




## VATT Control System


# User manual

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Title <b>VATT Telescope Control System</b>		Place of installation Mount Graham, Arizona		
		Archive number PS - 1642	Commission number ZAK 22 - 020266	
Operating section <b>VATT control system</b>		Project document number =ASLPM+VATT & EFE001		
		Degree of documentation Preliminary Design		
INT identification number <b>VATT-TCSR-PSD-01</b>		Label	Release date 2023/03/15	Sheet


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## 1. Document history


Revision 0      2023/03/15 First version of the document.

Revision 1      2024/06/04.Updated version

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## 2. Abbreviations

- PLC - Programmable Logic Controller
- VATT – Vatican Advanced Technology Telescope
- EMI - Electromagnetic interference
- PCB - Printed Circuit Boards
- PCI - Peripheral Component Interconnect
- UDP - User datagram protocol
- SCADA - Supervisory Control and Data Acquisition
- TCS – Telescope Control System
- TomPack – (TomPack2) is a SCADA system running on Windows servers, communicating with the Main PLC, providing a user interface and visualizing the state of the TCS as well as enabling the operator to control the TCS.
- Don – VATT’s control system by ProjectSoft is named "Don" in honor of Donald M. Alstadt, former chairman and CEO of Lord Corp, and of the Thomas Lord Charitable Trust.

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### 3. INTRODUCTION

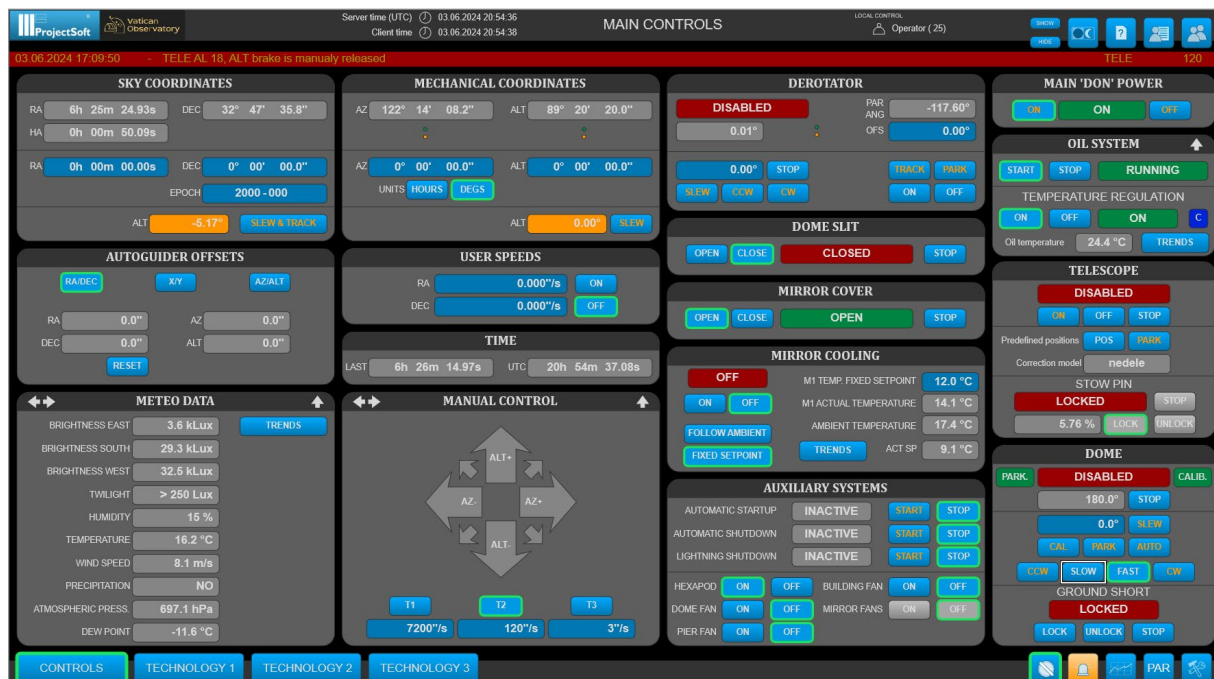
These OPERATING INSTRUCTIONS provide basic information necessary to operate the control and visualization system of the telescope. Before starting any operation, the personnel assigned to operate the system must be trained and familiar with these INSTRUCTIONS.


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## 4. OPERATING THE CONTROL COMPUTER

The visualization software is installed on the control computer (PC) with the Windows operating system. The control computer monitor displays the control process's actual status.

When the application starts, the main control screen is shown.



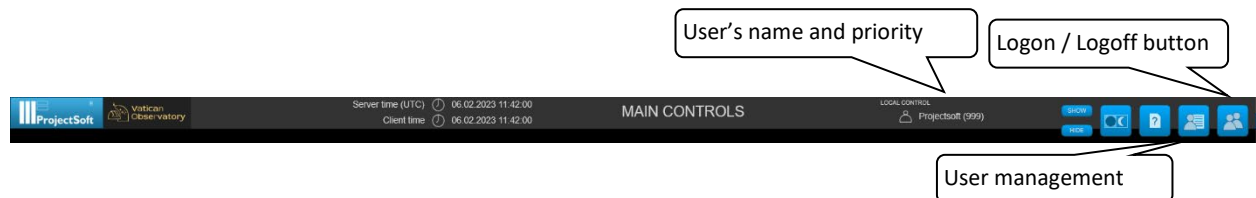
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## 4.1 System controls

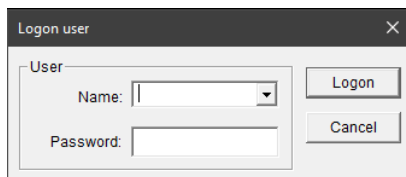
### 4.1.1 Logging on and off

Only authorized persons, logged on using their username and password can access the software.

Follow these steps to log on:



- Click the "Logon/Logoff button" on the right of the upper bar.
- The "Logon panel" will appear.



- Click inside the **Name** field and type in the user name.
- Then click inside the **Password** field, type in the required password and press Enter or click Logon to confirm. If the procedure was successful, the name of the logged user will appear in the upper bar. If the procedure was not successful, click on the Password field again and re-enter the password.
- **To log off**, press the **Logoff** button on this panel.

Individual authorized persons have the following access levels and corresponding restrictions to activities within the software (this can be modified on-site according to the specific needs of the customers):

- **PROJECTSOFT** priority 999, no restrictions
- **TECHNOLOGIST** priority 50, authorized to change selected set values and parameters
- **OPERATOR** priority 25, the basic level of operation, no authorization to change the above-mentioned parameters


**After work completion, the user should log off to prevent unauthorized usage!**

### 4.1.2 Screens - Overview

There are several groups, each group consists of one or more screens. Listed from left to right at the lower right-hand corner of the control screen.





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Group **CONTROLS**:

Screen **CONTROLS**

Screen **TECHNOLOGY**

Group **ALARMS**:

Screen **CURRENT ALARMS**

Screen **ALARM HISTORY**

Group **TRENDS**:

Screen **TRENDS**

Group **PARAMETERS**:

Screen **TELE PAR 1**

Screen **OTHER PAR 1**


Screen **OTHER PAR 2**

Screen **MODEL**

Group **SERVICE**:

Screen **GENERAL**

Screen **IO DEVICES**

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#### 4.1.3 Description of the upper and lower bar

Each screen contains the appropriate drawing or scheme and the upper and lower bars contain a set of control buttons and displayed information.

#### Upper bar




The following information can be found on the **upper bar**:

- the name of the screen
- the field showing the **name of the logged-on department and operator**
- the field showing the type of control – **LOCAL/REMOTE**
- the field showing server **date and time** (should be UTC)
- the field showing the client's **date and time**
- the lower red line displays information about the last active alarm

Buttons from the left:

- the **SHOW** button shows the application frame
- the **HIDE** button hides the application frame
- the **DAY/NIGHT** button reduces the brightness of a screen
- the **HELP** button opens this document
- the **USER LIST** button opens a dialogue where the user can edit user accounts
- the **USER LOGON** button

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### Bottom bar



Buttons from the left:

- **BOOKMARKS** for switching between screens
- The button/indicator signals an **ALARM** in the system. In case no alarm is active, the indicator is blue. If it is red-flashing, there is a non-acknowledged (non-confirmed) alarm in the system. If it is solid red, there is an acknowledged (confirmed) alarm in the system.
- The **TREND** button shows the screen with the graph of the selected technological variables
- The **PARAMETERS** button shows the screen with technical parameters.
- The **SERVICE** button shows the screen used to reach the documentation/ manual files and job termination.

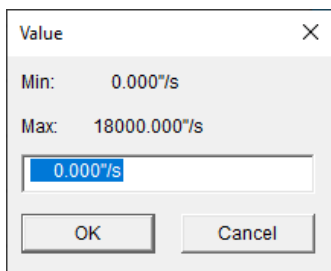
#### 4.1.4 Changing the value

- **Only authorized users with specified access levels can change** parameter values, alarm limits, etc.
- To change the value of a parameter move the mouse cursor to the **field of the variable value (light blue)**.



The field will be highlighted.

- Press **ENTER** or **click the left mouse button** to display the "Value" input window.




- Use the keyboard to enter the value and press **ENTER** to confirm.
- The value entered must be within the range set by the Min and Max values; values outside this range shall not be entered.

## 4.2 Alarm messages

Alarm messages notify the control system operator of existing non-standard conditions in the controlled technology such as drive failures, monitored variables outside working limits, stoppage of operation due to exceeding the control limits, etc.

- In case a new alarm occurs in the controlled technology, it is indicated by the **flashing indicator** in the Upper bar.

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#### 4.2.1 Actual alarms

- Select the **ALARM** button in the bottom bar and click to open the “Actual alarms” screen.
- **Actual alarms (i.e. new or persisting alarms) and so-called events** are displayed on this screen.




