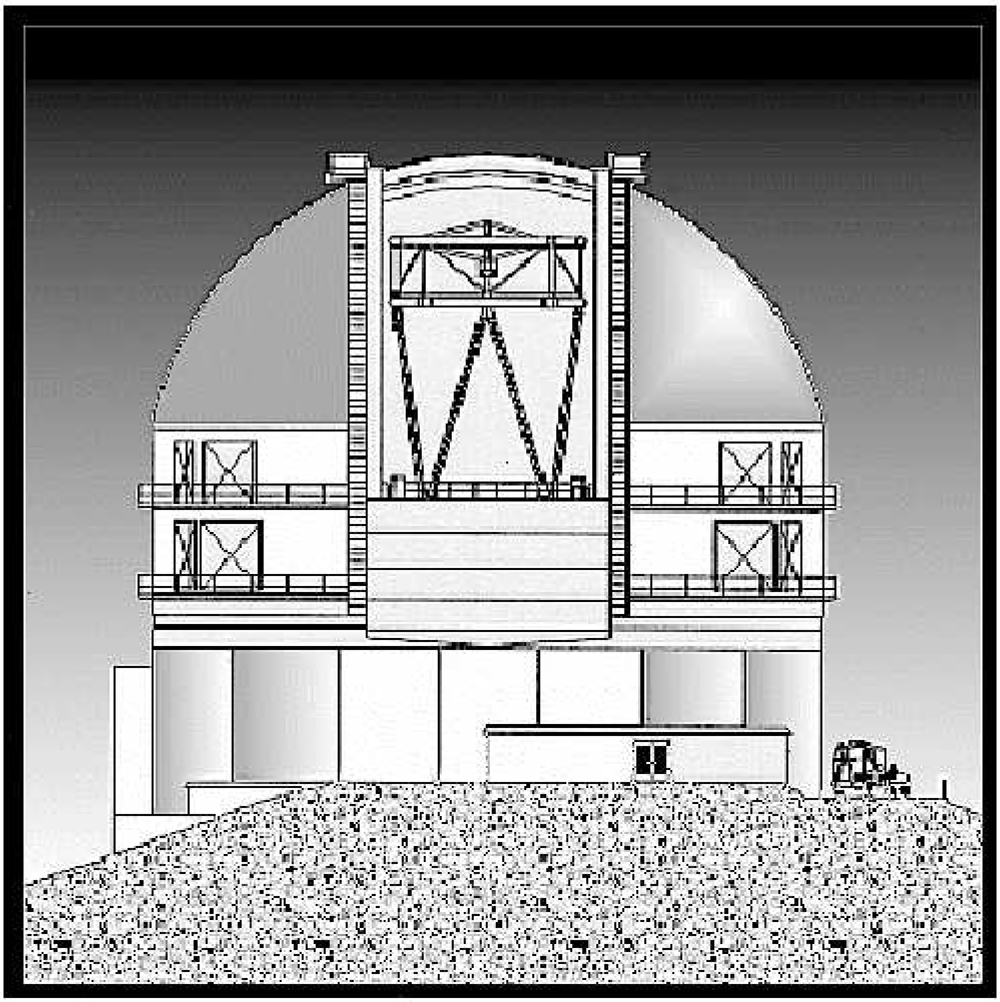
GEMINI
8-M Telescopes
Project

SPE-I-G0052

Cassegrain Assembly Design Requirements



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1 Introduction

This document is intended to specify the design requirements of the Cassegrain Assembly and its major substems. The design requirements will satisfy the Cassegrain Assembly functional requirements in addition to various interface requirements with other telescope systems and between the major elements of the Cassegrain Assembly. This document will be a guide in developing the Cassegrain Assembly preliminary design.

The Cassegrain assembly consists of three main subassemblies, the Cassegrain rotator, Cassegrain Cable Wrap and Instrument Support Structure.

2 Cassegrain Assembly functional requirements.

The functional requirements are developed in the Cassegrain Assembly functional requirements document. They are summarized here for convenience.

2.1 Instrument Rotator

- Provides an interface betweerr the instrument cluster and mirror cell
- Provides field orientation by physical rotation of the instrument cluster
- Provides field derotation by physical rotation of the instrument cluster

2.2 Cable/Services Wrap

- Provides cabling and services to the instruments from the mirror cell to the moving part of the Cassegrain rotator
  - copper connections
  - optical data fibers
  - vacuum
  - pressurized Helium
  - liquid coolant lines

2.3 Instrument Support Structure

- Provides versatile interface between instruments and Cassegrain rotator
- accessible focal surfaces
  - at least two science instruments mounted simultaneously
  - rapid changing of mounted instruments
  - standard interface
- Provides optomechanical interface for AO unit
- Provides optomechanical interface for facility calibration module
- Provides optomechanical interface to A&G modules

2.4 Cassegrain Area interface requirements.

The cassegrain area consists of the Cassegrain Assembly and all the other subsystems for which the Gemini Intrumention group is responsible. The cassegrain area has various interface requirements to other areas of the telescope which are outlined in this section.

