GEMINI
8-M Telescopes
Project

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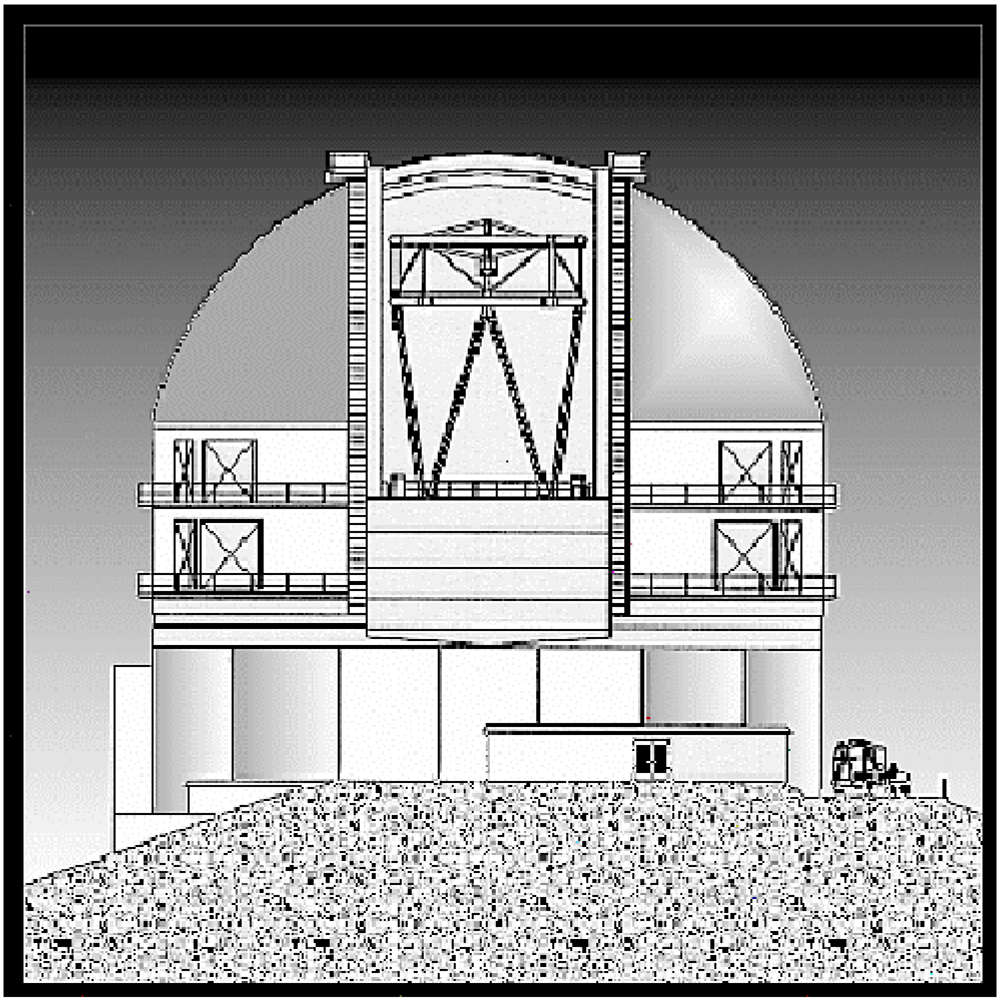
Revision 1

Gemini 8m Telescope Design Requirements Document



Telescope Structure, Building, and Enclosure Group

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1.1.2 General Description and Layout of Telescope

The Gemini telescope is an altitude over azimuth optical/infrared telescope with an 8m primary aperture (figure 1.1.01).

The telescope has two interchangeable top-end rings, an f/6 top-end and an f/16 top-end. The f/6 top-end supports a 2.4m diameter f/6 secondary mirror and can be used in two configurations; either wide field (45 arc minutes) or narrow field (6 arc minutes). The f/16 top-end can support either an f/16 IR secondary module, or an optical f/19.6 secondary module. Major configuration changes, including the exchange of top-end rings are accomplished during the daytime. Both top end assemblies are shown in figure 1.1.02.

Focal stations are provided at Cassegrain and Nasmyth. Both the f/6 and f/16 secondary mirrors feed the Cassegrain focus. By inserting a tertiary and a quaternary mirror the f/19.6 secondary can to be directed to the Nasmyth focii.

All Cassegrain instruments are supported from the instrument de-rotator which is mounted directly to the primary mirror cell. With an altitude over azimuth telescope design the field rotates as the telescope tracks an object. At the Cassegrain focus this field is de-rotated by rotating the Cassegrain instrument de-rotator. At Nasmyth, field de-rotation is achieved by rotating the instrument about a vertical axis.

The telescope mount, as shown in figure 1.1.03, is a combination of a welded steel-plate lower platform, and two columns fabricated from tube.

The altitude and azimuth axes are supported and located by hydrostatic bearings. Six externally pressurized hydrostatic oil bearing pads are attached to the underside of the mount and bear vertically downward against a 9.5m diameter steel azimuth track affixed to the pier structure. Four additional hydrostatic pads attached to the mount are preloaded radially against the inside diameter of the azimuth track and define the telescope's vertical, or azimuth, rotation axis. The telescope main tube structure is supported by two pairs of inclined hydrostatic oil pads which are bolted to the top of the mount columns. These four pads bear against the outside of the two trunnions and define the telescope's horizontal, or altitude, rotation axis. Four additional hydrostatic pads provide the axial location of the telescope tube structure.

The azimuth track is shown in figure 1.1.04. The azimuth friction drive ring and brake rotor are mounted on the azimuth track. In addition, the azimuth track provides a running surface for the friction driven encoders and a face for mounting a steel tape encoder.

The trunnions are welded to an octagonally-shaped center section which is fabricated from steel plate, as shown in figure 1.1.05. The center section, in turn, provides a mounting platform for the primary mirror cell, altitude drive disks, primary mirror covers, counter balance system, and main tube trusses.

Two altitude drive disks are fabricated from mild plate-steel, and are attached on both sides of the center section with bolts and tapered dowel pins. As shown in figure 1.1.06, these disks serve as a running surface for the altitude friction driven encoders as well as for attaching the tape encoders. In addition, the disks provide a surface for mounting both the altitude friction drive rings and the brake rotors.

The main tube trusses are attached to the center section as shown in figure 1.1.07.

At the upper end of the tube, the trusses are permanently attached to an octagonally-shaped truss ring. This ring serves as the attachment point for the two top end rings.

Both the azimuth and altitude axes are driven by self-aligning friction drive systems shown in figure nos. 1.1.04 and 1.1.06, respectively. Four drive motors and rollers are required on each axes. The crowned drive rings and vee-shaped drive rollers are machined from a hardened, high strength steel, and are intended to minimize misalignment effects such as drift and skip.

Braking is provided on both the altitude an azimuth axes with the use of "fail safe" brake calipers, which clamp against mild steel rotors. In addition, both axes can be locked in either the vertical or horizon positions with the use of locking pins.

High resolution azimuth and altitude incremental counts are provided to the Gemini Position Control System (GPCS) from a combination of friction driven encoders, tape encoders, and absolute proximity sensors. Required encoder resolution is 0.015 arcseconds. Absolute course encoders provide approximate positions for calibration and engineering.

The azimuth axis requires a TBD cable twister to transfer, with minimal torque, electrical power, signal cables, pneumatic lines, compressed helium lines, air and hydrostatic oil lines for rotations of $\pm 275^{\circ}$.

An altitude cable wrap transfers, with minimal torque, electrical power, signal cables, pneumatic lines and compressed helium lines for rotations of 0-95º. Figure 1.1.08 shows the location and approximate size of the azimuth cable twister and altitude cable wrap.

TBD altitude proximity sensors shall be mounted on each mount top frame section as shown in figure 1.1.06.

TBD altitude mechanical stops shall be attached as shown in figure 1.1.06

Six hydrostatic bearing pads (four master pads, two slave pads) shall be affixed to the underside of the mount lower frame sections as shown in figure 2.1.05. The expected vertical load per bearings is TBD. Provisions for adjusting the height of each bearing over a range of TBD to within TBD mm true position is TBD. Provisions for maintaining and replacing these azimuth bearings, i.e. jacking points, access, and methodology, is shown in figure 2.1.06.

Four hydrostatic pads shall be affixed to the underside of the mount lower frame sections as shown in figure 2.1.05. These bearings act in the radial direction and define the vertical, or azimuth, rotation axis. The radial preload of each bearing is TBD and is provided by TBD. Access for maintaining, repairing, and replacing these bearings is required. Minimum required stiffness of these mounting pads is TBD x, y, z, xx, yy, zz.

TBD seismic pads and attachment interface requirements are shown in figure 2.1.05.

Four TBD azimuth drive motor assemblies shall be mounted to support flanges attached to the bottom of the mount lower frame sections as shown in figure 1.1.04. Each motor assembly is capable of providing TBD N (TBD lbf) of force tangential to the drive ring. Access provisions for maintenance and replacement of drive motors is required. Minimum required stiffnesses of the mounting interfaces is TBD x, y, z, xx, yy, zz.

TBD azimuth friction driven encoders shall be mounted on the bottom of the mount lower frame sections as shown in figure 1.1.04. Also shown in the figure is TBD tape read heads which shall be mounted on the bottom of the lower frame sections. Access provisions for maintenance, repair, and replacement of encoders is required.

T'BD azimuth brake calipers shall be mounted on the bottom of the mount lower frame sections as shown in figure 1.1.04.

TBD azimuth locking pin mechanisms shall be mounted on the bottom of the mount lower frame sections as shown in figure 1.1.04.

TBD azimuth coarse encoders shall be mounted on the bottom of the mount lower frame sections as shown in figure 1.1.04.

TBD azimuth proximity sensors shall be mounted on the bottom of the mount lower frame sections as shown in figure 1.1.04.

Electrical cables, and hydrostatic cable runs and interfaces to azimuth cable twister and altitude cable Wrap are shown in figure 1.1.08.

Primary mirror rail guides mounting envelope and interface is shown in figure 2.1.07.

Cassegrain floor and railing attachment interfaces are shown in figure 1.1.03. Access platforms and stairs for altitude Drives and encoders, Nasmyth instruments, altitude bearings, primary mirror covers, ??, are also shown.

1.2 Environment and Seismic Requirements

1.2.1 Environment

The telescope shall be designed to operate satisfactorily in the conditions to be expected within the enclosure.

Air pressures will be influenced by the site altitude of approximately 4250m (14000 ft.) and by exposure of the observatory to local weather conditions. This dictates that all designed parts shall be vented so that changes in pressure when transporting from sea level to the observatory site shall not cause damage or failure. Any equipment designed to operate at normal atmospheric air pressures and incorporating air cooling shall be de-rated for the reduced air density.

The telescope shall be designed to operate over the range of - 15ºC to +20ºC.

The telescope shall be designed to operate in wind speeds external to the enclosure from 0 to 25 m/s (60 mph).

The telescope shall be designed to operate in relative air humidity ranging from 0 to 95% RH.

1.2.2 Seismic Forces

The telescope shall withstand, without damage, earthquake loadings corresponding to accelerations of TBD g acting in the horizontal direction, and TBD g in the vertical direction.

1.3 Specification Notes and Requirements

1.3.1 General Notes

1.3.1.1 Detail Design and Shop Drawings

All detail design drawings and shop drawings, including heat treatment schedules, weldment drawings, and fabrication drawings shall be submitted to the Gemini Project Office (PO) for approval prior to manufacture. In addition to shop drawings, a Bill of Materials with supporting specifications and full supporting information describing any commercial equipment or materials to be incorporated which is not detailed on the drawings shall be furnished to the PO for prior approval. Substitution of other materials, equipment, or design not specified on PO drawings will only be permitted where it can be shown that such items are at least equal in quality and properties to the ones specified.

The PO shall have free access to all design calculations, and if considered inadequate, may require that further calculations shall be made to ensure that the requirements of the specifications are met.

AR detail design drawings shall conform to ANSI Y14.5M-1982.

All detail design drawings shall be in System International (metric) units.

AR detail design drawings shall be generated in (or transferable to) Autocad Release 12.

All parts shall be designed to be in compliance with current OSHA and British Safety standards.

After completion and final acceptance of the work, all shop drawings shall be revised and brought up to date to reflect the work "as made". Two complete sets of these drawings, along with relevant computer diskettes, shall be furnished to the PO.

1.3.1.2 Materials and Workmanship

All materials specified shall be new and of high grade commercial quality. They shall be sound and free from defects, both internal and external, such as cracks, laminations, inclusions, blow holes or porosity.

