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1) SS-13 S-BAND DESIGN OP'J'JMIZA'J'1ON USING THE FOCAL-PLANE METHOD[†]

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ABSTRACT

In this paper, the Focal-1'lane (Complex-Conjugate Phase-Matching) Method is used to select the appropriate gain and location of a feed for S-1 Band (2.295 G] Iz) operation of 1) SS- 13, **the** new NASA/JPL Deep Space Network (I EN) 34-m Beam WaveGuide (BWG) antenna. It is found empirically that the Ibcal-}'lane Method gives a better design in terms of the G/T figure than previous S-hand designs.

1 N'J'RO1)UCYJ'1ON: A BWG design was chosen for DSS- 13 to take advantage of all the improvements achieved by placing the feed in the pedestal room rather than at the focal point of the dual reflector system (Figure 1) [1]. The original design of 1)SS-13 was done at X-hand; it consisted of a 22-dBi illuminating horn at F_3, a beam magnifier ellipse (M_5) which created a 29-dBi pattern at F_2, and a pair of parabolas which imaged the latter pattern to F_1, the focal point of a dual-shaped reflector system optimized for G/T. 22-dBi X- and Ka-band horns were placed vertically in the pedestal room by means of a flat or dichroic plate used to image the pattern about the ray from F_3 to M_5. An attempt was made to fit a 22-dBi S-hand corrugated horn verticall y but, due to lack of room, it had to be laid in a horizontal position. Also, the RF performance of D SS- 13 with the 22-dBi horn at S-hand was not satisfactory [2].

The previous analysis and synthesis of the RF performance of1)SS-13 was calculated using Physical Optics (J)()) [3] and the Jacobi- -Bessel series [4]. in these calculations a feed radiation pattern was modeled as a set of Slhcrical-Wave Expansion (SWE) coefficients expanded about F_3 [5]. The coefficients were used to illuminate M_5, the BWG mirror in the pedestal room. The induced currents cm M_5, by means of PO, were cascaded through M_4, h43, M_2, M_1, the Sub and the Main reflectors. The Jacobi-Bessel method was implemented at the Main reflector to obtain the secondary pattern of the antenna.

FOCAL PLANE METHOD: The goal of the new design was to maximize the G/T of1)SS-13. To do this empirically, a uniform plane wave was used to illuminate the Main reflector of 1) S- 13. PO was then used to analyze the induced currents on the Main and Sub reflectors, h4 $_1$, M2, M_3, M_4, and M_5. Finally, the currents on a circular aperture with a 23λ diameter at the focal plane centered at F_3 were computed. 1 By taking the complex-conjugate of these currents and applying the radiation integral, the far-field pattern for a **Theoretical Horn, which** empirically maximizes the 1)SS.13 gain, was obtained.

To synthesize a horn quickly and inexpensively, the **Theoretical Horn** pattern was matched as well as possible with one from a circular corrugated horn. Figure 2 shows the near-field E-plane patterns of the **Theoretical Horn** and a 19-

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dBi circular corrugated horn. The agreement in amplitude and phase out to $\theta = 21°$, the angle subtended by M_5, is quite good.

RESULTS: SWE coefficients were generated for the Theoretical Horn and the 19-dBi Corrugated Horn at S-Band. Using these as input, PO and Jacobi-Bessel computer software was run for the 1) SS-13 antenna on *Voyager,* JPL's CRAY Y-MP2E/11 G Supercomputer. TABLE 1 shows the results in terms of spillover, efficiency, noise temperature and G/T for 3 different feeds. The first feed is a 22-dBi circular corrugated horn, investigate in a previous design [2]. The second feed is the 19-dBi circular corrugated horn in a vertical position and the third feed is the Theoretical **Horn** calculated from the Focal-Plane method. The technique used to compute the efficiency and noise temperature of a beam waveguide antenna has been developed and successfully tested at JPL [6].

CONCLUSION: DSS-13 was designed to work at, X- and Ka-Bands with 22-dBi corrugated horns placed at F_3. At S-Band, a 22-dBi corrugated feed located at F_3 does not perform well. The Focal-Plane method suggested that a 19-dBi corrugated horn might perform better. Using PO and Jacobi-Bessel computer software, this was found to be the cam

Besides better RF performance, using a smaller gain horn enabled the designer to fit the feed in a vertical position which makes the mechanical layout of all the waveguide components easier to achieve. Figure 3 shows a complete layout, of the S- and X-Band systems in the pedestal room of DSS-13. The 19-dBi circular corrugated horn fits inside the S-Band package.

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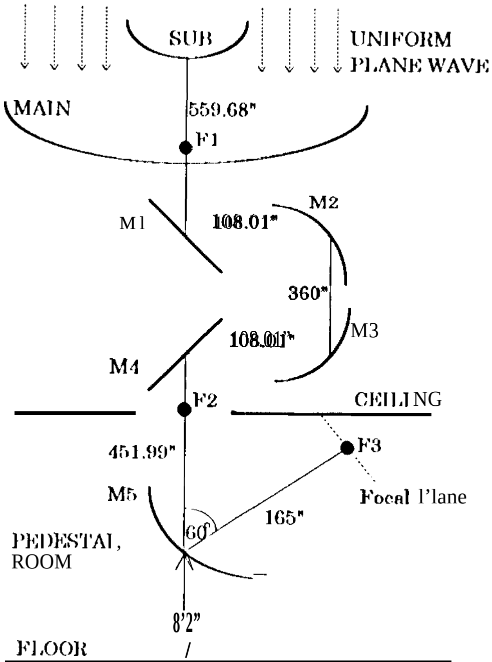

