APPROVAL SHEET

TITLE	:	***SALT Telescope Control System (TCS) Specification***
DOCUMENT NUMBER	**:**	1000AS0007 **ISSUE:** A
SYNOPSIS	**:**	This document describes the technical requirements for the SALT TCS. It defines the functional, operational, software and hardware requirements that must be met.
KEYWORDS	**:**	Telescope Control System, Integrated control system, Telescope Software, Telescope Operator
PREPARED BY	**:**	*Gerhard Swart*
APPROVED	**:**	Leon Nel TCS PROJECT MANAGER
		Kobus Meiring SALT PROJECT MANAGER
DATE	**:**	March 2001

This issue is only valid when the above signatures are present.

ACRONYMS AND ABBREVIATIONS

BITE	Built-in Test Equipment
BMS	Building Management System (formally known as the Environmental Control Computer)
CCAS	Centre-of-Curvature Alignment Sensor
CCD	Charge-coupled Device (Camera)
CFE	Client-furnished Equipment
COTS	Commercial off the shelf
DP	Data Processor
Dec	Declination
EE(50)	Image diameter containing 50% of Enclosed Energy
EL	Event Logger (computer)
FoV	Field-of-View
Gb/s	Giga-bits per second (baud rate)
GUI	Graphical User Interface
HET	Hobby-Eberly Telescope
HRS	High-resolution Spectrograph
I/O	Input/Output (Device)
ICD	Interface Control Dossier
IR	Infrared
LRS	Low-resolution Spectrograph
Mb/s	Mega-bits per second (baud rate)
MCP	Manual Control Panel
MMI	Man-Machine Interface
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
OCS	Observatory Control System
OEM	Original Equipment Manufacturer
PC	Personal Computer
PFIS	Prime Focus Imaging Spectrograph
PI	Principal Investigator (Astronomer)
PM	Primary Mirror
RA	Right Ascension
S.A.	South Africa(n)
SA	SALT Astronomer
SAAO	South African Astronomical Observatory
SAC	Spherical Aberration Corrector
SALT	Southern African Large Telescope
SO	SALT Operator
SW	Software
TAC	Time Assignment Committee
TBC	To Be Confirmed
TBD	To Be Determined
TCS	Telescope Control System
UPS	Uninterruptible Power Supply

DEFINITIONS

Acquisition time	This is the length of time required to put the target at a desired position (a bore-sight), within the offset pointing requirement, from end-of-slew, until start of the integration
Cost baseline	This is the design baseline at the end of the concept study, which was used to determine the cost of the SALT project, and on which the budget is based. It is contained in the “SALT Report of Interim Project Team, April 1999”.
Growth Path	This includes concepts that have not been fully explored, and do not form part of the deliverable. However, these concepts have to form part of the decision making process in reaching the Technical or Cost Baselines.
Technical Baseline	This is the design baseline that is required to fulfil the requirements of the SALT Observatory Science Requirements, Issue 7.1, and is the topic of this Specification. This baseline has not been costed, and the budget implications will have to be ratified by the SALT Board.

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Modification History

Revision	Changes	Pages effected
A	New Document	All

1 Scope

1.1 Identification

This document specifies the requirements (the Technical Baseline) for the Southern African Large Telescope (SALT) Telescope Control System (TCS). It is an internal document that will be used to guide the TCS development and to test the TCS against.

SALT is a reflecting optical astronomical telescope of the tilted Arecibo type, based on the design of the HET. The TCS forms the integrating node of the telescope and provides the Man-Machine Interface (MMI) to the SALT Operator (SO), the SALT Astronomer (SA) and the Principal Investigator (PI).

In general, the word “shall” is used to indicate mandatory requirements while descriptive statements are used to provide non-mandatory information.

1.2 System overview

The TCS performs the integrating function of SALT by controlling the interaction between the subsystems, presenting the SO and SA with relevant information and responding to their commands. Computers linked to the subsystems via a computer network implement the functions of the TCS.

The TCS also includes the observation planning and scheduling tools, fault reporting and logging, hereafter referred to as the Observatory Control System (OCS). SALT planning and budgets (cost baseline) exclude the OCS but where possible, these have been specified in this document. In order to optimise the use of available funding and time, TCS requirements that could be postponed until after First Light have been indicated in *italics*.

The TCS excludes all control functions related to any Science Instrumentation. A measure of information integration with the Science Instrumentation is anticipated and the SA workstation will be designed to allow client/server operation with the Instrument Computers.

Issue A of this document addresses primarily the TCS control functions (i.e. those not forming part of the OCS) and the associated Man Machine Interfaces.

2 Referenced documents

	Keck Visit Report dd. July 2000 GS, JS, KM, DB
	SPIE proceedings (various)
SALT-1000AA0030	SALT Safety Analysis
SALT-1000AA0034	SALT Electrical Power and Cooling Budget
SALT-1000AS0007	SALT System Specification
SALT-1000AS0013	SALT Electrical Interface Control Dossier
SALT-1000AS0014	SALT Physical Interface Control Dossier
SALT-1000AS0028	Specification for the SALT Fibre-Feed System (TBD1)
SALT-1000AS0029	Specification for the SALT Prime Focus Instrument (TBD1)
SALT-1000AS0031	SALT Axes and Calibration definition
SALT-1000AS0032	SALT Electrical Requirements
SALT-1000AS0033	SALT Support Requirements (TBD1)
SALT-1000AS0040	SALT Operational Requirement
SALT-1000BS0010	SALT Software Standard
SALT-1000BS0011	SALT Computer Standard (TBD1)
SALT-1000BS0021	SALT Requirements for Built-in Testing (TBD1)

3 Customer Furnished Equipment and Responsibilities

The Science Instruments and their computers are outside the scope of the Telescope project. These systems and their MMI/interface software are “Customer Furnished Equipment”.

Details of the data and functional interfacing will be agreed and documented in the SALT Interface Control Dossier and each instrument’s own specification.

The data connection to the existing data network at Sutherland and the Internet, though not CFE, will require close liaison with the SAAO.

4 Functional Requirements

4.1 Functional definition

4.1.1 Operational Concept

The SALT operational concept is defined in the “SALT Operational Requirement” document listed in section 2. The TCS will provide information to and receive instructions from the SALT Operator, SALT Astronomer, Principal Investigator and the maintenance personnel. The TCS will also store and distribute that data as required.

The TCS comprises a network of computers that together perform the desired functions.

Initially the SA and SO will operate the telescope from the SALT control room at the telescope but the design shall facilitate moving this to Cape Town at a later stage.

The PI may be located anywhere in the world and has limited interaction with the TCS across the Internet.

The maintenance staff will perform operational and maintenance tasks from various positions inside the telescope but the design shall facilitate also doing this from Cape Town at a later stage.

Science data will be stored on a data processor from which the PI will retrieve the data via FTP and/or CD-ROM.

4.1.2 Functional Diagrams

4.1.2.1 TIMELINE DIAGRAM

Timelines of the operation can be found in the SALT Operational Requirement.

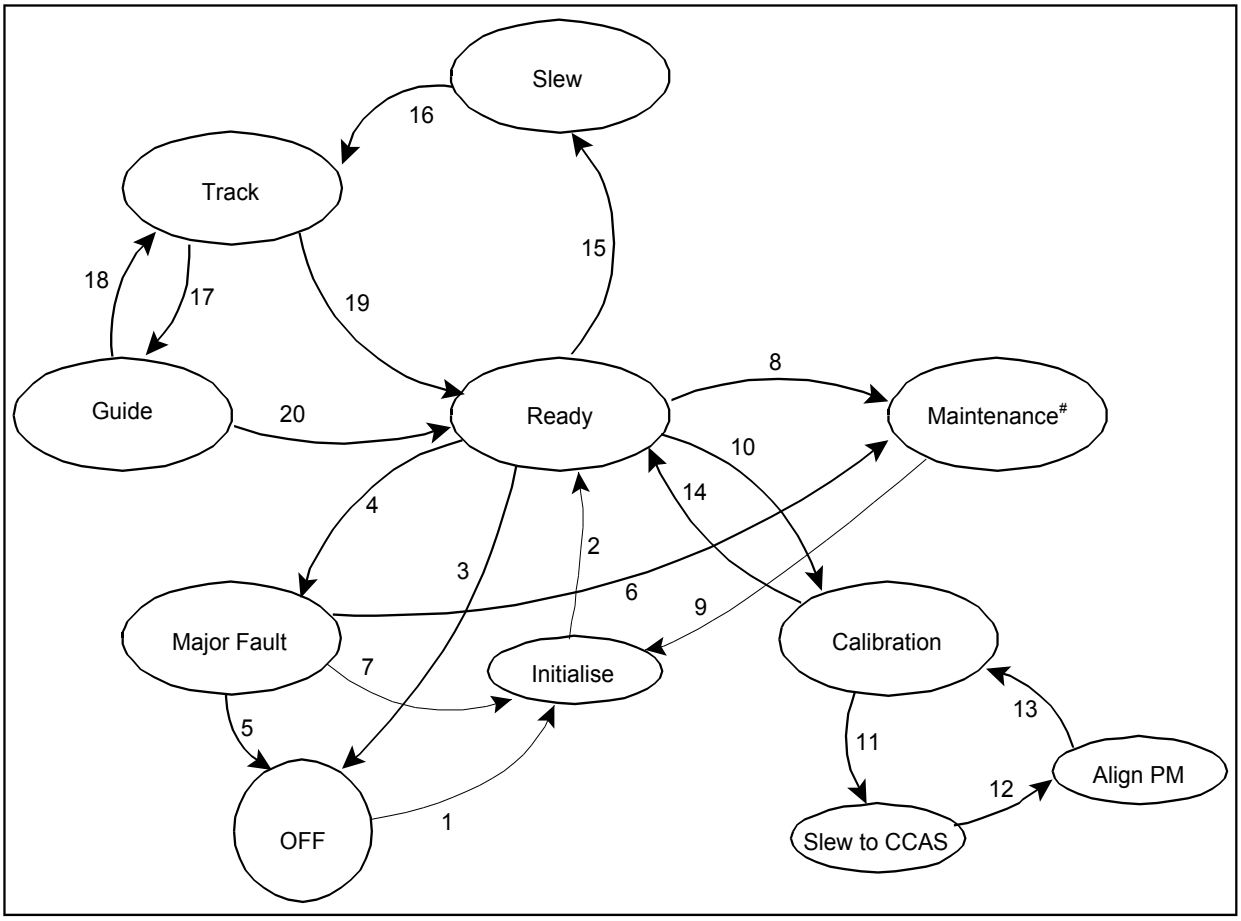
4.1.2.2 SYSTEM STATES

4.1.2.2.1 TCS Control States

Figure 1 below defines the anticipated control states of the Telescope System and will be controlled by the TCS Server. Each of the modes are defined in the paragraphs that follow while the conditions for state transitions are defined in Table 1. Final modes and states will be determined during the software design.

