8. JAMMER VS. NETWORK

8.1 Introduction

Jammer vs. Network (JVN) is an analysis of the effects of a jammer on the communication capabilities between a network of sites. A JVN scenario consists of a jammer and as few as two or as many as five sites. One site is name "Network Control." The location of this site must be established using latitude and longitude coordinates. The location of the other sites and the jammer is established with respect to Network Control via azimuth, range, and altitude. The received power of the communication between each site and every other site is computed. Thus, each site acts as both transmitter and receiver. The computations can be made with or without consideration of the jammer. The jammer may be either airborne or ground-based. The other sites are all ground stations.

8.2 Program Input

Most of the data used to run a Jammer vs. Network analysis is communicated by DOS file from a user-defined scenario in JEM. You will be asked for certain additional input as the analysis continues, as discussed below.

Site Location

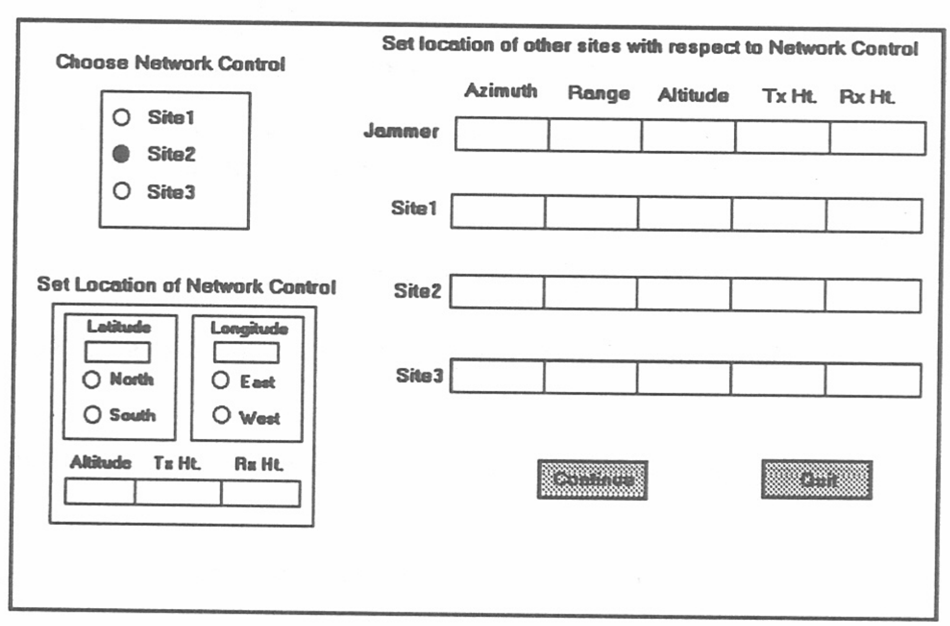


Figure 37. Jammer vs. Network equipment location.

Figure 37 is an example of a window for specifying the locations of JVN sites. This particular JVN scenario has three sites. There are three actions you should take in this window in the following order: 1.) choose Network Control by clicking on your choice in the box in the upper left corner; 2.) set location of Network Control by entering decimal values for latitude and longitude, altitude, and antenna heights in the box in the lower left corner and clicking on North, South, East or West as appropriate; and 3.) set locations of jammer and other sites in relation to Network Control. The location of these sites are defined by an azimuth in degrees east of due north and slant range in kilometers with respect to Network Control. The altitude values are in meters above mean sea level. The antenna heights are in meters. If the jammer site is airborne, the points on the flight path will be available. Click on the gray down arrow to view a list containing each point. Click on the point of your choice. Jammer vs. Network will calculate the azimuth/range and display these values in the appropriate boxes. Click on "Continue" when all locations have been set.

Antenna Direction

The main beam of each antenna can be set in the window shown in Figure 38. The site icons are

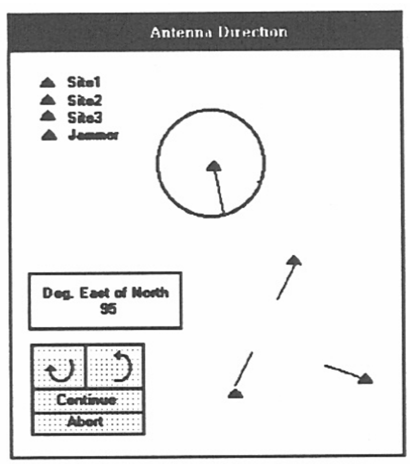


Figure 38. Setting antenna main beam.

located relative to the positions you have set. Each is identified by a color-coordinated triangle as indicated in the upper left corner. Initially, the main beam of the jammer and other sites are pointed at Network Control. To move any of the main beams, click on the triangle representing that site. Then, either enter an integer value in the box labelled "Deg. East of North" or click on the clockwise or counter-clockwise arrows to move the indicator. The "Deg. East of North" box may be moved if desired by clicking and dragging. Click on "Continue" when ready. Clicking on "Abort" will return processing to the location window.

IONCAP Input

If the frequency for the scenario ≤ 30 MHz, Jammer vs. Network includes calculations for the sky wave. In order to do this, Jammer vs. Network runs the IONCAP program which requires additional input. See Section 7.1.2. for a discussion of this program.

8.3 Program Output

Printed Output

Continue　Quit　Print/Plot　Jammer/No Jammer

Jammer vs. Network
(JVNExample)
Current Date
Network Control is SITE1 at 40N 105W
SITE2: 80.074 Degs. 35 Km　SITE3: 95 Degs. 55 Km
Jammer Location : 0 Degs., 112 Km. With Main Beam at 119 Deg.

LINK ESTABLISHED		NO LINK POSSIBLE	
SITE1 - SITE2	20.1dB	SITE2 - SITE3	-11.5dB
SITE1 - SITE3	10.6dB	SITE3 - SITE2	-21.7dB
SITE2 - SITE1	28.6dB		
SITE3 - SITE1	19.8dB		

Values = Interference Margin

Figure 39. Jammer vs. Network printed output.

The example of Jammer vs. Network shown in Figure 39 contains three sites, with "SITE1" being used as Network Control. The values given are the interference margin, that is, the difference between the power at the receiver and the jamming power necessary to disrupt communications. A 3-dB tolerance is used to indicate a region of marginal performance. If the jammer power level at the receiver is within ± 3 dB of that necessary to disrupt communications, then the communication quality is considered marginal and is listed as such. If the calculated received signal/noise ratio is less than the required signal/noise then the link is marked with an asterisk, meaning there is insufficient power.

The menu options along the top have the following functions.

Continue: Returns to the location window. You may change parameters which were set within Jammer vs. Network and run analysis again.

Quit: Returns processing to JEM.

Print/Plot: Presents a menu that allows printing results to a printer, to a file, or plotting the results to the screen.

Jammer/No Jammer: Presents a toggle menu with two choices. Jammer displays results considering the impact of the jammer (default). No Jammer displays results taking no consideration of the presence of the jammer. When the results are viewed with no jammer, the link/no link decision is made solely on the comparison of calculated received signal/noise ratio to required signal/noise ratio. The values printed are the calculated received signal/noise ratio.

