on the east side of the mount. Gemini will allow the mount to track past this point, but will not GoTo any object west of this point without a meridian flip, if needed, to put the telescope tube on the east side of the mount. Refer to section 5.3.10.2.6 for a description of the “Set GoTo” limit command.

3.4 Polar Alignment

3.4.1 Definition

Polar alignment is the process of aligning the mount’s polar (RA) axis with the Earth’s rotational axis. It involves physically adjusting the elevation and azimuth of the mount, usually accomplished by turning adjustment knobs. Although the mount does not need to be level to be polar aligned, a level mount can make the alignment process much easier since adjusting the elevation knob on a level mount just moves the mount in elevation (and the same for the azimuth adjustment). Moving the elevation knob on a mount that is not level introduces some azimuth component as well. While leveling is an important time saver for the Drift Alignment method, it is not necessary at all if you intend to use Gemini's Polar Axis Correction feature. As mentioned earlier, an accurately polar aligned mount can track the motions of the sky by driving just the RA motor.

3.4.2 Techniques

There are several techniques that you can use to polar align your mount. Each method varies in the amount of time it takes and the accuracy it can achieve.

3.4.2.1 Polar Alignment Scope

Most of the German equatorial mounts supported by Gemini have the option of installing a polar alignment scope (PAS). This is a small telescope that is attached to the mount parallel to the mount’s polar axis. In most cases, it is actually installed inside the hollow RA axis. Inside the alignment scope is a reticle with markings for certain alignment stars. The idea is to adjust the mount in elevation and azimuth until the alignment stars match up with the marks on the reticle. You should of course refer to the instructions for your particular polar scope for complete details.

Using a polar alignment scope can be very fast. Its accuracy depends primarily on how well calibrated the reticle is and the degree of mechanical play between the polar scope and the mount. For a well-calibrated polar scope, you can expect to be within 2 or 3 minutes of the actual refracted pole. The accuracy is also limited because the stars around the pole are lifted up somewhat by refraction (most noticeable at lower latitudes). The PAS will therefore align your mount to the "refracted pole.”

3.4.2.2 Drift Method

The drift method of polar alignment is probably the most accurate and most time consuming method. It involves centering a couple of well-chosen stars in an eyepiece

with some type of reticle, and watching for the star to drift north or south as the mount tracks in RA. Depending on where the star is in the sky and whether it drifts north or south, you can determine which way to move the mount in elevation or azimuth. You then repeat the process until you see no drift for 5 to 15 minutes. The longer you can go without any north/south drift, the better polar aligned you are.

Of course, stars used for drift aligning are also subject to refraction. Using a star near the eastern or western horizon aligns the telescope to a pole that is shifted slightly toward the zenith (as proposed in the King method.) Experienced astrophotographers recommend that a star you choose for drift alignment be near the object that is to be photographed.

There are many good references on the web to give you detailed instructions on how to do drift alignment.

3.4.2.3 Gemini Polar Alignment Tools

Gemini provides two tools to help you achieve fairly accurate polar alignment. They are “Polar Align Assist” and “Polar Axis Correction.” Both are available as submenus of “Align Telescope.”

You can use the Polar Align Assist to get close to polar alignment when you first start the system, especially if you cannot use a polar alignment scope. You can then use Polar Axis Correction to refine your polar alignment after you have built a good pointing model using several “Additional Align” commands.

Polar Align Assist

After you have cold started and completed the first “Align Telescope→Synchronize,” select the “Align Telescope→Polar Al. Assist” menu item. You will be in the menu of stars you can use for polar alignment.

You will need to select 2 stars for this alignment process. The first one should be near the celestial equator (Dec. near 0) and within about 20° of the eastern or western horizon. The other star should be near the meridian (such as Polaris in the northern hemisphere). Use the DEC buttons to scroll through the list of stars and select the first one by using the RA+ button. Gemini will display “Calculating...” briefly and then once again display the menu of stars. Scroll through the list and select the second star.

After you use the RA+ button to select the second star, the mount will slew to the first star. Once it reaches the star, “center object” will appear on the display. If the star is the one near the meridian, center the star only using the mount’s elevation adjustment knob (ignore azimuth). If it is in the western or eastern part of the sky, center the star using only the mount’s azimuth adjustment knob (ignore elevation). Having done this, completely center the star in both RA and Dec. using the Hand Controller.

Press the MENU 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 MENU

button to slew back and forth between the two stars. When you are finished, press the MENU button once more, and when the telescope starts to slew, press the RA+ button to escape from the loop and finish the polar alignment routine. You can expect to get to within one degree of the pole using this method.

IMPORTANT: Because this method depends on the mount pointing to where the stars should be if the mount were polar aligned, you cannot use this function if modeling parameters have already been calculated. You should only use it after a Cold Start before you do any Additional Aligns, or immediately after selecting the “Reset Alignment” menu item.

Polar Axis Correction

This feature assists you in accurately polar aligning your mount. Because Gemini's modeling feature calculates the mount's deviation from perfect polar alignment, it can be used to guide you to alignment as you adjust the mount's azimuth and elevation. It is important to note that before you can use this function, you must build an accurate pointing model by doing several Additional Aligns.

After you have done several alignments on different objects, select an object from the Object Database that is near the intersection of the celestial equator and the meridian. GoTo the object and center it in the eyepiece using the HC buttons. Now, select "Align Telescope→Polar Axis Corr." from the menu. Gemini will move the mount to where the object should be if the mount were accurately polar aligned. You should adjust the polar alignment of the mount using the azimuth and elevation adjustment knobs until the object is again centered in the eyepiece. Since the mount will approximate perfect polar alignment, all subsequent GoTo operations should result in target objects being near the center of the eyepiece. If not (for instance, because the mount's initial misalignment exceeded several degrees), you may repeat the correction process. Note that after using this function, the modeling parameters will be reset and you will need to rebuild the model by performing several alignments on different objects. If you are within about 2 degrees of being polar aligned and have done at least 5 Additional Aligns, you can expect this function to get you within 2 arc minutes of precise polar alignment.

3.4.3 Accuracy Required

How well must Gemini be polar aligned? The answer to this question really depends on what you are doing. For visual observing, it does not need to be well aligned at all. You can be as much as 6° off, and the modeling parameters will still allow accurate GoTo performance. In addition, you can use Closed Loop tracking to keep objects centered while observing.

Imaging requires more accurate polar alignment due to the possibility of image rotation. While Gemini can GoTo and track objects when polar alignment is off, the field of view in the telescope will slowly rotate as tracking takes place. The closer the mount is to being polar aligned, the less field rotation will occur. Field rotation is a problem

especially for longer exposures. It is recommended that you use one of the polar alignment methods above to achieve the best possible alignment before imaging.

3.5 Mount Modeling

One of the features that distinguishes the Gemini control system from anything else available today is its built-in sophisticated modeling that provides highly accurate pointing and tracking capabilities. This modeling allows Gemini to compensate for inaccurate polar alignment and a large variety of mechanical misalignments in both the mount and the telescope.

3.5.1 Definition

Without any kind of modeling, a telescope control system must assume that a given number of pulses to the RA motor will always move the telescope a certain constant distance in RA with no movement in declination at all. The same applies to pulses to the declination motor. This would only be true if the mount were exactly polar aligned, the RA and Dec. axes of the mount were exactly orthogonal, and there was no mechanical play of any sort in the system. Unfortunately, this is never the case in even the best professional mounts.

Modeling is a way to analyze the various imperfections in your system so that the system can compensate for them when pointing and guiding. By pointing the telescope at various known objects (usually bright stars) and performing an “Additional Align” function, you teach Gemini about the imperfections in your particular setup. For each additional alignment, Gemini calculates the model parameters based on the best fit of all the alignment points so far and then synchronizes the model to the coordinates of the latest alignment object. Because there are several parameters in the model, it won’t converge on nominal values until you have performed at least 4 or 5 alignments on one side of the meridian. As mentioned earlier, you will get the best results if you pick alignment objects with substantially different hour angles. An additional source of inaccuracy – gear play – is calculated with the first alignment on the opposite side of the meridian.

Up to 10 different models can be stored and reestablished. This can be useful if you swap your Gemini system between multiple mounts.

3.5.2 System Startup Modes

Because Gemini stores the modeling parameters in non-volatile memory, it may be powered off at any time without losing its pointing model. In fact, the model can continue to be refined from observing session to observing session by adding more alignment points. However, the modeling parameters are only valid if the telescope and mount have not been moved between observing sessions. Whenever you turn the Gemini unit on, you need to tell it whether anything has been moved since it was turned off. This allows Gemini to decide how much of the model is still valid. There are 3 startup modes that tell Gemini what has been moved:

- **Cold Start**
- **Warm Start**
- **Warm Restart**

When the Gemini is powered up for the first time or after a CMOS reset, "Cold Start" is the only menu choice since there was no valid model in memory. Once a model has been established, subsequent power-ups will add "Warm Start" and "Warm Restart" to the startup menu.

"Cold Start" is the "start-from-scratch" startup choice because it deletes all previously established model parameters of the current model derived from previous alignments. It is the startup mode that must be used anytime the mount has been moved from its previous polar-aligned position.

Upon selecting "Cold Start," Gemini allows you to change the UTC Date/Time, Longitude, and Latitude. You should enter these parameters at this point unless they are still valid from a previous observation, or were provided by a GPS receiver that was connected to the Gemini when it was powered on.

Assuming Gemini was powered on with the telescope in Startup Position, you can easily find a first alignment star using the Align Telescope→GoTo Bright Star command which displays a list of well-known bright stars currently above the horizon and slews to the selected star. Alternatively, you can select a star by navigating to the "Databases" menu, selecting a star from the Bright Star Catalog, and performing a GoTo operation. In either case, you should then center the star in the telescope's field of view, and select the "Align→Synchronize" menu item. Synchronizing on this object constitutes the initial star alignment in the process of building a pointing model. Subsequent star alignments can then be performed one at a time by slewing (via GoTo) to other Bright Stars, centering, and executing "Additional Align."

"Warm Start" is used to tell Gemini that the mount itself has not been moved since it was powered down, but the clutches were loosened and the telescope was moved by hand. Gemini keeps all of the modeling parameters from the previous session, but resets its assumed position to the startup position (counterweight down and OTA pointing to the pole). For this reason, you must make sure you have moved the telescope to the Startup Position before selecting "Warm Start."

Finally, if the Gemini is subsequently powered on without the telescope or mount having been moved in any way since the last observation, "Warm Restart" is the startup mode of choice, and the telescope is immediately ready for use. All modeling parameters and positional information is retained from the previous session. This startup mode is most useful for permanent installations, multi-night star parties, and daylight observing.

IMPORTANT: If you use the "Setup" menu to change Gemini's Geographic Location or UTC Date/Time immediately after a Cold Start, the new values are not used to set the initial pointing model or calculate Local Time until Gemini is powered off, powered back

on, and Cold Started again. This does not apply to geographic coordinates or UTC Date/Time that are changed when prompted during a Cold Start.

3.5.3 Modeling Parameters

Gemini models the following mount and telescope parameters:

- Azimuth misalignment from the pole
- Elevation misalignment from the pole
- Axis non-perpendicularity at the pole
- Axis non-perpendicularity at the equator
- Gear play
- Mirror flop
- Index error in hour angle
- Index error in declination
- Counterweight flexure

You can examine each of these parameters immediately after an additional alignment. The azimuth and elevation misalignment (**A** and **E**) are displayed right after the “Additional Align” is executed. You can also use the “Show Information” menu item to display the other parameters: **NP** = non-perpendicularity at the pole, **NE** = non-perpendicularity at the equator, **FR** = gear play (in RA), **FD** = mirror flop (in Dec.), **IH** = Hour Angle index error, **ID** = declination index error, and **CF** = counterweight flexure. All values are given in minutes of arc. These values give you valuable information about your alignment, your mount and your telescope.

4 Considerations for Imaging

The Gemini system has many features that make it especially suitable as an imaging platform. These include polar alignment tools, multiple tracking rates, guiding modes, an autoguider input, and a very sophisticated set of Periodic Error Control (PEC) functions. This chapter describes how to take full advantage of your Gemini when imaging.

4.1 Accuracy of Polar Alignment

As mentioned previously, accurate polar alignment is extremely important when imaging. Even though Gemini's pointing model and closed loop tracking can compensate for inaccurate polar alignment, photographs and CCD images can be ruined by field rotation. Gemini's Polar Axis Correction function helps you achieve sufficiently accurate polar alignment quickly for all but the longest wide field images, for which only the technique of drift alignment is likely to suffice.

4.2 Guiding

Theoretically, good polar alignment and the appropriate tracking rate (such as the adaptive King rate) should be enough to keep the telescope pointing at an object throughout a long exposure. In reality, however, mechanical imperfections, alignment errors and other factors will cause the telescope to stray slightly from perfect tracking. This can result in stars being trailed or bloated, or otherwise distorted in an image. To overcome this, most astrophotographers guide their mounts for exposures over a minute or two. This involves making occasional slight adjustments to the RA and Dec. so that a star (or the object being photographed) stays in exactly the same spot in the telescope's field of view throughout the exposure. Guiding corrections can be made manually using buttons on a Hand Controller, automatically using a CCD autoguider or by sending guiding commands over the serial ports. In all cases, these corrections are fed into the Gemini system, which actually moves the mount.

You can set the speed at which guiding corrections are made using the "Setup→Mount Parameters→Moving Speeds→Guiding" menu item. You can select a guiding rate between 0.2x sidereal and 0.8x sidereal. While the guiding occurs at a constant speed north or south in Dec., it is added to or subtracted from the tracking speed (1x sidereal) in RA. The RA drive always tracks the telescope to the west; it just speeds up or slows down when it receives a guiding correction. The standard Guiding Speed is 0.5x, giving 0.5x and 1.5x sidereal speed in RA. The highest guiding speed is 0.8x, giving approximately 0.8x tracking speed in Dec., and 0.2x and 1.8x in RA.

4.2.1 The Autoguider Port

IMPORTANT: There are two different versions of the Gemini Autoguider port hardware. The versions can be distinguished by the type of connectors used for the motor cables. The older Gemini version uses RJ-45 modular connectors, and the newer version uses 6-pin DIN connectors. The primary difference between the versions is that the older

version does not directly support autoguider with TTL output, but the newer version does.

Gemini contains a separate Autoguider port – a 6-pin modular RJ-11 socket located below the 15-pin connector to the left. It contains a common pin, four directional pins and one pin that is controlled by the alarm signal that can be used for shutter control. The common pin of the RJ-11 modular connector is connected to +5V on the older version of Gemini, and GND on the newer version. The 4 directional inputs must be connected to the common pin to be active (they are active at High potentials on the older version of Gemini, and at Low potentials on the newer version). Simultaneously activating opposing directional signals (DEC+ and DEC- or RA+ and RA-) will be ignored and displayed as “Autoguider Error.”

Note: The autoguider port is only active in the Photographic Mode and All-Speeds Mode of the Gemini system. Selecting the Visual Mode disables Guiding and therefore the Autoguider Port.

4.2.2 Manual Guiding

Manual guiding is usually done using an eyepiece with an illuminated reticle attached to an off-axis guider or separate guidescope. You center a star (or the object being photographed) in the reticle and use the buttons on the Deluxe Hand Controller to apply guiding corrections to keep the star on the reticle throughout the duration of the exposure.

Rather than using the Deluxe Hand Controller, you can instead guide with a Losmandy Standard Hand Controller plugged into the autoguider port. The LED of the Standard Hand Controller will not normally be lit, but will light up anytime the alarm sounds. Using a Standard Hand Controller in the autoguider port has a big advantage for manual guiding, in that accidentally pressing opposite directional buttons simultaneously will *not* result in movement at centering speed, as happens with the Hand Controller in its normal socket, or when using the Deluxe Hand Controller. This reduces the risk of spoiling a long exposure photograph due to an accidental key press.

In either case, you will need to make sure that the Hand Controller is set to either the Photographic or All-Speeds Mode.

4.2.3 Connecting an Autoguider to an Older Gemini

4.2.3.1 Connecting an Autoguider with Relay Output

Autoguiders with relay outputs (such as the SBIG ST-4) can be connected to the Gemini system directly. Simply connect one side of each of the four relay contacts to the Autoguider input common pin, and connect the other side of each relay to the appropriate direction input pins of the autoguider port. Cables are available for most compatible autoguiders to plug directly between the autoguider and Gemini.

4.2.3.2 Connecting an Autoguider with TTL Output

The typical "open collector" output stage (e.g. the ST-7/8/9/10, user-modified ST-4) has high impedance while inactive and pulls down the direction signals to a common ground when active. This is exactly the opposite of the way the Hand Controller and autoguider ports of the older version Gemini system work.

A relay (or optocoupler) decouples the switching device (the Autoguider) from the controlled device (the Gemini), thereby avoiding a direct connection between the two systems and protecting both systems against high currents that could cause damage.

IMPORTANT NOTICE:

(1) Never connect TTL output stages directly to the Hand Controller or autoguider ports of an older version Gemini! Severe damage may occur to the connected devices. Use a Relay Box (as provided by SBIG) or the optional Losmandy Optocoupler unit instead. By so doing, you get the additional advantage of providing electrical protection to these sensitive units.

(2) The use of two separate power supplies without a coupler unit is strongly discouraged. To do so would connect the ground of one system to the supply voltage of the other system, causing the two grounds to be at different potentials. If the grounds of the two systems are then connected, severe damage is likely to occur.

Detailed instructions for connecting an SBIG camera with TTL outputs to the older version of Gemini can be found in Appendix 8.6 (Autoguider Port).

4.2.4 Connecting an Autoguider to a Newer Gemini

The Autoguider port on the newer versions of Gemini is plug compatible with a large variety of autoguiders. You can use an autoguider with relay outputs such as the SBIG ST-4 and STV or an autoguider with TTL outputs such as the SBIG ST-7/8/9/10 directly using the appropriate cable. Use SBIG's "TIC" cable for the ST-4 and STV, and SBIG's "TIC-78" cable for cameras with TTL output.

The SBIG relay box can be used, but is not necessary. The Losmandy Optocoupler is not compatible with the newer Gemini.

4.2.5 Software Guiding

An alternative to using the autoguider port is to write your own software to send guiding commands over the serial connection using the LX200 protocol. There are commands to start and stop guiding movements, the serial transmission may cause a small delay and jitter that nevertheless should be adequate for most purposes. There are also Precision Guiding commands available allowing you to move the mount exactly for a precalculated amount of steps, time or arc seconds.

4.3 Periodic Error Control (PEC)

4.3.1 What is Periodic Error?

The Gemini servomotor on the RA axis turns a worm that meshes with a worm gear that moves the telescope. Ideally, the interaction between the worm and worm gear is such that for a constant speed of the worm, the worm gear also turns at a constant speed. However, in the real world, this is not the case. Slight imperfections in the shape of the worm, manufacturing tolerances in the gears and bearings, dirt, and misalignment can all cause slight variations in the speed of the worm gear while tracking. These variations generally occur in a pattern that repeats itself every time the worm makes a complete revolution, hence the term “periodic error.”

Periodic Error Control (or PEC) is meant to handle these imperfections of the worm and worm gear combination of your mount. This involves “training” the PEC by making appropriate corrections to keep a star centered during one or more revolutions of the worm. The Gemini software records these corrections, and then automatically plays back the corrections, offsetting the periodic error. When PEC is enabled, the LED on the hand controller will briefly turn off whenever a correction is applied. Gemini also provides sophisticated algorithms for manipulating this correction data to cancel the periodic error more effectively than would just a simple record/playback.

Alternatively, it is possible to record the periodic error using a CCD camera and PC software (e.g. PEMPro). It is then possible to analyze and manipulate the data and download them into Gemini.

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. However, it is possible that these two independent control systems can work against each other. You will want to experiment with some of the PEC options described below to find the best settings for using PEC and an autoguider together.

All PEC data is stored permanently in the Gemini SRAM memory. Gemini also stores the position of the worm whenever it is powered down, and as long as the motor is not loosened or disconnected from the worm, all acquired and stored PEC data will remain available and valid.

For users who are satisfied with the existing periodic error of their mount, Gemini's PEC function need not be used. PEC is needed when the mount's periodic error causes unacceptable tracking errors, especially noticeable when imaging. Users wanting to take unguided CCD frames and stack them into the final image may find PEC very useful to reduce tracking errors to an extent that allows several minutes of unguided exposures.

4.3.2 The PEC Submenu

The PEC submenu (“Setup → Mount Parameters → PEC”) has these options:

- Train PEC
- Clear Data
- Turn PEC On/Off
- Delay Correction
- Drift Correction
- Smooth Data
- Average Data
- Restore Data
- Maximum Pulses

The Gemini PEC can store 2 separate sets of correction data. One set, called the “current data set” is used to actually correct for periodic error. It is initially stored when the first PEC training is completed. The other set, called the “backup data set” is used for backing up and combining PEC data. These data sets will be described in more detail in the following sections.

4.3.2.1 Train PEC

Until an initial (current) data set has been recorded, no PEC data is available to the Gemini software. Also, a CMOS reset or the execution of “Restore Defaults” or “Clear Data” clears all PEC data and, in all these cases, only two PEC menu items, “Train PEC” and “Maximum Pulses” are visible and available for use.

