MICROWAVE LINK PREDICTIONS

PROGRAM DESCRIPTION **RADLNK**

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1. PROGRAMME DESCRIPTION

1.1 INTRODUCTION

The program RADLNK is designed to provide the microwave radio system designer a consistent means of obtaining a realistic evaluation of a microwave radio link. The link performance output can accommodate a basic system with variations such as frequency/space diversity, space grid coordinates, flexible equipment selection etc. Refer to the sample printout attached.

A segment on Path Geometry is included in order for the designer to evaluate path obstructions and tower heights. This is a graphics-style package and affects the link performance with respect to RMS Roughness of the terrain. The Path Geometry segment also shows the radio rayline clearance from the ground.

Part of the Path Geometry block is a section on Ground/Sea reflection analysis. This scans the terrain for potential reflective regions and presents a report detailing these regions. The analysis also recommends a space diversity separation for both ends of the link.

The designer then may examine the reflective region on a site visit and decide if space diversity need by used.

PROGRAM RADLNK is suitable for use on microwave radio equipment of all types, in all terrain areas and all realistic K factors.

The program does have limitations and there are summarized below:

- Frequency of operation: 0.001 GHz (1MHz) to 150 GHz
- For rain considerations: 2 GHz to 99 GHz
- For atmospheric absorption: 2 GHz to 99 GHz
- Path Length: 0.001 km (1m) to 999.999 km
The effect of the K factor on Earth Bulge is always considered. This permits the accurate profiling of a radio path with different K factors expected in regions.

The program is written in GWBASIC for the IBM PC and variants.

1.1.1 DESIGNING MICROWAVE RADIO LINKS

The starting point in a radio communications link is to identify it as an economic and practical means of bridging awkward terrain and flexible expansion of capacity in the future. The planning of a link must take into account, cost, equipment availability and propagation availability.

The designer may adopt "rules" on which to base a link or network. Such rules take the form of:

1. Minimization of cost, spares inventory, maintenance.
2. Propagation availability greater than 99.950\% End to End.
3. Hardware availability greater than 99.900\%.
4. Terrain clearance of rayline greater than 0.3F at K = 0.66 and F at K = 1.33, where F is Fresnel zone radius.

Program RADLNK can consider points 2) and 4) but it is up to the designer to specify the rules. Point 3) is the subject of another program titled "COMREL: Communications Network Reliability, Hardware Considerations. Point 1) is up to the ingenuity of the designer.

The designer may determine an equipment configuration to meet a specified requirement, or use "standard" equipment and obtain an availability figure to offer a client.
1.1.2 INFLUENCE OF TERRAIN

The microwave beam is influenced by the intermediate terrain between the stations and obstacles in its path. It follows a slightly curved path in the vertical plane, i.e., it is refracted in the atmosphere due to the dielectric constant of the atmosphere. The amount of refraction changes with temperature, vapour pressure and relative humidity. In addition to this effect, the microwave beam can be diffracted by obstacles in its path or in the extreme, the scattering effect from the troposphere. It is up to the designer to evaluate any diffraction or troposcatter effects separately from free-space data used in RADLNK. If a path is surveyed using optical means, the results would correspond to a K factor of approx 1.16. Obstacles such as trees should be considered as blocking a microwave beam, so adequate clearance should be considered even allowing for their growth.

The consideration of the Fresnel Zone clearance becomes paramount in highly reflective paths, e.g., over water. Rayline clearance to the 2nd Fresnel zone is important over this type of path.

1.1.3 INFLUENCE OF WEATHER

At microwave frequencies over 2 GHz, rain and precipitation can influence the attenuation on a route. Refer to the specific attenuation chart elsewhere in this handbook. The rain attenuation model in program RADLNK is modelled from this information in this chart. The effect of atmospheric absorption is presented, where, at certain frequencies, molecular resonance occurs. This can be significant at frequencies near 21 GHz and 60 GHz which correspond to the water vapour and oxygen resonance frequencies respectively.
1.1.4 SITUATIONS TO BE AVOIDED

Several situations should be avoided when designing a link:

1. Over water paths and paths over low flat terrain. Where they cannot be avoided, the use of space diversity or the High-low placement of antennas to move the reflection point onto rough terrain is recommended.

2. Sites near radar stations. Possible solutions here include RF filters, RF attenuators and utilization of terrain protection, ie placing a terminal in a radar shadow region.

3. Sites on the very top of high mountains or ridges are susceptible to more potential interference from distant links, and the effects of delay distortion from multiple path effects.

4. Having a microwave rayline pass near city buildings or down streets, results in severe reflection situations and increased outage times.
1.2 SUBROUTINES (LINK BUDGET)

1.2.1 SYSTEM DETAILS

A brief description of each subroutine (Block) utilized in the Link Budget calculation follows:

Data Input Block

Inputs station names, path distance, grid bearings, diversity selection, K factor. The option for a link utilizing both space and frequency diversity cannot be directly supported. The program would need to be run twice with each option.

1.2.2 RAIN DATA

Data Input Block

Inputs rain rate data and climate zone. The climate zone is based on the geographic location of the link.

N.B. Rain Data from Rain Contours 0.05% Probability elsewhere in this handbook.
1.2.3 EQUIPMENT
Data Input Block
Inputs type of equipment, allows selection of antenna size and peculiar equipment variations. The equipment shown in the menu is popular for links up to 8 Mb/s (120 channels) capacity. Any equipment may be configured providing specifications are known. Equipment without integral antennas would need some default antenna gains to be entered in the data block. Refer to equipment Data block.

1.2.4 PERFORMANCE REPORT OUTPUT
Calculation/Output Block
Calculation of path loss (free space) fade margin, Fading, 1st Fresnel zone radius and system availabilities. Where options like diversity are not selected, they do not appear on output. It is at the start of this block that all link calculations are performed.

1.2.5 EQUIPMENT DATA
Data Block
Hardware data not directly accessed from user. It is here that the user may enter other equipment as options.
1.2.6 AMPLITUDE DISPERSION FADING
Calculation Block
Fading calculation based on Algorithm from NEC DIGITAL MICROWAVE RADIO HANDBOOK for digital radio links. The fading prediction is applicable to FDM and video links.

1.2.7 RAIN FADING
Calculation Block
Fading calculation based on Algorithm derived from CCIR REP 721-1

1.2.8 STATION DISTANCES & BEARINGS
Calculation Block
Calculates distance between stations given grid coordinates and the bearing of station B from station A. This block operates using the spherical "Great Circle" calculations.

1.3 SUBROUTINE (PATH GEOMETRY)

A brief description of each subroutine (Block) utilized in the Path Geometry calculation follows:

1.3.1 PATH GEOMETRY
Menu Block
SUB-MENU SELECTION

1.3.2 SUPPORT HEIGHTS
Data Input Block
Inputs height of support structures at both stations. Radio Horizon distance shown for smooth earth. The radio horizon distance is presented as a course of station support heights, and suitable in an interference study.
1.3.3 PATH PROFILE ENTRY
Data input Block
Inputs path profile data from map. The number of input points is not critical.

1.3.4 PATH DATA RESET
Calculation Block
Resets path data to zero if a mistake or new data is inputted. Does not affect Link Budget subroutines.