Plotted Output

Figure 40 shows a Jammer vs. Network plot with three sites named "SITE1," "SITE2," and "SITE3." The location of each site is represented by its respective number, "1," "2," and "3." The location of the jammer is represented by **. The quality of the link is color-coded on the screen as shown in the legend. On printed media, the quality is shown with different line styles as in Figure 40. The line represents the link quality at the receiver. Thus in Figure 40, the link quality at SITE2 from SITE1 is marginal, while at SITE1 from SITE2 there is no link at all. Likewise, a good link is established at SITE3 from SITE1, but there is no link in the reverse direction.

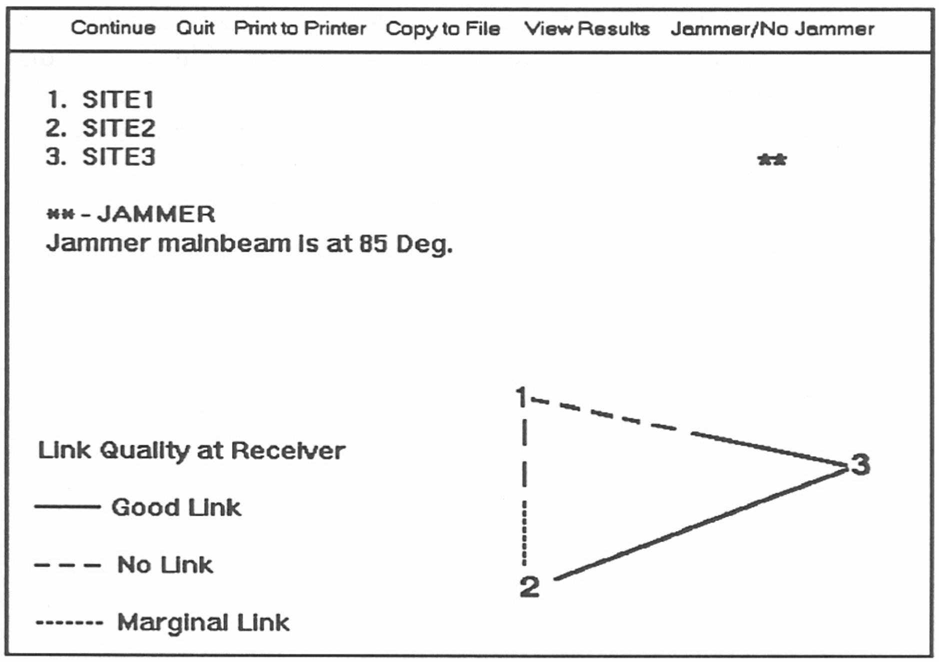


Figure 40. Jammer vs. Network plotted output.

The menu selections present the following options.

Continue: Returns to the location window. You may run analysis again.

Quit: Returns processing to JEM.

Print to Printer: Plots to the printer associated with Windows.

Print to File: Copies a bitmap image of the plot into a file you have chosen.

View Results: Redisplays answers in numerical form as in Figure 39.

Jammer/No Jammer: Presents a toggle menu to view results considering the impact of the jammer (default) or to view results taking no consideration of the presence of the jammer. When the results are viewed with no jammer, the link/no link decision is made solely on the comparison of calculated received signal/noise ratio to required signal/noise ratio.

9. EARTH-SATELLITE ANALYSES

9.1 Cumulative Distribution of Rain Attenuation

The cumulative distribution model of the rain attenuation calculates the distribution over the range of months you have specified. This analysis is performed for the path between the ground station and a designated point from the satellite orbit file.

9.1.1 Program Input

First and Last Month

Choose First Month
January February March April May June July August September October November December
< Cancel >

Figure 41. Month selection window.

Figure 41 illustrates the month selection window. Move the cursor to the month for which you desire to begin running the analysis and hit enter. You will see this screen twice in succession. The second time is asking for the last month for the analysis. The end month must be the same or later than the start month. The analysis cannot sweep from December to January.

Orbit Path Index Point

The index refers to the ordinal number of the point in the satellite orbit file (See Section 6.12) for which you wish to run this analysis. In the example in Figure 42, there are seven points in the orbit file. You must enter a number less than or equal to the number of points defined. You may enter a question mark, "?." This allows you to see a listing of the file in which you may choose the point by moving the cursor and hitting enter.

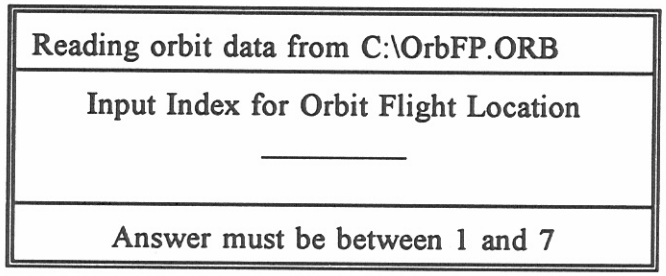


Figure 42. Flight path index selection window.

The following files must be in directory C:\VBEXE:

AB.DAT: A data file which is provided with JEM of rain attenuation coefficients.

ISOTHERM: A data file which is provided with JEM containing isotherm profile data

ES1.DAT: A file created by JEM which includes all scenario data.

9.1.2 Program Output

Printed Output

Figure 43, shows the losses due to rain attenuation per percentage of time. Thus, the loss for this location at this time of year exceeds 11.4 dB .05% of the time. Since the time span is the month of May, .05% = 22.32 minutes. Looking at the problem another way, the loss is less than 11.4 dB 99.95% of the time. The results are plotted in Figure 44.

Plotted Output

The rain attenuation value in dB is plotted on the x-axis against the base ten logarithm of the percentage of time the attenuation is exceeded along the y-axis (Figure 44).

Cumulative Distribution of Rain Attenuation for a Ground-to-Satellite Path

%Time ATTN EXCD	Time		Loss (db)	RSL (dBm)
10.0000	74.40	hr	0.00	80.0
5.0000	37.20	hr	0.00	80.0
2.0000	14.88	hr	0.00	80.0
1.0000	7.44	hr	1.40	78.6
0.5000	3.72	hr	1.48	78.5
0.2000	1.49	hr	4.79	75.2
0.1000	44.64	min	8.37	71.6
0.0500	22.32	min	11.04	70.0
0.0200	8.93	min	15.20	64.8
0.0100	4.46	min	17.90	62.1
0.0050	2.23	min	21.73	58.3
0.0020	53.57	sec	25.86	54.1
0.0010	26.78	sec	31.37	48.6
0.0005	13.39	sec	42.24	37.8
0.0002	5.36	sec	56.91	23.1
0.0001	2.68	sec	66.71	13.3

From: Boulder
To: GOES
Time Period: MAY
Frequency (GHz): 40
Path Length (km): 37662
Satellite Orbit: EOORB.ORB
Elevation Angle (deg): 41.533
Azimuth to Sat. (deg): 200.955
Xmitter Power (dBm): 20
Xmitter Gain (dBi): 30
Receiver Gain (dBi): 30

Figure 43. Rain attenuation printed output.

