REMOT project

Remote Operation of Generic Experimental Facilities

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D6.1: REMOTE OPERATION OF GENERIC EXPERIMENTAL FACILITIES

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1. INTRODUCTION

Top level ground observing facilities for astronomy are located in isolated sites, where atmosphere and light pollution conditions are the best possible. Normally, astronomers travel to such observing sites; recently, the concept of allowing remote observing from secondary control centers is becoming reality.

The availability of bandwidth-on-demand networking services, and the construction of new telescopes having integrated control systems, allow at least conceptually to perform observations from the user's own desk.

The aim of telescope teleoperation from the OAT point of view is to monitor and control remotely, using a common system and standard ISDN services, the "Telescopio Nazionale Galileo" (TNG) Italian National Telescope, located at La Palma in the Canary Islands. It is envisaged that within the REMOT project the feasibility of this goal will be demonstrated.

TNG has been designed and implemented with remote control as an essential requirement. The integration of Galileo in REMOT will be performed by building an appropriate software interface between the telescope control system and the new generalized software, being provided by the teleoperation system builders. As the final result of this activity it shall be possible to control TNG from any institute having access to standard ISDN services and a workstation running the TNG project's software.

2. THE STATE OF THE ART IN TELESCOPE REMOTE CONTROL

The first attempt of controlling remotely astronomical telescopes go back to the first astronomical observation from space (i.e. the late '60). Up to now remote control facilities have been implemented by providing a point to point connection through which the telecommands to control the basic telescope and the instrument operation are sent. If the bandwidth of the communication channels is large enough also the observational data can be sent; this is of course mandatory in the case of space-borne experiments while it is not common practice for the few ground-based observatories using remote control.

The concept of distributed remote observation, i.e. bringing the tools to perform and control an astronomical observation at the user's site, is relatively new (one of the first experiments of this kind was taken in 1992 between the Trieste Astronomical Observatory and ESO facilities in La Silla).

3. THE NEW GENERATION TELESCOPES

In the design of modern telescopes the main goal is the environment optimization in order to get the best seeing conditions. This is done by means of a strict coupling between the building (i.e. the dome and the associated auxiliary services) and the telescope main structure.

The first example of a New Technology Telescope is the ESO NTT, operating at La Silla. Other such telescopes have been designed all over the world. One of these is the TNG, a 3.5 meter telescope which will be fully operational at La Palma in 1997.

TNG is being built as a joint effort of the Italian astronomical community. The mode of operation for TNG is envisaged to be based on an end-to-end data flow model, and on assisted observing, with the possibility of flexible scheduling.

Optically and mechanically, TNG can be considered as basically derived from ESO's NTT, while the design of its control system is new and original.

The coupling among the different sub structures of a modern observatory is not a passive one, but allows interactions in order to optimize the observational conditions. This means that an integrated control system is mandatory. The control system will manage several physical structures which are monitored in real time and will send their status back.

4. THE TNG MAIN STRUCTURES

In the following we'll briefly describe as an example the different structures of the TNG Observatory in order to clarify the subsequent requests.

4.1 The external structure

The external structure of the observatory building is a rotating dome whose profile has been studied in order to minimize the air turbulences introduced in the optical path between the object being observed and the detectors.

Flaps and wind screens are provided to optimize the free-air flow. The dome moves on an independent bearing following the telescope.

4.2 The Telescope

The telescope is mounted on an alt-azimuth fork which lies on a oil bearing; the movements in azimuth and altitude are different depending on the user requirements: fast pointing , fine pointing, tracking.

The optical elements of the telescope are actively supported and their relative positions can be adjusted to exploit the observative performance.

The scientific instruments will be generally located on the two platforms at the Nasmyth foci, laterally with respect to the telescope structure.

4.3 The control room

The control room is located in a annex building, directly connected to the rotating one, to avoid the presence of people in the Dome and therefore uncontrolled air turbulences caused by undesired heat.