4.1.2.2.2 OCS States

The non TCS-server functions may have specific states but these will be determined during the design phase and are not defined here.



In Maintenance mode it is possible to force the system into most of the other modes.

Figure 1: System State Diagram

	Initial State	Next State	Event triggering the change of state
1	Off	Initialise	Electrical power turned ON
2	Initialise	Ready	Initialisation complete or initialisation time-out
3	Ready	Off	System Shut-down command issued or power turned OFF
4	Ready	Major Fault	Major System Fault detected
7	Major Fault	Initialise	Major System Fault recovers or is reset
5	Major Fault	Off	System Shut-down command issued or power turned OFF
6	Major Fault	Maintenance	Operator selects Maintenance mode while Major Fault
8	Ready	Maintenance	Operator selects Maintenance mode while system Ready
9	Maintenance	Initialise	Operator Quits Maintenance mode
10	Ready	Calibrate	Operator selects Calibrate mode
11	Calibrate	Slew to CCAS	Operator selects Primary Mirror Alignment mode
12	Slew CCAS	Align PM	Structure and Tracker reach desired destination for PM alignment
13	Align PM	Calibrate	Primary Mirror Alignment completed or aborted
14	Calibrate	Ready	Operator Quits Set-up mode
15	Ready	SIew	Operator commands system to Acquire an object
16	SIew	Track	Object Acquired
17	Track	Guide	Guidance object selected and guidance enabled
18	Guide	Track	Guidance discontinued
19	Track	Ready	Tracking discontinued or operator commands system to acquire new object
20	Guide	Ready	Operator commands system to acquire new object

Table 1: System State Transition Requirements

OFF: This is the state of the telescope when the power to all devices is OFF. In this state, the telescope shall be safe.
INITIALISE: This is a transitional state during which all the subsystems initialise to a known state. The TCS server monitors the initialisation of each subsystem and moves to the ready state when all the subsystems are initialised or after a pre-defined time-out.
READY: This is the default state of the telescope. During this state all systems are stationary but ready to enter into any other valid state. Non-intrusive adjustments and configuration of the system can be made in this state. Manual control of any subsystem is allowed in this state provided that it is authorised by the TCS server and does not interfere with other subsystems. Ventilation is automatically controlled in this state, to the appropriate program (i.e. Day or Night).
SLEW: In this transitional state the TCS server sends commands to lift the Structure, rotate it to the desired azimuth angle and to put down again. The Dome follows the structure rotation and the Tracker moves to the desired X, Y, Z, Phi, Theta and Rho angle. During normal operation, the system will automatically proceed to the TRACK state upon reaching the pointing destination.
TRACK: The structure is stationary on the pier, the dome is stationary, and the tracker is moving in all its degrees of freedom while tracking a celestial object. Tracking is open-loop assuming that the object is moving at the programmed rate. The object is acquired in the Acquisition camera, a guidance object selected and the light directed at the science instrument.
GUIDE: Closed-loop tracking using the selected guidance object is done in this mode. Manual guidance offsets can be entered by the operator or automatic offsets can be received from the science instrument. Disengaging the guidance returns the system to the TRACK mode.
MAINTENANCE: In this state, the user has full control of the system although warnings shall be issued before potentially dangerous actions are performed. In this state intrusive adjustments can be made to the system (e.g. actuator calibrations, software downloads etc). Any transition from this mode shall be accompanied by system re-initialisation to bring the system to a known condition. It shall be possible to “force” the system and each subsystem into any of the other system modes from this state and to override error conditions. This state will be used primarily during system commissioning. It will be possible to operate any single subsystem independent of the other systems in this state.

CALIBRATION: This is the state during which the system is configured, pointing adjustments made and the alignment of the Primary Mirror is performed. It has two sub-states:

SLEW-TO-CCAS: Similar to the SLEW state, except that the structure and dome rotate specifically to the angle of the CCAS tower and the Tracker moves to one side (position shall be selectable).

ALIGN PM: In this state the Primary Mirror subsystem performs the alignment of the Primary mirror. It shall be possible to manually adjust the angle and piston of each mirror individually in this state.

MAJOR FAULT: This state is entered automatically when a major failure that prevents safe use of the system has occurred. Actions that may be potentially unsafe are prevented in this mode (e.g. structure is put down and not allowed to rotate). It is possible to enter the maintenance state from this state to perform system diagnostics. It shall be possible to disable the transition to this state.

NOTE: Several functions can be activated in parallel with some of the above states (e.g. Instrument calibration, ventilation adjustment).

4.1.2.3 FUNCTIONAL FLOW DIAGRAM

The Functional Flow Diagram, indicating the major functions and data flow of the SALT System, including the TCS is shown in drawing 1000AD0022. Figure 2 shows the major TCS functions in more detail and allocates them to specific major components. The detailed functional flow will be determined during the TCS and subsystem designs that will supersede these drawings.

Section 6 defines the major components and their requirements.

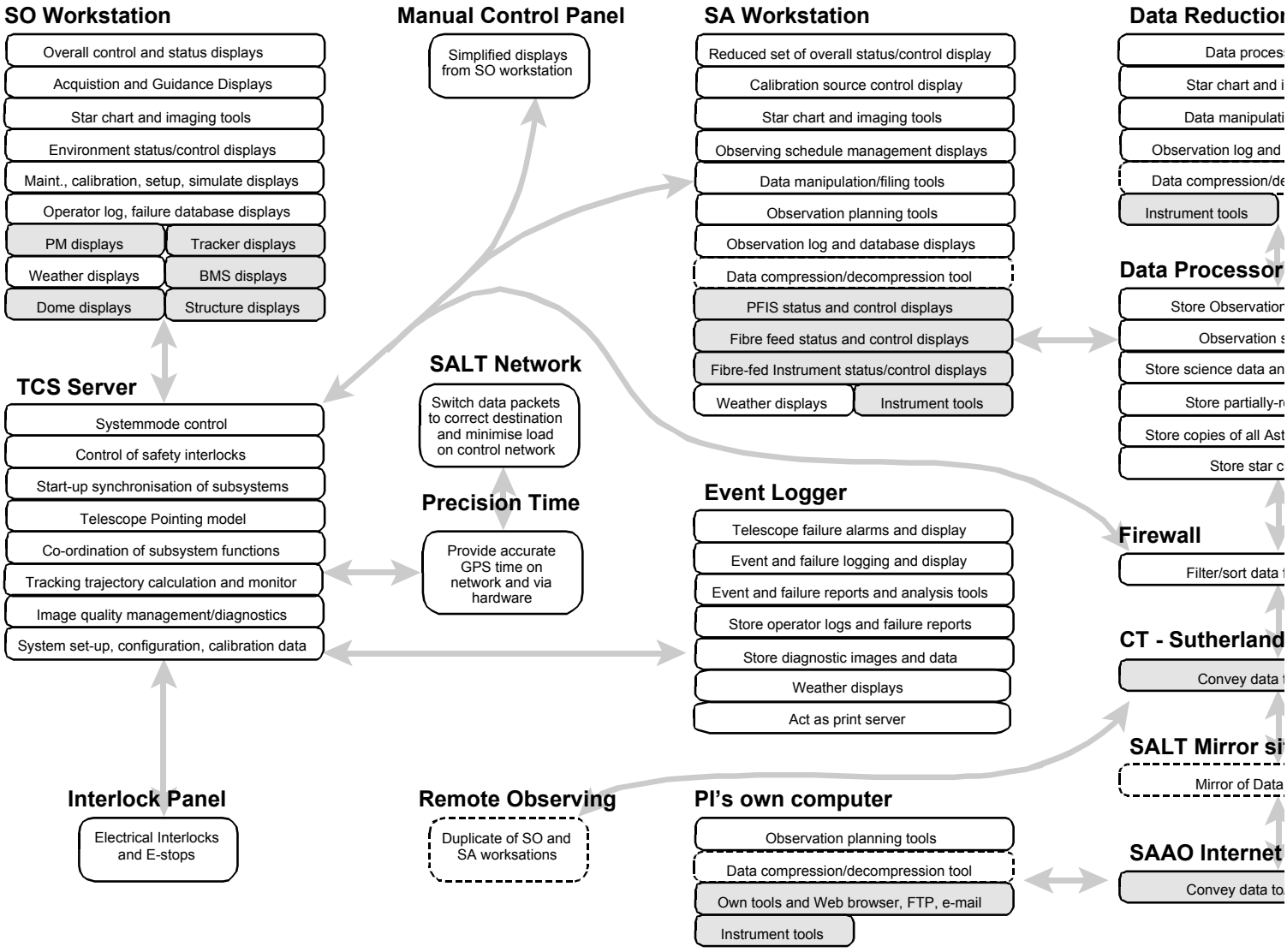


Figure 2: TCS Functional Diagram (shaded blocks are not part of TCS and dotted lines are for future growth)

4.1.3 Process

The work flow for an observation is described in the SALT Operational Requirements document. The paragraphs below indicate the information, displays, controls and software tools that the TCS must make available to support each phase of an observation. The phases are:

Phase 1: PI initial preparation prior to TAC approval
Phase 2: PI final preparation after TAC approval
Phase 3: Observation of object by SALT
Phase 4: Data retrieval and data reduction by PI

4.1.3.1 PHASES ONE AND TWO

The tools required by the PI and/or the Co-investigator are similar to those used by HET (see http://rhea.as.utexas.edu/HET_software.html). Details are TBD2.

