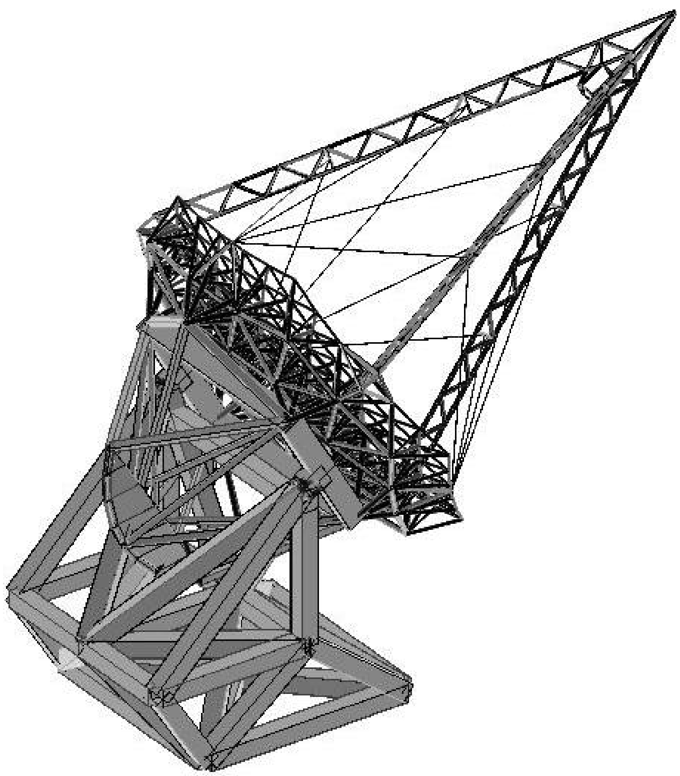
AURA New Initiatives Office
30m Telescope Project

**NIO-RPT-0001**

# Point Design for GSMT Optical System



**Jim Oschmann and Larry Stepp**
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## 1. INTRODUCTION

To advance the conceptual design work on the Giant Segmented Mirror Telescope (GSMT), a “point” design has been developed for the telescope optics. This report summarizes the optical design as well as the starting point for optomechanical details. Other GSMT studies will be based on this optical design as the starting point, but it is anticipated that the optical design will evolve over time as results from other studies become available.

## 2. DESCRIPTION OF OPTICAL DESIGN

The telescope optical design is a pseudo Ritchey-Chrétien design. The conic constant of the primary mirror has been adjusted slightly from a pure R-C design – the GSMT primary mirror is a paraboloid, but the difference from a true R-C design is negligible. To keep the telescope compact, the primary mirror is f/1.

The secondary focal ratio is f/15. The secondary mirror has been kept relatively small by minimizing the back focal distance of the telescope – the secondary mirror is 2 meters in diameter, and the BFL is 30 meters. This puts the Cassegrain focus approximately 2 meters behind the primary mirror vertex. The optical design is illustrated in Figure 1, below.

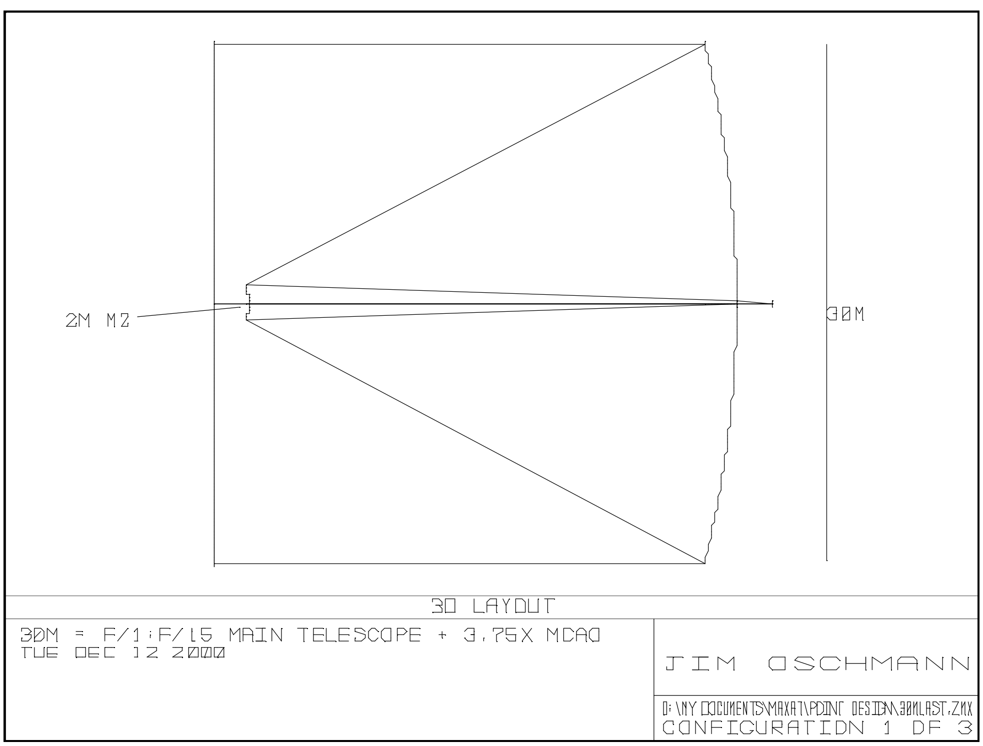


Figure 1. GSMT point optical design.

