VISTA

Visible & Infrared Survey Telescope for Astronomy

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This is an overview document and should not be used for any other purposes. While the VPO will use best efforts to ensure this document is up-to-date, it takes no responsibility for the currency and accuracy of the information herein.

Change Record

Issue	Date	Section(s) Affected	Description of Change/Change Request Reference/Remarks
1	25/9/01	All	Entire re-write based on Technical Specification
1.6	22/5/03	All	Major redraft following contract awards
1.7	16/6/03	Sections 1 & 12	Replacement of Telescope Structure Drawings, Update of Contract details

Table of Contents

1 Introduction

1.1 General

VISTA is being developed by the VISTA Project Office (VPO) at the UK ATC on behalf of the VISTA Consortium[1] and PPARC. Following completion the complete telescope will be handed over to ESO as part of payment in kind following the UK's ascension.

The VPO has developed the project in two phases:

- Phase A to achieve the conceptual design for VISTA
- Phase B to develop this conceptual design into work packages for and subsequent management of: detailing, manufacture, integration and commissioning.

This document is an overview of the VISTA Project from the perspective of the VPO. It is intended to give a broad description of the areas of development of the VISTA Telescope under the control of the VPO. It does not go into other areas such as operations or data processing. This version has been prepared following the completion of Phase A and during the early part of Phase B.

1.2 Telescope & Cameras Description

The Visible and Infra-Red Survey Telescope for Astronomy (VISTA) is a 4 metre diameter class wide field telescope. It is different from other 4 m telescopes in that it will be totally dedicated to conducting imaging surveys of the sky. At any time it will be able to accommodate either a visible or IR wavelength state-of-the-art wide field camera to achieve this. The visible camera has, however, been delayed due to funding issues.

- A Visible wavelength Camera: accepting a 2.13 degree diameter unvignetted field of view. The focal plane will be populated with ~50 off 2k x 4k three side buttable red optimised science CCDs with ~0.23"pixels. With the anticipated CCD arrangement two integrations, separated by an offset of ~33', will result in coverage of 95%, an area of ~3 deg^2.
- An IR Camera: accepting a 1.65 degree diameter unvignetted field of view. The focal plane will be populated with 16 off 2k x 2k non buttable IR science detectors with ~0.33"pixels. With the anticipated detector arrangement six offsets are required to fill the gaps.

[1] The VISTA Consortium is lead by Queen Mary University of London and consists of: Queen Mary University of London, Queen's University of Belfast, The University of Birmingham, University of Cambridge, Cardiff University, University of Central Lancashire, University of Durham, The University of Edinburgh, University of Hertfordshire, Keele University, Leicester University, Liverpool John Moores University, University of Nottingham, University of Oxford, University of St Andrews, University of Southampton, University of Sussex, University College London

This will make VISTA the most powerful wide-field imaging telescope in the world.

Being a dedicated survey telescope, the optical design has been optimised for this purpose. The power of the telescope is in the primary and secondary mirrors. The instruments provide field correction only. Figure 1 shows the telescope design, which has the following features:

- To achieve the field of view and plate scale, the telescope optics must deliver an ~f/3 beam resulting in an ~f/1 primary mirror.
- The telescope optics do **not** produce a working focus without field correction in the cameras.
- There is no re-imaging in the cameras and in particular no cold-stop in the IR camera.
- A dedicated mirror coating facility capable of coating the M1 and M2 with either protected silver or aluminium

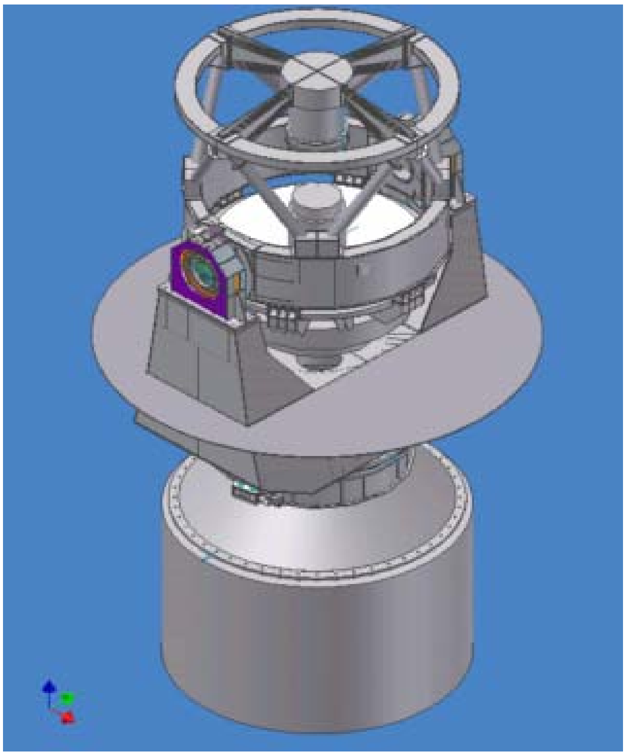

Figure 1: General view of the VISTA Telescope Design

2 Acronyms and Abbreviations

ESO	European Southern Observatory
LCU	Local Control Unit
NTT	ESO's New Technology Telescope
PPARC	Particle Physics and Astronomy Research Council
UK ATC	United Kingdom Astronomy Technology Centre
VLT	ESO's Very Large Telescope
VISTA	Visible and Infra-Red Survey Telescope for Astronomy
VPO	VISTA Project Office

3 Applicable and Referenced Documents

3.1 Applicable or Reference Documents

There are no applicable or reference documents.

4 Location

VISTA will be located on the "NTT peak" of ESO's Cerro Paranal Observatory. This is in the Atacama desert of northern Chile at an elevation of approximately 2500 m above sea level. The peak is situated approximately 1.5 km NE from the location of the Very Large Telescope site, as shown in Figure 2. ESO staff will carry out the operation and maintenance of VISTA. VISTA will, therefore, comply with the design and operational standards and policies in force at the site. The telescope will be operated and data quality assessed from the existing VLT Control Building and use existing electrical power generation. This requires installation of power feeds and communication links.

