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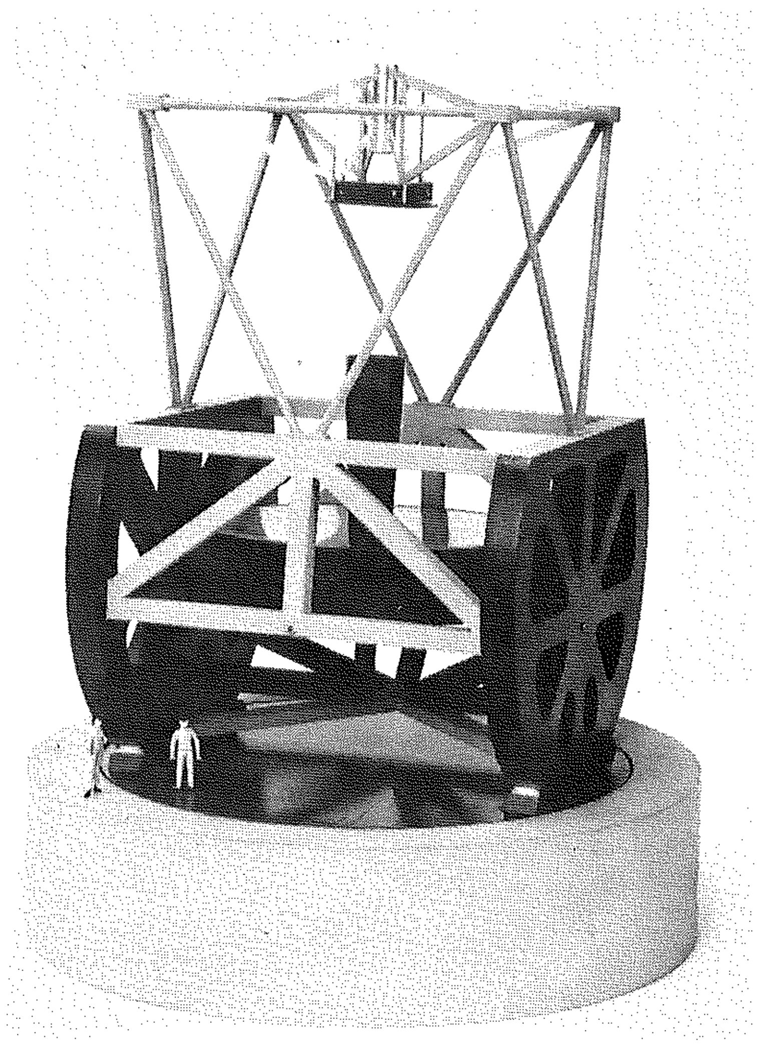

Tripod Disk Mount Preliminary Study

Steven M. Gunnels
Consultant, L & F Industries
Huntington Park, California
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Preface

In this report (Magellan Report No. 19) we present another design concept of the 8-meter telescope for the Magellan Project. This design has the following recent short history. We had been looking at various designs for the removal of the crossbracing in the Alt-Az Disk design and were not fully satisfied with any. Also, the problem associated with the fabrication of the large altitude disks was ever present on the back burner. During this period, David Chivens, President of L & F Industries, called me with some ideas for an alternate telescope design for the Magellan Project that would not require any crossbracing removal in preparation for primary mirror coating and would relieve the fabrication of the large altitude disks, but retain many of the favorable features of the Alt-Az Disk design. A few of us met at the L & F Industries office to discuss the proposed design. At that meeting we concluded that the design deserved further study. Intensive work was done by David Chivens and Terry King, Senior Project Engineer at L & F Industries, in advance of a second meeting where their preliminary work was given to Steve Gunnels for further development and analysis. A following meeting resulted in Report No. 19 authored by Steve Gunnels, Consultant for L & F Industries.

W. A. Hiltner

1.0 INTRODUCTION

The Alt-Az Disk mount for the Magellan Project 8-Meter Telescope (Magellan Project Report No. 5) involves the use of large diameter altitude disks and crossbracing between them. Although not unsolvable, the manufacturing and shipping of the altitude disks may prove to be demanding. The removal and reinstallation of the crossbraces for mirror cell removal is a significant task. The Tripod Disk mount (see ref. dwg. E271055 at end of report) is a variation of the baseline Alt-Az Disk which improves these two areas.