The optical prescription is listed in Appendix A. Spot diagrams indicating the performance of this design are shown in Appendix B.

Figure 2 shows the optical design including a point design of the multi-conjugate adaptive optics system. Note that the system may need to be folded differently than shown, for packaging considerations.

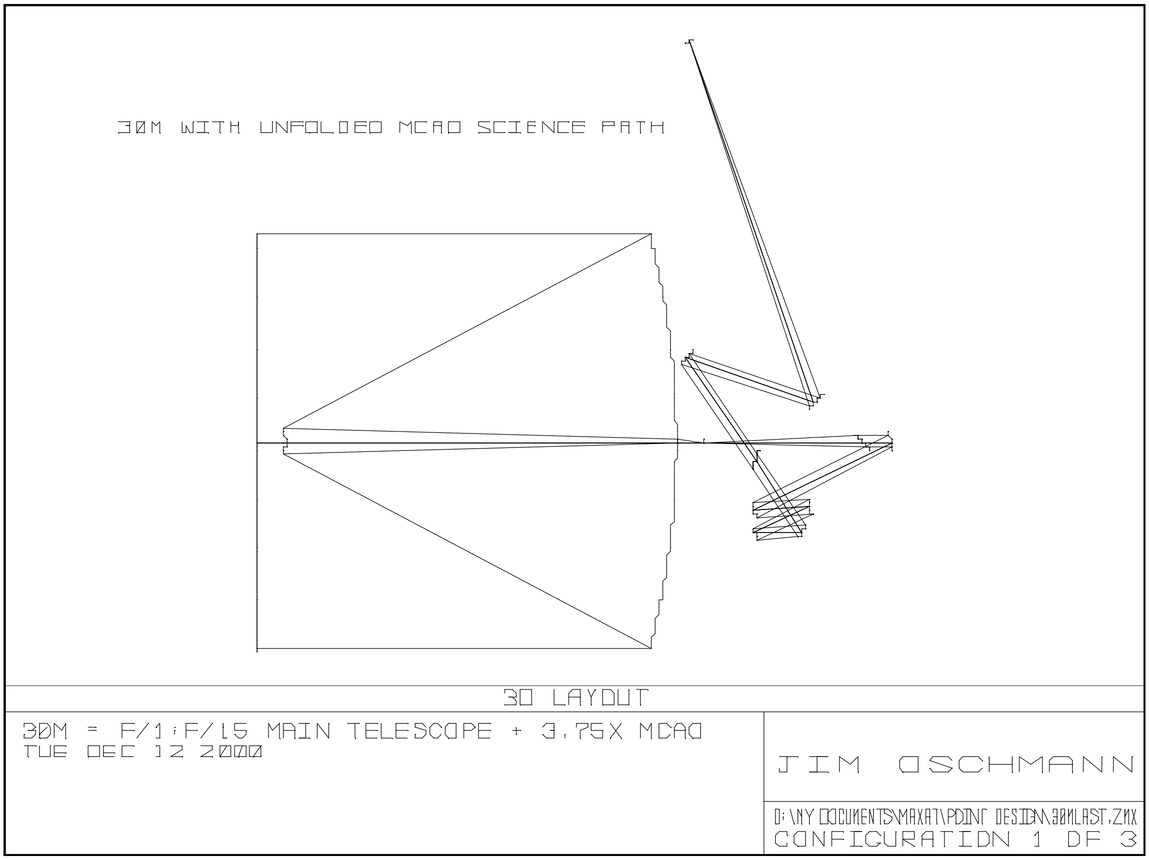


Figure 2. GSMT point optical design including multi-conjugate adaptive optics system.

Use of the prime focus is also being considered for seeing-limited imaging.

## 3. OPTOMECHANICAL PARAMETERS

An initial estimate has been made for the optomechanical properties of the optical elements. It is anticipated the primary mirror will have a glass or glass-ceramic face sheet with an areal density of 100 kg per square meter, which corresponds to approximately 50 mm thickness if the face sheets are made of Corning ULE. The total weight of just the glass will be more than 70 metric tonnes. To accommodate a Cassegrain focus field of 5 arc minutes, one segment will be left out to form the central hole. To accommodate a 20 arc minute Cassegrain focus field for seeing-limited work, seven segments would be left out to form the central hole.

The point design segment shape is hexagonal, with segment width of 1.152 meters across flats (1.33 meters point-to-point). This size will require about 618 segments in total (not counting spares).

The worst-case amount of astigmatic departure from the sphere for these segments is a Zernike coefficient of 98 microns (196 microns peak-to-valley). The worst-case amount of comatic departure from the sphere for these segments is a Zernike coefficient of about 8.4 microns (16.8 microns peak-to-valley). The worst case occurs in the segments at the edge of the aperture. These numbers are slightly smaller than the worst-case Keck segments.