Workmanship shall be of a high grade of commercial practice and adequate to achieve the accuracies and surface finishes called for on all drawings and in the specifications.

All manufacturing processes, such as plating, welding or heat treatment, shall be specified and performed in such a manner as to achieve the strength and properties required without introducing any material defects such as hydrogen embrittlement, excessive grain growth, or residual stress concentrations.

1.3.1.3 Metrology, Inspections, Tests

A series of tests and inspections shall be carried out both during fabrication and factory erection of all of the individual telescope parts, subassemblies, and the telescope assembly. These tests and inspections shall form the basis of acceptance of the telescope parts and subassemblies by the PO. The detailed procedure to be adopted in each test shall be approved by the PO. All test and inspection data shall be recorded as part of the systematic evaluation of the telescope.

These tests shall include, but not be limited to, the following: interface checks; dimensional accuracy of each subassembly and it’s component parts; alignment, concentricity, and other geometric tolerance accuracies; functional and performance operation of each subassembly and system.

1.3.1.4 Packing and Shipping

All materials and equipment for shipment shall be prepared in such a manner as to protect them from damage in transit and storage. Due attention shall be paid to protection of bearing surfaces and other exposed critical surfaces to prevent damage. Special care shall be taken with electrical and electronic components which shall be packed with a dehumidifying agent to eliminate condensation problems.

Proper identification of parts and adequate provision for slinging and handling of equipment without damage shall be made.

All packaging, packing materials, slinging, and handling equipment design shall be approved for use by the PO.

The materials and equipment may be stored in Hilo (or Chile equivalent) for a period of up to 3 months prior to transport to Mauna Kea (Cerro Pachon). The materials and equipment shall not corrode during this storage in the high humidity, salt-laden atmosphere.

1.3.1.5 Surface finish, plating, corrosion protection, coatings and paints.

Surface finishes are to be approved by the PO as suiting the location and function of each member, so as not to adversely affect the functioning of the telescope, and to require minimum maintenance during the life of the telescope. In particular, truss members, top-end components, and all other items that are located above the primary mirror are to be finished in a TBD coating. All parts of the telescope shall be finished so as to promote cleanliness of the telescope and to avoid contamination of any mirror surface. It is of prime importance that all protective coatings be of high quality and long life due to the high cost of recoating and interference with telescope operation. The PO reserves the right to inspect all surface preparation for each individual coating to be applied.

All metallic surfaces, other than mating machined surfaces, shall be painted or otherwise protected against atmospheric corrosion.

1.3.1.6 Thermal Sources

It is essential to avoid heat sources on or near the telescope which could thermally disturb the air in the optical path. AR heat sources located on or near the telescope are to be insulated in an enclosure and capable of being actively cooled. The contractor shall furnish the P.O. with details of power requirements for components during normal and peak operation.

Connections, interfaces to Thermal Control System....

1.3.1.7 Stresses, Deflections, Natural Frequencies

Stresses in all members shall be maintained with safe working values for all possible combinations of fabrication, erection, operation, and survival conditions. Unless specified otherwise by the PO, a nominal Factor of Safety = 4.0 under any combination of operational and environmental loading.

The operational requirements of the telescope demand that the structure be as rigid (stiff) as possible and that any deformations or deflections due to the effects of gravity or other normal causes be free of discontinuities or hysteresis effects. All motions shall be smooth, free of vibration and precisely controlled. Particular care is needed in the detailed design of connections so as to eliminate any possibility of joint movement and to minimize compliance.

The telescope has been designed with a lowest natural frequency of TBD Hertz. All mechanical and electrical components of the telescope are to selected, and approved by the PO, so as to avoid their exciting vibration (resonance) of the telescope.

Connections and detailed design of components shall be sufficient to ensure that the overall predicted stiffness of the component is not degraded by more than 10%. Stiffness requirements are detailed in Appendix TBD.

1.3.1.8 Maintenance

The telescope design shall ensure that all necessary maintenance operations can be effectively carried out without risk to personnel or to the telescope.

The telescope design shall ensure that maintenance requirements are to be minimal. All maintenance procedures shall be approved by the P.O.

1.3.2 Metal Requirements

1.3.2.1 Material Quality and Certification

All structural steel to be used in the construction of the work shall be examined and tested at the mills in accordance with the requirements established by the material specifications. Reports of all mill tests, including analyses and physical tests, shall be retained and made available to the PO at any time during the course of the contract. These reports shall include material certification sheets for all structural steel components.

An effective means of identification of the material from the time it is shipped from the mill to the time it is erected at site shall be maintained.

1.3.2.2 Welding Practice, Weld Inspection

All welding of steel parts shall be carried out by the shielded metal arc process, either manually or by an approved machine. The welding plant shall be of modem design, either AC or DC, and of adequate capacity to provide the required current to each welding point without significant fluctuation and to provide a continuous, full penetration weld, or as specified on the figure(s).

Suitable allowances for contraction and expansion during welding shall be made in the lengths of the steel parts prior to welding, so that the final machined lengths are correct within the accepted tolerances.

All members shall be accurately cut and fitted, securely fixed, and jigged or braced before welding to hold and maintain the parts to the drawing dimensions.

The surfaces to be welded shall be dry, clean and free from loose scale, grease or unsuitable protective paints or coatings.

The welding procedure shall be such that distortion and lock-up stresses are minimized. Tack welds, temporary stiffeners, tie bars, controlled peening, pre-heating, and stress relieving during welding may be used for this purpose if approved by the PO. All weldments shall be stress relieved after welding and prior to final machining, per section 2.1.1.3 Heat Treatment.

All welding operators employed in the work shall have passed a recognized qualification test for the appropriate class of work.

Welding procedures shall be approved by the PO before the work is started. Trial welds to demonstrate the soundness of any proposed welding method and the competence of operators may be requested by the PO prior to welding.

All welding shall be subject to rigorous examination as to size, profile, weld cleanliness and freedom from pin holes and surface cracks.

Where required by the specifications or as determined by the PO, weld penetration and continuity shall be tested by magnetic particle method, or an equivalent approved technique.

Where welded components are to be used for sumps or collection pathways for oil containment, leakage tests shall be required and verified by the PO.

Repairs to welds rejected under any of the above examinations shall be made using a procedure that is acceptable to the PO. Repaired welds shall be re-examined in the same manner as the original weld was examined.

1.3.2.3 Heat treatment

Shop drawings shall include heat treatment specifications for all parts requiring treatment to meet the properties specified on the PO drawings. Temperature-time charts and records of quenching treatments, material tests, etc., shall be kept and identified with the parts and submitted to the PO as required for approval.

All welded parts, unless specified or approved otherwise by the PO, shall be fully stress relieved prior to final machining operations. This includes, but is not limited to, the mount, center section and trunnions, (main tube trusses?), (truss ring?), azimuth track, altitude disks, and drive rings.

1.3.2.4 Bolted connections, dowelling

It is important to ensure the efficiency and satisfactory performance of all bolted and dowelled connections to preclude the possibility of joint movement and/or hysteresis under operational loading.

Except where specified otherwise by the PO, all bolts, nuts, screws, and other fasteners shall conform to the appropriate ANSI and British Standards, and be installed in a method that is specified in the standards.

All seating surfaces for bolts and nuts shall be pre-machined to provide a suitable flat surface perpendicular to the bolt shank.

Close tolerance bolts and their washer faced nuts shall be manufactured to approved dimensions. The diameter of the holes for close tolerance bolts, and all installation and tensioning procedures for them shall be approved by the PO.

1.3.2.5 Machined Edges, Ends, Surfaces

The edges and ends of all plates, tubes, and fabricated sections shall be accurately finished by planing, or milling, or other appropriate method.

All surfaces, unless specified or approved otherwise by the PO, shall have a surface finish of TBD or better.

1.3.3 Non-Metallics Requirements

Composite design
Testing and verification of mechanical properties
CTE
CME
Toughness
Repair
Passive damping treatments
Joint design
Surface treatment and surface finish
Youngs Modulus

This section will be completed after the completion of the composite testing and analysis program.

2 Telescope Design Requirements

2.1 Telescope mount

2.1.1 Applicable Drawings and Documents

Document Number	Description
1.1.03	General layout of mount.
2. 1.01 (not available)	Mount loading diagram.
2.1.02 (1-4)	Mount design, assembly w/ dims, tols.
2.1.03 (not available)	Alt. brng support box design w/ dims, tols.
2.1.04	Mount-alt. brng. replacement interface, method
1.1.06 (1,2)	Mount-altitude mech (drives, encoders, brakes, locking pins, prox. sensors, stops) interface
2.1.05	Mount-azimuth brngs, seismic pads interface
1.1.04	Mount-azimuth mech (drives, encoders, brakes, locking pins, prox. sensors, stops) interface
1.1.08 (not available)	Mount-cable wraps, twister, runs interface
2.1.07 (not available)	Mount-primary mirror guide rails interface
1.1.03	Mount-platforms, railing, stairs, guides, interface

2.1.2 Mount Design Requirements

The functional requirements of the mount are as follows:

- Transfer loads from altitude axial and radial bearings to the azimuth bearings.
- Allow ±275º rotation about the azimuth axis.
- Provide mounting interfaces for Nasmyth instruments, azimuth and altitude drive motor units, azimuth and altitude encoders, azimuth and altitude brakes and locking pin assemblies, altitude mechanical stops, azimuth cable twister, altitude cable wrap, azimuth radial and axial bearing pad assemblies, and access platforms and stairs.
- Provide for primary mirror troller rails.
- Provide for transfer of Cassegrain instruments from enclosure floor to Cassegrain area of telescope.

The general arrangement of the telescope mount and overall envelope dimensions is shown in figure 1.1.03.

The estimated loading that the mount will experience in operation has static and dynamic components. The static forces are primarily gravity-induced loads from the altitude bearings and the Nasmyth instruments. The dynamic loads are induced by wind loading on the structure, drive torques, seismic loading, and load variations when the telescope rotates about the altitude axis. An estimate of these loads is shown in figure 2.1.01. Four drive motor assemblies are attached to mount as shown. Each Motor is capable of providing TBD N. (TBD lbf) of force in a direction tangential to the altitude drive disk. This mount shall be capable of resisting this force with a stiffness of TBD N/m (TBD lbf/in). The design of this attachment is to be verified with the PO prior to manufacture.

The estimated mass of the mount structure = TBD kg (TBD lbm).

As shown in figure no. 2.1.02 (1-4) and 2.1.03, the mount shall consist of seven basic components: two lower frame sections, two top frame sections, the mount center section and two altitude bearing support boxes. As specified in the drawings, au seven items are to be fabricated from standard mild-carbon steel stock, and fully stress relieved after welding and prior to final machining. Sheet 4 of 2.1.02 specifies the manner in which the top frames, lower frames, and center section are to be aligned and assembled.

The two altitude bearing support boxes shall be attached to the top frame sections as shown in figure 2.1.03. Also shown in this figure are the mounting locations and orientations of the radial and axial bearings, in addition to the oil supply, containment, and recovery system. Provisions for maintaining and replacing the altitude bearings, i.e. jacking points, and methodology, is shown in 2.1.04.

After welding, and prior to final machining, the mount shall be fully stress relieved.

With the exception of mating hardware attachment locations, the mount shall be painted with TBD coating.

The mount shall provide mounting interfaces for two TBD altitude drive motor assemblies on each of the top frame sections, as shown in figure 1.1.06. The minimum stiffness of each motor mounting pad shall be TBD x,y,z,xx,yy,zz.

The mount shall provide mounting interfaces for TBD altitude manual drive mount attached to the top frame sections as shown in figure 1.1.06.

TBD altitude friction driven encoders shall be mounted on each mount top frame section as shown in figure 1.1.06. Also shown in the figure is TBD altitude tape read heads which are attached to the top frame section of the mount.

TBD altitude brake calipers shall be mounted on one mount top frame section as shown in figure 1.1.06.

TBD altitude locking pin mechanisms shall be mounted on one top frame section as shown in figure 1.1.06.

TBD altitude coarse encoders shall be mounted on one top frame section as shown in figure 1.1.06.

2.2 Telescope Altitude Trunnions and Center Section

2.2.1 Applicable Drawings and Documents

Document Number	Description
1.1.05	General layout of center section and altitude trunnions w/ envelope dims.
2.2.01 (not available)	Center section, trunnions loading diagram.
2.2.02 (not available)	Center section, alt. trunnions design, assembly w/ dims, tols.
2.2.03 (not available)	Center section-primary mirror cell interface.
2.2.04	Center section-mirror cover interface.
1.1.06	Center section-alt. disk interface.
2.2.05 (not available)	Center section railing and gates.
2.2.06 (not available)	Center section-counter balance sys. interface.
1.1.07	Center section-main tube trusses interface.
2.2.07 (not available)	Center section-alt. cable wrap, cables interface.

