Controlled Document
Confirm revision before using

Lick Automated Planet Finder

2.4m Telescope

Telescope to Enclosure ICD

ICD-5041-3

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DOCUMENT CONTROL

Issue: 3

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Document Revisions

Issue	Date	Description	Prep	Chk	*Appr*
1	10/20/2003	Initial release	RLM	JL	
2	9/28/2004	Revised with new diagram	AML	RB	
3	10/21/2009	Revised to remove mirror cover control, includes numerous additions (METS, Pier Seal, figures diagrams) UPS Specification revised			

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2.4 Meter Alt-Azimuth Telescope

Telescope to Enclosure ICD

1 INTRODUCTION

1.1 SCOPE

This document defines the interface between the Automated Planet Finder Telescope and the Enclosure. The Automated Planet Finder Telescope includes the telescope, telescope control cabinet and any ancillary equipment supplied with the telescope. The Enclosure includes the telescope pier, the building structure, the dome structure, and all other structures and systems necessary to support the telescope to observatory building interfaces.

1.2 RESPONSIBILITIES

Item	By	*Note*
APF telescope design	EOST	
Primary mirror cart design	EOST	
APF pier design	UC	*Requires close consultation with and review by EOS.*
APF enclosure design	EOS	
APF enclosure electrical design	UC	*Mains power, lights, emergency lighting, fire, communications, chiller and METS*
APF cooling system design	EOS	*Fan coils and controls*
APF cooling system plumbing design	UC	*Includes site drawings and supply of all insulated glycol lines from chiller to coils*
METS system design	EOST	*Includes supply of sensors and software integration*
METS system tower	*UC*	*Includes cabling from tower*

1.3 CONFIGURATION

This document has been configured as ICD-5041-3 and is a designated controlled document under the EOST Quality System.

1.4 DEFINITIONS

All items in this document are defined with respect to the telescope.

Inputs are inputs to the telescope that must be provided by the enclosure.

Outputs are outputs from the telescope and must be handled by the enclosure.

The connector definitions and part numbers are the connectors as supplied with the telescope. The mating connector is to be supplied by the enclosure.

In many instances, both SI and English units are included for convenience. In all cases, the SI units shall govern.

Where dimensions in text differ from enclosed Figures, dimensions in Figures shall govern.

EOS means EOS Space Systems Pty Ltd.

EOST means EOS Technologies Inc.

UC means University of California

APF means Automated Planet Finder

1.5 ASSOCIATED DOCUMENTS

EOS Technologies, Inc., UC LICK 2.4 Meter Telescope Contract. (CTR-4875-1), 2003

Automated Planet Finder Telescope Enclosure: Fixed Price Contract between the Regents of the University of California and EOS Space Systems Pty Ltd, June 28 2004

TS-06055 IceStorm 9m Co-rotating Observatory Technical Specification

TS-4190-1 UCSC APF 2.4M telescope Technical Specification

2 PHYSICAL INTERFACE

2.1 COORDINATE SYTEMS

The underside of the telescope base is the primary reference surface for the telescope.

The mean surface of the underside of the base will define a plane with a constant z-coordinate of 0 millimeters in the telescope coordinate system.

The origin of this coordinate system will be at the intersection of the two lines connecting two sets of reference holes. The positive *z*-axis of the observatory coordinate system will point toward the sky along a line defined by the local gravity vector. The positive *x*-axis will be normal to the *z*-axis will point exactly at true east. The positive *y*-axis will be normal to both the *x*-axis and the *z*-axis axis and will point due north. All of the dimensions in this document are defined relative to the observatory coordinate system.

The enclosure coordinate system uses grade as z = 0

Datum levels are summarized in Figure 1. Where discrepancies arise between dimensions given in text and Figures, dimensions in figures take precedence.

2.2 ELEVATION AXIS HEIGHT

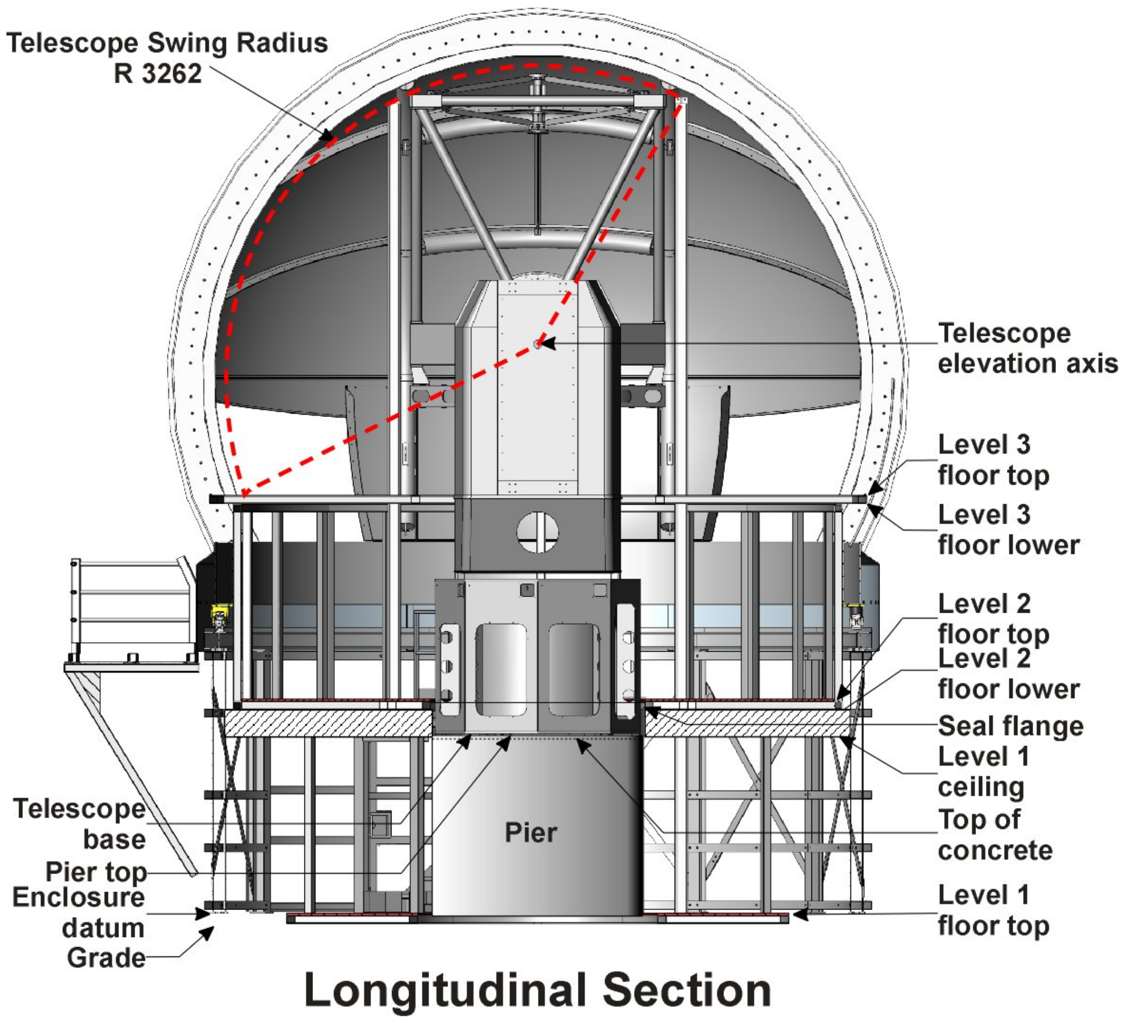
Z = 4641mm ± 15 mm (6778mm above grade) Refer to Figure 1

