

SHAPED REFLECTOR ANTENNAS FOR SATELLITE COMMUNICATIONS

M.Q. Tang, K.S. Rao, M. Cuchanski and R. Pokus
Spar Aerospace Limited
Satellite and Communications Systems Division
21025 Trans-Canada Highway
Ste-Anne-de-Bellevue, Quebec H9X 3R2

INTRODUCTION: Shaped reflector antennas are capable of producing desired coverage contours on earth by using a single horn thereby avoiding the need for complicated feed arrays and associated beamforming networks (BFNs). The advantages of shaped reflector technology for SATCOM antennas are lower cost, reduced mass and shorter delivery schedule. Development results of a dual-gridded shaped reflector designed for Canada and Conus (cities only) coverage at C-band are discussed in this paper. Measured results are compared with computed results and sensitivity analysis is carried out to establish tolerance requirements for shaped reflector antennas.

DESIGN: The coverage specifications are similar to those of Anik-E C-band antenna and are shown in Table 1. The antenna geometry, shown in Figure 1, consists of two overlapping gridded reflector shells with orthogonal linear polarizations. The VP and HP reflector surfaces are shaped such that the antenna produces the required coverage over a wide bandwidth of $\cong 54\%$ covering both Tx and Rx bands. Each reflector has a projected aperture of 60 in. diameter and is fed by a wideband corrugated horn.

The reflector surface optimization is carried out in few steps. First, the reflector surface is optimized with geometrical optics and an idealized Gaussian beam feed. This procedure is to generate an initial shaped reflector surface where the geometrical optics (GO) field is constant inside the specified coverage and zero outside. Using the GO optimized surface as the starting point, physical optics synthesis is carried out at the two center frequencies (3.95 GHz and 6.175 GHz). Then, the above procedure is repeated for six frequencies (3 Tx and 3 Rx). Finally, the latest surface is used as an initial guess for the final physical optics optimization with the computed near-field primary pattern of the corrugated horn. Synthesized surface plots showing the deviations from the paraboloid are shown in Figures 2 and 3. Computed directivity contour plots of the VP reflector at Tx and Rx bands are shown in Figures 4 and 5. A sensitivity analysis is carried out to establish tolerances on the rms surface error of the reflector and axial displacement of the feed phase action. For a maximum gain degradation of 0.1 dB and sidelobe deterioration of 2 dB, the tolerances for the surface error (rms) and phase center location are $\lambda/128$ and $\pm 0.25 \lambda$.

MEASURED RESULTS: The breadboard shaped dual-gridded antenna is shown in Figure 6. The corrugated horn has an aperture diameter of 10.9 in. and an axial length of 12.6 in. It is made up of 16 corrugations. Measured primary patterns have cross-polar levels of better than -33 dB over the Tx and Rx bands. Gain contours of the antenna have been measured in the compact range facility and are shown in Figures 7 and 8. The measured contours compare well with the computed contours shown in Figures 4 and 5. The cross-polar isolation values are measured as better than 36 dB for both polarization.

CONCLUSIONS: The breadboard development results have indicated that shaped reflector antennas can be efficiently used for future antenna payloads for fixed satellite services. Gain and cross-polar performance is similar to conventional reflectors with multiple feeds. However, the shaped reflector designs offer significant mass and cost reductions and enable faster delivery schedule of the antenna payloads. In addition to contoured beam coverage, shaped reflectors can also be employed for weighted beam coverage and multiple beams with overlapping or isolated coverages.