2.2.2 Trunnion, Centre-Section Design Requirements

The functional requirements of the telescope trunnions are as follows:

- Transfer loads from the center sections to the altitude radial bearings.
- Allow 0-90º rotation of the tube about the altitude axis.
- Provide smooth surface for altitude radial bearings to bear against.
- Provide mounting interface for altitude axial bearing flange
- Provide interface for altitude bearing replacement jacking system.
- Provide mounting interface for two altitude disks.
- Provide mounting interface for altitude cable wrap.
- Provide unobstructed path for Nasmyth instrument light path.

The functional requirements of the telescope's center section are as follows:

- Stiffly transfer loads from primary mirror cell and main trusses to the trunnions.
- Provide mounting interface for primary mirror cell.
- Provide mounting interface to main trusses.
- Provide mounting interface for primary mirror covers.
- Provide mounting interface for counter balance system.
- Provide mounting interface for primary mirror railing and gate.
- Support cable trays for telescope services.

The general arrangement and overall envelope space dimensions of the telescope center section/altitude trunnions assembly is shown in figure 1.1.05.

The estimated loading that the center section and trunnions will experience in operation has both static and dynamic components. The static forces are primarily gravity-induced loads from the main tube and truss ring structure, the primary mirror and cell, the top-ends, altitude disks, and the Cassegrain and Nasmyth Instruments. The Dynamic Loads are induced by wind loading on the structure, drive torques, seismic loading, and load variations when the telescope rotates about the altitude axis. An estimate of these loads is shown in figure 2.2.01.

The estimated mass of the center section/trunnion assembly = TBD kg (TBD lbm).

As shown in figure 2.2.02, the center section/trunnion assembly shall be fabricated from six primary items: two main center section box sections, two interface box sections, and two trunnion stub shafts. This figure gives the critical dimensions of these six items, and outlines the assembly/alignment method for fabrication including coaxiallity requirements for the two trunnions.

All center section/altitude trunnion joints shall use high strength (grade #8 or higher) bolts and approved dowels to minimize joint movement and hysteresis.

After welding, and prior to final machining, the center section and trunnions shall be fully stress relieved.

With the exception of bearing surfaces, and mating hardware attachment points, all center section and trunnion surfaces shall be painted with TBD coating.

The primary mirror cell shall be attached to the center section as shown in figure 2.2.03.

The primary mirror covers shall be attached to the center section as shown in figure 2.2.04.

The two altitude drive disks shall be bolted and dowelled to the center section as shown in figure 1.1.06.

The primary mirror Access Railing and Gate shall be bolted to the center section as shown in figure 2.2.05.

The TBD counter balance assemblies shall be mounted inside the main center section box sections as shown in figure 2.2.06. Access to the counter balance assemblies is through the TBD Access panels shown.

The telescope main tube trusses shall be attached to the center section as shown in figure 1.1.07.

2.3 Telescope Azimuth Track

2.3.1 Applicable Drawings and Documents

Document Number	Description
1.1.04	General layout of azimuth track w/ envelope dims and mounting interfaces.
2.3.01 (not available)	Azimuth track loading diagram.

2.3.02	Az. track design, assembly w/ dims, tols.
2.3.03	Az. track-pier interface w/ template jig layout.
2.3.04 (not available)	Az. track lifting fixture figure.

2.3.2 Azimuth Track Design Requirements

The functional requirements of the telescope's azimuth track are as follows:

- Stiffly transfer loads from the azimuth axial and radial bearings to the pier.
- Provide a smooth running surface/track for the azimuth axial and radial bearings; allow ±275º rotation of the telescope about azimuth.
- Provide mounting interface for large diameter azimuth drive ring segments.
- Provide mounting interface for large diameter azimuth brake rotor.
- Provide mounting interface for azimuth gear encoder rack and absolute proximity switches.
- Provide mounting interface for tape encoder including air lubrication system.
- Provide running surface for azimuth friction driven encoders.
- Transportable.
- Minimize mount deflections and tilt errors that influence pointing as the telescope rotates about azimuth.
- 9m diameter track is required for dynamic stiffness of mount.
- Allow for post-installation leveling.

The general arrangement and overall envelope space dimensions of the telescope azimuth track is shown in figure 1.1.04.

The loading that the track is required to sustain is shown in drawing 2.3.0 1.

Cable runs from the altitude cable wrap to the primary mirror cell and the main trusses are shown in figure 2.2.07.

2.4 Telescope Altitude Disks

2.4.1 Applicable Drawings and Documents

Document Number	Description
1.1.06 (1,2)	General layout of altitude disks w/ mech. interfaces.
2.4.01 (not available)	Altitude disk loading diagram.
2.4.02	Altitude disk design w/ dims, tols.
2.4.03 (not available)	Altitude disk cable routing, etc.

2.4.2 Altitude Disks Design Requirements

The functional requirements of the telescope's altitude disks are as follows:

- Stiffly transfer altitude drive torques to the altitude trunnions.

- Provide mounting interface for the large radii altitude friction drive ring segments.
- Provide mounting interface for large radii altitude brake rotor (one disk only).
- Provide mounting interface for coarse encoder gear rack and absolute proximity switches.
- Provide mounting interface for altitude tape encoders including air lubrication system.
- Provide running surface for altitude friction driven encoders.
- Minimize obstructing air flow over the primary mirror.
- Allow for installation of disks after center section/trunnions are installed onto mount. Installation procedure must ensure repeatability of runouts, concentricity requirements.
- Low, repeatable runouts.

The general arrangement and overall envelope space dimensions of one of the two telescope altitude disks are shown in figure 1.1.06.

The maximum tangential force from the friction drive system is TBD N (TBD lbf.) applied at the outer radius as shown in figure 2.4.01. The maximum tangential braking force is estimated to be TBD N (TBD lbf.).

Estimated mass of each altitude disk, less mass of brake rotor and drive ring, is TBD kg. (TBD lbm.).

The track shall be fabricated as a welded structure from mild steel plate, as shown in figure 2.3.02. Critical machined faces include axial and radial hydrostatic running surfaces, as well as the location for a tape-type encoder, and a running surface for a friction driven encoder(s).

TBD azimuth drive ring shall be attached to the outside diameter of the azimuth track as shown in figure 1.1.04

TBD azimuth tape encoder shall be attached to the outside diameter of the azimuth track as shown in figure 1.1.04.

TBD azimuth coarse encoder gear rack shall be attached to the outside diameter of the azimuth track as shown in figure 1.1.04.

TBD azimuth brake rotor shall be attached to the inside diameter of the azimuth track as shown in figure 1.1.04.

TBD azimuth bearing oil sumps and shields shall be attached to the azimuth track as shown in figure 1.1.04. The design of the shield mounting interfaces shall preclude the possibility of oil leakage and shall allow simple replacement if damaged.

After welding, and prior to final machining, the track shall be fully stress relieved.

With the exception of bearing surfaces, tape and friction driven encoder surfaces, and all mating hardware attachment points, all track surfaces shall be painted with TBD coating.

As shown in figure 2.3.03, the track shall be affixed to the pier structure by two rows of TBD threaded rods. The location of these rods is set during the pier construction through the used of a steel template jig, which is then used to locate the corresponding through-holes on the underside of the track.

Transportation of the azimuth track shall be facilitated by using a transportation/lifting fixture as shown in figure 2.3.04. This fixture allows the track to move without damaging or distorting any of the critical surfaces. A lifting point is incorporated in the center of the fixture, and removable lifting 'tangs' allow the track to be lowered onto the pier threaded rods and then removed.

2.5 Telescope Access Platforms, Railings, Flooring

2.5.1 Applicable Drawings and Documents

Document Number	Description
2.5.01	General layout of access platforms, stairs, etc., w/ env. dims.
2.5.02	General layout of access platforms, stairs, etc., w/ env. dims.
2.5.03 (not available)	Live load diagram.
2.2.05 (not available)	Access railing, gating-center section interface.

2.5.2 Access Platforms, Railing, Flooring Design Requirements

The functional requirements of the telescope's access platforms and railings shall be as follows:

- Provide complete access for installation, maintenance and repair of all mechanical components of the telescope including azimuth and altitude drives, encoders, and bearings; Cassegrain and Nasmyth instruments; primary, tertiary, and quaternary mirrors and covers; ?
- Non-slip/skid surfaces.
- Loading on all platforms, stairs, and flooring shall be a combination of Dead Load plus TBD N/m^2 (TBD psf) Live Load as shown in drawing 2.5.03.

The general arrangement and overall envelope space dimensions of the telescope's access platforms, railings and flooring are shown in figures 2.5.01 and 2.5.02.

Estimated mass of the various platforms, stairs, etc. is TBD kg. (TBD lbm).

Figure 2.5.01 shows the critical dimensions and locations of all required access platforms, stairs, flooring, and railings. AR stairs, platforms, and flooring is to be constructed of TBD (diamond plate?). Railings and gating are to be constructed of TBD (2" steel Tubing?).

The primary mirror cover railing, gate and interlock shall be as shown in figure 2.2.05. The interlock used shall be a Castel key arrangement. This system shall operate as follows: to open gate, the key is turned and removed; gate cannot be closed until key in re-inserted and turned; key is captive to lock. This system is interlocked such that the telescope drives cannot be powered on, and the mirror covers cannot be opened, if the key is removed.

All items shall be finished with TBD (non-slip?) coatings.

All items shall conform with latest OSHA, UBC, and BS safety standards.

The altitude disks shall be fabricated from mild plate steel as shown in figure 2.4.02. Critical dimensions, tolerances, and attachment bolt patterns are shown in this figure. Also shown in the figure are TBD through holes and TBD tapered dowel pin holes for mounting to the telescope center section. These dowel holes are to be match drilled with the center section to ensure repeatable TBD runouts of the altitude friction driven encoder and tape encoder surfaces.

After welding, and prior to final machining, the altitude disks shall be fully stress relieved.

With the exception of mating hardware attachment points and friction driven and tape encoder surfaces, all disk surfaces shall be painted with TBD coating.

The altitude drive rings are attached to the disks with TBD bolt pattern and TBD dowel pins as shown in figure 1.1.06. To ensure concentricity with the altitude disk, the final machining/grinding of the ring shall be performed while bolted and dowelled to the disk.

The altitude brake rotors shall be bolted to the disks as shown in figure 1.1.06.

The TBD altitude tape encoders shall be attached to the disks as shown in 1.1.06. TBD electrical leads are required by the tape encoders, and are to be routed as shown in figure 2.4.03 with location/tie hardpoints at TBD intervals.

The coarse altitude encoder/manual drive gear rack shall be attached to the disks as shown in figure 1.1.06.

TBD absolute proximity sensors shall be attached as shown in figure 1.1.06. TBD electrical leads from these sensors are routed as shown in figure 2.4.03.

The mechanical over-travel stops shall be attached to the altitude disks as shown in figure 1.1.06. The maximum force that stops shall experience in a run-away condition is expected to be approximately TBD N (TBD lbf).

2.6 Telescope tube main trusses

2.6.1 Applicable Drawings and Documents

Document Number	Description
1.1.07	General layout of tube main trusses w/envelope dims.
2.6.01 (not available)	Truss loading diagram.
2.6.02	Tube main trusses design, assembly w/ critical dms, tols.
2.6.03 (not available)	Truss cable runs, breaks, etc.

2.6.2 Main trusses Design Requirements

The functional requirements of the telescope's main trusses are as follows:

- Stiffly transfer loads from truss ring to the center section with minimal hysteresis.
- Provide mounting interface to center section.
- Provide mounting interface to truss ring assembly.
- Provide mounting surface for cable trays from center section to truss ring.

The general arrangement and overall envelope space dimensions of the telescope tube main trusses is shown in figure 1.1.07.

Static loads that the trusses experience is a function of altitude angle and are shown in figure 2.6.01. Dynamic loading is due primarily to wind forces exerted on the top ends, and seismic loading (shown in the figure).

Estimated mass of the main trusses is TBD kg. (TBD lbm.).

As shown in figure 2.6.02, the main trusses shall be fabricated from TBD, and are attached to the center section as shown. AR critical dimensions and mechanical joint details are shown in the figure. AU joints are designed to minimize movement, creep, and hysteresis effects as the telescope rotates about the altitude axis.