4.1.3.2 PHASE THREE

The TCS shall simplify the operation of the telescope by normally only displaying the information and control functions that are relevant in a particular state or phase of operation on the SO and SA workstations. This information is configurable (see section 5.3.1.2).

Table 2 shows the seven major groups into which the controls and displays can be combined.

Process Steps[#]	SO Task Name	SA Task Name
1,2,33	Day-time operations	Observation planning, data archiving
3-9	Twilight Preparation	Instrument set-up and calibration
10-15	Telescope Calibrations	
16-19	Object Acquisition	Object Acquisition
20-25	Object Setting	Object Setting
26-29	Observation	Observation
31,32	Dawn close-out	Instrument calibration

Table 2: TCS Work Flow

4.1.3.3 PHASE FOUR

A data decompression tool will be made available to the PI to decompress data, when data compression has been implemented. Some preliminary data analysis may be performed by the SA, but he will use tools described under Phase 3.

5 System Technical Requirements

This section defines the performance characteristics of the TCS and allocates the functions identified in section 4 to specific items of equipment or software.

5.1 Schematic diagram

The physical layout of the Telescope can be found in the SALT System Specification and the full SALT control system is shown in drawing 1000AD0005.

Figure 3 defines the proposed TCS Architecture and indicates the computer internal and external computer interfaces. This information is provisional and will be superseded by detailed designs.

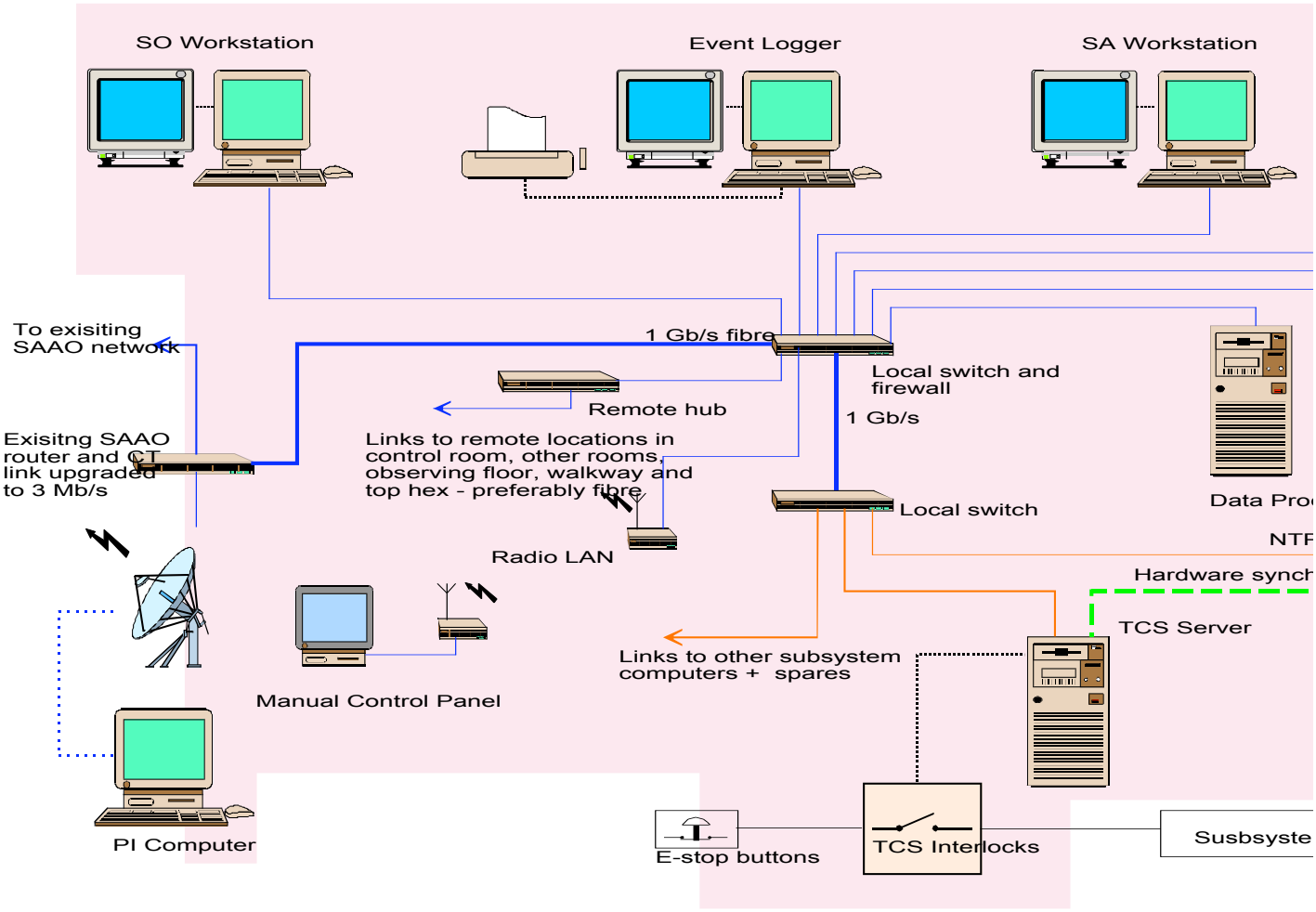


Figure 3: TCS Architecture

NOTE: The non-shaded areas are not part of the TCS

5.2 TCS Interfaces

5.2.1 External Interfaces

Figure 4 shows the major external interfaces of the TCS.

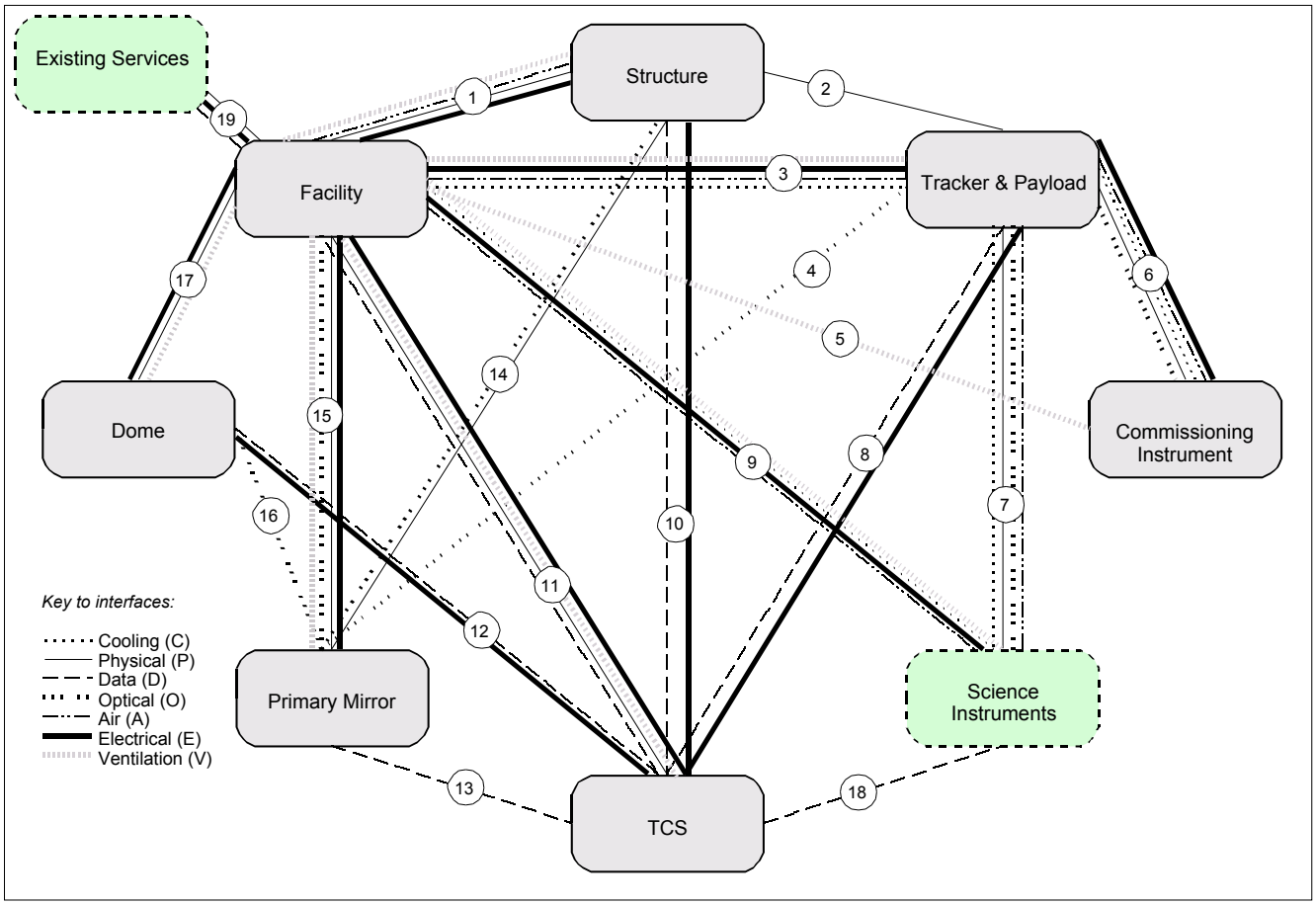


Figure 4: Schematic showing SALT Subsystem Interfaces

This information is provisional. The system interfaces shall comply with the Physical, Electrical and External Interface Control Dossiers referred to in Section 2, when these have been issued.

No.	Subsystem 1	Subsystem 2	Type#	Direction	Interface Description
8	Tracker & Payload	TCS	D	TCS-> ->TCS	Command information Tracker status
			E		Interlocks and manual control
10	Structure	TCS	D	TCS-> ->TCS	Command information Structure status
			E		Interlocks and manual control
11	Facility	TCS	E	->TCS	TCS power supply as per Power Budget
			V	->TCS	Ventilation/air-conditioning of TCS equip.
			P	->TCS	Data network and cable trays for all links to TCS, Control room desk etc.
			D	TCS-> ->TCS	Command information, internet, SAAO Facility status, weather, internet, SAAO
12	Dome	TCS	D	TCS-> ->TCS	Command information Dome status
			E		TCS interlocks and manual controls for dome shutter
13	Primary Mirror	TCS	D	TCS-> ->TCS	Command information Primary Mirror status
18	TCS	Science Instruments	D	TCS-> ->TCS	Commands to Science Instrument Data and Instrument Status info
20	TCS	Existing Services	D		Link to existing SAAO data network
NOTE #: See Figure 4 for key to interface types.					