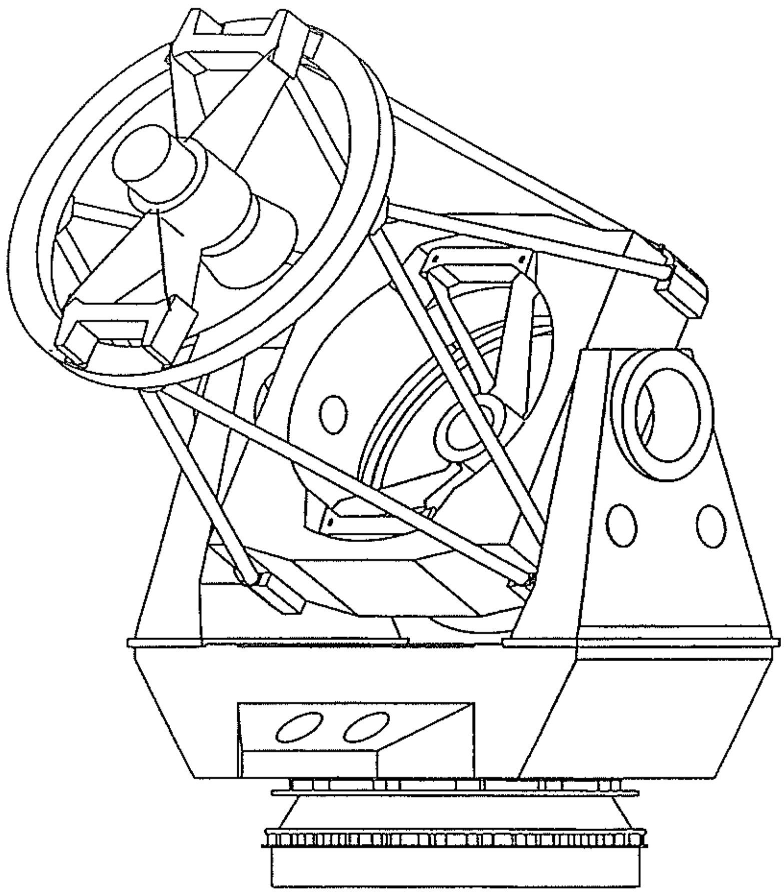

Figure 1: TNG Main Structures

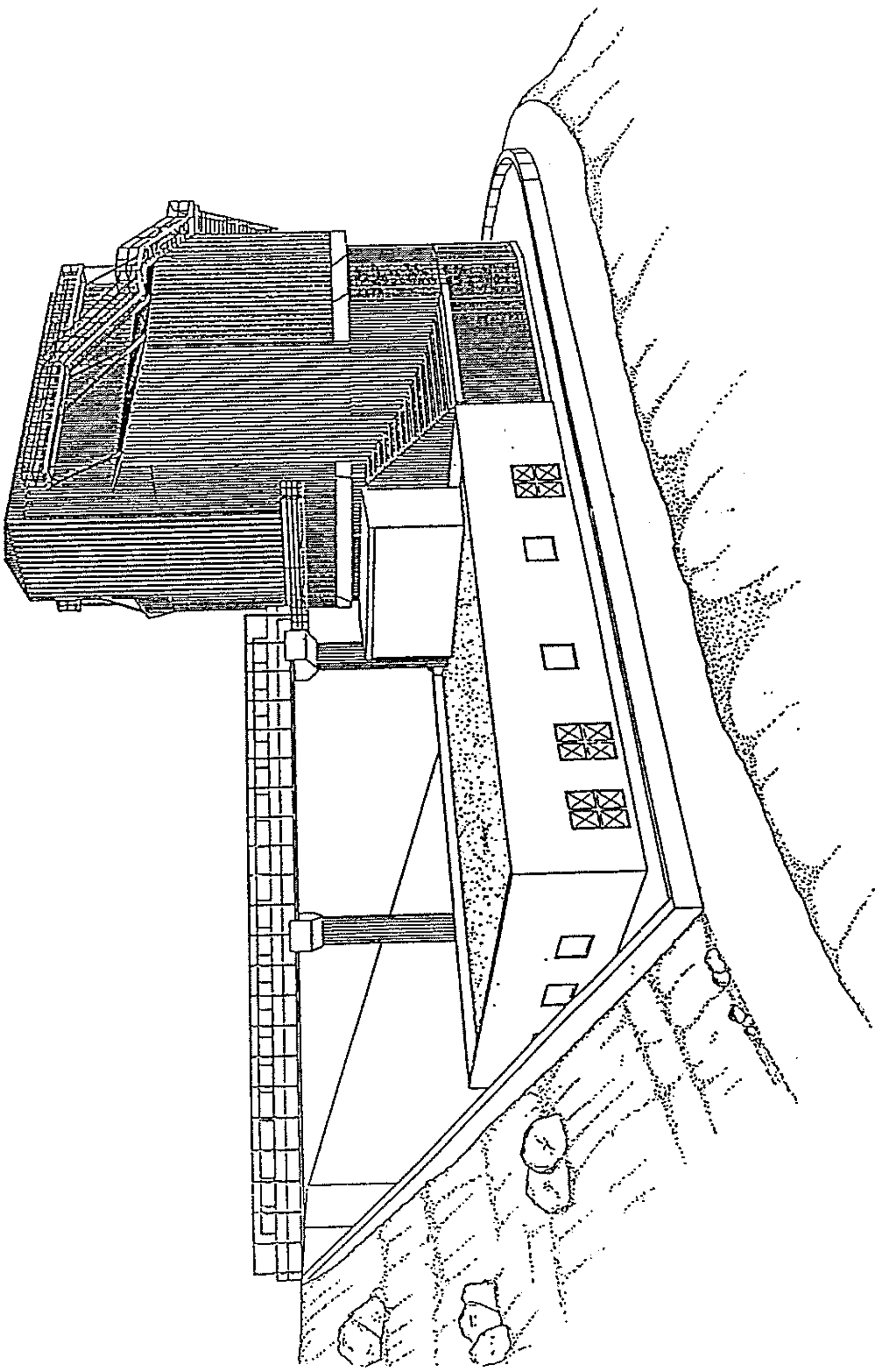

Figure 2: The TNG dome and annex building

5. THE TNG CONTROL SYSTEM

The general structure of the TNG control system can be described as based on a distributed network of workstations and VME crates, with the software on the VMEs managing device specific tasks, and the software running on the different workstations monitoring the VMEs behaviour and providing the user interface, as shown in fig. 3.