The screenshot displays the 'CURRENT ALARMS' screen. At the top, it shows the ProjectSoft logo, server and client times, and the user 'PS\_Admin'. The main area contains a table of alarms:

Timestamp	Alarm Description	Status	Count
11.04.2022 18:56:34	A SLIT AL 5, low level of hydraulic oil for slit	A	100
19.04.2022 07:43:40	E DOME BUTTON - start calibration procedures	E	1
21.04.2022 12:33:41	A METEO AL 10, wind speed error (wind speed limit exceeded) - WA...	A	100
25.04.2022 06:17:33	E GENE AL 1, control voltage (control voltage is off)	E	1

At the bottom, a legend identifies alarm statuses: ACTIVE AND UNACKNOWLEDGED (red), ACTIVE AND ACKNOWLEDGED (orange), INACTIVE AND UNACKNOWLEDGED (yellow), and EVENT (blue). The navigation bar includes 'CURRENT' and 'HISTORY' buttons, and a set of control icons: a checkmark, up/down arrows, and a refresh icon.

- Alarm history
- Acknowledge all alarms
- Shift to the top of the list
- Shift to the end of the list

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**Individual columns of the table have the following meaning:**

- date and time of the fault activation
- alarm status (A - active, + alarm activation, - alarm end)
- description of the fault
- location in the technology where the fault occurred
- value of the alarm variable

**Lines are colour-coded according to their status:**

- active non-acknowledged alarms: red
- active acknowledged alarms: orange
- inactive non-acknowledged alarms: yellow


**If a new alarm is generated, operators must check the reason and acknowledge (confirm) it.**

There are two possibilities to acknowledge alarms:

1. Acknowledge **all alarms in the system at one time** - click on the **“Acknowledge all”** button located on the bottom bar. The upper bar indicator will stop flashing and turn red, to indicate that acknowledged faults (operators are aware of them) are persisting in the system.

**Remark:** if the fault is resolved/removed indicator turns from red to blue.

2. **Acknowledge only selected alarms** - click on the appropriate alarm line.
  - **UP ARROW** and **DOWN ARROW** buttons in the middle of the bottom bar are used for navigation through the alarm list.
  - **LEFT ARROW** on the left of the lower bar is used to move back to the previous screen.
  - **RIGHT ARROW** on the left of the lower bar is used to move to the screen of alarm history.

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#### 4.2.2 Alarm history

- In the alarm history screen, all alarms and events can be displayed along with current alarms
- **An event** is an issue that **does not have the character of a fault** (log on of an operator, change of an important parameter, etc.) however, it is advisable to monitor it

**Note: acknowledging is not possible in alarm history.**



The screenshot shows the 'ALARM HISTORY' window. At the top, it displays the server and client times (06.02.2023 11:42:00). The main area is a table of alarm events. The legend at the bottom indicates:

- Red: ACTIVE AND UNACKNOWLEDGED
- Orange: ACTIVE AND ACKNOWLEDGED
- Yellow: INACTIVE AND UNACKNOWLEDGED
- Blue: EVENT

The filter bar at the bottom shows 'Group' set to 'METEO' and 'Prior.' set to '1 to 900'. Callout boxes point to the '24' filter (List for last 24 hours), the 'Group' dropdown (Filter by technological group), and the 'Prior.' dropdown (Filter by priority).

**Lines are colour-coded according to their status:**


- active non-acknowledged alarms: red
- active acknowledged alarms: orange
- inactive non-acknowledged alarms: yellow
- events: blue

#### 4.2.3 Alarm recordings backup

All alarms are saved on the hard disk in the database file (SQLite database with .db extension) divided into weekly periods. This file is located in C:\Users\Public\Documents\TomPack\VATT\HistAlarms\. Generally, history is set to 10 years. After this time, the oldest recordings in the file are automatically deleted and replaced by the newer ones.

**Therefore, if you want to archive data for a longer period, it is necessary to back up the file in a period shorter than the pre-set time of 10 years.**

If needed so, contact your IT department to solve the files backup.

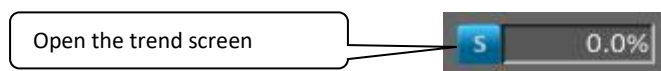
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### 4.3 Historical trends

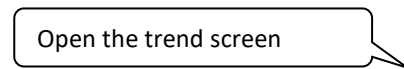
The system of historical trends is used to archive measured technological values and display them in the chart.

There are two ways of displaying historical trends in TomPack:

- To display the **trend of a specific measured variable**, click on the symbol of the controlled value (the left black section of the box).



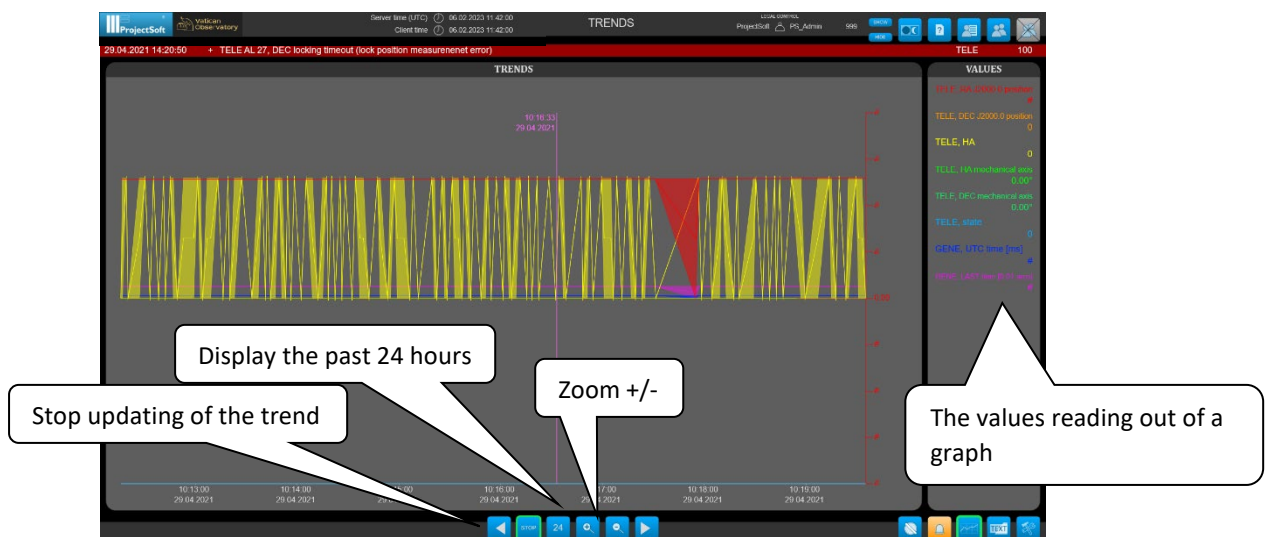
- To display the **summary trend of multiple measured inter-related variables**, click on the **TRENDS** button located on the bottom bar




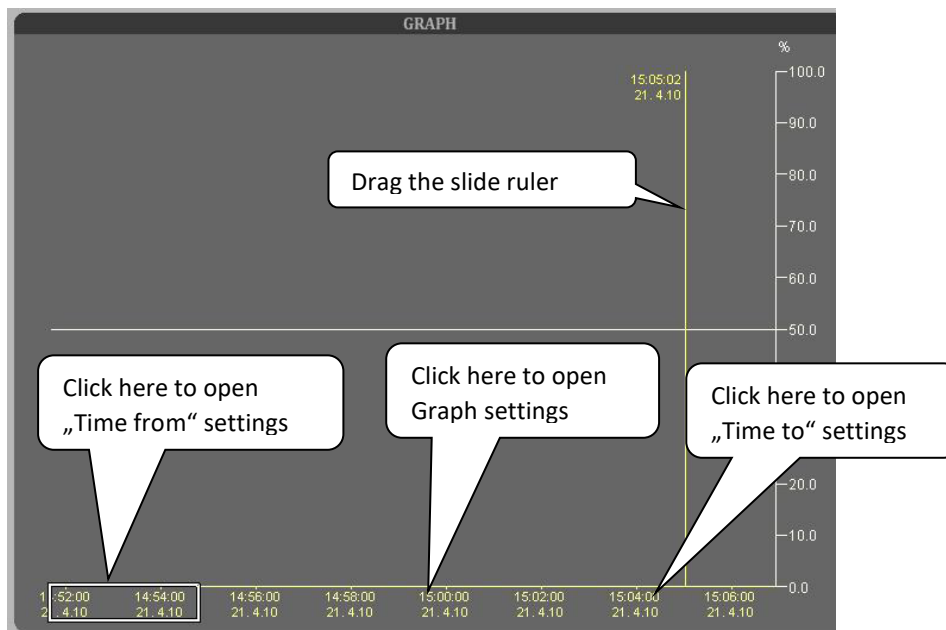
- When the trend screen is opened for the first time, the **real-time trend** is always displayed, i.e. the course of the measured variable is continuously updated in real-time

#### 4.3.1 Displaying a parameter trend graph

- On the **right** side, next to the graph, **trend variable values are listed**; the value of each trend variable is updated accordingly to the slide ruler position.
- How to **read out values from the graph using the slide ruler**: position the mouse cursor to the "Y" axis, press the left mouse button, hold it, and drag it to the left (back in time).
- Date and time are displayed above the ruler and listed variable values are displayed on the right, as was already mentioned.



