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FORSCHUNG

# GREGOR: GTCS Operation Manual

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## Signatures & Approval

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## 1 Scope

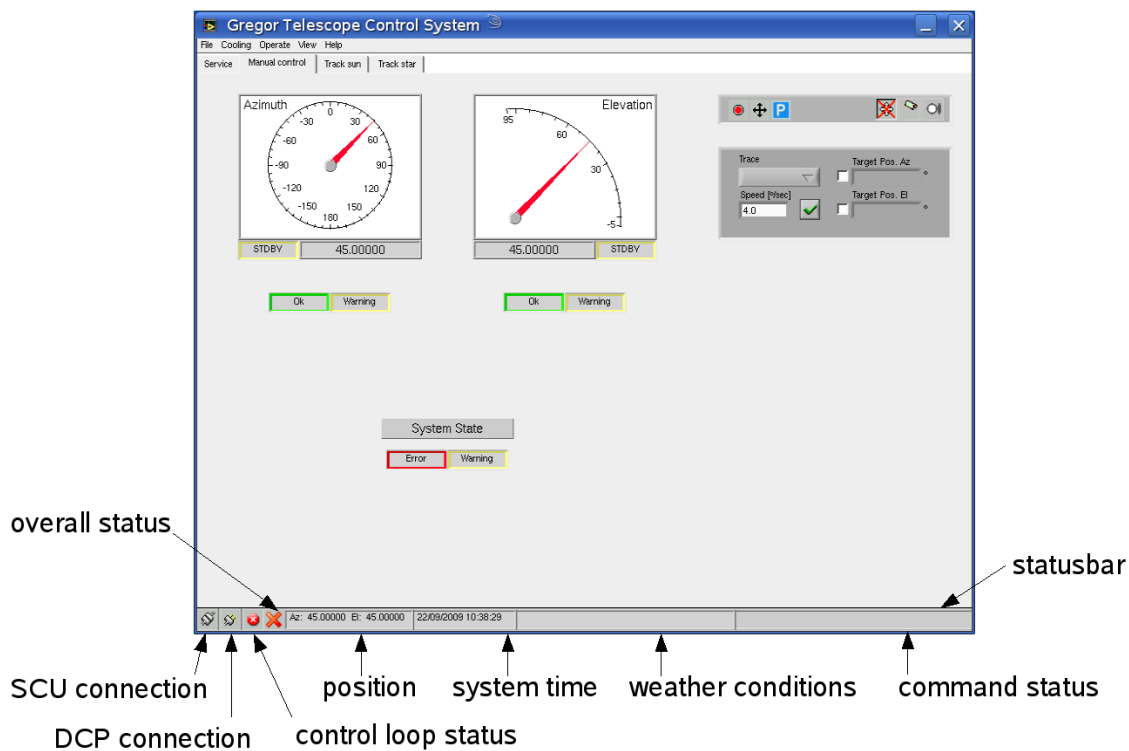
This document describes the functions of GTCS, the GREGOR telescope control system.

## 2 Abbreviations

GTCS	Gregor Telescope Control System.
GUI	Graphical User Interface.
HHP	Hand Held Panel (placed on the dome floor).
ICD	Interface Control Document.
LCP	Local Control Panel (of the Servo Control Unit).
SCU	Servo Control Unit.
MDE	MessDatenErfassung.

### 3 Overview

The gregor telescope control system is used to control all telescope movements as well as the F1 cooling unit, the M1 safety cover and the Coude cover. The complete telescope status including the readout of the temperature sensors of the structure and the mirrors as well as the readout of the force sensors of the M1 mount can be displayed. Weather data is used for refraction correction and to display warnings upon bad weather. If an error occurs the telescope is set to a safe state that means in general that the axes are stopped and the M1 safety cover is closed automatically (see sections 4.6.2, 5). Statusdata, errors and communication to the SCU is logged (see section 11.3). Some commands are accessible through the remote interface using DCP (see ICD GRE-KIS-SPE-0011.pdf for available commands and their use). The top level controls of the GTCS GUI are shown in figure 1:



**Fig. 1:** Top level controls of the GTCS GUI.

There are different control sections, represented by the different registers of the GUI (see appropriate sections of this manual for details). Section “Manual control” is used for basic setup like referencing, error display, and cooling. Sections “Track sun” and “Track star” are used to control settings for sun or star tracking. Section “Service” gives access to the stow positions and controls servicemode settings.

The menu provides additional functions like initializing the telescope, display settings and access to the temperature interface and the M1 force control. The statusbar displays general data like system time, interface status and command execution.

### 3.1 Normal Operation procedure

The following section describes the steps necessary for normal operation and tracking of the Sun or stars.

1. Open the dome and check for anything that the telescope could run into. Lock the door to the dome floor afterwards.
2. If necessary power up the telescope hardware with **Power On** at the GREST cabinet and reset the Interlock and the Servo Fault. This is not necessary if the telescope was left in state **standby**. Set LCP to mode **Remote Control** (sections 13.3, 13.4 and 13.5).
3. Initialize telescope with GTCS (section 3.3).
4. If necessary start reference drive (section 4.3).
5. Deactivate to reset errors (eventually activate first, section 4.2).
6. During daytime: activate cooling system (section 5).
7. Activate telescope, start tracking (sections 4 and 7). When the telescope is locked check pointing with the auxiliary telescope or the alignment of the telescope spiders. Then open the M1 cover (section 4.6.2).
8. To finish observation: close M1 cover (section 4.6.2).
9. Stop tracking, drive to park position with **start/ stop parking** (section 4.4).
10. Turn off cooling system (section 5).
11. Close the dome when the axes are in mode **Standby**.

You can leave the telescope in mode **Standby** until the next morning. For longer standby times turn off the **Power On** switch at the GREST cabinet. If coming from mode **Standby** and LCP mode **Remote Control** the steps 2,3 and 4 can be skipped. Refer to section 13.4 for complete shutdown.

### 3.2 Errorhandling

Errors can be reset by deactivating if they are not active anymore (potentially activate first, then deactivate). While an error is active, only some basic functions are allowed, tracking is not allowed. Warnings are displayed as long as they are active and reset automatically. Tracking while warnings are active is allowed, but depending on the warning proper function may not be guaranteed. Some functions are not allowed if certain warnings are active, for example the M1 cover may not be opened as long as the warning **sunPointLimit** is active.

### 3.3 Functions of the menu

#### File

- **Open...:** open subroutines for debugging (administrator mode only)
- **update Bulletin A:** update predictions for polar motion correction, necessary every 180 days (advanced user or administrator mode only)

- **Quit:** quit GTCS

### Subsystems

- **Temperature interface:** open temperature interface to adjust settings for M1 cooling and to display readout of temperature sensors (section 5.3).
- **M1 force control:** open M1 force control to display the readout of M1 force sensors (section 6).

### Operate

- **initialize telescope :** initialize system to default settings for pointing correction of the telescope axes and temperature settings for M1 cooling.

### View

Set display of live image in register `track sun`.

### Help

- **About TCS...:** display software version.

## 3.4 Indicators of the statusbar

### Status of SCU interface



Not connected.



Connection established.



Connection established, interface locked: either control is set to LCP or HHP is active.

### Status of Remote interface (see section 9.2 for details)



Not connected.



Connection established.



Connection established, interface locked.

### Status of control loops



Tracking is stopped.



Tracking is active and telescope is moving to the desired position.



Tracking is active, control loops are locked.

### Telescope position

Displays the current position of the telescope.

### System time

Displays the current system time that is used for ephemeris calculation.

### Weather conditions

Displays the current data of the weather sensor.

### Command status

Displays acknowledge and answer of commands. The indicator turns yellow if a command is received from the DCP interface or red if a command is rejected or aborted.

## 4 Manual control

To send commands to the SCU the LCP first has to be set to **Remote Control** otherwise all commands are rejected. This is only possible if no axis error is active (for example if the dome is closed). Activating the HHP disables remote control as long as the HHP is active. Afterwards the LCP is reset to its previous control mode.

Before the telescope can be moved via command the dome has to be opened. As long it is closed a software interlock is set and the telescope can only be moved with the HHP on the dome floor (see 13.6). If the dome is opened and the telescope is powered up from shutdown the first thing to do is to reset the servo fault and to start a reference drive. Afterwards the telescope is in mode **standby**. To move the telescope the axes have to be activated first so that the motors are powered up and the brakes are opened. Then slew, position, stow or track commands can be sent.