After welding, and prior to final machining, main trusses shall be fully stress relieved. (only if steel, need more info from feasibility study regarding this section ....)

With the exception of all mating hardware attachment points, truss surfaces shall be finished with TBD coating.

Cable runs and breaks are shown in figure 2.6.03.

2.7 Telescope Truss Ring

2.7.1 Applicable Drawings and Documents

Document Number	Description
1.1.07	General layout of truss ring w/ envelope dims.
2.7.01 (not available)	Truss ring loading diagram.
2.7.02 (not available)	Truss ring design, assembly w/ critical dims, tolerances.
1.1.02	Truss ring-top end interface.
2.7.03 (not available)	Truss ring cable runs, breaks, etc.

2.7.2 Truss Ring Design Requirements

The functional requirements of the telescope's truss ring assembly is as follows:

- Provide a stiff mounting location for the interchangeable top ends.
- Transfer loads from top ends to the main trusses.
- Provide mounting interfaces for top-end latching mechanisms.
- Provide mounting interfaces for cable detachment fittings.

The general arrangement and overall envelope space dimensions of the telescope truss ring is shown in figure 1.1.07.

The static loads that the truss ring will experience is a function of altitude angle. Dynamic loading is due primarily to wind forces exerted on the top ends and seismic loading. Expected loading shall be as shown in figure 2.7.01.

Estimated mass of the truss ring is TBD kg. (TBD lbm.).

As shown in figure 2.7.02, the truss ring shall be fabricated from TBD. AU critical dimensions, tolerances, and hardware attachment interfaces are shown in the figure. Location and locking arrangements for the removable top-ends are shown in figure 1.1.02.

After welding, and prior to final machining, the truss ring is to be fully stress relieved (if steel?? Need more info from composite study for this section ....).

With the exception of all mounting interfaces, the truss ring shall be finished in TBD coating. Cable runs, supports, and break points are shown in figure 2.7.03.

2.8 Top-end Rings

2.8.1 f/16, f/19.6 Top-end Ring

2.8.1.1 Applicable Drawings and Documents

Document Number	Description
1.1.02	General arrangement of telescope f/16-f/19.6 top end ring w/ envelope dims.
2.8.01 (not available)	f/16 top end loading diagram.
2.8.02	Top end design, assembly w/ crit. dims, tols.
1.1.02	Top end-truss ring interface.
2.8.03 (not available)	f/16 top end cable runs, breaks, etc.
2.8.04	f/16 top end frame structure.
2.8.05	Top end vane design and interface.
2.8.06 (not available)	f/16 top end support frame w/ secondary interface.

2.8.1.2 2.8.1.2 V16-VI9.6 Top end Design Requirements

The functional requirements of the f/16-f/19.6 top end are as follows:

- Provide stiff mounting point for secondary mirror modules.
- Transfer loads from secondary mirror assemblies to truss ring.
- Minimize emissivity.
- Light weight.
- Minimize wind loading inputs to tube.
- Transfer cables from top end to secondary mirror assemblies.

The general arrangement and overall envelope space dimensions of the telescope f/16, f/19.6 top end ring is shown in figure 1.1.02.

The static loads that the top end will experience is a function of altitude angle and are shown in figure TBD. Dynamic loading is due primarily to wind forces exerted on the top end, secondary chopping, and seismic loading. These loads are also shown in the figure 2.8.01.

Estimated mass of the top end assembly is TBD kg. (TBD lb.).

As shown in figure 2.8.02, the top end is assembled from three main components: frame structure, vanes, and module support frame. All critical dimensions, tolerances, and hardware attachment interfaces are shown in the figure.

Location and locking arrangements for the attachment to the truss ring are shown in figure 1.1.02.

With the exception of all mounting interfaces, the top end is to be finished in TBD coating. All cable routing shall be as shown in figure 2.8.03.

2.8.1.2.1 f/16-f/19.6 Top End Frame Structure

As shown in figure 2.8.04, the frame structure is made up of an adaptor ring, posts and bracing, and the vane ring. Each of these items shall be fabricated from TBD.

Factor of safety used in the design of the frame structure components shall be 4.0 based on maximum loading conditions.

Stiffness=TBD.
Damping=TBD.

2.8.1.2.2 f/16-f/19.6 Top End Support Vanes

Vanes shall be fabricated from TBD as shown in figure 2.8.05. Cross-section thickness shall be 10mm. Attachment of vanes to module support frame and to vane ring shall be as shown in the figure. Note that vane attachments to module support frame is offset from the center; this configuration provides additional rotation stiffness of secondary mirror assembly.

Factor of safety used in design shall be 4.0 based on maximum loading conditions.

Vanes shall be pre-tensioned to TBD N (TBD lbf) preload.

Damping requirements??

Stiffness Requirements??

Tensioning mechanisms....

Load sensors....

2.8.1.2.3 f/16-f/I9.6 Top End Module Support Frame

Module support frame shall be fabricated from TBD as shown in figure 2.8.06. Modules shall be fabricated from TBD material. Attachment interfaces to the support vanes are as shown in the figure.

Minimum factor of safety to be used in the design of the module shall be TBD.

Damping....

Stiffness ...

2.8.2 f/6 Top-End Ring

2.8.2.1 Applicable Drawings and Documents

Document Number	Description
1.1.02	General arrangement of telescope f6 top end ring w/ envelope dims.
2.8.07 (not available)	f/6 top end loading diagram.
2.8.08	Top end design, assembly w/ crit. dims, tols.
1.1.02	Top end-truss ring interface.
2.8.09 (not available)	f/6 top end cable runs, breaks, etc.
2.8.10	f/6 top end frame structure.
2.8.05	Top end vane design and interface.
2.8.11 (not available)	f/6 top end support frame w/ secondary interface

2.8.2.2 f/6 Top end Design Requirements

The functional requirements of the f/6 top end are as follows:

- Provide stiff mounting point for secondary mirror module.

- Transfer loads from secondary mirror assembly to truss ring.
- Minimize emissivity.
- Light weight.
- Minimize wind loading inputs to tube.
- Transfer cables from top end ring to secondary mirror module.

The general arrangement and overall envelope space dimensions of the telescope f/6 top end ring is shown in figure 1.1.02.

The static loads that the top end will experience is a function of altitude angle and are shown in figure 2.8.07. Dynamic loading is due primarily to wind forces exerted on the top end, secondary chopping, and seismic loading. These loads are also shown in the figure.

Estimated mass of the top end assembly is TBD kg. (TBD lbm.).

As shown in figure 2.8.08, the top end is assembled from three main components: frame structure, vanes, and module support frame. All critical dimensions, tolerances, and hardware attachment interfaces are shown in the figure.

Location and locking arrangements for the attachment to the truss ring are shown in figure 1.1.02.

With the exception of all mounting interfaces, the top end is to be finished in TBD coating.

Interface to the secondary mirrors assemblies shall be as shown in figure 2.8.06.

All cable routing shall be as shown in figure 2.8.09.

2.8.2.2.1 f/6 Top End Frame Structure

As shown in figure 2.8.10, the frame structure is made up of an adaptor ring, posts and bracing, and the vane ring. Each of these items shall be fabricated from TBD.

Factor of safety used in the design of the frame structure components shall be 4.0 based on maximum loading conditions.

Stiffness=TBD.
Damping=TBD.

2.8.2.2.2 f/6 Top End Support Vanes

Vanes shall be fabricated from TBD as shown in figure 2.8.05. Cross-section thickness shall be 10mm. Attachment of vanes to module support frame and to vane ring shall be as shown in the figure. Note that vane attachments to module support frame is offset from the center; this configuration provides additional rotation stiffness of secondary mirror assembly.

Factor of safety used in design shall be 4.0 based on maximum loading conditions.

Vanes shall be pre-tensioned to TBD N (TBD lbf) preload.

Damping requirements??

Stiffness Requirements??

Tensioning devices....

Load sensors....

2.8.2.2.3 f/6 Top End Module Support Frame

Module support frame shall be fabricated from TBD as shown in figure 2.8.1 1. Modules shall be fabricated from TBD material. Attachment interfaces to the support vanes are as shown in the figure.

Minimum factor of safety to be used in the design of the module shall be TBD.

Damping....

Stiffness...

Interface to the secondary mirrors assemblies shall be as shown in figure 2.8.1 1.

2.9 Telescope Bearings

2.9.1 Applicable Drawings and Documents

Document Number	Description
1.1.04	General layout of azimuth hydrostatic bearings w/ envelope dims.
2.9.01	Azimuth bearing locations.
2.9.02 (not available)	Azimuth bearing loading diagram.
2.1.06 (not available)	Azimuth bearing jacking system
2.9.03 (not available)	Azimuth bearing shim, machining dwg.
2.1.04	General layout of altitude hydrostatic bearings w/envelope dims and replacement method.
2.9.04 (not available)	Altitude bearing loading diagram.
2.9.05 (not available)	Altitude bearing shim, machining dwg.
2.9.06 (not available)	Altitude bearing covers, shields...
2.9.07 (not available)	Flow schematic and location of pumping plant
2.9.08 (not available)	Azimuth supply, recovery interface
2.9.09 (not available)	Altitude supply, recovery interface

2.9.10 (not available) Bearing supply, recovery line-cable twister interface figure.

2.9.2 Azimuth Bearing Design Requirements

The functional requirements of the azimuth bearing system is as follows:

- Transfer axial and radial azimuth loads from the telescope mount to the track
- Allow smooth, low friction rotation of the mount about the azimuth axis.
- Provide TBD axial and TBD radial minimum stiffness (static).
- Minimize thermal input into the enclosure.
- Minimize maintenance and simplify replacement and repair. High reliability.

The general arrangement and overall envelope space dimensions of the azimuth bearing system is shown in figure 1.1.04.

As shown in figure AZBRNG01, the mount shall be supported above the azimuth track by six externally pressurized oil pad bearings which are fixed to the bottom of the two mount lower frame sections. Option: Four of these bearings are to be master units defining the vertical location of the telescope, while two are to be slave units which carry equal shares of the loading, but do not position the telescope. The transverse, or radial, position of the telescope is maintained by four oil pads which bear radially outward on the inside diameter of the azimuth track.

The axial bearings shall be designed to carry the normal operational loads of the telescope, and be able to sustain, without damage, seismic loads of TBD horizontal and TBD vertical in either direction. The nominal vertical loading that each axial bearing will experience = TBD N (TBD lbf.). Loading shall be as shown in figure 2.9.02.

The radial bearings shall be designed to radially position the telescope with respect to the azimuth track, and be able to sustain, without damage, seismic loads of TBD horizontal and TBD vertical in either direction. The nominal radial preload that each radial bearing will experience = TBD N (TBD lbf.).

A jacking system, as shown in figure 2.1.06, shall allow installation, maintenance, and replacement of the axial bearings. The figure shows TBD jacks bearing against the underside of the telescope mount. The jacks shall be used with supporting stands as shown, to inhibit movement of the mount when it is supported on the jacks.

Required static stiffness of axial bearings = TBD N/m (TBD lbf/in). Required dynamic stiffness of axial bearings = TBD N/m.

Required static stiffness of radial bearings = TBD N/m (TBD lbf/in). Required dynamic stiffness of the radial bearings = TBD N/m.

Both the axial and radial bearings shall be designed to prevent oil contamination of the mount and adjacent areas. Each bearing shall have efficient oil seals and wipers around the edges of the pads. Care must be taken to minimize any rubbing friction induced by these wipers.

All pads are to be multiple recess pads capable of self-alignment to accommodate deflections in the azimuth track.

All pads are to be rectangular in shape, and are design to have a nominal working oil film thickness of TBD mm (TBD inches). Oil is to enter the pads at a temperature of TBD. Oil temperatures will be controlled so that the oil exiting the bearing is maintained at a temperature of O-.5ºC below the ambient air temperature when the air temperature is changing at a rate of 0.3ºC/hr or more (nominally -10 to + 15ºC).

Axial bearing pads are TBD by TBD mm (TBD by TBD inches) with an expected flow rate of TBD litres/min (TBD gpm). Mean recess pressure = TBD N/m^2 (TBD psi).

Radial bearing pads are TBD by TBD mm (TBD by TBD inches) with and expected flow rate of TBD litres/min (TBD gpm). Mean recess pressure = TBD N/m^2 (TBD psi).

Pads are to be constructed of TBD. top faces are to be finished to TBD surface finish and TBD flatness. Faces are to be Bronze? or Phosphated? ?? to minimize damage if contact is made (localize damage to bearing pad and not the track??).

