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Radio Mobile

Software for Wireless Systems Planning

**ICTP-ITU School on Wireless ICT Low Cost solutions in
Developing Countries: best practices**

Abdus Salam ICTP, Trieste, February 2009



What is Radio Mobile?

- A tool for the design and simulation of wireless systems
- Predicts the performance of a radio link
- Uses digital maps and GIS (Geographical Information Systems) as well as any other digital map, even the ones digitized by yourself
- It is freely available
- Runs on Windows 95, 98, ME, NT, 2000 and XP
- Uses Digital terrain Elevation Model for the calculation of coverage, indicating received signal strength at various point along the path



Terrain Profile

- Radio Mobile automatically builds a profile between two points in the digital map showing the coverage area and 1st Fresnel zone.
- Digital elevation maps (DEM) are available from several sources, some freely downloadable
- Different antenna heights can be tried to achieve optimum performance



Features

- Works from 20 MHz to 200 GHz
- Checks for **line of sight**
- Calculates **path loss**, including diffraction losses due to obstacles
- Creates networks of different topologies (net master/slave, PTP and PMP)
- Calculates coverage area from the base station in a point to multipoint systems.



Irregular Terrain Model

- **The ITS model of radio propagation for frequencies between 20 MHz and 20 GHz (the Longley-Rice model) is a general purpose model that can be applied to a large variety of engineering problems. The model, which is based on electromagnetic theory and on statistical analyses of both terrain features and radio measurements, predicts the median attenuation of a radio signal as a function of distance and the variability of the signal in time and in space**



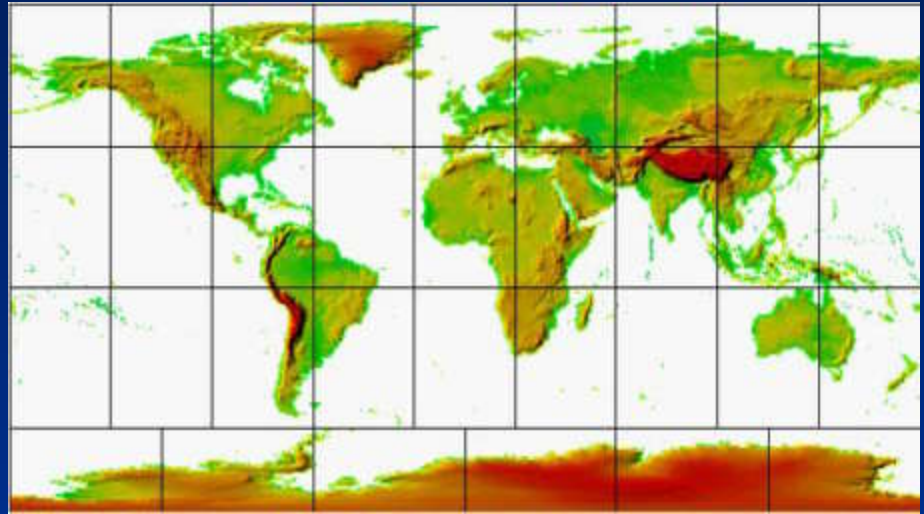
ITM parameters

d	Distance between the two terminals.
h_{g1}, h_{g2}	Antenna structural heights.
k	Wave number, measured in units of reciprocal lengths;
Δh	Terrain irregularity parameter.
N_s	Minimum monthly mean surface refractivity, measured in N-units;
γ_e	The earth's effective curvature, measured in units of reciprocal length
Z_g	Surface transfer impedance of the ground—a complex, dimensionless number;
radio climate	Expressed qualitatively as one of a number of discrete climate types.



What do you need to create a Network?

- Download Radio Mobile from internet:
<http://www.cplus.org/rmw/english>
- Where to get elevation data?
 - New sources are coming up and usually reported at the Radio Mobile home page



Resolution

- Resolution is expressed in arc sec ($1/3600$) of a degree
- At the equator, earth circumference is about 40000 km, 1 arc sec \sim 30 m
- At the pole, earth circumference is zero
- Actual east-west resolution depends of latitude, whereas north-south is constant



DEM Sources

- **Free World at 3 arc second resolution (100m) SRTM version 2**
- Shuttle Radar Topography Mission (SRTM) data products - Africa
- Shuttle Radar Topography Mission (SRTM) data products - Australia
- Shuttle Radar Topography Mission (SRTM) data products - Eurasia
- Shuttle Radar Topography Mission (SRTM) data products - Islands
- Shuttle Radar Topography Mission (SRTM) data products - North America
- Shuttle Radar Topography Mission (SRTM) data products - South America