To clear errors or warnings that are not pending any more the telescope has to be deactivated. Interlocks need to be reset at the GREST cabinet on the 5th floor first.

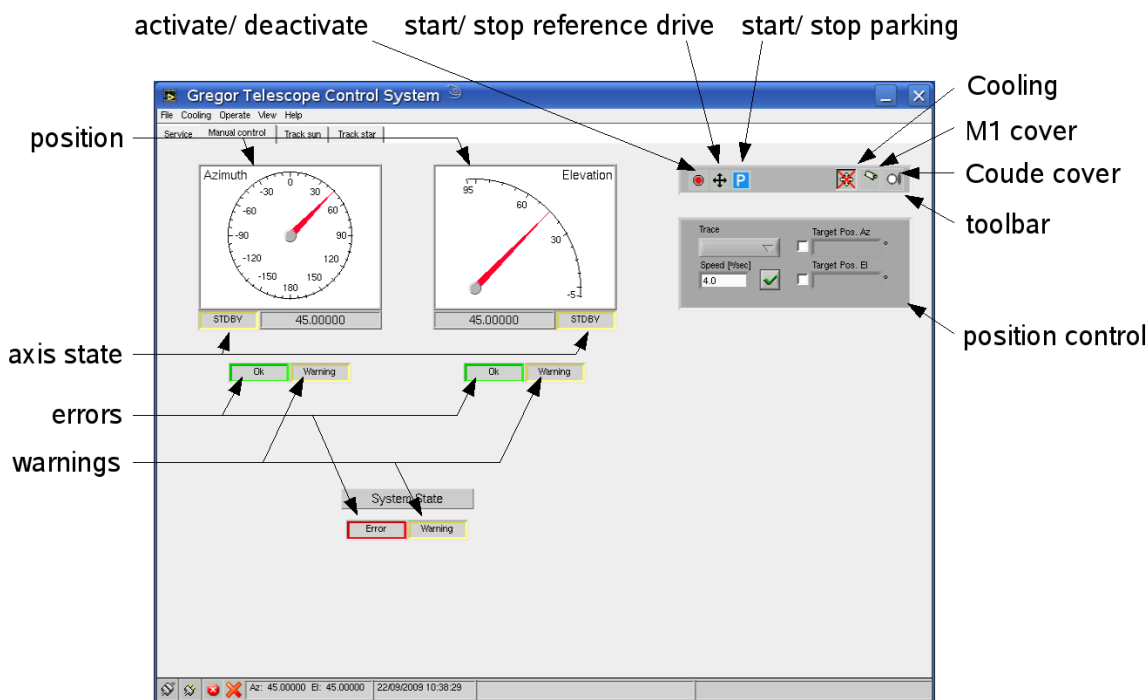


Fig. 2: Controls and indicators of mode Manual control.

### 4.1 Controls and indicators

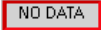
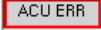

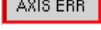
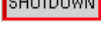
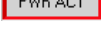
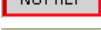
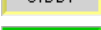
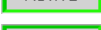
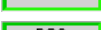
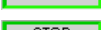
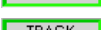
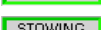

#### Telescope position

Displays the actual position of the telescope axes. Values may not be valid if axis is in one of the states Shutdown, Axis Error, Power activate or Not ref.

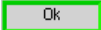
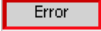
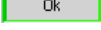
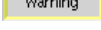


## Axis state

State of the telescope axes. State of last command execution is displayed: a position command displays state POS during execution and also after position is reached and axis is stopped.

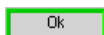
	No data from SCU.
	ACU error.
	Stowed: stowpin not out.
	Axis error.
	Shutdown. "Power On" switch off.
	Power activate. Powering up servo controllers.
	Not referenced. Reference drive required.
	Standby. Brakes closed.
	Active.
	Slewing.
	Positioning.
	Stopped.
	Tracking.
	Stowing.

## Axis error and warning

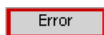
	No error.
	Error. Move cursor over indicator to get details.
	No warning.
	Warning. Move cursor over indicator to get details.

## System error and warning

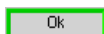
Error and warning indicator for complete system including telescope and subsystems. If this indicator displays an error tracking is not allowed. Warnings notify user of possible restrictions.



No error.



Error. Move cursor over indicator to get details.



No warning.



Warning. Move cursor over indicator to get details.

## Toolbar

The buttons of the toolbar are indicator and control at the same time.

1. Activate/ deactivate



State standby.



State active.

2. Start/ stop reference drive



Start reference drive (see section 4.3).



Stop reference drive (see section 4.3).

3. Start/ stop parking



Start parking (see section 4.4).



Stop parking (see section 4.4).

4. Cooling on/ off



Cooling is off (see section 5).



Cooling is on (see section 5).



Error. Click to reset.

5. Open/ close M1 safety cover



Cover is closed.



Cover is open.



Error. Click to reset.

6. Open/ close Coude cover



Cover is closed.



Cover is open.



Error. Click to reset.

## 4.2 Activate, deactivate and reset errors

Use the **activate/ deactivate** button of the toolbar to reset errors of the GTCS and Servo Faults of the SCU or to switch to states **Standby** or **Active**. If necessary activate first to be able to deactivate to reset errors. Errors of subsystems like cooling system, M1 cover or Coude cover are reset by deactivating the related subsystem. Interlocks can only be reset manually with the Interlock switch at the GREEST cabinet.

## 4.3 Reference drive

Use the **start/ stop referencing** button to control the reference drive. Both axes are referenced simultaneously by slewing in positive direction until the hardware pre limit switch strikes. Then the axis is slewed to the next reference mark of the encoder. If the reference drive is finished the axis is set to mode **Standby**. A reference drive is only necessary if one or both axes are in state **not ref**. Otherwise the command is rejected. Once referenced, only an Interlock, shutdown or an uncompleted reference drive using the HHP require new referencing. Make sure M2 is not illuminated during the reference drive.

## 4.4 Parking

Use the **start/stop parking** button to start or stop slewing to the parking position. Once the parking position is reached the axes are deactivated automatically. Always leave the telescope in the parking position due to lightning protection and to open and close the dome safely.

## 4.5 Drive to position

Use the position control to drive one or both telescope axes to a certain position. Select with the checkboxes which axis to move and enter target position and speed for positioning. Start or stop with the **Start/stop positioning** button. During daytime positioning is not allowed if the M1 cover is not closed (see section 10.4 for exceptions). Make sure M2 is not illuminated during positioning.

## 4.6 Other functions

### 4.6.1 Cooling

See section 5 for details about the control of the cooling system.

### 4.6.2 M1 cover

Open, close or reset errors of the M1 cover with the **open/close M1 safety cover** button of the toolbar. If the button is pressed while the cover is in motion a close command is sent. During daytime the cover cannot be opened if the system is in one or more of the following states:

- sun pointing limit is exceeded
- F1 cooling is not active
- the F1 fieldstop is overheated or coolant flow is too low
- the MDE is turned off
- SCU Interlock is active

If the M1 cover is open and one of those states becomes active the cover is closed automatically (see section 10.4 for exceptions and section 5 for details of the F1 cooling system).

To disable the cover for maintenance its motor can be unplugged. If it is unplugged, the error `m1CoverConError` is generated. To reset this error reconnect the motor and deactivate the F1 cooling (the digital input is connected to the field bus of the F1 cooling system).

### 4.6.3 Coude cover

Open, close or reset errors of the Coude cover with the `open/close coude cover` button of the toolbar. If the button is pressed while the cover is in motion a close command is sent.

## 5 Cooling system

The GREGOR telescope contains two cooling systems. One controls the M1 mirror temperature and is not relevant for safety. The F1 fieldstop is liquid cooled by a second cooling system and its temperature is monitored. Control and monitoring of this system is done by the telescope control system. The hardware can force closing of the M1 cover if temperature limits are exceeded.

If setup correctly, both systems are de-/ activated with the `Cooling on/off` button in the toolbar of register `Manual control`. Select `Temperature interface` from menu `Cooling` for cooling related sensors and settings.

