Visible & Infrared Survey Telescope for Astronomy

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Change Record

Issue	Date	Section(s) Affected	Description of Change/Change Request Reference/Remarks
1.0	090206	-	First formal issue.

Table of Contents

Acronyms and Abbreviations

ADC	Atmospheric Dispersion Corrector
ALARP	As Low As Reasonably Possible
Altitude Angle	Angle above horizon
BOB	Broker for Observation Blocks
Canbus	Controller Area Network Bus
COSHH	Control of Substances Hazardous to Health
CCB	Change Control Board
CCD	Charge Coupled Device
CCS	Central Control Software
CWL	Central Wavelength
DRP	Design Reference Program
DVD	Digital Versatile Disc
EED	Encircled Energy Diameter
EMU	Electromechanical Unit
ESO	European Southern Observatory
FIERA	Fast Imager Electronic Readout Assembly
FITS	Flexible Image Transfer System
FMEA	Failure Mode Effect Analysis
FIO	For Information Only
FWHM	Full Width at Half Maximum
HVAC	Heating Ventilation and Air Conditioning
HW	Hardware
ICD	Interface Control Document
IRACE	Infra Red Array Control Electronics
IWS	Instrument Workstation
LCU	Local Control Unit
LEMP	Lightning and Electro Magnetic Pulse
LTO	Linear Tape Open
LN_2	Liquid Nitrogen
LRU	Line Replaceable unit
M1	Primary Mirror
M2	Secondary Mirror
MLE	Maximum Likely Earthquake
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
OBE	Operating basis Earthquake
OCDD	Operational Concept Definition Document

OPD	Optical Path Difference
OB	Observation Block
OHS	Observation Handling Software
OS	Observation Software
P2PP	Phase 2 Proposal Preparation
PCB	Printed Circuit Board
PP	Peak to Peak
PTV	Peak to Valley
RMS	Root Mean Square
SCP	Standard Connection Panel
SIQ	Systems Image Quality
SRD	Science Requirements Document
SW	Software
TCS	Telescope Control System
T_0	Predicted minimum observing air temperature
VCS	VLT Control System
VDFS	VISTA Data Flow System
VISTA	Visible and Infrared Survey Telescope for Astronomy
VPB	VISTA Project Board
VPO	VISTA Project Office
VTS	VISTA Technical Specification
WFE	Wave Front Error
WS	Workstation
ZD	Zenith Distance (i.e. 90deg – altitude angle)
Zenith Blind Spot	Area around zenith that the telescope **cannot** track in azimuth

NOTE Where numerical values of deviations are given, unless they are qualified (e.g. by rms), they are to be taken as maximum absolute values.

1 SCOPE

1.1 General

The purpose of this document is to define all the technical acceptance criteria of the VISTA system, in accordance with AD02.

1.2 Requirements Capture and Verification

1.2.1 SRD Requirements Capture

While translating the requirements of the SRD (AD01) into System Requirements, the following guidelines have been used:

- Requirements contained in the SRD (AD01) have been translated into engineering requirements only if they constitute a Technical Specification.
- Such requirements shall be detailed in this Technical Verification Specification in a form that is quantifiable and verifiable – such verification will be developed as part of the Acceptance strategy.

1.2.2 Verification Strategy

Verification of technical requirements shall be carried out in accordance with the agreed strategy of AD02.

1.2.3 Traceability

To ensure traceability to the Technical Specification [RD06], the numbering system herein is consistent with that of the VISTA Technical Specification in accordance with AD02 section 5.1.2.

No text means the equivalent section of the VISTA Technical Specification v3 was empty

Deleted means the equivalent section of the VISTA Technical Specification v3 has been deleted for the reason given, usually because it was not suitable for verification,

1.3 Exclusions

1.3.1 Future Development

Deleted – unnecessary detail

1.3.2 Supply of Visible Camera

Deleted – unverifiable

2 Applicable and Referenced Documents

2.1 *Applicable Documents*

The following documents of the exact issue shown form a part of this Technical Verification Specification to the extent specified herein. In the event of conflict between the documents referenced and the content of the present specification, the order of precedence in AD02 shall apply.

2.1.1 Science Requirements Documents and Verification Strategy Documents

Document Title		Document Number and Issue
AD01.	VISTA Science Requirements Document (SRD)	VIS-SPE-VSC-00000-0001 issue 2
AD02.	Strategy for the Preparation of the Verification Plan for the VPO Deliverables to ESO	VIS-PLA-ATC-00000-0007 issue 1.0

2.1.2 ESO Applicable Documents

Document Title		Document Number and Issue
AD03.	Basic Telescope Definitions	VLT-SPE-ESO-10000-0016-issue 2
AD04.	VLT Environmental Specification	VLT-SPE-ESO-10000-0004 issue 6
AD05.	Instructions to perform Earthquake analyses for VLT instruments and similar equipment	VLT-SPE-ESO-10000-1853, issue 1
AD06.	Service Connection Point Technical Specification	VLT-SPE-ES0-10000-0013 issue 4
AD07.	Intentionally blank	
AD08.	EMC and Power Quality Specification - Part 1	VLT-SPE-ESO-10000-0002, issue 2
AD09.	EMC and Power Quality Specification - Part 2	VLT-SPE-ESO-10000-0003, issue 1
AD10.	Acceptance Procedure Electrical Safety and EMC	VLT-VER-ESO-10000-0958, issue 2
AD11.	Construction requirements of the VLT Observatory Infrastructures/Buildings/Enclosures related to EMC	VLT-SPE-ESO-12000-0262, issue 1
AD12.	VLT Electronic Design Specification	VLT-SPE-ESO-10000-0015, issue 5
AD13.	*Deleted (duplicate of AD10).*	
AD14.	VLT Requirements for Safety Analyses	VLT-TRE-ESO-00000-0467, issue 1
AD15.	VLT CANopen Specifications	VLT-SPE-ESO-10000-2772, issue 1

Note: Documents AD15 to AD19 intentionally blank

AD20.	VLT-Programming Standards	VLT-PRO-ESO-10000-0228 issue 1
AD21.	LCU Common Software User Manual	VLT-MAN-SBI-17210-0001 issue 3.7
AD22.	VLT Instrumentation Software Specification	VLT-SPE-ESO-17212-0001 issue 3

AD23.	VLT Instrument Common Software Specification	VLT-SPE-ESO-17240-0385 issue 3
AD24.	Data Interface Control Document	GEN-SPE-ESO-19400-0794 issue 2.0
AD25.	Telescope Control System User Manual	VLT-MAN-ESO-17230-0942 issue 2
AD26.	Broker for Observation Blocks User Manual	VLT-MAN-ESO-17220-1332 issue 4
AD27.	Central Control Software User Manual	VLT-MAN-ESO-17210-0619 issue 2.4
AD28.	Final Layout of VLT Control LANs	VLT-SPE-ESO-17120-1355, Issue 2

Note: Documents AD 29 - AD 30 intentionally blank

2.1.3 Interface Control Documents

	Document Title	**Document Number and Issue**
AD31.	Interface Control Document between the Paranal infrastructure and VISTA	VIS-ICD-ATC-10000-00000 issue 1
AD32.	ICD between VLT Control System and Observation Handling System	VLT-ICD-ESO-17240-19200 issue 2
AD33.	Telescope Optical Interface to IR Camera	VIS-ICD-ATC-01000-06000 issue 2.0
AD34.	Telescope to IR Camera Services Interface Control Document	VIS-ICD-ATC-01000-04020 issue 5.0
AD35.	Primary Mirror to Primary Mirror Cell Interface Control Document	VIS-ICD-ATC-02000-03000 issue 2.0
AD36.	Telescope Structure to M2 System Interface Control Document	VIS-ICD-ATC-01000-05000 issue 4.0
AD37.	Interface Control Document Between the Telescope Structure and the Site Development	VIS-ICD-ATC-01000-09000 issue 1.0
AD38.	Interface Control Document Between the Telescope Structure and the Enclosure	VIS-ICD-ATC-01000-10000 issue 1.0
AD39.	Instrument Interface to telescope	VIS-DWG-ATC-06000-01000 issue D
AD40.	Mechanical Interface with Cassegrain Focus Instruments	VIS-DWG-ATC-06000-04000 issue D
AD41.	VDFS Requirements for VISTA Data Information	VDF-SPE-QMU-00001-*00001 not yet issued*

Note: Documents AD 42-49 intentionally blank

2.1.4 Safety and Standards

Note: In lieu of DIN standards equivalent national standards or European directives can be used upon approval from the VPO.

Document Title		Document Number and Issue	
AD50.	VISTA Project Safety Management Plan	VIS-PLA-ATC-00001-0019	Issue 3.0
AD51.	Eurocode No.8 Structures in seismic regions--Design- Part 1	Commission of the EC Report EUR 12266 EN 1988	1988
AD52.	Recommendations for calculating the effect of wind on constructions, European Convention for Constructional Steelwork	ECCS Technical Committee 12-wind, report no. 52, 2nd edition	1997
AD53.	General principles for the Safety Design of Technical Products	DIN 31000 (1979-03) including DIN VDE 31000-2 (1987-12)	1979, 1987
AD54.	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	2.1.4.1.1.1 EN 60204-1:1997	1997
AD55.	Protection against electrical shock – Common aspects for installation and equipment	2.1.4.1.1.2 IEC 61140	1997-11
AD56.	Electrical installation of buildings	IEC 60364	2001
AD57.	Safety of information technology equipment	IEC 60950, 3rd edition	1999-04
AD58.	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	IEC 60664-1, Ed. 1.1	2000-04
AD59.	Intentionally Blank		
AD60.	Hydraulic fluid power -- General rules relating to systems	ISO 4413:1998 , 2nd edition	1998
AD61.	Electromagnetic Compatibility (EMC) including Electromagnetic Pulse (EMP) and lightning Protection – Programme and Procedures – Procedures for Systems and Equipment”	VG 95 374 Part 4	
AD62.	COSHH Regulations	Framework Directive98/24/EC	1999
AD63.	ESO Safety Policy		

2.2 Reference Documents

Reference documents provide background information for use as appropriate.

Document title		Doc Number
RD01.	Interface Control Document Between Telescope Structure and M2 Unit	VLT-ICD-ESO-11310-11210, issue 3
RD02.	IRACE Design Description	VLT-TRE-ESO-14100-1654, Issue 2.0
RD03.	Reflecting Telescope Optics II	Wilson, R, N. ISBN 3-540-60356-5 Springer-Verlag
RD04.	Operational Concept Definition Document (OCDD)	VIS-SPE-VSC-00000-0002 issue 1
RD05.	VISTA Project Overview	VIS-TRE-ATC-00000-0004 Latest Issue
RD06	VISTA Technical Specification	VIS-SPE-ATC-00000-0003 Issue 3.0

3 Systems Description of VISTA

3.1 Physical Description

Deleted as descriptive.

3.2 Definitions

The following terms shall be used throughout this Verification Specification, with the meaning herein:

Term	**Definition**
VISTA	The object of this specification comprising the design, manufacture, testing and integration the sub-systems into a fully integrated astronomical facility and subsequent commissioning of this facility.
Vista Project Office or VPO	The management organisation entrusted with the procurement of the VISTA.
Sub-System	Part of the works comprising one or more workpackages and which are defined in Section 3.3.2.
Camera	For the purposes of the VISTA project the IR and Visible scientific instrumentation shall be described as the IR Camera and the Visible Camera
Integration	A simple snapshot, within the Data Acquisition System (DAS), of a specified elapsed time. This elapsed time is known as the integration time.
Exposure	The stored product of many individual *integration*s, which have been co-added in the Data Acquisition System (DAS). Each exposure is associated with an exposure time. The stored product is a single FITS file.
Exposure Sequence	A series of exposures
Observation	All necessary operations required completing an exposure sequence and preparing for the next exposure.
Altitude	The altitude axis of the telescope (aka elevation). The VLT software makes frequent reference to altitude in this context.

CCS	Common Control Software: the ESO software infrastructure used on the VLT etc.
Instrument	A generic term that applies to VLT and similar instruments. VISTA shall initially have one instrument *viz.* the IR Camera.
Instrument Control System	The module within the Instrument Software that controls an instrument's mechanisms.
LCS	LCU Common Software: that part of the CCS which runs on an LCU
LCU	Local Control Unit: a computer system comprising CPU, VME backplane, VxWorks real time operating system and software based on the LCC
TCS	Telescope Control System: the collection of software modules, which control the hardware associated LCU systems. VISTA's TCS is closely based on the VLT Telescope Control Software.
Workstation	An HP workstation running the HP-UX operating system and software based on the CCS. A workstation may or may not be used directly by a user.
Pawprint	The 16 non-contiguous images of the sky produced by the VISTA IR camera, with its 16 non-contiguous detector chips.
Tile	A filled and fully sampled area of sky formed by combining multiple *pawprint*s. Because of the detector spacing, the minimum number of pointed observations (with fixed offsets) required for reasonably uniform coverage is 6, which would expose each piece of sky, away from the edges of the tile, to at least 2 camera pixels.
VDFS	The VISTA Data Flow System a related project to provide to ESO; an Exposure Time Calculator; modules for a pipeline in Chile to assess data quality (QC); modules for a pipeline in Garching to remove instrumental artefacts, and calibrate the data both photometrically and astrometrically; a Survey Area Definition Tool.

3.3 Product Tree and Sub-System Definition

3.3.1 Product Tree

A Product Tree of the hardware and software of VISTA, covered by this specification is given in Figure 1.

3.3.2 Sub-System Definition

The sub-systems comprising VISTA are defined in this section. Items in *italics* while essential to proving the sub-system performance do not form part of the final deliverables of the project.

Telescope	The Telescope Sub-System comprises: the Telescope Structure, M1 Cell, Cassegrain Rotator, Control Hardware and software, Service and *Test Equipment*, *Factory Service and Test Equipment*, in-service handling equipment, and all supporting documentation.
M1	The M1 Sub-System comprises: M1 Mirror, *M1 test equipment*, Test Specimens and *M1 Transport Container*, in-service handling equipment, and documentation.
M2	The M2 Sub-System comprises: M2 Mirror, M2 Support, M2 Unit, *test equipment*, service equipment, in-service handling equipment and documentation.
IR Camera	The IR Camera Sub-System comprises: Cryostat, Cryogenic and Vacuum systems, corrector optics, filters, filter mechanism, baffles, 16 off 2k x 2k IR Detectors, detector controllers, Guiding and wavefront sensing systems, control hardware and software, *test equipment*, service equipment, handling equipment and documentation.
Enclosure	The Enclosure Sub-System comprises: The Dome (Enclosure rotating part), Basement and Auxiliary Building (the adjoining building to the Enclosure that houses plant and support services for both the Telescope and the Enclosure), dedicated maintenance and in-service handling equipment, and documentation.
Coating Plant	The Coating Plant Sub-System Comprises: The Coating Plant, Wash Facility, *test equipment*, service equipment, documentation and spares suitable for coating the VISTA M1 and M2 in either Aluminium or Protected Silver. The Coating Plant facility is housed in the Auxiliary building.
Data Handling	Comprising hardware and software for data storage and making the data available to the quality control pipeline for which VDFS provides modules, and associated documentation.

Telescope Software	Comprising the software and associated hardware required for operating the telescope and its sub-systems. It also includes network equipment specific to VISTA.
M2 baffle	Reflective baffle around the M2 to baffle the IR Camera
Site	All development activities for site preparation prior to installation of the enclosure.

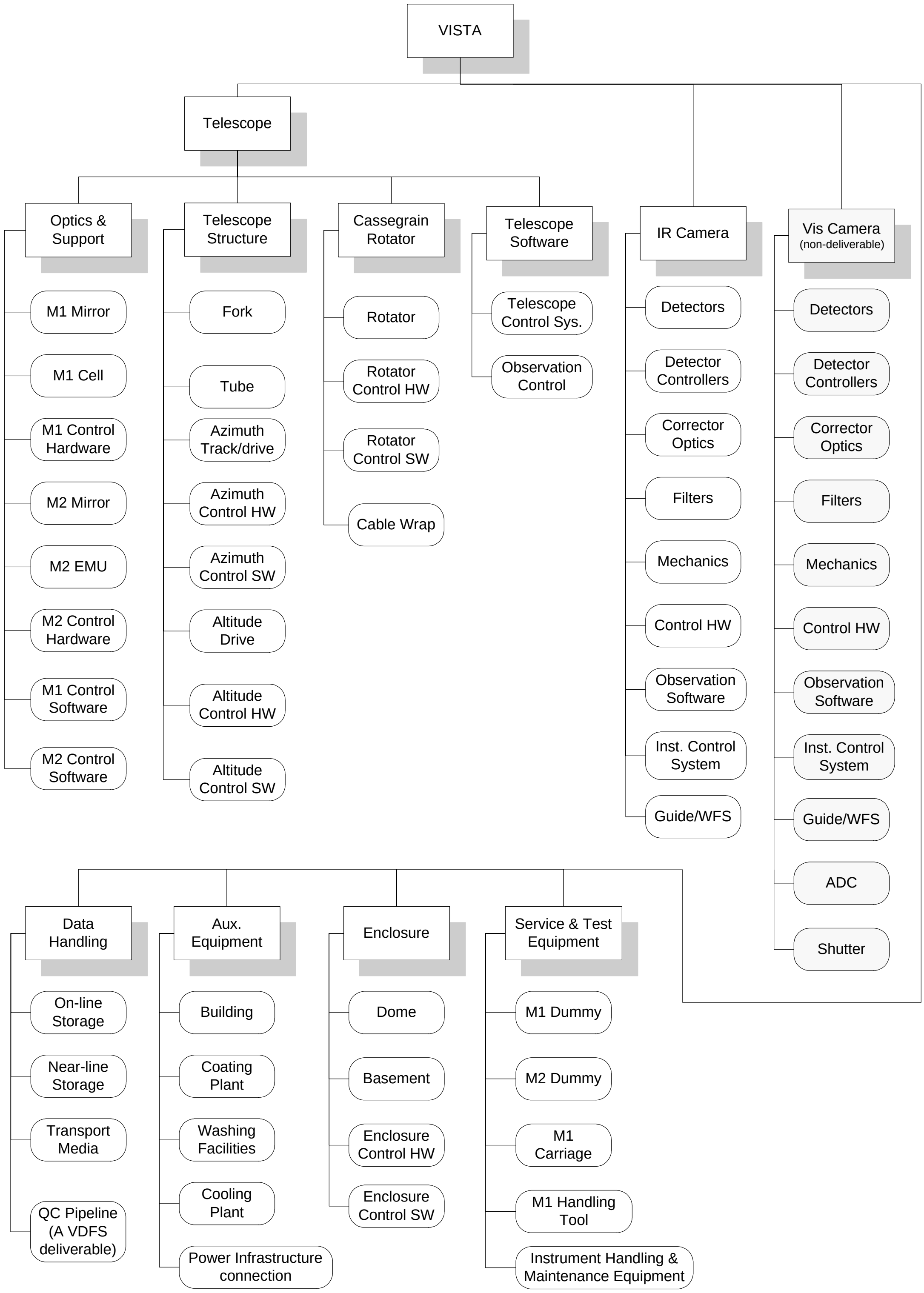

Figure 1 VISTA Product Tree

3.4 System Context

3.4.1 VISTA Context

Deleted as descriptive.