2.3 FREE MOTION VOLUME

The enclosure co-rotates with the telescope with a minimum clearance > 100 mm between the telescope and the structure.

The swing radius of the telescope defines a cylindrical volume of the dome that must be free of obstructions and available for telescope elevation excursions. Space required for handling operations is in addition to this.

Cylindrical Swing Radius: 3262 mm ± 10 mm Refer to Figure 1



ENCLOSURE DATUM LEVELS	
Telescope elevation axis	+6778
Level 3 floor top (RHS), co-planer with yoke top	+4978
Level 3 floor lower	+4878
Level 2 floor (top of plywood)	+2553
Level 2 floor (underside of framing)	+2428
Seal flange - top	+2428
Level 1 ceiling (underside)	+2326
Telescope Datum-Telescope base (underside)	+2137
Pier Top (top of grout dam)	+2152
Top of pier concrete	+2117
Level 1 floor (top of plywood)	+0003
Enclosure Datum-Underside of ring wall column	+0000
Grade	-0030

Figure 1 Summary of Enclosure Datum Levels

2.4 PIER CONFIGURATION

The underside of the base, which is grouted to the top of the pier, provides the connection between the telescope and the earth. The location and the position of the underside of the base define the location and orientation of the telescope. The telescope global coordinate system is attached to the underside of the base.

The top of the pier form must be higher than the underside of the base to allow liquid grout to be poured between the concrete fill and the base after leveling.

Plane of underside of base:	$Z \equiv 0$ mm [0'-0"]
Base mounting Orientation:	Indicated mark at True North
Level (with respect to zenith):	$\pm$ 30 arcseconds each axis

2.5 NULL POINT

The telescope null point is **100° East of True North.**

Note that the null point influences the design of the pier, which has azimuth cable chain attachment points at the null point. The enclosure attachment points are directly opposite the pier attachment points at the null point i.e. when the telescope and enclosure are pointing at 100^{o} east of true north.

2.6 PIER REACTION FORCES AND STIFFNESS

Reaction forces are produced on the pier from the telescope upper bound mass, telescope accelerations, telescope center of gravity above the pier top and Zone 4 earthquake load.

Telescope upper bound mass	$20x10^{3}$kg
Maximum telescope acceleration (Azimuth)	$2^{o}/s^{2}$
Telescope C of G above pier top	3421.2 mm
Zone 4 earthquake load	0.4 g.

The pier must be constructed to resist these reactions with a foundation stiffness that is high enough to provide a rigid support against telescope accelerations and wind disturbances.

The required stiffness is:

Axial stiffness:	> 20 MN/mm [11.4 x 10^{4} kip/in]
Lateral stiffness:	> 20 MN/mm [11.4 x 10^{4} kip/in]

UC are responsible for specifying reinforcing steel requirements and concrete strength to meet the above specifications.

2.7 PIER CAP DESIGN

A site specific design for the pier cap (pier formwork) is required. The pier cap acts as an attachment point for the enclosure and telescope azimuth cable chain, which has the following requirements.

The pier cap retains the Unisorb® Jakebolts®, (post grout tensioning fasteners) whose final position is determined by the telescope base design and the null point position. Jake bolts must be held in the pier form securely to avoid movement during concrete placement and vibration

The grout dam/form work should be integrated with the pier cap design, eliminating the need to build leak proof formwork on site during telescope installation.

Concrete fill point tabs are required as an indicator for contractors to stop filling and rough finish the concrete in the pier. These tabs should indicate the concrete fill to point to be 35mm below the top of the grout dam.

The pier cap requires a pass through sized to allow all telescope cables from the azimuth cable chain through to the telescope base connection panel. Edges of the pass through must have cable protection to prevent insulation damage.

The pier cap should have a “North” reference mark.

The PCD of the 8 equi spaced Unisorb® Jakebolts®, layout, is 2100 mm.

NO	QTY	DCCM	DRAWING NO	TITLE/DESCRIPTION	MASS
10	16		491–0049	M12 SPRING WASHER ZINC	5 G
9	4		04914	JACKING FLANGE PLATE	460 G
8	16		490–0142	SCREW HEX HEAD M12x30 ZINC	45 G
5	3		05151	COLUMN SET OUT JIG QUADRANT 3	192 KG
4	1		05149	COLUMN SET OUT JIG QUADRANT 1 – DOOR	189 KG
3	16		492–0021	M12 NUT ZINC	15 G
2	8		05152	JIG JACKING SCREW	1.7 KG
1	4		05153	JIG JACKING PLATE	1.5 KG

ELECTRO OPTIC SYSTEMS PTY.LTD.
55A MONARO STREET, QUEANBEYAN, N.S.W. 2620.

TITLE
RINGWALL COLUMN SET OUT JIG ASSEMBLY

Figure 2 Ring Wall Jig Drawing References

2.8 THERMAL SEAL (PIER TO TELESCOPE BASE)

The telescope base shall incorporate a seal mounting surface for the single flap seal to the level 2 Floor. The purpose of this seal (provided by EOS) is to prevent air movement between the “hot” Level I Equipment Room to the Observing space (Level 2).

The top of the seal flange shall be 296mm above the telescope base and shall not impede opening of the access door into the telescope base. Refer to Figure 7.

