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MF Broadcasting System Performance Model

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U.S. DEPARTMENT OF COMMERCE
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CONTENTS

List of Figures

List of Tables

MF BROADCASTING SYSTEM PERFORMANCE MODEL

Eldon Haakinson, Susan Rothschild, and Brent Bedford*

An interactive program has been developed to evaluate the performance of medium frequency (MF) broadcasting systems. The model calculates both ground-wave and sky-wave signals. The user can select from three ground-wave methods: (1) smooth Earth, homogenous path; (2) smooth Earth, mixed path; and (3) irregular Earth, mixed path. The available sky-wave methods are: (1) FCC/Region 2, (2) CCIR, and (3) Wang. Three options are available for making the ground-wave and sky-wave predictions: (1) a point-to-point mode that allows the user to define all of the parameters and test the sensitivity of different parameters, (2) a point-to-point mode which compares the desired signal and interference signals at the reception point, and (3) an area mode that produces signal-to-interference or signal coverage plots. The program utilizes the characteristics of transmitting stations found in a Region 2 data base to make interference calculations. The program also incorporates a Region 2 ground conductivity data base, a Region 2 terrain elevations data base, and a worldwide atmospheric noise data base.

Key words: ground-wave propagation; MF antenna models; MF broadcasting; MF system characteristics; sky-wave propagation

1. INTRODUCTION

International broadcasting regulations have been developed to ensure compatible operation between broadcasters and to lessen potential interference to their listeners. The International Radio Consultative Committee (CCIR), under the International Telecommunication Union (ITU), has provided recommendations that assist administrations in developing telecommunication systems and managing the radio spectrum. Within the Western Hemisphere, administration members of the ITU have adopted radio regulations that pertain to their region of the world, specifically Region 2. Each administration in turn defines how a broadcast service is to be used within the confines of its country boundaries while conforming to the Region 2 radio regulations. Within the United States, the Federal Communications Commission (FCC) allocates and manages the broadcast spectrum.

If the CCIR recommendations, the ITU Region 2 radio regulations, and the FCC broadcast rules and regulations were all identical, then one broadcast system analysis method could be used to verify that a proposed station's characteristics meet all of the

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national, regional, and international criteria. Unfortunately, interference requirements and propagation methods differ between the three levels of spectrum management. The Institute for Telecommunication Sciences (ITS) has developed a medium frequency (MF) broadcasting performance method covering the frequency band from 530 to 1750 kHz for the United States Information Agency's Voice of America (VOA). The model allows the VOA system planners to develop the characteristics of a proposed MF broadcast station and to ensure that the station satisfies different international criteria by selecting appropriate propagation methods.

In the next section of this report, the model in the ITS MF system analysis method is described. Following the description, the model organization, the prediction accuracies, and several sample problems are provided. The appendixes to this report describe the data bases, the channel occupancy algorithm, and the antenna algorithm needed and used by the model. The questions asked of the model user and their acceptable responses are also given in Appendix D.

2. MODEL DEVELOPMENT

2.1 System Performance

Due to changes in the ionosphere, an MF broadcast station has much greater signal coverage during the nighttime than during the daytime. While nighttime signal coverage is greater, the potential for interference to and from other stations is also greater at nighttime as compared to the daytime interference potential. During daytime, only ground-wave signals are considered in the analysis; whereas during the nighttime, both ground-wave and sky-wave signals must be considered. As will be shown, there are several acceptable methods to compute ground-wave and sky-wave signal strengths. The methods are described below and the model user has the option of selecting which methods are to be used during any particular analysis.

To study the performance of a proposed MF broadcast station, the analysis is divided into three phases: (1) initial parameter selection, (2) signal-to-interference calculations at the desired receiver location, and (3) signal coverage and signal-to-interference contour plots. For convenience, the three analysis methods for the three phases are called System 1, System 2, and System 3, respectively. The following paragraphs describe the purpose of each model.

System 1

System 1 allows the user to treat the MF broadcast circuit from the proposed transmitter to the desired receiver site as a point-to-point problem. The user is asked to select transmitter characteristics (including power, antenna configuration, etc.), site characteristics (including location, ground constants, etc.), receiver characteristics (including location, man-made noise environment, antenna type, etc.), and propagation models. Then with these initial parameter values, the field strength and received power at the receiver are calculated. Figure 1 shows a sample of the type of output System 1 provides.

Season - Winter (December, January, February)
Local time - 1200

Site	Receiver site noise density (dBW/Hz) 10%	50%	90%	Ground-wave field strength (dBuV/m)	Ground-wave rec'd power (dBm)	Sky-wave field strength (dBuV/m)	Sky-wave rec'd power (dBm)	Rec'd S/N (dB-Hz)	Fade margin (dB)
1	-122	-131	-138	57	-17	62	-13	80	4
2	-122	-131	-138	42	-33	60	-14	78	19
3	-122	-131	-138	30	-44	59	-15	77	29
4	-122	-131	-138	20	-54	58	-16	76	38
5	-122	-131	-138	11	-64	58	-17	76	47

Figure 1. A sample output of System 1.

A complete sample of System 1 showing the input and associated output is given in Section 5 and Appendix E. The user can continue to modify any of the parameters with the purpose of testing the sensitivity of the parameters on the computed field strength or until the user believes an optimum set of transmitter parameter values has been achieved.

System 2

System 2 continues to treat the proposed transmitter and desired receiver site as a point-to-point problem but interference effects are included. All adjacent and co-channel transmitters within a user-specified search radius are used to compute signal-to-interference ratios at the receiver location. For each adjacent and co-channel transmitter, the model lists the computed signal-to-interference ratio as well as the amount the ratio exceeds or fails to exceed the required signal-to-interference ratio for the adjacent or co-channel case. Figure 2 shows a System 2 sample output. System 2 used the channel occupancy algorithm which is completely described in Appendix B.

VOA MF Relay System Design model

Title: VOA Test
Proposed VOA transmit frequency: 1000 kHz
Major population center to be covered: M
VOA transmitter location: 1
Daytime - groundwave predictions
Groundwave method: Smooth earth

Noise at B is:

10%	-119. dBW/Hz
50%	-129. dBW/Hz
90%	-136. dBW/Hz

Field strength from VOA transmitter at M is:

		signal/ noise (50%) (dB-Hz)
groundwave	55.06 dBuV/m	39.5

--------Non-VOA Station---------										
Freq (kHz)	Call Sign	Class	Power (kW)	Location	Data Base	Dist. (km)	S/I (dB)	S/Ith-S/I (dB)	S/Smax (dB)	S/I+N (dB)
970	XEMH	B	1.00	MERIDA YUC 2	IFRB	41.9	-6.3	-23.2	35.8	140
990	XEUM	B	1.00	VALLADOLID YUC	IFRB	188.5	26.5	-26.5	OK	206
1000	XENV	B	1.00	MERIDA YUC 7	IFRB	37.1	-8.2	34.2	-17.8	137
1020	XEMO	B	1.00	CHETUMAL QR 1	IFRB	329.9	43.1	-72.6	OK	240

Figure 2. Sample output of System 2.

In the table portion of Figure 2 there are four columns labeled S/I, S/Ith - S/I, S/Smax, and S/(I+N). The value S refers to the proposed VOA transmitter's signal at the reception point and equals the ground-wave field strength during the daytime. At nighttime, S equals the maximum of the ground-wave field strength and the sky-wave field strength exceeded for 50 percent of the time. The value I refers to a non-VOA station whose characteristics are partially listed in the figure. For daytime calculations, I equals the ground-wave field strength. For nighttime calculations, I equals the root-sum-square (rss) value of the ground-wave signal and the sky-wave signal that is exceeded for 10 percent of the time. When S/I is greater than 0 dB, the desired VOA transmitted signal is greater than the potential interference from the non-VOA station. Otherwise, when S/I is less than 0 dB, the non-VOA transmitted signal is greater than the VOA signal at the reception point. The next column, S/Ith - S/I, indicates how severe is the potential interference to the VOA signal.

S/Ith refers to the required signal-to-noise ratio threshold that is to be maintained to control objectionable interference. S/Ith is a function of frequency, and the relationship is given in Table 1.

Table 1. Required S/I Versus Frequency Separation

Interfering transmitter's frequency relative to desired transmitter's frequency (kHz)	Required signal-to-interference ratio to minimize objectionable interference S/Ith (dB)
0	26.0
5	29.0
10	0.0
15	-23.0
20	-29.5
25	-29.5
30	-29.5

In Figure 2, if the S/Ith - S/I value exceeds 0 dB then the interfering transmitter will cause objectionable interference to the proposed VOA transmitter's signal at the reception point. Values in this column that are less than 0 dB are not predicted to cause interference from the non-VOA station to the VOA station's signal. For example, the station whose call sign is XEMH is on frequency 970 kHz and the proposed VOA station is on 1000 kHz; the difference in carriers is 30 kHz. From Table 1, for a frequency difference of 30 kHz, the required S/I that is not expected to cause interference between the two stations is -29.5 dB; in this case, the interference can be 29.5 dB greater than the desired signal. The value in the S/I column shows a predicted -6.3 dB. Then S/Ith - S/I equals -29.5 - (-6.3) or -23.2 dB. The value is negative, so there is a safety margin of -23.2 dB before interference is predicted to be objectionable. Note, however, that station XENV is expected to cause interference.

Again in Figure 2, the column heading S/Smax refers to the potential interference from the proposed VOA transmitter to existing signals. If the non-VOA signal is calculated to be so weak at the reception point that it is below the noise threshold for the region, then the program will print "OK" in the column. If the non-VOA signal is greater than the threshold, then the same checks are made as in the column to the left. The desired signal is the non-VOA station's signal and the interference is the VOA's signal. The values in Table 1 are required protection ratios. For example, with station XEMH as the desired station, the desired signal-to-VOA interference ratio is 6.3 dB. For the 30-kHz difference in carriers, the required protection is -29.5 dB from Table 1. Thus, the required S/I of -29.5 dB minus the actual S/I of 6.3 dB gives -35.8 dB, which states there is a margin of 35.8 dB before interference is expected. Station XENV, on the other hand, is expected to receive interference from the VOA station.

The last column has the heading S/(I+N). This is a calculation of the signal-to-interference plus noise[1] at the receiver's antenna terminals. The interference and noise are summed on an rss basis. The noise term N has the units of dB/Hz and represents the noise power in a 1-Hz bandwidth. To determine the actual S/(I+N), the receiver's audio bandwidth, say 5 kHz or 37 dBHz, would have to be known. For the calculations, the program assumes an audio bandwidth of 5 kHz.

When interference does exceed the required ratios, the user can alter the transmitter characteristics (such as the transmit frequency) and rerun the System 2 analysis. The process is repeated until a characteristic is found that satisfies the desired signal level requirements at the receiver location and also meets the required signal-to-interference ratios.

System 3

System 3 evolves from the System 2 analysis by treating the broadcast situation as an area problem. The System 3 output is a map of the user-selected area showing contours of signal coverage or signal-to-interference ratios. The area to be analyzed is

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[1] Noise is determined as the sum of atmospheric galactic and man-made noise (see Appendix A and DeMinco (1986)). The model computes the noise power based on the receiver's geographical location, frequency, the time of day, and the season. The noise power density is a constant value regardless of the antenna that is used unless the antenna's ground-wave gain is less than 0 dBi. Whenever this occurs, the noise power density is reduced by the antenna's ground-wave gain. For example, if the noise power density were -129 dBW/Hz and the ground-wave antenna gain were 20 dBi, the noise power density would remain at -129 dBW/Hz. If the gain were -20 dBi, the noise power density would be reduced to -149 dBW/Hz. Only the ground-wave antenna gain is used to alter the noise power density, since for monopole antennas, for example, the sky-wave gain can be negative at high elevation angles.

divided into a grid of cells with the map size selected by the user. Within each cell the signal from the desired transmitter is computed as well as the total interference from all the adjacent and co-channel interfering transmitters. The output plot shows either the signal coverage in the desired reception region or the signal-to-interference ratio contours. The plot also provides the user information about interference from the proposed station to the reception areas of other existing stations. Figure 3 shows a sample plot from System 3.

2.2 Ground-Wave Propagation

In the Western Hemisphere, which the ITU defines as Region 2, three sets of ground-wave propagation curves are used, depending upon national (e.g., in the United States, see FCC, 1982), regional (ITU, 1982), or international (CCIR, 1986a) requirements. In each case to compute ground-wave field strength, the user interpolates from the given curves using the three parameters of distance, frequency, and ground conductivity. Depending upon the choice of values for the parameters, the user may obtain different values of field strength from the three sets of curves. In recent years, the FCC and CCIR have attempted to develop computer programs that interested parties can use to compute field strength based on theoretical calculations rather than interpolation of curves. Eckert (1986) has documented the FCC's program and extensively compared the results of the CCIR's new ground-wave method (Rotheram, 1981) with those of the FCC's method and those of the ITS method developed independently by L.A. Berry ("User's Guide to Low Frequency Radio Coverage Programs," OT Technical Memorandum 78-247, January 1978, limited distribution). Eckert has determined that the three methods give ground-wave field strength predictions sufficiently close in value that they could be considered identical for propagation purposes (private communication, 1986). If the FCC, IFRB Region 2, and CCIR all adopt the new ground-wave algorithms, then calculations made by any of their methods should match those calculations made by the ITS method.

The methods, as described in this report, calculate the theoretical field strength from the given parameters rather than perform an interpolation from the field strength curves. The methods utilize the ground-wave algorithm developed by Berry. A discussion of the ground-wave analysis method used is contained in a companion document by DeMinco (1986). Three modes of ground-wave predictions are available from which the user can choose: (1) smooth Earth, homogeneous path, (2) smooth

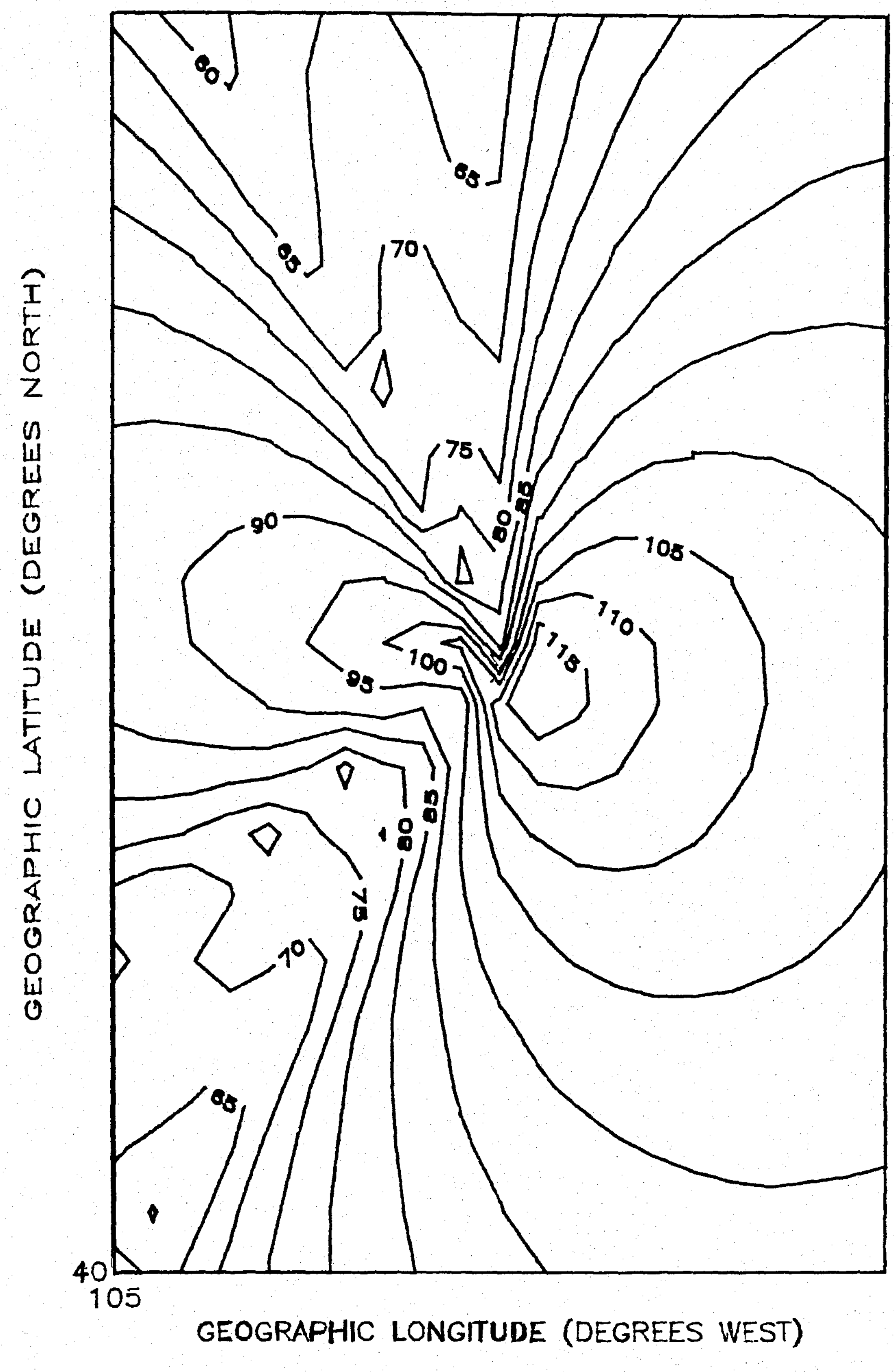

Figure 3. A sample plot from System 3.

Earth, mixed path, and (3) irregular terrain, mixed path. Each mode is briefly defined below and is more fully described by DeMinco (1986).

Smooth Earth

This method is used for computing ground-wave field strengths over a smooth homogeneous Earth. The algorithm only needs a single set of ground constants for the entire path to make the computations.

Smooth Earth, mixed path

The smooth-Earth, mixed-path method is used when the path is made of sections having different ground constants. The field strength is computed for each section and then combined for a total field strength using an algorithm proposed by Millington (1949; CCIR, 1986a).

Irregular terrain, mixed path

If, along a particular path, the terrain irregularity is of the order of a wavelength or less, then smooth-Earth calculations are adequate (Knight, 1983). In mountainous conditions, the terrain irregularity can be several wavelengths.

Under these conditions, the field strength may not monotonically decrease with increasing distance from the transmitter. For some situations, this extra computational complexity may be required; for example, if the only location available for the proposed transmitter antenna were on the other side of a mountain ridge from the desired reception area, then the user would use the irregular-terrain, mixed-path method to compute signal coverage. The method uses an integral equation solution to the irregular terrain problem (Hill, 1982; Ott, 1971). As computation times can be quite long, the method should be used only when the path(s) warrant its use.

2.3 Sky-wave Propagation

During the daytime, i.e., the time period roughly from local sunrise to local sunset, the ionosphere does not reflect enough electromagnetic energy at MF to cause interference or to allow communications. Absorption of the MF energy by the D region of the ionosphere, the layer 50 to 90 km above the Earth's surface, is the principal reason that MF sky wave is not useful in the daytime. During the nighttime, however, the ionosphere will reflect MF signals because the D region disappears and the E region, the layer 90 to 130 km in altitude, supports MF reflections. This means the MF broadcast service can provide signal coverage at long distances from the transmitter but also can cause severe disruptions of service to adjacent and co-channel stations with interference that would not be present during the daytime.

Various sky-wave field strength prediction methods are in use, with proponents of each method believing their method works specifically in their part of the world (CCIR, 1986c; PoKempner, 1980). The available methods in this model are: (1) the FCC's procedure for computing AM sky-wave field strengths (FCC, 1982), (2) the Region 2 procedure (ITU, 1982), (3) the CCIR recommended method (CCIR, 1986b), and (4) a new procedure proposed by Wang (1985) for use in the United States and Region 2. All of the procedures assume a reference field strength at 1 km from the transmitter in the development of their field strength curves (FCC and Region 2 methods) or of their field strength algorithms (CCIR and Wang methods). Then given the distance along the path plus other parameters that may be needed, such as frequency and geomagnetic latitude, the annual median field strength is found. This value is modified by the actual transmitter power relative to the reference power and by the antenna gain for the take-off angle needed to reach the reception area. Other factors such as excess polarization loss, and sea-gain correction, are applied in some cases.

In the following paragraphs, the procedures are described in more detail.

FCC MF sky-wave signal strength prediction method

The FCC method uses a curve of field strength versus distance developed from measurements made in 1935. The FCC applies the curve to all frequency assignment analyses for all MF frequencies at all latitudes within the United States; the curves of field strength exceeded for 50 and 10 percent of the year are shown in Figure 4. The FCC made additional measurements from 1939 to 1944 which show a dependence on latitude. Curves from those measurements are used by the FCC for interference analyses. No other terms are added to the field strength except for transmitter power and antenna gain. Note that the curves extend to 2600 mi (about 4200 km) from the transmitter.

Region 2 MF broadcasting conference method

The Region 2 method uses the FCC's 50 percent curve shown in Figure 4 out to a distance of 4250 km. For distances exceeding 4250 km, the method uses the expression

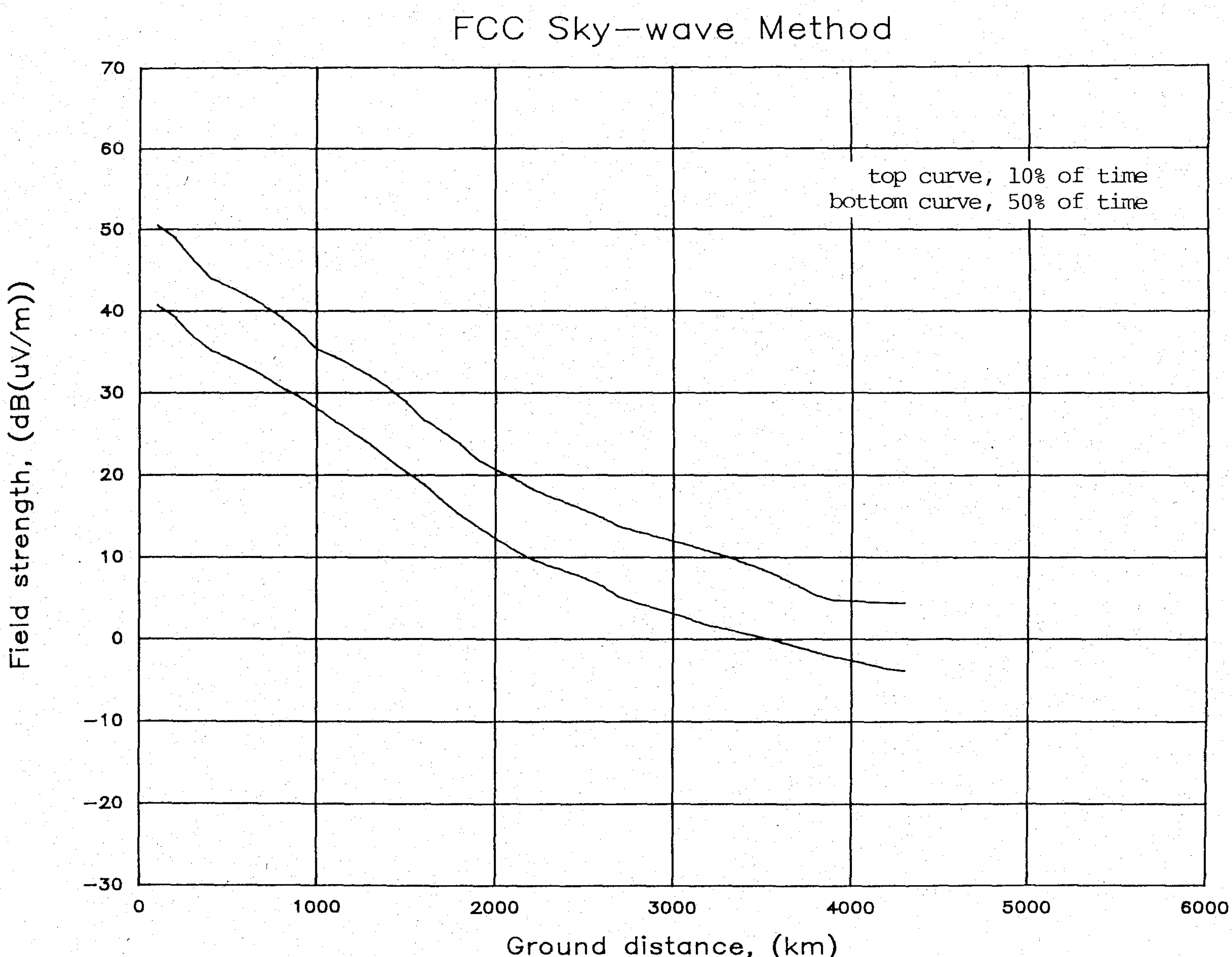

Figure 4. FCC sky-wave curves of field strength for 10 and 50 percent of the time.

$$F_c = \frac{231}{3 + d/1000} - 35.5 , \quad (1)$$

where

F_c = characteristic field strength, dBuV/m, referenced to 100 mV/m at 1 km, and
d = distance, km.

This expression is adapted from the CCIR Cairo curves (Wang, 1985), the results of long-distance measurements made in the late 1930s across the Atlantic and from North to South America. The field strength that is exceeded for 10 percent of the time is found from (Wang, 1985)

$$F(10\%) = F(50\%) + 8 \text{ dBuV/m}. \quad (2)$$

The Region 2 field strength versus distance curve is shown in Figure 5 and is called the FCC/Region 2 curves.