4 System Requirements

4.1 Context

No text.

4.2 VISTA System Tree

No text

4.3 Environmental Conditions

4.3.1 General

The equipment shall comply with the requirements defined in the VLT Environmental Specification AD04, (unless specifically amended by the requirements defined herein), which describes the overall environmental conditions to be expected in operation, maintenance, storage at the Chilean site and transportation from Europe.

4.3.2 Transportation Environment

The transportation environment defined under Section 4.1 of AD04 is applicable.

4.3.3 Installation, Operation & Maintenance Environment

The VISTA system has been defined to meet the environment defined under Section 4.2 of AD04 which is applicable except for that specified herein.

4.3.3.1 Natural Temperature

Operational temperature range is defined as the ambient air temperature range under which all performance requirements shall be met; it is defined as:

Operational temperature range 0 to 15 °C

Functional temperature range is defined as the ambient air temperature range under which it shall be possible to operate the system, although performance requirements may not be met; it is defined as:

Functional temperature range -5 to 25 °C

4.3.3.2 Natural Wind

Operational wind speed

VISTA shall be able to operate within its nominal performances, achieving the SIQ defined in Section 4.9, for average external wind speed up to 18 m/s over 15 minutes, providing when the average wind speed is larger than 12m/s the Telescope shall point at least 90 degrees away from the wind direction, and the Telescope shall be closed for wind speed larger than 18m/s.

Survival wind speed

Each subsystem of VISTA has been designed for the relevant expected wind speed, taking into account the requirement of Section 4.2.9.1 of AD04 including possible accidental condition [in case that the Enclosure cannot be closed, parts of the telescope may be exposed to stronger wind than the operational wind speed]. Unless otherwise substantiated by proper design and/or analysis the survival wind speed to be used for the design of equipment inside the VISTA enclosure shall be 36 m/s.

The survival wind speed to be used for the dimensioning of buildings and external facilities shall be as per AD04, section 4.2.9.1.

4.3.3.3 Earthquakes

VISTA has been designed to withstand earthquakes as defined by the requirement of AD04 section 4.2.14: the Operating Basis Earthquake (OBE) and the Maximum Likely Earthquake (MLE). The excitation characteristics used are defined in Section 8.1.1.4 (Earthquake Analyses).

4.4 External Interfaces

4.4.1 Power Distribution

The interface of VISTA to the Power Distribution System of the Cerro Paranal Observatory shall be in accordance with AD31.

4.4.2 Local Area Network

Local Area Networks shall comply with ESO standards, as defined in applicable documents AD12 and AD28 or otherwise subject to specific agreement with ESO; VISTA shall interface to the Observatory's Local Area Network as defined in these documents.

4.5 Reference Frame Definition

The co-ordinate system requirements detailed in AD03 shall be applied to all levels of VISTA. Local co-ordinate systems linked to telescope, telescope assemblies and other parts of VISTA are defined as necessary, in accordance with the requirements of AD03.

4.6 Telescope Aperture

1 The telescope shall have a primary mirror of diameter ≥ 4m.

2 The diameter of the equivalent clear aperture, taking into account the telescope pupil at the secondary mirror shall be ≥ 3.7 m.

4.7 Wavelength Coverage

VISTA shall be capable of operating over the wavelength range 0.95 microns to 2.40 microns with the IR Camera.

Table 1 Deleted - see Table 6

4.8 Sky Coverage

4.8.1 Zenith Distance

1. The system shall operate and meet its specifications at zenith distances:

   - 2º to 70º at all azimuth angles

The region within 2º radius of the zenith is referred to as the zenith blind spot.

4.8.2 Visible Camera Field

no text

4.8.3 IR Camera Field

1. The IR Camera shall provide an available field of ≥ 1.6° diameter. This shall be unvignetted compared to the centre of the field, except for the outermost 25% by radius, which may be vignetted by up to 3% compared to the centre of the field.
2. The plate scale shall be within the following values: 54.5 ≤ plate scale ≤ 60 µm/arcsec.
3. The IR Camera pixel size shall be within the following values: 0.30 arcsec ≤ pixel size ≤ 0.34 arcsec.
4. The IR Camera shall observe a contiguous area of the sky ≥ 1.6 deg^2. This shall be achieveable using six telescope pawprints for 16 detectors each of size 2048 x 2048 pixels on a 90%/42.5% spacing.

4.9 System Image Quality

4.9.1.1 SIQ Visible Channel Requirements

Deleted as descriptive.

4.9.1.2 SIQ IR Channel Requirements

Definition: SIQ = max(50%EED, 80%EED/1.54) where EED excludes the free atmosphere seeing

The following IR Camera *SIQ* requirements shall be met for an exposure of duration up to 30 minutes in the J, H and K_s passbands without micro-stepping:

- $SIQ \leq 0.5 \times f_w \times f_{am} \times f_{fov} \times f_p$ (arcsec)

where:

f_w is the high windspeed correction factor for windspeed.

f_{am} is the airmass correction.

f_{fov} is the factor allowed for optimisation of the image quality towards the centre of the field - (the power of 1.3 is chosen to give a smoothly varying factor, ~10% at 1.5^O and ~20% at 1.6^O).

f_p is the factor allowed for change in pixel scale from the original concept of 17.8µm - the value of 2% has been chosen to reflect the contribution of this parameter to the image quality performance.

These factors shall be applied as follows:

Factor	f_w	f_{am}	f_{fov}	f_p
Parameter	average windspeed	air mass	FoV diameter	pixel scale
if	average windspeed >14 m/s	air mass >1.3	FoV diameter >1.4degrees	-
Equal to	1.1	$(airmass/1.3)^{0.6}$	$(FoV/1.4)^{1.3}$	1.02
Otherwise equal to	1.0	1.0	1.0	1.02

4.10 Astrometry

To achieve the Astrometric performance requirements, requirements 4.10.1 shall apply.

4.10.1 Stability of the IR focal plane

4.10.1.1 Co-planarity

1. The pixels on all detectors shall be contained within two planes spaced by ≤50 µm across the focal plane.

2. The tilt relative to the focal plane of any one detector array shall remain stable within 0.0125 deg.

4.10.1.2 Thermal Expansion

Differential thermal expansion between the arrays in the focal plane, leading to distortion of the array during operation shall be ≤ 4.5µm

4.10.1.3 Flexure

Differential flexure between arrays in the focal plane under stable temperature conditions shall be

≤ 3µm laterally
≤ 30µm axially

4.10.1.4 Distortion

The centre of the pincushion distortion pattern shall remain stable relative to the focal plane within a circle of ≤ 180µm radius

4.10.2 Neutral Density Filter

no text

4.11 Photometry

No explicit photometric requirements are defined in the Technical Specification, but technical parameters are specified to ensure that the photometric requirements in the SRD (AD01) can be achieved. These requirements are listed in Table 2.

Photometric Requirement	TVS Section
Basic Stability	
Detector and Controller non-linearity	4.15
Detector and controller gain	5.3.6
Flat field	5.6.5.8
Filter	
Opaque Filter	5.3.2
Filter Stability	5.3.3.3
Positional accuracy	5.3.3.3
Transmission Stability (SRD 4.3.1/2)	5.10.3
Other	
Readout noise pickup test	6.1.8
Slew rotator when tracking open loop	5.1.17.5
Dome light tightness	5.6.5
Offset focus	5.1.18

Table 2 Photometric Requirements

4.12 Sensitivity

4.12.1 Sky Brightness Definitions

Some later specifications relate to percentages of sky brightness; the following sky brightness values (Vega system) shall be assumed where necessary for calculation, however they do not in themselves constitute specifications:

1. *The intrinsic natural sky brightness is assumed to be as follows, independent of lunar phase:*

Band	**J**	**H**	**Ks**
mag's/sq. arcsec	16.0	14.1	13.0

2. deleted as duplicated

4.12.2 Throughput

The System Throughput includes the effects of optics, filters and detectors, but not those of the atmosphere or degradation from dust or reflectivity decay of mirrors. The System Throughput assumes M1 and M2 with clean, untarnished silver coating.

1. Under these assumptions, the System Throughput at each band using mirrors coated with protected silver shall be equal or greater than those defined in Table 3
2. Detector pixels defined as 'bad' in Section 5.3.6.1 shall not be subject to this requirement.

Band	**J**	**H**	**Ks**
System Throughput	0.22	0.33	0.36

Table 3: VISTA Throughput Requirements

4.12.3 Scattered Light

The following definitions are used in specifying the scattered light requirements:

Natural Sky	Light detected at the focal plane from the directly observed science field including moonlight scattered in the atmosphere.
Scattered light	Light detected at the focal plane in addition to that of the natural sky including moonlight scattered from other sources.

1. Light scattered from a 1st magnitude object 1.5° from the centre of the field shall not contribute >50% additional light over and above the dark night sky background.
2. For the IR Camera, the contribution to detector background from 'locally scattered' light, in any filter, shall not exceed 5% of the 'natural sky' background at any angle ≥ 25˚ from the Full Moon.
3. For the IR Camera, the contribution to detector background from 'locally scattered' light in any of the J,H and K_s filters shall not exceed 50% of the natural sky value at angles 15˚ - 25˚ from the Full Moon.

4.12.4 Emissivity

1. To achieve a comparable performance to a cold stop IR camera, the total background (telescope + sky) of the system at K_s band shall not be more than a factor of 1.3 higher than a perfectly baffled system.
2. The effective emissivity of the system (telescope + IR camera) in the K_s band with a clean, untarnished Ag-coated M1 and M2, and a clean camera window and M2 baffle shall be ≤12%.

4.12.5 Ghosting

Ghosting is defined as image artefacts caused by multiple reflections of objects in the field of view; the ghosting characteristics of the system shall be:

1. Ghosting with two or more unwanted reflections shall not generate any images with diameter ≤ 75 arcsec.
2. From an 6^{th} magnitude star at any point in the field, the proportion of detector pixels in the focal plane that receive ghost flux exceeding 50% of the dark sky background shall be ≤ 0.1%.

4.12.6 Light Leakage

The camera shall be designed such that light leakage (being any light bypassing the science filters from any source) shall be designed out and the maximum permissible increase in background from this source shall be 0.1%.

4.12.7 System Noise Characteristics

The power spectrum of the system noise shall be such that coadding images measured through a broad band filter shall improve the S/N as $(time)^{0.5}$ between 15 minutes and 16 hours to within 10% within any 2 month period under the similar operating conditions[1].

[1] The similar operating conditions include factors such as mirror cleanliness, change of detector controller, moon proximity etc.

4.13 Target Acquisition

4.13.1 Accuracy

4.13.1.1 Definition

In the context of target acquisition, the pointing accuracy is defined as that achievable in open-loop (i.e. without guiding) after correction for repeatable effects with an operational pointing model.

4.13.1.2 Absolute Pointing

Absolute pointing accuracy on the sky shall be ≤ 3 arcsec rms.

4.13.1.3 Offset Pointing

Offset pointing is that achieved by moving a certain distance from a known accurate position.

1. For offsets of up to 2° on the sky in any direction, the relative pointing accuracy shall be ≤ 2arcsec (95% confidence).
2. For offsets where the guide star remains on the autoguider CCD, the offset pointing accuracy shall be ≤ 0.5 pixel on the science arrays (95% confidence).

4.13.1.4 Re-Acquisition

It shall be possible to reacquire objects across the field, previously observed at the same airmass, to the same position in the detector focal plane as before to an accuracy of <1 pixel. Re-acquisition to this accuracy shall be achieved through an offset applied after initial target acquisition.

4.13.2 Acquisition Time

Target acquisition speed defines the maximum time to acquire a new object and start tracking open loop. It includes motions of both the telescope mount and the enclosure. It does **not** include filter change, or detector read-out overheads.

1. It shall be possible to acquire a target up to 60° from the previous position within 45s.
2. It shall be possible to acquire a target up to 15° from the previous position within 30s.
3. It shall be possible to acquire a target up to 2° from the previous position within 10s.
4. It shall be possible to acquire a target up to up to 10 arcmin from the previous position within 6s.
5. It shall be possible to acquire a target up to up to 2 arcmin from the previous position within 3s.
6. It shall be possible to acquire a target up to up to 20 arcsec from the previous position within 2s.

4.14 Tracking

4.14.1 Open Loop Tracking

Open loop tracking is defined as the image drift whilst not auto-guiding.

1. Open-loop tracking shall be accurate to within 0.2 arcsec rms over 15 seconds.
2. Open-loop tracking shall be accurate to within 0.5 arcsec rms over 5 minutes.
3. It shall be possible to track open-loop, objects moving at non-sidereal rates of up to 1 arcsec/s. The size of the zenith blind spot may be increased by 25% radius for non-sidereal tracking at the maximum rate and proportionally for lesser rates.

4.14.2 Closed Loop Tracking

1. Closed loop tracking shall be performed whilst auto-guiding; closed loop tracking performance is not defined explicitly, since it is one of the contributors to the SIQ (Section 4.9).
2. The autoguider shall be operational within 1 second of acquisition unless a further offset on the guide detector is required. If a further offset is necessary, the autoguider shall be operational within 5 seconds.

4.14.3 Non-Sidereal Tracking

1. The design of the VISTA system shall not preclude the later development of closed-loop non-sidereal tracking at rates of up to 2 arcsec/min.

4.15 Exposure Requirements

4.15.1 Exposure Length

It shall be possible to make exposures of any duration specified between at least 1.5 s and 1 hour.

4.15.2 Exposure Accuracy

1. The duration of exposures shall be within 0.1s or 1% of that requested, whichever is the larger.
2. The duration of the exposure at any point in the field shall be recorded to an accuracy of 0.01s or 0.25%, whichever is the larger.

4.15.3 Time Stamping

The absolute timing of each exposure shall be recorded so as to permit reconstruction of the absolute UT of mid-exposure at each pixel to ≤ 0.1s.

4.15.4 Exposure Rate and Readout

4.15.4.1 Visible Camera

no text

4.15.4.2 IR Camera

Using the IR Camera, it shall be possible to start an exposure sequence within 5s of the completion of the previous exposure sequence (assuming no reconfiguration is required).

4.15.4.3 Multiple Integrations per IR Exposure

Using the IR Camera, it shall be possible to execute and process, prior to data storage, multiple integrations per exposure; during an exposure it shall be possible to perform individual integrations at the rate of one every 10s.

4.15.4.4 Rapid Sequence of IR Integrations

1. Using the IR Camera and looking at the same point on the sky through the same filter, it shall be possible to execute a predefined sequence of integrations such that the delay between completing one integration within the sequence and starting the next shall be ≤ 1.5s.
2. It shall be possible to perform data acquisition and save to disk the individual integrations within a sequence at a rate of one frame every 10s (raw data) or 20s (coadded or NDR data). *The resulting data cube is for diagnostic purposes (e.g. readout anomaly etc) and shall not be regarded as a science data product*
3. *Incorporated into 4.15.4.4 above.*

4.16 Data Handling

4.16.1 Stored Data

4.16.1.1 Visible

no text

4.16.1.2 IR

It shall be possible to store data from the IR Camera in any of the following forms, all 4 bytes/pixel:

1. Raw data with or without differencing
2. Coadded
3. *deleted as not supported by Raytheon detectors*

Any set of data shall be stored in one form only.

Using the IR Camera it shall be possible to perform data acquisition and store exposures at a sustained rate of one exposure per 10s over a period of 14 hours. (*This is a requirement on data acquisition and storage alone.*)

4.16.2 Writing to Disk

1. The system shall ensure that adequate free disk space is available to store the data when an exposure is initiated, so long as the maximum data volume per night as stated in Section 4.16.1.2 is not exceeded. If adequate disk space cannot be made available, e.g. due to an equipment or operational failure, the exposure shall not be initiated without specific operator intervention.

2. It shall be possible to store data to disk whilst concurrently moving the telescope and reconfiguring the camera.

4.16.3 Archiving

All science and calibration exposures shall be stored to disk with adequate meta-data to allow subsequent data reduction, and in the format compliant with the ESO Data Interface Control Document (AD24).

4.16.4 Transport

The system shall write data to transport media provided by ESO.

4.16.5 Data Storage

(a) On-line storage shall be provided for the maximum data volume generated over 2 nights.
(b) On-line storage shall be provided for the typical data volume generated over 10 nights.

4.16.6 Near Line Storage

no text

4.16.7 Data Quality Control

Note: Software Modules for Quality Control (QC) are deliverables of the related VISTA Data Flow System project, with whom necessary information will be shared to assist the work [as per AD41].

4.16.8 Local Data Reduction

1. The VISTA system shall allow data to be read and processed on a local workstation within 10 minutes of the data's acquisition. This shall not interfere with the observing process (including data acquisition, pipeline data reduction and data archiving) either in functionality or performance.

2. Use of this local workstation shall not impact the performance of VISTA's data acquisition, pipeline data reduction and data archiving processes.

3. Authorised personnel shall be able to install new application software, provided it can be compiled and run on the specific hardware and complies with any constraints imposed by ESO. (SRD 7.7/1, 7.1/5)

4. It shall be possible to export data from VISTA to external computers, *e.g.* via FTP / ssh. External computers may include computers at the Paranal site connected outside security firewalls.

4.17 Thermal Control

Any systems capable of introducing thermal seeing effects shall fulfil the following requirements:

1. Systems above primary mirror level shall not have a surface temperature which differs more than +1.5°C / -3°C from the ambient air temperature, for a 2m/s wind speed within the open dome and the telescope pointing to zenith. This requirement shall be met with ambient air variation of +/- 0.5°C.
2. Systems below primary mirror level shall not have a surface temperature which differs more than +1.5°C / -5°C from the ambient air. This assumes 1m/sec wind speed within the open dome and the telescope pointing to zenith. This requirement shall be met with ambient air variation of +/- 0.5°C.
3. All concentrated heat sources generating > 100 W shall be cooled.
4. Dispersed heat generating systems with combined heat sources of 200 W shall be actively cooled.

