TRADEOFF STUDY OF ANTENNA SYSTEMS FOR TYPICAL INTELSAT COVERAGES

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1. INTRODUCTION

This paper describes the tradeoff study result of antenna systems for typical INTELSAT coverages. In this study, we investigated the antenna dimensions versus minimum coverage area gain(MCAG) and isolation for the four zone beam coverages. As the results, we clarified the relationship of the antenna dimension versus MCAG with satisfying the desired isolation for the specified coverage separation.

2. DEFINITION OF ANTENNA SYSTEMS CONSIDERED

The antenna systems considered in this study consist of a single offset palaboloidal reflector illuminated by an array of feed horns. A reflector geometry should be selected with sufficient offset so that the feed array will not block any of the scanned element beams radiated by the array. The array element excitations should be optimized to provide the best possible performance of the composite beam. Figure 1 outlines the principal antenna parameters.

Figure 2 shows the four INTELSAT VII zone beam coverages which formed the basis of the tradeoff study. For the tradeoff study, we assumed that the zone-1 coverage should be the desired coverage area and be kept fixed at its nominal position. The other three zone coverages should be the isolation areas and be moved, keeping all beam separations uniform, to provide beam separations S of 2°,2.5°,3°,3.5° and 4°. For each coverage spacing, five different isolation requirements, i.e., 30dB,27dB,24dB,21dB and no isolation requirements, were considered.

The antenna dimensions considered in this study are obtained by varying the aperture diameter D over the values of 1.0, 1.5, 2.0, 2.5 and 3.0m, the focal length to diameter ratios f/D over the values of 0.75, 1.0 and 1.25, and the element beam spacing to beamwidths ratios X at the center frequency over the values of 1.0, 1.1 and 1.2. The element beamwidth was set equal to the half-power beamwidth of the uniformly illuminated circular aperture which is approximately equal to 58.9 x wavelength/D degrees. The element beam spacing was determined from the simplified relation as shown below:

$$d = 1.0597\ f/D\ \ X\ (\ 1 + (\ (D/2 + d_c)\ /2f\ )^2\ )$$

The reflector clearance of offset hight dc is determined from the condition of no blockage:

$$d_c = 2\ f\ \tan(\ \theta_{sc} + \theta_{cl}/2\ )$$

where θ_{sc} is the maximum scan angle and θ_{cl} is the clearance angle defined in Figure 1. We assumed the angle $\theta_{sc} = 9^\circ$ and $\theta_{c1} = 4^\circ$. This condition for no blockage was used to determine θ_0 and θ^* from the ralations:

$$\theta_0 = \theta_2 + \theta_1 \quad \text{and} \quad \theta^* = \theta_2 - \theta_1$$

where

$$\theta_2 = \mathrm{Arctg}(\,(D+ d_c)/\,2f\,) \quad \text{and} \quad \theta_1 = \mathrm{Arctg}(d_c/2f)$$

Table 1 lists the resulting antenna parameters θ_0, θ^*, d_c, d and No. of feeds. An asteriks at the feed diameter indicates that the dual-mode horn is used as feed element. Otherwise the fundamental mode horn is used.

3. DESCRIPTION OF OPTIMIZATION AND ANALYSIS APPROACH USED

Accurate element beams were calculated by using Physical Optics(PO) and Geometrical Theory of Diffraction(GTD) at the edge of the frequency band, 3.7 and 4.075 GHz, towards the synthesis stations. The major approximations in the calculations are the neglect of mutual coupling in the feed array, antenna farm scattering effects and the assumption of perfect BFNs and reflector systems. The simple feed models used are most accurate for the larger feed diameters.

The general minimax algorithm originated by Madsen (1) with refinements by Frandsen and Madsen was used to ensure the best possible solution in each case. And we optimized the element beam excitations at the above mentioned two frequencies simultaneously. Additionally, we used a least-squares sulution as initial solution to the minimax algorithm.

4. SUMMARY RESULTS OF TRADEOFF STUDY

Figure 3 (a) thru (e) summarize the resulting relationsip of the antenna dia. versus MCAG under the condition of each desired isolation and each coverage separation, respectively. In these figures, we selected the case which gives the maximum MCAG for each isolation and for each coverage separation. From the tradeoff study, we found out the following results;

(1) the case of larger aperture diameter D and/or large coverage separation S gives the higher MCAG and larger isolation,
(2) the improvements of the MCAG almost saturates around D = 2 - 2.5m,
(3) in case of small aperture diameter D and/or small coverage separation S, the desired isolation cannot be obtained,
(4) the case of larger isolation level gives the lower MCAG.