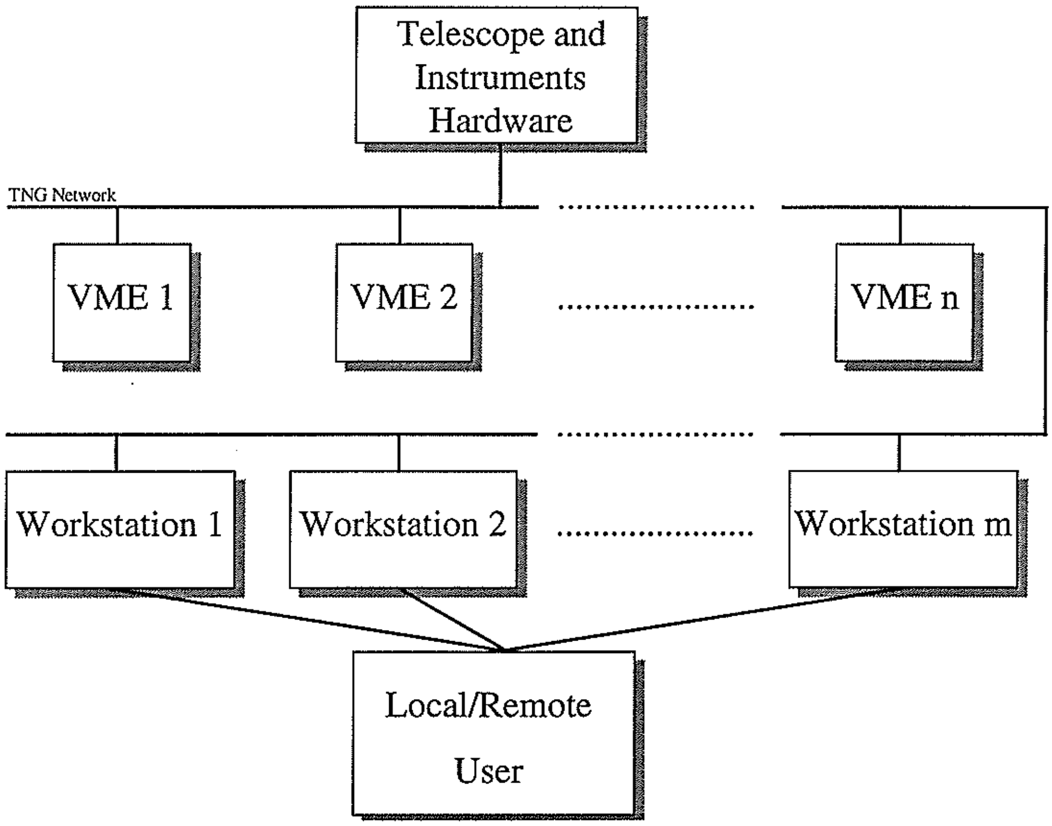

Figure 3: The TNG Control System

The whole TNG integrated system has been designed with client/server features; these server and client parts (each having a set of workstations to monitor/control the telescope and its instruments) will have the workststions' software in common. This feature gives the possibility of developing and handling a control system with the following charachteristics: independence from the instruments (both from the point of view of hardware and software), modularity, direct interface to the instruments, easy design and realization of new instruments, high number of standard components, fault tolerance.

The TNG Control System has been developed with a particular care for its portability and modularity, close telescope-instruments integration, and remote control.

Three main points to take as a reference in this design are the following:

- the technology used to build the system has been devised in a way that will guarantee an adequate support for future developments and changes;
- the Control System will be managed/modified in an easy way when this happens;
- people working on the system to develop instruments, high level software modules, will have a good approach with the system.

This is why the TNG Control System has been designed and developed using only standard systems, either hardware and software, with a modular and flexible structure, and with interfaces hiding all the low level details, allowing programmers to operate in an user friendly environment.

As previously stated, the TNG Control System architecture is distributed over a communication network which connects two differents sets of hardware objects: the first one is identified by a group of UNIX workstations, aimed at interfacing users with the telescope; the second is made up of a family of local processors, based on the VME technology, directly connected to the telescope and its instruments.

A further software layer is designed to make these two parts communicate with each other, with the telescope and with users.

6. THE TNG NETWORK CONFIGURATION

All systems (VMEs and workstations) are nodes of a Local Area Network.

The communications among these nodes are based on UNIX System V messages (for workstations' internal message exchange) and BSD sockets (for the communications between different systems).

The provisional choice for the LAN is a high bandwidth FDDI backbone, with Ethernet or full FDDI (depending on available hardware) connections to single VMEs; the backbone will run from the annex building up to the telescope observing floor with the double ring of optic fibres.

7. THE TNG USER INTERFACE

The User Interface represents the only way through which the user can interact with the computer system. Being so, it is important that this doorway is built using software technology which takes in account both the efficiency of the system and the human ease of interaction.

8. TELEOPERATION SYSTEM FACILITIES AT TNG

In this chapter we'll briefly describe the high level correspondence between the TNG functionalities and the application level services which should be provided by the teleoperation system being developed within the context of the REMOT project.

In the following paragraphs we'll show what we expect from the teleoperation system functionalities in order to realize a remote management of the TNG.

An important feature which is in common to all the following sections is that, in case of network faults, the control has to be given back to the local site, while at the remote one the last configuration, before the fault occurred, has to be saved.

8.1 Session control

This service should control the access rights of a user. This means that the service should validate the user remote login and open a connection to the local control system.

When the user has come to the end of his work and logs out, the Session control service passes the connection closing command to the teleoperation system . After that the system will wait for another user access request.

8.2 System administration

This service should help the particular domain System Administrator(s) to manage and control the Teleoperation System whithin the context of its usage in the remote control of scientific facilities.

