Operating the 2.7m Harlan J. Smith Telescope and its Telescope Control System

The 2.7m telescope is operated mostly under computer control with the TCS (Telescope Control System). It can be used to point to objects and follow them across the sky and have the dome slit follow the telescope. In this manual, different operations will be highlighted in the various sections.

1. **Powering up the telescope**

Powering up the telescope is a function that is done without computer control. The user must push certain buttons to put power on the telescope and dome. However, the control computer must be running before the telescope is powered on.

The telescope control computer is “colossus”. It runs the TCSMON software. The Telescope Control System Monitor (TCSMON) receives data from many sources, including high-level commands from TCSGUI (see below) or some other agent (e.g. the guider software), the position encoders for HA and DEC, weather systems, and data from IRAF/ICE. It processes these data and commands the embedded motion control computer, with its own complex software, which in turn controls the HA and DEC motors. It also streams telescope status data back to each TCSGUI connected to it, and interacts with the dome automation system.
If the TCSMON program is not responding, the TCSGUI will display the flashing error message "TCSConnectError".

TCSMON should be running whenever a user powers up the telescope but, if it is not, the user should not attempt to power it up. Powering up TCSMON is a job for the Observing Support team. They should leave the telescope for the observer with a GUI running on the computer terminal on the dome floor. The telescope should have been rebooted with the telescope pointing to the zenith.

If TCSMON is running when you want to start the telescope, you should check to see that there are no warning signs posted on the main console telling you not to run the telescope. Sometimes the telescope is being worked on and should not be moved.

- To turn on the telescope, you need to go into the North control room (the old Cassegrain control room) to push buttons. The image shows what you will see.

Looking into right side of old control room

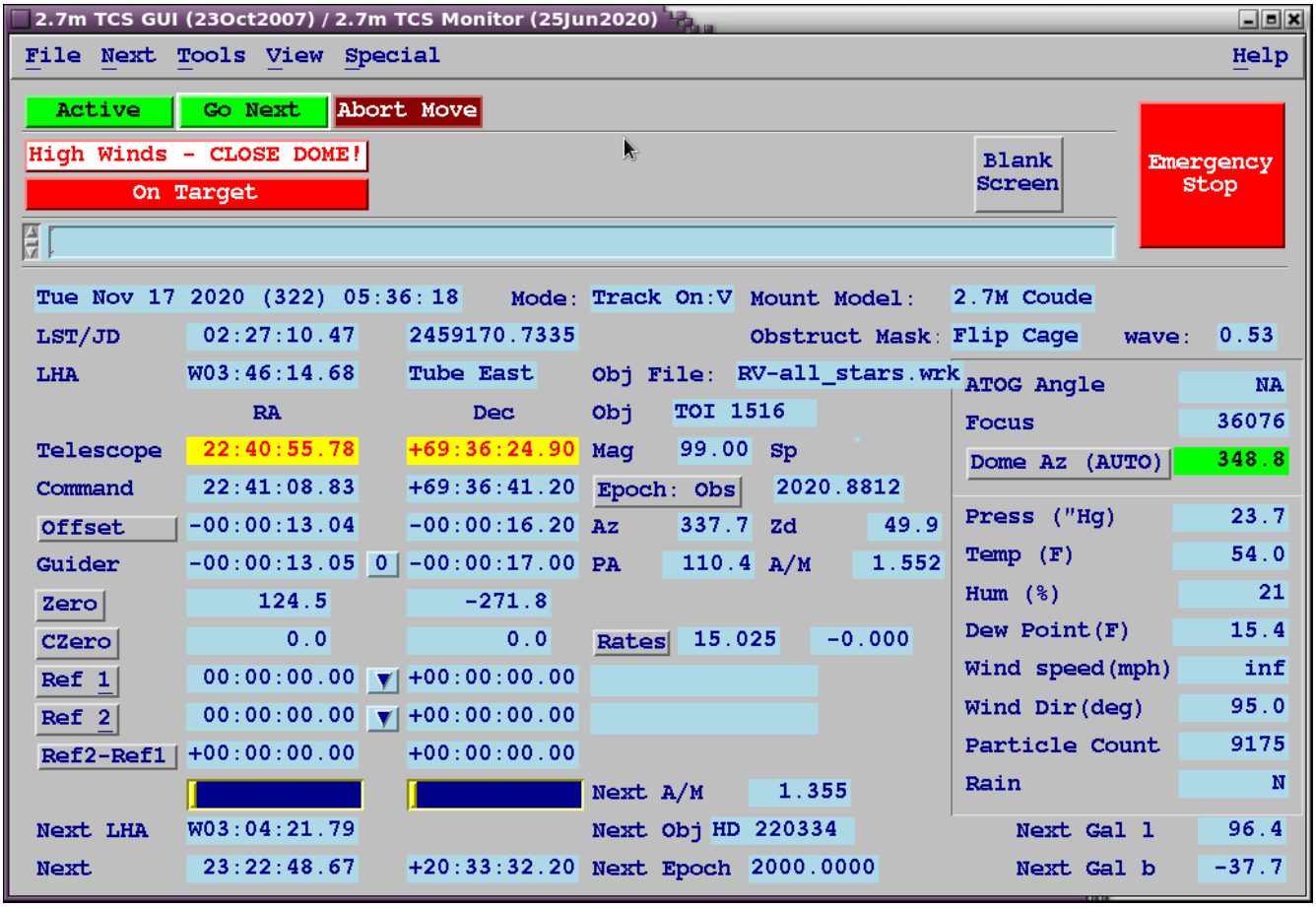
- Turn on the DECLINATION and HA Servo amplifiers located in the right hand side rack shown in the picture. Turn on only the AC power by pressing the ON button located on the front of the amplifiers near the left hand side. These are labeled DECLINATION and HOUR ANGLE. The OUTPUT indicators will turn on when the RESET button is pressed (see below).
- Turn on the telescope "Hydraulic Bearing" pump by pressing the green START button. There are two buttons labeled START with a selector switch (pointing to PUMP1 or PUMP2) directly above and between the two buttons. Press the button to which the selector switch is pointing and hold it for about 3 seconds. NOTE: If you do not hold this button in long enough, there will be a " No Hydraulic Pressure" error message on the TCSGUI. Also note that the lights on the ON/OFF switches are always lit *and are not indicator lamps.*
- Verify that the "Maintenance Mode" switch is "off", the "Normal/Balance" switch is in the "Normal" position and the "Autoslew Enable/Inhibit" switch is in the "Enable" position. These switches are located in the old control room in the equipment rack located just to the left of the workbench and just above Colossus' display & keyboard.

