# PERFORMANCE EVALUATION OF LARGE REFLECTOR ANTENNAS FOR SATELLITE COMMUNICATION APPLICATIONS

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Introduction. Currently, much attention is being devoted to feasibility studies for employing large antennas (20-100 meters) in space for communication, scientific and radiometry applications. In this paper, a methodology of designing multiple beam antennas with large reflectors is described and the importance of system tradeoff studies among a wide range of reflector parameters is highlighted. The effects of mesh surfaces on far-field patterns are shown by demonstrating how non-uniform mesh cell structures can significantly increase the level of cross-polar fields. This is an important consideration when polarization diversity is used to conserve the frequency spectrum. Due to the fact that large antennas are subject to thermal and dynamic distortions, the effects of both systematic and random distortions on reflector antenna performance are presented. Most of the results are tailored to a recently developed concept for the third generation UHF Land Mobile Satellite Service (LMSS) antenna, which is a Shuttle-compatible mesh-deployable offset wrap-rib parabolic reflector with a diameter of 55 meters and a focal length of 82 meters (see Fig. 1).

Methodology of the RF Design. The design of a multiple beam reflector antenna system involves the interplay of many parameters. A schematic of the design steps is shown in Figs. 2(a, b, c). In these figures, the ellipses typically refer to input and output information, rectangles refer to some available formulas or graphs and the three-cornered rectangles refer to appropriate computer programs. Using the steps outlined in Fig. 1(a), one can arrive at a first time estimate of the reflector's geometry to fulfill a desired set of performance requirements. The next important question is what the realizable feed configuration will be in order to both meet the available feed spacings and provide the desired feed pattern [see Fig. 2(b)]. Experience has revealed that, for most contiguous multiple beam designs, the need for achieving low sidelobes, which is achieved by high illumination taper (thus requiring highly directive feeds), and limited spacing between feed elements prevents one from using the single element approach. Among different possibilities, the concept of an overlapping cluster of feed elements has been found to be very attractive. In this concept one employs a central feed element with a few neighboring elements (6, for example) to provide a highly directive feed pattern to achieve a low sidelobe beam. This process is continued for the next central feed element which shares some of the elements of the first beam, hence, the concept of the

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overlapping cluster of feed elements. This information is then used in a detailed RF study to carefully assess how well the system objectives, such as gain and C/I (carrier over interference), are met (see Fig. 2c).

RF Performance Evaluation. The results recently obtained for the large reflector antenna of a proposed third generation land mobile satellite system are summarized here. The parameters of the antenna are presented in Fig. 1. The goal has been to achieve 87 beams of approximately a 0.45° beamwidth covering the continental United States (CONUS). A single circular polarization 7-frequency reuse layout is selected. A 7-element cluster arrangement for all of the beams is used. Each element itself is composed of 4 microstrip patches.

Accurate performance analysis of LMSS type mesh-deployable satellite communications antennas for multiple and contour beam applications demands that the effect of the mesh be properly accounted for in the vector diffraction analysis. A strip-aperture model has been used to formulate the reflection coefficient matrix for a variety of mesh cell configurations (see Fig. 3). For example, for square and rectangular mesh cell configurations of the LMSS reflector, Fig. 4 depicts the far-field patterns. It is clearly observed that the elongated mesh cell results in a drastic degradation of the cross-polar field for the circular polarization case.

The effects of both the systematic and random distortions have been investigated. This is essential in order to properly assess the performance of large antenna systems in the space environment. For example, Fig. 5 shows the result of a stochastic model in establishing the required rms surface value to maintain the sidelobe level within a specified level with a prescribed probability of occurrence. For the systematic distortion, Fig. 6 demonstrates the effects of a typical periodical surface distortion on the far-field pattern. It is noticed that, based on the period and level of this type of distortion, unwanted and relatively high pseudo-grating lobes can occur. In summary, in order to properly assess the RF performance of large deployable antenna configurations, a systematic design approach is required which necessitates a sophisticated collection of design data and accurate and efficient computer software to allow in-depth parametric studies and performance evaluation of the overall system under a variety of conditions.