- **Free World and US in BIL format at up to 1/9 arc second resolution (3m)**
- **Seamless data distribution system**
- **Convert BIL to SRTM with BILxSRTM V2**



Pictures

- DEM do not show coastlines or other readily identifiable landmarks, but they can be combined with other kind of data in several layers to obtain a more useful and readily recognizable representation.
- You can digitize your own maps and combine them with DEM



Datum as used here refers to a smooth surface somewhat arbitrarily defined as "zero elevation," consistent with a set of surveyor's measures of distances between various stations, and differences in elevation, all reduced to a grid of **latitudes**, **longitudes**, and **elevations**.

WGS 84. It is currently the reference system being used by the **Global Positioning System**. It is geocentric and globally consistent within ± 1 m

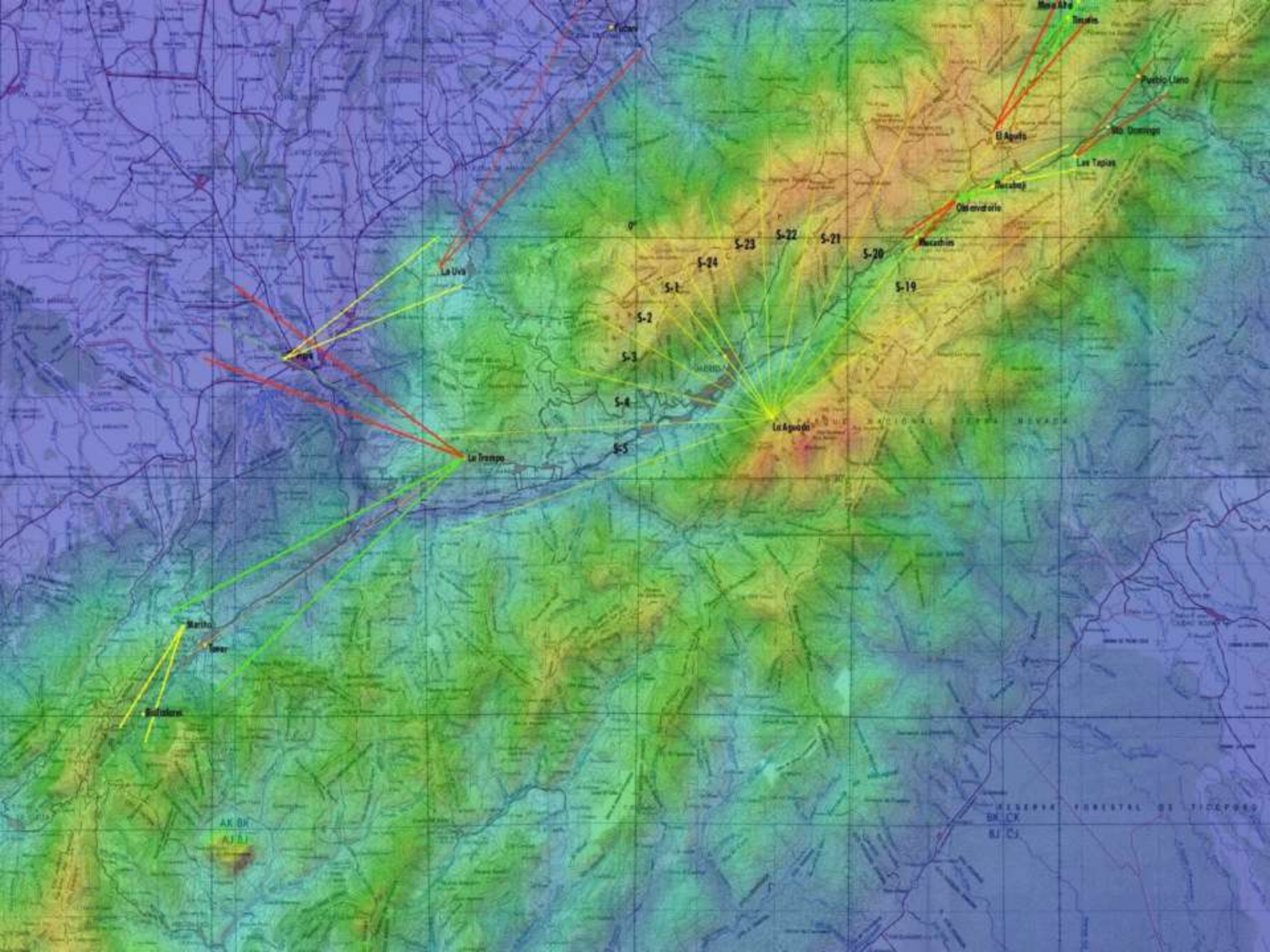
From: Wikipedia



Terminology used in R.M.