The telescope will be mounted in an enclosure on the NTT peak, which is being levelled to provide a suitable foundation and vehicular access. The enclosure will consist of a rotating dome and a static basement area. The enclosure will provide environmental protection to the telescope during operation and survival conditions and thermally condition the interior to minimise operational disturbance. VISTA will be equipped with a certain number of dedicated operation and maintenance facilities. In particular this will include the provision of a washing and coating facility capable of maintaining both mirrors, a maintenance and storage area for the instruments and enclosure thermal conditioning. Some of these functions will be housed in an auxiliary building, others in the telescope basement. An outline of the position of VISTA on the NTT peak is shown in Figure 3.

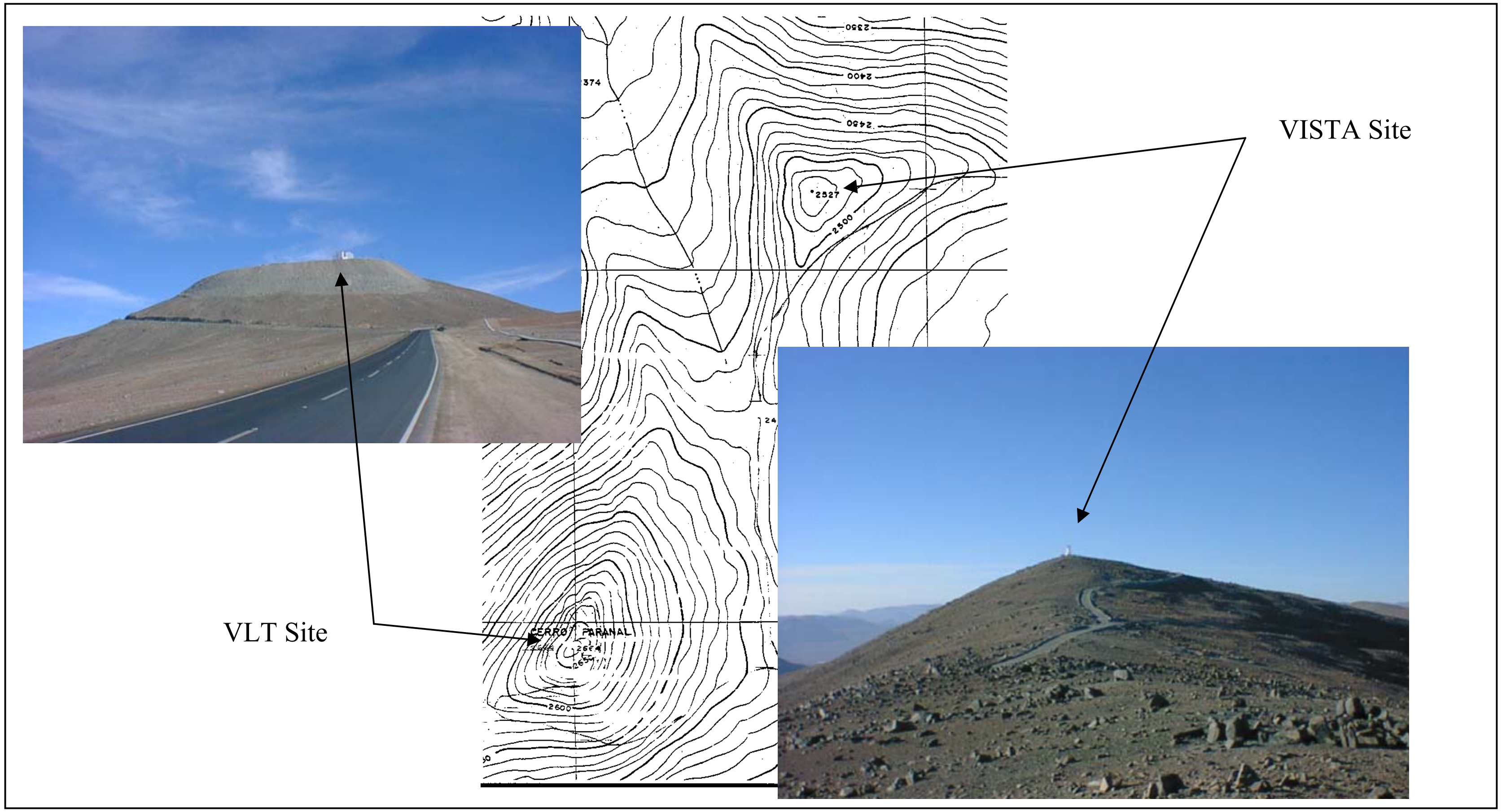

Figure 2: VLT and VISTA Site

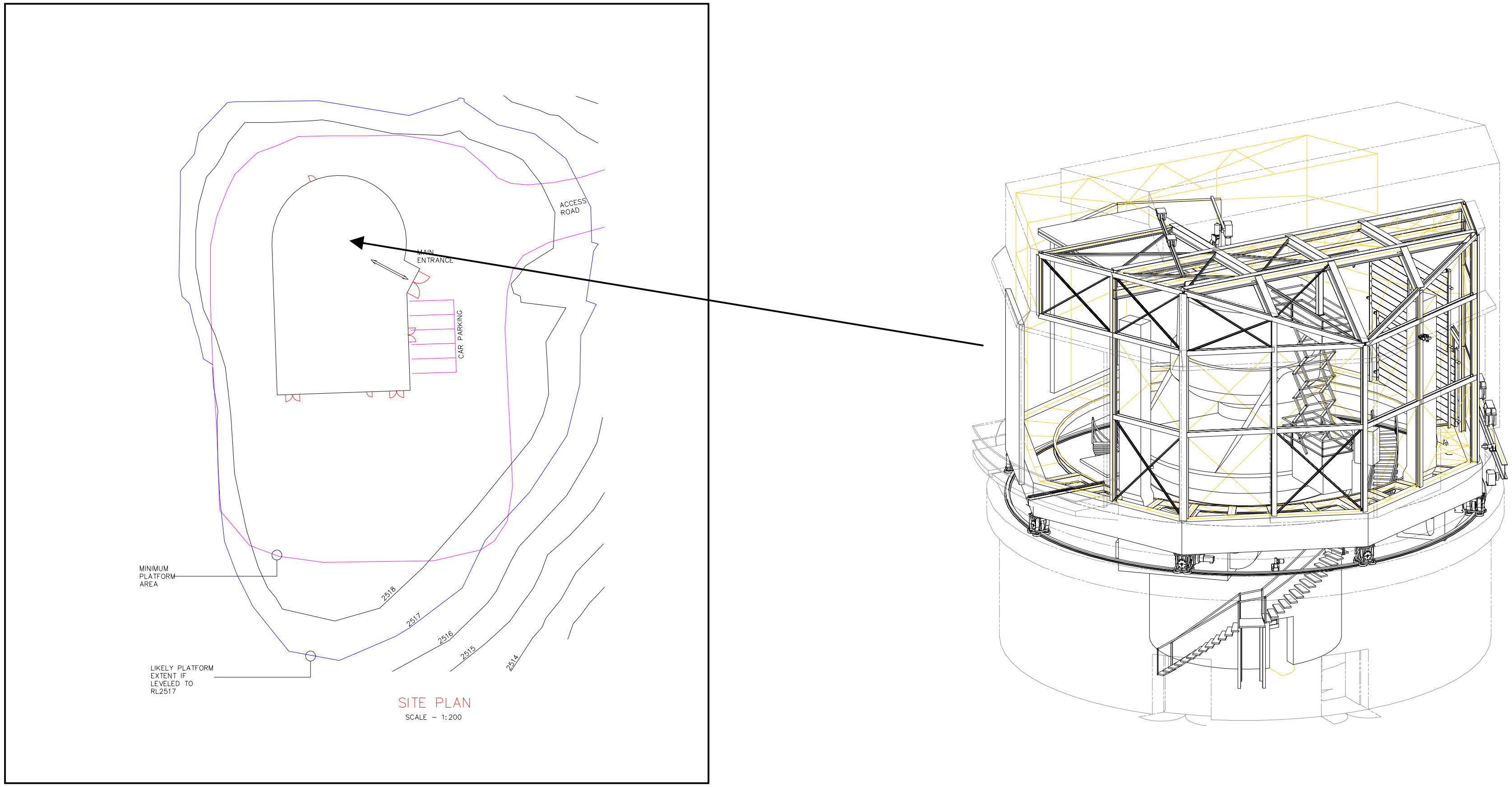

Figure 3: VISTA Site and Conceptual Enclosure

5 Optical Characteristics

VISTA will be a quasi-Ritchey-Chretien telescope equipped with a Cassegrain focus. The design is based on a ~f/1, 4.1 m primary mirror, in the form of a meniscus and a rigid light-weighted secondary mirror of 1.24 m diameter. The desired intrinsic image quality is obtained by means of a field corrector physically included in each of the two instruments. Each instrument will be equipped with wavefront sensors to measure the image quality. This allows periodic corrections of the primary mirror, telescope focussing and collimation. This is achieved through an active primary mirror cell that includes 84 axial supports, 24 lateral supports and a 5 axis M2 support system. Both instruments are equipped with annular baffles with the IR camera baffle being situated within the IR cryostat. In addition, a fixed baffle is mounted around the secondary mirror in order to stop light from the sky being detected from around the edge of the M2. A view of the Telescope Optical layout is given in Figure 4.