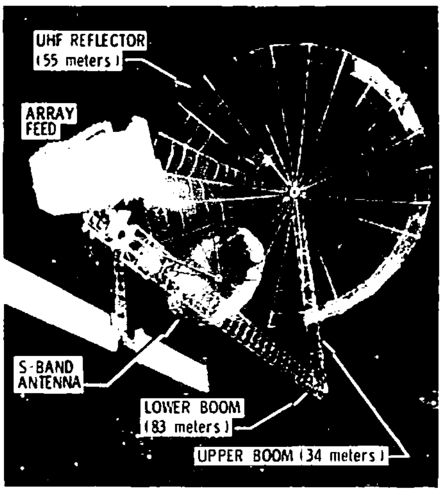
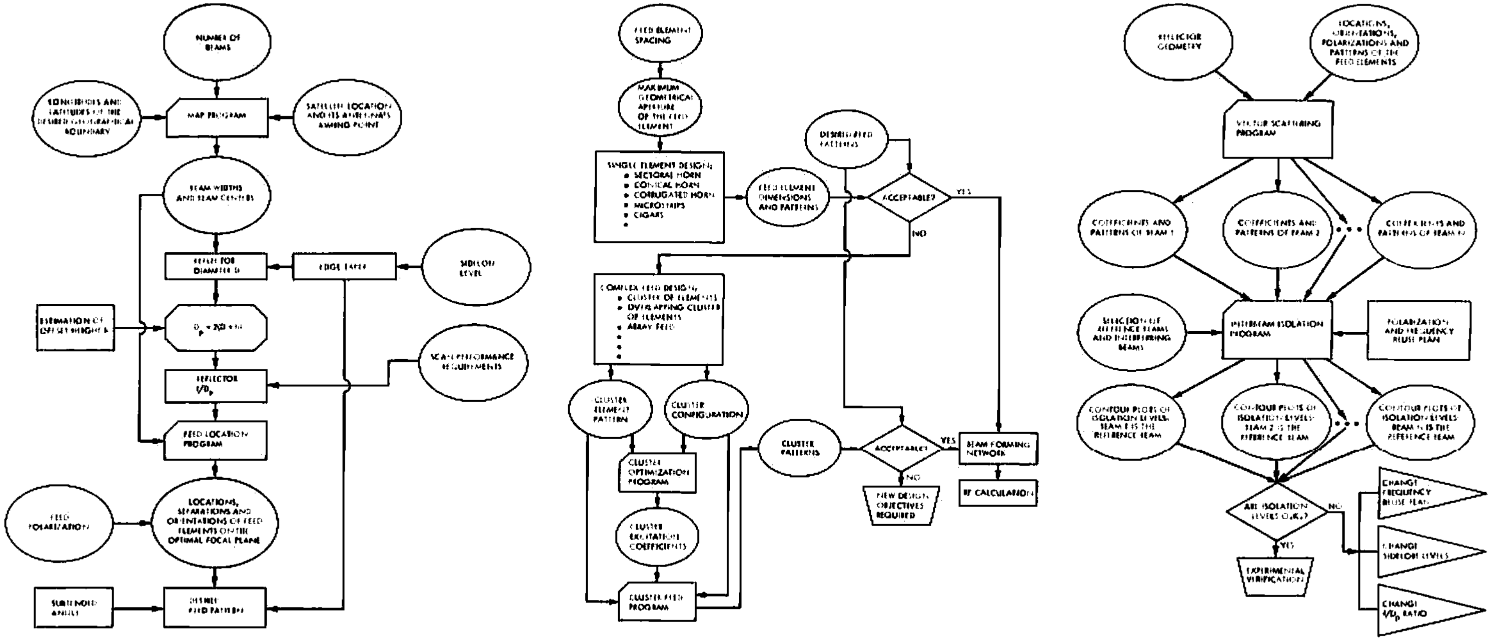



Fig. 1. Land Mobile Satellite System Conceptual Design (UHF).