TABLE 1: C-BAND SHAPED REFLECTOR ANTENNA SPECIFICATIONS

PARAMETER		SPECIFICATION
Frequency,	Transmit Receive	3.7 - 4.2 GHz 5.925 - 6.425 GHz
Polarization		VP (Tx & Rx) HP (Tx & Rx)
Coverage		Canada, U.S. cities
Orbital Positions		104.5°, 107.5°, 110.5° and 117.5° West longitude
Minimum Coverage Area Gain (excluding cities)		26.6 dBi (Tx) 26.8 dBi (Rx)
Polarization Isolation		≥ 33 dB

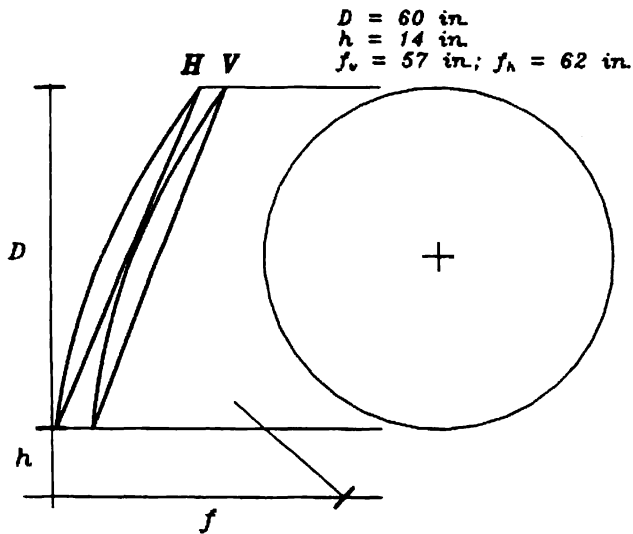


FIGURE 1: ANTENNA GEOMETRY

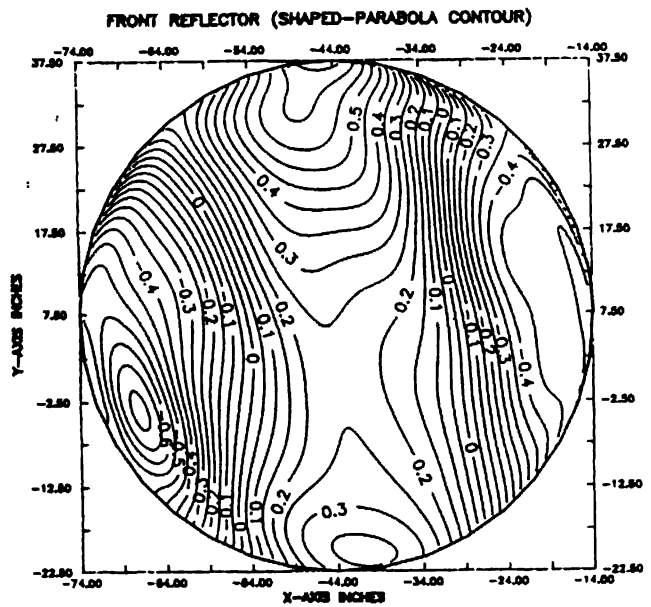


FIGURE 2: SYNTHESIZED REFLECTOR SURFACE DEVIATIONS FOR VI

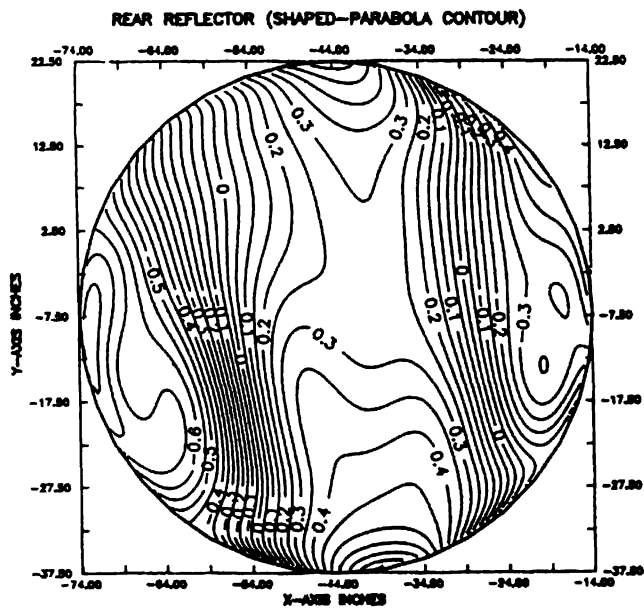


FIGURE 3: SYNTHESIZED REFLECTOR SURFACE DEVIATIONS FOR HP

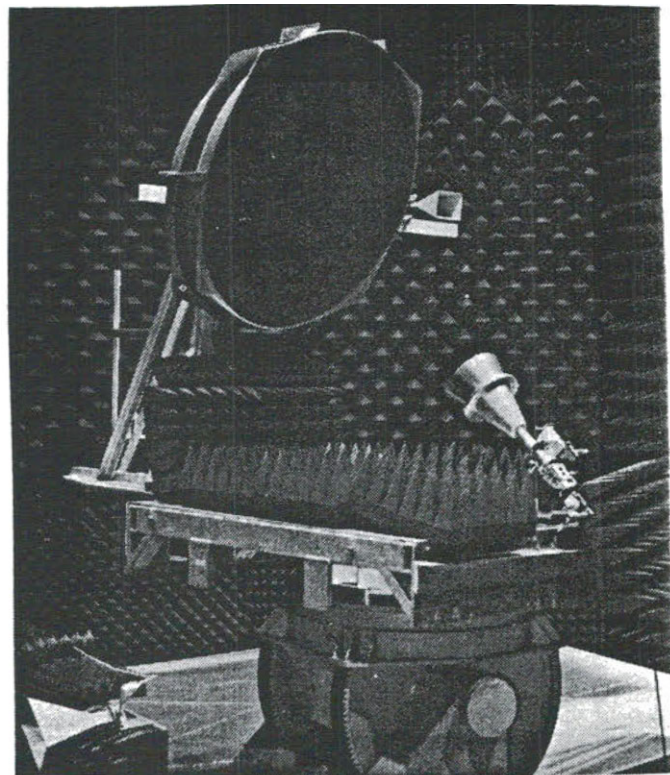
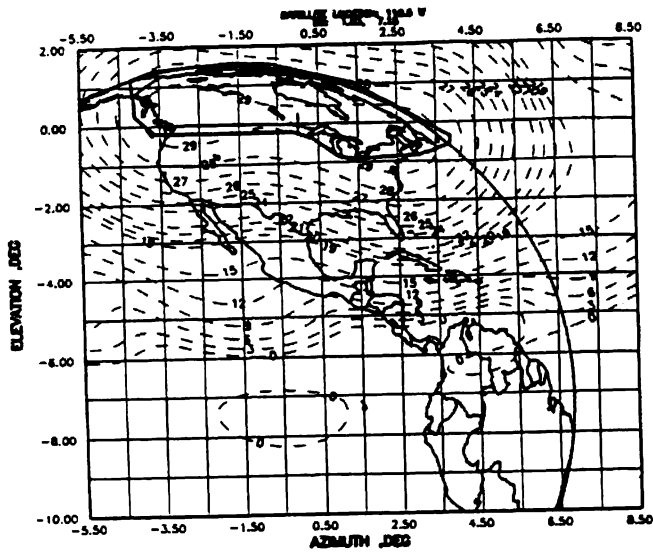
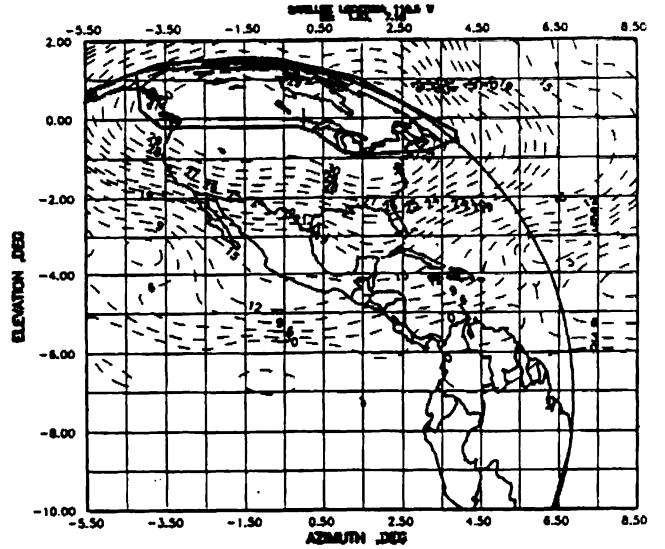