Once you select “Train PEC,” you start a training session, where your task is to keep an object (preferably a star near the meridian) centered in the crosshair of an eyepiece or at a given CCD pixel location. You have about 10 seconds to center the object used for the first training, while a countdown (“Training PEC –xx”) is displayed. A short beep marks the start of a training session, and another beep marks the end of training after one period. The length of a training session will vary according to the period, normally one worm rotation on your mount. This is about 4 minutes on a G-11, HGM-200 and MI-250, 5.33 minutes on an HGM Titan, and 8 minutes on a GM-8 and CI-700. You can interrupt the training session by depressing the MENU button on the Hand Controller.

The countdown time for subsequent training runs will vary, since training is always started at the same point on the worm. Thus, you may need to wait up to 8 minutes (on a GM-8 or CI-700 mount) to do additional training runs. You may do as many training runs as you desire.

After each training run, the PEC data just entered is stored in the current data set, and is immediately available for use. Any previous data is moved into the backup data set where it can be manipulated by several of the other PEC commands.

4.3.2.2 Clear Data

Selecting this menu item clears both PEC data sets and disables PEC correction. This is useful if the PEC data becomes invalid because you have removed the RA servomotor. This command also reduces the PEC menu to just “Train PEC” and “Maximum Pulses.”

4.3.2.3 Turn PEC On/Off

Selecting this menu item toggles the PEC function on and off. If PEC is currently off, this menu item will turn it on (changing the menu item to “Turn PEC Off”), and vice versa. Gemini’s PEC can be switched on or off without affecting any of the stored data. PEC is turned off when the Gemini is first powered up, so you need to select this menu item each time you start the Gemini if you want PEC to be active.

4.3.2.4 Delay Correction

One of the problems with PEC is that during playback, the corrections are applied a certain amount of time after the error has occurred. This is caused either by the reaction time of the human as he or she guides manually, or by the integration time of an autoguider during the training run. In other words, during a training run, the correction doesn’t get recorded until after the error has occurred and is noticed by either the person guiding or the autoguider. Not only is the correction applied after the error occurs, but with autoguiding CCD cameras, a problem might arise during playback as a result of two control circuits working against each other because of the described time difference. The autoguider would see the error and attempt to correct it at the same time that the PEC is also attempting to correct it, resulting in over-correction.

To overcome this problem, Gemini allows advancing the replay of the corrections a certain amount of time. This allows the PEC to anticipate the error rather than react to it. The amount of shift needed to remove the time delay depends upon the setup used during the training run. Manual guiding reaction delays depend on the telescope’s magnification and partially on the seeing, while autoguiding delays depend on the integration time used.

The amount of shift specified in this command is the number of correction steps. Gemini systems other than those on the Titan 50 are geared for 6400 steps per revolution of the worm. So, the 3.99 minute worm period on a G-11, HGM-200 and MI-250 gives 0.5625 arcsec/step, the 5.32 minute worm on the HGM Titan gives 0.75 arcsec/step, and the 7.98 minute worm on the GM-8 and CI-700 gives 1.13 arcsec/step. The Titan 50 mount is geared for 12800 steps per revolution, so its 5.32 minute worm period gives 0.375 arcsec/step. You can specify between 0 and 255 steps to shift the PEC playback. Setting the shift to 0 disables the function. As an example, on a G-11 with a 239.34 second worm period, there are about $6400/239.34 = 26.74$ steps/second for sidereal tracking. This means that shifting the PEC playback by 27 steps advances the corrections by about one second.

The following table lists the number of steps per second (sidereal tracking) for several mounts:

Worm Period	Steps per second
239.344658 sec. (G-11, HGM-200, MI-250)	26.73967759
319.1262611 sec. (HGM Titan)	20.05475819
478.68939 sec. (GM-8, CI-700)	13.3698388
319.1262611 sec. (Titan 50)	40.10951639

4.3.2.5 Drift Correction

When you train the PEC, it is assumed that the only error being corrected is the periodic error in the worm. Because of the periodic nature of this error, the star will appear to drift back and forth in RA during the period of the worm's rotation, but will always end up in the same spot at the end of every rotation. Theoretically then, at the end of a training run, the total amount of correction to the west should exactly equal the total amount of correction to the east. If, however, there was systematic drift of the object caused by something other than periodic error (i.e. misalignment of the mount, differential refraction, etc.), then the corrections made during the training run would reflect this error also.

This is not a problem if (1) the object being imaged is the same as (or very near) the object used to train the PEC and (2) the mount has not been moved since the training. In that case, the same systematic errors that were present during the training run will also be present during playback, and both the periodic and systematic errors will have been corrected. However, in many cases, you will want to use the same PEC data for widely scattered objects over several observing sessions when the telescope has likely been moved between the sessions. In this case, the amount of systematic error will likely be different than during the training run, so just playing back the corrections made during training will actually introduce errors.

Drift Correction solves this problem by effectively removing the systematic drift component from the recorded PEC data. If everything were perfect and there were no systematic drift, corrections in both directions would cancel each other out, and this feature would not be needed. If, however, they do not cancel out after a worm period, the existence of systematic drift is assumed.

Selecting this menu item removes this non-periodic component. Gemini sums up the corrections (negative and positive) made in both directions, and spreads them evenly throughout the worm period. It does not, however, change the tracking rate itself, because to do so would lead to imprecise tracking in other regions of the sky.

Because you may choose to train the PEC on the same object as the one that is to be imaged, Drift Correction of the PEC data is not done automatically after each training run; this helps minimize the guiding corrections necessary. You should only select the

“Drift Correction” function if you want to use the PEC in a region of the sky other than the one where you trained it, or if you plan to use the PEC data across multiple sessions where the mount will be moved between sessions. After you have selected this function, the drift correction will remain active until a new training session overwrites the data. Using this function multiple times is not necessary, but also is not harmful. The amount of drift compensation is displayed, and should become zero after subsequent calls.

If you measure a constant drift component over several areas of the sky you can train and use PEC together with Gemini's Comet Tracking feature. Comet Tracking allows you to use calculated or trained tracking rates to eliminate any drift.

Note: Drift Correction applies only to the current data set. It does not alter data in the backup data set.

4.3.2.6 Smooth Data

In addition to periodic error and systematic drift, the corrections recorded during PEC training runs can also contain random errors caused by scintillations (“seeing”) and over-corrections. The Smooth Data function helps eliminate these random influences by removing pairs of alternating corrections within an interval defined by the user. The interval can be selected between 2 and 255 steps, the same units described for shifting the PEC playback. (On a G-11, this corresponds to about 9.6 seconds maximum.) Any alternating corrections made within this interval will be removed from the data. This function can be used multiple times, with a smaller interval at the beginning and larger intervals if needed.

Note: Smooth Data applies only to the current data set. It does not alter data in the backup data set.

4.3.2.7 Average Data

Because of random fluctuations in the periodic error and random guiding errors during the training run, you can often get more accurate PEC data by averaging the corrections from more than one training session. After the second training run, two independent sets of data are available. The latest data trained or calculated is stored in the current data set that is used for guiding. Any data that was previously in the current data set is moved into the backup set when you perform another training session. When you select “Average Data,” the arithmetic means of the tracking runs is calculated and stored in the current data set. The previously used data (the second training run) is saved into the backup set.

The “Average Data” function is not limited to two runs. During the third training run, with the average function used on the previous two, the current data is backed up and averaged with the new data. Once more, the newly averaged data is stored in the current data set. The algorithm that is used to average the data correctly weights the previous average so that all individual training runs are equally weighted. This process can be repeated to average up to 255 training runs.

If the averaging function is not used, newly trained data simply replaces the previous training run in the current data set. The previously averaged data remains available in the backup data set, allowing you to ignore bad training runs (those with lower quality guiding).

4.3.2.8 Restore Data

This function simply copies the data from the backup data set to the current data set. You can use this to overwrite a flawed training run with the previous trained or calculated data.

4.3.2.9 Maximum Pulses

Gemini divides the worm revolution into 6400 intervals, and periodic error corrections are made by applying the guiding rate on top of normal sidereal motion. If guiding rate is 0.5x sidereal then during any of the 6400 worm intervals the rotational speed could be 1.5x sidereal (moving faster), 1.0x sidereal (no correction needed), or 0.5x sidereal (moving slower).

Correction can be applied for more than one interval consecutively when larger corrections are required. So, for example, on a mount with a 240 second worm period, each worm interval will be $240 / 6400 = 37.5\text{ms}$. If you press the hand controller RA key for 1 second, this will apply guiding rate correction for 26.67 worm intervals.

The Maximum Pulses setting establishes a limit on the number of consecutive worm intervals to which Gemini will apply correction in response to a correction command from the hand controller, auto-guider, or control software. Thus, in the example above, if Maximum Pulses had been set to 5, the guiding rate would have been applied for just 5 intervals instead of 26.7, even though the RA key was pressed for 1 second.

This feature allows very small time intervals to be generated reliably even when the method used to train the periodic error correction is not capable of so doing. This might be the case, for example, if the required corrections are small, but a slow PC is being used or human reaction time is slow to release the guider button.

Set Maximum Pulses to zero (the default) if you don't want to set a limit, and always want to apply the full correction that is requested.

4.4 Other Functions

There are two other functions that are especially useful when imaging. They are:

- **TVC** – Helps compensate for the response delay when changing direction in Dec. caused by gear backlash.
- **Alarm Timer** – Allows you to set alarms to alert you to the end of an exposure time.

Refer to chapter 5 for a complete description of these functions.

5 Gemini Command Menu Reference

The Gemini Menu system consists of a tree of menus and submenus displayed on the Hand Controller's 16-character LED display. There is a Main Menu (the first hierarchical level) and several levels of submenus. As previously described, you can scroll through menu choices using the up (DEC+) and down (DEC-) directional buttons on the Hand Controller, and move from higher menu levels to submenus by pressing the right (RA+) directional button (unless the RA REV button on the Hand Controller has been pressed).

Generally, pressing the RA+ button while at the lowest level of the menu tree causes Gemini to select or execute the command or menu choice that is visible on the display. When this occurs, the display either acknowledges the choice (e.g. "FINISHED"), returns to a higher menu item (e.g. "Object Database"), or merely goes blank, requiring that the MENU button be pressed again to return to the menu system. An exception is where the menu item calls for multi-digit numeric input; in that case, pressing the RA+ button moves the input cursor 1 digit to the right. Finally, pressing RA+ when the cursor is at the digit on the far right enters the input data.

5.1 Startup Mode Menu

In addition to the menu system that is available during normal usage, there is a separate menu that is displayed each time Gemini is powered on. This menu allows you to select the startup mode of the system for that particular observing session. The choices are:

- **Cold Start**
- **Warm Start**
- **Warm Restart**

5.1.1 Cold Start

When Gemini is powered on for the first time or after a CMOS reset, a "Cold Start" is the only startup option available. Once Gemini has been cold started, "Cold Start," "Warm Start," and "Warm Restart" are displayed as menu items the next time Gemini is powered on. "Cold Start" is the "start-from-scratch" choice because it deletes all previously established star alignments, as well as the current pointing model derived from previous alignments. It is the startup mode that must be used after the mount has been moved from its previous polar-aligned position.

You can change the UTC Date/Time, Mount Type, Longitude and Latitude immediately after a Cold Start. Refer to section 2.4.2.1 Cold Start Setup Options for an explanation of how this is done.

Assuming Gemini was polar aligned (sections 2.4.1.1 and 3.4) and powered on with the telescope in Startup Position (section 2.4.1.2), you can easily GoTo a first alignment star from the "GoTo Bright Star" menu item, or select a star from the "Bright Stars" catalog and perform a GoTo operation. Using either method, the star to be used for alignment is

then centered in the telescope's field of view and "Synchronize" is executed. This constitutes the initial star alignment, and is the first step in the process of building a pointing model for improved GoTo accuracy. Subsequent star alignments can then be performed one at a time by commanding Gemini to GoTo other Bright Stars, centering them in the field of view, and executing "Additional Align." The Gemini may be powered off at any time without losing its pointing model.

5.1.2 Warm Start & Warm Restart

If the Gemini is subsequently powered on without the telescope having been moved in any way, "Warm Restart" is the startup mode of choice and the telescope is immediately ready for use. If the clutches were loosened, you should select "Warm Start." This mode preserves the current pointing model but assumes that the telescope is in the Startup Position. In this case, the telescope must first be centered and Synchronized on a known star before it is used (as with a Cold Start).

5.2 The Main Menu

Because the Hand Controller has only a single display line, it is easy to lose track of the menu level at which one is looking. For this reason, it is recommended that you memorize the ten items of the Full Main (highest level) Menu, and become thoroughly familiar with those submenus that you regularly use.

5.2.1 Full Main Menu

The Full Main Menu consists of the following:

- **Align Telescope**
- **Object Database**
- **Show Information**
- **{GoTo <object>}**
- **{Guide → <object>}**
- **Coordinates**
- **Identify**
- **Object Search**
- **Show Date/Time**
- **Setup**

5.2.2 Reduced Main Menu

Using the QuickMenu (see section 5.4), Gemini's Full Main Menu can be truncated into a Reduced Main Menu that consists of the following:

- **Align Telescope** (only displayed while scrolling upwards using the DEC+ button)
- **Object Database**
- **Show Information**

- {GoTo <object>}
- Coordinates
- Identify

The Reduced Main Menu is restored to the Full Main Menu using the QuickMenu in like manner. In all the menus in this chapter, curly brackets {...} surrounding a menu item indicates that the item is not always available. For example, the Main Menu items "GoTo <object>" and "Guide → <object>" are only visible after you have selected or downloaded a database object.

This chapter of the Gemini Manual lists and describes the function of each menu command. For further information about the Hand Controller and menu structure, see "Getting Started," section 2.3. In addition, for your convenience, a chart of the entire menu system appears in section 8.1 of the Appendix.

5.3 Subordinate Menu System

This section presents an item-by-item list of the menus subordinate to the Main Menu, along with a brief description of what each submenu item does and how to use it. While some of the menu items can stand alone (such as "Dim Display"), others (such as "Additional Align") require a broader understanding of certain concepts. See Chapters 2 through 4 of this manual for further clarification.

5.3.1 Align Telescope

- **GoTo Bright Star**
- {Reset Alignment}
- {Additional Align}
- Synchronize
- {Polar Al. Assist}
- {Polar Axis Corr.}

Although "Align Telescope" is the first menu item encountered after a "Cold Start," it is not necessarily the first that should be used. If Gemini has been powered on for the very first time, has had its CMOS parameters reset, has been moved to a new geographic location, "Setup" is the menu item that should be used first, and all needed parameters should be entered therein. Of course this can also be done during the cold start phase without the need to go into "Setup."

After a "Cold Start," pressing the MENU button displays "Align Telescope" with a limited submenu containing only "GoTo Bright Star" and "Synchronize." The remaining items of the submenu become visible after one or more star alignments.

5.3.1.1 GoTo Bright Star

"GoTo Bright Star" is a convenient way to slew to a bright star for the purpose of doing an alignment. It is essentially equivalent to selecting a bright star from the Object Database and executing a GoTo command.

Select "Align Telescope→GoTo Bright Star" to display a list of bright stars currently above the horizon. Scroll through the list until a suitable alignment star is found. Then press the RA+ button on the Hand Controller to select the star and cause the telescope to slew toward it. When it arrives at the star, the LED displays "FINISHED" and goes blank.

If Gemini was powered on with the telescope polar aligned and in the Startup Position, the targeted star will either be in the telescope's field of view or close to it. Center the star in the field of view using the Hand Controller. Next, press the MENU button and select "Align Telescope→Synchronize." When the selected star is confirmed on the display, press the RA+ button again, and "Aligned!" appears, indicating that this first star alignment was successful. This defines a reference point and is the first in a series of alignments required to build a pointing model for GoTo accuracy. This is the same procedure that you would use after a "Warm Start" or "Warm Restart," but rather than starting a pointing model, it synchronizes the existing pointing model with the actual sky.

You can also use "GoTo Bright Star" to slew to stars for subsequent alignments after the procedure described above. In this case, after executing the "GoTo Bright Star" command and centering the object, you should next select "Align Telescope→Additional Align."

5.3.1.2 {Reset Alignment}

Occasionally, the observer wants to clear Gemini's current pointing model, and build the model again. To clear Gemini's pointing model while retaining an original first (one) star alignment, GoTo a star (using either "Align Telescope→GoTo Bright Star" or using "GoTo <object>"), center it in the telescope's field of view, and then execute "Align Telescope→Reset Alignment."

There is no displayed confirmation that the model has been reset. Instead, Gemini presents you with the last selected object for alignment. For this reason, before doing a "Reset Alignment," it is best to slew to the star that you want to be the first in your new model. If you select "Reset Alignment" but do not want to reset the pointing model at this time, escape from the Menu Mode by pressing the MENU button.

5.3.1.3 {Additional Align}

Use this function to add other alignment objects to Gemini's pointing model.

IMPORTANT: You must already be pointing at the object on which you wish to align before using this command. You should use either the "Align Telescope→GoTo Bright Star" command or the "GoTo <object>" command to point the telescope to a known object, center it, and then execute "Additional Align." After selecting "Additional Align," Gemini responds by verifying the object by name. Now press the RA+ button, and Gemini displays the mount's offset from the pole in both elevation (E) and azimuth (A), which were calculated as a result of the alignment object.

The difference between the position Gemini pointed to when you did the "GoTo" operation and the one you moved to when you centered the object, gives Gemini the required data for refining the pointing model. Careful centering (for example, by using a reticle eyepiece) will improve the accuracy of the calculated model parameters. The number of these parameters increases with the number of alignments, and they can be looked at in the Information Buffer by executing the "Show Information" menu item after performing the additional align.

5.3.1.4 Synchronize

After any type of startup (Cold Start, Warm Start, Warm Restart), or in the course of an observation, Gemini may be slightly off in its pointing orientation while retaining its pointing model. In other words, Gemini's concept of where it is pointing in RA and Dec. may be slightly off from the actual sky by a constant amount. This can occur anytime the telescope's clutches are loosened or certain components of the optical path are moved or replaced (e.g. the star diagonal is rotated). It can also occur as a result of imprecise polar alignment or non-orthogonality of the optical tube assembly (OTA). The phenomenon may be noticed when, after performing several accurate GoTo operations, subsequent GoTo slews leave the target object unexplainably uncentered in the field of view.

To correct this, center any known star (or other object) using the Hand Controller, and execute "Align Telescope→Synchronize." Gemini responds by verifying the object by name. Now press the RA+ button, and Gemini responds by displaying "Synchronized!" The "Synchronize" function does not alter the modeling data, so it can be safely used anytime during an observing session.

The "Synchronize" function is especially important after a "Warm Restart," because it must be executed in order to enable the other submenus of "Align Telescope." It is also very useful if you need to loosen the clutches to rebalance the telescope after changing equipment. After you are done rebalancing, simply return the telescope to approximately the same position it was in when you loosened the clutches. Re-tighten the clutches, GoTo a bright star, center it with the hand controller and use the "Synchronize" function.

Note: In the above scenario, make sure that you carefully re-center the object in RA before tightening the clutches. This ensures that Gemini will correctly enforce the safety limits.

5.3.1.5 {Polar Al. Assist}

The "Polar Al. Assist" menu item does not appear after a "Cold Start" until you have executed "Synchronize." It is used to roughly polar align your mount by slewing back and forth between 2 stars and adjusting the mount's elevation and azimuth at each star. A complete description of how to use this function can be found in Chapter 3, section 3.4.2.3 of this manual.

5.3.1.6 {Polar Axis Corr.}

Similarly, the "Polar Axis Corr." menu item does not appear until a pointing model is established by performing at least one "Additional Align." This function (polar axis

correction) allows you to polar align your mount with fairly high accuracy by taking advantage of the pointing model that Gemini is building. A detailed description of how to use this function can be found in Chapter 3, section 3.4.2.3 of this manual.

5.3.2 Object Database

- **Messier M**
- **NGC**
- **IC**
- **Sh2-**
- **Solar System**
- **Bright Stars**
- **SAO**
- **WDS**
- **GPN**
- **LDN**
- **LBN**
- **{User Defined}**

5.3.2.1 Database Use

Gemini's "Object Database" contains 11 predefined catalogs and 1 user defined catalog. Objects from these catalogs are accessed by executing "Object Database→<catalog>" and then either scrolling to the desired object from the selected catalog, or "typing in" (scrolling each digit to) the object's catalog number. When the object is then selected by pressing the RA+ button, Gemini confirms the object's identifier (name) or catalog designation, and displays the hour angle of the object in minutes, and its elevation in degrees.

There is an important difference between the catalogs that enumerate their objects using a catalog number (such as Messier or NGC) and those that identify their objects by coordinates (such as GPN and WDS). In the case of the former, simply entering the catalog number will select the object. In the latter case, after you enter a number of digits and press the RA+ key to make your selection, Gemini displays the full designation of the object in the catalog that is the closest match to the digits you entered. For example, in the WDS catalog, if you entered the digits "00040" and pressed the RA+ button, Gemini would display the catalog item closest to your entry: "WDS 00042+6217." You can then scroll through the catalog with the DEC buttons and must press the RA+ button a second time to select the object and display the hour angle and elevation. This same selection method is used for the SAO catalog, which is only a subset of the full SAO catalog (i.e. some entry numbers are missing).

For convenience, pressing the RA+ button again causes Gemini to jump to the "GoTo <object>" menu, so if you do not want to slew to the object at this time, press the DEC+ or DEC- buttons to scroll to other menu items, or press the MENU button to escape the Menu Mode.