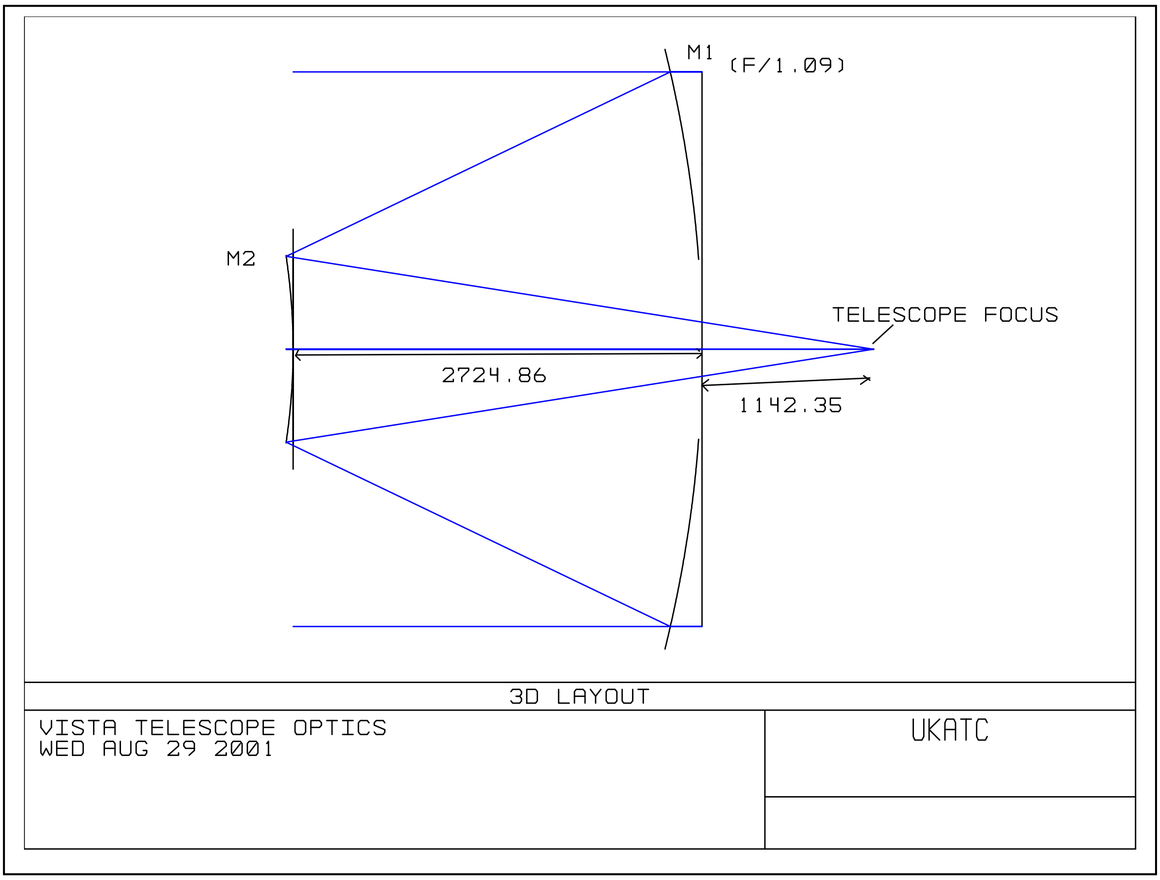

Figure 4: View of the Telescope Optical Layout

The M1 blank was produced by Schott in Germany and is made from Zerodur. LZOS of Moscow are under contract to carry out the Figuring and Polishing and will also provide the transportable container to deliver the completed mirror to Chile. LZOS have also been contracted to manufacture the M2 Mirror and Support Cell. They will manufacture the mirror from Astro Sitall.

6 Telescope Layout

The telescope structure is based on an Alt/Azimuth mount with the altitude axis above the primary mirror. The telescope fork consists of a welded steel structure that rotates around the azimuth axis by means of bearings and an azimuth track. Drive motors and a tape encoder will be used to control this axis. The base of the fork has a platform for access to the M1 Cell and to the instrument. The tube is based on a Serurrier type of design mounted on a centrepiece. The centrepiece supports altitude motors. A top end ring connects the upper ends of the Serurrier and interfaces the spiders connecting the M2 Unit. The altitude axis is mounted on bearings interfacing to either side of the fork.

The M1 Cell interfaces directly to the centrepiece of the telescope. The mirror is supported by means of axial and lateral supports in addition to lateral and axial defining points. During installation the M1 Cell is brought below the centrepiece and lifted into position using the facility handling equipment. The mirror is lowered into position through the telescope structure following the removal of the upper structure. The selected instrument can then be attached onto the field rotator mounted at the bottom of the M1 Cell whilst the telescope is horizon pointing. Figure 5 shows the general layout of the Telescope.

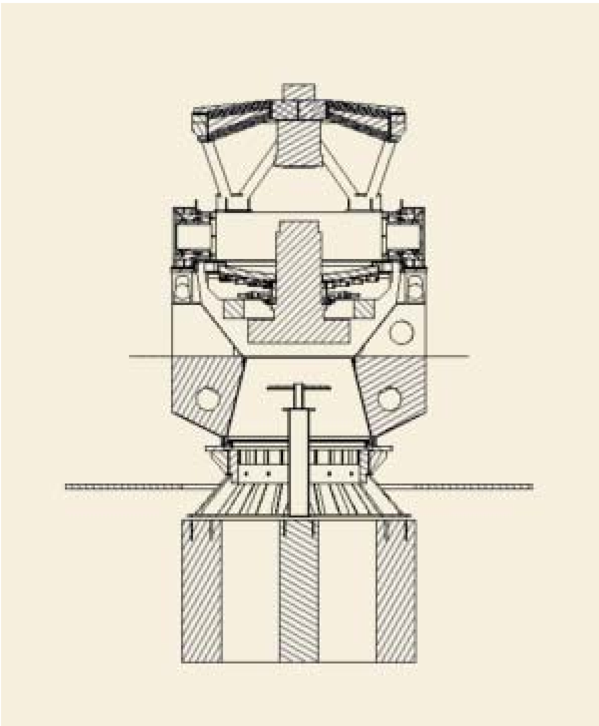

Figure 5: General view of the VISTA Telescope

7 M2 Unit

The M2 Unit will be of a hexapod design and has been contracted by NTE in Barcelona. They manufactured the M2 Unit for Grantecan. The M2 Unit consists of a rigid mechanical structure connected to the telescope spiders. An outline of the Hexapod arrangement can be seen in Figure 6. During observations it will be possible to move the mirror in discrete steps under the command of the Telescope Control System in order to maintain the optical alignment of the telescope. The M2 Unit mechanism achieves this by adjusting the position of the M2 Mirror around two axis orthogonal to the mirror optical axis as well as along the optical axis. The use of flexures in the design solution will help the linear response and thus the repeatability of this high precision system whilst the hexapod arrangement offers a high level of control.

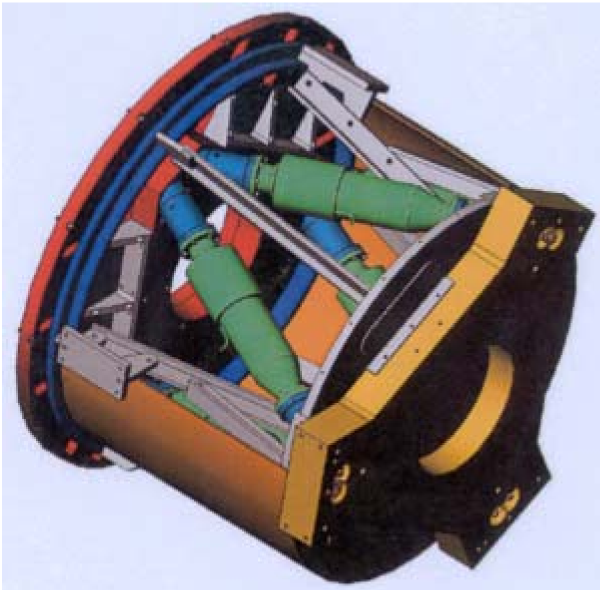

Figure 6: General View of M2 Unit Hexapod Arrangement

8 Cameras

VISTA can mount one of two cameras operating in visible or IR wave bands at the Cassegrain focus. Each camera will contain optics to correct the image provided by the telescope. The two cameras share the same interface flange at the rotator mechanism. The cameras will be balanced to produce the same balance on the telescope elevation drive. As noted earlier, the visible camera is delayed due to budgetary reasons.

8.1 Visible Camera (Information only)

Note: The development of the Visible Camera has been postponed due to funding issues. The concept is shown in this document for completeness.