Each pad is to fitted with pressure monitoring devices activating safety devices should the oil pressure fall below TBD N/m^2 (TBD psi). This low pressure warning system shall be interlocked to the telescope drive system. Accumulators shall be required to provide sufficient supply to maintain the oil gap while allowing the telescope to come to a complete rotational stop.

During installation of the telescope, the bearings are to be adjusted in position by the use of shims. The axial bearings rest on a spacing plate which can be machined to the appropriate thickness such that all bearings are within TBD mm (TBD inches) of a common plane, as shown in figure 2.9.03.

2.9.3 Altitude Bearing Design Requirements

The functional requirements of the altitude bearing system is as follows:

- Transfer axial and radial azimuth loads from the telescope tube to the mount.
- Allow smooth, low friction rotation of the tube about the altitude axis.
- Provide TBD axial and TBD radial minimum stiffness (static).
- Minimize thermal input into the enclosure.
- Minimize maintenance and simplify replacement and/or repair.
- High reliability.

The general arrangement and overall envelope space dimensions of the altitude bearing system is shown in figure 2.1.04.

As shown in figure 2.1.04, the tube is supported above the mount by four inclined, externally pressurized oil pad bearings which are fixed to the bottom of the two altitude bearing support boxes. All four of these bearings are to be master units defining the vertical location of the telescope. The axial position of the tube is maintained by four oil pads which axially 'pinch' the two altitude axial flanges as shown.

The radial bearings are designed to carry the normal operational loads of the tube, and be able to sustain, without damage, seismic loads of TBD horizontal and TBD vertical in either direction. The nominal normal-direction loading that each radial bearing will experience = TBD N (TBD lbf.). Bearing loading is shown in figure 2.9.04.

The axial bearings are designed to axially position the telescope with respect to the mount, and be able to sustain, without damage, seismic loads of TBD horizontal and TBD vertical in either direction. The nominal radial preload that each axial bearing will experience = TBD N (TBD lbf.). Bearing loading is shown in figure 2.9.04.

A jacking system, as shown in figure 2.1.04, is designed to allow installation, maintenance, and replacement of the radial bearings. The figure shows TBD jacks bearing against the outer edge of the altitude trunnions. The jacks are to be used with supporting stands and stays as shown, to inhibit movement of the tube when it is supported on the jacks.

Required static stiffness of radial bearings = TBD N/m (TBD lbf/in). (dynamic stiffness??)

Required static stiffness of axial bearings = TBD N/m (TBD lbf/in). (dynamic stiffness??)

Both the radial and axial bearings are designed to prevent oil contamination of the tube and adjacent areas. Each bearing is to have efficient oil seals and wipers around the edges of the pads. Care shall be taken to minimize any rubbing friction induced by these wipers.

All pads are to be multiple recess pads capable of self-alignment to accommodate deflections in the center section and trunnions.

All pads are to be rectangular in shape, and are designed to have a nominal working oil film thickness of TBD mm (TBD inches). Oil is to enter the pads at a temperature of TBD.

Radial bearing pads are TBD by TBD mm (TBD by TBD inches) with an expected flow rate of TBD litres/min (TBD gpm). Mean recess pressure = TBD N/m^2 (TBD psi).

Axial bearing pads are TBD by TBD mm (TBD by TBD inches) with an expected flow rate of TBD litres/min (TBD gpm). Mean recess pressure = TBD N/m^2 (TBD psi).

Pads are to be constructed of TBD. Top faces are to be finished to the same accuracy as the mating surface on the azimuth track. Faces are to be Bronze? or Phosphated? ?? to minimize damage if contact is made (localize damage to bearing pad and not the trunnions??).

Each pad is fitted with pressure monitoring devices activating safety devices should the oil gap fall below TBD N/m^2 (TBD psi). Accumulators similar to the azimuth bearings shall be used to prevent damage from occurring if oil pressure drops below TBD.

During installation of the telescope, the bearings are to be adjusted in position by the use of shims. The radial bearings rest on spacing plates which can be machined to the appropriate thickness such that all bearings are within TBD mm (TBD inches) of true position, as shown in figure 2.9.05.

The altitude bearings are to be encased in insulated metal covers as shown in figure 2.9.06. The purpose of these covers is to retain oil within them. Particular care is required in designing the covers such that any optical equipment, including the primary mirror, is not contaminated by oil. It should be noted that this contamination is possible by any transport mechanism of oil, including splashing, migration, and vapor transport.

2.9.4 Oil Pumping plant and Oil Supply, Recovery Design Requirements

The general flow schematic and location of the oil pumping plant is shown in figure 2.9.07. The azimuth and altitude bearing oil supply and recovery interfaces are shown in figure 2.9.08 and 2.9.09.

General Description and Critical Dimensions TBD.... Description of recovery sumps, labyrinths, etc... Thermal insulation.... TBD....

The pumping plant is located TBD...

A single oil supply tank and hydraulic system shall serve all bearing pads. The system is to be complete with all equipment necessary for the safe and efficient operation of the bearings. Main controls and alarms are to be in the control room, per the Control System Design Requirements Document. All filters, relief valves, flow dividers, and other items of the hydraulic system are to be mounted on or beside the tank unit, and not in or on the telescope mounting. Removal and replacement of oil filters shall be facilitated by appropriately placed valving. Purging shall be .... Pressure differential monitoring equipment shall be installed to indicate filter blockage and/or leakage.

Azimuth and altitude oil supply and return pipework runs from the pumping plant, across the azimuth cable twister, and onto the mount as shown in figure 2.9. 10.

It is important that the amount of heat dissipated from the piping and bearings be kept to a minimum, so as to avoid thermal disturbances of the air in the enclosure. To achieve this, the oil in the hydrostatic system is to enter the pads at TBD temperature. All supply and return pipework, and collection sumps and shields are to be insulated to prevent heat losses into the enclosure.

A minimum Factor of Safety on all bearing plumbing, fittings, sumps, etc. is to be 4.0.

Interface to the Thermal Control System....

Hydrostatic bearing operation, including safety interlocks, is to be controlled by the GPCS as outlined in Control System Design Requirements Document.

Failsafe devices are to be incorporated to avoid damage to the bearings in the event of a malfunction of the systems, such as loss of oil pressure.

2.10 Telescope Drives

2.10.1 Applicable Drawings and Documents

Document Number	Description
1.1.04	General layout of azimuth drive system w/envelope dims.
2.10.01	Az. drive motor system detail.
2.10.02 (not available)	Az. drive ring design w/ crit. dims, tots.
2.10.03 (not available)	Az. drive roller design w/ crit. dims, tots.
2.10.04 (not available)	Az. drive pinch roller design.
2.10.05 (not available)	Az. drive pinch bar assembly design.
2.10.06 (not available)	Az. drive motor, 5-bar mount design...
2.10.07 (not available)	Az. drive system cable runs, breaks, interfaces...
2.10.08 (not available)	Az. drive motor-thermal interface.
1.1.06	General layout of altitude drive system w/envelope dims.
2.10.10	Alt. drive ring design w/ crit. dims, tots.
2.10.11 (not available)	Alt. drive roller design w/ crit. dims, tots.
2.10.12 (not available)	Alt. drive pinch roller design.
2.10.13 (not available)	Alt. drive pinch bar assembly design.
2.10.14 (not available)	Alt. drive motor, 5-bar mount design.
2.10.15 (not available)	Alt. drive cable runs, breaks, interfaces...
2.10.16 (not available)	General layout of altitude axis manual drive systems w/ env. dwgs.
2.10.17 (not available)	Alt. gear rack-track interface.
1.1.06	Alt. gear train-mount interface.

2.10.2 Azimuth Drives Design Requirements

The functional requirements of the telescope's azimuth drive system are as follows:

- Provide smooth, precisely controlled rotation of the telescope about the azimuth axis.
- Provide (maximum) acceleration about azimuth axis of 0.1 deg/s^2.
- Provide (slewing) velocity about azimuth axis of up to 3 deg/s.

- Provide total range of travel about azimuth axis of ± 275 degrees.
- Operate satisfactorily in anticipated wind speeds within the enclosure.
- Minimize repeatable and non-repeatable error sources.
- Minimize thermal input into the enclosure.
- Inexpensive (including operational, maintenance and repair).
- High reliability.
- Minimize maintenance and simplify replacement and/or repair.

The general arrangement of the telescope azimuth drive system and overall envelope dimensions is shown in figure 1.1.04.

As shown in figure 2. 10.0 1, the azimuth axis is positioned by four TBD motor friction drive systems. Each drive system shall consist of a TBD motor direct-driving a TBD roller which is 'pinched' against a TBD m (TBD inch) diameter drive ring.

The crowned drive ring shall be machined from a hardened, high strength TBD steel that is designed to tolerate the high Hertzian contact stresses between the rollers and the rings. The critical dimensions and tolerances of the drive ring are shown in figure 2.10.02. The drive ring is assembled from individual ring segments. The track segments are then joined by using lap-ground tapered plugs at the mechanical joints, as shown in figure 2.10.03.

The vee-shaped drive rollers, machined from high strength TBD steel and hardened to TBD, shall be designed to minimize misalignment effects such as drift and skip associated with crowned or flat roller systems driving on flat surfaces. Figure 2.10.04 shows critical dimensions and tolerances.

As shown in figure 2.10.05, hardened TBD steel pinch rollers provide the TBD normal force required to eliminate slippage under normal operating conditions. This pinch force shall be applied with a pinch-bar arrangement as shown in figure 2.10.06. The required pinch force of TBD N (TBD lbf) exerts a nominal Hertzian contact stress of TBD N/M2 (TBD psi). This pinch is based on an assumed wind velocity of TBD m/s (TBD ft/s) and a coefficient of friction of 0.1.

As shown in figure 2.10.07, the TBD drive motors shall be mounted on tangentially stiff, five-bar linkages that are relatively 'soft' in both the radial and axial directions. This arrangement allows the drive motors to accommodate ring runouts, as well as seismic events, without damaging either the drive ring or the rollers. Minimum tangential motor mount stiffness = TBD N/m (TBD lbf/in). Maximum radial and axial motor mount stiffness = TBD N/m (TBD lbf/in).

Each TBD drive motor shall be capable of providing up to TBD N-m (TBD ft-lbf) of torque. At the drive radius of approximately 5m, and with a roller diameter of TBD mm, this translates to T'BD N (TBD lbf) of tangential force. Torque ripple not to exceed TBD. Torque cogging not to exceed TBD. Maximum motor velocity during stewing operations = TBD rpm. Motor specification is TBD....

Azimuth drive motor operation, including safety interlocks, is to be controlled by the GPCS as outlined in Control System Design Requirements Document.

Azimuth drive motor power supplies are to be located TBD, with cable routing as shown in figure 2.10.08.

Drive motors shall be enclosed in insulated shields with air drawn from outside into, and then piped out to the thermal control system as shown in figure 2.10.09.

2.10.3 Altitude Drive Design Requirements

The functional requirements of the telescope's altitude drive system are as follows:

- Provide smooth, precisely controlled rotation of the telescope about the altitude axis.
- Provide (maximum) acceleration about altitude axis of 0.025 deg/s^2.
- Provide (slewing) velocity about altitude axis of up to 0.75 deg/s.
- Provide total range of travel about altitude axis of zenith to horizon (0-90 degrees).
- Perform satisfactorily in all the environmental conditions to be expected in the enclosure including temperature, humidity, contamination, etc....
- Operate satisfactorily in anticipated wind speeds within the enclosure.
- Minimize repeatable and non-repeatable error sources.
- Minimize thermal input into the enclosure.
- High reliability.
- Minimize maintenance and simplify replacement and/or repair.

The general arrangement of the telescope altitude drive system and overall envelope dimensions is shown in figure 1.1.06.

As shown in figure 1.1.06, the altitude axis is positioned by four TBD motor friction drive systems. Each drive system shall consist of a TBD motor direct-driving a TBD roller which is 'pinched' against a TBD m (TBD inch) diameter drive ring.

The crowned drive ring segment shall be machined from a hardened, high strength TBD steel which is designed to tolerate the high Hertzian contact stresses between the rollers and the rings. The critical dimensions and tolerances of the drive ring are shown in figure 2.10.10. The drive ring shall be machined from a single rolled stock with the correct track radius and crown cross-race curvature.

The vee-shaped drive rollers, machined from high strength TBD steel and hardened to TBD, shall be designed to minimize misalignment effects such as drift and skip associated with crowned or flat roller systems driving on flat surfaces. Figure 2.10.11 shows critical dimensions and tolerances.