For each segment the glass weight will be about 115 kg. The additional weight of a whiffletree load spreader with pivots and adjustment points made of some combination of aluminum, beryllium, silicon carbide and/or graphite-reinforced epoxy is estimated to be 40 kg. It is anticipated this will be supported on three position actuators of mass 10 kg each (including local electronics). Including edge sensors, the total mass would be 190 kg per segment. This makes the total mass of the primary mirror segments about 118 metric tonnes.

The position actuators will need to be supported stiffly by the telescope structure. The three actuators will be equally spaced around a circle of about 0.75 m diameter centered on the center of the segment. Each actuator should have a stiffness of about 100 N per micron. The height from the bottom of each actuator to the optical surface of the glass will be about 0.5 meter, however the mounting flange of the actuator does not necessarily need to be at the bottom.

The 2-meter diameter secondary mirror was assumed to be beryllium, having a mass of 200 kg (about 64 kg per square meter). It should be supported on a mechanism that includes fast tip/tilt/focus and slower positioning functions. It is estimated this mechanism will weigh 2 metric tonnes and will fit within an envelope 2 meters in diameter and 2 meters long.

It is anticipated the prime focus instrument assembly would include a large corrector and atmospheric dispersion compensator with some elements more than one meter in diameter. The corrector/ADC would contain almost a tonne of glass. The entire instrument package would fit within an envelope 1.8 meters diameter by 3 meters long. The total weight of the prime focus instrument would be about 3 metric tonnes.

## 4. ACKNOWLEDGEMENTS

The final version of the optical design listed here was prepared by Richard Buchroeder, who modified a design originated by Jim Oschmann to incorporate the needs of the adaptive optics system.

The New Initiatives Office is a partnership between two divisions of the Association of Universities for Research in Astronomy (AURA), Inc.: the National Optical Astronomy Observatory (NOAO) and the Gemini Observatory.

NOAO is operated by AURA under cooperative agreement with the National Science Foundation (NSF).

The Gemini Observatory is operated by AURA under a cooperative agreement with the NSF on behalf of the Gemini partnership: the National Science Foundation (United States), the Particle Physics and Astronomy Research Council (United Kingdom), the National Research Council (Canada), CONICYT (Chile), the Australian Research Council (Australia), CNPq (Brazil) and CONICET (Argentina).

# 5. APPENDICES

## Appendix A

System/Prescription Data

Date: WED JUL 5 2000

GENERAL LENS DATA:

Surfaces : 6
Stop : 3
System Aperture : Entrance Pupil Diameter = 30
Glass Catalogs : schott misc INFRARED
Ray Aiming : Off
Apodization :Uniform, factor = 0.00000E+000
Effective Focal Length : 450.0002 (in air)
Effective Focal Length : 450.0002 (in image space)
Back Focal Length : 30.00001
Total Track : 62
Image Space F/# : 15.00001
Paraxial Working F/# : 15.00001
Working F/# : 15.00416
Image Space NA : 0.03331482
Object Space NA : 1.5e-009
Stop Radius : 1
Paraxial Image Height : 0.1311615
Paraxial Magnification : 0
Entrance Pupil Diameter : 30
Entrance Pupil Position : 480
Exit Pupil Diameter : 2
Exit Pupil Position : -30
Field Type : Angle in degrees
Maximum Field : 0.0167
Primary Wave : 1
Lens Units : Meters
Angular Magnification : 15

Fields : 2
Field Type: Angle in degrees
# X-Value Y-Value Weight
1 0.000000 0.000000 1.000000 2 0.000000 0.016700 1.000000

Vignetting Factors
# VDX VDY VCX VCY 1 0.000000 0.000000 0.000000 0.000000 2 0.000000 0.000000 0.000000 0.000000

Wavelengths : 1
Units: Microns
# Value Weight
1 1.000000 1.000000

SURFACE DATA SUMMARY:

| Surf | Type | Comment | Radius | Thickness | ass | Diameter | Conic |
|---|---|---|---|---|---|---|---|
| OBJ | STANDARD | | Infinity | Infinity | | 0 | 0 |
| 1 | STANDARD | | Infinity | 60 | | 30.27981 | 0 |
| 2 | STANDARD | | -60 | -28 | MIRROR | 30.24595 | -1 |
| STO | STANDARD | | -4.285714 | 30 | MIRROR | 2.009223 | -1.306124 |
| 4 | STANDARD | | Infinity | 0 | | 0.2628506 | 0 |
| 5 | STANDARD | | Infinity | 0 | | 0.2628506 | 0 |
| IMA | STANDARD | | -2.00966 | | | 0.2625271 | 0 |

F/# DATA:

F/# calculations consider vignetting factors and ignore surface apertures.

Wavelength: 1.000000
# Field Tan Sag 1 0.0000 deg: 15.0042 15.0042 2 0.0167 deg:
15.0024 15.0024

# Appendix B
Spot Diagrams