1.3.5 DEFAULT VALUES SET

1.3.6 PATH DATA PARAMETER OUTPUT
Output Block
Dumps path profile data onto printer.

1.3.7 PROFILE DISPLAY
Menu Block
SUB-SUB MENU SELECTION.

1.3.8 DOT JOINING/DATA FILL
Calculation Block
Joins all the path profile data points (linear).

1.3.9 EARTH BULGE CORRECTION
Calculation Block
Modifies the data fill to account for earth Bulge.

1.3.10 RMS ROUGHNESS
Calculation Block
Calculates the RMS roughness of corrected data. This is used in LINK BUDGET. Default values are set.

1.3.11 RAYLINE CLEARANCE
Calculation Block
Calculates the clearance between the rayline and the terrain. This is titled CLR on the plotter output.
1.3.12 PLOT SCALING
Calculation Block
Determines maximum and minimum data and calculates suitable plot dimensions.

1.3.13 PLOTTER
Output Block
Plots data size A3 or A4 or any specified size.

1.4 GROUND/SEA REFLECTION ANALYSIS

A brief description of each subroutine (Block) utilized in the Reflection Analysis follows:

1.4.1 SELECTION AND TESTING REFLECTIONS
Scans through the region selected by the designer, or due to illumination or full path. (Note: Full path testing is time consuming). Testing performed at 3 K values.

1.4.2 ILLUMINATED REGION
Calculation Block
This scans the path profile to determine the illuminated region open for reflections.
PROGRAM VARIABLES

F1  - FREQUENCY (GHz)
P1  - PATH LENGTH (KM)
P2  - TRANSMIT POWER (DBM)
P9  - FREE SPACE PATH LOSS (DB)
G1,G2 - ANTENNA GAIN (DBI)
G3  - OTHER ATTENUATION (DB)
F8  - RAIN MARGIN
F9  - FADE MARGIN (DB)
R1  - RECEIVE THRESHOLD (DBM)
R2  - RAIN RATE EXCEEDED R4% PER MONTH
R3  - CLIMATE FACTOR
R4  - RAINFALL RATE PERCENTILE VALUE
R9  - RECEIVE LEVEL (DBM)
A8  - RAIN ATTENUATION
PRM - RAIN OUTAGE TIME PER MONTH
PRY - RAIN OUTAGE TIME PER YEAR
O1  - AMPLITUDE DISPERSION OUTAGE TIME
O2  - DIVERSITY LINK OUTAGE TIME
O8  - SYSTEM AVAILABILITY PER YEAR
O9  - SYSTEM AVAILABILITY PER MONTH
D1,D2 - SUPPORT HEIGHTS FOR STATIONS
N1,%
N2,% - STATION NAMES
N3,% - EQUIPMENT NAMES
QX,% - INPUT VARIABLE FOR MENU'S
Z  & - DATA DISPLAY FIELD
AA1,AA2- COORDINATES OF STATION N1,%
BB1,BB2- COORDINATES OF STATION N2,%
H  - BEARING OF STATION N2,% FROM STATION N1,%
XD(101),
YD(101)- MATRIX WHERE INPUT PATH DATA IS ENTERED
X(101),
Y(101) - PLOTTER DATA
RF(101)- SURFACE ROUGHNESS CALCULATION DATA
U5  - NUMBER OF X VALUES IN PLOT
U6 - NUMBER OF Y VALUES IN PLOT
R  - PLOTTER X AXIS INCREMENT
L  - PLOTTER Y AXIS INCREMENT
KN - COUNTER FOR DATA X VALUES CLOSER THAN 0.5R
KF - K FACTOR
Y1, Y2 - MINIMUM, MAXIMUM PLOT VALUES
KK - NUMBER ROUNING FACTOR
T44 - EARTH BULGE (MAXIMUM POINT)
T46 - RMS ROUGHNESS
T48 - FRESNEL ZONE RADIUS (MAXIMUM, MID PATH)
SD1 - SPACE DIVERSITY SEPARATION (M)
FD1 - FREQUENCY DIVERSITY SEPARATION (MHZ)
ALF - ANGULAR VARIABLE FOR REFLECTION CALCULATION
BET - ANGULAR VARIABLE FOR REFLECTION CALCULATION
MJ  - Metric/Imperial units selection
MES - USER message/name
2. PROGRAM OPERATION

2.1 DESCRIPTION

Program RADLNK effectively consists of three separate programs with the only interlinked variables P1, KF and T46. The three programs consist of the Link Budget Block, Path Geometry Block, and Ground/sea reflection analysis. All are menu driven for ease of use. The output procedure follows the following steps, for full variable interlinking.

a) Enter all data, no particular order
b) Print Path Data (optional)
c) Ground/sea reflection analysis (optional)
d) Plot Path Profile
e) Print Link Performance report

The output procedure in a different order of operation will operate on default values where they are necessary. The Ground/sea reflection analysis cannot operate without frequency and path profile data.

To obtain the rainfall rate, refer to the contour map of Australian and Fiji. Rainfall data for other regions can be used to calculate the 0.05% or 0.01% levels as required by the program.

2.1.1 LINK BUDGET BLOCK

The link budget block calculates the link signal levels and predicted attenuation and fading due to rain. One-way link availability is calculated for the worst month and annual period. All menu options except path geometry and Ground/sea reflection analysis need be selected to operate this block. Where appropriate, default values are set, pending execution of the other blocks.
At any time, the designer can edit any of the data that has been entered. This allows easy access to results using different equipments for example.

2.1.2 PATH GEOMETRY BLOCK

Input options can be selected on the actual data available. if insufficient data is available for output, RADLNK will advise the user.

Dot joining and earth bulge cannot be disabled under user control. Note, the degree of earth bulge is defined as the K Factor. The K Factor has a theoretical range of 0 thru infinity, however practical values in the program range 0.4 thru 10 (Default at 1.333).

A A3 size output is available with expanded X-Axis and Y-Axis. This provides higher resolution where clearances are marginal.

The CLR heading data, shows the clearance in metres between rayline and ground, the height of trees or buildings would need to be subtracted from the CLR data, if they were not considered in the path profile.

The rayline between stations must be drawn in by hand.

2.2 REFERENCE LIST

"Rain Attenuation Considerations for Satellite Paths in Australia" R.K. Flavin, Telecom Australia.

"Attenuation by Hydrometeors, Precipitation and other Atmospheric Particles" CCIT REP 721-1.
"Propagation data for design Terrestrial, Troposcatter, Trans-Horizon and Earth-Space Telecommunication systems CCITT REC 530-1, REP 338-4.