<u>Enclosure and Pier Interfaces</u>

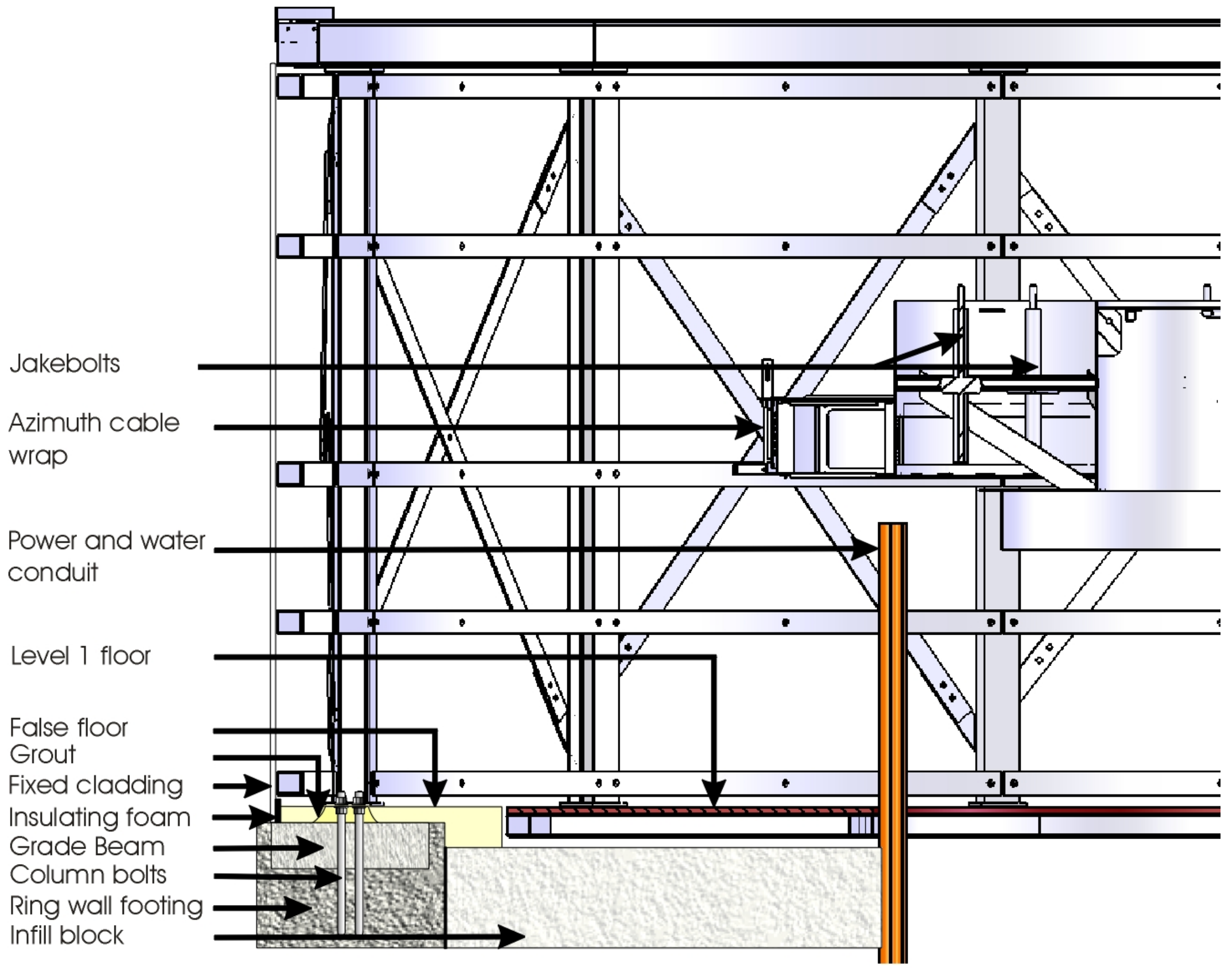


Figure 3 Section at Grade

2.9 DIFFERENTIAL POSITION SENSOR

To support co-rotation, a differential position sensor (DPS) will detect any motion of the telescope with respect to the enclosure and correct the enclosure position. Thus the enclosure will be slaved to the telescope.

The DPS shall have a range of ± 100mm (10mm more than the absolute maximum differential movement of the enclosure and telescope).

The enclosure and telescope attachment points for the DPS are shown in Figure 4 (provided on the telescope by EOST).

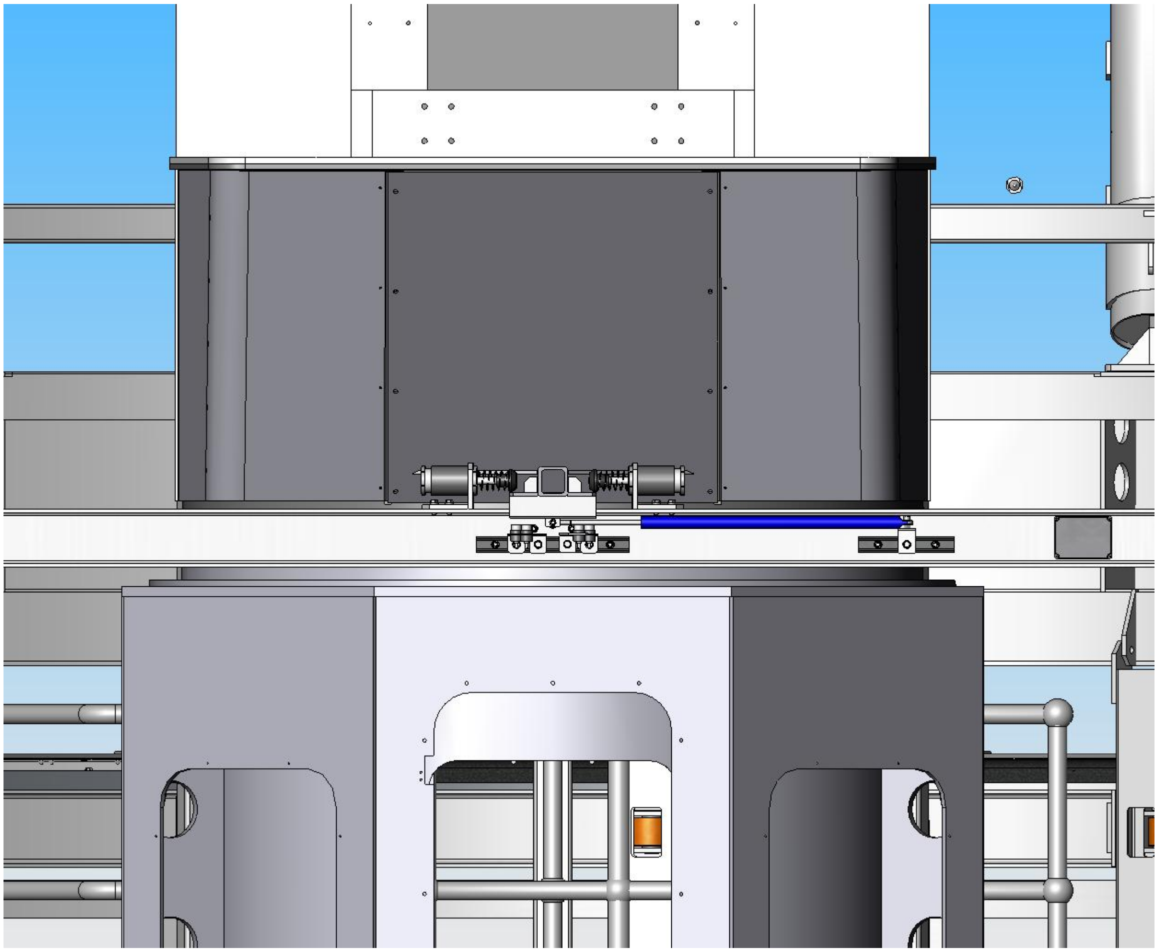


Figure 4 Azimuth Interface (DSP, Limits & Shock Absorbers)

2.10 AZIMUTH LOCK

A locking plate shall be provided to lock the telescope to the enclosure. This lock is provided to prevent differential rotation during major maintenance such as M1 removal.