CCIR MF sky-wave method

The development of the CCIR sky-wave field strength prediction method has been an evolutionary process since the 1930's (Wang, 1985; PoKempner, 1980). The present method uses the so-called USSR method as its basis with modifications (such as the United Kingdom sea-gain correction). The field strength expression is

$$F = V + G_s - L_p + A - 20\log(p) - 0.001(K_r)(p) - L_t \quad (3)$$

where

F = field strength, dBuV/m,

V = transmitter cymomotive force above the reference 300 V, dB,

G_s = sea-gain correction, dB,

L_p = excess polarization-coupling loss, dB,

A = 106.6 - 2sin(phi), where phi is the average of the transmitter and receiver geomagnetic latitudes, dB,

p = slant-propagation distance, km,

K_r = loss factor including ionospheric absorption, focusing and terminal losses, and losses between hops, dB, and

L_t = hourly loss factor, dB.

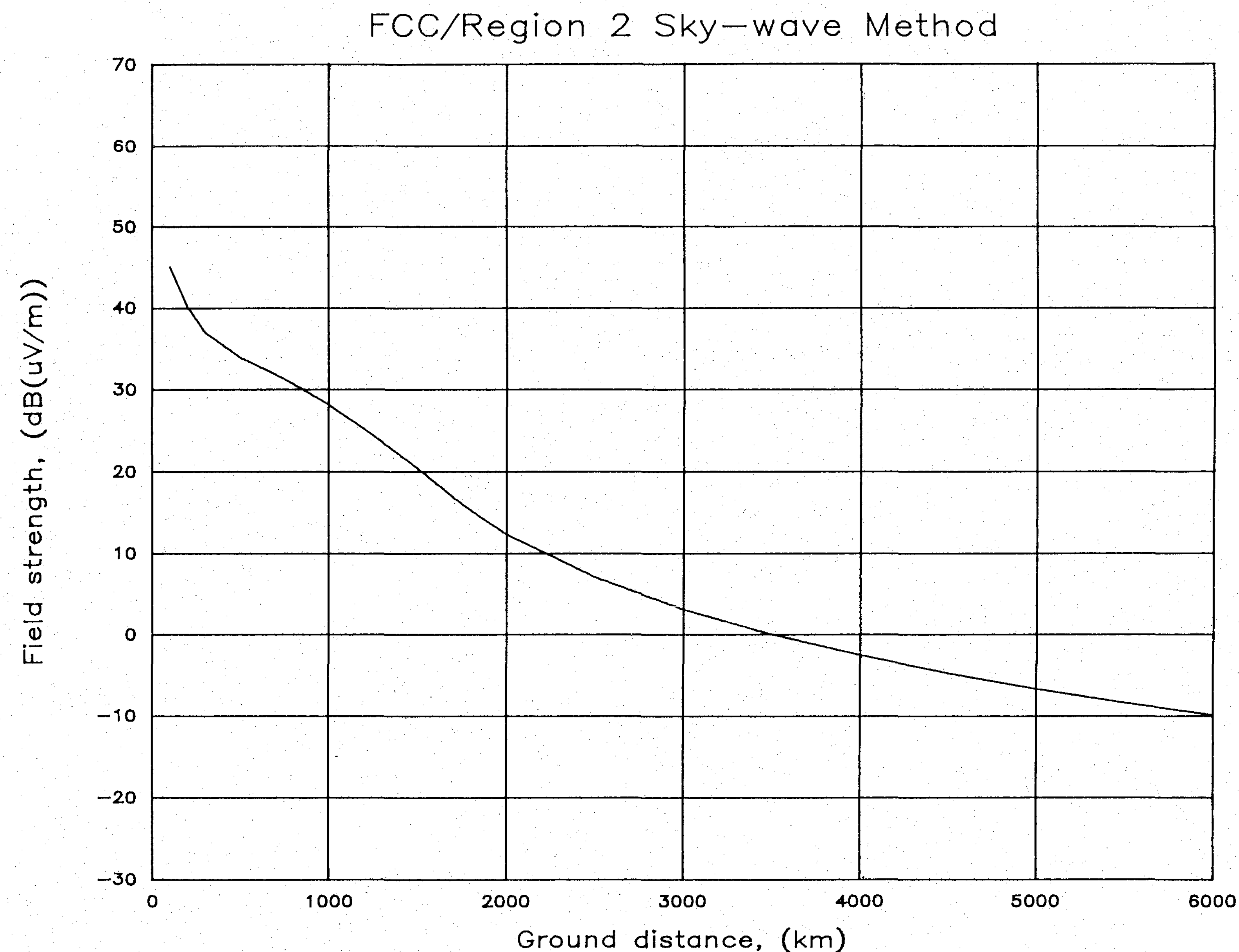

Figure 5. FCC/Region 2 sky-wave curve of median field strength versus distance.

For the time period from 4 h after sunset to 2 h prior to sunrise, the value of L_t is nearly 0 dB; so this term is ignored in the method. Over long distances of 1000 to 6000 km, sea gain can add from 3 to 10 dB to the predicted field strength if one of the terminals is on the coast. However, the present method does not have land-sea boundary information, so the sea-gain correction is set to 0 dB.

The CCIR method is both frequency and geomagnetic latitude dependent. Note also the method does not predict field strength values that are symmetrical about geomagnetic latitude equal to 0 deg. A family of field strength curves for 1000 kHz is shown in Figure 6. The CCIR (1986b) notes the CCIR field strength expression predicts greater field strength values at higher frequencies whereas measurements made in the United States show the opposite effect. Such results indicate why the CCIR has not found a consensus for a worldwide prediction method.

Wang MF sky-wave field strength method

Wang (1985) has investigated all of the available MF methods and attempted to develop one that is easy to use and is valid at least in Region 2. He notes, for example, the original FCC curves have a hump at roughly 1000 km. He attributes this to ground-wave interference that he believes was present in the 1935 data. When those data are removed, the curves become smoother. His expression for field strength is

$$F_c = 95 - 20\log(d) - [(6.28 + 4.95\tan^2 (phi)] (d/1000)^{1/2}, \qquad (4)$$

where

F_c = characteristic field strength, dBuV/m, referenced to 100 mV/m at 1 km,

d = distance, km,

phi = mid-point geomagnetic latitude, deg.

He states that if d is less than 250 km, then the expression should be evaluated at 250 km. Also he limits phi to no greater than 60 deg and no less than -60 deg. When compared to the CCIR expression, Wang's expression is symmetrical about phi equal to 0 deg and is not dependent upon frequency. A family of field strength curves for several values of phi is shown in Figure 7.

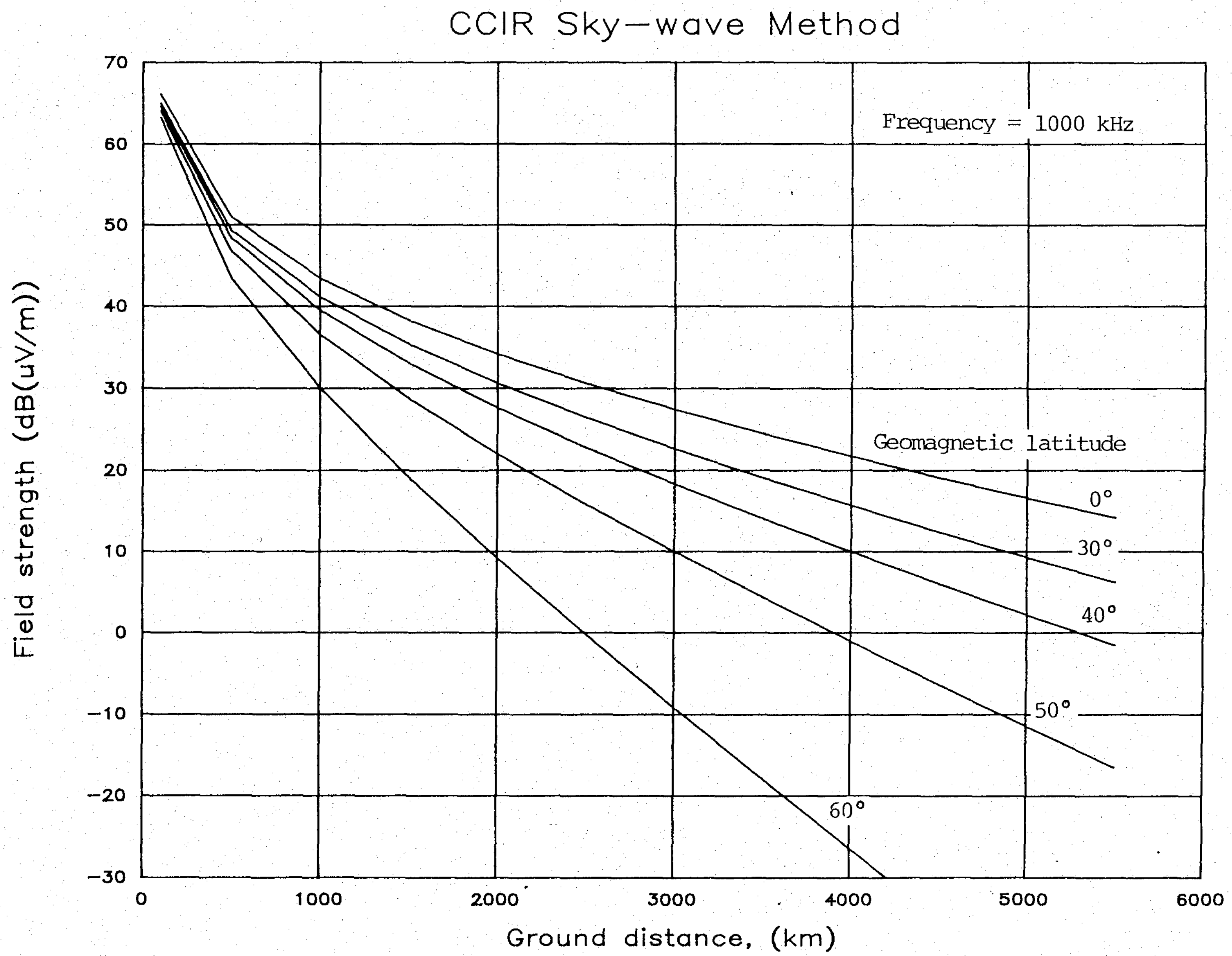

Figure 6. CCIR sky-wave curves of median field strength for several values of geomagnetic latitude and frequency of 1000 kHz.

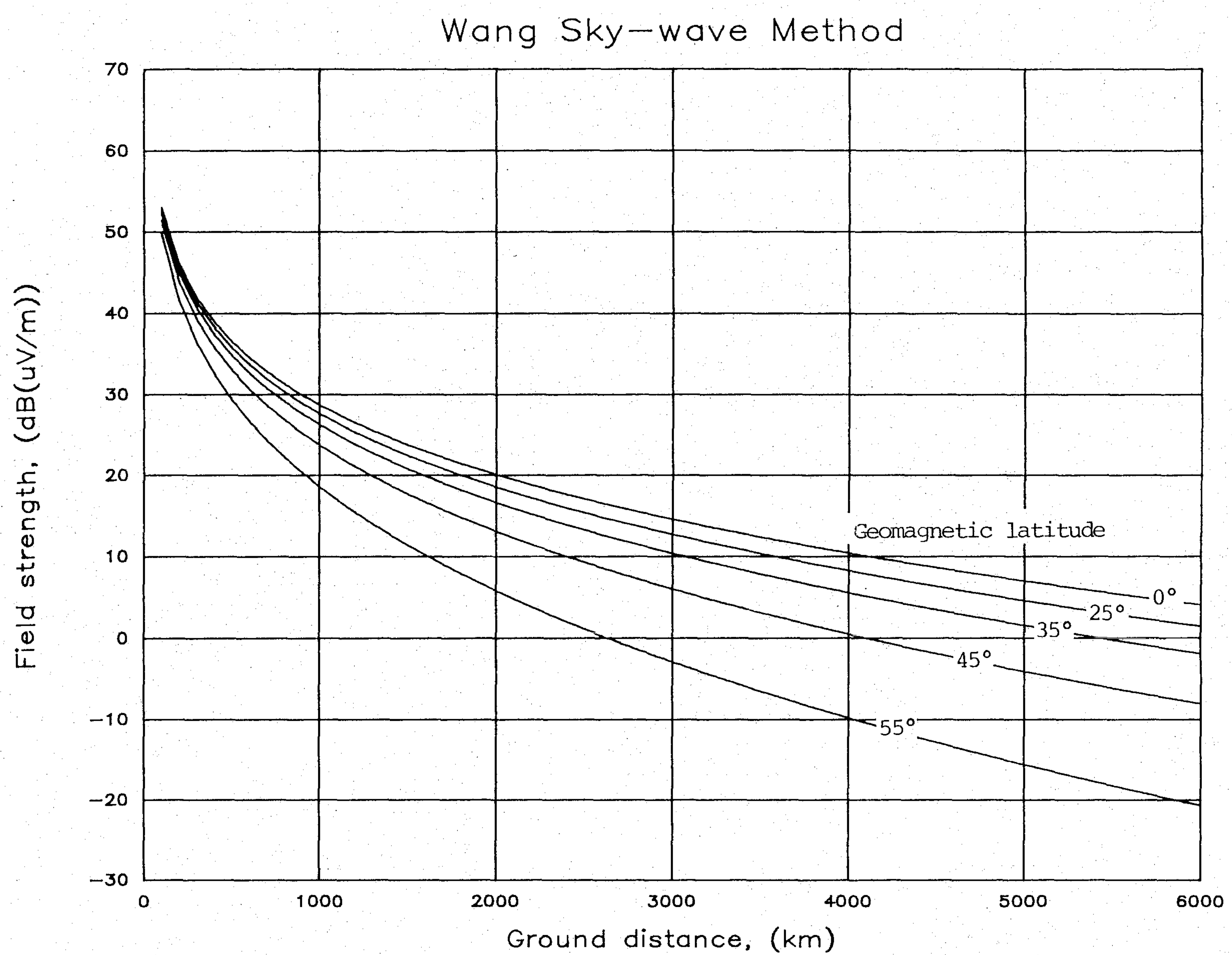

Figure 7. Wang's sky-wave curves of median field strength for several values of geomagnetic latitude.

3. MODEL ORGANIZATION AND USAGE

Each of the models is available as a time-share computer program. When the user enters the program, guidance is provided by a menu of options. In general, the user would first input the desired parameter values. A summary of the parameters could be listed to verify selections. Next the data would be processed. After reviewing the results, the user could edit selected parameters and process the data again. This procedure will be shown in later examples.

The user can choose to have the program ask for parameter values using either verbose or concise questions. Concise questions usually only provide a question number, a short parameter description, and a default value, which is the user's last entered value or is supplied by the program. For example, the concise question might appear as

```
12) Conductivity ( 0.005 S/m) ?
```

The verbose question supplies more information for the user, for example

```
Conductivity for the path (between 0.001 and 10.0 Siemens(mhos)/meter)
   0.001 for poor ground
   0.005 for average ground
   0.020 for good ground
   5.000 for sea water
   0.010 for fresh water
12) Conductivity ( 0.005 S/m) ?
```

In either case, the user can enter his/her own value followed by a carriage return or accept the value within the parentheses by merely typing a carriage return.

For questions wanting an alpha response rather than a numeric response, the user can usually type a single letter to indicate a desired selection. For example, typing an S to the following question

```
Tower structure
   V = Vertical, simple antenna
   T = Top-loaded antenna
   S = Sectionalized antenna
44) Tower structure (Vertical, simple antenna) ? S
```

would cause the program to ask the user for information about a sectionalized antenna and use the data for later calculations.

Complete lists of the questions and their meanings for the three models, System 1, System 2, and System 3, are given in Appendix D, Tables D-1, D-2, and D-3, respectively. Each table lists the verbose question for every parameter asked of the user. For some parameters, additional information is provided to indicate to the user how the program will utilize the parameter or what additional questions have to be answered if various selections are made.

4. METHOD ACCURACIES

As the ground-wave methods and the sky-wave methods were developed, they were tested against available data to compare predictions with field strength measurements. In this section, the comparisons are discussed and the accuracies of the methods are provided to give the user some guidance when they are appropriate and adequate.

4.1 Ground-wave Method Accuracies

The smooth-Earth, ground-wave methods are functions of frequency, ground constants, and distance. The transmitting and receiving antennas are assumed to be at ground level and the refractive index is assumed to be decreasing exponentially with height. The only parameters that are not well known in the above list of variables are the ground constants, and in the MF band, ground conductivity is the critical ground constant. When the FCC developed M3, the map of ground conductivities for the United States (see Figure A-5 in Appendix A), the FCC elected to show contours of 2, 4, 8, 15, and 30 mS/m, because these levels give changes in field strength that nearly double between levels (or changes of 6 dB between levels) depending upon the distance from the transmitter, of course. For example, Table 2 compares the field strengths at 50 km from a certain transmitter operating at 1000 kHz.

Note from Table 2, as we change from one level to the next, the predicted field strength approximately doubles in linear units and increases by 6 dB in logarithmic units. Thus if the conductivity value is uncertain, say between 4 and 15 mS/m, then for this example there is an uncertainty of +/- 6 dB in the field strength value about the median value.

Table 2. Comparison of Field Strengths for the FCC's M3 Ground Conductivity Levels

M3 ground conductivity (mS/m)	Field strength at 50 km from a specific transmitter operating at 1000 kHz (dBuV/m)	(uV/m)
2	48	251
4	54	·501
8	61	1122
15	67	2238
30	70	3162
5000 (sea water)	74	5011

A CCIR document (CCIR, 1986e) shows the ground conductivities for North, Central, and South America. The figures from the atlas for Region 2 are reproduced in Appendix A. The figure showing the conductivities for the United States has levels that are more coarse than those in M3. The CCIR report suggests replacing the conductivity bands of all the administrations with a standard set of conductivity bands. These ground conductivity bands are shown in Table 3.

Table 3. Comparison of Ground Conductivity Bands for the United States

FCC M3 map (mS/m)	CCIR atlas of conductivities for the United States (mS/m)	CCIR proposed standard values (mS/m)
-	0.3 - 1.0	1
2	2 - 6	3
4		
8	7 - 15	10
15		
30	20 - 30	30
5000 (sea water)	5000	5000

If a user were to select the proposed 10 mS/m band of conductivities for a particular case and if the path crossed the boundary between 10 mS/m and 3 mS/m, for example, the change in field strength would be approximately 6 dB. If the same path were analyzed using the M3 map, the path might go from 15 mS/m to 2 mS/m, which would result in a change in field strength of approximately 20 dB. The uncertainty of conductivity can result in a large change in predicted field strength. On the other hand, measurements of conductivity are difficult to make, and conductivity can change with the seasons.

The irregular-terrain, mixed-path ground-wave method has the added complexity of including the terrain elevations in the calculations of field strength. DeMinco (1986) and Ott et al. (1979) have compared measured data with predictions on irregular-terrain paths. Ott demonstrates that the prediction can be made to fit the measurements quite closely if the ground conductivity along the path is appropriately adjusted. This gives confidence to the irregular-terrain prediction method but it also shows how critical are the conductivity values along the path. As discussed in Appendix A, the terrain data base (NGDC, 1985) that is available for Region 2 has a grid size of 5 min in latitude and longitude. In other words, for increments of 5 min of latitude and longitude, the data base contains the arithmetic average elevation from contour charts for each 5 min by 5 min grid cell. DeMinco has compared the predictions made using the 5-min elevation data base with predictions using 30 sec spacing between elevations. His conclusion for the MF broadcast band is that there is little improvement in prediction accuracy when using the 5-min elevation data with the irregular-Earth method compared with using the smooth-Earth method.

Thus, if the user knows the terrain elevations along the path, then the irregular-terrain method could be used to provide a more accurate prediction compared with a smooth-Earth prediction, assuming, of course, that the ground conductivities are known along the path for either method. However, if the user is going to use the 5-min terrain elevation data base, then the irregular-terrain method will provide comparable predictions to the smooth-Earth method. The user will need to decide if the application warrants the use of the added complication of terrain with a spacing of 5 min between elevation values.

4.2 Sky-wave Method Accuracies

All of the sky-wave methods are functions of distance and all except the FCC method are latitude (actually geomagnetic latitude) dependent. Only the CCIR method has a frequency-dependent term. Report 1014 (CCIR, 1986d) discusses the various methods and rates their prediction abilities versus measured data. Table 4 is copied from the CCIR report and summarizes the findings where an error is defined as the difference between a measured field strength and the value predicted by a particular method. The table shows the errors by latitude bands, by inter-regional paths, and totals.

Table 4. Prediction Errors (Table II from CCIR (1986d))

Case	Rms errors for different methods FCC/Region 2 (dB)	CCIR (dB)	Wang (dB)
Latitude			
0 - 45 deg	9.9	7.8	8.2
45 - 52.5 deg	4.7	6.0	5.8
> 52.5 deg	11.1	13.4	6.8
Subtotal	8.1	8.7	6.9
Inter-regional paths	13.6	17.2	8.9
Total	11.0	14.0	8.1

The CCIR report states that the FCC/Region 2 method will under-predict the field strength in the low-latitude areas, will work well in mid-latitude areas, and will over-predict in the high-latitude areas. Under-predict means the actual field strength is greater than that predicted and over-predict means actual field strength is less than predicted. The report has similar comments about the CCIR method.

The report notes that the Wang method works well for long and short paths. It calls the Wang method a blend of the CCIR field strength curve and the FCC/Region 2 curve, which results in the Wang method's overall usefulness.

4.3 Sky-wave Field-strength Variations

Measurements have been reported on the variations in sky-wave field strength due to fading, diurnal, and seasonal variations (CCIR, 1986c). Those variations are summarized here.

Fading rate

Fading rate is defined as the number of times that the signal increases through the median signal level per unit time. Although the fading rate for a specific path is a function of frequency and angle of incidence with the ionosphere, the fading rates of mid-band MF sky-wave signals have been measured at 10-30 fades per hour. During the fade, the field-strength amplitude follows the Rayleigh distribution. The night-to-night amplitude variation between 10 percent of the nights and 50 percent of the nights is typically 5.5 dB.

Wang (1985) has analyzed the field strength data from Region 2 to determine the signal variation with time. Table 5 shows his results.

Table 5. Measured Field Strength Variation with Time

Geomagnetic latitude (deg)	Field strength exceeding the annual median field strength for stated percent of time 10% (dB)	1% (dB)
0 - 40	6.	9.5
60 - 90	10.	15.
average	8.	12.25

Diurnal variations

The CCIR method has a frequency-dependence term that reduces the predicted field strength with increasing frequency (for example, the field strength predicted for a 2000 km path at 30 deg latitude is 2 dB less at 1500 kHz than at 500 kHz). Wang (1985) notes measurements in United States have exactly the opposite result. He says signals at 1530 kHz measured at sunset or sunrise are about 15 dB greater than those at 700 kHz. The difference reduces to 3 - 5 dB at 2 h after sunset or 2 h before sunrise; also the difference is insignificant at midnight.

Seasonal variations

The measurements of field strength show a seasonal dependence. The field strength is at a minimum during the summer and reaches its maximum during spring and fall. Winter shows a reduction in field strength although not as much as in the summer. The difference between the summer minimum and the spring/fall maximums is about 15 dB at 500 kHz and reduces to about 3 dB at 1700 kHz.

5. SAMPLE DIALOGS WITH THE PROGRAMS

In Appendix E, sample dialogs with the three programs are provided to show how the programs may be used. Some comments about the dialogs and program usage apply to all of the programs:

1. At each point of the dialog when the program needs a response from the user, the program will print a parameter name or a statement followed by a question mark. The program then waits for the user to make a data entry.
2. The user must end each data entry with a carriage return.

3. Some questions will have a default value or data value in parentheses. If that value is satisfactory, the user can merely type a carriage return to have the program accept that value.
4. The questions are asked either in a concise form or a verbose form. The verbose form provides the most information about the question, whereas the concise form states the parameter, a default value for the parameter in parentheses, and a question mark. A user unfamiliar with the questions should select the VERBOSE DIALOG from the menu. By typing two questions marks (??), the verbose form of any question will be printed by the program.
5. The user can exit the questions at any time by typing two colons (::) in response to the questions. The program stops asking for input parameters and returns to the MENU question. To exit the program, the user should type "Q" for quit in response to the MENU question. At that point all of the user input data is lost and must be re-entered the next time the program is run.
6. A normal sequence of program use is to
   a. enter the VERBOSE DIALOG mode to supply data values for the parameters
   b. select SUMMARY to list the parameters by number, parameter name, and user-selected value
   c. select PROCESS to make the calculations and output the analysis results
   d. 1. choose EDIT if a few parameters are to have their values changed, then go to b. or
      2. choose VERBOSE or CONCISE if many values are to be changed, then go to b.
      3. select QUIT to exit the program

The following describes each sample dialog.

Sample #1

The first sample dialog uses the System 1 program to obtain the smooth-Earth ground-wave calculations on a path whose distance varies from 10 to 100 km in 10 km increments. The choice of sky-wave method is not important because the sky-wave methods produce a constant field strength at distances less than 250 km. In order to compare the ground-wave results with those of the CCIR (1986a), a fixed strength of 300 mV/m at 1 km is required from the transmitter. This is obtained by using the transmitter antenna type set to the FIELD STRENGTH OPTION. The ground constants for the path are set to 0.003 S/m and 15.

Sample #2

The second sample dialog uses the System 1 program to calculate sky-wave field strength calculated by the ITU Region 2 method on a path whose distance varies from 100 to 1000 km in 100-km increments. To compare the results with the sky-wave curve of Figure 5, the field strength from the transmitter must be sent to the characteristic field strength of 100 mV/m at 1 km by setting the transmitter antenna to the FIELD STRENGTH OPTION and the ground constants to 5 S/m and 80.

