Electromagnetic Simulations for an Axisymmetric Gregorian Reflector System for a Space-Deployed Inflatable Antenna

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***Abstract*— An axisymmetric array-fed confocal parabolic Gregorian reflector system for potential space deployment is explored. The antenna utilizes a planar array located near the vertex of the primary reflector. Numerical electromagnetic simulations based on the multilevel fast multipole method (MLFMM) were used to analyze and optimize the antenna parameters for fixed on-axis peak directivity performance. Simulations of the radiation pattern performance of a dual reflector system with a 2.4m diameter primary reflector operating at Ku band are presented.**

Keywords—Gregorian, reflector, antenna, array, MLFMM

I. Introduction

Reflector antennas are of interest for space applications requiring high gain and low sidelobes. It is assumed here that a satellite has accurate attitude control pointing so that errors in the antenna main beam pointing direction can be neglected. In the case of a space-deployable antenna, a reduction in mass is an important goal, which might be achieved using an inflatable design as depicted as an artist's concept in Fig. 1 In this study, an axisymmetric Gregorian antenna system design with confocal paraboloids was desired, which could allow easier fabrication compared to an offset Gregorian design [1-4]. Thin-film materials with and without electrically conducting coatings can be considered for designing an inflatable space-deployable antenna [5-8]. An ideal planar array source feeding the Gregorian subreflector is assumed in this study. When a large focal magnification is used, the blockage of the main beam by the subreflector can be relatively small. A 2.4m diameter Ku-band Gregorian reflector system operating at 16 GHz (λ=1.875 cm) has been analyzed and optimized using numerical simulations with the multilevel fast multipole method (MLFMM).

II. Antenna numerical simulation modeling

As shown in Fig. 2, a Ku-band Gregorian confocal reflector system with a primary parabolic reflector diameter D=2.4m and focal distance f_p=0.9m (f_p/D=0.375), parabolic subreflector diameter d=0.25 m and focal distance f_s=0.08m (f_s/d=0.32), and phased array diameter 0.2m, has been analyzed and optimized using numerical simulations conducted with the FEKO software (www.feko.info) MLFMM solver. The primary and secondary reflectors were analyzed as perfect electric conductors with ideal parabolic shape. Optimization was performed as a grid search with the subreflector diameter and subreflector focal distance taken as the search parameters. The search optimization goal was assumed here to be peak directivity at boresight. The magnification factor for this reflector system is given by the ratio of the primary to subreflector focal distances or $m= f_p/f_s$ =11.25. The angle from the center of the feed array to the edge of the subreflector is 8°.

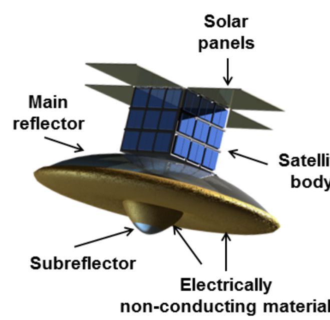

Figure 1. Artist's concept for an inflatable axisymmetric dual-reflector antenna deployed from a satellite.

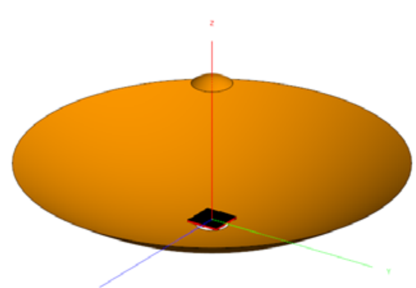

Figure 2. Electromagnetic model for axisymmetric Gregorian antenna with confocal paraboloids and planar array feed.

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The array feed (Fig. 3) is an ideal 20 cm diameter circular aperture source with linearly polarized elements spaced 1.5 cm (0.8λ) on a square grid. The feed array is desired to be located close to the satellite body, and is spaced 3 cm from the vertex of the primary reflector. The feed array half-power beamwidth is 5.6° at 16 GHz, so the subreflector will be efficiently illuminated with little spillover losses.

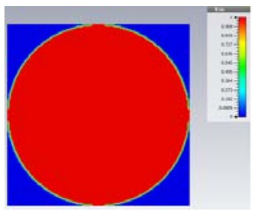

Figure 3. Feed array with uniform amplitude illumination.

III. RESULTS

The MLFMM simulated surface currents in dBA/m on the primary and secondary reflectors are shown in Fig. 4. Direct illumination of the primary reflector from the near-field sidelobes of the phased array feed is observed. The simulated near-field radiation pattern (total field) is shown in Fig. 5. The simulated E-plane and H-plane directivity patterns at 16 GHz are shown in Fig. 6. The simulated radiation pattern characteristics are as follows: peak directivity is 49.4 dBi, half-power beamwidth is 0.52°, first sidelobe level is –28.5 dB. For a 2.4 meter diameter aperture with 100% efficiency, the peak directivity at 16 GHz is 52 dBi, so the simulated aperture efficiency of this antenna design is 55%.

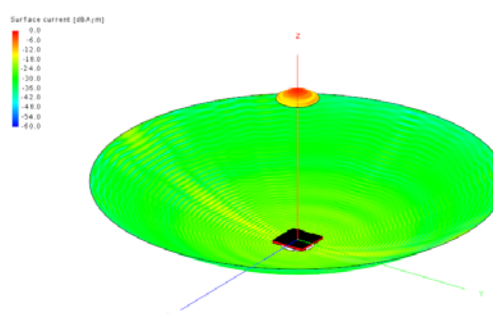

Figure 4. Simulated surface currents at 16 GHz.

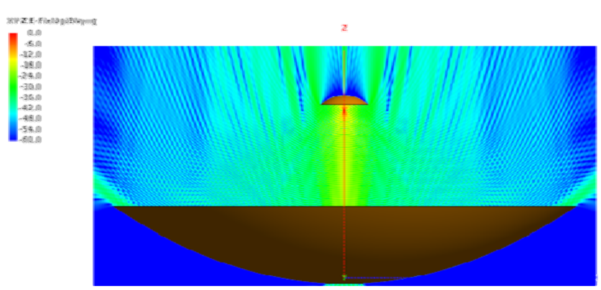

Figure 5. Simulated near-field amplitude at 16 GHz.

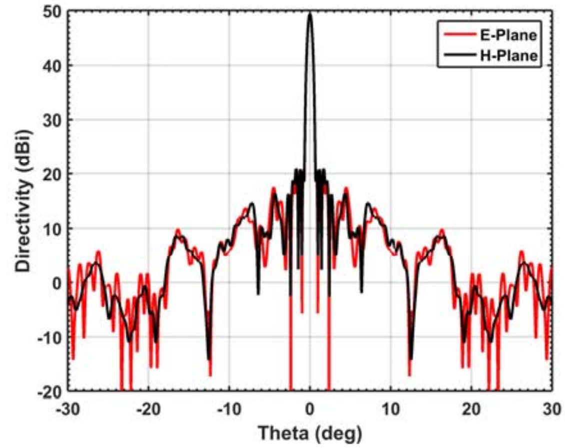

Figure 5. Simulated directivity patterns at 16 GHz.

IV. SUMMARY

A Gregorian dual-reflector antenna system with confocal paraboloids and a planar array feed has been explored for a possible space-deployed inflatable antenna. Optimization using the multilevel fast multipole method indicates high gain and low sidelobes can be achieved for this antenna design.

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