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APOLLO SPACECRAFT SYSTEMS ANALYSIS PROGRAM

TECHNICAL REPORT

TASK E-34D

NAS9-8166

31 DECEMBER 1968

PRELIMINARY LR REFLECTIVITY MODEL

Prepared by

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TRW SYSTEMS GROUP

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In order to facilitate the Guidance and Control Division of NASA in making computer simulated performance estimates of the landing radar, it was necessary to specify an interim reflectivity model. This model is based on theoretical reflectivity curves as well as measured radar data [1].

Measured data from White Sands Missile Range gives a good estimate of how the landing radar will perform in the lunar environment. This statement is supported by the similarity of the electrical properties of the lunar surface and the reflectivity sites at WSMR. The dielectric constant of the lunar surface is reported to be 3.0 ± 0.2 by G. L. Taylor [2]. This value of the permittivity is very close to the value of the permittivity measured for the three reflectivity sites at WSMR [3].

Theoretical results were compared to measured data in a previous report [4]. That report presented a reflectivity curve based on the Beckmann-Smith reflectivity function. Data supporting this model presented in reference [4] were obtained from earth based radar data.

The following curves presented in this report give an estimate of the lunar reflectivity for various altitudes above the lunar surface based on the above studies and measured data from WSMR. In each case a band of uncertainty is specified. This band of uncertainty can be considered as a three sigma value of each of the reflectivity curves.

To date theory and data are inadequate to specify a single reflectivity curve for all altitudes above the lunar surface without a large variance. For this reason it was necessary to specify several reflectivity curves to cover the wide range of altitudes. The altitude above the lunar surface was broken down into three regions as follows: 40,000 ft. to 8000 ft., 8000 ft. to 2000 ft., and 2000 ft. to the lunar surface. Reflectivity curves for these regions are presented below.

Figure 1 is an estimate of the lunar reflectivity for LM altitudes between 40,000 ft. and 8000 ft. based on theoretical and measured data. Since preliminary data indicate that the variance is smaller at high altitudes the band of uncertainty was chosen to be $\pm$ 2 db about the mean. Note that the uncertainty is $\pm$6 db for incidence angles less than 5 degrees. This uncertainty is due to the absence of data to adequately determine the contribution from the specular component near normal incidence.

Figure 2 is an estimate of the lunar reflectivity for LM altitudes between 8000 ft. and 2000 ft. It should be noted that a wider band of uncertainty is specified in this region. When supporting data from WSMR become available this band will be reviewed and updated as required.

Figure 3 and 4 are estimates of the lunar reflectivity for LM altitudes below 2000 ft. and different local terrain roughness. Figure 3 gives an estimate of the lunar reflectivity when the local large scale roughness is in the range of 25 to 40 ft. Figure 4 gives an estimate of the reflectivity when the large scale roughness is in the range of 2-4 feet. For a smooth terrain below 2000 ft. it is recommended that the mean curve of Figure 2 be used. A band of uncertainty of $\pm$3 db was chosen for all reflectivity curves below 2000 ft.