8.3 Element monitoring and control

In order to manage a remote facility we need real-time monitoring and controlling of several elements; we can split these elements in two main classes respectively related to the telescope structure and to the instrument one.

As far as the telescope structure is concerned we need to know the actual status of its functionalities such as dome movimentation, telescope status and absolute position, environmental data etc.

With reference to the instruments we have to be able to check their specific functionalities that could span over a wide variety depending from their nature (i.e. camera, spectrographs etc.). These data should be transmitted to the remote user and, if enabled, he/she should be able to control the above elements by means of the specific local Control System commands.

An important additional action which the above services should provide, together with the ones we have just described, is the displaying of the informations related to the actual data transfer status.

8.4 Element monitoring

A sub sample of the above functionality (i.e. read only the actual status of the local facilities) should be available for another kind of remote session: the so called passive observation run.

8.5 Element configuration

As another sub sample of the Element monitoring and control functionality, this one is devoted to the setup of the telescope and/or to the configuration of the instruments. At this point we want to stress the importance of the time scale for the response of different functions:

- within long time scales (i.e. longer than 1 sec.) a telescope and/or instrument function can be remotely controlled;
- within short time scales (i.e. <= 1 sec.) the control loop should be closed at the observatory site.

The teleoperation system should offer the possibility of "hiding" all the commands which fall into the short time scales case.

8.6 Element calibration

As element calibration we mean all the procedures devoted to prepare the telescope and/or the instruments for an experimental run. All the above statements should apply to this service, with the additional storing of these actions into the appropriate scientific archive.

8.7 Engineering access

We foresee the remote engineering access as a passive session in the sense that the user enabled to use this service cannot directly interact with the low level shell of the local maintenance software. The direct interactions with the local facilities can only be performed by a qualified local operator.

8.8 Automatic sequences preparation and Auto sequences execution

The most common scenario for the set up of an experiment is that in which the user writes a series of sequential commands and data in a startup file which will be used to avoid time losses during the scientific run. The validation of these commands has to be provided by the local parsing protocol.

8.9 Experiment source acquisition

This service should be devoted to the transfer of data which are necessary to perform the subsequent experiment (i.e. point the telescope and control the actual field of view). In this case speed and reliability of the data transfer are the most important features required to the service.

Attention has to be payed to the data compression quality that, in this case, can be lossy. It would be useful to be warned about the possible problems that could occur on the network.

8.10 Experiment execution

More than in the previous section, the reliability and security of the data transfer are a must. Moreover the data compression has to be lossless.

8.11 Quick look acquisition

This service is devoted to the transfer of data which will inform the user about the preliminary results of the experiment by means of a local pre-processing of the raw data performed by the local software facilities. In this case too speed and reliability of the data transfer are the most important features required to the service.

Attention has to be payed to the data compression quality that, in this case must be chosen by the user.

8.12 Access to archive data

The archive access is an important facility for the remote user; his/her rights in this sense are checked by the Session Control service. The quality and speed of the transfer should be chosen by the user.

8.13 Inter-users comunications

Exchange of messages between the remote user and the local operator should be provided with a security and reliability sufficient to allow a fast and safe communication also when a network fault occurs.

Voice and message writing facilities are mandatory while video conferencing could be considered as an optional service.

8.14 Environment monitoring

Access to environmental data could be useful and in some case necessary to perform the experiment. These data could be provided by systems not directly related to the experiment LAN by from some external devices.

The teleoperation system should be able to connect the remote user to these different data sources (for instance a seeing monitoring station near the telescope), if such a serviced is provided locally.

9. TELESCOPE OBJECT MODEL

In this section we present a simplified Object Model of the Telescopio Nazionale Galileo (TNG), tracing the various items with the guidelines sketched in the previous sections.

