VLT PROGRAMME

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Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
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Very Large Telescope

Requirements for Scientific Instruments on the VLT Unit Telescopes

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Prepared:	G. Rupprecht	21. 3. 05	
	Name	Date	Signature
Approved:	R. Tamai, J. Spyromilio	21/03/2005, 21/3/05	
	Name	Date	Signature
Released:	R. Gilmozzi, A. Moorwood	21/3/05	
	Name	Date	Signature

VLT PROGRAMME ⋆ Telephone: +49-89-32006-0 ⋆ Fax: +49-89-3202362

Change Record

Issue	Date	Section/Paragraph Affected	Reason for Change Remarks
1	18.03.2005	all	new document; merged from Cassegrain and Nasmyth interface documents

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1 Scope

1.1 General

This document specifies the requirements for scientific instruments for the Cassegrain and Nasmyth foci of the ESO Very Large Telescope (VLT) Unit Telescopes (UT). It lists documents that are applicable to the construction of scientific instruments and to other instrument related equipment. It merges the original requirements documents for VLT Cassegrain and Nasmyth instruments, respectively, and therefore replaces and supersedes

- VLT-SPE-ESO-10000-0005 issue 2 dated 23.05.2001 'VLT Observatory requirements for Cassegrain Instruments'
- VLT-SPE-ESO-10000-0006 issue 2 dated 20.09.1995 'VLT Observatory requirements for Nasmyth Instruments'

This document also contains general information on the design of the VLT, the infrastructure at the Paranal Observatory, and on the various interfaces between the Observatory and the scientific instruments installed at the Cassegrain or Nasmyth foci of the Unit Telescopes.
Mandatory requirements are written in **bold type-face**.
Although this document has been created with great care it is strongly advised to double-check with the ESO instrument responsible all necessary details before designing critical items.

1.2 Document hierarchy

All VLT instruments shall conform to the mandatory requirements contained in this document, in the Applicable Documents listed in section 2.1 and to the Applicable Drawings listed in the Appendix. Designs incompatible with 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, or by superseding requirements contained in the Technical Specification or Statement of Work prepared for individual instruments.

1.3 Acknowledgements

This issue is expanded from documents originally prepared by M. Cullum. Input and useful comments for the current version came from G. Avila, M. Cullum, H. Dekker, V. Heinz, G. Huster, G. Hüdepohl, A. Longinotti, G. Huster, F. Salgado, M. Sarazin, J. Spyromilio and R. Tamai but especially from M. Kraus and J. Quentin who prepared all Applicable Drawings for the telescope interfaces. All these contributions are gratefully acknowledged.

2 Applicable and Reference Documents

The following list gives the full references of documents cited in the text. Many of the software and data flow documents are available online from ESO. The others will be made available by the ESO Instrument responsible.

2.1 Applicable documents

The following Applicable Documents (AD) contain mandatory requirements and specifications for VLT instruments.
The precise issue number of these documents applicable to any particular instrument contract will, where necessary, be specified in the contract (Technical Specifications, Statement of Work).
Applicable drawings (ADWG) are listed separately in Appendix A and B.

References

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

[2] **'Basic Telescope Definitions', document no. VLT-SPE-ESO-10000-0016**

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

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

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

[6] **'ESO Technical Standards' document no. GEN-SPE-ESO-00000-2961** release pending

[7] **'Vacuum and Cryogenic Standard Components', document no. VLT-TRE-ESO-15800-2315**

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

[9] **'Data Flow for VLT/VLTI Instruments Deliverables Specification', document no. VLT-SPE-ESO-19000-1618**

[10] **'Data Interface Control Document', document no. GEN-SPE-ESO-19400-0794**

[11] **'ESO Safety Program', document no. SAF-POL-ESO-00000-0001**

[12] **'Safety Conformity Assessments Procedure', document no. SAF-INS-ESO-00000-3444** release pending

2.2 Reference documents

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

[13] 'The VLT White Book', available from the ESO web site at `http://www.eso.org/outreach/ut1fl/whitebook/`

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

[15] 'VLT Optics: Design of telescope optics', document no. VLT-TRE-ESO-10000-0526 issue 1.B

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

[17] 'Final Lay-out of VLT Control LANs', document no. VLT-SPE-ESO-17120-1355

[18] G. Avila, G. Rupprecht, J. Beckers: "Atmospheric Dispersion Correction for the FORS Focal Reducers at the ESO VLT", in: Optical Telescopes of Today and Tomorrow", A. Ardeberg (ed.), Proc. SPIE 2871, 1135 (1997)

[19] 'Scientific and Technical Detector Systems for the ESO VLT', VLT-TRE-ESO-XXXXX-XXXX in preparation

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

[21] 'Implementation of an Alarm System for the Paranal Observatory', document no. VLT-SPE-ESO-12115-2795

[22] 'Guideline for the ESO Safety Conformity Assessment Procedure', document no. SAF-INS-ESO-00000-3445 release pending

[23] 'Lockout/Tagout Procedure for Telescope', document no. VLT-PRO-ESO-11000-3396

[24] 'Safety and Emergency Procedure', document no. VLT-PRO-ESO-00000-3399

All VLT documents are available from the ESO Technical Archive via the Instrument Responsible.

3 An Overview of the Very Large Telescope Project

3.1 Introduction

3.1.1 VLT Concept

The general concept of the Very Large Telescope and its principal performance goals are given in RD[13]. 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 mode and visitor mode observing
- a 2.6m VLT Survey Telescope (VST)
- a 4m Visible and Infrared Survey Telescope for Astronomy (VISTA)
- observatory infrastructure for technical support and for the accommodation of personnel.

The fact that the Unit Telescopes are also part of the VLT Interferometer is in several cases the reason for various requirements towards the VLT instruments.

3.1.2 VLT location

The Very Large Telescope 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 70 km of unpaved road. Width of the road is 6 m, load width ≤12 m and gradient ≤12%.
The coordinates of the telescopes are listed in table 1.

Telescope		Latitude	Longitude
Antu	UT1	-24° 37′ 33″	70° 24′ 12″
Kueyen	UT2	-24° 37′ 31″	70° 24′ 11″
Melipal	UT3	-24° 37′ 30″	70° 24′ 10″
Yepun	UT4	-24° 37′ 31′′	70° 24′ 08″

Table 1: Location of the four VLT Unit Telescopes

3.1.3 Environmental and observing conditions at Paranal

Information on the environmental conditions on Paranal is given in AD[1].
The statistical distribution of the seeing (500 nm) at zenith on Paranal, from data collected between VLT-Antu First Light (May 1998) and September 2004, is shown in Figure 1. Seeing is reconstructed from Differential Image Motion Monitor (DIMM) measurements taken 6 m above ground at 500 nm and zenith. VLT science images have shown that seeing at the UTs limited by the atmosphere is about 10% better than simultaneous DIMM estimates. More information on current conditions is available via the Paranal Astroclimatology web pages.

3.1.4 VLT site

The Paranal Observatory comprises three main locations: the Telescope Area at the summit, the "NTT Peak" with VISTA, and the Base Camp with the Residencia and Maintenance Areas. Base Camp and Telescope Area are separated by a distance of 3.4 km. The Telescope Area contains mainly the telescopes, the combined focus and interferometric laboratories, service laboratories and the Control Building.
The plan view of the Telescope Area of the observatory is shown in Figure 2.

3.1.5 Site infrastructure

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

1. Telescope Area:
   (a) The four Unit Telescopes and their enclosures
   (b) VLT Interferometer (VLTI) with auxiliary telescopes which feed the interferometric laboratory
   (c) The VLT Survey Telescope (VST)
   (d) The Control Building, separated from the telescope enclosures
   (e) Optical and electronics laboratories
   (f) Laboratory for instrument integration and tests (section 3.6.1)

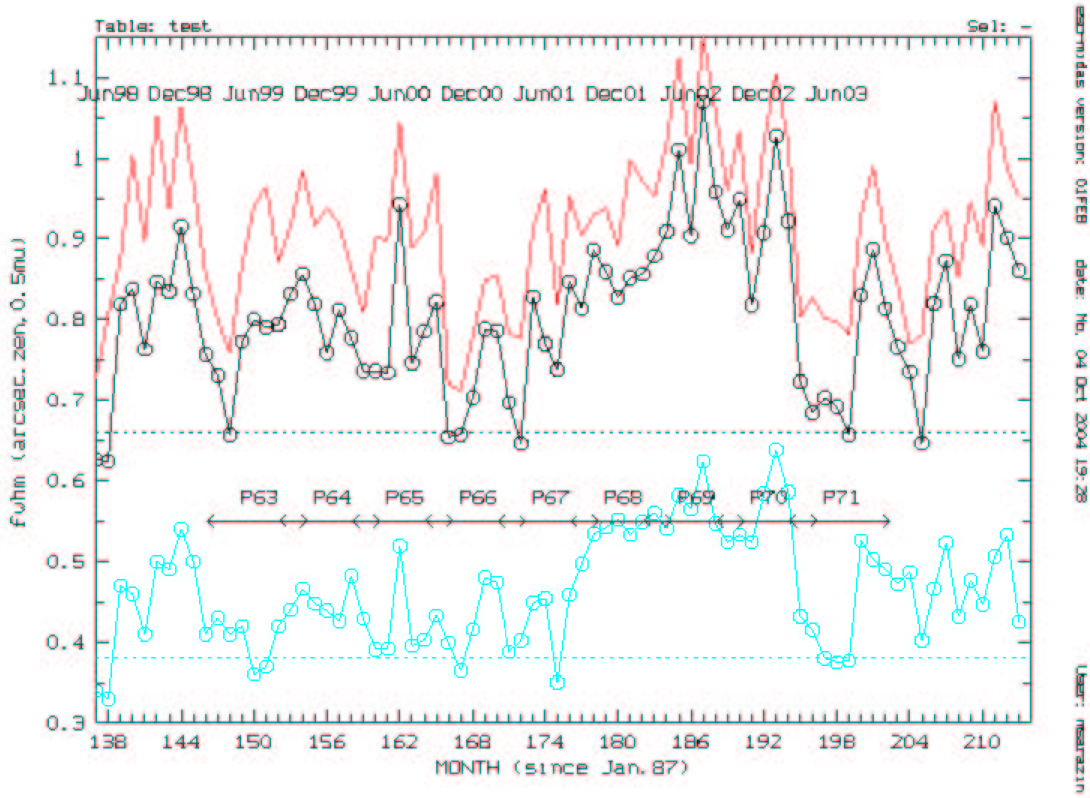

Figure 1: Statistical seeing distribution at Paranal since UT1 First Light. From top: monthly average (no symbol), monthly median (circles), long term (1989-1995) median=0.66″ (dashed line), monthly 5 percentile (grey circles), long term (1989-1995) 5 percentile=0.38″ (dashed grey). See text.

   (g) Time Reference System and Astronomical Site Monitors (section 3.5.2)
   (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. No provisions are made for the supply of liquid Helium, and its use is considered incompatible with operations of Cassegrain instruments.

3. Residencia:
   (a) accommodation for site personnel and visitors (visiting astronomers, instrument teams); in case the Residencia's capacity is exhausted visitors will have to be transferred to containers.
   (b) Restaurant and recreational rooms

4. General services:

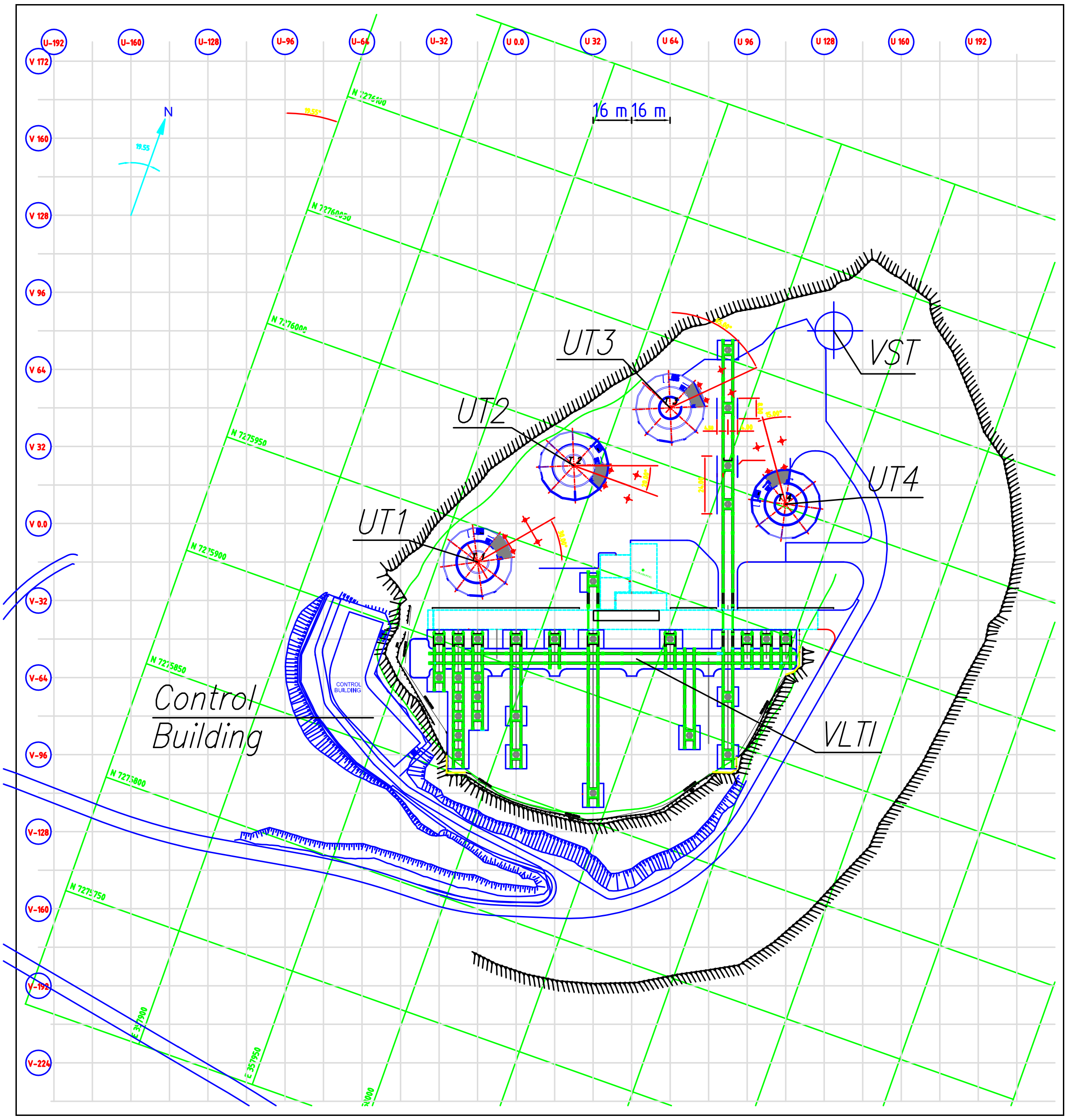

Figure 2: Plan of the Telescope Area of the Paranal Observatory

(a) On-site technical personnel. For VLT instruments, the observatory technical staff is able to carry out planned maintenance operations (including e.g. the exchange of filters, grisms etc.), emergency repairs and the filling of dewars where necessary (section 8).

(b) Standard vehicles for the handling of equipment and transportation of personnel (section 3.6.2)

3.1.6 VLT observing

An overview of the way of observing with the VLT, including the complete cycle from proposal preparation through to the final data release, is contained in the most recent VLT Call for Proposals. This includes information on and references to the Phase 2 Proposal Preparation and the corresponding software tool P2PP (see RD[14]).

3.2 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.

3.2.1 VLT Optics

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 nominal optical design data of the Cassegrain and Nasmyth foci are given in tables 2 and 3, respectively. **The optical design of an instrument shall use the values given in RD[15]** where the optical design parameters for the UTs are given. All VLT mirrors have been manufactured within these specifications.

Parameter		value	
Entrance pupil diameter		8115.0	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[15]

3.2.2 Optical image quality

The unit telescopes at Nasmyth are of classical Ritchey-Chretíen (RC) design and therefore have field astigmatism. At Cassegrain they deviate from the RC design and in addition to field astigramtism suffer from field coma.