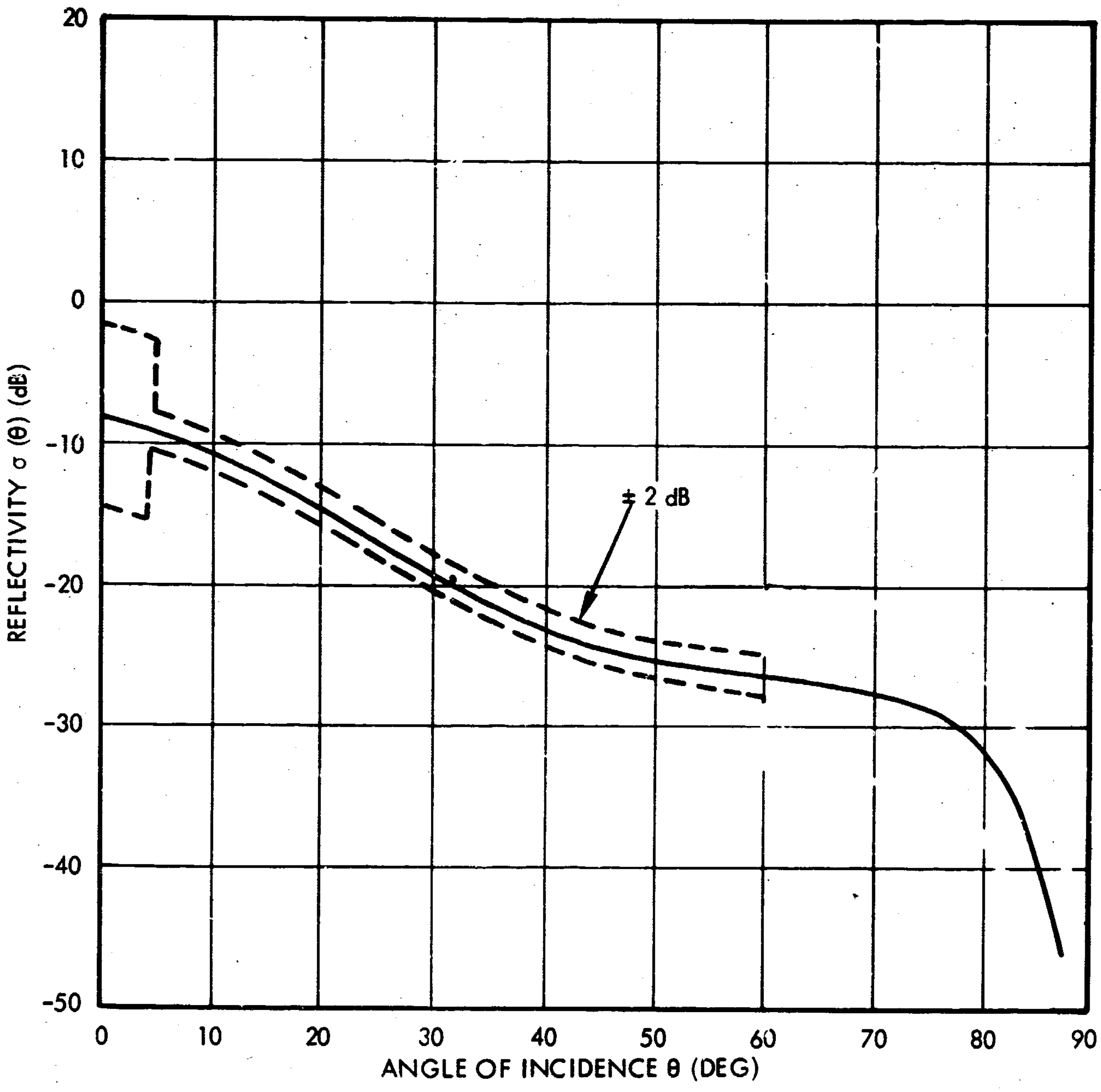

Figure 1. Reflectivity Curve for Altitudes Between 8,000 Feet and 40,000 Feet