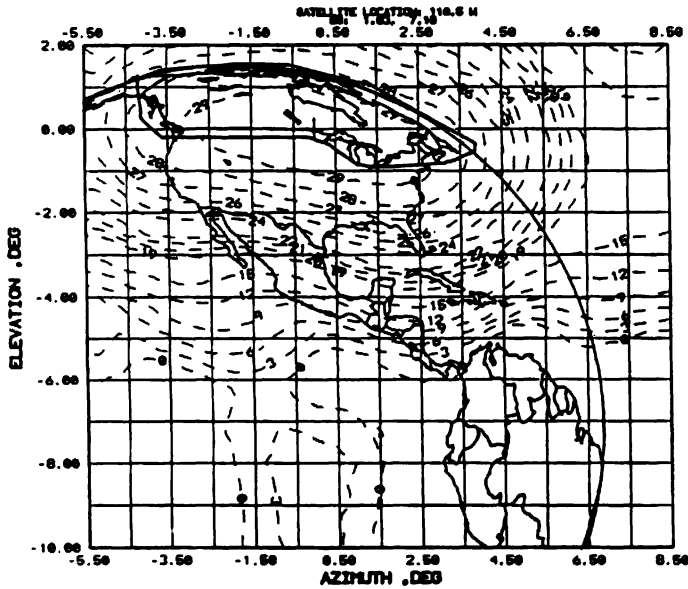
FIGURE 6: DUAL-GRIDDED SHAPED REFLECTOR ANTENNA



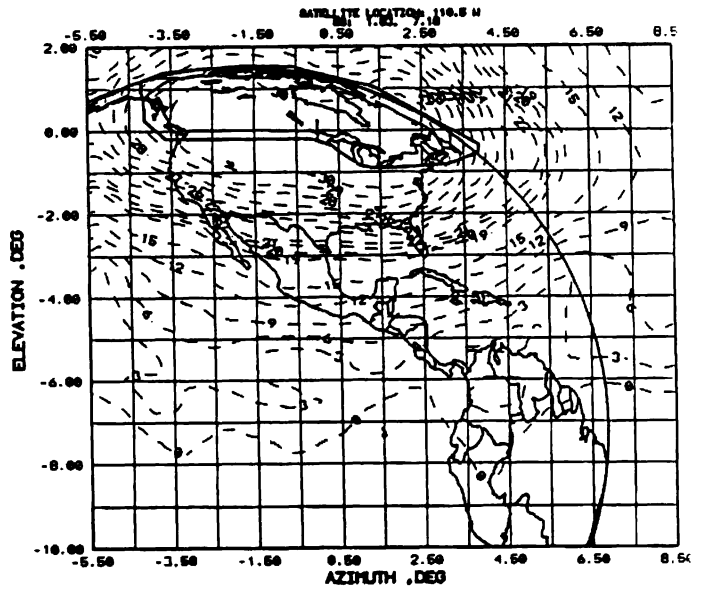
**FIGURE 4: COMPUTED DIRECTIVITY PLOTS
FOR VP AT 3.95 GHz**



**FIGURE 5: COMPUTED DIRECTIVITY PLOTS
FOR VP AT 6.175 GHz**



**FIGURE 7: MEASURED DIRECTIVITY (GAIN + LOSSES)
CONTOUR PLOTS FOR VP AT 3.95 GHz**



**FIGURE 8: MEASURED DIRECTIVITY (GAIN + LOSSES)
CONTOUR PLOTS FOR VP AT 6.175 GHz**