CHAPTER 5

ANTENNA SELECTION

The most suitable antenna for the shore terminal of an HF radio path is selected on the basis of the propagation mode (sky-wave or ground-wave propagation), the physical characteristics of the terminal site, and the type of service (point-to-point, ship/shore/ship, ground/air/ground, or broadcast). Major considerations are the operating frequency and radiation angle requirements, which are determined by a propagation path analysis, and antenna characteristics such as gain, directivity, polarization, power handling capability, VSWR limitations, sidelobe suppression, and physical size.

5.1 PROPAGATION PATH ANALYSIS

An analysis of the propagation path is, basically, a statistical prediction procedure based on data accumulated by various agencies over the years. Prediction procedures for both sky-wave and ground-wave propagation are discussed in reference 2, and a brief summary is given below for convenient reference.

5.1.1 Sky-Wave Propagation Prediction

In the case of sky-wave propagation, predictions of the long-term behavior of the ionosphere are used to determine the complement of frequencies and radiation angles most promising for reliable communications over a given path for the life of the communications requirement. Predictions of losses (signal attenuation) and the noise at the receiver site are also included in the evaluation of HF transmission over a sky-wave path so that the path effective power (transmitter power plus antenna gains) required to sustain a specified degree of signal transmission reliability may be estimated. The effect of propagation predictions, then, is to establish the basis for trade-off considerations between transmitter power and antenna gain, and to prescribe a range of operating frequencies and radiation angles necessary for the most effective use of the propagation path. Usually, the result of the analysis is aimed at finding a set of frequencies that will satisfy the communications requirement with the smallest possible spread of radiation angles. For long-term flexibility in the assignment of operating frequencies it is desirable to have many frequencies usable within a narrow range of radiation angles. On the other hand, the number of operating frequencies needed for a short-term, a day or a season, should be as few as possible to avoid numerous frequency changes.

The outcome of such deliberations can be summarized in a matrix such as that in figure 5-1, taken from reference 2. Each "X" in this figure represents a combination of a frequency and a radiation angle for which the probability of satisfactory ionospheric propagation is predicted to be 90 percent. The dashed line encloses a relatively narrow range of radiation angles that can be used, with proper selection from a wide band of frequencies, to maintain communications. Predictions such as this can be used to choose or design an antenna with a radiation angle/frequency pattern that matches the matrix and with gain characteristics suitable for the effective power required to overcome the path losses and noise.