4.17.1.1 Temperature sensors

Temperature sensors shall be provided at various locations on the telescope for monitoring and calibration purposes. As a minimum, sensors shall be provided on the telescope structure, the M1, M1 Cell and the M2 Unit. In addition, air temperature at the M2 level and at the M1 level shall be measured.

5 VISTA Subsystem Characteristics and Requirements

Text deleted as descriptive.

5.1 Telescope Requirements

5.1.1 General Characteristics

no text

5.1.2 Telescope Design Volume

no text

5.1.3 Telescope-related Masses

1. Design moving mass on Cassegrain Rotator shall be ≤2.9 tonnes.
2. The mass of the heaviest sub-assembly to be lifted during maintenance shall not exceed the capacities of the enclosure crane (10 tonne).
3. Provision shall be made for the addition of masses on the Telescope to facilitate balancing.

5.1.4 Telescope Dynamic Performance

Deleted as descriptive.

5.1.5 Telescope Optics Requirements

The Telescope optical requirement is such that it shall permit mounting of M1, M2 and the IR Camera in accordance with AD33.

5.1.5.1 Optical Design Data

The design characteristics of M1 and M2 are defined in AD33.

5.1.6 M1 Blank Characteristics

Text deleted as descriptive.

The major geometrical parameters of the blank shall comply with the following:

- Outside diameter of the blank 4100 mm
- Tolerance on diameter (out of roundness) ± 0.5 mm

- Diameter of centre hole	1200 mm
- Concentricity of centre hole with outer diameter	0.5 mm
- Nominal thickness	170.5 mm
- Radius of convex surface	≈ 8.3 m
- Surface finish (concave surfaces, edges)	D76

Preliminary values of residual stresses (compressive) are:

- Mean absolute value:	10 nm / cm
- Maximum absolute value:	20 nm / cm

Coefficient of Thermal Expansion (CTE)	$0 \pm 0.07 \cdot 10^{-6}$ /K
Homogeneity of thermal expansion coefficient in the blank:	$\leq 0.02 \cdot 10^{-6}$ /K

5.1.7 M1 Mirror Optical Characteristics

VISTA shall incorporate an active mirror. The optical specification takes into account the active optics correction capability of the system. This specification covers:

Low spatial frequency errors:
These are the errors that can be removed from the final figure of the M1 mirror by use of the active optics capability of the system.

High spatial frequency errors:
These are the residual surface errors after removal of the low spatial frequency errors defined above.

5.1.7.1 M1 Mirror Optical Prescription

The design characteristics of M1 shall be in accordance with AD33.

5.1.7.2 Low Spatial Frequency Errors

Incorporated into 5.1.7.3.

5.1.7.3 M1 Optical Quality

5.1.7.3.1 M1 Test Set-up

1. The primary mirror shall be tested on a support system with the same geometry and interfaces as the final support system of the M1 Cell as defined in AD35.
2. The testing process shall ensure effective removal of the axial print-through with the M1 mirror pointing at Zenith.

5.1.7.3.2 M1 Spatial Frequency Errors

1. High spatial frequency errors are the residual wavefront errors after removal of low spatial frequency wavefront errors using a maximum of ± 65 N active force applied to the M1 axial supports.
2. The high spatial frequency errors are defined as rms slope error of the wavefront and shall be ≤ 0.06 arcsec rms over the operating range

3. All M1 spatial frequency errors shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.

5.1.7.4 Microroughness

The micro roughness of the polished surface shall be ≤ 2nm.

5.1.7.5 Interface to the M1 Cell

1. The axial and lateral interfaces to the M1 Cell shall be realised by means of bonded low thermal expansion pads.
2. The axial interface design shall only be able to transmit push forces to the mirror back.

5.1.7.6 Polishing requirements

1. The primary mirror shall be polished on a support system equivalent to the final support system. The support system shall have the same geometry and interfaces as in the final support system of the M1 Cell, in order to have the same print-through as in the telescope.
2. *deleted as descriptive and as covered by 5.1.7.3.2/3*
3. The verification of the Optical Performance Requirements shall be performed with the M1 mirror pointing at zenith with the mirror on the polishing support system.

5.1.8 Secondary Mirror Assembly

5.1.8.1 M2 Optical Design Characteristics

1. The design characteristics of M2 shall be in accordance with AD33.
2. The mirror shall be polished up to the external rim, except for a small chamfer to avoid chips (typically 0.25mm).

5.1.8.2 M2 Optical Quality

Optical quality in Passive mode:
The optical quality in Passive Mode is defined as including all surface errors with the exception of curvature and conic constant (active optics correction not in operation). The optical quality is expressed in terms of the rms slope error of the mirror surface. The requirement for the optical quality is:

The rms slope error of the wavefront after removal of the curvature error (focus) and of the conic constant error (third order spherical aberration) shall be ≤ 0.35 arcsec rms; the effect of any surface errors shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2..

5.1.8.2.1 Test Set-up

1. The M2 mirror shall be tested on its support system.
2. The testing process shall ensure removal of the axial print-through with the M2 mirror pointing at nadir (*i.e.* equivalent to the Telescope zenith pointing.)

5.1.8.2.2 M2 High Spatial Frequency Errors

1. High spatial frequency errors shall be defined as the residual wavefront errors after removal of wavefront errors using a maximum of ± 65 N applied to the M1 axial supports.
2. The high spatial frequency errors are defined as rms slope error of the M2 wavefront and shall be ≤ 0.15 arcsec rms over the operating range.

5.1.8.3 Micro Roughness

The micro roughness of the polished surface shall be ≤ 2nm.

5.1.8.4 M2 Assembly Mechanical Characteristics

1. The mirror blank shall be of lightweighted Zerodur or similar ultra low expansion glass or ceramic.
2. The mass of the mirror shall be ≤ 150 kg.
3. *no text*
4. The first eigenfrequency of the M2 assembly rigidly supported at the M2 Electromechanical Unit interface shall be ≥40 Hz.
5. *deleted as descriptive and non-quantitative*.
6. Thermal effects on the mirror figure have been considered in accordance with meeting the SIQ performance requirements of section 4.9.1.2.
7. The connection between the support system and the mirror substrate shall be optimised for safety.
8. A safety backup support system shall be included in the M2 Assembly to prevent the mirror or major part of it from falling in case of failure. Under normal operation the safety backup support shall not influence the mirror performance.
9. The M2 Cell shall be used for interfacing the M2 Unit and for all handling operations.
10. Features for the safe and secure handling of the mirror shall be provided.
11. The M2 Mirror shall be provided with a flat area at the centre and a target for alignment purposes.
12. All items permanently attached to the mirror shall be compatible with high vacuum applications.

5.1.9 Telescope Structure

The dimensions of the telescope shall be in accordance with AD38.

5.1.9.1 Azimuth Bearing and Pier Interface

1. The Pier interface shall comprise all hardware interfacing the pier with the Azimuth bearing and shall support the telescope axially and restrain it radially against all imposed load conditions as defined in Section 8.1.
2. The pier interface shall be compliant with AD37.

3. The azimuth bearing shall support the telescope axially and restrain it radially against all imposed load conditions as defined in Section 8.1.
4. The azimuth bearing shall be designed to meet the tracking requirements of Section 4.14.
5. Earthquake restraints shall be provided.
6. Bearing shall be sealed against moisture and dirt ingress.
7. In case of failure of the oil supply no damage shall occur to the bearing.
8. Provisions shall be made for avoiding oil contamination either to or from the bearing.

5.1.9.2 Azimuth Cable wrap

1. The cable wrap shall be mounted to the yoke below the azimuth floor.
2. The implementation of the cable wrap shall ensure that the tracking requirements of Section 4.14 are met throughout the operational range as defined in Section 5.1.10.8.
3. The implementation of the cable wrap shall ensure that the cables are not damaged throughout the possible range of travel of the telescope as defined in Section 5.1.10.8.
4. The cable wrap shall have capacity for permanent installation of all services for the telescope, Cassegrain rotator, and IR camera.
5. The cable wrap shall be populated with services for the telescope, Cassegrain rotator and IR camera

5.1.9.3 Telescope Fork and Base

1. The telescope forks and base shall comprise all systems between the azimuth drive systems and the altitude drive system.
2. *no text*
3. *no text*
4. *deleted as non-specific*
5. The forks and base shall allow access to bearings, encoders and all components of the drives.
6. A continuous azimuth floor meeting the interface requirements defined in AD38 (telescope/enclosure ICD) and the floor loading defined in Section 5.6.4 shall be mounted from the base structure.
7. The azimuth floor shall include necessary provision for handling equipment.
8. The azimuth floor shall provide a safe working surface for inspection and maintenance access to components on the mirror cell and instrument mount and camera.

5.1.9.4 Altitude Bearings and Drive System

1. The altitude axis shall use two bearing sets, one at either side of the fork.
2. The altitude bearings shall support the telescope tube imposed load conditions as defined in Section 8.1.
3. The Altitude drive shall be designed to meet the tracking requirements of Section 4.14.
4. The bearing system shall provide restraint against earthquake loads.

5.1.9.5 Telescope tube

1. The allowable design space of the telescope tube shall be in accordance with AD38.
2. *no text*

3. The design shall incorporate a ring centre-section interfacing with the M1 Cell and the altitude bearings, and a support truss for the M2 system.
4. *no text*
5. The obscuration caused by M2, M2 Unit, baffles, and supporting vanes *etc*. shall be consistent with meeting the SIQ and Throughput requirements of sections 4.9.1.2 and 4.12.2 respectively.
6. Cables and insulated coolant tubes shall be run in channels above the spiders without further obstruction of the optical path.

5.1.9.6 Telescope tube structural performance

Deleted as descriptive.

The stability and accuracy of alignment with respect to the positioning of M1, M2, and the IR Camera shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.

5.1.9.7 Altitude Axis Cable Wrap

1. *no text*
2. The cable wrap shall be driven by the altitude axis drive which shall be designed taking account of the induced torque loading from the wrap.
3. The cable wrap shall have capacity for permanent installation of all services for the telescope, Cassegrain rotator, and IR camera.
4. The cable wrap shall be populated with services for the telescope, M2 Unit, Cassegrain rotator and IR camera.

5.1.9.8 Adjustment and balancing

5.1.9.8.1 Telescope Upper Structure Alignment to Centre Section

The alignment tolerances for the telescope truss shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2. *This shall include the effect of the interface that is split to allow removal of the M1 Mirror from the M1 Cell for coating*.

5.1.9.8.2 Balancing

1. There shall be provision for the addition of masses on the Telescope structure to enable the balancing around the altitude axis.
2. Once balanced, the residual torque around the altitude axis shall be ≤ 200 Nm in any orientation of the Telescope Tube.
3. Provision shall be made for the fine-tuning of the telescope tube balancing.

5.1.10 Alt/Az Axis Control

5.1.10.1 Reuse of ESO Software

Deleted as descriptive

5.1.10.2 TCS Interface

The Axis Control System shall be controlled by the TCS, using a similar interface definition to that used on the VLT, modified in detail only if necessary.

5.1.10.3 Software/Hardware Interface

The interface between VISTA hardware and the Axis Control System shall be defined at the level of hardware signals delivered by VME interfaces in the LCU.

5.1.10.4 Control Algorithms

The control algorithms shall be as implemented and documented in ESO software release.

5.1.10.5 Position measurement

The measurement accuracy of the position measurement systems shall be sufficient for the system to meet the pointing accuracy as per section 4.13.1.2, and shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.

5.1.10.6 Velocity Measurement

Deleted as no longer relevant.

5.1.10.7 Motors

1. *no text*
2. The system shall have sufficient margin between its rated output torque and the computed maximum torque for operational and survival loads.
3. The effect of the motor system on pointing and tracking shall be consistent with achieving the poointing accuracy as per section 4.13 & 4.13, and the overall SIQ performance as per section 4.9.1.2.

5.1.10.8 Telescope Angular Range

The angular ranges are defined in accordance with the system of co-ordinates and the origin as per AD03 (Basic Telescope Definitions)

5.1.10.8.1 Kinematic ranges

Azimuth axis

- Azimuth zero — South, increasing towards East
- Azimuth angular range — +130° to -310°

Altitude axis (limited by software limit)

- Altitude zero — Tube pointing to horizon
- Altitude angular range — -0° to +90°
-

5.1.10.8.2 Operational conditions

Zenith Blind Spot (Tracking) — ≤ 4.0° diameter

Azimuth

- Azimuth range — +130° to -310°
- maximum Azimuth tracking velocity — 480 arcsec/s
- maximum Azimuth tracking acceleration — 10 arcsec/s^2
- maximum Azimuth slew velocity — 2.0°/s
- maximum Azimuth slew acceleration — 0.5°/s^2

Altitude

- Altitude range — +20° to +88°
- maximum Altitude tracking velocity — 17 arcsec/s
- maximum Altitude tracking acceleration — 0.5 arcsec/s^2
- maximum Altitude slew velocity — 2.0°/s
- maximum Altitude slew acceleration — 0.5°/s^2
-

5.1.10.8.3 Maintenance conditions

no text

5.1.10.8.4 Telescope Limits

1. Each axis shall be equipped at both ends with a set of limit switches and end-stops. The location of these switches and stops shall be such as to allow the telescope to decelerate to a complete stop before activation of the next limit. In the event that a reduced slew speed is implemented, e.g. to limit the altitude axis overshoot, this reduced speed region shall be hardware interlocked to the drive system.
2. *Operational limits.* Operational limits shall be implemented, in the form of software protections that are programmed in the LCU controlling the axis. They shall decelerate the telescope to a complete stop within the maintenance range. It shall be possible to drive the telescope out of a software limit under TCS control or drive at a reduced speed to the software limit in maintenance mode.
3. *Software Limits*. Software limit protections shall be programmed in the LCU controlling the axis. They shall decelerate the telescope to a complete stop before it reaches the

vicinity limit. It shall be possible to drive a telescope out of a software limit towards the operational range.

4. *Vicinity Limits*. Vicinity Limits (hardware switch) shall decelerate the telescope, using the motor torque (LCU controlled deceleration) to a complete stop before it reaches the Interlock limit switch. It shall be possible to drive the telescope out of a vicinity limit towards the operational range.
5. *Interlock Limits*. In the event that the telescope reaches an Interlock Limit (hardware switch), the latter shall de-power the drives and actuate the brakes by hardware connection such that the telescope is decelerated from the maximum safe speed down to a complete stop before it reaches the end stops.
6. *End Stops*. There shall be devices (*e.g.* cushioned end stops, or other means) capable of decelerating the telescope from maximum safe speed to a complete stop without damage to the telescope and all mounted equipment.

5.1.10.9 Telescope Lockout

1. Pins shall be provided to prevent rotation about the azimuth, altitude and rotator axes, and shall be capable of resisting motor torque, unbalance due to disassembly, or MLE external loading.
2. Use of a locking pin shall disable the relevant axis drive.
3. The pins shall have provision to be tagged out *i.e.* a technician can lock out the pin preventing unauthorised removal.
4. As a minimum, locking pin positions specified in Table 4 shall be used for orientation of the telescope for mirror and camera handling operations.
5. Accuracy of position 0.05 deg

Table 4: Lockout Positions

Axis	**Lockout #1**	**Lockout #2**	**Further Lockouts**
Azimuth	+0°	+45°	-180°
Altitude	+0°	+90°	+20°
Rotator	+0°	+180°	90° and 270°

5.1.10.10 Brakes

Brakes shall be provided both on altitude and azimuth axes. The systems shall be equipped with status detection capability for interlock purposes. The systems shall be capable of preventing rotation about the axis when the Telescope is not in use, stopping the rotation in emergency, or when limit switches are actuated. The brake systems shall have the capacity to resist the maximum motor torque combined with survival wind loading.

5.1.10.11 Auxiliary drives

1. An auxiliary drive system shall be provided on the altitude axis.
2. The manual drive shall have suitable gearing to allow the Telescope to be driven with a maximum out of balance load of 1000 Nm with respect to the altitude axis.
3. The auxiliary drive shall be interlocked to disable the main altitude drives when used.

5.1.11 Primary Mirror Cell

5.1.11.1 M1 Cell General Requirements

1. *Deleted as descriptive.*
2. *Deleted as descriptive.*
3. *Deleted as descriptive.*
4. *Deleted as descriptive.*
5. The effect of the M1 Cell, M1 Mirror Support *etc*. shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.

5.1.11.2 M1 Mirror Support

1. The primary mirror shall be kinematically supported by means of a distributed axial and lateral support system conforming to the geometry defined in AD35.
2. The supports shall apply force control.
3. The mirror position along the optical axis shall be defined by means of three axial definers.
4. By changing the force pattern applied to the mirror back, by the axial supports, it shall possible to modify the mirror figure.
5. The mirror position in the lateral plane shall be defined by means of three lateral definers.
6. The mirror shall be protected against earthquakes by safety devices.
7. The mirror shall be restrained at low elevation angles.
8. The mirror cell shall have provision for Telescope balancing.
9. The M1 definer system shall have the range and step size of adjustment defined in Table 5

Table 5: M1 definer range and step size of adjustment

	Range of Adjustment	Adjustment Step Size
Axial	±3.0 mm	±0.05 mm
Lateral	±1.0 mm	±0.02 mm

5.1.11.3 M1 Cell Stability Requirements w.r.t M1

The effect of the stability of the M1 Cell shall be consistent with achieving the pointing and tracking accuracy as per sections 4.13 and 4.14, and the overall SIQ performance as per section 4.9.1.2.

5.1.11.4 Axial Support Requirements

There shall be 84 axial supports disposed in four rings, with symmetry of 120 degrees of which 81 are active and three are position definers. Each active support shall incorporate a load cell and the force generated shall be controlled in an individual closed loop using "Bellofram"-type membranes (as on Gemini, UKIRT). The axial definer supports shall be equipped with force limiting devices to prevent over-stressing the mirror in case of system malfunction. Each axial definer shall incorporate a load cell. The required value of force in each definer shall be controlled in closed loop to ensure that the gravity and external axial loads are equally applied to all 84 supports. External moment loads shall be resisted by generation of additional support forces. These shall be proportional to the pitch circle radius of the support and the sine of its angular position with respect to the moment. The effect of the M1 Axial Support system shall be consistent with achieving the pointing and tracking accuracy as per sections 4.13, 4.14 and the overall SIQ performance as per section 4.9.1.2.