As shown in figure 2.10.12, hardened TBD steel pinch rollers shall provide the TBD normal force required to eliminate slippage under normal operating conditions. This pinch force shall be applied with a pinch-bar arrangement as shown in figure 2.10.13. The required pinch force of TBD N (TBD lbf) causes a nominal Hertzian contact stress of TBD N/m^2 (TBD psi). This pinch is based on an assumed wind velocity of TBD m/s (TBD ft/s) and a coefficient of friction of 0.1.

As shown in figure 2.10.14, the TBD drive motors shall be mounted on tangentially stiff, five-bar linkages that are relatively 'soft' in both the radial and axial directions. This arrangement allows the drive motors to accommodate maximum ring runouts, as well as seismic events, without damaging either the drive ring or the rollers. Minimum tangential motor mount stiffness = TBD Nlm (TBD lbf/in). Maximum radial and axial motor mount stiffness = TBD N/m (TBD lbf/in).

Each TBD drive motor shall be capable of providing up to TBD N-m (TBD ft-lbf) of torque. At the drive radius of approximately 5m, and with a roller diameter of TBD mm, this translates to TBD N (TBD lbf) of tangential force. Torque ripple not to exceed TBD. Torque cogging not to exceed TBD. Maximum motor velocity during slewing operations = TBD rpm.

Altitude drive motor operation, including safety interlocks, shall be controlled by the GPCS as outlined in Control System Design Requirements Document

Altitude drive motor power supplies are to be located TBD, with cable routing as shown in figure 2.10.15.

2.10.4 Altitude Manual Drive Systems

The functional requirements of the telescope's altitude manual drive system are as follows:

- Allow for manual (hand operated) rotation of the tube about the altitude axis for maintenance, repair, and engineering purposes.
- Simple, high reliability design.
- Inexpensive.

Figure 2.10.16 shows the basic layout of the altitude manual drive system, along with the general envelope space dimensions.

The manual drive system shall use a TBD gear train box as shown in figure 2.10.16. The main pinion gear shall be driven against a TBD gear rack through the shown hand crank. This gear rack shall also be used for driving the engineering coarse encoder system and is interlocked so that when the manual system is engaged, the drives cannot operate.

The altitude gear rack interface is shown in figure 2.10.17 to the outside diameter of the altitude brake rotor. The gear train box shall be attached to the mount lower frame section as shown in figure 1.1.06. During normal operation, the gear train is retracted from meshing with the gear rack.

2.11 Telescope Encoders

2.11.1 Applicable Drawings and Documents

Document Number	Description
1.1.04	General layout of azimuth FDE system w/ envelope dims.
2.11.01 (not available)	Az. FDE assembly.
2.11.02 (not available)	Az. FDE detail design and mount interface.
2.11.034 (not available)	Az. FDE cable runs, breaks, etc
2.11.04 (not available)	Az. tape read head design
2.11.05 (not available)	Az. tape tension cleat design.
2.11.06 (not available)	Az. tape thermal interface
2.11.07 (not available)	Az. tape cable runs, breaks, etc
2.11.08 (not available)	Az. GDE rack-trackt design, interface
2.11.09 (not available)	Az. GDE cable runs, breaks, etc.
2.11.10 (not available)	Az. absolute proximity sensor-track interface
2.11.11 (not available)	Az. proximity sensor cable runs, breaks, etc.
1.1.06	General layout of altitude FDE system w/ envelope dims
2.11.12 (not available)	Alt. FDE assembly
2.11.13 (not available)	Alt. FDE detail design
2.11.14 (not available)	Alt. FDE cable runs, breaks, etc
2.11.15 (not available)	Alt. tape read head design
2.11.16 (not available)	Alt. tape tensions cleat design.
2.11.17 (not available)	Alt. tape-thermal interface
2.11.18 (not available)	Alt. tape cable runs, breaks, etc
2.11.19 (not available)	General layout of altitude gear drive enc. sys.
2.11.20 (not available)	Alt. GDE rack-mount design, interface
2.11.21 (not available)	Alt. GDE cable runs, breaks, etc.
2.11.22 (not available)	Alt. absolute proximity sensor-track interface
2.11.23 (not available)	Alt. proximity cable runs, breaks, etc.

2.11.2 Telescope Encoder System Functional Requirements

The functional requirements of the telescope's encoder systems are as follows:

- Provide azimuth and altitude absolute position information to the control system to within 0.15 arcsecond rms accuracy of true position.
- Provide azimuth and altitude tracking position information to the control system to within 0.015 arcseconds over 30 arcminutes of travel.
- Provide signals to control system from which position, rate, and acceleration information on both altitude and azimuth axes can be determined.
- Perform satisfactorily in all the environmental conditions to be expected in the enclosure including temperature, humidity, contamination, etc.
- Provide position information at telescope slewing rates of up to ± 3 degrees/sec.
- Provide long-term stability of output with minimal maintenance requirements.
- Provide true position information upon initial nightly start-up without requiring the telescope to rotate more that 8º about any axis.

- High reliability.
- Minimize maintenance and simplify replacement and/or repair.

2.11.3 Azimuth Encoders Design Requirements

The primary purpose of the azimuth axis encoder system is to provide information to the control system so that azimuth position, rate, and acceleration information during all telescope pointing, offsetting, and tracking operations. The system is also used to provide position, rate, and acceleration for engineering purposes. The system includes TBD friction driven encoders for high resolution tracking and offsetting, T'BD tape encoder for pointing, tracking and offsetting, TBD coarse encoder for coarse absolute position information, and TBD absolute proximity sensors for absolute azimuth position information.

2.11.3.1 Azimuth Friction Driven Encoder System

The azimuth friction driven encoder (FDE) system shall consist of TBD FDE assemblies attached to the underside of the mount lower frame sections in the locations shown in figure 1.1.04. Each FDE assembly shall roll against the machined outside diameter of the azimuth track. The output of the FDE system shall be used primarily for control loop feedback for high resolution tracking and offsetting operations.

Each FDE assembly shall consist of .... TBD as shown in figure 2. 1 1.0 1. (waiting for results of testing ....) All dimensions, tolerances, materials, surface specifications, and assembly procedures shall be maintained as outlined in figure 2.11.02.

Mounting interface to the underside of the mount lower frame sections shall be as shown in figure 1.1.04.

The roller diameter of 100mm (4 inches), rolling against the 10m (394 inches) diameter azimuth track, gives an approximate drive ratio of 100: 1. The encoder shall be a Heidenhain ROD-800 with 36000 pulses per revolution. Maximum angular resolution with each FDE assembly = (360º x 3600 arcsec/º) / (36000 pulses x 4 x 25 x 100) = 0.004 arcsec/pulse. System shall be considered incremental (not absolute) and must be position reset/verified with ABS sys.

Data acquisition rate from each encoder assembly is TBD....

All encoder power supplies, interpolation electronics, and associated electronics are to be located TBD to minimize heat transfer to the enclosure and optical path. Heat producing electronics shall be enclosed in insulated boxes which are negatively pressurized with their air outputs routed to the thermal control system.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points.

Output leads shall be routed to the azimuth cable Wrap as shown in figure 2.11.03.

Azimuth FDE system is to be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.3.2 Azimuth Tape Encoders

The azimuth tape encoder system shall consist of a continuous, 40nun (or wider) steel tape that is attached to the outside diameter of the azimuth track, as shown in figure 1.1.04. Optically printed onto this tape is a layer of copper, arranged in a square wave pattern, with a pitch of 2mm by 15mm wide. TBD four inductive sensor read heads, which are designed to detect Sine and Cosine signals from the tape scale, are attached to the underside of the mount lower frame sections located as shown in the figure.

The tape encoder system is used primarily for high resolution pointing, tracking, and offsetting operations; at 10m (395 inches) outside diameter, encoder scale resolution = 0.0049 arcsec. System shall be incremental (not absolute) and must be position calibrated/reset with ABS system at start-up.

The four read heads are arranged to detect translations and eccentricity errors of the mount as it rotates about the azimuth axis, as well as to eliminate print pattern alignment and tape end errors. As shown in figure 2.11.04, each read head assembly consists of the read head, mounting and alignment brackets, and roller. The purpose of the roller is to maintain an air gap between the tape and read head of TBD microns ± TBD microns.

Read head mounting interface to the underside of the mount lower frame sections shall be as shown in figure 1.1.04.

As shown in figure 2.11.05, the steel tape shall be mounted to the azimuth track by use of a tension cleat affixed to each end. The tape length, and cleat design, shall be calculated to allow the two ends of the tape to match print patterns within TBD mm. To minimize errors due to uneven tape tension, a system of airport and groove are machined into the azimuth track underneath the tape. When installing the tape, air at TBD N/m^2 (TBD psi) is admitted underneath the tape, the cleats are tensioned (bolted) together, and the air pressure released. This system shall provide uniform tape tension of TBD N ± TBD N.

Maximum azimuth rotation encoder velocity to be TBD rpm.

Interpolation and related electronics shall be located TBD to minimize heat transfer to the enclosure and optical path. Power amplifiers for the read head assemblies, are required to be mounted within I meter of each read head. Because of this, a negatively pressurized enclosure interfaced to the thermal control system at each amplifier is required to n-dnimize thermal output. This is shown in figure 2.11.06.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points.

Input and output leads shall be routed through the azimuth cable wrap as shown in figure 2.11.07.

Azimuth FDE system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.3.3 Azimuth Coarse Gear Driven Encoder

The azimuth coarse gear driven encoder (GDE) system shall consist of a TBD gear rack, affixed to the outside diameter of the azimuth track, and a gear driven, TBD absolute encoder.

The primary purpose of the GDE is to provide continuous, absolute position information for system de-bugging, and engineering purposes. The GDE also provide telescope operators with an inexpensive, continuous absolute position system.

The required resolution of GDE shall be 6 arcmin. Accuracy shall be 6 arcmin.

GDE assembly shall consist of .... TBD as shown in figure 1.1.04.

Mounting interface to the underside of the mount lower frame sections shall be as shown in figure 1.1.04.

The azimuth gear rack, with critical dimensions and tolerances, shall be as shown installed in figure 2.11.08 to the outside diameter of the azimuth track.

All encoder power supplies, interpolation electronics, and associated electronics shall be located TBD to minimize heat transfer to the enclosure and optical path.

All power and signal cables, leads are shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points.

Output leads shall be routed to the azimuth cable Wrap as shown in figure 2.11.09.

Azimuth GDE system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.3.4 Azimuth Proximity Sensors

The azimuth proximity sensor system shall consist of TBD sensors affixed to the azimuth track at approximately every TBDO increment, as shown in figure 2.11.10. A single magnetic pick-up is attached to the underside of the mount lower frame section as shown. This system is intended primarily as a high resolution, absolute position encoder to provide incremental encoders (tape and FDE) with initial start-up, and continuous position update information.

Resolution of each TBD sensor shall be ±1.0 microns (TBD inches). At a 10m radius, this is equivalent to ±TBD arcsec absolute position.

Magnet mounting interface to the underside of the mount lower frame sections shall be as shown in figure 2.11.10.

All proximity sensor power supplies and associated electronics shall be located TBD to minimize heat transfer to the enclosure and optical path.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points. Cable runs are as shown in 2.11.11.

Azimuth proximity sensor system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.4 Altitude Encoders Design Requirements

The primary purpose of the altitude axis encoder system is to provide altitude position (rate and acceleration) information to the GPCS during all telescope pointing, offsetting, and tracking operations, as well as engineering tests and maintenance procedures. The system includes TBD friction driven encoders for high resolution tracking and offsetting, TBD tape encoder for high resolution pointing, tracking and offsetting, coarse encoder for coarse absolute position information, and TBD absolute proximity sensors for absolute altitude position information.

2.11.4.1 Altitude Friction Driven Encoders

The altitude friction driven encoder (FDE) System shall consist of TBD FDE assemblies attached to the mount top frame sections in the locations shown in figure 1.1.06. Each FDE assembly rolls against the machined outside diameter of each of the altitude disks.

Each FDE assembly consists of TBD as shown in figure 2.11.12. (waiting for results of testing ...) All dimensions, tolerances, materials, surface specifications, and assembly procedures are shown in figure 2.11.13.

Mounting interface to the mount top frame sections shall be as shown in figure 1.1.06.

The roller diameter of 100mm (4 inches), rolling against the 7m (275 inches) diameter azimuth track, gives an approximate drive ratio of 70:1. The encoder shall be a Heidenhain ROD-800 with 36000 pulses per revolution. System shall be considered incremental (not absolute) and must be position reset/verified with absolute proximity system.

