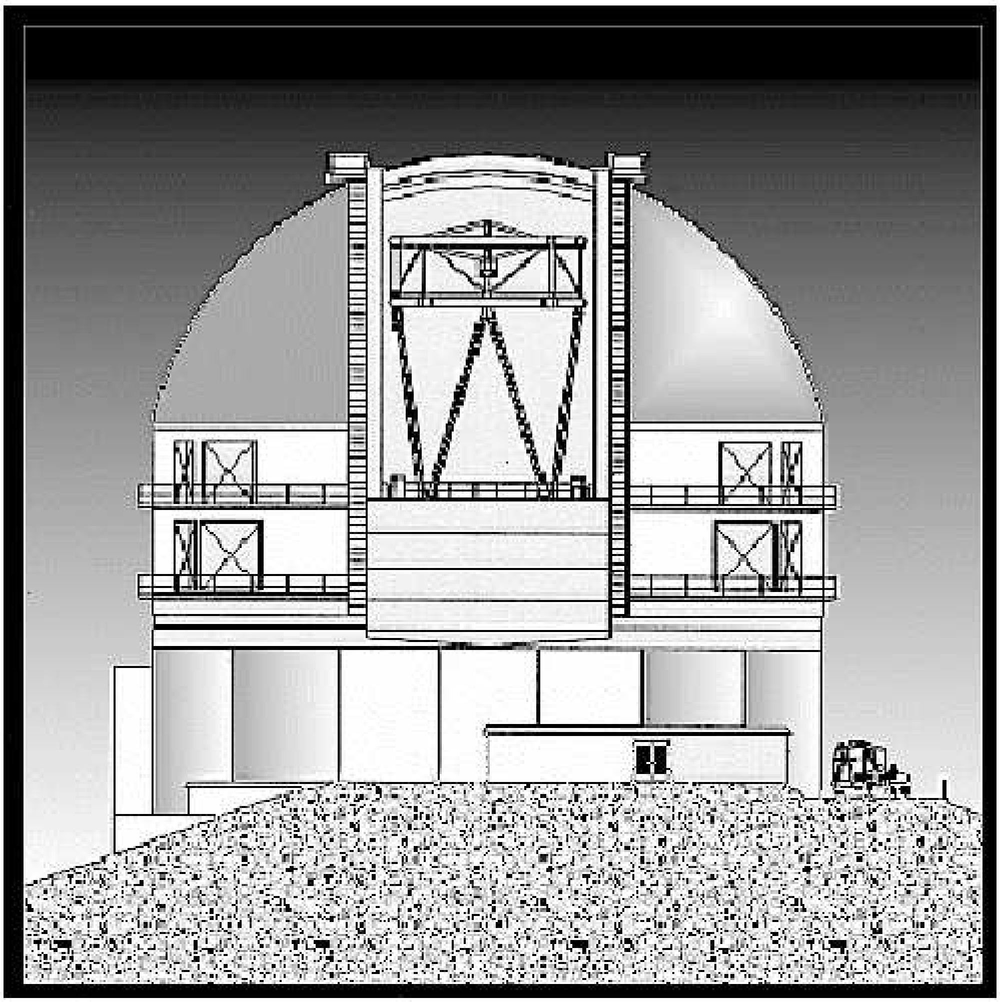
GEMINI
8-M Telescopes
Project

SPE-O-G0057

M2 POSITIONING SYSTEM
DESIGN REQUIREMENTS DOCUMENT



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1.0 Scope

This document details the requirements of the two axis M2 Positioning System for the f/16 Secondary Assembly of the Gemini eight meter Telescopes. The M2 Positioning System consists of the M2 Positioning Mechanism, the M2 Positioning Sensor Electronics Module, the M2 Positioning Drive Amplifier Module, and their associated cabling. Control Functions for the M2 Positioning System are performed by the M2 Tilt System. The M2 Positioning Mechanism must support and translate the f/16 Secondary Mirror and the M2 Tilt Mechanism.