Sample #3

This sample dialog used the System 1 program to calculate the field strength pattern of the three-monople array antenna of Figure C-2 in Appendix C. The array characteristics are given on Figure C-2 and the field strengths are listed under the output table heading of ground-wave field strengths. Those field strengths are compared with the field strengths listed in Table 6, which has listed the field strengths for the same three-monopole array antenna. The field strengths listed in the output table under ground-wave are for an elevation angle of 0 deg. Although the program will calculate the field strength at 1 km for every elevation angle as needed by the calculations, there presently is no way to list out the field strengths for elevation angles other than 0 deg as shown in this sample. In this same sample, the EDIT mode is used to alter a few of the parameter values and to calculate the field strengths at 100 km from the transmitter.

Sample #4

Signal-to-interference calculations are made using the System 2 program. The dialog shows the input parameter values and the resultant calculations for a proposed transmitter in Central America at 14 deg, 05 min, 07 sec N and 89 deg, 45 min, 30 deg W. The explanation of the output table is give in Appendix B.

Sample #5

Sample #5 is a signal coverage map produced by using the System 3 program. The antenna shown in Figure C-2 is used with its main beam rotated 90 deg so that it points to the east. Close in to the transmitter, the ground-wave signal dominates while

Table 6. Field Strength Pattern for Three-monopole Array

Azimuth (deg)	Field strength at 1 km (mV/m)	(dBuV/m)
0	874	118.8
15	858	118.7
30	801	118.1
45	682	116.7
60	489	113.8
75	243	107.7
90	13	82.6
105	176	104.9
120	246	107.8
135	224	107.0
150	158	104.0
165	96	99.7
180	72	97.6
195	96	99.7
210	158	104.0
225	224	107.0
240	246	107.8
255	176	104.9
270	13	82.6
285	243	107.7
300	489	113.8
315	682	116.7
330	801	118.1
345	858	118.7

further out the sky-wave signal dominates. For distance locations, the elevation angle or takeoff angle from the transmitter is close to the horizon where the antenna gain is at a maximum. As locations nearer to the transmitter are considered, the elevation angle increases, which results in decreased antenna gain. Thus, locations far from the transmitter have more basic transmission loss; they also have more antenna gain to counter the loss. Locations near the transmitter have less loss but also less antenna gain because of the steep takeoff angles. The results of the two opposing effects are shown on the map associated with Sample #5. The 60 and 70 dB V/m contours are good examples increasing losses opposed by increasing antenna gain and vice versa.

6. CONCLUSIONS

The MF broadcasting system performance model allows a user to develop the characteristics of an MF broadcasting station by

- computing the station's ground-wave and sky-wave field strengths according to nationally, regionally, and internationally recognized procedures

- determining the station's signal coverage and signal-to-interference ratios at a desired location or over a specified region
- verifying the signal-to-interference ratios meet Region 2 requirements for noninterfering operations

The model computes transmitter antenna array patterns based on Region 2 and FCC algorithms. Other transmitter and receiver antenna gains in the model are based on theoretical gains over a lossy Earth. The model contains a worldwide noise data base, a 5-min terrain elevation data base, and a ground conductivity data base for Region 2. The model operates as three separate user-interactive programs.

7. ACKNOWLEDGMENTS

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APPENDIX A. DATA BASES

Terrain

A 5-min terrain elevation data base is available from the NGDC (1985) that includes northern South America, Central America, and most of North America. The elevation data base used by this program covers northern South America, Central America, Mexico, and the Caribbean. The actual coverage range is 8 to 31 deg N latitude and 60 to 120 deg W longitude as shown in Figure A-1. The X's on Figure A-1 indicate regions of no terrain data. Each terrain elevation represents the arithmetic mean of data digitized from contour charts of the elevations within a 5-min by 5-min grid cell.

Noise

The noise data base contains worldwide estimates of atmospheric noise values for each season and for each 4-h time block during the day. The noise values represent the lower decile, the median, and the upper decile of measured noise characteristics. The noise contours are provided in a CCIR booklet (CCIR, 1986a and the noise coefficients are available on magnetic tape (NTIS, 1986). To the estimate of atmospheric noise are added estimates of man-made and galactic noise. All three noise power values are frequency dependent, and man-made noise is a function of the environment. The four environment categories are business, residential, rural, and quiet rural. The resultant value of noise is given as a noise power density (dBW/Hz). To compute the actual noise at the receiver terminals, the noise power density would have to be multiplied by the receiver baseband bandwidth, if both are in linear units, or added if both are converted to decibels,

$$P_n = PD_n + BW$$

where

P_n = noise power at the receiver terminals, dBW,

PD_n = noise power density, dBW/Hz, and

BW = receiver baseband bandwidth, dBHz.

The algorithm used to predict the noise power in this program is described in greater detail by DeMinco (1986) and by Spaulding and Washburn (1985).

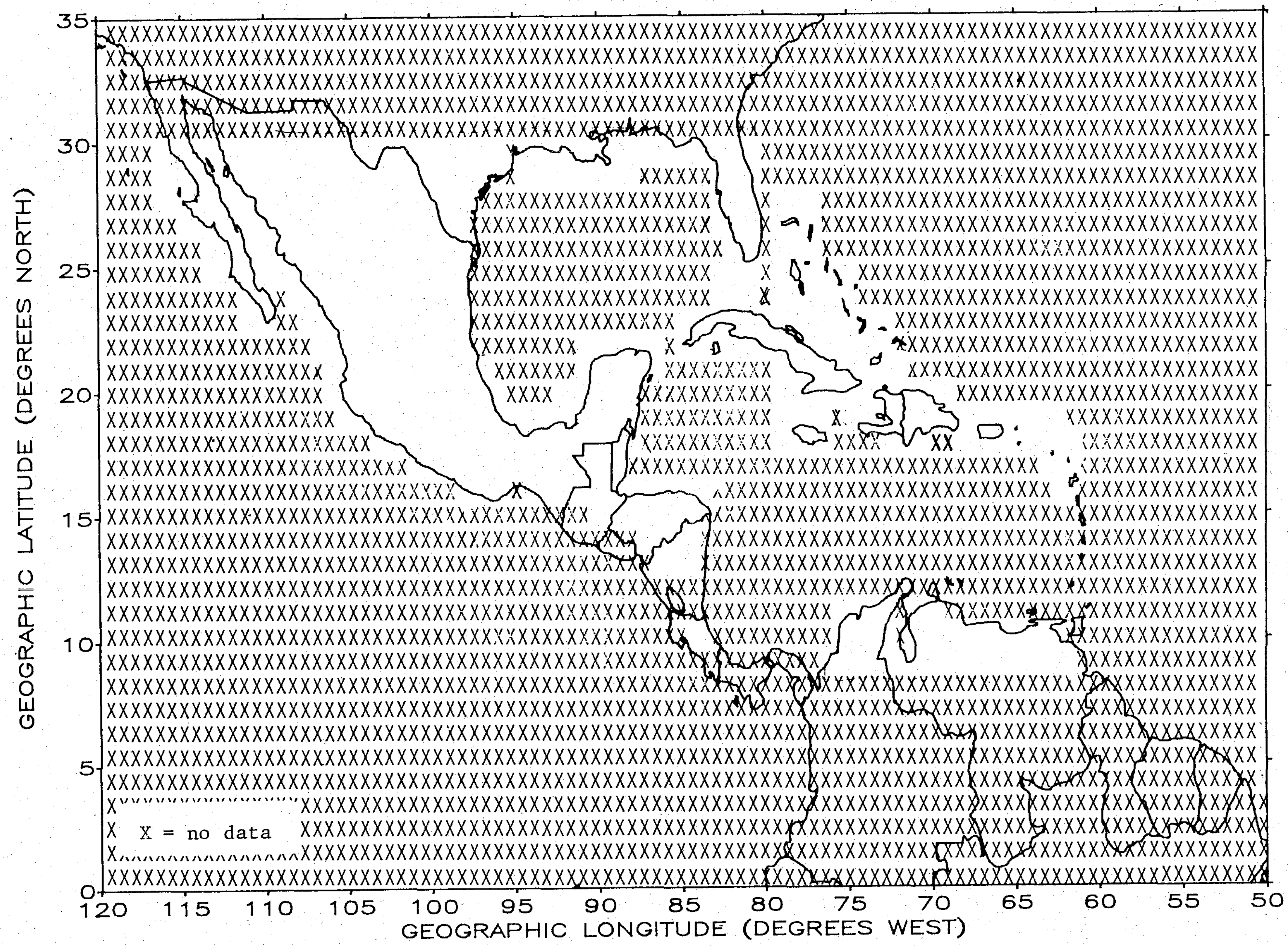

Figure A-1. Areas where 5-min terrain elevation data are available.

Ground conductivity

In the MF band, the ground constant that most affects the ground-wave field strength prediction is the ground conductivity value. For Region 2, ground conductivity data are available from the International Frequency Registration Board (IFRB, 1986) in a digitized format. Figures A-2 through A-4 show the ground conductivities for North America, Central America, and South America, respectively, as supplied by the CCIR (1986b). The FCC uses the ground conductivity map called M3 (FCC, 1982) which is reproduced in Figure A-5. The M3 map has different contours and levels than those in the CCIR map for North America. This program uses the ground conductivity data supplied by the IFRB.

Region 2 MF station characteristics

The IFRB maintains a file of characteristics of MF stations in Region 2. The file is available in a digitized format from the IFRB. The transmitter characteristics that are available are listed in Table A-1. There are sufficient data in the file to compute the transmitting antenna pattern based on the techniques described in Appendix C, Antenna Models. To be reasonably accurate, the file should be updated approximately every 3 months.

Table A-1. Transmitter Characteristics from IFRB Station Data Base

Assigned frequency
Name of the transmitting station
Call sign
Station class (A, B, or C)
Operational status
Country
Geographical coordinates of the transmitting station

Daytime operation
- station power
- rms value of radiation (mV/m at 1 km) for daytime station power
- antenna type
  - simple omnidirectional antenna
  - directional antenna when the design is known
  - top-loaded omnidirectional antenna
  - sectionalized omnidirectional antenna
- simple vertical antenna electrical height

Nighttime operation
Same as daytime operation

Table A-1. Continued

Data for array of towers
ratio of the tower field to the field from the reference tower
positive or negative difference in the phase angle of the field from the tower with the field from the reference tower
electrical spacing of the tower from the reference point
angular orientation of the tower from the reference point
tower structure
simple vertical antenna
top-loaded antenna
sectionalized antenna
Data for augmented patterns
radiation at the central azimuth of augmentation
central azimuth of augmentation
total span of the augmentation
Data for top-loaded antenna
electrical height of the antenna tower
height of lower section
Data for sectionalized antenna
difference between apparent electrical height and actual height
difference between apparent electrical height of lower section and actual height of lower section
total height of antenna
difference between apparent electrical height of the total tower and the actual height of the total tower

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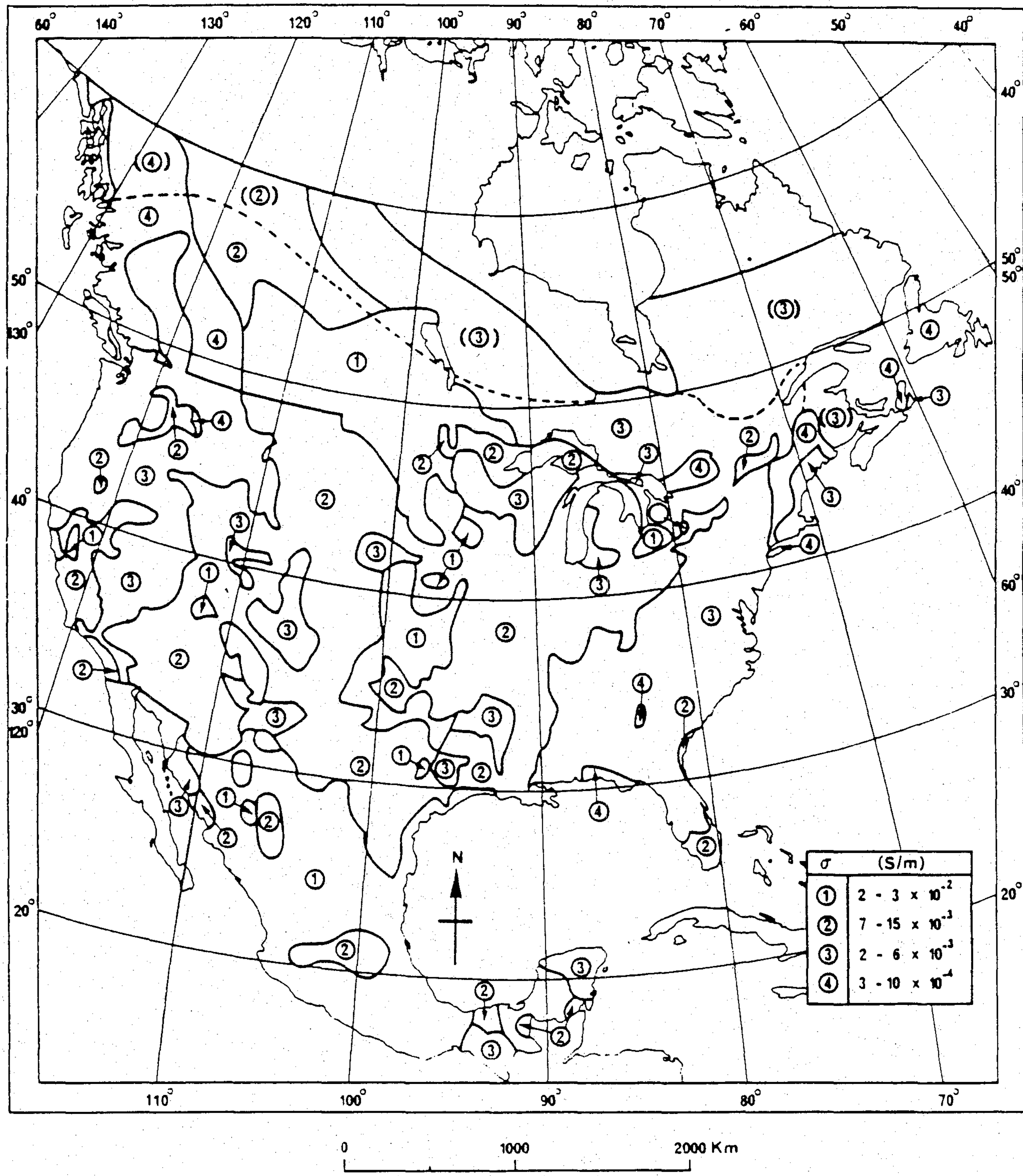


Figure A-2. Ground conductivities for North America.

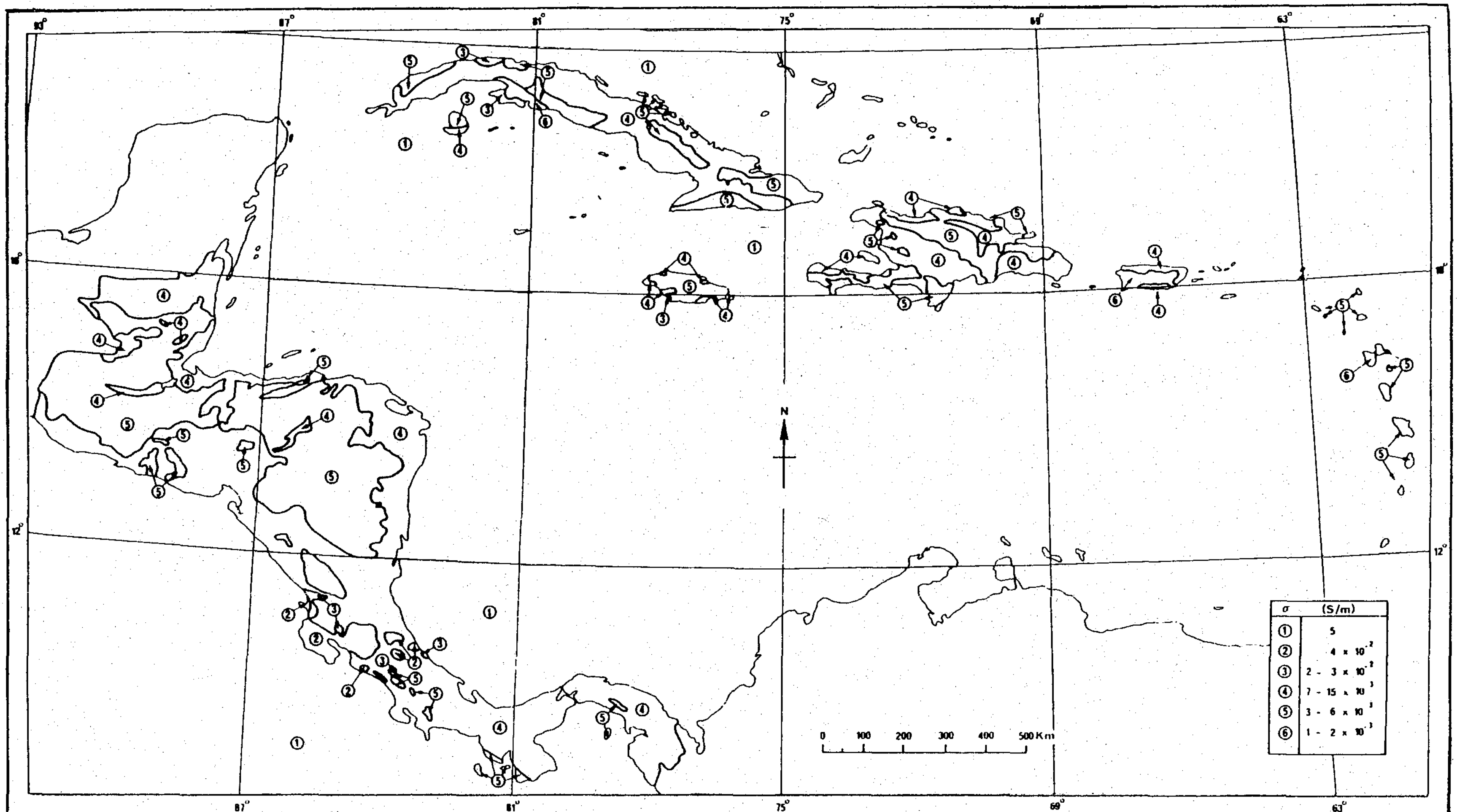


Figure A-3. Ground conductivities for Central America.

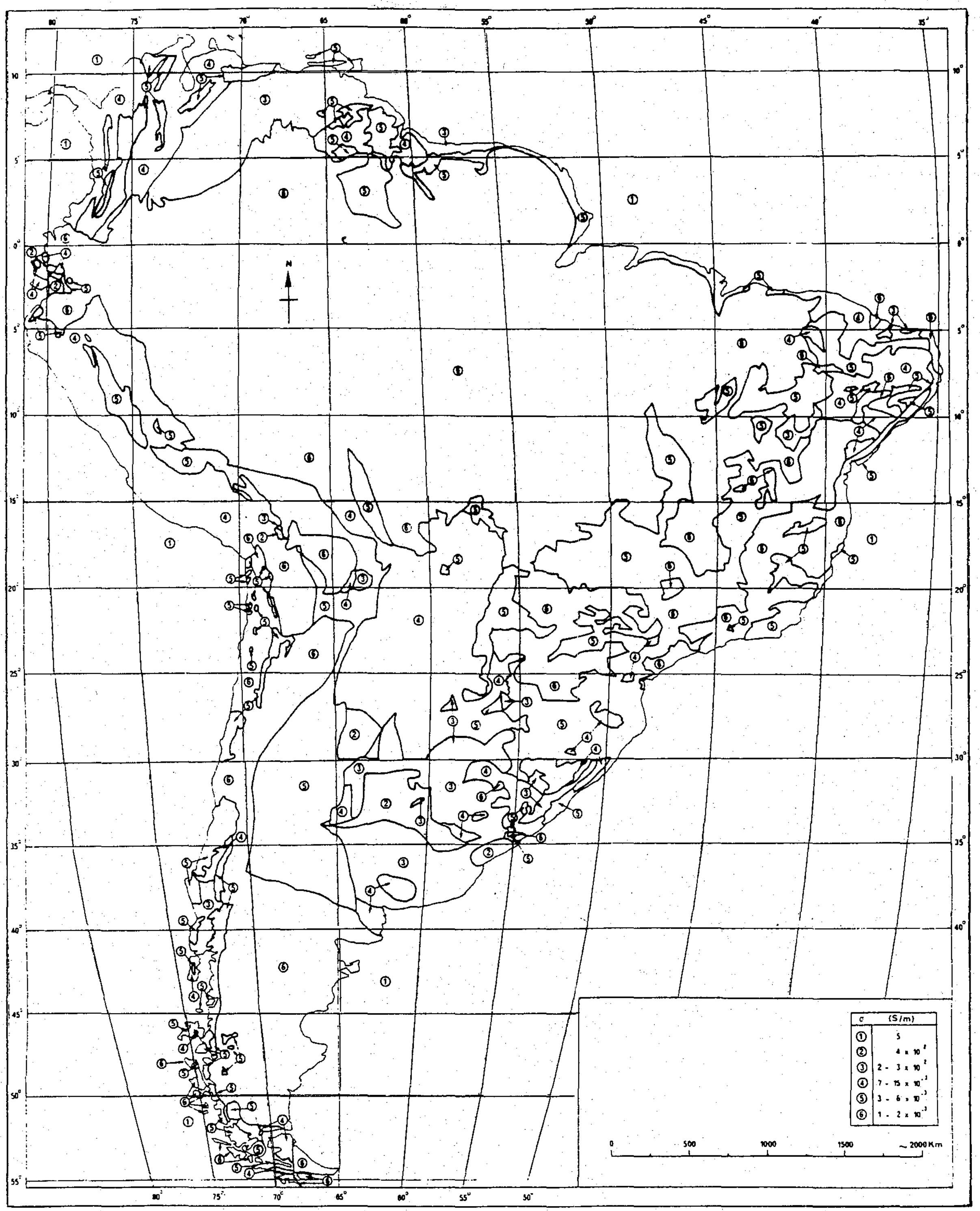


Figure A-4. Ground conductivities for South America.

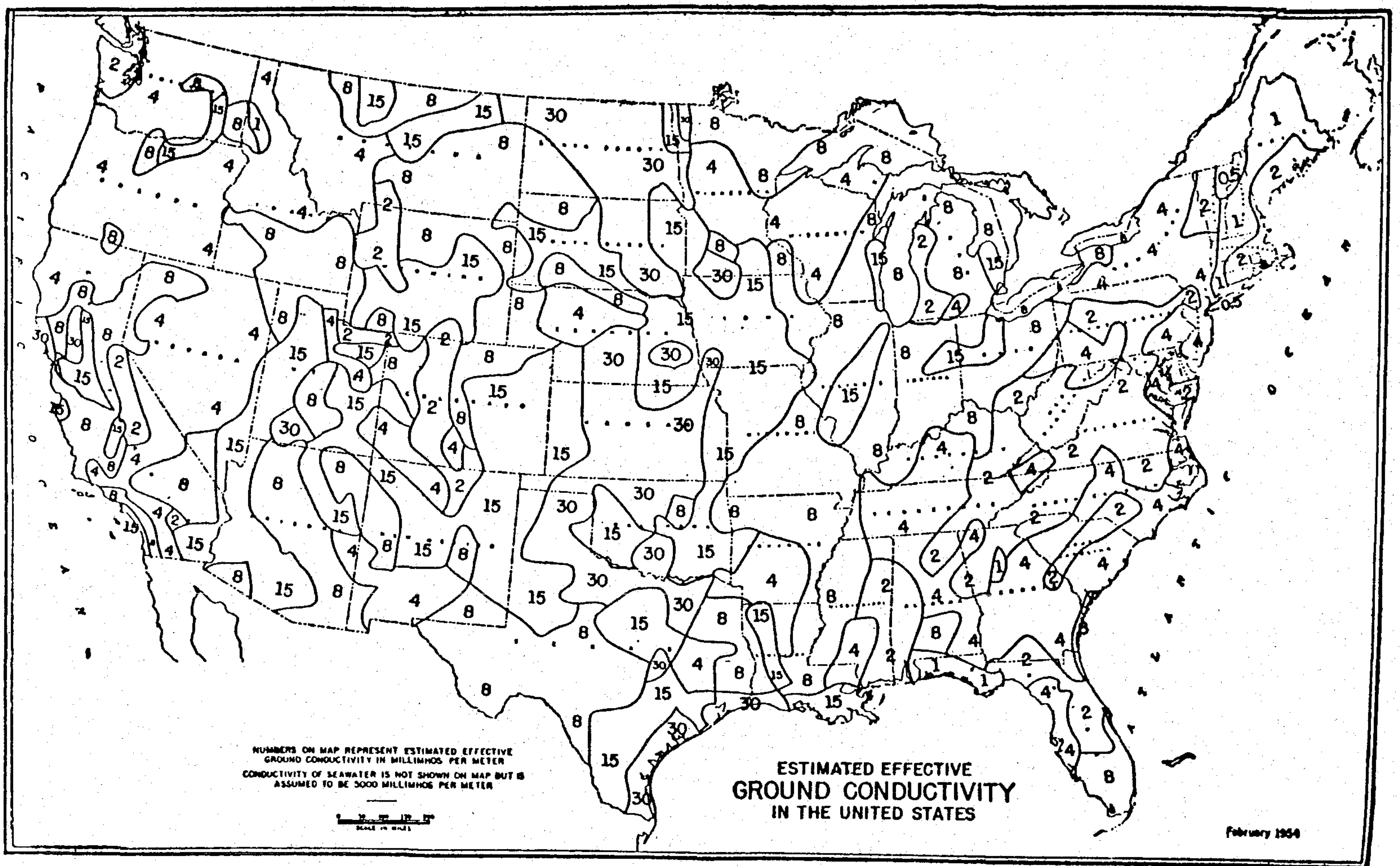


Figure A-5. The FCC ground conductivity map (M3) for the continental United States.