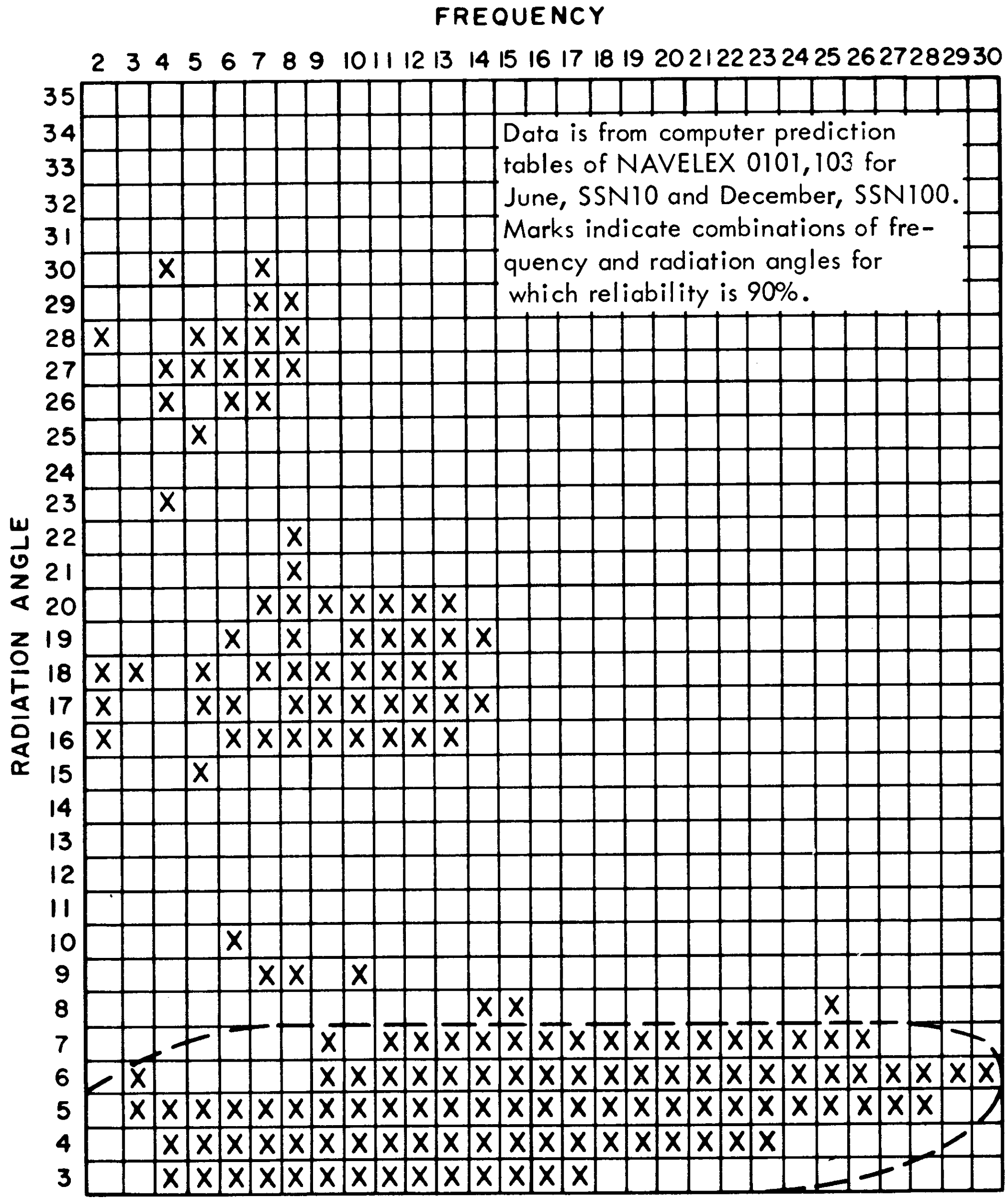

Figure 5-1. Radiation Angle/Frequency Matrix

Although the principal concern with sky-wave propagation predictions is for point-to-point communications, the same general procedure can be used to estimate the propagation path requirement between shore and ship terminals. The application of the prediction methods in such cases, however, is limited by the voluminous calculations that would be required to predict the performance of the many paths corresponding to the movements of the mobile terminal. In order to confine the problem within reasonable bounds, predictions for ship/shore/ship communications circuits are usually made for a geographic ship-movement area, and the shore terminal antennas are selected to provide area coverage.

5.1.2 Ground-Wave Propagation

For ground-wave propagation, the basic consideration for antenna selection is the fact that the electrical characteristics of the earth's surface cause horizontally polarized waves to be attenuated much more rapidly than vertically polarized waves. Because of this, vertically polarized antennas must be used for ground-wave transmission distances of more than a few miles.

Prediction procedures for ground-wave propagation depend upon propagation curves that show the expected signal field intensity, as a function of frequency and distance, based upon certain specified assumptions concerning the type of antenna and the power radiated.

Sets of curves are available for various combinations of ground conductivity and dielectric constant. These ground constants represent the electrical characteristics of the earth's surface and have a major effect on the propagation of radio waves over the earth's surface. To make a prediction, the field intensity at a specified distance for a given frequency is obtained from the set of curves for the ground constants that most nearly match the ground constants for the propagation path being considered. The result is then adjusted to compensate for the differences between the actual situation and the type of antenna and the radiated power assumed for the curves. The procedure is illustrated in reference 2 by examples which include consideration of the noise and the required signal-to-noise ratio at the receiving location.

5.2 SELECTION CONSIDERATIONS

The most useful combination of operating frequency, radiation angle, and power gain are dictated by the requirements of the propagation path as determined by the path analysis. The other factors of major importance in selecting the most effective antenna are related to certain antenna characteristics discussed below.

5.2.1 Polarization

Antenna polarization is a necessary consideration in the antenna selection process. For example, commonly used types of vertically polarized antennas such as conical monopoles and inverted cones are capable of providing sufficiently low radiation angles if they are located near earth of high conductivity, or near sea water. If, however, they are located in an area of poor ground conductivity antenna losses are high and the lower radiation angles are unusable. On the other hand, horizontally polarized antennas require only that the earth's surface be reasonably flat under the antenna and in the direction of propagation. Rhombic antennas, for instance, have useful vertical radiation angles from approximately 3^{o} to 35^{o}, with the angle largely unaffected by the electrical characteristics of the ground, when they are erected one-quarter wavelength or higher above the earth's surface.

5.2.2 Power Handling Capability

Antennas under consideration must match the transmission line so as not to exceed the VSWR limitations. Transmitting antennas must be capable of operating at required power levels without being susceptible to current or voltage breakdown.

5.2.3 Sidelobe Suppression

The antenna radiation pattern should have sufficiently low sidelobe levels to minimize the probability of interfering with other propagation paths or communications services, and to minimize reception of unwanted signals.

5.2.4 Antenna Size

The size of antennas must be considered in view of the real estate necessary for installation and the area needed to comply with antenna separation requirements. Real estate and antenna costs should not be overlooked. This is not to imply, however, that cost considerations should take precedence over the requirements defined by the propagation analysis.

5.3 SUMMARY

The antenna system selected must be capable of operation at the assigned frequencies, and must provide sufficient power gain at the correct radiation angles while suppressing energy at the higher angles to minimize possible multipath distortion (discussed in reference 2). To assist in the final choice among antenna types under consideration, typical performance limits and characteristics of the antennas discussed in chapter 4 are presented in tabular form in the Antenna Characteristics Chart, foldout 5-1. This chart includes those antennas in common use and some other types that fall into special purpose categories.

In some cases the most logical technical selection cannot be implemented due to space limitations, insufficient funds, or other reasons. In this event, the planner must adopt the compromise that results in the least reduction of efficiency or reliability.