<u>Performances</u>

- Force Range	5 to 900 N
- Absolute accuracy	± 2.0 N
- Load cell resolution	± 0.5 N
- Limiting force of axial definers	≤1700 N
- Minimum stiffness of axial definers	30.10^6 N/m

5.1.11.5 Lateral Supports Requirements

There shall be 24 lateral supports arranged on the periphery of the mirror. The position of the supports shall be optimised to minimise the surface errors generated by the lateral support loads.
The design incorporates a rolling-diaphragm sealed pneumatic cylinder. Tangential links, lateral definers, shall provide the lateral component of kinematic location. The lateral definers shall incorporate load cells. The measured forces shall be used to control the lateral supports in a closed loop to balance gravity and external lateral loads. The effect of the M1 Lateral Support system shall be consistent with achieving the pointing and tracking accuracy as per sections 4.13, 4.14 and the overall SIQ performance as per section 4.9.1.2.

The supports shall provision for disconnection for mirror removal and repeatable assembly.

Lateral supports Performance

- Force range (push or pull) 10 to 2700 N
- Absolute accuracy +/-10 N
- Resolution 1.5 N

Lateral definer performance

- Total stiffness $\geq 1.2 \cdot 10^8$ N/m
- Maximum force limiter setting 5000 N

The linkage between the mirror and supports shall use low-friction rolling element bearings in the pivots. The performance shall be such that

- Max frictional torque in the linkages at mirror rim ≤150 Nmm

5.1.11.6 M1 Restraint

A mechanism shall be provided to restrain the M1 mirror when operating at low altitude angles; the design of the mechanism shall take into account potential earthquake loads.

5.1.11.7 Requirement for the Cassegrain Interface Flange

The effect of Cassegrain rotator mounting stability and accuracy shall be consistent with achieving the pointing and tracking accuracy as per sections 4.13, 4.14 and with achieving the overall SIQ performance as per section 4.9.1.2.

The Cassegrain flange shall include features for ensuring repeatability of the mounting of the Cassegrain rotator.

5.1.12 M1 Cell Thermal requirements

5.1.12.1 Cooling of heat sources

no text

5.1.12.2 Thermal Conditioning of Primary Mirror

Active cooling of the primary mirror will not be provided; the primary mirror temperature shall be regulated by means of Enclosure air-conditioning during the daytime and and ventilation whilst observing. The design of the telescope (Telescope structure and M1 Cell) shall accommodate openings for flushing the primary mirror in operation.

5.1.13 M1 Control

5.1.13.1 TCS Interface

The M1 Control System shall run on an LCU controlled by the TCS, using the similar interface definition as used on the VLT, modified in detail only if necessary.

5.1.13.2 Hardware Interface

Hardware shall be controlled via signals transmitted from the M1 LCU on one or more ESO-VLT compliant field buses.

5.1.14 M2 Unit

5.1.14.1 M2 Unit Functional Requirements

1. The M2 Unit mechanism shall provide adjustment of the M2 mirror in five degrees of freedom (any five degrees shall be used that meet the performance requirements).
2. These degrees of freedom shall be combined to produce effective motions in focus, centring and tilt as shown in Figure 2 and defined in clauses 3, 4, and 5.
3. Focus shall be defined as movement of the M2 Mirror along the M2 unit z-axis (nominally co-incident with the telescope optical axis).
4. Centring shall be defined as movement of the M2 mirror on an ideal sphere with centre located on the M2 Unit z-axis and 4018.8 mm behind the mirror vertex when it is co-incident with the z-axis.
5. Tilt shall be defined as movement of the M2 mirror on an ideal sphere with centre located on the M2 Unit z-axis and 1050 mm behind the mirror vertex when it is co-incident with the z-axis.

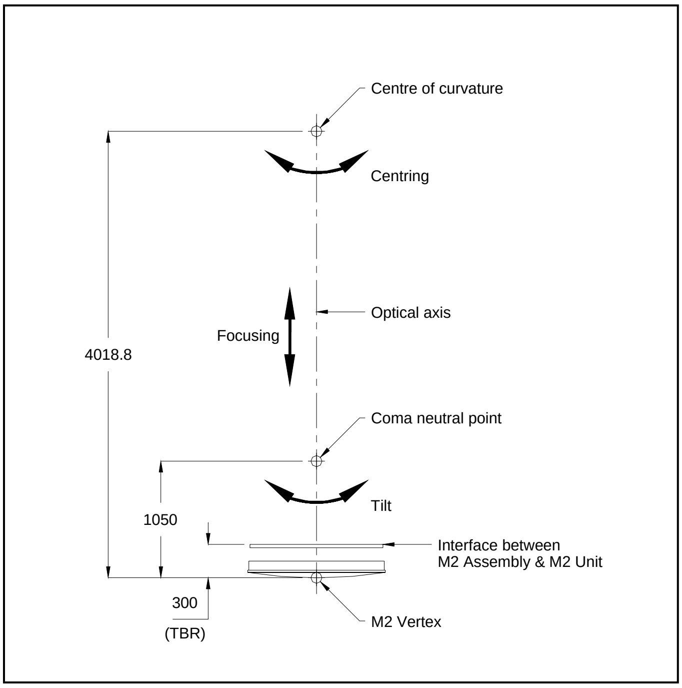

Figure 2 M2 Unit Effective Axes

6. These effective motions shall be controllable via the electrical interface to the TCS.
7. The M2 Unit shall not require fast tip-tilt control.

8. The resolution, accuracy, and stability of M2 Unit motion shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.

5.1.14.2 Functional Description

no text

5.1.14.3 Interface Requirements

The M2 unit shall meet the interface requirements of AD36.

5.1.14.4 Co-ordinate Systems

no text

5.1.14.5 M2 Unit Physical Characteristics

no text

5.1.14.6 Requirements on M2 Mirror Positioning

no text

5.1.14.7 M2 Mirror Position Stability

no text

5.1.14.8 M2 Baffle Requirements

1. A reflective annular baffle shall be placed around the M2 to block out the sky background seen by the IR camera between the outer edge of the M2 and the edge of the cryostat window.
2. The M2 Baffle shall present a spherical reflective surface or surfaces to the camera; the radii of curvature chosen such that any point on the IR focal plane sees a cold surface (inside the cryostat) reflected in the baffle.

5.1.15 M2 Control

5.1.15.1 TCS Interface

The M2 Control System shall run on an LCU controlled by the TCS, using the similar interface definition as used on the VLT, modified in detail only if necessary.

5.1.15.2 Hardware Interface

Hardware shall be controlled via signals transmitted from the M2 LCU. By agreement with ESO, the M2 control shall be implemented by the LCU CPU sending demands via a serial interface to a Delta Tau PMAC multi-axis controller card mounted in the VME backplane of the LCU.[1]

5.1.16 Cassegrain Rotator

5.1.16.1 Cassegrain Rotator Bearing

1. *Deleted as descriptive.*
2. The rotator shall be designed in conjunction with the mirror cell to ensure that bearing performance is predictable and meets its performance requirements over the operational range of the Telescope.
3. Rolling element bearings shall be sealed to prevent ingress of dirt.

5.1.16.2 Cassegrain Rotator Tracking Requirements

The Cassegrain rotator performance shall be consistent with achieving the pointing and tracking accuracy as per sections 4.13, 4.14 and the overall SIQ performance as per section 4.9.1.2.

5.1.16.3 Cassegrain Rotator Interface

The Cassegrain rotator interface with the Camera shall meet the requirements of AD40.

The rotator shall incorporate a mounting surface with features to ensure repeatable mounting of the cameras.

The effect of Cassegrain rotator interface accuracy and stability shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.

5.1.16.4 Cassegrain Cable wrap

1. The cable wrap shall be equipped with a dedicated drive system and shall be synchronised with the rotator azimuth axis.
2. The cable wrap shall exceed the rotator angular range of travel by a margin of at least 5° beyond the end-stops.
3. The cable wrap shall be interlocked to the main Cassegrain rotator drive to prevent damage to the cable wrap from differential motion or drive failure.
4. The cable wrap shall have capacity for permanent installation of all services for the telescope, Cassegrain rotator, and IR Camera.
5. The cable wrap shall be populated with services for the Cassegrain rotator and IR Camera.

[1] This will have a similar interface as used in the VLT Auxiliary Telescopes System

5.1.17 Cassegrain Rotator Control

5.1.17.1 Reuse of ESO Software

1. The rotator axis shall be controlled from LCU(s), running similar software to the VLTs Rotator Control System.
2. This software shall be configured to VISTA's specific requirements.

5.1.17.2 TCS Interface

The Rotator Control System shall be controlled by the TCS, using the similar interface definition as used on the VLT, modified in detail only if necessary.

5.1.17.3 Software/Hardware Interface

The interface between VISTA hardware and the Rotator Control System shall be defined at the level of hardware signals delivered by VME interfaces in the LCU.

5.1.17.4 Control Algorithms

The control algorithms shall be as implemented and documented in ESO's software release.

5.1.17.5 Slew When Tracking Open-Loop

It shall be possible, as a specific implementation, to slew the rotator while tracking the telescope open-loop.

5.1.17.6 Performance

The Cassegrain Rotator angle is defined as zero degrees, with the Telescope azimuth angle of zero (South) and the altitude angle 90 (Zenith pointing) and increasing to the east. The values of the performance parameters shall be:

- The range of Cassegrain rotation	+180° to -360°
- Tracking velocity maximum	480 arcsec/s
- Tracking acceleration maximum	10 arcsec/s^2
- Slew velocity maximum	3.6°/s
- Slew acceleration maximum	1.0°/s^2

The effect of Cassegrain rotator performance shall be consistent with achieving the overall pointing and tracking performance as per sections 4.13, 4.14 and SIQ performance as per section 4.9.1.2.

5.1.17.7 Position measurement

no text

5.1.17.8 Velocity Measurement

no text

5.1.17.9 Motors

The combined effect of ripple and cogging shall typically be less than 1% of the maximum torque, and shall be consistent with achieving the pointing and tracking performance as per sections 4.13, 4.14 and the overall SIQ performance as per section 4.9.1.2.

5.1.17.10 Brakes

Brakes shall be provided which are capable of preventing rotation when the Telescope is not in use and stopping the rotation in emergency or when hardware limit switches are actuated. The brakes shall have the capacity to resist the maximum motor torque.

5.1.17.11 Limit switches and end stops

Operational aspects covered in section 5.1.10.8.4 *(left in as placeholder to preserve consistency of numbering). Specific numbers deleted as inappropriate low-level detail.*

5.1.17.12 Safety locking

The Cassegrain rotator shall be capable of being locked out; the locking pins shall be part of the Telescope Interlock System.

5.1.18 Guiding and Wavefront Sensing Requirements

5.1.18.1 Telescope Feedback Requirements

Three types of feedback shall be provided in order to achieve the functionality. These are:

1. guide sensing to generate tracking corrections to feed into the Telescope Control Software.
2. low order wavefront sensing (LOWFS) to generate wavefront errors, operating concurrently with science observing, to feed into the Telescope Control Software.
3. a high order wavefront sensing (HOWFS) for off-line calibration of the M1 figure.

5.1.18.2 Sensor Requirements

5.1.18.2.1 Guiding

1. The autoguider shall deliver a user-selectable frame rate, up to 10Hz.
2. Centroiding accuracy shall be commensurate with meeting the SIQ requirements.
3. Guide star acquisition probability ≥ 99%
4. *deleted as not specific*

5.1.18.2.2 LOWFS

1. The LOWFS shall operate concurrently with observations
2. The LOWFS shall have 99% probability of finding a usable star, assuming the telescope pointing is near a galactic pole, with a full moon and no clouds.
3. Sample rate ≤ 1/minute.
4. Integration time ≥ 30s
5. *no text*
6. The LOWFS shall yield as a minimum M2 focus, M2 tilt, M2 decentre, M1 astigmatism corrections.
7. The accuracy of each term shall be commensurate with meeting the SIQ requirements.
8. The LOWFS shall monitor the health of the wavefront and alert the operator of deterioration in image quality.

5.1.18.2.3 HOWFS

1. The HOWFS shall be capable of fully determining the force correction of the M1.
2. The HOWFS shall provide the first 15 mirror modes. (NB: non-axisymmetric mirror patterns are counted as two independent modes).
3. The accuracy of each term shall be commensurate with meeting the SIQ requirements.

5.1.18.3 Sensor Location

The sensors for guiding and wavefront sensing shall be integrated into the Cameras.

5.1.18.4 Sensor Implementation

Deleted.

5.2 Visible Camera

Deleted as not relevant to verification of deliverables

5.3 IR CAMERA

1. The IR Camera shall comply with the requirements of AD33, AD34, AD39 and AD40.
2. To avoid re-balancing the telescope between camera changeovers in the event that a Visible camera is commissioned at a later date, the IR camera has a centre of gravity defined relative to the Telescope structure Cassegrain mechanical interface.

5.3.1 Infrared Camera Optics

5.3.1.1 Infrared Camera Optical design characteristics

1. Unvignetted field of view 1.65 degrees (diagonal)
2. *Deleted as duplicate of section 4.7*
3. Plate scale 58.52 μm/arcsec [subject to meeting the SIQ requirements of 4.9.1.2].

5.3.1.2 Infrared Camera Optical Interface

The IR Camera shall utilise the optical input characteristics defined in AD33.

5.3.2 IR Filters

1. Three science filters sufficient to cover the focal plane, and an opaque filter shall be provided for use in the IR camera.
2. The science filters shall correspond with J, H, and K_s as defined in Table 6.
3. *no text*

Band	J	H	K_S
Centre Wavelength (µm)	1.25	1.65	2.15
Tolerance	±0.5%	±0.5%	±0.5%
Bandwidth FWHM (µm)	0.18	0.30	0.30
Tolerance	±5%	±5%	±5%

Table 6: Filter Passbands

5.3.3 Filter Mechanism Assembly

5.3.3.1 Filter Sets

1. The filter mechanism shall accommodate up to eight filter holders (seven science + one opaque) at any time.

5.3.3.2 Access for Manual Filter Replacement

The filter holders shall be accessible via a port on the filter wheel housing, in order to allow filters holders to be changed without major disassembly of the camera.

5.3.3.3 Filter Deployment

1. It shall be possible to move to adjacent filters within 25s.
2. It shall be possible to move to any other filter within 60s.
3. It shall be possible to position the filters in the optical path to better than 100µm horizontally and 500µm vertically.

5.3.4 Camera Structure Assembly

no text

5.3.5 Flexure

no text

5.3.6 Focal Plane Unit Assembly

1. The focal plane module shall be used to hold, thermally condition and protect the IR detector arrays and their associated circuit boards, electronics and cables.
2. There shall be supplied sixteen detectors on a 4x4 array, with spacing 90% in the Camera x-direction by 42.5% in the y-direction, these percentages being relative to the detector active widths.
3. Over-voltage and electro-static discharge protection circuitry shall be provided to protect the detectors.
4. Detector and controller non-linearity shall be ≤ 3% before calibration.
5. Detector and controller gain shall vary by ≤ 2% peak to valley across the full range of operating temperatures.
6. Electrical Crosstalk between any pair of pixels separated by ≥ 10 pixels shall be no greater than 5 $x10^{-5}$.

5.3.6.1 IR Detector

The following IR Detector specifications form the baseline for VISTA.

1. Wavelengths of Operation. The required wavelengths of operation shall be 1.0 to 2.50 microns
2. Quantum Efficiency. The QE of the best 90% of pixels shall be: J > 38%, H > 47%, K_s > 47%.
3. Format The IR detectors shall have an array of 2048 x 2048 active pixels
4. Pixel Size. Pixel size shall be between 15.5 and 20.5 microns
5. Read Noise. Detector and controller read noise shall be <32 electrons, for a double-correlated sample.
6. Read-out Time. The maximum acceptable read time shall be 1 second at maximum well depths.
7. Defects. The number of bad pixels shall be less than 4% in the central 1952x1952 pixel area.
8. Dark Current. The detector dark current shall be < 8 e/s per pixel.
9. Remnant Image Artefacts. The decay time constant τ shall be < 60s.
10. Maximum dT/dt. Detectors shall be capable of surviving a temperature gradient of 8 degrees per hour.
11. Image smearing. Charge diffusion from a pixel to its neighbouring pixels shall not exceed 10% totalled over the 8 neighbouring pixels.
12. On-chip Glow. The on-chip glow shall be less than 8 e/s per pixel everywhere.
13. Physical Flatness. The array flatness shall be consistent with achieving the overall SIQ performance as per section 4.9.1.2.
14. Well Depth. The detectors shall possess well depth at least $100ke^-$ (defined as the number of electrons above which the response non-linearity becomes > 5%).

5.3.6.2 Detector Controller

The IR Camera shall use a 256 channel ESO IRACE Detector Controller (RD 02) to acquire data from the detector arrays

5.3.6.3 Detector Pre-amps and Circuitry

Deleted as descriptive.

5.3.6.4 Temperature Sensors, Cabling and Connectors

no text

5.3.7 IR Camera Guiding and Wavefront Sensing

Requirements from this section have been moved to 5.1.18.2.