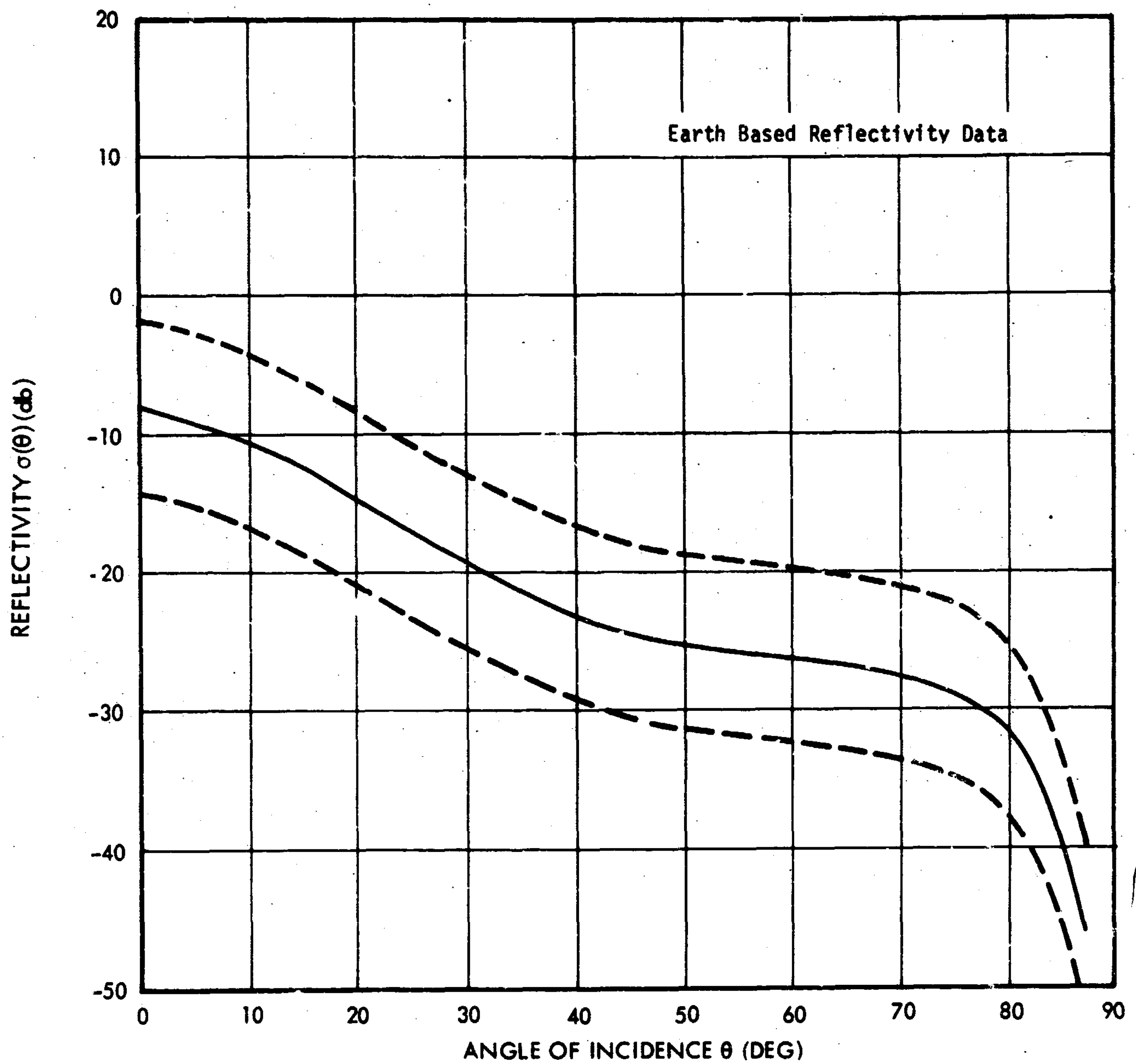

Figure 2. Reflectivity Curve for Altitudes Between 2000 Feet and 8000 Feet.