The Tripod Disk structure uses smaller altitude disks in conjunction with a short fork structure (or modified tripods) mounted on the azimuth disk. With low out-of-plane bending stiffness, the azimuth disk allows the tripods to be individually fully defined to the azimuth plane bearing at their three points of support. Therefore, the telescope as a whole is more overconstrained than in the Alt-Az Disk, since it uses six stiffness load paths to define three of its six degrees of freedom (vertical translation and the two horizontal rotations). It is believed that this is acceptable as long as the optics support structure (OSS) is defined laterally to the azimuth structure using only one stiffness load path, or one stiffness load path and one "high frequency overconstraint".

2.0 PHYSICAL COMPARISONS

Some of the basic differences in the two mounts are:

1. The elimination of the crossbraces and asymmetry in the altitude disks causes the balance point for the OSS to shift about 4 feet (1.2 m) toward the secondary end. This increases the vertical dimension from the observing floor to the altitude axis, if a fixed Cassegrain instrument length is maintained (clearance required from the mirror cell to the observing floor with the telescope at zenith).

2. Item 1. above causes an increase in the moment arm of the telescope center of gravity above its horizontal support plane.

3. Item 1. above causes the clearance radius for the enclosure to reduce, allowing a smaller, lighter enclosure. If full advantage can be taken of this [that is, if the enclosure diameter is reduced by 8 feet (2.4 m)], this would leave a slit opening (inside dimension between shutters) of about 8.8 meters for the octagonal enclosure.

4. Item 1. above will cause the observing floor to *lower*, with the altitude axis left at its original height above grade. In the case of the two-story building the support facility would be lowered. However, this would probably leave inadequate space in the first floor for ceiling height and utilities distribution. Therefore, it is anticipated that the altitude axis would instead be *raised*.

5. The OSS is about 50,000 lbs. lighter than in the Alt-Az Disk, due to the net effect of the smaller altitude disks, elimination of the crossbrace, but heavier "center section". However, the azimuth structure is about 50,000 lbs. heavier, due to the net effect of the addition of the tripods, larger azimuth disk, but larger center hole. Therefore, the total telescope weight is virtually the same for the two configurations.

6. The azimuth "plane bearing", that is the large flat bearing which is (presumably) grouted to the large concrete pier has a 45.5 foot pitch diameter, whereas the Alt-Az Disk plane bearing is 38 feet in pitch diameter.

7. The Tripod Disk will not accommodate the back eccentric Nasmyth instrument mounting, but will allow an on-axis Nasmyth.

8. The circular center section in the Tripod Disk OSS will require a considerably more complex mirror cover system than will the Alt-Az Disk.

9. The Tripod Disk requires a two-step motion for mirror removal; that is, it must be partially lowered, then moved out from under the telescope, then lowered some remaining distance. This will require a more complex mirror cart with a separate "carriage".

10. The Alt-Az Disk has critical structural members (crossbraces and "main plane" truss) which by necessity rotate very near the observing floor when the telescope is rotated about the altitude axis. These crossbraces provide a possible safety hazard for personnel or equipment. With the heightened altitude axis and elimination of crossbraces, this risk is negligible of the Tripod Disk mount.

3.0 MODAL ANALYSIS

A critical issue in comparing the two structures is that of modal performance. Therefore, a finite element model was constructed of the Tripod Disk with sufficient detail to be comparable to the current versions of the Alt-Az Disk models. The model consisted of 583 nodes, 520 plate elements, 278 beam elements, and 3390 degrees of freedom.

As shown in Figure 1 (see following page), the analysis was run at zenith, since both the altitude disks and center section probably have their lowest stiffness there in limiting the lateral translation vibrational mode.

In early models (models MMTELM1 through MMTELM9) a fabricated plate box beam cross-section was used for the center section structure (the structure between the two altitude disks). Since this structure should be open (for ventilation of the primary mirror and telescope structure), a reduced modulus of elasticity (material stiffness property) was used for these members. However, the center section was opened even more in later models, and this was then accounted for by modelling the bracing members with beam elements defining the actual shape and section properties of the braces, as shown in Figure 2. Of course, beam element centerlines are depicted in the graphics plot. A more realistic appraisal of the "openness" of the structure can be gotten from drawing E271055.