Table 3: TCS External Interfaces

5.2.2 Internal Interfaces

Refer to the Electrical ICD.

5.3 Characteristics

5.3.1 Performance

5.3.1.1 COMMUNICATION

a. The TCS shall provide a communications network for SALT using TCP/IP across an Ethernet network. The Physical Layer and data will be defined in the Electrical ICD.
b. The data shall be communicated at a rate commensurate with the latency, bandwidth and timing requirements of each data item.
c. It shall be possible to locate the SO Workstation and the SA Workstation anywhere on the SALT network or at the SAAO Cape Town.
d. It shall be possible to locate the Manual Control Panel anywhere on the SALT network.
e. It shall be possible to connect many instances of the SO Workstation, SA Workstation and Manual Control Panel, although certain control functions would then only be available at a selectable "master".
f. A means shall be provided whereby changes to the data which is communicated between computers, will not necessitate updates to all the computers' software. A method using a central "*.ini" file which is communicated to the various subsystem computers at start-up, is suggested. A tool to co-ordinate the "*.ini" file with the contents of the ICD is required (see 5.4.5.1).

5.3.1.2 CONFIGURABLE MMI

The SO and SA workstations shall allow the user to configure the following characteristics of the display. It shall be possible to save such a configuration and return to it later so that each user has a custom "set-up".
- *Open windows*
- *Active window*
- *Position of each window on each particular monitor*
- *Default set of user-configured commands (see next section)*

5.3.1.3 USER-CONFIGURED COMMANDS

It shall be possible for the user to schedule a series of defined steps/instructions/ commands to be triggered at a particular time or with a simple key-stroke or mouse-click the user to "batch-process" activities that can be planned in advance (mouse-activated script files may suffice). Examples of such actions are listed below:
- *Steps of a calibration process*
- *Steps associated with a particular instrument change*
- *All steps required to prepare SALT for the night (e.g. open shutter, turn off air-conditioning, open louvers)*
- *All admin steps required to proceed to the next observation (e.g. log all details in the observation report, open new observation report and populate some fields)*

5.3.1.4 OPERATOR TASK TIMES

a. The TCS SO and SA interface shall be such that once an object has been positioned in the acquisition field-of-view, a trained operator and astronomer will together take no longer than 5 minutes (90^{th} percentile) to perform all the following tasks:
   - Confirm that the correct object is displayed
   - Adjust the telescope rotation and pointing direction to correctly position the image in the field
   - Switch the Tracker Payload fold mirror so that the light enters the science instrument

- Activate the Guidance

The above is an integration of information and commands from/to the TCS server, Payload Computer and PFIS computer (see 5.3.1.5).

b. The SO and SA shall be able to view the telescope environmental conditions and telescope mode, health status, track time remaining and time at all times, without interrupting the normal work flow.

5.3.1.5 INFORMATION DISPLAY INTEGRATION

The TCS shall provide an integrated Man-Machine Interface workstation to the each of the following users, positioned according to the requirements of the SALT Operational Requirements.

a. **SALT Operator**: All the information and controls related to operating the telescope and monitoring its performance (i.e. everything except the Science Instrument). The information shall be displayed on the SO Workstation as specified in section 6.2.1.3. This includes information from the various sources:
   i. **TCS Server**- Overall telescope status and control, pointing, interlock status, observation information, summary of each subsystem's status
   ii. **Payload Computer**- Guidance and Acquisition images/commands, image quality (TBC1 during the design process)
   iii. **Event Logger**- OCS data such as a summary observation plan, operator log entries, fault report forms,
   iv. **Other subsystems**- Detailed status and control of each subsystem, diagnostic MMI, manual control MMI.
   v. **Internet**- Image catalogues, weather forecasts etc.

b. **SALT Astronomer**: All information and controls related to operating the science instrument, storing the data, performing preliminary data analysis and preparing for an observation. The information shall be displayed on the SO Workstation as specified in section 6.2.2.3. This includes information from the various sources:
   i. **TCS Server**- Overall telescope status and observation information.
   ii. **Payload Computer**- Guidance and Acquisition images/commands, image quality (TBC1 during the design process)
   iii. **Data Processor**- Observation plan details, observation details, calibration data, science data, database information/control
   iv. **Science Instruments** (incl. PFIS, Fibre Feed, HRS)- Instrument status/control, data display, data manipulation controls, data visualisation
   v. **Internet**- Image catalogues, weather forecasts etc.

c. **Shared information, normally not requiring controls**: Situational information that has to be permanently visible to both the SA and SO such as Telescope failure alarms, outside weather data, internal environmental data etc. This information shall be displayed as specified in section 6.2.6.3. This includes information from the following sources:
   i. **TCS Server**- Alarm information, time left to end of track, S.A. Standard Time
   ii. **Other subsystems**- *User-configurable trends and alarms*
   iii. **Building Management System**- Internal and external environmental information
   iv. **Internet**- *Possibly additional weather forecast information*

5.3.2 Physical Characteristics

5.3.2.1 LOCATION

The TCS components shall be located primarily in the SALT control room and computer rooms.

5.3.2.2 TELESCOPE AXIS SYSTEM

All subsystems shall comply with the axes defined in the SALT Axes and Calibration definition document referred to in section 2.

5.3.2.2.1 Reference Axis System

The Reference Axis shall be used by the Pointing Model in the TCS to convert Celestial co-ordinates to the required local co-ordinates and vice-versa.

Although this axes system has its origin at the centre of the ideal upper surface of the pier, the software implementation of the pointing model may use an alternative reference (e.g. the optical axis of the central Primary Mirror segment) if this is more practical.

5.3.2.2.2 Local Axes

a. All angular and position information transferred between the TCS and each of the subsystems shall be in the local axes of each subsystem. The axes are relative to the physical interfaces between the subsystem and its neighbours.
b. The pointing model in the TCS shall correct any fixed rotational or positional misalignment of the reference planes from the design ideal.
c. The correction or calibration of any misalignment within each subsystem shall be performed within that subsystem.

5.3.2.2.3 Celestial Axis System

All operator interfaces referring to sky object positions, shall use the Equatorial Axis System where the position of an object is defined in RA, DEC and sidereal time.

5.3.2.2.4 Pointing Model

a. A pointing model shall be provided in the TCS to compensate for system misalignments (see 6.2.4.3).
b. The pointing model shall be comprised of two parts:
    1. An analytical part, based on the known geometry of the Telescope and the measured “static” misalignments measured between the interfaces of the subsystems
    2. An empirical part, comprising of a model built from the absolute residual errors measured during Telescope commissioning and operation.

5.3.3 Environmental Requirements

5.3.3.1 NORMAL OPERATIONAL ENVIRONMENT

The TCS shall meet all the requirements specified in this document when operated in the computer room and control room ambient condition defined in Table 4 below:

Parameter	Value	Notes
Minimum Temperature in SALT rooms below observing floor	10ºC	
Maximum Temperature in SALT rooms below observing floor	30ºC	Excluding Mirror coating room, where no active TCS equipment is located.
Minimum Temperature in Telescope Chamber	0ºC	
Maximum Temperature in Telescope Chamber	20ºC	
Minimum Humidity	5%	
Maximum Humidity	97%	Non-condensing
Site altitude	1798m	

Table 4: TCS Normal Operating Environment

5.3.3.2 SURVIVAL ENVIRONMENT

The TCS shall survive when exposed to environment specified in Table 5 below (non-specified values as per 5.3.3.1).

Parameter	Value	Notes
Minimum Temperature	0ºC	
Maximum Temperature	40ºC	
Maximum Humidity	100%	Occasional exposure to condensing conditions

Table 5: SALT Survival Operating Environment

5.4 Operation and Maintenance Requirements

5.4.1 Packaging, handling, storage

Packaging, handling and storage requirements will be determined for each individual type of component, taking into account the specific requirements of the component, the method of shipping and interim storage locations. Storage at SALT will be in the SALT Store Room, in dry, air-conditioned conditions. Containers shall be sufficient for one return shipping only, unless otherwise specified.

5.4.2 Product Documentation

A “SALT Pointing Calibration Instruction” document shall be defined, summarising the pointing model calibration and adjustment procedure.

For COTS equipment and software, the standard manufacturers documentation will be supplied, and no special documentation will be developed. Software documentation requirements are defined in the SALT SW Standard.

5.4.3 Personnel and Training

5.4.3.1 OPERATION

SALT will be operated from the control room at the telescope. A SALT operator (SO) and a SALT Astronomer (SA) will be on duty during the whole night, for every operational night. Any ad hoc repair work will be performed by the SAAO standby maintenance staff, to be called by the SO when required. The SO will have a National Diploma (N6/S3) or equivalent qualification in electronic or mechanical engineering or have adequate experience. The SA will be a PhD astronomer.

5.4.3.2 MAINTENANCE

SALT will be maintained by the SAAO staff at Sutherland and Cape Town. Personnel will be trained in the maintenance of SALT, and be granted a “SALT – license” upon completion of training. All maintenance work carried out on SALT will be supervised/signed off by a SALT licensed person. It is anticipated that the following people will be required to maintain SALT (this will be updated when the Operational Requirements have been received) :

<u>At Sutherland:</u>	
Mechanical Technician:	2
Electronic Technician:	1
Electrical Technician:	1
<u>In Cape Town:</u>	
Mechanical Engineer:	1
Electronic Engineer:	1
Software Engineer:	1

These positions should not be SALT only, i.e. these personnel must be part of the SAAO technical staff, who will also work on the other SAAO telescopes. Thus, two Electronic technicians, each working 50% on SALT, can constitute the one full time Electronic Technician listed above.

One mechanical and one of the electrical/electronic technician will also required to be on standby during every night of operations. These standby personnel will form part of the normal SAAO standby team.

In the above requirements, “Technicians” require a N6, T3 or equivalent qualification, and “Engineer” means an S6 or Bachelors degree in Engineering and/or Computer Science.

