COMPARISON OF PROPAGATION MEASUREMENTS WITH PREDICTED VALUES IN THE 20 TO 10,000 MHz RANGE

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Predictions of tropospheric transmission loss over irregular terrain using the computer methods described by Longley and Rice (1968) are compared with measurements, to determine their limits of applicability and define the boundary conditions for their use. Area predictions for mobile systems where individual path profiles are not available are compared with measurements made with low antennas in Colorado, Ohio, Virginia, Wyoming, Idaho, and Washington. Point-to-point predictions for fixed antenna locations are compared with measurements for each of these paths and for a large number of propagation paths in various parts of the world.

Key Words: Fixed point systems, irregular terrain, mobile systems, prediction methods, tropospheric propagation.

1. INTRODUCTION

Predictions of tropospheric transmission loss over irregular terrain using the computer methods described by Longley and Rice (1968) are compared with a large amount of data to determine their limits of applicability and define the boundary conditions for their use. The computer methods may be used either with detailed terrain profiles to predict the transmission losses expected for specific paths or for "area" predictions where path parameters that are representative of median terrain characteristics for a given area are calculated. These calculations are based on a large number of terrain profiles for widely different types of terrain ranging from smooth plains to rugged mountains.

Median propagation conditions for a specific area are characterized by a terrain parameter Δh expressed in meters. To obtain an estimate of Δh, the interdecile range $\Delta h(d)$ of terrain heights above and below a straight line (fitted by least squares to elevations above sea level) is first calculated at fixed distances for a representative group of terrain profiles. The median values of $\Delta h(d)$ increase with distance, approaching an asymptotic value Δh that characterizes the terrain. When an estimate of Δh is available, the median value of $\Delta h(d)$ at any desired distance may be obtained from the relationship:

$$\Delta h(d) = \Delta h \left[1 - 0.8 \exp(-0.02d)\right] \quad \text{m}, \tag{1}$$

where Δh and $\Delta h(d)$ are in meters, and the distance d is in kilometers.

When an estimate of the terrain parameter Δh has been obtained the other essential parameters are: the radio frequency f in MHz, the path distance d in km, and the transmitting and receiving antenna heights above ground h_{g1} and h_{g2} in meters. From these required parameters the others used to calculate basic transmission loss as a function of distance are derived. Some of the more important additional parameters are the effective heights h_{e1} and h_{e2}, the horizon distances d_{L1} and d_{L2}, and the horizon elevation angles θ_{e1} and θ_{e2}.

For area predictions, estimates of the effective heights depend on the procedures followed in choosing antenna sites. When sites are selected randomly with respect to hills or other obstructions, the effective heights are assumed to be equal to the structural heights. If antenna sites are chosen on or near hilltops to improve propagation conditions, the effective heights are larger than the structural heights by an amount that depends upon the terrain irregularity and the structural heights. When antennas are high and the terrain is relatively smooth, the effective and structural heights are almost equal, but with low antennas over irregular terrain the improved propagation conditions that can be achieved by careful site selection may be highly significant.

Because area predictions of basic transmission loss as a function of distance do not depend upon individual path profiles, they are particularly useful for military communication and surveillance, for mobile systems including ground-to-ground and air-to-ground communication, for broadcasting systems, and for calculating preliminary estimates of performance for system design.

When detailed profiles for individual paths are available, the parameters for each separate path are obtained from its profile and used in calculating the basic transmission loss. Such point-to-point predictions are particularly useful in the design and operation of systems with fixed antenna locations.

Both point-to-point and area predictions are compared with data from several measurement programs carried out in the United States. Point-to-point predictions are also compared with measurements recorded over a large number of established communication links in several countries. For convenience in handling, all measured values have been converted to basic transmission loss, defined as the system loss that would occur between loss-free isotropic antennas, free of polarization and multipath coupling losses.

2. AREA PREDICTIONS COMPARED WITH MEASUREMENTS

Measurements of transmission loss with low antennas over irregular terrain have been made in several areas in the United States including Colorado, Idaho, Ohio, Virginia, Washington, and Wyoming. These measurements cover a wide range of frequencies, from 20 to 9200 MHz, with structural heights ranging from less than a meter to 15 meters, in areas where the terrain characteristics range from