VLT PROGRAMME

European Southern Observatory
Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
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D 7463

Very Large Telescope

Requirements for visitor instruments at UT Cassegrain foci

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1 Scope

1.1 A visitor instrument

A visitor instrument is defined as an instrument that shall be attached to the VLT but not operated by ESO. Such an instrument may avoid some of the requirements placed on normal ESO instrumentation. It is the aim of this document to specify the interfaces and requirements that such an instrument will have to meet in order to successfully operate at the Unit telescopes of the VLT.

The points below are further elaborated upon within the document. However, they are explicitly mentioned here to emphasize the importance that ESO places upon these issues.

- Paranal is located in a seismically active area. Provisions have to be made such that the instrument is secure in case of earthquake at all times including the times of mounting and dismounting. The safety of the personnel and equipment has to be assured.

- No system attached to the VLT may transmit vibrations to the telescope systems such that it may interfere with the use of the telescope in its interferometric mode.

- No system attached to the VLT may interfere with the Local Area Network configuration or permissions. Visitor instruments must comply with the observatory rules for connectivity.

- No system attached to the VLT may produce electromagnetic interference outside the ESO specifications.

1.2 General

This document describes the minimum requirements for a visitor instrument to be successfully mounted at the Cassegrain focus of the Unit telescopes of the VLT. The document is a subset of the VLT requirements for Cassegrain instruments VLT-SPE-ESO-10000-0005 (issue 2.0) with some additional explanations with respect to visitor instrumentation. Items which appear in this font are intended to focus the reader's attention as particularly applicable to visitor instrumentation. Items in bold **font** are of major significance.

Issues regarding the safety at the VLT, mechanical and electrical interfaces, network interfaces and environmental impact (*e.g.* electromagnetic interference, mechanical/vibrational interference with VLTI) are of paramount importance to the operation of the VLT facility and the security of the personnel and cannot be violated irrespective of the status of the instrument. ESO reserves the right to request an acceptance test in Europe whereby the instrument shall be demonstrated to be safe.

In addition, this document contains general information on the design of the VLT, the infrastructure at the Paranal site, and on the various interfaces between the VLT Observatory and scientific instruments installed at the Cassegrain focus of the Unit Telescopes. Such general information should be used by prospective instrument builders to optimize their designs and interactions with the facility.

1.3 Policies

The policies described here are the same as those in the announcement of the visitor focus and are reproduced for consistency purposes only.

- Scientific Requirements

  Acceptable VI's shall offer observational capabilities not covered by other VLT instruments, or a largely superior performance in at least one valuable and sufficiently extensive scientific application. A major advantage of a VI is the capability to react quickly to new scientific and/or technical opportunities. Speed shall be a major criterion for the selection of VI's.

- Technical Requirements

  VI's should be fully standalone, complete instruments, including their own data acquisition and storage capabilities. VI's should comply with VLT standards, including those for safety, interface to the Cassegrain adapter/rotator, power and coolant supplies, and LAN connection to the VLT.

- Operation Mode

  VI's shall be operated exclusively in Visitor Mode. The use of Observation Block procedures shall be optional.

- Data Flow and Archiving

  VI data shall not enter the VLT data flow system. The VI Team will take care of storing the data, with a copy delivered to ESO headquarters. If scientifically appropriate and technically feasible, data shall be made publicly accessible one year thereafter, following current regulations on proprietary periods.

- Proposals

  Following its approval, the present document will be posted as an Announcement of Opportunity on the ESO WEB. Proposals for a visitor instrument could then be submitted at any time by individual institutes in ESO member states and Chile, Consortia of such institutes or international Consortia led by an ESO member state institute.

- Procedures for the Approval of VI Proposals

  VI proposals shall be submitted to ESO where they will be scientifically, technically, and operationally evaluated. Proposals should contain a broad scientific justification, a thorough technical description of the instrument and its operation, including the number of nights required for the commissioning. Any support required on ESO side should be explicitly mentioned in the proposal. Each proposal will also contain a scientific Observational Proposal of the VI Team, specifying the number of nights requested and their distribution through the ESO Observing Periods.

  The proposals along with their ESO evaluation will be presented jointly to the STC and OPC. The STC will give its recommendations concerning the scientific and technical value of the proposed VI. The OPC will give its recommendations concerning the number of VLT nights to be granted to the VI Team.

- VI Contract

  Following the OPC and STC recommendations, a contract shall be negotiated and stipulated between ESO and the VI Consortium. The contract will specify the performance requirements of the instrument, the periods during which it will be attached to the telescope, the operational procedures, as well as the number and distribution of the observing nights allocated to the VI Team. The Consortium shall be responsible for delivering, installing, commissioning and operating the instrument, as well as for disinstalling it from the VLT at the end of the contract. The contract could be extended upon mutual agreement.

- Development and Construction of VI's

  ESO will be kept informed on the progress and status of the instrument during its construction phase, e.g. by participating in the PDR/FDR. At the end of commissioning, the instrument will be accepted, upon verification that it meets the performance, safety and operational requirements specified in the contract.

- Use of VI's

  After acceptance the VI Team shall be entitled to use the instrument on the VLT for the amount of time specified in the contract. Any extra-time required for commissioning may be deducted from the scientific time.

  If appropriate, VI's may also be offered to the community for specified periods of time via the regular Calls for Proposals. The implementation of this possibility will be subject to the positive recommendation of the OPC and STC, as well as of the operational feasibility as assessed by ESO. The corresponding VI proposals shall be evaluated by the OPC following the normal procedures.

- Property of the VI's

  VI's shall remain property of the VI Consortia, unless differently agreed upon between ESO and such Consortia. In case it has been agreed upon by the ESO Consortium to transfer to ESO the property of a VI, the Consortium will be entitled to guaranteed observing nights whose number shall be specified following the general ESO guidelines for this matter.

1.4 Change procedures and document hierarchy

Deviations from the applicable documents and requirements contained herein have to be approved in writing by ESO, following the VLT change request or request for waiver procedures.

2 The VLT project

2.1 Introduction

In this section we describe the overall VLT system, including operational parameters and descriptions.

2.1.1 VLT Concept

The general concept of the VLT Observatory and its principal performance goals are given in RD[8]. The observatory has the following main elements:

- four 8-metre diameter telescopes with their enclosures, each with two Nasmyth foci, a Cassegrain focus and a coudé focus
- an interferometer and its supporting auxiliary telescopes
- optical and infrared instrumentation
- control and communication systems to support both "service" and "visitor" mode observing
- observatory infrastructure for technical support and for the accommodation of personnel

A more exhaustive description is given in RD[9].
Technical support for visitor instrumentation shall be, a priori, limited to supervision and assistance with mounting and dismounting the instrument on the telescope and connecting the instrumentation computer facilities to the VLT LAN.
It is explicitly not permitted that the instrument team attaches any device to the VLT system without prior approval. Changes in the network configuration cannot be made by the visitor instrument team[1]. Such modifications can only be made by authorized ESO staff or persons authorized by ESO.
It is explicitly not permitted that the instrument weight and its HW configuration be modified after the instrument is mounted without prior agreement with Paranal engineering[2].

2.1.2 VLT location

The VLT Observatory is located on Cerro Paranal in northern Chile, at a distance of 130 km from the city of Antofagasta, at an altitude of 2635 m above sea level. Access to the observatory is from the (paved) Panamericana via 60 km of unpaved road. Width of the road is 6 m, load width ≤12m and gradient ≤12%.
The telescopes have the following coordinates:

Telescope		Latitude	Longitude
Antu	UT1	−24°37′33.117″	70°24′11.642″
Kueyen	UT2	−24°37′31.465″	70°24′10.855″
Melipal	UT3	−24°37′30.300″	70°24′9.896″
Yepun	UT4	−24°37′31.000″	70°24′8.000″

Table 1: Location of the four VLT Unit Telescopes

[1] Specifically the instrument team may not change any IP address within their instrument nor attach/detach any cabling that connects the instrument to the VLT LAN

[2] For example removing an electronic rack from the instrument requires prior approval of ESO Paranal engineering staff as it could modify the balance of the telescope.

2.1.3 Environmental and observing conditions at Paranal

Information on the environmental conditions on Paranal is given in AD[1].

The statistical distribution of the delivered seeing transformed to an airmass of 1.0 and to an equivalent wavelength of 500 nm at zenith on Paranal, from data collected between VLT-Antu First Light (May 1998) and December 2000, is shown in Figure 1. Given are the monthly average, median and 5th percentile plus the respective long term (1989-1995) site characteristics. Seeing is reconstructed from DIMM measurements taken at 6 m above ground, at 500 nm and zenith. VLT science images have shown that the delivered image quality at the telescope is limited by the atmosphere. More information on current conditions is available via the Paranal Astroclimatology at
`http://www.eso.org/gen-fac/pubs/astclim/paranal/seeing/`.

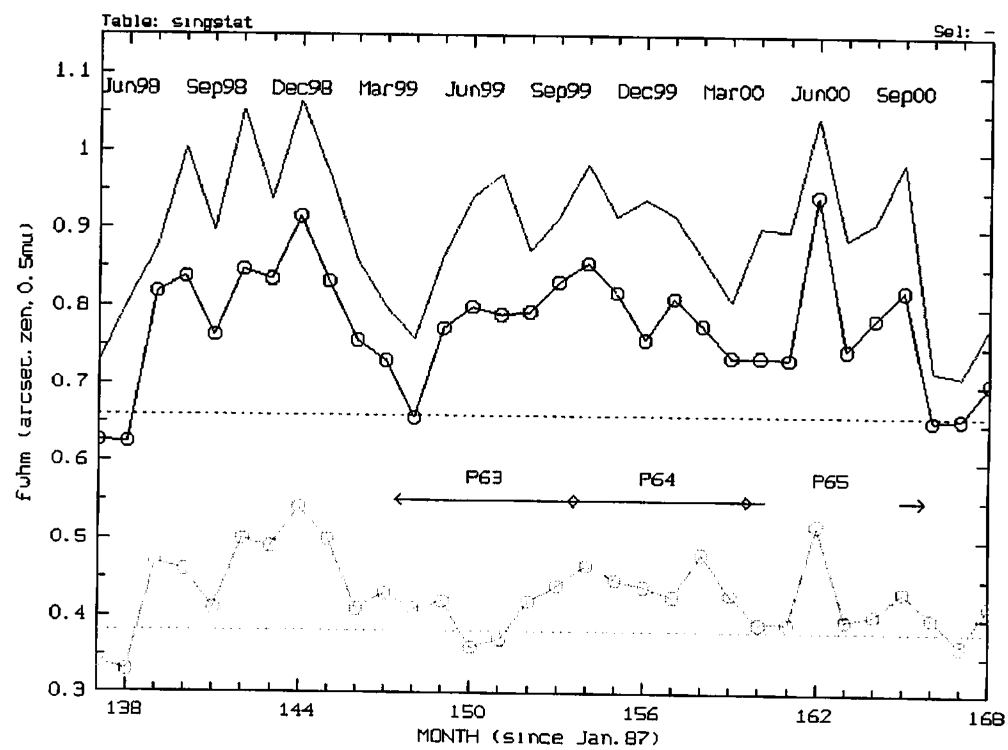

Figure 1: Statistical seeing distribution at Paranal. From top: monthly average (no symbol), monthly median (circles), long term (1989-1995) median=0.66″ (dashed), monthly 5 percentile (grey circles), long term (1989-1995) 5 percentile (dashed grey). See text.