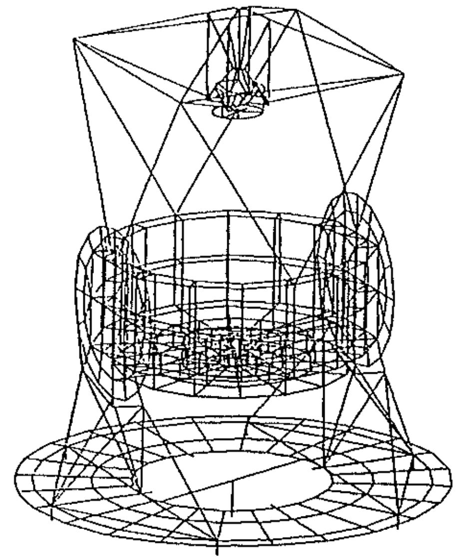


Figure 1 - Finite element model of Tripod Disk.

Composite elements, that is, elements with artificial thickness, elastic modulus, and mass density were used for the altitude disks and azimuth disk. This provides accurate in-plane membrane and shear stiffness, and out-of-plane bending stiffness, while considerably simplifying the computer model.

Various stiffening tests and optimizing runs were made, with the results of all analyses shown in Table 1 "Tripod Disk Vs. Alt-Az Disk Modal Performance" at the end of this report. All results reflect "controlled rotor", or "locked encoder" altitude and azimuth modes; that is, with the drive and control sufficiently high in performance to act infinitely stiff. Models were run with and without "high frequency overconstraint" (HFOC) of the OSS-to-azimuth structure laterally, and the entire telescope to ground both laterally and in the fore-aft direction. These descriptions, as well as optimizing criteria, are listed under "model description" in Table 1.

From the models listed, it can be stated that:

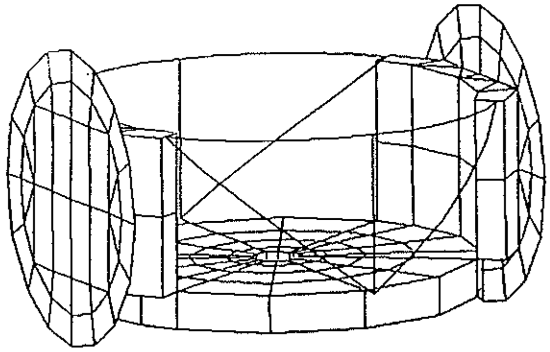


Figure 2 - Finite element model of center section.

1. The altitude mode is better if the drives are located as shown on E271055, as opposed to rotated to the bottom area of the altitude disks. (Model M2 vs. M1).

2. Stiffening the altitude disks has more potential for improving the altitude mode than does stiffening the center section (model M3 vs. M4) or the tripods (M3 vs. M11).