5. CONCLUSION

We studied the antenna system for the typical INTELSAT coverage and clarified the relationship of the antenna dimension versus MCAG with satisfying the desired isolation for the specified coverage separation.

This paper is based on work performed under the sponsorship and technical direction of the International Telecommunications Satellite Organization (INTELSAT). Any views expressed are not necessarily those of INTELSAT.

Reference

(1) K. Madsen, H. Schjaer Jacobsen, "A nonlinear minimax optimization program not requiring derivatives", IEEE Trans. Antennas Propagat., vol. AP-25, pp. 454-456, 1977

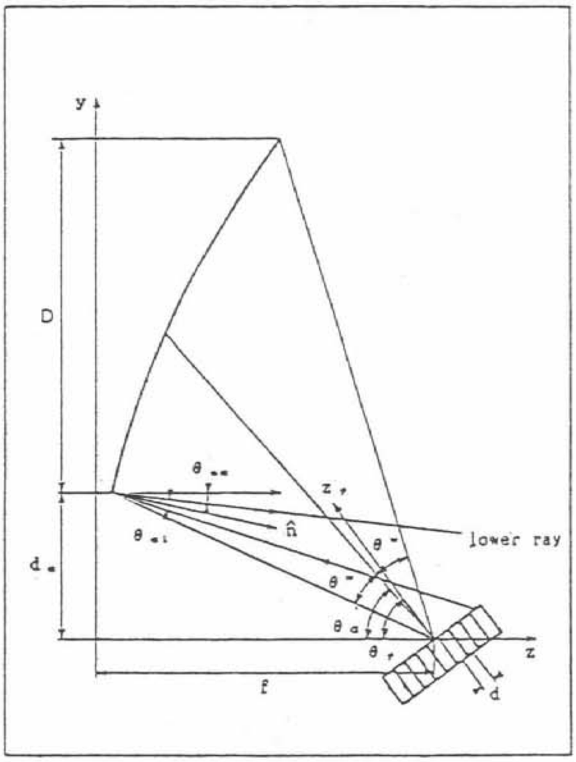

Figure 1 Principal Geometrical Antenna Parameters

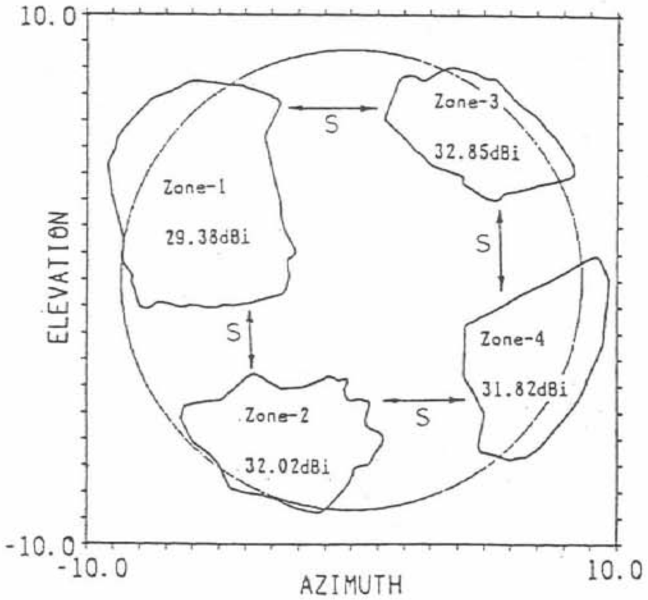

Figure 2 INTELSAT VII Zone Beam Coverages

Table 1 Principal Reflector and Feed Array Parameters

f/D	x	θ_0 [deg]	θ^* [deg]	d_c/D	d [m]	No. of feeds D [m] 1	1.5	2	2.5	3
0.75	1.0	51.73	29.73	0.2916	0.0785	13	22	31	44	51
0.75	1.1	51.73	29.73	0.2916	0.0864	13	18	27	40	42
0.75	1.2	51.73	29.73	0.2916	0.0942-	9	14	23	32	37
1.00	1.0	45.78	23.77	0.3889	0.0980-	13	22	31	44	51
1.00	1.1	45.78	23.77	0.3889	0.1080*	13	18	27	40	42
1.00	1.2	45.78	23.77	0.3889	0.1176*	9	14	23	32	37
1.25	1.0	41.73	19.73	0.4860	0.1183*	13	22	31	44	51
1.25	1.1	41.73	19.73	0.4860	0.1302*	13	18	27	40	42
1.25	1.2	41.73	19.73	0.4860	0.1419*	9	14	23	32	37