The M2 Positioning System is for use with the Gemini 8 meter Telescopes operated with the f/16 Secondary Mirror and the M2 Tilt System. The M2 Positioning System produces translation in two axes to assure accurate alignment of the f/16 Secondary Mirror to the Telescope optical system. The M2 Positioning System will be used to correct for Telescope structural sag at different zenith angles, temperature gradients and for wind induced errors. It will also be used to correct for initial misalignments within the f/16 Secondary Assembly and to the Telescope optical system.

1.1 Paragraph References

When a paragraph within this Design Requirements Document is referenced each applicable subindentured paragraph shall be considered as referenced also.

1.2 Definitions

The following terms and their use throughout this Design Requirements Document will be consistent with these definitions.

(a) Actuator - An "Actuator" is a device used to produce motion of the M2 Tilt Mechanism Mounting Features.

(b) c.g. - The term "c.g." means center of gravity.

(c) f/16 Secondary Assembly - The "f/16 Secondary Assembly" consists of the f/16 Secondary Mirror, the M2 Tilt System, the M2 Positioning System, the M2 Deployable Baffle, and the M2 Central Baffle.

(d) f/16 Secondary Mirror - The "f/16 Secondary Mirror" is defined on drawing 85-GP-3200-0004.

(e) f/16 Secondary Mirror Position - "f/16 Secondary Mirror Position" is the combination of the location of the f/16 Secondary Mirror c.g. and tilt of the f/16 Secondary Mirror about its c.g. relative to the M2 Positioning Mechanism Mounting Features.

(f) focus - Motion of the f/16 Secondary Mirror Position in the Z direction is termed "focus".

(g) Horizon pointing - "Horizon pointing" is defined as the mechanical axes, as defined in section 1.3, below, oriented with the X and Z axes in the horizontal direction and the Y axis oriented vertically up.

(h) Lifting Points - The "Lifting Points" are shown and identified on drawing 85-GP-3400-0001.

(i) M2 Positioning Drive Amplifier Module - The "M2 Positioning Drive Amplifier Module" contains the drive amplifiers for the motors of the M2 Positioning System, the M2 Deployable Baffle and the M2 Central Baffle. The "M2 Positioning Drive Amplifier Module" is a single enclosure containing the electronics that are not necessary to be in close proximity to the M2 Positioning Mechanism. Its size, location mounting details and interfaces are specified on drawing 85-GP-3400-0001.

(j) M2 Positioning Mechanism - The "M2 Positioning Mechanism" contains the Actuators and Sensors used to produce the required motion of the f/16 Secondary Mirror Position. It is contained in the envelope specified by drawing 85-GP-3400-0001. The M2 Tilt Mechanism with or without the f/16 Secondary Mirror installed is attached to the M2 Positioning Mechanism with the parts and in the manner specified on drawing 85-GP-3000-0002. The M2 Positioning Mechanism is mounted in the manner specified on drawing 85-GP-3000-0002.

(k) M2 Positioning Sensor Electronics Module - The "M2 Positioning Sensor Electronics Module" contains the electronics that must be located in close proximity to the M2 Positioning Mechanism in order for the M2 Positioning System to meet its requirements. Its size, location, mounting details and interfaces are specified on drawing 85-GP-3400-0001.

(l) M2 Positioning System - The "M2 Positioning System" is the system used to translate the M2 Tilt Mechanism with or without the f/16 Secondary Mirror installed, in the X and Y directions. It contains the M2 Positioning Mechanism, the M2 Positioning Sensor Electronics Module, the M2 Positioning Drive Amplifier Module, and their associated cabling. The M2 Positioning System envelope is specified on drawing 85-GP-3400-0001.

(m) M2 Tilt Mechanism - The "M2 Tilt Mechanism" is the mechanism used to tilt and focus the f/16 Secondary Mirror. Its envelope is shown on drawing 85-GP-3100-0004.

(n) M2 Tilt Mechanism Mounting Features - The "M2 Tilt Mechanism Mounting Features" are the features the M2 Tilt Mechanism mounts to on the M2 Positioning Mechanism. They are shown on drawing 85-GP-3400-0001.

(o) Mounting Features - The M2 Positioning Mechanism shall be mounted on the "Mounting Features" as shown on drawing 85-GP-3400-0001.

(p) non-repeatability - Use of the term "non-repeatability" in this document is defined as the event being between ±3 standard deviations, six (6) standard deviations total, of a Gaussian frequency distribution. The value stated is the full six (6) standard deviation range.