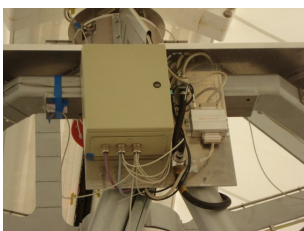
### 5.1 F1 cooling system

The F1 cooling system will keep the F1 temperature at a predefined offset with respect to ambient temperature. The controller is implemented within the GTCS, temperature and flow data is read from the MDE (“MessDatenErfassung”) and the “Ferneyschaltbox” is used to turn the liquid cooler on or off and to pass commands via the network to its RS232 interface.

Because overheating could damage the hardware the F1 cooling system must be fully functional for tracking (see section 10.4 for exceptions). During daytime it must be activated to open the M1 cover. An error will force closing of the M1 cover, stop tracking, and disable restart of tracking. The observer has no access to any settings of this system, all settings are written to the hardware by deactivating the cooling system (see section 4).

The following components belong to the F1 cooling system and must be operational:

1. “MessDatenErfassung”



If one of the F1 temperature sensors exceeds its limit or if the MDE is turned off, the M1 cover will be closed immediately. If the coolant flow falls under the limit, the GTCS will set an error and close the M1 cover by software.

2. F1 liquid cooler and “Ferneinschaltbox”



The F1 liquid cooler (on the right side) is turned on or off by the “Ferneinschaltbox” (black or grey box in the wall outlet). Therefore its power switch always must be set to On and its plug must be connected to the “Ferneinschaltbox”. A spare “Ferneinschaltbox” is usually located in a cabinet in GREGOR’s basement.

The Cooling on/off button will display an error if the F1 cooling system is turned off, but the M1 cooling system is turned on. In that case turn the cooling system off and on again with the Cooling on/off button.

5.2 M1 cooling system

The M1 cooling system is controlled by the SCU, some settings may be adjusted through the GTCS (see section 5.4 for details). It is not safety relevant so an error is displayed as warning but tracking is possible. The user can decide if M1 cooling should be activated or not. Once enabled it is turned on or off with the Cooling on/off button as well. The SCU calculates the cross temperature off all enabled M1 temperature sensors and controls the mirror temperature to the predefined offset with respect to ambient temperature by adjusting the coolant flow through the heat exchangers. The fan speed of the heat exchangers may be preset by the user.

5.3 Temperature interface

To adjust M1 cooling settings and to display the readout of cooling system related sensors, errors and warnings the GTCS temperature interface is used. Only register M1 allows to adjust settings, all other registers are for display only. Use entry Temperature interface in the GTCS menu Subsystems to open the temperature interface.

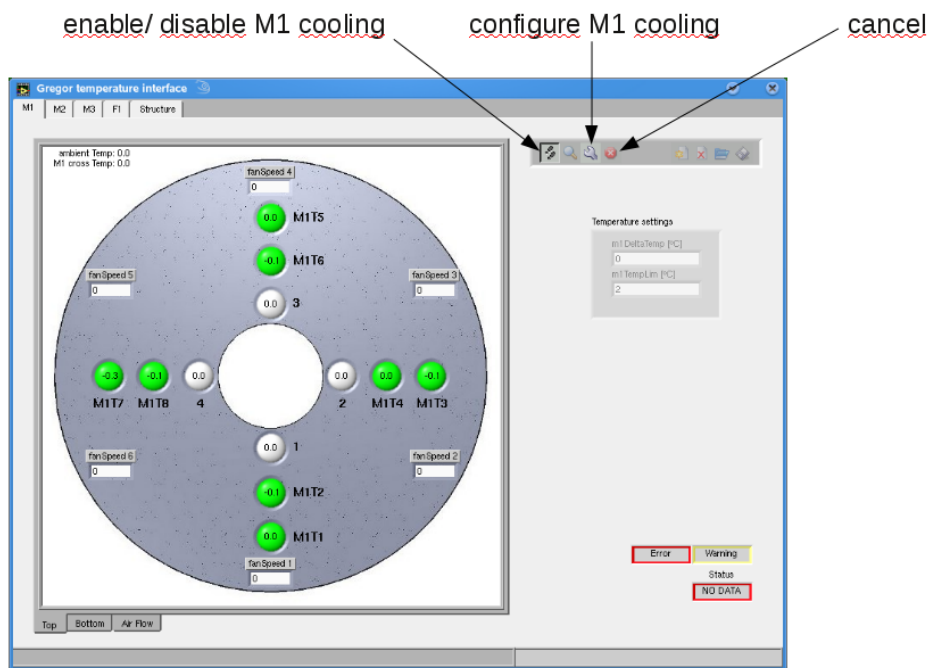


Fig. 3: GTCS temperature interface.

With the temperature interface the M1 temperature sensor selection, the M1 temperature set-point with respect to ambient temperature and the temperature warning limit can be adjusted.

## Controls and indicators of register "M1"

### Toolbar

The buttons of the toolbar are indicator and control at the same time.

1. enable/ disable M1 cooling



Disable M1 cooling.



Enable M1 cooling.

2. configure M1 cooling



Enter configuration mode.



Accept changes and leave configuration mode.

3. cancel

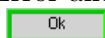


Discard changes and leave configuration mode.

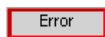
All other buttons of the toolbar are currently not used.

### Errors and warnings

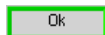
Error and warning indicator for M1 cooling system.



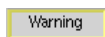
No error.



Error. See statusdata for details.



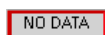
No warning.



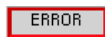
Warning. See statusdata for details.

### Status

Error and warning indicator for M1 cooling system.



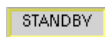
No data from SCU.



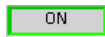
M1 cooling system error.



M1 cooling system disabled and off.



Standby: M1 cooling system enabled but off. Waiting for being turned on with **Cooling on/off** button in GTCS register **Manual control**.



M1 cooling system enabled and on.

### Temperature settings

- m1DeltaTemp Desired temperature difference to ambient temperature for M1 cross temperature.
- m1TempLimit Maximum difference to ambient temperature. If m1TempLimit is exceeded by any temperature sensor (M1 or structure) GTCS will show warning "m1TempLimit".

## 5.4 Configuration

To adjust any setting use the temperature interface and enter configuration mode with the **configure M1 cooling** button from the toolbar in register M1. In configuration mode the following adjustments are possible:

- Click on any M1 temperature indicator to en- or disable the related temperature sensor. If greyed out, the temperature sensor is disabled and the SCU will not use it to calculate the M1 cross temperature.
- Adjust fan speed setting for each M1 cooling box (0..1000 ‰). Changes for fanspeed are only accepted if the M1 cooling system is active when configuration mode is left. Changes are only possible in the top view of the M1 temperature sensors.
- Adjust `m1DeltaTemp` and `m1TempLimit`.

To accept and send changes to the SCU use the **configure M1 cooling** button, otherwise use **cancel** to leave configuration mode without saving changes.