APPENDIX B. CHANNEL OCCUPANCY MODEL

The VOA has developed an MF channel occupancy model that is based upon Region 2 requirements. The model is described in a VOA Information Memo (informal communication, M. Weissberger, Dec. 1984); the information in the VOA memo is repeated below.

Parameter definitions:

E_{V-S-50}	=	Sky wave field of the VOA station that is exceeded 50% of the time.
$E_{NV-S-50}$	=	Sky wave field of the non-VOA station that is exceeded 50% of the time.
$E_{NV-S-10}$	=	Sky wave field of the non-VOA station that is exceeded 10% of the time.
E_{V-G}	=	Ground wave field of the VOA station
E_{NV-G}	=	Ground wave field of the non-VOA station.

All quantities are in units of microvolts per meter.

Definition of Terms Appearing in the Output

S, in S/I:

This is the VOA field strength when it is considered as the desired signal. It is computed as shown below.

DAY	NIGHT
E_{V-G}	$\mathrm{MAX}\,(E_{V-G}, E_{V-S-50})$

I, in S/I:

This is the field strength of the non-VOA station, when this station is considered as a source of interference to the VOA. It is computed as shown below.

DAY	NIGHT
E_{NV-G}	$[(E_{NV-G})^2 + (E_{NV-S-10})^2]^{1/2}$

Note the rss value computed for night interference. Different thresholds are used to account for channel separations.

S/I th:

This is the desired minimum ratio (in dB) of the VOA signal to the non-VOA signal. (The letters "th" are an abbreviation for "threshold.") The ratio is a function of the frequency separation, delta-F, between the VOA and non-VOA stations. The values for separations of 0, 10, and 20 kHz are taken from the 1981 Region 2 Agreements. The values for separations of 5 and 15 kHz are taken for CCIR Recommendation 560-1, 1982. The Curve labeled "c", in Figure 1f of the CCIR Recommendation, was used. It is based on a compression that is realistic and a bandwidth that is consistent with the one assumed in the Region 2 Agreement. The S/I th values for frequency separations larger than 20 kHz are the same as the value for 20 kHz. The values versus the frequency separation between a VOA and non-VOA station are given in Table B-1.

Table B-1. S/I th Values versus Frequency Separation

Delta-F (kHz)	S/I th (dB)
0	26.0
5	29.0
10	0.0
15	-23.0
20	-29.5
25	-29.5
30	-29.5

S in S/S_{max}:

This is the VOA field strength when it is considered as a source of interference. Its values are listed below.

DAY	NIGHT
E_{V-G}	$[(E_{V-G})^2 + (E_{V-S-50})^2]^{1/2}$

S_{max} in S/S_{max}:

This is the maximum VOA signal strength that will not produce interference to the specific non-VOA station that is being examined S_{max} is computed for the target city. The means of calculating S_{max} are described below.

E_{NV}, used in Determining S_{max}:

This is the signal strength of the non-VOA signal, which is to be used in the determination of S_{max}. It is computed as shown below.

DAY	NIGHT
E_{NV-G}	MAX (E_{NV-G}, $E_{NV-S-50}$)

Determining S_{max}:

In some cases, the non-VOA signal level is so low that it is designated as unhearable and there is no restriction of the VOA signal strength, for the case being considered. These situations are determined by comparing the non-VOA signal level, E_{NV}, with the nominal usable signal strength, E_{nom}.

(The Region 2 Agreements allow the root sum square, rss, approach to be used to determine hearability in certain situations. The present version of the Channel Occupancy Model does not include an rss algorithm. As a result, an interference assessment made using the model will be conservative in some cases, and equitable in all other cases. Leaving out the rss option permits the model runs to be made quickly. The rss algorithms might be added to the model later. Computer time requirements could be kept reasonable by using the option for studies of a few selected channels, rather than for across-the-band checks.)

The procedure for determining S_{max}, using the nominal usable field strengths, is presented below.

A. Compute the signal strength of the non-VOA station, E_{NV}, using the rules presented before.

B. Determine the nominal usable field strength, E_{nom}. This depends on the class of the non-VOA station, and the geographical location of the target reception point. The possible values are shown in Tables B-2 and B-3.

If the "target point" (assumed receiver location) is within both Central America and a Noise Zone, the data for the Noise Zone is to be used in the calculations.

Table B-2. Daytime Values of E_{nom}

Station Class	Central America	Noise Zone 1	Noise Zone 2
A	0.500 mV/m	Co-channel 0.100 mV/m Adj. channel 0.500 mV/m	Co-channel 0.250 mV/m Adj. channel 0.500 mV/m
B	Use Value for Noise Zone	0.500 mV/m	1.250 mV/m
C	Use Value for Noise Zone	0.500 mV/m	1.250 mV/m

Table B-3. Nighttime Values of E_{nom}

Station Class	Central America	Noise Zone 1	Noise Zone 2
A	1.000 mV/m	0.500 mV/m	1.250 mV/m
B	Use Value for Noise Zone	2.500 mV/m	6.500 mV/m
C	Use Value for Noise Zone	4.000 mV/m	10.000 mV/m

C. If E_{NV} is less that E_{nom}, then there are no restrictions on the VOA signal level. In order to quickly alert someone who is skimming a printout that there are no restrictions, the letters "OK" are printed in the column labeled S/S_{max}.

D. If E_{NV} is greater than or equal to E_{nom}, then the term S_{max} is calculated. $S_{max} = E_{NV}/PR$, where PR is the protection ratio needed for two signals separated by Delta-F (kHz). Values of PR are shown in Table B-4.

Table B-4. Protection Ratio versus Frequency Separation

Delta-F (kHz)	PR (Dimensionless)
0	19.95
5	28.18
10	1.0
15	1/14.13
20	1/29.85
25	1/29.85
30	1/29.85

APPENDIX C. ANTENNA MODELS

The programs have available five transmitting antenna models and four receiving antenna models. The models are listed in Table C-1.

Table C-1. Antenna Model Types

Transmitting Antennas	Receiving Antennas
Vertical monopole	Vertical monopole
Standard monopole array	Ferrite loop
General monopole array	Field strength option
Field strength option	User gain input
User gain input	

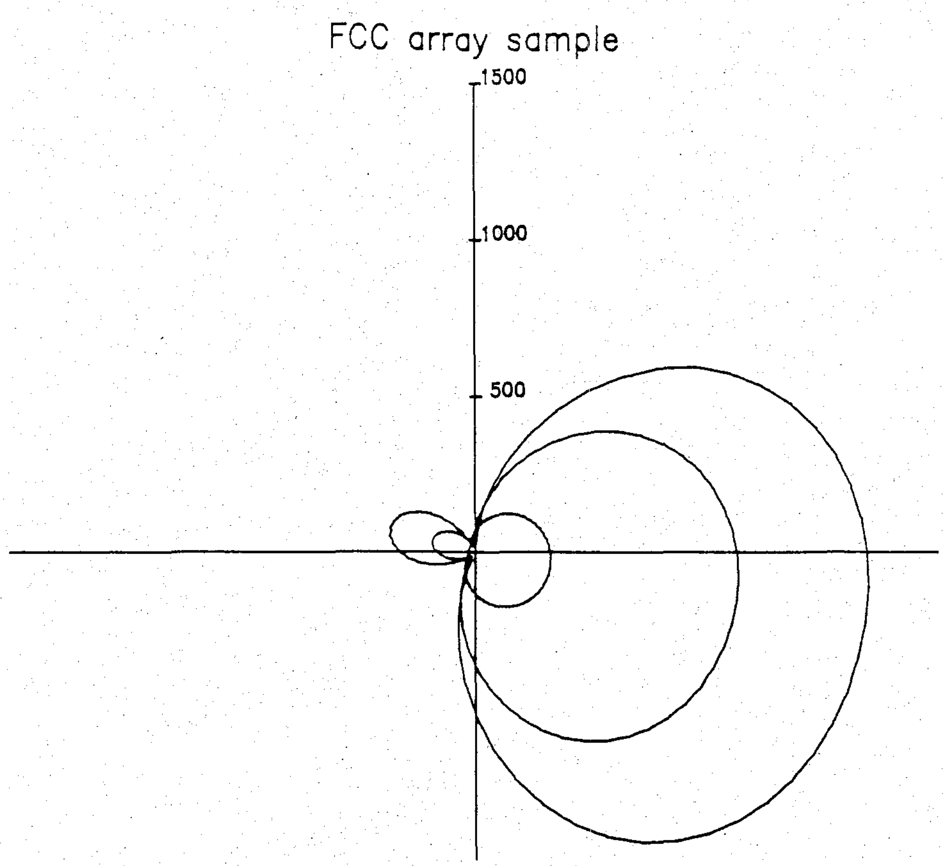
The general monopole array model is based upon the array equations given by the FCC (1982) and the ITU (1982). To compute the array pattern, the model needs the following information:

- the number of monopoles
- the electrical height of each monopole
- the relative phasing between each monopole
- the relative spacing between each monopole
- the relative current amplitude between each monopole
- the relative angular orientation between each monopole
- if a monopole is sectionalized, the monopole characteristics
- if a monopole is top-loaded, the monopole characteristics
- if the pattern is augmented, the augmentation characteristics
- the rms field strength mV/m at 1 km.

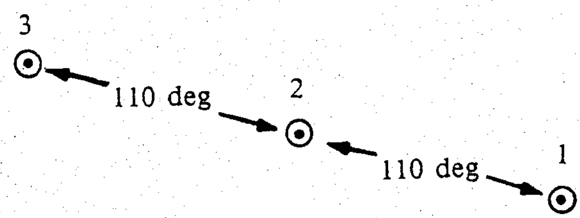
Figure C-1 shows the monopole array pattern for the sample antenna characteristics given by the FCC (1982).

From the given data, the general monopole array pattern is computed and the antenna gain at any azimuth and elevation angle is calculated and used by the program. For all of the other antenna types, an equivalent antenna gain is calculated by first determining the desired antenna's gain relative to a reference dipole and then adding that gain to the dipole's gain over a lossy Earth. The technique is described by DeMinco (1986).

For the vertical monopole and the general monopole array, the gain changes with elevation angle. The standard monopole array antenna model assumes three-, four-, and six-monopole array geometries that are standard designs used by the VOA. Although the computed gain of the standard monopole array changes with azimuth, its gain in elevation is the same as the computed gain for the given azimuth.



Theoretical field strength in mV/m per kW at 1 km.



Characteristic	Towers 1	2	3
Field ratio	1.0	1.89	1.0
Phase (deg)	-128.5	0.0	128.5
Spacing (deg)	0.0	110.0	220.0
Orientation (deg)	0.0	285.00	285.0
Structure	simple	top-loaded	sectionalized
Height (deg)	120.0		
A (deg)		120.0	120.0
B (deg)		20.0	20.0
C (deg)			220.0
D (deg)			15.0

Transmitter power = 5 kW
RMS field strength at 1 km = 685 mV/m

Figure C-1. Characteristics and pattern for FCC array sample.

The ferrite-loaded loop antenna is modeled to approximate the antenna found in MF receivers. The antenna is not directional and is very lossy, with gains of-40 to -80 dBi typically.

The user gain option allows the user to enter a fixed antenna gain relative to an isotropic that is used for all azimuths and elevations. The field strength option allows the user to specify a fixed field strength at a fixed distance from the transmitter whose transmitter power is at a fixed reference level. The algorithm then computes the equivalent antenna gain to be used in the calculations.

DeMinco (1986) defines the valid frequency ranges for the antenna models and gives the restrictions in their use. A summary is provided in Table C-2.

Table C-2. Model Restrictions for the Available Antenna Types

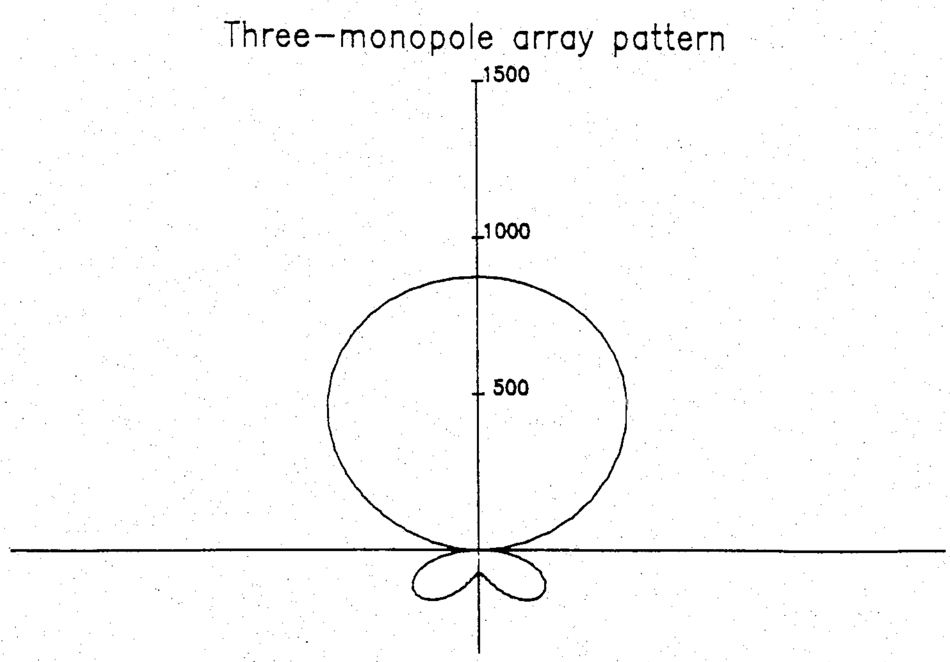
Antenna Model	Valid Frequency range	Restrictions
Vertical monopole ground screen	0.01 - 30 MHz	monopole length > .01 wavelength < .7 wavelength ground screen > .01 wavelength < .6 wavelength no. of radials > 5 < 360
Standard monopole array three-monopole	0.5 - 1.7 MHz	See Figure C-2 for array characteristics and patterns. Sky-wave gain equals ground-wave gain.
four-monopole		See Figure C-3 for array characteristics and patterns. Sky-wave gain equals ground-wave gain.
six-monopole		See Figure C-4 for array characteristics and patterns. Sky-wave gain equals ground-wave gain.
Ferrite-loaded loop	0.5 - 1.7 MHz	length < 25.4 cm diameter < 2.54 cm

REFERENCES

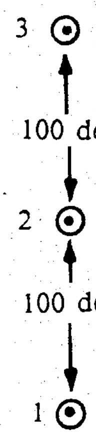
DeMinco, N. (1986), Ground-wave analysis model for MF broadcast systems, NTIA Report 86-203 (NTIS Order No. PB 87-124293/AS).

FCC (Federal Communications Commission) (1982), Part 73 - Radio broadcast service, Subpart A - AM broadcast stations, Rules and Regulations (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402).

ITU (International Telecommunication Union) (1982), Final acts of the regional administrative MF broadcasting conference (Region 2), Rio de Janeiro, 1981 (International Telecommunication Union, Geneva, Switzerland).



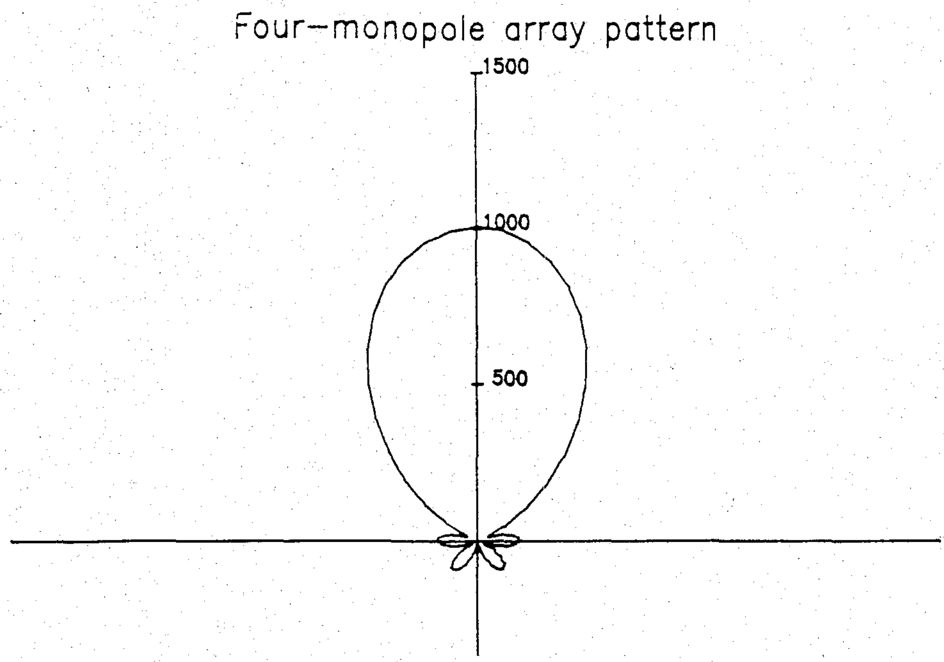
Theoretical field strength in mV/m per kW at 1 km.



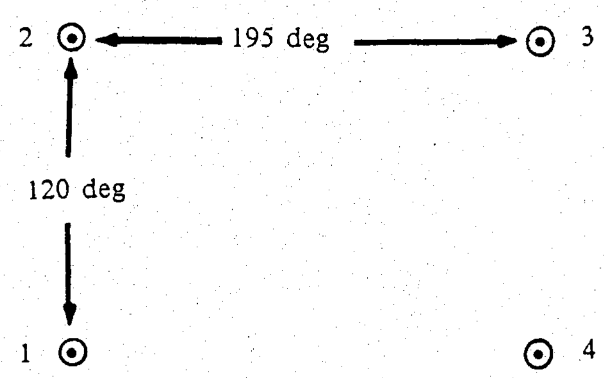
Characteristic	Towers 1	2	3
Field ratio	1.0	1.16	1.0
Phase (deg)	251.24	125.62	0.0
Spacing (deg)	0.0	100.0	200.0
Orientation (deg)	0.0	0.00	0.0
Structure	simple	simple	simple
Height (deg)	225.0	225.0	225.0

RMS field strength = 452 mV/m per kW at 1 km
= 281 mV/m per kW at 1 mi

Figure C-2. Characteristics and pattern for three-monopole array.



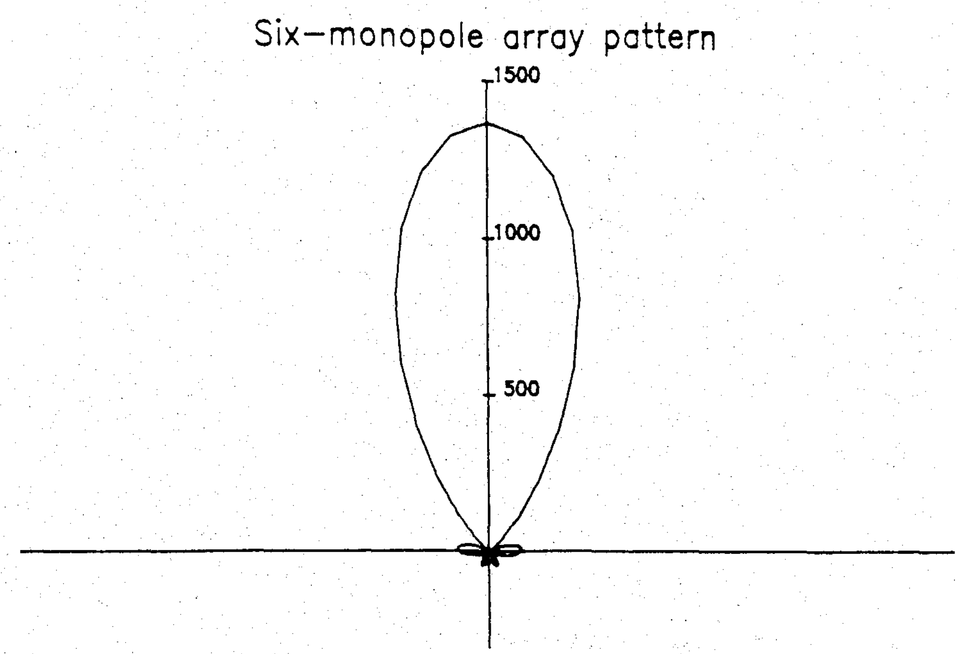
Theoretical field strength in mV/m per kW at 1 km.



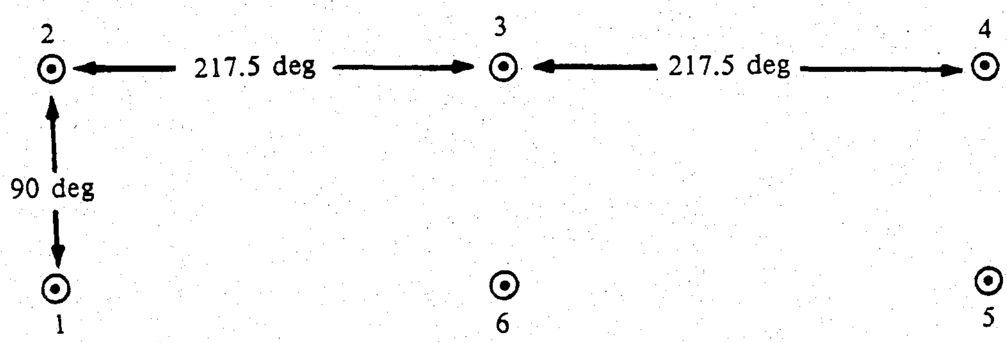
Characteristic	Towers			
	1	2	3	4
Field ratio	1.0	1.16	1.0	1.0
Phase (deg)	62.0	0.0	0.0	62.0
Spacing (deg)	0.0	120.0	229.0	195.0
Orientation (deg)	0.0	0.00	58.4	90.0
Structure	simple	simple	simple	simple
Height (deg)	225.0	225.0	225.0	225.0

RMS field strength = 398 mV/m per kW at 1 km
= 247 mV/m per kW at 1 mi

Figure C-3. Characteristics and pattern for four-monopole array.



Theoretical field strength in mV/m per kW at 1 km.



Characteristic	Towers					
	1	2	3	4	5	6
Field ratio	1.0	1.0	2.0	1.0	1.0	2.0
Phase (deg)	90.0	0.0	0.0	00.0	90.0	90.0
Spacing (deg)	0.0	90.0	235.4	444.2	435.0	217.5
Orientation (deg)	0.0	0.0	67.5	78.3	90.0	90.0
Structure	simple	simple	simple	simple	simple	simple
Height (deg)	225.0	225.0	225.0	225.0	225.0	225.0

RMS field strength = 418 mV/m per kW at 1 km
= 259 mV/m per kW at 1 mi

Figure C-4. Characteristics and pattern for six-monopole array.

APPENDIX D. MODEL PARAMETER QUESTIONS AND THEIR MEANINGS

Tables D-1, D-2, and D-3 contain all of the verbose questions asked of the user by the models, System 1, System 2, and System 3, respectively. The tables list the questions along with guidance as to their meanings and what additional parameters will require values if the user makes certain selections.

Table D-1. System 1 Questions, Their Meaning, and Acceptable Range of Values

Questions description, acceptable value ranges, and default values	Meaning
Title of the analysis (up to 30 characters) 1) Title (VOA Test)?	The title will be printed on the analysis output. (Note a default value or the last value entered is given in parentheses. If that value is acceptable, merely type a carriage return in response to the question.)
Length units: M = Metric, kilometers and meters E = English, statute miles and feet 2) Length units (Metric, kilometers and meters)?	All parameters dealing with length will be asked in the user-specified units. Enter either M or E.
Frequency (530.0 to 1750. kHz) 3) Frequency (1000. kHz)?	Predictions will be made at the selected frequency.
Groundwave model: S = Smooth earth M = Mixed path, smooth earth I = Irregular terrain, mixed path 4) Ground wave model (Smooth earth)?	SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.
Sky-wave model: F = FCC Interregional C = CCIR Plenary Assembly W = Wang I = IFRB skywave 5) Skywave model (FCC Interregional)?	FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.

Transmitter site

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.

10) Transmitter lat (20.0000 deg N or 20 0 0 dms N)?
10) Transmitter lon (90.0000 deg W or 90 0 0 dms W)?

Note that N (north) and E (east) are the default hemispheres. Append N or S to latitude values and E or W to longitude values to ensure correct locations.

Receiver site(s)

At each receiver site specified, the ground-wave and sky-wave field strengths and received powers will be computed. Signal-to-noise ratios and fade margins will be calculated.

Paths to be analyzed are defined from the transmitter site (ref site) to the receiver site(s). The transmitter site is defined by its latitude and longitude. The receiver site(s) can be defined by:

- L = Latitude longitude pairs
- D = Distance - bearing pairs
- IB = Incremental bearing at a fixed distance
- ID = Incremental distance at a fixed bearing

11) Path option (Latitude - longitude pairs)?

The following Questions 12 and 13 depend upon the path option chosen in Question 11.

If SMOOTH EARTH is chosen as the ground-wave method, the receivers can be specified in any of the four ways. Enter either L, D, IB, or ID.

Latitude-longitude pairs

If path option is LATITUDE-LONGITUDE pairs, then Question 12 will request receiver locations specified by their latitude and longitude.