"Digital Microwave Radio, Engineering Fundamentals" NEC, Tokyo. MSD-3003 8208-01.
FIGURE 1 - Specific attenuation $\gamma_R$ due to rain

Raindrop size distribution [Laws and Parsons, 1943]
Terminal velocity of raindrops [Gunn and Kinzer, 1949]
Index of refraction of water at 20° C [Ray, 1972]
Spherical drops
FIG. 7a WORST-MONTH RAIN INTENSITY CONTOURS (mm/hr)
FOR 0.1% PROBABILITY
RAINFALL RATE EXCEEDED 0.01% OF THE YEAR.
(mm/hour)

NEW ZEALAND
RADIO LINK FROM TERMINAL [A] TO PASSIVE REPEATER
Path Length 5.700 Km
Earth Bulge @ K = 1.33 0.48 m
RMS Roughness @ K = 1.33 82.59 m
Max Fresnel Zone Radius 6.33 m

LINK SIGNAL LEVELS
Frequency 10.680 GHz
Free Space Path Loss 128.2 dB
Stn [A] Antenna Gain 39.4 dBi
Feedline Loss 0.4 dB
Stn [B] Antenna Gain 39.4 dBi
Feedline Loss 0.0 dB
Transmit Power 13.0 dBi
Atmospheric Attenuation 0.0 dB

MEDIAN RECEIVE LEVEL -36.8 dB
Receive Threshold -80.0 dBm

FADE MARGIN 43.2 dB

RADIO LINK FROM PASSIVE REPEATER TO TERMINAL [B]
Path Length 1.200 Km
Earth Bulge @ K = 1.33 0.02 m
RMS Roughness @ K = 1.33 80.21 m
Max Fresnel Zone Radius 2.91 m

LINK SIGNAL LEVELS
Frequency 10.680 GHz
Free Space Path Loss 114.7 dB
Stn [A] Antenna Gain 39.4 dBi
Feedline Loss 0.4 dB
Stn [B] Antenna Gain 39.4 dBi
Feedline Loss 0.4 dB
Transmit Power -36.8 dBi
Atmospheric Attenuation 0.0 dB

MEDIAN RECEIVE LEVEL -73.5 dB
Receive Threshold -80.0 dBm

FADE MARGIN 6.5 dB

RAIN ATTENUATION OUTAGES
Climate Factor 1.2
Rain Rate Exceeds 0.050% /M 30.0 mm/H
Rain Attenuation 4.5 dB
RAIN MARGIN 2.1 dB
Rain Outage TIME/MONTH 0.0170 %
Rain Outage TIME/YEAR 0.0027 %

AMPLITUDE DISPERSION OUTAGES
Outage Time (Single Link) 0.0163 %

LINK AVAILABILITY (Excluding Hardware, One Way)
Availability (WORST MONTH) 99.9667 %
Availability (ANNUAL) 99.9810 %
Passive Repeater  Support Height = 35 m
Terminal B  Support Height = 35 m
Path Length (Km) = 1.2

Terrain Profile Data

<table>
<thead>
<tr>
<th>Data Point</th>
<th>Distance From [A] (Km)</th>
<th>Height at this Point (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>760</td>
</tr>
<tr>
<td>2</td>
<td>.5</td>
<td>660</td>
</tr>
<tr>
<td>3</td>
<td>1.2</td>
<td>630</td>
</tr>
</tbody>
</table>
TERMINAL [A]  Support Height = 35 m
PASSIVE REPEATER  Support Height = 35 m
Path Length (Km) = 5.7

<table>
<thead>
<tr>
<th>Data Point</th>
<th>DISTANCE From [A] (Km)</th>
<th>HEIGHT at this Point (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>848</td>
</tr>
<tr>
<td>2</td>
<td>.5</td>
<td>730</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>700</td>
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<td>4</td>
<td>1.5</td>
<td>710</td>
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<tr>
<td>5</td>
<td>2</td>
<td>650</td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>670</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>660</td>
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<td>8</td>
<td>3.5</td>
<td>660</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>690</td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
<td>700</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>630</td>
</tr>
<tr>
<td>12</td>
<td>5.5</td>
<td>730</td>
</tr>
<tr>
<td>13</td>
<td>5.7</td>
<td>760</td>
</tr>
</tbody>
</table>
RADIO LINK FROM PENSHURST TO HAMILTON
Path Length 24.200 Km
Earth Bulge [K = 1.33] 8.62 m
RMS Roughness [K = 1.33] 70.60 m
Max Fresnel Zone Radius 11.72 m

LINK SIGNAL LEVELS
Frequency 13.250 GHz
Free Space Path Loss 142.5 dB
Stn ‘A’ Antenna Gain 34.0 dBi
Feedline Loss 0.0 dB
Stn ‘B’ Antenna Gain 34.0 dBi
Feedline Loss 0.0 dB
Transmit Power 22.0 dBi
Atmospheric Attenuation 0.2 dB
MEDIAN RECEIVE LEVEL -52.7 dB
Receive Threshold -80.0 dBm
FADE MARGIN 27.3 dB

RAIN ATTENUATION OUTAGES
Climate Factor 1.0
Rain Rate Exceeds 0.050% /M 15.0 mm/H
Rain Attenuation 11.5 dB
RAIN MARGIN 15.8 dB
Rain Outage TIME/MONTH 0.0046 %
Rain Outage TIME/YEAR 0.0006 %

AMPLITUDE DISPERSION OUTAGES
Outage Time (Single Link) 0.0063 %

LINK AVAILABILITY (Excluding Hardware, One Way)
Availability (WORST MONTH) 99.9891 %
Availability (ANNUAL) 99.9931 %
### System Details

<table>
<thead>
<tr>
<th>Frequency</th>
<th>10.680 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Path Length</td>
<td>20.700 km</td>
</tr>
<tr>
<td>Station A</td>
<td>DARKES FOREST</td>
</tr>
<tr>
<td>Station B</td>
<td>ENGADINE</td>
</tr>
<tr>
<td>Equipment Type</td>
<td>MINILINK 10</td>
</tr>
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</table>

#### Terrain Data

<table>
<thead>
<tr>
<th>Earth Bulge</th>
<th>6.3 m</th>
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</thead>
<tbody>
<tr>
<td>RMS Roughness</td>
<td>42.0 m</td>
</tr>
<tr>
<td>Fresnel Zone Radius</td>
<td>12.1 m</td>
</tr>
</tbody>
</table>

#### Link Signal Levels

<table>
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<tr>
<th>Free Space Path Loss</th>
<th>139.4 dB</th>
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<tbody>
<tr>
<td>Transmit Antenna Gain</td>
<td>32.0 dBi</td>
</tr>
<tr>
<td>Receive Antenna Gain</td>
<td>32.0 dBi</td>
</tr>
<tr>
<td>Transmit Power</td>
<td>13.0 dBm</td>
</tr>
<tr>
<td>Waveguide/Other Losses</td>
<td>0.0 dB</td>
</tr>
<tr>
<td>Receive Level</td>
<td>-62.4 dBm</td>
</tr>
<tr>
<td>Receive Threshold</td>
<td>-80.0 dBm</td>
</tr>
<tr>
<td>Fade Margin</td>
<td>17.6 dB</td>
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</tbody>
</table>

#### Rain Attenuation Outages

<table>
<thead>
<tr>
<th>Climate Factor</th>
<th>1.0</th>
</tr>
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<tbody>
<tr>
<td>Rain Rate Exceeded 0.05%</td>
<td>30.0 mm/h</td>
</tr>
<tr>
<td>Rain Attenuation</td>
<td>13.5 dB</td>
</tr>
<tr>
<td>Rain Margin</td>
<td>4.1 dB</td>
</tr>
<tr>
<td>Rain Outage Time/Month</td>
<td>0.0947 %</td>
</tr>
<tr>
<td>Rain Outage Time/Year</td>
<td>0.0216 %</td>
</tr>
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</table>