5.4 Control

5.4.1 Control Hierarchy Block Diagrams

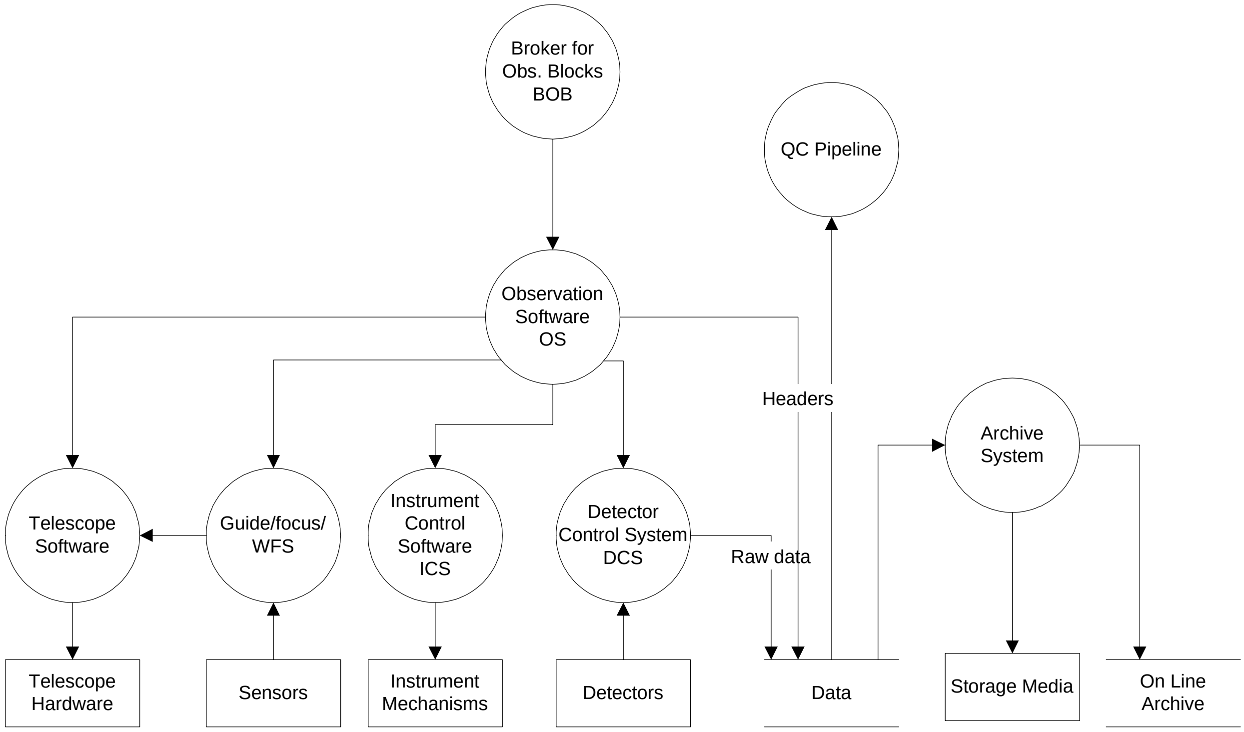

Figure 3 The control hierarchy of the principal VISTA software systems.

The overall structure of the VISTA Control System is illustrated in Figure 3. This includes modules specific to VISTA, modules reused from the VLT and, in the case of the QC (quality control) Pipeline, a module provided by the separate VDFS project. The Telescope Software is further illustrated in Figure 4.

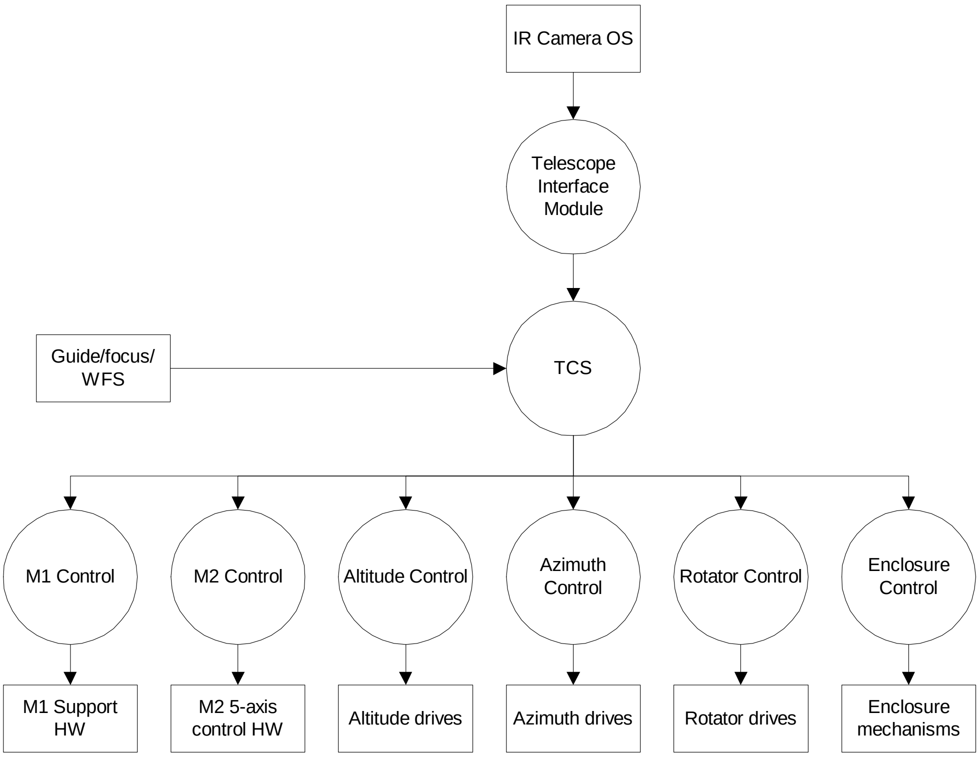

Figure 4 The control hierarchy of the TCS and its subsystems.

5.4.2 Product Tree

The modules that comprise VISTA's control software are listed in Figure 5. These modules generally include the hardware required to run the software, but since the logical and physical models differ there is not a one-to-one correspondence between software module and hardware. Some hardware runs both control software, described in this section, and data handling software, covered in Section 5.5.

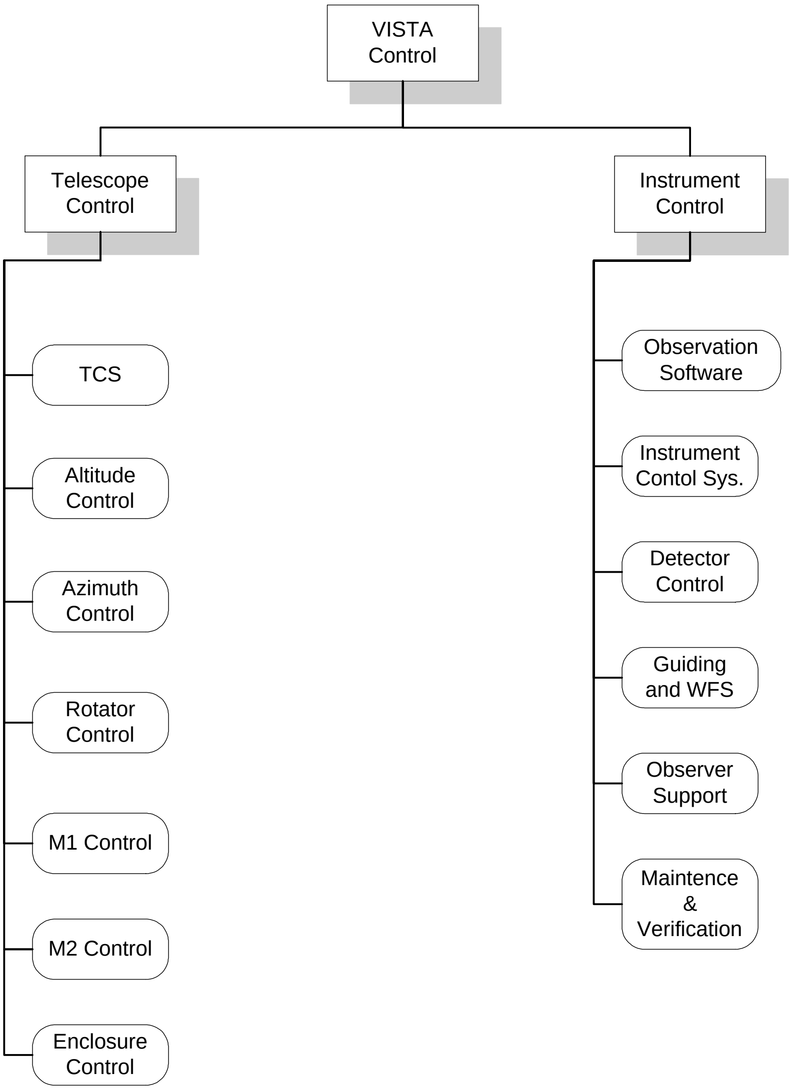

Figure 5 Product tree for VISTA control.

5.4.3 Requirements

5.4.3.1 LCU Hardware

Where software is required to control hardware directly or is required to have deterministic performance, it shall run on a VME/VxWorks based computer system conforming to the requirements and constraints of an ESO LCU (AD21).

5.4.3.2 Unix Hardware

Where software is not required to control hardware directly or to have deterministic performance, it shall run on a Unix workstation conforming to the requirements and constraints of an ESO workstation. (In this context a workstation may actually be a server not used directly by a human operator).

5.4.3.3 Visible and IR Cameras

deleted as not relevant to deliverables

5.4.3.4 Location of Computing Equipment

1. All LCUs shall be located in the VISTA telescope enclosure, which will also contain any X-terminals required for engineering work.
2. All workstations shall be located in the Cerro Paranal Control Building, unless they are dedicated data-processing devices ("number-crunchers") associated with particular systems.
3. It is assumed that VISTA shall share a console (an open-plan work area) in the VLT Control Room with the VST. This console shall accommodate all keyboards, screens and, where appropriate CPUs and storage, necessary for the Telescope Operator to control VISTA and its camera. Within the Control Building, some VISTA equipment may also reside in other computer rooms.
4. A local control workstation shall be situated in the office in the Enclosure Basement.

5.4.3.5 Local Area Networking

1. VISTA's computing equipment, both in the Telescope Enclosure and the Control Building, shall be interconnected using media and equipment that complies with ESO standards (AD28). These standards require that fibre optics are used to connect equipment, except in special circumstances where copper may be used.

2. Communications shall utilise:
    - 10Mbps Ethernet
    - Gigabit Ethernet or ATM, as agreed with ESO.

5.4.3.6 Software Infrastructure

All software shall use ESO's infrastructure Common Control Software (AD27) and LCU Common Software (AD21) and shall not duplicate functionality contained in these systems.

5.4.3.7 Telescope Control System

1. *Deleted as descriptive.*

2. The VISTA TCS and its subsystems shall provide the functionality as defined in (AD25), excluding:

    a) Adaptive Optics.
    b) M3
    c) Chopping.
    d) Field stabilisation

3. VISTA's TCS software shall be a copy of the VLT TCS (AD25), modified where necessary.

5.4.3.8 Observation Control

1. High level observation control at the Cerro Paranal site shall be performed using standard ESO VLT software, configured for VISTA use. This shall include software schedulers and the Broker for Observation Blocks (AD26).
2. Observation control software shall run on the Instrument Workstation or other workstation as agreed with ESO.

5.4.3.9 Instrument Control

1. The Instrument Software shall comply with the VLT Instrument Software Specification (AD22). It shall include:
   - Observation Software
   - Instrument Control Software
   - Detector Control Software
   - Observer Support Software
   - Maintenance and Verification Software

2. Interfaces shall comply with the corresponding interfaces on the VLT including
   a) Observation Handling Software (AD32)
   b) Archive System (AD24)
   c) TCS (AD25)
3. The Observation Software shall receive commands from the Broker for Observation Blocks (AD26).

4. The instrument hardware shall be sufficient to run the software and shall include:
   - Instrument workstation
   - Instrument control LCU
   - Detector Control System
   - Any networking equipment necessary to allow these systems to communicate with each other
   - Storage

5.5 Data Handling

5.5.1 Definitions

Data Handling, described in this section, includes hardware and data flow software to transfer and store data. The requirements are somewhat more general than this and apply also to the functionality of other subsystems described in this document.

5.5.2 Block Diagram

The systems that perform data handling are illustrated in Figure 6 . This figure includes the IR Camera as an external, although functionally many of the requirements listed below also apply to the Camera software and hardware. *Note that the Quality Control system software modules are deliverables from the VDFS, not the VPO.*

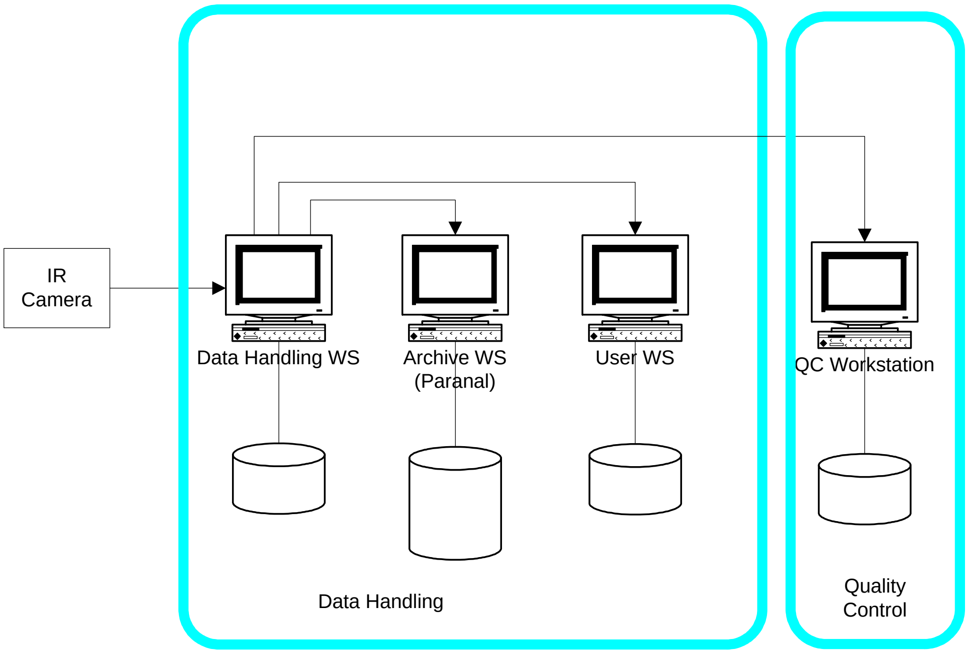

Figure 6 Block diagram of data handling systems.

5.5.3 Product Tree

The product tree for data Handling is shown in Figure 7. In general all the modules include a workstation, data storage and software. Except for the Archive system the hardware is specific to VISTA whereas the software is generally existing VLT software configured to VISTA's requirements. In the case of the QC pipeline software modules are provided by the related VDFS project.

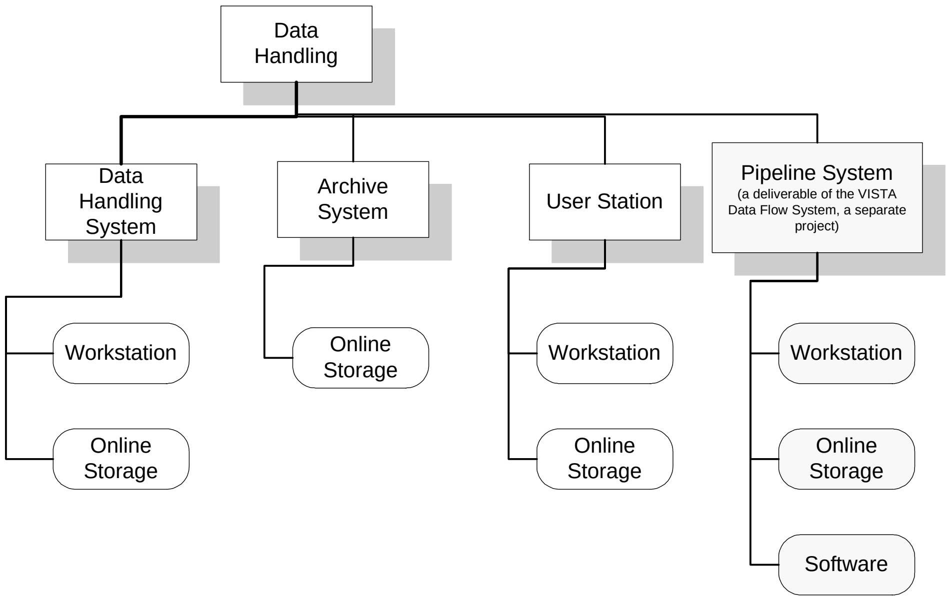

Figure 7 Product tree of systems associated with data handling.

5.5.4 Requirements

5.5.4.1 Stored Data

no text

5.5.4.2 Writing to Disk

no text

5.5.4.3 Archiving

1. Science and Calibration data shall be stored in FITS format, conforming to the specifications in the Data Interface Control Document (AD24).
2. The FITS headers shall, when associated with other logged data, contain all ancillary data necessary to characterise the data fully and to allow complete data reduction subsequently to be performed.

5.5.4.4 Data Storage and Transport

As per 4.16.4 and 4.16.5.

5.5.4.5 Data Quality Control (QC)

no text

5.5.4.6 Local Data Reduction

no text

5.5.4.7 On Line Archive System

Science and calibration files shall be stored to disk and catalogued using ESO's On Line Archive System software. Components of the VLT archive software shall run on VISTA hardware i.e. the Instrument Workstation and the Data Handling Workstation. The VISTA Data Handling Workstation shall send data to the Paranal Observatory's Archive hardware via the local area network.

5.5.4.8 Hardware and Data Rates

1. The data handling hardware shall include the workstations listed in Table 7.
2. Each workstation shall be able to store data at the rate and volume specified in Table 7.

Workstation	Data Capacity	Storage Rate
IR Camera Instrument WS[11]	2.8 TB	54 MB/s
Data Handling	2.8 TB	27 MB/s
Archive[2]	2.8 TB	27 MB/s
User	2.8 TB	14 MB/s
Pipeline	2.8 TB	27 MB/s

Table 7 Workstations that handle instrument data

3. These workstations exist as discrete entities in the VLT architecture adopted by VISTA. ESO and VPO may agree that software functionality may be distributed across fewer workstations, in which case the disk capacities required will reduce accordingly.

[1] [1]The IR Camera IWS will be procured within the IR Camera work package.
[2] The Archive Workstation will be the Paranal Observatory's system

5.6 Enclosure

5.6.1 Purpose of the Enclosure

The Enclosure shall perform three functions:

1. The Enclosure shall provide a safe environment for the telescope, protecting it from extreme weather conditions.
2. The Enclosure shall maintain a stable operating environment through thermal control, stray light control and wind attenuation.
3. The Enclosure shall provide all infrastructure for the Telescope.

In achieving these functions, the Enclosure shall not be detrimental to Telescope operation, *i.e.* no function of the Enclosure shall degrade Telescope performance.

5.6.2 Definitions

The Enclosure shall comprise the sub-systems shown in Figure 8, namely:

- The Dome: consisting of the rotating portion of the Enclosure providing access to and environmental protection of the Telescope.
- The Basement: consists of the static portion of the enclosure providing foundations and support for the Dome and access to maintenance systems below the level of the Telescope azimuth floor.
- HVAC system: Heating, Ventilation and Air Conditioning of the Dome and Basement and Auxiliary Building
- Enclosure Control System
- Power supply infrastructure.

