2-IV D3

LOW ANGLE TROPOSPHERIC FADING IN RELATION TO SATELLITE COMMUNICATIONS AND BROADCASTING

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During the period from 24 Oct. to 15 Nov. 1970, measurements were made of the received signal strength of the U.S. TACSATCOM-1 satellite beacon at 7.3 GHz. Two receiving systems were employed in this experiment, one using a precision 9 m tracking antenna and the other a transportable 1.8 m antenna.

The satellite, in a near-synchronous orbit, was drifting in a westerly direction so that its elevation angle decreased at a rate of about 0.25 deg. per day. The measurements were begun when the satellite, as viewed from Ottawa, was at an elevation angle of approximately six deg., and nearly continuous observations were made until it reached an elevation angle of 0.5 deg.

Fig. 1 shows samples of received signals on 1 Nov. 1970. During this time, the elevation angle to the satellite was 4.0 deg. It is evident that signal fluctuations of about ±2 dB occur during this interval. These data were used to calculate cumulative amplitude distributions, autocorrelation functions and cross-correlation functions between the two received signals.

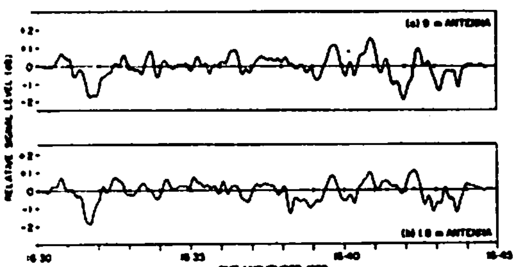

Fig. 1 Received Signal Strength as a Function of Time

The medians for the nine metre system are plotted as a function of time in Fig. 2. For periods after Nov. 9 the elevation angles were below 2 deg. At these low elevation angles, the median level decreased much more rapidly than can be explained by the increase in atmospheric absorption as the path length through the troposphere increases. Effects such as beam divergence due to regular refraction may be significant but cannot account for the entire loss.

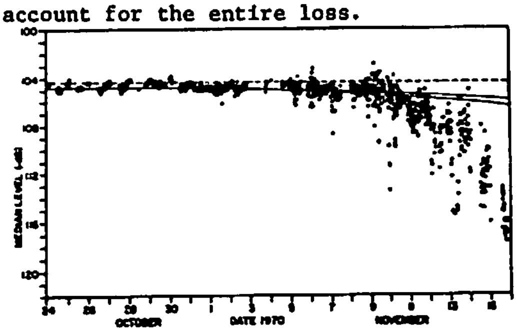

Fig. 2 Median Signal Strength as a Function of Time

In this paper, it is assumed that the power scattered by refractive inhomogeneities is a linear function of frequency. Using this assumption, Fig. 3 shows the predicted distributions of fading amplitudes, based on the 7.3 GHz data at 4-5 deg. elevation angle, for various frequencies between 1 and 20 GHz. The 99 percent margins increase from 0.8 dB at 1 GHz to 3.6 dB at 20 GHz.

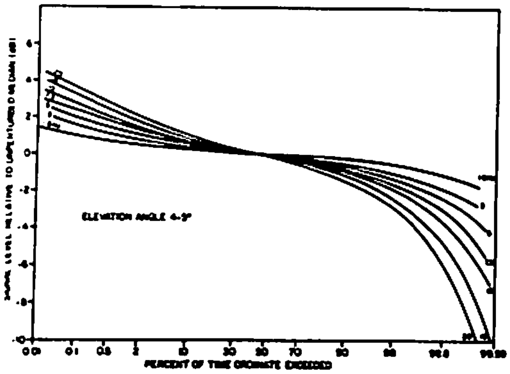

Fig. 3 Predicted Distribution of Fading Amplitude at Various Frequencies

SCALE SIZE OF THE REFRACTIVE STRUCTURES

The time delay between the two curves of Fig. 1, and the correlation between the fading patterns suggest that the refractive structures causing the fading are drifting.

Fig. 4 shows the cross-correlation function for the data of Fig. 1. The function falls to a value of 1/e in a time of about 15 sec., and shows a maximum value of 0.63 with a lag of -7 sec. Since the separation of the two antennas was 23 m, this implies a drift velocity in the transverse direction of 3.3 ms^{-1}, and a scale size of the scattering structure of 50 m.

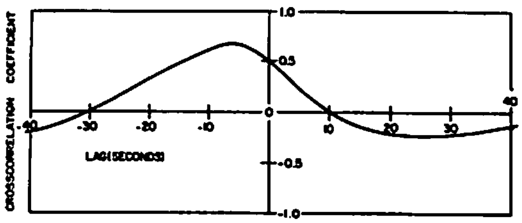

Fig. 4 Cross-correlation Function for Data of Fig. 1

Fig. 5 shows, for the 9 m antenna and for different ranges of elevation angle, distributions of scale sizes derived in the above manner. Values of scale size up to a maximum of about 300 m were observed with a median value of the order of 30 m.

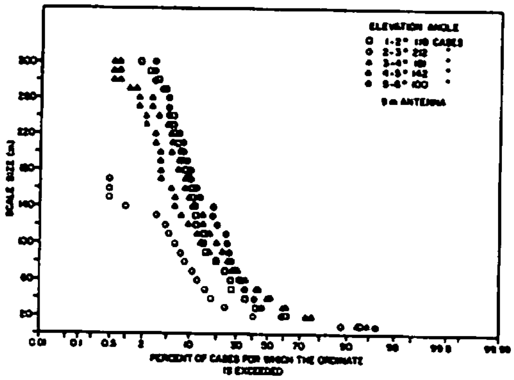

Fig. 5 Distributions of Scale Sizes

SUMMARY

For any given geostationary satellite, there will be large regions of the earth for which the satellite is visible only at low elevation angles. To ensure reliable operation at these low angles, a fairly large propagation margin must be included in the system design to overcome the effects of tropospheric fading. This fading depends on elevation angle and meteorological conditions.

Estimates of the scale size of the structures causing the fading suggest that separation distances of about 300 m would be required if space diversity systems are to be used to overcome the effects of the fading.