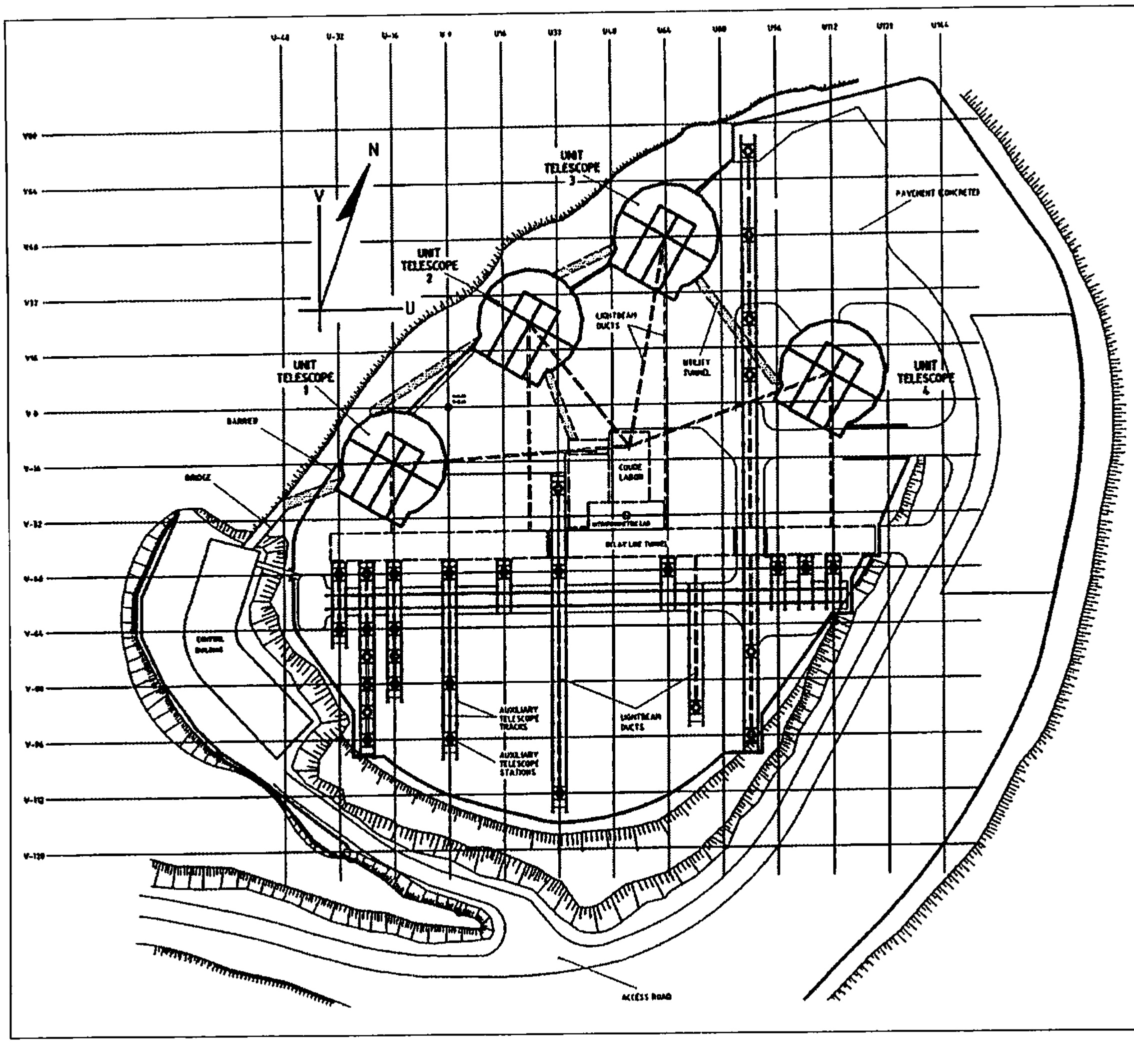

Figure 2: Plan of the Telescope Area of the VLT Observatory

2.1.4 VLT site

The VLT Observatory comprises two main locations: the Telescope Area and the Base Camp with the Hotel and Maintenance Areas. They are separated by a distance of 3.4 km. The Telescope Area contains the telescopes, the combined focus and interferometric laboratories, service laboratories and the telescope control room.
The plan view of the Telescope Area of the observatory is shown in Figure 2.

2.1.5 Site infrastructure

The main facilities that are available at the VLT Observatory are as follows:

1. Telescope Area:

   (a) The four main telescopes and their enclosures

(b) Incoherent combined focus room and interferometric laboratories

(c) Auxiliary telescopes which feed the interferometric laboratory

(d) Engineering storage and warehouses in the basements of the UT enclosures

(e) Telescope Control Building, separated from the telescope enclosures

(f) Laboratories and offices of Paranal Engineering

(g) Time Reference System and Astronomical Site Monitors (section 2.5.2)

(h) Facilities for the supply of electrical power, compressed air and cooling liquid, telecommunications facilities

2. Maintenance Area:

   (a) Mirror maintenance facility

   (b) Auxiliary Telescope hall

   (c) Warehouse and storage facilities

   (d) Facilities for the storage of liquid nitrogen

3. Hotel Area:

   (a) Hotel accommodation for site personnel and visitors (visiting astronomers, instrument teams)

   (b) Restaurant and recreational rooms

4. General services:

   (a) On-site technical personnel. The use of ESO technical staff to service a visitor instrument (e.g. refill LN_2) shall require prior agreement between the visitor instrument team and ESO.

   (b) Standard vehicles for the handling of equipment and transportation of personnel (section 2.6.3) No automatic allocation of vehicles to a visitor instrument team should be assumed. Car pooling is the norm on Paranal.

2.2 The Unit Telescopes

The four Unit Telescopes (UT1-4) are of identical design but may not be identically equipped. Drawings of the telescope structure, indicating the main features, are shown in figures 3 and 4.

2.2.1 VLT Optics

The optical design parameters for the VLT are given in RD[11]. Each VLT Unit Telescope has two Nasmyth foci, a Cassegrain and a coudé focus. In addition, the beams from the four Unit Telescopes can be combined in the coherent (interferometric) focus. The most important optical data of the Cassegrain focus are given in table 2. **The data in table 1 are for information. Optical design should refer to RD[11]**

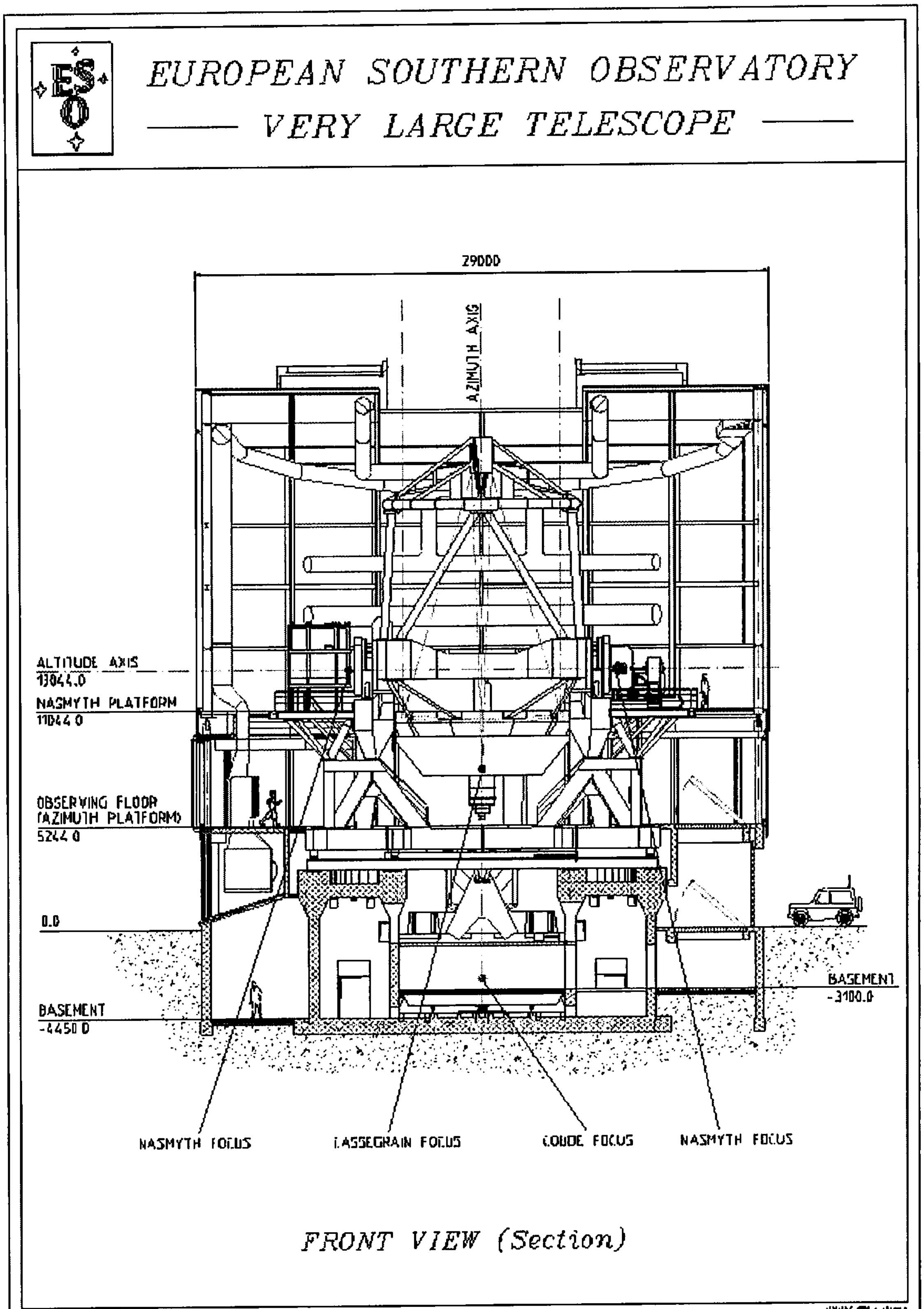

Figure 3: Front view of a Unit Telescope

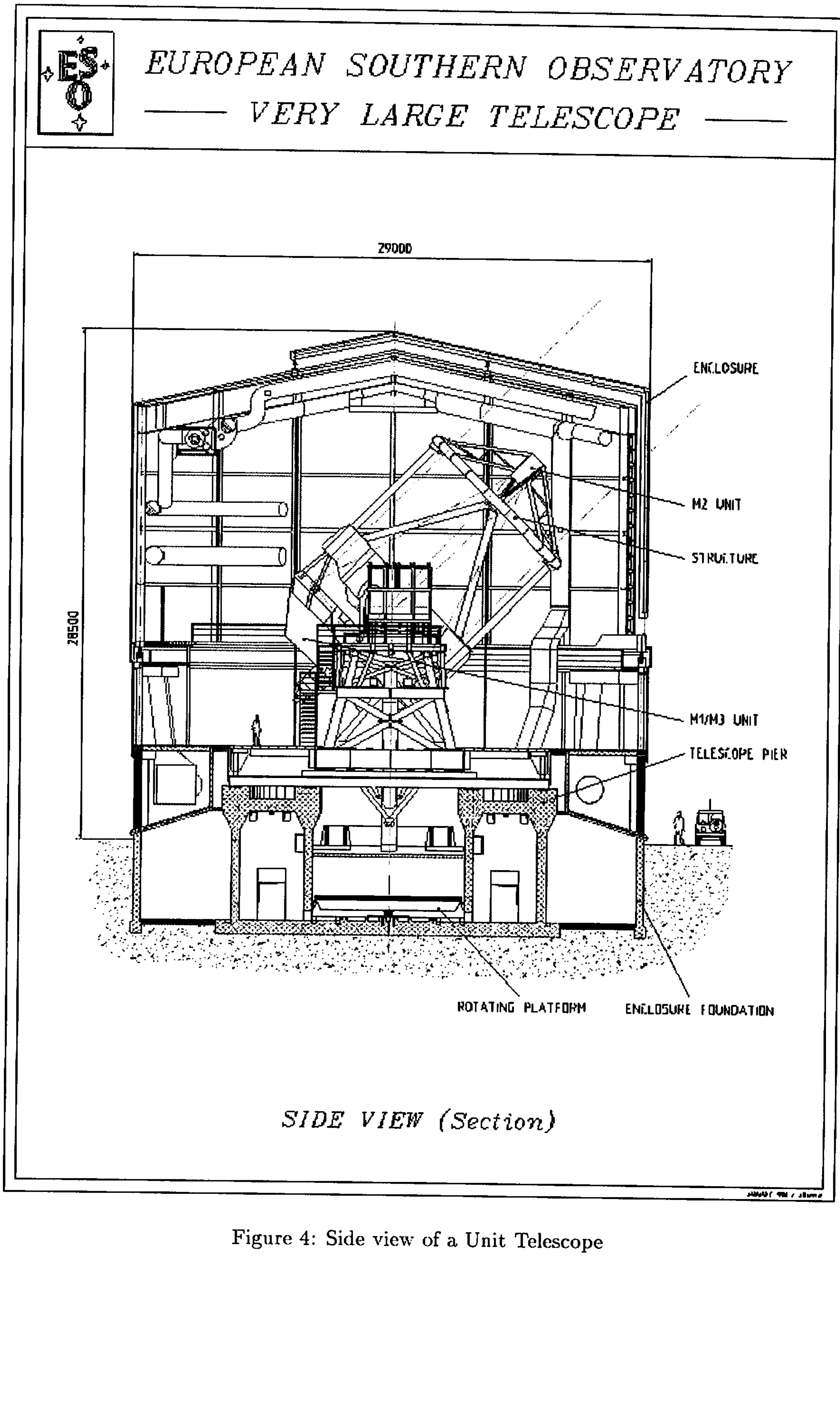

Figure 4: Side view of a Unit Telescope

Parameter		value	
Entrance pupit diameter		8115.0	mm
Exit pupil diameter		1113.1	mm
Focal ratio		13.4106	-
Focal length		108827	mm
Object field of view	total	15	arcmin
	unvignetted	2.68	arcmin
	vignetting (5′ dia. field)	0.32	%
	vignetting (10′ dia. field)	1.30	%
Image field of view	total	474.4	mm
	unvignetted	85.0	mm
Image scale	slightly field dependent	528	μm/arcsec
Radius of image curvature	concave towards M2	1981.4	mm

Table 2: Cassegrain focus optical parameters. For details see RD[11]

2.2.2 Optical image quality

The telescope is specified to deliver a Central Intensity Ratio of 0.8 with an atmospheric seeing of 0.4″ at 500 nm. This number includes the effects of wind buffeting and tracking errors. *The performance is achieved in field stabilization mode with active optics in closed loop. There is no provision for operating the telescope in any other mode and no performance specification is applicable when these criteria are not met.*

When observing with a large field of view, the telescope aberrations and, in particular, field curvature are usually the limiting factors for image quality.