The telescopes are 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

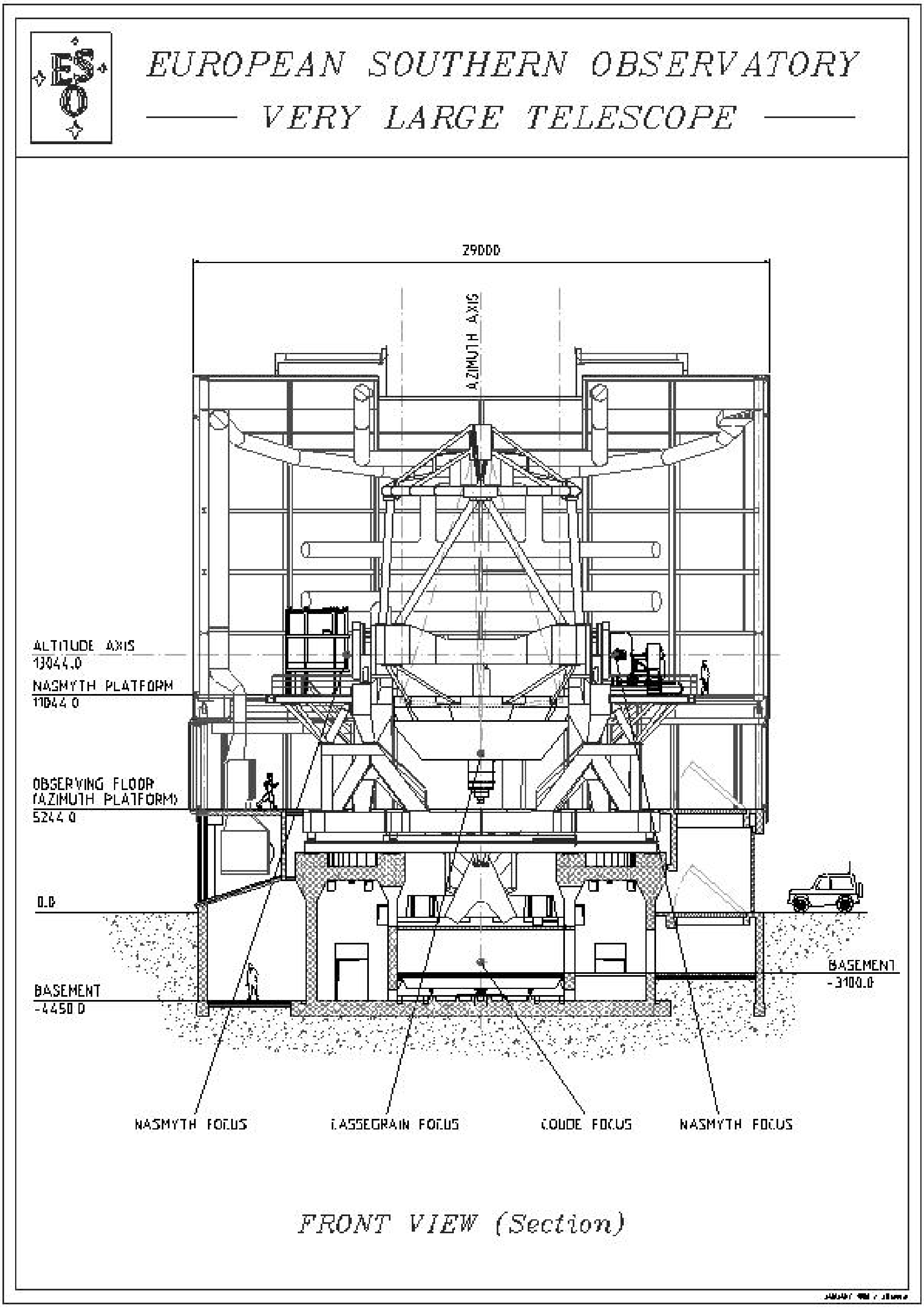

Figure 3: Front view of a Unit Telescope

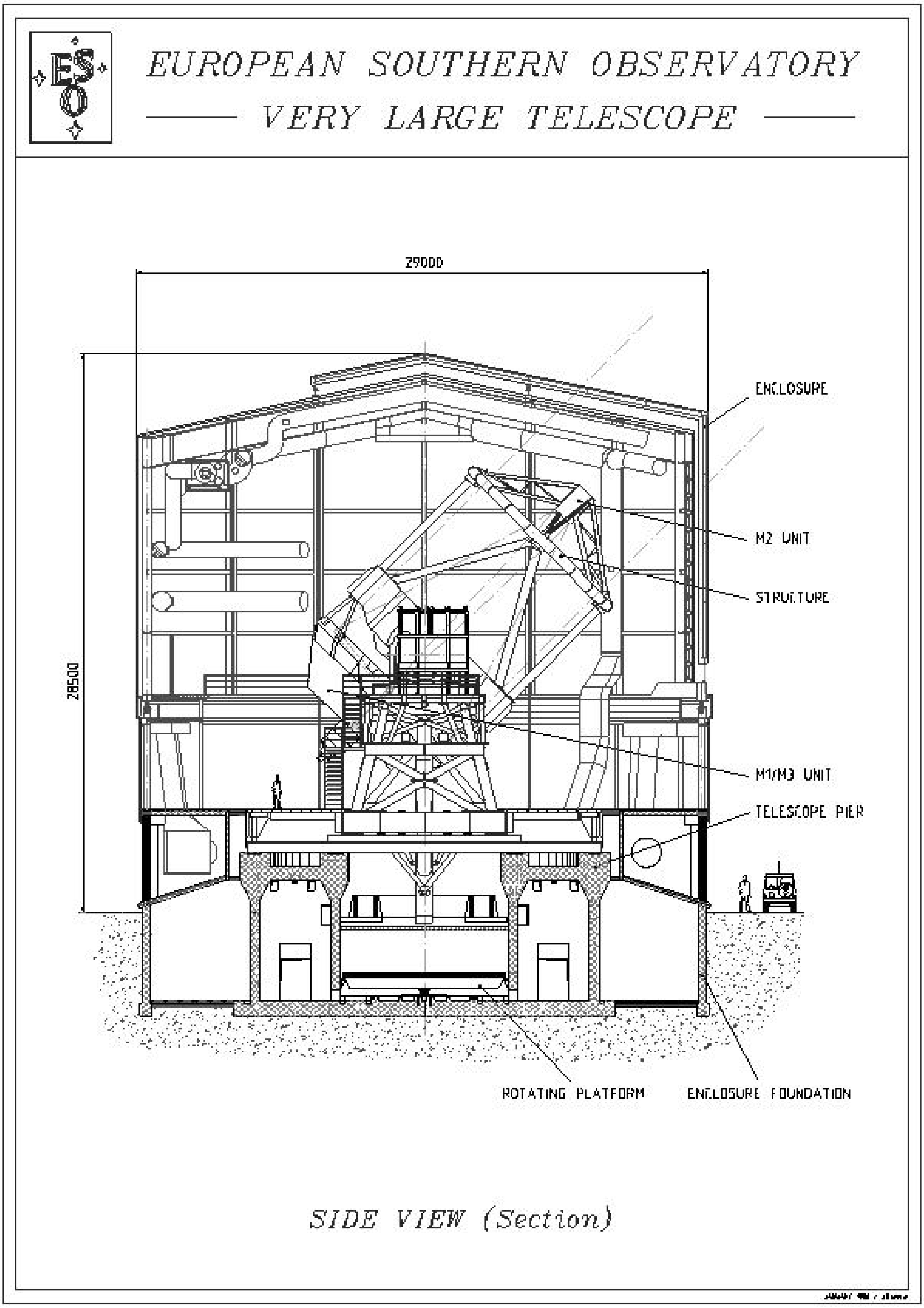

Figure 4: Side view of a Unit Telescope

Parameter		value	
Entrance pupil diameter		8000	mm
Focal ratio		15.000	–
Focal length		120000	mm
Object field of view	total	30	arcmin
	unvignetted	7.15	arcmin
	vignetting (10′ dia. field)	0.31	%
	vignetting (20′ dia. field)	2.14	%
Image field of view	total	1043.8	mm
	unvignetted	249.6	mm
Image scale	slightly field dependent	582	μm/arcsec
Radius of image curvature	concave towards M2	2089.6	mm

Table 3: Nasmyth focus optical parameters. For details see RD[15]

errors. The performance is achieved in field stabilization mode with active optics in closed loop. The image quality is then limited by the seeing. There is no provision for operating the telescopes in any other mode and no performance specification is applicable when these criteria are not met.
The field of view may be partially obstructed by the shadow produced by the adapter sensor arm (see section 3.3.5).

3.2.3 Telescope transmission and emissivity

The primary and tertiary mirrors of the VLT UTs are recoated on average every 18 months. The secondaries which face down are cleaned and inspected but have not as yet needed to be recoated.
When freshly coated the mirrors have reflectivities above 90% at 670nm. Apart from the early degradation in the ultraviolet, the mirrors degrade mostly due to the deposition of dust which is grey. Typically after 18 months the primary and tertiary mirrors have a reflectivity of around 85% each.
The emissivity at the Cassegrain focus has lately been measured at 10μm with the VLT Imager Spectrometer for the Infrared (VISIR). According to these measurements the emissivity of the VLT-UT mirror surfaces is of the order of 3% each. For an infrared instrument with rigorous masking of the pupil at an intermediate cold stop the effective emissivity of the telescope (excluding sky and instrument entrance window) can be as low as 6% at the Cassegrain and 9% at the Nasmyth focus.

3.2.4 Light baffling

The Unit Telescopes are optimized for both optical and infrared spectral ranges. As a result they do not have conventional baffles. The pupil is determined by the secondary mirror which is designed to cover the 8 m aperture for the Nasmyth unvignetted field of view. The principal baffling must therefore be incorporated in the instrument optical design (see section 4.11).
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 which is usually controlled by the instrument via the observing templates should be limited to at most a few actions per night.

3.2.5 Field stabilization and chopping

The default operation of the VLT unit telescopes requires that the secondary mirror be used in field stabilization mode to remove the effects of wind shake. The same star is used for active optics wave front sensing and for the generation of field stabilization corrections. The magnitude of the guide star should be in the range $V = 12^m \ldots 14^m$, depending on its colour. Classical autoguiding is also available at the VLT (i.e. not sending the corrections to the secondary mirror but rather to the main axes of the telescope). This option does not change the magnitude limits for the guide star (as it is also used for wavefront analysis) and does not remove the effects of the wind shake. Details of this issue should be discussed with ESO.
The secondary mirror may also be used for chopping.
At chopping frequencies lower than 0.5 Hz it is possible to use field stabilisation mode simultaneously with chopping during the stationary periods of the chop cycle. The range of parameters for chopping is given in table 4. See section 4.14 for the chopping control by the instrument.

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 4: Chopping parameters

3.2.6 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 Dec of the offset to achieve the specific aim of nodding.

3.2.7 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° (horizon) and 93°. This range of motion is required for access to areas of the telescope during routine maintenance. **It is therefore necessary that Cassegrain instruments also be immune to problems over this whole range. Moreover, all instruments shall be able to operate over this entire range of elevations for periods**

up to 8 hours without requiring maintenance[1]

3.2.8 Pointing, off-setting and tracking accuracy

The telescope pointing accuracy is of the order of 2″ RMS in routine operations. Offsetting accuracy of 0.1″ RMS is achieved for cases where the same guide star is recovered. Offsets that require a change of guide star will recover the pointing to 0.1″ RMS plus the differential error in the astrometry of the two guide stars.
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 1° in radius.

3.3 The Adapter/Rotator

3.3.1 General function

Each adapter/rotator comprises two separate functional units: the adapter and the rotator. These form a single sub-assembly called the Adapter/Rotator the basic functions and performance of which are described in this section.
The rotator forms the mechanical interface between the instrument 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 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. To illustrate the design principle, Figure 5 shows a cross section of the Cassegrain adapter/rotator. Note that in this view the light from the telescope comes from *below*. Details are given on ADWG-C4 and ADWG-N1+2.
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 stabilisation, and the second for wavefront sensing for the active optics system. The beam-splitter directs wavelengths in the approximate range 600 − 700nm towards the acquisition/guide sensor (AGS); the remaining part of the spectrum is sent to the wavefront sensor (WFS). The sensor arm is schematically shown in Figure 6.

[1] This includes the refilling of the instrument or the detector cryostat with LN_2, as the instrument is unreachable while the telescope is horizontal.

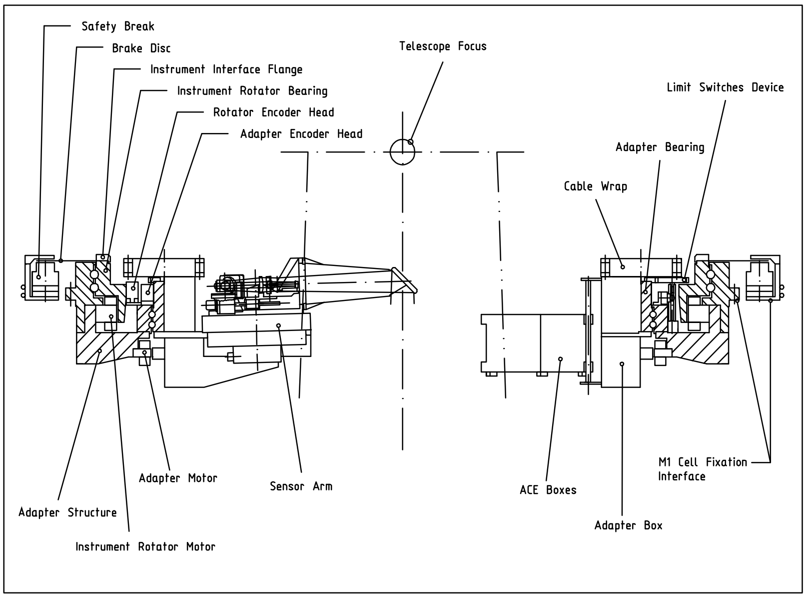

Figure 5: Cross section of the Cassegrain adapter/rotator. Note that in this view the light from the telescope comes from below. The design principles of the Nasmyth adapter/rotator are the same, the dimensions differ.

3.3.2 Field acquisition

In acquisition mode the adapter pick-up mirror is positioned on the telescope axis to relay the central part of the 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 (Cassegrain): 109 μm/arcsec ($\approx$ 5 pixels/arcsec)
4. Sensor image scale (Nasmyth): 116 μm/arcsec ($\approx$ 5 pixels/arcsec)
5. Sensitivity: magnitude $m_V \approx 21$ under average conditions and 1 s integration.
6. Frame refresh rate: 2 Hz for full frame, correspondingly faster for partial or binned readout.

3.3.3 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 normally 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 3.2.2 is applicable to guiding mode.

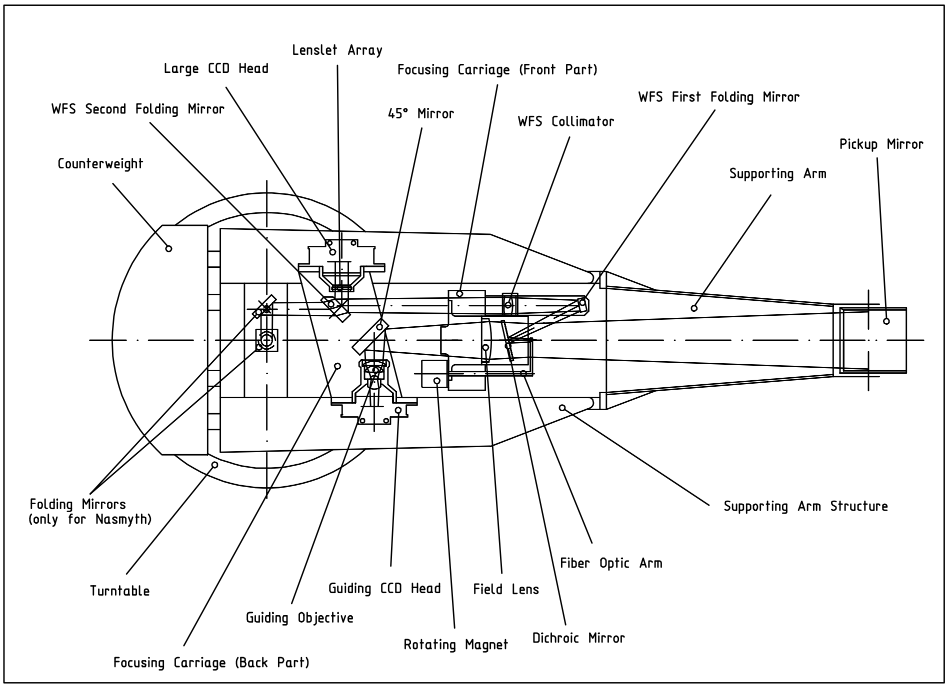

Figure 6: Schematic view of the adapter sensor arm.

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[2]. This selection takes into account a defined unvignetted field (see section 3.3.5). Observers may specify in the observation block 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 as 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 has 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 3.2.2.

[2]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 4.13).

3.3.4 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 3.3.3.
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.*

3.3.5 Shadow from the sensor unit

The adapter sensor arm shadows a part of the telescope field of view. The shadow patterns in the Cassegrain and Nasmyth focal planes have similar shapes but different dimensions, see figure 7, 8 and table 5.