All encoder power supplies, interpolation electronics, and associated electronics shall be located TBD to minimize heat transfer to the enclosure and optical path.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points.

Output leads shall be routed to the azimuth cable Wrap as shown in figure 2.11.14.

Altitude FDE system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.4.2 Altitude Tape Encoders

The altitude tape encoder system shall consist of a continuous, 40mm wide steel tape that is attached to the outside diameter of each of the altitude disks, as shown in figure 1.1.06. Optically printed onto this tape is a layer of copper, arranged in a square wave pattern, with a pitch of 2mm by 15mm wide. Four inductive sensor read heads, which are designed to detect Sine and Cosine signals from the tape scale, shall be attached to the mount top frame sections located as shown in figure 1.1.06.

The tape encoder system shall be used primarily for high resolution pointing, tracking, and offsetting operations; at 7m (275 inches) outside diameter, encoder scale resolution = 0.0055 arcsec. System shall be consider incremental and must be position reset/initialized with ABS system at start-up.

Four read heads shall be arranged to detect translations and eccentricity errors of the tube as it rotates about the altitude axis, as well as to eliminate print pattern alignment and tape end errors. As shown in figure 2.11.15, each read head assembly shall consist of the read head, mounting and alignment brackets, and roller. The purpose of the roller is to maintain an air gap between the tape and read head of TBD microns.

Read head mounting interface to the mount top frame sections shall be as shown in figure 1.1.06.

As shown in figure 2.11.16, the steel tape shall be mounted to the altitude disk by use of a tension cleat affixed to each end. To minimize errors due to uneven tape tension, a system of air-ports and groove shall be machined into the altitude disk underneath the tape. When installing the tape, one end of the tape shall be affixed to the end of the altitude disk and the tape segment is wrapped around the outside edge of the disk. Air at TBD N/m^2 (TBD psi) shall be admitted underneath the tape, the unattached cleat end of the tape tensioned, and the air pressure released. This system shall allow for uniform tape tension of TBD N ±TBD N.

Maximum data acquisition rate = TBD.

Interpolation and related electronics shall be located TBD to minimize heat transfer to the enclosure and optical path. Power amplifiers for the read head assemblies, are required to be mounted within I meter of each read head. Because of this, an interface to the thermal control system at each amplifier is required to minimize thermal output. This is shown in figure 2.11.17.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points.

Input and output leads shall be routed through the azimuth cable wrap as shown in figure 2.11.18.

Altitude tape system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.4.3 Altitude Coarse Gear Driven Encoder

The altitude coarse gear driven encoder (GDE) system shall consist of a TBD gear rack, affixed to the outside diameter of the altitude brake rotor, and a gear driven, TBD absolute encoder. The primary purpose of the GDE shall be to provide continuous, absolute position information for system de-bugging, and engineering purposes. The GDE shall also provide telescope operators with an inexpensive, continuous absolute position system.

The required resolution of GDE shall be 6 arcmin. Accuracy shall be 6 arcmin.

Each GDE assembly shall consist of TBD as shown in figure 2.11.19.

Mounting interface to the mount top frame sections shall be as shown in figure 2.11.19.

The altitude gear rack, with critical dimensions and tolerances, shall be as shown installed in figure 2.11.20 to the outside diameter of the altitude brake rotor.

All encoder power supplies, interpolation electronics, and associated electronics shall be located TBD to minimize heat transfer to the enclosure and optical path.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points.

Output leads shall be routed to the azimuth cable Wrap as shown in figure 2.11.21.

Altitude GDE system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.11.4.4 Altitude Proximity Sensors

The altitude proximity sensor system shall consist of TBD sensors affixed to the altitude disks at approximately every 15' increment, as shown in figure 2.11.22. A single magnetic pick-up shall be attached to the mount top frame section as shown. This system is intended primarily as a high resolution, absolute position encoder to provide incremental encoders (tape and FDE) with initial start-up, and continuous position update/reset information.

Resolution of each TBD sensor is ±1.0 microns (TBD inches). At a 7m diameter, this is equal to ± TBD arcsec absolute position.

Magnet mounting interface to the mount top frame section shall be as shown in figure 2.11.22.

All proximity sensor power supplies and associated electronics shall be located TBD to minimize heat transfer to the enclosure and optical path.

All power and signal cables, leads shall be shielded per TBD.

All power and signal cables shall be strain relieved at all disconnects and end points. Cable runs shall be as shown in 2.11.23.

Altitude proximity sensor system shall be controlled, read by the GPCS as outlined in Control System Design Requirements Document.

2.12 Telescope Brakes and Locks

2.12.1 Applicable Drawings and Documents

Document Number	Description
1.1.04	General layout of azimuth brake system w/envelope dims.
2.12.01 (not available)	Az. brake rotor design.
2.12.02 (not available)	Az. brake caliper brackets design.
2.12.03 (not available)	Az. brake thermal interface.
2.12.04 (not available)	Az. brake cable runs, breaks, etc.
1.1.06	General layout of altitude brake system w/envelope dwgs.
2.12.05 (not available)	Alt. brake rotor design.
2.12.06 (not available)	Alt. brake caliper brackets design.
2.12.07 (not available)	Alt. brake cable runs, breaks, etc.
2.12.08 (not available)	Alt. brake thermal interface.
2.12.09 (not available)	altitude locking pin locked positions.
2.12.10 (not available)	Alt. locking pin mechanism design.
2.12.11 (not available)	Alt locking pin cable runs, breaks, etc.

2.12.2 Azimuth Brakes Design Requirements

The functional requirements of the telescope's azimuth braking system is as follows:

- Bring the telescope to a complete rotational stop about the azimuth axis during normal telescope operation, as well as during emergency stops.
- Fail safe operation; i.e. ability to apply braking torque to mount in event of complete observatory power failure.
- High reliability (redundancy).
- Minimize maintenance and simplify replacement and/or repair.

The general arrangement of the telescope azimuth brake system and overall envelope dimensions shall be as shown in figure 1.1.04.

At a minimum, the braking system shall be required to stop the telescope, during a complete observatory power failure, within TBD seconds from any normal rotational velocity. Required braking torque, per caliper, shall be TBD N-m (TBD ft-lbf). The maximum tangential force that is applied to the rotor is TBD N (TBD lbf).

Estimated mass of the brake rotor is TBD kg. (TBD lbm).

As shown in figure 2.12.01, the azimuth brake rotor shall be machined from TBD mild steel sections. Critical dimensions and tolerances, as well as segment joint details, shall be as shown in the figure. Attachment of the rotor to the azimuth track shall be through TBD bolts as shown in figure 1.1.04.

TBD calipers shall be spring applied on, TBD actuated off: i.e. power failure mode causes brakes to clamp rotor, therefore apply braking torque. Minimum factor of safety = 2.0. Max power consumption per caliper = TBD watts.

TBD brake caliper mounting brackets shall be as shown in figure 2.12.02.

TBD brake calipers shall be attached to the underside of the mount as shown in figure 1.1.04.

Azimuth brake heat due to powered-off operation, as well as during braking operations, shall be transferred to the Thermal Control System as shown in figure 2.12.03.

Azimuth brake operation, including safety interlocks, shall be controlled by the GPCS as outlined in Control System Design Requirements Document.

Azimuth brake power supplies shall be located TBD, with cable routing as shown in figure 2.12.04.

2.12.3 Altitude Brakes Design Requirements

The functional requirements of the telescope's altitude braking system is as follows:

- Bring the tube to a complete rotational stop about the altitude axis during normal telescope operation, as weft as during emergency stops.

- Fail safe operation; i.e. ability to apply braking torque to tube in event of complete observatory power failure.
- High reliability (redundancy).
- Minimize maintenance and simplify replacement and/or repair.

The general arrangement of the telescope altitude brake system and overall envelope dimensions shall be as shown in figure 1.1.06.

At a minimum, the braking system shall be required to stop the telescope, during a complete observatory power failure, within TBD seconds from any normal rotational velocity. Required braking torque, per caliper, shall be TBD N-m (TBD ft-lbf). The maximum tangential force that is applied to the rotor shall be TBD N (TBD lbf).

Estimated mass of each the two altitude brake rotor segments is TBD kg. (TBD lbm).

As shown in figure 2.12.05, the two altitude brake rotor segments shall be machined from TBD mild steel sections. Critical dimensions and tolerances shall be as shown in the figure.

Attachment of the rotors to both altitude disks shall be through TBD bolts as shown in figure 1.1.06.

TBD calipers shall be spring applied on, TBD actuated off: i.e. power failure mode shall cause brakes to clamp rotor, therefore apply braking torque. Factor of safety = 2.0. Max power consumption per Caliper = TBD watts.

TBD brake Caliper Mounting Brackets shall be as shown in figure 2.12.06.

TBD brake calipers shall be attached to the mount top frame sections as shown in figure 1.1.06.

Altitude brake operation, including safety interlocks, shall be controlled by the GPCS as outlined in Control System Design Requirements Document.

Altitude brake power supplies shall be located TBD, with cable routing as shown in figure 2.12.07.

Interface to Thermal Control System shall be as shown in figure 2.12.08.

2.12.4 Altitude Locking Pin System Design Requirements

The functional requirements of the altitude locking pin system are as follows:

- Hold the telescope tube structure in various locked positions about the altitude axis during installation, maintenance, and repair of various telescope mechanical components; e.g. A

'horizon locked' position is required for removal and installation of each of the top end assemblies
- Utilize existing altitude brake rotor as a locking shear plate.
- High reliability.
- Fail safe operation; i.e. locking pin remains engaged in event of complete observatory power failure.
- Minimize maintenance and simplify replacement and/or repair.

The general arrangement of the telescope altitude locking pin system and overall envelope dimensions shall be as shown in figure 1.1.06.

Locking pin system allows TBD 'locked' positions as shown in figure 2.12.09.

Maximum shear force that locking pin will experience shall be TBD N (TBD lbf). A factor of safety = 4.0 shall be used in the design of this pin.

Locking pin mechanism design shall be as shown in figure 2.12. 10. The mechanism is spring-applied, TBD actuated off. The locking pin, as shown, shall be tapered to allow small misalignments between locking shear plate (brake rotor) and pin.

The locking pin mechanism interface to the mount top frame section shall be as shown in figure 1.1-06.

Altitude locking pin operation, including safety interlocks, shall be controlled by the GPCS as outlined in Control System Design Requirements Document.

Altitude locking pin power supply shall be located TBD, with cable routing as shown in figure 2.12.11.

2.13 Telescope Cables, Twisters and Wraps, Guides, Break Panels, Hydrostatic Lines

2.13.1 Applicable Drawings and Documents

Document Number	Description
2.13.01 (not available)	General layout of azimuth cable twister w/ envelope dims.
2.13.02 (not available)	Az. cable twister-mount, pier interface
2.13.03 (not available)	General layout of altitude cable wrap w/ envelope dims.
2.13.04 (not available)	Alt. cable wrap-mount, center section interface.
2.13.05 (not available)	Cable runs, breaks, interfaces, etc....

2.13.2 Azimuth Cable Twister Design Requirements

The functional requirements of the azimuth cable twister are as follows:

- Carry the various electrical power and signal cables, instrumentation electrical and fiber-optic lines, pneumatic lines, and hydrostatic bearing supply and return lines, across the azimuth axis while allowing the mount to rotate ± 275º.
- Minimal friction, stiction, and hysteresis.
- Expandable to allow addition of extra lines and cables.
- Minimal maintenance and simplify replacement and/or repair.
- Simple, high reliability.

Figure 2.13.01 shows the location and overall envelope dimensions of the azimuth cable twister.

Mounting interfaces on the bottom of the mount center section and the top of the pier structure shall be as shown in figure 2.13.02.

Maximum allowable torque (stiction, viscous, coloumb, etc ...) shall not to exceed TBD N-m (TBD ft-lbf).

Twister shall be required to carry the following cables and line:

TBD electrical power cables (TBD diameter)
TBD electrical signal lines (TBD diameter)
TBD fiber-optic lines (TBD diameter)
TBD pneumatic lines (TBD mm diameter)
TBD insulated hydrostatic supply and return lines (TBD mm diameter)
TBD ???

In addition, space for TBD future cables (TBD mm diameter) shall be required.

All cables and lines shall be adequately supported over their entire length.

Twister design shall allow removal and installation of any individual cable or line without requiring removal of any other cable or line.