Once the position of the selected object is calculated, additional data related to the object can be displayed using the "Show Information" menu item. The information shown there depends upon the catalog and object type selected. Mutual cross references, constellation, common name, type, magnitude and size are shown for the Messier, NGC and IC catalogs. Type and size are provided for the Sharpless 2 catalog, and constellation, sometimes Greek letter designation, type, magnitude and spectral class are provided for the Bright Stars. Only magnitude information is stored for SAO stars, and double stars are marked with a "D."

5.3.2.2 Accuracy and Epochs

With the exception of the Solar System objects and the Alignment Bright Star list, all coordinates are stored rounded to 20 arcsec, giving 10 arcsec accuracy for the standard epoch J2000.0. The coordinates are precessed to the equinox of the date when the object is selected; nutation is neglected. The apparent position of objects is calculated (for standard air pressure and temperature), taking refraction into account. For the Moon, topocentric coordinates are calculated.

By default, Gemini assumes that any input coordinates are for the epoch of the current date. This default can be changed to Epoch J2000.0 by executing "Setup→Communication→Coordinate Epoch→Epoch J2000.0." If this change is made and Epoch J2000.0 coordinates are entered, Gemini will precess the entered coordinates to the epoch of the date so that GoTo slews will be accurate. The coordinates of the resident catalogs will not, however, be affected regardless of which epoch is selected.

5.3.2.3 Credits

In general, the whole astronomical community has to be credited with contributing to Gemini's databases by their collecting, checking, sorting, and providing this great amount of data. Special credits are due to Wolfgang Steinicke for long years of work checking the NGC and IC catalogs, and correcting many bugs and errors. If there are errors in converting his data into the internal Gemini databases, they are caused by the system's developer.

5.3.2.4 Messier M (Messier Objects Catalog)

There are 110 Messier objects stored in this catalog, among which are nebulae, galaxies and clusters. To select one of them, type in its Messier number from M001 to M110 and then press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.5 NGC (New General Catalog)

There are 8290 objects stored in this catalog, among which are nebulae, galaxies and clusters. To select one of them, type in its catalog number and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.6 IC (Index Catalog)

There are 5437 objects stored in this catalog, among which are nebulae, galaxies and clusters. To select one of them, type in its catalog number and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

Note: Both NGC and IC catalogs include some objects identified by an extension letter after the numeric identification. For example, NGC 6246 and 6246A are both in the NGC catalog. To select such objects, use the keypad keys to enter the numeric designation as with any other NGC or IC object. However, when you press the RA+ button after the numeric designation, you will see a “→” symbol after the number. This symbol indicates that you can either press the RA+ button again to select the object without an extension letter, or you can press DEC+ or DEC- to scroll through the extension letters for that object. For example, if you enter “NGC 6246” and press RA+, you will see “NCG 6246→” in the display. Pressing the RA+ key again selects NGC 6246. However, if instead, you press the DEC+ or DEC- key, the “→” changes to “A” and the display reads “NGC 6246A.” Press the RA+ key to select NGC 6246A.

5.3.2.7 Sh2- (Sharpless 2 Catalog)

There are 313 HII objects of the Sharpless 2 catalog stored in Gemini. To select one of them, type in its catalog number and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.8 Solar System (Solar System Catalog)

There are 10 objects (8 planets, the Sun and the Moon) stored in this catalog. To select one of them, scroll through the list until you see the one desired, and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

WARNING: Never point the telescope at the Sun without proper filtration! Doing so can cause severe damage to your eyes and your equipment.

5.3.2.9 Bright Stars (Bright Star Catalog)

There are 169 Bright Stars with their common names stored in this catalog and arranged alphabetically. To select one of them, scroll through the alphabet until you see the first letter of the star's common name. Press RA+ to display the list of all stars that begin with that letter. Scroll through the list until you see the star desired, and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.10 SAO (Smithsonian Astrophysical Observatory Catalog)

This is a subset of the Hubble Guide Star Catalog (GSC) containing 17636 stars down to the 7th magnitude. To select one of them, type in its catalog number and press the RA+ button. Gemini responds by confirming the object's catalog number and also its magnitude (e.g. "6m4" means magnitude 6.4). If the desired object is not in Gemini's

catalog subset, the next available object with higher designation is displayed. You can scroll through all of the available objects using the DEC buttons. Pressing the RA+ button again confirms the object's designation, and displays its hour angle and elevation, indicating that it has been selected.

5.3.2.11 WDS (Washington Double Star Catalog)

This is an abridged catalog containing 3989 double stars selected from the full WDS, with the primary star being brighter than 7m2, the secondary brighter than 14m5 and a separation not below 0.4 arcsec. To select one of them, type in its catalog number and press the RA+ button. If the selected double star is not in the database, the next available object is displayed. You can scroll through all of the available objects using the DEC buttons. After pressing RA+ again, the object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.12 GPN (Galactic and Planetary Nebulae Catalog)

This catalog contains 1143 planetary nebulae of the Strasbourg/ESO Galactic and Planetary Objects Catalog (includes most objects of the Perek, Kohoutek Catalog). To select one of them, type in its catalog number and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.13 LDN (Lynd's Dark Nebulae Catalog)

This catalog contains the 1802 dark nebulae of Lynd's Dark Nebulae Catalog. To select one of them, type in its catalog number and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.14 LBN (Lynd's Bright Nebulae Catalog)

This catalog contains the 1125 bright nebulae of Lynd's Bright Nebula Catalog. To select one of them, type in its catalog number and press the RA+ button. The object's designation, hour angle and elevation will be displayed, indicating that it has been selected.

5.3.2.15 {User Defined} (User Defined Catalog)

This catalog can be built to order by downloading (and uploading) via Gemini's serial interface, the coordinates of the more than 4000 objects stored in Gemini's resident catalogs, as well as others that may be stored on your computer. This can best be accomplished using the Gemini Control Center program designed by Daniel Görlich; it can be downloaded from the Gemini website at <http://www.docgoerlich.de/>.

Creating a User Defined Catalog can be very useful because it allows you to compile a catalog of objects not resident in Gemini's databases, or to limit a catalog to only those objects needed for a particular night's observation. For your convenience, the objects stored in Gemini's permanent databases are available as ".guc" (Gemini User Catalog") files on the above-mentioned web site. These files can be used to build your own catalogs for planned observing sessions.

5.3.3 Show Information

This menu item allows you to scroll through Gemini's information buffer. Pressing the RA+ button speeds up the scrolling, and pressing RA- sets it back to the beginning if pressed alone. Pressing first RA+, then RA- stops the scrolling and freezes the information buffer display. If either of the DEC buttons is pressed, all scrolling stops and Gemini proceeds to the adjacent menu item. Emulated hand controllers can display all of the information at once without the need for scrolling.

Upon powering up, Gemini's hand controller display scrolls a welcome message. The information buffer also contains this startup message, and later on contains additional status information. It will contain object data after you select an item from the database, mount modeling parameters after you do an "Additional Align" or "Synchronize," and debug information if Gemini is in Debug Mode (powered on while pressing a direction button on the Hand Controller). In Debug Mode, the commands received from a connected PC (without numeric parameters) are stored in the buffer.

5.3.4 {GoTo <object>}

This menu item only appears if you previously selected a "Database Object," entered RA and Dec. coordinates or a Bookmark using the Hand Controller or a PC, or an object was selected using the "Identify" function. This menu item remembers the last selected object, coordinates, or Bookmark, and allows you to GoTo that object. Consequently, if you want to GoTo a different object, the new object must first be selected from the "Object Database" (or one of the other methods mentioned above). Slews to objects below the horizon will be rejected. Pressing any Hand Controller button during the slew will interrupt the GoTo function.

5.3.5 {Guide → <object>}

This menu item only appears if you have selected a "Database Object," entered RA and Dec. coordinates or a Bookmark using the Hand Controller or a PC, or an object was selected using the "Identify" function. This menu item shows the difference between the actual telescope position and the unmodeled location of the selected object, coordinate pair or Bookmark. You can move the telescope manually (if you have encoders) and/or using the Hand Controller until the display shows all zeros. Selecting this menu item switches you back to Telescope Control Mode. The display saver is off so the display will not go blank while you are using this feature. "Guide → <object>" shows the distance to the un-modeled position of an object, informing you of what deviations were calculated by the model after a GoTo. It can be used to offset the polar axis when using the King method for photography. Refer to chapter 4 for more details.

5.3.6 Coordinates

- **RA/DEC Display**
- **Enter RA/DEC**
- **Az/El Display**
- **Enter Az/El**
- **Set Bookmark**

- {GoTo Bookmark #n}

5.3.6.1 RA/DEC Display

Upon selecting "RA/DEC Display," Gemini switches to the Telescope Control Mode and displays the telescope's current RA and Dec. coordinates (hms +/-dms). Then, while observing the display, you can move the telescope to a new position via the RA and DEC directional buttons. As the telescope moves, the display will continuously change to show the new position.

Note: See section "2.3.4 Moving the Mount Manually" of this manual for how the telescope's movement speed depends upon the Mode of the Hand Controller and the way the directional buttons are pressed.

5.3.6.2 Enter RA/DEC

This command allows you to enter the RA and Dec. coordinates for a point in the sky. As in the previous menu item, selecting "Enter RA/DEC" displays the telescope's current RA and Dec. coordinates. You can now enter a new set of coordinates by changing the displayed numbers.

To enter new coordinates, navigate from digit to digit with the RA directional buttons on the Hand Controller, and change their values with the DEC buttons. After you have completed the entry, navigate to the far right digit and press the RA+ button. The new coordinates will be stored as a selected object that you can slew to via Gemini's GoTo function (provided the object is above the horizon). If

Setup→Communication→Coordinate Epoch→Epoch J2000.0 was selected, the input coordinates are interpreted as referring to the IAU standard epoch J2000.0, and are precessed to the equinox of the date. As when selecting catalog objects, entering RA and Dec. coordinates with this function causes Gemini to display the object's hour angle (in minutes) and elevation (in degrees).

5.3.6.3 Az/El Display

Upon selecting "Az/El Display," Gemini switches to the Telescope Control Mode and displays the telescope's current Azimuth and Elevation coordinates. Then, while observing the Az/El display, you can move the telescope to a new position via the RA and DEC directional buttons. Note that although the directional buttons move the telescope in RA and Dec. in the same manner as in the "RA/DEC Display" menu described above, as the telescope moves, the display will continuously change in Azimuth and Elevation to show the new position.

The format of the coordinates displayed depends on the hand controller mode currently selected. In Visual Mode, azimuth is displayed with arcmin accuracy and elevation with arcsec accuracy. In Photo Mode, both azimuth and elevation are displayed with arcsec accuracy, alternating every few seconds.

Note: See section “2.3.4 Moving the Mount Manually” of this manual for how the telescope’s movement speed depends upon the Mode of the Hand Controller and the way the directional buttons are pressed.

5.3.6.4 Enter Az/El

This command allows you to enter the telescope’s Azimuth and Elevation for a point in the sky. As in the previous menu item, selecting "Enter Az/El" displays the telescope's current Azimuth and Elevation coordinates. You can now enter a new set of coordinates by changing the displayed numbers.

To enter new Azimuth and Elevation coordinates, navigate from digit to digit with the RA directional buttons of the Hand Controller, and change their values with the DEC buttons. After you have completed the entry, navigate to the far right digit and press the RA+ button. The new coordinates will be stored as a selected object that you can slew to via Gemini's GoTo function (provided the object is above the horizon). If

Setup→Coordinate Epoch→Epoch J2000.0 was selected, the input coordinates are interpreted as referring to the IAU standard epoch J2000.0, and are precessed to the equinox of the date.

5.3.6.5 Set Bookmark

This menu item allows you to store as retrievable bookmarks, the coordinate position of up to 10 objects. To mark the first object, center it in the telescope's field of view and execute "Coordinates→Set Bookmark #0," where 0 is the number of the first Bookmark. The process can be repeated 9 more times for Bookmarks #1 to #9. Any Bookmark can be overwritten by scrolling to it with the DEC buttons before setting the new Bookmark.

Note: The bookmark does not replace the selected object, so slewing to the bookmarked position can only be done by executing the "{GoTo Bookmark #n}" menu item.

5.3.6.6 {GoTo Bookmark #n}

This menu item is only visible if at least one Bookmark is stored. To GoTo the object at stored Bookmark #n (where n is an integer from 0 to 9), merely execute "Coordinates→GoTo Bookmark #n." This function is exceedingly useful for doing differential photometry, where one must slew back and forth between the star being measured, and several comparison and check stars.

5.3.7 Identify

- New Selection
- Continuous Ident
- {Previous Objects}

Catalogs

- M/NGC/IC/Sh2 Cat
Object Types

Object Types

Arbitrary Obj.
Stellar Objects

Magnitudes

All Magnitudes
Magnitudes <15m0

- | | | | |
|---|------------------|-----------------|------------------|
| | Magnitudes | NonStellar Obj. | Magnitudes <14m0 |
| • | Messier Objects | Planetaries/SNR | Magnitudes <13m0 |
| | Object Types | Galaxies | Magnitudes <12m0 |
| | Magnitudes | Clusters | Magnitudes <11m0 |
| • | NGC Objects | Nebulae | Magnitudes <10m0 |
| | Object Types | | |
| | Magnitudes | | |
| • | IC Objects | | |
| | Object Types | | |
| | Magnitudes | | |
| • | Sharpless 2 Obj. | | |
| | Object Types | | |
| | Magnitudes | | |

This menu item identifies up to ten celestial objects that lie within a range of about 10 degrees from where the telescope is currently pointing. Those objects nearest the central axis are listed first, and the selection is refined as you designate the object's catalog, type, and maximum magnitude (These latter items appear in the menu tree as submenus of each other).

You can scroll through the list of identified objects with the DEC buttons. As each object is displayed, it becomes the "selected object," with coordinates and data available in the information buffer. You now have two choices: (1) The RA+ button will immediately GoTo the selected object; (2) the RA- button will display the information buffer and then the object, ready for you to perform a GoTo.

5.3.8 Object Search

- **FOV 2 degrees**
- **FOV 1.5 degrees**
- **FOV 1 degree**
- **FOV 50 arcmin**
- **FOV 40 arcmin**
- **FOV 30 arcmin**
- **FOV 20 arcmin**
- **FOV 10 arcmin**
- **FOV 5 arcmin**
- **Wobble Object**

5.3.8.1 Field of View Search

This feature is useful for systematically searching for objects that you know or suspect are close to where the telescope is pointing, but are not in the field of view. After selecting the "Object Search" menu item, you will be asked to select an FOV (field of view) between 5 arcmin and 2 degrees, or select "Wobble Object."

If one of the FOVs is selected, the telescope moves in alternating, increasing movements around the starting position in both RA and Dec. The selection you make affects the fineness or coarseness of the search; the distance between lines of search is determined by the selected FOV divided by the square root of 2.

5.3.8.2 Wobble Object

"Wobble Object" is used when you are pointing in the right place for a dim object, but you cannot see it. The telescope moves continuously in a "Z" shape pattern, 5 arcmin per axis. This can help you detect a faint object in the field of view since the human eye is more sensitive to faint objects when they are moving.

Pressing any directional button on the Hand Controller stops the search.

5.3.9 Show Date/Time

- **UTC Date/Time**
- **Julian Date**
- **Civil Time**
- **Local Sidereal**

Executing this menu item permits you to see the date and/or time stored in Gemini's Real Time Clock (RTC) displayed according to one of four different date/time standards. The "UTC Date/Time" and "Civil Time" displays read from left to right as follows: "yymm.dd hh:mm:ss," where yy = year, mm = month, dd = day, hh = hour, mm = minutes, and ss = seconds. In addition to just taking note of the time, this is a convenient way to check on whether you entered the UTC date and time correctly in the "Setup" menu. Remember that local Civil Time and UTC Time usually refer to different time zones, so their respective dates are not necessarily the same.

This menu item anticipates that you may want to move the telescope while displaying the time. It therefore returns you to Telescope Control Mode from where you can guide, center or slew.

5.3.9.1 UTC Date/Time (Coordinated Universal Time)

A full discussion of UTC is beyond the scope of this manual. For most practical purposes, it corresponds to Greenwich Mean Time (the date and time in Greenwich England). UTC is the time provided by all GPS receivers, and is the time that must be entered into Gemini's RTC.

5.3.9.2 Julian Date

A full discussion of "Julian Date" is likewise beyond the scope of this manual. It is interesting to note, however, that "Julian Date" 0.0 was Greenwich Mean Time at noon on January 1, 4713 BC. It is a time scale widely used by astronomers because it is unambiguous, employs no leap-years, and because a single number represents both date and time. For convenience, Gemini's display of "Julian Date" also includes the day of the week for the longitude of Greenwich, England.

5.3.9.3 Civil Time (Local Civil Time)

Expressed in 24 hour format, local "Civil Time" is converted to GMT (or UTC) by adding or subtracting the time zone (Daylight Saving Time must be accounted for when determining the time zone). For example, New York City in Eastern Standard Time is 5 time zones behind the time in Greenwich England (expressed as GMT or UTC). Consequently, at 03:05 UTC (GMT) on May 5 -- the local time in Greenwich England, the local time in New York City (at UTC-5) is 22:05 (10:05 P.M.), on May 4.

If Gemini's RTC is set with the Hand Controller, UTC must be entered. In contrast, when you set Gemini's time from a PC using a planetarium program, local "Civil Time" must be transmitted. The time zone must therefore be set before setting the time, so that the UTC stored in the RTC is correctly calculated.

5.3.9.4 Local Sidereal (Local Sidereal Time)

"Local Sidereal" time (LST) at a given location is the right ascension (RA) of the local meridian of the celestial sphere, and is related to the hour angle (HA) of the telescope's RA setting by the equation $HA=LST-RA$. It is useful for positioning the telescope, and for planning an observation sequence at or near the meridian. For example, suppose you had a list of objects and wanted to observe the objects within 2 hours of the meridian. If the LST were 13:24, you would look for objects with RA coordinates between 11h 24m and 15h 24m.

5.3.10 Setup

- **Hand Controller**
- **Mount Parameters**
- **Encoder**
- **Alarm/Buzzer**
- **UTC Date/Time**
- **Credit Info**
- **Restore Defaults**
- **Dim Display**
- **Geogr. Location**
- **Communication**

Although "Setup" appears as the last menu item, you will often want to begin with it. All parameters entered here are stored in Gemini's battery-backed-up memory (SRAM) together with a checksum. If the checksum is wrong at the time of powering on, all stored values return to their default settings, and a "CMOS reset" message is displayed on the Hand Controller. "Setup" is used often, and contains the greatest number of submenus; it is therefore highly recommended that you commit the "Setup" menu to memory, and be thoroughly familiar with the submenus you most frequently use.

5.3.10.1 Hand Controller

- **Visual Mode: C-S**
- **Photo Mode: G-C**
- **All Speeds: G-C-S**

This menu item contains three modes for controlling the telescope with the Hand Controller. The modes differ by the "Moving Speed"s each can access. These speeds are "Centering" (C), "Slewing" (S), and "Guiding" (G).

In "Visual Mode: C-S," pressing one directional button of the Hand Controller moves the telescope at centering speed. Pressing the opposite button while the first button remains depressed accelerates the telescope to slewing speed. "Guiding" speed is not available in this mode because, when doing visual observations, it is usually not necessary to guide the telescope in order to keep objects sufficiently centered in the field of view.

In "Photo Mode: G-C," pressing one directional button of the Hand Controller moves the telescope at guiding speed. Pressing the opposite button while the first button remains depressed, will change to 1/8 of centering speed to allow fine centering of the target, then after about 2 seconds speed will increase to 1/4 centering speed, then after another 2 seconds 1/2 centering speed and finally to full centering speed. Pressing the opposite button twice will change to full centering speed immediately. During a guiding operation, accidentally accelerating to centering speed is undesirable. To avoid this, you can guide via a Losmandy Standard Hand Controller plugged into Gemini's Autoguider port. In this way, accidentally pressing an opposite button of the Hand Controller will not cause the telescope to speed up.

In "All Speeds: G-C-S" mode, all three moving speeds are available. Pressing one directional button of the Hand Controller moves the telescope at guiding speed. Pressing the opposite button while the first button remains depressed accelerates the telescope to centering speed. Pressing the opposite button again while the first button remains depressed accelerates the telescope to slewing speed.

Executing any of the above choices returns Gemini to Telescope Control Mode.

5.3.10.2 Mount Parameters

- **Tracking Speed**
- **Moving Speeds**
- **TVC Value:**
- **PEC**
- **Mount Type**
- **Set Safety Limit**
- **Set Home Posit.**
- **{Pointing Model}**

Each of the above Mount Parameters is discussed in detail below:

5.3.10.2.1 Tracking Speed

This menu item allows you to set the speed and method used to track objects in the sky. You can select any of the following tracking speeds:

- **Sidereal**
- **Lunar**
- **Solar**
- **Adaptive King**
- **None/Terrestrial**
- **Closed Loop**
- **Comet Tracking**
 - Enter RA Rate**
 - Enter DEC Rate**
 - Train Tracking**
 - Calculate Rates**
 - {Activate}**

"Sidereal" speed causes the telescope to track in right ascension (RA) at the rate of the Earth's rotation. It is therefore an accurate tracking rate for stars and other deep space objects.

"Lunar" speed causes the telescope to track the right ascension component of the lunar trajectory. Since the Moon has a non-circular orbit and moves in both RA and Dec. relative to Earth, "Lunar" tracking speed is calculated for the apparent movement of the Moon within the next hour. Especially if the Moon is near the horizon, reselecting Lunar tracking speed a while later will result in a slightly different tracking speed because refraction and parallax play a large role.