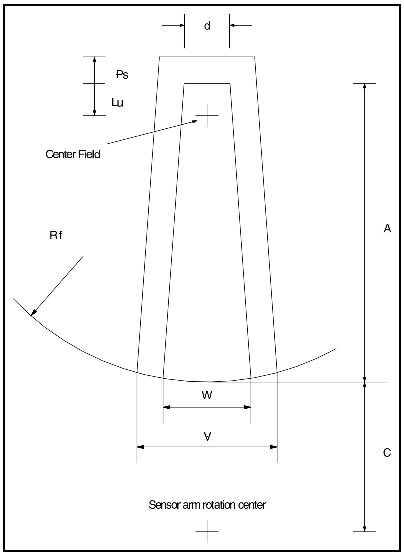

Figure 7: Guide-probe shadow in the Cassegrain focal plane. See table 5 for the dimensions.

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 Telescope Co-ordination Software (TCS) setup 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 prefers a guide star which does not cause vignetting of this area.

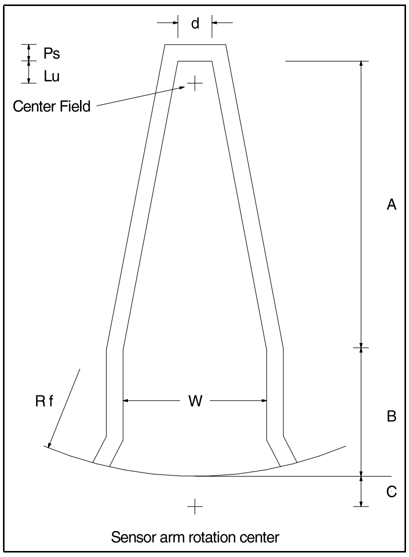

Figure 8: Guide-probe shadow in the Nasmyth focal plane. See table 5 for the dimensions.

In the case where all available guide stars cause vignetting of the field of view the operator may overrule the control system and demand a particular guide probe setting. The telescope database reflects the fact that the probe is vignetting the field of view and the instrument should notify the user, usually by a check in the observing template, 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.

3.3.6 Compensation of field rotation

To compensate for field rotation the position angle of the rotator (upon which the instrument is mounted) is continuously adjusted.
RD[16] gives details on the rotation of the field and pupil images at the VLT Cassegrain and Nasmyth foci 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 or Nasmyth field due to field rotation during a 1 hour exposure does not exceed 0.1 $''$.
The rotator can rotate without limit in either direction. Note that a rotation of 580° at Cassegrain and 640° at Nasmyth 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 the motion of the rotator under specific circumstances (see section 4.19.1 item 1(e) for a related safety advice).

3.3.7 Maximum angular velocities and accelerations

Full details on the rotational tracking velocity and angular acceleration for VLT instruments as a function of telescope position are also given in RD[16]. The maximum rates, at a zenith

		Cassegrain	Nasmyth
A	guide probe geometry (approx.)	266 mm	382 mm
B	guide probe geometry (approx.)	–	167 mm
C	guide probe geometry (approx.)	133 mm	40 mm
R_s	radius of sensor rotation axis	371 mm	560 mm
Rf	field radius	237.2 mm	521.9 mm
W	width of umbra at the field edge	78 mm	190 mm
V	width of penumbra at the field edge	124 mm	–
d	width of umbra at guide probe tip	41 mm	45 mm
		$7.5'$	$15'$
P_s	length of penumbra at guide probe tip	24 mm	22 mm
		$0.76'$	$0.63'$
L_u	length of umbra beyond field centre	28 mm	29 mm
		$0.88'$	$0.92'$

Table 5: Dimensions of the shadow (umbra and penumbra) of the guide probes in the Cassegrain and Nasmyth foci. See figures 7 and 8, resp.

max. angular tracking velocity	$25'$/sec
max. angular tracking acceleration	$8''/sec^2$
max. slewing speed	$7.5°$/sec
max. angular slewing acceleration	$1°/sec^2$
max. deceleration (emergency braking)	tel. structure: $10°/sec^2$
	rotator: $12°/sec^2$

Table 6: Maximum angular velocities and accelerations to be sustained by VLT instruments. Emergency braking refers to maximum instrument load attached. Values are valid for Cassegrain and Nasmyth foci.

distance of 0.5°, are given in table 6.

3.3.8 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 4.7) to allow for insertion or removal of pre-slit optics, for example. The adapter sensor arm contains a separate focusing mechanism that also compensates for the curvature of the focal plane as it moves across the field.

3.3.9 Cassegrain focus 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 location of the screen is given on Applicable Drawing ADWG-C1 (appendix A). The space between the instrument and the calibration screen is light tight; calibrations can be performed during daytime even when the lower lights are switched on in the enclosure. See section 4.10.

3.3.10 Nasmyth focus calibration screen

The telescope provides covers to protect the Nasmyth adapters and instruments against dust, mechanical damage, and strong illumination. These covers consist of roller-blind shutters on the inside of each altitude bearing shaft at a distance of 2.56m from the focal plane. On the instrument side of these shutters, an area larger than the telescope beam is painted with a white diffusing paint to form a screen that can be illuminated by calibration sources.

3.4 The telescope and instrument control systems

The VLT control system has been designed with the concept that the TCS (Telescope Coordination Software) is a subsystem of the instrument.

3.4.1 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 9. More information on the configuration of the system are given in RD[17].

3.4.2 Local Control Units

Each VLT instrument is controlled by one or more dedicated Local Control Units (LCU) which are linked to the overall system via a LAN. The LCU(s) form an integral part of the instrument, 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 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.
Instrument detector systems like CCD systems or infrared arrays normally have their own separate LCU.

3.4.3 Local Area Networks

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 9 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

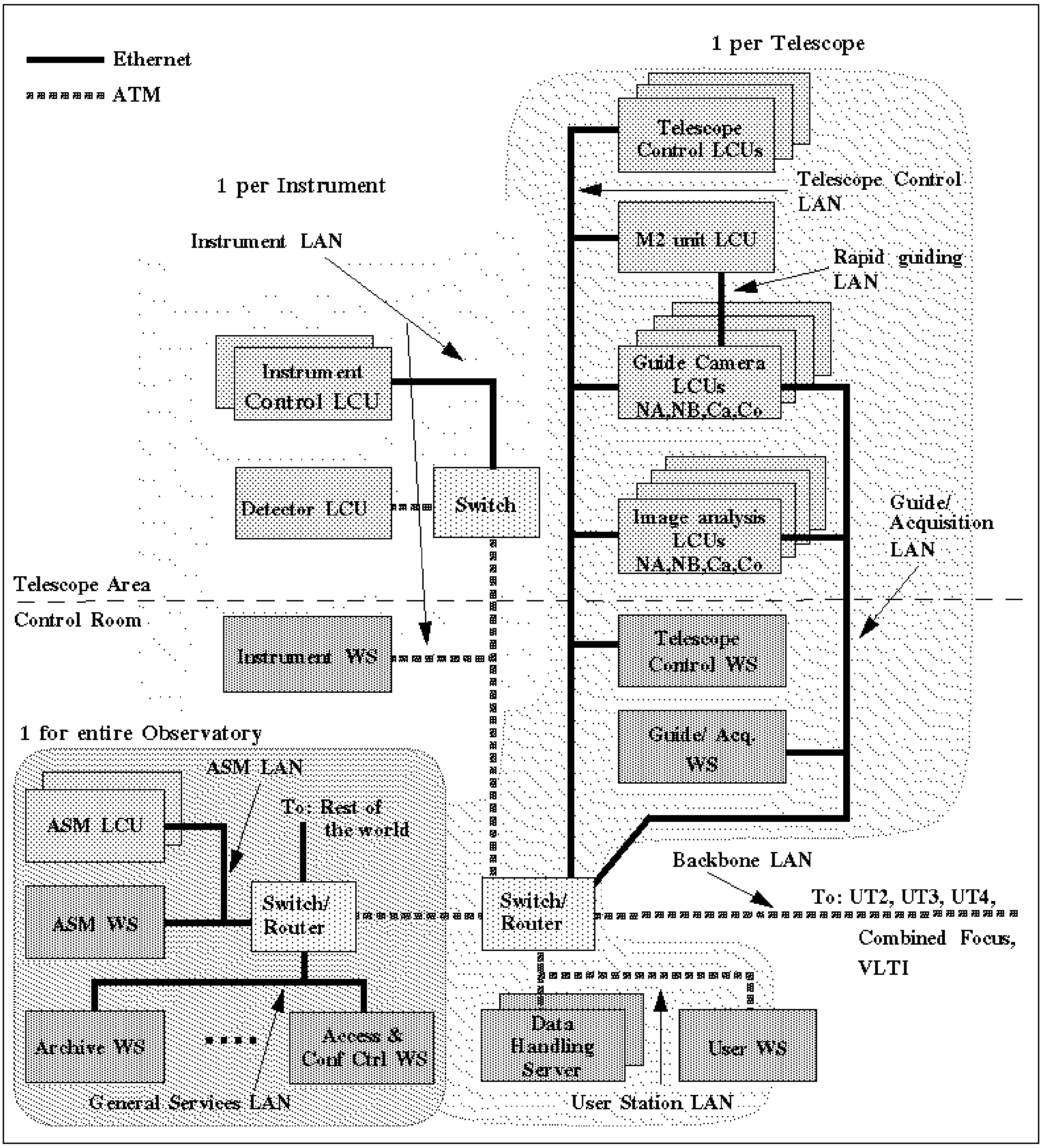

Figure 9: Logical lay-out of the VLT LANs

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.
In general, each VLT instrument is operated from one workstation called Instrument Workstation (IWS), and connected to the instrument LCUs through one LAN. 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 [17].

3.4.4 User interface

The interface between the observer and the instrument is the User Workstation (UWS). It normally consists of a workstation with double screen console, acting as display server for the Graphical User Interface (GUI) applications running on the IWS, and optionally a set of auxiliary terminals, if needed by an instrument. No control software is supposed to run on the UWS. The whole control software runs on the IWS. In a development/integration/test environment, the functionality provided by the IWS and UWS can be merged into one single workstation.
The telescopes are operated from separate but similar workstations, called Telescope Workstations (TWS). The on-site UWS, IWS and TWS for all VLT unit telescopes and the VLT Interferometer are located in the Control Building close to but separate from the telescope enclosures.

3.4.5 Software

Because of the open system architecture of the VLT control system and the many different contractors producing software for VLT sub-systems, a high degree of software standardization is necessary to guarantee homogeneity, maintainability, and to establish well defined software interfaces between the various components and sub-systems. All software written for the VLT and instrumentation must therefore conform to defined standards for the overall software environment, including the system architecture, operating systems for the LCUs and Workstations, programming languages, communication protocols, programming methodology and software engineering standards. In addition, in order to accurately monitor modifications and upgrades, a formal software configuration control procedure has been implemented. These requirements and specifications are referenced in section 5.

3.5 Other observatory services

3.5.1 Time Reference System

The Paranal 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 3.4.3). 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.

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	±20%
Satellite Sky Monitor			
Cloud cover (all sky coverage)	Phot/Variable/ Cloudy/Overcast	3 hr	90 % hit
Precipitable water vapour (all sky coverage)	mm H_2O	3 hr	1 mm RMS
Line Of Sight Sky Monitor			
RMS Atmospheric Extinction	rel. flux variation, %	10 min	±10%
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 (0 ... +36h)			
Ground air temperature at 30m	°C	6 hr	1° C RMS
Ground air pressure at 2.5m	mb	6 hr	1 mb RMS
Wind velocity at 10m	m/s	6 hr	3 m/s RMS
Wind velocity at 200mb=12km	m/s	6 hr	5 m/s RMS
Cloud cover (all sky average)	Phot/Variable/ Cloudy/Overcast	3 hr	80 % hit
Precipitable water vapour (all sky average)	mm H_2O	3 hr	1.5 mm RMS

Table 7: Parameters available from the Astronomical Site Monitor

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.

3.5.2 Astronomical Site Monitors

The observatory operates 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. Some of the parameters currently available from the ASM are given in table 7 as well as some parameters delivered by the experimental Prediction Unit. The complete ASM data dictionary of fits keywords is available in the ESO Science Archive at `http://archive.eso.org/DICB/`.

3.6 Instrument handling

3.6.1 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 exact place and schedule of the instrument integration at Paranal will be decided by ESO, in close coordination with the instrument consortium.
The ATH offers a 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, clean room facilities and the availability of LAN and Telescope Co-ordination Software (TCS) for test purposes. Instrument integration in the ATH requires however 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 3.6.2)). Instrument integration in the ATH requires close coordination of the schedule with the needs of the Auxiliary Telescopes and therefore strict adherence to the assigned time slot.
Facilities available for instrument integration in the ATH include

1. space: a floor area of up to 10×20 m^2. Height >10 m.
2. access door: width >7 m, height >10 m
3. a horizontal flange identical to the instrument attachment flange of the Cassegrain rotator of the UTs (load capacity 2.5 t, flange distance to the floor 3050 mm) can be made available. The flange can be rotated by hand but cannot be tilted. Attachment points for lifting the instrument identical to those on the M1 cell are also available with the same load capacity of 2.5 t. The exact location of this stand will be determined in coordination with Paranal Engineering.
4. a vertical Nasmyth mounting flange load capacity 3 t, Its use requires the written agreement by ESO.
5. overhead crane, see section 3.6.2
6. standard Service Connection Point (SCP) with electric mains and LAN connection (see section 4.19.1).
7. filtered compressed air
8. additional small mobile cooling unit
9. 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.
10. TCS
11. access to the clean-room 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 6.7×13.5 m^2

2. a flange identical to the instrument attachment flange of the Cassegrain rotator of the UTs, load capacity 2.5 t, flange distance to the floor: 3050 mm. It can be rotated by hand but cannot be tilted. Attachment points for lifting the instrument identical to those on the M1 cell are also available with the same load capacity of 2.5 t. The exact location of this stand will be determined in coordination with Paranal Engineering.

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

4. size of access door: 3.1 m × 3.0 m (width × height)

5. overhead crane, see section 3.6.2

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 authorisation. **Instrument teams shall discuss and agree with ESO well before the planned start of instrument integration on Paranal which facilities to use.** This is to ensure that there are no conflicts between different teams in the use of the rooms, laboratories and handling equipment.

3.6.2 Instrument transport

Having being assembled and tested the instrument is transported to the telescope (about 3.4 km from the ATH, about 0.5 km from the Control Building). Normally the instrument trailer (see below) is used to carry the instrument on its carriage. When entering the telescope building the instrument mounted on its carriage (and, if applicable, any associated equipment) must pass through the following:

1. the telescope enclosure main entrance door: 3.6 m × 3.9 m (width × height). Note that the clearance is reduced by the height at which the carriage with the instrument is transported (e.g. the height of the instrument trailer is approximately 0.3 m). Details of the transport into the enclosure should be discussed well in advance with ESO.

2. the enclosure trap door: 3.4 m × 3.2 m with small obstructions (0.8 m × 0.2 m each) in two corners.

Details are given in ADWG-C3 (see appendix A). Normally the enclosure crane (see below) is used to lift the carriage together with the instrument (or, in the case of major Nasmyth instruments, its major parts) through the trap door to the azimuth platform or directly onto the Nasmyth 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 at the time of the Final Design Review.**

For smaller items the enclosure lift can be used. It can handle loads of up to 1.2 t, the cabin inner dimensions are 2.0 m × 1.4 m × 2.1 m (length × width × height); the doors (two sided access) have a free passage of 1.4 m × 2.0 m (width × height). This lift connects all levels of the enclosure: the basement (coud/'e level), the ground floor, the azimuth platform (Cassegrain area) and the Nasmyth level.

The Cassegrain area of the telescope is accessible from the azimuth platform. ADWG-C3 shows the azimuth floor layout together with the present fixed installations and its allowed floor load.

Standard access to the Nasmyth platforms is from the azimuth floor by means of staircases. See ADWG-N3.