- Turn on the main telescope console (located on the dome floor - east platform).
- Press and hold the RESET button on the main telescope control console until you hear the telescope brakes audibly release (takes a few seconds). The telescope is now ready to be operated by the TCSGUI.
- When you are ready to open the dome shutter and telescope mirror cover, do so from the main telescope control console.
- Observers need to start a second TCSGUI on the control room computer atlas with the appropriate launcher icon.

2. The TCSGUI

The Telescope Control System Graphical User Interface (TCSGUI) gives the observer command of the telescope and displays its position and status. After the telescope is powered-up, TCSGUI should be running on the dome floor monitor. Observers need to start another TCSGUI on the control-room computer atlas with the TCSGUI launcher icon.

The figure shows the TCSGUI screen as it is seen on the dome floor monitor or on the observing computer.



The different types of options on this GUI are described next, followed for each by a link to a more detailed document.

Along the top are a series of five **drop-down menus**. They include

File - handles input and output (worklists, ephemerides, command files,...)

Next - handles the selection to prepare for the next object.

Tools - provides various operational options (handpaddle rates, dome automation,...)

View - shows various sets of information (Point info, weather & command history, object history,...)

Special - this menu allows the user to set various items such as the mount model and the obstruction mask (items under this menu should be selected with great forethought as they can affect the safety of the telescope). Please note that the moves on this menu going to and from the service positions do not require "Go Next" to be pushed. In fact, the moves won't happen if you do.

More info on these menus can be found here. Drop Down Menus

Just below the menus, near the top, are the **command buttons**. There are 4 buttons that always show plus a fifth that appears in certain circumstances.

Active/Inactive - A green Active button indicates that the system will accept commands from this window. A red Inactive button indicates that the system will not accept commands from this window (however, all display information is still updated). Note that while the GUI is in an Inactive status, all of the commands and menus are grayed out as they are not operational in this mode. To change an inactive GUI to the active GUI, simply click on the Inactive button.