"Solar" speed is very close to sidereal speed, but slightly more accurate for observing the Sun. It is, however, so close, that visual observers of the Sun can usually use sidereal speed without difficulty. As with "Lunar" tracking, "Solar" speed takes into account the changes caused by the elliptic orbit of the Earth, and adapts the tracking rate accordingly.

"Adaptive King" speed is an enhancement of the fixed King Rate. Its purpose is to take refraction into account when observing near the horizon, thereby adapting the tracking rate for the apparent change in an object's position. See Chapter 3, section 3.3.1.2 of this manual for a more complete explanation.

"None/Terrestrial" stops all telescope tracking. It can be used for terrestrial observing, or when it is desirable to stop the telescope from moving without powering Gemini off.

"Closed Loop" tracking is a tool for keeping an object centered in the field of view (1) when the mount is not accurately polar aligned or (2) when an object moves slowly with respect to the background sky, and its coordinates are downloaded cyclically. Gemini accomplishes this by comparing the apparent modeled coordinates of the object being tracked with the actual coordinates of the telescope, and makes slow RA and Dec.

corrections. Although an object can usually be kept centered using this technique, field rotation occurs if there is polar misalignment. See Chapter 3, section 3.3.1.4 of this manual for further details.

"Comet Tracking" is a tool that allows you to set independent RA and Dec. tracking rates to track comets and other solar system objects that follow unique trajectories. This menu item contains a submenu of five additional items which are "Enter RA Rate," "Enter DEC Rate," "Train Tracking," "Calculate Rates" and "Activate" (reselecting a previously trained, calculated, or PC-downloaded rate). See Chapter 3, section 3.3.1.2 of this manual for details on how to use this feature.

5.3.10.2.2 Moving Speeds

- **Guiding**
- **Centering**
- **Slewing**
- **GoTo**

The "Moving Speeds" entered through this menu are accessed when the telescope is moved by means of the Hand Controller or a during a GoTo operation.

"Guiding" is the slowest of the "Moving Speeds"; it can be set within a range of 0.2 to 0.8 of the tracking speed. While guiding occurs at constant speed in Dec., it adds to or subtracts from, the tracking speed in RA. For example, a "Guiding" speed of 0.5 increases RA tracking to 1.5 when guiding with the RA+ button of the Hand Controller, and reduces it to 0.5 when guiding with the RA- button.

"Centering" speed is intended to be faster than "Guiding," but slower than "Slewing." It can be set as high as 255 times "Sidereal" speed, and should be set to the comfort of the observer for centering objects in the telescope's field of view.

"Slewing" speed is for moving the telescope over long distances using either the Hand Controller or PC slewing control. It is set by default to 800 times "Sidereal" speed, and it ramps down in speed when you release the Hand Controller button. If your mount is slewing reliably without straining or stalling at the default speed, you may be able to increase the speed to as much as 1200 times sidereal rate.

"GoTo" speed is for moving the telescope over relatively long distances during a GoTo operation initiated from either the hand controller or PC software. As with "Slewing," the "GoTo" speed can be set as high as 1200, but the telescope mount often operates more effectively if it is left at the default value of 800. In order not to overshoot its target, GoTo slews ramp down to "Centering" speed as the telescope approaches its destination object.

5.3.10.2.3 TVC Value (Time Variable Compensation)

This menu item helps compensate for the response delay caused by gear backlash when changing direction in Dec. The TVC can eliminate the hysteresis that causes this to

happen. 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.

5.3.10.2.4 PEC (Periodic Error Control)

- **Train PEC**
- **Maximum Pulses**
- **{Clear Data}**
- **{PEC Off (On)}**
- **{Delay Correction}**
- **{Drift Correction}**
- **{Smooth Data}**
- **{Average Data}**
- **{Restore Data}**

Periodic Error Control ("PEC") helps eliminate the periodic error caused by the very slight helical path variation in the shape of the RA worm. You experience these as changes in the tracking speed, causing a star to periodically move a few arc seconds forward or backward while the worm gear turns. The "period" is defined as the time of one worm revolution – about 4 minutes for the G-11, HGM-200 and MI-250, 5.33 minutes for the HGM Titan, and about 8 minutes for the GM-8 and CI-700.

As long as PEC isn't trained, the only submenu items that appear are "Train PEC" and "Maximum Pulses." You should only select the "Train PEC" item if you already have a star centered in the eyepiece reticle and are ready to train. If you select "Train PEC," you'll have about 10 seconds to precisely center your guide star before training starts. During the training phase, a counter on the display begins counting down from 240 to 0 for the G-11/HGM-200/MI-250, from 320 to 0 for the HGM Titan, and from 480 to 0 for the GM-8 or CI-700.

See Chapter 4, section 4.3 of this manual for a thorough explanation of PEC and for detailed instructions on how to use each one of the submenus.

5.3.10.2.5 Mount Type

- **Losmandy GM-8**
- **Losmandy G-11**
- **HGM 200**
- **M.I. MI-250**
- **Losmandy Titan**
- **L. Titan (50:1)**
- **Custom Mount**
 - RA Spur:**
 - RA Worm:**

DEC Spur:
DEC Worm:
RA M. Enc:
DEC M. Enc:

In addition to using the Setup command, you are able to change the Mount Type immediately after a Cold Start. Refer to section 2.4.2.1 Cold Start Setup Options for an explanation of how this is done.

Use the "Mount Type" menu item to select one of the telescope mounts listed above.

IMPORTANT: You must restart the Gemini after changing the mount type (power off, then power on and select "Cold Start").

All of the selectable mount types except "Custom Mount" are recognized immediately upon their selection. Selecting "Custom Mount" brings up a submenu consisting of six mount parameters; each numerical parameter must be entered within the following ranges:

RA & DEC Spur (Spur Gear Ratio): 20 to 150

RA & DEC Worm (Worm Gear Ratio): -720 to +720, excluding -99 to +99

RA & DEC M. Enc (Motor Encoder Resolution) range: 100 to 2048

Note: For any given Custom Mount, the RA or DEC angular movement θ for each tick of the mount's synchronous motor is computed by the following formula:

$$\theta = 1.296 \times 10^6 / (\text{Worm Gear Ratio} * \text{Spur Gear Ratio} * \text{Nominal Motor Encoder Resolution})$$

where $0.1 \leq |\theta| \leq 2.5$ arcseconds / tick

The sign of θ indicates the direction of the mount's tracking movement.

For custom mount designs, besides this given step range you also have to consider how much torque the planned gearing is able to deliver. Additionally, the product of the nominal motor encoder resolution and the spur gearing must not exceed 26,800.

5.3.10.2.6 Set Safety Limit

- Confirm to Set
- Reset to Defaults
- Set East:
- Set West:
- Set GoTo:

The nature of a German Equatorial Mount is that while it will never make a complete turn in RA, at the extreme ends of its RA movement, the optical tube assembly (OTA) can collide with the tripod legs or other equipment, causing damage. Gemini has factory-set default limits as to how far the mount can turn to the east and to the west. These limits were established with the selected mount in mind, but without knowing which OTA will

be mounted, and the accessory equipment that may be attached. The default safety limits are 114 degrees when the telescope is on the east side of the mount and to 122 degrees on the west side, with respect to the RA startup (CWD) position. This applies to all the listed mount types except the MI-250. The default safety limits for the MI-250 are 92 degrees in the east, and 95 degrees in the west.

Gemini provides a means, via this menu item, to change the pre-set Safety Limits. First of all, in order to be protected by Gemini's safety limits or to change them, you have to start up the system in the CWD position. To narrow the previously set limits, merely slew to the position you want to set as the new limit and execute "Setup→Mount Parameters→Set Safety Limit." Gemini will then display "Confirm to Set." Press the RA+ button to set the safety limit.

Extending the previously set limits involves a bit more work, but is not difficult. Slew toward the old limit you wish to extend. About 10 degrees before you reach the limit, the speed softly ramps down until the motor stops (You are not yet at the established limit). Release the buttons on the hand controller and then press them again to continue moving the mount toward the limit. When you reach the limit, the motor will stop and a buzzer will sound (You are now outside the safety range and the buzzer won't stop until you go back inside or set a new limit with this menu item). Now, by pressing the buttons again, move (the motor will start up again) to the position you want to set as the new Safety Limit, and execute "Setup→Mount Parameters→Set Safety Limit." Again, Gemini will display "Confirm to Set." Press the RA+ button to set the safety limit.

Alternatively, you can examine and change the safety limits using the "Set East:" and "Set West:" submenu items of the "Set Safety Limits" menu. Selecting either of these commands will show the current limit expressed in degrees from the CWD position. You can then edit these values using the hand controller buttons if desired. Remember that the east safety limit is the furthest the mount can move to the east, and the west safety limit is the furthest the mount can move to the west.

You can reset the safety limits to the default values by executing the "Setup→Mount Parameters→Set Safety Limit→Reset to Defaults" menu item.

IMPORTANT NOTICE: The limits are stored in CMOS SRAM. Whenever the "CMOS reset" message is displayed during startup, all values are reset to the factory default. If you need different limits to be set, you must set them again.

Set GoTo:

The "Set GoTo" command allows you to specify an angle relative to the CWD 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.

For example, setting the GoTo limit to 95 degrees means that a GoTo command to any object 5 degrees or further west of the meridian will cause Gemini to point to this object with the telescope tube on the east side of the mount (doing a meridian flip if needed). The telescope will still track an object past this point if the tube is on the west side of the mount, but once an object has passed the GoTo limit, a subsequent GoTo command to this object will force a meridian flip.

A value of 90 sets the GoTo limit to the meridian itself; meaning that a GoTo command to any object west of the meridian will force the telescope to the east side of the mount.

The default value of zero means that the GoTo limit is set 2.5 degrees east of the western safety limit.

Note: Use caution when setting the GoTo limit to values between 1 and 89 degrees. 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, and “*Interrupted*” being displayed on the hand controller.

5.3.10.2.7 Set Home Posit. (Set Home Position)

This menu item allows you to set a Home Position for the telescope that is different from its Startup (CWD) Position default. This is the position to which the telescope will slew when "Park Mount!→Park @Home Pos!" is executed from the "QuickMenu" (see this Chapter, section 5.4)

If not expressly changed, the Home Position defaults to the Startup (CWD) Position. Either position can be slewed to from the “QuickMenu.”

5.3.10.2.8 {Pointing Model}

- **Undo Last Align**
- **Store Model #<n>**
- **Reload Model #<n>**

The Pointing Model menu item is available only after you have performed at least one Additional Align. The first submenu item allows you to remove the data of the last Additional Align from the modeling data set, undoing the last alignment. This is useful if you misidentified an alignment star. The other submenu items allow you to store and reload, as the current model, one of 10 permanently stored models. This function is especially useful while testing several models or while using several OTAs from the same permanently setup mount.

5.3.10.3 Encoder

- **EncRes RA**
- **EncRes DEC**
- **Test Encoder**
- **Use/Ignore Encoder**
- **Use/Ign End Switches**

Without optional encoders installed, all movements of the telescope must be done electronically, with the RA and Dec. clutches tight so that no slippage of the OTA can occur. Although not necessary for operating Gemini, optional encoders are useful because, if they are installed, you can loosen the axis clutches of your mount, and move the telescope to any position by hand without Gemini losing track of where the telescope is pointing.

The first items of this menu, "EncRes RA" and "EncRes DEC," enable you to define the axial encoder resolutions. The RA and Dec. encoders may have different resolutions, and each may be up to 32,768 ticks/revolution. In general, the sign is "plus" if the encoders are moved in the same direction as the axes, and "minus" if the direction is reversed by a gear. Setting up the encoders incorrectly will result in unwanted behavior of your system, in which case 'R' or 'D' will be displayed at the right side of the display, indicating a correction to the internal position counters caused by and derived from the encoder data.

The "Test Encoder" menu item displays the actual values of both encoders, and can be used for testing if you are connecting your encoders for the first time. One revolution of an axis should bring the counter back to the same value. This is easily tested for Dec. but for RA, you can only move between the mechanical limits of your mount.

By default, encoder input is ignored. Select "Use Encoder to cause Gemini to accept input from encoders. When encoder input is being accepted, this menu item will change to "Ignore Encoders." Selecting "Ignore Encoders" will cause Gemini to return to the default state of ignoring any input from the encoders.

You can optionally connect physical limit switches to the encoder port instead of encoders. This can provide a failsafe mechanism to prevent the mount from exceeding the RA limits and damaging the mount or telescope. Use the "Use End Switches" menu item to enable the use of end switches. Once "Use End Switches" has been selected, the menu item changes to "Ign End Switches" which can be used to again ignore input from limit switches. See Appendix section 8.7 for more information on connecting end switches.

5.3.10.4 Alarm/Buzzer

- **Activate Alarm / Set Alarm Off**
- **Set Alarm Time**
- **Turn Buzzer Off / Turn Buzzer On**

These functions allow you to use the Gemini as an alarm timer and to control the safety limit buzzer. The time for sounding the alarm (useful for determining when to close a camera's shutter) is set in UTC using "Alarm/Buzzer→Set Alarm Time." Although the alarm time remains stored in Gemini's real time clock (RTC), it is always set to "off" after powering up. You can activate the alarm by executing "Alarm/Buzzer →Activate Alarm" and can disable the alarm by executing "Alarm/Buzzer →Set Alarm Off."

Selecting "Alarm/Buzzer →Turn Buzzer Off" or "Alarm/Buzzer →Turn Buzzer On" allows the user to disable or enable the buzzer sound while keeping the alarm in an activated condition. These commands also control whether or not the buzzer sounds when Gemini has reached one of the RA safety limits. Note that turning the buzzer off only affects the buzzer; it does not disable the actual safety limit.

5.3.10.5 UTC Date/Time

The "UTC Date/Time" menu item is where you set Gemini's real time clock (RTC). Upon executing "UTC Date/Time" the UTC date and time display freezes but the RTC continues to keep time.

The display of date and time from left to right reads as follows: "yymm.dd hh:mm:ss" (yy = year, mm = month, dd = day, hh = hour, mm = minutes, ss = seconds). You can modify the displayed time and date in the usual way by using the Hand Controller's DEC buttons to change the current digit, and using the RA buttons to move from digit to digit. When you are at the far right digit of the display, pressing the RA+ button causes the new UTC date and time, to the second, to be entered into the RTC.

Make sure that you properly consider the time zone difference while calculating the UTC time. Western longitudes (e.g. the Americas) are behind, eastern longitudes (e.g. Asia, Australia) ahead of UTC. This may also affect the date. You can use a GPS receiver to set the correct values. You can also visit <http://www.DocGoerlich.de/utcdate.php> to get the current UTC date and time in Gemini format.

IMPORTANT: If you use the "Setup→UTC Date/Time" menu item to change the date and/or time of Gemini's RTC immediately after a Cold Start, the new values are not used to set the initial pointing model until Gemini is powered off, powered back on, and Cold Started again. This does not apply if you set the date and time when prompted during the Cold Start, a feature first made available with Level 3 version 1.01. Refer to section 2.4.2.1 Cold Start Setup Options for an explanation of how this is done.

5.3.10.6 Credit Info

This menu item loads the information buffer and displays credits for those who participated significantly in Gemini's design and development.

5.3.10.7 Restore Defaults

- **Losmandy**
- **Mountain Instr.**

Executing this menu item allows you to do a CMOS reset, restoring all of Gemini's parameters to their default values. Since the defaults are different for the Losmandy and Mountain Instruments GEM mounts, you must select one or the other. For example, to restore Losmandy defaults, execute "Restore Defaults→Losmandy."

Note: Mountain Instruments and some Losmandy dealers set some mount parameters such as latitude and longitude to the correct value for individual customers before shipping the mounts. The "Restore Defaults" command resets all values, including mount type, latitude and longitude to their default values, requiring the user to enter the correct values for their location.

5.3.10.8 Dim Display

- **100% Brightness**
- **53% Brightness**
- **40% Brightness**
- **27% Brightness**
- **20% Brightness**
- **13% Brightness**
- **6.6% Brightness**

This menu item allows you to set the brightness of the LED display on the Hand Controller to a range from 6.6% to 100%. The display should be kept as dim as is comfortable to prevent losing your dark adaptation. The brighter settings can be used during the daytime.

5.3.10.9 Geogr. Location

- **Longitude**
- **Latitude**
- **Timezone**
- **Query GPS Rec.**
- **Store Site**
- **Load Site**
- **Name Site**

The "Geogr. Location" menu item allows you to input the Longitude, Latitude and Time Zone of the telescope's geographic location. Setting the geographic coordinates accurately is important because they are used to calculate the initial pointing model during a Cold Start, and are also used to calculate the position of the Moon. The longitude is measured from Greenwich, England; eastern longitudes have the designation 'E', and western longitudes (including the American continent) have the designation 'W.'

From the sign of the latitude, Gemini knows the hemisphere; northern latitudes are "plus," and southern latitudes are "minus." You should set your longitude and latitude first, because the tracking direction in RA depends on the sign of the latitude.

5.3.10.9.1 Longitude

The "Longitude" display is as follows: "E/Wddd°mm'" where E/W = either E or W, ddd = degrees, and mm = minutes. Each digit of the "Longitude" is scrolled to the correct value using the DEC buttons. Pressing the RA+ button from the right-most digit enters the "Longitude."

5.3.10.9.2 Latitude

The "Latitude" display is as follows: "+/-ddd°mm'" where +/- = either plus or minus, ddd = degrees, and mm = minutes. Each digit of the "Latitude" is scrolled to the correct value using the DEC buttons. Pressing the RA+ button from the right-most digit enters the "Latitude."

5.3.10.9.3 Timezone

The "Timezone" display contains a list of time zones that can be scrolled through with the DEC buttons and selected with the RA+ button.

5.3.10.9.4 Query GPS Receiver

Use this menu to get Longitude, Latitude and UTC Date/Time by querying a GPS receiver connected to the serial port. This is the same function that occurs automatically when Gemini is powered on.

5.3.10.9.5 Store Site

Execute "Geogr. Location→ Store Site→ Site #" (where # = 1 to 4) in order to store Gemini's currently set Longitude, Latitude, and Time Zone as one of four numbered user sites. Once saved, any of the four sites can be retrieved by executing "Geogr. Location→ Load Site→ Site #," further described below. If the current latitude and longitude are different from those currently stored for the specified site number, the "Store Site" command will change the name of that site to "User Site." This can be edited using the "Name site" command described below. However, if the latitude and longitude are the same as those currently stored for that site number, the site name remains unchanged. This is useful if you only want to change the time zone (to specify daylight savings time, for example) without changing any other parameters for the site.

5.3.10.9.6 Load Site

Execute "Geogr. Location→ Load Site→ Site #" (where # = 1 to 4) in order to load one of four possible user sites that were stored as previously described in section "5.3.10.9.5 Store Site" above. By default, sites 1-4 are predefined to be certain cities worldwide. These are overwritten as you store your own sites.

5.3.10.9.7 Name Site

Use this menu item to enter a name for any of the stored site locations. To enter or change characters in the name, use the RA+ and RA- keys to select the desired character

to change. The selected character will blink. Use the DEC+ and DEC- keys to scroll through the possible characters for that position in the name. Once the correct character is displayed, use the RA+ key to scroll to the next character position. The character “→” is used to indicate the end of the name that you are entering. Pressing the RA+ key when the “→” is blinking finishes the “Name Site” operation. Any characters after the “→” are not used in the name.

IMPORTANT: If you use the “Setup” menu to change Gemini's Geographic Location or Timezone immediately after a Cold Start, the new values are not used to set the initial pointing model or calculate Local Time until Gemini is powered off, powered back on, and Cold Started again. This does not apply to geographic coordinates that are changed when prompted during a Cold Start.

5.3.10.10 Communication

- **RS 232 Speed**
- **GPS Rx Speed**
- **Serial HC Speed**
- **Synch or Align**
- **Coordinate Epoch**

5.3.10.10.1 Communication Speeds

The three Communication Speeds that can be customized are “RS 232 Speed,” “GPS Rx Speed,” and “Serial HC Speed.” Selecting any of them by pressing the RA+ directional button on the Hand Controller, results in a submenu of selectable Communication Speed choices, ranging from 4800 to 38400 bits per second.

5.3.10.10.2 Sync or Align

- **Sync only**
- **Sync ↔ Add. Al.**

Gemini accepts two different kinds of Sync commands over the serial line. The LX200 protocol :CM# command shifts the internal coordinate system to reflect the latest position correctly, "Synchronizing" it to an object. On the other hand, the additional ":Cm#" command uses the detected positional difference to enhance the internal pointing model, performing an “Additional Align.” The software running on a connected computer can choose between either.

Since there are still some software packages on the market not supporting the Additional Align feature, you can use the “Sync or Align” commands to determine the way :CM# and :Cm# commands are interpreted. "Sync only" selects Gemini's standard behavior as described above, while "Sync ↔Add. Al." swaps the functionality of both commands, allowing enhancement of the pointing model even with PC software that does not explicitly support it.

Note: The “Sync or Align” commands are used only to modify the behavior of the serial line commands and do not in any way affect the “Synchronize” or “Additional Align” commands found in the Gemini menu tree.