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

1. Medium fork lift, motorized
   Safe Working Load (SWL) = 3.5 t at 0.5 m and 1.5 t at 1.0 m from the fork base
2. Small fork lift, hand operated
   SWL = 2.5 t at 0.5 m, normally located at Mirror Maintenance Building (MMB)
3. ATH overhead crane
   SWL =10 t, maximum hook height >5 m
4. UT enclosure crane, one in each telescope enclosure
   SWL = 5 t; for the operating range see ADWG-C3. Travel and hoist speeds are:
   (a) "Long Travel" (radial) speed = 2000 mm/min (fast), 200mm/min (slow)
   (b) "Cross Travel" (tangent) speed = 2000 mm/min (fast), 200mm/min (slow)
   (c) Hoist speed = 5000 mm/min (fast), 100mm/min (slow)
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. Truck including crane.
   Crane: mounted at the rear end of the platform. Its SWL is 3 t at 3 m
   Platform: height ∼1.2 m, length = 5 m, width is standard truck size, load capacity 7 t
7. 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
8. Cassegrain carriage (2 copies) designed for the FORS instruments and the Cassegrain mass dummy; its use requires special permission by ESO and it is not permitted to make any modifications or additions which would have an impact on their original design purpose.
   Special interface, SWL = 2.5 t; it requires suitable overhead attachment points for lifting the instrument.
9. Mobile air cushion system; its use requires special permission by ESO
   special interface, SWL 4× 15 t.
10. Enerpac roller system; its use requires special permission by ESO
    special interface, SWL 20 t
11. For special handling or access requirements an "aerial work platform" is available inside the telescope enclosures. Its location is indicated on ADWG-C3. Persons wishing to use it need to undergo a training session and checkout. Therefore it is usually easier and more efficient if for short use this platform is driven by Paranal engineering staff. Its use requires therefore special permission by ESO.

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 4.17.
In addition all basic devices (ropes, chains, shackles etc) necessary to move or secure loads up to 10 t are available. It is however recommended that instrument teams check with ESO which devices are needed and possibly bring their own set.

3.6.3 Instrument installation

Installation of the instrument at the focus takes place using the carriage supplied with the instrument.
Note that for any installation activities for a Cassegrain instrument the telescope must be mechanically locked in zenith position. Furthermore the telescope cannot be moved in altitude before it is properly balanced, and is therefore not operational. Both locking/unlocking and balancing are done by Paranal engineering staff.
The detailed planning of all installation activities, including schedule and required resources (manpower, equipment), shall be closely coordinated with ESO.

4 Requirements for VLT Science Instruments

The design requirements and interface specifications for VLT scientific instruments are given in this section. Where necessary, the requirements are given separately for Cassegrain and Nasmyth instruments.

4.1 General requirements

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

4.2 Instrument concept

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.
Note that due to the location below the main mirror cell Cassegrain instruments will be routinely (i.e. at least once per year) dismounted from the telescope, e.g. every time the main mirror is removed for re-aluminisation, or in case access to the Cassegrain adapter/rotator is necessary for maintenance or repair.
Instruments at the Nasmyth foci must likewise allow access to the adapter/rotator in case it needs servicing; for details see section 4.9.2.
Nasmyth instruments may be re-assembled after the transport from Europe directly on the assigned Nasmyth platform, or pre-assembled in one of the integration facilities (section 3.6.1).

4.3 Instrument attachment

4.3.1 Cassegrain instruments

All Cassegrain instruments shall be attached directly to the Cassegrain rotator.
Details on the Cassegrain rotator flange and the allowable space are given in ADWG-C4, for the dis-/mounting operation see section 8.4.2.
To allow an unambiguous orientation and a high reproducibility for the mounting of the instrument, the instrument flange of the rotator provides 3 precision pins separated by 90°; their locations and dimensions are also given in ADWG-C4. In case an instrument does not require a high reproducibility of the mounting on the rotator flange it is recommended to leave three oversized holes in the instrument attachment flange. In case an instrument does require a high reproducibility it is recommended to provide two holes equipped with an adjustment device (e.g. designed according to Figure 10) which is locked when the instrument is mounted on the flange for the first time.
Four attachment plates are available at the bottom of the M1 cell for use with auxiliary equipment by Cassegrain instruments. Their locations and further details are given in ADWG-C2. 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; their details are also given in ADWG-C2. Their combined load capacity is such that they can be used for attaching a complete Cassegrain instrument during a mounting operation.

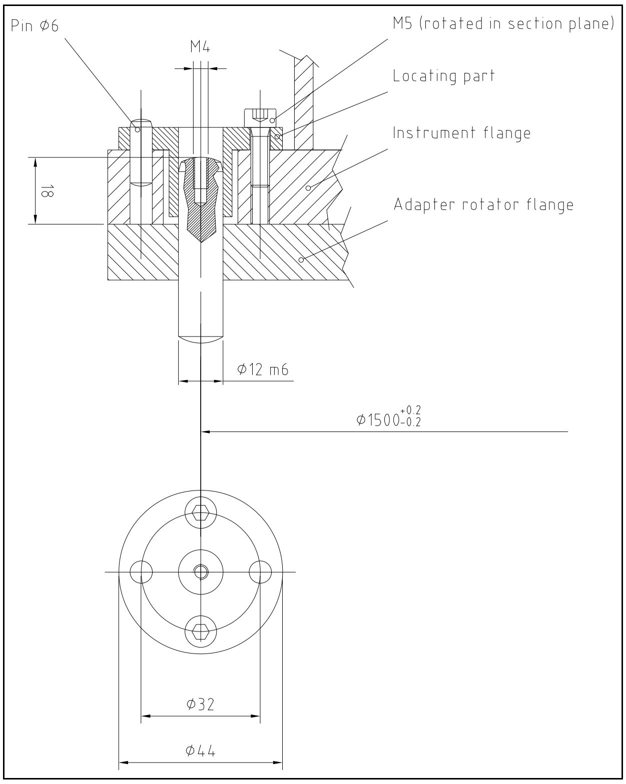

Figure 10: Proposed design for a reference pin adjustment device

4.3.2 Nasmyth instruments

Nasmyth instruments shall be either attached directly to the Nasmyth rotator or to the Nasmyth platform independently of the rotator.
Instruments attached to the rotator shall be compatible with the mounting flange specified on ADWG-N[1,2].
Instruments attached directly to the platform, as well as all instrument related equipment such as electronic cabinets, shall be anchored to the Nasmyth platform using the threaded holes specified on ADWG-N3. These holes are located on the load-bearing beams of the platform.

4.4 Use of the Azimuth platform by Cassegrain instruments

The Azimuth platform may be used for the temporary location of transport, handling and test equipment during the installation of Cassegrain instruments and for access for test and maintenance purposes.

4.5 Use of the Nasmyth platform

Apart from instrument attachment, the Nasmyth platform may be used for the installation of independent ancillary equipment associated with instruments, for example control electronics, thermal enclosures, etc. **Such items shall be designed in such a way as to allow them to be installed and removed in as few units as is practicable.** For example, **any electronic units not attached directly to the instrument shall be mounted in a free-standing cabinet with the minimum of interconnecting cables between the cabinet and the instrument. All such items shall be anchored to the platform**

using standard fixation holes indicated on ADWG-N3, or an alternative arrangement with the written agreement of ESO. Note the requirements in section 4.16 on vibration isolation and section 4.19.2 on cabling). The Nasmyth platform may also be used for the temporary location or transportation and test equipment during the installation and commissioning of Nasmyth instruments. These items do not need to be anchored to the platform. The platform may also be used for personnel access for test and maintenance purposes. It is however not accessible during observations.

4.6 Deflection of the Nasmyth platform under load

The mechanical deflection under load of the Nasmyth platform does not exceed the following limits:

1. Operational loads:
   An operational load of 80 kN equally distributed over four points – two points on each threaded hole axis (ADGW-N3) separated by a distance of 2.5 m in the direction of the altitude axis – will not cause a vertical deflection of the support points of more than 0.1 mm. Under the 80 kN operational load mentioned above, an additional load of 1500 N anywhere on the platform will not cause an average vertical deflection of the 4 support points of more than 0.02 mm.

2. Maintenance and installation loads:
   Under a maximum load of 6000 N/m^2 distributed over the platform area plus an additional point load of 25 kN anywhere on the platform, the vertical deflection will not exceed 2 mm at any location on the platform. Under a maximum point load of 50 kN anywhere on the axis of the threaded holes, the platform vertical deflection will not exceed 0.2 mm.

4.7 Focus position

The focal plane of instruments attached directly to the rotator shall be located at a nominal on-axis Back Focal Distance (BFD) of 250 mm from the rotator instrument mounting flange. The adapter sensor arm focusing mechanism can accommodate on-axis BFD in the range 215 – 255 mm.

The nominal height of the optical axis above the floor of the Nasmuth platform is given in ADWG-N1,2,4,5. At the individual Nasmyth foci this height may deviate from the nominal value. The actual value will be communicated by ESO when the instrument is assigned to a certain focus station.

4.8 Mass and torque limits

4.8.1 Cassegrain instruments

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.

It is explicitly not permitted, also and especially not during instrument commissioning, **that the instrument weight and its hardware configuration be modified after the instrument is mounted and the telescope balanced, without prior permission by the UT Manager**[3].

4.8.2 Nasmyth instruments

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

1. **The total mass attached to the instrument rotator shall not exceed 3000 kg.**

2. **The moment applied to the instrument rotator with a moment vector perpendicular to the optical axis, at any telescope altitude, shall not exceed 30 kNm.**

3. **Instruments attached to the instrument rotator shall not apply a total moment to the instrument rotator flange due to imbalance and friction, with a moment vector parallel to the optical axis, exceeding 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 mechanical configuration, evaporation of cryogenic liquid, the weight and stiffness of cryogen transfer hoses, cable friction, etc.

4. **The maximum mass of instrument equipment attached to the Nasmyth platform shall not exceed 8000 kg. This limit may not be exceeded without the written agreement of ESO. The maximum platform loading during installation and maintenance operations shall not exceed that defined in Section 4.6**.

5. The mass limits of the rotator and the platform are independent.

4.9 Overall dimensions

4.9.1 Cassegrain instruments

Cassegrain instruments, and any associated ancillary equipment such as electronics cabinets, cooling equipment and thermal enclosures, shall not exceed the space envelope allocated for Cassegrain instruments in ADWG-C1.

[3] An example is the removal of an electronic rack

4.9.2 Nasmyth instruments

Nasmyth instruments together with all associated ancillary equipment such as electronics cabinets, cooling equipment and thermal enclosures, shall not exceed the overall space envelope specified in ADWG-N3. Note that, although there is no explicit limit to the instrument height above the Nasmyth platform, instruments should not extend beyond 4 metres above the Nasmyth platform floor.
A passageway next to the staircase must be permanently kept free on the Nasmyth platforms. In addition it must be possible to remove any instrument related equipment from an area in front of the adapter/rotator to allow access in case the adapter/rotator needs servicing or needs to be removed completely. Details about the location and size of these "red carpet areas" are given on ADWG-N3.

4.10 Calibration

4.10.1 Light Tightness

Calibration of VLT scientific instruments are generally performed during daytime. Nighttime calibrations are permitted only in exceptional cases and need explicit approval by ESO.
During daytime various activities are usually scheduled to take place inside the telescope enclosure, requiring varying levels of illumination. Therefore **instruments shall be designed and built to be insensitive to outside illumination** so that all kinds of calibrations (e.g. flatfield, wavelength calibration, bias exposures) can be performed without affecting or being affected by routine observatory operations. See sections 3.3.9 and 3.3.10.

4.10.2 Calibration Sources

All necessary 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 screens mentioned in sections 3.3.9 and 3.3.10 should also be integrated into the instrument where possible.
Cassegrain instruments only: 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 for Cassegrain instruments. The location of these fixation points is shown in ADWG-C4.
Externally mounted lamps may only be used if the use of integrated calibration lamps is proved to be impractical, 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 consortium. The control of such lamps will be defined on a case-by-case basis by ESO, in close coordination with the consortium.
The intensity of the provided calibration sources should be high enough to keep exposure times for calibration exposures reasonably short. The details and what is regarded as "reasonable" will be defined on a case-by-case basis. **Note that the calibration lamps should comply with the heat dissipation requirements** (section 4.18).

4.11 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 3.2.4 may be used to supplement the internal baffling.

4.12 Atmospheric dispersion compensation

The Cassegrain foci of two Unit Telescopes (currently the ones where the FORS1+2 instruments are mounted) are equipped with longitudinal atmospheric dispersion compensators (LADC, see RD[18]). They are controlled by the TCS. No provision is made at this time to equip the other two unit telescopes with a similar device.
If an ADC is deemed necessary for the particular type of observing envisaged with the instrument it shall be incorporated in the instrument itself.

4.13 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 offsetting the guide probe while the telescope is under the primary guiding loop.
Instruments requiring a secondary guiding sensor shall incorporate it in the instrument design. Performance and interfaces to the Technical CCDs normally used for this purpose are given in RD[19]. If suitable, the science detector of the instrument may also be used for this purpose.
The data interface between a secondary guiding system and the telescope control system will be defined by ESO in cooperation with the instrument team 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 observed object itself could be used as position reference or another object very close by, thus allowing the errors due to non-isoplanarity 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. **The direct use of the rapid guiding by the instrument rather than the telescope must be agreed upon by ESO already during the design phase.**

4.14 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, see section 3.2.5), 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 uses the information to synchronize control and data taking. The set-up procedure for the M2-unit allows the chop transition time to be accurately ascertained and accounted for.

4.15 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 causes a motion of the telescope pupil with respect to the instrument pupil. The maximum tilt of the axes does not exceed 2 arcminutes. **If this is considered as a serious problem, a pupil motion control shall be included in the instrument.**

4.16 Vibration

All equipment attached to the telescope or installed on the Nasmyth or Azimuth platforms 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.

4.17 Instrument handling and storage

4.17.1 Cassegrain instruments

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 given in ADWG-C1.
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. In addition, the M1 cell provides supports (detail "U" on ADWG-C2, combined load capacity of 2.5 t) for assisting the mounting and dismounting of Cassegrain instruments.
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. The requirements for earthquake and other safety aspects apply to these devices, especially when they support the instrument. 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.
A list of standard handling and transportation devices that are available at the observatory is given in section 3.6.2. **Any additional handling, transportation or adaption devices necessary for the instrument shall be provided with the instrument.**
Major instrument carriages shall be certified for compliance with applicable safety regulations by an approved agency (TÜV or equivalent).
Instruments that are not otherwise protected from dust ingression and mechanical damage when off the telescope shall be provided with protective cover.

4.17.2 Nasmyth instruments

The telescope Nasmyth Platform is normally accessed from a platform on the fixed part of the enclosure at the same level as the Nasmyth platform (as shown in Figure 3). Note that this enclosure platform can only access one Nasmyth platform at a time, and the telescope must therefore be turned through 180° in azimuth to go from Platform A access position to Platform B access position and vice versa. Both platforms can be reached at any time, however, by means of staircases on the telescope structure which go down to the Azimuth platform level (see Figure 4 and ADWG-N3).
The enclosure access platform is served by a lift as well as an additional staircase. The lift is suitable for carrying personnel as well as service equipment, its properties are given in section 3.6.2.
The enclosure access platform and the telescope Nasmyth platforms are protected by guard rails and sliding gates, see ADWG-N[4+5+6]. To transport bulky equipment onto the Nas-

myth platform, the gates and railings can be removed completely in sections. In this case **the corresponding Paranal lockout procedure shall be followed.**
Larger pieces of equipment can be brought into the enclosure via the main access doors at ground level. They are lifted onto the Nasmyth platform through the enclosure trap door using the enclosure crane. Details of the passages and the crane are given in section 3.6.2 where also the handling of exceptionally bulky equipment is mentioned.
All Nasmyth instruments mounted on the adapter/rotator shall be provided with a mechanism which allows to move the instrument on the Nasmyth platform, in particular to give access to the adapter/rotator (see section 4.9.2). Provisions shall be included for mounting the instrument on the rotator or platform. This mechanism shall use the rails available in the floor of the Nasmyth platforms (see ADWG-N3). It is mandatory that at least the "red carpet areas" (see 4.9.2 and ADWG-N3) can be cleared within 1 hour. A separate storage stand or base shall also be provided for the instrument when not attached to the telescope if the rail-based mechanism cannot fulfil this function.
Any handling, transportation or adaptation devices necessary for the instrument apart from the standard devices available on Paranal (section 3.6.2) shall be provided with the instrument.
Major instrument carriages shall be certified for compliance with applicable safety regulations by an approved agency (TÜV or equivalent).
If necessary, the main beams installed in the Nasmyth platform may be employed for the attachment of rails for instrument installation. The location of these beams is specified in ADWG-N3.
All instrument equipment that has to be lifted onto the Nasmyth platform using the enclosure crane must be provided with lifting eyes suitable for the purpose. Instruments that are not otherwise protected against dust ingression and mechanical damage when off the telescope shall be provided with a protective cover.

4.18 Thermal control

The maximum temperature difference between any exposed surface of the instrument (or of any associated equipment) and ambient shall be $\leq +1.5/\text{-}5.0^{\circ}$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, instruments and their associated control electronics may need active thermal control and have their exposed surfaces insulated. Instruments may make use of the telescope cooling system (see section 4.19.1) in order to meet the thermal environment requirements.

4.19 Electrical and fluid connections

4.19.1 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 RD[20]. The following sections provide an overview of the SCP connections and lists the principal interface requirements.