The field of view may be partially obstructed by the shadow produced by the Adapter sensor arm (see section 2.3.5).

2.2.3 Light baffling

The Unit Telescopes do not have conventional baffles. The pupil is determined by the secondary mirror which is designed to cover the 8m aperture for the Nasmyth unvignetted field of view. The principal baffling must therefore be incorporated in the instrument optical design (see section 3.9).

However, because an instrument pupil will usually need to be slightly oversized due to the fact that the size and position of the pupil image is usually wavelength dependent, the secondary mirror units of the VLT UTs are equipped with extensible annular baffles located on top of the M2 units at 11729 mm above the telescope's altitude axis. These baffles can be extended to a diameter of 1550 mm according to the needs of the instrument. If the baffle is not used, the central obstruction is that produced by the secondary mirror alone (1116 mm diameter). Intermediate values of the baffle diameter are not possible. The deployment time for the sky baffle is approximately 30 seconds. Its operation should be limited to a few actions per night.

Parameter	Value
frequency range	0.1 - 5 Hz
chop wave form	quasi square-wave
chop throw	0″ to 30″ on the sky
chop orientation	any
chop offset	−15″ to +15″ on the sky
chop dwell ratio (on/off ratio)	0.7 - 1.5
maximum chop settling time	20 msec

Table 3: Chopping parameters

2.2.4 Field stabilization and chopping

The default operation of the VLT unit telescopes requires that the secondary mirror be used in field stabilisation mode to remove the effects of wind shake. The same star is used for active optics wavefront sensing and for the generation of field stabilization corrections. The magnitude of the guide star should be between 12 and 14th in the visual range.
Classical autoguiding is also available at the VLT (*i.e.* not sending the corrections to the secondary but rather to the main axes of the telescope). This option does not change the magnitude limits for the guide star as it also used for wavefront analysis and does not remove the effects of the wind shake. Details on this issue should be discussed with ESO.
The secondary may also be used for chopping. The range of parameters for chopping are in table 3. At chopping frequencies lower than 0.5 Hz it is possible to use field stabilizing mode simultaneously with chopping during the stationary periods of the chop cycle.

2.2.5 Nodding

No provision is made within the telescope control system for nodding. Normal offsets of the telescope should be used for this purpose. It is the responsibility of the instrument to calculate the appropriate values for the RA and Declination of the offset to achieve the specific aim of nodding.

2.2.6 Range of telescope movement

The telescope can be moved about the Azimuth axis in the range −180° to +360° measured eastwards from the South-point. See AD[2] for an explanation of the VLT coordinate system.
The range of movement about the Altitude axis during observations is from approximately 20° to 89.5° elevation. However, tracking so close to zenith is not recommended. The recommended zone of avoidance is 1° radius. The total range of altitude for access and maintenance purposes is between 0° and 93°.
This range of motion is required for access to areas of the telescope during routine maintenance. It is therefore necessary that the visitor instrument also be immune to problems over this whole range. Moreover, all instruments shall be able to tolerate this entire range of elevations for periods up to 8 hours without requiring maintenance[3].

[3]This includes the refilling of the instrument with LN_2, as the instrument is unreachable while the

2.2.7 Pointing, off-setting and tracking accuracy

The telescope pointing accuracy is of order 2″ rms in routine operations. Offseting accuracy of 0.1″ RMS is achieved for cases where the same guide star is recovered. Offsets that require a change of guide star should be considered as new pointings.
The pointing of the telescope is always to the centre of rotation of the adapter. Offsets from this pointing axis are the responsibility of the instrument.
Tracking accuracy for the VLT over 30 minutes is better than or equal to 100 mas rms.
The zone of avoidance for the zenith is 2° radius.

2.3 The Cassegrain Adapter/Rotator

2.3.1 General functions

Each Cassegrain Adapter/Rotator comprises two separate functional units: the Adapter and the Rotator. These form a single sub-assembly called the Adapter/Rotator. This section contains an overview of the basic functions and performance of the Cassegrain Adapter/Rotator.
The Rotator forms the mechanical interface between Cassegrain instruments and the telescope. It defines the location of the focal plane and allows instruments to be rotated about the telescope optical axis and to follow the rotation of the optical field.
The Adapter is used for the following functions:

1. field acquisition
2. guiding (auto-guiding mode using the telescope drive alone)
3. field stabilization (auto-guiding mode using the actuation of M2 in addition to the telescope drives for a faster response time)
4. wavefront sensor for the Active Optics system

Each Cassegrain adapter has a pick-up mirror mounted at the end of the sensor arm which can be rotated in the field of view of the telescope. The centre of the pick-up mirror field of view can be positioned on the optical axis of the telescope. The sensor arm, in turn, is mounted on a rotating flange which can be rotated, independently of the rotator, about the optic axis of the telescope thus permitting the acquisition sensor to explore the entire field of view of the telescope. A cross section of the Cassegrain Adapter/Rotator is shown in Figure 5. Note that in this view the light from the telescope comes from *below.*
Light from the pick up mirror is split, by means of a dichroic beam-splitter, to feed two separate CCD sensors. One sensor is used for acquisition, guiding and field stabilization, and the second for wavefront sensing for the active optics system. The acquisition/guide sensor and wavefront sensor are referred to in this document as the AGS and WFS respectively. The beam-splitter directs wavelengths in the approximate range 600 – 700nm towards the AGS; the remaining part of the spectrum is sent to the WFS. The sensor arm is schematically shown in Figure 6.

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telescope is horizontal.

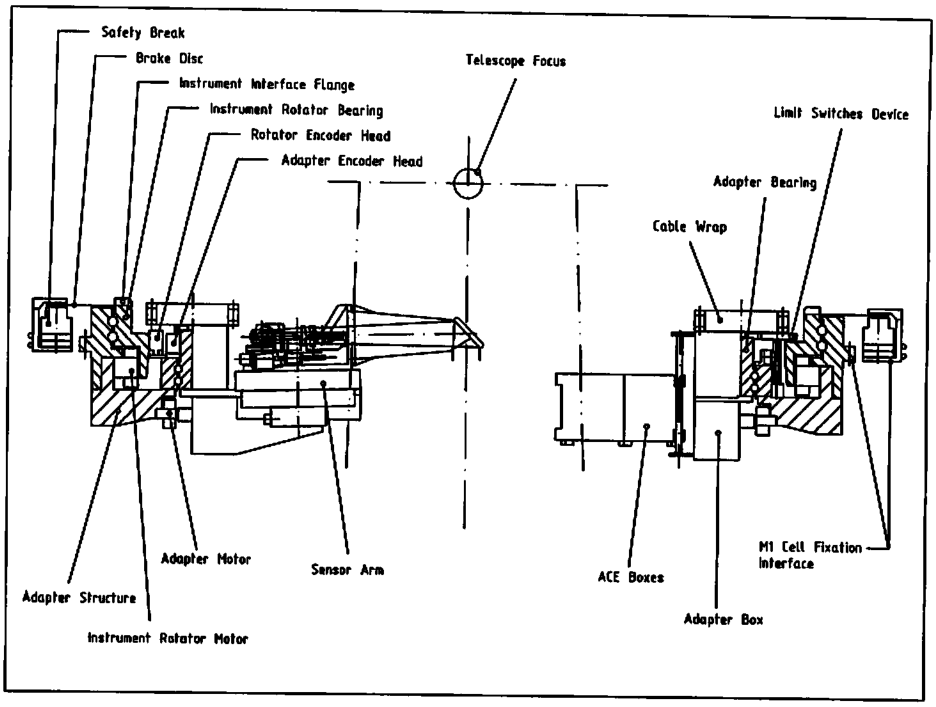

Figure 5: Cross section of the Cassegrain Adapter.

2.3.2 Field acquisition

In acquisition mode the Adapter pick-up mirror is positioned on the telescope axis to relay the central part of the Cassegrain field to the AGS. In acquisition mode the AGS has the following design performance characteristics:

1. Nominal field of view: 1 arcmin.
2. Nominal optical bandwidth: 600 - 700 nm (fixed)
3. Sensor image scale: 109 μm/arcsec ($\approx$ 5 pixels/arcsec)
4. Sensitivity: magnitude $m_V \approx 21$ under average conditions and 1 s integration.
5. Frame refresh rate: 2 Hz for full frame, correspondingly faster for partial or binned readout.

2.3.3 Guiding and field stabilization

For guiding and field stabilization modes the adapter pick-up mirror is centered onto a reference star in the peripheral field of view of the telescope. The star used for guiding is also used simultaneously by the WFS for Active Optics correction using a complementary waveband. Note that the optical image quality specification for the telescope given in section 2.2.2 is applicable to guiding mode.
The selection of the most suitable guide star and the positioning of the pick-up mirror is normally done automatically by the telescope control system once the object position and relevant instrument parameters have been defined[4]. This selection takes into account a defined unvignetted field (see section 2.3.5). Observers may specify in the setup to the TCS the guide star they want to use.
The telescope control system also corrects the guide star reference position during observations for the effects of differential atmospheric refraction between the wavelength used for guiding and the central wavelength used by the instrument as well of course for the relative changes in the observed positions of the target and the guide star with time.
In guide and field stabilization modes the AGS have the following performance characteristics:

1. Nominal optical bandwidth: 600 - 700 nm (fixed)
2. Sensitivity: Usually there will be a reference star of magnitude $m_V \leq 14$ suitable for guiding and field stabilization. The sensor magnitude range for guiding and field stabilization is $m_V \approx 12 - 14$
3. Measurement frequency: ≤ 30 Hz for field stabilization, ≈ 1 Hz for guiding.
4. Guiding precision: The guiding tolerance is included in overall image quality criteria mentioned in section 2.2.2.

[4]Observers will nevertheless be required to select guide stars in advance to verify if sufficient guide stars are available for the observation

The instrument may provide its own wavefront sensing and guiding capabilities if compliant with the interfaces to the telescope. A more normal secondary guiding capability to remove errors introduced by flexure in the instrument is fully supported by the VLT control system (see section 3.11).
Lack of full VLT compliance in the software of an instrument will make the communication of the wavefront sensing information to the telescope systems extremely difficult.

2.3.4 Wavefront sensing for Active Optics correction

The Active Optics system of the VLT compensates for static or slowly varying optical errors such as those caused by manufacturing errors, gravitational and thermal effects, the effect of lateral supports which depends on the zenith distance, etc.
During observations, the Adapter WFS continually provides information on the telescope image quality to the telescope control system for active correction of the primary mirror figure and the position of the secondary, using the same reference star as the AGS as mentioned in section 2.3.3.
The operation of the telescope requires that the active optics system is run in closed loop. The instrument may request that this system is not operational but this is at the expense of image quality. *There is no specification on image quality for the system in open loop.* Moreover, the degradation of the image quality in open loop also has effects on the plate scale and the accuracy of the guiding. **It is not advisable to operate the facility in open loop.**

2.3.5 Shadow from the sensor unit

The Adapter sensor arm shadows a part of the telescope field of view. The shadow pattern in the Cassegrain focal plane is indicated in Figure 7. The exact location of the shadow depends on the position of the reference star within the field. In general there are two possible positions of the sensor arm for each reference star and there is an available option to the TCS setup[5] to select a specific orientation of the probe.
It is possible for the instrument software to specify an area in the telescope focal plane which is to remain unvignetted by the Sensor Arm. If such an area is defined, the telescope control system preferentially selects a guide star which does not cause vignetting of this area.
In the case where no guide stars are available that do not vignet the field of view the operator may overrule the control system and demand a particular guide probe setting. The telescope database will reflect the fact that the probe is vignetting the field of view and the instrument should notify the user that this is the case.
The guide probe can be preset in RA and Dec and offset in the same co-ordinate system. There is no option for scanning the field for guide stars.

2.3.6 Compensation of field rotation

To compensate for field rotation the position angle of the rotator (upon which the instrument is mounted) is continuously adjusted.