Telescope tube balance.

In all configurations of the telescope, the telescope tube must always be balanced. To first order this balance is achieved by allocating masses to the elements which make up the telescope tube. Table xxx shows the telescope tube mass/mass moment table.

The figure for mass moment of for the Cassegrain area is taken and allocated among the elements of the cassegrain area. Table XXX shows this budget.

Space envelope.

The allowable space envelope for the cassegrain area is a compromise between the potential needs of the cassegrain systems and the telescope structural performance. The allowable space evelope for the Cassegrain area is shown in figure 1. This space envelope is allocated to each Cassegrain area subsytem as shown in figure 2.

Thermal management.

Thermal management of the nighttime enclosure air power dissipation is required to reduce dome seeing effects. Table xxx shows the allocation of allowable power dissipation within the enclosure for the cassegrain area. The power allocated to the casegrain area is alloacted to the various subsystems as shown in Table xxx.

Cable/services routing.

The cables/service routing from the cassegrain area to the telescope is a compromise between accessability, structural considerations for the mirror cell support and space envelopes for instrumentation. The route chosen is shown in figure xx.

Telescope focus.

The telescope focus is 4 meters behind the primary mirror vertex.

3 Cassegrain rotator design requirements.

This section outlines the overall design requirements of the rotator as a subsystem and will go on to cover the major elements which comprise the rotator in the current preliminary concept.

The cassegrain rotator is the mechanical interface between the cassegrain cluster and the primary mirror cell. It is able to rotate the entire cluster to provide field orientation and derotation for the cassegrain instrument systems.

3.1 General description

The cassegrain rotator is a squat cylindrical assembly comprising of a bearing sandwiched between static and rotating housings. The static housing interfaces to the mirror cell while the rotating housing forms the interface to the instrument support structure. The static housing acts as the mount for four servo actuators operating gear pinions which drive a ring gear mounted on the rotating housing. The upper housing also acts as the support for 4 gear driven rotary encoders. the rotating housing acts as the support for the rotating section of the cable wrap.

3.1.1 Operational Range.

The normal operating range will be ± 270°

3.1.2 Maximum feasible range

The maximum feasible range is set at ± 280°. This will give an allowance for the endstop travel and misalignment of the cable wrap.

3.1.3 Overrun Limit Switches

A microswitch will signal an error to the control system and actuator controllers at 273°. Recovery from this condition will require manually driving the rotator back into the normal operating range and resetting the control system.

3.1.4 Mechanical Endstops

Hydraulic bumpers are provided as an absolute limit to travel. They will engage just beyond the overrun limit switch and will be capable of stopping the rotator, fully loaded and with the motors driving at maximum speed, within 2 degrees. Endstop-to-endstop travel is ± 275°, with the endstops full compressed.

3.1.5 Zero angle definition and sense of rotation.

With the telescope parked facing east, the zero rotation angle will be along the x axis of the telescope coordinate system. Looking from the secondary to the primary, the rotation sense will be clockwise positive.

3.1.6 Absolute datum Switch

A datum switch will be used at the zero angle as an absolute reference.

3.1.7 Design Loads

The design loads derive from a mass and mass moment budget applied to the telescope tube.

• Mass	12000 kg
• Center of gravity of mass load	on axis, 1.1 meters from ISS interface
• Mass Moment[1]	12000 kg-m
• Rotational Inertia[2]	200000 $kg\text{-}m^2$

3.1.8 Performance requirements

• Slew rates	2.0°/sec
• Tracking rates	0° to 0.5° per sec
• Max track / slew acceleration deceleration	$0.1°/sec^2$
• Positioning accuracy	44.0 microrad
• Tracking accuracy	14.5 microrad

- Unbalanced torque with respect to rotator axis
  The rotator will be able to drive the following out of balance torques

• drive capability	>1000 Nm
• balance goal for rotator	<5 Nm

3.1.9 Mass

The mass allocation given to the cassegrain rotator is 700 Kg.

This is apportioned from the total cassegrain mass balance budget. Table x shows the distribution of mass among the different cassegrain subassemblies which is consistent with maintaining overall telescope tube balance.

3.1.10 Overall dimensions.

The cassegrain rotator will allow for the passage of a 45 arcmin field at f/6. The rationale being that the rotator would serve both the f / 16 and f / 6 configurations.

The rotator assembly will be accomodated within the volume of a squat cylinder of dimensions 1450mm ID, 1750mm OD, and 300mm deep.