FIGURE 1: DSS-13 Geometry

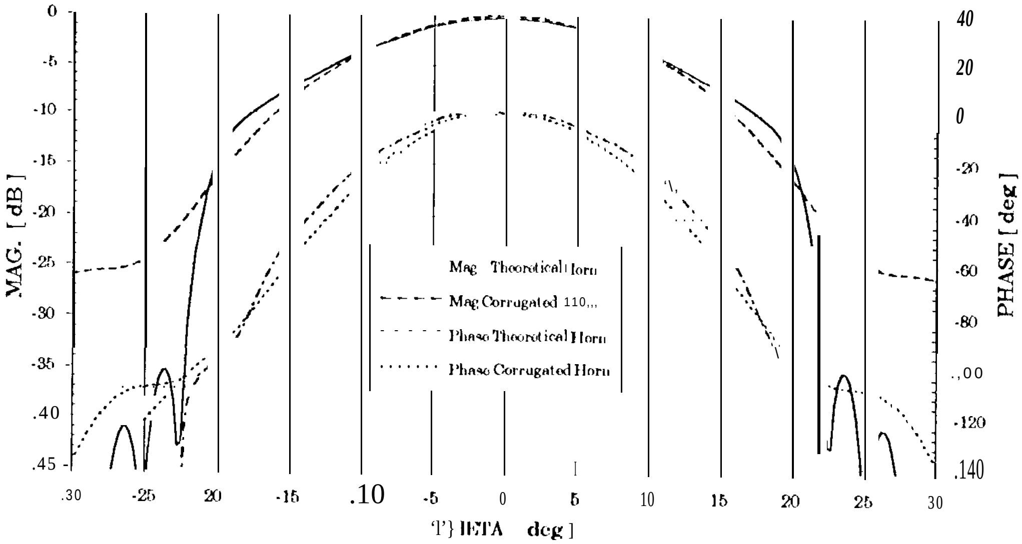

FIGURE 2: E-Plane Near-Field (R= 165", referenced to F_3) Patterns

	22-dBi Corrugated Horn	19-dBi Corrugated Horn	Theoretical Horn
Spillover [%]			
M_6	...	0,32	---
M_5	2.05	2.50	0.24
M_4	1,57	0.67	1.19
M_3	5.91	0.66	0.86
M_2	5.55	1.03	1.29
M_1	1.36	0.27	0.46
Sub	---	1,69	1.94
Main	...	2.18	3.61
Efficiency			
Total Efficiency	0.48415	0.66219	0.69502
Tot. Efficiency [dB]	55.102	56.462	56.672
Noise Temperature			
Total Noise [K]	73.574	36.444	35.314
Total Noise [dB]	18.67	15.62	15.48
G/T [dB]	36.43	40.84	41.19

TABLE 1: DSS-13 S-Band PO & Jacobi-Bessel Calculations

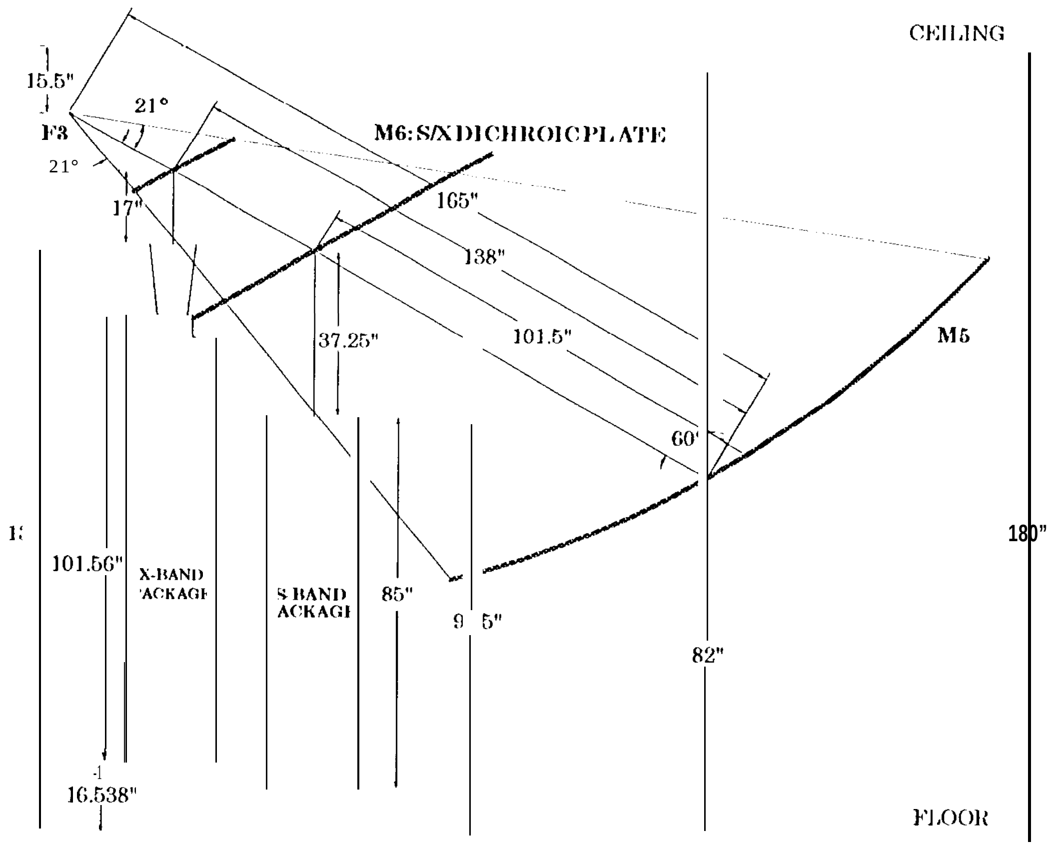

FIGURE 3: DSS-13 Pedestal Room Mechanical Layout