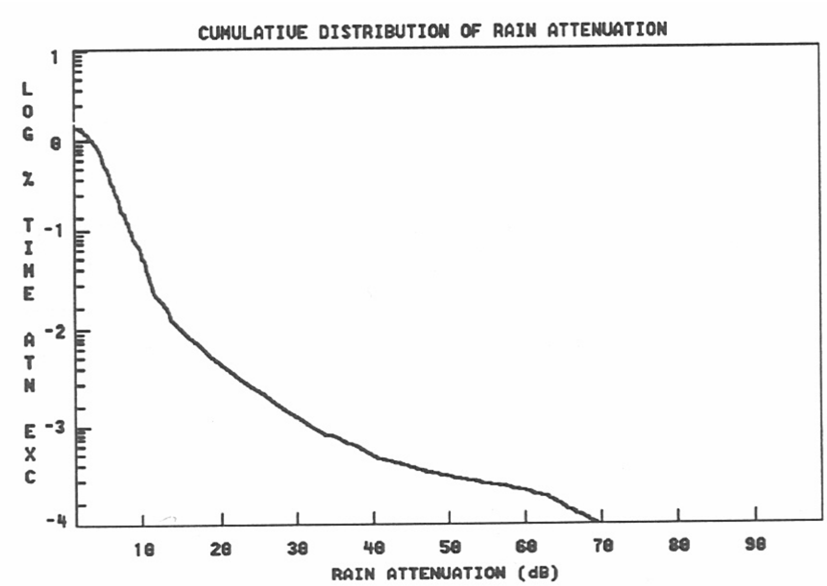


Figure 44. Rain attenuation plot.

9.2 Cumulative Distribution of Clear Air Attenuation

The cumulative distribution of clear air attenuation calculates the distribution over the range of months you have specified. This analysis is performed for the path between the specified ground station and a chosen point on the satellite orbit file. For earth-satellite paths the cumulative distribution of atmospheric water vapor pressure is used to model the cumulative distribution of clear air attenuation.

9.2.1 Program Input

First Month: See Section 9.1.1.

Last Month: See Section 9.1.1.

Index Point of Satellite Orbit Path: See Section 9.1.1.

The following files must be in directory C:\VBEXE.

AB.DAT: A data file provided with JEM that contains rain attenuation coefficients.

ES2.DAT: A data file created by JEM that contains all the scenario data.

9.2.2 Program Output

Printed Output

Figure 45 on the following page shows the losses due to clear air attenuation per percentage of time. Thus, the loss for this location at this time of year exceeds .61 dB .05% of the time. Since the time span is the month of June, .05% = 21.60 minutes. Looking at the problem another way, the loss is less than .61 dB 99.95% of the time.

Plotted Output

The attenuation value is plotted on the x-axis against the base ten logarithm of the percentage of time the attenuation is exceeded along the y-axis (Figure 46).

Cumulative Distribution of Clear Air Attenuation for a Ground-Satellite Path

%Time ATTN EXCD	Time	Loss (db)	RSL (dBm)
10.0000	72.00 hr	0.48	79.5
5.0000	36.00 hr	0.49	79.5
2.0000	14.40 hr	0.51	79.5
1.0000	7.20 hr	0.52	79.5
0.5000	3.60 hr	0.54	79.5
0.2000	1.44 hr	0.60	79.4
0.1000	43.20 min	0.61	79.4
0.0500	21.60 min	0.61	79.4
0.0200	8.64 min	0.63	79.4
0.0100	4.32 min	0.64	79.4
0.0050	2.16 min	0.69	79.4
0.0020	51.84 sec	0.69	79.3
0.0010	25.92 sec	0.72	79.3
0.0005	12.96 sec	0.73	79.3
0.0002	5.18 sec	0.76	79.3
0.0001	12.59 sec	0.77	79.3

From: Boulder
To: GOES
Time Period: JUN
Frequency (GHz): 40
Path Length (km): 37662
Satellite Orbit: GEOORB.ORB
Elevation Angle (deg): 41.533
Azimuth to Satellite (deg): 200.955
Xmitter Power (dBm): 20
Xmitter Gain (dBi): 30
Receiver Gain (dBi): 30

Figure 45. Clear air attenuation printed output.

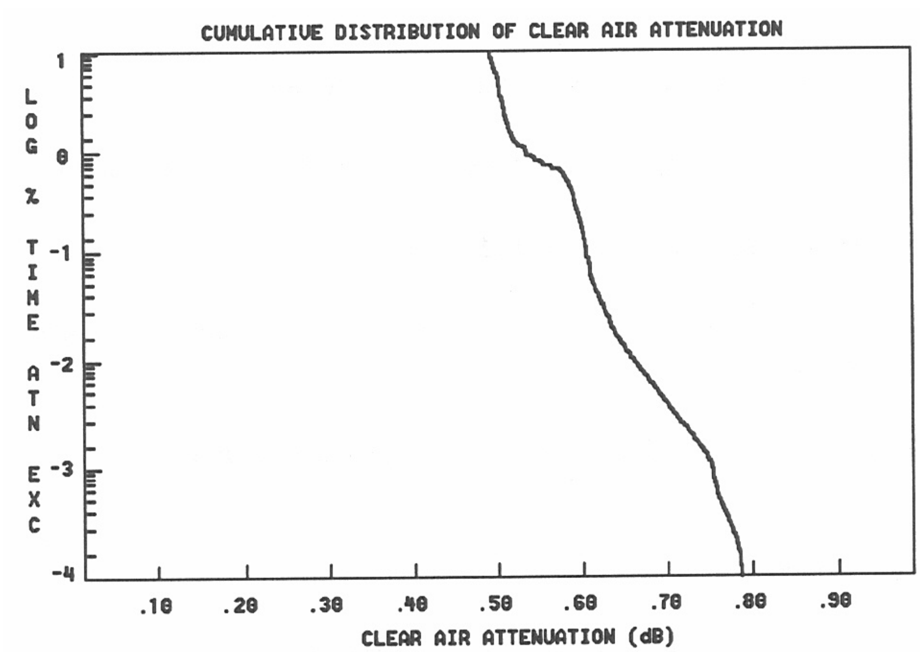


Figure 46. Clear air attenuation plot.

10. GROUND-AIRCRAFT ANALYSES

10.1 Attenuation and RSL - Looping on Frequencies

This analysis calculates the attenuation and Received Signal Loss (RSL) for a range of frequencies specified you have specified along a path between the ground station as defined in JEM and a point chosen by the user from the aircraft flight path profile.

10.1.1 Program Input

Index Point for Flight Path: Identifies the location of the flight path for which you want to run analysis - Section 9.1.1.

Low Frequency of Loop: Enter starting frequency (in GHz) of loop for frequencies. The default is 10 GHz.

High Frequency of Loop: Enter the final frequency (GHz) value for loop. The default is 100 GHz.

Step Frequency: Enter the interval for the frequency loop. The default is 10 GHz.

Earth's Radius Factor k: enter k factor, default value is 1.3.

The analysis may be cancelled at any time by entering the letter "A" for abort.

The following files must be in directory C:\VBEXE

AD.DAT: A data file which is provided with JEM containing rain attenuation coefficients.

GA1.DAT: A file created by JEM containing all the scenario data.

10.1.2 Program Output

Figure 47 on the following page shows the format of the output.