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[1]

[2] Inertia limited by motor torque and servo loop parameters.

3.2 Bearing

The bearing will support the weight of the cassegrain assembly including the inner cable wrap. The loading is single ended, the cassegrain assembly can be considered as a mass located on axis, but at some distance from the plane of the bearing. The bearing must therefore be able to resist axial radial and moment loads which will change systematically with telescope tube altitude. Bearing accuracy and flexure will effect the pointing of the telescope and so this must be kept to a minimum. In particular non-repeatable errors of the bearing must be reduced.

3.2.1 Size

The diameter of the bearing is determined by matching its size to the instrument support structure. The most direct load path is desired to minimize flexure and hysteresis. This diameter obtained in this way is adequate to accommodate the wide field mode and provides for a bearing of adequate stiffness and static capacity.

3.3 Cassegrain rotator servo system.

The servo sytem is required to position and track the rotator accurately to commands issued by the Telescope Control System. The servo system must be stable from tracking velocities which approach zero, to slewing speeds. The accelerations involved are minimal as are external disturbance torques, however the friction in the rotator bearing is considerable, varies with telescope tube elevation, and is very non-linear at slow speeds. The servo system must be able to position and track accurately despite these effects.

4 Cassegrain cable wrap-up system

This section will outline the overall design requirements of the cable wrap as a subsytem and will go on to cover the major elements which comprise the cable wrap in the current preliminary concept.

The cassegrain cable wrap provided cables and services to the facility and instrumentation systems mounted on the cassegrain rotator.

4.1 General description.

The cassegrain cable wrap is a squat cylindrical assembly located beneath the primary mirror cell. It occupies the space between the cassegrain rotator and the mirror cell support structure. Its function is to maintain cabling and services from the primary mirror cell to units located on the cassegrain rotator. It will do this by employing a rolling loop arrangement, the services being carried in flexible channel trunking. It will comprise of two main parts, the static cable guide, attached rigidly to the mirror cell and the rotating cable guide attached to the Cassegrain rotator. The static guide will have interfaces to the mirror cell services distribution system, while the rotating part will have interfaces to the cassegrain systems (instruments, A&G, AO e.t.c).

4.1.1 Mechanical range

The rotation range of the cable wrap will be ± 280°.

The normal operating range will be ± 270° and the extra travel is required to ensure that cables/services are not damaged in the event that the rotator hits a mechanical endstop. In addition an allowance is required for ease of aligning the rotator zero position with the cable wrap zero position.

4.1.2 Capacity

The capacity of the cable wrap will be two cable chains with 80mm x 300mm internal space. The effective availablel space will be reduced by fixed partitions within the cross section and the need to allow space for cables and hoses to move during the operation of the cable wrap.

4.1.3 Mass

The mass allocation attributed to the cable wrap will be 300kg.

This is apportioned from the cassegrain mass balance budget. Table x shows the distribution of mass among the different cassegrain subassemblies which is consistent with maintaining overall telescope tube balance.

4.1.4 Cable wrap drive.

The cassegrain cable wrap will not be driven independently. The inner, moving, part of the cable wrap will be attached to and supported by the cassegrain rotator. This will increase the loads on the rotator bearing and drive system but will not significantly effect the rotator performance.

4.1.5 Compressed Helium, coolant and vacuum lines.

These services will be supported by the cable wrap. The inclusion of these services will have an impact on the capacity of the cable wrap and on the minimum bend radius used in the rolling loop arrangement. This in turn will be a major factor in determining the outer diameter of the cable wrap.

4.1.6 Balance.

During rotation, the center of gravity will move, from nearly on the rotator axis, out to 1.2 m away from the axis. The locus of this movement will have a preferred direction relative to the initial rotational alignment. It will be necessary to align the cable wrap such that this direction lies along the telescope tube elevation axis reducing the out of balance torque on the telescope elevation drives. There will be no active balancing of the mechanism.
Table x. Shows the allocation of dynamic out of balance for the cassegrain assembly.

4.1.7 Cable access.

It will be possible to replace a cable, hose, or other service without demounting the major elements of the cable wrap.

4.1.8 Performance

These performance requirements are derived from the requirements and loads placed on the cassegrain rotator.

• Max moment of inertia (loaded)	< 2000 kg-m^2 (1/10 of rotator inertia)
• Drive friction	< 200 Nm wrt rotator axis
• Max track speed	0.5°/sec
• Max slew rate	2.0°/sec
• Max track / slew acceleration	0.1 /sec^2
• Balance Goal	<100Nm/360 degrees perpendicular to telescope tube elevation axis

4.2 Static cable support.

The static cable support will be fixed to the primary mirror cell. It will be formed from an inward facing channel which supports the rolling loop and a distribution channel which will be used to distribute the cables and services to mirror cell breakout panels. The distribution channel can be accessed from beneath by removing inspection covers. The mirror cell breakout panels will extend up into the mirror cell. The primary mirror cell will have 8 equispaced pads with fastener detail forming the mechanical interface.