[5] To be made available in March 2001 software release

RD[12] gives details on the rotation of the field and pupil images at the VLT Cassegrain focus as a function of telescope position.
The precision of the correction of field rotation is such that the position error of a star at the edge of the Cassegrain field due to field rotation during a 1 hour exposure does not exceed 0.1 arcsec.
The Rotator can rotate without limit in either direction. Note that a rotation of 580° would be necessary to allow the instrument to be set to any arbitrary orientation on the sky, and for it to follow the chosen orientation during a 10-hour integration in the worst case. In order to protect instrument cable wrap systems, the rotation range can be restricted by setting upper and lower rotation limits in the Telescope Control Software. In addition, the Rotator electronics is equipped with adjustable range limits which prevent movement beyond preset angles. These limits may be set to match the requirements of the instrument in use.
The Rotator also has an electrical interlock circuit that can be connected to the instrument control electronics to block motion of the Rotator under specific circumstances (see section 3.17.1).

2.3.7 Maximum angular velocities and accelerations

Full details on the rotational tracking velocity and angular acceleration for Cassegrain instruments as a function of telescope position are also given in RD[12]. The maximum rates, at a zenith distance of 0.5°, are 26′/sec and $7.7''/sec^2$, respectively. The maximum deceleration of the telescope structure during emergency braking is $10°/sec^2$. The maximum deceleration of the Rotator during emergency braking, with maximum instrument load attached, is $12°/sec^2$.

2.3.8 Focusing

Telescope focusing is achieved by moving the secondary mirror (M2). The optimum focus position is determined by the wavefront sensor in the Adapter. The allowable range of movement of the focal plane is limited by the range of focus adjustment in the Adapter Sensor Arm. The telescope control system is able to maintain the focal plane position to within an accuracy of ± 0.25mm. The instrument may request the focus to be off-set from the nominal position (within the limits specified in section 3.5) to allow for insertion or removal of pre-slit optics, for example. The adapter sensor arm focusing mechanism also compensates for the curvature of the Cassegrain focal plane as it moves across the field.

2.3.9 Calibration Screen

The telescope provides a beam shutter to protect the Cassegrain adapter and instrument against dust, mechanical damage, and strong illumination. On this shutter an area of 600 mm diameter is painted with a white diffusing paint on the side facing the instrument to form a screen that can be illuminated by calibration sources. The distance between the screen and the Cassegrain focal plane is given on ADWG 1. The space between the instrument and the calibration screen is reasonably light tight; calibrations can be performed during daytime while work is going on in the enclosure with the lower lights switched on.

2.4 The telescope and instrument control systems

The VLT control system has been designed with the concept that the TCS (Telescope Co-ordination Software) is a subsystem of the instrument. This makes the stand-alone operation of the telescope tedious as the system has been designed to be operated in an integrated manner. Compliance with the software standards of the VLT is therefore strongly advisable.
Below three options are presented. These options will be refered to later in the text to refer to particular functionalities that may be excluded when particular choices are made. The specific proposal for compliance in the area of software should be assessed on a case by case basis. There is no provision at all other communications protocols.

1. Complete compliance. All software and electronics hardware systems comply with the VLT standards. This solution is clearly the preferable one. ESO does provide to instrument consortia baseline OS and ICS software. This will allow the use of P2PP and DFS systems to execute observations as well as full communication with all subsystems of the VLT.

2. Partial compliance. Software and hardware systems comply with the VLT standards. Full communication with the Telescope subsystems is possible. Usage of the VLT software code management archive is restricted. Documentation and quality assurance issues are relaxed. DICB compliance is also relaxed. Use of DFS systems is not possible. VLT scripting and usage of templates is possible.

3. The minimalist compliance would have a thin layer of VLT Control software interfacing with the telescope systems and a further thin layer interfacing that with the visitor instrument dedicated software. Such a system however would have drawbacks with respect to the availability of other options such as chopping. **ESO has no example of such a minimalist system but can envisage how such a system could be built.**

For options 1 and 2 above ESO does provide standard software packages for the instrument control both at the LCU and workstation level and for the Observation software at the workstation level. Assuming the hardware (LCU) is VLT compliant then only configuration files need to be specified for the instrument control software.
Instrument consortia are strongly advised to discuss with ESO with respect to these issues.

2.4.1 Overview

The control system for the VLT and its instrumentation is based on a system of distributed micro-controllers supplemented by intelligent workstations. These processors act as nodes on Local Area Networks (LANs) which permit information and commands to be transmitted between them. The logical lay-out of the system is shown in Figure 8. More information on the configuration of the system are given in RD[13].
ESO reserves the right to refuse to install instrument computers on the Paranal LAN if it has reason to suspect that prior to transportation to ESO the system may have been infected by virus or that security at the home institute of the visitor instrument could have been compromised[6]. It shall be possible that instrument computers, irrespective of system and applications used, can have their software completely re-installed and re-compiled from a secure system.

[6] Fully VLT compliant systems automatically qualify as the systems are regenerated from scratch prior to installation at the Paranal site

Specifically the instrument team shall be required to demonstrate that all software in use on their computers are owned by the team and that licenses for the use made exist where appropriate[7]

2.4.2 Local Control Units

Visitor instruments may deviate from the VxWorks LCU standard that ESO has selected for its own subsystems. With respect to communication between the control room and the instrument it is outlined below that all such communication must take place over the VLT LAN. This by default implies a distributed system the nature of which may be VLT compliant or not. Below the ESO scheme is briefly described.

Each VLT instrument is controlled by one or more dedicated Local Control Unit (LCU) which is linked to the overall system via a LAN. The LCU forms an integral part of the instrument and is normally physically located on the instrument itself. The LCU contains the electronic hardware necessary for the set-up, control and functioning of the instrument, data readout, self-tests, etc. Control of the instrument is done from workstations located on the network. The system architecture is intentionally very open and permits, in principle, any instrument to be controlled from any workstation on the network. This implies that no dedicated instrument control hardware can be located in the workstation itself. This arrangement also offers a number of advantages, including the minimization of the number of cable inter-connections, the solution of most real-time control problems in dedicated micro-processors, straightforward testing of the instrument when off the telescope, and is very flexible for future expansion.

2.4.3 Local Area Networks

Visitor instruments must comply with the network specifications of the VLT LAN [13]. No provision is made for dedicated cabling of any sort within the VLT system. All communications of the instrument with units that do not form part of the mechanical assembly of the instrument (e.g. workstations) must go via the VLT LAN system. Absolutely no communications are permitted to the VLT control LANs from the outside world (i.e. outside the mountain top). The base camp and offices of the Paranal observatory form part of the outside world in this context. Specifically this implies that the control software for the instrument should not rely on data that are to be delivered to it from facilities outside the control LANs of the VLT. Typically the reverse process (i.e. communcation from the inside to the outside) is unrestricted. For one instrument specific IP addresses shall be allocated by Paranal, typically on a single subnet.

The LAN system provides the means of communication and data transmission between the many LCUs on the telescopes and Workstations in the control building. The LAN system comprises several parallel fibre-optic LANs, each serving specific functions such as telescope control, acquisition data, field stabilization data, as well as instrument control and science data transmission.

Figure 8 shows an overview of the VLT LAN system. The system has been designed to allow the maximum flexibility in configuration, but also to ensure that different telescope sub-systems can operate without being affected by data congestion and priority conflicts

[7] ESO may require that the instrument consortium remove software from its systems that are deemed to potentially interfere with the VLT system. Specifically no internet browsers are permitted within the control LANs.

from other sub-systems. The separate LANs are connected through a router to a backbone network which allows communication between individual telescopes and general services. No cross communication between telescopes is available, so one telescope cannot be commanded to be moved from another telescope console.
In general, each VLT instrument is operated from one or more workstations connected to the instrument LCUs through one LAN subnet. Although the LAN system can be configured to allow instruments to be tested from Workstations located on the backbone network or elsewhere, in normal operation the router only allows operation from local workstations to ensure minimum risk of accidental interference. An overview of the complete VLT LAN system is given in [13].

2.4.4 User interface

An instrument workstation (IWS) is used amongst other things to communicate to the telescope. There is no alternative communication protocol other than CCS (Central Co-ordination Software) messaging. For an instrument requiring communication with the TCS it is therefore necessary that such a workstation suitably equiped is available.
The telescope(s) are operated from separate but similar workstations called the Telescope Workstation (TWS). The on-site IWSs and TWSs for all VLT telescopes are located in the Control Building close to but separate from the telescope buildings.
No provision is made for dedicated cabling within the VLT environment. The only connection between the control room and the instrument is via the VLT LAN.

2.4.5 Software

Any visitor instrument proposal shall include a section on software and how the compatibility with the ESO interfaces shall be achieved. It should be noted that since the telescopes and instruments form an integrated environment the software issue is not only one of interfaces but also one of safety for the telescope and personnel.

2.5 Other observatory services

2.5.1 Time Reference System

The VLT Observatory has a central Time Reference System (TRS) which distributes Universal Time information to the telescope and instrument control systems, as well as any other systems that may require this information.
For general time setting requirements, UTC is available to instrument control software via the Instrument-LAN (see section 2.4.3). For applications requiring a high accuracy time reference, the UTC signal is distributed directly to the individual instrument LCUs by means of a dedicated fibre-optic Time-Bus. In this case a standard electronic module (Time Interface Module TIM) within the LCU decodes the full UTC signal and provides a high accuracy local time reference for instruments. The absolute time accuracy of this reference, measured from the moment at which a processor interrupt is generated, is $10\mu s$ or better.
While UTC is available at the LCU level with high accuracy and via ntp to all systems at a lower accuracy, other timing values are also computed by the system (e.g. sidereal time)

but not distributed as such.
Access to the distributed time is only available on systems that comply with VLT standards. Such access is necessary for any system that requires chopping as the synchronization with M2 is based on absolute time.

2.5.2 Astronomical Site Monitors

The observatory has a central Astronomical Site Monitor (ASM) to provide continuous monitoring of the prevailing astronomical conditions at Paranal as well as meteorological data. This information is available to instrument control software via the Online DataBase System. The facility also provides an archiving system to allow the accumulation of statistics for modeling and prediction. The parameters currently available from the ASM are given in table 4.
The ASM data are available online for any instrument that can communicate with the TCS.
In addition to the prevailing conditions, ESO calculates and distributes off-line predictions of the meteorological conditions at its observatories, also given in table 4.

2.6 Instrument handling

2.6.1 Instrument integration

Two facilities are available at the Paranal observatory for the integration of complete instruments or parts thereof. Complete instruments are usually integrated in the Auxiliary Telescope Hall (ATH) which is located in the Maintenance Area of the Base Camp; smaller units can be integrated in the integration facility of the Control Building in the Telescope Area. The main advantages of integrating instruments in the ATH are the comparatively large available space (area and height), easy access at any time of the day or night due to its location in the base camp, superior clean room facilities and the availability of LAN and Telescope Control Software (TCS) for test purposes. Instrument integration in the ATH requires the transport of the assembled and tested instrument to the telescope (about 3.4 km on smooth asphalted road), usually by means of the instrument trailer (section 2.6.3).
Facilities available for instrument integration in the ATH include

1. space: a floor area of up to 10 $\times$ 20 m^2. Height >10 m.
2. access door: width >7 m, height >10 m
3. an integration stand with a flange identical to the instrument attachment flange of the Cassegrain rotator of the UTs (load capacity 2.5 t, distance to the floor 3050 mm) can be made available but cannot be tilted. The flange can be rotated by hand. Attachment points identical to those on the M1 cell are also available with the same load capacity of 2.5 t.
4. overhead crane, see section 2.6.3
5. standard Service Connection Point (SCP) with electric mains and LAN connection (see section 3.17.1).
6. filtered compressed air

7. additional small mobile cooling unit

8. separate control room with duplicate control LANs for each telescope. These control LANs are not accessible from outside the ATH nor can they access the external world. Separate LANs are available at the ATH for such activities.

9. TCS

10. access to the cleanroom facilities of the mirror maintenance building (its use requires prior approval by ESO)

The integration facility in the Control Building comprises

1. space: a floor area of up to 6.7 $\times$ 13.5m^2

2. a flange identical to the instrument attachment flange of the Cassegrain rotator of the UTs, load capacity 2.5 t, mounted at the ceiling, distance to the floor: 3050 mm. It can be rotated by hand. Attachment points identical to those on the M1 cell are also available with the same load capacity of 2.5 t but cannot be tilted.

3. access to a small (ca 10 m^2) lower class (than MMB) cleanroom

4. size of access door: 3.10 m $\times$ 3.00 m (width $\times$ height)

5. overhead crane, see section 2.6.3

As the Control Building is located in the Telescope Area integration work should preferably be done during the day; night time access is strictly controlled and needs prior authorization. **Instrument teams shall discuss with ESO well before the planned start of instrument integration on Paranal which facilities are to be used.** This is to ensure that there are no conflicts between different teams in the use of the rooms, laboratories and handling equipment.