5.3.10.10.3 *Coordinate Epoch*

- **Equinox of Date**
- **Epoch J2000.0**

This menu item allows you to tell Gemini whether celestial coordinates entered via the Hand Controller or the PC are to be mathematically precessed to the equinox of the date (i.e. they are Epoch J2000.0 coordinates), or whether they are already valid for the current equinox and must not be precessed. By default, Gemini assumes that object coordinates transferred by a planetarium program and any coordinates input through the Hand Controller are for the epoch of the current date (current equinox). This default can be changed to Epoch J2000.0 by executing "Setup→Communication→Coordinate Epoch→Epoch J2000.0." Similarly, to change to the "Equinox of Date," execute "Setup→Communication→Coordinate Epoch→Equinox of Date."

Note: These settings only apply to data sent *from* the PC *to* Gemini. Coordinates sent from Gemini to the PC always refer to the Equinox of the current date. This avoids confusion for the software that is controlling the Gemini system.

IMPORTANT: Epoch J2000.0 coordinates and Equinox of the Date coordinates cannot be mixed since Gemini has to be set to recognize one or the other. Also, the coordinates in the resident catalogs, the User Database, and Bookmarks, are not affected by how this menu item is set.

5.4 *QuickMenu*

- {Focusing}
- → Photo Mode / → Visual Mode
- Reduced Menu / Full Menu
- Centering
- Park Mount!
- {Meridian Flip}
- Exit w/o Change

The "QuickMenu" is a convenience that is accessed by holding down the MENU button for at least a second. Useful menu items such as Centering Speeds, Hand Controller Modes and a Park Mount command scroll through the display. The item that is displayed at the moment you release the button is the one selected, and Gemini returns to the Telescope Control Mode or to a submenu; an exception is described in section 5.4.1 {Focusing} below.

IMPORTANT: Once QuickMenu is accessed and begins to scroll, entering one of its menu items is unavoidable. For this reason you should be very aware of which item is displayed at the moment you release the MENU button. If you do not want to execute any of its commands, release the MENU button when “Exit w/o Change” scrolls into view.

5.4.1 Focusing

Gemini now supports focusing units having 9 to 12 volt DC motors (e.g. JMI's NGF series). In order to focus using the Gemini, you must have an adapter board accessory connected to the feature port.

The Gemini focusing function uses the Meade LX-200 serial line focusing commands. You can also change focus using the hand controller by putting it into focus mode. Selecting “Focusing” from the Quick Menu does this. This menu item is only available if the adapter board was connected. When in Focus Mode, the RA buttons move in and out, and the DEC buttons toggle between fast and slow focusing modes.

To disengage from the Focus Mode, press the MENU button.

5.4.2 Set Photo/Visual Modes

This is a shortcut alternative for changing from "Visual Mode" to "Photo Mode" and vice versa. These can also be set using the "Setup→ Hand Controller" menu item. Note that “All Speeds Mode” cannot be set from the QuickMenu.

5.4.3 Reduced Menu / Full Menu

This is a convenience for truncating and restoring the list of items that appears on Gemini's Full Main Menu. When “Reduced Menu” is executed, five items listed on the Full Main Menu are hidden; when “Full Menu” is executed, the items are restored (see this chapter, section 5.2.1 Full Main Menu, and section 5.2.2 Reduced Main Menu).

5.4.4 Centering

- **Exit w/o Change**
- **2x Centering**
- **8x Centering**
- **16x Centering**
- **32x Centering**
- **64x Centering**
- **128x Centering**

This is a shortcut alternative for setting Gemini's "Centering Speed" in increments from 2 to 128 times "Sidereal Speed." "Centering Speed" can also be set using “Setup→ Mount Parameters→ Moving Speeds.” To enter a Centering Speed from the QuickMenu, hold down the MENU button for at least a second and release it when “Centering” scrolls into view in the display. To escape from “Centering” without making an entry, release the MENU button when “Exit w/o Change” scrolls into view.

5.4.5 Park Mount!

- **Exit w/o Change**
- **Park @CWD pos!**
- **Park @Home pos!**
- **Stop Tracking!**

The CWD (counterweight down) position is the standard Startup position of the RA and Dec. shafts (see this manual, section 2.4.1.2 Startup Position). Releasing the MENU button when “Park @CWD pos!” scrolls into view, causes the telescope to slew to its Startup Position, and all tracking to stop (Tracking Speed is set to Terrestrial).

The Home position defaults to the CWD position at startup, but can be changed by executing “Setup→ Mount Parameters→ Set Home Posit.” at any position of the telescope (see this manual, section 5.3.10.2.7 Set Home Posit.). Thereafter, releasing the MENU button when “Park @Home pos!” scrolls into view, causes the telescope to slew to its Home Position, and all tracking to stop.

Releasing the MENU button when “Stop Tracking!” scrolls into view stops the mount from tracking at its current position.

To escape from “Park Mount!” without making an entry, release the MENU button when “Exit w/o Change” scrolls into view.

5.4.6 Meridian Flip

If the telescope is pointing to an object that can be safely reached from either side of the meridian, this command causes Gemini to perform a meridian flip and point back to the same object. This can be very useful if you are tracking an object as it approaches the western safety limit, and you want to continue to observe it from the other side of the mount. Please see sections 3.3.2 and 3.3.4 for more information about meridian flips.

Note: This menu item only appears in the QuickMenu if a meridian flip to the current coordinates can be safely done without violating the safety limits or the western GoTo limit.

5.4.7 Exit w/o Change

To escape from the “QuickMenu” without entering one of its menus, release the MENU button when “Exit w/o Change” scrolls into view.

5.5 Cold Start Scrolling Menu

- **UTC Date/Time**
- **Mount Type**
- **Longit.**
- **Latitude**

This menu presents itself immediately after a "Cold Start" as a convenient alternative for changing previously set "UTC Date/Time," "Mount Type," "Longit." (Longitude), and "Latitude." Each item is displayed for a few seconds before going on to the next one. If you want to change the currently displayed item, press one of the four direction buttons on the Hand Controller. To skip to the next item without waiting, press the MENU button. All of these items can also be set from submenus of the "Setup" menu item. Consult the relevant sections of this chapter as well as chapter 2 for further instructions regarding their entry.

6 Serial Communication

Gemini supports two serial ports. The first one is available to the user via the RJ22 RS-232 socket, and is described in section 6.1. This port allows you to connect devices such as GPS receivers, computers, and handheld devices to extend Gemini's functionality. The second serial port is normally used to drive the LED displays in the hand controller (or in the electronics box in older Gemini units). By connecting a separately available adapter to the DB15 hand controller port, Gemini level 4 allows you to use this second serial port to connect another device to emulate the hand controller using a serial line protocol. This is described in section 6.2. The new serial port supports the complete command set and works independently from the first. It is up to the user to assure that the commands sent do not conflict.

6.1 RS 232 Interface

6.1.1 Pinout and Wiring

Gemini connects to external devices via a serial RS232C port. To avoid any possibility of accidentally plugging in a wrong cable, a smaller RJ22 modular socket, (4P4C - 4 pin, 4 connectors) is used for this port. The pinout of Gemini's serial port is shown in the following table:

Gemini RJ22 socket	Function
Pin 1	Not Connected
Pin 2	GND Signal Ground
Pin 3	RxD Received Data (Input)
Pin 4	TxD Transmitted Data (Output)

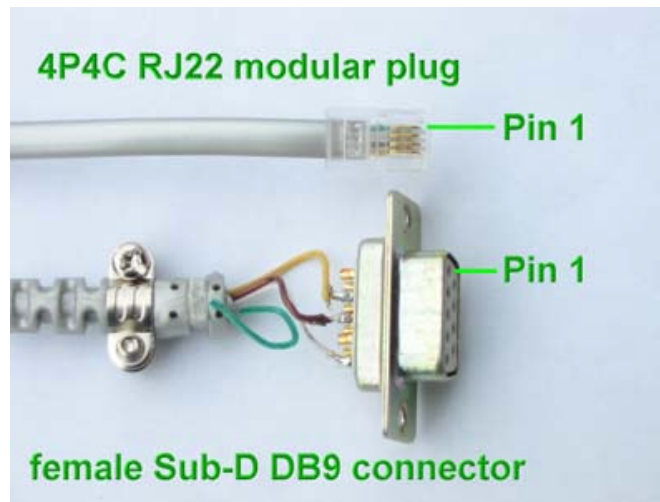
The serial port does not use any modem control signals. Gemini can be connected to a computer using a null modem cable. While both GND pins are connected directly, the receive (RxD) input of one connector has to be connected to the transmit (TxD) output of the other (and vice versa).

Personal computers usually have DB9 or DB25 connectors for their serial (COM) ports. If your PC does not have a serial port but a USB connector, there are several units on the market to convert RS-232 signals to USB.

To build a null modem cable, connect the pins as follows:

Gemini RJ22	DB9	DB25
Pin 1	Not Connected	Not Connected
Pin 2 (GND)	Pin 5 (GND)	Pin 7 (GND)
Pin 3 (RxD)	Pin 3 (TxD)	Pin 2 (TxD)
Pin 4 (TxD)	Pin 2 (RxD)	Pin 3 (RxD)

The following picture shows a cable to connect the Gemini to a PC equipped with a DB9 serial COM port (The locking tab of the RJ22 and the four-pin row of the DB9 face away from the viewer):



Serial cable to connect Gemini to a PC

The maximum usable cable length depends on several factors including the serial interface of the PC connected, the cable used, electromagnetic fields at the location and even the power supply's ground resistance.

Longer cables must be of higher quality than shorter cables. A heavier gauge of wire will result in lower resistance, and consequently a lower voltage drop. Straight (not coiled) cables are recommended. Twisted pair cables can be used, but be careful not to twist the Rx/D and Tx/D wires. Twist each of these signal wires with a wire connected to GND instead. For long distances, using multiple wires for GND helps reduce the disadvantages of the asymmetric (common GND wire) circuitry.

A shielded cable with the shield connected to the metal of the Sub-D connector on the computer side is also recommended.

With good cabling, communication over distances of about 50 ft. should be possible. Longer distances may be bridged by using relay modems. These units change the asymmetric circuitry to symmetric circuitry (no common GND wire) that is relatively insensitive to electromagnetic fields and ground potential differences, and can therefore communicate up to several miles.

The serial ports provide an electrical connection between the Gemini and the computer. If there are differences between the ground potentials of the devices, ground loop currents may occur, potentially damaging both pieces of equipment. To avoid such currents, you should ensure that both devices have the same ground potential. Whenever possible, the

negative power terminals should be connected with low resistance wire. Alternatively, electrically isolated power supplies or batteries can be used.

6.1.2 Settings

Except when querying GPS units, Gemini's serial port is set to communicate at 9600 baud (9600 bps), no parity, 8 data bits, 1 stop bit. You must configure the COM port of the connected computer to match these settings. In addition, the handshake protocol setting for the COM port should be set to "None" (neither hardware nor software handshake). Most planetarium programs perform these settings automatically for you.

6.1.3 Troubleshooting Serial Communications

If you cannot communicate with the Gemini after checking the wiring, you can use Gemini's Debug Mode to find out if serial data is being received correctly. In this mode, the commands received (without their numeric parameters) are stored in the Information Buffer and can be displayed using the "Show Information" menu item.

At the PC side, any terminal emulation program such as HyperTerm under Windows, or MiniCom under Linux can be used. Connect to the COM port after setting the parameters as described above and type some commands from the serial command set like :P#, :GR# or :GD# on the PC. Gemini should send characters in response.

If there is no response displayed, use Gemini's "Show Information" command to check whether or not Gemini received the commands sent. If not, try the following steps:

- Connect PC and Gemini with a minimum of cabling and hardware. Use a short cable.
- Double-check the settings of the serial port.
- Make sure Gemini started up correctly and the startup process is finished (otherwise most commands will not be recognized).
- Make sure no other program (planetarium program, ActiveSync,...) is accessing the port.
- Make sure the port is not redirected to IrDA.

If Gemini is still not receiving commands, try different settings of the "Send Buffer FIFO" in the Extended Settings for the COM port of the PC.

Once the commands reach Gemini, the response should be seen quickly. If not, try the other possible settings of the Receive Buffer FIFO.

See also section 7.1.14.

6.2 Hand Controller port

There are two sockets available to connect a hand controller to Gemini: the modular RJ11 socket for the classic Losmandy hand controller and the DB15 sub-D socket to connect the Deluxe Hand Controller to the Gemini board. From level 4 up, the DB15 port can also be used alternatively as a second serial port. Since the serial pins connect directly to the

internal micro controller with 5V TTL signals, an adapter is necessary to use it to communicate with RS232 ports. Adapters for Bluetooth or USB can be designed. Several adapters are available from third party sources.

If an adapter is connected to make use of the second serial port, the Deluxe Hand Controller cannot be connected. However, the classic hand controller can still be used to slew the telescope. The onboard display of the first generation Gemini units will be disabled by the adapter. All hand controller functions are also available using the Gemini Control Center software Hand Controller Emulation mode (see section 6.6.1 below).

The table below gives the pinouts of the DB15 hand controller port:

Gemini DB15 socket	Function
Pin 1	+5V
Pin 2	+5.4V
Pin 4	Menu button (active Low)
Pin 5	GND Signal Ground
Pin 6	LED (minus, with resistor, LED+ at +5V or 5.4V)
Pin 7	RA- (left button, all buttons active High, 3.3k load)
Pin 8	DEC- (down)
Pin 9	DEC+ (up)
Pin 10	RA+ (right)
Pin 11	RxD Received Data (5V TTL, serial input to Gemini)
Pin 14	Connect to GND to enable the use of pins 11 and 14 as serial channels and disable onboard LED displays.
Pin 15	TxD Transmitted Data (5V TTL, serial output from Gemini)

6.3 Serial Command Sets

6.3.1 Meade® LX200 Commands

Gemini supports a subset of the LX200 command set that is necessary for the control of German Equatorial Mounts. The majority of these commands start with a colon “:” and end with a hash mark “#”. Each character received is stored into a buffer. After the hash (or an ACK character) is received, Gemini interprets and executes the command(s).

In addition to the commands defined by Meade Corporation, Gemini supports additional, LX200-like commands following the syntactic rules described above. Both are described in Appendix 8.4, Serial Line Protocol.

6.3.2 Gemini Native Commands

Access to the Setup data, modeling parameters, tracking rates and much more is possible by means of Gemini's Native Command set. These commands have a format that allows for easier parsing and execution. The use of a checksum allows for safe transmission.

Command	Return Value	Description
<<id>:<checksum>#	<parameter value><checksum>#	Get Value (from L2 up)
><id>:<parameter value><checksum>#	#	Set Value (from L2 up)

Native Serial Command Syntax

Each command has a numeric identification, "id" that is interpreted as an integer; leading zeros are ignored. To request a value from Gemini, the command begins with the "less than" character "<", and to set a value, the command begins with ">". Some commands are grouped (e.g. the tracking rates are group 130). If any one of the commands within this group is used in a "Get Value" command, the actual setting (e.g. 131 for Sidereal Tracking) is returned.

The checksum for the native commands is calculated by a bitwise XOR operation of the transmitted characters, including the Get/Set command sign ("<", ">"). The highest significant bit of the result is cleared (modulo 128 operation) and 64 is added. For sending, the checksum is separated by a colon. On receiving, there is no colon, but the checksum can easily be recognized after the parameter value because it is never a number (in the ASCII alphabet, number characters range from 48 (30H) to 57 (39H), so the checksum will always be greater.)

Commands received with a wrong checksum are not executed. If Gemini is in Debug mode, both the received and the expected internally calculated checksums are displayed as hexadecimal characters instead.

6.4 Connecting a GPS Receiver

The serial ports of many GPS receiver units have a special, non-standardized design. To connect these GPS units to a computer, you will have to obtain a cable from your GPS manufacturer for that purpose. On the PC side, these cables have a DB9 connector like the one shown in section 6.1. There are two options for connecting this cable to the Gemini. The first is to buy a commercially available null modem adapter (male DB9 connectors on both sides). A simple "gender changer" will not work, since it would connect the outputs of both ports (TxD to TxD) and inputs (RxD to RxD) to each other. The null modem adapter will cross TxD to RxD.

Alternatively, a cable can be made with an RJ22 plug as described in section 6.1, but with a male DB9 connector and the RxD and TxD wires swapped.

Once you have connected your GPS receiver to Gemini, you should configure your GPS to output either Garmin Textout protocol, or NMEA 0183 protocol. Gemini requires only the “Recommended Minimum” (RMC) NMEA 0183 sentence to be sent, which is supported by all GPS receivers. In addition to the NMEA standard baud rate of 4800, Gemini can be configured to use other baud rates when it checks for GPS data.

6.5 Using Planetarium Programs

You can use many popular planetarium programs to control your Gemini. Most will allow you to select any object and command Gemini to go to that object. Many will also show where on the sky Gemini is pointing.

6.5.1 Telescope Driver

Some popular planetarium programs come with a dedicated Gemini driver; if not, they will have an LX200 driver that should work flawlessly. Examples of Windows PC planetarium programs that are successfully being used with Gemini are TheSky, Guide, SkyMap, and Starry Night. In addition, Voyager and Starry Night can be used on Macintosh, XEphem under Linux, and TheSky PE on PDAs.

6.5.2 Communication Port Access

One disadvantage of a serial port is that it cannot be shared between programs. If you plan to use a planetarium program such as TheSky and the Gemini Control Center (GCC) together, you will have to toggle the serial link off in one program to activate it in the other. If the program provides this capability, there will be no need to stop the programs and restart.

6.5.3 Coordinate Epoch

Gemini expects the coordinates sent from a PC to be precessed to either the standard epoch J2000.0 or to the equinox of the date. You can select the appropriate epoch using the “Setup→Communication→Coordinate Epoch” menu item. If J2000.0 coordinates are selected, Gemini precesses the coordinates once they are received. If “Equinox of the Date” is selected, no precession calculation is done and the coordinates are expected to be correct for the current date.

NOTE: These settings only apply to data sent *from* the PC *to* Gemini. Coordinates sent from Gemini to the PC always refer to the Equinox of the current date. This avoids confusion for the software that is controlling the Gemini system.

NOTE: A program can send J2000.0 coordinates (using :Sr, :Sd commands) followed by a precess command :Sp#. Gemini checks its settings and if “Equinox of the date” is active, the precession calculation will be done. If “J2000.0” is active, the coordinates were already precessed after the :Sd command was received and the :Sp# command will not precess them again.

6.5.4 Coordinate Precision

Both LX200 coordinate modes, low and high precision, are supported. After a CMOS reset or the “Restore Defaults” command is executed, Gemini is in High Precision mode. This is different from the LX-200 and may cause problems with programs expecting it to be in Low Precision mode. For this reason, Gemini stores the coordinate mode it was set to, and next time starts up in the same mode as when it was shut down. You can use one of the supported software packages or a terminal emulation program to switch the mode permanently (The command :U# toggles the mode, :P# returns the current setting).

6.6 Using Control Programs

There are several very good control programs available for Gemini which fill many gaps between commercial planetarium programs that target telescope control, and many of the setup options and additional functionality that Gemini offers.

6.6.1 Gemini Control Center – GCC

The Gemini Control Center has been designed as a tool for easy remote setup and for remotely controlling the specific high-level functionality that the Gemini System provides. It has been extensively enhanced recently to control virtually all functions that Gemini Level 4 provides. Most functions are accessible via a comprehensive graphical user interface (GUI), while a very few remaining Gemini functions can be accessed using a Hand Controller Emulation mode that copies the original Hand Controller’s behavior and thereby lets the user control his Gemini System from his living room or observatory exactly the way he would when standing near-by his telescope.

The Gemini Control Center has primarily been designed as a remote setup tool to control the specific, high-level functionality that the Gemini System provides. It has not been developed, however, to function as a planetarium program such as TheSky or a PEC trainer such as PEMPro. It does, however, provide several advanced functions such as Catalog Management, Internet Time Synchronization, Observation Schedule set-up, Precession calculation & conversion, huge databases, advanced activity logging, parameter profiles, and much more. It thereby enhances Gemini’s native comprehensive functionality with many add-on features, and can work in tandem with planetarium software.

Finally, although the Gemini Control Center has been designed as a PC application for MS Windows®, a downsized version featuring the aforementioned Hand Controller Emulation has been designed for Pocket PCs (PDA’s) to completely replace the original Hand Controller with a very functional Bluetooth-based, wireless remote control. More information about this software and the GCC, as well as trial versions, can be found at <http://www.DocGoerlich.com>.

7 Troubleshooting

7.1 Common Error Cases

7.1.1 Gemini Does Not Start

- If the power LED is off, the display stays blank, and the buzzer does not sound, check the power supply and the power cable to the Gemini. Also check the polarity. Applying a voltage with the wrong polarity will not harm the Gemini, but it will not work. If everything looks correct, turn off the power switch and remove the cover plate from the Gemini. Slightly wiggle the power switch and try again. If this works, there may be a problem with the switch. Contact your dealer in this case.
- If the power LED is on, the buzzer does not sound and the display displays one to 5 dots as the leftmost characters, Gemini has detected a problem at startup. Contact your dealer in this case.
- If the power supply is delivering 12 to 18 volts, the power LED is lit and the buzzer continuously beeps, then the CPU will not start up. Check that the EPROM is properly inserted (see Appendix 8.11). Ensure that the notch on the end of the EPROM matches the side where the notch is printed on the board (at the left side) and that it is completely plugged into its socket.