5.4.4 Availability

The TCS reliability is critical to the operation of SALT. The TCS Server shall not fail catastrophically (i.e. hang or experience hardware failure) more than once per year.

One of the other TCS machines shall be defined as a “backup TCS Server” and shall be able to take over the role of the TCS server within 10 minutes.

All normal maintenance actions will be able to be completed within one working day, unless otherwise specified. Where maintenance actions take more than a day and happen regularly, enough spares will be held to ensure that the operation of the telescope system is not affected.

5.4.5 Test Equipment and Tools

5.4.5.1 INTERFACE MANAGEMENT TOOL

A means shall be provided to automate the update of Ethernet-communicated data directly from the ICD. A simple tool that creates the “*.ini” file specified in section 5.3.1.1, directly from an Excel spreadsheet containing the ICD, is suggested.

5.4.5.2 DATA MONITORING TOOL

A tool shall be provided that displays the value of any selected parameter or set of parameters being communicated between computers. The tools shall be able to record the data for a period.

5.4.5.3 TCS SIMULATOR

A TCS simulator shall be provided to perform subsystem testing prior to final system integration (see 6.2.4.3.8).

5.4.6 Data and Software Backups

A system to automatically create backups of critical data and software shall be installed. Backups are to be copied and stored in a separate building on at least a weekly basis.

5.5 Design and Construction constraints

5.5.1 General design guidelines and constraints

The following guidelines and constraints apply to SALT (where these general guidelines contradict specific requirements in other parts of this document, the other requirements shall have precedence):

a. The telescope chamber shall have the same temperature as the ambient air during observing, i.e. it shall be cooled during the day, to match ambient temperature at the start of observing
b. No warm air will be exhausted directly from the building.
c. Commercial, off the shelf (COTS) equipment will be used unless specifically stated otherwise.
d. All computer hardware will be COTS equipment, using “mainstream” equipment and vendors.
e. Computer operating system and application software will be COTS, using “mainstream” packages and vendors
f. Optical fibres will be used for any digital communications travelling more than 30m
g. No artificial light will intrude into the telescope chamber, or outside the building during observation.
h. The SI units shall be used in all documentation and MMI’s.
i. All surfaces inside the telescope chamber should follow the ambient temperature as closely as possible, the effect of a positive delta being air turbulence, causing bad seeing, and a negative delta being the risk of condensation, damaging mirrors and equipment.
j. The design, implementation and testing of safety-critical functions shall be subject to the review and approval of the SALT safety committee.

5.5.2 Materials, Processes and Parts

a. All components will be protected against corrosion by proper surface treatment (e.g. anodising), painting, etc.
b. Wherever a component is mounted in an optically sensitive area, it shall be painted with a non-fluorescing, non-radioactive paint.
c. All components or material used in the Telescope Chamber and the Main Instrument Room shall be non-reflective, non radiating in the spectrum 320 to 2500nm, as possible.
d. All custom components will be marked as follows:

SALT
Supplier name
Product name
Product number
Serial number (where applicable)
Version number (where applicable, e.g. controllers/computers with embedded software)
Hazard/danger/poison warning (where applicable)

e. No special markings are required on COTS equipment.
f. The normal operation of any component/subsystem shall have no negative impact on the environment, and shall comply with the Montreal Protocol.
g. Radioactive, fluorescent and luminescent materials are to be avoided in the Telescope Chamber and Main Instrument Room. Building material such as gravel, cement and paint shall be tested for radioactivity and shall not exhibit radiation more than the background radiation of the 1.9m telescope spectrometer room.

5.5.3 Electromagnetic Radiation

The normal operation of any component or system will not affect the normal operation of any other system or component, or any other equipment at the Observatory at Sutherland, and has to comply with the EMC standards as defined in the SALT Electrical Requirements document.

5.5.4 Workmanship

Workmanship shall comply with good practice in the computer industry (e.g. ISO9001and ISO9002).

5.5.5 Interchangeability

Interchangeability shall be maximised by using identical COTS equipment wherever possible.

5.5.6 Safety

5.5.6.1 SAFETY-CRITICAL FAILURES

All single-point failures that can lead to loss of life, serious injury to personnel or damage to equipment shall be identified and the design modified to prevent such failures.

A preliminary safety analysis to identify such potential failures is contained in the SALT Safety Analysis referred to in section 2.

5.5.6.2 SOFTWARE SAFETY

Where the malfunction of software alone could cause a safety-critical failure, alternate means shall be provided to prevent the occurrence of such a failure. This would typically take the form of electrical interlocks designed in a fail-safe manner (see 6.2.7.3).

5.5.6.3 SAFE INITIALISATION

All systems, when initialising from power-up or when reset, shall be in a safe, non-active state (e.g. equipment stationary, drives off). It shall take a specific command from the TCS (by exception) or the operator via the TCS, to proceed with potentially unsafe actions (such as rotating the structure or dome, moving the tracker or opening/closing the shutter).

5.5.6.4 EMERGENCY STOP

Emergency stop buttons will be located at various locations in the building (as defined in the SALT System Specification). The TCS shall provide a central hub to which these signals are routed and shall initiate appropriate action. The action shall be trigger by software commands to the appropriate subsystems and also by hardware signals (see 6.2.7.3), where applicable. The final design will be subject to the Safety Analysis Document listed in Section 2.

5.5.6.5 ENHANCEMENT OF OPERATOR AWARENESS

Potentially unsafe commands that can be initiated by the operator using the TCS MMI, shall accompanied by suitable warnings and confirmations to enhance the operators awareness of the unsafe condition.

5.5.7 Ergonomics

Comfortable working positions and conditions shall be provided at both workstations.

5.5.8 Special commissioning requirements

5.5.8.1 SUBSYSTEM MMI'S

The TCS shall support the running of subsystem MMI GUI's on the SO and SA workstations.

5.5.8.2 TEST POINTS

Means shall be provided to measure electrical signals and interpret data transferred between subsystems and major electronic items within each subsystem.

5.5.8.3 TEST DATA

Each subsystem shall send to the TCS (Event Logger) the values of all internal variables that may need to be interrogated during commissioning and testing, but would not normally be needed for telescope control by the TCS. Details will be provided in the SALT Electrical Interface Control Dossier.

5.5.9 Software

Each subsystem shall comply to the requirements defined in SALT Software Standard referred to in Section 2.

5.5.10 Computer Hardware

Each subsystem shall comply to the requirements defined in SALT Computer Standard referred to in Section 2.

5.5.11 Electrical Design

5.5.11.1 UPS

5.5.11.1.1 Installed Capacity

The UPS will provide power to the TCS computers for at least 20 min during a power failure.

5.5.11.1.2 UPS monitoring

The TCS shall monitor the UPS in the following way:

- The battery charge level and overall health, with operator warnings as appropriate.
- A "normal power-fail" signal to indicate the loss of normal power so that contingency software can be activated (if applicable)
- A "UPS power-fail" signal to warn the operator to shut-down critical software processes

5.5.11.2 STANDBY POWER GENERATORS

5.5.11.2.1 Installed Capacity

The installed emergency power generation capacity will be adequate to allow normal operation of SALT during a power failure. Non-essential power users may be turned off.

5.5.11.2.2 TCS operation upon power failure

The emergency power source shall has the following features:

- It will become active within 30s of a general power failure and will remain on until manually turned off
- The quality of power (voltage, frequency drift, harmonics) will be no worse than the normal electrical supply
- At least the following error conditions will also be reported to the TCS: low fuel, low oil pressure, generator fault, low voltage, over-current, system overheating, power status (normal, emergency, off).

If the generator fails to start after a power failure an operator warning shall be generated so that critical software processes can be shut down.

5.5.12 Data security

a. The TCS shall allow various users to log in with different levels of security. The following level of access are required, each with their own particular restrictions:
   - SA
   - SO
   - Maintainer
   - Administrator
   - PI
   - Co-Investigator
   - Partner
   - Guest

b. A firewall shall protect the SALT network from unauthorised access outside the site.

5.5.13 Future growth

The following potential growth areas shall be borne in mind during the design process and accommodated where this does not have an impact on the achievement of the immediate performance, schedule and cost requirements.

5.5.13.1 PHASING

The primary mirror array of SALT may be required to be phased in future, to make use of the advantages of Adaptive Optics (AO).

5.5.13.2 IMPROVED OPTICAL PERFORMANCE

The optical performance of SALT may be improved by using the latest technology mirror coatings.

5.5.13.3 IR PFIS

A near IR channel may be added to the PFIS.

5.5.13.4 REMOTE OBSERVING

The whole or parts of the SALT control room may be required to be duplicated at the SAAO in Cape Town, to allow remote operating of SALT.

5.5.13.5 ADDITIONAL INSTRUMENTS

Specific provisions shall be made in the TCS architecture, network sizing and MMI design to facilitate the addition of more science instruments during SALT's life-time.

5.5.13.6 DATA MIRROR OFF-SITE

The science data and PI-related software may later be moved to a mirror site elsewhere, to minimise data communication between Sutherland and Cape Town.

6 Subsystem Technical Requirements

6.1 Major Component List

Figure 5 below shows the major components of the TCS.

