SPACEBORNE MEMBRANE REFLECTOR ANTENNAS WITH PERIODIC AND APERIODIC DISTORTIONS

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The 21^{st} century space science mission visionaries have been considering membrane structures for light weight and deployable large reflector antennas. For these reflectors, performance critically depends on the manufacturing accuracy of their surfaces. Structural inaccuracies may cause different types of surface distortions. In particular, since these reflector surfaces are very thin, (typically 5 to 10 mils) they are susceptible to various types of periodic and aperiodic distortion caused by gravitational effects or torsions from antennas attachment mechanism to the supporting structure. In particular, these distortions could become very important during 1-g ground testing of the antenna.

The focus of this paper is to characterize the effects of periodic and aperiodic surface distortions on the performance of membrane reflector antennas. The particular antenna dimensions used for this study are similar to the specifications for the JPL/UCLA half scale model of second generation precipitation radar (PR-2) mission reflector. Analytical expressions are introduced to model periodic and aperiodic surfaces and based on these models the effects of distortions on the radiation performance of the antenna are simulated. Aperiodic distortions are more realistic cases of distortions due to the fact that the period of the distortions is not constant through out the reflector surface. For each case, far-field patterns of the reflector are simulated and it is shown that closed-form expressions can then be derived which result in a very efficient computational method to predict some of the unique features of these patterns including location and level of observed grating lobes.

The simulation and calculation results reveal that the locations of these grating lobes are determined by the number of ripples on the reflector surface. The level of the grating lobe depends, in general, on the rms of the reflector surface and number of ripples. To calculate the gain loss, an expression is derived to relate the distortion peak level to rms of the surface. Furthermore, based on spatial Fourier analysis of the surface distortion, it is shown that deviation from periodicity in the distortions of reflector surface results in lowering these grating lobes. For the reflectors with no dominant spatial frequency, the energy will be radiated in a broad angular region. In the limit, the far-field pattern of a distorted reflector with spread spatial spectrum will approach to the average power pattern of the reflector with random surface errors. Parametric studies have been performed to provide design guidelines for acceptable surface behavior. This is an important consideration for evaluation the performance of large deployable membrane reflector antennas for future spaceborne missions.