7.1.2 Motor(s) Slew Uncontrollably on Startup

- There may be a poor connection between the main panel and the motor. Check that the cables are firmly plugged into the motors and the electronics box. If this fails, one of the cables, the motor encoder or the motor control circuitry of the Gemini box may be defective.

7.1.3 Mount Tracks in the Wrong Direction

- The tracking direction depends on the mount type and the hemisphere (specified by your latitude setting). Use the “Setup” menu item to check that you have set the correct mount type and the latitude sign (‘+’ for northern, ‘-’ for the southern hemisphere). Set them correctly and restart the mount.

7.1.4 Stalls While Slewing or Tracking

- The mechanics of your mount must be working smoothly to allow Gemini to operate correctly. Check that both axes of your mount move freely when the clutches are loose. Re-lubricate your mount if necessary.
- Before attaching the servomotors to the mount, make sure the worms can be turned easily using your fingers. If there are spots where you cannot turn the worm by hand, then it may be too tight. Refer to your mount’s instructions and adjust the worm against the worm gear until you can turn the worm by hand, but there is only a minimum of play. The worm may have some tight spots that require a looser mesh with the gear; this can result in some spots having more

play than others. The RA worm gear can have somewhat more play than the Dec., but it should not be more than necessary.

- Make sure that the correct mount type is set. Gemini is designed to drive different mounts at different speeds because of their different worm gear ratios.
- Ensure that the motor cables are correctly seated.
- Check the power supply and the power cable. A weak supply or a long power cable with too small a conductor diameter will cause the voltage to drop under load. The power supply and cable must deliver at least 3 amperes of continuous current at 12 to 18 volts. A higher voltage within the range will produce more torque. A regulated power supply whose negative pole is at ground voltage or a battery is recommended.
- Make sure that the telescope is balanced correctly. Making the RA axis *slightly* heavier to the east ensures that the worm is in good contact with the worm gear as it drives forward.
- Reduce both the manual and the GoTo slewing speed for heavy loads.

7.1.5 UTC Date or Time Setting Wrong

- If you are located west of Greenwich England at positive longitudes (such as the American continent), your local time is behind UTC (or GMT). In America, you must set Gemini's timezone setting to GMT-x (x is between 5 and 9 hours depending on the timezone). To calculate the UTC time, you will have to add these hours. If you do this in the evening, you probably will have to advance the date, too. There is a web page <http://www.DocGoerlich.de/utcdate.php> that will show you the current UTC in the correct format for Gemini.
- East of Greenwich at negative longitudes (such as Australia), you have to subtract the timezone value from the local time to get the UTC time.
- If you use a planetarium program like TheSky, be sure to set the timezone correctly before you set date and time. This is very important, since these programs send the civil time to Gemini, and the timezone value is needed to calculate the UTC time that Gemini needs.
- **Note:** Some programs and computer clocks may define their timezones with signs (+/-) opposite to those required by Gemini.

7.1.6 GoTo or Park Commands Are Rejected

- Level 4 software allows you to set important parameters of your mount such as the gearing ratios. Changing these settings while operating the mount using the hand controller or serial commands invalidates the internal position data. The mount state is changed to "Unaligned". It is recommended that you slew the mount manually into the Startup Position and to proceed with a Cold Start for the settings to take effect.
- The mount is positioned outside the Safety Limits in RA. Manually slew back within the limits.
- You have set the safety limits or GoTo limit such that the telescope cannot reach the requested GoTo target. Try resetting the safety limits or GoTo limit to their default values.

7.1.7 GoTo Position is Completely Wrong

- UTC Date/Time, Mount Type and Geographic Location must be set correctly. Be sure to Cold Start the mount after changing these settings, or set them during the startup procedure of the Cold start.
- Be sure to correctly identify the objects you use for alignments. Misidentification of the first alignment star will result in a wrong GoTo position.

7.1.8 Poor Pointing Accuracy

- Make sure your mount is polar aligned within a few degrees of the pole.
- Accuracy is impossible if the mount is not accurately polar aligned and no Additional Alignments have been done. Select some of the Bright Stars in the Alignment menu, center them, and do an “Additional Align.” With the alignment of each object, accuracy should improve.
- Inaccuracy in GoTo operation can occur if you did a meridian flip and have not yet done an Additional Align on this side of the meridian. Gear play and mirror flop are taken into account after the first “Additional Align” on this side of the meridian is done.
- Check that you have not misidentified a star used for an alignment. This would cause the pointing model to be inaccurate.
- For the first few “Additional Align” operations, make sure that the stars used are well spaced in RA, and are accurately centered prior to performing the “Additional Align.”
- Avoid systematic errors when building a pointing model. Many star diagonals will de-center stars when they are rotated relative to the OTA. Rotate the diagonal back to a consistent position before centering objects for alignment.
- For highest accuracy, use the Bright stars of the “Align Telescope” menu for alignments, since their positions are stored with the highest accuracy. Alternatively, use objects transferred from a PC in High Precision mode.
- If pointing at stars and deep sky objects is accurate, but solar system objects are significantly off, the UTC date or time setting may be wrong.

7.1.9 Strange or Garbled Characters in Deluxe Hand Controller Display

- Try using the “Setup→Restore Defaults” menu item to reset the CMOS. Also check to see you have the latest EPROM software.

7.1.10 Mount Takes Too Long to Center Object

- The object may be close to the east or west limit, where it will move the last few degrees in centering mode.

7.1.11 Mount Continuously Beeps

- You have hit the east or west limit. Slew away from limit.

- If this happens immediately after start-up, limits may be incorrectly set. Cold start the mount, and check the limits. Slew to the places where the limits should be and select “Setup→Mount Parameters→Set Safety Limit” for both the east and the west limits.

7.1.12 Autoguider Calibration Problems

- Be certain that you are in Photo Mode or All Speed Mode. The autoguider port will only work in these two modes. Make sure you have not left Gemini in Menu Mode, and that you are using a tracking rate that is appropriate for your observation.
- Make sure you have the correct cable to connect the autoguider to the Gemini. Be sure to use an Optocoupler unit or Relay Box (with appropriate cable) if you have an autoguider without relays and an older Gemini (motor cables use RJ-45 connector). If your Gemini unit uses DIN connectors for the motors, you *can* connect TTL output autoguiders directly to Gemini. Refer to Appendix 8.6 for more details.
- If RA calibration works but Dec. does not, check the backlash in the Dec. gear. Set the TVC or increase the autoguider’s hysteresis setting.

7.1.13 Gemini Displays “Autoguider Error”

- This message indicates that Gemini received contradictory signals (RA+ and RA- or DEC+ and DEC-) at the same time. If this happens occasionally, it can be ignored. Otherwise check the cable from the autoguider to the Gemini and keep it as short as possible. Do not use a twisted cable; it could induce spurious signals from one wire to the other.

7.1.14 Serial Communications Problems

- Ensure that you are using the correct cable between Gemini and the PC or GPS receiver. Refer to Appendix 8.5 for details.
- Start Gemini in Debug Mode and look at the information buffer to see if data is actually being received from the PC. Refer to section 7.2 below.
- If you are using a PC with a fast CPU and buffered serial I/O circuitry, the microcontroller of the Gemini system may not be fast enough to receive and store all characters sent to it. Check the setting of the communication port of your PC and disable the 16550A serial controller’s FIFO. You can try to use a smaller FIFO send buffer first.
- See also section 6.1.3.

7.1.15 "CMOS reset" Message upon Startup or Incorrect Date/Time

- The internal Li battery was exchanged or is low. Power off the Gemini and open the Gemini electronics unit. Replace the internal battery with a fresh one. Older Gemini units use a CR2032 Li battery, while newer units use a CR2354 Li battery. Be sure to replace the battery with the same type that came with your Gemini. After you power up the Gemini again, you will see this message. Use

the “Setup” menu to set all of the appropriate settings for your mount (see chapter 2). If the problem persists, contact your dealer.

Note: Mountain Instruments and some Losmandy dealers set some mount parameters such as latitude and longitude to the correct value for individual customers before shipping the mounts. Replacing the battery resets all values, including mount type, latitude and longitude to their default values, requiring the user to enter the correct values for their location.

7.1.16 Gemini Displays “DEC/RA motor lags”

- This message indicates that one of the servo motors (either RA or Dec. depending on the exact message) is not moving as smoothly as it should, typically at slow speeds (guiding and/or tracking). It is detected when the motor is some number of steps away from the expected position, and Gemini increases the amount of current to the motor in order to get it to move. This may be caused by a tight spot in the gear mesh or by a balance problem. If higher current continues to flow in order to overcome whatever problem exists, the motor will heat up and may eventually burn out. This message is an early warning that you should check the motor temperature, and possibly adjust your worm mesh or the mount balance.

7.2 Debug Mode

If you have problems with the serial link to your computer or your planetarium software, you can press one of the Hand Controller keys while powering up. Doing this will put Gemini into "Debug Mode" and show all commands that are received from the PC in the Information Buffer. You can scroll through this buffer with the "Show Information" menu item. You should see the commands sent by the software (omitting numerical values), that are ASCII characters (e.g. ":GR#:GD#"). If not, the serial link is not operational.

The phrase "Debug Mode" is appended to the welcome message when Gemini is started up in Debug Mode.

8 Appendices

8.1 Gemini Menus

Align Telescope

- |GoTo Bright Star
- |{Reset Alignment}
- |{Additional Align}
- |Synchronize
- |{Polar Al. Assist}
- |{Polar Axis Corr.}

(Available only if there was a pointing model established)

Object Database

- |Messier
- |NGC
- |IC
- |Sh2
- |Solar System
- |Bright Stars
- |SAO
- |WDS
- |GPN
- |LDN
- |LBN
- |{User Defined}

(available only if the user downloaded catalog objects)

Show Information

{GoTo <object>}

{Guide → <object>}

Coordinates

- |RA/DEC Display
- |Enter RA/DEC
- |Az/El Display
- |Enter Az/El
- |Set Bookmark (0 ≤ n ≤ 9, where n is number of bookmark)
- |{GoTo Bookmark #n} (n = bookmark number)

Identify

- |New Selection
- |Continuous Ident
- |{Previous Objects}

- ||M/NGC/IC/Sh2 Cat (submenu for both “New Selection” and “Continuous Ident”)
- ||Messier Objects
- ||NGC Objects
- ||IC Objects
- ||Sharpless 2 Obj.

- |||Arbitrary Obj. (submenu for all kinds of objects)
- |||Stellar Objects
- |||NonStellar Obj.
- |||Planetaries/SNR
- |||Galaxies
- |||Clusters
- |||Nebulae

- ||||All Magnitudes (submenu for all kinds of objects)
- ||||Magnitude < 15m0
- ||||Magnitude < 14m0
- ||||Magnitude < 13m0
- ||||Magnitude < 12m0
- ||||Magnitude < 11m0
- ||||Magnitude < 10m0

Object Search

- |FOV 2 degrees
- |FOV 1.5 degrees
- |FOV 1 degree
- |FOV 50 arcmin
- |FOV 40 arcmin
- |FOV 30 arcmin
- |FOV 20 arcmin
- |FOV 10 arcmin
- |FOV 5 arcmin
- |Wobble Object

Show Date/Time

- |UTC Date/Time
- |Julian Date
- |Civil Time
- |Local Sidereal

Setup

- |Hand Controller
 - ||Visual Mode: C-S
 - ||Photo Mode: G-C
 - ||All Speeds: G-C-S
- |Mount Parameters
 - ||Tracking Speed
 - |||Sidereal
 - |||Lunar
 - |||Solar
 - |||Adaptive King
 - |||None/Terrestrial
 - |||Closed Loop

- |||Comet Tracking
 - ||||Train Tracking
 - ||||Calculate Rates
 - |||||1st RA/DEC pos., 2nd RA/DEC pos., Hours
 - ||||Enter RA Rate
 - ||||Enter DEC Rate
 - ||||{Activate} (available only if rate has been set)
- ||Moving Speeds
 - |||Guiding:
 - |||Centering:
 - |||Slewing:
 - |||GoTo:
- ||TVC Value:
- ||PEC
 - |||Train PEC
 - |||Maximum Pulses
 - |||{Clear Data}
 - |||{Turn PEC Off (if On)} OR Turn PEC On (if Off)
 - |||{Delay Correction}
 - |||{Drift Correction}
 - |||{Smooth Data}
 - |||{Average Data}
 - |||{Restore Data}
- ||Mount Type
 - |||Losmandy GM-8
 - |||Losmandy G-11
 - |||Losmandy HGM 200
 - |||M.I. MI-250
 - |||Losmandy Titan
 - |||L. Titan (50:1)
 - |||Custom Mount
 - ||||RA Spur
 - ||||RA Worm
 - ||||DEC Spur
 - ||||DEC Worm
 - ||||RA M.Enc
 - ||||DEC M.Enc
- ||Set Safety Limit
 - |||Confirm to Set
 - |||Reset to Defaults
 - |||Set East:
 - |||Set West:
 - |||Set GoTo:
- ||Set Home Posit.
- ||{Pointing Model}
 - |||Undo Last Align

- |||Store Model #<n>
 - |||Reload Model #<n>
- |Encoder
 - ||EncRes RA
 - ||EncRes DEC
 - ||Test Encoder
 - ||Use/Ignore Encoder
 - ||Use/Ign End Switches
- |Alarm/Buzzer
 - ||Activate Alarm (if off) OR Set Alarm Off (if on)
 - |Set Alarm Time
 - ||Turn Buzzer Off (if on) OR Turn Buzzer On (if off)
- |UTC Date/Time
- |Credit Info
- |Restore Defaults
 - ||> Losmandy
 - ||>Mountain Instr.
- |Dim Display
 - ||100% Brightness
 - ||53% Brightness
 - ||40% Brightness
 - ||27% Brightness
 - ||20% Brightness
 - ||13% Brightness
 - ||6.6% Brightness
- |Geogr. Location
 - ||Longitude
 - ||Latitude
 - ||Timezone
 - ||Query GPS Rec.
 - ||Store Site
 - ||Load Site
 - ||Name Site
- |Communication
 - ||Coordinate Epoch
 - |||Equinox of Date
 - |||Epoch J2000.0
 - ||RS232 Speed
 - ||GPS Rx Speed
 - ||Serial HC Speed
 - |||4800 bit/s (submenu for all Speed items)
 - |||9600 bit/s
 - |||14400 bit/s
 - |||19200 bit/s
 - |||28800 bit/s
 - |||38400 bit/s

||Sync or Align
|||Sync only
|||Sync ↔Add.AI.

QuickMenu

{Focusing} (only available if focuser board connected)
Focus In, Focus Out with RA buttons, Focus Slow, Focus Fast with DEC buttons
→ Photo Mode / → Visual Mode
Reduced Menu/Full Menu*
Centering
|Exit w/o Change
|2x Centering
|8x Centering
|16x Centering
|32x Centering
|64x Centering
|128x Centering
Park Mount!
|Exit w/o Change
|Park at CWD pos!
|Park @HOME pos!
|Stop Tracking!
{Meridian Flip} (if possible)
Exit w/o Change

Cold Start Setup Menu

UTC Date/Time
Mount Type
Longit.
Latitude

*Reduced Menu

Align Telescope (only available while scrolling upwards with DEC+)
Object Database
Show Information
{GoTo <object>}
Coordinates

8.2 Catalogs

Level 4 software contains

- 8290 objects of the New General Catalog (NGC)
- 5437 objects of the Index Catalog (IC)
- 110 Messier objects
 - Credits for compiling the above data goes Wolfgang Steinicke. For a list of the objects, please visit the pages of Wolfgang Steinicke at the site of the NGC/IC project (<http://www.ngcic.org>).
- 17636 SAO stars down to 7th magnitude
- 169 Bright Stars with common names
- 313 HII objects of the Sharpless 2 catalog
- 8 Planets, Sun and Moon.
- 3989 Double Stars selected from the Washington Double Star catalog,
- 1143 Planetary Nebulae of the Strasbourg/ESO Galactic Planetary Objects catalog, including most objects of the PK (Perek, Kohoutek) catalog
- 1802 Dark Nebulae from Lynds' Catalog of Dark Nebulae
- 1125 Bright Nebulae from Lynds' Catalog of Bright Nebulae

... and 4000+ User Catalogs objects down- and uploadable via the serial interface.

You can prepare your observations by building user catalogs using your computer and downloading them into the Gemini using the Gemini Control program. Well prepared observing, together with the automatic logging of your actions, can be much more effective.

For complete listings of the contents of each catalog, go to the Gemini website at <http://www.docgoerlich.de/Rene.html>

8.3 Alignment Star List

Although Gemini can perform an alignment or sync operation on any object, it is often most convenient to use the “GoTo Bright Star” function under the “Align Telescope” menu. This function allows you to select from a list of bright stars currently above the horizon. To aid in selecting appropriate stars, this table lists all of the 49 stars available in the “GoTo Bright Star” function. It is sorted by Right Ascension.

Gemini Name	Const	Bayer	Flamsteed	RA	Dec	Mag.
Alpheratz α And	And	Alpha	21	00h08.4m	+29°05'26"	2.1
Algenib γ Peg	Peg	Gamma	88	00h13.2m	+15°11'00"	2.8
Diphda β Cet	Cet	Beta	16	00h43.6m	-17°59'12"	2.0
Mirach β And	And	Beta	43	01h09.7m	+35°37'14"	2.1
Achernar α Eri	Eri	Alpha		01h37.7m	-57°14'12"	0.5
Hamal α Ari	Ari	Alpha	13	02h07.2m	+23°27'45"	2.0
Polaris α UMi	UMi	Alpha	1	02h31.8m	+89°15'51"	2.0
Mekab/Menkar α Cet	Cet	Alpha	92	03h02.3m	+04°05'23"	2.5
Mirfak α Per	Per	Alpha	33	03h24.3m	+49°51'40"	1.8
Zaurak γ Eri	Eri	Gamma	34	03h58.0m	-13°30'31"	3.0
Aldebaran α Tau	Tau	Alpha	87	04h35.9m	+16°30'33"	0.9
Rigel β Ori	Ori	Beta	19	05h14.5m	-08°12'06"	0.1
Capella α Aur	Aur	Alpha	13	05h16.7m	+45°59'53"	0.1
Betelgeuse α Ori	Ori	Alpha	58	05h55.2m	+07°24'25"	0.5
Canopus α Car	Car	Alpha		06h24.0m	-52°41'45"	-0.7
Sirius α CMa	CMa	Alpha	9	06h45.1m	-16°42'58"	-1.5
Castor α Gem	Gem	Alpha	66	07h34.6m	+31°53'18"	2.0
Procyon α CMi	Cmi	Alpha	10	07h39.3m	+05°13'30"	0.4
Pollux β Gem	Gem	Beta	78	07h45.3m	+28°01'34"	1.2
Alphard α Hyd	Hyd	Alpha	30	09h27.6m	-08°39'31"	2.0
Regulus α Leo	Leo	Alpha	32	10h08.4m	+11°58'02"	1.4
Dubhe α UMa	UMa	Alpha	50	11h03.7m	+61°45'04"	1.8
Zosma	Leo	Delta	68	11h14.1m	+20°31'25"	2.6
Denebola β Leo	Leo	Beta	94	11h49.1m	+14°34'19"	2.1
Gienah γ Cor	Cor	Gamma	4	12h15.8m	-17°32'31"	2.6
Acrux α Cru	Cru	Alpha		12h26.6m	-63°05'57"	1.3
Vindemiatrix ϵ Vir	Vir	Epsilon	47	13h02.2m	+10°57'33"	2.9
Mizar ζ UMa	UMa	Zeta	79	13h23.9m	+54°55'31"	2.3
Spica α Vir	Vir	Alpha	67	13h25.2m	-11°09'41"	1.0
Hadar β Cen	Cen	Beta		14h03.8m	-60°22'23"	0.6
Arcturus α Boo	Boo	Alpha	16	14h15.7m	+19°10'57"	-0.0
Alpha Centauri, Rigel Kentaur	Cen	Alpha		14h39.6m	-60°50'02"	-0.0
Zuben Elgenubi	Lib	Alpha	8	14h50.7m	-15°59'50"	2.8
Unukalhai α Ser	Ser	Alpha	24	15h44.3m	+06°25'32"	2.6

Antares α Sco	Sco	Alpha	21	16h29.4m	-26°25'55"	1.0
Kornephoros β Her	Her	Beta	27	16h30.2m	+21°29'23"	2.8
Shaula λ Sco	Sco	Lambda	35	17h33.6m	-37°06'14"	1.6
Ras Alhague α Oph	Oph	Alpha	55	17h34.9m	+12°33'36"	2.1
Kaus Australis ϵ Sge	Sge	Epsilon	20	18h24.2m	-34°23'05"	1.8
Vega α Lyr	Lyr	Alpha	3	18h36.9m	+38°47'01"	0.0
Nunki σ Sge	Sge	Sigma	34	18h55.3m	-26°17'48"	2.0
Albireo β Cyg	Cyg	Beta	6	19h30.7m	+27°57'35"	3.1
Altair α Aql	Aql	Alpha	53	19h50.8m	+08°52'06"	0.8
Deneb α Cyg	Cyg	Alpha	50	20h41.4m	+45°16'49"	1.2
Sadalsuud β Aqu	Aqu	Beta	22	21h31.5m	-05°34'16"	2.9
Eniph ϵ Peg	Peg	Epsilon	8	21h44.2m	+09°52'30"	2.4
Sadalmelik α Aqu	Aqu	Alpha	34	22h05.8m	-00°19'11"	3.0
Fomalhaut α PsA	PsA	Alpha	24	22h57.7m	-29°37'20"	1.2
Markab α Peg	Peg	Alpha	54	23h04.8m	+15°12'19"	2.5

8.4 Serial Line Protocol

The Gemini system supports a subset of the Meade®² LX200 Command Set making it compatible with many planetarium programs. Programs and drivers (such as the Gemini ASCOM driver) which specifically support Gemini can make use of these LX200 style commands as well as Gemini extensions described below. From Level 2 up, nearly all Gemini parameters and settings can be downloaded or uploaded using the native command set described at the end of the section.