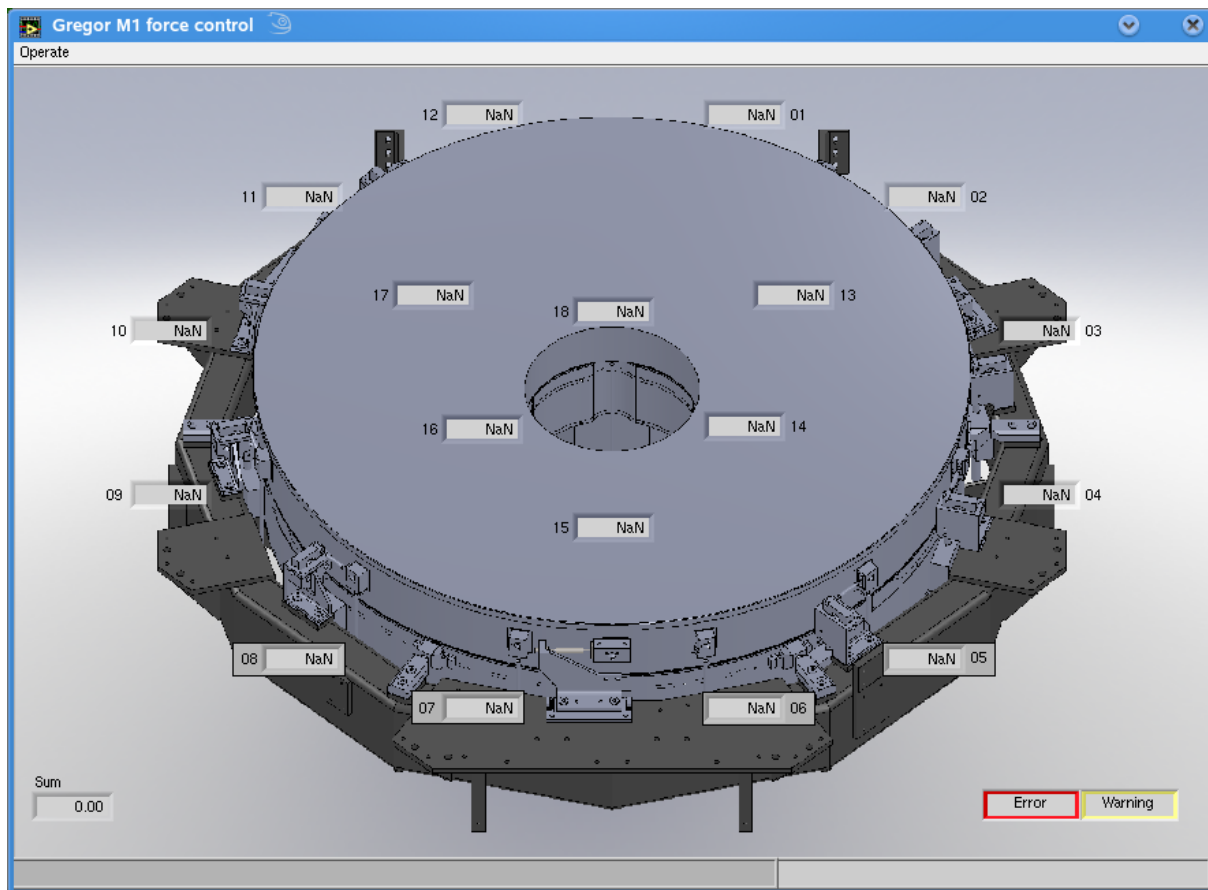


Note: all changes are lost when the GTCS is shut down.

As mentioned before in normal operation mode the M1 and the F1 cooling systems are activated or deactivated simultaneously with the **Cooling on/off** button in the toolbar of GTCS register **Manual control**. When the M1 cooling system is de-/ activated with the **enable/ disable M1 cooling** button from the temperature interface it will be de-/ activated immediately and disabled/ enabled for the next time the **Cooling on/off** is used. In case **Cooling on/off** is off and M1 cooling is enabled with **enable/ disable M1 cooling** the button **Cooling on/off** will show an error because the overall cooling setting is off and M1 cooling is on. Clear this error with **Cooling on/off** and turn cooling on again with the same button if necessary.

## 6 M1 force control

The mount of the M1 mirror is equipped with 18 force sensors to display the distribution of forces throughout the mount. The GTCS M1 force control is used to display the readout of these sensors and to calculate the sum of the forces of selected sensors to adjust the mirror mount.



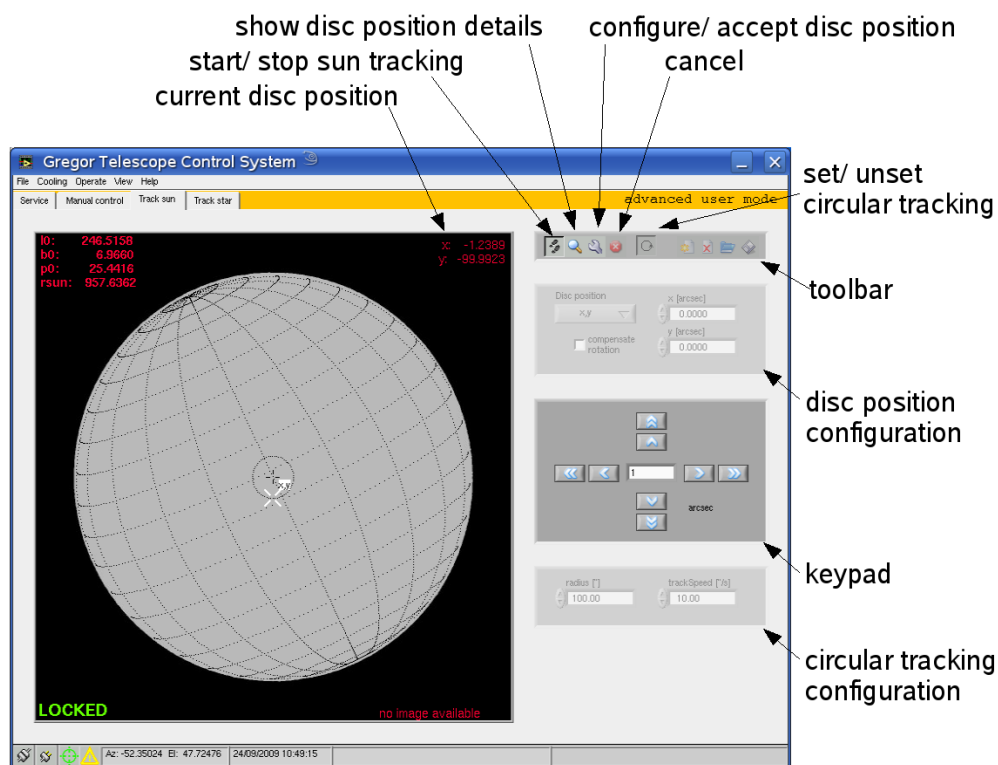
*Fig. 4: GTCS M1 force control.*

Sum displays the sum of the readout of selected sensors. Use **Select M1 force sensors** from menu **Operate** to open the dialog to select sensors. The changes are applied immediately and only affect the display in Sum.

In case of an error, the hardware currently cannot be reset with the GUI. It is reset automatically when the TCP/IP connection to the hardware is established.



## 7 Track sun



*Fig. 5: Controls and indicators of mode Track sun.*

The GTCS provides the following features for sun tracking:

- numeric definition of disc positions
- graphical definition of disc positions
- finetune disc positions with the keypad
- load disc positions from file
- save disc positions to file
- differential rotation compensation
- circular tracking for flatfielding
- display ChroTel live images to find region of interest

## 7.1 Tracking

If the telescope is initialized, all errors are cleared and the axes are activated tracking of the Sun can be started with the **start/stop sun tracking** button of the toolbar in register **Track sun**. Tracking will start with the settings displayed in the disc position configuration box and eventually in the circular tracking configuration. The current disc position is displayed as bold cross-hair and can be finetuned with the keypad.



Note: changes with the keypad are not saved automatically to the definition of the disc position. Therefore they are lost if not saved by the user as soon as tracking is stopped or configuration mode is left without cancelling.

## 7.2 Disc positions

The GTCS allows to define a list of disc positions in two coordinate systems:

1. Disc coordinates: x,y in arcseconds [note that this is not in heliocentric projected coord., i.e. unlike SDO coordinates. See the derotator manual for more details on coordinates.]
2. Heliographic coordinates: l,b in degrees

Disc positions can either be tracked in static mode or can be compensated for differential rotation. Therefore an absolute timestamp is saved with each disc position. Any change of the disc position leads to an update of its timestamp. When using the GUI this update occurs when accepting the new settings, changes by command lead to an immediate update. After a restart of the GTCS the default disc position has no timestamp defined. It is updated upon changes as any other disc position or when tracking is started for the first time. Each disc position is identified by its name, that means defining a disc position with a name that already exists will overwrite the current settings.

To add or change a disc position enter configuration mode with the "configure/ accept disc position" button. During configuration tracking is continued without changes and changes are not applied before leaving configuration mode with "configure/ accept disc position". If cancelled tracking continues without any changes.

Note that the AO can overrule the rotation tracking set in GTCS. If the AO checkbox **offload TT** is active, then the AO drives the telescope to track the selected object, which effectively is similar to rotation tracking. The rotation tracking equation is defined in the Fortran GREGOR ephemeris program and should at some point be tested in more detail because there are different equations in the literature.

### 7.2.1 Add or change disc positions

The easiest way to change the settings of the current disc position is a right mouse click into the sun image, to select **redefine disc position** from the context menu and to leave configuration mode. Then a new timestamp is assigned to the disc position and tracking is continued with the new settings. If coordinates are given or you want to add a defined offset, numerical values may be entered directly into the disc position configuration box as well.