2.6.2 Instrument transport

Having being assembled and tested the instruments is transported to the telescope (about 3.4 km from the ATH, about 0.5 km from the Control Building). Normally the instrument trailer described in section 2.6.3 is used for this purpose. When entering the telescope building the instrument (and, if applicable, any associated equipment) must pass through

1. the telescope enclosure main entrance door: 3.60 m $\times$ 4.00 m (width $\times$ height). Note that the clearance is reduced by the height at which the instrument is transported. E.g. the height of the instrument trailer is approximately 35 cm. The maximum height the instrument can have when it is on the instrument trailer is 365 cm. The exact maximum height below the trap door in cm is 397, 398, 396 and 397 for UT1 through 4. Exact details of transportation into the enclosure should be discussed with Paranal Engineering.

2. the enclosure trap door: 3.40 m $\times$ 3.40 m with small obstructions (800 $\times$ 30 mm each) in two corners.

Details are referenced in appendix A. Normally the enclosure crane (section 2.6.3) will be used to lift the instrument or its major parts through the trap door to the azimuth platform. In exceptional cases bulky equipment can be lifted with a mobile crane through the main enclosure observing door. This option requires the expensive rental of a commercial mobile crane and therefore **has to be approved beforehand by ESO.**
For smaller items the enclosure lift can be used. It can handle loads of up to 1.2 t, the cabin inner dimensions are 2.00 m × 1.40 m × 2.15 m (length × width × height); the doors (two sided access) have a free passage of 1.40 m × 2.00 m (width × height).
The Cassegrain area of the telescope is accessible from the azimuth platform. The applicable drawing showing the azimuth floor is referenced in appendix A.

2.6.3 Handling and transport devices

The following standard handling and transport devices are available at the VLT Observatory:

1. medium fork lift, motorized
   Safe Working Load (SWL) = 3.5 t at 500 mm and 1.5 t at 1000 mm from the fork base

2. small fork lift, hand operated
   SWL = 2.5 t at 500 mm, normally located at Mirror Maintenance Building (MMB)

3. ATH overhead crane
   SWL =10 t, maximum hook height >5 m

4. enclosure crane, one in each telescope enclosure
   SWL = 5 t; for the operating range see the drawing referenced in appendix A. Hoisting height ca. 25 m; hoist speed adjustable between 100 and 5000 mm/min, horizontal speed 200-2000 mm/min adjustable

5. control building integration facility crane serving part of the area.
   SWL = 5 t, maximum hook height 3350 mm above the floor, positioning accuracy suitable for the handling of delicate equipment

6. mobile crane
   load capacity 75 m×t (e.g. 15 t at 5 m)

7. truck including crane (mounted at the rear end)
   SWL = 3 t at 3 m, height ~1.2 m, platform: standard truck size, length = 5 m, load capacity 7 t

8. instrument trailer
   SWL = 5 t, platform size 5.0m × 2.5m (l × w); height 0.5 m which can be reduced to <0.4 m

9. Cassegrain carriage (2 copies) designed for the FORS instruments and the Cassegrain mass dummy; its use requires special permission of ESO
   special interface, SWL = 2.5 t, requires suitable overhead attachment points for lifting the instrument.

10. mobile air cushion system; its use requires special permission of ESO
    special interface, SWL 4 × 15 t.

11. enerpac roller system; its use requires special permission of ESO
    special interface, SWL 20 t

Availability and suitability of these devices for the intended use shall be clarified with and confirmed in writing by ESO before incorporating them into the individual instrument operations, handling or maintenance plans. See however section 3.15.

In addition all basic devices (slings, ropes, chains, shackles etc) necessary to move or secure loads up to 10 t are available. It is however advisable that instrument teams check with ESO which devices are needed and possibly bring their own set.

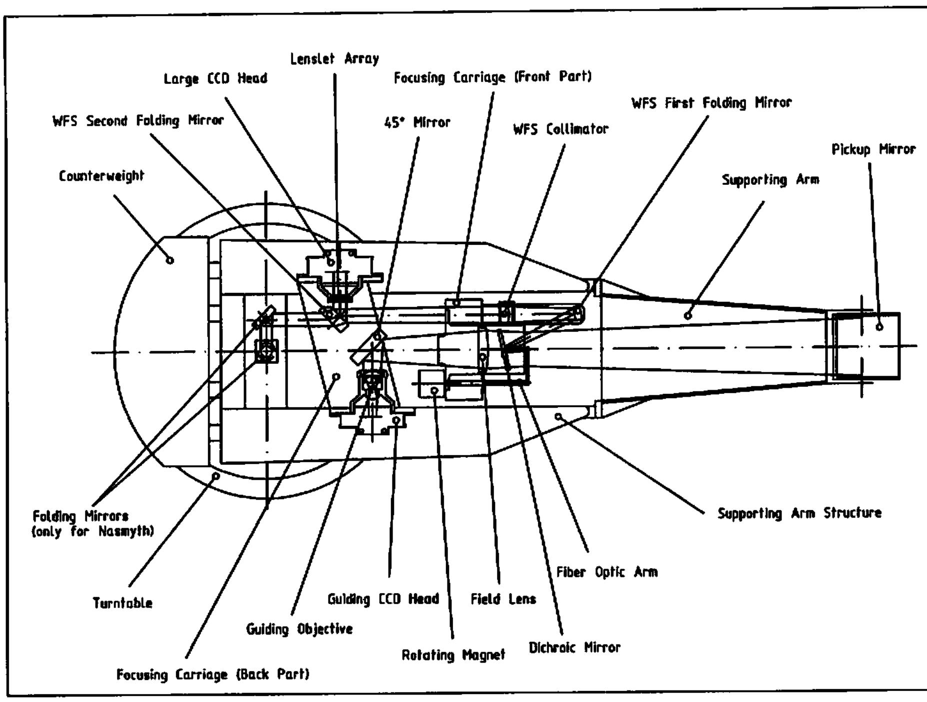

Figure 6: View of the Cassegrain Adapter sensor arm.

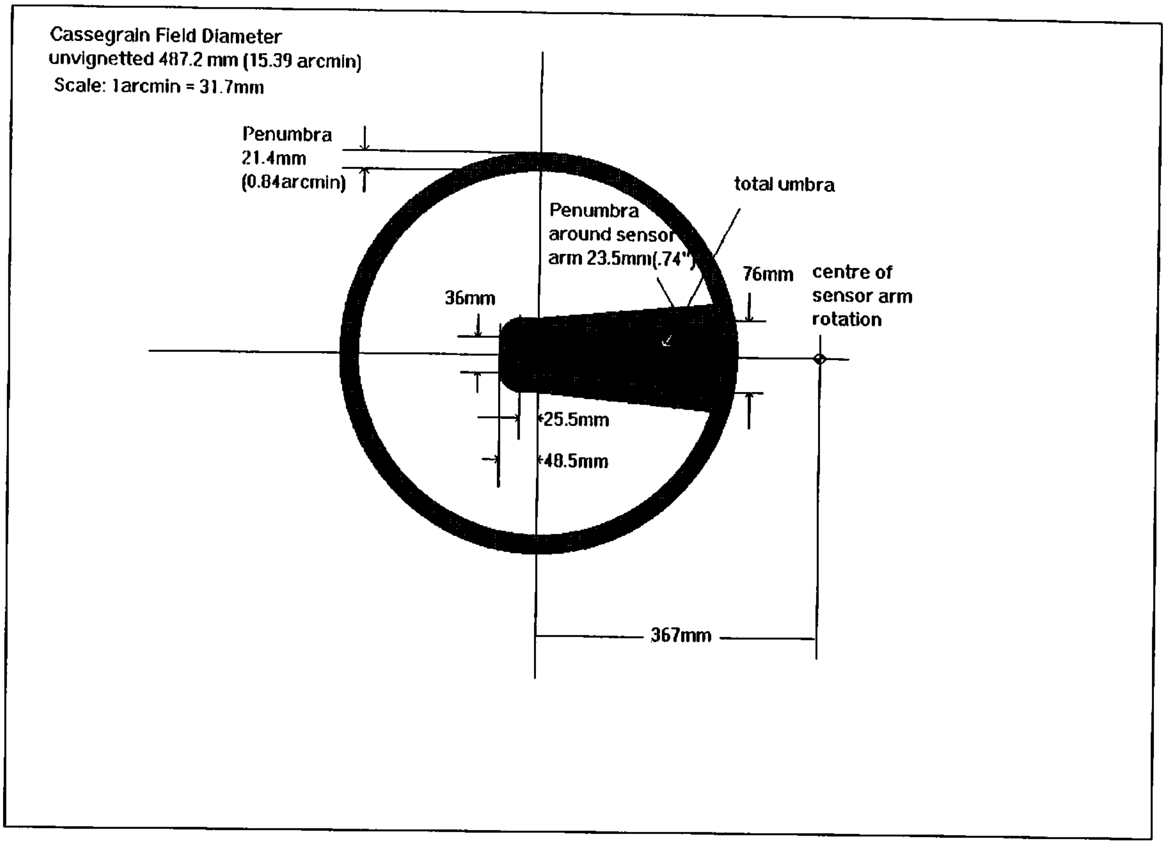

Figure 7: Guide-probe shadow in the focal plane at the Cassegrain focus

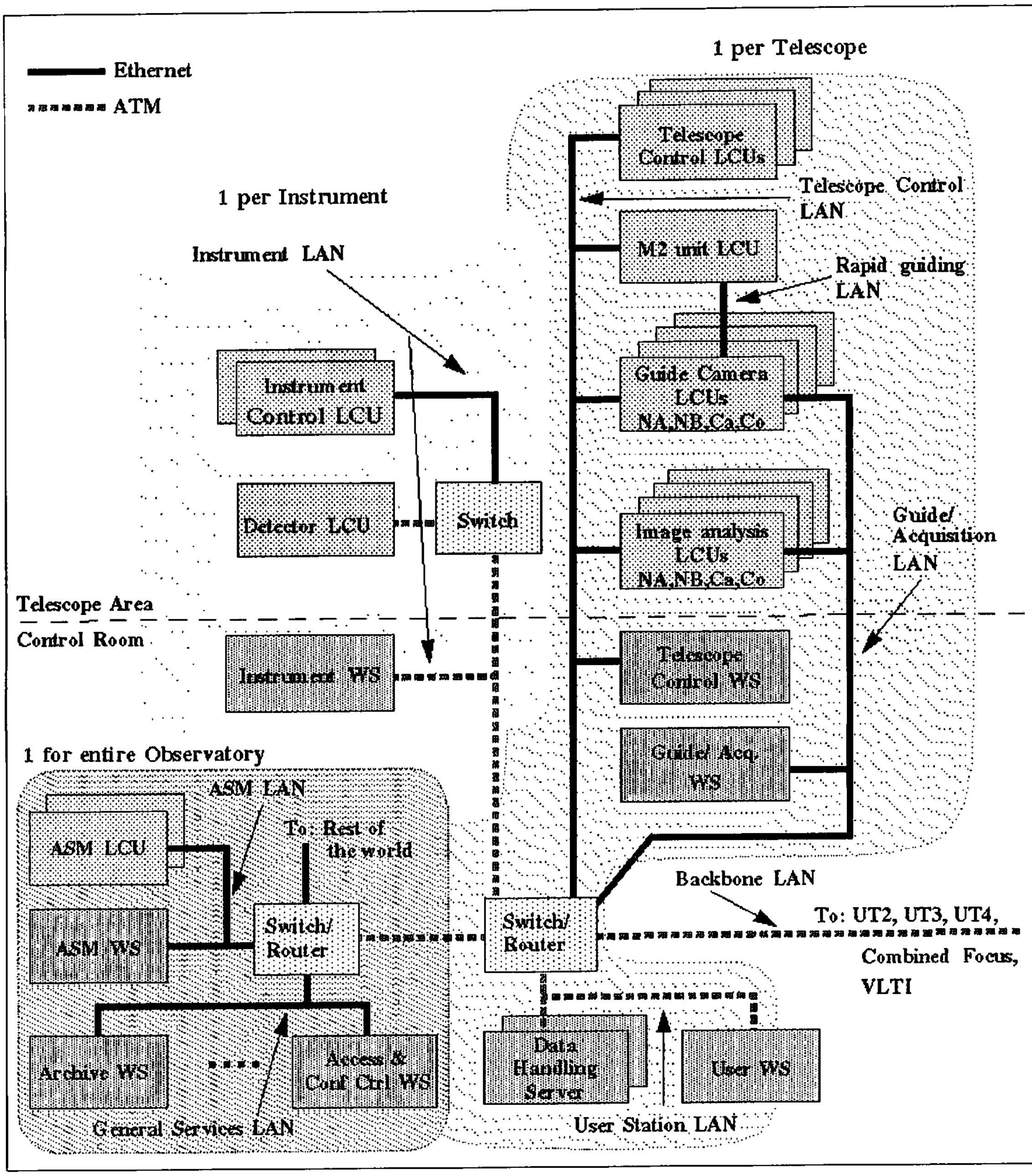

Figure 8: Logical lay-out of the VLT LANs

Parameter	Unit	Update interval	Accuracy and/or Resolution
Seeing and Coherence Monitor			
Seeing	arcsec at 500 nm, zenith	1 min	±5%
Scintillation index	% at 500 nm, zenith	10 min(**)	±10%
Isoplanatic angle	arcsec at 500 nm, zenith	10 min(**)	±20%
Wavefront temporal coherence	ms at 500 nm, zenith	10 min(**)	lowest exp. value
Satellite Sky Monitor			
Cloud cover	Phot/Variable/ Cloudy/Overcast	3 hr(*)	80 % hit, all sky average
Precipitable water vapour	mm H_2O	3 hr(*)	1 mm RMS, all sky average
Line Of Sight Sky Monitor			
RMS Atmospheric Extinction	magnitude m_V	10 min(*)	0.01^m
Ground Meteorological Station			
Ground temperature	°C	1 min	±0.1° C
Air temperature	°C	1 min	±0.1° C
Relative humidity/dew point	%	1 min	±1%
Atmospheric pressure	mb	1 min	±1%
Wind direction	degrees	1 min	±5.63°
Wind velocity	m/s	1 min	±2%
Airborne particles	particles/m^3	20 min	±10%
Prediction Unit			
Air temperature	°C	6 hr(*)	1° C RMS
Air pressure	mb	6 hr(*)	1 mb RMS
Wind velocity	m/s	6 hr(*)	3 m/s RMS
Cloud cover	Phot/Variable/ Cloudy/Overcast	3 hr(*)	90 % hit, all sky average
Precipitable water vapour	mm H_2O	3 hr(*)	1.5 mm RMS, all sky average

Table 4: Parameters available from the ASM,
(*) currently as web-based operational prototype
(**) currently under development

3 Requirements for Cassegrain instruments

The design requirements and interface specifications for Cassegrain instruments are given in this section.

