To: Ravi Subrahmanyan Technical Doc. AT 39.3/119

From: William A. Imbriale

Subject: Gravity Distortion Correction via Subreflector Motion

This memo serves to document our interactions on your proposed gravity correction system.

I have completed all the calculations and can say with pretty much certainty that your subreflector rotation and translational scheme will work. This is primarily because the surface is better than your raw distortions (as given by the polynomial coefficients) would appear to indicate [1]. If you "best fit" the distortions to your design surface (see Levy, Structural Engineering of Microwave Antennas, IEEE Press, New York, 1996 Chapter 2) the worst case error over the elevation angles is 0.0455mm which gives 97.1% efficiency at 90 GHz.

Paraphrasing from the book: The microwave performance of a distorted parabolic surface is related to the rms path length error over the surface and the gain reduction is given by the Ruze equation. It is not necessary to compute the pathlength error in terms of the original surface equation, but it is permissible (and advisable) to compute the pathlength error from an alternative surface that best fits the deformed surface. The alternative surface is defined in terms of five parameters that constitute a rigid-body motion and an additional parameter related to a change in the original focal length. However, it is necessary for the position of the subreflector in a dual reflector system to be moveable. This allows compatible variations in the microwave path geometry established by the fitting parameters. The parameters consist of three translations parallel to the X, Y and Z coordinate axis, rotations about the X and Y-axis and a parameter related to the new focal length. The six parameters are called "homology parameters" because they representation of the original parabolic surface to an alternative parabolic surface.

The best-fit surface rms is shown in table 1 and includes the Ruze calculated efficiencies at 90 GHz. These rms values are much smaller than the panel surface accuracies that are quoted to be about 0.1mm rms accuracy. So the efficiency loss due to gravity deformation would be much less than the gain loss due to small-scale surface irregularities. Of course, the proposed subreflector displacements cannot overcome the panel manufacturing tolerances.

Table 1 Best-fit surface

Elevation angle (degrees)	Raw Rms (mm) (polynomials)	Best-fit Rms (mm)	90 GHz efficiency (%)
15	.2035	.0364	98.1
30	.1871	.0364	98.1
45	.0958	.0262	99.0
75	.0710	.0389	97.9
90	.1033	.0455	97.1

In theory, to achieve the stated efficiencies would require a full six degrees of motion for the subreflector. The real question, of course, is how well do we do if only one rotation and one translation are allowed. To access that performance, a full dual reflector PO calculation was run with an optimization program used to vary the stated parameters.

As an initial condition, the feed displacements and subreflector displacement and rotations given in your e-mail were used along with the polynomial coefficients for the surface. I left the other parameters unchanged and only rotated in y and translated the subreflector in z from this initial geometry. The results are shown in table 2.

Elevation angle (degrees)	Initial condition (dB)	Optimized Geometry (dB)	Efficiency relative to 60 degrees (%)	Delta z (mm)	Delta rotation (deg)
15	83.98	85.21	96.3	-1.1	.067
30	84.36	85.20	96.2	-0.75	.064
45	85.17	85.28	97.9	-0.04	.032
60	85.37	85.37	100	0.0	0.0
75	85.13	85.15	95	0.0	-.015
90	85.01	85.14	94.8	0.04	-.035

This indicates that the using only a single translation and rotation will limit the gravity deformation loss to 5 percent or less over the entire elevation range.

Reference:

[1] Ravi Subrahmanyan, “Mm performance of the ACTA antennas II: effects of gravity deformations” AT 39.3/115, July 2002