9.1 The Dome

Description: The Building where the Telescope is located
Number: 1
Includes:
Attributes: Azimuth, Real, Degrees

Operations: OPEN
Descritpion: Open the Dome
Return: OK/Error Code
CLOSE
Description: Close the Dome
Return: OK/Error Code
ROTATE
Description: the Dome is moved according to the parameters
Parameters: Azimuth, Real, Degrees
Return: OK/Error Code

9.2 The Telescope

Description: Telescope is the complete observation system.
Number: 1
Includes: (1) Telescope Mounting
(1) Camera
Attributes: Telescopio Nazionale Galileo (TNG), stringchar
Operations:
Events:
Complex Behaviour:

9.2.1 Telescope Mounting

Description: The physical structure that hosts the mirrors and the instruments.
Includes:
Attributes: Nasmyth A, Nasmyth B, stringchar, writable
Operations: GO TO
Description: Move the telescope according to the parameters
Parameters: Right ascension, real, hour, minutes, seconds
Declination, real, degrees
Parallattic angle, real, degrees
Speed: fast, fine, track
Telescope time to limit, real, seconds
Rotator time to limit, real, seconds
Return: OK/Error Code

TRACK
Description: The telescope follows the target in the sky
Parameters: ON, OFF, Boolean
Return: OK/Error Code

Events:
* The telescope is moved towards a prefixed direction
* The telescope follows the target by means of the tracking facility.

9.2.2 Camera

Description: The instrument devoted to the acquisition of the Astronomical Images
Number: 1
Includes: Image type
Attributes:
* State: stringchar
* Focus: integer, steps
* Shutter speed: real, seconds
* Filter: integer
* Writable

Operations:

START EXPOSURE
Parameters: Start, Boolean
Return: Elapsed Time/Error Code

STOP EXPOSURE
Parameters: Stop, Boolean
Return: OK/Error Code

FILTER POSITION
Parameters: Identification number, integer
Return: OK/Error Code

FOCUS POSITION
Parameters: increase (+), decrease (-)
Return: step number, integer

LAMP
Parameters: ON, OFF, boolean
Return: OK/Error Code

SHUTTER SPEED
Parameters: seconds, integer
Return: Error Code/seconds, integer

EXPOSURE IDENTIFICATION
Parameters: exposure label, stringchar
Return: exposure label

Events: Image
Information: image type
Overheat
Event Conditions: Event is fired when temperature exceeds allowable range
Effect: No further images are provided until temperature goes back to the to the right value

Complex Behaviour: By means of the previous operations, the user can perform different actions as for instance the internal calibration which will be described in document D6.2.

9.2.2.1 Image type

Description: Acquired when a camera is in a specified state
Attributes: Frame, 2048 x 2048, 2 bytes/pxl
Headers: time, date, target, etc..., stringchar

9.3 Remote User Interface

Description: A set of windows on a computer environment each devoted to allow the user to interact with the objects of the telescope model. It is necessary that these windows are represented in an iconized menu bar.
Number: 1
Includes: Login Window (1), Session Notification Window (1), Telescope movements Window (1), Autoguiding Window (1), Camera Window (1), Graphic Window (1)
Attributes: Writable
Operations: LOGIN
Description: Access to the system with an authorized password.
Parameters: User Name, Password, stringchar
Return: OK/Error Code
DISPLAY STATUS
Description: Read and display the responses of the System Access Administrator and of the Local Control System.
Parameters:

Return: Status of the system

CHOOSE COMMAND

Description: Select an active command from a predefined set of standard commands available for the system usage.

PRESS BUTTON

Description: Click on an active button representing the operation to perform or the element to access.

Parameters:

Return: OK/Error Code

DISPLAY IMAGES

Description: Display the acquired images on a graphical window.

Parameters:

Return: OK/Error Code

LOGOUT

Description: Exit the system pressing a button with a connection closing confirmation

Parameters:

Return: OK/Error Code

Events: Activation/deactivation of the windows related to the different objects involved in the experiment.

Complex Behaviour: Every element of the various windows of the user interface should be activated/deactivated by the LCS depending on the actual availability of the required facility. This means that the Remote User Interface should be able to hide/show the related buttons to let the user know what actions he/she is allowed to perform.

9.3.1 Login Window

Description: Window used to connect the user to the system.