2.10.1 Position Interlock

During operation, angular misalignment between the telescope and the dome shall not exceed ±1°. This equates to approximately ±26 mm (at a radius of 1.5 m) at the interface between the telescope and the dome floor on level three, measured on the top of the interface beam. Two sets of limit switches fitted to the enclosure allow the telescope control system to confirm that this angular misalignment is not exceeded.

2.10.2 Hard Stop Dampers

As a further precaution, shock absorbers on the enclosure physically limit misalignment and prevent the telescope from contacting the enclosure. The shock absorbers are positioned to contact bump stop on the telescope tow hitch before any other part of the telescope collides with any part of the enclosure.

To avoid damage to the mirror cell and supports, the deceleration of the telescope shall be no greater than $35^{o}/sec^{2}$. To allow the shock absorbers to be sized to provide optimal deceleration under the given displacement constraints, the telescope speed will be limited to 4.5^{o}/sec.

2.10.3 Azimuth Limit Switch Summary

Angular misalignment		Limit Switch Action
±1° maximum	Adjustable	Actuate inner limit switch (soft limit)
±1.5° maximum	Adjustable	Actuate outer limit switch (hard limit)
±1.6°	Fixed	Start of travel of shock absorber
±3.4°	Fixed	End of travel of shock absorber

3 UTILITY INTERFACE

3.1 CABLE PATHS

The co-rotating nature of the enclosure allows the majority of telescope cables to connect to the telescope via cable drapes from the enclosure to the telescope Yoke which co-rotates with the enclosure.

Cables required to be connected from the control rack to the **non-rotating** telescope base shall be routed via the enclosure cable chain assembly, attached to the telescope pier. The cable lengths in the cable chain require careful installation to prevent wear on the cable insulation caused by tight cables rubbing on the cable chain retainers and must not be tied except at the strain relief panels provided at each end of the chain.

Cable chain diagrams are provided at **Figure 6.**

Note: Cable termination to connectors must be completed on site for one end of all telescope cables routed through the azimuth wrap. The cable chain does not have room to pull through standard telescope connectors.

A cable ladder or tray is provided on the enclosure to contain, support, and protect cables running from the control cabinet to the cable wrap and drapes. The cable trays shall support the cables at least every 200 millimeters [8 inches] and allow easy installation and/or replacement of cables.

All telescope control cable runs will extend from their respective strain relief points to a point 500 millimeters [20 inches] above the floor at the back of the telescope control rack located on the rotating floor on level one. Any cable run shall not exceed the lengths specified in the table below.

Route	Length (meters)
Control Rack to Telescope Base	19
Control Rack to Telescope Fork Base	7.5
Control Rack to AC Power	2