To add a new disc position use either **new disc position** from the toolbar or right click into the sun image and select **new disc pos.** from the context menu. This will open a disc position configuration dialog box as shown below.



*Fig. 6: Disc position configuration dialog.*

Parameters are copied from the current tracking settings, the systemtime when opening the dialog is set as timestamp. All values can be changed, when changing the coordinate system, values are translated into the new system if possible.



Entering new values and translating those into another coordinate system will not work. Only the automatically preset values are translated.

The system will automatically assign a new name that is not found in the list. This name can be changed as well, eight ASCII characters are allowed. The first three characters will show up in the graphical display.



Entering a name that is already defined will overwrite the settings for the defined disc position. Therefore this method can be used to save finetuned parameters of a disc position (see below).



New disc positions are appended to the list. To track the new disc position select it from the list before leaving configuration mode.

### 7.2.2 Delete disc positions

As long as there is more than one disc position defined the current disc position may be deleted from the list with the **delete disc position** button from the toolbar.

### 7.2.3 Finetune disc positions

Use the keypad in register track sun to finetune the current disc position. The buttons with one arrow will stepwise move with the defined increment, the buttons with two arrows will double the increment. Continuously pressing the buttons changes the disc position continuously. The keypad is not accessible in configuration mode.



The fine tuning does not change the definition of the disc position in the list. To save the new values enter configuration mode and save a new disc position with the same name as the disc position you want to change (see previous chapter for details).

#### 7.2.4 Load or save list of disc positions

Use `load disc positions from file` and `save disc positions to file` to load or save a list of disc position. When loading a list the currently defined list is overwritten.

### 7.3 Differential rotation compensation

The GTCS is able to compensate differential solar rotation. It is en- or disabled with the checkbox in the disc position configuration box (accessible in configuration mode). The GTCS calculates the difference between current system time and the timestamp defined with each disc position and rotates the disc positions by this difference. Disc positions that are on the backside of the disc due to the differential rotation compensation are displayed as circle instead of a cross-hair.

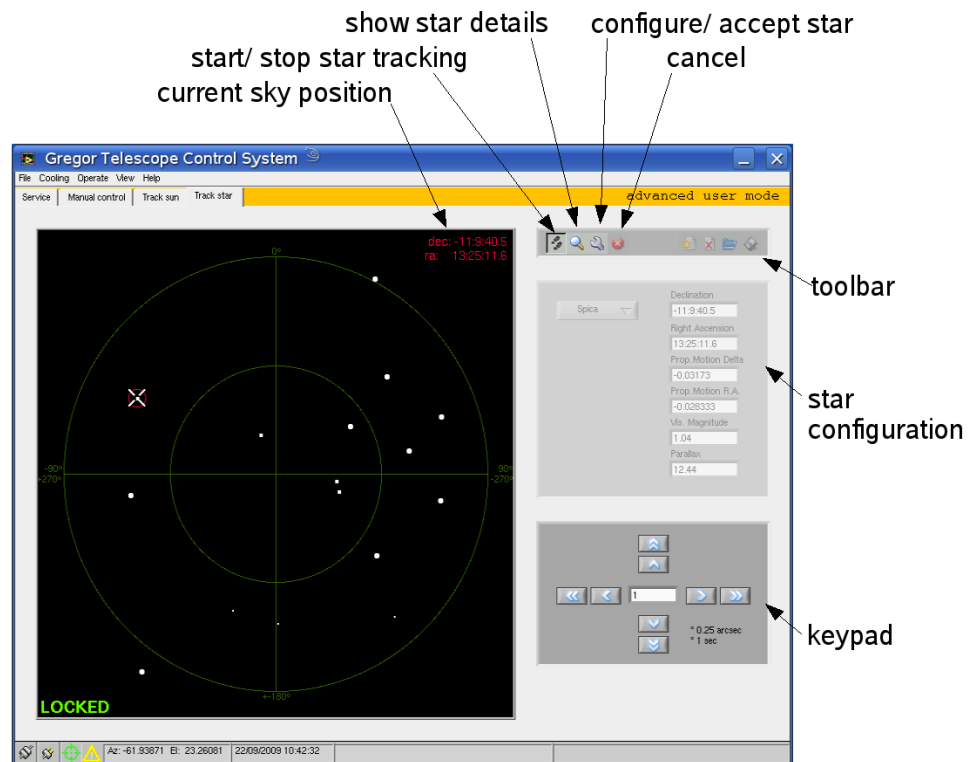
Differential rotation compensation is possible only for disc positions inside the solar disc.

### 7.4 Circular tracking

To take flatfield images it is possible to track circles around defined disc positions. Use the `set/unset circular tracking` button from the toolbar to en- or disable circular tracking. Radius and tracking speed may be defined in the circular tracking configuration box. The GTCS will track a circle around the disc position that is shown in the disc position configuration box. Points on the circle are calculated with a time difference of one second. The maximum speed depends on the radius of the circle and is limited so that at least three positions on the circle can be calculated.

Circular tracking is only allowed for disc positions inside the solar disc.

## 8 Track star



*Fig. 7: Controls and indicators of mode Track star.*

The GTCS provides the following features for star tracking:

- numeric definition of stars
- finetune star positions with the keypad
- load stars from file
- save stars to file
- show starnames when clicking with the mouse on the star

### 8.1 Tracking

If the telescope is initialized, all errors are cleared and the axes are activated tracking of stars can be started with the **start/stop star tracking** button of the toolbar in register **Track star**. Tracking will start with the settings displayed in the star configuration box. The current position is displayed as bold cross-hair and can be finetuned with the keypad.



Note: changes with the keypad are not saved automatically to the definition of the star. Therefore they are lost if not saved by the user as soon as tracking is stopped or configuration mode is left without cancelling.

## 8.2 Stars

The GTCS allows to define a list of stars. To add or change a star enter configuration mode with the `configure/ accept star` button. During configuration tracking is continued without changes and changes are not applied before leaving configuration mode with `configure/ accept star`. If cancelled, tracking continues without any changes. Parameters have to be defined for Epoch 2000.

### 8.2.1 Add or change stars

The easiest way to change the settings of the current star is to enter new values directly into the star configuration box. To add a new star use `new star` from the toolbar. This will open a star configuration dialog box as shown below. Parameters are copied from the current tracking settings, all values can be changed.



The dialog box titled "Enter new star parameters" contains the following fields and values:

Field	Value	Unit
name	0	
Declination	-11:9:40.5	
Right Ascension	13:25:11.6	
Prop.Motion Delta	-0.03173	[arcsec/yr]
Prop.Motion R.A.	-0.028333	[sec/yr]
Vis. Magnitude	0	
Parallax	12.44	

Buttons: OK, Cancel

*Fig. 8: Star configuration dialog.*

The system will automatically assign a new name that is not found in the list. This name can be changed as well, eight ASCII characters are allowed.



Entering a name that is already defined will overwrite the settings for the defined star. Therefore this method can be used to save finetuned parameters of a star (see below).



New stars are appended to the list. To track the new star select it from the list before leaving configuration mode.

### 8.2.2 Delete stars

As long as there is more than one star defined, the current star may be deleted from the list with the `delete star` button from the toolbar.

### 8.2.3 Finetune stars

Use the keypad in register track star to finetune the current star. The buttons with one arrow will stepwise move with the defined increment, the buttons with two arrows will double the increment. Continuously pressing the buttons changes the star position continuously. The keypad is not accessible in configuration mode.



The fine tuning does not change the definition of the star in the list. To save the new values enter configuration mode and save a new star with the same name as the star you want to change (see previous chapter for details).

### 8.2.4 Load or save list of stars

Use `load stars from file` and `save stars to file` to load or save a list of stars. When loading a list the currently defined list is overwritten.

## 9 Remote interface

The GTCS provides two interfaces for remote control:

- LabVIEW Remote Panel for user access to the GUI
- DCP interface for communication with other instruments

The user will generally not work directly at the gcs-computer itself, but operate it with the Remote Panel functions. A VNC server is setup for debugging and support purposes only and not accessible to the user. The gcs-computer can also be accessed via OT Teamviewer.