(q) Sensors - The "Sensors", which are contained in the M2 Positioning Mechanism, measure the position of the M2 Tilt Mechanism Mounting Features and, therefore, f/16 Secondary Mirror Position within the requirements of this Design Requirements Document.

(r) Set Position - The "Set Position" is the f/16 Secondary Mirror Position in X-Y translation, tilt and focus set by the M2 Positioning System and the M2 Tilt System.

(s) Telescope - The "Telescope" is the Gemini 8 meter telescope.

(t) Telescope Control System - The "Telescope Control System" is the electronic control system for the Telescope.

(u) Zenith pointing - "Zenith pointing" is defined as the mechanical axes, as defined in section 1.3, below, oriented with the X and Y axes in the horizontal direction and the Z axis oriented vertically up.

1.3 Coordinate axes and directions

Coordinate axes and directions will be referenced in this document. The coordinate system used is a right handed Cartesian coordinate system. The Z axis is the optical axis of the Telescope positive from the primary mirror towards the f/16 Secondary Mirror. The X axis is parallel to the Telescope elevation axis. The Y axis forms the third axis of the right handed Cartesian coordinate system and is pointed vertically up with the Telescope in the horizon pointing orientation.

2.0 Applicable Documents

The following documents form a part of this specification to the extent referenced.

2.1 U. S. Government Documents

2.1.1 Military Standards

MIL-STD-810E, July 1989

2.2 AURA Documents

2.2.1 Drawings

85-GP-3100-0004	ENVELOPE, TIP-TILT SYSTEM, f/16 SECONDARY MIRROR
85-GP-3400-0001	ASSEMBLY, M2 POSITIONING MECHANISM

85-GP-3200-0004	ASSEMBLY, f/16 SECONDARY MIRROR
85-GP-3300-0001	ASSEMBLY, M2 DEPLOYABLE BAFFLE
90-GP-0003-0001	ICD, f/16 SECONDARY MIRROR ASSEMBLY TO TIP-TILT SYSTEM

2.2.2 Requirements Documents

SPE-ASA-G0008	GEMINI ELECTRONICS DESIGN SPECIFICATION
SPE-O-G0039	M2 TILT SYSTEM DESIGN REQUIREMENTS DOCUMENT

3.0 Requirements

3.1 Mechanical Requirements

3.1.1 Physical Requirements The M2 Positioning System shall conform to the envelope defined by drawing 85-GP-3400-0001.

3.1.1.1 The M2 Positioning Mechanism shall mount on the features shown and as specified on drawing 85-GP-3000-0002.

3.1.1.2 The M2 Tilt Mechanism shall mount to the M2 Positioning Mechanism on the features shown and as specified on drawing 85-GP-3000-0002.

3.1.1.3 The f/16 Secondary Mirror Assembly shall mount on the M2 Tilt Mechanism as shown on drawing 90-GP-0003-0001.

3.1.1.4 The coordinate system for the M2 Positioning System is shown on drawing 85-GP-3400-0001. The axes are located and oriented from the datums as shown on drawing 85-GP-3400-0001. The X-axis is oriented horizontally for all operations.

3.1.1.5 The M2 Positioning Mechanism shall have a mass no more than 200 kg. The M2 Sensor Electronics Module shall have a mass no more than 30 kg.

3.1.2 Range of Motion The M2 Positioning System shall be capable of producing translation of the f/16 Secondary Mirror Position in the X and Y directions, centered on the origin as defined on drawing 85-3400-0001. Translation in the X direction shall be 0.005 m total minimum. Translation in the Y direction shall be 0.010 m total minimum.

3.1.3 Mechanical Accuracies The M2 Positioning System shall meet the requirements contained in this paragraph 3.1.3 after initial alignment of the f/16 Secondary Assembly to the Telescope optical system, with the f/16 Secondary Mirror mounted to the M2 Tilt Mechanism in accordance with drawing 90-GP-0003-0001, the M2 Tilt Mechanism mounted to the M2 Positioning Mechanism in accordance with drawing 85-GP-3000-0002, and the M2 Positioning Mechanism mounted in accordance with drawing 90-GP-0003-0001.