5.6.3 Aesthetics

Deleted as descriptive/unverifiable.

5.6.4 General Requirements Applicable to the Enclosure

5.6.4.1 Environmental Conditions

The Enclosure shall comply with all environmental conditions specified in AD04.

5.6.4.2 Floor Loading:

The nominal floor loading shall be:

1. Rail load 120kN/wheel
2. General loading $10kN/m^2$
3. Localised loading $100kN/m^2$

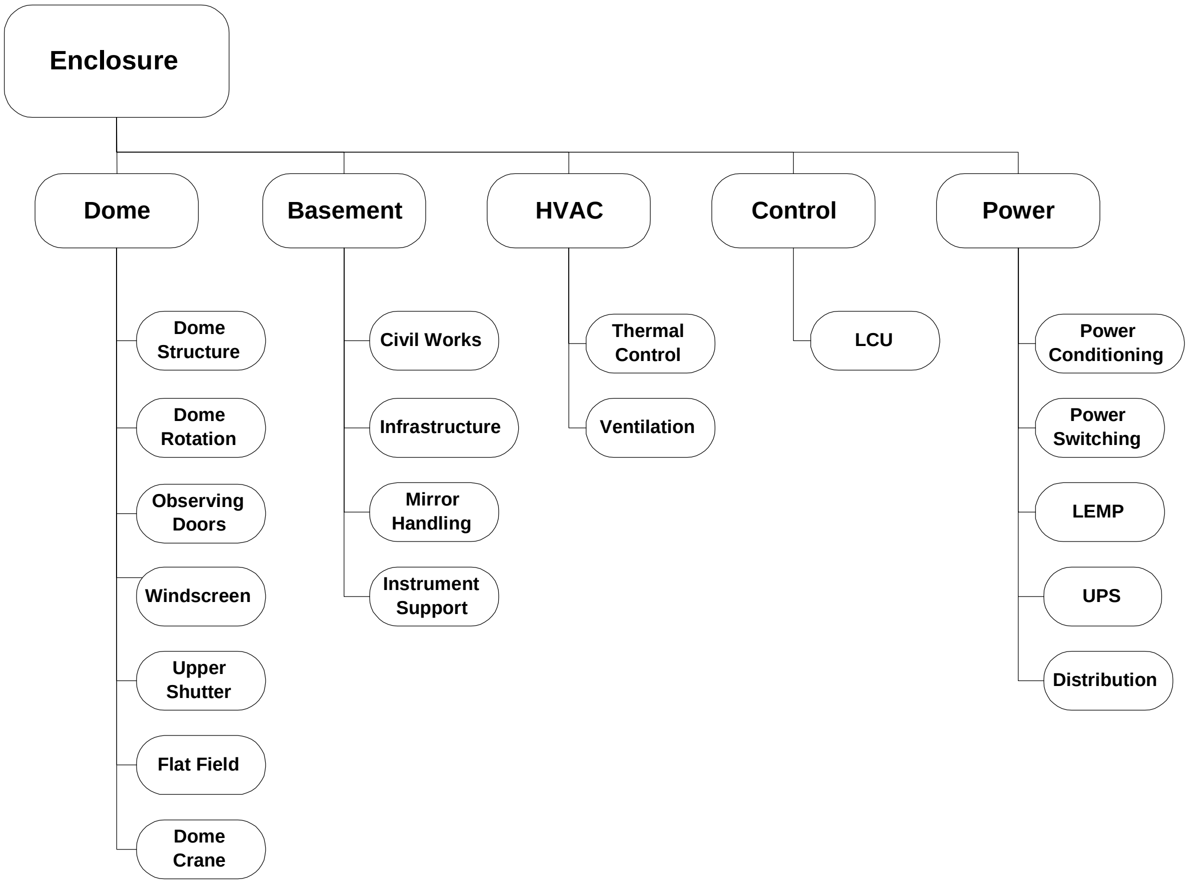

Figure 8 Enclosure Sub-Systems

5.6.4.3 Emergency Lighting

Lighting shall be provided to allow safe egress from all parts of the Enclosure and Auxiliary Building. It shall be installed to comply with applicable safety/legislative requirements. Night observing conditions shall be taken into account.

5.6.4.4 Protection against Fire

A Fire Alarm system shall be provided to ensure the safety of personnel and equipment, and shall be connected to the Control Building. Sufficient fire fighting equipment shall be fitted to the building in accordance with the regulations in force.

Deleted as descriptive.

Figure 9 VISTA Enclosure (For Information Only)

Deleted as descriptive.

Figure 10: Cross-section of Basement and Auxiliary Building (*nominal, for information only*)

5.6.4.5 Enclosure Video and Audio Monitoring

Video and audio signals shall be transmitted to the Paranal Control Room.

5.6.5 Dome

5.6.5.1 General Requirements

1. The Dome shall have an observing aperture, or slit, allowing unvignetted observations throughout the observational range.
2. The observing slit shall be closed by doors or shutters.
3. The Dome shall have the same rotation axis as the telescope azimuth axis
4. The Dome shall be able to rotate independently of the telescope, without any physical interference at any position of the telescope under operational conditions.
5. The Dome shall have a floor at the same level as the fixed azimuth floor and the telescope azimuth platform.
6. The observing slit shall be equipped with a moveable windscreen.
7. The Dome shall have ventilation apertures above the azimuth floor level.
8. The Dome shall include a roof gantry crane in order to perform handling tasks.
9. Ladders and access platforms shall be supplied for the maintenance of all mechanisms.
10. Any radio Frequency (RF) remote control shall not contribute noise to the output of the IR and/or visible detectors in the camera.

5.6.5.2 Cladding

1. The exterior walls, the roof, and exterior doors of the dome shall be clad with thermally insulating panels.
2. The cladding shall afford water and air-tightness to the enclosure.
3. Bonding of the external metal sheets of the cladding for protection against lightning and lightning electromagnetic pulse (LEMP) in accordance with AD12. Bonding conductors shall allow effective and reliable electrical connections to the structural elements.

5.6.5.3 Observing Slit Door

1. The observing slit door(s) shall have a minimum clear aperture to allow unvignetted observations throughout the observational range.
2. The time for opening and closing shall be $\leq$ 60s.
3. Open/Closed status indicators shall be provided.
4. The doors shall be designed for operation in wind speed up to 36 m/s.

5.6.5.4 Rotation System

1. The Dome Rotation performance shall exceed that of the Telescope such that it does not accrue additional overheads on the observing efficiency.
2. The rotation system shall sustain all vertical and horizontal Dome loads.
3. The rotation system shall allow unlimited rotation in both rotation directions.

4. The rotation system shall stop the rotation from maximum speed in less than 5 seconds in emergency situations.
5. The rotation system shall allow adjustment and assembly during the on-site erection of the Enclosure.
6. All rotation system mechanical parts shall be adequately protected against corrosion.
7. Choice of materials between wheel and track shall ensure that any wear occurs preferentially on the wheels.

5.6.5.5 Seals

Seals shall be provided between the fixed and moveable parts of the building and shutters when closed.

5.6.5.6 Windscreen

An adjustable windscreen shall be provided that shall track the lower extent of the observing slit, providing both ventilation and stray light control.

5.6.5.7 Moon Screen

1. An adjustable screen shall be provided that will track the upper extent of the observing slit, providing stray light control.
2. The range of travel shall be at least ±2.5m from the centre of dome rotation.
3. The moon screen may be combined with the Flat-field screen.

5.6.5.8 Flat Field

A system for carrying out flat fielding of the telescope shall be installed within the enclosure. The system may be installed permanently or may be deployable by remote control. This system shall consist of a flat field and a flat field light system which may in turn consist of multiple sources as required to meet the nominal illumination requirements:

1. Illumination of the flat field shall be controllable from the Paranal Control Room.
2. The illumination of the flat field shall be even to within 10% over its entire area.
3. The illumination shall be repeatable to ≤ 0.5 %, and shall be of a continuous spectrum (*e.g.* tungsten, halogen)
4. The flat field shall have a minimum area corresponding to a 4.5m diameter (this illuminated area must cover the whole of the telescope aperture and is therefore dependent on the field's distance from the telescope).
5. The flat field shall be perpendicular to the telescope optical axis when the telescope is pointed at the flat field.
6. The flat field light sources shall be installed in the Enclosure and not on the telescope.
7. The flat field light system shall provide a minimum of 2 light clusters. Each light cluster shall have three independently switched sets of lights *i.e.* Select set1 or set2 or set3.

5.6.5.9 Dome Crane

A dome mounted overhead crane shall be provided with the following characteristics:

1. The crane shall be capable of radial access to the azimuth floor
2. The crane shall be capable of reaching the primary mirror handling locations.
3. During normal operation, the dome shall be interlocked to enable rotation only when the crane is in the park location.
4. The dome rotation shall incorporate a manual override to allow rotation with the crane in a maintenance location.
5. Safe working load: 10 tonne
6. Minimum clear distance: 1m from hook in highest position to any telescope structure element.
7. Hoist speed: variable between 100 and 2000 mm/min.
8. Horizontal speeds: variable between 100 and 2000 mm/min.
9. Radio Frequency (RF) remote control. Any RF transmission links shall be robust to interference by similar local systems such as the dome RF link, and shall comply with relevant certification standards.
10. Manual control with velocity control joysticks for the Enclosure and crane shall be implemented; these shall default to slow speed and shall have a fast speed enabled on holding down an override button.
11. A hardware signal shall be provided from the crane to indicate when the crane is in use or out of its park position.
12. It shall be possible to inhibit crane operation by means of an external hardware input signal.

5.6.5.10 Maintenance Platform

1. A mobile access platform shall be installed on the azimuth floor level to enable safe access to the telescope and other maintenance locations.
2. Alternative access arrangements shall be installed where required for access to and maintenance of the various Enclosure installations where the access platform cannot be utilised.

5.6.6 Basement

5.6.6.1 General Requirements

1. The circular external wall of the Enclosure base shall be concentric with the telescope pier.
2. In the volume between pier and Enclosure base wall there shall be service rooms to house the equipment required for telescope operation.
3. A mirror and instrument handling area shall be accommodated directly below the hatch.
4. Foundations and structure of the Telescope pier and the Enclosure shall remain isolated from each other to minimise the transmission of wind-induced vibrations, vibrations resulting from the Dome rotation and any other possible vibration source.
5. The Enclosure base shall provide access doors for personnel and equipment to the Enclosure and the staircases shall be installed in this access area.
6. The Enclosure base shall provide access to the Auxiliary Building Coating Plant room by means of a roller door or similar.

7. On the upper part of the Enclosure base an embedded beam suitable to receive the circular rail (or equivalent) for the rotation mechanism of the Enclosure shall be installed.

5.6.6.2 Access

1. A mezzanine floor shall be provided at a suitable level to access the azimuth bearing and motors of the Telescope for maintenance purposes.
2. The basement shall incorporate two stairs to access the mezzanine and azimuth floors and to provide emergency exit routes from the enclosure.

5.6.6.3 Vibration

no text

5.6.6.4 Drainage

no text

5.6.6.5 Equipment Housing

no text

5.6.6.6 Primary Mirror Washing Requirements

1. An area in the basement, designated for primary mirror stripping, shall be provided with cast in drainage leading to an external storage tank.
2. The mezzanine and azimuth floor levels shall provide space above the stripping area for taking the primary mirror from the Telescope to the basement.
3. The Azimuth floor shall be covered during normal operation of the telescope with covers meeting the basic floor loading requirements of Section 5.6.4.2.
4. Two parallel rails shall be installed between the coating area and the stripping area. These shall be recessed into the floor and covered by steel floor plating when not in use.
5. Safety cabinets shall be provided for storage of stripping and washing materials when not in use.

5.6.6.7 Camera Storage and Support

1. Facilities to store one camera shall be provided in the basement. These shall include all necessary support to operate the camera remotely from the telescope.
2. It shall be possible to perform minor maintenance activities in this area. For larger engineering tasks, the mirror stripping area shall be utilised.
3. *deleted as irrelevant to deliverables*

5.6.7 HVAC System

5.6.7.1 Enclosure Temperature Stabilisation

In order to provide the optimum observing conditions, the environmental systems shall ensure that all internal surfaces of the enclosure have at the start of the night a temperature close to the predicted midnight air temperature (T_o) for that night.

Thermal control shall be achieved by:

1. Minimising the heat input both from the external environment and from the lower basement area by use of adequate insulation and seals.
2. Air-conditioning the inner volumes, above the azimuth floor during the day and below the azimuth floor level during observing. Cooled air shall be distributed throughout the entire volume by means of air outlets distributed along the inner surface, including the upper part of the dome when the dome is locked in its parking position.
3. When the dome is first opened in the evening the surface temperatures above the azimuth floor level shall be within 2°C of T_o.

5.6.7.2 Auxiliary Building

1. The heat (or residual heat) produced from the various machines (pumps, transformer, UPS, air compressor, etc.) shall be removed from the Auxiliary Building.
2. The heat shall be exhausted, to an outlet point away from and downwind (prevailing) of the Enclosure area.

5.6.7.3 Cooling

1. A number of heat dissipating systems are located inside the Enclosure and also on-board the telescope structure itself - the heat produced by these systems shall be removed by means of a cooling system based on a liquid coolant.
2. The cooling system shall have a primary cooling circuit to provide coolant for all facilities located on the VISTA site.

5.6.7.4 Ventilation Doors

1. In the Dome at least three ventilation openings shall be provided:
2. These openings shall be equally sized and spaced with respect to the dome slit around the circumference of the Dome.
3. The combined open aperture free area shall be not less than $100m^2$.
4. For safety reasons, the door opening/closing mechanisms shall be designed for operation in wind speeds up to 36m/s.
5. A system of fixed louvres for the control of stray light shall be installed.
6. Each opening's door(s) shall be motor-driven and equipped with position/status feedback.

5.6.8 Enclosure Control System

5.6.8.1 Command Interface

The Enclosure shall be controlled by a Enclosure Control System (ECS), interfaced to the Telescope Control System (TCS) via a Local Area Network (see 5.4). The ECS shall consist of a Local Control Unit (LCU), a VME/VxWorks based computer with software, and a network of control units (PLC's), as well as all sensors and actuators required to control and supervise the Enclosure hardware.

5.6.8.2 Hardware Interface

The ECS PLCs shall comprise a hierarchical network of controllers linked to:

- the various sensors that detect the Enclosure status, such as encoders, contact and end switches, flow and temperature sensors, *etc.*
- all electrical drives, valves, etc. which drive the motion mechanisms and the thermal control systems.

The Control hardware shall comply with the requirements of the Electronic Design Specification (AD12). CANbus devices may also be used as specified in the CANopen Specifications (AD15).

5.6.8.3 Manual Control

It shall be possible to operate the various functions of the Enclosure through a manual control panel(s).

5.6.9 Telescope Pier

5.6.9.1 Definition

1. The Telescope Pier consists of the static portion of the VISTA telescope providing foundations and support for the telescope.
2. In the volume within the pier there shall be access areas for equipment required for Telescope operation.
3. The top face of the pier shall incorporate the Telescope anchoring system.

5.6.9.2 Stiffness

The Pier shall be designed in such a manner that it shall not degrade the telescope fundamental natural frequencies by more than 1.5 Hz.

5.6.9.3 Vibration

1. The Telescope pier shall be vibration de-coupled from the Enclosure:
2. Foundations shall be cast separately with a gap between the pier and enclosure floor rafts.
3. No equipment shall connect between the Telescope Pier and the Enclosure base in such a manner that vibration can be transmitted through the coupling.

5.6.9.4 Access

The centre of the pier shall be accessible from the basement at ground level. Provision for access to equipment inside the pier (*e.g.* Telescope cable wrap) shall be provided.

5.7 *Auxiliary Equipment*

5.7.1 Definition

Auxiliary equipment is defined as any ancillary equipment necessary for the operation and maintenance of the VISTA facility.

5.7.2 Equipment Location

Deleted as descriptive.

Deleted as descriptive.

Table 8: Equipment Location Table (For Information Only)

5.7.3 Mirror Stripping

5.7.3.1 Washing Facility

An area within the Enclosure basement shall be designated for primary mirror stripping and cleaning.

5.7.3.2 Water Supply for mirror washing

1. A supply of de-ionised water shall be required for washing the mirror.
2. A 500ltr storage tank shall be provided with plumbing feed to point of use.
3. De-ionised water shall be stored as required.
4. Provisions for water purification shall **not** be provided.

5.7.3.3 Mirror Washing

The mirror shall be stripped and washed manually.

5.7.3.4 Lighting

Fluorescent lighting shall be provided for general illumination in this area, the level of illumination to be 100lux. A higher level of illumination shall be provided for the mirror washing process. This level of illumination shall be 500 lux and shall be achieved by use of metal halide or similar luminaires.

5.7.3.5 Hazardous Material

1. Hazardous substances shall be stored and subsequently disposed of safely in accordance with COSHH requirements (AD62).
2. Chemical and Flammable materials shall be stored in appropriate cabinets.
3. Data sheets shall be kept for all substances at an appropriate designated location on site.

5.7.3.6 Emergency Shower

Shall be provided and available at all times in the event of chemical contamination from, for example, spillage whilst undertaking the Mirror Wash process.

5.7.4 Transformer Room (Power Substation)

1. A suitably rated dry resin type transformer and the required Medium Voltage switch gear to step down the Paranal power supply shall be provided.
2. The transformer shall be installed in a dedicated room within the auxiliary building.
3. *subsumed into (1).*
4. Under normal operating (observing) conditions the peak load will be ≤ 250 kVA.
5. When the Mirror is being coated the peak load will be ≤ 300 kVA.

5.7.5 Electrical Power Distribution Room

1. Low Voltage switchgear and distribution panels shall be provided.
2. It shall be installed in a dedicated room within the Auxiliary building.
3. This room shall be directly accessible from the Enclosure.
4. UPS power shall be provided with a rating of at least 20 kWh

5.7.6 Plant Room

1. A compressor, air dryer and air receiver shall be provided in a plant room in the Auxiliary building.
2. This room shall house additional service equipment.

5.7.7 Office/rest area

1. An office and document store shall be provided.
2. This room shall be equipped for network, communications and heating and ventilation.

5.7.8 Sanitary Provision

Toilet and washroom facilities shall be provided.