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#### 4.3.2 Movements in time


##### 1. Viewing of real-time course

- If you want to change the time range of the displayed variable in real-time, you can use the following buttons located on the right of the graph:
- the **ZOOM+** button to enlarge the time range
- the **ZOOM-** button to reduce the time range
- the **24h** button to display the last 24 hours
- the **STOP OF TREND** button is used to stop updating the graph
- alternatively, the following steps can be used:
- click on the time axis, as shown in the picture, to open the "**Time from setting**" control panel for the time shift
- in this control panel, set the start time of the course either directly by filling in the date and time or by the usage of the buttons for shifting the time
- in this way, the graph will be extended from the current time to the past

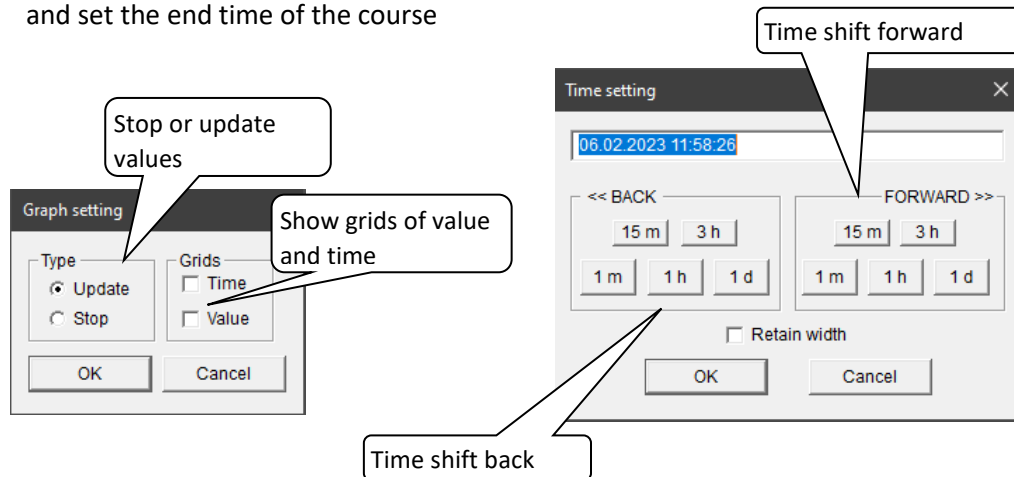
##### 2. Viewing the course in the past

- use the **STOP OF TREND** button to stop updating the graph
- as previously, click on the time axis, as shown in the picture, to open the "**Time from setting**" control panel for the time shift and set the start time of the course
- in this way, the graph will be extended to the past
- however, if you want to shift the course back in time while maintaining the same width of the graph, the "**Retain width**" box should be checked



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- similarly, if the course has already been shifted to the past and you want to adjust its end, click on the time axis to open the "Time to setting" control panel for the time shift and set the end time of the course



#### 4.3.3 Setting graph properties

- click on the time axis, as shown in the picture, to open the "Graph setting" control panel for changing graph properties
- in the left part "Type", graph updating can be stopped (the same function as the **STOP OF TREND** button)
- in the right part "Grid", an auxiliary grid can be displayed for both axes by marking the appropriate checkbox

#### 4.3.4 Trend recordings backup


All trend-monitored variables are saved on the computer's hard disk, where the "TpServer2" application is running. The format is the same as for alarms archives and the location of the files is C:\Users\Public\Documents\TomPack\VATT\. **Files will be stored on the disk for the pre-set time. After this time, the oldest files will be overwritten automatically. Therefore, if you want to archive data for a longer period, it is necessary to back up the file in a period shorter than the pre-set time of 10000 days.**

If needed so, contact your IT department to solve the files backup.

#### 4.4 Service screen

To open the screen, click on the SERVICE button located on the bottom bar.

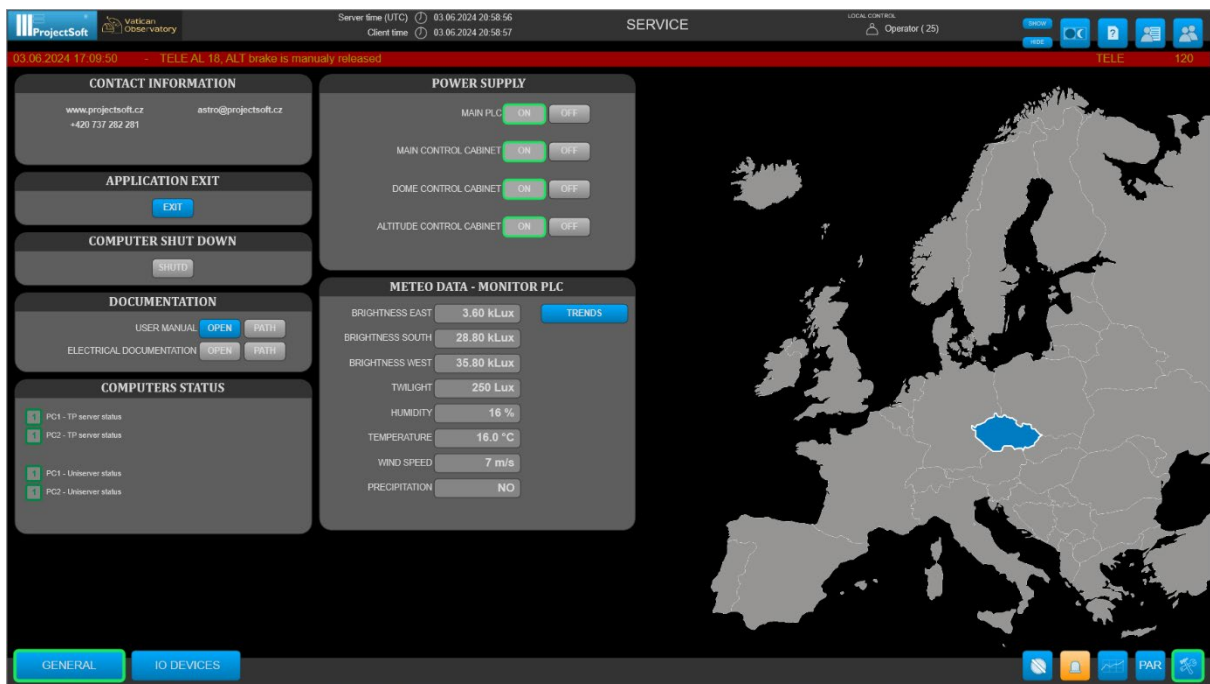


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#### 4.4.1 General screen


This screen consists of:

- Contact information
- Application exit
- Computer shutdown
- Documentation
- Computer status
- Power supply control
- Meteo data (from MonitorPLC)



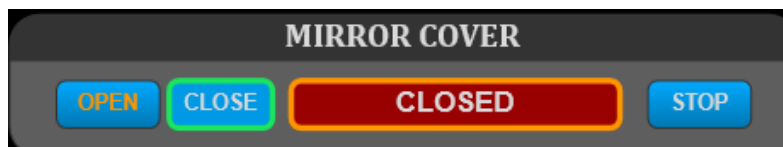
#### 4.4.2 IO Devices screen

Screen with diagnostic data of PLCs and the status of each IO card and device.

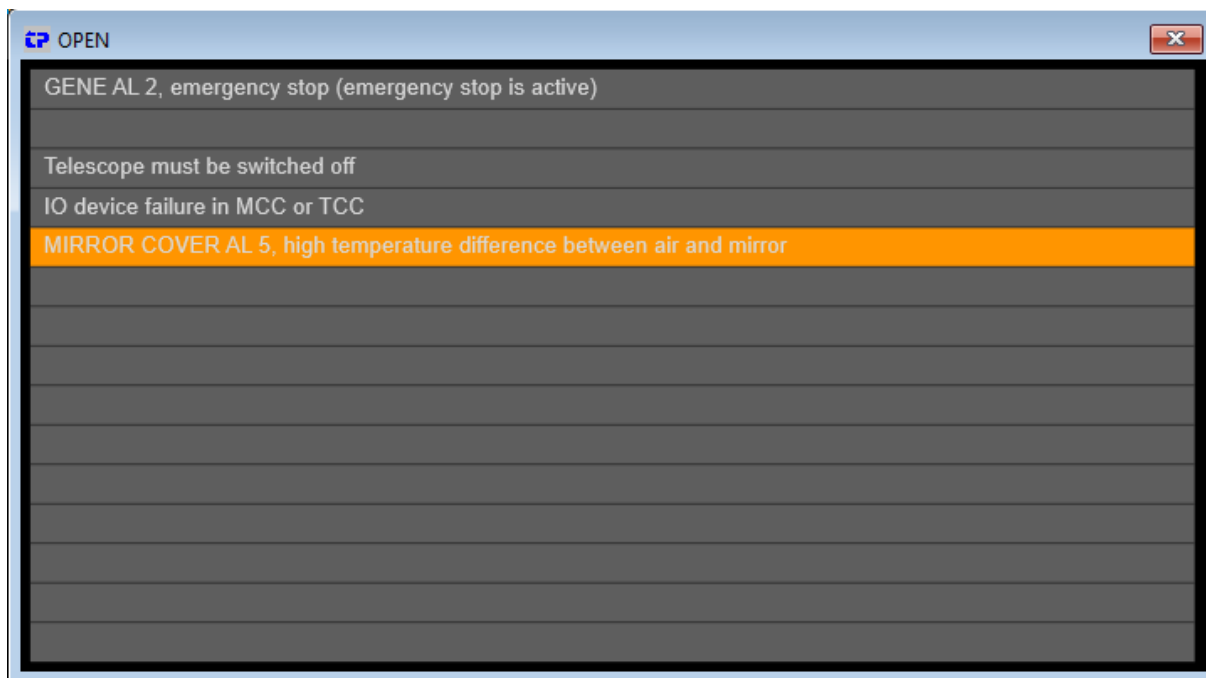
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#### 4.4.3 Alarm signaling in the screen


When there is an active alarm assigned to a specific part of the system, the border around its state field is blinking orange. To check what is wrong, the user is supposed to open the alarm screen and check all active alarms.