Syntax: values in <> are (to be) replaced by actual values. Curled brackets { } show alternative characters.

Upon completion, ASCII characters or strings are returned, if indicated.

Command	Returns	Remarks
0x06 (ACK char)	B# while the initial startup message is being displayed (new in L4), b# while waiting for the selection of the Startup Mode, S# during a Cold Start (new in L4) or G# after completed startup.	Usable for testing the serial link and determining the type of mount (German equatorial). During Startup, with a "b#" being returned, the PC can select the startup mode by sending a <ul style="list-style-type: none"> • bC# for selecting the Cold Start, • bW# for selecting the Warm Start and • bR# for selecting the Warm Restart.
Synchronize		
:Cm#	No object!# or <object name>#	The string "No object!#" is returned if the mount is not aligned or no object was selected, otherwise the name of the selected object used is returned. This command does an "Additional Alignment", (re)calculating the pointing model parameters and synchronizing to the position given.
:CM#	No object!# or	The string "No object!#" is

² Meade® is a trademark registered by Meade Instruments Corporation, California, USA.

	<object name>#	returned if the mount is not aligned or no object was selected, otherwise the name of the selected object used is returned. The position (RA and DEC) is synchronized to the position of the object without affecting the modeling parameters.
Focus Control		
:F+#		Focus In
:F-#		Focus Out
:FQ#		Stop focusing
:FF#		Focus Fast
:FM#		Focus Medium
:FS#		Focus Slow
Get Information		
:GA#	In High Precision mode: {+-} <dd>:<mm>:<ss># In Low Precision mode: {+-}<dd>°<mm>#	Get Altitude (from L1, V2.0 up)
:GB#	<n>#	Get LED Display Brightness Value(from L1, V2.0 up) n=0: 100% n=6: 6.6% n=7: blank display n=8: test mode (all pixels lit).
:GC#	<mm>/<dd>/<yy>#	Local Calendar Date, month mm, days dd and years yy separated by slashes.
:Gc#	12# or 24#	Clock Format
:GD#	In High Precision mode: {+-} <dd>:<mm>:<ss># In Low Precision mode: {+-}<dd>°<mm>#	Apparent (refraction included) Declination the telescope is pointing to, to the equinox of the date. Despite during GoTo operations, the coordinates are corrected according to the pointing model.

		Signed degrees (-90 to +90), minutes, seconds. The degree sign in Low Precision mode is the character 0xDF.
:GE#	<hh>:<mm>:<ss>#	Get Alarm time (from L1, V2.0 up)
:GG#	{+-}<hh>#	Get the number of hours by which your local time differs from UTC (from L1, V2.0 up). If your local time is earlier than UTC this command will return a positive value, if later than UTC the value is negative.
:Gg#	{+-}<ddd>°<mm>#	Get Site Longitude (from L1, V2.0 up)
:GH#	[-]<hh>:<mm>:<ss>#	Hour Angle the telescope is pointing to. From L4, V1.0 up.
:GL#	<hh>:<mm>:<ss>#	Civil Time (UTC time from the internal Real Time Clock + UTC offset), hours, minutes, seconds in 24-hour format.
:Gm#	{EW}#	Get Telescope Mount's Side of Meridian. E# for East or W# for West side is replied. From L4, V1.0 up.
:GM#	<name string>#	Name (up to 15 characters) of the first site stored.
:GN#	<name string>#	Name (up to 15 characters) of the second site stored.
:GO#	<name string>#	Name (up to 15 characters) of the third site stored.
:GP#	<name string>#	Name (up to 15 characters) of the fourth site stored.
:GR#	High Precision mode: <hh>:<mm>:<ss># Low Precision mode: <hh>:<mm>.<m>#	Apparent (refraction included) Right Ascension the telescope is pointing to, to the equinox of the date. Except during GoTo operations, the coordinates are corrected according to the pointing model.

		Hours (0 to 24), minutes, seconds or tenth of minutes.
:GS#	<hh>:<mm>:<ss>#	Sidereal Time. From L4, V1.0 up.
:Gt#	{+-}<dd>°<mm>#	Get Site Latitude (from L1, V2.0 up)
:GV#	<l><vv>#	Get Software Level l (one digit) and Version vv (two digits)
:GVD#	<mm> <dd> <yyyy>#	Get Software Built Date (from L4, V1.0 up)
:GVN#	<l>.<vv>#	Get Software Level l (one digit) and Version vv (two digits) (from L4, V1.0 up)
:GVP#	Losmandy Gemini#	Product String (from L4, V1.0 up)
:GVT#	<hh> <mm> <ss>#	Get Software Built Time (from L4, V1.0 up)
:Gv#	N (for "no tracking") T (for Tracking) G (for Guiding) C (for Centering) S (for Slewing)	Get Velocity (from L1, V2.0 up)
:GZ#	In High Precision mode: <ddd>:<mm>:<ss># In Low Precision mode: <ddd>°<mm>#	Get Azimuth. From North over East. (From L4, V1.0 up)
Home Position		
:hP#		Move to Home Position. The Home Position defaults to the celestial pole visible at the given hemisphere (north or south) and can be set by the user at the Gemini.
Startup Position		
:hC#		Move to the Startup Position. This position is the position required for a Cold or Warm Start, pointing to the celestial pole of the given hemisphere (north or south), with

		the counterweight pointing downwards (CWD position). From L4, V1.0 up.
:hN#		Sleep Telescope: stop tracking, blank displays.
:hW#		Wake Up Telescope, restart tracking.
:h?#	2: Home/CWD move in progress 1: Home/CWD move done 0: Home/CWD move failed or no home/CWD move command was received.	Move to Home/CWD Position Status Inquiry
Move Telescope		Note: the directions mentioned depend upon the hemisphere of the observing site and the side of the mount the telescope actually is. Directions do not change when crossing one of the poles.
:MA#	0 1Object below horizon.# 2No object selected.# 3Manual Control.#	Slew to an object. The object selection had to be done by sending the Sz and Sa commands with the horizontal (Azimuth and Altitude) object coordinates. This command will be rejected while the system is in Manual Mode, f.i. identifying or selecting an object from the internal databases. From L4, V1.0 up.
:MF<n>#	#	Move Find: For n=0 the position is changed ("wobbled") shaping an X with 5 arcmin legs moving at a quarter of the centering speed to detect faint objects.
:ML#	#	Move Lock: Slew commands :MS# and :MA# will be suppressed, error code 3 (Manual Control) will be returned.

:Ml#	#	Move Unlock: Slew commands :MS# and :MA# will be executed again.
:Mf#	0 1Object below horizon.# 3Manual Control.# 4Position unreachable.#	Do a meridian flip and slew to the current coordinates.
:MM#	0 1Object below horizon.# 2No object selected.# 3Manual Control.# 4Position unreachable.# 5Not aligned.# 6Outside Limits.#	Slew to an object, doing a meridian flip if possible. Selection has had to be done locally (from Gemini's databases) or by sending the Sr and Sd commands with the equatorial object coordinates. This command will be rejected while the system is in Manual Mode, f.i. identifying or selecting an object from the internal databases.
:MS#	0 1Object below horizon.# 2No object selected.# 3Manual Control.# 4Position unreachable.# 5Not aligned.# 6Outside Limits.#	Slew to the selected object. Selection is done locally (from Gemini's databases) or by sending the Sr and Sd commands. This commands will be rejected if the system is in Manual Mode, f.i. Identifying or selecting an object from the internal databases.
:Me#		Move eastwards at the selected speed rate.
:Mw#		Move westwards at the selected speed rate.
:Mn#		Move northwards at the selected speed rate.
:Ms#		Move southwards at the selected speed rate.
Precision Guiding		
:Ma<direction><arcsecs>#		Moves into <direction> "e", "w", "n", "s" for <arcsecs> arc seconds. <arcsecs> are converted into motor encoder ticks, the result

		must not exceed 255 or will be cut off modulo 256.
:Mi<direction><steps>#		Moves into <direction> "e", "w", "n", "s" for <steps> (1 <= steps <= 255) motor encoder ticks.
:Mg<direction><time>#		Moves into <direction> "e", "w", "n", "s" for <time> milliseconds. <time> is converted into motor encoder ticks, the result must not exceed 255 or will be cut off modulo 256.
Object/Observing		
:OC#		Clears the Observing Log.
:OI<catalog-id><object-id>#		Select an object object-id from Gemini's internal databases. Catalog-id is a character selecting one of the internal catalogues: '1': Messier, '2': NGC, '3': IC, '4': Sh2, '7': SAO, ':': LDN, ';': LBN. Object-id is a numeric designation of the object in the catalogue; it can be followed by an extension character for NGC and IC catalogues.
:ON<name>#		Tells the Gemini system the name or identification of the selected object. If this command is not used, the name defaults to "PC Object". Using this command is recommended between the :Sr and :Sd commands for equatorial coordinates or the :Sz and :Sa commands for horizontal coordinates respectively. From L4, V1.0 up.
:OR#	<log entry>#	Reads the next line from the Observing Log.
:OS#		Points to the beginning of the Observing Log.
:Oc#		Delete all User Catalog entries.

:Od<object line>#		<p>Download a User Catalog entry to the Gemini. The object line consist of</p> <ul style="list-style-type: none"> • the object name (up to 10 ASCII characters), • a comma ',' as delimiter, • Right Ascension <hh>:<mm>:<ss>, • Declination {+-}<dd>:<mm>:<ss>. <p>The coordinates have to be given for the epoch 2000.0.</p>
:On#	<n>#	0 <= n <= 4096: Read current number of Gemini's User Catalog entries.
:Or#	<object line>#	Upload a User Catalog entry from the Gemini.
:Os#		Points to the beginning of the User Catalog (for downloading).
Precession and Refraction		
:p0#		No precession calculation necessary in the Gemini. Coordinates transferred to the Gemini are already precessed to the equinox of the date. Refraction is not calculated.
:p1#		Precession calculation is to be done by Gemini. Coordinates transferred to the Gemini refer to the standard epoch J2000.0. Refraction is not calculated.
:p2#		No precession calculation necessary in the Gemini. Coordinates transferred to the Gemini are already precessed to the equinox of the date. Refraction is calculated. From L4, V1.0 up.
:p3#		Precession calculation is to be done by Gemini. Coordinates

		transferred to the Gemini refer to the standard epoch J2000.0. Refraction is calculated. From L4, V1.0 up.
Precision		
:P#	HIGH PRECISION or LOW PRECISION	Both strings are 14 characters long (there are 2 blanks between LOW and PRECISION).
:U#		Toggle between Low Precision (short) and High Precision (long) mode. The system is in High Precision mode after starting up.
Quit Moving		
:Q#		Quit all movements mentioned below.
:Qe#		Quit movement eastwards.
:Qw#		Quit movement westwards.
:Qn#		Quit movement northwards.
:Qs#		Quit movement southwards.
Rate		
:RC#		Rate Center. Subsequent Move commands will move at Centering Speed.
:RG#		Rate Guide. Subsequent Move commands will move at Guiding Speed.
:RM#		Rate Move. Subsequent Move commands will move at Centering Speed.
:RS#		Rate Slew. Subsequent Move commands will move at Slewing Speed.
Set		
:Sa{+-}<dd>{*°}<mm># or :Sa{+-}<dd>{*°: <mm>:<ss>#	0 if invalid or 1 if valid	Sets the object's altitude. A negative sign is ignored. Values greater than 90 degrees are set to 90 degrees. It is important that the

		:Sz# command has been sent prior. If the coordinate selection is valid the object status is set to "Selected". From L4, V1.0 up.
:SB<n>#		Set LED Display Brightness Value(from L1, V2.0 up) n=0: 100% n=6: 6.6% n=7: blank display n=8: test mode (all pixels lit).
:SC<mm>/<dd>/<yy>#	0 if invalid or 1 Updating planetary data# <24 blanks>#	Set Calendar Date: months mm, days dd, year yy of the civil time according to the timezone set. The internal calendar/clock uses GMT.
:SE<hh>:<mm>:<ss>#	1	Set Alarm Time from the civil time hours hh, minutes mm and seconds ss. The timezone must be set before using this command.
:SG{+-}hh#	1	Set the number of hours by which your local time differs from UTC. If your local time is earlier than UTC set a positive value, if later than UTC set a negative value. The time difference has to be set before setting the calendar date (SC) and local time (SL), since the Real Time Clock is running at UTC.
:SL<hh>:<mm>:<ss>#	1	Set RTC Time from the civil time hours hh, minutes mm and seconds ss. The timezone must be set before using this command.
:Sd{+-}<dd>{*°}<mm># or :Sd{+-}<dd>{*°}<mm>:<ss>	0 if invalid or 1 if valid	Sets the object's declination. It is important that the :Sr# command has been send prior. Internal calculations are done that may take up to 0.5 seconds. If the coordinate selection is valid the object status is set to "Selected".
:SM<name string>#	1	Set name of the first site stored. The minimum length of site name strings is 1 byte, the maximum length 15 bytes.

:SN<name string>#	1	Set name of the second site stored.
:SO<name string>#	1	Set name of the third site stored.
:SP<name string>#	1	Set name of the fourth site stored.
:Sg{+-}<ddd>*<mm>#	1 if valid	Sets the longitude of the observing site to ddd degrees and mm minutes. The longitude has to be specified positively for western latitudes (west of Greenwich, the plus sign may be omitted) and negatively for eastern longitudes. Alternatively, 360 degrees may be added to eastern longitudes.
:Sp#	No object!# 1 if object coordinates were set.	Precess coordinate transmitted by means of :Sr and :Sd to the equinox of the date.
:Sr<hh>:<mm>.<m># or :Sr<hh>:<mm>:<ss>#	0 if invalid or 1 if valid	Sets the object's Right Ascension and the object status to "Not Selected". The :Sd# command has to follow to complete the selection. The subsequent use of the :ON...# command is recommended.
:St{+-}<dd>*<mm>#	1 if valid	Sets the latitude of the observing site to dd degrees, mm minutes. The minus sign indicates southern latitudes, the positive sign may be omitted.
:Sw<n>#	1 if valid	Sets the Slewing rate for the Move commands
:Sz<ddd>{*°}<mm># or :Sz<ddd>{*°}<mm>:<ss>#	0 if invalid or 1 if valid	Sets the object's azimuth. From L4, V1.0 up.
Site Selection		
:W<n>#		Select stored site n (0-3)

Gemini Native Commands

Many of Gemini's system settings that cannot be accessed using the LX200-like command set can be read or modified using the native command set implemented in Gemini. The native commands follow a simple syntax:

Gemini Native Commands	Return Value	Description
<<id>:<checksum>#	<parameter value><checksum>#	Get Value(from L2 up)
><id>:<parameter value><checksum>#		Set Value(from L2 up)

Id's and possible values in Level 4, Version 1.0:

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
0..6			0: Custom Mount 1: GM8 2: G-11 3: HGM-200 4: MI-250 5: Titan 6: Titan50	Mount Type. Custom mount support (Id 0 and also commands 21..28) is new in L4. Attention: The CI-700 entry was replaced by the MI-250. CI-700 can be supported as a custom mount.
10, 11..15			10: Neither use encoder nor end switches 11: Use Encoder 12: Test Encoder 13: Ignore Encoder 14: Use end switches 15: Don't use end switches	Axis Encoder port status. 10 can be used for requesting.
21		{+-}80..720	{+-}80..720	RA worm gear ratio. The sign indicates the direction. Note: The 1,296,00 arcsec of a circle divided by the

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				product of worm gear ratio, spur gear ratio and motor encoder resolution define the step size per encoder tick. Gemini L4 supports step sizes from 0.1 arcsec/tick to 2.5 arcsec/tick. Combinations exceeding this range are not allowed.
22		{+-}80..720	{+-}80..720	DEC worm gear ratio. The sign indicates the direction. See note for command 21.
23		20..150	20..150	RA spur gear ratio. See notes for commands 21 and 27.
24		20..150	20..150	DEC spur gear ratio. See note for command 21.
25		100..2048	100..2048	RA motor encoder resolution. See notes for commands 21 and 27.
26		100..2048	100..2048	DEC motor encoder resolution. See note for command 21.
27			2000..25600	Number of RA steps for one worm revolution (since is a product of spur ratio and motor encoder ratio, this command can only be used for reading out the

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				maximum step count, not for setting it). Note: This product must not exceed 25600. If higher values are reported the combination of RA spur gear ratio and motor encoder is invalid.
28			2000..25600	Number of Dec. steps for one worm revolution (since is a product of spur ratio and motor encoder ratio, this command can only be used for reading out the maximum step count, not for setting it).
99			Decimal sum of 1: Telescope is Aligned, 2: Modeling in use, 4: Object is selected, 8: GoTo operation is performed, 16: RA limit reached, 32: Precess coordinates from J2000.0 to the equinox of the date.	Status Inquiry.
100		{+}2048..32768	{+}2048..32768	Encoder Resolution in RA.
110		{+}2048..32768	{+}2048..32768	Encoder Resolution in DEC.
120		20..2000	20..2000	Manual Slewing Speed.

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
130, 131..137			131: Sidereal 132: King Rate 133: Lunar 134: Solar 135: Terrestrial Mode 136: Closed Loop 137: Comet/User Defined	Tracking Rate. 130 can be used for requesting.
140		20..2000	20..2000	GoTo Slewing Speed.
150		0.2..0.8	0.2..0.8	Guiding Speed.
160, 161..163			161: Visual Mode 162: Photo Mode 163: All Speeds	Hand Controller Mode. 160 can be used for requesting.
170		1..255	1..255	Centering Speed.
180, 181..182			181: Alarm Off 182: Alarm On	Alarm Mode. 180 can be used for requesting.
190, 191..192			191: RA Motor stopped. 192: RA Motor moving.	RA Motor Movement. Command 190 can be used to obtain the current status, 191 for stopping and 192 for restarting the tracking.
200		0..255	0..255	TVC Step Count.
201		{+}0..65535	{+}0..65535	Modeling Parameter A (Polar Axis Misalignment in Azimuth), in seconds of arc.
202		{+}0..65535	{+}0..65535	Modeling Parameter E (Polar Axis Misalignment in Elevation), in seconds of arc.
203		{+}0..65535	{+}0..65535	Modeling Parameter

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				NP (Axes Non-Perpendicularity at the Pole), in seconds of arc.
204		{+}0..65535	{+}0..65535	Modeling Parameter NE (Axes Non-Perpendicularity at the Equator), in seconds of arc.
205		{+}0..65535	{+}0..65535	Modeling Parameter IH (Index Error in Hour Angle), in seconds of arc.
206		{+}0..65535	{+}0..65535	Modeling Parameter ID (Index Error in Declination), in seconds of arc.
207		{+}0..65535	{+}0..65535	Modeling Parameter FR (Mirror Flop/Gear Play in RA), in seconds of arc.
208		{+}0..65535	{+}0..65535	Modeling Parameter FD (Mirror Flop/Gear Play in Declination), in seconds of arc.
209		{+}0..65535	{+}0..65535	Modeling Parameter CF (Counterweight & RA axis Flexure), in seconds of arc.
211		{+}0..65535	{+}0..65535	Modeling Parameter TF (Tube Flexure), in seconds of arc.
220			<ddd>d<mm>; <ddd>d<mm>	Set the respective Safety Limit to the current position. The Get function returns the eastern and

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				western safety limits currently set. NOTE: Gemini will automatically compensate if you change hemispheres by swapping the eastern and western limits. This is because the mount is oriented northwards in the northern hemisphere and southwards in the southern hemisphere and so the side of the mount that faces east in the northern hemisphere will face west in the southern hemisphere and vice versa.
221		<ddd>d<mm>	<ddd>d<mm>	Get/Set eastern Safety Limit with respect to the meridian in degrees ddd and minutes mm. See note at command 220.
222			<ddd>d<mm>	Get/Set western Safety Limit with respect to the meridian in degrees ddd and minutes mm. See note at command 220.
223		<ddd>d<mm>	<ddd>d<mm>	Get/Set Western GoTo limit (with respect to the meridian) in degrees ddd and minutes mm from the CWD

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				<p>position. GoTo operations will include a meridian flip if necessary to stay outside this limit. Note: If the RA angles usable for GoTo operations (East Safety Limit to Western GoTo limit) are not sufficient to point to any location, GoTo operations to unreachable locations will be refused and the hand controller will display "Interrupted". A zero value (000d00) indicates that the GoTo Limit wasn't set yet and the default (002d30 from the western safety limit) is to be used.</p>
230			<east>;<west>	<p>Get physical Safety Limits in clusters of 256 motor encoder ticks. See note at command 220.</p>
235			<ra_clusters>;<dec_clusters>	<p>Get current physical RA and DEC axes position in clusters of 256 motor encoder ticks.</p>
237			<ra_clusters>;<dec_clusters>	<p>Get the size of an half circle of RA;DEC in clusters of 256 motor encoder ticks.</p>