The Visible Camera interfaces to the rotator by means of a mounting flange. A lens barrel extends from the mounting flang through a central bore in the primary mirror. The barrel keeps the corrective optics, including the Atmospheric Dispersion Compensator, aligned accurately. It also supports a baffle for controlling stray light. On the lower side of the mounting there is a shutter mechanism, a jukebox-like filter assembly and the focal plane assembly. The focal plane assembly is contained within a cryostat along with the autofocus, autoguiding and wavefront sensing devices. The science detector area in the camera is approximately 2 square degrees. There will be up to fifty 2K x 4K three side buttable CCD detectors with ~0.23" pixels. Figure 7 shows the general layout of the Visible Camera.

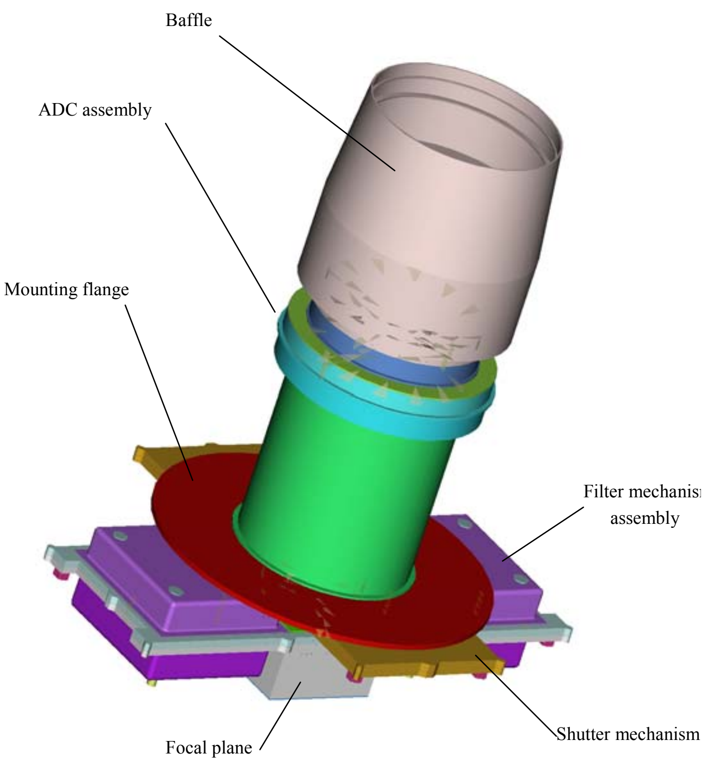

Figure 7: General view of the Visible Camera

Typical layout of the CCDs in the focal plane is shown in Figure 8.

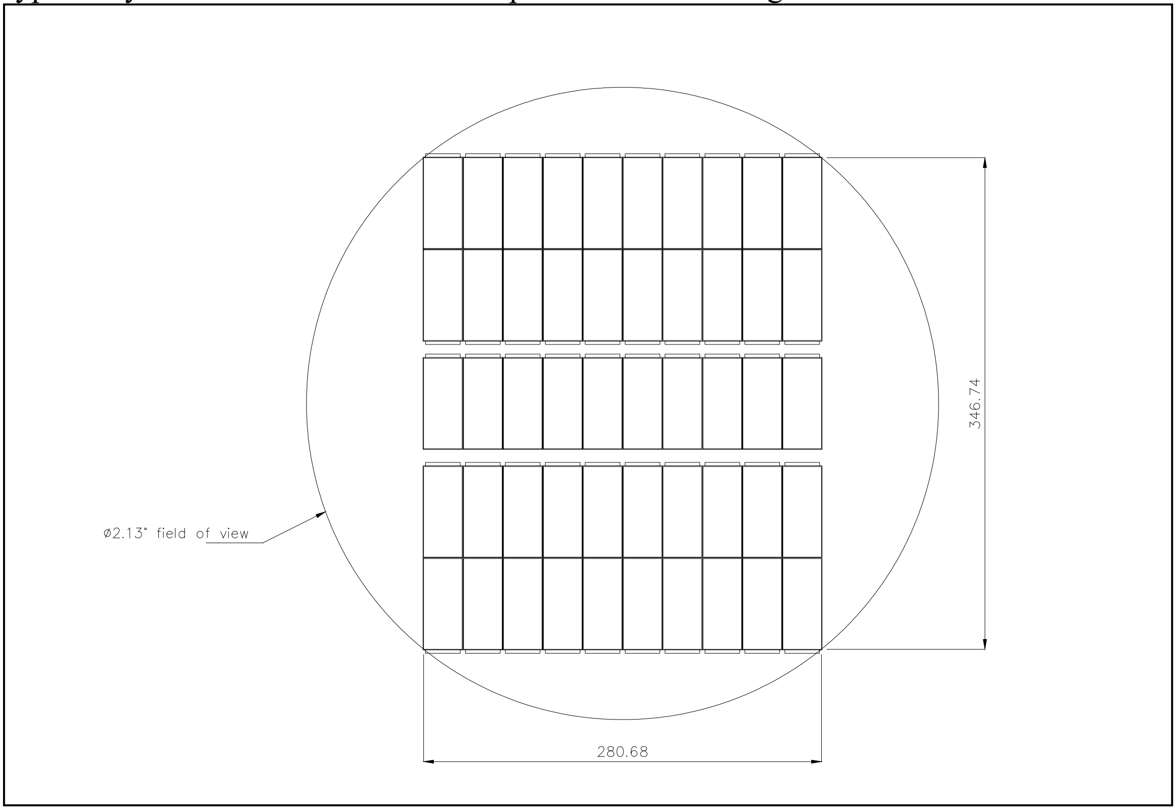

Figure 8: Visible Camera Science Array Layout

Based on the anticipated sky brightness, atmospheric extinction at 1.2 airmass, median site seeing of 0.66” at 0.5µm, and the predicted telescope performance[1], the anticipated 5σ 15 minute magnitudes on the Vega scale for photometry in a 1.6 arcsec diameter software aperture are:

Band	u’	B	g’	V	r’	i’	z’
Assumed Sky							
Sky Brightness Mag/arcsec^2	22.0	22.7	22.2	21.9	20.8	19.8	18.5
Extinction coefficient mag/air mass	0.5	0.2	0.17	0.15	0.09	0.05	0.05
Corresponding Sensitivity							
5σ 15 min limiting (Vega=0) mag	23.3	25.9	25.9	25.4	25.0	24.3	23.3