### 9.1 LabVIEW Remote Panel

Once setup completely, the Remote Panel functions are used to operate the GTCS. The user will open a Remote Panel with the instrument control system instead of working locally on the gcs-computer. The access to the Remote Panel is restricted by the settings in the GTCS configuration file (see 11.2). The user can decide if he wants only to view the display or if he wants to control as well. The GTCS checks for Remote Panels waiting for control and immediately closes the currently controlling Remote Panel to transfer control to a waiting Remote Panel. Open the context menu for Remote Panel functions with a right click on any free area of the GUI to request or release control of the GUI. If control is released before another client is requesting control the Remote Panel will not be closed. Too many control changes seem to sometimes lead to a freeze (white window) of the original panel on gcs, in which case killGTCS in the instrument control at gcs has to be used and then GTCS can be restarted on gcs and later on the remote clients.

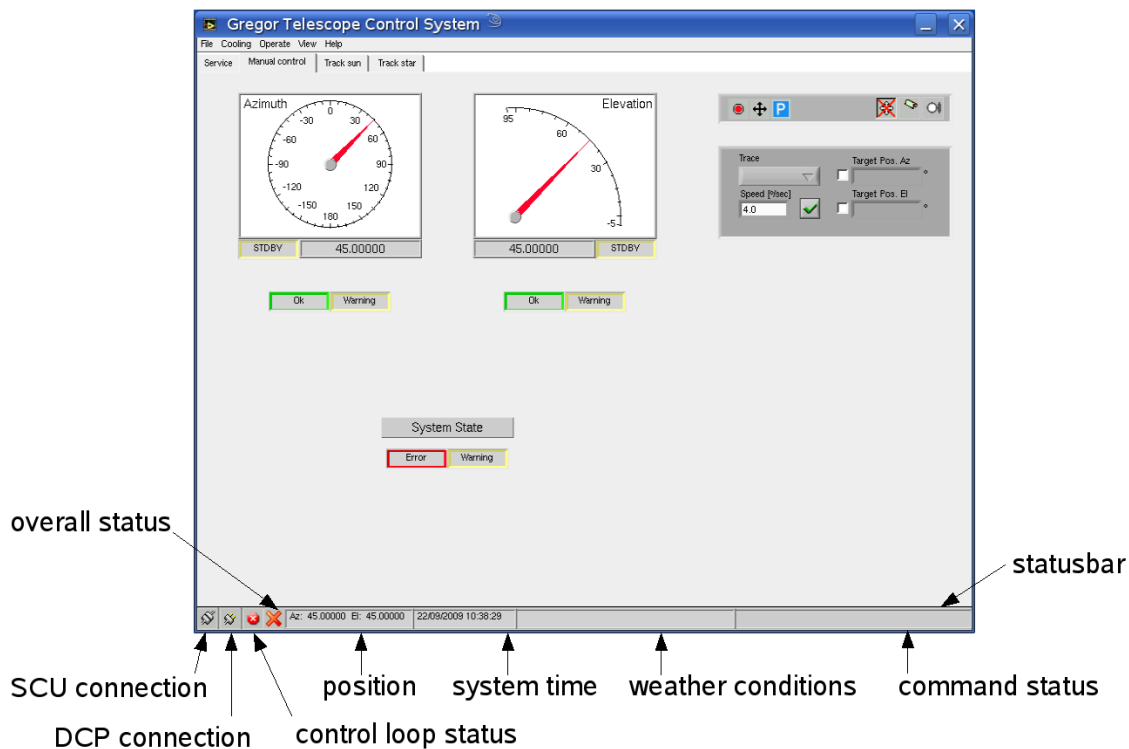
On the server (that means the local GUI of the GTCS) the user can always regain or lock the control so that Remote Panels can only view but not control the GUI. Use the context menu of the GUI to control the server. Depending on the state the menu may contain the following items:

- **Lock control:** clients can view but not control the GUI.
- **Unlock control:** clients can view and control the GUI.
- **Regain control:** transfer control to server and lock control.
- **Switch controller:** transfer control to server but do not lock control.
- **Show last message:** show last message from Remote Panel server.






## 9.2 DCP interface

The DCP interface is used for communication with other instruments via the network. Most of the functions of the GTCS can be controlled via DCP and status data and system parameters can be queried (see ICD GRE-KIS-SPE-0011.pdf for complete documentation of available commands). The current status of the DCP interface is shown in the status bar (see image below).



*Fig. 9: Top level controls of the GTCS GUI.*

### Status of Remote interface

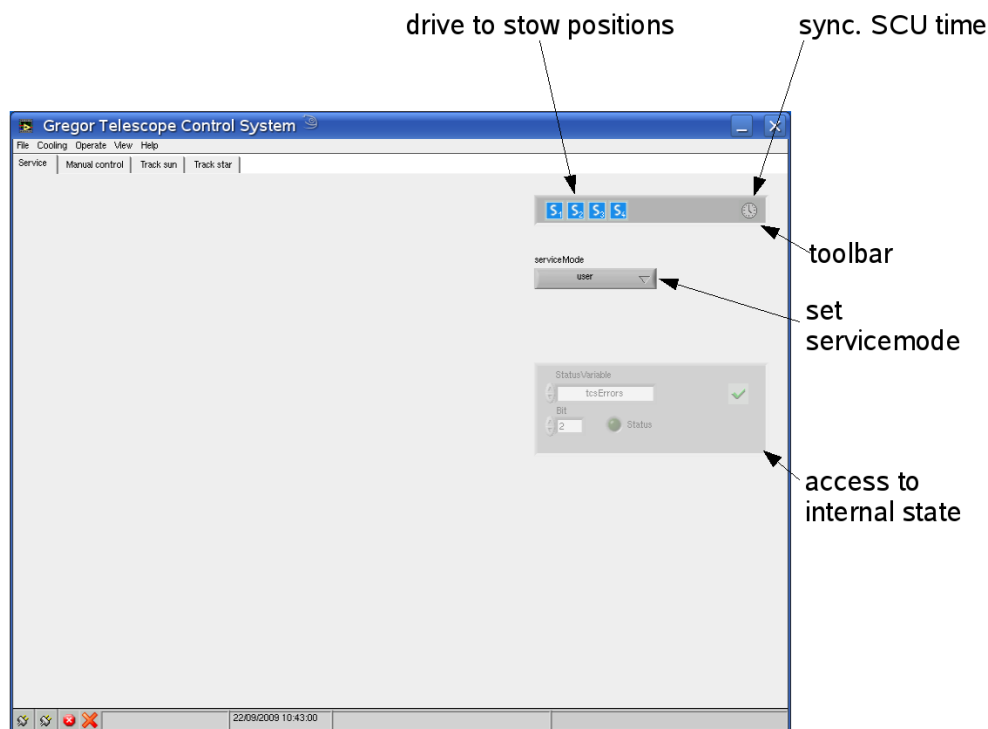
-  Not connected.
-  Connection established.
-  Connection established, interface locked.

In some cases the user may want to disable execution of commands sent to the DCP interface. With a right click on the DCP connection icon in the status bar the user can select from the context menu to lock or unlock the DCP interface. If locked, any command that would change settings of the GTCS is rejected but inquiries of variables are still possible.

To avoid interference between user actions and DCP commands all DCP commands related to sun tracking are blocked as long as the GTCS is in configuration mode for sun tracking as well as all DCP commands related to star tracking are blocked during GTCS configuration mode for star tracking.

To inform the user about incoming DPC commands the command status indicator of the statusbar is highlighted yellow if a DCP command is received.

## 10 Service functions



*Fig. 10: Controls and indicators of mode "Service".*

The GTCS provides the following service functions:

- drive to stow positions
- synchronize SCU time to GTCS time (password required)
- update configuration file for polar motion correction (password required)
- set different servicemodes with advanced rights (password required)
- directly access internal state (password required)
- open subroutines for debugging (password required)

### 10.1 Drive to stow positions

Each telescope axis has two stow positions at which the stowpin can be inserted. Both axes are moved to their stow position simultaneously that makes overall four different stow positions of the telescope. These are:

1. Azimuth  $0^\circ$ , elevation  $90^\circ$
2. Azimuth  $135^\circ$ , elevation  $90^\circ$
3. Azimuth  $0^\circ$ , elevation  $0^\circ$
4. Azimuth  $135^\circ$ , elevation  $0^\circ$

## 10.2 Synchronize SCU time

The GTCS systemtime and the SCU systemtime must not differ more than five seconds otherwise a timeSync error is set. Normally the GTCS systemtime is set by the NTP-protocol, the SCU systemtime is obtained from GPS. In case of a timeSync error the SCU systemtime can be set to the GTCS systemtime. This is available in advanced user mode only (see section 10.4 for details).