- A radio station is referred to as a **Unit**, there can be numerous Units defined to operate within a given **Network**. Each different type of station used in a network has to be defined with a separate **Radio System** which sets the parameters for that type of station, i.e. Transmit Power/receiver sensitivity/antenna gain/antenna height/cable losses.
- Thus each Unit will be allocated to an operating **system** within the network. Finally, all units are given a
- **Role**, which is either **Command** or **Subordinate**. The effect of this is to set which links are shown on the network display





GPS tracking

- Opens a form in order to initiate GPS position acquisition via a serial port and enter Internet addresses at which position will be reported (see How to use a local GPS and report position)



Elevation grid

- The deployment area is a rectangular zone with horizontal coordinates for the center position and a size in kilometers that should be large enough to contain all units
- Opens a small window that shows 5x5 elevation data records centered at cursor position along with cursor coordinates

Deployment area

- The deployment area is a rectangular zone with horizontal coordinates for the center position and a size in kilometers that should be large enough to contain all units



Maps

- Maps are based on a matrix of up to 2000x2000 elevation records (meters above sea level), which can be saved in a file with a .MAP extension. Map data can be viewed with the Elevation grid.
- **Terrain Elevation Data**
- Digital Terrain Elevation Data (MIL-D-89020 AMENDMENT 1).
- Maps are based on digital terrain elevation data. The program can actually access a resolution of 1, 3, or 30 seconds of an arc, which corresponds to a spacing of approximately 30m, 100m, or 1 km between records.



What do you need to create a network?

- Obtain the coordinates of your stations.
 - From Maps, GPS, or database
 - For example: Site 1 (Main Repeater Galileo 13°43'11" E, 45°42'15"N)
- Specifications of the system:
 - Topology of the network (Point to multipoint,PP).
 - Gain of antennas and type.
 - Max Transmit power (Watt or dBm).
 - Line or guide wave loss.
 - Received power level (dBm).
 - Antennas height in meters.
 - Frequency of operation.
 - Polarization used.
 - Other parameters of radio link and radio communications.



Acquire elevation data

Step by step

- 1. In **View** menu, select World map. On the world map picture, click on the desired position for the map center position.
- 2. In **File** menu, select **Map properties**. This will open a form with all the necessary controls to create a map. Click on Use cursor position button.
- 3. Optionally use city or **coordinates in DMS** (Latitude and longitude in degree, minute, second) to enter a more precise position for the center of the map.
- 4. Select the database and associated logical drive.
- 5. Select 400x400 pixels and 100 km size.
- 6. Click on the **Apply** button.
- 7. If an error message occurs, verify the database drive and redo from step 2.
- 8. In File menu, select **New picture** (See How to create a map picture).



Set up the network

Step by step

- 9. In the file menu select **Networks properties**. Enter network name, frequency of operation, polarization and climate. Accept defaults for the other parameters.
- 10. Click the **Systems** tab. Enter System name, Tx power, RX Threshold, line loss, antenna gain, and antenna height. Then select add to radiosys.dat.
- 11. Repeat the previous step for the other site(s). You can have a different antenna gain in different systems. Then click **Apply**.
- 12. From the file menu, select **unit properties**. There are several methods for specifying the unit. If you enter the coordinates, the altitude will be calculated from the DEM. West and south coordinates will be negative.
- 13. Repeat for all the units involved



Radio Coverage

- **Radio link:**
 - Opens a form with a picture box that shows earth profile, radio performance, and observation features between each pair of units (see Radio link and system performance).
- **Visual coverage:**
 - Opens a form in order to initiate visual coverage drawing on a map picture (see How to perform visual coverage).
- **Radio coverage:**
 - Opens a form in order to initiate radio coverage drawing on a map picture (see How to perform radio coverage).