[1] Entrance Pupil 3.7m diameter, protected silver coated mirrors, red-optimised CCDs and 1.6m diameter secondary baffle

8.2 *Infrared Camera*

The IR camera, which is being developed and manufactured by a consortium consisting of Rurtherford Appleton Laboratories, United Kingdom Astronomy Technology Centre and University of Durham, is based on the use of a cold baffle instead of a traditional cold stop on a re-imaged pupil. This is a consequence of the f/3 design, image quality requirements and the field of view. The direct imaging produces excellent uniformity of image quality across the field. A cold baffle is mounted around the inside of the vacuum vessel. This limits the field of view so that only cold surfaces or reflections of cold surfaces are visible from the focal plane. It also limits the heat load on the cryostat by reflecting heat back towards the cryostat window. This latter function is achieved by a number of reflective curved surfaces inside the baffle, which have coatings that are reflective above 3 µm. Extensive modelling of this system shows it has a performance comparable to a cold-stop design.

The instrument is composed of four main assemblies. The vacuum vessel with its integral baffle, the focal plane unit with the IR detectors, autoguider and wavefront sensor hardware consisting of 4 2k x 2k CCDs for curvature sensing and 2 2k x 1k CCDs for autoguiding, a lens barrel and a filter wheel with associated mechanism. There will be sixteen 2k x 2k Raytheon Virgo IR detector arrays with ~0.33" pixels. Figure 9 shows the general layout of the Infrared Camera.

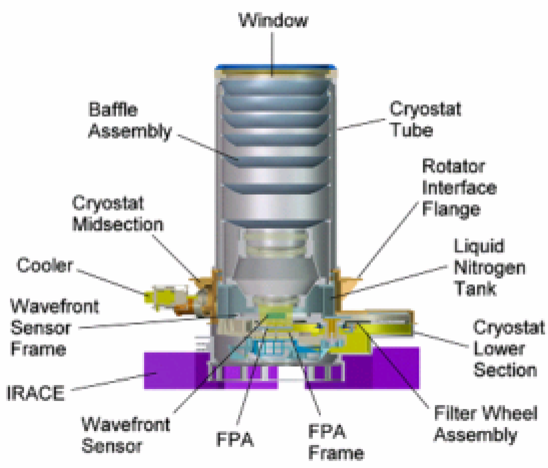

Figure 9: General view of the IR Camera

The layout of the IR detectors in the focal plane is shown in Figure 10

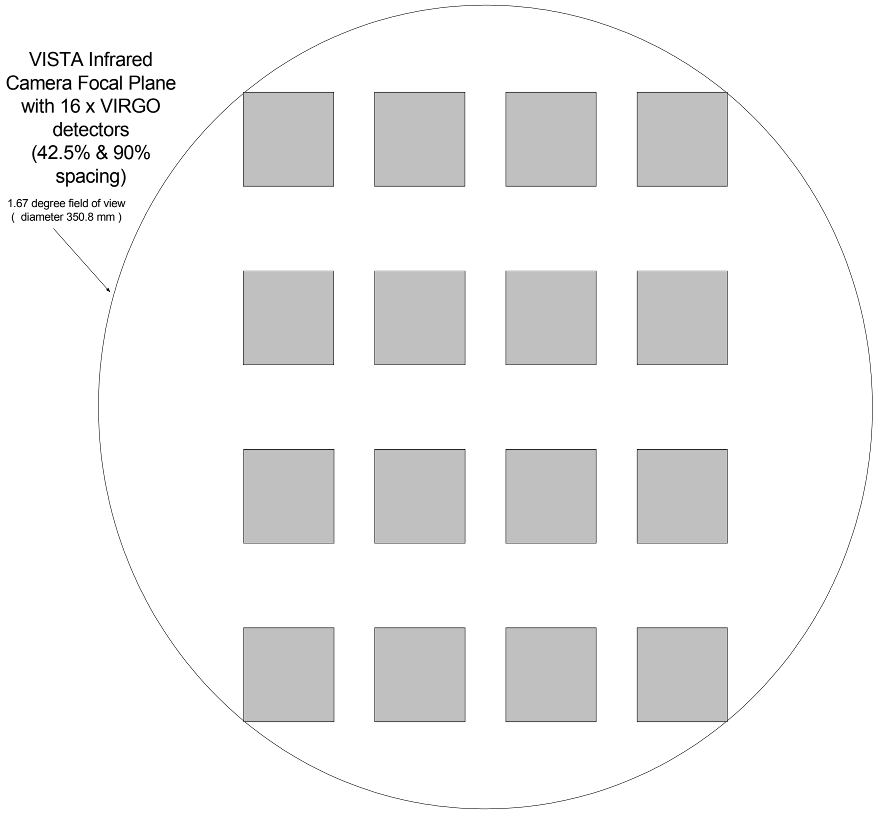

Figure 10: IR Science Array Layout

IR Science Array Layout: The dotted line shows the full 1.67 degree diameter field of view. The science detectors are spaced by 90% in the vertical direction and 42.5% in the horizontal direction to give a filled field in 6 pointings. The focal plane is oriented such that the filter wheel hub is in the vertical direction.

Based on the anticipated sky brightness, atmospheric extinction at 1.2 airmass, median site seeing of 0.66" at 0.5µm, the predicted telescope performance[1], and a detector quantum efficiency of 75%, the anticipated 5σ 15 minute magnitudes on the Vega scale for photometry in a 1.6 arcsec diameter software aperture are:

[1] Entrance Pupil 3.7m diameter, protected silver coated mirrors and 1.6m diameter secondary baffle

Near IR camera Band	J	H	Ks
Assumed Sky			
Sky Brightness Mag/arcsec^2	16.0	14.1	13.0
Extinction coefficient mag/air mass	0.1	0.08	0.08
Corresponding Sensitivity			
5σ 15 min limiting (Vega=0) mag	22.15	20.98	20.05

9 Enclosure and Auxiliary Building

9.1 Enclosure

The enclosure will be based on a rotating part (dome) having its azimuth floor at the same level as the telescope and a fixed part in concrete (enclosure base) with one intermediate floor at the level of the azimuth track and bearing of the telescope for maintenance purposes. The rotation of the dome will be independent from that of the telescope, in order to guarantee flexibility for maintenance. The foundation of the enclosure will be separate from that of the telescope to minimise dynamic disturbances during rotation.