Number: 1

Includes:

Attributes: * Username: stringchar

* User Type: selectable menu

* Password: stringchar

* Writable

Operations: OK

CLEAR
CANCEL

Events:

9.3.2 Session Notification Window

Description: Window used to notify the session identification to the LCS.
Number: 1
Includes:
Attributes: Writable
Operations: WRITE
Parameters: Session Identificative, stringchar
Return: OK/Error Code
Events: START SESSION
Information: the session is started, the user can start with the commands.
Effect: Green or Red Light. The Telescope Camera and Graphical Windows are activated/not activated.

9.3.3 Telescope Movements Window

Description: Window used to manage the telescope
Number: 1
Includes:
Attributes: Writable
Operations: WRITE
Parameters: Target Name, stringchar
Right Ascension, real, hours, minutes, seconds
Declination, real, degrees
Epoch, integer, years
Return: Previous Target, Actual target, Next target (if any)
GO TO
Parameters:
Return: running coordinates,
Complex behaviour: the fine pointing is performed by means of a system of arrows: UP, DOWN, LEFT, RIGHT.

TRACKING
Parameters: ON, OFF, boolean
Return: OK/Error Code

Events: Actual Status Display
Information: the telescope actual coordinates and limits, the actual parallattic angle, the rotator limits.
Effect:

9.3.4 Autoguiding Window

Description: window used to define the guide star(s).
Number: 1
Attributes: writable
Operations:

WRITE
Parameters: Guide Star name, stringchar
Right Ascension, real, hours, minutes, seconds
Declination, real, degrees
Epoch, integer, years
Return:

OK
CLEAR

9.3.5 Camera Window

Description: window used to manage the camera
Number: 1
Includes:
Attributes: OIG, (Optical Imager Galileo) stringchar
Operations: WRITE
Description: insert the exposure time, choose the Image Type, stringchar
Parameters: exposure time, real, seconds
Image Type, stringchar
Comments for the image headers, stringchar
Return: OK/Error Code

CHOOSE THE FILTER
Description: choose the filter from the displayed menu
Parameter: filter identification code, integer
Return: actual filter position

CALIBRATION LAMPS
Description: Select the calibration lamp (if more one)
Parameters: lamp identification code, integer
lamp ON/OFF, boolean
Return: actual lamp, lamp ON/OFF

FOCUS
Description: adjust the camera focus
Parameters: steps, relative, +/-number of steps
Return: actual focus position

START EXPOSURE
Parameters: Start, boolean
Return: OK/Error Code
Elapsed time, real, seconds

STOP EXPOSURE
Parameters: Stop, boolean
Return: OK/Error Code

Events: Exposure Over
Information: exposure time expired,
Effect: reading image,
transferring image

Overheat
Information: the temperature exceeds allowable range
Effect: STOP EXPOSURE
No further images are provided until temperature goes back to the right value.

9.3.6 Graphic Window

Description: Window used to show the compressed images acquired with the OIG and/or the guiding camera. It allows the storage in the session file.

Number: 1

Includes: colours palette (1)
Attributes: writable, colour window
Operations: STORE
Description: store the image in the session file
Parameters: store, boolean
Return: OK/Error Code

LOAD
Description: load a stored image
Parameters: Image identification, stringchar
Return: OK/Error Code
ERASE
Description: erase the window display
Parameters: erase, boolean
Return:
PALETTE
Description: select a colours palette and low/high cuts.
Parameter: clickable buttons
Return:
INSERT COMMENT
Parameters: Comment, stringchar
Return: Comment/Error Code
Events: Image Title
Information: actual image identification
Effect: the windows title reflects the actual image

9.3.6.1 Colours Palette

Description: Graphical facility which provide a fast colours selection and a low/high values cuts.
Number: 1
Includes:
Attributes:
Operations: COLOURS SELECTION
Parameters: name of the pre-loaded colours tables, stringchar
Return: OK/Error Code
CUTS
Description: select the low/high values to cut.

Parameters: moving cursor
Return: OK/Error Code
Events: Correction of the image appaearance.

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