2.13.3 Altitude Cable Wrap Design Requirements

The functional requirements of the altitude cable wrap are as follows:

- Carry the various electrical power and signal cables, instrumentation electrical and fiber-optic lines, pneumatic lines, and TBD, across the altitude axis while allowing the tube to rotate from zenith to horizon.
- Minimal friction, stiction, and hysteresis.
- Expandable to allow addition of extra lines and cables.
- Minimal maintenance and simplify replacement and/or repair.
- Simple, high reliability.

Figure 2.13.03 shows the location and overall envelope dimensions of the altitude cable wrap.

Mounting interfaces on the mount and the center section shall be as shown in figure 2.13.03.

Maximum allowable torque (stiction, viscous, coloumb, etc...) shall not to exceed TBD N-m (TBD ft-lbf).

Wrap is required to carry the following cables and line:

TBD electrical power cables (TBD diameter)
TBD electrical signal lines (TBD diameter)
TBD fiber-optic lines
TBD pneumatic lines (TBD mm diameter)
TBD ???

Space for TBD additional future cables (TBD mm diameter) shall be required.

All cables and lines shall be adequately supported over their entire length.

Wrap design allows removal and installation of any individual cable or line with out requiring removal of any other cable or line.

2.13.4 Cable Runs, Guides, Break Panels Design Requirements

Figure 2.13.05 showing all cable runs, breaks, interfaces to wraps/twisters, interface w/ hydrostatic lines...
Strain relief all cables minimum of TBD inches.
BNC connectors and mounting plates, flanges?
Cable trays ....

2.14 Telescope Baffles

2.14.1 Applicable Drawings and Documents

Document Number	Description

2.14.2 Baffles Design Requirements

The functional requirements of the optical baffles is as follows:

- Prevent unwanted ’stray light’ from entering the optical path.
- Minimize wind loading inputs to the telescope.
- Light weight.
- Easily mounted, de-mounted.
- Low emissivity.

- Long-life.

The general arrangement of each of the telescope baffles and overall envelope dimensions is shown in figure TBD.

There are TBD baffles, as shown in figure TBD.

Wind Loading... Required Stiffness....

Mass...

Fabrication....

finish...

interface to Telescope..

handling arrangements...

Need more information from optics group to write this section.

2.15 Telescope Counter Balance System

2.15.1 Applicable Drawings and Documents

Document Number	Description
2.15.01 (not available)	General layout of counter balance system w/envelope dims, and two axes locations.
2.15.02 (not available)	Counter balance assembly design, w/ critical dims, ranges, etc.
2.15.03 (not available)	Counter balance system-center section interface w/ access panels, etc.
2.15.04 (not available)	Counter balance system cable runs, breaks, etc...

2.15.2 Counter-Balance System Design Requirements

The functional requirements of the tube counter-balance system is as follows:

- Provide automatic balance of the telescope tube about the center point of the altitude rotation axis to within 2 kg-m.
- High reliability.
- Minimize maintenance and simplify replacement and/or repair.

The general arrangement of the telescope counter-balance system and overall envelope dimensions shall be as shown in figure 2.15.01.

In order to achieve the specified telescope balance, the counter balance system shall translate TBD kg. (TBD lbm.) a total of ± TBD mm (TBD inches) along the axis of the tube. In addition, the counter balance system shall also translate TBD kg. (TBD lbm) a total of ± TBD mm (TBD inches) perpendicular to the tube axis and the altitude axis. Both of these requirements shall be as shown schematically in figure 2.15.01.

Each balance assembly shall consist of a TBD drive motor, TBD lead screw, TBD kg. mass, and mounting housing. Total range of move shall be as shown in figure 2.15.02. Each assembly also shall have two limit switches to sense Mass end of travel, as well as an on-axis TBD absolute encoder to provide Mass position information to the GPCS. The lead screw and motor selection shall eliminate unwanted mass movement when the balance assembly is powered off. Drive components shall be designed so that counterbalance mass can be driven into hard limits without drive system component failure.

T'he counter balance system shall consist of two balance assemblies, located inside of the telescope center section as shown in figure 2.15.02. Installation, maintenance, and repair of each assembly shall be accomplished through the access panels shown.

2.16 Telescope Primary Mirror Covers

2.16.1 Applicable Drawings and Documents

Document Number	Description
2.16.01	General layout of primary mirror covers w/envelope dims.
2.16.02 (not available)	Mirror cover design.
2.16.03 (not available)	Mirror cover-center section interface.
2.16.04 (not available)	Mirror cover cable runs, breaks, etc.

2.16.2 Primary Mirror Covers Design Requirements

The functional requirements of the primary mirror covers is as follows:

- Completely enclose mirror when closed to prevent dust settling on mirror and to allow nitrogen gas to be admitted and contained in the space between the mirror and the mirror cell when the covers are closed.
- Personnel must be able to walk on the covers.
- Be able to survive a 15lbm tool dropped from 15m.
- When open, present a minimum obstruction to the flow of ambient air over the primary mirror surface.
- When open, present a minimum area to wind loading.
- Low mass.
- High reliability.
- Able to open and close with the tertiary mirror and the optical baffles in place. Mechanisms used must not contaminate mirror surface.
- Fail safe operation, i.e. damage to mirror is avoided.

- Allow tube to rotate zenith-to-horizon with covers open or closed.

The general arrangement of the telescope primary mirror covers and overall envelope dimensions shall be as shown in figure 2.16.01.

Estimated loading that the mirror covers will experience shall be Dead Load plus TBD N/m^2 (TBD psi) Live Load.

Covers shall be required to operate (open and close) in TBD m/s (TBD ft/s) wind.

Counter balance operation, including safety interlocks, shall be controlled by the GPCS as outlined in Control System Design Requirements Document.

Counter balance power supplies shall be located TBD, with cable routing as shown in figure 2.15.04.

Available power (voltage, amperage).... for operation?

As shown in figure 2.16.01, the mirror Cover system shall be comprised of eight cover panel assemblies. Each panel shall be fabricated from three trapezoidal aluminum-faced, honeycomb segments. The three segments shall be joined together by TBD hinges that are arranged to compressively lock into place when a live load is applied. In addition, the odd numbered panel assemblies shall have 'up-angled' edges, which are designed to mate with the even numbered panel's 'down-angled' edges. This arrangement further locks the panels assemblies in the closed position, while maintaining an effective seal to preclude mirror contamination.

Each folded panel assembly shall be vertically translated by a DC torque motor/worm and wheel assembly into it's stowed position alongside the primary mirror on the inside diameter of the center section. This arrangement has been chosen to prevent drive back in the event of a power failure.

Critical dimensions and tolerances of the mirror cover system shall be as shown in figure 2.16.02.

Mirror cover interface to center section shall be as shown in figure 2.16.03.

Top surface of mirror covers shall be finished in non-skid TBD coating.

Mirror cover operation, including safety interlocks, shall be controlled by the GPCS as outlined in Control System Design Requirements Document.

Mirror cover power supplies shall be located TBD, with cable routing as shown in figure 2.16.04.

2.17 Telescope Handling Carts

2.17.1 Applicable Drawings and Documents

Document Number		Description
2.17.01		General layout of top end handling cart w/envelope dims.
2.17.02	(not available)	Top end handling cart design.
2.17.03	(not available)	Top end handling cart-top end(s) interface.
2.17.04	(not available)	General layout of primary mirror handling cart w/ envelope dims.
2.17.05	(not available)	Primary mirror handling cart design.
2.17.06	(not available)	Mirror handling cart-mirror cell interface.

2.17.2 Top End Handling Cart Design Requirements

The general arrangement of the telescope top end handling cart and overall envelope dimensions shall be as shown in figure 2.17.0 1.

The primary purpose of the top end handling cart is to support the top end assemblies (f/16, f/19.6 top end and f/6 top end) when off of the telescope. The cart also provides a stiff maintenance, repair, and storage platform for both top ends.

Maximum estimated forces acting on the handling cart, due to the TBD top end, = TBD N (TBD lbf).

Estimated mass of the handling cart is TBD kg. (TBD lbm.).

Figure 2.17.02 shows the critical dimensions, tolerances and overall layout of the cart.

The cart shall be fabricated from TBD.

Cart attachment interface to each top end assembly shall be as shown in figure 2.17.03.

Suspension system shall be designed to minimize shock loading of each top end assembly.

With the exception of all mating hardware attachment points, handling cart surfaces shall be finished with TBD coating.

Use of the handling cart is outlined in Appendix A.

2.17.3 Primary Mirror Handling Cart & Rail Design Requirements

The general arrangement of the telescope primary mirror handling cart and Rail, with overall envelope dimensions is shown in figure 2.17.04.

Maximum allowable time to open or close the covers shall be TBD seconds.

Estimated mass of the mirror Cover assembly is TBD kg. (TBD lbf.)

The main purpose of the primary mirror handling cart is facilitate removal and installation of the primary mirror and Mounting cell.

Maximum estimated forces acting on the handling cart, due to the primary mirror and cell, TBD N (TBD lbf).

Estimated mass of the handling cart is TBD kg. (TBD lbm.).

Figure 2.17.05 shows the critical dimensions, tolerances and overall layout of the cart.

The cart shall be fabricated from TBD.

Mirror handling cart interface to the primary mirror cell shall be as shown in figure 2.17.06.

Suspension system shall be designed to minimize shock loading of primary mirror assembly.

With the exception of all mating hardware attachment points, handling cart surfaces shall be finished with TBD coating.

Use of the handling cart is outlined in Appendix A.

Rail Guide figure w/ critical dimensions...

2.18 Thermal Control

2.18.1 Applicable Drawings and Documents

Document Number	Description

2.18.2 Thermal Control Design Requirements

The primary purpose of the Thermal Control System is to remove any radiated, conducted, or convected energy (heat) from the various components of the telescope (and from stored energy due to external sources). These include azimuth and altitude drives, encoders, and bearings, primary mirror actuators, secondary mirror actuators and chopping assemblies, Cassegrain and Nasmyth Instruments, ???

Entire section TBD

2.19 Interlock Switches, Sensors

2.19.1 Applicable Drawings and Documents

Document Number   Description

2.19.2 Interlock Switches, Sensors Design Requirements

The primary purpose of the telescope's interlocks and sensor system is to prevent injury to personnel and/or damage to the telescope, instrumentation, or enclosure that could occur if a subassembly or system (e.g. telescope drive motors) is activated incorrectly or without activating interfacing equipment. The following interlocks shall be required:

Disable altitude drives if altitude hydrostatic bearings are not pressurized. This will eliminate bearing and/or drive surface damage if the drives are inadvertently activated.

Disable altitude drives if altitude locking pin and/or altitude brakes engaged. This will eliminate brake and/or drive surface damage if the drives are activated.

Disable azimuth drives if azimuth locking pin and/or brakes are engaged. This will eliminate brake and/or drive surface damage if the drives are activated.

Disable azimuth drives if azimuth hydrostatic bearings are not pressurized. This will eliminate bearing and/or drive surface damage if the drives are inadvertently activated.

Disable locking pin (i.e. can not disengage) when top-end, instruments, or mirror cell is removed, and/or mirror cover gate key is removed. This will eliminate the tube from experiencing an out-of-balance-induced rotation.

Disable Top-end latching mechanisms if altitude locking pin is not inserted.

Disable mirror covers when cover gate key is removed. The gate key is a removable lever-type key that electrically disables the mirror cover circuitry. This will prevent the covers from accidentally being opened when personnel are working on top of them.

Prevent enclosure rotation if the telescope azimuth brakes and locking pins are not disabled. This will eliminate the possibility of the enclosure damaging the telescope if an interference-type condition exists.

Prevent enclosure rotation if the telescope azimuth hydrostatic bearings are not fully pressurized. T'his will eliminate the possibility of the enclosure damaging the telescope if an interference-type condition exists.

Interlock operation is to be controlled by the GPCS as outlined in Control System Design Requirements Document.

Interlock power supplies and/or associated electronics are to be located TBD, with cable routing as shown in figure no. TBD ....

Appendix A: Handling Procedures

Removing primary mirror for Re-coating
Exchanging top-end rings
Exchanging f/16 and f/19 secondary mirrors Handling optical baffles
Mirror Cleaning

Appendix B: Track installation

The track is aligned (leveled) on the threaded rods by using the lower retaining nuts as jacking devices. After leveling, the upper track retaining nuts are tightened against the track. Then the upper and lower jam nuts (or are we going to 'stake' the retaining nuts?) are tightened, the track level is re-checked, and any additional minor adjustment operations are carried out. Following this step, the space underneath the track is grouted with TBD grout per procedure TBD. (is this paragraph required in DRD? or should it be part of installation instructions???)