The rotating dome will be a steel frame structure clad with panels providing insulation from the external ambient temperature. A number of wheel supports will be placed on a rail fixed to the basement. The wheel will carry the load of the dome and will also drive its rotation.

The observing slit is generated by two 'L' shaped doors moving parallel to the side of the enclosure. Ventilation doors and a wind screen are required for control of ventilation to achieve good thermal performance, without generating telescope windshake. A flat field facility is included in the dome. During the day the ambient temperature in the dome is controlled in order to bring the telescope and the mirrors to the expected night temperature.

9.2 Auxiliary Building

An Auxiliary Building is located adjacent to the enclosure. The location of the building and specifically its direction has been chosen taking into account the predominant wind direction in order to minimise the disturbance to the wind flow during observation. This building and parts of the Enclosure Base are utilised for maintenance and support functions.

This will include the primary mirror coating plant, capable of coating in protected silver or aluminium, the washing and stripping facilities of the primary mirror, a maintenance area for the instruments and a local control workstation.

Housed within the Auxiliary Building are the power sub-station, containing the medium to low voltage transformer, switching gear and other necessary functions. Handling and hoisting facilities will be included for the various foreseen operations.

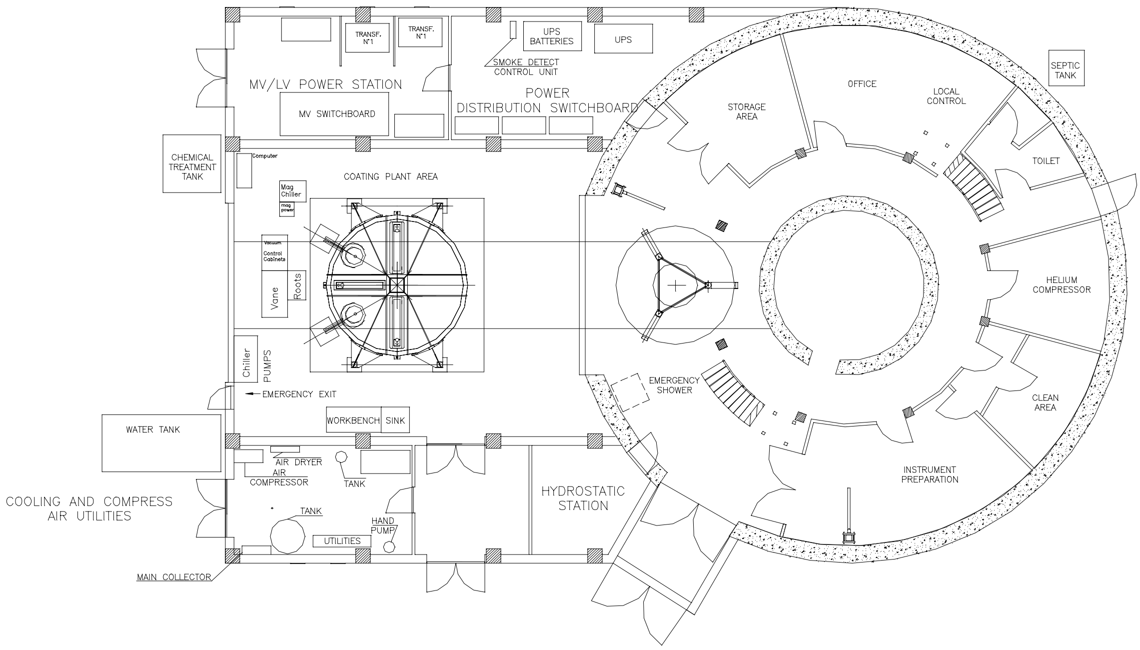

Figure 11: Shows the Enclosure Base and Auxiliary Building layout

9.3 Computing and Controls

VISTA and its systems will be controlled by a network of computers. In order to minimise development and operations costs, the hardware and software systems closely follow the architecture of the VLT system and several systems will be reused without modification.

All the equipment will be operated by Local Control Units located within the Enclosure. These LCU's comprise VME based computers running the VxWorks realtime operating system. Higher level control, user interfaces and data handling will be performed on Unix workstations located in the VLT Control Building.

The LCU's and the workstations will be networked via fibre optics. Significant bandwidth will be required to handle the datarates from the detectors: 54 MBytes/s peak and 27 MBytes/s sustained. In order to handle the datarates, use of Gigabit Ethernet and 622 Mbps ATM is currently being reviewed. Offsite networking will be provided by ESO's satellite link to Garching, but this will not be used for data transfer or remote control.

10 Description of the Operational Scenario

10.1 Operation of Equipment

Since VISTA will be operated by ESO staff, it is designed to be compatible with the operational procedures laid down by ESO. During observing, the telescope building will be operated remotely. The VLT control building will provide this function where VISTA will share a control console with the VLT Survey Telescope. The telescope operator will control all telescope and instrument functions, including selecting the observation or queue to be executed, initiating observations and calibrations, responding to changing conditions and unexpected events and ensuring generally that the requested observations are executed successfully.

Engineering access to the equipment in the VISTA enclosure will be possible during the day, both for routine preventive maintenance and possible corrective actions.

10.2 Observation Submission and Execution

For all normal operations, VISTA will be queue scheduled. Observations, including the necessary calibrations to allow the subsequent reduction and analysis of the data, will be specified in advance, using ESO's Phase II Programme Preparation tool (P2PP). Observation Blocks (OB) specifying the required observations, will be approved by staff at Garching and transmitted electronically to Cerro Paranal, where they will be placed in one or more queues. The VISTA operator will control which queue is executed and the system will then automatically translate the Observation Block into commands to the various telescope and instrument subsystems.