Interface Plan View

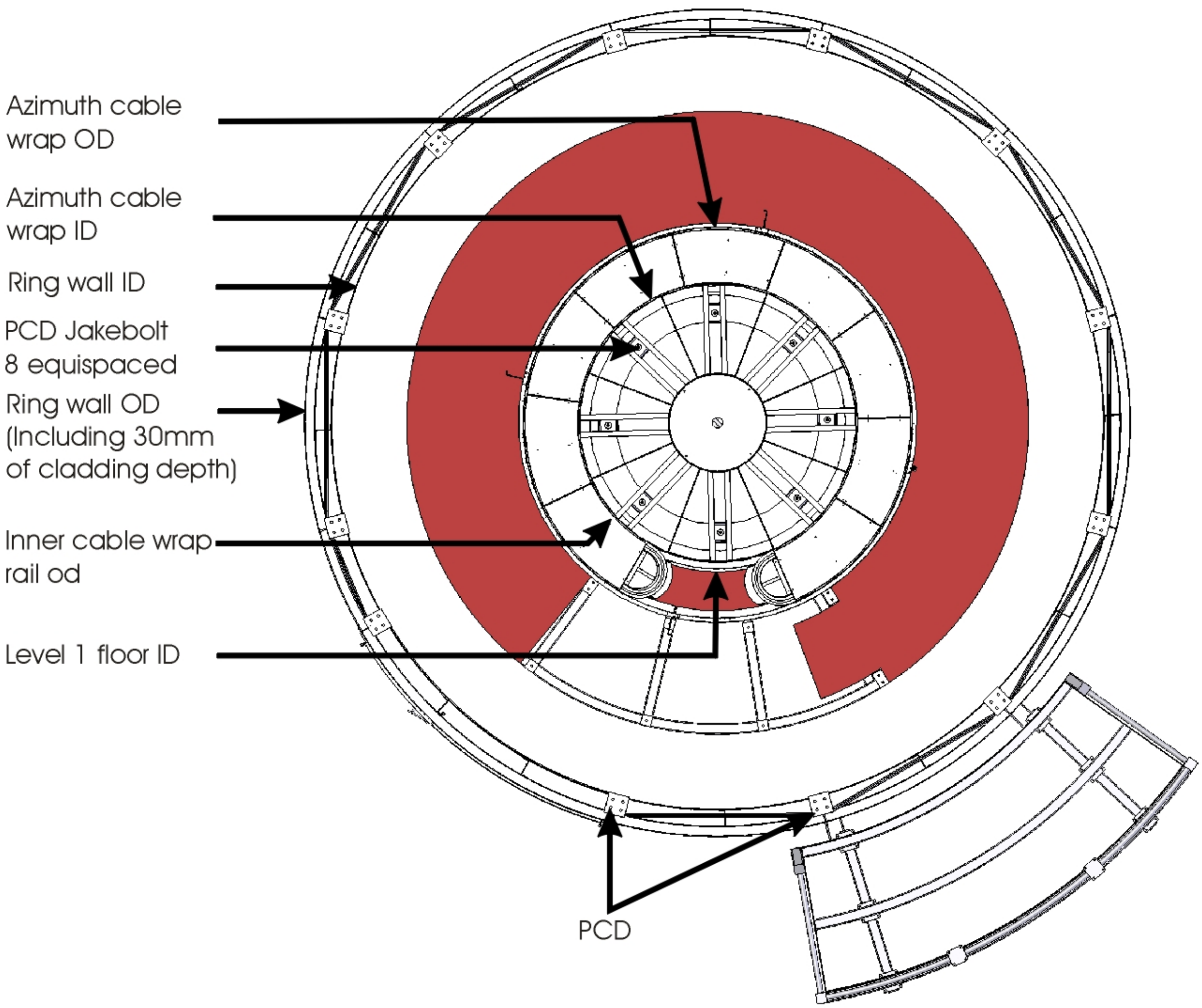
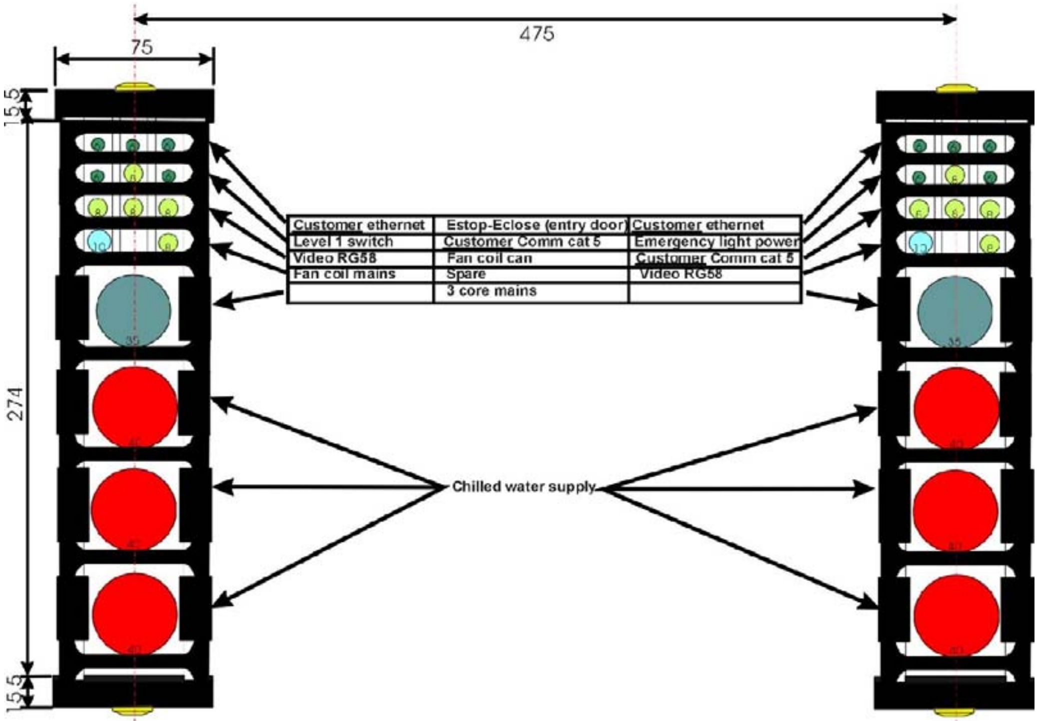
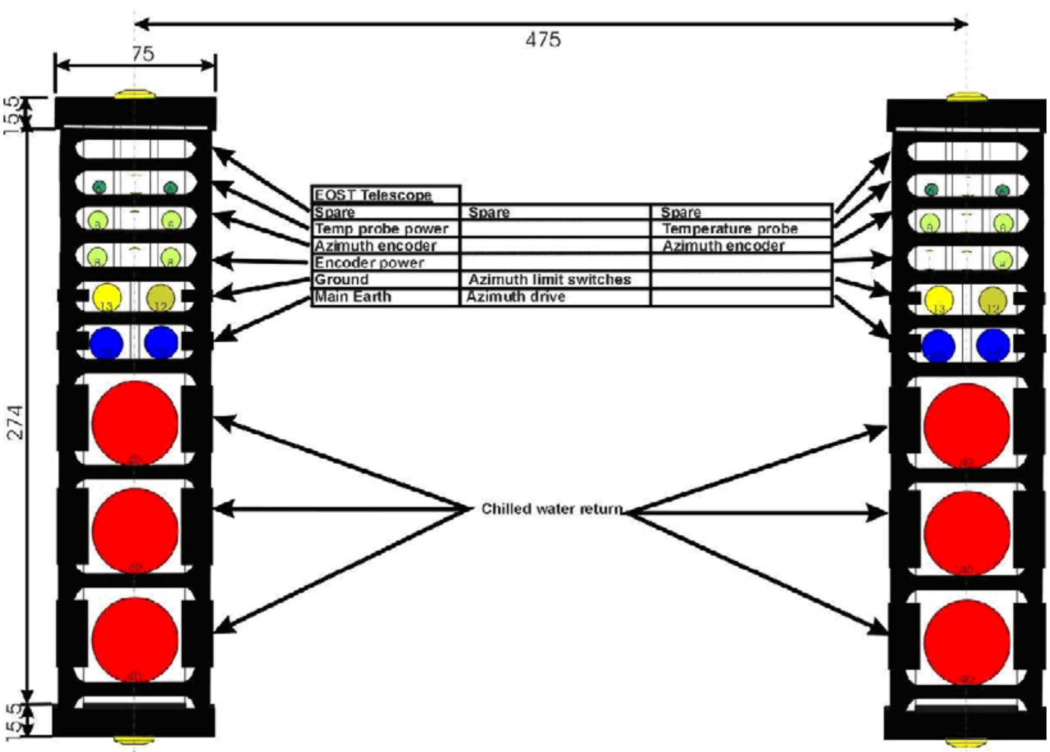


Figure 5 Level 1 Plan



Cable Chain Allocated Fill – Right Side



Cable Chain Allocated Fill – Left Side

Figure 6 Cable Chain Distribution

3.1.1 Telescope Fork Connections

A connector panel is fitted to the rear of the fork base near the center. Cables connecting to the telescope fork shall terminate at this connector panel and be strain relieved to the enclosure structure in such a way as to form a simple cable drape. Sufficient slack shall be provided by the drape to allow for the maximum mechanical misalignment ($\pm 3.4^{o}$) of the telescope and enclosure, or approximately ±90 mm [±3.5 inches] at this point.

3.1.2 Telescope Base Connections

Electrical connections to the telescope base shall be via a panel on the telescope base, with the panel center at 180° from the telescope null point, i.e. at an absolute azimuth position of 280°.

3.2 METS

EOST are supplying the METS sensor which will be installed by UC on a tower provided by UC and connected via UC supplied cabling to the observatory control system.