Synchronizing the SCU to GTCS systemtime will turn off GPS and leave the SCU clock in crystal mode. This is less accurate especially over long time. Currently GPS can only be turned back on at the LCP.

## 10.3 Update Bulletin A

The configuration file for polar motion correction has to be updated regularly (see section 11.1 for details). This can be done in advanced user mode (see below) by selecting **Update Bulletin A** from the **File** menu.

## 10.4 Service modes

The GTCS provides different service modes to disable certain modules or to access internal functions and variables. Because in some cases hardware may be damaged those service modes are password protected. Currently the following modes are available:

- user
- advancedUser
- administrator

### 10.4.1 User mode

This is the default mode for observation. The user can use all telescope functions but cannot change any settings except for the M1 cooling system. During daytime the M1 cover is locked as long as the dome is opened and the sun pointing limit is exceeded or the F1 cooling is not active. It will be closed automatically as soon as the system gets into one of these states.

### 10.4.2 Advanced user mode

In case that F1 cooling system errors cannot be cleared it can be disabled by switching to advanced user mode. Errors of the F1 cooling system are blocked and tracking and opening the M1 cover is allowed. Tracking limits for defining disc positions are still active but if tracking is stopped or for example a positioning command is sent the M1 focus may leave the F1 field stop. In advanced user mode the M1 cover will not close automatically if the tracking limits are exceeded so parts of the structure getting into M1 focus may be burned. Depending on the error of the cooling system the hardware interlock of the M1 cover may not work and the F1 field stop may be overheated.



This user mode is only for those who really know what they are doing. There will be no notification about temperature rise and depending on the system state there may be no fallback to prevent hardware from being damaged or destroyed.

In addition to disabling the F1 cooling system in advanced user mode the file “Bulletin A” for polar motion correction may be updated (see section 11.1) and the SCU system time can be synchronized to the GTCS system time.

### 10.4.3 Administrator mode

Administrator mode includes all rights and functions of advanced user mode and additionally allows to open subroutines and parameter definitions for debugging and online change for example of tracking limits. Furthermore internal bit coded status variables may be changed online.



This user mode is only for those who really know what they are doing. There will be no notification about temperature rise and depending on the system state there may be no fallback to prevent hardware from being damaged or destroyed.

## 11 Configuration and logging

### 11.1 Polar motion correction

The ephemeris program applies polar motion corrections for Izana as a function of date (day, month, year). Therefore an input file has to be constructed - and updated - from the “IERS Bulletin A”, which contains predictions ahead of time: The data, therefore, are neither final nor absolutely correct, but they are sufficiently accurate for our purpose (simply because these corrections are small, anyway). “Bulletin A” has to be downloaded from the U.S. Naval Observatory.

Example:

I E R S B U L L E T I N - A Rapid Service/Prediction of Earth Orientation  
15 January 2004 Vol. XVII No. 002

To receive this information electronically, contact:

ser7@maia.usno.navy.mil  
or use  
<http://maia.usno.navy.mil/>

Then the header portion and the trailer portion of the file must be removed, leaving the required part of the data table only (the latter is to be appended to the existing file, thus extending it further into the future (out-dated data at the beginning may of course be removed). This file then has to be stored as “bulletinextract.txt” in the “config” folder of the TCS installation directory. If this file is missing or not up to date the warning `noPolarMotionCorrection` is generated. Tracking is still possible.

The file may be updated automatically in advanced user mode by selecting `Update Bulletin A` from the `File` menu. This will download the current Bulletin A and save it in the config folder as “tempBullA.dat”. The extracted portion of the file is saved as “bullA\_YYYYMMD\_hhmmss.txt” and a symbolic link “bulletinextract.txt” to this file is generated. For backtracking, old versions of the created file are not deleted.

## 11.2 Configuration file

For basic settings the TCS uses the configuration file “tcs.ini” saved in the “config” folder of the installation directory. It is a “LabVIEW configuration File” containing the following definitions:

- path definitions
- IP address and port of systems the TCS connects to
- MDE configuration
- type of interpolation during tracking
- maximum allowed offset during sun tracking
- offset and precision of calculation of pupil angle
- maximum allowed offset to disc center during sun tracking before M1 cover is closed (pointLimit)
- system settings like storage time of logfiles, parkposition or Remote Panel access configuration

If the file is missing or if for a variable no value is given the system uses the default settings for the missing variable. In this case tracking is not allowed.

## 11.3 Logfiles

Error information and statusdata is logged in the folder `/var/local/GTCS/log/`. Upon startup and every night at 12pm a new set of logfiles is created. Afterwards the previous set is compressed and old files are deleted (storage time can be set in “tcs.ini”, see [11.2](#)). Four separate logfiles are used:

- `scu_comm_log_xx.txt`:  
ASCII file saving commands send to and replies received from the SCU
- `scu_status_log_xx.txt`:  
binary log of the SCU statusdata, can be read with the `scu-statusreader`, see ICD (GRE-KIS-SPE-0011) for details
- `tcs_error_log_xx.txt`:  
ASCII file saving errors and warnings that occurred anywhere in the system
- `tcs_status_log_xx.txt`:  
binary log of the TCS statusdata, readable with the `tcs-statusreader`, see ICD (GRE-KIS-SPE-0011) for details

## 12 Known issues

- Currently the GTCS calculates upon startup and each night shortly after 12pm the path of the Sun for the current day. The actual telescope pointing is compared to this path to check if the pointing limit is exceeded. To be able to track the solar limb without problems the resolution of this path had to be increased. For this reason startup takes much longer than before and the system can block during calculation. So during tracking around midnight tracking may be blocked and errors may occur. In this case stop tracking, reset errors and start over.

## 13 Howto's

### 13.1 How to define disc positions

1. Enter configuration mode in register `Track sun`.
2. Select `new disc position` either in the toolbar or from the context menu of the sun image.
3. Enter name, select coordinate system and define variables. Values are preset either to the current tracking settings or to the position selected in the image.
4. Accept settings and select the new disc position from the list.
5. Leave configuration mode.

### 13.2 How to define stars

1. Enter configuration mode in register `Track star`.
2. Select `new star` in the toolbar.
3. Enter name and define variables. Values are preset either to the current tracking settings.
4. Accept settings and select the new star from the list.
5. Leave configuration mode.

### 13.3 How to turn the telescope on

Telescope main power supply and control computers are turned off.

1. Turn on main power switch at cabinet “GREST S1”. **Power On** switch is off, **Interlock Fault** and **Servo Fault** are off.
2. Turn on the “Servo Control Unit” at cabinet “GREST S2”. The switch is located behind the locked cover on the front side of the computer. Wait until control screen “Gregor LCP” is visible.
3. Turn on green **Power On** switch at cabinet “GREST S1”. **Power On** starts blinking, **Interlock Fault** is on and **Servo Fault** starts blinking. Reset the interlock by pushing the switch. If the dome is opened reset the servo fault as well by pushing the switch. Wait until **Power On** stops blinking. This may take up to two minutes. Now the telescope can be moved via the HHP or, if the dome is opened, referenced by command.
4. In case you want to use the M1 cooling system, turn on power switch of the left Lauda liquid cooler.

### 13.4 How to turn the telescope off

Both axes are stowed if possible, otherwise deactivated.

1. Turn off green **Power On** switch at cabinet “GREST S1”.
2. Shut down “Gregor LCP” program running on the servo control unit by pressing key combination **Alt F4** and shut down Windows using the Windows Start Menu.
3. If the servo control unit is shut down, turn off the main power switch at cabinet “GREST S1”.
4. Turn of power switch of left Lauda liquid cooler.

### 13.5 How to switch LCP between local or remote control

If the LCP is set to remote control there is always a button “Local Control” (F2) displayed at the LCP. Use this button to set the LCP to local control.

To switch to remote control the SCU needs to be at least in state “Not Referenced”. That means power must be activated, Interlocks and Servo Faults must be reset. Use button “Remote Control” (F2) of the LCP to switch to remote control. Potentially close any open menu of the LCP to display the button.

### 13.6 How to move the telescope using the Hand Held Panel

Telescope power is on.