#### Amplitude Dispersion Outages

<table>
<thead>
<tr>
<th>Outage Time (Single Link)</th>
<th>0.0300 %</th>
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<tbody>
<tr>
<td>Space Diversity Separation</td>
<td>8.0 m</td>
</tr>
<tr>
<td>Outage Time (Diversity Link)</td>
<td>0.0120 %</td>
</tr>
</tbody>
</table>

#### Link Availability (Excluding Hardware)

<table>
<thead>
<tr>
<th>Availability (Worst Month)</th>
<th>99.8932 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability (Annual)</td>
<td>99.9664 %</td>
</tr>
</tbody>
</table>
PROGRAM ***RADLINK***

RADIO PATH DETAILS

DARKES FOREST SUPPORT HEIGHT = 20 M
ENGADINE SUPPORT HEIGHT = 15 M
PATH LENGTH (KM) = 20.7

TERRAIN PROFILE DATA

DATA POINT 1
DISTANCE FROM A (KM) 0
HEIGHT AT THIS POINT (M) 380

DATA POINT 2
DISTANCE FROM A (KM) 3
HEIGHT AT THIS POINT (M) 300

DATA POINT 3
DISTANCE FROM A (KM) 4
HEIGHT AT THIS POINT (M) 300

DATA POINT 4
DISTANCE FROM A (KM) 5
HEIGHT AT THIS POINT (M) 280

DATA POINT 5
DISTANCE FROM A (KM) 6.3
HEIGHT AT THIS POINT (M) 310

DATA POINT 6
DISTANCE FROM A (KM) 7.5
HEIGHT AT THIS POINT (M) 280

DATA POINT 7
DISTANCE FROM A (KM) 8
HEIGHT AT THIS POINT (M) 260

DATA POINT 8
DISTANCE FROM A (KM) 8.8
HEIGHT AT THIS POINT (M) 200

DATA POINT 9
DISTANCE FROM A (KM) 10.5
HEIGHT AT THIS POINT (M) 240

DATA POINT 10
DISTANCE FROM A (KM) 12.6
HEIGHT AT THIS POINT (M) 200

DATA POINT 11
DISTANCE FROM A (KM) 13.5
HEIGHT AT THIS POINT (M) 120

DATA POINT 12
DISTANCE FROM A (KM) 14.3
HEIGHT AT THIS POINT (M) 200

DATA POINT 13
DISTANCE FROM A (KM) 19.5
HEIGHT AT THIS POINT (M) 100

DATA POINT 14
DISTANCE FROM A (KM) 20.7
HEIGHT AT THIS POINT (M) 200

RAIN RATE 0.05% PER MONTH = 30
CLIMATE ZONE = 1
PROGRAM *RADLNK* GROUND/SEA REFLECTION ANALYSIS

REGION FOR CONSIDERATION IS ILLUMINATED PATH LINK FROM DARKES FOREST TO ENGADINE

K FACTOR 0.600
REFLECTION POINT AT 1.294 KM FROM A. RAY CLEARANCE 36.174 M
SD SEPARATION. STN A 0.8 M
STN B 12.5 M

REFLECTION POINT AT 1.553 KM FROM A. RAY CLEARANCE 39.924 M
SD SEPARATION. STN A 0.9 M
STN B 10.7 M

SCAN FOR CLEARANCE < 2 FRESNEL ZONES
SCAN COMPLETE

K FACTOR 1.333

REFLECTION POINT AT 1.294 KM FROM A. RAY CLEARANCE 37.980 M
SD SEPARATION. STN A 0.8 M
STN B 12.4 M

SCAN FOR CLEARANCE < 2 FRESNEL ZONES
SCAN COMPLETE

K FACTOR 10.000

REFLECTION POINT AT 1.035 KM FROM A. RAY CLEARANCE 34.944 M
SD SEPARATION. STN A 0.1 M
STN B 1.3 M

SCAN FOR CLEARANCE < 2 FRESNEL ZONES
SCAN COMPLETE
<table>
<thead>
<tr>
<th>HEIGHT (M)</th>
<th>CLR</th>
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<td>75.0</td>
<td>20.0</td>
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K FACTOR = 1.33  RMS ROUGHNESS = 42.00
OPERATION

FOR THE INITIAL RUN, IT IS NECESSARY TO IDAD THE PROGRAM WITH DATA. THIS IS PERFORMED BY SELEcrING ALL MAIN MENU OPTIONS (IN ANY SEQuENCE) PRIOR TO PRINTIN3 THE REPORT (5).

THE OPTION 'PATH GEOMETRy' AND IT'S SUB-MENU ITEMS DOES NOT HAVE TO BE USED INITIALLY AS DEFAULT VALUES ARE SET.

SUBSEQUENT CHANGES CAN BE MADE BY SELECTING ANY OF THE MAIN MENU OPTIONS AND THEN PRINTIN3 THE NEW REPORT (OR PLOT).

THE PATH PROFILE PLOT OPTION IS INDEPENrANT OF THE REST OF THE PROGRAM. THREE VARIABLES ARE INERLINKED, REFER TO 2.1 PROGRAM.

ROUTE PRINCIPAL ASSUMES UNCIBSTRUeJrED PATHS FOR THE RADIO RAYLINE.

CONVrRISON OF UNITS: DBM=10*LOG(WATTS/0.001)

PROGRAM WRITTEN BY: DAVID BURGER JULY 1985
CLS:PRINT"PROGRAM ***RADLINK*** MICROWAVE LINK PREDICTI
ONS"
505 SOUND 88,4:SOUND 151,3:SOUND 88,2
510 PRINT TAB(44)"D. BURGER VS 2.4":PRINT:PRINT:PRINT:PRINT
515 PRINT TAB(22)"1 - INPUT SYSTEM DETAILS"
520 PRINT TAB(22)"2 - PATH PROFILE GEOMETRY"
525 PRINT TAB(22)"3 - INPUT RAIN INTENSITIES"
530 PRINT TAB(22)"4 - EQUIPMENT PARAMETERS"
535 PRINT TAB(22)"5 - LINK PERFORMANCE REPORT":PRINT TAB(22)"6 - DEFAULT PARAMET
ERS":PRINT TAB(22)"7 - EXIT"
540 KEY OFF
545 QX$=INKEY$:IF QX$="" THEN 545
550 IF VAL(QX$)>7 OR VAL(QX$)<1 THEN 545
555 SOUND 88,3
560 ON VAL(QX$) GOSUB 700,3800,1000,1200,2000,4700,7500
565 GOTO 500
570 END
**SYSTEM DETAILS**

**RADLINK** SYSTEM DETAILS INPUT

PRINl': RETURN TO MAIN MENU <EXIT>"; PRINT

STATION B "; N2$}

INPUT "TERMINAL A NAME "; QX$

IF QX$="" THEN 745

IF QX$="EXIT" THEN RETURN ELSE N1$=QX$

INPUT "TERMINAL B NAME "; QX$

IF QX$="" THEN 760

IF QX$="EXIT" THEN RETURN ELSE N2$=QX$

FLAG2=0: PRINT: PRINT "ENTER GRID COORDINATES Y/N"