3.3 OTHER UTILITIES

Additional utility interfaces associated with the instrument are described in the Telescope to Instrument Interface Control Document (ICD-5042).

4 EQUIPMENT INTERFACE

4.1 CONTROL CABINET

Type: Standard 19" rack

Width: approx 572mm [22.5"]

Depth: approx 788mm [31"] (Cabinet only)*

Height: Approx 1982mm [78"] (without lifting eyes)

Approx 2070mm [81.5"] (with lifting eyes)

Mass: <150kg [330 lb]

Other: lifting eyes, and casters

*Cabinet must have >200mm [8"] clearance front and back for cables and doors.

4.2 MAINTENANCE, INSTALLATION AND AUXILLARY EQUIPMENT

Reasonable access to the entire telescope is required for mirror handling, instrument handling, and periodic maintenance.

Access to the secondary mirror mount / spider / truss structure is provided when the telescope elevation is at horizon, from the level 3 floor. Access to the remainder of the telescope is provided by the enclosure floor levels 2 & 3.

Dummy weights compensating for primary mirror or secondary mirror removal will be provided by EOST.

4.2.1 M1 Handling

Periodically the primary mirror will be removed for re-coating. Special handling equipment is provided for transporting the primary mirror and its cell to and from the telescope and the coating chamber.

The enclosure supports mirror handling operations. This includes a service balcony and rail system that will handle the dynamic load of a mirror cart and M1 mirror, plus two people.

A mobile crane with enough capacity and control to safely remove the Mirror cart from the enclosure service balcony is required for every M1 removal or installation.

4.2.2 M1 Mirror Cart

A mirror handling cart designed by EOST is provided. The mirror cart will be required to suspend from a mobile crane while containing the weight of the primary mirror and its supporting structure. The mirror cart will retain and provide mechanical protection to the primary mirror.

Mirror Cart rail spacing	*1550mm*
M1 glass only mass	*1650kg*
Mirror cart, M1 cell and M1 combined mass	*3040kg*
M1 cart, M1 cell, LSF, and M1 combined mass	*4440kg*

4.2.3 M2 Handling

Periodically the secondary mirror and its mount must be removed from the telescope for re-coating or maintenance. The removable components are 50 kg maximum weight.

The enclosure provides access to this area, from the level 3 floor when the telescope is pointing at horizon.

4.2.4 Instrument Handling

The enclosure will provide sufficient space for handling the instrument.

4.2.5 Telescope installation

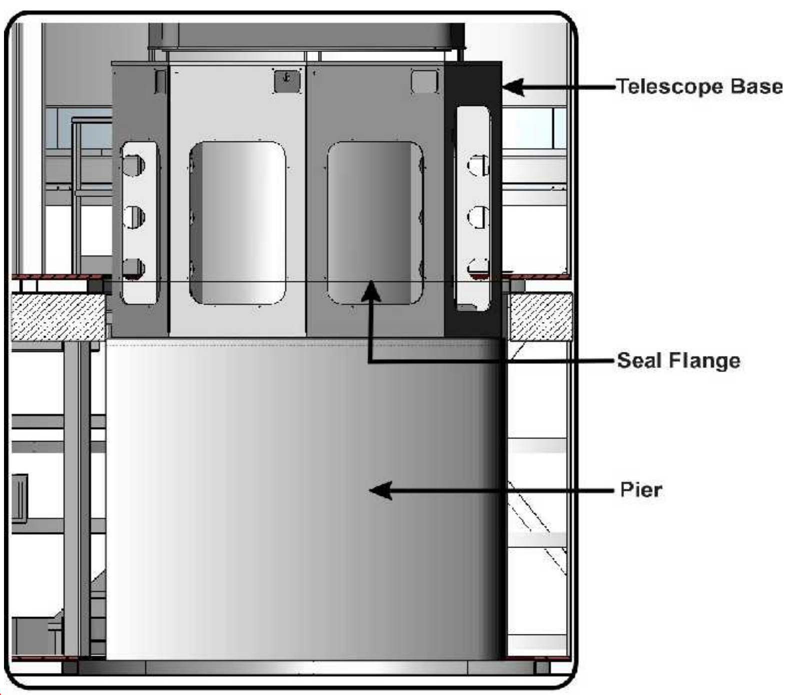
The telescope is installed through the open slit of the enclosure. The base fits on the pier and requires an azimuth seal assembly to the L2 Floor inner ring member. See Figure 7.

The yoke is lowered by crane through the slit. There must be enough clearance inside the enclosure, above the Level 3 floor, to rotate the yoke and lifting bar. The Yoke has to be rotated 90° through azimuth before assembly to the base. This involves avoiding contact with the upper steel work with the lift bar, as well as weaving the suspended assembly between the hangers into its final position orthogonal to the slit. See Figure 8 and Figure 9.

There is no clear space diameter for rotating the yoke and centre section, due to hanger encroachment on the space: the centre section must be rotated and lashed to the lifting bar to enter the slit, and model simulation reveals that yoke orientation inside the enclosure relies on careful back and forth swinging and incremental rotation between the hangers. Allow 30 minutes for this, with careful coordination of dogman and manual handlers.

The truss assembly is also installed through the open slit of the enclosure. It is disassembled and installed in 5 separate pieces in order to provide adequate clearance through the slit.