Receiver sites to be included in the predictions:
L = List current set of receiver sites
D = Delete a receiver site
A = Add a receiver site
C = Change a receiver site
N = No change
12) Receiver site (Add)?

Receiver site location

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.
Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E
The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.
12) Receiver lat (10.0000 deg N or 10 0 0 dms N)? 15
12) Receiver lon (85.0000 deg W or 85 0 0 dms W)? 90W

Receiver site location
12) Receiver lat (15.0000 deg N or 15 0 0 dms N)?
12) Receiver site (Add)? N

Enter a carriage return to terminate the entering of additional receiver sites. After the sites have been entered, typing an L will list the sites; typing a C or D will allow the sites to be changed or deleted; and typing an N for no changes will terminate Question 12.

Distance-bearing pairs

If path option is DISTANCE-BEARING PAIRS, then Question 12 will request receiver locations specified by their distance and bearing from the transmitter site.

Receiver sites to be included in the predictions:
L = List current set of receiver sites
D = Delete a receiver site
A = Add a receiver site
C = Change a receiver site
N = No change
12) Receiver site (Add)?

Receiver site location

Distance from reference site to terminal site (0.0 to 10000.0 km)
12) Distance (0.0 km)? 10

Bearing from reference site.
Enter in degrees clockwise from north.
(0.0 to 360.0 degrees)
12) Bearing (10.0 deg)?

Receiver site location
12) Distance (10.0 km)?
12) Receiver site (Add)? N

Incremental bearing, fixed distance

If path option is INCREMENTAL BEARING, then Question 13 will ask for receiver locations specified by the minimum bearing, maximum bearing, and incremental bearing from the transmitter site. The distance from the transmitter, specified by the user, is fixed.

Receiver site location
Bearing from reference site.
Enter in degrees clockwise from north, i.e., north = 0, east = 90, south = 180, west = 270. Answer can be in decimal degrees (X.Y) or in deg., min., and sec. (X,Y,Z), and must be between 0.0 and 360 degrees.

Initial bearing.
Enter the bearing of your first terminal site.
Enter in degrees clockwise from north, i.e., north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees (X.Y) or in deg., min., and sec. (X,Y,Z), and must be between 0.0 and 359.0 degrees.
13) Min bear(0.0 deg)?

Final bearing.
Enter the bearing of your last terminal site.
Enter in degrees clockwise from north, i.e., north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees (X.Y) or in deg., min., and sec. (X,Y,Z), and must be between 0.0 and 359.0 degrees.
13) Max bear(315.0 deg)?

Bear increment.
Enter the number of degrees you wish to increment. Answer can be in decimal degrees (X.Y) or in deg., min., and sec. (X,Y,Z), and must be between 1.0 and 180.0 degrees.
13) Bear inc(45.0 deg)?

Distance from reference site to terminal site (0.0 to
10000.00 km)
13) Distance (10.0 km.)?

<u>Incremental distance, fixed bearing</u>

If path option is INCREMENTAL DISTANCE, then Question 13 asks for the minimum distance, maximum distance, and distance increment from the transmitter at a fixed, user-specified bearing.

Receiver site location

Initial Distance (.1 to
10000.0 km)
13) Min Dist (.1 km)?

Final Distance (.1 to
10000.0 km)
13) Max Dist (500.0 km)?

Distance Increment (0.0 to 10000.0 km)

13) Dist Inc (100.0 km)?
13) Bearing (10.0 deg)?

The following Questions 14 through 17 depend upon the ground-wave method chosen in Question 4.

Smooth Earth

If SMOOTH EARTH is chosen, Questions 14 and 15 will request the values of the ground constants to be used for all paths.

Conductivity for the path (between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
14) Conductivity for the path (.005 S/m)?

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
15) Dielectric constant for the path (15. S/m)?

Mixed path or irregular terrain

Conductivity and relative dielectric constants are needed for each section of the mixed path. Starting at the transmitter site (ref site at 0.0 km) and ending at the receiver site (at 400.1 km), give the length of each segment having different ground constants and the values of conductivity and dielectric constant for each segment. Up to 10 segments may be entered.

If MIXED PATH or IRREGULAR TERRAIN is chosen, Question 16 will break the path into segments whose lengths are chosen by the user. For each segment, the user supplies the ground constants. The path can be as many as 10 segments. The program always defaults the segment length to the remaining path length.

Segment 1 length (0.0 to 400.1 km)
16) Segment 1 length (400.1 km)? 200

This example, the distance from the transmitter to the receiver is 400.1 km. The user indicated the first segment is 200 km. The conductivity and dielectric constant for the segment must be supplied by the user.

Conductivity for the segment between 0.0 and 200.0 km (between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water

Conductivity for the path between 0.0 and 200. km (.005 S/m)?

Dielectric constant for the segment between 0.0 and 200.0 km (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
Dielectric constant for the segment between 0.0 and 200.0 km (15.)?
16) Segment 2 length (200.1 km)? 200

Repeat for the next segment(s). The program always shows the maximum segment length left in the path.

Conductivity for the path between 200.0 and 400.0 km (.005 S/m)?
Dielectric constant for the segment between 200.0 and 400.0 km (15.)?
16) Segment 3 length (.1 km)?

Conductivity for the path between 400.0 and 400.1 km (.005 S/m)?
Dielectric constant for the segment between 400.0 and 400.1 km (15.)?

<u>Irregular terrain</u>

Terrain elevations are needed along the irregular path. Starting at the transmitter site (ref site), give the distance from the ref site and the elevation values.

Terrain elevation options:
U = User-defined terrain elevations
D = Elevations obtained from data base
17) Terrain elevation option (User-defined)? U

Distance Increment (0.0 to 1000.0 km)
17) Dist Inc (10.0 km)?

Elevation at 0.0 km (0.00 to 1000.0 m)
Elevation at 0.00 km (0.00 m)?
Elevation at 100.00 km (10.00 m)?
Elevation at 200.00 km (20.00 m)?
Elevation at 300.00 km (30.00 m)?
Elevation at 400.00 km (40.00 m)?
Elevation at 400.10 km (50.00 m)?

If IRREGULAR TERRAIN is chosen, Question 17 allows the user to enter the path terrain elevations at a user-specified increment along the path. The terrain elevation data base has elevation values from Mexico to northern South America. The elevations are on a grid whose spacing is 5 minutes in latitude and longitude. If the path is outside of the region covered by the data base, the program will print that there are no topographic data along the path from the data base.

The following Questions 19 through 56 ask for transmitter parameter values.

Transmitter power into the antenna terminals (1.00 to 10000.00 kW)

19) Transmitter power into the antenna terminals (1.00 kW)?

Antenna types:

VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array

21) Transmitter antenna type (Vertical monopole)?

The user is asked to select the type of transmitter antenna from this list. After selecting an antenna type, the user will be asked for additional information. If the user has transmitter station data in the IFRB or FCC format, then select GM, the general monopole array gain calculations. The standard monopole array is a specific three- four- or six-monopole array antenna. For the field strength option, the user supplies the field strength at a reference distance and the program will compute an equivalent antenna gain. The user-defined gain, field strength option, and the standard monopole will use the same gain for the sky-wave calculations as for the ground-wave calculations. The general monopole array and vertical monopole antennas have sky-wave gains that depend upon the takeoff sky-wave signal.

<u>Vertical monopole antenna</u>

For VERTICAL MONOPOLE, the antenna's height and ground screen characteristics will be specified.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
22) Transmitter antenna feed point height above ground (0.00 m)? 1

The antenna height is the actual height of the antenna feed point above the surrounding terrain. It is not necessarily the height of the structure.

Transmitter vertical monopole length (between 0.00 and 400.0 m)
23) Transmitter vertical monopole length (0.00 m)? 1

The antenna length should not be less than 0.01 wavelengths or greater than 0.7 wavelengths.

Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
23) Transmitter antenna monopole efficiency (100.0 %)?

Ground screen
Y = Yes
N = No
24) Ground screen (Yes)?

Transmitter antenna ground screen radius (between 1.00 and 2500.00 m)
25) Transmitter antenna ground screen radius (0.00 m)?

Transmitter antenna number of radials (between 5 and 360)
26) Transmitter antenna number of radials (0)?

User-specified gain option

For USER-SPECIFIED GAIN, the user will specify an antenna gain relative to an isotropic radiator. This single gain value is used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
22) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
34) Transmitter gain (0.0 dBi)?

Field strength option

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
22) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)
31) Transmitter antenna field strength (0.0000 mV/m)?

Transmitter antenna reference power (.001 to 10000.000 kW)
32) Transmitter antenna reference power (0.000 kW)?

Transmitter antenna reference distance (0.00 to 100.00 km)
33) Transmitter antenna reference distance (0.00 km)?

The FIELD STRENGTH OPTION allows the user to specify the field strength at a reference distance with a given input power. The equivalent antenna gain is computed and used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal. The transmitter antenna reference power is the power at the input to the antenna terminals.

General monopole array

The GENERAL MONOPOLE ARRAY should be used with IFRB- or FCC-format station data information.

Hours of operation for which the given characteristics of the antenna are applicable:
D = Day
N = Night
A = All
37) Hours of operation (Day)?

This is a reminder to the user that many stations have different characteristics for day and night operations.

Reference point:
C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
P = Spacing and orientation are shown with respect to the previous tower
38) Definition point indicator (Common reference tower)?

Most data are provided with the first tower as the reference, so C would be entered for COMMON REFERENCE.

Total number of towers (1 to 20)
39) Total number of towers (1)?

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
40) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
41) Phase difference of the field (0.0000 degrees)?

Questions 41 through 55 ask for parameters whose values have units of degrees. This is the same as portions of a wavelength where 360 degrees equals one wavelength.

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
42) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
43) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
44) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
45) Electrical height of tower (225.0 degrees)?

Only question 45 is asked if the tower type is VERTICAL, SIMPLE ANTENNA.

Electrical height of antenna tower (0.0 to 360.0 degrees)?
50) Electrical height of antenna tower (120.0 degrees)?

Questions 50 and 51 are asked if the tower type is TOP-LOADED ANTENNA.

Difference between apparent electrical height (based on current distribution) and actual height (0.0 to 360.0 degrees)
51) Difference between apparent electrical height and actual height (20.0 degrees)?

Height of the lower section (0.0 to 360.0 degrees)
52) Height of lower section (120.0 degrees)?

Questions 52 through 55 are asked if the tower type is SECTIONALIZED ANTENNA.

Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (0.0 to 360.0 degrees)
53) Difference between apparent electrical height of lower section and actual height of lower section (20.0 degrees)?

Total height of the antenna (0.0 to 360.0 degrees)
54) Total height of antenna (220.0 degrees)?

Difference between apparent electrical height (based on current distribution) of the total tower (0.0 to 360.0 degrees)
55) Difference between apparent electrical height of the total tower (15.0 degrees)?

Augmentations to be included in the predictions:
L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change
56) Augmentation (A)?

Augmentations can be made to a directional antenna to enhance the gain in various directions. The user will have to supply the central angle of the augmentations, their total angular spans, and their radiated field strengths in mV/m at 1 km.

Radiation at the central azimuth of augmentation (mV/m at 1 km) (>= the value for the theoretical pattern)
Radiation at central azimuth of augmentation (1300.0 mV/m)?

Central azimuth of augmentation (center of the span) (0.0 to 360.0 degrees)
Central azimuth of augmentation (110.0 degrees)?

Total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. If the spans overlap, augmentations are processed clockwise according to the central azimuth of augmentations. (0.1 to 360.1 degrees)
Total span of augmentation
(40.0 degrees)?

Radiation at central azimuth of augmentation (10.0 mV/m)?
56) Augmentation (A)? N

Enter only a carriage return to terminate augmentation entries.

Standard monopole array

One of three STANDARD MONOPOLE ARRAYS can be chosen. The gain value determined at each azimuth will be used for both ground-wave and sky wave predictions.

Transmitter antenna number of poles (3, 4 or 6)
27) Transmitter antenna number of poles (3)?

Transmitter antenna boresight bearing (0.0 to 360.0 degrees east of north)
28) Transmitter antenna boresight bearing (0.0 degrees)?

The main beam pointing angle is to be specified by the user.

The following Questions 61 through 70 ask for receiver parameter values.

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
61) Receiver antenna type (Vertical monopole)?

The user will be asked to specify the receiver antenna type. The vertical monopole antenna, user-specified gain, and field strength option descriptions are the same as those for the transmitter antenna type.

Ferrite loop antenna

The calculated antenna gain value of the ferrite loop is used for all ground-wave and sky-wave predictions regardless of azimuth or reception elevation angle of the signal.

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
62) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
69) Receiver antenna length of ferrite rod (0.00 cm)?

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
70) Receiver antenna diameter of ferrite rod (0.00 cm)?

The following Questions 80 through 82 are used to determine the man-made and atmospheric noise environment.

Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)
80) Man-made noise environment (Residential)?

The user selects the type of environment in which the receiver will be placed. The values in parentheses give the median man-made noise in 1 Hz bandwidths at 1 MHz. The value is adjusted for the selected frequency.

Local time of day:
L = List current set of times
D = Delete a time
A = Add a time
C = Change a time
N = No change
81) Time of day (Add)?

For each time entered, the program will compute the signal-to-noise ratio tables. This question only affects the noise calculations.

Up to 24 times (between 0 and 2300)
(A carriage return exits this mode)
Time (200)? 23
Time (2300)? 22
Time (2200)?

Values between 1 and 24 or 100 and 2400 will be accepted.

81) Time of day (Add)? L
Time(s)
1) 2300
2) 2200
81) Time of day (Add)? N

Seasons to be included in the predictions:
L = List current set of seasons
D = Delete a season
A = Add a season
C = Change a season
N = No change
82) Season (Add)?

For each season entered, the program will compute the signal-to-noise ratio tables. The question only affects the noise calculations.

Seasons (up to 4 values)
W = Winter (December, January,February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)

Season (Winter (December,
January, February))? SP
Season (Spring (March, April, May))? SU
Season (Summer (June, July, August))?
82) Season (Add)? N

Required reliability (between 0. and 100.%) 83) Required reliability (90.%)?

The noise power is adjusted by the reliability. A 90 percent reliability implies that the computed signal-to-noise power ratio will be available for 90 percent of the time in a 1-hour/3-month season time block for the selected season, local time of day, and frequency.

Earth radius ratio (.500 to 3.000)
84) Earth radius ratio (1.330)?

The effective Earth radius to the actual Earth radius ratio is used in the ground-wave predictions. Use of 1.33 gives a standard refractive atmosphere and assumes a 4/3 effective to actual Earth radius ratio.

Table D-2. System 2 Questions, Their Meanings, and Acceptable Range of Values

Question descriptions, acceptable value ranges, and default values	Meaning
Title of the analysis (up to 30 characters) 1) Title (VOA Test)?	The title will be printed on the analysis output. Note a default value or the last value entered is given in parenthesis. If that value is acceptable, merely type a carriage return in response to the question.
Frequency (530 to 1750 kHz) Frequencies must be in increments of 10 kHz 3) Frequency (1000 kHz)?	Predictions will be made at the selected frequency and the data base will be searched for interfering transmitters within the range of 30 kHz above and 30 kHz below the selected frequency.
Groundwave model: S = Smooth earth M = Mixed path, smooth earth I = Irregular terrain, mixed path 4) Ground wave model (Smooth earth)?	SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.
Skywave model: F = FCC Interregional C = CCIR Plenary Assembly W = Wang I = IFRB skywave 5) Skywave model (FCC Interregional)?	FCC and IFRB currently use the same prediction method and they can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.
Propagation conditions to be analyzed D = Daytime, groundwave only N = Nighttime, groundwave and skywave 6) Propagation conditions (Daytime)?	Interfering transmitters to be considered in the calculations will be those broadcating during the day or both day and night. If only daytime is requested, there will be no skywave predicitons made.

Transmitter site

Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country
code (ZZ)?

The country code and location descriptions of the transmitter site are printed on the analysis summary of input parameters but not on the output tables.

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site
location (Boulder, Co.)?

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)?

The code letter for the transmitter site is printed on both the summary and the output tables.

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

Note that N (north) and E (east) are the default hemispheres. Append N or S to latitude values and E or W to longitude values to ensure correct locations.

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.

Inputs of the form X.Y imply decimal degrees.
14) VOA site lat (20.0000 deg N
or 20 0 0 dms N)?
14) VOA site lon (90.0000 deg W
or 90 0 0 dms W)?

Receiver site

Country code for population center site (2 characters)
21) Population center site
country code (ZZ)?

Location description of population center site (up to 14 characters)

22) Population center site
    location (St. Louis, Mo.)?

The country code and the location description of the reception population center are printed on the summary of input values but not on the output tables.

Code letter for population center site (1 character)

23) Population center site
    ID (B)?

The code letter for the population center is printed on both the summary and output tables.

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
             0S <= lat <= 90S
             0W <= lon <= 180W
             0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.

Inputs of the form X.Y imply decimal degrees.

24) Population center lat
    (10.0000 deg N or
     10 0 0 dms N)?

24) Population center lon
    (85.0000 deg W or
     85 0 0 dms W)?

Distance to be searched around population center for non-VOA transmitters (between 0.0 and 10000.0 km)

25) Distance to be searched around
    population center (100.0 km)?

A much larger search distance should be used for nighttime calculations compared with ground-wave daytime calculations.

Smooth earth

Conductivity for the path
(between .001 and 10.000
Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
30) Conductivity for the path
(.005 S/m)?

Delectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
31) Dielectric constant for the
path (15.)?

The following Questions 19 and 41 through 76 ask for transmitter parameter values

Transmitter power into the antenna terminals (1.00 to 10000.00 kW)
19) Transmitter power into the
antenna terminals (1.00 kW)?

If SMOOTH EARTH is chosen, Questions 30 and 31 will request the values of the ground constants to be used for all paths.

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array
41) Transmitter antenna type (Vertical monopole)?

The user is asked to select the type of transmitter antenna from this list. After type selection, the user will be asked for additional information. If the user has transmitted station data in the IFRB or FCC format, then the user should select GM, the general monopole array gain calculations. The standard monopole array is a specific three-, four-, or six-monopole array antenna. For the field strength option, the user supplies the field strenth at a reference distance and the program will compute an equivalent antenna gain. The user-defined gain, field strength option, and standard monopole will use the same gain for the sky-wave calculations as for the ground-wave calculations. The general monopole array and vertical monopole antennas have sky-wave gains that depend upon the takeoff angle of the sky-wave signal.

Vertical monopole antenna

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
42) Transmitter antenna feed point height above ground (0.00 m)?

The antenna height is the actual height of the antenna feed point above the surrounding terrain. It is not necessarily the height of the structure.

Transmitter vertical monopole length (between 0.00 and 400.0 m)
43) Transmitter vertical monopole length (1.00 m)?

The antenna length should not be less than 0.01 wavelengths or greater than 0.7 wavelengths.

Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
43) Transmitter antenna monopole efficiency (100.0 %)?

Ground screen
Y = Yes
N = No
44) Ground screen (Yes)?

Transmitter antenna ground screen radius (between 1.00 and 2500.00 m)
45) Transmitter antenna ground screen radius (1.00 m)?

Transmitter antenna number of radials (between 5 and 360)
46) Transmitter antenna number of radials (10)?

<u>User-specified gain antenna</u>

The user can specify an antenna gain relative to an isotropic radiator. This single gain value is used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
54) Transmitter gain (1.0 dBi)?

<u>Field strength option</u>

The field strength option allows the user to specify the field strength at a reference distance with a given input power. The equivalent antenna gain is computed and used for all ground-wave and sky-wave predictions regardless of azimuth or take-off angle of the signal. The transmitter antenna reference power is the power at the input to the antenna terminals.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)

51) Transmitter antenna field strength (300000 mV/m)?

Transmitter antenna reference power (.001 to 10000.000 kW)

52) Transmitter antenna reference power (1.000 kW)?

Transmitter antenna reference distance (0.00 to 100.00 km)

53) Transmitter antenna reference distance (0.00 km)?

<u>General monopole array</u>

The general monopole array should be used with IFRB- or FCC-format station data information.

Hours of operation for which the given characteristics of the antenna are applicable:

D = Day
N = Night
A = All

57) Hours of operation (Day)?

This is a reminder to the user that many stations have different characteristics for day and night operations.

Reference point:

C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower

P = Spacing and orientation are shown with respect to the previous tower

58) Definition point indicator (Common reference tower)?

Most data are provided with the first tower as the reference, so C would be entered for COMMON REFERENCE.

Total number of towers (1 to 20) 59) Total number of towers (1)?

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
60) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
61) Phase difference of the field (0.0000 degrees)?

Questions 61 through 75 ask for parameters whose values have units of degrees. This is the same as portions of a wavelength where 360 degrees equals one wavelength.

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
62) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
63) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
64) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
65) Electrical height of tower (225.0 degrees)?

Only question 65 is asked if the tower type is VERTICAL, SIMPLE ANTENNA.

Electrical height of the antenna tower (0.0 to 360.0 degrees)
70) Electrical height of antenna tower (120.0 degrees)?

Questions 70 and 71 are asked if the tower type is TOP-LOADED ANTENNA.

Difference between apparent electrical height (based on current distribution) and actual height (0.0 to 360.0 degrees)
71) Difference between apparent electrical height and actual height (20.0 degrees)?

Height of the lower section (0.0 to 360 degrees)
72) Height of lower section (120.0 degrees)?

Questions 72 through 75 are asked if the tower type is SECTIONALIZED ANTENNA.

Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (0.0 to 360.0 degrees)
73) Difference between apparent electrical height of lower section and actual height of lower section (20.0 degrees)?

Total height of antenna 0.0 to 360.0 degrees) 74) Total height of antenna (220.0 degrees)?
75) Difference between apparent electrical height of the total tower (15.0 degrees)?

Augmentations to be included in the predictions:
  L = List current set of augmentations
  D = Delete an augmentation
  A = Add an augmentation
  C = Change an augmentation
  N = No change
 76) Augmentation (A)?

Augmentations can be made to a directional antenna to enhance the gain in various directions. The user will have to supply the central angle of the augmentations, their total angular span, and their radiated field strength in mV/m at 1 km.

Radiation at the central azimuth of augmentation (mV/m at 1 km) (>= the value for the theoretical pattern)
  Radiation at central azimuth
  of augmentation (1300.0 mV/m)?

Central azimuth of augmentation (center of the span) (0.0 to 360.0 degrees)
    Central azimuth of
    augmentation
    (110.0 degrees)?

Total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. If the spans overlap, augmentations are processed clockwise according to the central azimuth of augmentations.
(0.1 to 360.1 degrees)
Total span of augmentation
(40.0 degrees)?
Radiation at central azimuth
of augmentationn (10.0 mV/m)?
 76) Augmentation (A)?

Standard monopole array

One of three standard monopole arrays can be chosen. The gain value determined at each azimuth will be used for both ground-wave and sky-wave predictions. The main beam pointing angle is to be specified by the user.

Transmitter antenna number of poles (3, 4 or 6)
47) Transmitter antenna number of poles (3)?

Transmitter antenna boresight bearing (0.0 to 360.0 degrees east of north)
48) Transmitter antenna boresight bearing (0.0 degrees)?

The following Questions 81 through 94 ask for receiver parameter values.

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
81) Receiver antenna type (Vertical monopole)?

Ferrite loop antenna

The calculated antenna gain value of the ferrite loop is used for all ground-wave and sky-wave predictions regardless of azimuth or reception elevation angle of the signal.

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
89) Receiver antenna length of ferrite rod (0.00 cm)?

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
90) Receiver antenna diameter of ferrite rod (0.00 cm)?

The following Questions 95 through 99 are used to determine the man-made and atmospheric noise environment

Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)
95) Man-made noise environment (Residential)?

The user selects the type of environment in which the receiver will be placed. The values in parentheses give the median man-made noise in 1-Hz bandwidths at 1 MHz. The value is adjusted for the selected frequency.

Time of day to be used in calculations (between 0 and 2300)
96) Time (200)?

This question affects the noise calculation for the signal-to-noise ratio tables.

Seasons:
W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)
97) Season (Winter (December, January, February))?

This questtion affects the noise calculation for the signal-to-noise ratio tables.

Required reliability (between 0. and 100.%)
98) Required reliability (90.%)?

The noise power is adjusted by the reliability. A 90-percent reliability implies that the computed signal-to-noise power ratio will be available for 90 percent of the time in a 1-hour/3-month season time block for the selected season, local time of day, and frequency.

Earth radius ratio (.500 to 3.000)
99) Earth radius ratio (1.330)?

The effective Earth radius to the actual Earth radius ratio is used in the ground-wave predictions. Use of 1.33 gives a standard refractive atmosphere and assures a 4/3 effective to actual Earth radius ratio.

Table D-3. System 3 Questions, Their Meanings, and Acceptable Range of Values

Question descriptions, acceptable value ranges and default values	Meaning
Title of the analysis (up to 30 characters) 1) Title (VOA Test)?	The title will be printed on the analysis output.
Frequency (530 to 1750 kHz) Frequencies must be in increments of 10 kHz 3) Frequency (1000 kHz)?	Predictions will be made at the selected frequency and the data base will be searched for interfering transmitters within the range of 30 kHz above and 30 kHz below the selected frequency.
Groundwave model: S = Smooth earth M = Mixed path, smooth earth I = Irregular terrain, mixed path 4) Ground wave model (Smooth earth)?	SMOOTH EARTH is the simplest prediction method. MIXED PATH requires ground constants to be given along the path. IRREGULAR TERRAIN requires ground constants and terrain elevations along the path.
Skywave model: F = FCC Interregional C = CCIR Plenary Assembly W = Wang I = IFRB skywave 5) Skywave model (FCC Interregional)?	FCC and IFRB currently use the same prediction method and can be used for U.S. or Region 2 analyses. CCIR is the international method. WANG incorporates features of all the other methods.
Propagation conditions to be analyzed D = Daytime, groundwave only N = Nighttime, groundwave and skywave 6) Propagation conditions (Daytime)?	Interfering transmitters to be considered in the calculations will be those broadcasting during the day or both day and night. If only daytime is requested, there will be no sky-wave predictions made.