3.1 General requirements

All Cassegrain instruments shall be designed to conform to the mandatory requirements (in bold type face) contained in this document and in the referenced Applicable Documents

3.2 Instrument concept

Cassegrain instruments shall be conceived as complete self-contained units which, as far as possible, can be installed on the telescope as a single pre-tested and functioning unit.

3.3 Use of the Azimuth platform

The Azimuth platform may be used for the temporary location or transportation and test equipment during the installation of Cassegrain instruments and for access for test and maintenance purposes.
In exceptional cases, and with the written agreement of ESO, certain instrument equipment may be installed semi-permanently on the Azimuth platform when it is not practicable to attach it directly to the instrument. In such cases, platform installed equipment shall be positively anchored to the platform and located within the overall space allocation for Cassegrain instruments referenced in appendix A. (See comment at end of section 3.17.4.) **It shall be removable as a single physical unit.** (See also requirements in section 3.14 on vibration isolation and section 3.17.2 on cabling).

3.4 Instrument attachment

All Cassegrain instruments shall be attached directly to the Cassegrain Rotator. The applicable drawing of the Rotator mounting flange is referenced in appendix A.
At the bottom of the M1 cell four additional attachment plates are available for use by Cassegrain instruments. The locations and the applicable drawing are referenced in appendix A. Their load capacity is:

1. total mass on 4 plates not exceeding 200 kg

2. mass on any one plate not exceeding 100 kg

Two more attachment points are available in opposing rafters of the M1 cell; they are referenced in appendix A. Their combined load capacity is such that they can be used for attaching a complete Cassegrain instrument during a mounting operation.

3.5 Focal plane position

The focal plane of instruments attached directly to the Rotator shall be located at a nominal on-axis distance of 250 mm from the Rotator instrument mounting flange. The Adapter Sensor Arm focusing mechanism can accommodate on-axis distances in the range 215 – 255 mm from the flange.

3.6 Mass and torque limits

Cassegrain instruments shall not exceed the following weight and torque limits. These limits shall not be exceeded during operation, instrument mounting or maintenance operations.

1. The total mass attached to the Cassegrain Rotator shall not exceed 2500 kg
2. The moment applied to the Rotator flange with a moment vector perpendicular to the optical axis, at any telescope altitude, shall not exceed 20 kNm
3. The moment applied to the Rotator flange with a moment vector parallel to the optical axis, at any telescope altitude, shall not exceed 500 Nm in any instrument orientation. The maximum torque component due to friction alone, for example from the instrument cable wrap mechanism, shall not exceed 100 Nm.
   The rate of change of torque during tracking shall not exceed 3 Nm/sec. Care must be taken in the instrument design to take account of factors such as the movement of the centre of gravity due to a change of configuration, evaporation of cryogenic liquid, the weight and stiffness of cryogen transfer hoses, cable friction, etc.

3.7 Overall dimensions

Cassegrain instruments, and any associated ancillary equipment such as electronics cabinets, cooling equipment and thermal enclosures, shall not exceed the overall space envelope allocated for Cassegrain instruments referenced in appendix A.

3.8 Calibration Sources

All calibration sources shall be provided with the instrument.
All calibration sources that illuminate the entrance aperture of the instrument directly shall be integrated into the instrument.
Calibrations sources that illuminate the calibration screen mentioned in section 2.3.9 should also be integrated into the instrument where possible.
Alternatively, three standardized fixation points are provided within the primary mirror cell between the Cassegrain Adapter and the beam shutter for the installation of externally mounted calibration lamps. The location of these fixation points is shown in ADWG 1.
Externally mounted lamps may only be used if the use of integrated calibration lamps is proved to be impracticable, and with the written agreement of ESO.

The procurement of external calibration lamps or sources, their power supplies and interface circuitry shall be the responsibility of the instrument contractor. The control of such lamps will be specified on a case-by-case basis by ESO. Note that calibration lamps should comply with the heat dissipation requirements.

3.9 Sky baffles

The principal sky baffling shall be provided by an adequate design of the instrument; in particular it is recommended to insert a light stop at a pupil image. The optical design of the instrument should provide a good quality pupil image at an accessible position for this stop. The secondary mirror baffle described in section 2.2.3 may be used to supplement the internal baffling.

3.10 Atmospheric dispersion compensation

The Cassegrain foci of Unit Telescopes 1 and 2 are equipped with a longitudinal atmosperic dispersion compensator (LADC). No provision is made at this time to equip telescopes 3 and 4 with a similar device.
It is not envisaged that a visitor instrument would be mounted in place of FORS1 or FORS2 and therefore if an ADC is deemed necessary for the particular type of observing envisaged with the instrument it shall be incorporated into the instrument itself. However, the control of the pre-installed ADCs forms part of the telescope control system and no additional software is required by any instrument wishing to use it.

3.11 Secondary guiding

Instruments for which there is a possibility of varying axial misalignment or differential flexure between instrument and the Adapter/Rotator may need to incorporate a secondary guiding system to correct any residual image drift. Secondary guiding at the VLT is performed by offseting the guide probe while the telescope is under the primary guiding loop.
Instruments requiring secondary guiding systems shall incorporate them in the instrument design.
The data interface between a secondary guiding system and the telescope control system will be defined by ESO in concertation with the instrument contractors concerned.
Although the concept of secondary guiding was originally conceived for the compensation of slowly varying effects, it is also possible to use it in field-stabilizing mode to correct for fast tilt errors, for example due to the atmosphere. In this way the observational object itself could be used as position reference or another object very close by, thus allowing the errors due to non-isoplanaticity to be avoided or minimized. In this case the Adapter autoguider would not be used. The fast secondary guiding mode would use a dedicated LAN for transmission of the control information and **shall only be used with the agreement of ESO.**
Visitor instruments not fully compliant with the ESO software and hardware cannot use the field stabilisation as a secondary guiding facility. The communication from field electronics (e.g. detectors) to the M2 is only allowed over the m2com interface which requires that the field

electronics is a VLT LCU. (see [21]) Also, a handshake procedure with the TCS control system, on the workstation level, is required for field stabilisation from the instrument to take place.

3.12 Chopping control

The normal way of synchronizing the chopping of the M2-unit and instrument data taking is through the use of the Time Reference System TRS. In addition to the normal chop parameters provided by the instrument software, (chop throw, chop orientation, chop position), the sequencer program in the host workstation defines the absolute UT starting time for the chop sequence and the dwell times in each position. This information is used by the M2-unit control system to move from one chop position to the other at the absolute UT time defined by the set-up parameters. The instrument control system will use the information to synchronize control and data taking. The set-up procedure for the M2-unit will allow the chop transition time to be accurately ascertained and accounted for.
Visitor instruments not fully compliant in the field (LCU) software with ESO specifications will have no synchronisation signal from M2 as this is done on absolute time only. The visitor instrument that wishes to use chopping will require an LCU with a TIM (TRS) board.

3.13 Pupil motion compensation and alignment

Gravitational and thermal flexure as well as alignment errors may cause the nominal optical axis of the telescope to be misaligned with the mechanical axis of the Rotator. This will cause a motion of the telescope pupil with respect to the instrument pupil. The maximum tilt of the axes will not exceed 2 arcminutes. **If this should be considered a serious problem, a pupil motion control shall be included in the instrument.**

3.14 Vibration

All equipment attached to the telescope or installed on the Azimuth platform which produces vibration (motors, pumps etc.) shall be adequately isolated mechanically from the telescope structure to prevent the transmission of vibrational disturbance to the telescope structure. Installation and operation of such equipment requires the written approval of ESO who will determine if any special verification procedures are required.

3.15 Instrument handling and storage

All handling and maintenance operations for Cassegrain instruments shall be carried out with the telescope in zenith position. The free space between the M1 cell and the azimuth floor as well as all other relevant data are referenced in appendix A.
All Cassegrain instruments shall be provided with a transportation carriage which shall allow the instrument to be moved on the Azimuth platform and adjoining floor area, and include provisions for mounting the instrument on the Rotator. Alternatively the supports on the M1 cell may be used for dis/mounting a Cassegrain instrument. A separate storage stand or base shall also be provided for the instrument when it is not attached to the telescope if the transportation carriage cannot fulfill this function. In case one of the carriages

already available at Paranal can be used for transporting and mounting of the instrument, a waiver of this requirement can be negotiated with ESO.
Instruments that are not otherwise protected from dust ingression and mechanical damage when off the telescope shall be provided with protective cover.
A list of standard handling and transportation devices that are available at the observatory is given in section 2.6.3. **Any additional handling, transportation or adaption devices necessary for the instrument shall be provided with the instrument.**
Visitor instruments shall specify explicitly their storage requirements. A priori no provision exists on Paranal for storage of delicate optomechanical systems other than when mounted on the telescopes. Storage of the instrument must comply with the earthquake and other safety aspects. ESO while excercising all due care does not take any responsibility for visitor instrumentation stored on the Paranal site.

3.16 Thermal control

The maximum temperature difference between any exposed surface of the instrument (or of any associated equipment) and ambient shall be $\leq +1.5/-5.0$°C in wind-still conditions, with a maximum upwardly convected energy for the instrument and all associated equipment of 150 W. The weighting factor to be used for negative energies is 0.3. These thermal requirements are considered to be average values over any 30-minute period.
In order to meet the thermal specification, Cassegrain instruments and their associated control electronics may need to be actively controlled thermally and their exposed surfaces insulated. Cassegrain instruments may make use of the telescope cooling system in order to meet the thermal environment requirements (see section 3.17.1).

3.17 Electrical and fluid connections

3.17.1 Service Connection Point

Most telescope sub-systems and equipment are connected to the telescope electrical and fluid supplies, and to the communication networks at centralized distribution points called Service Connection Points (SCP). The SCPs are composed of three parts which provide electrical, communications and fluid connections, respectively. A full description of the SCP is given in AD[3]. The following sections provide an overview of the SCP connections and lists the principal interface requirements.
Two SCPs, one located on the primary mirror cell (1-N; N being the number of the Unit Telescope) and the second on the Azimuth platform (7-N), are reserved for Cassegrain instruments. The latter one is intended to be used for maintenance purposes and during instrument integration/installation. **All cables and hoses from the instrument mounted on the Cassegrain rotator shall normally be connected to the SCP 1-N on the primary mirror cell. In exceptional cases, instruments may also use the SCP on the Azimuth platform foreseen for Cassegrain instruments** (see section 3.17.4).
The location of the Cassegrain instrument SCPs is referenced in Appendix A.
The following list gives a summary of the services provided at the SCPs.

