A Proposed Method of Reducing the Gravity Distortions of the 64-Meter Antenna Main Reflector

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The surface panels of the 64-m main reflector are presently set to a prescribed paraboloid at 45 deg elevation angle. Rotation about the elevation axis to the horizon or zenith attitude introduces additional root-mean-square (rms) distortions due to the change in the direction of the gravity vector with respect to the symmetric axis. This article proposes a method of reducing the humps or bumps over the unyielding "hard" portions of the elevation wheel assembly supporting the reflector structure, thus reducing the rms distortions due to gravity for the structure. The bumps can be effectively removed by controlling the height of the panels above the reflector structure by means of mechanical leverage connections to the elevation motion, thus maintaining the simplicity and reliability of the reflector system. A table of overall rms distortions resulting from the summations of various options is included.

I. Introduction

From the initial outputs of the contour maps describing the normal distortions to the best fit paraboloid (Ref. 1), two humps or bumps existed over the elevation bearings for the gravity "off to on" loading case with the reflector at the zenith attitude or look. In the studies for a larger reflector structure, an upgraded 64-m model with deleted bumps was used as a basis for dimensional analysis with the expectation that it would be feasible.

This article describes a proposed method for actuating the surface panels to effectively reduce the bumps to almost zero. The improvements in the rms distortion values were computed as vector distortions, using the NASTRAN structural analysis program, and evaluated by the rms program which best fits a paraboloid and outputs SC4020 contour plots of the residuals and the rms of the ½ RF pathlength errors (Ref. 2).

II. Analysis Discussion

The primary outputs of the structural analysis are the distortion (3-dimensional) vectors from the two loadings as follows:

(1) Gravity "off to on" loading in the symmetric axis direction.

(2) Gravity "off to on" loading in the antisymmetric direction.

For any particular elevation angle, the relations of the unit gravity vector and its component values along the symmetric and antisymmetric directions are pictured in Fig. 1.

Since the symmetric axis gravity component value Z is equal to the cosine of the elevation angle multiplied by the unit value, it follows that an eccentric crank arrangement rotating 90 deg produces an offset S equal to the cosine of the angle multiplied by the eccentric radius R. If the eccentric radius R is selected to equal the maximum correction required at the surface panel support as shown by the contour maps, this support will be fully corrected throughout the elevation angle range.

The analysis method also revealed that an overcorrection is actually necessary since the best fit paraboloid adjusts for the corrections in a Z lateral motion in the next iteration of best fitting. At first, only the bumps from the symmetric loading case were removed; but with the large percentage change resulting from the analysis, two bumps of smaller area were removed from the antisymmetric loading case for study.

Figures 2, 3, and 4 show half views (the reflector assembly at Goldstone, California, is symmetric about the center vertical plane) of the contour maps describing the residuals after the paraboloid best fitting of the computed distortion vectors as "before" and "after" corrections. Figure 2 shows the change for the symmetric gravity loading case and Fig. 3 shows the change at horizon look with the panels set at 45 deg with only the symmetric bumps removed. Figure 4 shows the differences for the antisymmetric loading case. Here, the bumps were over the top and bottom trusses of the rectangular girder where strong and rigid connections with the elevation wheel assembly occur.

III. Results

Table 1 details the analytically computed rms performance values in ½ RF pathlength errors for the various options noted. Included also are rms values for available surface panels and a figure for the subreflector surface attained for the multiple panel assembly for the symmetric hyperboloid. It should be pointed out that an unsolved problem at this time is the manufacture of the subreflector symmetric about one plane as required for the shaped cassegrain optics arrangement.

References

1. Katow, M. S., "Primary Reflector Analysis," in *Supporting Research and Advanced Development*, Space Programs Summary 37-52, Vol. II, pp. 86–92. Jet Propulsion Laboratory, Pasadena, Calif., July 1, 1968.
2. Katow, M. S., and Schmele, L. W., "Antenna Structures: Evaluation Techniques of Reflector Distortions," in *Supporting Research and Advanced Development*, Space Programs Summary 37-40, Vol. IV, pp. 73–76. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 30, 1968.

Table 1. Half-pathlength error, rms, distortion from gravity loadings, mm (in.)