5.7.9 Heat Exchange

1. A cooling circuit shall be provided for cooling of equipment and air conditioning heat exchange.
2. The chiller shall be mounted remotely from the Enclosure.
3. Charge tanks and boost pumps may be installed as necessary.

5.7.10 Storage

no text

5.7.11 Computing Facilities

no text

5.8 Coating Plant

5.8.1 General Description

The Coating Plant shall be situated in the auxiliary building immediately adjacent the basement outer wall. The plant consist of two sections, designated the lower and upper vessel. The vessel shall mount all systems necessary for coating the primary mirror and secondary mirror. The control systems including the pumping station, heat exchange, gas supply and magnetron control panel shall be housed in the coating plant room.

5.8.2 Coating the Primary Mirror

Deleted as descriptive.

5.8.3 Lower Vessel

1. The lower vessel shall include a rotating whiffle-tree arrangement to mount the primary mirror. For safe mounting, earthquake lateral restraints shall engage the mirror.
2. The whiffle-trees shall mount on a rotating drive which shall revolve the assembly and mirror at a pre-determined rate for mirror coating quality.
3. The lower vessel shall be mounted on rails to allow it to be driven into the basement for installation and removal of the mirror.

5.8.4 Upper Vessel

The Magnetron and vacuum systems shall be mounted through the upper vessel. The upper vessel shall be raised on four screw jacks to open the vessel and allow the lower vessel to move on the rail system.

5.8.5 Magnetron

Three magnetrons shall be installed in the upper vessel. Each shall consist of a magnetron, water cooled with copper backed targets.

The following targets shall be provided:
1. Al Target, for testing the system and individual magnetrons
2. Ag reflective coating target
3. NiCr adhesor layer target
4. Ag protective layer target (silicon)
5. Al reflective coating target.

5.8.6 Vacuum Pumping Equipment

1. The vacuum shall be achieved through a cryo-pumping system.
2. Two cryo-pumps shall be installed in the upper vessel with gate valves, capable of three position control: closed, fully open and intermediate pumping. The system shall be equipped with a Rootes-style roughing pump-set.
3. Pumping shall be fully automated.

5.8.7 Power Requirements

Peak demand (estimated to be 120kW) shall be within the capacity of the installed electrical supply infrastructure. [*Note: during coating operations, normal Enclosure HVAC system operation will not be required.*]

5.8.8 Cooling

1. The vacuum system, magnetrons, shall be water cooled.
2. If necessary, masks and shutters shall be water cooled.
3. The cooling system shall be closed circuit with a heat exchanger in a stand-alone unit.

5.8.9 Process Gas

1. Provision for injection of the process gas shall be provided.
2. Automatic control of the gas flow rate shall be enabled.

5.8.10 Lighting

Fluorescent lighting shall be provided for general illumination in this area. Level of illumination to be 100 lux. A higher level of illumination shall be provided for the mirror coating process. This level of illumination shall be 500 lux and shall be achieved by use of metal halide or similar luminaires.

5.8.11 Coating Plant Control

1. A system shall be implemented, that shall control the coating processes from start-up to shut-down.
2. This process shall be automated but shall require operator supervision throughout the process.

5.9 Service and Handling Equipment

5.9.1 General

The following guidelines have been adopted in provision of service and handing equipment:
1. The dome crane shall be the prime lifting facility within the Enclosure
2. Any equipment necessary for safe service and handling shall be provided.
3. Any special tools necessary for maintenance shall be provided.
4. Sufficient basic tools shall be provided for maintenance of VISTA and servicing of the sub-systems.

5.9.2 Lifting Equipment

The dome crane shall be utilised for all major lifts. Additional craneage shall be supplied as follows:
1. A wall mounted jib crane shall be fitted in the camera service area, capacity 1 tonne.
2. A wall mounted jib crane shall be fitted in the area designated for mirror stripping, capacity 1 tonne.
3. Overhead rail-crane to be installed within Auxiliary Building, capacity 1.6 tonne.

5.9.3 Basic Handling Equipment

The following basic handling equipment shall be provided:
1. Manual pallet trolley, capacity 5 tonne.
2. Slings and shackles as necessary

5.9.4 Special Handling Equipment

The follow special handling equipment shall be provided:
1. Top-end handling tool
2. Primary mirror handling tool
3. M2 handling equipment
4. Camera removal and handling equipment

Some functions may be duplicated and where beneficial, special equipment can be dual purpose.

5.10 Test Equipment

5.10.1 Test Camera

Not verifiable – for internal VPO use only

5.10.2

A reflectometer shall be provided to measure the performance of the Coating Plant.

5.10.3

A monochromator or similar test device for monitoring long term stability of filter transmission curves shall be provided.

(The instruments of 5.10.2 and 5.10.3 may be combined into a single device.)

6 Operational requirements

6.1.1 Control of Equipment

It shall be possible to operate all equipment, required for observing and normal calibration procedures, from the Cerro Paranal Control Building.

6.1.2 Independent Operation of Cameras

1. Each camera shall be capable of being operated, maintained and tested without interfering with the other camera.
2. Each camera shall be capable of being operated stand-alone off the telescope.

6.1.3 Engineering Calibration Procedures

Calibration procedures shall, where feasible, be implemented in software. These procedures shall:

1. Record all changes so that it is possible to revert to previous calibrations and perform trend analysis.
2. Record all raw data used to generate new calibrations (e.g. FITS files in the archive)
3. Be capable of being initiated and run automatically, whilst remaining under control of the operator.

6.1.4 Observing Modes

1. The normal method of observing shall be queue scheduling, in which observations are completely specified in advance using P2PP together with any other specific associated tools agreed with ESO's DMD.
2. The operator shall be able to override any automatic operation and control observing directly.

6.1.5 Observing and Engineering Logs

1. All observations, including calibrations, shall be logged.
2. All significant engineering events shall be logged including
   a) telescope motions
   b) camera configurations
   c) faults
3. Logs shall be transmitted during the day following the observations.
4. Logs shall properly take account of non-operating detectors *i.e.* record that the relevant area of sky has not been observed.

6.1.6 Handling Faults

1. Where feasible, the system shall continue normally to operate in the presence of faults. Such faults may include non-operating detectors.
2. The existence of missing or poor quality data shall be indicated in the data headers.
3. All faults shall be logged. Each log entry shall contain relevant details to assist an engineer to diagnose the problem.

6.1.7 Weather Monitoring

1. Weather monitoring data from Paranal Observatory shall be incorporated into the science data headers.
2. As a minimum this shall include seeing monitoring, local temperature and wind speed data.

6.1.8 Readout Noise Pickup

It shall be possible to operate any single mechanism during detector readout for noise pickup testing.

7 Reliability Maintainability & Safety Requirements

7.1 Telescope Lifetime

VISTA shall be designed for a minimum lifetime of 15 years of operation, comprising an average 12 hours of observation and 12 hours of stand-by per day.

7.2 System Reliability

7.2.1 Overall Availability

1. The system shall be designed and manufactured in order to ensure that the non-scheduled down time does not exceed 5% of the observing time.
2. During the initial year of operations the non-scheduled down time shall not exceed 15% of the observing time.

7.2.2 Specific Reliability Requirements

A Failure is defined as an event causing complete loss of observing capability and which cannot be recovered by corrective maintenance (including fault identification) in less than 4 hours.

1. Major subsystems of VISTA shall be designed for a Mean Time Between Failures (MTBF) of 3 years. As a minimum, this shall apply to the following subsystems:
   - Telescope (including drive and control system)
   - M1 Cell
   - M2 Electromechanical Unit.
   - Enclosure
   - Instruments.
2. Although MTBF criteria may not be suitable for equipment used only occasionally (example Coating Plant), a high reliability shall be enforced in the design and manufacturing process by appropriate methodology and review.

7.3 Maintainability Guidelines and Requirements

7.3.1 Guidelines for Diagnosis and Maintenance by Software

As a general rule Maintenance procedures shall, where feasible, be implemented in software. These procedures shall:

1. Check performance against predetermined requirements and if necessary alert the operator.
2. Be capable of being initiated and run automatically, whilst remaining under the control of the operator.
3. Log all procedures, whether successful or not.

4. Log relevant data so that trend analysis can be performed.

7.3.2 Maintenance Approach

ESO shall operate VISTA and perform the on-site maintenance. Therefore the maintenance philosophy to be considered during the design of VISTA is the one established by ESO at the Cerro Paranal Observatory. The major elements of this philosophy are as follows:

1. The maintenance work-load and therefore manpower at the Chilean site shall be minimised and shall be limited as far as possible to preventive maintenance tasks.
2. Maintenance work shall be performed at system level and by exchange of module (Line Replaceable Units, LRUs) when practical.
3. LRUs are defined as units which can easily (*i.e.* without extensive calibration *etc.*) be exchanged by maintenance staff of technician level, and that can be easily shipped to a suitable ESO repair location, or to an industrial supplier for repair.
4. This concept implies that spare LRUs shall be available at the Observatory.
5. Standardisation of equipment, fully applicable to VISTA is given in applicable documents AD06 and AD12, covering Service Connection Points and Electronic components. As a general design guideline the VISTA design shall make use of standard equipment already selected by ESO for the VLT, with a minimum of specialist tooling.
6. Three different category of maintenance shall be considered:
    - Predictive Maintenance
    - Preventive Maintenance
    - Overhaul

7.3.2.1 Predictive Maintenance

Predictive maintenance is “condition driven” preventative maintenance. Instead of reliance on life-time statistics, predictive maintenance uses direct monitoring of the system performance or condition. Typical examples are testing of gearbox oil for bearing deterioration or monitoring of drive currents for change in loading characteristics.

The VPO shall define predictive maintenance opportunities for adoption on site and provide the interfaces necessary for such activities.

7.3.2.2 Preventive Maintenance

1. Preventive maintenance actions (not including periodic mirror re-coating) shall be planned with a frequency of:
    - every month for inspections and relatively simple actions of less than 4 hours in total;
    - multiple of 6 months for other actions with a maximum of 12 hours every 6 months.
2. The preventive maintenance tasks shall be accomplished by two trained technicians with a minimum of special equipment or tools.

7.3.2.3 Overhaul

Overhaul is defined as special preventive maintenance operation during which the equipment is not operational and observing time is lost. Overhaul involves removal of the equipment from the telescope for partial or total disassembly. For VISTA, limited overhauls lasting up to 48 hours can be undertaken during the periodical re-coating of the primary mirror, provided they do not impact the coating process.

Overhauls which would require the loss of more than 3 observing nights shall not take place more often than every 3 years

7.3.3 Monitoring & Test routines

Software routines shall be used to facilitate maintenance and fault detection and location.
As a general rule two monitoring and test levels are to be considered:

1. Monitor level: executed continuously as a background task by the LCUs, shall carry out checks such as:
   - Interlock system
   - power supply level
   - temperatures
   - positions
   - correct execution of commands
   - other variables and signal, as required by the system controlled by the specific LCU.
   - The selection of which parameter has to be monitored (also some not included in the above list) depends on the criticality of the parameter for the overall safety and performance. Monitored parameters shall be stored in the local database to be accessible from the central control software. The list of all parameters being monitored shall be already identified at the design level.

2. Self-test: This shall execute on switch-on and at other times. It shall carry out operations such as
   - Checking memory access and communication links
   - Checking the presence of necessary hardware on the LCU bus
   - Exercising any other functions that would be safe to carry out automatically without human intervention (i.e. NOT including any functions that would switch on or move a device that could pose a safety hazard)

3. Diagnostic-test: This shall execute additional checks on an individual device or sub-assembly which shall test all its functions. This test shall ONLY be initiated by the operator or by an engineer, and it is assumed that the operator shall be familiar with the test and any safety implications (*e.g.*, stay clear of the Telescope while testing the azimuth drive).

7.3.4 Spares

VPO will provide the necessary spare parts, including the ‘life spares’ (specially produced spares at time of manufacture) and the common user spares sufficient for commissioning and the first six months of operation. The ranging and scaling of these spares shall be defined during the design and manufacture phase. This shall be based on standard operating conditions and notified to ESO.

7.3.5 Specific Maintainability Requirements

7.3.5.1 In Situ Cleaning

The design of the System shall allow *in-situ* cleaning of the M1 and M2 mirrors and the camera window.

7.3.5.2 Primary Mirror coating

A complete re-coating operation, by an experienced and rehearsed team, shall not delay science observations by more than 3 nights.

7.3.5.3 Camera Installation/Removal

1. The total time to remove and install a camera shall not exceed 8 hours and shall not demand more than three technicians.
2. It shall be possible to perform all maintenance functions on either camera whilst it is off the telescope, without impacting on the operation of the camera mounted on the telescope.
3. Following a camera change, it shall be possible to reach standard operating performance and take sufficient calibration data to calibrate out any systematic changes, using not more than 2 hours of clear night time and 4 hours of additional daylight following the camera change.
4. Following cool down, the cameras shall be capable of meeting the Astrometry stability requirements within 48hrs for the IR Camera and 24hrs for the Visible Camera.

7.3.5.4 Camera Intervention

1. It shall be possible to thermally cycle the IR camera from operating to room temperature and back again in no more than 10 days.[1]
2. It shall be possible to change any or all the IR filters in the IR filter slots within 11 days.

[1] Any engineering activities are in addition to the 10 day allocation.

7.4 Safety

Safety of equipment and personnel shall be in accordance with AD50 (VISTA Project Safety Management Plan)

According to the general rules of AD50, non-standard equipment, specifically designed and built for VISTA shall be designed to ALARP ("As Low As Reasonably Practicable") principles, which means that an Hazard analysis based on a probabilistic risk assessment is used to identify hazards, to determine their severity and acceptability. The overall criteria for the review of the Hazards shall be as detailed in AD50. Hazards shall be treated in order that they reach ALARP status.

7.4.1 Hazard Risk Acceptance Criteria

7.4.1.1 Hazard Severity

no text

7.4.1.2 Hazard Probability

no text

7.4.1.3 Hazard Risk Category

no text

7.4.2 General Safety Requirements

The general principles of safety design of technical products defined in AD53 and AD54 shall be applied.

7.4.3 Mechanical Safety

1. A minimum safety margin of 1.5 with respect to sigma 0.2% has to be used in the design of all those mechanical components which in case of a failure lead to an Unacceptable or Undesirable hazard risk as defined in AD50.
2. Transport, lifting, hoisting devices and similar equipment shall be approved by an officially recognised independent verification agency.

7.4.4 Protection against electric shock and other hazards

7.4.4.1 Introduction

The low-voltage electrical installations of the Cerro Paranal Observatory are designed and erected according to AD56 (IEC 60364 Electrical Installation of Buildings); their system earthing is TN-S.

7.4.4.2 Safety compliance

In order to achieve protection against electric shocks and other hazards VISTA and is components shall be designed and erected in compliance with the applicable documents AD54 (EN 60204-1), AD55 (IEC 61140) and AD56 (IEC 60364)

7.4.4.3 Electrical and electronic equipment

1. Electrical and electronic equipment to be installed onto VISTA shall comply with AD55, taking into account the VLT Observatory altitude.
2. Information Technology Equipment to be integrated into VISTA shall comply to AD57 (IEC 60950)

7.4.4.4 Bond corrosion

In order to prevent bond corrosion, pairing of dissimilar metals shall be avoided where possible. Shall joints between dissimilar metals be essential, the metals in direct contact shall exhibit the lowest possible combined electrochemical potential (in any case below 0.6V) and the anodic member of the pair shall be the larger in size of the two.

7.4.5 Primary Mirror safety

1. Under any conditions the maximum principal tensile stress in the primary mirror shall not exceed the following values:
   - 6MPa for a duration shorter than 24 hours
   - 3.5MPa for a duration longer than 24 hours

7.4.6 Hydraulic Safety

All hydraulic systems shall be designed in accordance with AD60.

7.4.7 Pneumatic Safety

All compressed air installations shall be designed in accordance with AD53.

7.4.8 Cooling System Safety

Cooling systems shall be designed in accordance with the electrical safety requirements and AD53.

7.4.9 Software Safety

No software failure or combination of failures shall lead to an unacceptable or undesirable hazard risk - the only exception to this principle may be the introduction of means to avoid pointing the telescope at the sun. In this context, an appropriate hazard assessment/mitigation exercise shall be performed.

7.4.10 Handling, Transport and Storage Safety

The design of VISTA shall incorporate all means necessary to preclude or minimise hazards to personnel and equipment during assembly, disassembly, test, transport, transport on site and short/long term storage of VISTA and/or parts thereof.

7.4.11 Operational Safety

None of the following cases shall lead to an unacceptable or undesirable hazard risk

- One or two independent operator errors
- One operator error plus one hardware failure
- One or two hardware failures
- One or two software failures
- Partial or complete loss of energy supplied to the VISTA or subsystems of it
- Emergency braking of the telescope tube
- OBE or MLE earthquakes
- Wind loads.

7.4.12 Safety Interlock System

Interlocks shall be implemented wherever necessary to prevent a dangerous situation or to respond to a dangerous situation. Dangerous situations include hazards both to personnel and to equipment. The implementation of Interlocks shall be in accordance with AD12.

8 General Requirements for Design and Construction

8.1 Requirements for analyses

8.1.1 Finite Element Structural Analyses

1. All the Finite Element Analyses necessary for the verification of the performance of the major subsystems of VISTA shall be performed with an internationally recognised numerical code. The structural models used shall be adapted to the particular analysis for which they are to be used and shall be accurate enough to provide a good description of the behaviour of the structure under examination in terms of displacements, stress and frequencies.
2. The analysis error due to mesh density shall be <10% in terms of FE internal criteria such as the 'Percentage error in energy norm'. Alternatively this type of error can be evaluated by mesh refining. The verification of the accuracy of the modal analysis by experimental methods is in any case the preferred solution.
3. Analyses used for verification of optical performances (example M2 mirror) shall have a sufficient number of points on the optical surfaces

8.1.1.1 Modal analysis

1. Modal analysis shall be performed in order to obtain accurate information concerning the eigenfrequencies and the eigenmodes of the various subsystems, as required.
2. The number of degrees of freedom shall be such as to have a good representation of the frequency range required. Boundary conditions shall be correctly represented.

8.1.1.2 Gravity load analysis

The effect of gravity shall be taken into account by means of FE analysis.

8.1.1.3 Wind stress analysis

1. The effect of the wind to be expected during operational conditions or survival conditions shall be verified by means of a finite element analysis.
2. The wind load application method shall follow the methods of applicable document AD52.