Ground-Aircraft Analysis: Loop on Frequency for a Single Flight Path Point

From Boulder to F4A
Boulder Latitude: 40' 0' 01N"
Boulder longitude: -105'15'00.0W
F4A Latitude: 40' 2' 50N
F4A Longitude: -105'15'00.0W
F4A Altitude(m): 3500
Elev. Angle to Aircraft(deg): 27.76

Xmitter Power(dBm): 20
Xmitter Gain(dBi): 30
Receiver Gain(dBi): 30
Distance to Aircraft (km): 20.57
Azimuth to Aircraft(deg): 290.60

Frequency(GHz)	Attenuation(dB)	RSL(dBm)
10.00	0.02	-40.7
20.00	0.15	-46.8
30.00	0.10	-50.3
40.00	0.14	-52.9
50.00	0.48	-55.1
60.00	30.09	-86.3
70.00	0.66	-58.3
80.00	0.38	-59.1
90.00	0.40	-60.2

Figure 47. Ground-Aircraft - loop on frequency.

10.2 Attenuation and RSL - Looping on Flight Locations

This analysis calculates the attenuation and RSL for a single operating frequency for the points you have defined on an aircraft flight path.

10.2.1 Program Input

Earth's Radius Factor k: Enter k factor. The default value is 1.3.

The analysis may be cancelled at any time by entering the letter "A" for abort. The following files must be in directory C:\VBEXE.

GA2.DAT: A file created by JEM that contains all the scenario data.

OXYGEN.DAT: A file provided with JEM that contains oxygen coefficients.

WATER.DAT: A file provided with JEM that contains water vapor coefficients.

10.2.2 Program Output

There are two choices for printed output, the long form and the short form as shown in Figures 48 and 49.

Ground-Aircraft Analysis - Loop on Flight Path for a Single Frequency

From: Boulder to F4A

Boulder Latitude: 40' 0' 05" — Xmitter Power(dBm): 20

Boulder Longitude: -105' 2' 48' — Xmitter Gain (dBi): 30

Frequency in GHz: 40 — Receiver Gain (dBi): 30

Latitude	Longitude	AZ Ang (deg)	El Ang (deg)	Flight Alt (m)	Path Length (km)	Attenuation (dB)	RSL (dBm)
40.0472	-105.2550	290.60	27.76	3500.00	2.58	0.14	-52.8
40.0500	-105.2500	297.50	35.25	4000.00	2.95	0.15	-54.0
40.0528	-105.2500	303.63	69.07	9000.00	7.17	0.18	-612.8

Figure 48. Ground-Aircraft - loop on flight path; long form.

Ground-Aircraft Analysis - Loop on Flight Path for a Single Frequency

From Boulder to F4A

Boulder Latitude: 40' 0' 05" — Xmitter Power (dBm): 20

Boulder Longitude: -105' 02' 48" — Xmitter Gain (dBi): 30

Frequency in GHz: 40 — Flight Path: Airpath2.FLT

Data Point	Latitude	Longitude	Attenuation (dB)	RSL (dBm)
1	40.04722	-105.25000	0.14	-52.9
2	40.05000	-105.25000	0.15	-54.0
3	40.0600	-105.25000	0.18	-61.8

Figure 49. Ground-Aircraft - loop on flight path; short form.

10.3 Cumulative Distribution or Rain Attenuation

The cumulative distribution of the rain attenuation model calculates the distribution over the range of months you have specified. This analysis is performed for the path between the ground station and a designated point from the aircraft flight path file. The RSL calculation includes the rain attenuation and free space loss.

10.3.1 Program Input

First and Last Month: The last month must be the same as or later than the first month.

Flight Path Index Point: The index refers to the ordinal number of the point in the Aircraft Flight Path File (See Section 6.7) for which you wish to run this analysis.

The following files must be in directory C:\VBEXE.

AB.DAT: A data file which is provided with JEM of rain attenuation coefficients.

ISOTHERM: A data file which is provided with JEM containing isotherm profile data

GA3.DAT: A file created by JEM that includes all scenario data.

10.3.2 Program Output

See Section 9.1.2 for a description of the Rain Attenuation Analysis.

10.4 Cumulative Distribution of Clear Air Attenuation

The model for the cumulative distribution of clear air attenuation calculates the distribution over the range of months you have specified. This analysis is performed for the path between the ground station as specified in JEM and a chosen point on the aircraft flight path file. The only loss considered for the attenuation calculation is the clear air attenuation above free space loss. The RSL calculations include the clear air attenuation and free space loss.

10.4.1 Program Input

First Month: See Section 9.1.1.

Last Month: See Section 9.1.1.

Index Point of Flight Path: See Section 9.1.1.

The following files must be in directory C:\VBEXE.

AB.DAT: A data file which is provide with JEM that contains rain attenuation coefficients.

GA4.DAT: A data file created by JEM that contains all the scenario data.

10.4.2. Program Output

See Section 9.2.2 for a description of the Clear Air Attenuation Analysis.

11. AIRCRAFT-SATELLITE ANALYSES

11.1 Attenuation and RSL - Loop on Aircraft Locations

You will choose a single satellite location from the orbit path file. The attenuation and RSL is then computed for paths between that satellite location and each of the locations designated in the aircraft path file.

11.1.1 Program Input

Index Point for Satellite Orbit Path: The index refers to the ordinal number of the point in the satellite orbit file (see Section 6.12) for which you wish to run this analysis. See Section 9.1 for a fuller description.

Equivalent Earth's Radius Factor k: Defaults is 1.3.

Ground Elevation below Aircraft: Measured in meters.

Rain Rate: Measured in mm/hr. The default value is zero.

While answering these questions, you may abort the analysis by entering "A."

The following files must be in directory C:\VBEXE.

OXYGEN.DAT: A data file provided with JEM containing oxygen coefficients.

WATER.DAT: A data file provided with JEM containing water vapor coefficients.

AS1.DAT: A data file created by JEM including ail scenario data.

11.1.2 Program Output

There are two choices of output formats; the long form and the short form as displayed in Figures 50 and 51. These examples show the Attenuation and RSL results at each of the three points defined on the flight path for an aircraft platform named "F4A" from a specific location on the path of a satellite name "SAT."

Aircraft-Satellite Attenuation and RSL Calculations - Loop on Flight Path for a Single Frequency

From SAT to F4ASAT Latitude: 0' 0' 0"

SAT Longitude: 119' 0' 0"	Xmitter Power (dBm): 20
SAT Altitude 35786 Km	Xmitter Gain (dBi): 30
Frequency in GHz: 40	Receiver Gain (dBi): 30
Flight Path Airpath2.FLT	Rain Rate(mm/hr): 20

Aircraft Latitude	Aircraft Longitude	Az Ang (deg)	El Ang (deg)	Aircraft Altitude (m)	Path (km)	Attenuation (dB)	RSL (dBm)
40.0472	-105.2550	195.88	41.53	3500.00	37661.37	0.16	-136.2
40.0500	-105.2500	195.88	41.53	4000.00	37661.26	0.13	-136.1
40.0428	-105.2500	195.88	41.42	9000.00	37658.16	.03	-136.0

Figure 50. Aircraft-Satellite - loop on flight path; long form.

Aircraft-Satellite Attenuation & RSL Calculations; Loop on Flight Path with Single Frequency

From SAT to F4A
SAT Latitude: 0' 0' 0"
SAT Longitude: 119' 0' 0"
SAT Altitude 35786 Km
Frequency in GHz: 40
Flight Path Airpath2.FLT

Xmitter Power (dBm): 20
Xmitter Gain (dBi): 30
Receiver Gain (dBi): 30

Data Point #	Latitude	Longitude	Attenuation (dB)	RSL (dBm)
1	40.0472	-105.2550	0.16	-136.2
2	40.0500	-105.2500	0.13	-136.1
3	40.0528	-105.2500	0.03	-136.0

Figure 51. Aircraft-Satellite - loop on flight path; short form.