QX$=INKEY$: IF QX$="" THEN 765

IF QX$="Y" THEN 3500

IF QX$="EXIT" THEN RETURN ELSE Pl=VAL(QX$)

IF Pl<=0 THEN PRINl': <ERROR>: SOUND 88,3: GOTO 775

PRINT: PRINT "1 - NO DIVERSITY"; PRINT "2 - SPACE DIVERSITY"

PRINT: PRINT "3 - FREQUENCY DIVERSITY"; PRINT: PRINT "INPUT DIVERSITY OPTION"

QX$=INKEY$: IF QX$="" THEN 805

IF QX$="EXIT" THEN RETURN ELSE FLAG3=VAL(QX$)

IF FLAG3<2 OR FLAG3>3 THEN 860

IF FLAG3=2 THEN 825 ELSE 845

PRINT "VERTICAL SEPARATION (M) "; SD1; INPUT "; QX$

IF QX$="" THEN 835 ELSE SD1=ABS(VAL(QX$))

IF SD1>0.01 THEN PRINT "<ERROR>"; SOUND 88,3: GOTO 825

GOTO 860

PRINT "FREQUENCY SEPARATION (MHZ) "; FD1; INPUT "; QX$

IF QX$="" THEN 855 ELSE FD1=ABS(VAL(QX$))

IF FD1<7 THEN PRINT "<ERROR>"; SOUND 88,3: GOTO 845

RETURN
1200 REM *************************EQUIPMENT PARAMETERS CONTROL
1205 CLS:PRINT"PROGRAM ***RADLNK*** EQUIMENT PARAMETERS INPUT"
1210 PRINT:"Z$=""NOT IN DATABASE"
1215 PRINT:PRINT:PRINT
1220 PRINT TAB(17)"KEYBOARD INPUT":PRINT TAB(22)"1 - SPECIFY DATA";PRINT
1225 PRINT TAB(17)"FILE INPUT":PRINT TAB(22)"2 - VIEW DATA BASE"
1230 PRINT TAB(22)"3 - MODIFY EQUIPMENT DATABASE":PRINT TAB(22)"4 - WRITE NEW EQ
1235 PRINT TAB(22)"5 - PRINT EQUIPMENT LIST":PRINT:PRINT TAB(17)"EXIT":PRINT TAB
1240 QX$=INKEY$:IF QX$="" THEN 1240
1245 IF VAL(QX$)<1 OR VAL(QX$)>6 THEN 1240
1250 IF VAL(QX$)=6 THEN RETURN
1251 IF VAL(QX$)=1 THEN 1265
1252 PRINT"CURRENT EQUIPMENT FILES"
1253 FILES "*.EQP"
1255 PRINT:INPUT"INPUT EQUIPMENT MANUFACTURER ";Z$
1260 Z$=LEFT$(Z$,5)+".EQP"
1265 ON VAL(QX$) GOSUB 1500,2500,3000,2600,2800
1270 GOTO 1205
REM ****************************SPECIFY EQUIPMENT PARAMETERS
CLS:PRINT"PROGRAM ***RADIINK*** SPECIFY EQUIPMENT PARAMETERS"
PRINT"EQUIPMENT MANUFACTURER FILE: ");Z$ 
PRINT"FREQUENCY ");F1:PRINT" TX POWER ");P2 
PRINT"RX THRESHOLD ");R1:PRINT" TX ANT GAIN ");G1:PRINT" RX ANT GAIN ");G2 
PRINT"WAVEGUIDE LOSS ");G3 
INPUT"EQUIPMENT TYPE ");QX$ 
IF QX$="" THEN 1545 
IF QX$="EXIT" THEN RETURN ELSE N3$=QX$ 
INPUT"SIGNAL FREQUENCY GHZ ");QX$ 
INPUT"TRANSMIT POWER DBM ");QX$ 
INPUT"RECEIVE THRESHOLD DEM ");QX$ 
IF QX$="" THEN R1=VAL(QX$) 
INPUT"TOTAL WAVEGUIDE LOSSES ");G3 
PRINT"<INPUT DISH SIZE (M) Y/N" 
QX$=INKEY$: IF QX$="" THEN 1585 
IF QX$="Y" THEN 1625 
INPUT"TRANSMIT ANTENNA GAIN (DBI)";QX$ 
IF QX$="" THEN G1=VAL(QX$) 
INPUT"RECEIVE ANTENNA GAIN (DBI)";QX$ 
IF QX$="" THEN G2=VAL(QX$) 
N5$=" " 
RETURN 
INPUT"SIZE OF BOTH DISH ANTENNAS (M) ");DD 
G1=10*LOG(4.78*(ABS(DD)*P1/.3)^2)/LOG(10) 'DISH ANTENNA GAIN 
N5$=" +"+STR$(DD)+"M DISH" 
G2=G1 
RETURN
2000 REM ********************LINK PERFORMANCE REPORT
2005 IF P1<=0 OR P1=0 THEN PRINT"<NO DATA>";SOUND 88,3:GOSUB 4100:RETURN
2010 P9=92.5+20*LOG(P1)/LOG(10)+20*LOG(F1)/LOG(10)
2013 GOSUB 3300 'ATMOSPHERIC ATTENUATION
2015 R9=P2+G1+G2-P9-G3-ATMOS
2017 GOSUB 3200
2020 F9=R9-R1
2022 GOSUB 3240
2025 GOSUB 3200
2030 T44=P1*P1/(KF*50.96)
2035 T48=17.34*SQR(P1/(4*F1))
2040 O2=0
2045 IF FLAG3=3 THEN 2050 ELSE 2060
2050 IF O1<=.05 THEN X=SQR(O1)/.18*FD1/F1 ELSE X=O1/(.035*FD1/F1)
2055 GOTO 2065
2060 IF FLAG3=2 THEN X=830*P1*10^(-F9/10)/(F1*SD1*SD1) ELSE 2070
2065 X=X/SQR(1+X*X)
2070 IF O1>=.05 THEN X=SQR(O1)/.18*FD1/F1 ELSE 2080
2080 IF 01>=.05 THEN X=SQR(O1)/.18*FD1/F1 ELSE 2090
2090 IF 01>100 THEN 01=100
2100 IF 02>100 THEN 02=100
2105 IF 09<0 THEN 09=0
2110 IF 08<0 THEN 08=0
2115 PRINT"SUBROUTINE *LINK PERFORMANCE PRINTOUT*"
2120 LPRINT"PROGRAM ***RADINK*** MICROWAVE LINK PREDICTIONS"
2125 LPRINT;LPRINT"SYSTEM DETAILS"
2130 LPRINT USING " Frequency " ###.###";F1;LPRINT" GHz"
2135 LPRINT USING " Path Length " ###.###";F1;LPRINT" Km"
2140 IF FLAG2=1 THEN LPRINT USING " Bearing of STATION B " ###.###";H;LPRINT"
2145 PRINT"STATION A " ;N1$
2150 IF FLAG2=1 THEN LPRINT" Latitude & Longitude " ;
2155 IF FLAG2=1 THEN LPRINT USING " ###.### " ;AA1;AA2
2160 LPRINT" STATION B " ;N2$
2165 IF FLAG2=1 THEN LPRINT" Latitude & Longitude " ;
2170 IF FLAG2=1 THEN LPRINT USING " ###.### " ;BB1;BB2
2175 LPRINT" Equipment Type " ;N3$;N5$
2180 LPRINT;LPRINT" TERRAIN DATA";TAB(36)"PERFORMED AT K = ",;KF
2185 LPRINT USING " Earth Bulge " ###.###";T44;LPRINT" m"n
2190 LPRINT USING " RMS Roughness " ###.###";T46;LPRINT" m"
2195 LPRINT USING " Fresnel Zone Radius " ###.###";T48;LPRINT" m"
2200 LPRINT;LPRINT" LINK SIGNAL LEVELS"
2205 LPRINT USING " Free Space Path Loss " ###.###";P9;LPRINT" dB"
2210 LPRINT USING " Transmit Antenna Gain " ###.###";G1;LPRINT" dB"
2215 LPRINT USING " Receive Antenna Gain " ###.###";G2;LPRINT" dB"
2220 LPRINT USING " Transmit Power " ###.###";P2;LPRINT" dBm"
2225 LPRINT USING " Waveguide + Other Losses " ###.###";G3;LPRINT" dB"
2227 LPRINT USING " Atmospheric Attenuation " ###.###";ATMOS;LPRINT" dB"
2230 LPRINT;LPRINT USING " MEDIAN RECEIVE LEVEL " ###.###";R9;
2235 LPRINT" dBm"
2240 LPRINT USING " Receive Threshold " ###.###";R1;LPRINT" dBm"
2245 LPRINT;LPRINT USING " FADE MARGIN " ###.###";F9;
2250 LPRINT" dB"
2255 LPRINT;LPRINT" RAIN ATTENUATION OUTAGES"
2260 LPRINT USING " Climate Factor " ###.###";R3
2800 REM *************************PRlNT EQUIPMENT LIST
2805 LPRINT"PROGRAM ***RAD LINK*** EQUIPMENT LIST"
2810 LPRINT:"Manufacturer ";Z$
2815 LPRINT:"  TYPE";TAB(28);"F GHz";TAB(35);"Tx P OW";TAB(45);"Rx THRS";TAB(55)
2820 OPEN Z$ FOR INPUT AS #1
2825 INPUT #1,N3$,G3,P2,R1,G1,F1
2830 IF LEFT$(N3$,3)="END" THEN 2855
2835 LPRINT TAB(5);N3$;TAB(26);:LPRINT USING"###.###";F1;
2840 LPRINT USING"###.###";P2;LPRINT USING"###.###";R1;
2845 LPRINT USING"###.###";G1;LPRINT USING"###.###";G3
2850 GOTO 2825
2855 CLOSE #1
2860 LPRINT:LPRINT
2865 RETURN
*MODIFY EQUIPMENT FILE*