(a) (b) (c)

Fig. 2. Design steps for offset-fed parabolic reflector with contiguous multiple beams: (a) Steps for initial RF design, (b) Steps for feed realization, (c) Steps for RF pattern and beam isolation calculations.

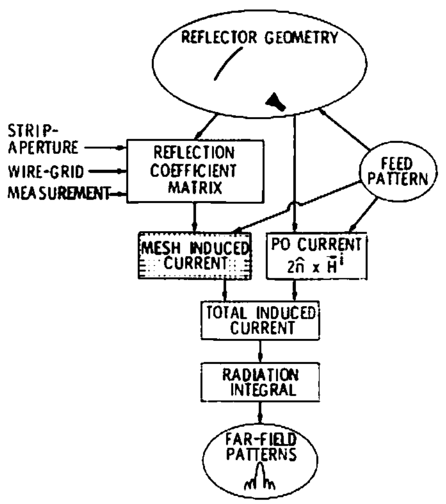



Fig. 3. Schematic of Computational Steps.

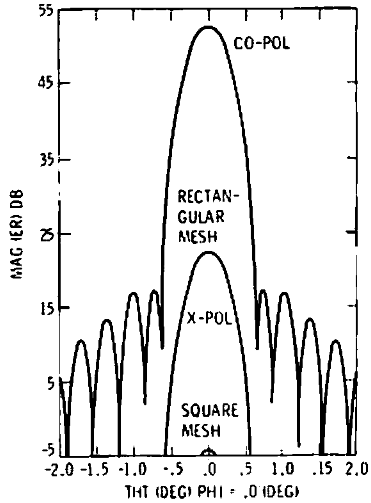



Fig. 4. Generation of circularly cross-polarized fields as a function of mesh cell shapes.

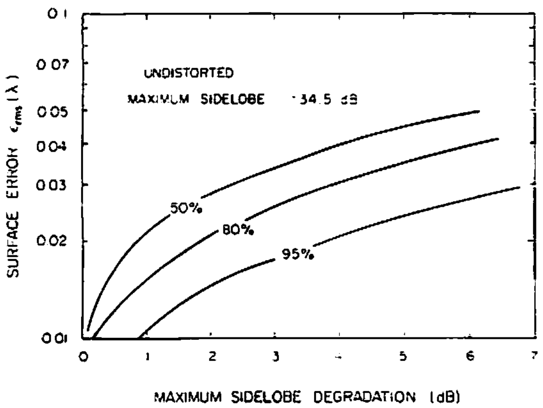



Fig. 5. Surface tolerance vs. degradation of maximum sidelobe level for different probabilities.

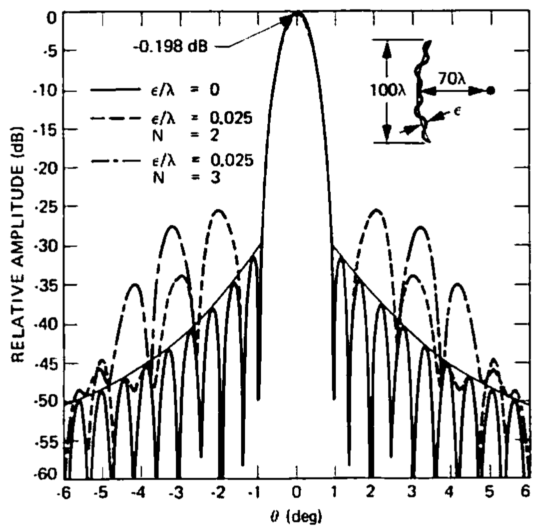



Fig. 6. Far-field patterns as a function of periodic distortions.