11.2 Attenuation and RSL - Multiple Frequencies

This analysis requires you to pick one point on each of the flight paths connected with the aircraft and with the satellite. The attenuation and RSL will be calculated along that path looping through a range of frequencies you have defined. The calculated attenuation is the sum of the free space attenuation and the clear air and rain attenuation losses.

11.2.1 Program Input

Index Point for Satellite Orbit Path: The index refers to the ordinal number of a point in the satellite orbit file (See Section 6.12) for which you wish to run this analysis. See Section 9.1 for a fuller description.

Index Point for Aircraft Flight Path: The index refers to the ordinal number of the point in the aircraft flight path file (See section 6.7) for which you wish to run this analysis. See Section 9.1 for a fuller description.

Low Frequency of Loop: Enter starting frequency (in GHz). The default is 10 GHz.

High Frequency of Loop: Enter the final frequency (GHz) value. The default is 100 GHz.

Step Frequency: Enter the interval for the frequency loop. The default is 10 GHz.

Earth's Radius Factor k: Enter the k factor. The default value is 1.3.

Ground Elevation below Aircraft: Measured in meters.

Rain Rate: Measured in mm/hr. The default is zero.

The analysis may be cancelled at any time by entering the letter "A" for abort.

The following files must be in directory C:\VBEXE.

OXYGEN.DAT: A data file provided with JEM containing oxygen coefficients.

WATER.DAT: A data file provided with JEM containing water vapor coefficients.

AS2.DAT: A data file created by JEM including all scenario data and names of necessary JEM files.

11.2.2 Program Output

An example of the program output is shown in Figure 52.

Aircraft-Satellite Attenuation and RSL Calculations; Loop on Frequency

From SAT to F4A
SAT Latitude: 0' 0' 0"
SAT Longitude: 119' 0' 0"
SAT Altitude 35786 Km
F4A Latitude 40' 2' 50
F4A Longitude -105' 15' 00.0
F4A Altitude(m): 3500

Xmitter Power (dBm): 20
Xmitter Gain (dBi): 30
Receiver Gain (dBi): 30
Rain Rate(mm/hr): 20
Distance from F4A to SAT (km): 37661.37

Frequency (GHz)	Attenuation (dB)	RSL (dBm)
30.00	0.06	-133.6
40.00	0.16	-136.2
50.00	0.92	-138.9
60.00	137.97	-277.5

Figure 52. Aircraft-Satellite - loop on frequency.

11.3 Attenuation and RSL - Loop on Matched Points on Flight Paths

The attenuation and RSL is calculated on a one-to-one correspondence of points in the flight paths for the satellite and aircraft.

11.3.1 Program Input

Earth's Radius Factor k: Enter the k factor. The default value is 1.3.

Ground Elevation below Aircraft: Measured in meters.

Rain Rate: Measured in mm/hr. The default is zero.

The analysis may be cancelled at any time by entering the letter "A" for abort. The following files must be in directory C:\VBEXE.

AS3.DAT: A file created by JEM containing all scenario data.

OXYGEN.DAT: A file provided with JEM containing oxygen coefficients.

WATER.DAT: A file provided with JEM containing water vapor coefficients.

11.3.2 Program Output

Printed Output - Short Form

Figure 53 shows the results for loop on matched points in short form.

Aircraft-Satellite Attenuation and RSL Calculations; Loop on Matched Points

Frequency in GHz: 40
Aircraft Flight Path: Airpath2.FLT
Satellite Orbit Path: GeoOrb.Orb
Rain Rate(mm/hr): 20

Xmitter Power (dBm): 20
Xmitter Gain(dBi): 30
Receiver Gain(dBi): 30

Data Point #	Attenuation (dB)	RSL (dBm)
1	6.39	-142.4
2	5.52	-142.5

Figure 53. Aircraft-Satellite - loop on matched points; short form.

Printed Output - Long Form

The orbit path file for the example in Figure 54 has only two points. Therefore, the analysis has two matched points between the files.

Aircraft-Satellite Attenuation and RSL Calculations; Loop on Matched Points

Frequency in GHz: 40	Xmitter Power (dBm): 20
Aircraft Flight Path: Airpath2.FLT	Xmitter Gain(dBi): 30
Satellite Orbit Path: GeoOrb.Orb	Receiver Gain(dBi): 30
Rain Rate(mm/hr): 20	

Location	Satellite			AirCraft		
Pt. #	Latitude	Longitude	Alt.(km)	Latitude	Longitude	Alt.(m)
1	0.000000	-119.0000	35786.	40.0472	-105.2500	3500.
2	0.000000	-19.000	35786.	40.0500	-105.2500	4000.

Location	Az Ang.	El. Ang.	Path Length	Attenuation	RSL
Pt. #	(deg)	(deg)	(km)	(dB)	(dBm)
1	0.00	0.00	37661.4	6.38	-142.4
2	0.00	0.00	42327.2	5.52	-142.5

Figure 54. Aircraft-Satellite - loop on matched points; long form.

12. TERRESTRIAL ANALYSES

12.1 Cumulative Distribution of Rain Attenuation

This analysis calculates the cumulative distribution of rain attenuation along the path between 2 ground stations over the range of months you have specified. The attenuation calculation considers only the rain attenuation.

12.1.2 Program Input

First Month: The first month for which to perform the analysis.
Last Month: The end month must be the same or later than the start month.

You may enter "A" to abort analysis.

The following files must be in directory C:\VBEXE.

AB.DAT: A data file provided with JEM of rain attenuation coefficients.

ISOTHERM: A data file provided with JEM containing isotherm profile data.

TER.DAT: A file created by JEM that includes all scenario data.

12.1.3 Program Output

See Section 9.1.3 for description of printed and plotted output.

12.2 Cumulative Distribution of Multipath Attenuation

This analysis calculates the cumulative distribution of multipath attenuation for the month when the attenuation is greatest. The only propagation loss considered is the multipath loss above free space loss.

12.2.1 Program Input

Equivalent Earth's Radius Factor k: The default is 1.33.

The following file must be in directory C:\VBEXE

TER.DAT: a file created by JEM containing all the scenario data.

12.2.2 Program Output

Printed Output

Figure 55 shows the losses due to multipath attenuation per percentage of time.

Cumulative Distribution of Multipath Attenuation for a Terrestrial Path

% Time ATTN EXCD	Time (db)		Loss
10.0000	72.00	hr	6.60
5.0000	36.00	hr	9.61
2.0000	14.40	hr	13.59
1.0000	7.20	hr	16.60
0.5000	3.60	hr	19.61
0.2000	1.44	hr	23.59
0.1000	43.20	min	26.60
0.0500	21.60	min	29.61
0.0200	8.64	min	33.59
0.0100	4.32	min	36.60
0.0050	2.163	min	39.61
0.0020	51.84	sec	43.59
0.0010	25.92	sec	46.51
0.0005	12.96	sec	49.61
0.0002	5.18	sec	53.59
0.0001	2.59	sec	56.60

Scenario: MPath
From: SITE1
To: SITE2
Frequency (GHz): 30
Path Length(km): 42.0620
Tx Beamwidth: 2
Rx Beamwidth: 2
Min. Ht. at Midpath(m): 67.510

Figure 55. Terrestrial multipath printed output.