CLS: FLAG5 = 0

OPEN "DUMP.EQP" FOR OUTPUT AS #2

OPEN #2 FOR INPUT AS #1

INPUT #1, N3$, G3, P2, R1, G1, F1

IF LEFT$(N3$, 3) = "END" THEN FLAG5 = 1

GOSUB 1500

WRITE #2, N3$, G3, P2, R1, G1, F1

PRINT: PRINT"<MORE DATA ? Y/N >"

QX$ = INKEY$: IF QX$ = "" THEN 3045

IF QX$ = "N" THEN 3055 ELSE IF FLAG5 = 1 THEN 3030 ELSE 3020

IF FLG5 = 0 THEN 3060 ELSE 3075

INPUT #1, N3$, G3, P2, R1, G1, F1

WRITE #2, N3$, G3, P2, R1, G1, F1

WRITE #2, "END", G3, P2, R1, G1, F1

CLOSE #2

CLOSE #1

REM SWAP FILES

OPEN #2 FOR OUTPUT AS #1

OPEN "DUMP.EQP" FOR INPUT AS #2

INPUT #2, N3$, G3, P2, R1, G1, F1

WRITE #1, N3$, G3, P2, R1, G1, F1

WRITE #1, "END" THEN 3120 ELSE 3105

CLOSE #1: CLOSE #2

KILL "DUMP.EQP"

RETURN
3200 REM  ******AMPLITUDE DISPERSION FADING
3205 IF T46<6 THEN T4=6
3210 IF T46>42 THEN T4=42 ELSE T4=T46
3215 O1=.002088*(10^(-F9/20»'2*F1*(P1'3)*(T4'-1.27)*R3
3220 IF O1>=99 THEN 3230
3225 RETURN
3230 O1=100-2.37*(T4'-1.27)*R3*10^(F9/7.88)/LOG(P1/10)
3235 RETURN

3240 REM  ******RAIN FADING
3245 IF F1>75 THEN DU=75+.3*(F1-75) ELSE DU=F1
3250 A8=.495*LOG(R2)-1.931+(2.847-.1911 *LOG(R2)) *LOG(.4344*LOG(DU))
3255 A8=P1*10^A8
3260 IF R4$="M" THEN R4=R44 ELSE R4=R44
3265 IF A8<F9 THEN PRY=R4*(ABS(A8/F9))'3.2 ELSE PRY=R4*(ABS(A8/F9))'2.6
3270 PRT=(3.45*PRY)'8.7
3275 RETURN

3300 REM  ******ATMOSPHERIC ATTENUATION
3305 IF F1>57 THEN 3320
3310 A8=(6.6/(F1'2+.33)+9/((ABS(F1-57))'2+1.96))*F1'2*.001
3315 GOTO 3335
3320 IF F1<63 THEN A8=14.9:GOTO 3335 ELSE 3325
3325 IF F1>350 THEN A8=100:GOTO 3335
3330 A8=(4.13/((ABS(F1-63)^2+1.1)+.19/(ABS(F1-118.7)^2+2)))*F1'2*.001
3335 ATMOS=P1*A8
3340 RETURN
************BEARINGS & DISTANCE**
**OUTPUT**
H=HORIZONTAL DEGREES
**P=**DISTANCE(KILOMETERS)
**PRINT:** PRINT"BEARINGS & DISTANCE"
PRINT"SOUTH LATITUDES ENTER AS -VE"
PRINT"EAST LONGITUDES ENTER AS -VE"
PI#=3.1415927#:FLAG2=1

INPUT"TERMINAL A LAT, LONG :";AA1,AA2
A1#=AA1/360*2*PI#
A2#=AA2/360*2*PI#

INPUT"TERMINAL B LAT, LONG :";BB1,BB2
B1#=BB1/360*2*PI#
B2#=BB2/360*2*PI#

A3#=B2#-A2#
A4#=SIN(A1#)*SIN(B1#)+COS(A1#)*COS(B1#)*COS(A3#)

A5#=SQR(1-A4#*A4#)
A6#=A5#/A4#:A7#=ATN(A6#)

IF A6#<0# THEN 3585 ELSE 3590
A7#=PI#+A7#
D#=60*360*A7#/2*PI#)

H1#=(SIN(A1#)*SIN(A1#)*COS(A7#))/SIN(A7#)*COS(A1#))

IF H1#*H1#=1# THEN H2#=0#: ELSE H2#=SQR(1-#H1#*H1#)
H3#=H2#/H1#
H4=ATN(H3#)