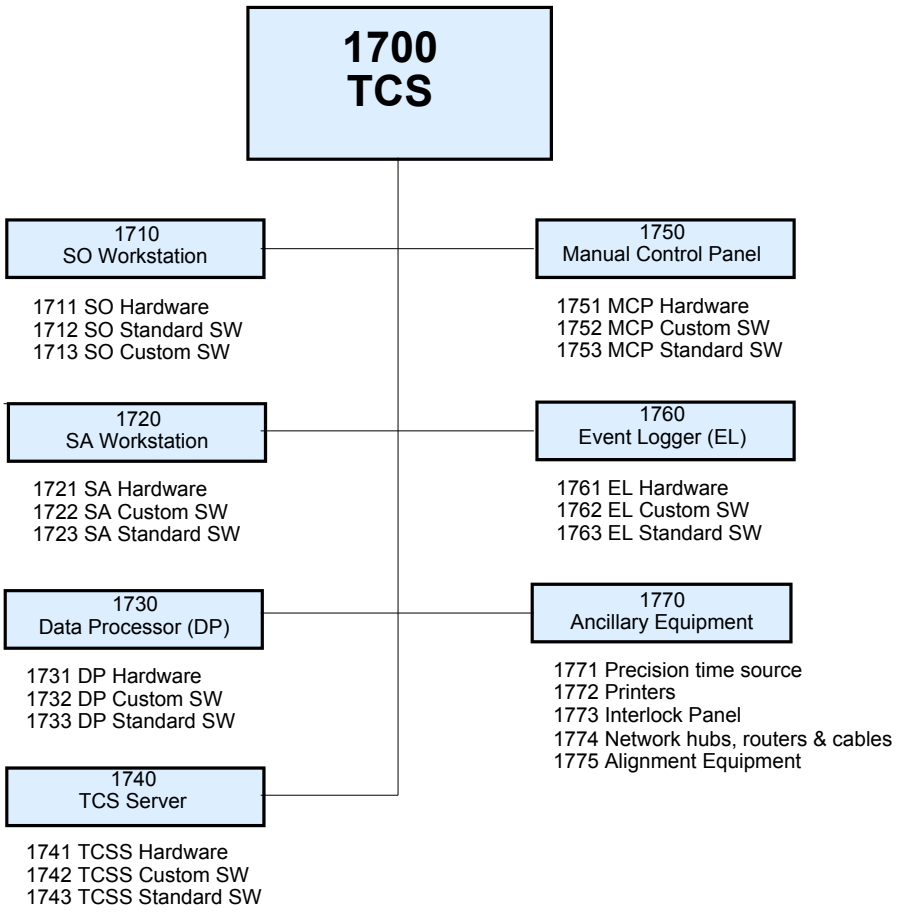


Figure 5: TCS Major Components

6.2 Subsystem Characteristics

6.2.1 SO Workstation

6.2.1.1 HARDWARE

The SO workstation shall comprise a Pentium PC with the appropriate network card (see 6.2.7.4). Detailed requirements can be found in the SALT Computer Standard.

This PC shall have two large monitors (17” or larger) and shall be located in the SALT control room. The user interface shall be a single keyboard and mouse.

6.2.1.2 STANDARD SOFTWARE

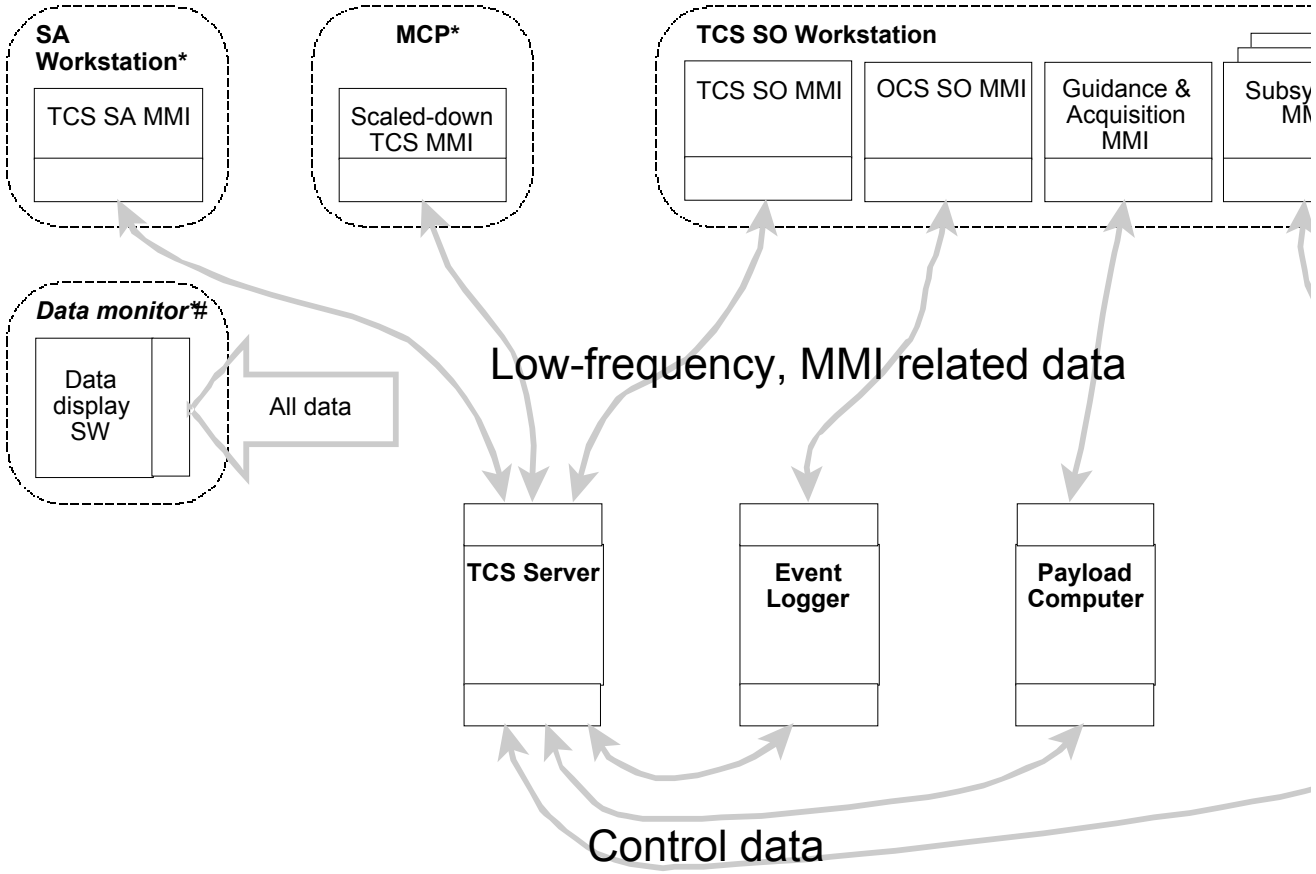
The following standard software shall be installed on this machine:

- Linux operating system in accordance with the SALT SW Standard
- X-Windows environment
- GNU-C
- KDE
- Star Office

6.2.1.3 CUSTOM SOFTWARE

6.2.1.3.1 Purpose

The purpose of the SO Workstation is to provide the full interface to the SO to control the telescope. It displays information from various computers and can send commands to these computers, as shown in Figure 6 overleaf.



NOTES: * Not all software shown for these computers; # Maintenance equipment, not part of TCS

Figure 6: Communication relating to the TCS SO Workstation

6.2.1.3.2 TCS MMI Functions for the SO (TCS SO MMI)

This software shall provide a graphics user interface (GUI) with the following characteristics:

a. Two separate, configurable and independent displays displaying the information listed in Appendix A.
b. The final layout, presentation format and content shall be finalised by liaison with the Project Scientist.
c. All operational control functions shall be routed via the TCS to ensure co-ordinated operation from the various subsystems. In Maintenance mode (see Figure 1), interaction directly with the subsystems will be allowed.
d. An exception to c above, is the Guidance and Acquisition control, which will operate directly to the Tracker Payload Computer (see 6.2.1.3.5 d).
e. The TCS SO MMI software shall only store configuration information relevant to its own appearance and operation. All other display and control information shall simply be routed to/from the TCS.
f. All scaling and data manipulation *solely for MMI purposes*, shall be performed as part of this software.

6.2.1.3.3 OCS MMI Functions for the SO

This software shall provide a graphics user interface (GUI) linked to the Event Logging computer with the following characteristics:

a. A observation log data entry form that automatically provides default data from the TCS server where this is available (e.g. date, time, seeing, operator name).
b. *Additional pages/reports showing previous reports and allowing certain statistics to be generated.*
c. *A fault-report data entry form that automatically provides default data from the TCS server where this is available (e.g. date, time, operator name).*
d. *A data logging and display facility to record any TCS display variable and perform limited analysis and graphical presentation of such data.*

6.2.1.3.4 Guidance and Acquisition MMI Functions for the SO

The following provisional requirements are stated, but this will be subject to review:

a. The Guidance and Acquisition MMI functions for the SA and SO are identical, but only one can be active at any one time. Whether this SW will be part of the TCS SW or part of the Payload Computer SW is to be determined during the design. Figure 6 has assumed the latter.
b. Normal acquisition will be in automatic mode, i.e. the targets are pre-programmed during observation planning, and acquisition will be executed as soon as the previous target has been completed. Manual acquisition will be done by typing in an RA and Dec for the target object, and then clicking on a “GO” command.
c. An active schematic representation of the optical path through the payload, shall indicate the route and destination of the light to the acquisition camera, science instrument and fibre feed, as applicable.
d. The acquisition window shall display the acquisition camera image and if selected, superimpose on the image, dots representing the expected star image positions (from a sky catalogue). The purpose of this display is to allow the SO or SA to check that the correct field has been acquired and to verify correct pointing and image rotation.

e. The acquisition window shall also, when selected, superimpose on the acquisition image, fiducial marks representing the instrument or fibre feed slit positions and orientations. A means shall be provided whereby the SO or SA can interactively re-orientate and move the telescope to the required orientation using a mouse. The data used to position the fiducial marks shall be received from the relevant instrument or fibre feed system.
f. The guidance window shall display the image from the guidance camera. Guidance will be activated by mouse selection of the guidance object and appropriate symbology will be superimposed on the image to indicate that guidance is in process. A means shall be provided whereby the SO or SA can interactively re-orientate and move the telescope (add guidance offsets) either by typing in offset or using a mouse. It shall also be possible to accept guidance offsets from a science instrument.

6.2.1.3.5 Other subsystem MMI Functions for the SO

The details of this requirement are to be determined in co-operation with the subsystem designers. The following is envisaged at this stage:
a. A GUI that either runs on the subsystem computer but displays on the SO Workstation (using X-Windows) or, preferably, a separate MMI executable that runs on the SO workstation but has a data link to the appropriate subsystem computer.
b. During normal operation the GUI provides information only and all control functions are disabled (the master control being performed via the TCS MMI software).
c. When the entire system is placed in “Maintenance Mode” (see Figure 1), the subsystem control functions are enabled and commands from the TCS are overridden. Appropriate warning messages appear on the TCS SO MMI.
d. The exception to the above is the Guidance and Acquisition function of the Tracker Payload Computer, which will be used during normal operation and will not be duplicated in the TCS SO MMI.