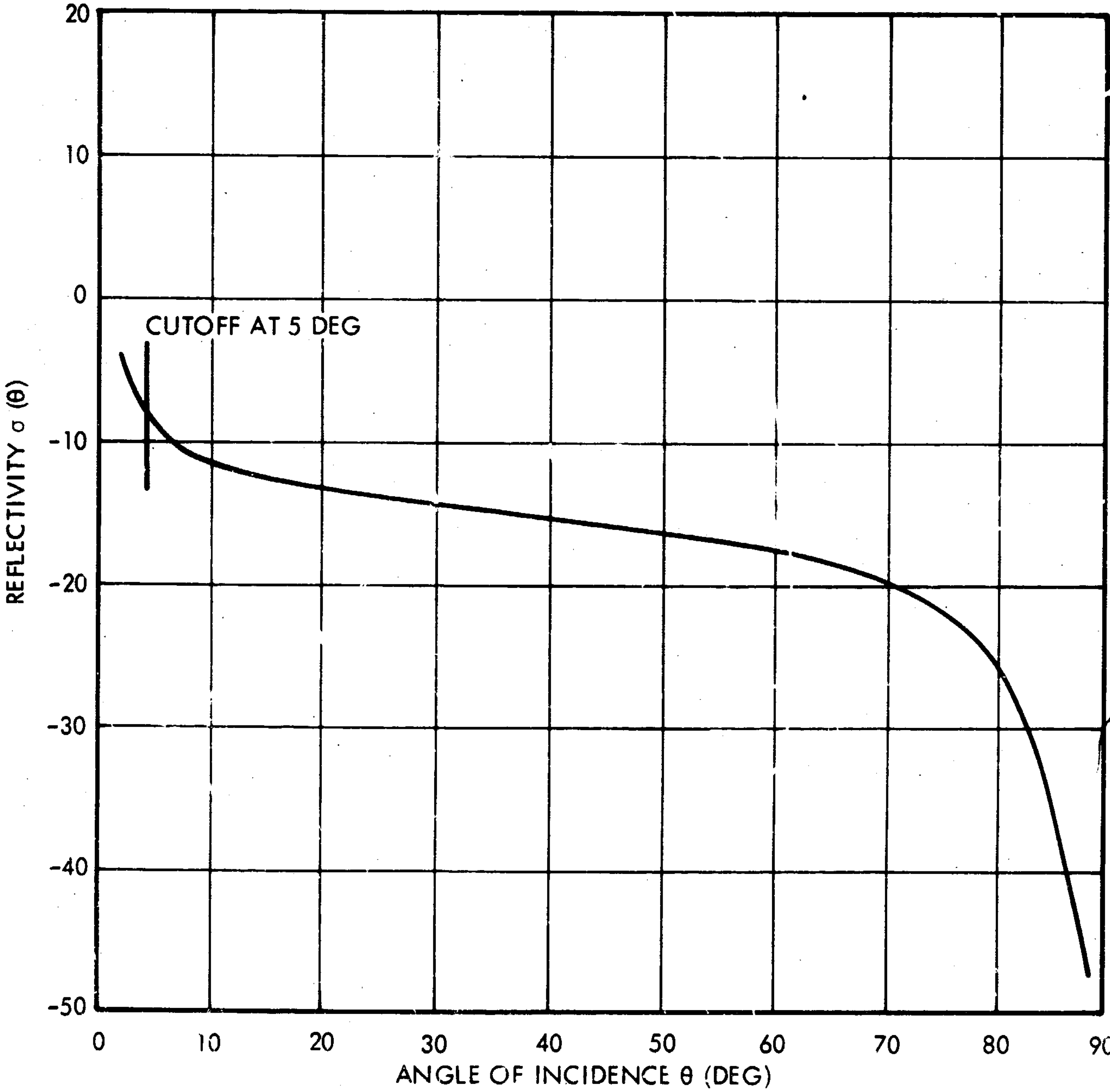

Figure 3. Reflectivity Curve for Altitudes Below 2000 Feet With 25-40 Feet Surface Roughness.