When the color of the text on the button is orange, it means that not all conditions to proceed that action are met. The user can however click the button and a new window with all conditions will be



shown. The conditions that are highlighted are not met.

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## 5. CONTROL

### 5.1 General control

There are two options to control the system. The LOCAL CONTROL mode and the REMOTE CONTROL mode. The mode is selected by the position of the switch on the control box in the control room.

The mode cannot be overridden by the software, so be sure to activate remote mode after leaving



the building.

#### 5.1.1 Local control

Main 'DON' power can be activated only by pressing a button on the box in the control room. This provides security protection from unwanted powering on the system.

#### 5.1.2 Remote control

Normal operational mode. The control voltage can be activated from the visualization system. Opening any doors leading to the dome will turn the Main 'DON' power off in this mode.

Main 'DON' power is used for powering motors. Not all devices are without power if the Main 'DON' power is switched off. If you are going to work on the electric device, check if the voltage is off.



- **ON** button turns on the Main 'DON' power (only in Remote control).
- **OFF** button turns off the Main 'DON' power (only in Remote control).

## 5.2 Oil system


### 5.2.1 Oil system states

#### 5.2.1.1 INACTIVE

The oil pumps are inactive.

#### 5.2.1.2 TEMPERATURE CHECK

The system checks that the oil temperature is within the range for starting the oil system.

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#### 5.2.1.3 STARTING 1

The low pressure oil pump is activated and the system waits until the low pressure switch is activated.

#### 5.2.1.4 STARTING 2

The high pressure oil pump is activated and the system waits until the oil pressure reaches required value for certain period of time.

#### 5.2.1.5 STARTING 3

This state is used for restarting the oil system from the *STAND BY* state. The system is restarted right after the oil pressure reaches required value.

#### 5.2.1.6 STAND BY


The oil pumps are turned off. The system is ready to perform faster start up sequence from this state. If the oil system is not restarted in the certain period of time, it is turned off.

#### 5.2.1.7 RUNNING

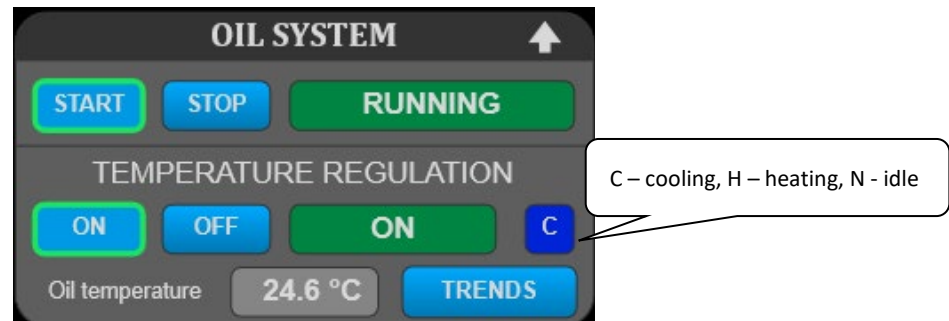
The oil system is running correctly and is ready for operating of the telescope.

#### 5.2.1.8 CIRCULATION

The circulation pump is activated.

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## 5.2.2 Description of controls



**START** button starts the oil system.

**STOP** button stops the oil system.

**ON** button starts the temperature regulation.

**OFF** button stops the temperature regulation.

## 5.3 STOW pin

The control of STOW pin is allowed only to the users with higher user level.

### 5.3.1 STOW pin states

#### 5.3.1.1 STOPPED

The movement of the STOW pin is stopped and it is not in the locked or unlocked position.

#### 5.3.1.2 LOCKING

The STOW pin is being locked.

#### 5.3.1.3 LOCKED


The STOW pin is in a locked position.

#### 5.3.1.4 UNLOCKING

The STOW pin is being unlocked.

#### 5.3.1.5 UNLOCKED

The STOW pin is in unlocked position and the altitude axis is no longer secured by the STOW pin.

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## 5.4 Telescope

### 5.4.1 Telescope states

#### 5.4.1.1 *DISABLED*

The servo drives are switched off, meaning the motors stand still and are braked by the pneumatic brakes.

#### 5.4.1.2 *DISABLING*

The telescope is halted and the servo drives are still powered on for a few seconds.

#### 5.4.1.3 *ENABLING*

The power sources for the servo drives are turned on and the system is waiting a few seconds for their initialization.

#### 5.4.1.4 *ENABLED*


The servo drives are powered on. The motors stand and are held in their actual position by control system regulators. The telescope can be moved using the manual movement function.

#### 5.4.1.5 *TRACKING*

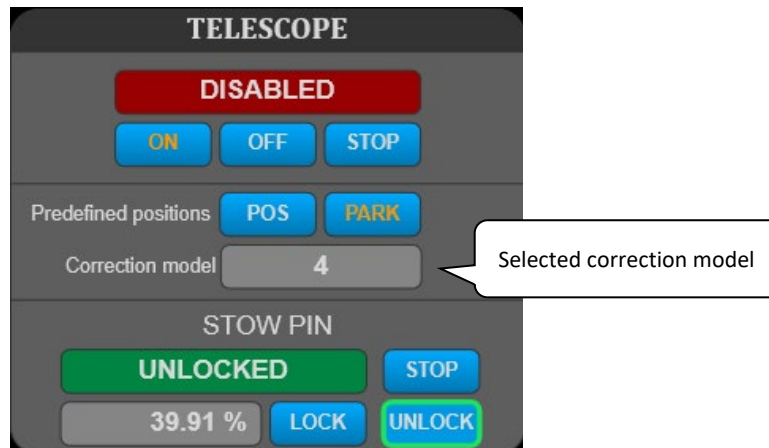
The control system uses actual Right Ascension and Declination as required position values and it calculates appropriate mechanical coordinates. This calculation is rectified by aberration, precession, nutation, refraction, and error model. The regulators maintain the telescope position in this requested position.

#### 5.4.1.6 *PARKING*

The telescope moves to the specified mechanical parking position.

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#### 5.4.2 Description of controls



**ON/OFF** button enables/disables the telescope drives.

**STOP** button stops the movement of the telescope.

**PARK** button moves the telescope to the predefined parking position.

**POS** button opens the window with predefined positions of the telescope.


#### STOW pin

**STOP** button stops the movement of the STOW pin.

**LOCK** button starts the locking of the STOW pin.

**UNLOCK** button starts the unlocking of the STOW pin.



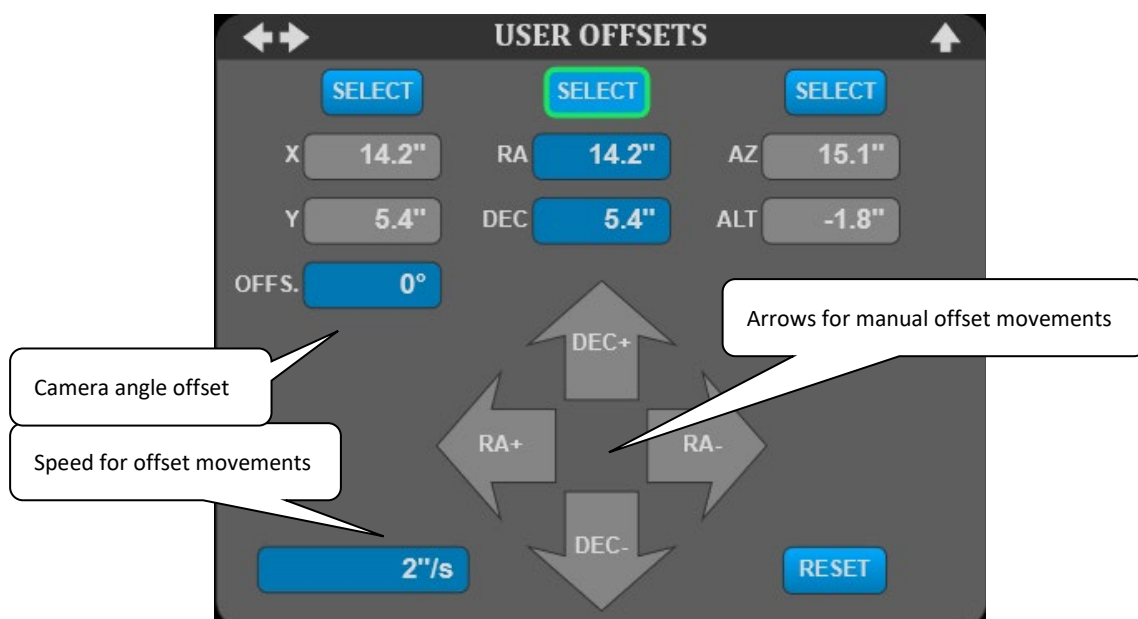
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### 5.4.3 Offsets


Offsets are used for compensation of an error, which is not removed by the correction model and must be corrected by the observer or autoguider.

#### 5.4.3.1 User offsets

These offsets are entered manually by the observer. The observer has to choose in what coordination system he wants to enter the offsets. After entering the offsets, the values are transformed to the mechanical coordinates.



- **RESET** button sets the offsets to zero.

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#### 5.4.3.2 Autoguider offsets

For the autoguider offsets, the observer has only to select in what coordinate system the autoguider sends the offsets.

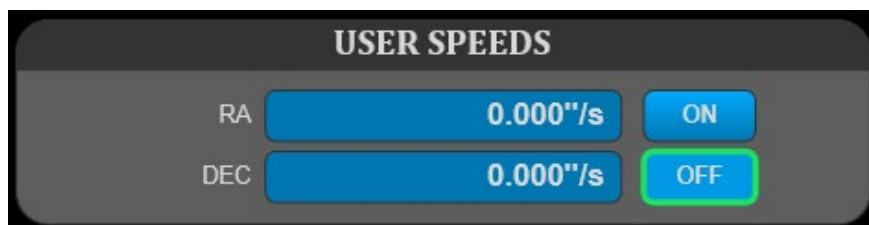



- **RESET** button sets the offsets to zero.