1. SCP Part A: Electrical connections

(a) 400 VAC, 50 Hz, three-phase, neutral and earthing

(b) 230 VAC, 50 Hz, single-phase, neutral and earthing

(c) 230 VAC Uninterruptible Power Supply (UPS), 50 Hz, single-phase, neutral and earthing

(d) Auxiliary earth connection

The power quality is specified in AD[4].
In addition to the socket outlets, power connection to normal or UPS power may also be via direct connection to terminal blocks inside the SCP. Details of the socket outlets and the internal electrical connections are given in [3].
Equipment connected to the SCP electrical socket outlets shall conform to the following requirements:

- **The peak electrical current drawn from one SCP must not exceed 16A per phase for the normal electrical supply, and 16A total for the UPS supply.**
- **The total average electrical power taken from the UPS outlets by Cassegrain instruments shall not exceed 2kW per SCP. The total average non-UPS electrical power shall not exceed 4kW per SCP without the written agreement of ESO.**
- **Electrical equipment connected to the SCP must respect the EMC requirements for susceptibility and emissions given in AD[5].**
- **The requirements for the design and implementation of electronic equipment contained in RD[14] shall be applicable to all equipment connected to the SCP.**
- **All fuses, circuit breakers and residual current detectors required for the protection of the instrument, supply cables or operator shall be incorporated in the instrument concerned.**

During the commissioning period of instruments, it may be more convenient to connect the instrument to the power socket outlets on the front panel of the SCP to allow easy disconnection. Once commissioning is completed, instruments will normally be connected to the internal power distribution terminal blocks of the SCP.

(e) Local interlock connections
Each Cassegrain instrument SCP provides access to the Cassegrain instrument Rotator interlock system. This comprises a normally closed loop circuit which, when opened, prevents motion of the Rotator by cutting power to the drive motor. Note that it does not cut electrical power to the instrument or Adapter/Rotator LCU. This facility is intended for use during operation or maintenance activities to prevent damage or injury to the instrument, telescope or personnel.
The Local Interlock connection can be used, for example, to prevent damage to the instrument cable wrap in the event of an emergency situation. Such a situation could conceivably occur if the Rotator units have been incorrectly initialized, or due to a hardware failure in the Rotator control electronics. It is

strongly recommended that instrument designers use this facility as a secondary security system in cases where uncontrolled rotation of the Rotator could lead to serious instrument damage.
Access to this circuit is only possible through direct connection to terminal blocks inside the SCP. The following must be observed by instruments using the Local Interlock facility:

i. **External switches and relays used to break the Local Interlock circuits shall be normally closed rated at ≥ 2 A with 230VAC and 24VDC. The exact type of switch used shall be approved by ESO.**
ii. **There must be no galvanic connection between the Local Interlock circuit and any other circuit or ground.**
iii. **If an instrument has more than one condition for generating an Local Interlock condition, the exact source of the interlock must be available in the instrument status which is accessible from the Telescope Control Software.**

(f) Emergency Stop facility
In addition to the Local Interlock, each instrument SCP is equipped with a Emergency Stop facility. This comprises a red mushroom-type button on top of the SCP and a key switch. Either pressing the button or removing the key will immobilize all major subsystem functions in the telescope enclosure.
A centrally located set of lockout switches are available to imobilize particular parts of the telescope/enclosure. The usage of these is governed by the lockout procedure. Note that, like the Local Interlock, emergency stops do not cut power to the LCUs (see section 2.4.2).
A connector is available on the lower surface of all instrument SCPs to allow the attachment of an extension cable for a remotely located Motion Stop button. A bridging connector is provided on each SCP which must be plugged in when no extension cable is in use. **All such extensions shall be approved by ESO prior to use.**
A single emergency stop button for each telescope is available in the control room at each console. No provision is made for any dedicated cabling from the instrument to the control room.

2. SCP Part B: LAN connections

(a) Local Area Network (see section 2.4.3)
SCP Part B allows the physical possibility of connection to the VLT LAN system. The allocation of the LAN connections for Cassegrain Instruments will be specified by ESO for each individual instrument. The SCP fibre-optic cables are supplied from Network Access Points (see RD[13]) where the function of each SCP LAN connection is determined. All SCP LAN connectors are of the following type:

- SCP Output connector: ST type
- Fibre-type: Multi-mode, graded index (62.5 μm core, 125 μm cladding)

(b) Time Reference System (see section 2.5.1)
The TRS connectors and optical fibres are identical to those for the LAN given in the previous item.

3. SCP Part C: Fluid connections

(a) Compressed air supply
Compressed air is provided at the SCPs with the following characteristics:

- Supply pressure: 7-8 bar
- Filtering: $\geq 5\mu m$
- Oil content: < 0.01 ppm
- Relative humidity: $\leq 10\%$ at 20°C at local atmospheric pressure
- SCP Outlet connector: Self-sealing female connector according to ISO 7241-1 Series B, nominal diameter 12.5 mm.

(b) Coolant supply
The central observatory chiller system provides a supply to coolant at the SCPs which may be used for instrument cooling. The coolant has the following characteristics:

- Coolant: water with 33% (vol.) ethylene glycol
- Nominal supply pressure: 6 bar
- Supply differential pressure: min 0.8 bar, max 2 bar
- Supply temperature: 8°C below ambient[8]
- The flow rate of the cassegrain instrument SCP depends on the other users of the system which are the M1 cell and the cassegrain adapter/rotators. The specific needs of the instrument shall be assessed for the focus in question to establish the feasibility of connection.
- Equipment connectors: self-sealing connectors according to ISO 7241-1 series B, size 12.5 mm (output male, return female)

Equipment connected to the SCP coolant supply shall conform to the following requirements:

i. **Connected equipment shall use self-sealing connectors on both feed and return lines**
ii. **All connecting cooling hoses shall be insulated to ensure that the thermal requirements specified in section 3.16 are met.**
iii. **Hoses shall be positively clamped to the connector.**
iv. **All hoses shall be of a type suitable for a working design pressure of at least 12 bar. Equipment shall be filled and leak tested at a pressure of 10 bar before connection.**
v. **Equipment having a total coolant capacity greater than 3 litres, as well as all equipment which is not self-purging, must be pre-filled with the appropriate cooling liquid before connection to the**

[8]The temperature of the coolant will be nominally 8°C below ambient, but it will not sink below −8°C or the external dew point.

SCP coolant supply. Other equipment may be filled by direct connection to the cooling system.

vi. **The coolant return temperature shall not be higher than 8°C above the supply temperature. The maximum thermal load for each SCP shall not be more than 6kW (30 minute average).**

vii. **The instrument cooling system shall be dimensioned such that the coolant flow speed through any part of the system is not greater than 1.2 m/sec.**

viii. **All equipment attached to the coolant supply shall provide monitoring of the coolant return temperature.**

ix. **All instruments which make use of the telescope cooling system shall incorporate any protection mechanisms necessary to prevent damage to the instrument or to its control electronics in the event of a failure in the flow of coolant.**

x. **the use of additional shut-off valves is strongly recommended.**

3.17.2 Cables and hoses, cable wraps

No unguided free hanging cables or hoses longer than 1 m are allowed. Wherever possible, all interconnecting cables and hoses longer than 1 m should be laid in fixed cable ducts with removable covers.

A cable wrap/twist system for transferring cables and hoses between the SCP on the main mirror cell and the instrument shall be provided. The torque induced by this facility shall be included in the global torque budget of the instrument (3.6).

The cable wrap system should be designed with special care and aiming for especially high reliability, taking into account the fact that the cable wrap is continuously moved whenever the instrument is observing.

3.17.3 Cable and connector markings

All interconnecting signal cables and non-standard power cables that are not permanently attached to equipment shall be marked to identify the instrument or equipment to which they belong.

In addition, all connectors (or cable ends) shall be marked to uniquely identify them. All mating sockets shall also be correspondingly marked. Cable connector and socket identifications shall be the same as those used in the instrument documentation.

All standard power cables that are not attached to equipment need not be marked. However, **power cables that are permanently attached to equipment as well as panel mounted power inlet sockets shall identify whether the cable is intended for normal mains or UPS power.**

Additional requirements on cables and connectors are given in RD[14].

3.17.4 Connections to equipment on the Azimuth platform

In certain circumstances, as mentioned in section 3.3, instrumentation equipment may be located on the telescope Azimuth platform below the primary mirror cell. **In this case all cables and hoses between the instrument or primary mirror cell and the Azimuth platform shall be transferred via the Altitude cable wrap.** Cable ducts have an internal diameter of 50 mm each. Thus, the cable distance from the mirror cell to the Azimuth platform is approximately 25 m. **The details of the cable transfer, especially the availablity of the ducts in the telescope cable wraps will be decided in advance with ESO on a case-by-case basis.**
A separate SCP (7-N) is available on the Azimuth platform for the connection of platform mounted equipment associated with Cassegrain instruments (see section 3.17.1). The total thermal load attached to the telescope cooling system shall not exceed the figure specified in section 3.17.1.
Equally, the torque and friction limits w.r.t. the cable wraps (section 3.6 remain valid. Compatibility with the telescope's altitude and azimuth cable wraps has to be checked.
It shall be possible to easily disconnect platform installed equipment from the rest of the instrument, and to remove it when the instrument is not in use to allow full access to the platform for telescope maintenance.
Alternative possibilities for the installation of equipment on the Azimuth platform may also exist, and these will be agreed upon by ESO on a case-by-case basis.

3.18 Requirements for instrument control electronics

Visitor instrumentation may deviate from the ESO standards with respect to the selection of components to be used. Clearly the level of support that can be provided to such a system by the engineers at the observatory is significantly less than in a compliant system.
Full details on standard electro-mechanical components are listed in RD[14].

3.19 Recommendations on the selection of some non-listed components

The following recommendations refer to selection of non-listed electro-mechanical components:

1. Drive Systems:
   For all drive systems it is recommended that DC-motors be used. Experience at ESO in the past has shown that their small volume, low heat dissipation, high speed and wide torque range improve the overall reliability of the electro-mechanical system especially when used in prototypes. **The motors shall, however, be of industrial quality.** If it is desired to improve the gain in a position loop, the measurement of the actual speed of the velocity loop should be done with a DC-tachometer. ESO recommends the use of DC-motors with drive voltages of between 24-30 Volts available from the firms Portescap, Harmonic Drive, Maxon, and Inland. **Critical mechanical systems which must not move at all after the positioning shall be locked with a spring loaded brake (released only with supply voltage 'ON').**

2. Position Encoders:
   In general, position encoding should be done using opto-electronic encoders. In order

to avoid additional initialization procedures, absolute encoders should preferentially be used. Incremental encoders may be used only where the resolution or the count range is too high for an absolute encoder, or where the volume of an absolute encoder is too large. In applications where very high resolution incremental encoders are needed ESO would prefer the use of encoders with interpolation electronics (EXE's) from the firm Heidenhain.

3. Limit Switches:
   In order to limit the mechanical movements, or for initialization purposes, inductive or opto-electronic limit switches are preferred. Electro-mechanical switches may only be used when the motor current is directly switched off locally. Throughout its own instrumentation, ESO has used inductive limit switches from the firm Baumer Electric, and these are recommended for VLT instruments. Preferred would be 'NPN types' (normally open contacts) with 5 - 24 Volts operating voltage.

3.20 General software requirements

It is re-emphasized that for a system using VLT standard hardware components the software to operate any instrument is available from ESO and requires only configuration rather than significant coding. It is strongly recommended that a visitor instrument team discuss their requirement with ESO in advance of the proposal.
The requirements on software supplied with instruments are contained in the following document and the references contained therein. This document also defines the software standards to be adopted for the VLT and instrumentation:
A visitor instrument may deviate from these requirements depending on the level of compliance chosen.

- **'VLT Software Requirements Specification' (RD[16])**

Further essential documents are

- **'VLT Software Programming Standards' (RD[17])**
- **'VLT Software Instrumentation Specification' (RD[18])** (partly obsolete)
- **'ICD between VLT Control Software and the Observation Handling Subsystem' (RD[19])**
- **'ICD between VLT Control Software and the VLT Archive System' (RD[20])**

3.21 Detailed software specifications

3.21.1 Workstation Operating System

UNIX System V shall be used as the standard operating system for the Workstation system software, and X-Windows Version 11 shall be the standard presentation software for the User Interface. Standard configurations for Paranal (e.g. workstation hardware platforms and operating systems) can be obtained contacting ESO[9].

[9] The use of non-standard hardware may complicate the installation procedure.

3.21.2 Communications Software

The TCP/IP protocol shall be used for LAN communications.

3.22 System and common software to be made available by ESO

Standard software packages are made available to instrument contractors for use by the instrument software. They are listed and described in RD[23] and the documents referenced therein.

3.23 Maintenance Software MS

Maintenance software is required for a visitor instrument if it has safety implications. (e.g. checking the cool down of a cryogenic instrument.)

4 Instrument implementation requirements

In addition to the requirements mentioned elsewhere in this document, there are several other considerations that must be respected for all VLT instrumentation control systems. These are necessary because of the need for multiple-telescope use as well as for maintenance purposes.
A number of these implementation requirements are explicitly refering to issues that make it possible to interface an instrument on the VLT telescopes. As such some applicability for the visitor instrumentation exists as marked below.

1. **There must be no need for physical proximity or local intervention to the instruments during observations. All status and controls, as well as reset/restart procedures shall be under software control and accessible via the Instrument-LAN.** This is applicable to visitor instrument irrespective of the software solution proposed.