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
311		0..15	0..63	Feature Port Status. 4 bits (0..15) can be used for setting input/output bits, 6 bits (including two additional input only bits 16 and 32, extending the range to 0..63) are available for input.
312			0..15	Encoder Port Status. 4 bits (0..15) can be used for reading or setting input/output bits if it is not intended to connect mount axis encoders but to use these channels alternatively.
411		256..65535	256..65535	RA comet tracking rate divisor. The RA timer runs at 1.5 MHz, using this divisor the tracking rate can be adapted to the (mount dependent) speed of an object to be tracked. Attention: several internal prescalers may be used for further dividing down the frequency.
412		{+-}0..65535	{+-}0..65535	Dec. comet tracking rate divisor. Attention: Changed Meaning! In L3, there was no timer for Dec. comet tracking available,

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				<p>the DEC divisor referred to the number of RA steps to be done for one step in Dec. New in L4, the divisor value counts the number of internal timer ticks (at 22.888 18359 Hz) per one step in Dec., independently from RA. This corresponds to 0.657154312 arcsec/tick. A zero value disables comet tracking Dec. movements.</p>
413		0..65535	0..65535	<p>RA- (slow, eastwards) guiding rate divisor. While guiding eastwards, an additional 4x prescaler is active. A value of zero returned means a prescaler set to 65536.</p>
414		0..65535	0..65535	<p>RA+ (fast, westwards) guiding rate divisor.</p>
415		0..65535	0..65535	<p>DEC guiding rate divisor.</p>
501		0..PECmax	0..PECmax	<p>Current RA PEC counter in steps, from 0 to the maximum step count per worm revolution PECmax. This</p>

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				maximum is the product of RA motor encoder resolution and spur gear ratio. It can be calculated multiplying the return values of the <23 and <25 commands or can be obtained directly by <27.
502			0.2 .. 0.8	Guiding Speed used for training PEC. Only valid if PEC was trained or PEC data were downloaded, see command 509. The set command can be used without parameters and sets the guiding speed back to the value used for training.
503		0..25600	0..25600	Maximum RA PEC counter in steps, from 0 to the maximum step count per worm revolution PECmax. This maximum is calculated as the product of RA motor encoder resolution and spur gear ratio at startup and whenever mount type or mount parameter are changed. Using this command, PECmax can be set

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				to user defined values, f.i. to allow multiple worm cycles to be recorded.
504		0..255	0..255	Maximum consecutive RA PEC steps. 0 disables step supervision. Higher values define the maximum count of PEC steps in a row to enforce tiny corrections. After this maximum count is reached, normal tracking speed is reestablished.
509		0..63	0..63	PEC status. Decimal sum of: 1: PEC active, 2: freshly trained (not yet altered) PEC data are available as current PEC data, 4: PEC training in progress, 8: PEC training was just completed, 16: PEC training will start soon, 32: PEC data are available.
511	offset	value;offset;repeat count	value;repeat count	Currently used PEC data. [value] can be 0 (=normal tracking), 1 (RA-, guiding eastwards) or 8 (RA+, guiding westwards). [offset] ranges from

Id	Get Parameters	Set Parameters	Get Return Values	Description and Remarks
				0 to PECmax-1. [repeat count] indicates the number of equal values starting at the given offset.
512	offset	value;offset;repeat count	value;repeat count	Saved PEC data. [value] can be 0 (=normal tracking), 1 (RA-, guiding eastwards) or 8 (RA+, guiding westwards). [offset] ranges from 0 to PECmax-1; [repeat count] indicates the number of equal values starting at the given offset.
521			RA-/slow step count; normal step count; RA+/fast step count	PEC statistics. Three decimal values, summing up the steps at the three speeds.
43690				Reset to Losmandy HGM default values.
43691				Reset to Mountain Instruments default values.
65533				Reboot the Gemini controller software, forcing a Cold Start.
65534				Reboot the Gemini controller software.
65535				Reboot the Gemini controller software.

Using the native commands:

- The Identification tag is interpreted as an integer value, leading zeros are ignored.
- Parameters are separated from the Id and from each other by hyphens.
- The checksum for the native commands is calculated by a bitwise XOR operation of the transmitted characters, including the Get/Set command sign ('<', '>') and colon ':'. The highest significant bit of the result is cleared (modulo 128 operation) and 64 is added.
- Undefined Id's are ignored in Set operations. For Get operations, only a hash mark will be returned.
- In Debug Mode, the expected and the received checksum are displayed on the hand controller display in hexadecimal format whenever a discrepancy is detected. A command sent with a wrong checksum will not be executed.

Examples:

- Get the Mount Type: "<0:v" and "<00:F#" are equivalent.
- "<1:w#" and "<2:t#" and "<3:u#" will deliver the same result, f.i. the string "1q#" if the mount type is set to GM-8 or "2r#" if G-11 is selected.

Pseudo Code Example:

The following sample pseudo code shows how to calculate the checksum for a Gemini native command.

```
FUNCTION CalcGeminiCkSum (CommandString)

SET cksum TO 0 ' Initialise checksum variable

IF LENGTH OF CommandString IS GREATER THAN 0

FOR i = 1 to LENGTH(CommandString)
SET cksum = cksum XOR (CHARACTER i OF CommandString)
NEXT
SET cksum = (cksum AND 127) + 64

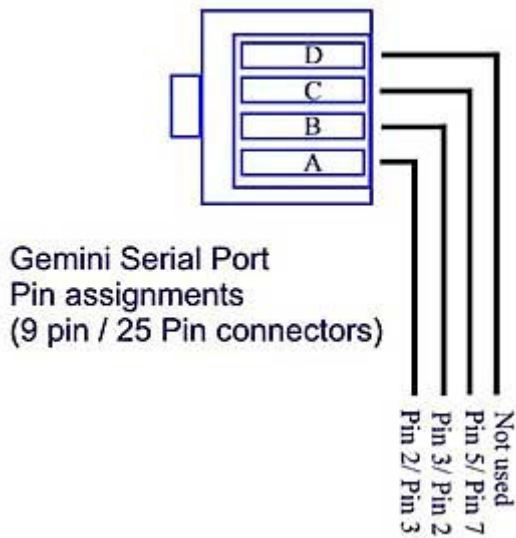
ENDIF

RETURN cksum

ENDFUNCTION
```

Note: If Gemini is started in Debug Mode (see section 7.2), the display will show the expected and received checksum in hexadecimal notation for any native Gemini command received with an incorrect checksum. This may be useful for debugging any software that sends native Gemini commands.

8.5 Serial Communications



A graphical representation of the Gemini Serial socket is pictured left (i.e. Pin D is closest to the top of the Gemini main Panel)

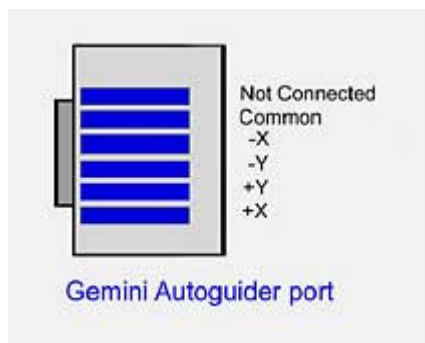
Either a DB9 or DB25 connector can be used for serial communications to a PC.

9-Pin	25-pin	Name	In/Out	Connected to
1	8	DCD	In	NC (or bridged to RTS)*
2	3	RD	In	Gemini A
3	2	TD	Out	Gemini B
4	20	DTR	Out	bridged to DSR*
5	7	GND	-	Gemini C
6	6	DSR	In	bridged to DTR*
7	4	RTS	Out	bridged to CTS (and DCD)*
8	5	CTS	In	bridged to RTS*
9	22	RI	In	NC*

NC= Not connected

* = Optional connection, e.g. serial pins 2,3 & 5 are often all that are required to be connected on a 9 pin port.

8.6 Autoguider Port



IMPORTANT: There are two different versions of the Gemini Autoguider port hardware. The versions can be distinguished by the type of connectors used for the motor cables. The older Gemini version uses RJ-45 modular connectors, and the newer version uses 6-pin DIN connectors. The primary difference between the versions is that the older version does not directly support autoguiders with TTL output, but the newer version does.

Both versions of the Gemini Autoguider port are plug compatible with SBIG model ST-4 and STV autoguiders.

8.6.1 Connecting Autoguiders with TTL Outputs to Older Gemini Systems

SBIG ST-237/ST-7/ST-8/ST-9/ST-10/ST-2000 series cameras with TTL outputs must be connected using the SBIG Relay Box, the optional Losmandy Optocoupler or equivalent when using an older version of Gemini.

IMPORTANT NOTICE (Older Gemini only):

- (1) Never connect TTL output stages to the hand controller or autoguider ports directly! Severe damage may occur to the connected devices! Use a Relay Box (as provided by SBIG) or the optional Losmandy Optocoupler unit instead. By so doing, you get the additional advantage of providing electrical protection to these sensitive units.
- (2) The use of two separate power supplies without a coupler unit is strongly discouraged. To do so would connect the ground of one system to the supply voltage of the other system, causing the two grounds to be at different potentials. If the grounds of the two systems are then connected, severe damage is likely to occur.

To connect cameras with TTL output, you will need the following:

- SBIG Relay Adapter Box cable (diagram at http://www.sbig.com/pdf/Relay_Adapter_Box_Cable3.pdf)
- SBIG Relay Box **OR** Losmandy Optocoupler
- SBIG 15 pin TIC cable (needed only if using the SBIG Relay Box)
- SBIG Dual Relay cable (needed only if you are using optional SBIG accessories such as the CFW-8 filter wheel or AO7 adaptive optics unit). This is a 9 pin ribbon cable with one male DB9 connector and 2 female DB9 connectors.

Camera Without Accessories

If you are using the camera alone (no filter wheel or AO7 unit), simply plug the DB9 connector of the Relay Adapter Box cable into the camera, and the modular connector on the cable into the Relay Box or Optocoupler. If you are using the Optocoupler, plug the modular connector on the Optocoupler into Gemini's Autoguider port. If you are using the Relay Box, plug the modular cable supplied with the Relay Box between the Relay Box and Gemini's Autoguider port.

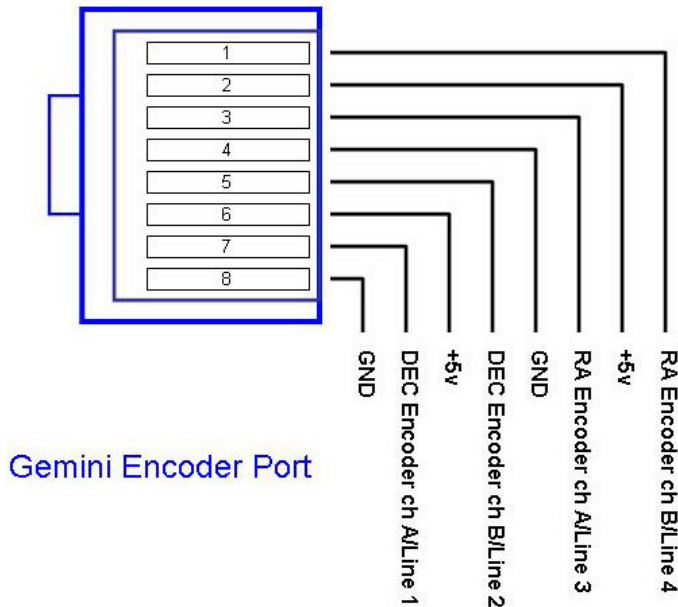
Camera With CFW-8 Only

Plug the male DB9 of the Dual Relay cable into the camera. Connect the DB9 on the CFW-8 cable to one of the female DB9s on the Dual Relay cable. Connect the DB9 end of the Relay Adapter Box cable to the other female DB9 on the Dual Relay cable. Plug the modular connector end of the Relay Adapter Box cable into the socket on the Optocoupler or Relay Box. If you are using the Optocoupler, plug the modular connector on the Optocoupler into Gemini's Autoguider port. If you are using the Relay Box, plug the modular cable supplied with the Relay Box between the Relay Box and Gemini's Autoguider port.

Camera with CFW-8 and AO7

Connect the cable coming from the AO7 to the DB9 connector on the camera. Connect the male DB9 on the Dual Relay cable to the other DB9 on the AO7 cable. Connect the DB9 on the CFW-8 cable to one of the female DB9s on the Dual Relay cable. Connect the DB9 end of the Relay Adapter Box cable to the other female DB9 on the Dual Relay cable. Plug the modular connector end of the Relay Adapter Box cable into the socket on the Optocoupler or Relay Box. If you are using the Optocoupler, plug the modular connector on the Optocoupler into Gemini's Autoguider port. If you are using the Relay Box, connect the modular cable supplied with the Relay Box between the Relay Box and Gemini's Autoguider port.

8.7 Encoder Port



The Gemini encoder port is compatible with the “Y” cable typically used with many encoders such as the Losmandy DSCs or NGC Max. If you are using such a system, you should just be able to plug your encoders in and enable them via Gemini’s menu. The pinout information above will be useful however, if you are building your own encoders or cables.

Over the years, only a small percentage of Gemini users connected axis encoders. Axis encoders are now set offline by default. The 4 digital (TTL) inputs bits can be used alternatively to connect to custom hardware such as limit switches or other devices. Their state can be read using the extended serial line protocol (Gemini native command 312). By utilizing these 4 bits for end switches, you can further customize your Gemini for fully unattended operation.

Line 1 is the LSB, line 4 the MSB for the serial line command 312.

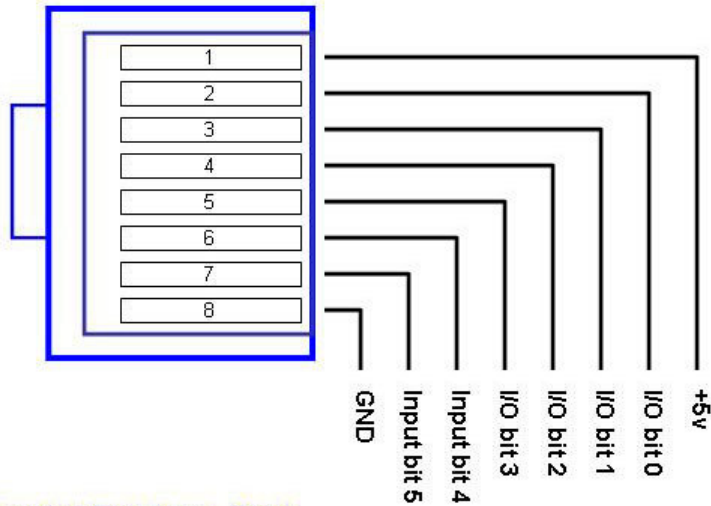
The four lines connect directly to the CPU's digital I/O pins and have weak pullups. Electrically, they are 5V TTL compatible. If you attach a custom device to the encoder port, it should actively drive the lines high when needed rather than relying on the internal CPU pullups.

Connecting End Switches

As mentioned above, the 4 lines of the encoder port can be used to implement physical end switches to limit your mount's motion. You can use micro switches or Hall sensors wired to provide +5v to each of the 4 encoder port lines under normal operation. As the mount moves out of normal operating range, the switch should pull one of the lines to ground.

If you have enabled the use of end switches using the “Setup→Mount Parameters→Encoder→Use End Switches” menu item or using the Gemini serial command, Gemini will stop all motor motion when any of the 4 encoder port lines are pulled to ground. You can further provide custom software can then query the state of the encoder port over the serial line using Gemini native command 312 to see which switch was activated. The software can then disable the use of end switches over the serial line, move the appropriate axis away from the limit, then re-enable the end switches.

8.8 Feature Port

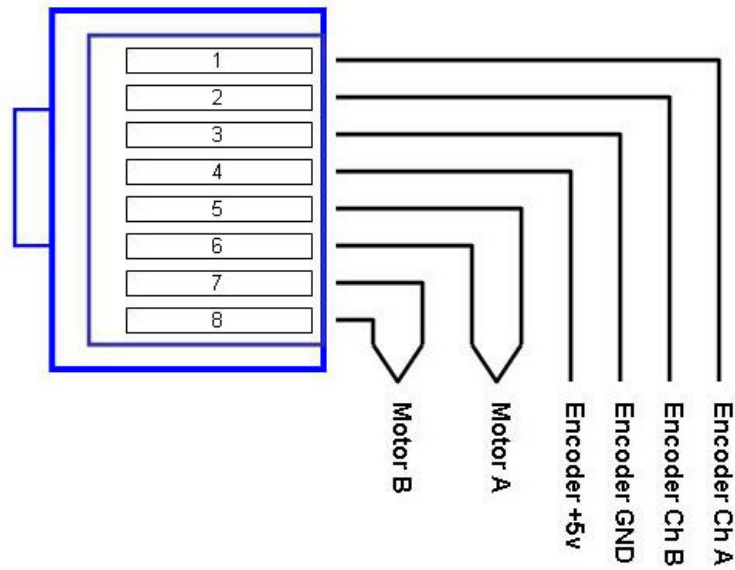


Gemini Feature Port

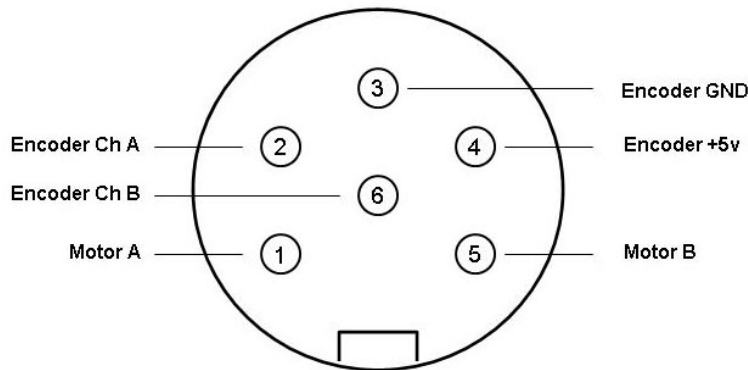
The Gemini Feature Port allows hardware designers to add additional functionality to Gemini that can be controlled via the serial connection. Gemini native serial command 311 allows you to read and write values on the Feature port. The low order 4 bits (values 0-15) can be used for both input and output. The high 2 bits are used for input into Gemini only. Thus, for command 311, “Get” values range from 0-63, and “Set” values should be limited to 0-15.

Pins 2-5 are digital I/O pins with the typical Intel 8051 behavior – they are TTL signals having weak pullups. As with the encoder port, if you attach a custom device to the encoder port, it should actively drive the lines high when needed rather than relying on the internal CPU pullups. For use as output bits, if the software uses Gemini's serial command 311 to write a '0' into the port, it acts as a strong pulldown, capable of sinking about 1.6mA. Feature port pins 2-5 have 10k pulldown resistors to protect them from noise.

8.9 Motor Connector Pinouts



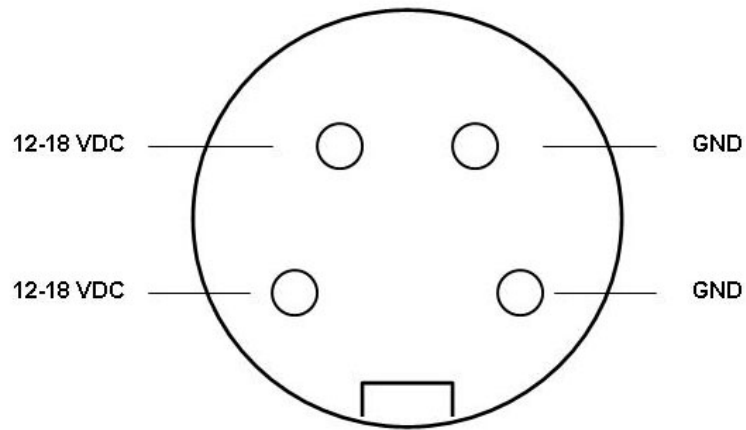
RJ-45 Connector



DIN Connector

Either flat or twisted pair cables can be used. If using twisted pairs, the two motor cables should be twisted together, one of the encoder channels should be twisted with GND, and the other encoder channel should be twisted with +5v.

8.10 Power Connector Pinout



Power Connector

8.11 Upgrading the EPROM

The software for the Gemini system is programmed into an EPROM that resides in the electronics box. You can obtain upgrades for this software in two different forms:

- A new EPROM containing the new software
- A .hex file that must be programmed into a blank EPROM

If you get the upgrade in the form of a .hex file, you will need a blank EPROM and a burner capable of programming it. Gemini uses a 512Kx8 EPROM such as a 27C4001 or 27C040 with an access speed of 120ns or faster.

Once you have obtained a programmed EPROM (either by buying one or programming your own using the .hex file) you must install it in the Gemini system. This can be accomplished as follows:

1. Unplug all cables from the Gemini electronics box
2. Remove the 6 screws that hold the faceplate onto the box
3. Remove the faceplate from the box
4. Identify the old EPROM on the board using the diagram to the right
5. Use a small flat-blade screwdriver to gently pry the old EPROM out of the socket. Be sure to loosen alternately from each end and avoid bending the pins.
6. Install the new EPROM into the socket. Be sure that the notched end of the EPROM matches the notched end of the socket. Ensure that all pins actually go into the socket and are not bent underneath.
7. Replace the faceplate and all 6 screws
8. Replace all cables



Depending on the contents of the upgrade, you may see the message “CMOS Reset” when you power up the Gemini. This indicates that all parameters have been returned to factory defaults. You will need to follow the procedures outlined in chapter 2 to re-enter all of the setup parameters.