It is not envisaged to operate VISTA or its instruments from off-site. However it will be possible to have observations made at short notice, eg in response to a gamma ray burst, by a combination of human procedures and down loading of quickly prepared observation requests.

10.3 Data Handling

Data, both science and calibration, will be stored to disk as FITS files containing not only the detector data but also headers containing keywords that fully describe the data. A complete observation log will also be maintained daily. Final data reduction will be performed in Europe. Because of their volume, typically 400 GB per night, the data will be transferred on physical media (ESO currently use DVD but this is under review). These media will be ingested into the ESO archive and also copied to the UK. Final data reduction is not part of the Vista Project undertaken by the VPO. Data at Cerro Paranal will be reduced to a sufficient extent to allow the quality of the data to be assessed well before the commencement of the next night's observing. This will help allow problems to be identified more quickly and if necessary, defective observations to be rescheduled. Although the Paranal data reduction pipeline is required for quality assessment purposes, it also offers the potential to perform near real-time analysis of the data. eg for detection of Near Earth Objects; however, this is outwith the scope of this project.

10.4 VISTA System Diagram

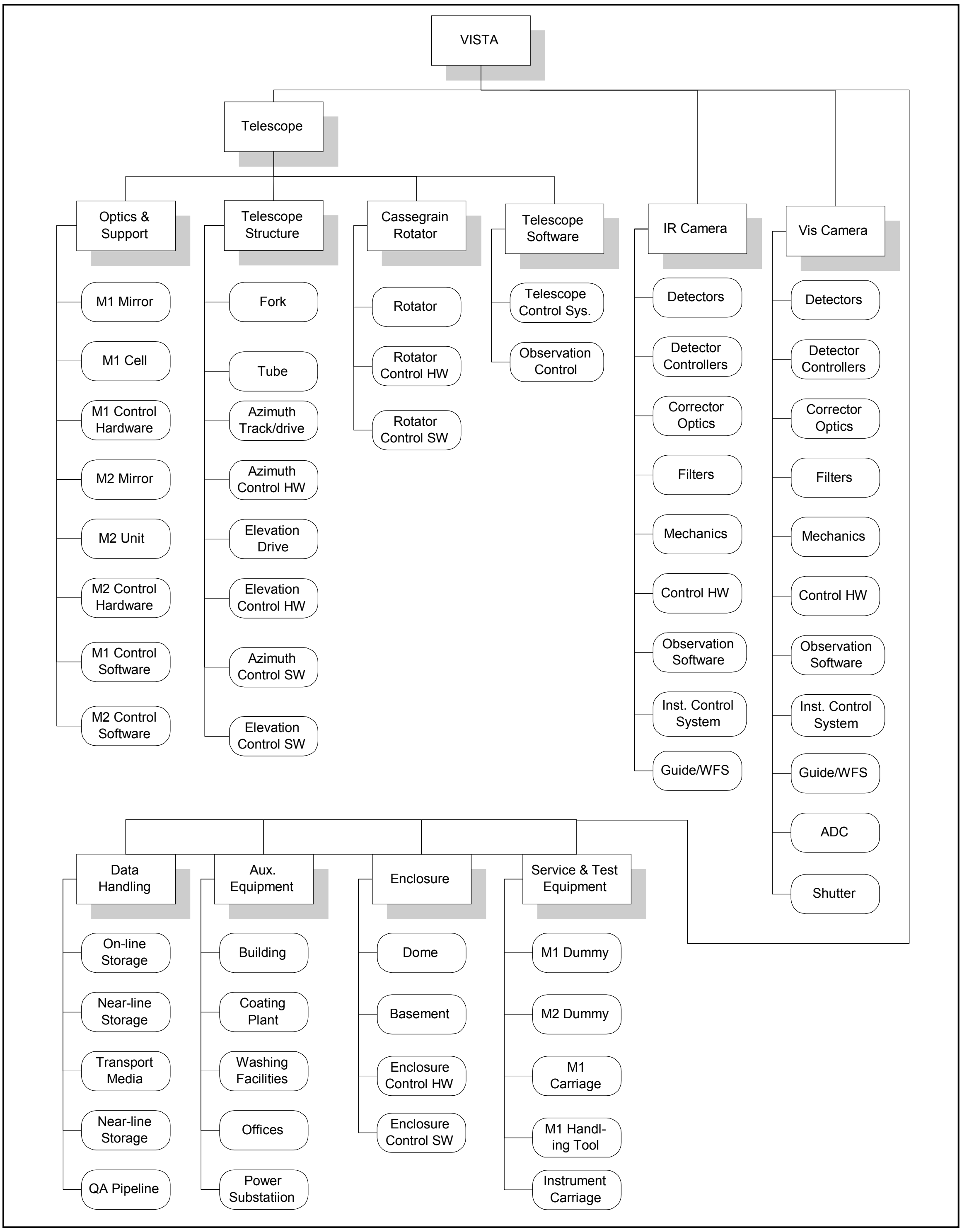

Figure 12: VISTA System Diagram

11 Contact

For further information please contact:

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12 Contractors

The following have been contracted as part of the VISTA Project:

Assembly	Contractor	Contact	Comments
M1 Blank	Schott, Germany	Dr Thorsten Doehring	Contract completed April 2003
M1 Figuring and Polishing	LZOS, Moscow	Ms Tatyana Vygovsky Export Manager	
M2 Assembly	LZOS, Moscow	Ms Tatyana Vygovsky Export Manager	
M2 Unit	NTE, Barcelona	Mr Joan Manel Casalta	Also manufactured Grantecan M2 Unit
Telescope Structure	Vertex RSI, USA	M F Campbell	
Site Preparation	Constructora San Miguel, Chile	O U Romero	
Enclosure	EIE, Venice	G Marchiori	
Active Optics and Guiding Control Software	Rutherford Appleton Laboratory	Dr D Territ	
M1 Control Software	Observatory Sciences	Andy Foster	
Coating Plant	Stainless Metalcraft Chatteris Ltd, Cambridge	Mr Peter Kenny, Managing Director	
IR Camera	Consortium of: CCLRC, UK ATC, UoDurham	Mr A K Ward	