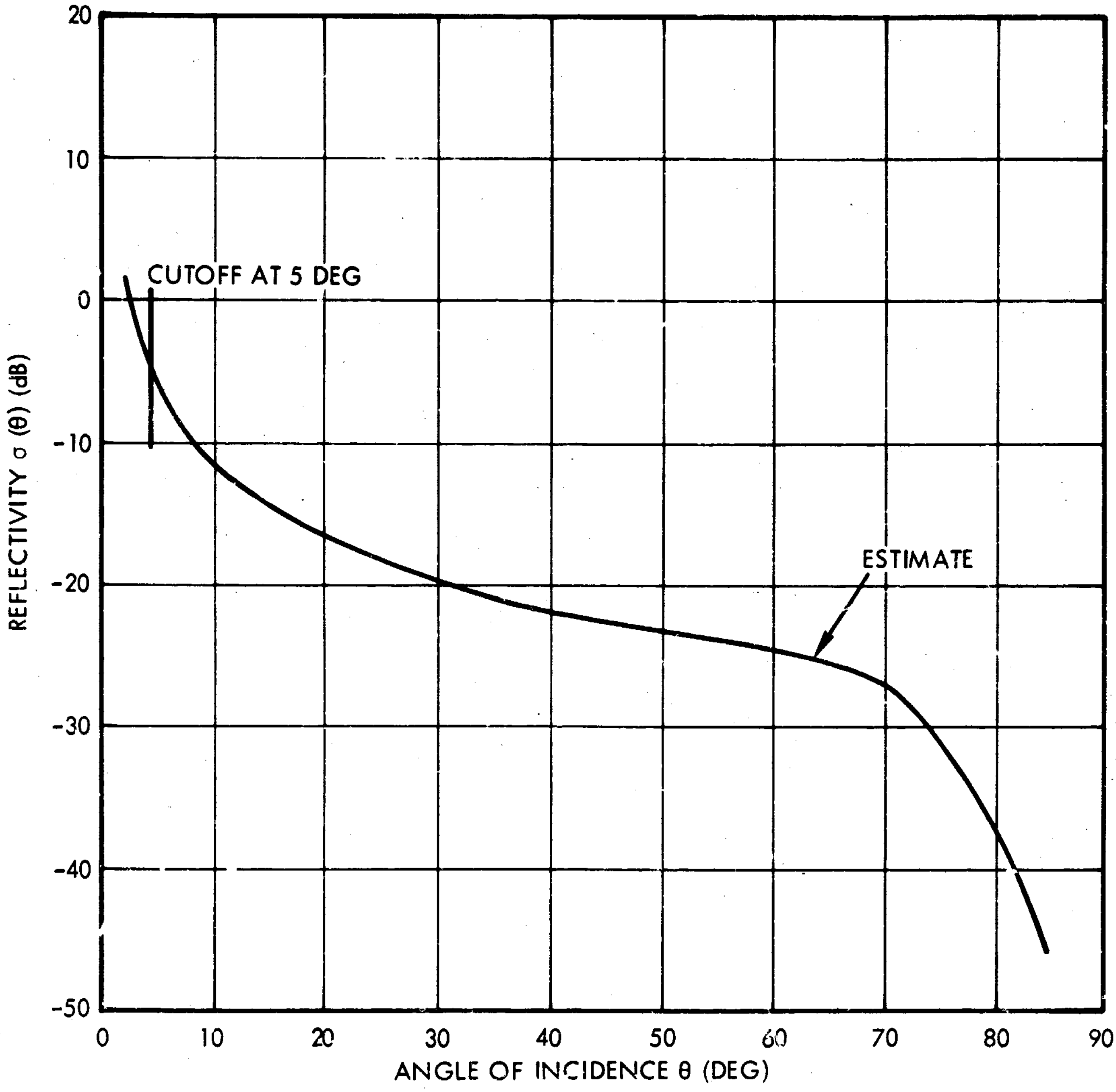

Figure 4. Reflectivity Curve for Altitudes Below 2000 Foot With 2-4 Feet Surface Roughness.

REFERENCES

1. Dickerson, E. T., "Comparison of Surveyor Data With Beckmann-Smith Reflectivity Model", TRW Report Number 05952-H505-RO-00, 15 May 1968.

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3. Gonzales, H. F., "Terrain Dielectric Constants", U. S. Army Technical Report, 15 November 1968.

4. Dickerson, E. T., "Interim LR Reflectivity Model", TRW Report Number 11176-H018-T0-00, 9 August 1968.