4.2.1 Mechanical interface to mirror cell

The lower face of the mirror cell will have 8 raised mounting pads with M12 clearance holes on 4.4 m and xxxm diameters.

The mirror cell will have clearance holes which allow the breakout panels to protrude upwards, 400mm from the cell/ former interface.

4.2.2 Mirror cell breakout panels

Two breakout panels will be used to interface with the mirror cell services distribution system. They will be 800 x 300mm mounted on breakout boxes attached to the static cable guide. These boxes will be re-entrant into mirror cell; all cables/hoses will terminate with through bulkhead connectors. Helium lines, vacuum lines, and coolant lines will have self sealing connectors.

4.3 Rotating cable support.

The rotating cable support will be formed from an outward facing channel which supports the rolling loop and a distribution channel used to distribute the cables and services to the 8 services interface panels. Access to the distribution channel will be provided by detaching the interface panels.

4.3.1 Mechanical interface to rotator.

8 support brackets will be used to join the inner cable guide to the cassegrain rotator.

4.3.2 Services interface panels

There will be 8 panels 1000 x 150 mm; all cables will terminate with through bulkhead socket connectors, helium and coolant lines will terminate with through bulkhead self sealing couplings.

4.4 Cable chain

There are a number of commercially available cable chains. These are articulated trunking formed by joining hinged sections together to form a chain. The hinges can have restrictions on their movement giving a minimum bend radius. The sections can be opened form one side to allow insertion or removal of cables. Partitions are also available to separate and protect the cables/hoses.

The cable wrap will employ two nested cable chain loops each 80 x 300mm capacity. The type used is E-Chain TI /E-Tube TI Cable carrier systems or equivalent.

4.4.1 Cables and services

The cables and services which will be contained within the cable carrier are listed as follow.

- 8, 3/4" Helium lines (4 sets)
- 6 AC lines
- 6 Reset Cables
- 12 Fiber Optic Cables
- 6 RS 232 Ribbon Cables
- 4, 3/4" Coolant Hose

4.4.2 Helium lines.

The cable wrap will support high pressure helium lines for closed cycle and Joule Thomson coolers. These will be corrugated metal hoses with a stainless steel braiding and an outer covering of PVC. They are designed to flex by bending and have a minimum working bend radii depending on initial diameter and configuration. The lines which will be used at the cassegrain will be 3/4inch ID pipe with a minimum working bend radius of 7 1/2 inches (centerline).

4.4.3 Cables, fibre optics and hoses for cable wraps.

Special cables. fiber optics and hoses are available for use within this type of rolling loop cable wrap. These generally have no tendency to twist on bending, are more flexible and have outer sheathing which is selected with this application in mind. Where possible the cable wrap will employ these cables and hoses.

5. Instrument Support Structure (ISS)

This section will outline the overall design requirements of the instrument support structure as a subsystem and will go on to cover the major elements which comprise the ISS in the current concept.

The instrument support structure acts as the mechanical interface between the facility and science instrumentation systems and the cassegrain rotator. The design must also accommodate electrical and optical interfaces where appropriate.

5.1 General description

An upper flange will locate on the cassegrain rotator and the assemblies will be bolted together. Beneath the flange, the structure is roughly cubic in shape. In effect it forms a type of three dimensional "optical bench". There will be five available mounting faces, one upward looking (telescope tube z axis) and the remaining will be side looking. These faces will form the interfaces for the facility and science instruments, Adaptive C)ptics and facility calibration. The base of the cube will be removable to allow access to a cylindrical cavity within the structure. This space will house the guidance /wavefront sensing units and the science beam fold unit which can be used to direct the telescope beam to the side looking instruments.

5.1.1 Overall dimensions

The overall dimensions will be 1600 x 1600 x 1650 m across the flats (I x w x h, telescope at zenith)

5.1.2 Mass

The mass allocated to the instrument support structure will be 3200kg.

This is apportioned from the total cassegrain mass balance bidget. Table X shows the distribution of mass among the different cassegrain subassemblies which is consistent with maintaining overall telescope tube balance.

5.1.3 Focal Stations - available field Size

The ports in the ISS will be sized as follows

- Upward-looking science port diameter will be 350mm, sufficuent to pass up to 7 arc min @ f/16
- Sideward-looking science ports diameter (4) will be 350mm, sufficient to pass up to 7 arc min @ f/16
- Side-looking Adaptive optics feed port diameter will be 200mm, sufficient to pass up to 3 arc min @f/16

5.1.5 Dimensional accuracy.

The dimensional accuracies stated here are geometric tolerances of positions and angles of planes, obtained by sampling points on the spatial scales equal to the overall dimensions.