3.1.3.1 Inaccuracy of f/16 Secondary Mirror Position, in decenter, shall be no greater than 20 µm total, including, without limitation, M2 Positioning System inaccuracies, non-repeatability, resolution and decenter due to tilt.

3.1.3.2 Inaccuracy of f/16 Secondary Mirror Position, in focus, shall be no greater that 5 µm total, including, without limitation, fabrication and assembly inaccuracies in the M2 Positioning Mechanism.

3.1.3.3 Rotation of the M2 Tilt Mechanism Mounting Features about the Z axis shall not exceed 74 arcsecond total through the full range of motion specified in section 3.1.2 above, and over the environments of sections 3.4.1 and 3.4.2 below.

3.1.4 Natural Frequencies The minimum natural frequency of the M2 Positioning System when mounted on the Mounting Features shown on drawing 85-3400-0001 and with the M2 Tilt Mechanism installed in accordance with drawing 85-GP-3000-0002 and the f/16 Secondary Mirror installed in accordance with drawing 90-GP-0003-0001, shall be 60 Hz.

3.1.5 Deflection Under Load. With the M2 Tilt Mechanism installed in accordance with drawing 85-GP-3000-0002 and the f/16 Secondary Mirror installed in accordance with drawing 90-GP-0003-0001, f/16 Secondary Mirror Position shall not change due to deflection of the M2 Positioning Mechanism more than 125 µm in decenter (X-Y direction) including without limitation decenter due to tilt, 70 µm in the Z direction nor 30 arcsecond in tilt. The deflection shall be measured between the horizon pointing and zenith pointing orientations.

3.1.6 Lifting Points. The M2 Positioning Mechanism shall have three Lifting Points. They shall be located as shown on drawing 85-GP-3400-0001. Each Lifting Point shall be capable of supporting the M2 Positioning Mechanism weight with the M2 Tilt Mechanism installed in accordance with drawing 85-GP-3000-0002 and the f/16 Secondary Mirror Assembly installed in accordance with drawing 90-GP-0003-0001.

3.2 Electrical Requirements

3.2.1 Power Consumption The M2 Positioning Mechanism and the M2 Positioning Sensor Electronics Module shall meet the following requirements with no active cooling.

3.2.1.1 Power input to the M2 Positioning Mechanism shall not exceed 5 watts rms over any 1 minute period while operating in accordance with any requirement in this Design Requirements Document.

3.2.1.2 Power input to the M2 Positioning Sensor Electronics Module shall not exceed 10 watts rms over any 1 minute period while operating in accordance with any requirement in this Design Requirements Document.

3.2.1.3 The total power transferred to the atmosphere by the M2 Positioning system shall not exceed 25 watts rms over any 1 minute period when operated in accordance with any requirements of this Design Requirements Document.

3.2.2 Encoder Accuracy The position of the M2 Positioning Mechanism shall be encoded to an accuracy of 2 µm total, including, without limitation, non-repeatability, non-linearity and resolution, in the X and Y directions.

3.2.3 Electro-Magnetic Interference (EMI) The M2 Positioning System shall comply with the requirements of SPE-ASA-G0008.

3.2.4 Static Sensitive Devices The M2 Positioning System shall comply with the requirements of SPE-ASA-G0008.

3.2.5 Cables and Connectors Electronic cables and connectors shall comply with the requirements of SPE-ASA-G0008.

3.2.6 M2 Tilt System Interface The electrical interface between the M2 Positioning System and the M2 Tilt System is contained in paragraph 3.2.6.7 of the M2 Tilt System Design Requirements Document SPE-O-G0039.

3.3 Operation/Performance

3.3.1 Incremental Movement The M2 Positioning System shall be capable of setting f/16 Secondary Mirror Position in the X-Y plane in steps of 8.0 µm or less.

3.3.2 Velocity The M2 Positioning Mechanism shall be capable of changing the f/16 Secondary Mirror Position over the range of section 3.1.2 above in X-Y translation in 60 seconds maximum. The M2 Positioning Mechanism shall be capable of changing the f/16 Secondary Mirror Position in incremental steps of 3.3.1, above, within 2 seconds maximum.