Transmitter site

Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country code (ZZ)?

The country code and location descriptions of the transmitter site are printed on the analysis summary of input parameters but not on the output tables.

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, CO)?

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)?

The code letter for the transmitter site is printed on both the summary and the output tables.

Type site lat (followed by carriage return) and site lon (return) for each of the sites. Enter the reference site location first.

Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations can be specified by adding an S to the latitude value or adding an W to the longitude value.

Note that N (north) and E (east) are the default hemispheres. Append N or S to latitude values and E or W to longitude values to ensure correct locations.

Inputs of the form X,Y,Z imply degrees, minutes and seconds.

Inputs of the form X.Y imply decimal degrees.

14) VOA site lat (20.0000 deg N or 20 0 0 dms N)?
14) VOA site lon (90.0000 deg W or 90 0 0 dms W)?

Receiver site

Country code for population center site (2 characters)
21) Population center site country code (ZZ)?

The country code and location descriptions of the transmitter site are printed on the analysis summary of input parameters but not on the output tables.

Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, MO.)?

Code letter for population center site (1 character)
23) Population center site ID (B)?

The code letter for the population center is printed on both the summary and output tables.

Western plot boundary
Limits are - 20 W <= lat <= 160W
24) Western plot boundary
(90.00 degrees W)? 106

Western boundary for the receiver sites.

Eastern plot boundary
Limits are - 20 W <= lat <= 160W
25) Eastern plot boundary (100.0
degrees W)? 100

Eastern boundary for the receiver sites.

Southern plot boundary
Limits are - 0 N <= lat <= 90N
Limits are - 0 S <= lat <= 90S
The default hemisphere is N. The S location can be specified by adding an S to the latitude value
26) Southern plot boundary
(90.00 degrees N)? 20

Southern boundary for the receiver sites.

Northern plot boundary
Limits are - 0 N <= lat <= 90N
Limits are - 0 S <= lat <= 90S
The default hemisphere is N. The S location can be specified by adding an S to the latitude value

27) Northern plot boundary
(90.00 degrees N)?

Northern boundary for the receiver sites.

Distance to be searched around population center for non-VOA transmitters (between 0.0 and 10000.0 km)

28) Distance to be searched around
population center (100.0 km)?

The program searches for interfering transmitters both within the plot boundaries and the requested search distance surrounding the area. If a search distance of 0 is input, only the area within the plot boundaries will be searched.

Smooth Earth

If SMOOTH EARTH is chosen, Questions 30 and 31 will request the values of the ground constants to be used for all paths.

Conductivity for the path (between .001 and 10.000 Siemens(mhos)/meter)
  0.001 for poor ground
  0.005 for average ground
  0.020 for good ground
  5.000 for sea water
  0.010 for fresh water
30) Conductivity for the path
  (.005 S/m)?

Dielectric constant (between 1. and 81.)
  4.0 for poor ground
  15.0 for average ground
  25.0 for good ground
  81.0 for sea and fresh water
31) Dielectric constant for the path
  (15.)?

The following Questions 19 and 41 through 76 ask for transmitter parameter values.

Transmitter power into the antenna terminals (.10 to 10000.00 kW)
19) Transmitter power into the
  antenna terminals (1.00 kW)?

Antenna types:
  VM = Vertical monopole
  UG = User gain input
  FS = Field strength option
  GM = General monopole array
  SM = Standard monopole array

41) Transmitter antenna type (Vertical monopole)?

The user is asked to select the type of transmitter antenna from this list. After type selction, the user will be asked for additional information. If the user has transmitter station data in the IFRB or FCC format, then select GM, the general monopole array gain calculations. The standard monopole array is a specific three-, four-, or six-monopole array antenna. For the field strength option, the user supplies the field strength at a reference distance and the program will compute an equivalent antenna gain. The user-defined gain, field strength option, and the standard monopole will use the same gain for the sky-wave calculations as for the ground-wave calculations. The general monopole array and vertical monopole antennas have sky-wave gains that depend upon the take-off angle of the sky wave signal.

Vertical monopole antenna

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) Transmitter antenna feed point height above ground (0.00 m)?

The antenna height is the actual height of the antenna feed point about the surrounding terrain. It is not necessarily the height of the structure.

Transmitter vertical monopole length (between 0.00 and 400.0 m)

43) Transmitter vertical monopole length (1.00 m)?

The antenna length should not be less than 0.01 wavelengths or greater than 0.7 wavelengths.

Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
43) Transmitter antenna monopole efficiency (100.0 %)?

Ground screen
Y = Yes
N = No
44) Ground screen (Yes)?

Transmitter antenna ground screen radius (between 1.00 and 2500.00 m)

45) Transmitter antenna ground screen radius (1.00 m)?

Transmitter antenna number of radials (between 5 and 360)
46) Transmitter antenna number of radials (1)?

User-specified gain antenna

The user can specify an antenna gain relative to an isotropic radiator. This single gain value is used for all ground-wave and sky-wave predictions regardless of azimuth or takeoff angle of the signal.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)
42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna power gain relative to an isotropic radiator (-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
54) Transmitter gain (1.0 dBi)?

Field strength option

The field strength option allows the user to specify the field strength at a reference distance with a given input power. The equivalent antenna gain is computed and used for all ground-wave and sky-wave predictions regardless of azimuth or take-off angle of the signal. The transmitter antenna reference power is the power at the input to the antenna terminals.

Transmitter antenna feed point height above ground (between 0.00 and 100.0 m)

42) Transmitter antenna feed point height above ground (0.00 m)?

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)

51) Transmitter antenna field strength (3.0000 mV/m)?

Transmitter antenna reference power (.001 to 10000.000 kW)

52) Transmitter antenna reference power (1.000 kW)?

Transmitter antenna reference distance (0.00 to 100.00 km)

53) Transmitter antenna reference distance (0.00 km)?

<u>General monopole array</u>

The general monopole array should be used with IFRB- or FCC-format station data information.

Hours of operation for which the given characteristics of the antenna are applicable:

D = Day
N = Night
A = All

57) Hours of operation (Day)?

This is a reminder to the user that many stations have different characteristics for day and night operations.

Reference point:

C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower

P = Spacing and orientation are shown with respect to the previous tower

58) Definition point indicator (Common reference tower)?

Most data are provided with the first tower as the reference, so C would be entered for COMMON REFERENCE.

Total number of towers (1 to 20)
59) Total number of towers (1)?

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)

60) Tower field ratio (1.0000)?

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-180.0000 to 180.0000 degrees)
61) Phase difference of the field (0.0000 degrees)?

Questions 61 through 75 ask for parameters whose values have units of degrees. This is the same as portions of a wavelength where 360 degrees equals one wavelength.

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
62) Electrical tower spacing (0.0000 degrees)?

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
63) Angular tower orientation (0.0000 degrees)?

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
64) Tower structure (Vertical, simple antenna)?

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
65) Electrical height of tower (225.0 degrees)?

Only Question 65 is asked if the tower type is VERTICAL, SIMPLE ANTENNA.

Electrical height of the antenna tower (0.0 to 360.0 degrees)

70) Electrical height of antenna tower (120.0 degrees)?

Questions 70 and 71 are asked if the tower type is TOP-LOADED ANTENNA.

Difference between apparent electrical height based on current distribution) and actual height (0.0 to 360.0 degrees)

71) Difference between apparent electrical height and actual height (20.0 degrees)?

Height of lower sesction (0.0 to 360.0 degrees)

72) Height of lower section (120.0 degrees)?

Questions 72 through 75 are asked if the tower type is SECTIONALIZED ANTENNA.

Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (0.0 to 360.0 degrees)

73) Difference between apparent electrical height of lower section and actual height of lower section (20.0 degrees)?

Total height of the antenna (0.0 to 360.0 degrees)

74) Total height of antenna (220.0 degrees)?

Difference between apparent electrical height (based on current distribution) of the total tower (0.0 to 360.0 degrees)

75) Difference between apparent electrical height of the total tower (15.0 degrees)?

Augmentations to be included in the predictions:

L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change

76) Augmentation (A)?

Augmentations can be made to a directional antenna to enhances the gain in various directions. The user will have to supply the central angle of the augmentations, their total angular spans, and their radiated field strengths in mV/m at 1 km.

Radiation at the central azimuth of augmentation (mV/m at 1 km)
(>= the value for the theoretical pattern)

Radiation at central azimuth of augmentation (1300.0 mV/m)?

Central azimuth of augmentation (center of the span) (0.0 to 360.0 degrees)

Central azimuth of augmentation (110.0 degrees)?

Total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. If the spans overlap, augmentations are processed clockwise according to the central azimuth of augmentations. (0.1 to 360.1 degrees)

Total span of augmentation
(40.0 degrees)?

Radiation at central azimuth of augmentation (10.0 mV/m)?
76) Augmentation (A)?

<u>Standard monopole array</u>

One of three standard monopole arrays can be chosen. The gain value determined at each azimuth will be used for both ground-wave and sky-wave predictions. The main beam pointing angle is to be specified by the user.

Transmitter antenna number of poles (3, 4 or 6)
47) Transmitter antenna number of poles (3)?

Transmitter antenna boresight bearing (0.0 to 360.0 degrees east of north)
48) Transmitter antenna boresight bearing (0.0 degrees)?

The following Questions 81 through 94 ask for receiver parameter values.

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
81) Receiver antenna type (Vertical monopole)?

The user will be asked to specify the receiver antenna type. The vertical monopole antenna, user-specified gain, and field strength option descriptions are the same as those for the transmitter antenna type.

Ferrite loop antenna

The calculated antenna gain value of the ferrite loop is used for all ground-wave and sky-wave predictions regardless of azimuth or reception elevation angle of the signal.

Receiver antenna feed point height above ground (between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)?

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
89) Receiver antenna length of ferrite rod (0.00 cm)?

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
90) Receiver antenna diameter of ferrite rod (0.00 cm)?

Earth radius ratio (.500 to 3.000)
98) Earth radius ratio (1.330)?

The effective Earth radius to the actual Earth radius ratio is used in the ground-wave predicitons. Use of 1.33 gives a standard refractive atmosphere and assures a 4/3 effective to actual Earth radius ratio.

Type of plot:
C = Coverage
I = Interference
99) Type of plot (Interference)?

A COVERAGE plot will plot the coverage of the VOA transmitter without searching for interfering non-VOA transmitters.

APPENDIX E. SAMPLE DIALOGS

Institute for Telecommunication Sciences

MF RESYDE
System 1
Voice of America
MF Relay System Design Model
Version 1.0

```
Choose from the menu:
     H = Help
     D = Program Description
     C = Concise Dialog
     V = Verbose Dialog
     E = Edit Data
     S = Summary of Data
     P = Process Last Data Set Entered
     Q = Quit

Menu (Verbose)? ______ ↵

Title of the analysis (up to 30 characters)
 1) Title (VOA Test)? ground wave check ↵

Length units:
   M = Metric, kilometers and meters
   E = English, statute miles and feet
 2) Length units (Metric, kilometers and meters)? ______ ↵

Frequency (530.0 to 1750. kHz)
 3) Frequency (1000. kHz)? ______ ↵

Groundwave model:
   S = Smooth earth
   M = Mixed path, smooth earth
   I = Irregular terrain, mixed path
 4) Ground wave model (Smooth earth)? ______ ↵

Skywave model:
   F = FCC Interregional
   C = CCIR Plenary Assembly
   W = Wang
   I = IFRB skywave
 5) Skywave model (FCC Interregional)? ______ ↵
```

Sample #1
Smooth Earth,
ground-wave calculations

```
Type site lat (followed by carriage return) and
site lon (return)  for each of the sites.  Enter
the reference site location first.
   Limits are -  0N <= lat <=   90N
                  0S <= lat <=   90S
                  0W <= lon <=  180W
                  0E <= lon <=  180E
  The default hemispheres are N and E.  The S and
  W locations can be specified by adding an S to
  the latitude value or adding an W to the longitude
  value.
  Inputs of the form X,Y,Z imply degrees, minutes and seconds.
  Inputs of the form X.Y imply decimal degrees.
10) Transmitter lat ( 20.0000 deg N or  20  0  0 dms N)?  40
10) Transmitter lon (  90.0000 deg W or   90  0  0 dms W)?  90w

Paths to be analyzed are defined from the transmitter site
(ref site) to the receiver site(s).  The transmitter site is
defined by its latitude and longitude.  The receiver site(s)
can be defined by:

   L  = Latitude longitude pairs
   D  = Distance - bearing pairs
   IB = Incremental bearing at a fixed distance
   ID = Incremental distance at a fixed bearing
11) Path option (Latitude - longitude pairs)?  id

Receiver site location

Initial Distance  (      .1 to  10000.0   km)
13) Min Dist (     .1    km)?  10

Final Distance  (   10.0 to  10000.0   km)
13) Max Dist ( 500.0    km)?  100

Distance Increment  (     0.0 to  10000.0   km)
13) Dist Inc ( 100.0    km)?  10

Bearing from reference site.
Enter in degrees clockwise from north,
i.e. north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees(X.Y) or
in deg. min. and sec. (X,Y,Z), and must be
between   0.0 and 360.0 degrees
13) Bearing (  10.0 deg)?  0
```

Sample #1
Smooth Earth,
ground-wave calculations

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
14) Conductivity for the path (.005 S/m)? .003 ↵

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
15) Dielectric constant for the path (15.)? ______ ↵

Transmitter power into the antenna terminals (.10 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)? ______ ↵

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array
21) Transmitter antenna type (Vertical monopole)? fs ↵

Transmitter antenna feed point height above ground
(between 0.00 and 100.0 m)
22) Transmitter antenna feed point height above ground (0.00 m)? ______ ↵

Transmitter antenna field strength (.0010 to 100000000.0000 mV/m)
31) Transmitter antenna field strength (3.0000 mV/m)? 300 ↵

Transmitter antenna reference power (.001 to 10000.000 kW)
32) Transmitter antenna reference power (1.000 kW)? ______ ↵

Transmitter antenna reference distance (0.00 to 100.00 km)
33) Transmitter antenna reference distance (10.00 km)? 1 ↵

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
61) Receiver antenna type (Vertical monopole)? ug ↵

Receiver antenna feed point height above ground
(between 0.00 and 100.0 m)
62) Receiver antenna feed point height above ground (0.00 m)? ______ ↵

Receiver antenna power gain relative to an isotropic radiator
(-100.0 to 100.0 dBi). If gain is known to a dipole,
then dBi = dBd + 2.5
74) Receiver gain (3.0 dBi)? 0 ↵

Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)
80) Man-made noise environment (Residential)? ______ ↵

Local time of day:
L = List current set of times
D = Delete a time
A = Add a time
C = Change a time
N = No change
81) Time of day (Add)? ______ ↵

Up to 24 times (between 0 and 2300)
(A carriage return exits this mode)
Time (200)? 1200 ↵
Time (1200)? ______ ↵
81) Time of day (Add)? n ↵

Seasons to be included in the predictions:
L = List current set of seasons
D = Delete a season
A = Add a season
C = Change a season
N = No change
82) Season (Add)? ______ ↵

Seasons (up to 4 values)
W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)
Season (Winter (December, January, February))? sp ↵
Season (Spring (March, April, May))? ______ ↵
82) Season (Add)? n ↵

Sample #1
Smooth Earth,
ground-wave calculations

Required reliability (between 0. and 100.%)
83) Required reliability (90.%)? ______ ↵

Earth radius ratio (.500 to 3.000)
84) Earth radius ratio (1.330)? ______ ↵

Do you want a summary of the input data (Y or N)? _y_ ↵

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations Summary

1) Title:	ground wave check
2) Units:	Kilometers and meters
3) Transmit frequency:	1000. kHz
4) Ground wave model:	Smooth earth
5) Sky wave model:	FCC Interregional
10) Transmitter latitude:	40.0000 N 40 0 0 N
10) Transmitter longitude:	90.0000 W 90 0 0 W
11) Path options:	Incremental distance at a fixed bearing
13) Receiver site(s)	

Site	Latitude (deg)		Longitude (deg)		Great circle Distance (km)	Bearing from Ref site (deg E of N)
1	40.0900 N	40, 5,24 N	90.0000 W	90, 0, 0 W	10.0	0.0
2	40.1799 N	40,10,48 N	90.0000 W	90, 0, 0 W	20.0	0.0
3	40.2699 N	40,16,12 N	90.0000 W	90, 0, 0 W	30.0	0.0
4	40.3599 N	40,21,36 N	90.0000 W	90, 0, 0 W	40.0	0.0
5	40.4499 N	40,26,60 N	90.0000 W	90, 0, 0 W	50.0	0.0
6	40.5398 N	40,32,23 N	90.0000 W	90, 0, 0 W	60.0	0.0
7	40.6298 N	40,37,47 N	90.0000 W	90, 0, 0 W	70.0	0.0
8	40.7198 N	40,43,11 N	90.0000 W	90, 0, 0 W	80.0	0.0
9	40.8098 N	40,48,35 N	90.0000 W	90, 0, 0 W	90.0	0.0
10	40.8997 N	40,53,59 N	90.0000 W	90, 0, 0 W	100.0	0.0

14) Conductivity for the path:	.003 S/m
15) Dielectric constant for the path:	15.
19) Transmitter power into the antenna terminals:	1.00 kW
21) Transmitter antenna type:	Field strength option
22) Transmitter antenna height:	0.0 m
31) Transmitter antenna field strength:	300.0000 mV/m
32) Transmitter antenna reference power:	1.000 kW

Sample #1
Smooth Earth,
ground-wave calculations

33) Transmitter antenna reference distance:	1.00 km
61) Receiver antenna type:	User gain input
62) Receiver antenna height:	0.0 m
74) Receiver antenna gain:	0.0 dBi

80) Man-made noise: Residential
82) Seasons:
1) Spring (March, April, May)

81) Local times:
1) 1200

83) Required reliability: 90.
84) Earth radius ratio: 1.330

Do you want to process this data (Y or N)? y

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title:	ground wave check
Transmit frequency:	1000. kHz
Transmitter latitude:	40.0000 N 40 0 0 N
Transmitter longitude:	90.0000 W 90 0 0 W
Transmitter input power:	1.000 kW
Transmitter antenna type:	Field strength option
Antenna height:	0.0 m
Antenna field strength:	300.0000 mV/m
Antenna reference power:	1.000 kW
Antenna reference distance:	1.00 km
Receiver antenna type:	User gain input
Antenna height:	0.0 m
Antenna gain:	0.0 dBi
Ground wave model:	Smooth earth
Ground constants	
Conductivity:	.0030 S/m
Dielectric constant:	15.0000
Sky wave model:	FCC Interregional

Sample #1
Smooth Earth,
ground-wave calculations

Discrete stations:

Site	Latitude (deg)		Longitude (deg)		Great circle Distance (km)	Bearing from Ref site (deg E of N)
1	40.0900 N	40, 5,24 N	90.0000 W	90, 0, 0 W	10.0	0.0
2	40.1799 N	40,10,48 N	90.0000 W	90, 0, 0 W	20.0	0.0
3	40.2699 N	40,16,12 N	90.0000 W	90, 0, 0 W	30.0	0.0
4	40.3599 N	40,21,36 N	90.0000 W	90, 0, 0 W	40.0	0.0
5	40.4499 N	40,26,60 N	90.0000 W	90, 0, 0 W	50.0	0.0
6	40.5398 N	40,32,23 N	90.0000 W	90, 0, 0 W	60.0	0.0
7	40.6298 N	40,37,47 N	90.0000 W	90, 0, 0 W	70.0	0.0
8	40.7198 N	40,43,11 N	90.0000 W	90, 0, 0 W	80.0	0.0
9	40.8098 N	40,48,35 N	90.0000 W	90, 0, 0 W	90.0	0.0
10	40.8997 N	40,53,59 N	90.0000 W	90, 0, 0 W	100.0	0.0

Man-made noise: Residential

Seasons:
Spring (March, April, May)

Local times:
1200

Earth radius ratio: 1.330

Season - Spring (March, April, May)
Local time - 1200

Site	Receiver site noise density (dBW/Hz) 10%	50%	90%	Groundwave field strength (dBuV/m)	Groundwave rec'd power (dBm)	Sky wave field strength (dBuV/m)	Sky wave rec'd power (dBm)	Rec'd S/N (dB/Hz)	Fade margin (dB)
1	-122	-131	-138	82.4	4.9	56.1	-21.4	97.3	26.3
2	-122	-131	-138	70.8	-6.7	56.1	-21.4	85.7	14.7
3	-122	-131	-138	63.1	-14.4	56.1	-21.4	78.0	7.0
4	-122	-131	-138	57.3	-20.2	56.1	-21.4	72.2	1.2
5	-122	-131	-138	52.9	-24.6	56.1	-21.4	71.0	3.2
6	-122	-131	-138	49.2	-28.3	56.1	-21.4	71.0	6.9
7	-122	-131	-138	46.2	-31.3	56.1	-21.4	71.0	9.9
8	-122	-131	-138	43.5	-34.0	56.1	-21.4	71.0	12.6
9	-122	-131	-138	41.1	-36.4	56.1	-21.4	71.0	15.0
10	-122	-131	-138	39.0	-38.5	56.1	-21.4	71.0	17.1

Sample #2
Sky-wave
calculations

Institute for Telecommunication Sciences

MF RESYDE
System 1
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
- H = Help
- D = Program Description
- C = Concise Dialog
- V = Verbose Dialog
- E = Edit Data
- S = Summary of Data
- P = Process Last Data Set Entered
- Q = Quit

Menu (Edit)? ______ ↵
1) Title (ground wave check)? sky wave check ↵
2) Length units (Metric, kilometers and meters)? ______ ↵
3) Frequency (1000. kHz)? ______ ↵
4) Ground wave model (Smooth earth)? ______ ↵
5) Skywave model (FCC Interregional)? ______ ↵
10) Transmitter lat (40.0000 deg N or 40 0 0 dms N)? ______ ↵
10) Transmitter lon (90.0000 deg W or 90 0 0 dms W)? ______ ↵
11) Path option (Incremental distance at a fixed bearing)? ______ ↵

Receiver site location
13) Min Dist (10.0 km)? 100 ↵
13) Max Dist (100.0 km)? 1000 ↵
13) Dist Inc (10.0 km)? 100 ↵
13) Bearing (0.0 deg)? ______ ↵
14) Conductivity for the path (.0030 S/m)? 5 ↵
15) Dielectric constant for the path (15.)? 80 ↵
19) Transmitter power into the antenna terminals (1.00 kW)? ______ ↵
21) Transmitter antenna type (Field strength option)? ______ ↵
22) Transmitter antenna feed point height above ground (0.00 m)? ______ ↵
31) Transmitter antenna field strength (300.0000 mV/m)? 100 ↵
32) Transmitter antenna reference power (1.000 kW)? ______ ↵
33) Transmitter antenna reference distance (1.00 km)? ______ ↵
61) Receiver antenna type (User gain input)? ______ ↵
62) Receiver antenna feed point height above ground (0.00 m)? ______ ↵
74) Receiver gain (0.0 dBi)? ______ ↵
80) Man-made noise environment (Residential)? ______ ↵
81) Time of day (Add)? n ↵

Sample #2
Sky-wave
calculations

82) Season (Add)? _n_ ←┘
83) Required reliability (90.%)? ______ ←┘
84) Earth radius ratio (1.330)? ______ ←┘

Do you want a summary of the input data (Y or N)? _y_ ←┘

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations Summary

1) Title:	sky wave check
2) Units:	Kilometers and meters
3) Transmit frequency:	1000. kHz
4) Ground wave model:	Smooth earth
5) Sky wave model:	FCC Interregional
10) Transmitter latitude:	40.0000 N 40 0 0 N
10) Transmitter longitude:	90.0000 W 90 0 0 W
11) Path options:	Incremental distance at a fixed bearing
13) Receiver site(s)	

Site	Latitude (deg)		Longitude (deg)		Great circle Distance (km)	Bearing from Ref site (deg E of N)
1	40.8997 N	40,53,59 N	90.0000 W	90, 0, 0 W	100.0	0.0
2	41.7995 N	41,47,58 N	90.0000 W	90, 0, 0 W	200.0	0.0
3	42.6992 N	42,41,57 N	90.0000 W	90, 0, 0 W	300.0	0.0
4	43.5990 N	43,35,56 N	90.0000 W	90, 0, 0 W	400.0	0.0
5	44.4987 N	44,29,55 N	90.0000 W	90, 0, 0 W	500.0	0.0
6	45.3985 N	45,23,54 N	90.0000 W	90, 0, 0 W	600.0	0.0
7	46.2982 N	46,17,54 N	90.0000 W	90, 0, 0 W	700.0	0.0
8	47.1980 N	47,11,53 N	90.0000 W	90, 0, 0 W	800.0	0.0
9	48.0977 N	48, 5,52 N	90.0000 W	90, 0, 0 W	900.0	0.0
10	48.9975 N	48,59,51 N	90.0000 W	90, 0, 0 W	1000.0	0.0

14) Conductivity for the path:	5.000 S/m
15) Dielectric constant for the path:	80.
19) Transmitter power into the antenna terminals:	1.00 kW
21) Transmitter antenna type:	Field strength option
22) Transmitter antenna height:	0.0 m
31) Transmitter antenna field strength:	100.0000 mV/m