Deformations are stated as maximums, occurring from zenith to horizon pointing.

- Mounting Surface Accuracy (typical)
  - positional tolerances ± 0.05 mm
  - parallelism / perpendicularity tolerance ± 0.0055°
- Deformation (instrument relative to bearing axis)
  - instrument de-center < 0.05 mm
  - instrument tilt < 0.0055°

5.2 Cassegrain rotator mechanical interface

The cassegrain rotator interface will perform the functions of locating the ISS on the rotator and of transmitting the structural loads from the ISS to the rotator. The requirements on the support of the rotator bearing play a major role in the specification of this interface. The interface will be designed to distribute loads evenly into the rotator, and to deform in a smoothly varying manner with a limited amplitude. The initial flatness of the interface is also important to the smooth operation and longevity of the bearing. The design will incorporates a circular flange attached to the internal cylinder of the ISS. The upper surface of the flange will be machined to provide a locating pilot diameter and a flat interface surface. The flange will have a PCD of clearance holes for fasteners. The flange will be deep enough to allow access to the fasteners and to facilitate their extraction from outside the ISS.

Circumferential (waviness) deformation must be within 0.254 mm/90° segment

5.3 Side-Looking Instrument Interface

The side looking ports will be parallel to the xz and yz planes of the telescope tube coordinate system when the rotator is at Zero angle of rotation. Each side looking interface will have two possible ports through which the telescope beam can be directed, the main science port, located central to the interface and a higher port (in positive z direction) used by the Adaptive Optics system. The mechanical interface will be formed by an array of raised bosses into which receivers will be inserted. The receivers will define a mounting plane. Instruments will use a subset of these receivers for mounting and support.

In order to simplify reconfiguration of the cassegrain instruments, the interface loads will be constant. This will be achieved by mounting a ballast weight with each instrument which will maintain the loading and center of gravity position. In this way the telescope tube balance can be maintained as well as the validity of the telescope pointing model.

The requirement to accommodate a range of instrument sizes and masses has led to standardizing the mechanical interface detail.

5.3.1 Telescope foci

The telescope focus is located central to the mechanical fastening detail and is 300 mm out from the interface plane.

At the upper adaptive optics port, the cental axis located 517 mm above the science port and is therefore 817 mm out from the interface plane.

5.3.2 Mounting face loads.

The four side looking ports will be divided into two opposite ports which will carry 20OOKg each and two opposite ports which will carry 80OKg. These will be designated ports 2 and 4, 3 and 5 respectively. The loads will have their centers of gravity, along the port axis and 1 meter from the mechanical interface. The load will include the instrument, associated electronics and a ballast weight. These loads and C of G positions will be consistent with the telescope tube balance budget.

• Allowable Mass Load (ports 2,4) Ballast will be required to bring the total weight up to 2000Kg. and adjust the CofG position	0 to 2000 kg at 1.0 m from face.
• Allowable Mass Load (ports 3,5) Ballast will be required to bring the total weight up to 800Kg and adjust the CofG position	0 to 800 kg at 1.0 m from face
• Maximum Allowable Mass Load. Load can be redistributed from other ports while maintaining rotator and telescope tube balance.	
• Side port (approx.)	< 4300 kg at 1 m from face (mass redistribution from adjacent port faces)

5.3.4. Instrument Mechanical Changeover Time

The goal for instrument changeover is 20 minutes. The design of the fastener detail will support this goal by providing a standard interface which is compatible with the instrument handling equipment. The time taken for the mechanical attachment and reattachment of instruments will not dominate instrumentation changeover times.

5.3.5 Ballast weight.

Each instrument will have a ballast weight which, when combined with the instrument places a load on the port of 2000 or 800 kg with a C of G central to the port face and 1000 mm from the port face. Given the range of sizes and masses of instruments it is impractical to design a universal ballast weight and support system which satisfy all requirements. As a rule of thumb, for smaller instruments the Gemini project office will design the ballast system while builders of larger instruments will integrate the design with their instrument.

5.4 Upward-Looking Instrument Interface

The upward looking port is parallel to the xy plane of the telescope tube co-ordinate system. The term ’upward looking’ refers to the telescope tube at zenith. The telescope beam will pass directly through the main science port, located central to the ISS interface. The mechanical interface will be formed by an array of raised bosses into which receivers are inserted. The receivers will define a mounting plane for instrumeny support. Instruments will use a subset of these receivers.

5.4.1 Telescope focus

The science port focus is located central to the mechanical fastening detail and is 300 mm out from the interface plane (negative z).