2. **There shall be no special hardware links between the instrument LCU and the IWS or the user**, such as command switches or potentiometers, lamp displays, oscilloscope displays, etc. This is applicable to visitor instruments

3. **Instruments shall be conceived so that they can be switched to Stand-by Mode when they are not in operation. In this mode, all parts of the instrument and its associated ancillary equipment that are not required for reasons of maintaining LAN contact, or for maintaining the temperature of critical components (for example detectors) should, where possible, be powered off. Switching between Power-on and Stand-by modes shall be done through commands received via the Instrument-LAN.**

4. **Dewars supplied by instrument contractors for instrument and/or detector cooling shall not require re-filling more frequently than once every 24-hour period after the normal operating temperature has been attained.** This is applicable to visitor instruments

5. LN_2 containers for refilling the instruments shall be compatible with standard ESO fittings. Visitor instruments should contact ESO for specifications of LN_2 containers and standard fittings.

6. **VLT instruments shall be easily removable from the telescope, preferably as single units including the LCU**, so that they can be connected to any other LAN node for testing in a stand-alone configuration. This is applicable to visitor instruments.

5 Environmental requirements

The requirements below have safety implications and are therefore applicable to a visitor instrument.
All VLT Instruments, as well as any associated ancillary equipment and components, are required to meet the environmental conditions specified in AD[1]. These specify storage temperature ranges, humidity levels, dust and shock specifications, etc., to be met during transportation, storage and operation and include the survivability of earthquakes.
For information purposes, instruments should be designed for *operation* under the following conditions:

1. Max. ambient air temperature range (day and night): $-5°$ C to $+25°$C

2. Max. ambient air temperature range (night only = operational range): 0°C to +15° C

3. Ambient air temperature change during the observing night: $\leq \pm 3°$C on 80% of nights, $\leq \pm 4°$C on 95% of nights

4. Maximum ambient air temperature gradient during the observing night: $\leq^{+0.5}_{-0.9}$ °C/hour on 80% of nights, $\leq^{+1.0}_{-1.4}$ °C/hour on 95% of nights

5. Change in minimum ambient temperature between consecutive nights: $\leq \pm 2.2°$C on 80% of nights, $\leq \pm 3.5°$C on 95% of nights

6. Relative humidity: 0 - 95 %

All VLT Instruments, as well as any associated ancillary equipment and components, are required to meet the electro-magnetic compatibility requirements which are specified in AD[5]. This document specifies limits for electro-magnetic emission and immunity applicable to instrument electrical and electronic systems.
For the applicable thermal control requirements, see section 3.16.

6 Documentation requirements

For visitor instrumentation the documentation shall include instructions for powering the system down and removing it from the telescope in the absence of members of the instrument team. The procedures to be followed during the powering up of the instrument should also be provided[10]. Documentation on emergency shutdown procedures shall also be included.

7 Safety requirements

The general safety requirements defined in AD[6] are applicable to the instruments as well as all associated handling, test maintenance and alignment devices. A safety analysis shall be carried out for each Cassegrain instrument according to AD[7].

The consortium shall be able to demonstrate its compliance with the requirements described in this document and any additional requirements placed at the time the contract is agreed upon prior to shipment of the instrument to Paranal (see verification section below).

Specifically, a full hazard analysis shall be presented and accepted by ESO prior to shipment to Paranal.

8 Verification

Visitor instruments shall be required to demonstrate their compliance with the basic requirements of the observatory. ESO shall follow its standard verification rules for such checks:

The verification of all requirements and specifications for VLT instruments listed in the mandatory applicable documents shall be dealt with according to the verification procedures laid down in the documents concerned.

Additional verification procedures for VLT instruments are specified in the agreement specific to each instrument. Verification of the requirements and specifications contained in this document are detailed in the following sections.

8.1 Verification by design

Except were otherwise mentioned below in sections 8.2 and 8.3, **all requirements defined in this document shall be subject to design review by ESO during the instrument design phases using computer modeling where necessary.** Commercial components shall be checked against manufacturers data sheets and test reports.

8.2 Verification by inspection

The requirements listed in sections 3.17.2 and 3.17.3 on cable installations and marking shall be verified by inspection after installation.

8.3 Verification by test

The requirements listed in sections 3.5, 3.6 and 3.7 shall be verified by test after instrument integration. The requirements listed in sections 3.14 and 4 shall where applicable be verified by test after installation.

[10] In the rare event of a power failure on Paranal or the necessity to power down the entire telescope it might be necessary to power cycle the instrument in the absence of the instrumentation team

9 Visitor instrument proposal template

9.1 Scientific justification

No comment here.

9.2 Safety

A preliminary hazard analysis of the instrument for all phases of its re-integration, installation, operation, uninstallation and removal following delivery to Paranal shall be provided at the time of proposal. Potential hazards (e.g. high voltages, liquid helium &c) shall be explictly addressed in the proposal.

9.3 Operational scenario

A visitor instrument proposal shall be required to describe the operational scenario envisaged by the instrument builders.

In particular the number of nights to be used possibly split into the amount of time expected to be used to make the instrument operational at the telescope (commissioning) and the number of nights to be used for scientific programmes. How the later would be distributed over the ESO observing periods should also be addressed.

Specifically the requirements on the number of personnel required to operate the instrument &c must be addressed in the proposal & the use of consumables at Paranal (e.g. LN_2, magnetic media &c).

The kind of observations envisaged should be discussed (e.g. frequency of presetting, offsetting, chopping &c).

The operational scenario shall include the amount of daytime access to the instrument required for calibrations, maintenance etc.

9.4 VLT compliance choices

A visitor instrument proposal shall explain the software and hardware compliance and/or deviations from the VLT standards.

9.5 Integration requirements

The specific support required to re-integrate the instrument on site as well as the duration of the re-integration period should be addressed in the proposal.

9.6 Installation requirements

The specific support and time required to install the instrument on the telescope should be addressed. Any requirements on the focus to be used should be discussed here.

Specifically the cooling and connectivity requirements should be addressed.

10 List of Acronyms

AD	Applicable Document
ADC	Atmospheric Dispersion Compensator
AGS	Acquisition/Guide Sensor
ASM	Astronomical Site Monitor
ATH	Auxiliary Telescope Hall
CCD	Charge Coupled Device
DC	Direct Current
DCS	Detector Control Software
DFS	Data FLow System
DRS	Data Reduction Software
EMC	ElectroMagnetic Compatibility
ESO	European Southern Observatory
FDR	Final Design Review
FIERA	Fast Imager Electronic Readout Assemby
FITS	Flexible Image Transport System
GUI	Graphical User Interface
ICS	Instrument Control Software
IR	Infrared
IRACE	InfraRed Array Control Electronics
IWS	Instrument WorkStation
LAN	Local Area Network
LCU	Local Control Unit
LRU	Line Replaceable Unit
MIDAS	Munich Image and Data Analysis System
MMB	Mirror Maintenance Building
MS	Maintenance Software
OPC	Observing Programmes Committee
OS	Observation Software
P2PP	Phase 2 Proposal Preparation
PDR	Preliminary Design review
PULPO	(CCD temperature and shutter controller)
RQE	Responsive Quantum Efficiency
RMS	Root Mean Square
SCP	Service Connection Point
STC	Scientific & Technical Committee
SWL	Safe Working Load
TBC	To Be Confirmed
TBD	To Be Defined
TCS	Telescope Coordination Software
TIM	Time Interface Module
TPA	Telescope Pointing Axis
TRS	Time Reference System
TWS	Telescope WorkStation
UPS	Uninterruptible Power Supply

UT	Unit Telescope
UTC	Coordinated Universal Time
VI	Visitor Instrument
VLT	Very Large Telescope
WFS	WaveFront Sensor

11 Applicable and reference documents

The following list gives the full references of documents cited in the text. Many of the software documents are available online from ESO. The others will be made available by the ESO Instrument responsible.
The precise revision and issue number of these documents applicable to any particular instrument contract will, where necessary, be specified in the contract/agreement.

11.1 Applicable documents

The following Applicable Documents (AD) contain a number of mandatory requirements and specifications for Cassegrain instruments.

References

[1] **'VLT Environmental Specification', document no. VLT-SPE-ESO-10000-0004**

[2] **'Basic Telescope Definitions', document no. VLT-SPE-ESO-100000-0016**

[3] **'Service Connection Point Technical Specification', document no. VLT-SPE-ESO-10000-0013**

[4] **'Electro-magnetic Compatibility and Power Quality Specification', Part I, document no. VLT-SPE-ESO-10000-0002**

[5] **'Electro-magnetic Compatibility and Power Quality Specification', Part II, document no. VLT-SPE-ESO-10000-0003**

[6] **'General Safety Requirements for Scientific Instruments' document no. VLT-SPE-ESO-10000-0017**

[7] **'Requirements for Safety Analyses', document no. VLT-TRE-ESO-00000-0467**

11.2 Reference documents

The following Reference Documents (RD) contain general information relevant to the VLT and its instrumentation and operations.

[8] 'VLT Level 1 Requirements', document no. VLT-SPE-ESO-00000-1423

[9] 'The VLT White Book', available online at URL `http://www.eso.org/outreach/info-events/ut1fl/whitebook/`

[10] 'P2PP Users' Manual', document no. VLT-MAN-ESO-19200-1644, available from `http://www.eso.org/observing/p2pp/P2PP-tool.html#Manual`

[11] 'VLT Optics: Design of the VLT Optics', VLT-TRE-ESO-10000-0526 issue 1.B February 1995

[12] 'Field and Pupil Rotation for the VLT Units', VLT Report No. 63, October 1990.

[13] 'Final Lay-out of VLT Control LANs' VLT-SPE-ESO-17120-1355

[14] 'VLT Electronic Design Specification', document no. VLT-SPE-ESO-10000-0015

[15] 'VLT Software Management Plan', document no. VLT-PLA-ESO-00000-0006

[16] 'VLT Software Requirements Specification', document no. VLT-SPE-ESO-10000-0011

[17] 'VLT Software Programming Standards', document no. VLT-PRO-ESO-10000-0228

[18] 'VLT Software Instrumentation Specification', document no. VLT-SPE-ESO-17212-0001

[19] 'ICD between VLT Control Software and the Observation Handling Subsystem', document no. VLT-ICD-ESO-17240-19200

[20] 'ICD between VLT Control Software and the VLT Archive System', document no. VLT-ICD-ESO-17240-19400

[21] 'TCS user manual VLT-MAN-ESO-17230-0942

[22] 'Software Documentation to be Provided for Instrumentation Projects', document no. TEC-TSW-00/0044

[23] 'VLT Instrumentation Software Acceptance Test Plan Template Document', document no. VLT-PLA-ESO-17240-2266

[24] 'ESO Archive – Data Interface Requirements', document no. ARC-SPE-ESO-00000-0001

[25] 'Data Interface Control Document', document no. GEN-SPE-ESO-19400-794

[26] 'VLT Instrumentation Common Software Specification', document no. VLT-SPE-ESO-17240-0385

[27] 'MIDAS Environment', document no. MID-SPE-ESO-11000-0001

[28] 'VLT Documentation Plan', document no. VLT-PLA-ESO-00000-0005

[29] 'J. Beletic, R. Gerdes, R. C. DuVarney: "FIERA: ESO's New Generation CCD Controller", in: Optical Detectors for Astronomy p. 103 (1998), Kluwer: Astrophysics and Space Science Library

[30] 'Technical CCD System Operating Manual' VLT-MAN-ESP-11700-1775

[31] 'Infrared Array Control Electronics (IRACE) Design Description' VLT-TRE-ESO-14100-1654

[32] 'Infrared Array Control Electronics (IRACE) Interface Description' VLT-TRE-ESO-14100-1561

[33] 'VLT Software: IRACE-DCS User Manual' VLT-MAN-ESO-14100-1878

APPENDICES

Full scale copies of the drawings listed in this appendix are available from ESO.

A Interfaces between Cassegrain instrument and telescope environment

The interfaces between VLT Cassegrain instruments and the telescope environment is given in the following applicable drawings:

ADWG	Title of Drawing	drawing number
1	**VLT-Cassegrain Interface:** **Unit Telescope: Section Alt/Az axis**	**VLT-DWG-ESO-11430-2052**
2	**VLT-Cassegrain Interface:** **Cassegrain Flange: View from below**	**VLT-DWG-ESO-11430-2053**
3	**VLT-Cassegrain Interface:** **Observing Floor Plan:** **Installations and floor loads**	**VLT-DWG-ESO-11430-2054**
4	**VLT-Cassegrain Interface:** **Unit Telescope Section:** **Alt/Az axis, detail of AZ rotator**	**VLT-DWG-ESO-11430-2055**

Table 5: Applicable drawings for the interface between Cassegrain instruments and the telescope environment

All Cassegrain instruments and their handling and maintenance procedures shall be designed to be compatible with these drawings. The current valid version of these drawings shall be used for all design and construction work.
All Cassegrain instruments, including any associated ancillary equipment, shall be located within this volume.