Go Next - Clicking on this button will cause the telescope to move to the object specified in the "Next Buffer" (located at the bottom left of the GUI). It will also send a command to the dome automation system to start the dome moving to the location of the specified object. **NOTE**: for the telescope to actually move, the "Auto-slew" *deadman* switch must be held down. More detail on the “NEXT” process is given below.

Go Ref1, **Go Ref2** -*These buttons only appear if the specified reference position has been defined* (see Offset pointing). Clicking on either one of these will cause the telescope to move to the reference position specified.

Abort Move - Clicking on this button will abort the current automatic move.

Emergency Stop - Clicking this button will activate the emergency stop system and halt all telescope motion and power down several systems. See Safety for more details.

Just below the command buttons is an area for **alerts** (in the image this says “High Winds”). Alerts might be about the weather or some abnormal conditions. If the TCS Connect Error is flashing here for more than 30 seconds, this indicates that TCSMON has probably died. You can restart TCSMON via the special -> Restart TCS monitor menu. After ~30 seconds, the error should clear. If it does not, contact one of the Observing Support staff members for assistance.

A small, one-line window is located just below the alert message window. The window is scrollable via the arrows located at the left side and displays the responses to the last 5 commands given by the TCSGUI to the TCSMON. (A complete history of these commands may be viewed explicitly under the View->Command History menu.)

The rest of the display is dedicated to **system status display** and more buttons and menus to change options. Most of the information is updated 5 times a second, or whenever it changes.

There is a lot of information relating to the position of the telescope. The **Telescope coordinates** are shown in a different color so it makes them easier to pick out on the screen. The coordinates shown are the on-sky telescope coordinates for a perfect telescope precessed to the current (or selected) epoch. (Flexure & zeros have already been removed from these values before being displayed.)

The **Command coordinate** line shows the location that the telescope was told to go to. The **Offset** line is the difference between the current telescope position and the commanded position. It is normal for this line to show a small difference (normally less than 1 arc second).

The **Guider** line displays the total integrated amount of correction that the autoguider has made to the current object. These values are cleared when you move to a new object. To clear the guider values manually, click on the "0" in between the RA & DEC fields.

The **Next coordinates** and info show the coordinates and information for the object that will be moved to on the next autoslew.

The **weather** information is updated every 5 minutes. However, it is not necessarily reading from the same collectors as the weather information that can be displayed via the weather system. We advise the weather info from Official Weather Site be used.

Hidden buttons/options: At various locations on the TCSGUI are labels that seem to have a "box" around them. These unveil hidden features and commands. Clicking on these with the left mouse button will reveal various menus and options. These are described at this link. See other commands. A few of the more important ones are described here.

A digital handpaddle may be brought up by clicking on the **"offset"** box on the left-hand side of the TCSGUI. This is a digital version of the actual handpaddles that are found either on the dome floor console or in the control room, but with a limited array of options. Here you can enter position offsets manually or by clicking on the arrow buttons to offset from your current position. You can also adjust the telescope focus here as well. See the link for more detail.

3. Pointing the telescope to targets and the "Next" button

The Next buffer allows the next target to be prepared while data are still being collected on the current object.

Pointing under the 2.7M TCS system requires the use of the Next buffer (or the Ref1,Ref2 buffers). This allows the user to set up the next object that they wish to move to, before actually moving to it. This should allow for greater efficiency of observing (e.g. the next move can be set up while the data are still being collected on the current object).

The next buffer is displayed in several fields across the bottom of the TCSGUI. The fields displayed are:

Next LHA - local hour angle of the next object

Next A/M - air mass of the nextobject

Next RA, Dec, & Epoch

Next Obj - object name (if selected from a catalog or worklist)

Next Gal l & b - galactic longitude & latitude

All commands that are used to select the next object can be found under the Next pull down menu on the TCSGUI.

Manual Coordinate Entry:
To enter coordinates manually, go to the Next menu and select “Manual Entry". The popup menu will allow you to choose between the type of coordinates that you wish to enter (most observers use the RA/Dec... option).