Plotted Output

The plot data option for cumulative distribution of multipath attenuation produces a graph such as shown in Figure 56. The multipath attenuation value in dB is shown on the x-axis and the y-axis is the base ten logarithm of the percentage of time the attenuation is exceeded.

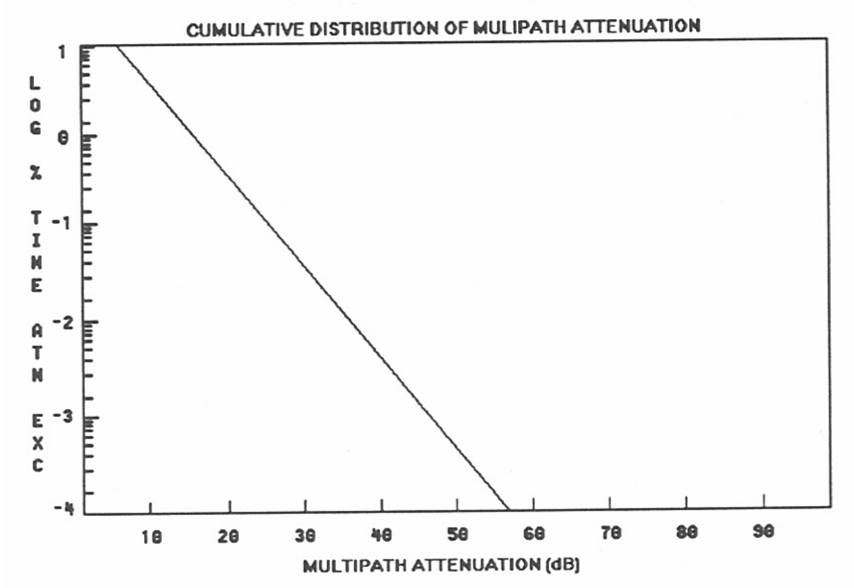


Figure 56. Terrestrial multipath plot.

12.3 Terrain Profile and Ray Path Plot

This analysis uses the terrain profile data you have selected to define and plot the terrain of a terrestrial path. With this information, you can plot the path as well as the ray path and its Fresnel clearance envelope. The analysis also allows you to calculate the antenna heights necessary to ensure the specified Fresnel clearance for this path.

12.3.1 Program Input

Equivalent Earth's Radius Factor: The default is 1.3.

Number of Fresnel Zone Clearances: This is used only for plotted output. The default is zero.

"Antenna Calculation" requests the following information:
Please enter the desired Fresnel clearance.
Please enter the desire Earth radius factor.
Please enter the frequency.
Which antenna height is known; 1=left site, 2=right site, 3=none.

The following file must be in directory C:\VBEXE.

TER.DAT: A file created by JEM that contains all of the scenario data.

12.3.2 Program Output

Printed Output

There are two forms of printed output from this analysis. The first as shown in Figure 57, shows the minimum ray clearance and take-off angles. This is the "Print Data to Screen" option. The "Antenna Calculations" are shown in Figure 58 for a Fresnel clearance of 4.16 with neither antenna height known.

Terrain Profile and Ray Path Information
SITE1 to SITE2

Site	Coordinates Latitude	Longitude	Elevation(m) Above MSL	Antenna Ht. (m) Above Ground
SITE1	40' 2' 24"	-105' 13' 29.9"	2300	10
SITE2	39' 46' 12"	-105' 52' 47.9"	2500	40

Path Length is 42.0620 kilometers
For an Earth Radius Factor of k = 1.3

RAY PATH MINIMUM CLEARANCE:
Minimum clearance is 12.99 meters at 1 km from SITE1.
Minimum clearance is 4.16 times the first Fresnel zone.
radius at 30 GHz, and 1 km from SITE1.

ANGLES OF ATMOSPHERIC PENETRATION:
Take off angle at SITE1 is .168 degrees.
Take off angle at SITE2 is -.459 degrees.
Minimum angle of penetration is -.459 degrees.

Mean atmospheric pressure on path is 75.48 kPa.
Mean path height form k=4/3 is 151.19 meters.

Figure 57. Terrain profile and ray path output.

Antenna Calculations
Site1 to Site2
To obtain 4.16 First Fresnel clearance(s) at an Earth radius factor of k = 1.3 and a frequency of 30 GHz
The following antenna heights would be required:

Left site Ht (m)	Right site Ht (m)	Min. Clear. (m)	Distance from SITE1 (km)
10.00	34.39	18.41	40.00
20.00	33.87	18.41	40.00
30.00	33.36	18.41	40.00
40.00	32.84	18.41	40.00
50.00	32.33	18.41	40.00
60.00	31.81	18.41	40.00

Figure 58. Antenna calculations options.

Plotted Output

"Plot Profile" produces a plot of the terrain profile, the ray path and the boundary of the n^{th} Fresnel zone clearance. In the example in Figure 59, the lower line is the terrain profile as input by the user. The top solid line is the ray path. The dotted line is the boundary of the n^{th} Fresnel zone clearance.

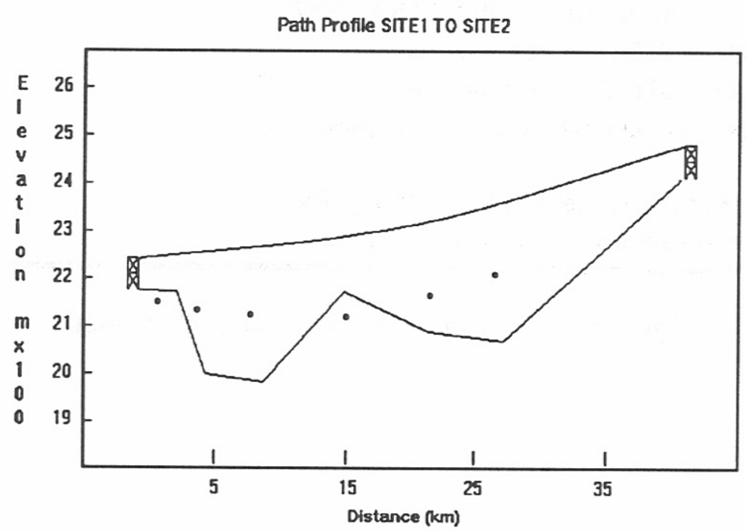


Figure 59. Terrain profile and ray path plot.

12.4 Cumulative Distribution of Clear Air Attenuation

This analysis calculates the cumulative distribution of the clear air attenuation for the path between two ground stations over the range of months you have specified. The only propagation loss considered is the clear air losses above free space loss.

12.4.1 Program Input

Equivalent Earth's Radius Factor k: The default is 1.33.

First Month: See Section 9.1.1.

Last Month: See Section 9.1.1.

The following files must be in directory C:\VBEXE.

AB.DAT: A data file provided with JEM that contains rain attenuation coefficients.

TER.DAT: A data file created by JEM that contains all the scenario data.

12.4.2 Program Output

See Section 9.2 for a description of printed and plotted output for clear air attenuation output.