#### 5.4.4 User Speeds

The user's speeds serve for moving of the telescope with the selected speed in **Track** mode. This function is useful for tracking comets and objects moving in the sky.

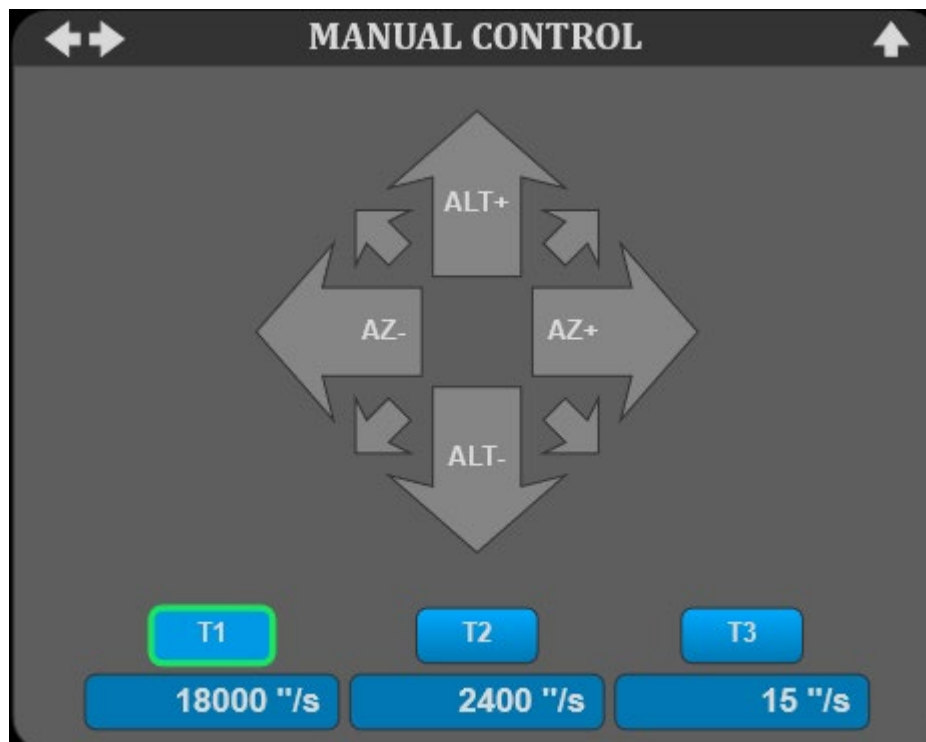
This function is switched on and off by buttons **ON** and **OFF**.



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#### 5.4.5 Manual movements

Used for movements of the telescope in the specific direction. May be used when the software alarm



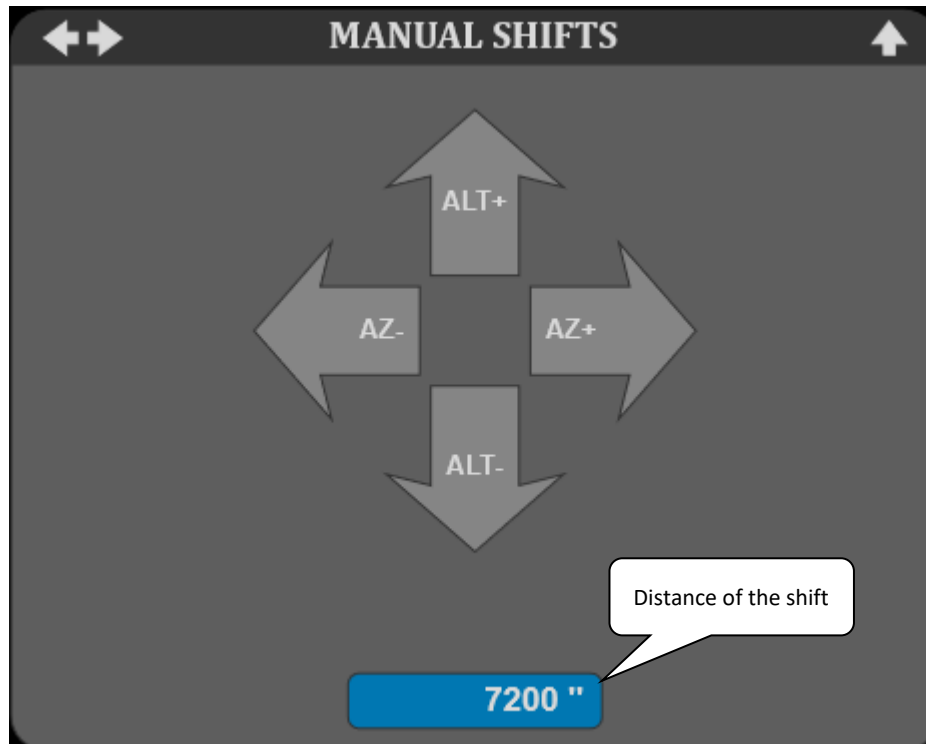
is on and the telescope needs to be moved to the safe position.


- **T1, T2, T3** button selects the speed for manual movement of the telescope.

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#### 5.4.6 Manual shifts

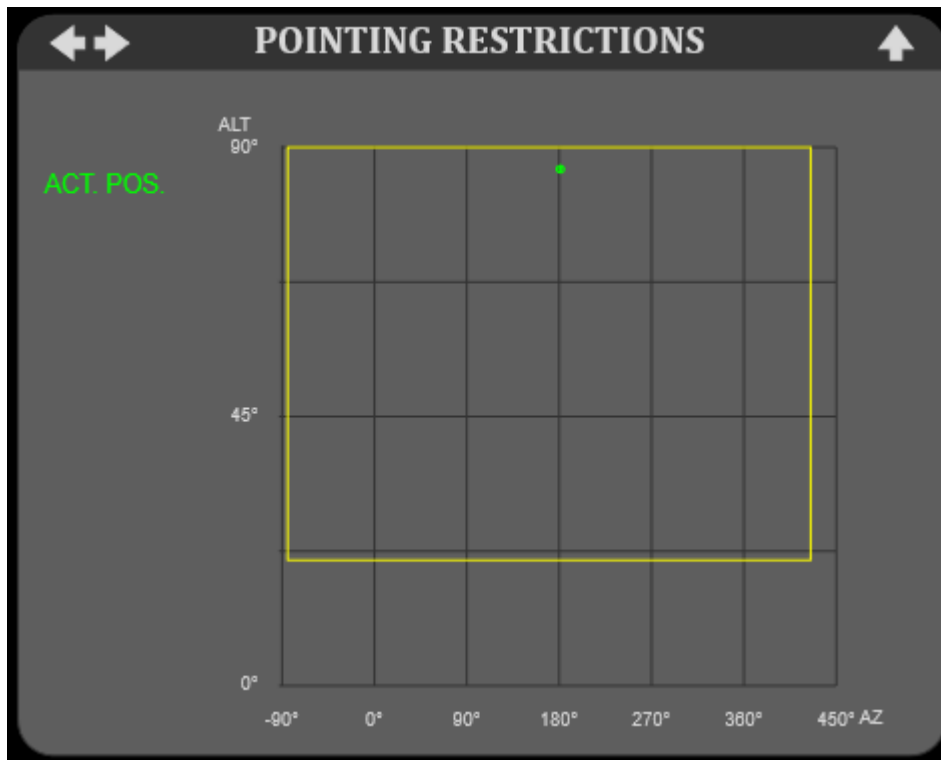
Used for moving the telescope by the specified distance in selected direction.




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#### 5.4.7 Pointing restrictions

Used for monitoring of the telescope movement, its actual position, target position etc. Yellow border indicates telescope's pointing limits.



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## 5.5 Correction model

### 5.5.1 Introduction

A couple of astronomical corrections are implemented in the PLC software. It is mainly annual aberration, precession and nutation when sky coordinates are used. Actual precession correction values depend on the epoch of coordinates entered.

The actual local apparent sidereal time is computed from actual UTC. To be able to use the UT1 time for more precise sidereal time, a manually entered DUT1 correction is a necessary regular update.

Inaccuracies of the mount are corrected using these steps:

#### 1. Measuring the inaccuracies

The user has to create a measurement database. It is accomplished by pointing the telescope to stars, fixing the telescope to the reference point of the camera and storing the actual difference in to text file. Both Main and Reverse positions should be used, but they will result in only one set of coefficients. To speed up data collection, part of the delivery is a star database, which includes uniformly selected stars of equal magnitude with the lowest amount of neighbourhood stars. There is also a screen where the user can enter the X/Y coordinates of the measured star on the CCD camera and the control system computes the required correction.

#### 2. Computation of the coefficients

The next step is the computation of the coefficients, using the command line program TeleModel. It uses the least square fit of the measured data to compute the values of the coefficients. The User can choose a text file with measured data and a set of computed coefficients. Selection of the coefficients is important for the correct and effective computation.

#### 3. Transfer coefficient values into the control system

The next step is simple - the user fills in the parameter screen with computed coefficient values. It is possible to use 5 sets of parameters. The selection can be done by "1-5 Selection index" buttons. During obtaining the coefficients all other corrections must be switched on.


#### 4. Test of the model

The last step should prove the validity of the data. The method is the same as step 1, but the necessary correction to reach the reference point of the camera should be in the expected range of the model.

It is possible to merge data from different measurements, but all conditions must be the same! Even a small change of the full optical or mechanical part disallows data merging.

The different measurement and coefficients computation must be done for different optical configurations of the telescope. It is common for different optical configurations to have a different set of coefficients, not only different values.


It is suitable to perform the preliminary setting of the error model at the first step so that the deviations are measured for twenty objects only and the error model is used with these preliminary coefficients. The entire process is then repeated, as described in the preceding paragraph, with the preliminary error model turned on.