5.4.2 Mounting face size.

Each raised boss will have a circular locating area 100mm in diameter. These will be arranged on an orthogonal grid, centered on the science port. The pattern is interrupted by the science port. The locations will be shared by the instrument, its associated electronics and its ballast weight. The bosses located at the extreme edges will form a square 1200 mm x 1200 mm.

5.4.3 Mounting face loads.

The upward looking port will carry a load of 2000Kg. with a C of G along the port axis 1 meter from the mechanical interface (negative z). The load will include the instrument, associated electronics and a ballast weight. This load and C of G position is consistent with the telescope tube balance budget.

• Allowable Mass Load Ballast is required to bring the total weight up to 2000Kg. and adjust the CofG position	0 to 2000 kg at 1.0 m from face.
• Maximum Allowable Mass Load. Load may be redistributed from other ports while maintaining rotator and telescope tube balance.	
Upward looking (approx.)	< 4300 kg at 1 m from face (mass redistribution from adjacent port faces)
• Locating dowel hole size	050 -0,+0.012, 100mm deep
• Tapped Detail	M20
• Flatness (Form) when assembled	± 0.05 mm
• Optical axis accuracy	

  - positional when mounted ± 0.05 mm
  - parallelism/perpendicularity when mounted ± 0.0055°
- Repeatability
  - postitional < 0.02 mm
  - parallelism 0.002°

5.4.5. Instrument Mechanical Changeover Time

The goal for instrument changeover is 20 minutes. The design of the fastner detail will support this goal in providing a standard interface which will be compatible with the instrument handling equipment. The time taken for the mechanical attachment and reattachment of instruments will not dominate instrumentation changeover times.

5.4.6 Ballast weight.

Each instrument will have a ballast weight which, when combined with the instrument mass places a load on the port of 2000 or 800 kg with a C of G central to the port face and 1000 mm from the port face. Given the range of sizes and masses of instruments it is impractical to design a universal ballast weight and support system which will satisfy all requirements. As a rule of thumb, for smaller instruments the Gemini project office will design the ballast system while builders of larger instruments will integrate the design with their instrument.

5.5 Instrument support structure base

The instrument support structure base will form the upward looking instrument mechanical interface and also the mechanical interface to the assemblies contained within the ISS. The base of the instrument support structure will be removable, to allow access to the assemblies housed inside.

The base must be rigid but efficient in terms of mass. It has a fraction of the mass apportioned to the ISS in the cassegrain system mass/mass moment budget. Optimization of the ISS for flexure vs. mass will include the base.

In the current preliminary design the structure consists of a top and bottom plate sandwiching orthogonal shear webs in an 'eggcrate pattern'. The bosses for the instrument fastener receivers are located at the shear web intersections and run between the top and bottom plate. The resulting structure is efficient and will allow high 'point' loading at the bosses.

5.5.1 Mechanical interface to the ISS.

The interface will be rigid, repeatable and easily engaged /disengaged.

The current design will consist of a guiding pilot diameter which is be a clearance fit on the ISS. Accurate location will be obtained by engaging self jacking or expanding dowels, and the process will be completed by bolting the assemblies together with clearance fasteners.

5.5.2 Mechanical interface to the guidance /wavefront sensing modules.

The current design will consist of a guiding pilot diameter which is be a clearance fit on the guiding/wavefront sensing module. Accurate location will be obtained by engaging self jacking or expanding dowels, and the process will be completed by bolting the assemblies together with clearance fasteners.

Locating the guider interface on the base of the ISS will compensate to some extent the lateral gravity induced flexure of the upward looking instrument interface improving facility tracking performance.

5.6 Guidance / wavefront sensing / science fold unit interfaces

The design of the ISS will support these functions. At this time the implementation of these functions is the subject of a design study by the Royal Greenwich Observatory. This section is based on the preliminary design concept as it exists at this time.

These functions will be carried cfut by 3 separate cylindrical modules located within the ISS. The modules are stacked together forming a subassembly which is attached to the ISS base.

5.6.1 Space requirements.

The space available within the ISS is a cylindrical cavity 700mm on radius and 1400mm high. The design for the internal modules will meet its functional requirements within this space envelope.

5.6.2 Mechanical interface.

The mechanical interface for the modules will be on the ISS base. The ISS / ISS base interface will be designed to facilitate disassembly to aid in access to the internal modules.

The current design will consist of a guiding pilot diameter which is be a clearance fit on the guiding/wavefront sensing module. Accurate location will be obtained by engaging self jacking or expanding dowels, and the process will be completed by bolting the assemblies together with clearance fasteners.

5.6.3 Electronics interface.

The electronics interface allow efficient dissassembly and re-assembly of the guidance WFS module to the ISS.

Provision will be made for supporting and routing of a cabling /services harness. This harness will connect the module to its electronics enclosure.