12.5 Troposcatter/Diffraction Attenuation

This analysis calculates either the median long-term troposcatter loss or the median long-term diffraction loss for terrestrial paths that are beyond the horizon. It returns the attenuation of the lower propagation effect. This analysis includes the free space losses. It should be emphasized that the program assumes the input path is not line-of-sight. The method used to calculate the troposcatter loss is the CCIR Method I which is a simplified version of the National Bureau of Standards procedure described in CCIR Report 238-5 (1986) [12]. The diffraction path loss is calculated as the sum of the free space loss in the absence of any obstacles plus the diffraction loss introduced by the obstacles. The analysis is capable of two cases of diffraction: smooth earth and knife edge. The algorithm for the smooth earth diffraction is based on Roda's [13] simplification of the CCIR expression for the smooth case.

12.5.1 Program Input

Equivalent Earth's Radius Factor k: The default is 1.33.

Type of Surface beneath Horizon 1 and Horizon 2: choices are Land, Water or Unknown. Unknown defaults to land.

Type of terrain along path: The choices are (I)nland, (M)ixed land and water or (U)nknown.

Type of Diffraction Calculations Desired: The choices are (KN)ife-edge or (SM)ooth Earth. You should select smooth earth for water paths or any path without distinct changes in elevation. Or you should select knife-edge for any path with obvious obstacles along it. If you select a smooth earth path and the diffraction model is not valid for the terrain information in the terrain profile, the program will default to the knife-edge diffraction calculation.
Unknown defaults to knife-edge.

The following files must be in directory C:\VBEXE.

OXYGEN.DAT: A file provided with JEM containing Oxygen coefficients.

WATER.DAT: A file provided with JEM containing water vapor coefficients.

TER.DAT: A file created by JEM containing all the scenario data.

12.5.2 Program Output

Figure 60 illustrates the output format of troposcatter attenuation analyses.

Troposcatter Attenuation Information

Site1 to Site2

Site	Latitude	Longitude	Elevation(m) Above MSL	Antenna Ht.(m) Above Ground
SITE1	32' 44' 24"	-96' 49' 48"	157	123
SITE2	30' 17' 59.9"	-97' 42' 35.9"	189	55

The Path Length (km) = 283.16
For an Earth Radius Factor of k of 1.3
Operating Frequency (GHz) = .105
CCIR climate type = 6
The scatter angle = 1.87 degrees (32.62 mrad.)

For this path the dominant propagation mode is troposcatter
Troposcatter and free space losses = 111.80 dB
Received signal level for the troposcatter propagation mode = -31.8 dBm

Figure 60. Troposcatter attenuation.

12.6 Terrestrial Link Margin Analysis

This analysis determines the link margin for a terrestrial path for each of the 12 months of the year. The analysis considers the propagation effects of clear air attenuation, free space losses, diffraction and troposcatter. For each case, the median clear air attenuation is calculated. The analysis considers the median climate data at the two ground stations. It assumes that there is no rain along the path and that the suspended water droplet concentration is 0. The analysis determines if the path is line-of-sight or beyond the horizon. For the line-of-sight path, the clear air attenuation is added to the free space losses. For the path that is beyond the horizon, the troposcatter attenuation and diffraction losses are calculated. See Figure 61 for an example of the output.

12.6.1 Program Input

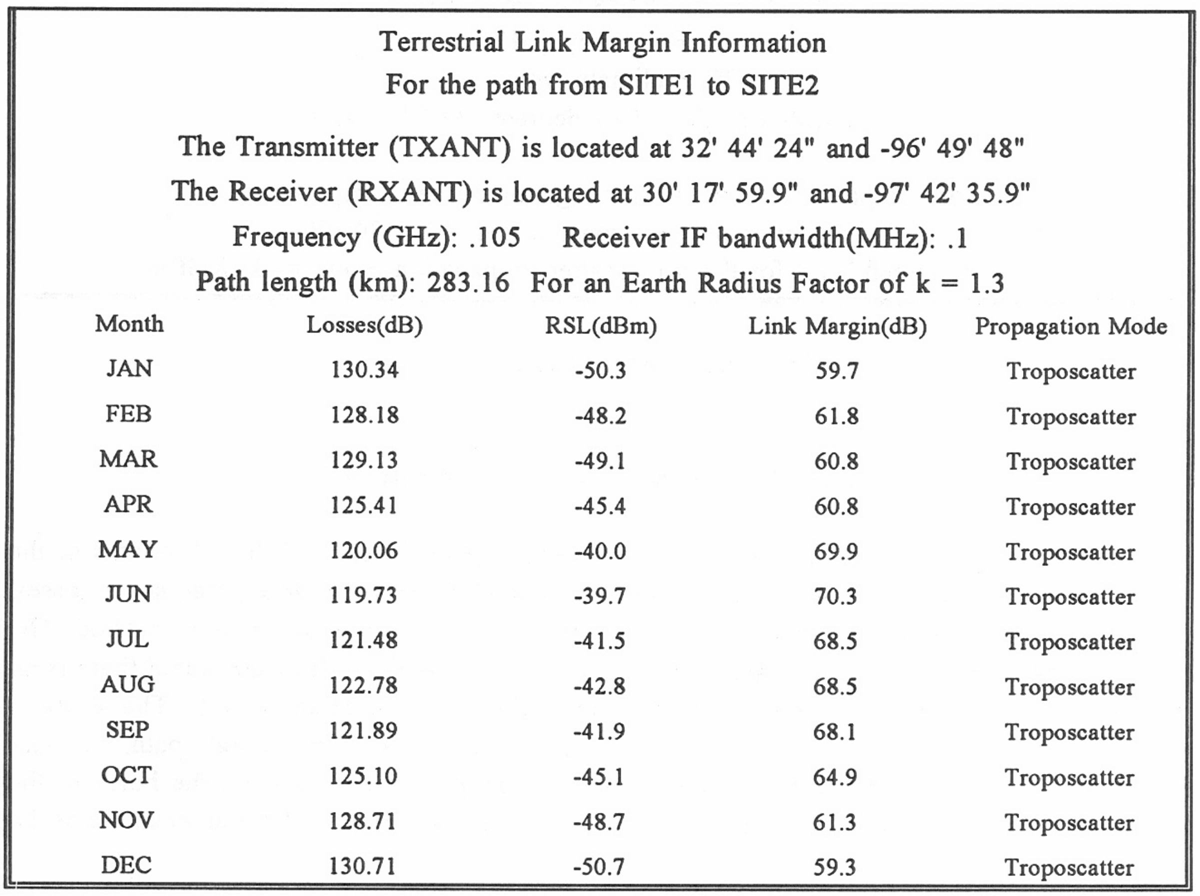
Equivalent Earth's Radius Factor k: The default is 1.3.

Type of Surface beneath Horizon 1 and Horizon 2: The choices are Land, Water or Unknown. Unknown defaults to land.

Type of Terrain along Path: The choices are (I)nland, (M)ixed land and water or (U)nknown.

12.6.2 Program Output

A sample output for the terrestrial link margin analysis is found in Figure 61.