Cassegrain instruments: 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 connecting the Cassegrain instrument to the telescope service supplies during normal operations shall be connected to the SCP 1-N on the primary mirror cell.** The location of the Cassegrain instrument SCPs is given in ADWG-C2 and ADWG-C3.
Nasmyth instruments: Two SCPs are provided on each Nasmyth platform, one located on each side of the platform, for the connection of Nasmyth instruments. The SCPs on platform A are 15-N and 16-N, on platform B are 17-N and 18-N; N being the number of the Unit Telescope. **All cables and hoses connecting Nasmyth instruments to the telescope service supplies shall be connected via these SCPs.** The locations of the Nasmyth instrument SCPs are shown on ADWG-N[3+4+5].
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[3]. Safety is provided by FI circuit breakers with a typical rating of 30 mA. (Cassegrain: Note that the complete M1 cell electronics (i.e. M1/M3 LCUs including Cassegrain instrument) is depending on one such device.)
   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 [20].
   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.**
   - *Cassegrain instruments:* **The total average electrical power taken from the UPS outlets 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.**
   - *Nasmyth instruments:* **The total average electrical power taken from the UPS outlets by Nasmyth instruments shall not exceed 2 kW per SCP. The total average non-UPS electrical power shall not exceed 6 kW 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[4].**
   - **The requirements for the design and implementation of electronic equipment contained in AD[5] 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 are normally connected to the internal power distribution terminal blocks of the SCP.

(e) Local interlock connections
Each instrument SCP provides access to the 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 unit has 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 $\geq$ 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 is available to immobilize either all or particular parts (Altitude Axis only, Azimuth Axis only, Enclosure only) 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 3.4.2).
A connector is available on the lower surface of all instrument SCPs to allow the attachment of an extension cable for a remotely located Emergency 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.

2. SCP Part B: LAN connections

   (a) Local Area Network (see section 3.4.3)

SCP Part B allows the physical possibility of connection to the VLT LAN system. The allocation of the LAN connections for scientific instruments is specified by ESO for each individual instrument. The SCP fibre-optic cables are supplied from Network Access Points (see RD[17]) 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 3.5.1)
The TRS connectors and optical fibres are identical to those for the LAN given in the previous item.

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[4]. Such modifications can only be made by authorized ESO staff or person authorized by ESO.

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: ≥ 5 μm
- 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 maximum supply pressure: 6 bar
- Supply differential pressure: min 0.8 bar, max 2 bar
- Supply temperature: 8°C below ambient.[5] Despite all precautions the danger of condensation cannot be completely ruled out and **instruments shall not suffer damage from condensing humidity.**
- Cassegrain instruments: Maximum flow rate (per SCP): 12 l/min. 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 in cooperation with ESO.**
- Nasmyth instruments: Maximum flow rate (per SCP): 15 l/min. **The specific needs of the instrument shall be assessed in cooperation with ESO.**

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

[5] 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. During day time, "ambient" is the target temperature for the enclosure air conditioning system which corresponds to the estimated temperature for the start of the forthcoming night.

- 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 4.18 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 liters, as well as all equipment which is not self-purging, must be pre-filled with the appropriate cooling liquid before connection to the 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.**

It may be assumed that the reliability level of these services (and including LN_2 although it is not delivered from an SCP) is as given in table 8:

	First year of operation	Mature instrument
LN2 and 230 VAC mains	B	C
Water and 230 VAC UPS	C	D

Table 8: Expected frequency of instrument failures due to interrupts of various services.

where the frequency rating is given in table 9.

The actual reliabilty of these services - as delivered at unused SCPs - is at the C-D level, but experience with instrument commissioning and operation at Paranal (FORS1/2, ISAAC, UVES) has shown that during the first year of operation the reliability is lower due to a number of causes (design flaws internal to the instrument, interface issues that were not detected during commissioning, learning effects etc.).

A	Frequent	Likely to occur more than once per year
B	Probable	Will occur 6 to 10 times during the total lifetime
C	Occasional	Will occur 2 to 5 times during the total lifetime
D	Remote	Unlikely but possible to occur once during the total lifetime
E	Improbable	So unlikely that an occurrence can be assumed not to be experienced

Table 9: Rating of occurence of failures

4.19.2 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.
Cassegrain instruments: **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 (section 4.8.1).** 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. Where possible the four plates at the bottom of the main mirror cell (see ADWG-C2, detail C) should be used for attaching the Cassegrain instrument cable wrap.
Nasmyth instruments: **There shall be no loose cables crossing areas of the Nasmyth platform that will be frequented by observatory maintenance staff** (except cables of a temporary nature required for commissioning only). Note that access holes on the Nasmyth platforms are provided to allow cables and hoses from an instrument installed on the platform to pass underneath the platform to equipment installed along the sides of the platforms. See ADWG-N3 for details.
It is strongly recommended that Nasmyth instruments which are mounted on the adapter/ rotator use as a starting point the design of the motorized cable co-rotator as implemented for ISAAC, NACO and VIMOS. The final decision shall be taken in coordination with ESO. ESO will then make the complete design of this co-rotator available to the instrument team for individual adaptation if necessary.

4.19.3 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 AD[5].

4.19.4 Connections to equipment on the azimuth platform

Cassegrain instruments only: A separate SCP (7-N) is available on the Azimuth platform

for test and maintenance purposes (see section 4.19.1). However, **only one connection to the Instrument-LAN** (see section 3.4.3) **may be made for the entire Cassegrain instrument, and the total thermal load on the telescope cooling system shall not exceed the figure specified in section 4.19.1.**
Equally, the torque and friction limits (section 4.8.1) remain valid.

4.20 Alarm handling

The handling of alarms is described in AD[8]. In particular **alarm conditions which can seriously endanger people and/or expensive equipment shall be handled by hardware**, see section 7.
All alarms shall be transmitted through the VLT software. In addition, **alarms resulting from the vacuum or cryogenic systems of an instrument shall be indicated by a siren (type TBD) and a flashing light (type TBD)**. To supplement these *three primary alarm channels* a Central Alarm System (CAS) alerting maintenance staff via beepers is implemented on Paranal. The beeper alerts are sent as a consequence of particular alarm conditions generated by the instrument. **VLT instruments shall be connected to this CAS. Critical alarm conditions that require prompt attention shall be reported automatically to the CAS** which will alert the engineer on duty.
By default, any instrument should connect only one alarm to the CAS. In special cases several different alarms may be connected but this requires explicit approval by ESO. The electronic interface to the CAS is described in RD[21]. It is strongly recommended to use an alarm annunciator box (referenced in [6]) on the instrument side.
Connection to CAS does not guarantee a response time nor should it be regarded as a safety measure. It is only intended as an additional means of alerting maintenance staff. It does not replace safety devices. **The safety plan for the instrument shall not take into account CAS as means to mitigate problems.**

4.21 Standardisation of components

Technical standards are specified in the the VLT programme for the following main reasons:

- to simplify and accelerate the design process for VLT equipment (including instruments) and reduce the amount of development work required
- to assure mutual compatibility between all VLT sub-systems
- to reduce the required stock of spare parts on Paranal
- to maximise the commonality between all VLT equipment and instruments installed on Paranal so that the observatory staff can become familiar with new systems in the shortest possible time and to simplify the maintenance activities
- to reduce the global cost of operations at the observatory.

The current ESO Technical Standards are referenced in AD[6].
Standard cryogenic and vacuum equipment is defined in AD[7].
Three types of standards shall be distinguished:

1. Standard components: **The use of standard components is compulsory when a functionally suitable standard item is available.**

2. Non-standard components: These are other components that are functionally similar to standard components. **Non-standard components may only be used with the written agreement of ESO, following a formal Request for Waiver**. The Waiver will only be granted in cases of exceptional justification.

3. Non-listed components: These are components where no functionally similar or functionally alternative standard components exists. The use of non-listed components is not subject to any restriction. Nevertheless, non-listed components that have been selected by one or more contractors may be defined as an ESO Technical Standard at a later date.

The following items are also considered to be standard items, but are specified individually:

- **Instrument Workstation (IWS)**: The choice of IWS is made at the time the units are required for instrument development. Due to the rapid evolution of the commercial market in this area, the IWS finally installed at the VLT site may differ from that used initially for instrument development, but will be software compatible with that selected initially.

- **Detector systems**: Typically the detector systems used for scientific observations (optical and infrared) and for slit-view/guiding applications are provided by ESO. Both are discussed in RD[19].

4.22 Basic requirements for cryogenic, evacuated instruments

The following list is non-exhaustive, more details, design guidelines and lists of standard parts to be used in cryogenic and vacuum systems are given in AD[7].

1. Preferred materials inside vacuum vessels are aluminium and stainless steel

2. Internal surfaces shall be polished to reduce outgassing

3. In case black painting is required (for stray light reduction around the optical path) the area to be painted, materials and processes shall be agreed in writing by ESO

4. No seal shall depend on the use of vacuum grease Enclosed volumes (blind holes) shall be avoided

5. Whenever possible, standard-size O-rings and vacuum flanges shall be used. The material used for O-rings and seals must be Ozone-resistant, e.g. Viton.

6. Before final assembly, all parts have to be carefully cleaned especially from oil, grease and solder flux and baked under vacuum at min 60° C.

Automatic on-board backup pumps shall be implemented to minimise any risk of contamination of detectors and the optics in case of unexpected leaks or warm-up that would lead to outgassing (Safe State, see section 7). For initial evacuation, larger external pumps may be used.

5 Instrumentation Software Requirements

5.1 General software requirements

All software supplied with instruments shall conform to the general requirements and specifications contained in the following documents and the references contained therein.

1. **'VLT Instrumentation Software Specification' (AD[8]). Software management, configuration control and test procedures adopted for all software supplied with VLT instruments shall conform to the requirements defined in this document and the references contained therein.**
2. **'Data Flow for VLT/VLTI Instruments Deliverables Specification' (AD[9]).** This document lists a complete set of Data Flow System related tasks to be completed by an Instrument Consortium and specifies the products to be delivered.

5.2 Overview of the VLT software

The following sections give an overview of the VLT software concept and standards. For specific information on instrument software requirements consult AD[8].

5.2.1 Software configuration control

All instrumentation software shall be managed using the VLT standard tool for software configuration management, *cmm***.** This tool provides, among others, the archiving functionality for all VLT software.

5.2.2 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.

5.2.3 LCU operating system

VxWorks from Wind River Systems shall be the standard real-time operating system for the LCUs. This uses a UNIX-based systems support and cross-development environment for the development and maintenance of real-time application programs that run on the LCUs under the VxWorks operating system.

5.2.4 Programming language

Programs for the LCU shall be written in the ANSI C-language.
The programming languages for the Workstations shall be ANSI C++ for control programs and Tcl/Tk for graphical user interfaces (GUIs) and template scripts. The use of existing off-line data reduction software in FORTRAN 77 shall be discussed on a case-by-case basis by ESO and might be authorized in exceptional cases.

5.2.5 Communications software

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

5.3 System and common software to be made available by ESO

Standard software packages are made available to instrument consortia for use by the instrument software. They are listed in AD[8].

5.4 Software to be supplied with instruments

This section gives an overview of the software packages to be delivered with a VLT instrument. A detailed description of the functionality of each package is given in AD[8]. As specified there, each package must provide also the associated test Software. Instrument-specific specifications are given in the instrument's Technical Specifications.

5.4.1 Instrument Control Software (ICS)

The Instrument Control Software package resides partly in the Instrument LCUs and partly in the IWS. It carries out all the control functions of the instrument except for the detector(s). The ICS deals uniquely with the hardware functions of the instrument and shall not deal with any commands to other LCUs, telescope, adapter, etc.
Comprehensive information on the status of the instrument is made available on request by this software (see section 5.4.5). ICS shall be able to work in simulation mode when the instrument is not connected. It shall also be able to work in stand-alone mode through a dedicated GUI.

5.4.2 Detector Control Software (DCS)

The Detector Control Software consists of a package, resident partly in the detector LCU and partly in the IWS. It carries out all the control functions of the detector(s). The DCS deals uniquely with the hardware functions of the detector(s) and shall not deal with any commands to other LCUs, telescope, adapter, etc.
Comprehensive information on the status of the detector(s) is made available on request by this software (see section 5.4.5). DCS shall be able to work in simulation mode when the instrument is not connected. It shall also be able to work in stand-alone mode through a dedicated GUI.

5.4.3 Observation Software (OS)

The Observation Software is the highest layer of the Instrumentation Control Software. It is resident in the IWS. It implements the instrument's observation, acquisition and calibration templates and is responsible for the coordination of the instrument software subsystems (ICS, DCSs, TCS).
OS also presents a high level view of the instrument status to the user.
Data and all relevant instrument and telescope parameters are recorded in the VLT Archive in FITS format, conforming to the specifications given in AD[10]. OS therefore interfaces with the Data Flow System, see AD[9].
The OS shall also be capable of working in degraded mode, when one or more subsystems are not present.

5.4.4 Observer Support Software (OSS)

The Observer Support Software supports the observer in the preparation of Observation Blocks (OBs) with the P2PP tool (see RD[14]). Typical tasks of OSS are the performance of a precise and efficient target selection and acquisition, depending on the observing mode(s) of the instrument (e.g. slit positioning in multi object spectroscopy, based on catalogue input or pre-imaging). If the P2PP tool already covers all the needs of the instrument and the users, then the OSS package may be empty. Detailed requirements on the OSS package will be given in the instrument's Technical Specification.

5.4.5 Maintenance Software (MS)

Maintenance Software provides the following functionality:

1. Control over changes to the instrument configuration (e.g. of optical components).
2. Operational procedures in form of Maintenance Templates. An example is the exchange of optical components (filters, grisms etc) including the corresponding update of the instrument database.
3. Preventive maintenance procedures, in form of Maintenance Templates, if and whenever necessary. An example is the trend analysis of instrument parameters (liquid nitrogen level, temperature, pressure, motor current trends etc.).

5.4.6 Data Reduction Software DRS

All VLT instruments have a pipeline which is used on-line at Paranal and off-line in Garching. In addition, the reduction recipes can be used standalone. Within the end-to-end operation concept, the main pipeline missions are

- to process raw calibration frames into master calibration products
- to produce Quality Control products for monitoring telescope, instrument and detector performance
- to process raw science frames using master calibration products, into science data products. hese consist of data with the instrumental signature removed and whenever possible calibrated into physical units (e.g. flux, wavelength).

The general requirements on DRS for VLT instruments are listed in AD[9], detailed requirements on the individual instrument specific DRS package will be given in the instrument Technical Specification.
To facilitate building instrument pipelines ESO offers the Common Pipeline Library (CPL). CPL is a set of C libraries which have been developed at ESO and elsewhere to standardize VLT instrument pipelines, to shorten their development cycle and to ease their maintenance. The CPL addresses two primary requirements:

1. to provide an interface to the VLT pipeline runtime environment and
2. to provide a software kit of medium-level tools that allow rapid implementation of DRS tools that allow to rapidly build astronomical data reduction tasks.

The Common Pipeline Library User Manual is an Applicable Document of AD[9].

6 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.

1. **The requirements and recommendations contained in AD[5] are applicable to all VLT instruments.**

2. **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.**

3. **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.

4. **No other computers apart from the IWS and the LCUs shall be necessary to operate or maintain the instrument.**

5. **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.**

6. **VLT instruments shall be easily removable from the telescope, preferably as single units including the LCU(s)**, for the purpose of connecting them to any other LAN node for testing in a stand-alone configuration or for giving access to certain telescope subsystems (typically the adapter/rotator, section 3.3).

7 Safety Requirements

ESO's Safety Policy is defined in AD[11]. **The designs of instruments and associated equipment (e.g. for handling, test, maintenance and alignment) as well as operating and maintenance procedures shall comply with this policy. The ESO Safety Conformity Assessment Procedure as described in AD[12] shall be followed.** Guidelines for executing the ESO Safety Conformity Assessment are given in RD[22].

Standard safety procedures of Paranal Observatory are described in RD[23] and RD[24].

The control electronics of the instrument is also responsible for its safety aspects. **Safety critical electronics shall operate without supervision by humans or software. Status and alarm signals shall however be made available. These electronics shall autonomously and adequately react to emergency conditions that may occur at any time like:**

- Electrical Power failure (UPS and/or non-UPS),
- Failure of VLT cooling fluid supply,
- Failure of cryogenic cooling system, lack of coolant,
- Vacuum leak (sudden rise of pressure),
- Failure of critical sensors (e.g. pressure or temperature) or their cables/connectors,
- Overheating of electrical cabinet, cabinet door not closed,
- Cable wrap problem.

When such an event occurs, the instrument shall if necessary place itself automatically in a Safe State that maintains the integrity and safety of the instrument and detectors. In addition, alarms shall be sent as defined in section 4.20. The Safe State shall be compatible with the findings and requirements of the Hazard Analysis of the individual instrument (see AD[12]).