8.1.1.4 Seismic analysis

1. The seismic analyses shall be based on the modal response spectrum technique. The design response spectra for OBE and MLE are given in AD04. The applicable percentage of critical damping to be used is:
   - 1 % for OBE for the telescope and its subsystems (Page 31 of AD04)
   - 1 % for MLE for the telescope and its subsystems (Page 25 of AD04)

- 3 % for OBE for the buildings, pier and enclosure (Page 33 of AD04)
- 5 % for MLE for the buildings, pier and enclosure (Page 33 of AD04)

2. For the verification of specific scenarios, where the equipment is in a configuration which is used only occasionally (for example M1 mirror in coating plant), a reduced Response Spectrum may be used (MLE_{LR}). In particular this is covered by the curve of AD04
   - MLE_{LR}: Mirror Maintenance 1%, q=1.0, B1 (Page 45 of AD04)
3. The model used and the number of dynamic degrees of freedom shall be such that an accurate modal response is obtained up to a frequency of 35 Hz. The model shall include the foundations and the interface to the ground.
4. The Square Root Sum of the Square method (SRSS) shall be used in order to combine the contribution of the various modes. The three spatial components of the response shall be combined according to the provisions of Chapter 6 of the Eurocode 8, Part 1.
5. The earthquake analysis of the cameras can either be performed with the general rules above, by physically including them in the model, or, provided that its first natural frequency is sufficiently high by the simplified method (quasistatic analysis) described in AD05.

8.1.1.5 Load combination Operational Condition

1. The load combinations for verification of stresses, displacement and in general the performances under operational conditions, shall take into account the sum of the relevant individual load cases applicable to the subsystem or part under examination. This includes but it is not limited to:
   - gravity loads (under different conditions)
   - wind (operational if applicable)
   - Differential thermal expansion (functional, operational)
   - operational loads dynamic (example telescope slew, acceleration)
   - all specific loading acting on the subsystem or part.
2. For any subsystem the relevant load cases shall be identified and specified.

8.1.1.6 Load Combination Survival Conditions

1. As a general rule the verification of the ability of any system to survive accidental loads shall take into account one survival loadcase at the time, <u>in addition</u> to the relevant (functional) operational loads acting on it. As a minimum the accidental loads to be considered are:
   - Operating Basis Earthquake
   - Maximum Likely Earthquake
   - Wind (Survival)
   - Telescope Emergency Braking (against hard stops)
   - and any specific loadcase that may arise from the particular condition of the system under study (example handling).

8.1.2 Requirement for Safety Analyses

Safety analyses shall be performed following best practice to meet the requirements within AD14.

8.1.3 Control loop design and analysis

1. Dynamic simulation analysis shall be performed for all the relevant functions and control loop of VISTA. The main purpose of these simulations is to confirm the fulfilment of the different relevant requirements.
2. As a general rule **dynamic** simulation shall include the effect of non-linear effects like friction, stick-slip, sensor noise, *etc*. For each of the functions to be controlled the stability margin shall be computed.

8.1.4 Electromagnetic Compatibility analysis

An electromagnetic compatibility (EMC) analysis may be used for VISTA as a method of verification of specific EMC requirements instead of tests. In this case, the analysis shall be performed with the procedure and goals defined in AD08, AD09, and AD10 as appropriate

Other references, standards, or methods may be used as an alternative, subject to agreement between ESO and VPO.

8.2 Material Parts and Processes

1. The selection of material shall be in accordance with the ESO preferred material list. Full details on standard electro-mechanical components are listed in AD12.
2. The use of non-standard components shall to the possible extent be avoided.
3. A stress release treatment of the major welded parts of the VISTA telescope shall be applied. The process used shall be agreed by the VPO.

8.3 Painting / Surface Treatment

8.3.1 Paints

1. The VISTA telescope tube structure are covered with low emissivity diffuse aluminium paint or aluminium foils.
2. The surfaces around the optical beam are painted with matt black paint (*e.g*. NEXTEL 2010C.10 Black Velvet coating from 3M Co.)
3. The telescope spiders are painted with matt black paint (*e.g*. NEXTEL 2010C.10 Black Velvet coating from 3 M Co). In the event that thermal plumes are an issue, this shall be covered with low emissivity MAXORB Nickel foil or similar.

8.3.2 Surface treatments

Unpainted Surfaces are treated against corrosion. In this case, the bonding requirements specified in AD09 shall be met.

8.4 Electromagnetic Compatibility

8.4.1 General

8.4.1.1 Intra-system electromagnetic compatibility

VISTA shall exhibit complete electromagnetic compatibility among the parts, components, devices, apparatus and equipment of which it is composed (intra-system electromagnetic compatibility).

No malfunction, degradation of performance or deviation from specified parameters is admitted because of lack of intra-system electromagnetic compatibility.

8.4.1.2 Inter-system electromagnetic compatibility

Minimisation of the electromagnetic interference between VISTA and its environment shall be a concern in the design and manufacture of VISTA (inter-system electromagnetic compatibility). In order to achieve inter-system electromagnetic compatibility, VISTA shall comply with the EMC requirements set by the applicable documents AD08 and/or AD09, or otherwise as agreed between ESO and VPO.

8.4.2 Electromagnetic environment

VISTA shall be installed, operated and located within the electromagnetic environment specified by AD08 and, therefore, shall comply with the requirements imposed by AD08.

Applicability:

1. VISTA shall be considered part of the VLT Observatory. Therefore the general requirement of the VLT observatory are applicable.
2. For the purpose of this Specification, the requirements applicable to Telescope Area of the VLT Observatory are to be intended as fully applicable to the VISTA Telescope Area.

Text deleted as duplication of AD contents.

8.4.3 Emission

As per AD08 *and* AD09 *as appropriate.*

8.4.3.1 Radiated emission

As per AD09.

8.4.3.2 Conducted emission (disturbance voltages)

As per AD09.

8.4.3.3 Conducted Emission (harmonic currents)

As per AD09.

8.4.3.4 Conducted emission (voltage fluctuations)

As per AD09.

8.4.3.5 Conducted emission (disturbance currents)

As per AD08, AD09 *as appropriate*.

8.4.3.6 Immunity

As per AD08, AD09 *as appropriate, or otherwise agreed between ESO & VPO*.

8.4.3.7 Input (and output, if any) AC power ports

As per AD08, AD09 *as appropriate*.

8.4.3.8 Control, signal ports

As per AD09.

8.4.3.9 Enclosure port

As per AD09.

8.4.3.10 Input and output DC power ports (if any)

As per AD09.

8.5 Nameplates and product marking

1. As a general rule the main parts of VISTA subsystems and all exchangeable units (LRUs) shall be tagged with nameplates.
2. The nameplates shall be visible after installation of the parts or LRUs. The nameplate shall contain the following information:
    - Part /Unit name
    - Drawing number including revision
    - Manufacturing month and year
    - Name of manufacturer

    Deviations from the above shall be subject to VPO agreement.

8.6 Workmanship

1. These requirements herein shall apply to all entities involved in the design, development and manufacturing of VISTA.
2. Only methods and procedures which are state of the art or as a minimum best practice in precision mechanics, optics, electric and electronics, hydraulics, design, development and manufacturing shall be used.
3. Quality assurance activities shall follow the guidelines of ISO9001-2000 or similar standards, subject to agreement between VPO and ESO.

9 Technical Documentation

The technical documentation related to VISTA shall meet the following general requirements:

1. The language used shall be English
2. Only SI units shall be used with the following exceptions:
   - degree
   - arcminute
   - arcsec
   - hour
   - minute
   - magnitude (on the Vega scale)

   Other exceptions may be agreed between VPO and ESO.
3. - Drawings shall be delivered on paper as well as in electronically readable format. (Format to be agreed between VPO and ESO, and between VPO and QMUL)
4. - Finite Element Models and results as part of analysis shall be delivered also in electronic form (format to be agreed between VPO and ESO, and between VPO and QMUL).
5. - Layouts for electronic circuits shall also be provided in electronically readable format.

10 Verification and Quality Assurance

This section summarises how the requirements listed in Sections 4 & 5 shall be verified. Verification shall be conducted in accordance with a Technical Verification Plan, as specified in AD02.

10.1 VISTA Test Philosophy

Several forms of verification activities shall take place during the design, manufacture, assembly and commissioning of VISTA. These activities shall take place in several locations ranging from sub-system manufacturers premises to the commissioning site in Chile.

10.2 Performance Verification

In addition to the inspections performed as part of quality assurance requirements by each supplier, the following three methods of verification shall be carried out to show that the requirements of VISTA:

10.2.1 Verification by Design

Verification of the design shall be carried out during the design phase to ensure that the required performance can be met. This shall include the use of Formal Design Reviews.

10.2.2 Verification by Analysis

The performance of the specific item shall be demonstrated by carrying out appropriate analysis during the design phase.

10.2.3 Verification by Test

The performance of the specific item shall be verified by specific tests. “Testing” may also encompass Inspection or Demonstration, as appropriate.

11 ANNEX A: Mapping Table to SRD

The following table maps the requirements listed in the Science Requirements Document AD01 to the appropriate section of the VISTA Technical Verification Specification. A column for comments is used to clarify points (e.g. where an SRD requirement is not a technical specification, where it is dealt with elsewhere (including by VDFS) or where the VTS requirement that can be achieved differs from that in AD01).

Specific goals within the SRD have been retained on a best efforts basis, the VPO shall endeavor to approach these goals unless cost or schedule are compromised.

11.1 A-1 Requirements from SRD Section 4

Note: Requirements relating to the Visible Camera only are designated 'n/a vis only' and are not referenced in this table.

SRD (AD01)	VTS Section	Comment
4.1/1	1.1	
4.2/1	4.6	
4.3/1	4.7	
4.3/2 (Goal)	4.7	
4.3.1/1	5.3.2	
4.3.1/2	5.10.3	Can be performed with monochromator supplied.
4.3.1/3	4.7, 5.3.3.1	
4.3.1/4	4.12.6	
4.3.1/5 (Goal)	n/a	Compliant – design does not preclude.
4.3.1/6 (Goal)	n/a	Compliant – design does not preclude.
4.3.2/1	*n/a*	*Partially compliant – filter holder design*

SRD (AD01)	VTS Section	Comment
4.4.1/5	*n/a vis only*	
4.4.2/1	4.9.1.2 but with <0.51" vice <0.5" for wind speed below 14m/s, SIQ can fall off from <0.51" at radius 0.7° to <0.61" at 0.8°	Raytheon pixel size raised base by 2%, and fall off occurs in outer 0.1° radius.
4.4.2/2 (Goal)	n/a	Not achievable
4.4.2/3 (Goal)	4.8.3/3 but 1.9 to 1.95 (not 2) pixels/FWHM	Raytheon pixel size raised pixel size
4.4.2/4	n/a	Not a tech spec
4.5.1/1	4.10 and astrometric error budget	
4.5.1/2	4.10 and astrometric error budget	
4.5.1/3	4.10 and astrometric error budget	
4.5.1/4 (Goal)	4.10 and astrometric error budget	
4.5.2/1	4.13.1.2	
4.5.2/2 (Goal)	4.13.1.2 but 3" rather	

SRD (AD01)	VTS Section	Comment
4.3.2/2	*n/a vis only*	
4.3.2/3 (Goal)	*n/a vis only*	
4.3.2/4	*n/a vis only*	
4.3.2/5	5.3.3.1	
4.3.2/6	5.3.2	
4.3.2/7	7.3.5.4	
4.3.2/8	n/a	Compliant – filter holder design
4.3.2/9	5.3.3.3/3	
4.3.2/10 (a) (Goal)	5.3.3.1	*Partially compliant*
4.3.2/11	*n/a*	Met by design
4.3.3/1	7.3.5.3	
4.3.3/2	7.3.5.4	
4.3.3/3	7.3.5.3	
4.3.3/4	7.3.5.3	
4.3.3/5 (Goal)		Cannot be met
4.4.1/1	*n/a vis only*	
4.4.1/2	*n/a vis only*	
4.4.1/3.a	*n/a vis only*	
4.4.1/3.b	*n/a vis only*	
4.4.1/3.c	*n/a vis only*	
4.4.1/3.d	*n/a vis only*	
4.4.1/3e (Goal)	*n/a vis only*	
4.4.1/4 (Goal)	*n/a vis only*	

SRD (AD01)	VTS Section	Comment
	than 2”	
4.5.2/3 range	5.1.17.6	Accuracy 5.1.17.8 was deleted
4.5.2/4	4.13.1.3/1	
4.5.2/5	4.13.1.3/2	
4.5.2/6 (Goal)	not specified	
4.5.2/7	4.13.1.4	
4.5.2/8	5.1.10.8.2	
4.5.2/9 (Goal)	5.1.10.8.2	Achieved over all sky positions
4.5.2/10	4.8.1	
4.5.3/1	4.14.1	
4.5.3/2 (Goal)	not specified	
4.5.3/3	4.9.1.2	
4.5.3/4	4.14.1 4.14.3 at 2“/min not 10”/min	Partially compliant Open loop non-sidereal tracking only
4.5.3/5 (Goal)	4.14.1 4.14.3	Open loop non-sidereal tracking only
4.6.1/1	4.11 and Photometric error budget	
4.6.2/1	*n/a vis only*	
4.6.3/1	*n/a vis only*	
4.6.4/1	4.8.3 5.3.6.1	
4.6.5/1	5.3.6/6	
4.6.6/1	4.15.1 4.15.2 5.3.6.1 and Throughput budget	
4.6.6/2	4.12.5 5.3.6.1/9	Ghosts (4.12.5) Chg bleeding (*n/a vis only*) Remnants (5.3.6.1)
4.6.6/3 (Goal)	4.15.1 and Throughput budget	
4.6.6/4 (Goal)	not specified	Cannot be met
4.6.6/5	4.15.3	

11.2 Requirements Mapping from SRD Section 5-7

SRD (AD 01)	TVS Section	Comment
5.2/1	4.12.2	
5.2/2	4.12.3/2	

SRD (AD 01)	TVS Section	Comment
7.1/5	4.16.8/3	External to firewall
7.3/1	not specified	ESO and VDFS responsibilities

5.2/3	4.12.4	Significantly is taken as 30%
5.2/4	4.12.7	10% variation
5.2/5 (Goal)	4.12.7	
5.2/6	4.15.1	
5.2/7	4.12.3/1	
5.2/8	4.12.3 and Photometric Error Budget	
6.3/1	Overheads in 4.13.2 4.15.4.2 4.15.4.4 5.3.3.3 and Survey efficiency budget	
6.3/2	4.8.3 but with 6 not 4 pawprints	Size of Raytheon detectors forced 4->6
6.3/3	*n/a vis only*	
6.3/4 (Goal)	4.8.3	16 detectors are provided.
6.3/5 (Goal)	not specified	
7.1/1	not a tech spec	
7.1/2	7.2.1/1	
7.1/3 (Goal)	not specified	
7.1/4	6.1.7 and Data Dictionary.	relies on input from ESO Weather site. ESO do not put such information in FITS headers

7.3/2	6.1.3	VDFS responsibility
7.3/3	6.1.4/2	
7.4/1	Not specified	ESO say not necessary
7.5/1	5.5	
7.5/2	5.5.4.5 6.1.3	VDFS
7.5/3	5.5.4.5	VDFS
7.5/4	5.5.4.5	VDFS
7.5/5	4.16.7	VDFS
7.5/6	not specified	No electronic data transmission from Paranal. Survey Progress Database by VDFS.
7.6/1	4.16.5 but for 10 not 30 nights.	
7.6/2 (Goal)	not specified	
7.7/1	4.16.8	ESO does not intend to normally offer VISTA in visitor mode.
7.8/1	not specified	Data will go from Paranal on disk by courier to Garching. then (a copy) on to UK
7.9/1	4.16.7	
7.9/2	not specified	UK side only

12 Consistency & Traceability

For purposes of traceability, below is a summary of changes between v3 of the VISTA Tech Spec and this document; these mostly reflect changes to low-level engineering design detail dictated by manufacturing considerations. Note: fundamental performance requirements still apply – it is only the low-level engineering detail that has been changed, and the impact of any low-level design detail change has been absorbed into the unchanged high-level requirements [the exception to this the minor impact on SIQ due to pixel size – this is addressed via VIS-CRE-ATC-95000-00016].

4.16.1.2(3)	Readout mode deleted as not implemented by chosen detectors.
5.1.6	Mirror CTE changed to reflect as-built situation.
5.1.9.5(5)	Minor amendment to throughput/vignetting spec (off-axis).
Table 5	Reflects updated RoM of M1 axial definer settings.
5.1.11.4	Low-level design changes to M1 Axial support parameters.
5.1.11.5	Low-level design changes to M1 Lateral support parameters.
5.1.14.8	Low-level design details of M2 Baffle deleted (superfluous information).
5.1.16.3, 5.1.17.6	Rotator tracking performance now absorbed into SIQ requirement.
5.1.16.4	No longer specify provision for Visible Camera services (in practice this does not preclude the Vis Camera as its service requirements are not foreseen to be significantly different to those of the IR Camera).
5.1.17.9	Motor torque removed as low level detail
5.1.17.11	Functional aspects of limit switch operation x-ref'd across; low-level design details removed as superfluous [covered in Telescope documentation].
5.1.18.2.1(4)	Guiding-whilst-defocussed functionality deleted as not quantified (although not specifically precluded by design).
Table 6	Re-instated as definitive (Table 1 deleted)
5.3.6.1(2)	Y-band performance deleted (was never a deliverable)
5.3.6.1(4)	Pixel size changed in accordance with design process and Change Request VIS-CRE-ATC-95000-0016.
5.3.6.1(7)	Defect requirement changed in line with Raytheon as-built performance.
5.3.6.1(13)	Physical flatness requirement reworded in line with Raytheon as-built status – absorbed into SIQ performance.
5.5.4.9	UK data-handling hardware requirement deleted as per v3 of TS.
5.6.4.2	Enclosure ground floor rail load increased to reflect as-built rail/plant design.
5.6.5.8	Flat-field lighting requirements re-written as a uniformity spec (illumination level in TS is too bright, and doesn't reflect as-built configuration).
5.7.4	Transformer power rating deleted as detail – refer to Enclosure documentation for evidence of suitability.
5.8.2	Detail of Coating process deleted; optimisation of coating process is still to be conducted, although typically it would be 6-8 layers.
8.3.1 (1)	Paint emissivity deleted as low level detail.

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