6.2.2 SA Workstation

6.2.2.1 HARDWARE

The SA workstation shall comprise a Pentium PC with the appropriate network card (see 6.2.7.4). Detailed requirements can be found in the SALT Computer Standard.

This PC shall have two large monitors (17” or larger) and shall be located in the SALT control room. The user interface shall be a single keyboard and mouse.

6.2.2.2 STANDARD SOFTWARE

The following standard software shall be installed on this machine:
- Linux operating system in accordance with the SALT SW Standard
- X-Windows environment
- GNU-C
- KDE
- Star Office
- IRAF

6.2.2.3 CUSTOM SOFTWARE

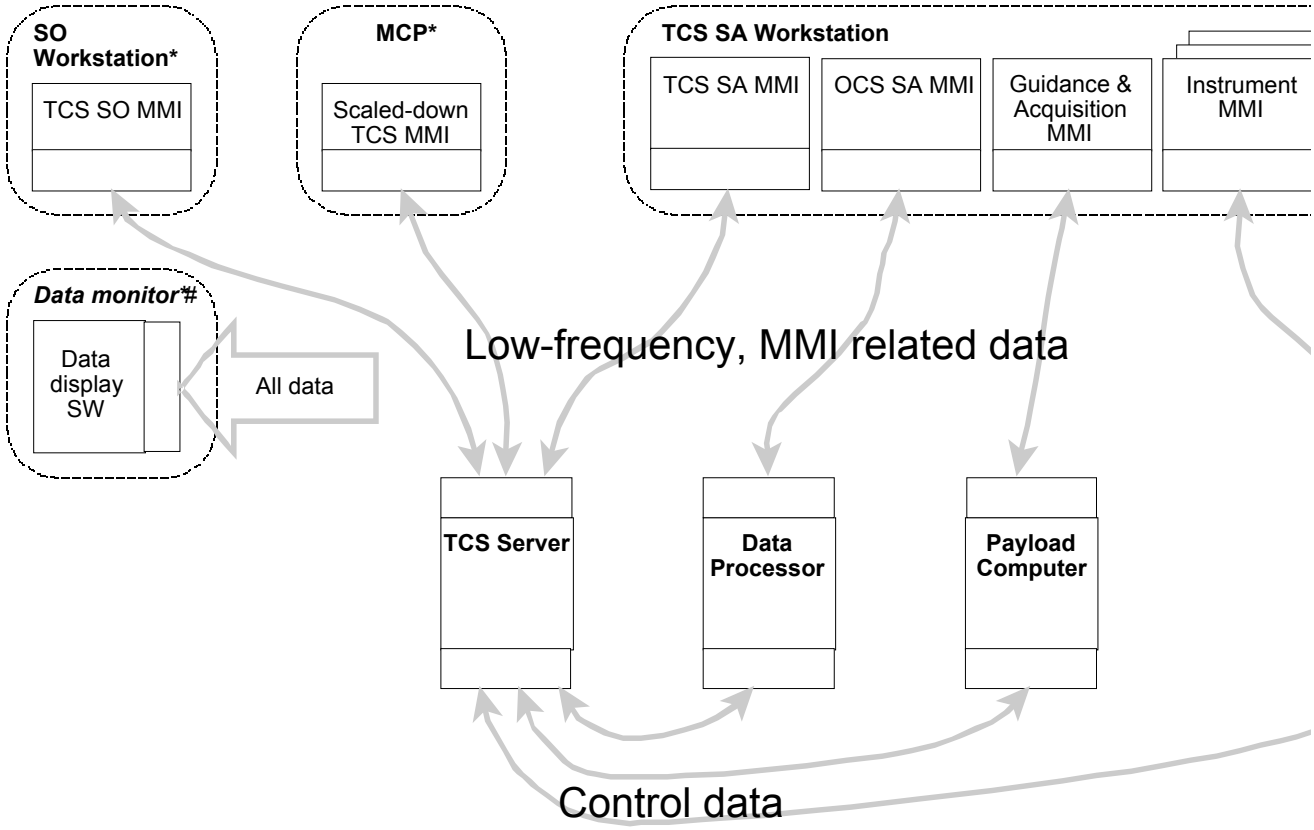
6.2.2.3.1 Purpose

The purpose of the SA Workstation is to provide the full interface to the SA to schedule an observation and perform it by monitoring the telescope and controlling the instrument. It displays information from various computers and can send commands to these computers, as shown in Figure 7.

6.2.2.3.2 TCS MMI Functions for the SA (TCS SA MMI)

This software is a scaled-down version of the SO MMI and shall provide a graphics user interface (GUI) with the following characteristics:

a. One configurable (limited) and display displaying the information listed in Appendix B.
b. The final layout, presentation format and content shall be finalised by liaison with the Project Scientist.
c. All telescope operational control functions shall be routed via the TCS to ensure co-ordinated operation from the various subsystems. In Maintenance mode (see Figure 1), interaction directly with the subsystems will be allowed. Direct interaction with the Instrument will generally be allowed.
d. An exception to c above, is the Guidance and Acquisition control, which will operate directly to the Tracker Payload Computer (see 6.2.1.3.5 d).
e. The TCS SA MMI software shall only store configuration information relevant to its own appearance and operation. All other display and control information shall simply be routed to/from the TCS.
f. All scaling and data manipulation *solely for MMI purposes*, shall be performed as part of this software.



NOTES: * Not all software shown for these computers; # Maintenance equipment, not part of TCS

Figure 7: Communication relating to the TCS SA Workstation

6.2.2.3.3 OCS MMI Functions for the SA

This software shall provide a graphics user interface (GUI) linked to the Data Processor computer with the following provisional requirements:

a. An observation log data entry form that automatically provides default data from the TCS server, observation schedule and Instrument where this is available (e.g. date, time, object details, filter type, exposure details).
b. *Additional pages/reports showing previous reports and allowing certain statistics to be generated.*
c. *A fault-report data entry form that automatically provides default data from the TCS server where this is available (e.g. date, time, operator name).*
d. *A data logging and display facility to record image information, some TCS variables and perform limited analysis and graphical presentation of such data.*
e. *Observation planning and scheduling software linked to the observation plan database in the Data Processor. This software shall be used to plan and schedule an observation.*
f. *Data storage, compression and manipulation tools to allow the SA to store the science and calibration data, compress it and archive/retrieve it.*

6.2.2.3.4 Guidance and Acquisition MMI Functions for the SA

The Guidance and Acquisition MMI functions for the SA and SO are identical, but only one can be active at any one time. See section 6.2.1.3.4 for details.

6.2.2.3.5 Instrument MMI Functions for the SA

The second monitor of the SA Workstation shall be used to display information pertaining to the applicable science instrument and the Fibre Feed. The information shall be all that is required to configure, calibrate and operate the equipment and will be described in the particular Instrument Specification.

6.2.2.3.6 Other subsystem MMI Functions for the SA

The details of this requirement are to be determined in co-operation with the subsystem designers. The following is envisaged at this stage:

e. A GUI that either runs on the subsystem computer but displays on the SO Workstation (using X-Windows) or, preferably, a separate MMI executable that runs on the SO workstation but has a data link to the appropriate subsystem computer.
f. During normal operation the GUI provides information only and all control functions are disabled (the master control being performed via the TCS MMI software).
g. When the entire system is placed in “Maintenance Mode” (see Figure 1), the subsystem control functions are enabled and commands from the TCS are overridden. Appropriate warning messages appear on the TCS SO MMI.

The exception to the above is the Guidance and Acquisition function of the Tracker Payload Computer, which will be used during normal operation and will not be duplicated in the TCS SO MMI.

6.2.2.4 DATA REDUCTION PC REQUIREMENTS FOR THE SA

A second Pentium PC with a network card and single monitor shall be located next to the SA Workstation, and will be used as a “Data Reduction PC”. It shall have the same OCS software as the SA Workstation but shall have additional Astronomical data reduction software as required.

6.2.3 Data Processor

6.2.3.1 HARDWARE

The Data Processor shall comprise a Pentium PC with the appropriate network card (see 6.2.7.4). Detailed requirements can be found in the SALT Computer Standard.

A CD-writer and/or Tape Drive shall be installed to archive data. A hard-disk of sufficient capacity to store 2 weeks of data shall be installed (size ~40GB).

6.2.3.2 STANDARD SOFTWARE

The following standard software shall be installed on this machine:

- Linux operating system in accordance with the SALT SW Standard
- X-Windows environment
- GNU-C
- KDE
- Star Office
- Database SW (specific type is to be determined during the design)

6.2.3.3 CUSTOM SOFTWARE

The following custom software shall be installed on the Data Processor, primarily for use by the PI's and the SA.

- Observation planning tools for the PI and the SA (details TBD2)
- Observation scheduling tools for the SA (details TBD2)
- *Data compression tool*
- Science and calibration data storage, archiving and retreival software
- *Observation log form generator and database*
- *Sky catalogue or star image database*

6.2.4 TCS Server

6.2.4.1 HARDWARE

The TCS server shall comprise the fastest available Pentium PC, at least 128MB of memory, timing input card and with the appropriate network card (see 6.2.7.4). Other requirements can be found in the SALT Computer Standard.

6.2.4.2 STANDARD SOFTWARE

The following standard software shall be installed on this machine:

- Linux operating system in accordance with the SALT SW Standard
- X-Windows environment
- GNU-C
- KDE

6.2.4.3 CUSTOM SOFTWARE

6.2.4.3.1 Purpose

The purpose of the TCS Server is to co-ordinate the operation of all the SALT subsystems according to the commands of the SO and SA and to monitor each subsystem's performance. It is the "integrating node" of the entire telescope.

6.2.4.3.2 Co-ordination of subsystem initialisation

The TCS shall co-ordinate the initialisation of each subsystem by:
a. Monitoring the initialisation status of each subsystem computer
b. Remaining in “initialisation mode” until all initialisation is completed or a preset period of time has elapsed
c. Reporting as a fault, any subsystem that fails to complete initialisation in the allocated time.