Sufficient space will be available for locating the module electronics enclosure outside the ISS. A mechanical interface for mounting the electronics enclosure will also be provided.

The electronics enclosure will interface to a standard instrument interface panel on the Cassegrain cable wrap.

5.6.4 Optical Interface.

The ISS provides AO feed ports on each side looking instrument interface to allow the telescope beam to be directed into the AO unit (a function of the guider / LRWFS unit). The science ports are provided to allow the telescope beam to be directed into the side looking instruments (a function of the science field fold unit).

5.6.5 Mass Balance

From the cassegrain mass/balance budget, the A&C internal modules have been apportioned a combined mass of 60OKg, with a C of G on axis (on the z axis of the telescope tube co-ord system) and 1 100 mm up from focus (positive z direction).

5.7 AO unit interface

The design of the ISS will support these functions.

At this time the implementation of these functions is the subject of a design study by the DAO. This section is based on the preliminary design concept as it exists at this time.

The AO module will be mounted on a side looking port. It will accept the telescope beam through the upper (AO) feed port, and returns the corrected beam, back through the science field port.

5.7.1 Optical interface

An AO feed port will be provided on each of the side looking interfaces of the ISS. The telescope beam is will be redirected by the AO feed mirror (a function of the A&G module) through this port, and into the AO module.

The feed port will be 200mm in diameter and will have provision for fitting light tight baffles. It is positioned 517 mm above the science field port (positive z in the telescope tube co-ord system).

The corrected science beam will be returned into the ISS through the science field port on the same face as the AO feed port. It will be directed to the other instrument ports by means of the science field fold flat. The science port will be 1100mm up from focus (positive z in the telescope co-ord system) and will be located at the midpoint of the instrument interface. Provision will be made for fitting light tight baffles.

5.7.2 Mechanical interface.

The mechanical interface for the AO unit will be a standard instrument interface. It will be subject to the same restrictions as any instrument mounted on a facility port. (ports 3 or 5, see section 'sideward looking instrument interface').

5.7.3 Electrical and services

The AO module will be treated as a science instrument. It will have access to the standard set of services for an -instrument. These will be provided on an instrument services panel located above the unit on the cable wrap inner.

6 Thermal management.

Because of the stringent image quality requirements placed on the telescope it will be necessary to limit heat released into the enclosure (reducing dome seeing effects). In the cassegrain systems most of the heat is generated by the electronics required to control detectors, or motors e.t.c. These electronics will be contained within insulated enclosures, cooled by air to liquid heat exchangers.

6.1 Heat generated by cassegrain systems

The following is an estimate of the heat generated by the cassegrain systems based on the preliminary design study.

- Power Generated
  - Rotator Drive Motor(s) — 0.3 kW (per motor)
    - drive motor electronics — 1 kW *
  - A&G Unit Electronics — 0.5 kW
    - A&G Unit — 0.05 kW
  - AO Unit Electronics — 1 kW
    - AO Unit — 0.05 kW from motors & mechanisms
  - Calibration Unit Electronics & Sources — 2 kW
  - Instruments Electronics (3 operational) — 3 kW

The rotator drive motor electronics will be located on the telescope center section.

6.2 Cooling system

The cooling system will consist of air to liquid heat exchangers within the electronics enclosures. The cooling liquid will be supplied by the telescope/enclosure heat exchanger circuit through the cassegrain cable wrap.

- Cooling System
  - Capacity — 8 kW
  - Type — Closed Circuit Gas to Liquid Heat Exchanger
  - Coolant — Water - Antifreeze mixture
  - Coolant Flow Rate — 6.0 gallons/min
  - Input Temperature — 0 °C
  - Output Temperature — 5 °C
  - Residual Power Leaked to Enclosure — 500 W (assumes electronics cabinets stabilized at 25 °C)
  - Electronics Cabinet Enclosure Insulation — 25.4 mm, thermal conductivity 0.04 W/m-°C
  - Electronics Cabinet ISS Insulation — Sufficient to avoid temperature differences of more than 2 degrees around the interface location on the ISS

6.3 Cooling system interface to instruments.

Supply and return coolant lines will run through the cable wrap. Each instrument services interface panel will furnish a supply and return linked to the coolant lines. Instruments will connect up to the panels with self sealing couplings.

6.4 Electronics enclosures.

The electronics enclosures will be compatible with standard 19 inch racks. They will have to be air tight and well insulated. The configuration of the racks will allow for efficient air circulation around the boards, particularly avoiding stagnant areas where components may overheat. Convenient access to the boards is essential for ease of maintenance. The circulation within the cabinet will not be significantly effected by change in orientation of the cabinet.

Temperature monitoring will be required to diagnose problems with the cooling system and to signal failure. Overheating can cause damage to the electronics.