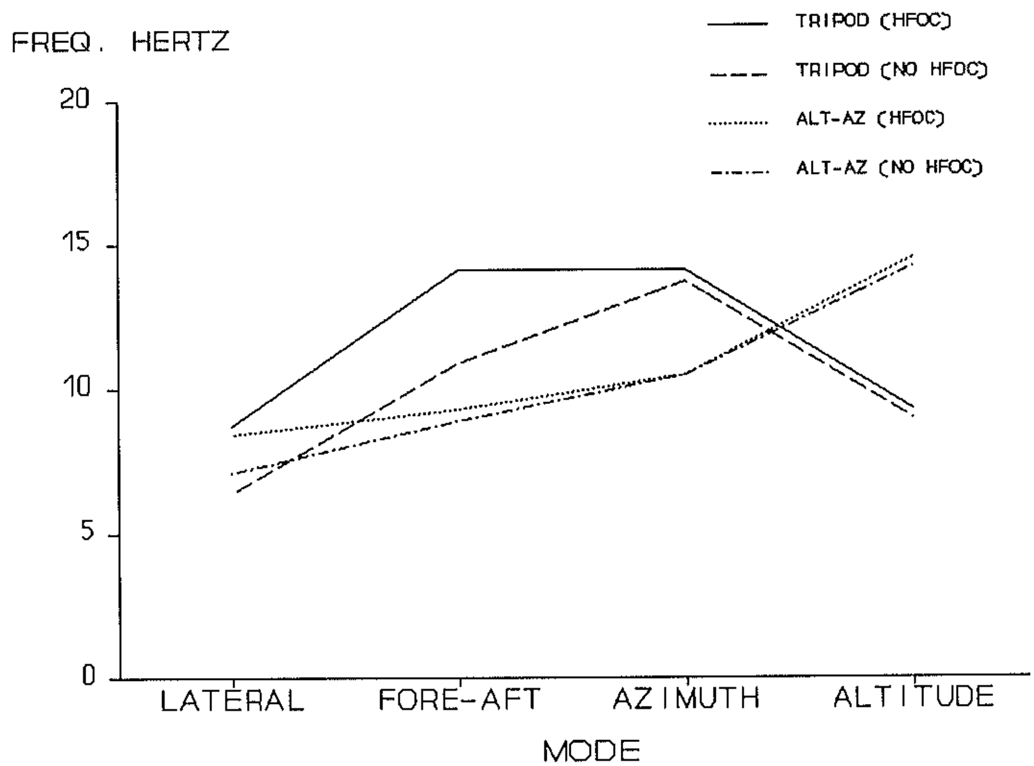


Figure 3 - Graphical illustration of modal performances.

3. Smaller altitude disks (than the current 20 foot diameter) reduce the altitude mode (M5 vs. M1).

4. Stiffening of the outer, or rim area, of the altitude disks is more effective than stiffening the entire disk, since the added mass in the center area of the disks does more harm to the lateral mode than it does good for the altitude mode (model M7 vs. M6).

5. Lighter fork members (that is, "tripod" members) causes all modes to reduce significantly (M9 vs. M7).

6. The open center section causes some loss in the lateral mode, but acceptably so considering the benefit (M10 vs. M7).

7. Mounting the altitude encoder on a separate reference (directly to the plane bearing) causes a small increase in the altitude mode.

Comparable performance for the Tripod Disk and Alt-Az Disk mounts with and without HFOC are shown in bold in Table 1, and graphically in Figure 3. As can be seen graphically, the Tripod Disk has considerably improved translational frequencies with high frequency overconstraint and is therefore better, on average, than the Alt-Az-Disk in that configuration. Without HFOC the average performance for the two is about equal. It can also be seen that the Tripod Disk has considerably better ("controlled rotor") azimuth performance, while the Alt-Az Disk has much better controlled rotor altitude performance. The lowest mode (lateral translation) is slightly better for the Alt-Az Disk when not overconstrained, but better for the Tripod Disk when overconstrained.