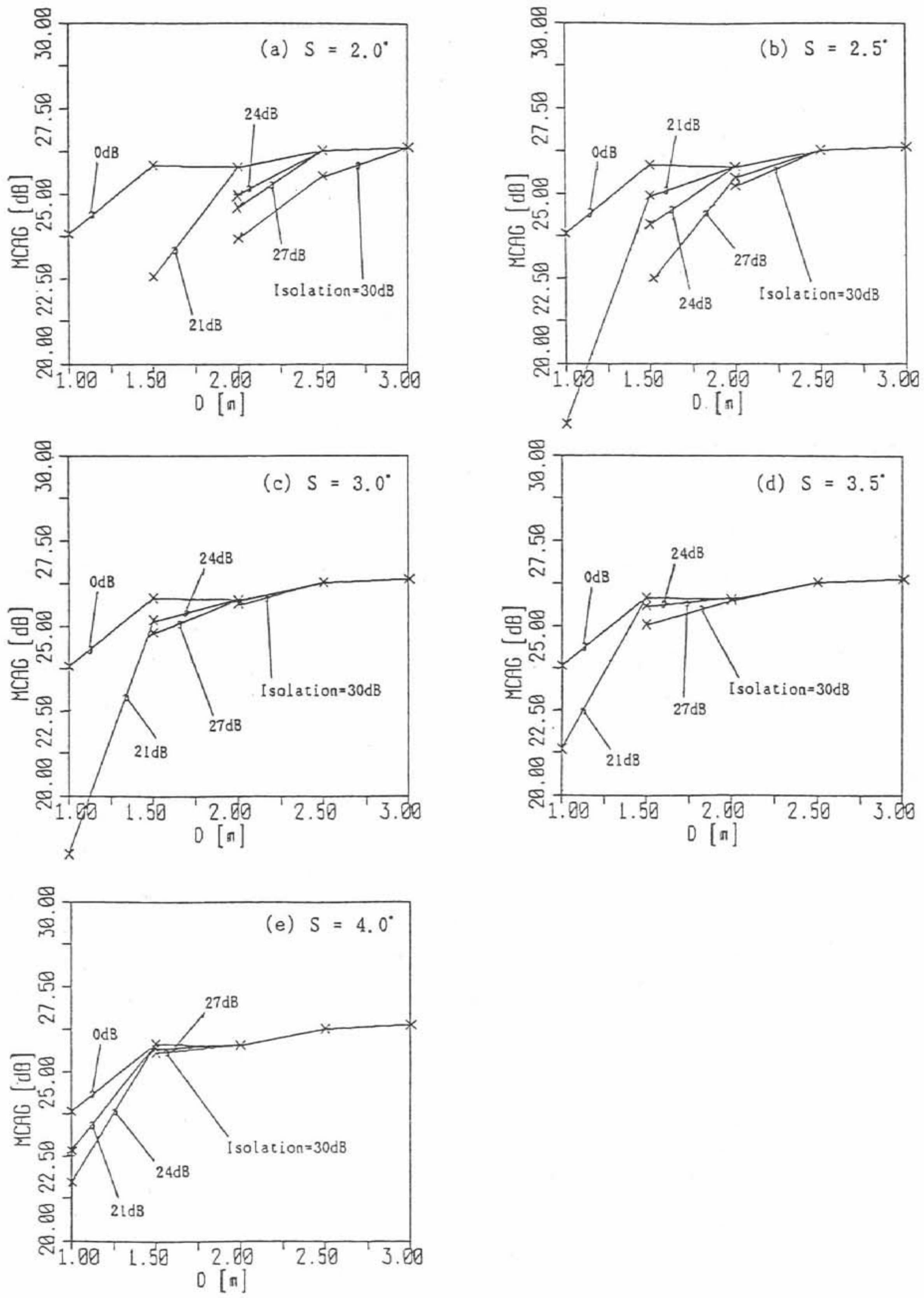

Figure 3 Calculation Summary of MCAG vs. D