Thermostatic flow control valves will be located within the enclosures.

7. Handling

Handling requirements involve specifying the equipment, systems and procedures necessary to configure the cassegrain assembly. The major design issues are safety, protection of instrument systems and operational efficiency.

7.1 Instrument handling rigs.

All instrument systems will have a handling rig which will facilitate the service, storage and movement of instruments within the telescope and enclosure environment. Its design will allow transfer of the instrument onto the cassegrain handling rig.

7.2 Cassegrain handling rig.

The cassegrain handling rig will be used to service the cassegrain assembly elements and to facilitate reconfiguration of the cassegrain instruments. A preliminary design for this device has not been developed at this time but it will have the following features.

- Lifting platform, height of 4.5 meters.
- Lift capacity of 5 tonnes, motorized.
- Stabilizing for lifting procedure
- Fine adjustment of load orientation when extended
- Maneuverability when collapsed and self powered.
- Interface with instrument handling rigs to allow load transfer

8 Cassegrain system performance.

The performance requirements and goals stated in the Gemini science requirements document generally refer to the overall telescope systems performance, of which the cassegrain assembly is only a part. Furthermore the cassegrain assembly itself is comprised of subassemblies and components each of which effect the overall system performance in different ways and to different extents. To ensure that the overall systems performance requirements are met, the Gemini error budget plan assigns performance figures to subassemblies which are consistent with the overall performance goals. This is a top down error budget. In developing a preliminary design, the performance of components and assemblies will be estimated in a form compatible the with the error budget plan and compared. This iterative process will be used to resolve conflicts. The following sections shows how well the current preliminary design meet's the performance goals.

8.1 Pointing

From the Gemini systems error budget plan the following goals are set for f / 16.

- Overall telescope pointing 3 arc second rms
- Detector position 1.391 arcsecods

8.2 Tracking

From the Gemini systems error budget plan the following goals are set for f / 16.

- Overall telescope tracking 0.02 arc second rms
- Drive servo position eff or 0.009 arcseconds
- Detector 0.005
- Guide detector position wrt science detector 0.005

Cassegrain tracking error budget.

The bottom up cassegrain error table is constructed by considering the errors which will occur in tracking the science object with the telescope control receiving signals from one of the peripheral wavefront sensors. The science object is considered to be on axis and the guide probe 6 arcmin... distant. The errors arise from two main sources, servo error of the cassegrain rotator which is derived from the cassegrain rotator servo model and differential flexure and thermal stability of the guider relative to the science focal plane. The rest of the telescope and the instrument is assumed to be perfect.

8.3 Image size.

In the IR optimized mode with a directly fed instrument, the image quality is affected by the cassegrain assembly only through its contribution to enclosure and telescope seeing. (excluding tracking effects, dealt with above). There will be further consideration for side looking instruments which use the folding flat.

From the Gemini systems error budget plan the following goals are set for f / 16, 50% encircled energy at 2.2 microns.

- Overall telescope image quality 0. 1 arc seconds
- Enclosure seeing 0.03 arcseconds
- Telescope (thermal seeing) 0.018

8.4 Emissivity.

The fully optimized IR configuration will have a telescope emissivity, including scattering and diffraction, of 2% immediately after coating or recoating optics, with 0.5% maximum degradation during operations, at any single wavelength beyond 2.2 micron.

In the error budget the contribution from the cassegrain area must fall within the category 'all other sources'. From the error budget.

- Overall telescope emissivity 2%
- All other sources 0.05%

8.5 Throughput.

In the Gemini science requirements the throughput goals are defined for optical and IR configurations.

8.5.1 Optical

The optical configuration throughput is not explicitly stated for the telescope system, but rather in terms of the performance of coatings and surfaces. In the optimized mode with a direct beam feed, the cassegrain assembly will not effect throughput unless vignetting occurs from the peripheral guide probes (all optical ports have sufficient diameter to avoid vignetting under all circumstances). For the side looking instruments the science fold mirror will have a direct effect.

The resultant design requirement will be a part of the fold mirror specifications.

8.6.2 IR

from the Gemini science requirements document 'For the IR, the throughput is calculated as the fraction of photons transmitted by the IR configuration compared to that transmitted by an 8.00 m diameter telescope with no obscuration and with perfectly reflecting mirror surfaces.'

The throughput requirement thus defined is 0.91 with 0.93 as the goal.

The cassegrain element, including the peripheral guide probes will not be allowed to shadow the IR field. The direct- upward looking instrument interface will satisfy this requirement.

Throughput will of course be reduced for the side looking instrument, but it can shown that if the goal is met for the direct IR optimized case, the requirement will be met with the side looking instrument, assuming a folding flat of reasonable quality.