8 Maintenance and Availability Requirements

The philosophy for the maintenance and availability (for observation) of VLT instruments is determined by two main factors: the limited personnel and facilities that are available at the Paranal Observatory site, and the large amount of high-technology equipment to be maintained there. Several related topics are involved.

8.1 Maintenance concept

8.1.1 Line Replaceable Units

The on-site maintenance is essentially at the level of Line Replaceable Units (LRUs)[6]. An instrument fault will be identified to this level and the LRU exchanged.
This maintenance concept requires that, as far as possible, the major functional part of all instruments consists of Line Replaceable Units. Individual LRUs must be small enough to be easily transported for repair. Replacement LRUs shall be, as far as possible, completely interchangeable with the originals and shall not require extensive alignment or calibration procedures.
The use of LRUs is preferred as they enable a rapid exchange and minimum downtime. However, in some cases it may be more cost effective to include as spares only those components within the LRU which are likely to fail and can normally be exchanged without a large overhead of time. Examples are a large XY table with expensive mechanical slides, encoders and motors, where a complete XY table would be an expensive LRU compared to spares of just the motors and encoders. In such cases the matter should be decided in coordination with ESO.

8.1.2 Self-test software

A heavy reliance is placed on self-test software to localize faults when they occur. This software has already been described in section 5.4.5.

8.1.3 Spare parts

Sufficient spare LRUs and other spare parts shall be delivered with each instrument compatible with the likelihood of breakdown, the importance of the component to the functioning of the instrument, the time needed for repair (including the delivery time of critical parts), and the specified lifetime of the instrument.

8.1.4 Standardisation

The diversity of equipment at the Paranal Observatory requires a high level of standardisation at component and module levels, as well as for software. The requirements for standardisation have already been detailed in section 4.21.

[6] A Line Replaceable Unit is an electronic/electrical, mechanical or optical instrument module or part that can be exchanged by a maximum of two technician level staff within a period of 4 working hours, not including the time necessary to localize a fault.

8.2 Useful lifetime

The design, construction and supply of spare parts of VLT instruments shall be be compatible with of a working lifetime of at least 10 years.

8.3 Availability

The overall availability goal for each VLT instrument is that no more than 1% of the scientific observing time of the instrument be lost due to unscheduled downtime. Unscheduled downtime includes the time required to localise and repair a fault, but excludes the time required to warm-up, evacuate and re-cool a cryogenic instrument. It does not include scheduled maintenance periods described in sections 8.4.1, 8.4.2 and 8.4.3. Instruments shall be designed for a Mean Time between Failure (MTBF) of at least one year. A failure is defined as a major loss of operation of 5 hours or more during which observing programmes cannot be executed.

8.4 Maintenance requirements

VLT instruments shall be designed for minimum on-site maintenance. Three different levels of maintenance are foreseen:

8.4.1 Operational tasks

Operational tasks shall not require more than 15 minutes per instrument per day for one observatory technician to carry out. Operation tasks may include the filling of dewars, routine external inspections, and the running of self-test programs. **The design goal for all instruments shall be to reduce the number of these task to the absolute minimum.**

8.4.2 Preventive maintenance

1. **Uncooled instruments**
   Preventive maintenance operations for uncooled instruments shall not be required more frequently than once every 6 months. They shall be carried out within a working day of 6 hours by no more than two observatory technicians and without removing the instrument from the telescope.
   Preventive maintenance may include items such as detailed inspections, alignment checks, performance checks on optical throughput and detector performance, functional checks on mechanisms and limit switches, renewal of consumables (lubricants, filters, etc.), cleaning of optical surfaces, vibration measurements or thermography .
   The mounting or dismounting of Cassegrain instruments shall be accomplished within a maximum of 3.5 hours.

2. **Cryogenic instruments**
   The principal preventive maintenance operations for cryogenic instruments (i.e. the operations listed above for the preventive maintenance of uncooled instruments) **shall not be required more frequently than once every 6 months. They shall be carried out within a working day of 6 hours by no more than two observatory technicians and without removing the instrument from the telescope. In addition, a maximum of two observing nights may be lost for instrument warming, evacuating and re-cooling operations.**
   Certain operations, for example the purging of sorption pumps, may be carried out more frequently than once per 6 months, **but the design goal for such instruments**

shall be to extend the period between these intermediate interventions to not more than once every three months, and/or to automate the required operations to permit them to be carried out without necessitating the presence of observatory technical staff.
Dismounting of the instrument from the telescope shall not require more than 8 man-hours and shall be possible without interference with the ongoing observing programmes at the other foci of the same UT. It shall be possible to to have the instrument ready for opening within 24 hours after switching off the closed cycle coolers.
The mounting of the instrument to the telescope shall not require more than 8 man-hours and shall be possible without interference with ongoing observing programmes. The instrument shall be operational at the latest 40 hours after beginning of installation.

Any special tools needed for preventive maintenance shall be delivered with each individual instrument.

8.4.3 Overhauls

Where necessary, **overhauls shall be scheduled to take place at intervals not shorter than two years, and would take place during non-scheduled observing time. Overhauls may involve removal of the instrument from the telescope and may cause the loss of not more than 4 observing nights.**
Any special tools and equipment needed for instrument overhauls shall be delivered with each instrument.

8.5 Computerized maintenance management system

Paranal Engineering department uses MAXIMO, a computerised maintenance management system (CMMS), for the following tasks:

- inventory control of spare parts and tools including their locations
- planning of preventive maintenance
- work order generation from preventive maintenance plans
- failure reporting and tracking
- work flow monitoring
- etc

All information necessary to include an instrument properly in the CMMS shall be delivered by the consortium in a Maintenance Plan and in computer readable form.
The Maintenance Plan should include an overview of the prescribed activities, their frequency, estimated time needed, staff numbers including qualifications, special tools needed, etc. In addition, full information about spare parts is required: supplier, designation (order number), contact addresses (telephone, email etc), special storage requirements (including maintenance of spares!).
MAXIMO uses a large part of this information, to be entered in spreadsheets. ESO will make the corresponding spreadsheet template available.
A necessary requirement for the CMMS is that **all instruments and their component LRUs, spare units, etc, shall be marked with identification numbers** to allow any unit to be unambiguously identified. These numbers will be allocated by instrument contractors according to a scheme agreed with ESO.

9 Environmental Requirements

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 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[4]. 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 4.18.

10 Verification

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 Technical Specifications for each instrument. Verification of the requirements and specifications contained in this document are detailed in the following section.

10.1 Verification by design

Except where otherwise mentioned below in sections 10.2 and 10.3, **all requirements defined in this document shall be subject to design review by ESO using computer modeling where necessary.** Commercial components shall be checked against manufacturers data sheets and test reports.

10.2 Verification by inspection

The requirements listed in sections 4.19.2 and 4.19.3 on cable installations and marking shall be verified by inspection after installation.

10.3 Verification by test

The requirements listed in sections 4.7, 4.8 and 4.9 shall be verified by test after instrument integration. The requirements listed in sections 4.16 and 6 shall where applicable be verified by test after installation.

11 Documentation Requirements

11.1 Deliverable Documents

The documentation to be delivered in the course of the development of a VLT instrument, including test reports and manuals, is specified in the Statement of Work for individual instruments. **All contractually requested documents shall be delivered in electronic form (preferably as PDF files). Technical drawings shall be delivered as electronic files in the format(s) of the programme(s, e.g. CAD, electronic circuit design) agreed upon with ESO.**
Documents shall as a minimum have a title page stating

- document title
- document number
- issue (integer; no draft issues will be archived)
- date
- author (with signature)
- approver (with signature; typically the project manager)
- releaser (with signature; typically the Principal Investigator)

ESO makes templates available for general and some special document types.

11.2 Numbering system

Although a project team may use any document numbering system for internal documents, it is strongly recommended to use the following numbering system in use by ESO for all VLT related documents. As a minimum **the ESO numbering scheme shall be used for all documents released by the instrument consortium for official transmission to ESO**. These documents will be stored in electronic form in the ESO Technical Archive.

11.2.1 Documents

Documents shall use the following numbering scheme:

VLT-BBB-CCC-DDDDD-GGGG

where

BBB	identifies the type of document (see list below)
CCC	is the code for the consortium (assigned by ESO)
DDDDD	is the product code of the instrument (assigned by ESO)
GGGG	is a sequential identification number (including leading zeros); typically assigned by the consortium's project office or internal archive.

The following document type codes (BBB) are defined:

CRE	Change Request
ICD	Interface Control Document
LIS	List
MAN	Manual
MIN	Minutes of meeting
PAL	Part List
VER	Verification document
PLA	Plan
PRO	Procedure
RFW	Request for Waiver
SOW	Statement of Work
SPE	Technical Specification
TRE	Technical Report

11.2.2 Drawings

The final numbering system to be used for drawings (DWG) is TBD. It will be communicated to the consortia.

12 List of Acronyms

AD	Applicable Document
ADC	Atmospheric Dispersion Compensator
ADWG	Applicable Drawing
AGS	Acquisition/Guide Sensor
ASM	Astronomical Site Monitor
ATH	Auxiliary Telescope Hall
BFD	Back Focal Distance
CAD	Computer Aided Design
CAS	Central Alarm System
CCD	Charge Coupled Device
CMMS	Computerised Maintenance Management System
DC	Direct Current
DCS	Detector Control Software
DRS	Data Reduction Software
ESO	European Southern Observatory
FITS	Flexible Image Transport System
GUI	Graphical User Interface
ICS	Instrument Control Software
IWS	Instrument WorkStation
LAN	Local Area Network
LCU	Local Control Unit
LRU	Line Replaceable Unit
MS	Maintenance Software
OSS	Observer Support Software
P2PP	Phase 2 Proposal Preparation
RD	Reference Document
RMS	Root Mean Square
SCP	Service Connection Point
SWL	Safe Working Load
TBD	To Be Defined
TCS	Telescope Co-ordination Software
TIM	Time Interface Module
TRS	Time Reference System
TÜV	Technischer Überwachungsverein
TWS	Telescope WorkStation
UPS	Uninterruptible Power Supply
UT	Unit Telescope
UTC	Coordinated Universal Time
UWS	User WorkStation
VLT	Very Large Telescope
WFS	WaveFront Sensor

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-C):

ADWG -C	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 10: Applicable drawings for the interface between Cassegrain instruments and the telescope environment

These drawings can be downloaded as .pdf files from
`http://www.eso.org/instruments/interfaces/Drawings/`.
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. These CAD files will be made available through the Instrument Responsible.