Antenna attitude	Reflector structure				Plus surface panels[a] and subreflectors			
	Normal	Bump removed			Normal	Bump removed		
		Zenith only	Horizon only	Both		Zenith only	Horizon only	Both
Zenith look, set 45 deg	0.50 (0.020)	0.45 (0.018)	0.40 (0.016)	0.33 (0.013)	0.81 (0.032)	0.79 (0.031)	0.76 (0.030)	0.74 (0.029)
45 deg elevation, panels set	0.25 (0.010)[b]	–	–	–	0.64 (0.025)	0.64 (0.025)	0.64 (0.025)	0.64(0.025)
Horizon look, set 45 deg	0.63 (0.025)	0.34 (0.013)	0.62 (0.024)	0.31 (0.012)	0.91 (0.036)	0.74 (0.029)	0.89 (0.035)	0.71 (0.028)
Zenith look, gravity off/on	0.86 (0.034)	0.43 (0.017)	–	–				
Horizon look, gravity off/on	0.63 (0.025)	–	0.46 (0.018)	–				

[a]Optimum manufacturing surface panel distortion rms = 0.51 mm (0.020 in.).
Optimum subreflector distortion rms = 0.31 mm (0.012 in.).
[b]Optimum surface panels setting error rms = 0.25 mm (0.010 in.).

Root-mean-square sum = $\sqrt{\Sigma\, rms_i^2}$; no rms distortion due to lateral offsets at the primary focus accounted; perfect pointing assumed (CONSCAN use equivalent to rms = 0.5 mm (0.020 in.) = 0.1 dB at X-band).

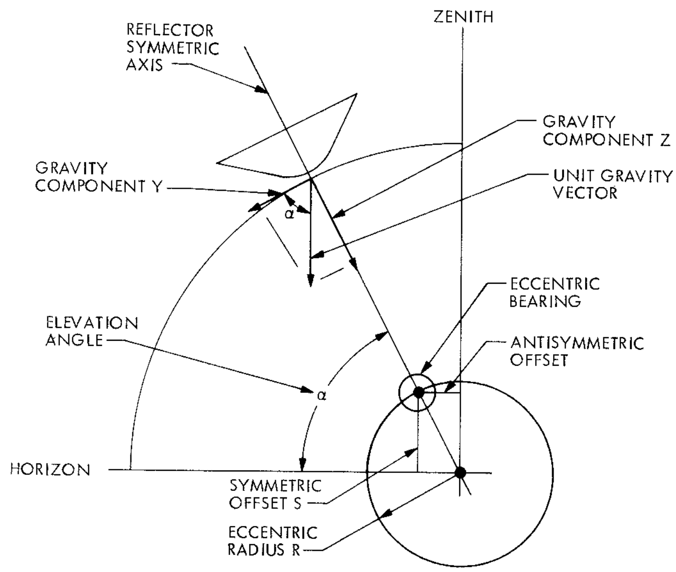


Fig. 1. Relations of the gravity vector components

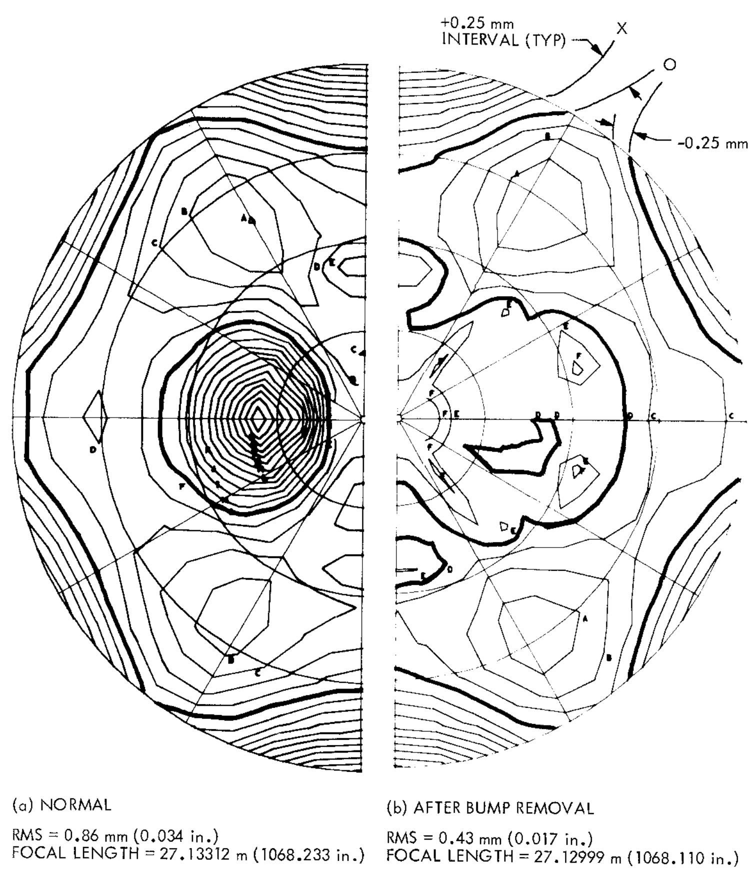
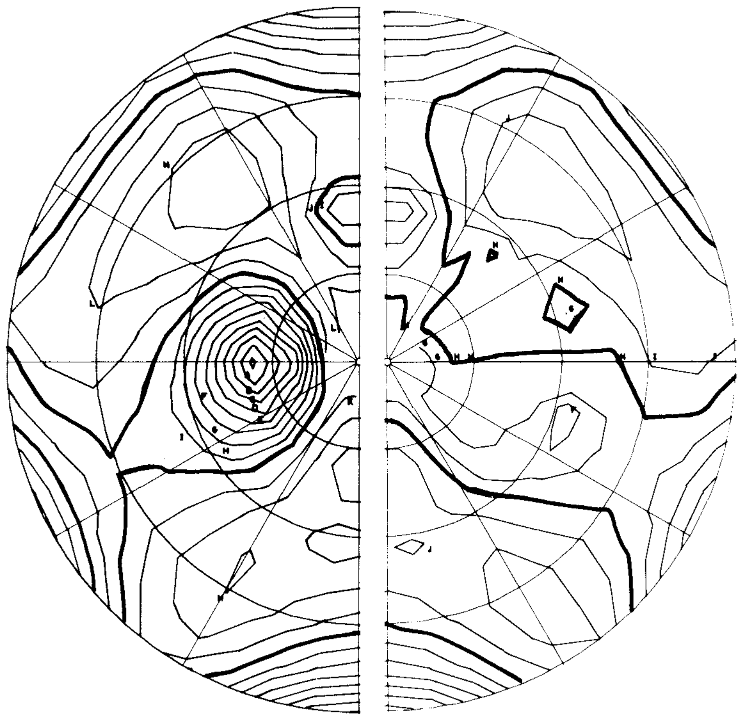