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The following terms could be currently used:

1. Shift of the zero position in Azimuth axis, IA
2. Shift of the zero position in Altitude axis, IE
3. Nonperpendicularity between Azimuth and Altitude, NPAAE
4. Colimation error, CA
5. Shift of the Azimuth axis towards North, AN
6. Shift of the Azimuth axis towards West, AW
7. Tube flexure, TFAA

Name	Azimuth axis influence	Altitude axis influence
IA	IA	0
IE	0	IE
NPAAE	$\tan(\text{alt})$	0
CA	$1/\cos(\text{alt})$	0
AN	$\sin(\text{az}) \cdot \tan(\text{alt})$	$\cos(\text{az})$
AW	$\cos(\text{az}) \cdot \tan(\text{alt})$	$\cos(\text{az})$
TFAA	0	$\cos(\text{alt})$

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5.5.2 The procedure for calculating the coefficients

5.5.2.1 Step 1 - Measuring the inaccuracies, collecting data

The coordinates can be entered manually on the **CONTROL screen**, or the selected objects can be loaded from a text file, prepared in advance. The pathname of the file can be entered in the correction model window, usually c:\model\stars.dat

The line data format:

The first six characters represent the identification number

RA (hours, minutes, seconds, degrees, arc minutes, arc seconds)

Dec

RA proper motions (seconds and arc seconds per year)

Dec proper motions

Equinox

The file is terminated by the word "END".

Example:

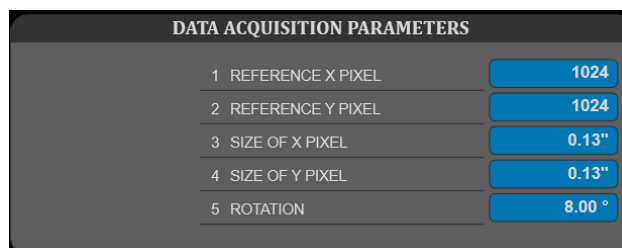
```
000001 01 33 13.030 -79 55 35.70 +.0126 +.011 2000.0
```

```
END
```

**The procedure for data acquisition is following:**


1. Switch the telescope to **STOPPED** mode.

Check or update the **DUT1** parameter value. This value can be obtained in IERS BULLETIN - A, for example here: <https://www.iers.org/IERS/EN/Publications/Bulletins/bulletins.html>, section Latest Version, column UT1-UTC, the value from the most recent date. The value can be also negative. Check also data acquisition parameters (on the parameter screen) for fast centering of

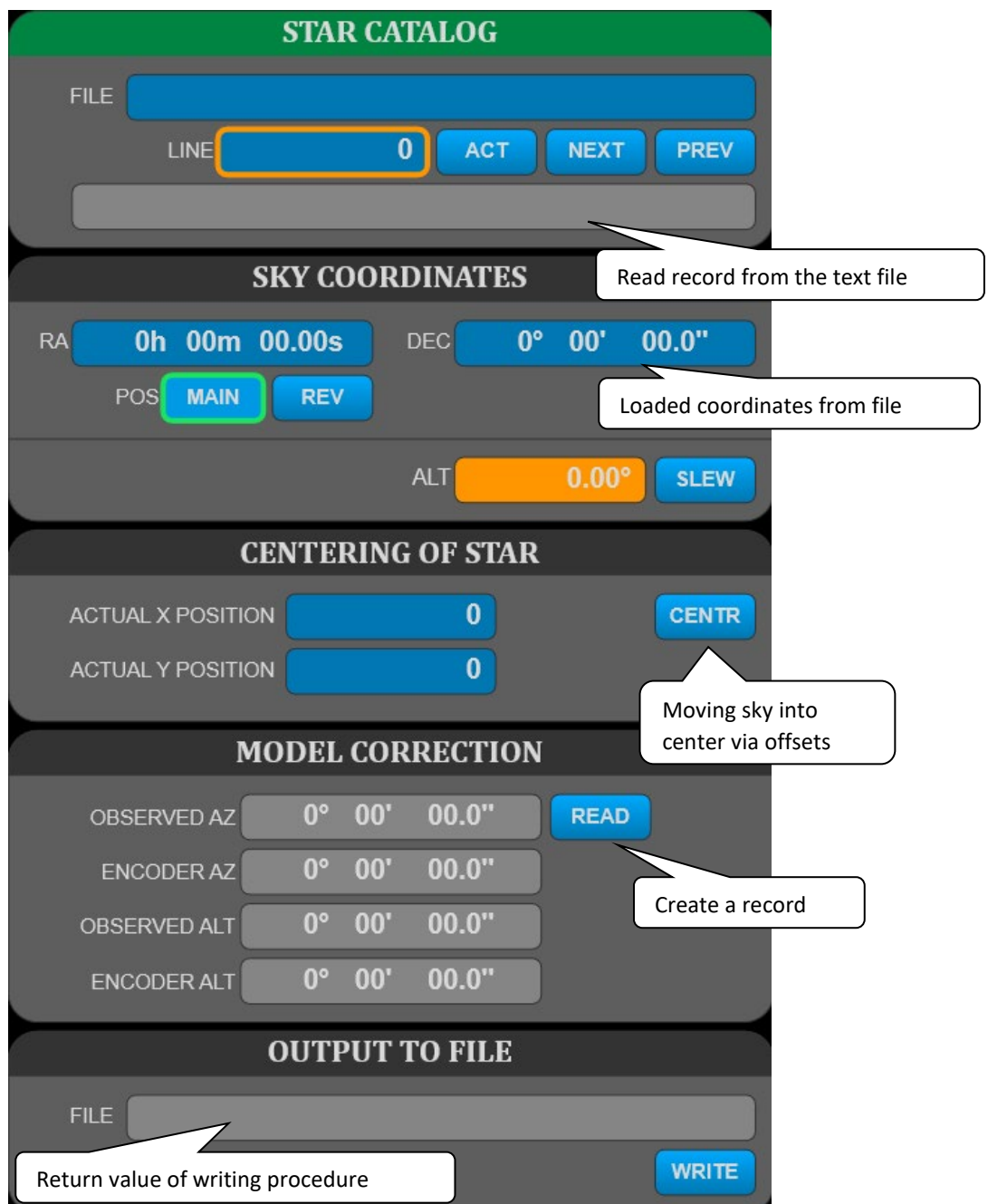


the star.




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2. Select the position of the telescope
3. Reset user offsets
4. Open the Data acquisition window (wrench button on Pointing model panel or DATA **ACQ** button on Pointing model screen)



The screenshot shows the STAR CATALOG interface with several sections and callouts:

- STAR CATALOG**: FILE field, LINE 0 (highlighted), ACT, NEXT, PREV buttons.
- SKY COORDINATES**: RA 0h 00m 00.00s, DEC 0° 00' 00.0", POS MAIN (highlighted), REV buttons. Callout: "Read record from the text file" pointing to the ACT button.
- CENTERING OF STAR**: ACTUAL X POSITION 0, ACTUAL Y POSITION 0, CENTR button. Callout: "Loaded coordinates from file" pointing to the POS buttons.
- MODEL CORRECTION**: OBSERVED AZ, ENCODER AZ, OBSERVED ALT, ENCODER ALT fields, READ button. Callout: "Moving sky into center via offsets" pointing to the CENTR button.
- OUTPUT TO FILE**: FILE field, WRITE button. Callout: "Create a record" pointing to the READ button.
- Callout: "Return value of writing procedure" pointing to the FILE field.

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- Enter the path to the file with the TeleModel database of stars.
- Start with line 1 (enter 1 into the column LINE).
- To read data from the selected line click the ACT button.
- To read data from the next line click the NEXT button. The line number will increase automatically.
- If the line is read successfully (green OK) then the coordinates and epoch of the star are transferred to Sky coordinates.
- If the coordinates of the star are above the horizon (ELEV. is not yellow) and are not covered by the shutter, click on the SLEW button.
- If the telescope is at the desired position, exposure.
- Align the camera using the derotator offset and select the RA/DEC user offsets mode.
- If the star is not at the reference pixel, enter the actual pixel position to the CENTERING OF STAR area and click on the button CENTR. Calculated corrections will be added to actual User corrections and the telescope will immediately change its position. Another possibility is to manually enter the desired correction into CORRECTION values or movement of the telescope using T3 speed and correction mode of the movement.
- Exposure an image.
- Repeat this procedure until the actual position of the star will correspond with the reference pixel. Sufficient accuracy is reached when the star is closer than approximately 1-2 arcs to the reference pixel.
- If the actual position of the star corresponds with the reference pixel click the READ button.
- If you have a centred sky and observed and encoder coordinates were read click WRITE to write data to the output file. The name of the file is generated automatically in the format model\_YYYY\_MM\_DD.dat. Check if data were successfully written to the file.
- Repeat this procedure by pressing the button READ NEXT until all visible stars from the database are measured


Repeat the whole procedure (using the same stars) for the reverse position of the telescope

#### 5.5.2.2 Step 2 - Computation of the coefficients

Command line program TeleModel.exe should be used for coefficients computation. Its first parameter is the name of the text file with measured data, next parameters are coefficient names to compute.