3.4 Environmental Requirements

3.4.1 Operating Environment The M2 Positioning System shall operate when subjected to any combination of the following environmental conditions:

Condition	***Requirement***
altitude	sea level to 4300 m
air temperature	-15° to +25° C
relative humidity	0% to 95%
wind speed	0 to 33 m/sec
gravity orientation	Z axis vertical up to vertical down

3.4.2 Performance Environment The M2 Positioning System shall meet all of the requirements of this document when subjected to any combination of the following environmental conditions:

Condition	***Requirement***
altitude	sea level to 4300 m
air temperature	-15° to +25° C
relative humidity	0% to 90%
wind speed	0 to 12 m/sec
gravity orientation	Z axis vertical up to vertical down

3.4.3 Survival Environment The M2 Positioning System shall survive any combination of the following environmental conditions without permanent damage and be capable of meeting all of the requirements of this Design Requirements Document after removal of these conditions:

Condition	***Requirement***
altitude	sea level to 15,500 m
air temperature	-20° to +40° C
relative humidity	0% to 100% with condensation
wind speed	0 to 35 m/sec in the -Z direction 0 to 18 m/sec in the +Z direction
seismic	12 g, .5 Hz to 100 Hz, all axes

The M2 Positioning System shall also meet these requirements when suspended by its Lifting Points, or installed on any handling equipment, with or without the M2 Tilt System installed in accordance with drawing TBD and the f/16 Secondary Mirror installed in accordance with drawing 90-GP-0003-0001. The M2 Positioning System shall also meet these requirements when packaged in its storage/shipping containers. Above these levels, the M2 Positioning System should be designed to sustain limited damage if necessary to protect other hardware. The M2 Positioning System should be capable of resuming normal operation with only moderate repair.

3.4.4 Transportation Environment The M2 Positioning System shall survive any combination of the following environmental conditions without permanent damage when package in its storage/shipping containers:

Condition	***Requirement***
altitude	sea level to 15,500 m
air temperature	-20° to +40° C
relative humidity	0% to 100% with condensation
wind speed	0 to 67 m/sec
vibration	IAW MIL-STD-810E, July '89 section 514.4
shock	IAW MIL-STD-810E, July '89 section 516.4

The M2 Positioning System shall be capable of meeting all of the requirements of this Design Requirements Document after removal from its storage/shipping containers.

3.4.5 Handling Environment The M2 Positioning System shall survive any combination of the following environmental conditions without permanent damage when suspended by its Lifting Points or its Mounting Features, and with or without the M2 Tilt Mechanism installed in accordance with drawing TBD and the f/16 Secondary Mirror installed in accordance with drawing 90-GP-0003-0001. The M2 Positioning System shall also survive any combination of the following environmental conditions when packaged in its storage/shipping containers:

Condition	***Requirement***
altitude	sea level to 4300 m
air temperature	-20° to +40° C
relative humidity	0% to 100% with condensation
wind speed	0 to 67 m/sec
shock and vibration	10 g, 0.5 Hz to 100 Hz, any axis

The M2 Positioning System shall be capable of meeting all of the requirements of this Design Requirements Document after being subjected to these environmental conditions.

3.5 Reliability/Maintainability

3.5.1 Reliability The M2 Positioning System shall have a shelf life of 1 year minimum. Mean time between failures of the M2 Positioning System shall be 2000 hours of normal operation minimum.

3.5.2 Maintainability Repairs of all failures arising as a result of normal operations of the M2 Positioning System shall be accomplished in no more than 6 hours by trained personnel.

4.0 Quality Assurance Provisions

4.1 General Requirements

A quality assurance plan will be developed and for the performance of all inspections and tests required to meet the detail requirements of this Design Requirements Document.

5.0 Preparation for Delivery

The M2 Positioning System shall be packaged suitable for transport by commercial carrier. Packaging materials/containers shall be reusable for repackaging and transportation of M2 Positioning System. Separate containers shall be used for the M2 Positioning Mechanism, the M2 Positioning Sensor Electronics Module, the M2 Positioning Control Electronics Module and the cabling. Containers and packaging materials shall meet the requirements of sections 3.4.3, 3.4.4 and 3.4.5 above.