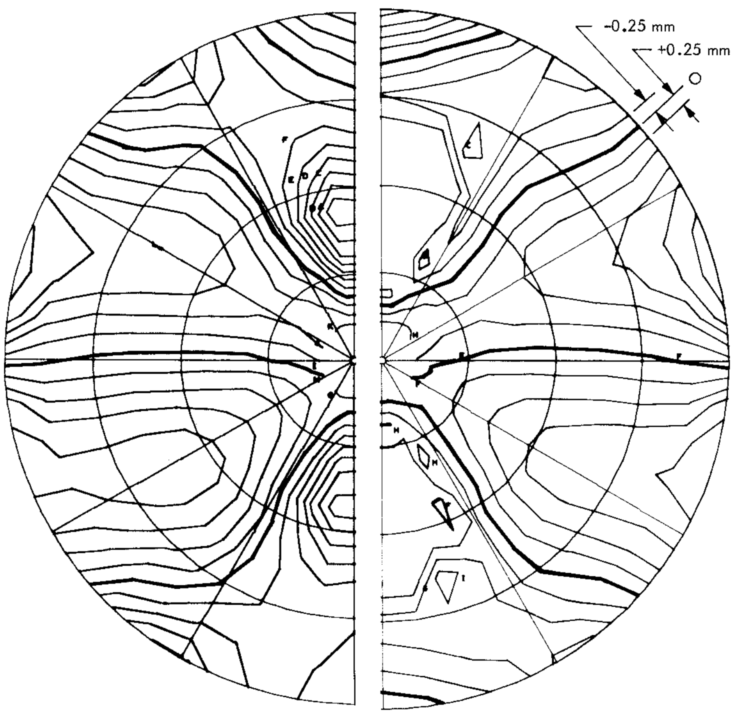
Fig. 2. Contour maps of the distortions measured normal to the surface of the best fit paraboloid. Loading: gravity off to on, zenith altitude



(a) NORMAL
RMS = 0.63 mm (0.025 in.)
FOCAL LENGTH = 27.09276 m (1066.644 in.)

(b) AFTER ZENITH BUMP REMOVAL
RMS = 0.34 mm (0.013 in.)
FOCAL LENGTH = 27.09497 m (1066.731 in.)

Fig. 3. Contour maps of distortions measured normal to the surface of the best fit paraboloid. Loading: gravity, horizon look, panels set at 45 deg



(a) NORMAL

RMS = 0.62 mm (0.025 in.)
FOCAL LENGTH = 27.11041 m (1067.339 in.)

(b) AFTER BUMP REMOVAL

RMS = 0.46 mm (0.018 in.)
FOCAL LENGTH = 27.11046 m (1067.341 in.)

Fig. 4. Contour maps of distortions measured normal to the surface of the best fit paraboloid. Loading: gravity off to on, horizon altitude