IF H4<0 THEN 3625 ELSE 3630
H4=PI+H4
H5=H4*57.2957795#

IF SIN(A3)<0 THEN H=H5 ELSE H=360-H5
GO TO 795
3800 REM ****B*U*R*G*E*R*****PATH GEOMETRY
3805 CLS:PRINT"PROGRAM *****RADLINK*** PATH GEOMETRY & EVALUATION"
3810 PRINT:PRINT:PRINT:PRINT:PRINT TAB(22)"1 - ENTER PATH PROFILE"
3815 PRINT TAB(22)"2 - ENTER SUPPORT HEIGHTS"
3820 PRINT TAB(22)"3 - PLOT A3 SIZE";PRINT TAB(22)"4 - PLOT A4 SIZE"
3825 PRINT TAB(22)"5 - PRINT PATH INFORMATION";PRINT TAB(22)"6 - GROUND/SEA REFLECTION ANALYSIS"
3830 PRINT TAB(22)"7 - EXIT TO MAIN MENU";PRINT:PRINT
3835 QX$=INKEY$:IF QX$="" THEN 3835
3840 IF VAL(QX$)<1 OR VAL(QX$)>7 THEN 3835
3845 SOUND 100,1;IF VAL(QX$)=7 THEN RETURN
3850 IF VAL(QX$)=3 THEN U5=80:U6=80 ELSE U5=35:U6=50
3860 ON VAL(QX$) GOSUB 4200,4000,5200,5200,5000,6500
3865 GOTO 3805
4000 REM ********************SUPPORT HEIGHTS
4005 CLS:PRINT"PROGRAM ***RADINK*** STATION SUPPORT HEIGHT [AGL]"
4010 PRINT:PRINT"EXISTING SUPPORT HEIGHT AT ";N1$;TAB(44);" =";D1;" M [A]"
4015 PRINT"EXISTING SUPPORT HEIGHT AT ";N2$;TAB(44);" =";D2;" M [B]"
4020 PRINT:INPUT"HEIGHT OF STATION [A] SUPPORT (M)";QX$
4025 IF QX$="" THEN 4030 ELSE D1=ABS(VAL(QX$))
4030 INPUT"HEIGHT OF STATION [B] SUPPORT (M)";QX$
4035 IF QX$="" THEN 4040 ELSE D2=ABS(VAL(QX$))
4040 RH2=4.12*(SQR(D1)+SQR(D2))
4045 PRINT"<RADIO HORIZON (SMOOTH EARTH) =";RH2;" KM"
4050 GOSUB 4100
4055 RETURN

4100 REM ****************************WAIT
4105 FOR COUNT=1 TO 655:NEXT COUNT
4110 RETURN
4200 REM ******************PATH PROFILE ENTRY
4205 CLS:PRINT"PROGRAM ***RADLINK*** CONTOUR PROFILE ENTRY [ASL]"
4210 PRINT:PRINT:PRINT"THE HEIGHT OF EACH STATION (ABOVE DATUM) IS ENTERED"
4215 PRINT"AT ZERO DISTANCE FROM STATION [A]. STATION [B] DATUM HEIGHT"
4220 PRINT"IS ENTERED AT THE ACTUAL PATH LENGTH DISTANCE":PRINT
4225 IF P1<=.0003 THEN INPUT"DISTANCE BETWEEN TERMINALS (KM) ";P1 ELSE PRINT"PATH DISTANCE = ";P1;" KM"
4230 PRINT:PRINT"<EDIT PATH DATA > Y/N"
4235 QX$=INKEY$:IF QX$="" THEN 4235
4240 IF QX$="Y" THEN GOSUB 4500
4245 PRINT:PRINT"TYPE 'EXIT' WHEN ALL DATA POINTS ARE ENTERED":PRINT
4250 PRINT"DATA POINT ";N+1:INPUT" DISTANCE FROM [A] KM ";QX$
4255 IF QX$="" THEN 4250
4260 IF QX$="EXIT" THEN 4290
4265 IF VAL(QX$)<0 OR VAL(QX$)>(P1+.001) THEN PRINT"<ERROR>";SOUND 88,3:GOTO 425
0 ELSE N=N+1
4270 XD(N)=VAL(QX$)
4275 INPUT" HEIGHT AT THIS POINT M ";YD(N)
4280 PRINT:PRINT
4285 GOTO 4250
4290 FOR J=1 TO N
4295 FOR I=2 TO N
4300 IF XD(I)>XD(I-1) THEN 4320
4305 DUMPX=XD(I-1):DUMPY=YD(I-1)
4310 XD(I-1)=XD(I):YD(I-1)=YD(I)
4315 XD(I)=DUMPX:YD(I)=DUMPY
4320 NEXT I
4325 NEXT J
4330 RETURN
4500 REM ***************PATH DATA EDITOR
4505 CLS:PRINT"PROGRAM ***RADLNK***
        PATH PROFILE DATA EDITOR"
4510 PRINT:PRINT"POINT", "DIST", "HEIGHT"
4515 FOR I=1 TO N:PRINT I,XD(I),YD(I):NEXT I
4520 PRINT:PRINT"(E)DIT (R)ESET  E(X)IT"
4525 QX$=INKEY$:IF QX$="" THEN 4525
4530 IF QX$="R" THEN 4560
4535 IF QX$="E" THEN INPUT"INPUT POINT,DIST,HEIGHT";J,XJ,YJ ELSE 4290
4540 IF J>N OR J<0 THEN PRINT"<ERROR>";SOUND 88,4:GOTO 4505
4545 IF XD(J)>P1+.0001 THEN PRINT"<ERROR>";SOUND 88,4:GOTO 4505
4550 IF XD(J)<0 THEN PRINT"<ERROR>";SOUND 88,4:GOTO 4505 ELSE XD(J)=XJ;YD(J)=YJ
4555 GOTO 4505
4560 FOR I=1 TO N
4565 XD(I)=0;YD(I)=0
4570 NEXT I
4575 FOR I=1 TO 101
4580 X(I)=0;Y(I)=0;RF(I)=0
4585 NEXT I
4590 N=0
4595 RETURN
REM ***************DEFAULT VALUES
CLS:PRINT"PROGRAM ***RADLNK*** DEFAULT PARAMETERS SET"
PRINT:PRINT:PRINT"RMS ROUGHNESS (M) ":TAB(40);T46;TAB(55);
INPUT QX$
IF QX$="" THEN 4725 ELSE T46=ABS(VAL(QX$))
PRINT:PRINT"K FACTOR ":TAB(40);KF:TAB(55);
INPUT QX$
IF QX$="" THEN 4740 ELSE KF=VAL(QX$)
IF KF<.4 THEN KF:.6
IF KF>10 THEN KF:10
PRINT:PRINT"RAINFALL RATE PERCENTILE DATA ":TAB(40);R44:TAB(55);
INPUT QX$
IF QX$="" THEN 4765 ELSE R44=ABS(VAL(QX$))
PRINT:PRINT"RAINFALL BASED MONTH OR YEAR M/Y ":TAB(42);R4$:TAB(55);
INPUT QX$
IF QX$="" THEN 4785
IF QX$="Y" OR QX$="M" THEN R4$:QX$:GO TO 4785 ELSE PRINT"<ERROR>":SOUND 88,3:GOTO 4765
4785 RETURN
5500 REM ********************DOT JOINING - DATA FILL
5505 PRINT 'NYQUIST SAMPLING OF INPUT DATA
5510 FOR I=1 TO 101:X(I)=0;Y(I)=0:RF(I)=0:NEXT I:PRINT"<WAIT>"
5515 FOR I=1 TO U5+1
5520 KN=0
5525 FOR J=1 TO N
5530 X(I)=R*(I-1)
5535 IF ABS(XD(J)-X(I))<.51*R AND KN=0 THEN Y(I)=YD(J):KN=1:GOTO 5545
5540 IF ABS(XD(J)-X(I))<.51*R AND KN=1 THEN Y(I+1)=YD(J)
5545 NEXT J
5550 NEXT I
5555 I=0
5560 REM DOT JOINING
5565 I=I+1
5570 IF I>U5+1 THEN PRINT"DOT JOINING COMPLETE":RETURN
5575 IF Y(I)=0 THEN 5565
5580 J=I
5585 J=J+1
5590 IF J>U5+1 THEN 5600
5595 IF Y(J)=0 THEN 5585
5600 FOR K=I TO J-2
5605 Y(K+1)=Y(K)-(Y(I)-Y(J))/(J-I)
5610 NEXT K
5615 I=J-1
5620 GOTO 5565
5700 REM ****************************EARTH BULGE
5705 REM  PERFORMED AT K
5710 FOR I=2 TO U5
5715 DS=P1/U5*(I-1)
5720 Y(I)=Y(I)+(DS*P1-DS*DS)/(KF*12.74)
5725 NEXT I
5730 PRINT"<EARTH BULGE ADJUSTMENT COMPLETE>"
5735 RETURN