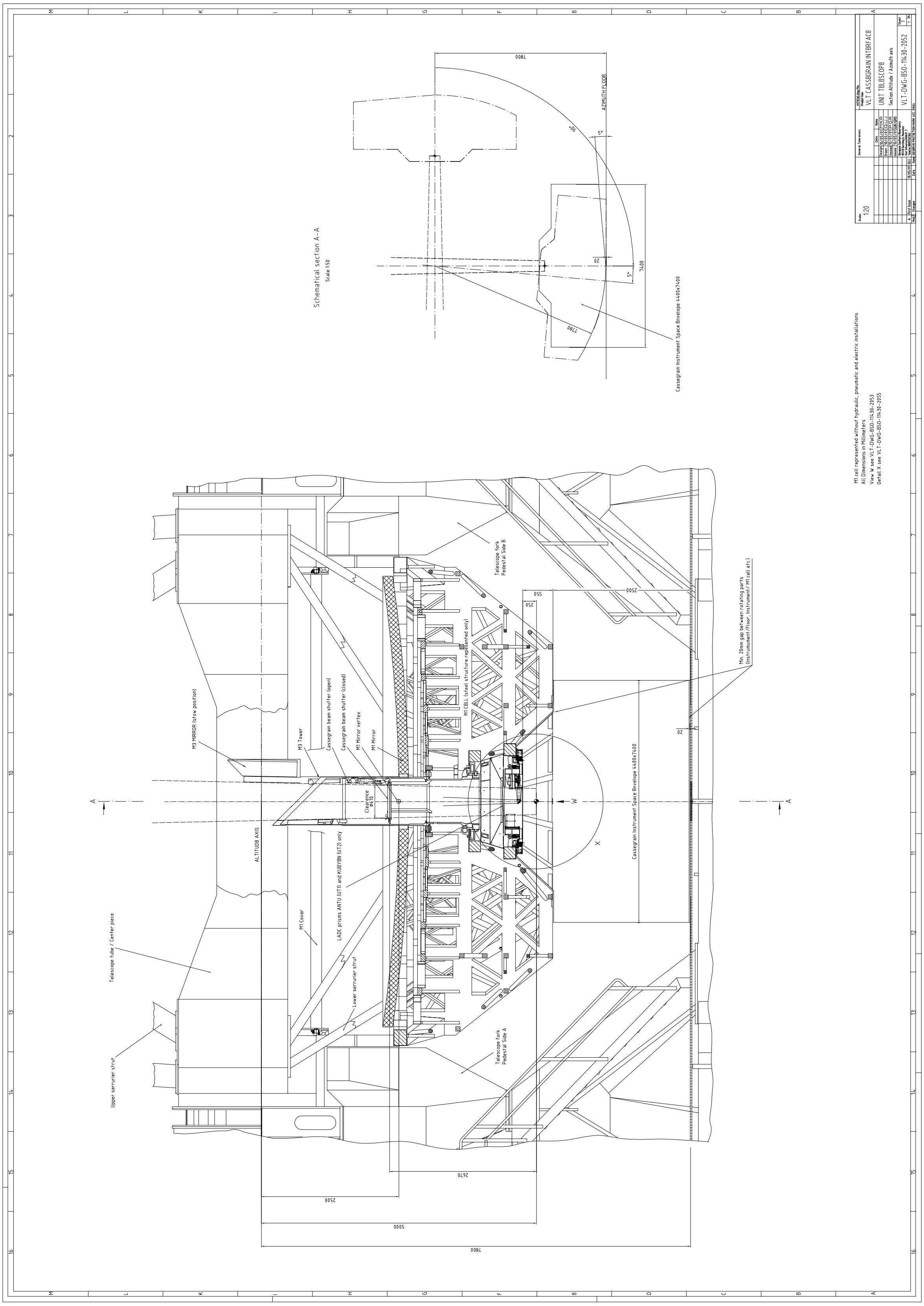

Figure 11: ADWG-C1

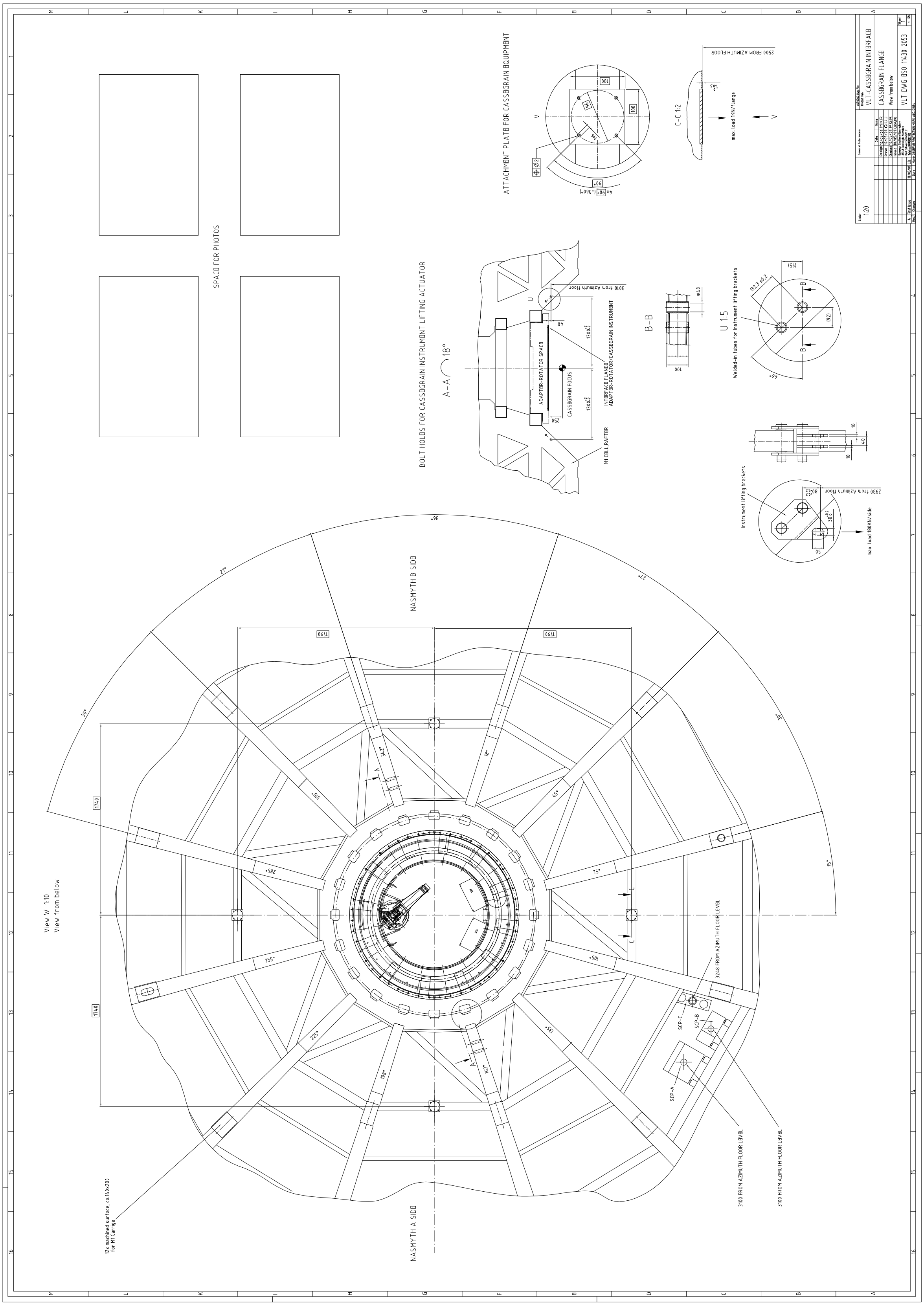

Figure 12: ADWG-C2

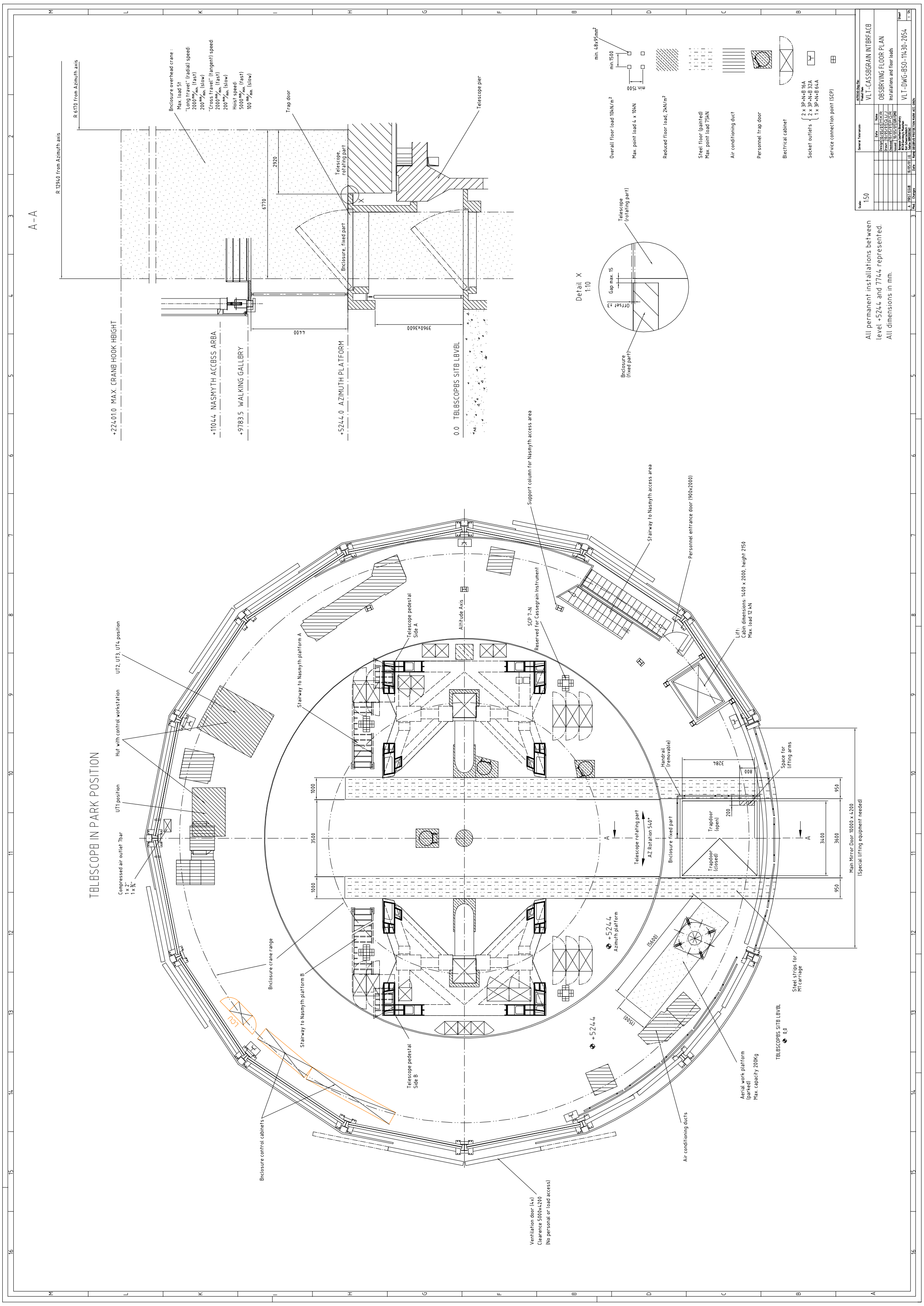

Figure 13: ADWG-C3

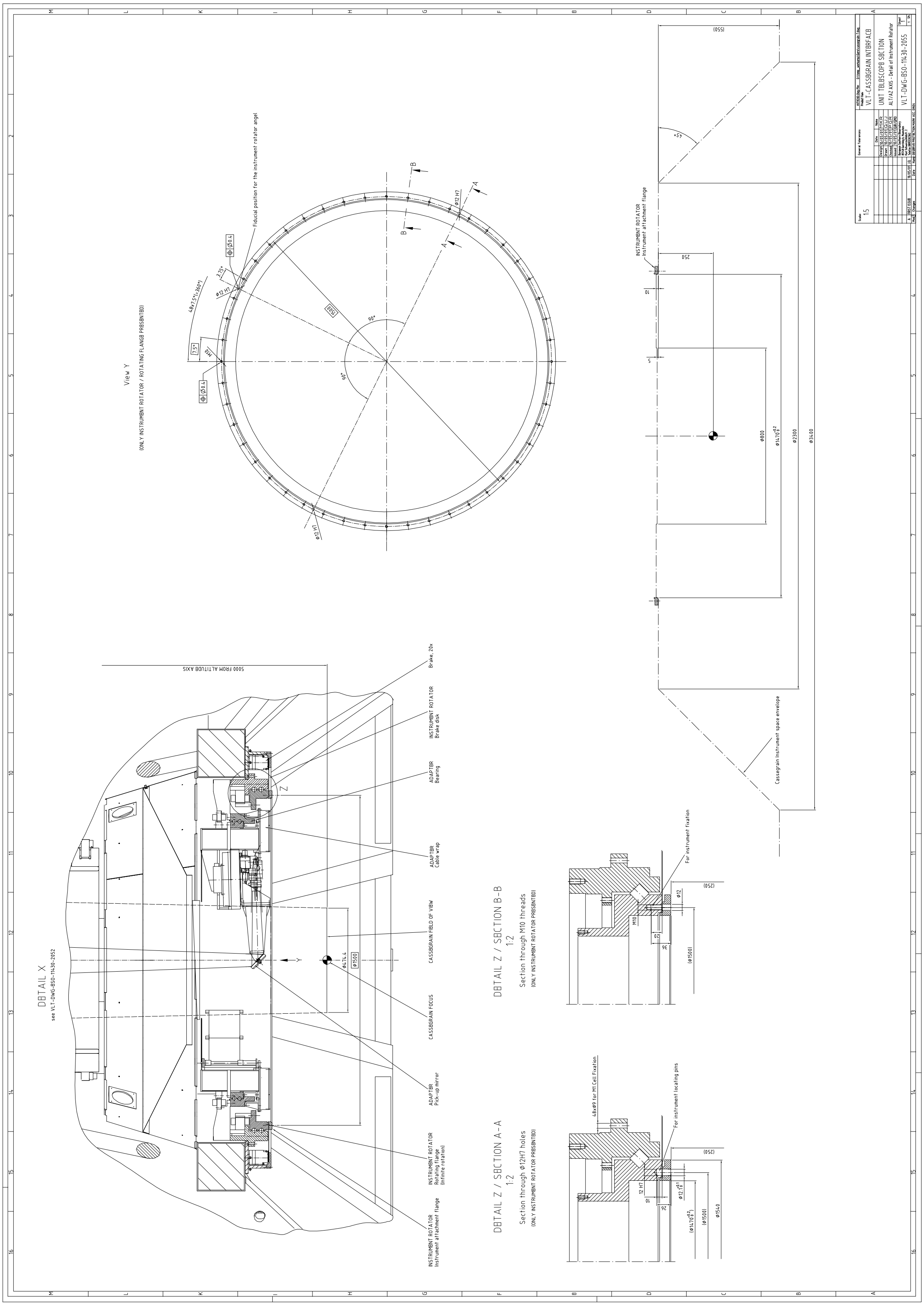

Figure 14: ADWG-C4

B Interfaces Between Nasmyth Instrument and Telescope Environment

The interfaces between VLT Nasmyth instruments and the telescope environment is given in the following applicable drawings (ADWG-N):

ADWG -N	Title of Drawing	drawing number
1	**VLT-Nasmyth Interface** **Nasmyth Instrument Flange A** **Rotator, cross section**	**VLT-DWG-ESO-11420-2615**
2	**VLT-Nasmyth Interface** **Nasmyth Instrument Flange B** **and Rotator cross section**	**VLT-DWG-ESO-11420-2616**
3	**VLT-Nasmyth Interface** **Nasmyth Platform A** **Top view and floor requirements**	**VLT-DWG-ESO-11420-2617**
4	**VLT-Nasmyth Interface** **Nasmyth Instrument Flange A:** **Front view with telescope installations**	**VLT-DWG-ESO-11420-2618**
5	**VLT-Nasmyth Interface** **Nasmyth Instrument Flange B** **Front view with telescope installations**	**VLT-DWG-ESO-11420-2619**
6	**VLT-Nasmyth Interface** **Nasmyth Platforms** **Access and handling constraints**	**VLT-DWG-ESO-11420-2620**

Table 11: Applicable drawings for the interface between Nasmyth instruments and the telescope environment

These drawings can be downloaded as high resolution .pdf files from `http://www.eso.org/instruments/interfaces/Drawings/`.
All Nasmyth 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. These CAD files will be made available through the Instrument Responsible.