Sample #2
Sky-wave
calculations

32) Transmitter antenna reference power:	1.000 kW
33) Transmitter antenna reference distance:	1.00 km
61) Receiver antenna type:	User gain input
62) Receiver antenna height:	0.0 m
74) Receiver antenna gain:	0.0 dBi
80) Man-made noise:	Residential

82) Seasons:
1) Spring (March, April, May)

81) Local times:
1) 1200

83) Required reliability:	90.
84) Earth radius ratio:	1.330

Do you want to process this data (Y or N)? _y_ ↵

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title:	sky wave check	
Transmit frequency:	1000. kHz	
Transmitter latitude:	40.0000 N	40 0 0 N
Transmitter longitude:	90.0000 W	90 0 0 W
Transmitter input power:	1.000 kW	
Transmitter antenna type:	Field strength option	
Antenna height:	0.0 m	
Antenna field strength:	100.0000 mV/m	
Antenna reference power:	1.000 kW	
Antenna reference distance:	1.00 km	
Receiver antenna type:	User gain input	
Antenna height:	0.0 m	
Antenna gain:	0.0 dBi	
Ground wave model:	Smooth earth	
Ground constants		
Conductivity:	5.0000 S/m	
Dielectric constant:	80.0000	

Sample #2
Sky-wave
calculations

Sky wave model: FCC Interregional

Discrete stations:

Site	Latitude (deg)		Longitude (deg)		Great circle Distance (km)	Bearing from Ref site (deg E of N)
1	40.8997 N	40,53,59 N	90.0000 W	90, 0, 0 W	100.0	0.0
2	41.7995 N	41,47,58 N	90.0000 W	90, 0, 0 W	200.0	0.0
3	42.6992 N	42,41,57 N	90.0000 W	90, 0, 0 W	300.0	0.0
4	43.5990 N	43,35,56 N	90.0000 W	90, 0, 0 W	400.0	0.0
5	44.4987 N	44,29,55 N	90.0000 W	90, 0, 0 W	500.0	0.0
6	45.3985 N	45,23,54 N	90.0000 W	90, 0, 0 W	600.0	0.0
7	46.2982 N	46,17,54 N	90.0000 W	90, 0, 0 W	700.0	0.0
8	47.1980 N	47,11,53 N	90.0000 W	90, 0, 0 W	800.0	0.0
9	48.0977 N	48, 5,52 N	90.0000 W	90, 0, 0 W	900.0	0.0
10	48.9975 N	48,59,51 N	90.0000 W	90, 0, 0 W	1000.0	0.0

Man-made noise: Residential

Seasons:
Spring (March, April, May)

Local times:
1200

Earth radius ratio: 1.330

Season - Spring (March, April, May)
Local time - 1200

Site	Receiver site noise density (dBW/Hz) 10%	50%	90%	Groundwave field strength (dBuV/m)	Groundwave rec'd power (dBm)	Sky wave field strength (dBuV/m)	Sky wave rec'd power (dBm)	Rec'd S/N (dB/Hz)	Fade margin (dB)
1	-122	-131	-138	59.0	-18.5	45.1	-32.4	73.9	13.9
2	-122	-131	-138	51.1	-26.4	39.3	-38.3	66.0	11.8
3	-122	-131	-138	45.2	-32.3	36.7	-40.8	60.2	8.5
4	-122	-131	-138	40.0	-37.5	35.1	-42.4	55.0	4.9
5	-122	-131	-138	35.2	-42.3	33.9	-43.6	50.1	1.3
6	-122	-131	-138	30.5	-47.0	32.9	-44.6	47.9	2.4
7	-122	-131	-138	25.9	-51.6	31.9	-45.6	46.9	6.0
8	-122	-131	-138	21.4	-56.1	30.7	-46.8	45.7	9.3
9	-122	-131	-138	17.0	-60.5	29.5	-48.0	44.5	12.5
10	-122	-131	-138	12.6	-64.9	28.1	-49.4	43.1	15.5

Menu (Edit)? q ↵

Sample #3
Field Strength
Patterns

Institute for Telecommunication Sciences

MF RESYDE
System 1
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
H = Help
D = Program Description
C = Concise Dialog
V = Verbose Dialog
E = Edit Data
S = Summary of Data
P = Process Last Data Set Entered
Q = Quit

Menu (Verbose)? v ↵

Title of the analysis (up to 30 characters)
1) Title (VOA Test)? Antenna array fields at 1km ↵

Length units:
M = Metric, kilometers and meters
E = English, statute miles and feet
2) Length units (Metric, kilometers and meters)? ______ ↵

Frequency (530.0 to 1750. kHz)
3) Frequency (1000. kHz)? ______ ↵

Groundwave model:
S = Smooth earth
M = Mixed path, smooth earth
I = Irregular terrain, mixed path
4) Ground wave model (Smooth earth)? ______ ↵

Skywave model:
F = FCC Interregional
C = CCIR Plenary Assembly
W = Wang
I = IFRB skywave
5) Skywave model (FCC Interregional)? ______ ↵

Sample #3
Field Strength
Patterns

```
Type site lat (followed by carriage return) and site lon (return)
for each of the sites.  Enter the reference site location first.
   Limits are -  0N <= lat <=  90N
                 0S <= lat <=  90S
                 0W <= lon <= 180W
                 0E <= lon <= 180E

The default hemispheres are N and E.  The S and W locations
can be specified by adding an S to the latitude value or adding an W
to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.
 10) Transmitter lat ( 20.0000 deg N or  20  0  0 dms N)? 30 ↵
 10) Transmitter lon (  90.0000 deg W or   90  0  0 dms W)? 80w ↵

Paths to be analyzed are defined from the transmitter site (ref site)
to the receiver site(s).  The transmitter site is defined by its
latitude and longitude.  The receiver site(s) can be defined by:
     L  = Latitude longitude pairs
     D  = Distance - bearing pairs
    IB  = Incremental bearing at a fixed distance
    ID  = Incremental distance at a fixed bearing
 11) Path option (Latitude - longitude pairs)? ib ↵

Receiver site location

Initial bearing.
Enter the bearing of your first terminal site.
Enter in degrees clockwise from north,
i.e. north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees(X.Y) or
in deg. min. and sec. (X,Y,Z), and must be
between   0.0 and 359.0 degrees
 13) Min bear(   0.0 deg)? _____ ↵

Final bearing.
Enter the bearing of your last terminal site.
Enter in degrees clockwise from north,
i.e. north = 0, east = 90, south = 180, west = 270.
Answer can be in decimal degrees(X.Y) or
in deg. min. and sec. (X,Y,Z), and must be
between   0.0 and 360.0 degrees
 13) Max bear( 315.0 deg)? 345 ↵
```

Bearing increment.
Enter the number of degrees you wish to increment.
Answer can be in decimal degrees(X.Y) or
in deg. min. and sec. (X,Y,Z), and must be
between 1.0 and 180.0 degrees
13) Bear inc(45.0 deg)? 15 ↵

Distance from reference site to terminal site (0.0 to 10000.0 km)
13) Distance (2282.5 km)? 1 ↵

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
14) Conductivity for the path (.005 S/m)? 5 ↵

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
15) Dielectric constant for the path (15.)? 80 ↵

Transmitter power into the antenna terminals (.10 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)? ____ ↵

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array
21) Transmitter antenna type (Vertical monopole)? gm ↵

Hours of operation for which the given characteristics of the antenna
are applicable:
D = Day
N = Night
A = All
37) Hours of operation (Day)? a ↵

Sample #3
Field Strength
Patterns

Reference point:
C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
P = Spacing and orientation are shown with respect to the previous tower
38) Definition point indicator (Common reference tower)? _____ ↵

Total number of towers (1 to 20)
39) Total number of towers (0)? _3_ ↵

Tower # 1

Ratio of the tower field to the field from the reference tower (0.0000 to 9.0000)
40) Tower field ratio (1.0000)? _____ ↵

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower (-360.0000 to 360.0000 degrees)
41) Phase difference of the field (0.0000 degrees)? _251_ ↵

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
42) Electrical tower spacing (0.0000 degrees)? _____ ↵

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
43) Angular tower orientation (0.0000 degrees)? _____ ↵

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
44) Tower structure (Vertical, simple antenna)? _____ ↵

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
45) Electrical height of tower (225.0 degrees)? _____ ↵

Sample #3
Field Strength
Patterns

Tower # 2

40) Tower field ratio (1.0000)? 1.16 ↵
41) Phase difference of the field (251.0000 degrees)? 125.6 ↵
42) Electrical tower spacing (0.0000 degrees)? 100 ↵
43) Angular tower orientation (0.0000 degrees? ____ ↵
44) Tower structure (Vertical, simple antenna)? ____ ↵
45) Electrical height of tower (225.0 degrees)? ____ ↵

Tower # 3
40) Tower field ratio (1.1600)? 1 ↵
41) Phase difference of the field (125.6000 degrees)? 0 ↵
42) Electrical tower spacing (100.0000 degrees)? 200 ↵
43) Angular tower orientation (0.0000 degrees)?____ ↵
44) Tower structure (Vertical, simple antenna)? ____ ↵
45) Electrical height of tower (225.0 degrees)? ____ ↵

Augmentations to be included in the predictions:
L = List current set of augmentations
D = Delete an augmentation
A = Add an augmentation
C = Change an augmentation
N = No change
56) Augmentation (A)? n ↵

Rms field strength at 1 km (0.0000 to 10000.0000 mV/m)
57) Rms field strength at 1 km (300.0000 mV/m)? 452 ↵

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
61) Receiver antenna type (Vertical monopole)? ug ↵

Receiver antenna feed point height above ground
(between 0.00 and 100.0 m)
62) Receiver antenna feed point height above ground (0.00 m)? ____ ↵

Receiver antenna power gain relative to an isotropic radiator
(-100.0 to 100.0 dBi). If gain is known to a dipole, then dBi = dBd + 2.5
74) Receiver gain (3.0 dBi)? 0 ↵

Man-made noise environment
 B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
 Q = Quiet rural (-150.4 dBW at 1 MHz)
80) Man-made noise environment (Residential)? ____ ↵

Local time of day:
 L = List current set of times
 D = Delete a time
 A = Add a time
 C = Change a time
 N = No change
81) Time of day (Add)? ____ ↵

Up to 24 times (between 0 and 2300)
(A carriage return exits this mode)
 Time (200)? 1200 ↵
 Time (1200)? ____ ↵
81) Time of day (Add)? n ↵

Seasons to be included in the predictions:
 L = List current set of seasons
 D = Delete a season
 A = Add a season
 C = Change a season
 N = No change
82) Season (Add)? ____ ↵

Seasons (up to 4 values)
 W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
 F = Fall (September, October, November)
 Season (Winter (December, January, February))? sp ↵
 Season (Spring (March, April, May))? ____ ↵
82) Season (Add)? n ↵

Required reliability (between 0. and 100.%)
83) Required reliability (90.%)? ____ ↵

Earth radius ratio (.500 to 3.000)
84) Earth radius ratio (1.330)? ____ ↵

Do you want a summary of the input data (Y or N)? n ↵

Sample #3
Field Strength
Patterns

Do you want to process this data (Y or N)? _y_ ↵

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title:	Antenna array fields at 1km
Transmit frequency:	1000. kHz
Transmitter latitude:	30.0000 N 30 0 0 N
Transmitter longitude:	80.0000 W 80 0 0 W
Transmitter input power:	1.000 kW
Transmitter antenna type:	General monopole array
Hours of operation:	All
Definition point indicator:	Common reference tower
No. of towers:	3

Tower no.	Field ratio	Electrical height (deg)	Relative phasing (deg)	Relative spacing (deg)	Relative orientation
1	1.0000	225.0	251.0	0.0	0.0
2	1.1600	225.0	125.6	100.0	0.0
3	1.0000	225.0	0.0	200.0	0.0

Number of towers that are top-loaded:	0
No. of towers that are sectionalized:	0
No. of augmentations to antenna pattern:	0
Rms field strength at 1 km:	452.0000 mV/m
Receiver antenna type:	User gain input
Antenna height:	0.0 m
Antenna gain:	0.0 dBi
Ground wave model:	Smooth earth
Ground constants	
Conductivity:	5.0000 S/m
Dielectric constant:	80.0000

Sample #3
Field Strength
Patterns

Sky wave model: FCC Interregional

Discrete stations:

Site	Latitude (deg)		Longitude (deg)		Great circle Distance (km)	Bearing from Ref site (deg E of N)
1	30.0090 N	30, 0,32 N	80.0000 W	80, 0, 0 W	1.0	0.0
2	30.0087 N	30, 0,31 N	79.9973 W	79,59,50 W	1.0	15.0
3	30.0078 N	30, 0,28 N	79.9948 W	79,59,41 W	1.0	30.0
4	30.0064 N	30, 0,23 N	79.9927 W	79,59,34 W	1.0	45.0
5	30.0045 N	30, 0,16 N	79.9910 W	79,59,28 W	1.0	60.0
6	30.0023 N	30, 0, 8 N	79.9900 W	79,59,24 W	1.0	75.0
7	30.0000 N	30, 0, 0 N	79.9896 W	79,59,23 W	1.0	90.0
8	29.9977 N	29,59,52 N	79.9900 W	79,59,24 W	1.0	105.0
9	29.9955 N	29,59,44 N	79.9910 W	79,59,28 W	1.0	120.0
10	29.9936 N	29,59,37 N	79.9927 W	79,59,34 W	1.0	135.0
11	29.9922 N	29,59,32 N	79.9948 W	79,59,41 W	1.0	150.0
12	29.9913 N	29,59,29 N	79.9973 W	79,59,50 W	1.0	165.0
13	29.9910 N	29,59,28 N	80.0000 W	80, 0, 0 W	1.0	180.0
14	29.9913 N	29,59,29 N	80.0027 W	80, 0,10 W	1.0	195.0
15	29.9922 N	29,59,32 N	80.0052 W	80, 0,19 W	1.0	210.0
16	29.9936 N	29,59,37 N	80.0073 W	80, 0,26 W	1.0	225.0
17	29.9955 N	29,59,44 N	80.0090 W	80, 0,32 W	1.0	240.0
18	29.9977 N	29,59,52 N	80.0100 W	80, 0,36 W	1.0	255.0
19	30.0000 N	30, 0, 0 N	80.0104 W	80, 0,37 W	1.0	270.0
20	30.0023 N	30, 0, 8 N	80.0100 W	80, 0,36 W	1.0	285.0
21	30.0045 N	30, 0,16 N	80.0090 W	80, 0,32 W	1.0	300.0
22	30.0064 N	30, 0,23 N	80.0073 W	80, 0,26 W	1.0	315.0
23	30.0078 N	30, 0,28 N	80.0052 W	80, 0,19 W	1.0	330.0
24	30.0087 N	30, 0,31 N	80.0027 W	80, 0,10 W	1.0	345.0

Man-made noise: Residential

Seasons:
Spring (March, April, May)

Local times:
1200

Earth radius ratio: 1.330

Season - Spring (March, April, May)

Sample #3
Field Strength
Patterns

Local time - 1200

Site	Receiver site noise density (dBW/Hz) 10%	50%	90%	Groundwave field strength (dBuV/m)	Groundwave rec'd power (dBm)	Sky wave field strength (dBuV/m)	Sky wave rec'd power (dBm)	Rec'd S/N (dB/Hz)	Fade margin (dB)
1	-122	-131	-138	119	41	15	-62	134	103
2	-122	-131	-138	119	41	15	-62	133	103
3	-122	-131	-138	118	41	15	-62	133	103
4	-122	-131	-138	117	39	15	-62	131	101
5	-122	-131	-138	114	36	15	-62	129	98
6	-122	-131	-138	108	30	15	-62	123	92
7	-122	-131	-138	83	5	15	-62	97	67
8	-122	-131	-138	105	27	15	-62	120	90
9	-122	-131	-138	108	30	15	-62	123	92
10	-122	-131	-138	107	30	15	-62	122	92
11	-122	-131	-138	104	26	15	-62	119	89
12	-122	-131	-138	100	22	15	-62	114	84
13	-122	-131	-138	97	20	15	-62	112	82
14	-122	-131	-138	100	22	15	-62	114	84
15	-122	-131	-138	104	26	15	-62	119	89
16	-122	-131	-138	107	30	15	-62	122	92
17	-122	-131	-138	108	30	15	-62	123	92
18	-122	-131	-138	105	27	15	-62	120	90
19	-122	-131	-138	83	5	15	-62	97	67
20	-122	-131	-138	108	30	15	-62	123	92
21	-122	-131	-138	114	36	15	-62	129	98
22	-122	-131	-138	117	39	15	-62	131	101
23	-122	-131	-138	118	41	15	-62	133	103
24	-122	-131	-138	119	41	15	-62	133	103

Choose from the menu:

- H = Help
- D = Program Description
- C = Concise Dialog
- V = Verbose Dialog
- E = Edit Data
- S = Summary of Data
- P = Process Last Data Set Entered
- Q = Quit

Menu (Edit)? ____ ↵

Question number? 1 ↵

Sample #3
Field Strength
Patterns

Title of the analysis (up to 30 characters)
1) Title (Antenna array fields at 1km)? Signals at 100 km ↵

Question number? 13 ↵

Distance from reference site to terminal site (0.0 to 10000.0 km)
13) Distance (1.0 km)? 100 ↵

Question number? 14 ↵

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
14) Conductivity for the path (5.000 S/m)? .005 ↵

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
15) Dielectric constant for the path (80.)? 15 ↵
Question number?_____ ↵

Do you want a summary of the input data (Y or N)? n ↵

Do you want to process this data (Y or N)? y ↵

MF RESYDE
VOA MF Relay System Design Model
System 1 Calculations

Title:	Signals at 100 km	
Transmit frequency:	1000. kHz	
Transmitter latitude:	30.0000 N	30 0 0 N
Transmitter longitude:	80.0000 W	80 0 0 W
Transmitter input power:	1.000 kW	
Transmitter antenna type:	General monopole array	
Hours of operation:	All	

Sample #3
Field Strength
Patterns

Definition point indicator: Common reference tower
No. of towers: 3

Tower no.	Field ratio	Electrical height (deg)	Relative phasing (deg)	Relative spacing (deg)	Relative orientation
1	1.0000	225.0	251.0	0.0	0.0
2	1.1600	225.0	125.6	100.0	0.0
3	1.0000	225.0	0.0	200.0	0.0

Number of towers that are top-loaded: 0

No. of towers that are sectionalized: 0

No. of augmentations to antenna pattern: 0

Rms field strength at 1 km: 452.0000 mV/m

Receiver antenna type: User gain input
Antenna height: 0.0 m
Antenna gain: 0.0 dBi

Ground wave model: Smooth earth
Ground constants
Conductivity: .0050 S/m
Dielectric constant: 15.0000
Sky wave model: FCC Interregional

Discrete stations:

Site	Latitude (deg)		Longitude (deg)		Great circle Distance (km)	Bearing from Ref site (deg E of N)
1	30.8997 N	30,53,59 N	80.0000 W	80, 0, 0 W	100.0	0.0
2	30.8688 N	30,52, 8 N	79.7287 W	79,43,43 W	100.0	15.0
3	30.7782 N	30,46,41 N	79.4764 W	79,28,35 W	100.0	30.0
4	30.6342 N	30,38, 3 N	79.2606 W	79,15,38 W	100.0	45.0
5	30.4468 N	30,26,48 N	79.0962 W	79, 5,46 W	100.0	60.0
6	30.2290 N	30,13,45 N	78.9941 W	78,59,39 W	100.0	75.0
7	29.9959 N	29,59,45 N	78.9611 W	78,57,40 W	100.0	90.0
8	29.7633 N	29,45,48 N	78.9988 W	78,59,56 W	100.0	105.0
9	29.5471 N	29,32,50 N	79.1043 W	79, 6,16 W	100.0	120.0
10	29.3618 N	29,21,42 N	79.2700 W	79,16,12 W	100.0	135.0
11	29.2198 N	29,13,11 N	79.4846 W	79,29, 4 W	100.0	150.0
12	29.1306 N	29, 7,50 N	79.7334 W	79,44, 0 W	100.0	165.0
13	29.1003 N	29, 6, 1 N	80.0000 W	80, 0, 0 W	100.0	180.0

Sample #3
Field Strength
Patterns

14	29.1306 N	29, 7,50 N	80.2666 W	80,15,60 W	100.0	195.0
15	29.2198 N	29,13,11 N	80.5154 W	80,30,56 W	100.0	210.0
16	29.3618 N	29,21,42 N	80.7300 W	80,43,48 W	100.0	225.0
17	29.5471 N	29,32,50 N	80.8957 W	80,53,44 W	100.0	240.0
18	29.7633 N	29,45,48 N	81.0012 W	81, 0, 4 W	100.0	255.0
19	29.9959 N	29,59,45 N	81.0389 W	81, 2,20 W	100.0	270.0
20	30.2290 N	30,13,45 N	81.0059 W	81, 0,21 W	100.0	285.0
21	30.4468 N	30,26,48 N	80.9038 W	80,54,14 W	100.0	300.0
22	30.6342 N	30,38, 3 N	80.7394 W	80,44,22 W	100.0	315.0
23	30.7782 N	30,46,41 N	80.5236 W	80,31,25 W	100.0	330.0
24	30.8688 N	30,52, 8 N	80.2713 W	80,16,17 W	100.0	345.0

Man-made noise: Residential

Seasons:
Spring (March, April, May)

Local times:
1200

Earth radius ratio: 1.330

Season - Spring (March, April, May)
Local time - 1200

Site	Receiver site noise density (dBW/Hz) 10%	50%	90%	Groundwave field strength (dBuV/m)	Groundwave rec'd power (dBm)	Sky wave field strength (dBuV/m)	Sky wave rec'd power (dBm)	Rec'd S/N (dB/Hz)	Fade margin (dB)
1	-122	-131	-138	52	-26	48	-30	67	4
2	-122	-131	-138	52	-26	47	-30	66	4
3	-122	-131	-138	51	-26	46	-31	66	5
4	-122	-131	-138	50	-28	45	-33	64	5
5	-122	-131	-138	47	-31	41	-36	62	5
6	-122	-131	-138	41	-37	35	-42	56	5
7	-122	-131	-138	16	-62	19	-58	34	4
8	-122	-131	-138	38	-40	34	-43	53	4
9	-122	-131	-138	41	-37	39	-39	56	2
10	-122	-131	-138	40	-37	41	-37	56	1
11	-122	-131	-138	37	-41	42	-36	57	5
12	-122	-131	-138	33	-45	42	-35	57	10
13	-122	-131	-138	30	-47	42	-35	57	12
14	-122	-131	-138	33	-45	42	-35	57	10
15	-122	-131	-138	37	-41	42	-36	57	5
16	-122	-131	-138	40	-37	41	-37	56	1

Sample #3
Field Strength
Patterns

17	-122	-131	-138	41	-37	39	-39	56	2
18	-122	-131	-138	38	-40	34	-43	53	4
19	-122	-131	-138	16	-62	19	-58	34	4
20	-122	-131	-138	41	-37	35	-42	56	5
21	-122	-131	-138	47	-31	41	-36	62	5
22	-122	-131	-138	50	-28	45	-33	64	5
23	-122	-131	-138	51	-26	46	-31	66	5
24	-122	-131	-138	52	-26	47	-30	66	4

Choose from the menu:
- H = Help
- D = Program Description
- C = Concise Dialog
- V = Verbose Dialog
- E = Edit Data
- S = Summary of Data
- P = Process Last Data Set Entered
- Q = Quit

Menu (Edit)? _q_ ↵

Sample #4
Signal-to-
interference
calculations

Institute for Telecommunication Sciences

MF RESYDE
System 2
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
  H = Help
  D = Program Description
  C = Concise Dialog
  V = Verbose Dialog
  E = Edit Data
  S = Summary of Data
  P = Process Last Data Set Entered
  Q = Quit

Menu (Verbose)? _____ ↵

Title of the analysis (up to 30 characters)
 1) Title (VOA Test)? Guat. site ↵

Frequency (530 to 1750 kHz)
Frequencies must be in increments of 10 kHz
 3) Frequency (1000 kHz)? 900 ↵

Groundwave model:
  S = Smooth earth
  M = Mixed path, smooth earth
  I = Irregular terrain, mixed path
 4) Ground wave model (Smooth earth)? _____ ↵

Skywave model:
  F = FCC Interregional
  C = CCIR Plenary Assembly
  W = Wang
  I = IFRB skywave
 5) Skywave model (FCC Interregional)?_____ ↵

Propagation conditions to be analyzed
  D = Daytime, groundwave only
  N = Nighttime, groundwave and skywave
 6) Propagation conditions (Daytime)? n ↵

Sample #4
Signal-to-
interference
calculations

VOA TRANSMITTER SITE PARAMETERS

Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country code (ZZ)? gt ↵

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, Co.)? Zee GT ↵

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)? _____ ↵

Type site lat (followed by carriage return) and site lon (return) for each of the sites.
Enter the reference site location first.
Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E
The default hemispheres are N and E. The S and W locations
can be specified by adding an S to the latitude value or adding
an W to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.
14) VOA site lat (20.0000 deg N or 20 0 0 dms N)? 14,05,07 ↵
14) VOA site lon (90.0000 deg W or 90 0 0 dms)? 89,45,30w ↵

POPULATION CENTER PARAMETERS

Country code for population center site (2 characters)
21) Population center site country code (ZZ)? SS ↵

Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, Mo.)? Xuata ↵

Code letter for population center site (1 character)
23) Population center site ID (B)? X ↵