5800 REM ****************************RMS ROUGHNESS
5805 M=0:B=0:C=0:T=0
5810 FOR I=2 TO U5
5815 RF(I)=D1+(D1-D2)/(I/05)-Y(I)
5820 NEXT I
5825 FOR I=2 TO U5
5830 C=C+RF(I):B=B+RF(I)*RF(I)
5835 NEXT I
5840 M=C/U5;V=(B-U5*M*M)/(U5-1):T46=SQR(V)
5845 PRINT"<RMS ROUGHNESS COMPLETE>":T46
5850 REM  ****************************RAYLINE CLEARANCE
5855 FOR I=1 TO 101:RF(I)=0:NEXT I
5860 RF(1)=D1:RF(U5+1)=D2
5865 FOR I=2 TO U5
5870 RF(I)=I*(D2+Y(U5+1)-D1-Y(I))/(U5+D1+Y(I)-Y(I)
5875 NEXT I
5880 PRINT"<RAYLINE CLEARANCE COMPLETE>"
5885 RETURN
REM ****************************SCALING PLOT
6005 X1=Y(1);Y2=Y(1)
6010 FOR I=1 TO U5+1
6015 IF(Y1-Y(I))<=0 THEN 6030 ELSE 6020
6020 Y1=Y(I)
6025 GOTO 6040
6030 IF (Y2-Y(I))<0 THEN 6035 ELSE 6040
6035 Y2=Y(I)
6040 NEXT I
6045 IF Y2<(Y(1)+D1) THEN Y2=Y(1)+D1
6050 IF Y2<(Y(U5+1)+D2) THEN Y2=Y(U5+1)+D2
6055 IF (Y2-Y1)>120 THEN KK=.04 ELSE KK=.2
6060 Y1=INT(KK*(Y1-2.6))/KK
6065 Y2=CINT(KK*(Y2+2.6)+.85)/KK
6070 YD=Y2-Y1
6075 PRINT"<PLOT SCALING COMPLETED>"
6080 RETURN
REM ******************** PLOTTER
6205 IF Y2>850 THEN Z$="#.##" ELSE Z$="#..#" "
6210 L=YD/U6;WIIIJI'H 1lLP1'1: 1I , 100
6215 OPEN "LP1":" FOR OUTPUT AS #1
6220 W=1:PRINT"<PLOTTING PATH PROFILE>"
6225 PRINT #1,"TERRAIN PROFILE ";N1$; " TO ";N2S
6230 PRINT #1," ";PRINT #1,TAB(10);"HEIGHT (M)";TAB(U6+14);"CLR"
6235 FOR U=0 TO U6/10:PRINT #1,TAB(U*9+8+U-1);:PRINT #1,USING Z$;U*10*L+Y1;
6240 NEXT U:PRINT #1," "
6245 PRINT #1,TAB(10);:FOR I=1 TO U6/5:PRINT #1,"+----";:NEXT I:PRINT #1,"+
6250 FOR I=1 TO U5+1
6255 J=SUB 4100 "WAIT"
6260 PRINT #1,MIDS("KILOMETERS",W,1);:PRINT #1,TAB(2);:PRINT #1,USING "###.##";X(I);
6265 IF I=1 THEN 6310
6.  IF I=U5+1 THEN 6325
6270 PRINT #1,TAB(9)"I";TAB((Y(I)-Y1)/L+10.5);">";TAB(U6+11);"I";
6280 PRINT #1,USING Z$;RF(I)
6285 W=W+1:NEXT I
67 I=SUB 4100 "WAIT"
6300 PRINT #1," ";PRINT #1," ";PRINT #1," ";CLOSE #1;WIDTH "LP1":",80
6305 RETURN
6310 PRINT #1,TAB(9)"I";TAB((Y(I)-Y1)/L+10.5);">";TAB((Y(I)+D1-Y1)/L+11.5);"*";TAB(U6+11);"I";
6315 PRINT #1,USING Z$;RF(I)
6320 GOTO 6285
6325 PRINT #1,TAB(9)"I";TAB((Y(I)-Y1)/L+10.5);">";TAB((Y(I)+D2-Y1)/L+11.5);"*";TAB(U6+11);"I"
6330 PRINT #1,USING Z$;RF(I)
6335 GOTO 6285
REM  **********************************PROFILE SCAN FOR ILLUMINATED REGION
Z$="ILLUMINATED PATH"
ALF=SQR(30000/10*(G1/10))/2 'HALF 3DB BEAMWIDTH
BET=SQR(30000/10*(G2/10))/2 'HALF 3DB BEAMWIDTH
HA=SIN(P1*8.980001E-03)*(6380.43+Y(1)+O1)
HB=SIN(P1*8.980001E-03)*(6380.43+Y(U5+1)+O2)
HA=ATN(HA/SQR(ABS(1-HA*HA)))*180/3.14159
HB=ATN(HB/SQR(ABS(1-HB*HB)))*180/3.14159
FOR I=1 TO U5+1
THET1=ATN(X(I)/(Y(1)+D1-Y(I))) 'ANGLE TO GND POINT
IF THET1>HB-BET THEN 7060
X1=I+1
THET2=ATN((P1-X(I))/(Y(U5+1)+D2-Y(I))) 'ANGLE TO GND POINT
IF THET2<HA-ALF THEN 7075
X2=I-1
NEXT I
IF X1>=X2 THEN X1=0:X2=0:Z$="NON EXISTANT"
PRINT"<ANT PROFILE SCAN COMPLETED>"
RETURN

REM  **********************************END
CLS:SOUND 88,6:END