1. Move stowpin of axis out.
2. Set left rotary switch to X. Select axis with right rotary switch: Y = azimuth, Z = elevation.
3. Check the **F1** and **F2** indicators for any interlocks or servo errors and reset them if necessary by pressing the button. If the **F9** indicator is blinking the telescope is in state "power activate". This may take up to two minutes, wait until **F9** stays on.
4. Check the **F3** indicator, to be sure the stowpin is out (illuminated if stowpin is out).
5. Activate the motors by pressing the yellow acknowledge switch to the medial position.
6. Choose via the handwheel the desired rate.
7. Turn off the HHP by setting the right rotary switch to X.



when moving the telescope with the dome closed it may crash into the dome.



## 14 Appendix

### 14.1 Configuration file "tcs.ini"

```
[pathes]
log=          directory for logfiles
config=      directory for configuration file
userConfig=  directory for user configuration file
userDefault= top directory for user to save disc positions
              or stars

[sockets]
scuIp=       IP address of SCU
scuCmdPort=  SCU port for commands and command answers
scuStatPort= SCU port for sending statusdata
derotIp=     IP address of derotator
derotCmdPort= Derotator port for commands and command answers
derotStatPort= Derotator port for sending statusdata
weathIp=     IP address of weather sensor
weathPort=   Weather sensor port for receiving weather data
mdeIp=       IP address of MDE
mdePort=     MDE port for commands and command answers
laudaIp=     IP address of Lauda liquid cooler
laudaPort=   port for commands and command answers to
              Lauda liquid cooler
laudaPwrPort= port for commands and command answers to
              "Ferneinschaltbox"
dcpServerIp= IP address of DCP server
dcpPort=     port of DCP server
webSrvPort=  port for webserver of GTCS (port for access
              to Remote Panel)

//Diagnose settings
diagnoseIp=  IP address of computer that is allowed to connect
              to the server. Server is only started if
              diagnosePort != 0.
diagnosePort= diagnosePort then is command port, diagnosePort+1
              is status port.
m1fcIp=     IP address of M1 force control hardware
m1fcPort=   m1fc port for commands and command answers

[dcpId]
tcsDcpId=   DCP Id of GTCS
tcsDebugDcpId=
databaseDcpId= DCP Id of database server
```

```
[mdeConfig]
configListX:      limit control list. Check MDE doku for details.
                  Use always exactly one digit of precision. Use
                  [] to define an empty list. The number before
                  the list is bit coded and defines which channels
                  force clearing outputs upon sensor error
                  (0: no channel,1: channel A,.. 3: all channels).

sensorTypeXX:     sensor type connected to mde channel X. Allowed
                  entries: 0 (smt160), 1 (pt100), 2 (frequency).
                  Changes are only written to mde if configList
                  changed as well. Otherwise writing needs to be
                  forced using "tcs_fscu_init_mde.vi".

// mde module 1. Used to measure flow through F1 field stop.
// Flow sensor should open safety circuit. If A==0Hz output is set
// as well as long as channel isn't set to force
// clearing.

moduleId1=
configList1=
sensorTypeA1=
sensorTypeB1=
sensorTypeC1=
sensorTypeD1=

// mde Module 2.Used to measure ambient temperature and temperature
// of F1 field stop. Closes M1 cover in case
// temperature exceeds limit.

moduleId2=
configList2=
sensorTypeA2=
sensorTypeB2=
sensorTypeC2=
sensorTypeD2=

// mde Module 3. Used to measure temperature of sensors S3, S4,
// S9, S10.

moduleId3=
configList3=
sensorTypeA3=
sensorTypeB3=
sensorTypeC3=
sensorTypeD3=

// mde module 4. Used to measure temperature of sensors S5, S6
// (M3 temperature), S7, S8 (M4 temperature)
```

```
moduleId4=  
configList4=  
sensorTypeA4=  
sensorTypeB4=  
sensorTypeC4=  
sensorTypeD4=  
  
// mde module 5. Used to measure temperature of sensors M1T1,  
M1T2, M1T3, M1T4  
  
moduleId5=  
configList5=  
sensorTypeA5=  
sensorTypeB5=  
sensorTypeC5=  
sensorTypeD5=  
  
// mde module 6. Used to measure temperature of sensors M1T5,  
M1T6, M1T7, M1T8  
  
moduleId6=  
  
// mde module 7. Used to measure temperature of sensors M1T9,  
M1T10, M1T11, M1T12 (cooling air temperature)  
  
moduleId7=  
  
// mde module 8. Actually not used.  
moduleId8= Reserved for future use to measure m3  
temperature.  
  
// mde module 9. four port digital input, used to check M1  
safety cover connection.  
  
moduleId9=  
  
swLimDF1= software limit for F1 coolant flow  
swLimT1F1= software limit for temperature of T1F1  
swLimDeltaT2AF1= software limit for temperature difference of  
T2F1 referred to ambient temperature  
b0TempCtrlF1= parameter b0 of F1 temperature controller  
b1TempCtrlF1= parameter b1 of F1 temperature controller  
b2TempCtrlF1= parameter b2 of F1 temperature controller  
laudaMinTemp= minimum temperature of Lauda liquid cooler  
laudaMaxTemp= maximum temperature of Lauda liquid cooler  
tempDeltaT1AF1= F1 temperature setpoint offset to ambient  
temperature  
m1CovDeltaT1AF1= For future use: maximum F1 temperature  
referred to ambient temperature at which the  
M1 safety cover may be opened.  
  
tSensoOffsetM1T1= Calibration offset of temperature sensor M1T1
```

tSensoOffsetM1T2=  
tSensoOffsetM1T3=  
tSensoOffsetM1T4=  
tSensoOffsetM1T5=  
tSensoOffsetM1T6=  
tSensoOffsetM1T7=  
tSensoOffsetM1T8=  
tSensoOffsetM1T9=  
tSensoOffsetM1T10=  
tSensoOffsetM1T11=  
tSensoOffsetM1T12=

[trackParam]

pgmTrackMode= type of interpolation during program track.  
Allowed entries: stepwise, newton, lagrange,  
spline

offsetLimX= maximum x value of disc position [arcsec]  
offsetLimY= maximum y value of disc position [arcsec]  
offsetLimL= maximum l value of disc position [arcsec]  
offsetLimB= maximum b value of disc position [arcsec]  
offsetPupilAngle= offset to adjust pupil angle [deg]  
precPupilAngle= maximum precision of pupil angle  
pointLimit= maximum allowed offset to center of Sun [deg]  
pointLimitInactive= offset to center of Sun to reset pointing limit  
error [deg]

pointCorrAz= pointing correction of azimuth axis [deg]  
pointCorrEl= pointing correction of elevation axis [deg]

[system]

statusLogSaveTime= maximum time to store logfiles [h]  
parkPosAz= parking position of azimuth axis [deg]  
parkPosEl= parking position of elevation axis [deg]  
azSwUp= Az software limit up [deg]  
azSwDown= Az software limit down [deg]  
elSwUp= El software limit up [deg]  
elSwDown= El software limit down [deg]  
minSlewRate= minimum slew rate [deg/s]  
maxSlewRate= maximum slew rate [deg/s]  
maxOffset= maximum axis offset [deg]  
sunImgResDef= resolution of sun default image  
sunImgResCa= resolution of Ca image display  
sunImgResHa= resolution of Ha image display  
sunImgResHe= resolution of He image display  
tcpIpAccessList= configuration of webserver access  
(see LabVIEW help for details)

tcsStatusLogList= TCS status variables to write to logging  
database

scuStatusLogList= SCU status variables to write to logging  
database

[m1fc]

fSensScale01= Scale factor of M1 force sensor 01

fSensOffset01= Offset of M1 force sensor 01

fSensScale02=

fSensOffset02=

fSensScale03=

fSensOffset03=

fSensScale04=

fSensOffset04=

fSensScale05=

fSensOffset05=

fSensScale06=

fSensOffset06=

fSensScale07=

fSensOffset07=

fSensScale08=

fSensOffset08=

fSensScale09=

fSensOffset09=

fSensScale10=

fSensOffset10=

fSensScale11=

fSensOffset11=

fSensScale12=

fSensOffset12=

fSensScale13=

fSensOffset13=

fSensScale14=

fSensOffset14=

fSensScale15=

fSensOffset15=

fSensScale16=

fSensOffset16=

fSensScale17=

fSensOffset17=

fSensScale18=

fSensOffset18=