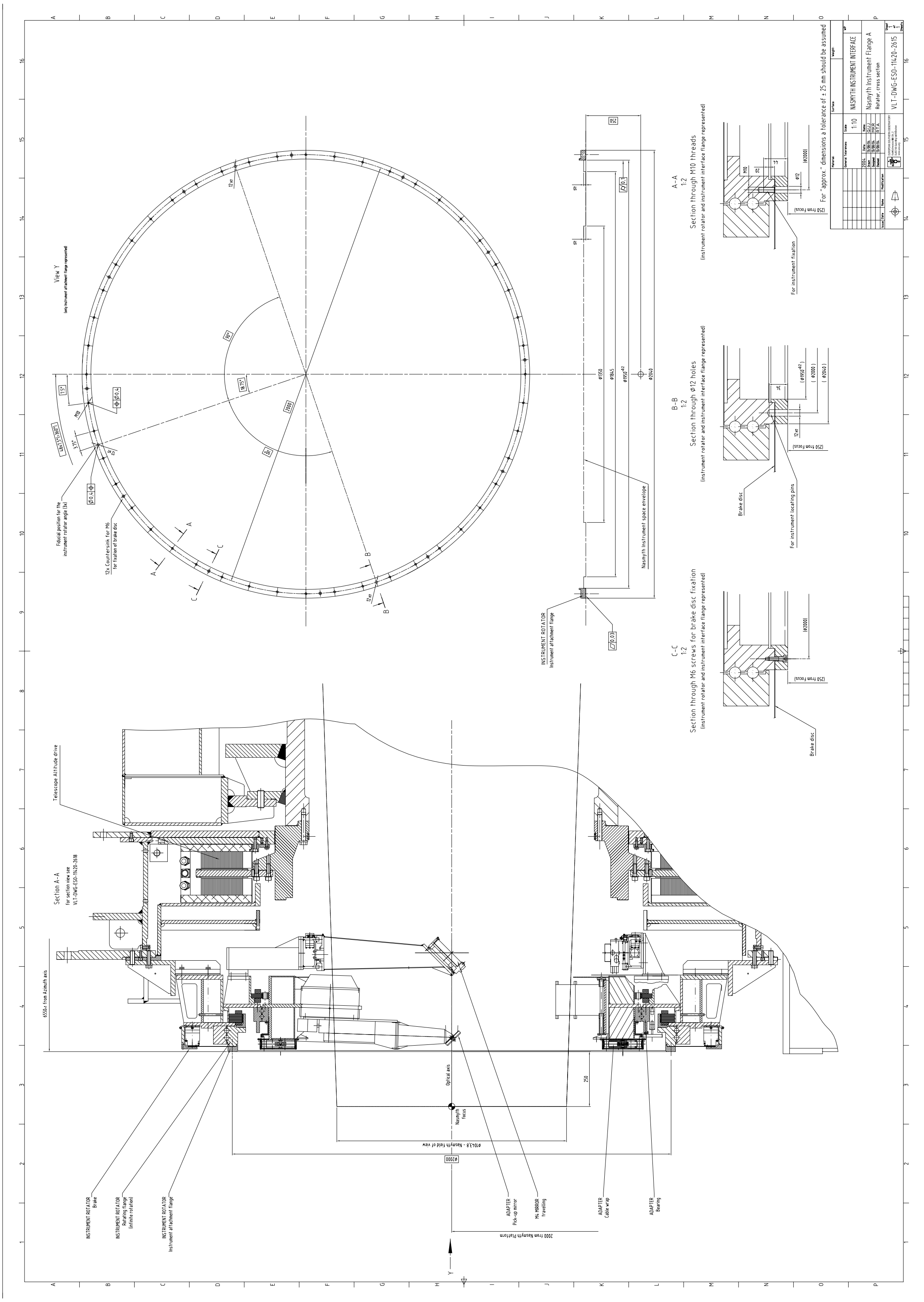

Figure 15: ADWG-N1

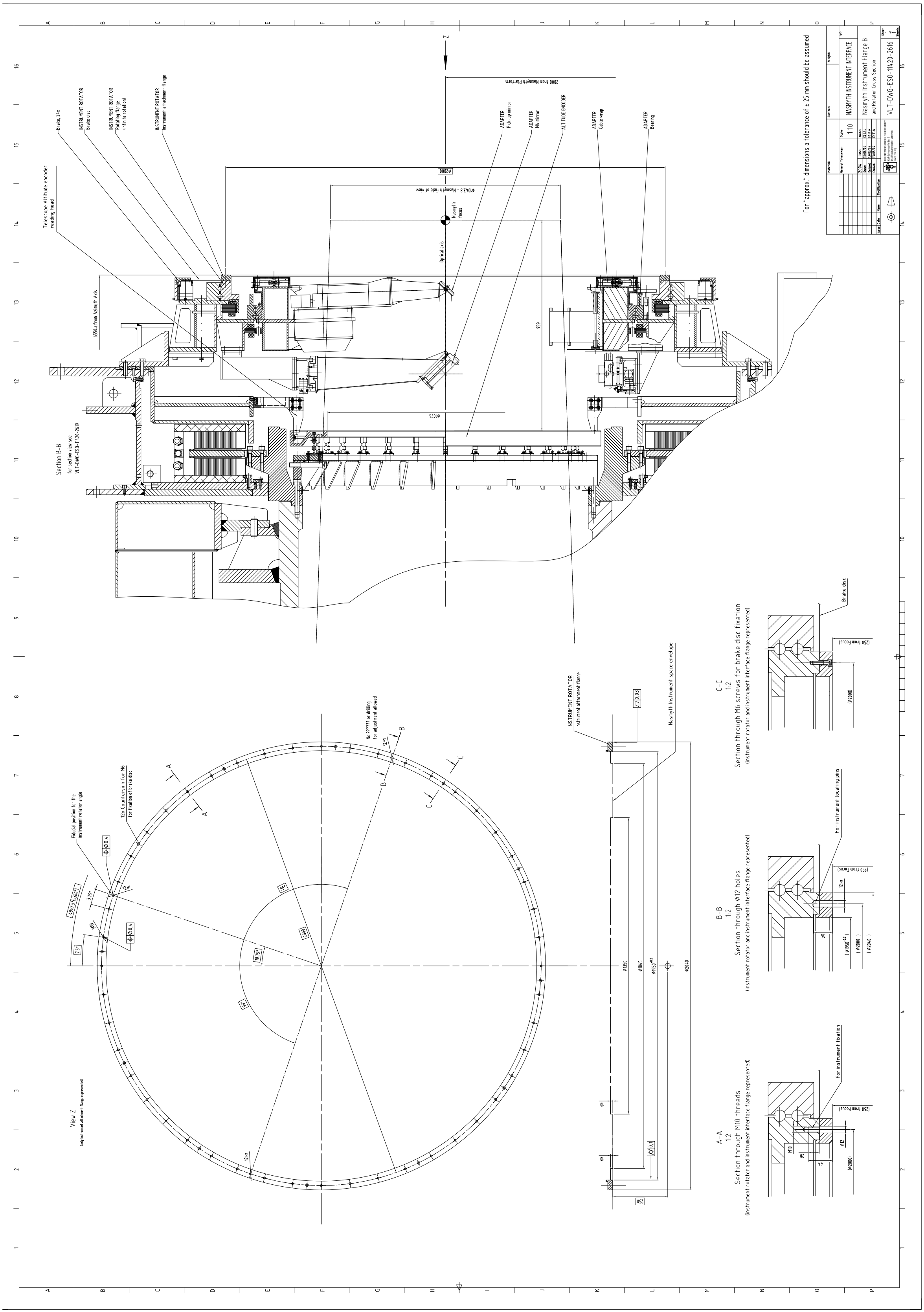

Figure 16: ADWG-N2

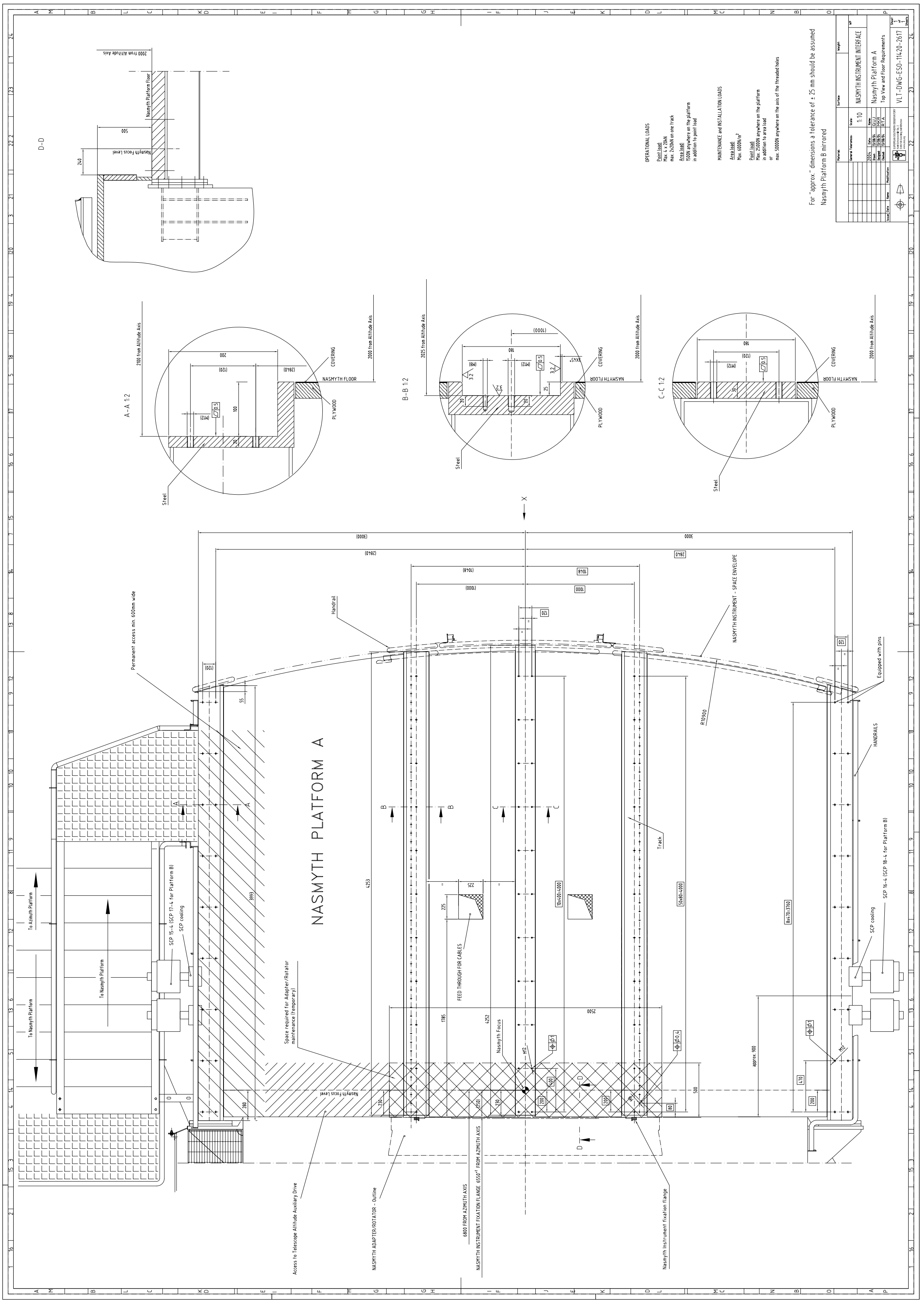

Figure 17: ADWG-N3

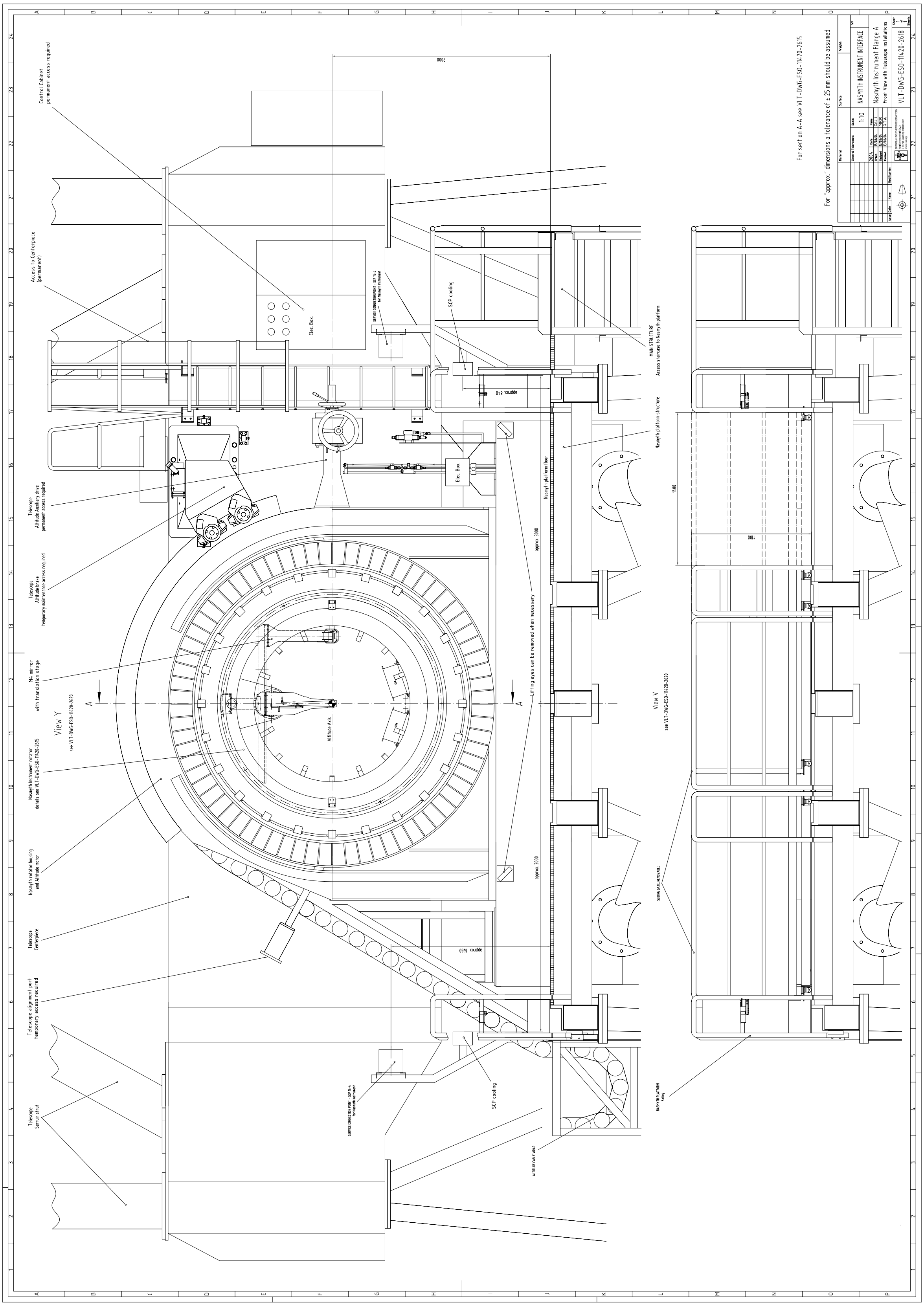

Figure 18: ADWG-N4

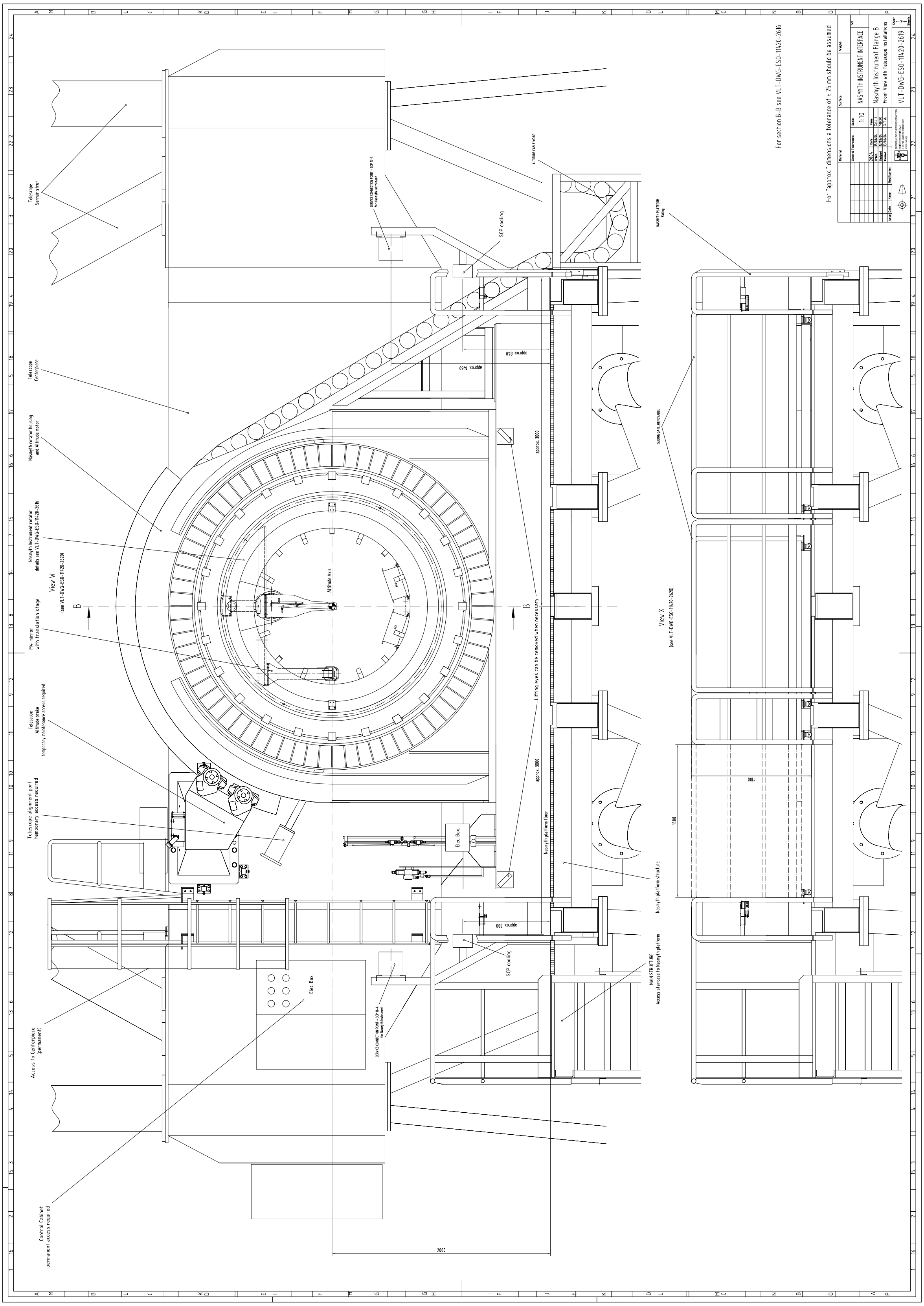

Figure 19: ADWG-N5

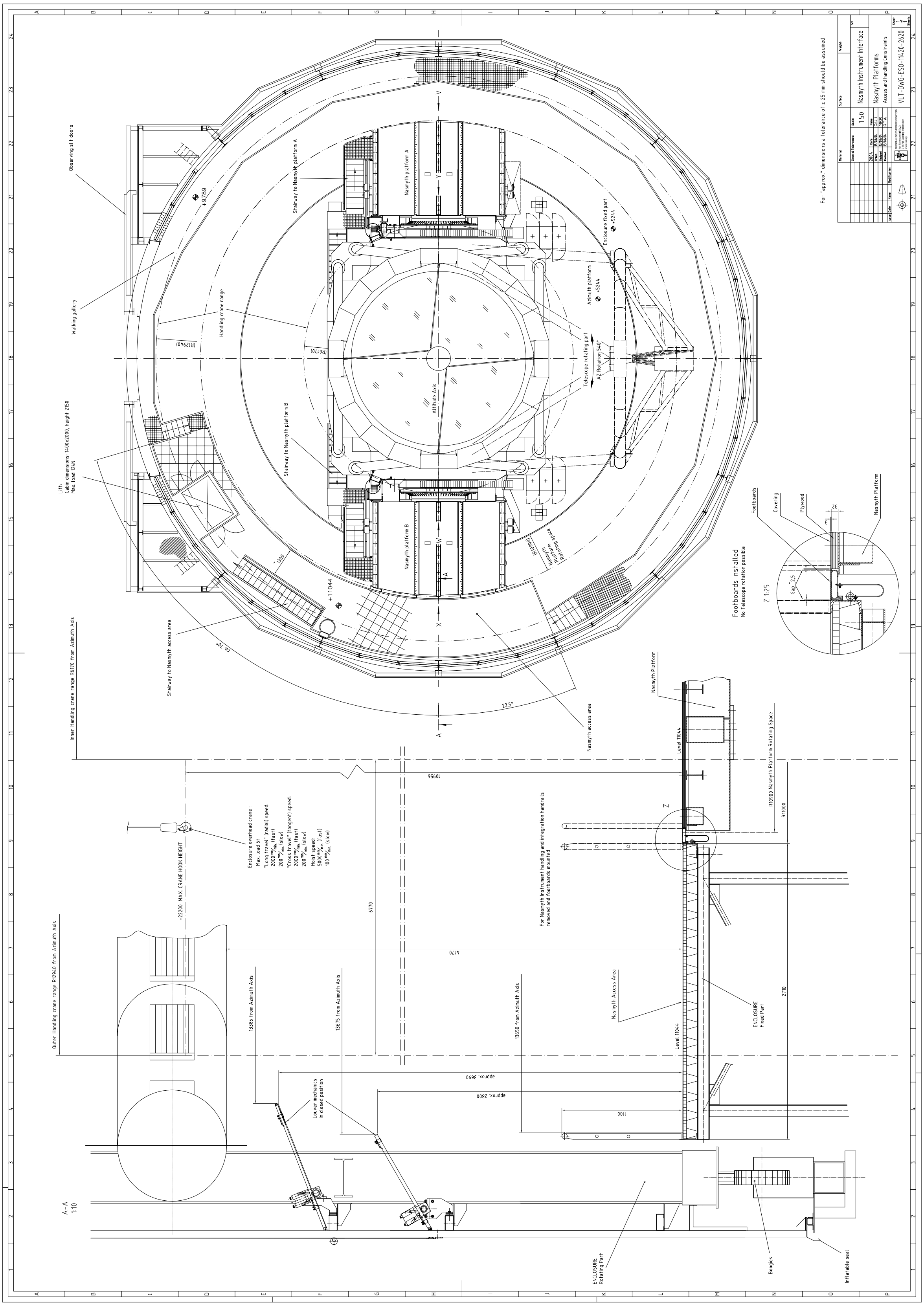

Figure 20: ADWG-N6

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