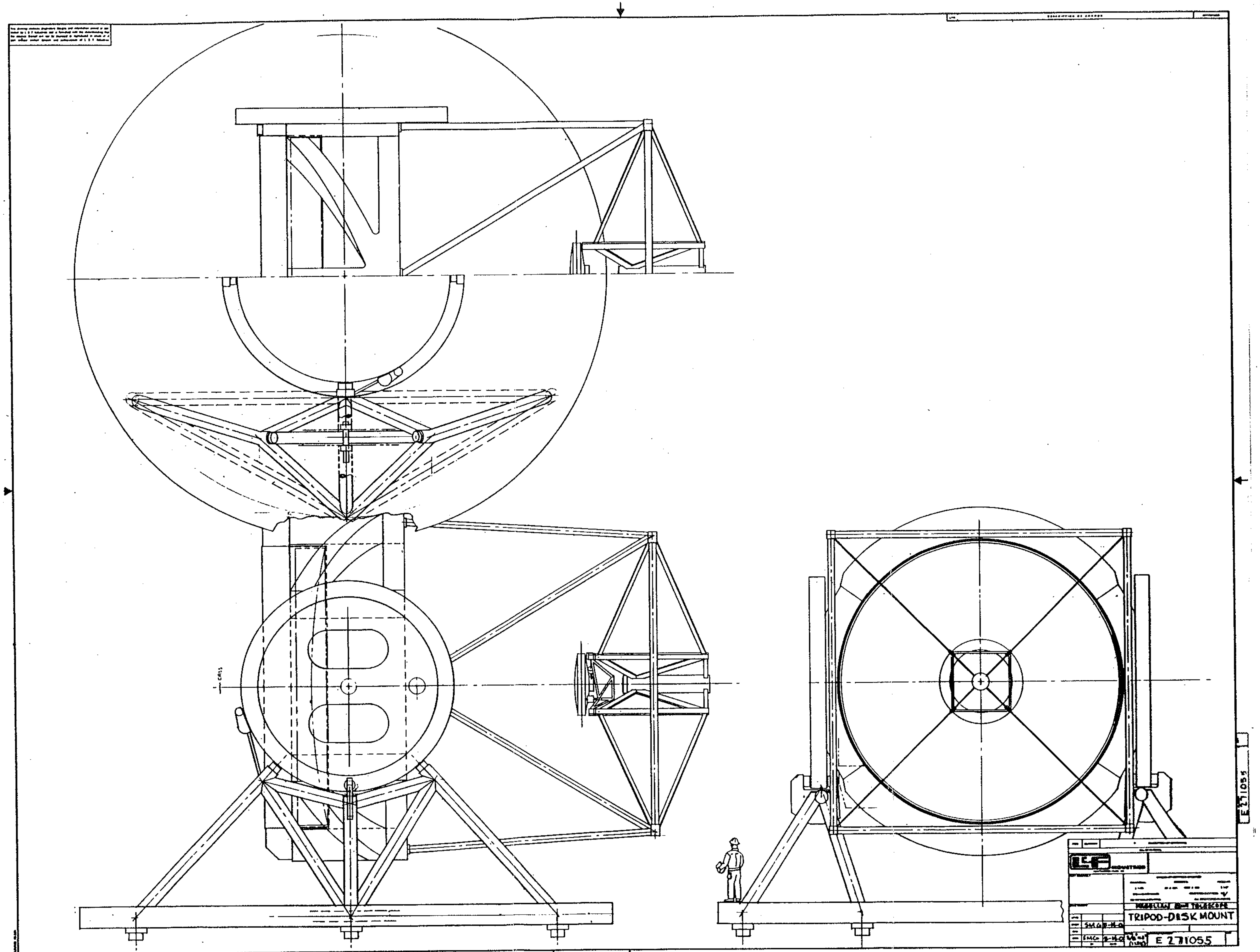
4.0 CONCLUSIONS

There are many system and cost-related differences between the Tripod Disk and Alt-Az Disk configurations. The Tripod Disk has about equal modal performance when not overconstrained, and is a little better, on average, when overconstrained.

TABLE 1 - TRIPOD DISK VS. ALT-AZ DISK MODAL PERFORMANCE

The following summarizes the preliminary modal analyses performed on the revised mount currently being considered for the Magellan Project. Finite element models of the revised configuration are designated MMTELM__ . Finite element models of the Alt-Az Disk configuration are designated ADTELM__. The most logically direct pairing of the two are shown in bold.

MODEL DESCRIPTION	LATERAL	FORE-AFT	AZIMUTH	ALTITUDE
MMTELM1 - Baseline; Controlled Rotor (CR) Modes; High Freq. Overconstraint (HFOC)	9.2	13.8	14.4	8.8
MMTELM2 - M1 but rotate altitude drives to very bottom (not feasible)	9.1	14.6	14.8	8.4
MMTELM3 - M1 but infinitely stiff altitude disks	10.4	15.6	15.2	11.1
MMTELM4 - M1 but infinitely stiff center section	9.7	15.0	14.9	10.4
MMTELM5 - M1 but with smaller altitude disks (18' vs. 20').	9.5	14.0	14.6	8.5
MMTELM6 - M1 but altitude disks stiffened (1" plates @ 18" vs. 1/2" @ 18").	8.8	13.8	13.9	9.5
MMTELM7 - M1 but only rims of altitude disks stiffened (1" @ 18").	9.1	14.0	14.3	9.3
MMTELM8 - M7 but without HFOC.	6.5	11.0	13.7	9.0
MMTELM9 - M7 but lighter fork (TS 16 x 16 x 1/2")	7.8	12.6	13.5	8.3
MMTELM10 - M7 but open center section	**8.7**	**14.1**	**14.1**	**9.3**
ADTELM32 - (HFOC)	**8.4**	**9.3**	**10.5**	**14.5**
MMTELM11 - M10 but infinitely stiff tripods	12.3	16.2	15.2	10.4
MMTELM12 - M10 but Schier encoder mount	8.8	14.2	14.1	9.6
MMTELM13 - M10 but without HFOC	**6.4**	**10.9**	**13.7**	**9.0**
ADTELM31 - (no HFOC)	**7.1**	**8.9**	**10.5**	**14.2**


CASS
TRIPOD-DISK MOUNT
E 271055