Maximum clear space width through slit 2800mm



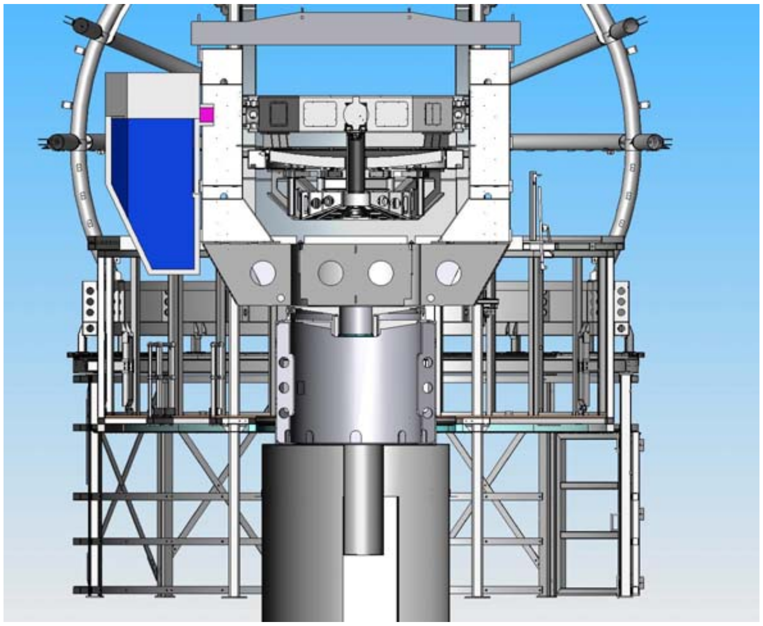


Figure 7 Pier Seal Position on Telescope Base

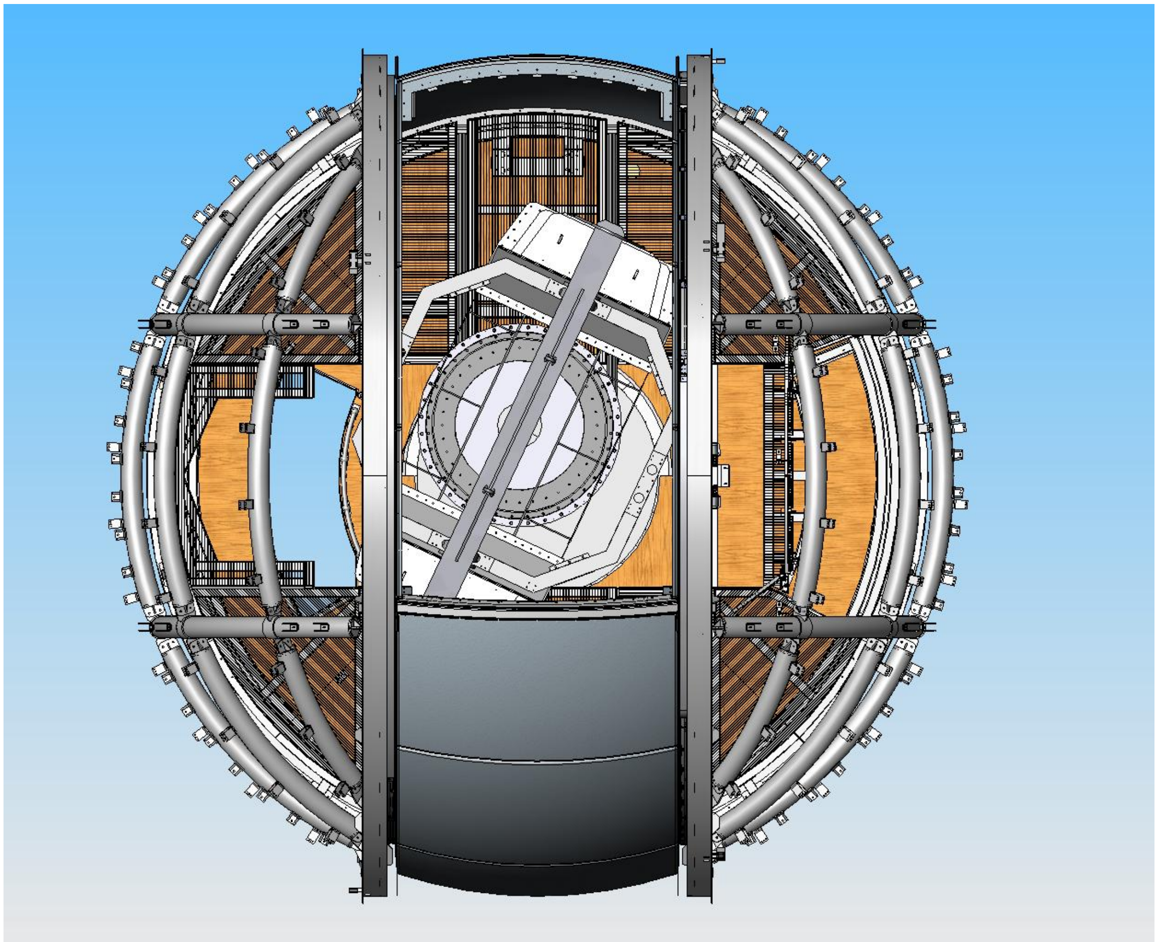


Figure 8 Yoke Installation

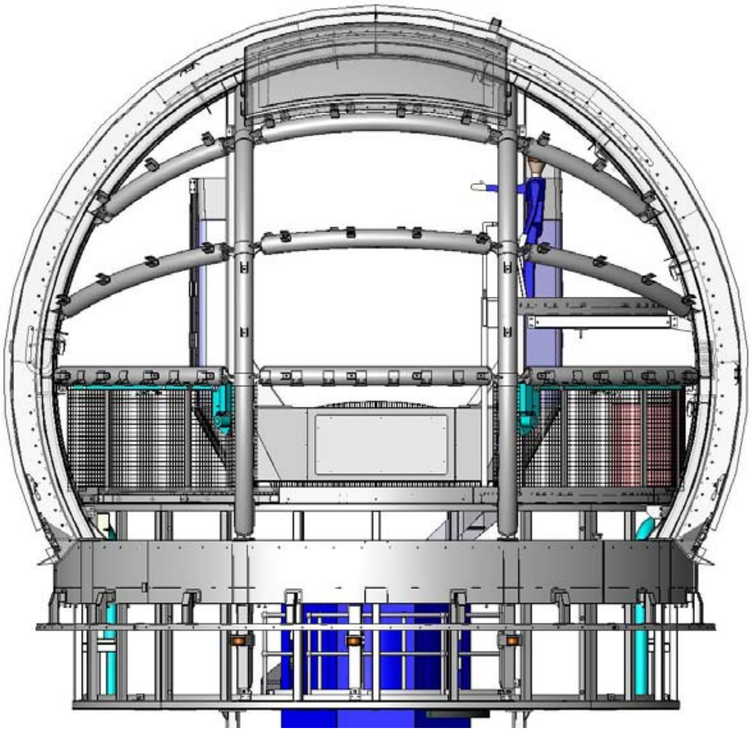


Figure 9   Yoke Installation

5 ENVIRONMENTAL INTERFACE

When the enclosure is closed it shall protect the telescope from dust and inclement weather and shelter it from direct solar radiation. When open the enclosure shall act as a partial wind-screen. The enclosure shall provide an environment for the telescope consistent with the telescope environmental requirements listed below.

5.1 OPERATING ENVIRONMENT

5.1.1 Telescope and Control Cabinet

Temperature (specified image quality)	-6°C to +30°C [21°F to +86°F]
Temperature (operating)	-15°C to +40°C [5°F to +104°F]
Temperature (storage)	-20°C to +50°C [-4°F to +122°F]
Humidity (non-condensing)	5% to 99%
Non-gust wind speed outside dome	< 18 m/s [40 mph]

6 CONTROL SYSTEM INTERFACE

6.1 HEAT DISSIPATION

The telescope control cabinet, enclosure control cabinet, two enclosure azimuth drives and two enclosure shutter drives are the main sources of heat. Most of the heat will be generated in the control cabinets.