The result is split into two parts. The first part shows the measured data with the following columns:

AZ	Azimuth axis angle of a measured star
ALT	Altitude axis angle of a measured star
Input d_az	Measured difference in azimuth axis
Input d_alt	Measured difference in altitude axis
Input sqr	Total measured difference (magnitude of the error)
Result d_az	Resulted difference in azimuth axis
Result d_alt	Resulted difference in altitude axis

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Result sqr      Total result difference (the expected remaining error)

The second part includes coefficients:

Input RMS      Root mean square of input data

Coeff          Coefficient name

Value          Computed coefficient value

Sigma          Deviation of coefficient value

Result RMS      Root mean square of resulted remaining error

Example:

```

C:\Windows\System32\cmd.exe
d:\work\Akce\VATT2021\model_vzor>telemodel model_2014_10_02.dat ia ie ca an aw tfaa
TeleModel v4.2 (c) ProjectSoft 2021

      AZ      ALT      Input      Result
      d_az     d_alt     d_az     d_alt     sqr     d_az     d_alt     sqr
0: 105 14 57.7 +031 47 55.7 -4931.9 -1558.2 4471.9 0.6 49.7 49.73
1: 235 41 30.2 +043 09 01.2 -5804.8 -1822.3 4610.4 2.5 5.9 6.20
2: 081 19 25.4 +028 28 10.4 -4936.2 -1379.2 4553.2 -6.1 66.4 66.61
3: 271 06 45.3 +034 08 29.7 -5599.4 -1635.4 4914.4 -19.0 41.5 44.35
4: 169 15 15.9 +065 35 27.2 -6390.8 -1721.5 3152.5 65.5 -23.0 35.55
5: 149 02 40.3 +062 15 03.0 -5837.6 -1631.0 3169.8 57.7 -37.4 46.05
6: 093 01 04.3 +051 23 05.4 -5173.1 -1261.2 3466.1 17.0 -25.4 27.52
7: 083 02 45.6 +041 34 52.8 -5025.2 -1263.2 3965.5 -0.2 1.1 1.06
8: 283 59 09.4 +040 36 23.5 -5826.2 -1442.3 4652.5 -29.9 -3.5 23.00
9: 277 52 12.5 +047 15 51.6 -6146.3 -1451.1 4416.2 -17.1 -10.5 15.65
10: 260 08 34.9 +054 15 23.4 -6556.1 -1547.3 4130.6 -1.7 -21.8 21.85
11: 064 36 05.8 +039 10 46.0 -5068.4 -1145.6 4092.5 1.2 13.4 13.46
12: 292 03 21.7 +048 34 21.5 -6211.8 -1303.4 4311.9 -24.1 -22.8 27.79
13: 093 43 57.3 +073 26 52.4 -6529.1 -1102.7 2162.4 38.8 -18.1 21.21
14: 054 09 54.9 +048 00 48.4 -5265.1 -967.9 3652.7 -16.0 -44.0 45.25
15: 018 24 08.0 +072 42 05.3 -7891.7 -687.1 2445.1 2.0 -17.3 17.27
16: 291 39 26.8 +143 48 33.4 -1783.9 -585.8 1554.3 2.7 -0.2 2.15
17: 063 05 36.2 +141 46 33.1 -2450.7 -348.2 1956.5 25.3 -0.2 19.85
18: 266 08 02.0 +147 06 05.7 -1896.8 -769.6 1768.8 2.1 -27.3 27.32
19: 096 01 57.1 +151 23 33.2 -2592.4 -515.1 2333.5 27.8 -54.9 60.12
20: 003 11 26.7 +114 36 11.4 -420.1 -358.8 399.2 -59.9 5.5 25.54
21: 341 01 43.8 +116 18 38.5 -253.1 -418.7 433.4 -50.0 10.8 24.65
22: 277 41 23.9 +124 39 12.6 -696.2 -860.5 947.2 -35.1 32.7 38.33
23: 266 59 45.1 +134 30 04.4 -1387.4 -891.5 1319.2 -14.2 33.7 35.17
24: 107 31 22.8 +144 19 08.2 -2554.5 -685.6 2185.3 19.1 -20.5 25.70
25: 101 38 14.8 +137 52 01.2 -2490.9 -697.1 1974.4 9.7 8.3 10.99
26: 085 09 22.6 +130 46 58.4 -2347.7 -624.9 1655.9 -1.6 37.1 37.14
27: 247 20 33.4 +137 20 49.7 -1610.0 -1012.9 1558.3 4.7 13.2 13.65
28: 114 31 25.0 +136 06 05.6 -2455.3 -838.7 1957.9 5.9 24.1 24.48
29: 277 24 24.5 +102 45 43.8 4521.4 -937.7 1370.0 -36.3 -53.3 53.90
30: 235 11 44.6 +129 06 36.9 -1272.2 -1170.1 1418.9 5.4 36.5 36.69

Input RMS: 3062.665

Coeff Value['] Sigma[']
IA 3745.0 8.813
IE -1067.6 5.956
CA 1280.5 5.963
AN -502.7 7.658
AW 108.1 6.170
TFAA 497.9 8.796


Result RMS: 33.109

d:\work\Akce\VATT2021\model_vzor>

```

### 5.5.2.3 Step 3 – Transfer coefficient values into the control system

The resulting values should be then typed into corresponding boxes on the parameter screen. Unused coefficients have to be zeroed.

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#### 5.5.2.4 Step 4 – Test of the model

The last step should prove the validity of the data. The user should repeat the same method as in the case of collecting data for the model. However, the measured corrections should be approximately in the expected range of the model resulted RMS. The newly created database could be then also used for new computation of the coefficients.

## 5.6 Derotator

### 5.6.1 Derotator states

#### 5.6.1.1 *DISABLED*

The servo drives are disabled, meaning the motors stand still and are not braked.

#### 5.6.1.2 *READY*

The servo drives are enabled and the motors are held in their current position.

#### 5.6.1.3 *SLEW*


The derotator is moving to a new position.

#### 5.6.1.4 *TRACK*

The derotator is tracking the telescope. It rotates to the angle that equals to the sum of paralactic angle and offset.

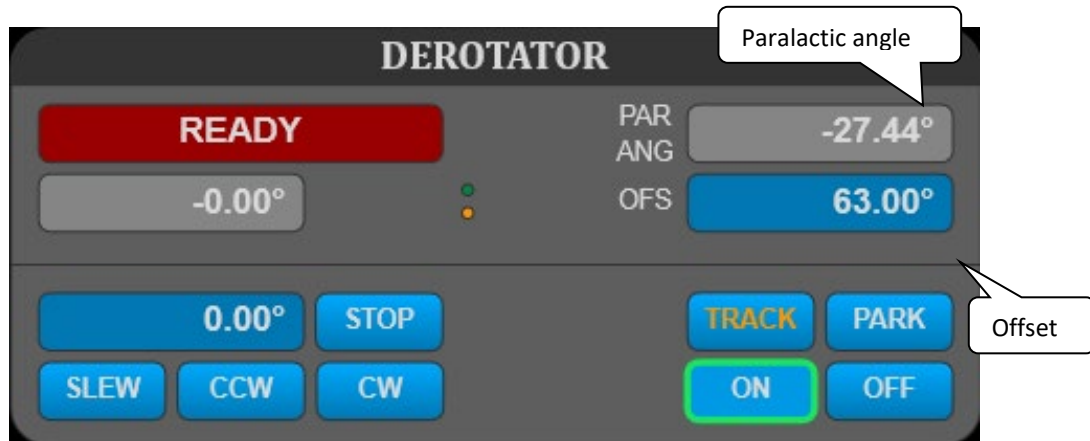
#### 5.6.1.5 *PARK*

The derotator is moving to its parking position.

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### 5.6.2 Description of controls

When the derotator is ready, it starts and stops tracking the telescope automatically, when the



telescope starts tracking.

**SLEW** button slews the derotator to the required position.


**CCW** button moves the derotator counter clock wise.

**CW** button moves the derotator clock wise.

**TRACK** button makes the derotator to track the telescope.

**PARK** moves the derotator to its parking position.

**STOP** button stops the movement of the derotator.

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## 5.7 Mirror Cover

### 5.7.1 Mirror cover states

#### 5.7.1.1 STOPPED

The mirror cover is not moving and the position is not defined (the end position signal is not received).

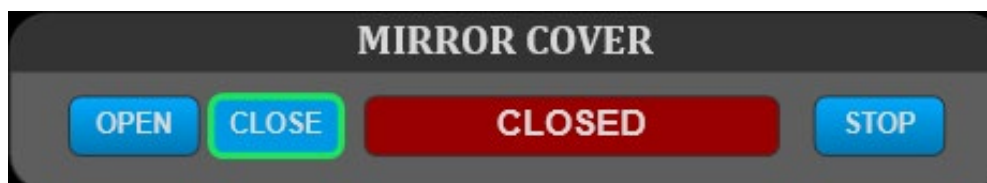
#### 5.7.1.2 OPENING, CLOSING

The mirror cover is opening/closing.

#### 5.7.1.3 OPEN, CLOSED

The mirror cover is open/closed and not moving.


### 5.7.2 Description of controls



**OPEN** button starts opening the mirror cover.

**CLOSE** button starts closing the mirror cover.

**STOP** button stops mirror cover movement.

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## 5.8 Dome

### 5.8.1 Dome states

#### 5.8.1.1 *DISABLED*

The dome is not moving and is ready to receive control signals.

#### 5.8.1.2 *MANUAL CW, MANUAL CCW*

The dome is moved manually.

#### 5.8.1.3 *AUTO*

The dome is in automatic movement mode. The slit of the dome follows the telescope's position.

#### 5.8.1.4 *AUTO CW, AUTO CCW*


The dome is moving automatically to a new position. The slit of the dome follows the telescope with a certain tolerance specified by the parameter.