Users will then be prompted for the coordinates, proper motions and epoch. (note: hitting the TAB key will move the cursor from one field to the next.

Choosing OK when finished will enter your coordinates into the Next buffer. Note that the telescope will not yet move to it at this point (see *Moving the telescope to another target* below)**.**

If HA/Dec or Az/El are used, the tracking is turned off. To start the tracking again, choose the Next -> Start Tracking menu selection.

Worklists and Ephemerides:

These user-defined lists can make the life of the observer much simpler. A worklist can be a compilation of targets grouped by type that the user points to repeatedly. An object just needs to be selected from the list to load the NEXT buffer.

An ephemerides is used for a target that moves relative to the sidereal sky. Examples are comets and asteroids. A minimum of three, equally spaced (in time) coordinates are given for an object. TCS will do a quadratic interpolation to the coordinates for “now” for the next object. It will also figure the coordinates for 15 minutes from now to compute the track rates.

See Worklists and Ephemerides for format of these files. *This file also includes a very important note on Epoch vs Equinox that users should read.*

4. Moving the telescope to another target:

Moving to a new object with the TCS automation system comes in two phases. The first phase is the selection of the object and loading its information into the Next buffer (see above). The second phase is the actual moving of the telescope.

To move to a new object:

Verify that the object that you want to move to is loaded in the Next"buffer.

Click on Go Next in the command button section of the TCSGUI. Note: As soon as you press this button, the command is issued from the TCS system to the dome automation system to move to the location of the next object.

> Go out into the dome and press the Auto button on the deadman switch (note that the telescope will not auto-slew unless this button is being held down).

When the telescope stops beeping and the "On Target" message is displayed on the TCSGUI, release the Auto button as the telescope has finished its move and is now tracking.

Deadman Switch:

There are two deadman switches (only one of which must be activated). One is located on a small white rectangular handpaddle on the dome floor(normally sits somewhere around the main control console). It has two buttons on it. One button is an **Emergency Stop** (labeled E-Stop). The other button is labeled Auto and is the actual deadman switch. The other deadman switch is on the main telescope console and is labeled Auto Slew.

> For automated slews of the telescope, the Auto or Auto Slew switch must be depressed.
>
> If the switch is released during a move, the telescope will ramp down to a stop. When the one of the switches is depressed again, the move is resumed.
>
> ***Note:*** *Disabling or bypassing the deadman switch will result in loss of observing privileges!*

Aborting a Move:

> If you need to abort a move simply release the Auto button on the deadman switch, then click on AbortMove on the TCSGUI. Note that this will also abort the dome motion as well.
>
> Note: If the telescope is about to run into something hit **Emergency Stop** on the Deadman Switch (stops the telescope much faster!).

Manual Moves:

As always, it is still possible to move the telescope manually via the handpaddle. Only the handpaddle on the dome console may move the telescope in slew or search speeds or move the wind curtains, platforms, etc...

5. Dome Automation

While the dome can be position manually using the console or the handpaddle, it is more convenient to have the computer control the positioning of the dome. The dome automation

process will move the dome to the appropriate location so that the telescope can view sky and will follow the telescope as it tracks to keep the telescope viewing the target. This following of the telescope is enabled from the *Tools* dropdown menu at the top of the TCSGUI. Under tools, choose **Enable Dome Automation** to start the automation.

A small red box next to this menu item indicates that the dome automation system is enabled. The label of the DomeAz button will also have an (AUTO) appended to it when the system is enabled. Note that it will take a few moments for any dome command to be implemented.