Control cabinets are located on level 1 of the enclosure, which is not part of the observing space. Level 1 is thermally isolated from the observing space by an insulated ceiling space, insulated pier collars and flap seals about the ring wall and telescope base.

The enclosure azimuth drives are located in the observing area. The drives are housed in individual insulated enclosures, ducted to the level one floor.

The total (continuous) heat produced by the telescope and telescope control electronics shall be:

Telescope and Telescope Control Cabinet: < 3 kW rms

The total (continuous) heat produced by the enclosure and enclosure control electronics shall be:

Enclosure and enclosure control cabinet: < 1 kW rms

Shutter regenerative brakes: <20 W hr each closure

6.2 POWER

The telescope control system shall be powered via the enclosure UPS, which provides 240V and 120V single phase. To achieve this, UC are providing an upgrade to the enclosure UPS. The UC provided UPS is an APC Symmetra LX 16KVA (model SYA16K16PXR).

6.2.1 Connector

Designation: (none)

Connector Type: L14-30P

Location: Pigtail from bottom back of Telescope Control Cabinet

6.2.2 Pinout:

Pin	Signal Name	Signal Level
1	GND	GND
2	L1	120VAC, 47-62Hz, 30 amp, phase A
3	N	Neutral
4	L2	120VAC, 47-62Hz, 30 amp, phase B

6.3 EARTH GROUND

This is the main system ground. It is the reference point for all of the telescope safety, signal, shielding, and power grounds. The telescope is connected to this ground by an attached 2AWG cable.

6.3.1 Connector

Designation: (none)

Connector Type: 8mm Ground Lug

Location: Back of Telescope Control Cabinet

6.4 NETWORK DATA INTERFACE

6.4.1 Connector

Designation: CJ45

Connector Type: RJ45

Location: Back of Telescope Control Cabinet

6.4.2 Pinout

Standard Cat5 Interface

6.4.3 Signals

Standard Cat5 Ethernet connection

6.5 M1 COVER CONTROL

Operation of the Primary Mirror cover is controlled by the Telescope Control rack. Signals are described in the interlock description below.

6.6 TELESCOPE AZIMUTH POSITION SIGNAL

6.6.1 Connector

Designation: J44

Connector Type: Heidenhain 291-698-07

Location: Back of Telescope Control Cabinet

6.6.2 Pinout:

	Signal Name
1	+A
2	-A
3	+5V
4	+5V Return
5	+B
6	-B
7	+R
8	-R
9	Shield

6.6.3 Signals

6.6.3.1 +A & -A

Buffered differential TTL output signal for phase A from one of the two telescope azimuth quadrature encoders. This encoder has a resolution of 53,200,000 cycles per 360 azimuth degrees.

6.6.3.2 +B & -B

Buffered differential TTL output signal for phase B from one of the two telescope azimuth quadrature encoders. This encoder has a resolution of 53,200,000 cycles per 360 azimuth degrees.

6.6.3.3 +R & -R

Buffered differential TTL output signal for phase C (reference phase) from one of the two telescope azimuth quadrature encoders. This phase supplies a positive pulse for each of the c-coded reference marks around the azimuth axis.

6.7 INTERLOCK SYSTEM

The telescope to enclosure interlock system allows each system to signal the other in cases of limit switch activation, failsafe limit activation and emergency stop situations.

6.7.1 Connector

Designation: CJ11

Control Cabinet Panel Connector Type: AMP CPC P/N 206438-1

Mating Connector Type: AMP CPC P/N 206437-1

Location: Back Panel of Telescope Control Cabinet

6.7.2 Pinout:

Pin	Signal Name	Signal Level
1	CW limit input	See signal description below
2	CCW limit input	See signal description below
3	Azimuth stop	See signal description below
4	Emergency Close	See signal description below
5	Emergency stop	See signal description below
6	Failsafe input	See signal description below
9	Failsafe output	See signal description below
13	Signal ground	Signal Ground
20	CW limit return	See signal description below
21	CCW limit return	See signal description below
22	Az stop return	See signal description below
23	Emergency close return	See signal description below

24	Emergency stop return	See signal description below
25	Failsafe input return	See signal description below
28	+24vdc	+24 volts dc output, <100ma

6.7.3 Signals

6.7.3.1 Input Signals - General

Input signals are active high. A low on this input signals a normal, non-fault condition to the telescope control system. A high signal requires >3.5v and a low signal requires <1.0v. Inputs can be used in two different signal level modes. They can either be driven as digital logic inputs or driven by switch contacts.

To drive them as digital inputs, connect the signal and corresponding return together and use the drive electronics to sink the signal to signal ground. The driver sink load is approximately 6ma.

To utilize this input with switch contacts, connect the signal input to one side of a normally closed switch, and the corresponding return to the other side. The switched signal will be approximately 4.5 mA and 24V.

6.7.3.2 Output Signals - General

Output signals are active low current sinks capable of driving a 24Vdc, 100mA load.

Outputs are open collector, and when paired with a +24Vdc supply pin (28,29,30) as a voltage source, can directly drive 24V, 100mA loads. These signals can also drive TTL level inputs, but require pull-up resistors to +5V at the receiving end.

6.7.3.3 Clockwise (CW) Limit

A high on the CW input signals the telescope control system that the telescope has rotated into the clockwise limit of the enclosure azimuth slot. In the event of a fault condition, the telescope control system halts motion of the telescope in the clockwise azimuth direction.

6.7.3.4 Counter Clockwise (CCW) Limit

A high on the CCW input signals the telescope control system that the telescope has rotated into the counter clockwise limit of the enclosure azimuth slot. In the event of a fault condition, the telescope control system halts motion of the telescope in the counter clockwise azimuth direction.

6.7.3.5 Stop Azimuth

A high on the Stop Azimuth input signals the telescope control system that the enclosure is no longer rotating (disabled or problem). In the event of a fault condition, the telescope control system halts motion of the telescope in the azimuth direction.

6.7.3.6 Emergency Close

A high on the Emergency Close input signals the telescope control system that the enclosure/ observatory level software has issued an emergency close of the enclosure. In the event of an emergency close condition, the telescope control system closes the mirror covers.

6.7.3.7 Emergency Stop

A high on the Emergency Stop input signals the telescope control system that an enclosure E-Stop button has been activated by observatory personnel. In the event of an emergency stop condition, the telescope control system halts all motion of all axes on the telescope.

6.7.3.8 Failsafe Input

A high on the Failsafe Input signals the telescope control system that the enclosure has experienced a fault condition triggered by exceeding the end of travel failsafe limits. In the event of an enclosure failsafe condition, the telescope control system halts azimuth motion of the telescope.

6.7.3.9 Failsafe Output

A low on this output signals to the enclosure that a telescope control system failsafe condition has occurred. Normal telescope operation has ceased, and operator intervention is required.