#### 5.8.1.5 *SLEW CW, SLEW CCW*

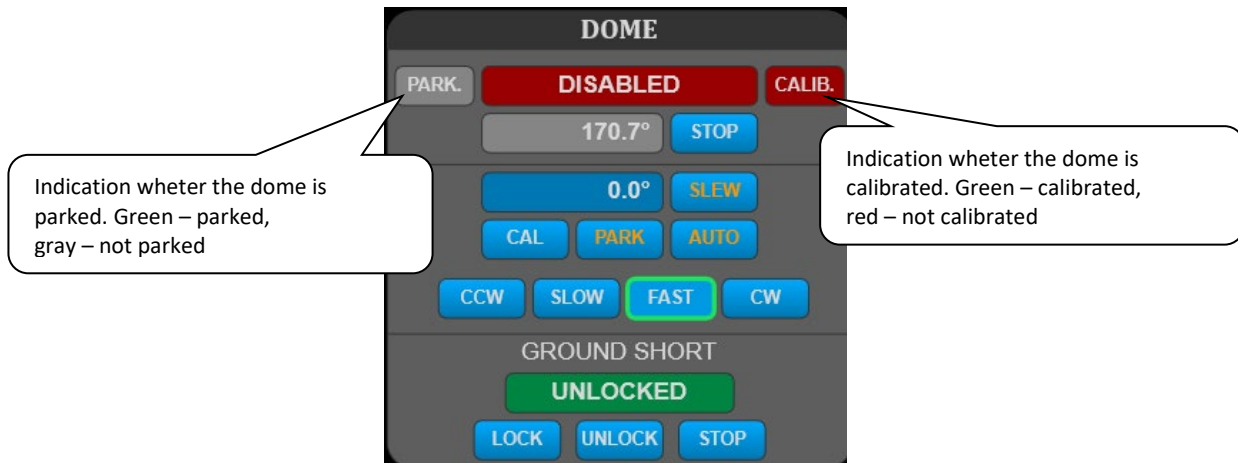
The dome is moving to a new position, determined by the azimuth, set by the operator.

#### 5.8.1.6 *CALIBRATING*

The dome is slewing until it slews over a calibrating sensor.

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### 5.8.2 Description of control



**SLEW** button starts slewing the dome to the inserted position.

**AUTO** button turns on the AUTO mode.

**PARK** button starts slewing the dome to the park position.

**STOP** button stops any movement of the dome.

**SLOW, FAST** buttons select the dome moving speed.

**CCW, CW** buttons move the dome manually.


#### Ground short

**LOCK** button locks the ground short.

**UNLOCK** button unlocks the ground short.

**STOP** button stops the movement of the ground short.



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## 5.9 Dome slit

### 5.9.1 Dome slit states

#### 5.9.1.1 UNKNOWN

The slit is not moving and is not open or closed.

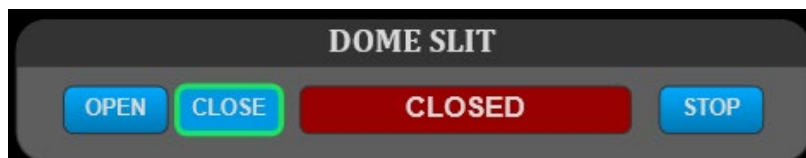
#### 5.9.1.2 OPENING, CLOSING

The slit is opening/closing.

#### 5.9.1.3 OPEN, CLOSED

The slit is fully open/closed and not moving.


### 5.9.2 Description of control



**OPEN** button starts opening the slit.

**CLOSE** button starts closing the slit.

**STOP** button stops the movement of the slit.

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### 5.10 Mirror cooling



**ON** button starts the mirror cooling system and mirror fans.

**OFF** button stops the mirror cooling system and mirror fans.

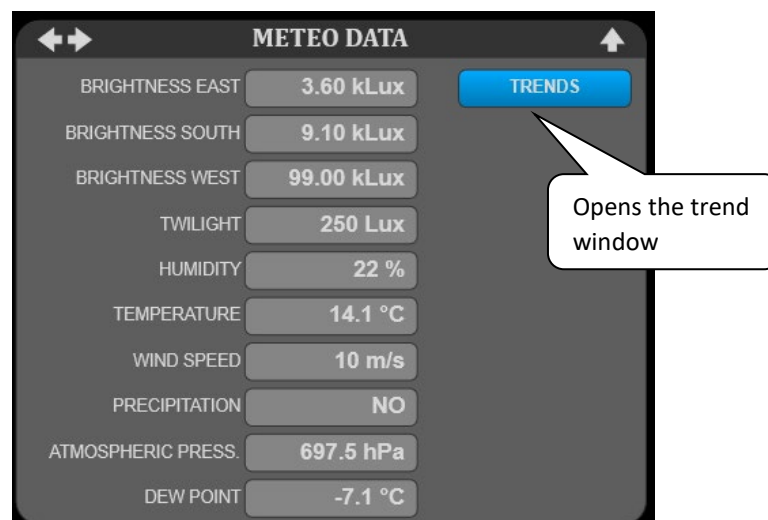
**FIXED SETPOINT** button selects the mode where the temperature setpoint is entered by user.

**FOLLOW AMBIENT** button selects the mode where the temperature setpoint equals ambient temperature.


The system checks that the temperature of the cooling fluid is above the dew point and the difference between the mirror temperature and the cooling fluid temperature is not too high. The system adjusts the temperature setpoint automatically if it is needed.


### 5.11 Meteorological data

Several meteorological values are measured and logged. Their actual values are shown in the Meteo



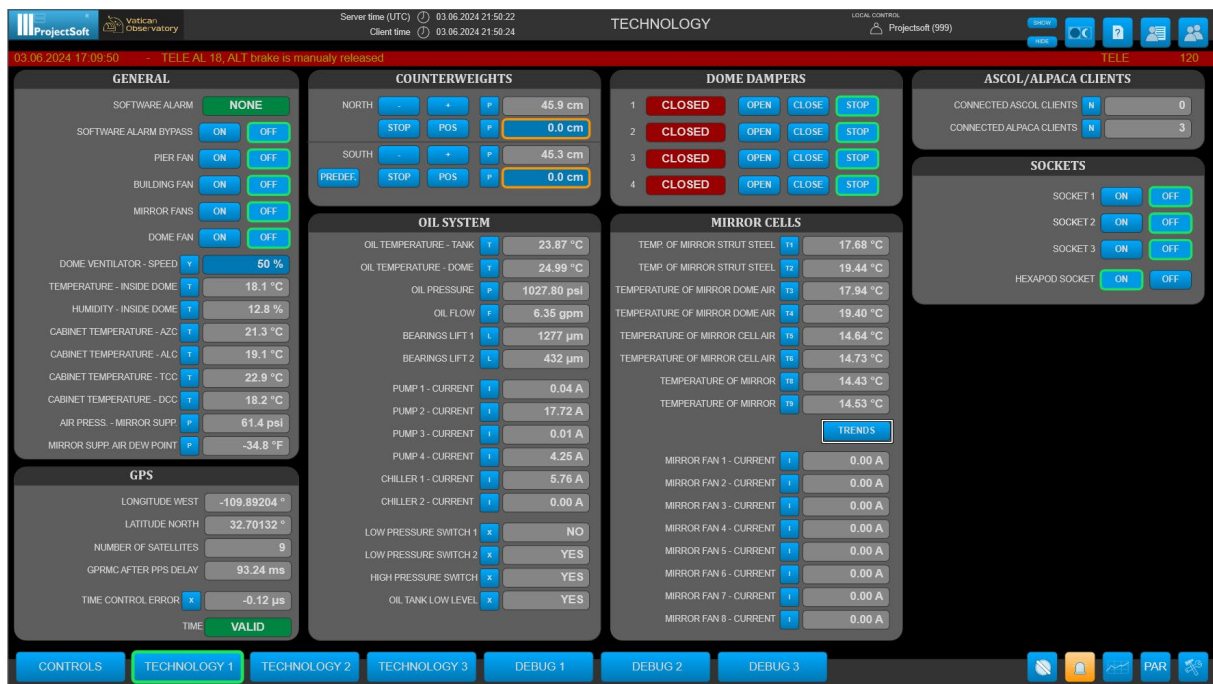
data window.

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## 5.12 TECHNOLOGY SCREEN

This screen is used for a more detailed view of some technology parts or to control less frequently used and less important systems.



The screenshot shows the 'TECHNOLOGY' control interface. It features several panels:

- GENERAL:** Includes controls for software alarm (NONE), pier fan, building fan, mirror fans, dome fan, and dome ventilator speed (50%). It also displays various temperature and pressure readings for the inside dome, cabinet, and mirror support.
- COUNTERWEIGHTS:** Shows NORTH and SOUTH counterweights with manual movement (+/-) and position (POS) buttons. The current positions are 45.9 cm and 45.3 cm, with a target of 0.0 cm.
- OIL SYSTEM:** Displays oil temperature (23.87°C), oil pressure (1027.80 psi), oil flow (6.35 gpm), and bearing lift levels (1277 µm and 432 µm).
- MIRROR CELLS:** Lists temperatures for mirror strut steel, dome air, cell air, and mirror surfaces, along with current draw for mirror fans 1 through 8.
- ASCOL/ALPACA CLIENTS:** Shows 0 connected ASCOL clients and 3 connected ALPACA clients.
- SOCKETS:** Controls for SOCKET 1, 2, 3, and HEXAPOD SOCKET.
- GPS:** Displays location data (Longitude: -109.89204, Latitude: 32.70132) and satellite information.

### 5.12.1 Counterweights




The close-up shows the 'COUNTERWEIGHTS' control panel. Callouts provide the following information:


- Predefined positions:** Points to the 'PREDEF.' button.
- Actual position:** Points to the numerical display showing the current counterweight position (e.g., 45.9 cm).
- Field for entering desired position:** Points to the input field where a target position (e.g., 0.0 cm) is entered.

**POS** button moves the counterweight to the desired position.

**STOP** button stops the counterweight movement.

**+/-** buttons move the counterweight manually.

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### 5.12.2 Dome dampers

The dampers open / close the four vents on the southern half of the silo just below the dome support ring.



**OPEN** button starts opening the specific dome damper.

**CLOSE** button starts closing the specific dome damper.

**STOP** button stops any movement of the specific dome damper.