Type site lat (followed by carriage return) and site lon (return) for each of the sites.
Enter the reference site location first.
Limits are - 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E

The default hemispheres are N and E. The S and W locations
can be specified by adding an S to the latitude value or
adding an W to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.
24) Population center lat (10.0000 deg N or 10 0 0 dms N)? 13 ↵
24) Population center lon (85.0000 deg W or 85 0 0 dms W)? 89.8w ↵

Distance to be searched around population center for non-VOA transmitters (between 0.0 and 10000.0 km)
25) Distance to be searched around population center (100.0 km)? 200 ↵

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
0.001 for poor ground
0.005 for average ground
0.020 for good ground
5.000 for sea water
0.010 for fresh water
30) Conductivity for the path (.005 S/m)?____ ↵

Dielectric constant (between 1. and 81.)
4.0 for poor ground
15.0 for average ground
25.0 for good ground
81.0 for sea and fresh water
31) Dielectric constant for the path (15.)?____ ↵

TRANSMITTER ANTENNA

Transmitter power into the antenna terminals (.10 to 10000.00 kW) 19) Transmitter power into the antenna terminals (1.00 kW)? 50 ↵

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
GM = General monopole array
SM = Standard monopole array
41) Transmitter antenna type (Vertical monopole)? vm ↵

Transmitter antenna feed point height above ground
(between 0.00 and 100.0 m)
42) Transmitter antenna feed point height above ground 0.00m)? _____ ↵

Sample #4
Signal-to-
interference
calculations

Transmitter vertical monopole length (between 0.00 and 400.0m)
43) Transmitter vertical monopole length (3.00 m)? 187 ↵

Transmitter antenna monopole efficiency (between 1.00 and 100.0 %)
43) Transmitter antenna monopole efficiency (100.0 %)? 89 ↵

Ground screen
Y = Yes
N = No
44) Ground screen (Yes)?____ ↵

Transmitter antenna ground screen radius
(between 1.00 and 2500.00 m)
45) Transmitter antenna ground screen radius (10.00 m)? 60 ↵

Transmitter antenna number of radials (between 5 and 360)
46) Transmitter antenna number of radials (10)? 36 ↵

RECEIVER ANTENNA

Antenna types:
VM = Vertical monopole
UG = User gain input
FS = Field strength option
FL = Ferrite loop
81) Receiver antenna type (Vertical monopole)? fl ↵

Receiver antenna feed point height above ground
(between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)? ____ ↵

Receiver antenna length of ferrite rod (0.00 to 25.40 cm)
89) Receiver antenna length of ferrite rod (3.00 cm)? 4.5 ↵

Receiver antenna diameter of ferrite rod (0.00 to 2.54 cm)
90) Receiver antenna diameter of ferrite rod (1.00 cm)? 1.25 ↵

Man-made noise environment
B = Business (-127.2 dBW at 1 MHz)
RE = Residential (-131.5 dBW at 1 MHz)
RU = Rural (-136.8 dBW at 1 MHz)
Q = Quiet rural (-150.4 dBW at 1 MHz)
95) Man-made noise environment (Residential)?____ ↵

Time of day to be used in calculations (between 0 and 2300)
96) Time (200)? 1600 ↵

Sample #4
Signal-to-
interference
calculations

Seasons:
W = Winter (December, January, February)
SP = Spring (March, April, May)
SU = Summer (June, July, August)
F = Fall (September, October, November)
97) Season (Winter (December, January, February))? _su_ ↵

Required reliability (between 0. and 100.%)
98) Required reliability (90.%)?_____ ↵

Earth radius ratio (.500 to 3.000)
99) Earth radius ratio (1.330)?_____ ↵

Do you want a summary of the input data (Y or N)?_y_ ↵

MF RESYDE
VOA MF Relay System Design Model
System 2 Calculations Summary

1) Title:	Guat. site	
3) Frequency:	900	
4) Ground wave model:	Smooth earth	
5) Sky wave model:	FCC Interregional	
6) Propagation conditions:	Nighttime	

VOA TRANSMITTER SITE PARAMETERS

11) VOA transmitter site country code:	GT	
12) VOA transmitter site location:	Zee GT	
13) VOA transmitter site ID:	X	
14) VOA site latitude:	14.0853 N	14 5 7 N
14) VOA site longitude:	89.7583 W	89 45 30 W

POPULATION CENTER PARAMETERS

21) Population center site country code:	SS	
22) Population center site location:	Xuata	
23) Population center site ID:	X	
24) Population center latitude:	13.5000 N	13 30 0 N
24) Population center longitude:	89.8000 W	89 48 0 W
25) Distance to be searched around population center:	200.0 km	
30) Conductivity for the path:	.0050 S/m	

Sample #4
Signal-to-
interference
calculations

31) Dielectric constant for the path:	15.0000

TRANSMITTER ANTENNA

19) Transmitter power into the antenna terminals:	50.00 kW
41) Transmitter antenna type:	Vertical monopole
42) Transmitter antenna height:	0.0 m
43) Transmitter antenna length:	187.0 m
43) Transmitter antenna monopole efficiency:	89.00 %
44) Transmitter antenna ground screen:	yes
45) Transmitter antenna length of screen:	60.00
46) Transmitter antenna number of radials:	36.

RECEIVER ANTENNA

81) Receiver antenna type:	Ferrite loop
82) Receiver antenna height:	0.0 m
89) Receiver antenna length of ferrite rod:	4.50 cm
90) Receiver antenna diameter of ferrite rod:	1.25 cm
95) Man-made noise:	Residential
96) Seasons:	Summer (June, July, August)
97) Local times:	1600
99) Earth radius ratio:	1.330

Do you want to process this data (Y or N)?_y_ ↵

MF RESYDE
VOA MF Relay System Design Model
System 2 Calculations

Title:	Guat. site
Frequency:	900
Ground wave model:	Smooth earth
Sky wave model:	FCC Interregional
Propagation conditions:	Nighttime

VOA TRANSMITTER SITE PARAMETER CALCULATIONS

VOA transmitter site country code:	GT
VOA transmitter site location:	Zee GT

Sample #4
Signal-to-
interference
calculations

VOA transmitter site ID:	X	
VOA site latitude:	14.0853 N	14 5 7 N
VOA site longitude:	89.7583 W	89 45 30 W

POPULATION CENTER PARAMETER CALCULATIONS

Population center site country code:	SS	
Population center site location:	Xuata	
Population center site ID:	X	
Population center latitude:	13.5000 N	13 30 0 N
Population center longitude:	89.8000 W	89 48 0 W
Distance to be searched around population center:	200.0 km	
Conductivity for the path:	.0050 S/m	
Dielectric constant for the path:	15.0000	

TRANSMITTER ANTENNA CALCULATIONS

Antenna height:	0.0 m
Antenna length:	187.0 m
Antenna monopole efficiency:	89.0 %
Antenna length of screen:	60.00 m
Number of radials:	36.

RECEIVER ANTENNA CALCULATIONS

Antenna height:	0.0 m
Antenna length of ferrite rod:	4.50 cm
Antenna diameter of ferrite rod:	1.25 cm

Man-made noise:	Residential
Seasons:	Summer (June, July, August)
Local times:	1600
Required reliability:	90.
Earth radius ratio:	1.330

MF RESYDE
VOA MF Relay System Design model

Title:	Guat. site
Proposed VOA transmit frequency:	900
Major population center to be covered:	X
VOA transmitter location:	
Propagation conditions:	Nighttime - skywave and groundwave predictions
Groundwave model:	Smooth earth

Sample #4
Signal-to-
interference
calculations

Skywave model: FCC Interregional

Noise at X is:

10%	-110. dBW/Hz
50%	-126. dBW/Hz
90%	-140. dBW/Hz

For a required reliability of 90.%
an assumed receiver bandwidth of 5000. Hz
and a ground wave antenna gain of -102.4 dBi,
the computed receiver noise power is -175.1 dBW

Field strength from VOA transmitter at X is:

			skywave/ groundwave (dB)	signal/ noise (50%) (dB)
groundwave		74.05 dBuV/m		40.2
skywave	10%:	61.4 dBuV/m	-12.6	27.6
	50%:	53.4 dBuV/m	-20.6	19.6

-------------Non-VOA Station-------------							S/Ith-	S/	S/	
Freq (kHz)	Call Sign	Class	Power (kW)	Location	Data Base	Dist. (km)	S/I (dB)	S/I (dB)	Smax (dB)	I+N (dB)
870	YSAR	B	2.00	SAN SALVADOR 15	IFRB	62.4	10.9	-40.4	OK	12.
880	YTGJ	A	10.00	NUEVOMUNDO	IFRB	147.5	.1	-29.6	-21.	-0.
880	YSCD	C	.50	USULUTAN 3	IFRB	145.3	26.0	-55.5	OK	26.
890	TGHU	A	5.00	ESCUINTLA	IFRB	138.4	5.8	-5.8	14.0	6.
890	YSLA	B	1.00	SANTA ANA 5	IFRB	57.7	16.1	-16.	OK	17.
900	YSQJ	B	1.00	SAN SALVADOR 12	IFRB	66.5	18.2	7.8	OK	20.
910	TGKL	A	10.00	EMPERADOR	IFRB	107.1	-.9	.9	7.4	-0.
920	TGRS	B	2.00	SUR	IFRB	138.4	13.8	-43.3	OK	14.
930	YSTG	B	1.00	LA PAZ	IFRB	102.7	19.0	-48.5	OK	20.
930	YSTG	B	1.00	SAN MIGUEL 3	IFRB	174.7	20.3	-49.8	OK	21.
930	YSTG	B	2.50	SAN SALVADOR 6	IFRB	70.8	11.2	-40.7	OK	14.
930	YSTG	B	1.00	SANTA ANA 2	IFRB	59.3	17.4	-46.9	OK	19.
930	YSTG	B	1.00	SONSONATE 2	IFRB	26.9	3.3	-32.8	-26.1	4.

Sample #4
Signal-to-
interference
calculations

Choose from the menu:

- H = Help
- D = Program Description
- C = Concise Dialog
- V = Verbose Dialog
- E = Edit Data
- S = Summary of Data
- P = Process Last Data Set Entered
- Q = Quit

Menu (Edit)? q

Sample #5
Signal Coverage

Institute for Telecommunication Sciences

MF RESYDE
System 3
Voice of America
MF Relay System Design Model
Version 1.0

Choose from the menu:
    H = Help
    D = Program Description
    C = Concise Dialog
    V = Verbose Dialog
    E = Edit Data
    S = Summary of Data
    P = Process Last Data Set Entered
    Q = Quit

Menu (Verbose)?_____ ↵

Title of the analysis (up to 30 characters)
 1) Title (MF TEST)? System 3 sample run ↵

Frequency (530 to 1750 kHz)
Frequencies must be in increments of 10 kHz
 3) Frequency (1000 kHz)? 850 ↵

Groundwave model:
  S = Smooth earth
  M = Mixed path, smooth earth
  I = Irregular terrain, mixed path
 4) Ground wave model (Smooth earth)?_____ ↵

Skywave model:
  F = FCC Interregional
  C = CCIR Plenary Assembly
  W = Wang
  I = IFRB skywave
 5) Skywave model (FCC Interregional)? w ↵

Propagation conditions to be analyzed
  D = Daytime, groundwave only
  N = Nighttime,, groundwave and skywave
 6) Propagation conditions (Daytime)? n ↵

VOA TRANSMITTER SITE PARAMETERS

Country code for VOA transmitter site (2 characters)
11) VOA transmitter site country code (ZZ)? US ↵

Location description of VOA transmitter site (up to 14 characters)
12) VOA transmitter site location (Boulder, Co.)? Denver ↵

Code letter for VOA transmitter site (1 character)
13) VOA transmitter site ID (A)?_____ ↵

Type site lat (followed by carriage return) and site lon (return)
for each of the sites. Enter the reference site location first.
Limits are- 0N <= lat <= 90N
0S <= lat <= 90S
0W <= lon <= 180W
0E <= lon <= 180E
The default hemispheres are N and E. The S and W locations
can be specified by adding an S to the latitude value or adding an W
to the longitude value.
Inputs of the form X,Y,Z imply degrees, minutes and seconds.
Inputs of the form X.Y imply decimal degrees.
14) VOA site lat (20.0000 deg N or 20 0 0 dms N)? 39 ↵
14) VOA site lon (90.0000 deg W or 90 0 0 dms W)? 105,20,10W ↵

POPULATION CENTER PARAMETERS

Country code for population center site (2 characters)
21) Population center site country code (ZZ) ? US ↵

Location description of population center site (up to 14 characters)
22) Population center site location (St. Louis, Mo.)? Denver region ↵

Code letter for population center site (1 character)
23) Population center site ID (B)? D ↵

Western plot boundary
Limits are - 20 W <= lat <= 160W
24) Western plot boundary (90.00 degrees W)? 115 ↵

Eastern plot boundary
Limits are - 20 W <= lat <= 160W
25) Eastern plot boundary (85.00 degrees W)? 95 ↵

Southern plot boundary
Limits are - 0 N <= lat <= 90N
Limits are - 0 S <= lat <= 90S
The default hemisphere is N. The S location
can be specified by adding an S to the latitude value
26) Southern plot boundary (85.00 degrees N)? 29 ↵

Northern plot boundary
  Limits are - 0 N <= lat <= 90N
  Limits are - 0 S <= lat <= 90S
  The default hemisphere is N. The S location
  can be specified by adding an S to the latitude value
27) Northern plot boundary (90.00 degrees N)? 49 ↵

Distance to be searched around population center for non-VOA transmitters
(between 0.0 and 10000.0 km)
28) Distance to be searched around population center (100.0 km)?_____ ↵

Conductivity for the path
(between .001 and 10.000 Siemens(mhos)/meter)
   0.001 for poor ground
   0.005 for average ground
   0.020 for good ground
   5.000 for sea water
   0.010 for fresh water
30) Conductivity for the path (.005 S/m)?_____ ↵

Dielectric constant (between 1. and 81.)
   4.0 for poor ground
   15.0 for average ground
   25.0 for good ground
   81.0 for sea and fresh water
31) Dielectric constant for the path (15.)?_____ ↵

TRANSMITTER ANTENNA

Transmitter power into the antenna terminals (.10 to 10000.00 kW)
19) Transmitter power into the antenna terminals (1.00 kW)? 50 ↵

Antenna types:
  VM = Vertical monopole
  UG = User gain input
  FS = Field strength option
  GM = General monopole array
  SM = Standard monopole array
41) Transmitter antenna type (Field strength option)? gm ↵

Hours of operation for which the given characteristics of the antenna
are applicable:
 D = Day
 N = Night
 A = All
57) Hours of operation (Day)? N ↵

Reference point:
C = Spacing and orientation are shown with respect to a common reference point which is generally the first tower
P = Spacing and orientation are shown with respect to the previous tower
58) Definition point indicator (Common reference tower)?_____ ↵

Total number of towers (1 to 20)
59) Total number of towers (1)? 3 ↵

Tower # 1

Ratio of the tower field to the field from the reference tower
(0.0000 to 9.0000)
60) Tower field ratio (1.0000)?_____ ↵

Positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower
(-360.0000 to 360.0000 degrees)
61) Phase difference of the field (0.0000 degrees)? 251.24 ↵

Electrical spacing of the tower from the reference point (0.0000 to 360.0000 degrees)
62) Electrical tower spacing (0.0000 degrees)?_____ ↵

Angular orientation of the tower from the reference point (0.0000 to 360.0000 degrees from True North)
63) Angular tower orientation (0.0000 degrees)?_____ ↵

Tower structure
V = Vertical, simple antenna
T = Top-loaded antenna
S = Sectionalized antenna
64) Tower structure (Vertical, simple antenna)?_____ ↵

Electrical height of the tower under consideration (0.0 to 360.0 degrees)
65) Electrical height of tower (225.0 degrees)?_____ ↵

Tower # 2
60) Tower field ratio (1.0000)? 1.16
61) Phase difference of the field (251.2400 degrees)? 125.62 ↵
62) Electrical tower spacing (0.0000 degrees)? 100 ↵
63) Angular tower orientation (0.0000 degrees)? 90 ↵
64) Tower structure (Vertical, simple antenna)?_____ ↵
65) Electrical height of tower (225.0 degrees)?_____ ↵

Tower # 3
60) Tower field ratio (1.1600)? 1 ↵
61) Phase difference of the field (125.6200 degrees)? 0 ↵
62) Electrical tower spacing (100.0000 degrees)? 200 ↵

63) Angular tower orientation (90.0000 degrees)?______ ↵
64) Tower structure (Vertical, simple antenna)?______ ↵
65) Electrical height of tower (225.0 degrees)?______ ↵

Augmentations to be included in the predictions:
  L = List current set of augmentations
  D = Delete an augmentation
  A = Add an augmentation
  C = Change an augmentation
  N = No change
76) Augmentation (A)? n ↵

Rms field strength at 1 km (0.0000 to 10000.0000 mV/m)
77) Rms field strength at 1 km (300.0000 mV/m)? 22600 ↵

Rms field strength at 1 km (0.0000 to 10000.0000 mV/m)
77) Rms field strength at 1 km (300.0000 mV/m)? 10000 ↵

RECEIVER ANTENNA

Antenna types:
  VM = Vertical monopole
  UG = User gain input
  FS = Field strength option
  FL = Ferrite loop
81) Receiver antenna type (Field strength option)? ug ↵

Receiver antenna feed point height above ground
(between 0.00 and 100.0 m)
82) Receiver antenna feed point height above ground (0.00 m)? ______ ↵

Receiver antenna power gain relative to an isotropic radiator
(-100.0 to 100.0 dBi). If gain is known to a dipole,
then dBi = dBd + 2.5
94) Receiver gain (3.0 dBi)? 0 ↵

Earth radius ratio (.500 to 3.000)
98) Earth radius ratio (1.330)?______ ↵

Type of plot:
  C = Coverage
  I = Interference
99) Type of plot (Interference)? c ↵

Do you want a summary of the input data (Y or N)? y ↵

Sample #5
Signal Coverage

MF RESYDE
VOA MF Relay System Design Model
System 3 Calculations Summary

1) Title:	System 3 sample run	
3) Frequency:	850	
4) Ground wave model:	Smooth earth	
5) Sky wave model:	Wang	
6) Propagation conditions:	Nighttime	

VOA TRANSMITTER SITE PARAMETERS

11) VOA transmitter site country code:	US	
12) VOA transmitter site location:	Denver	
13) VOA transmitter site ID:	A	
14) VOA site latitude:	39.0000 N	39 0 0 N
14) VOA site longitude:	105.3361 W	105 20 10 W

POPULATION CENTER PARAMETERS

21) Population center site country code:	US
22) Population center site location:	Denver region
23) Population center site ID:	D
24) Western plot boundary:	115.00 W
25) Eastern plot boundary:	95.00 W
26) Southern plot boundary:	29.00 N
27) Northern plot boundary:	49.00 N
28) Distance to be searched around population center:	100.0 km
30) Conductivity for the path:	.0050 S/m
31) Dielectric constant for the path:	15.0000

TRANSMITTER ANTENNA

19) Transmitter power into the antenna terminals:	50.00 kW
41) Transmitter antenna type:	General monopole array
57) Hours of operation:	Night
58) Definition point indicator:	Common reference tower
59) No. of towers:	3

Sample #5
Signal Coverage

	TOWER 1	TOWER 2	TOWER 3
60) Tower field ratio:	1.0000	1.1600	1.0000
61) Phase difference of the field (deg):	251.2	125.6	0.0
62) Electrical tower spacing (deg):	0.0	100.0	200.0
63) Angular tower orientation (deg):	0.0	90.0	90.0
64) Tower structure:	Vertcl	Vertcl	Vertcl
65) Electrical height of tower (deg):	225.0	225.0	225.0

76) No. of augmentations to antenna pattern: 0

77) Rms field strength at 1 km: 10000.0000 mV/m

RECEIVER ANTENNA

81) Receiver antenna type:	User gain input
82) Receiver antenna height:	0.0 m
94) Receiver antenna gain:	0.0 dBi
98) Earth radius ratio:	1.330
99) Plot type:	Coverage

Do you want to process this data (Y or N)?_y_ ↵

MF RESYDE
VOA MF Relay System Design Model
System 3 Calculations

Title:	System 3 sample run
Frequency:	850
Ground wave model:	Smooth earth
Sky wave model:	Wang
Propagation conditions:	Nighttime

VOA TRANSMITTER SITE PARAMETER CALCULATIONS

VOA transmitter site country code:	US	
VOA transmitter site location:	Denver	
VOA transmitter site ID:	A	
VOA site latitude:	39.0000 N	39 0 0 N
VOA site longitude:	105.3361 W	105 20 10 W

Sample #5
Signal Coverage

POPULATION CENTER PARAMETER CALCULATIONS

Population center site country code:	US
Population center site location:	Denver region
Population center site ID:	D
Western plot boundary:	115.0 W
Eastern plot boundary:	95.0 W
Southern plot boundary:	29.0 N
Northern plot boundary	49.0 N
Plot type:	Coverage
Distance to be searched around population center:	100.0 km
Conductivity for the path:	.0050 S/m
Dielectric constant for the path:	15.0000

TRANSMITTER ANTENNA CALCULATIONS

Hours of operation: Night
Definition point indicator: Common reference tower

No. of towers: 3

Tower no.	Field ratio	Electrical height (deg)	Relative phasing (deg)	Relative spacing (deg)	Relative orientation
1	1.0000	225.0	251.2	0.0	0.0
2	1.1600	225.0	125.6	100.0	90.0
3	1.0000	225.0	0.0	200.0	90.0

Number of towers that are top-loaded: 0

No. of towers that are sectionalized: 0

No. of augmentations to antenna pattern: 0

Rms field strength at 1 km: 10000.0000 mV/m

RECEIVER ANTENNA CALCULATIONS

Antenna height: 0.0 m
Antenna gain: 0.0 dBi
Earth radius ratio: 1.330
WRITING OUTPUT TO TRPL16 ...

Sample #5
Signal Coverage

Choose from the menu:
- H = Help
- D = Program Description
- C = Concise Dialog
- V = Verbose Dialog
- E = Edit Data
- S = Summary of Data
- P = Process Last Data Set Entered
- Q = Quit

Menu (Edit)? q

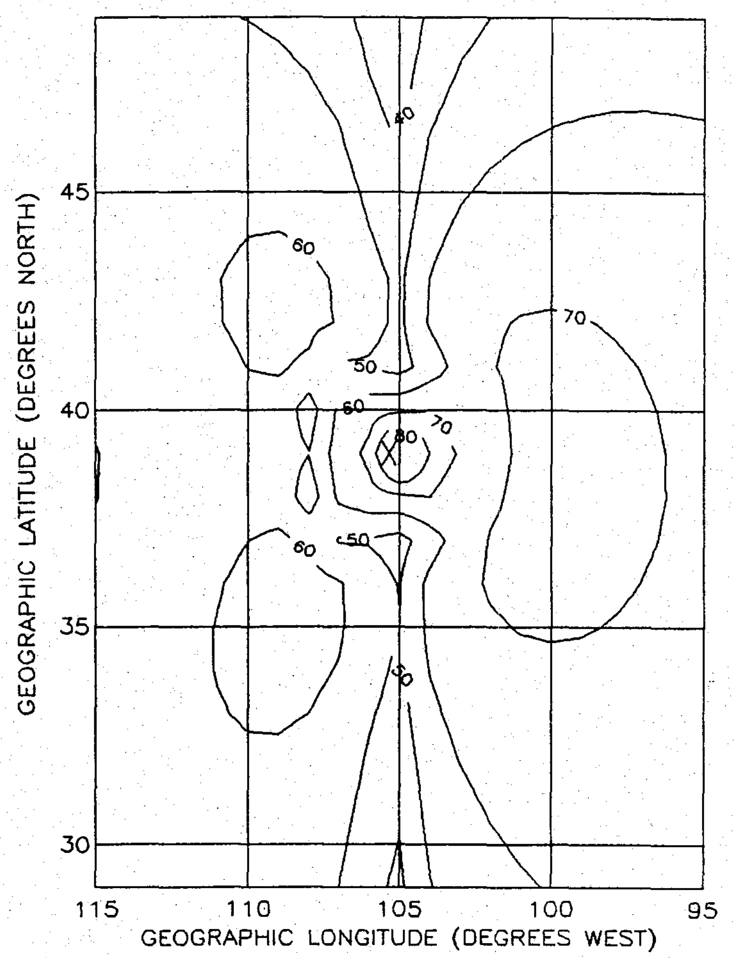


Figure E-1. Sample #5 signal coverage map.

FORM **NTIA-29**
(4-80)

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

An interactive program has been developed to evaluate the performance of MF broadcasting systems. The model calculates both ground-wave and sky-wave signals. The user can select from three ground-wave models; 1) smooth Earth, homogenous path, 2) smooth Earth, mixed path, and 3) irregular Earth, mixed path. The available sky-wave methods are: 1) FCC/Region 2, 2) CCIR, and 3) Wang. Three options are available for making the ground-wave and sky-wave predictions: 1) a point-to-point mode which allows the user to define all of the parameters and test the sensitivity of different parameters, 2) a point-to-point mode which compares the desired signal and interference signals at the reception point, and 3) an area mode which produces signal-to-interference or signal coverage plots. The program utilizes the characteristics of transmitting stations found in a Region 2 data base to make interference calculations. The program also incorporates a Region 2 ground conductivity data base, a Region 2 elevations data base, and a world-wide atmospheric noise data base.

16. Key Words *(Alphabetical order, separated by semicolons)*

ground-wave propagation; MF antenna models; MF broadcasting; MF system characteristics; sky-wave propagation

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