6.2.4.3.3 Pointing Model Functions

The TCS shall perform the angular/time transformations required to position an object at the desired position in the acquisition field. The system pointing accuracy is specified in the SALT System Specification and a portion of this is allocated to the TCS Pointing Model (see the SALT Error Budget).

The Pointing model shall do the following:
a. Perform all astrometric calculations required to convert the object position to Telescope Axes.
b. Perform axis transformations to determine required tracker X, Y, Z, phi, theta and Rho orientation, required Structure angle, required Dome angle to point at the object.
c. Perform adjustments to the Pointing Model to optimise pointing with time by modelling certain factors that influence pointing.
d. Allow adjustment of the pointing parameters based on measurements of system and subsystem misalignments.

6.2.4.3.4 System mode control

The TCS Server shall co-ordinate the modes and actions of each individual subsystem based on the TCS mode (as defined in 4.1.2.2.1) and user-initiated commands. A state-machine shall ensure an unambiguous and consistent relationship between the TCS mode and the subsystem modes.

6.2.4.3.5 System Safety monitoring

The TCS Server shall monitor subsystem failures and initiate steps to prevent hazardous situations (e.g. to enter the “Major Failure” state and halting all movements). Unsafe conditions shall be reported via the Event Logger and/or the SO and SA workstations.

The TCS Server shall monitor signals form the emergency stop switches and safety interlock panel (see 6.2.7.3) and generate appropriate software commands.

The TCS Server shall also monitor the communication with each of the subsystem computers using a Single Point Communication Test (as defined in the SALT SW Standard document) and report failures to the operator.

6.2.4.3.6 Tracker Trajectory determination

The TCS server shall, based on the pointing model outputs, send to the Tracker an ideal tracking trajectory (in all six degrees of freedom) to perform open-loop tracking of an object at a sidereal or pre-programmed rate. The trajectory shall be updated at least once every 15s, taking into account the latest guidance errors.

6.2.4.3.7 Precision command synchronisation

Time-critical commands communicated by TCS to subsystems shall be “future-dated” by 0.25s (TBD3) and time-stamped accordingly. The recipient shall place the commands in a buffer and only execute them at the required time instant, based on the information from the precision time source (see 6.2.7.1).

Time-critical responses received by the TCS shall be handled in a converse fashion.

6.2.4.3.8 Subsystem simulation

A special version of the TCS Server software shall be created, with minimal deviation from the original, which instead of communicating to the subsystems, can selectively perform a limited simulation any/all of the subsystem computers.

The purpose of this “TCS Simulator” is to test each subsystem’s interface to the TCS and other subsystems, during subsystem testing. Details are TBD4.

6.2.5 Manual Control Panel

6.2.5.1 HARDWARE

The Manual Control Panel shall comprise a ruggedised Pentium Notebook with the appropriate network card connected to a radio-modem (see 6.2.7.4).

6.2.5.2 STANDARD SOFTWARE

Windows NT or Linux, as defined in the SALT SW Standard.

6.2.5.3 CUSTOM SOFTWARE

6.2.5.3.1 Purpose

The MCP software is a simplified version of the TCS SO MMI software, which allows maintenance personnel to perform certain functions from the telescope floor.

6.2.5.3.2 Software Requirements

This software shall provide a GUI with controls and feedback that will allow at least the following commands:

a. Opening and closing of the Dome Shutter
b. Dome fast and slow rotation in either direction
c. Lifting and lowering of the structure
d. Structure fast and slow rotation in either direction
e. Tracker fast, slow and inching in the X and Y directions
f. Tracker payload fast and slow Tip, Tilt, Rho and Z movement

These commands will only be available if the MCP has been enabled from the SO and SA workstations.

6.2.6 Event Logger

6.2.6.1 HARDWARE

The Event Logger shall comprise a Pentium PC with the appropriate network card (see 6.2.7.4). Detailed requirements can be found in the SALT Computer Standard.

This PC shall have two large monitors (17" or larger) and shall be located in the SALT control room. The used interface shall be a single keyboard and mouse. A sound card shall be installed, that either interfaces to the control room audio system or has its own local speaker. Hard-disk capacity shall be ~20GB.

6.2.6.2 STANDARD SOFTWARE

Windows NT or Linux, as defined in the SALT SW Standard.

6.2.6.3 CUSTOM SOFTWARE

6.2.6.3.1 Purpose

The Event Logger provides information to be displayed to both the SO and SA but also collects data from the telescope for logging and alarming purposes. It also contains the database for telescope operational information (OCS).

6.2.6.3.2 Software Requirements

The following specific requirements shall be met:

a. The information listed in Appendix C shall be displayed. It will be obtained locally, from the TCS Server and from the BMS.
b. The weather information shall be published in a format that can be read using a standard web browser and shall be available on the SAAO network.
c. The Event logger shall monitor critical telescope and environmental parameters and generate audible and visible alarms when appropriate.
d. *Critical alarms shall also be displayed at the SO Workstation It shall be possible to acknowledge alarms from the SO workstation*.
e. Telescope health shall be indicated at a high level *and a "drill-down" capability provided to see detailed failures when these occur.*
f. Telescope failures shall be logged in a file.
g. A database program that interfaces to the SO workstation, shall record telescope-related fault-reports and SO operator logs.
h. *It shall be possible to perform user-configurable recording of data communicated between computers, for diagnostic purposes. Graphing/trending of the data shall be possible.*

6.2.7 Ancillary Equipment

6.2.7.1 PRECISION TIME SOURCE

A GPS time-source shall provide absolute time to the TCS and the other SALT subsystems. It shall provide this in two ways:

a. A network time signal using NTP, with an average accuracy of better than 150ms.
b. A hardware time signal comprising 1kHz and 1Hz hardware pulses with an accuracy of better than 0.1ms.

6.2.7.2 PRINTERS

A postscript-compatible laser printer shall be connected to one of the control room computers (possibly the event logger). Detailed requirements are to be defined during the design.

6.2.7.3 INTERLOCK PANEL

A hardware interlock panel shall be provided to generate safety-inhibit signals based on

hardware and software inputs. These signals shall be routed to the applicable subsystems and when activated, shall halt all potentially unsafe actions. The list of unsafe conditions requiring system-level interlocks will be identified in the SALT Safety Analysis document. The method of interfacing to each subsystem shall preferable be a voltage-free, normally-closed contact, but details will be contained in the SALT Electrical ICD.

6.2.7.4 NETWORK HUBS, ROUTERS AND CABLES

The following provisional requirements are stated, but these will be subject to confirmation during the final design:

a. The Sutherland-to-Internet backbone data link shall be upgraded to at least 2.5 Mb/s to support transfer of science data within reasonable times.
b. The SALT network shall be linked to the SAAO network at Sutherland.
c. The SALT control network and the SALT information network shall be separated by a router, such that the transfer of science data from the appropriate instrument computer to the Data Processor and from the Data Processor to the Internet or SAAO, does not degrade the control network throughput. The control network contains the nodes connected to subsystem computers and the TCS server whereas the data network is connected to the Data Processor, SO and SA workstations and Internet. These networks are shown as red and blue respectively on the SALT computer architecture drawing.
d. The network shall be the fasted affordable, mature technology, and if possible, be optic fibre-based. As a minimum, this shall be 100BaseT Ethernet.
e. The data link connecting the SALT building to the SAAO shall be optical fibre, preferably with a 1Gb/s throughput (to accommodate future growth).
f. A radio-modem shall be supplied to connect the MCP to the SALT network.
g. A firewall shall be used to restrict communication to the SALT network, to authorised computers only. The corollary of this is that the PI's will need to access a machine outside the SALT network (i.e. a SALT Mirror site) as mentioned in section 5.5.13.6.

6.2.7.5 ALIGNMENT EQUIPMENT

The requirement for alignment equipment will be determined during the Pointing Model design.

7 Test Requirements

7.1 Verification cross-reference Matrix

This section will indicate how system compliance to the requirements in the preceding sections will be proven. Various types of verification (Testing, Analysis, Demonstration and Inspection) will be used at various levels of system integration (System, Subsystem and component) as appropriate.

Para.	Requirement	Test Level [Note 1]	Test Method [Note 2]	Test Detail Ref. [Note 3]

Note 1: “Test Level” may be “system” (S), “subsystem” (SS) or component (C) level, depending on the particular requirement .

Note 2: The "Test Method" may be any one of the following:

- Review (R) - the design is reviewed and it is obvious to all whether or not the item complies (e.g. whether or not the system has a particular mode).
- Inspection (I) - the completed item is inspected and compliance can be easily observed. This is normally used for physical characteristics such as colour, dimensions and mass.
- Testing (T) - this entails a technical effort whereby the system is stimulated in a certain fashion and its response compared to the required response.
- Analysis (A) – compliance of the design to the requirement is proved by mathematical analysis.

Note 3: Where it is considered important, reference to the detail of the test method described in section 7.2 is be provided in the "Details" column of the table

Table 11: Verification Cross-Reference Matrix

7.2 Detailed Test Methods

Where applicable, provide details of particular tests that will be done. (Especially for potentially contentious requirements or critical performance criteria.)

8 Notes

a. Issue A of this document is for preliminary review and is not suitable for final use.

Appendix A: SO Display Information

This data is TBD5

Appendix B: SA Display Information

This data is TBD5

Appendix C: Common Display Information

This data is TBD5

Appendix D: List of TBD's and TBC's

The following issues are addressed in this document but require definition (TBD's – To Be Determined) or confirmation (TBC's – To Be Confirmed):

TBD1. These documents have not yet been defined but will be by June 2001. Specific technical issues will be addressed in an ad hoc fashion as required.

TBD2. The HET planning tools will be used as the basis for SALT. An investigation is in process to determine modifications that will be required. These requirements will be known by September 2001.

TBD3. The mechanism for synchronisation for time-critical data will be finalised during the detailed design process and co-ordinated with the applicable subsystems and Instruments.

TBD4. The requirements for the TCS Simulator will be finalised by Sept 2001.

TBD5. The provisional display requirements will be defined after approval of the SALT Operational Requirements document. This is will be completed by May 2001.

TBC1. The Guidance and Acquisition MMI on the So Workstation is provisionally part of the Payload Computer software. Some detailed concepts will require review prior to the finalisation of this decision.