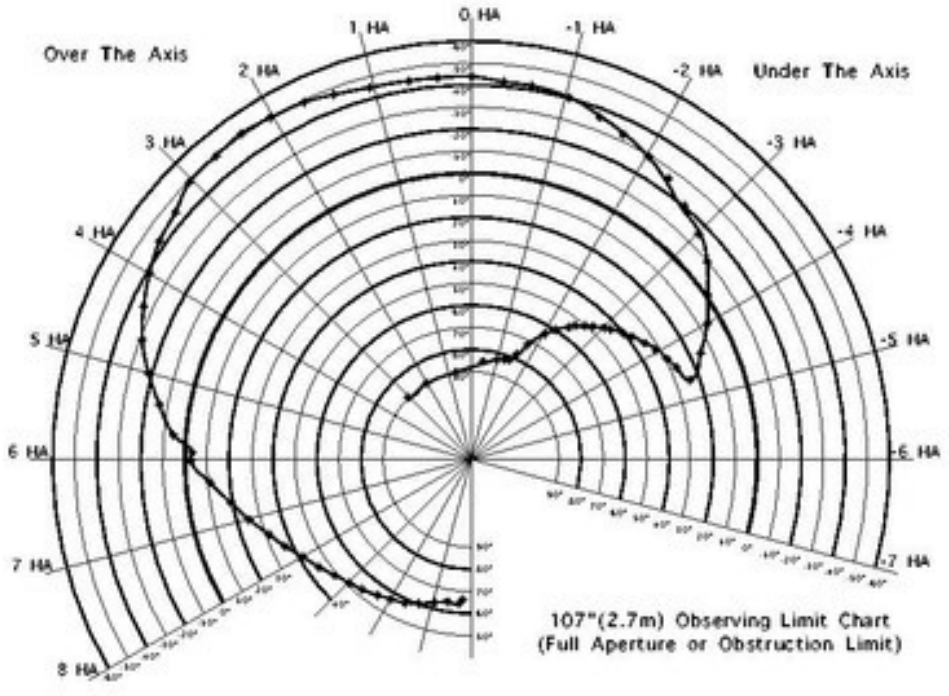
If emergency stop has been hit, the dome automation system will disable. It will remain in that state until re-enabled by the user via this menu function.

When the telescope is sent to the Flat or Stow positions, the dome will automatically be sent to its park position. If Zenith is chosen from the next menu, then the user is prompted if they wish the dome to go to the park position.

Note: by clicking on the Dome Az button on the TCSGUI, dome offsets may be entered although they are rarely (if ever) needed under the current dome automation system.

6. Observing Limits

The 2.7m telescope is an equatorial mount telescope. As a result, there is a large counterweight on the opposite side of the polar axis from the telescope. In addition, there are counterweights along the side of the telescope (they look like long pipes of about 1 foot diameter and contain weights that can be moved up or down to balance the telescope).



These weights, along with a fairly bulky north pier means that there are regions of the sky that cannot be viewed by the 2.7m telescope. The figure shows the observable limits. Inspection of the figure shows that the observable locations on the sky are a function of both the HA and Declination of the target.

In th normal mode, with the telescope tube on the East side of the polar axis, objects in the Northeast cannot be observed. The TCS system will not allow the telescope to point in these disallowed regions of the sky. More details on this are covered under telescope safety. Safety

Coudé observers can observe objects in the northeast by taking the telescope “over the axis” so the telescope is on the west side of the polar axis. *Observers must be trained to perform this maneuver. The telescope can be taken over the axis with* ***no other instrumen****t than coudé.*

Whenever the telescope is being slewed, an observer must be on the dome floor observing the telescope and holding down the deadman switch (see above). Observers should be trained on what parts of the telescope can collide with obstacles as it is not always obvious (for example, the telescope moving into the northeast region can have the counterweight on the side of the telescope impact the north pier while the nose of the telescope is nowhere near an obstacle). See the **Safety document** for more information and a more complete discussion on obstacles that can cause collisions. See Safety.

7. Powering Down the Telescope

At the end of the night or if closed by weather, the telescope dome and mirror cover must be closed and the telescope returned to its normal stow position.

- Close mirror cover.
- Close dome shutter.
- Lower platforms if necessary.
- Park the dome via the TCSGUI or manual control so that the shutters are facing west.
- Position the telescope to the proper stow position via the TCSGUI ("Next" Menu-choose stow position - Button "Go Next").

Next Menu Location	Coordinates
Stow (normal stow position)	HA = 00:00:00, DEC = -20:00:00
Zenith	HA = 00:00:00, DEC = 30:40:00
Stop Tracking	Halts track at current location

- Turn on one bank of fluorescent lights in the dome. (If other telescopes are still open, close the shutters on the doors before doing this.)

- Press any one of the EMERGENCY STOP buttons located on the front of the console near the lower right hand corner (or on any of the handpaddles, deadman switch paddle, TCSGUI, ...).
- Tidy up the dome floor and control room.
- Complete the night report.