Terrestrial Link Margin Information
For the path from SITE1 to SITE2

The Transmitter (TXANT) is located at 32' 44' 24" and -96' 49' 48"
The Receiver (RXANT) is located at 30' 17' 59.9" and -97' 42' 35.9"
Frequency (GHz): .105 Receiver IF bandwidth(MHz): .1
Path length (km): 283.16 For an Earth Radius Factor of k = 1.3

Month	Losses(dB)	RSL(dBm)	Link Margin(dB)	Propagation Mode
JAN	130.34	-50.3	59.7	Troposcatter
FEB	128.18	-48.2	61.8	Troposcatter
MAR	129.13	-49.1	60.8	Troposcatter
APR	125.41	-45.4	60.8	Troposcatter
MAY	120.06	-40.0	69.9	Troposcatter
JUN	119.73	-39.7	70.3	Troposcatter
JUL	121.48	-41.5	68.5	Troposcatter
AUG	122.78	-42.8	68.5	Troposcatter
SEP	121.89	-41.9	68.1	Troposcatter
OCT	125.10	-45.1	64.9	Troposcatter
NOV	128.71	-48.7	61.3	Troposcatter
DEC	130.71	-50.7	59.3	Troposcatter

Figure 61. Terrestrial link margin.

13. REFERENCES

[1] K.C. Allen, "EHF telecommunication system engineering model," NTIA Report 86-192, April 1986. (NTIS Order No. PB 86-2148141/AS).

[2] K.C. Allen, "Software for the analysis of microwave operational scenarios," Reprinted from Proc. of IEEE Military Communications Conference, CH2831-6/90/0000-0456, June 1990, pp. 17.5.1-17.5.5.

[3] H.J. Liebe, "MPM-an atmospheric millimeter-wave propagation model," *International Journal of Infrared and Millimeter Waves,* Vol. 10, No. 6, pp. 631-650, June 1989.

[4] R.K. Crane, "Prediction of attenuation by rain," *IEEE Transactions on Communications,* Vol. COM-28, No. 9, pp. 1717-1733, September 1980.

[5] D.D. Crombie, "Prediction of multipath fading on terrestrial microwave links at frequencies of 11 GHz and greater," in Proc. AGARD/NATO Conference No. 346, 1983.

[6] CCIR, Recommendations and Reports of the CCIR, 1986; Vol. V; Propagation in non-ionized media, Report 715-5; Propagation by diffraction, ITU, Geneva, Switzerland, 1986, pp. 60-72.

[7] CCIR, Recommendations and Reports of the CCIR, Vol. V; Propagation in non-ionized media, Report 238-5; Propagation data and prediction methods required for trans-horizon radio-relay systems, ITU, Geneva, Switzerland, 1986, pp. 367-388.

[8] A.G. Longley, and P.L. Rice, "Prediction of tropospheric radio transmission loss over irregular terrain," ESSA Technical Report ERL 79-ITS 67, 1968.

[9] G.A. Hufford, A.G. Longley, and W.A. Kissick, "A guide to the use of the ITS irregular terrain model in the area prediction mode," NTIA Report 82-100, April 1982, (NTIS Order No. PB 82-217977).

[10] F.G. Stewart, L.A. Berry, C.M. Rush, and V. Agy, "An air-to-ground HF propagation prediction model for fast multi-circuit computation, NTIA Report 83-131, August 1983, (NTIS Order No. PB 94-145861).

[11] L.R Teters, J.L. Lloyd, G.W. Haydon, and D.L. Lucas, "Estimating the performance of telecommunication systems using the ionospheric transmission channel IONCAP User's Manual," NTIA Report 83-127, July 1983, (NTIS Order No. PB 84-11210).

[12] CCIR, Recommendations and Reports of the CCIR, Volume V: Propagation in Non-ionized Media, Report 239-5: Propagation data and prediction methods required for trans-horizon radio-relay systems, ITU, Geneva, Switzerland, 1986, pp. 367-388.

[13] G. Roda, *Troposcatter Radio Links*, Norwood, MA: Arctech House, Inc., 1988.

APPENDIX A
Visual Basic Error Codes

3	Return without GoSub
5	Illegal function call
6	Overflow
7	Out of memory
9	Subscript out of range
10	Duplicate definition
11	Division by zero
13	Type mismatch
14	Out of string space
17	Can't continue
19	No resume
20	Resume without error
28	Out of stack space
48	Error in loading DLL
49	Bad DLL calling convention
51	Internal error
52	Bad file name or number
53	File not found
54	Bad file mode
55	File already open
57	Device I/O error
58	File already exists
59	Bad record length
61	Disk full
62	Input past end of file
63	Bad record number
64	Bad file name
67	Too many files open
68	Device unavailable
70	Permission denied
71	Disk not ready
75	Path/File access error
76	Path not found
91	Object variable not set
92	For loop not initialized
93	Invalid pattern string
94	Invalid use of null
95	Cannot destroy active form instance
260	No timer available
321	Invalid file format
340	Control array element 'item' does not exist
341	Invalid object array index
342	Not enough room to allocate control array 'item'
343	Object not an array
360	Object already loaded
361	Can't load or unload this object
364	Object was unloaded
365	Unable to unload within this context
380	Invalid property value
381	Invalid property array index
382	'item' property can't be set at run time
383	'item' property is read-only
384	'item' property can't be modified when form is minimized or maximize
385	Must specify index when using property array
386	'item' property not available at run time
387	'item' property can't be set on this control
389	Invalid key
390	No defined value
391	Name not available
392	MDI Child forms cannot be hidden
393	'item' property cannot be read at runtime
394	'item' property is write-only
401	Can't show non-modal form when a modal form is being displayed
402	Must close or hide topmost modal form first
404	MDI Child forms cannot be shown modally
420	Invalid object reference
421	Method not applicable for this object
422	Property 'item' not found
423	Property or control 'item' not found
425	Invalid object use
426	Only one MDI form allowed
460	Invalid clipboard format
480	Can't create AutoRedraw image
481	Invalid picture
482	Printer error
520	Can't empty clipboard
521	Can't open clipboard

FORM NTIA-29
(4-80)

U.S. DEPARTMENT OF COMMERCE
NAT'L. TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

BIBLIOGRAPHIC DATA SHEET

	1. PUBLICATION NO.	2. Gov't Accession No.	3. Recipient's Accession No.
	95-317		

4. TITLE AND SUBTITLE

Jammer Effectiveness Model

5. Publication Date

6. Performing Organization Code
NTIA/ITS

7. AUTHOR(S)
Janet Geikas and Nicholas DeMinco

9. Project/Task/Work Unit No.

8. PERFORMING ORGANIZATION NAME AND ADDRESS
National Telecommunications & Information Administration
Institute for Telecommunication Sciences
325 Broadway
Boulder, CO 80303

10. Contract/Grant No.

11. Sponsoring Organization Name and Address
National Ground Intelligence Center
220 Seventh St., NE
Charlottesville, VA 22901

12. Type of Report and Period Covered

13.

14. SUPPLEMENTARY NOTES

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.)*

The Jammer Effectiveness Model (JEM) is a Windows-based computer program which provides an integrated procedure for modeling propagation effects on telecommunication links and the effect of a jammer on communication links and networks. JEM provides the user with the ability of defining equipment such as transmitters, receivers and antennas and then using these definitions in a variety of analyses. JEM can be used easily after only a short learning period.

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

jammer, jamming, propagation, communications system models, electronic warfare, countermeasures

17. AVAILABILITY STATEMENT	18. Security Class. *(This report)*	20. Number of pages
☒ UNLIMITED.	Unclassified	79
☐ FOR OFFICIAL DISTRIBUTION.	19. Security Class. *(This page)* Unclassified	21. Price:

*U.S. GOVERNMENT PRINTING OFFICE:1995-673-018/00088