Example

MAPQUEST Elevation (m)

< -18 284 586 887 1189 1491 1793 2095 2396 2698 3000

0 9km 9mi

Radio Link

Edit View Swap

Elevation=2000.0m	Azimuth=49.8°	Clearance at 15.59km	Worse Fresnel=0.4F1	Distance=21.44km
PathLoss=126.8dB	E field=56.7dB μ V/m	Rx level=-64.7dBm	Rx level=130.09 μ V	Rx Relative=18.8dB

Transmitter

maracay

Role Command

Tx system name System 1

Tx power 0.032 W 15.05 dBm

Line loss 0.5 dB

Antenna gain 24 dBi 21.85 dBd

Radiated power EIRP=7.16 W ERP=4.37 W

Antenna height (m) 100 Apply

Receiver

sierra1

Role Subordinate

Rx system name System 1

Required E Field 37.98 dB μ V/m

Antenna gain 24 dBi 21.85 dBd

Line loss 0.5 dB

Rx sensitivity 15 μ V -83.48 dBm

Antenna height (m) 150 Apply

Net

maracay

Frequency (MHz)

Minimum 2400 Maximum 2483 Apply

© 2004 MapQuest.com, Inc.

Another Example, 5.4 GHz

Radio Link

Edit View Swap

Elevation=667,0m	Azimuth=136,1°	Clearance at 18,64km	Worse Fresnel=1,4F1	Distance=46,46km
PathLoss=144,2dB	E field=58,8dB μ V/m	Rx level=-62,2dBm	Rx level=174,36 μ V	Rx Relative=2,8dB

Transmitter

Hito Luminico

Role	Command
Tx system name	System 1
Tx power	0,1 W 20 dBm
Line loss	1 dB
Antenna gain	32 dBi 29,85 dBd
Radiated power	EIRP=125,89 W ERP=76,76 W
Antenna height (m)	80 <input type="button" value="Apply"/>

Receiver

Cerro el toro

Role	Command
Rx system name	System 1
Required E Field	55,94 dB μ V/m
Antenna gain	32 dBi 29,85 dBd
Line loss	1 dB
Rx sensitivity	125,89 μ V -65 dBm
Antenna height (m)	60 <input type="button" value="Apply"/>

Net

Net 1

Frequency (MHz)

Minimum	Maximum	<input type="button" value="Apply"/>
5400	5500	

Elevation grid (m)

587	652	629	602	583
601	667	633	566	534
594	655	639	558	482
608	613	611	542	484
607	572	535	495	471

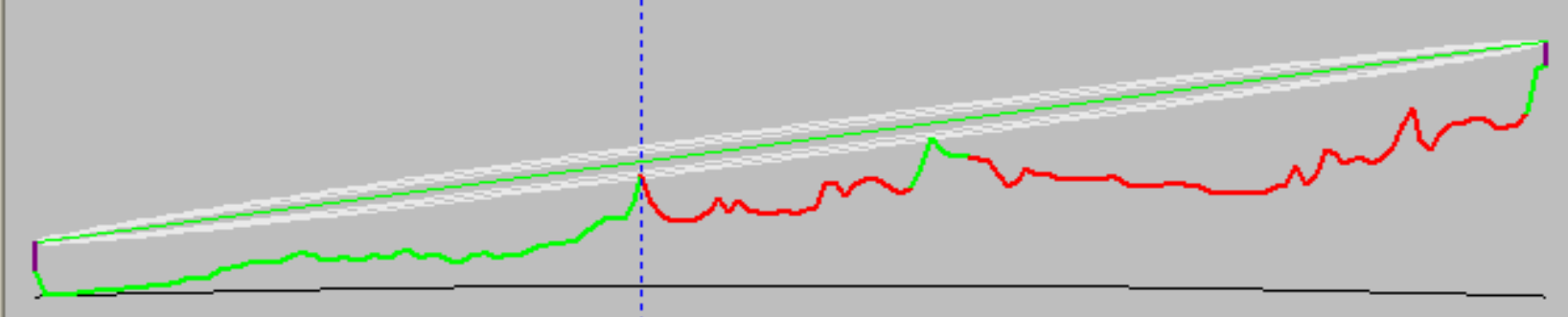
08°00'23"N 062°21'35"W
FJ88TA

Another Example, 5.4 GHz

Radio Link [X]

Edit View Swap

Elevation=336,0m	Clearance=35,03m	Fresnel=1,4F1	Distance=18,61km
PathLoss=131,0dB	E field=71,9dB μ V/m	Rx level=-49,0dBm	Rx level=793,32 μ V
			Rx Relative=16,0dB



Transmitter

[Progress bar] S6

Hito Luminico

Role	Command
Tx system name	System 1
Tx power	0,1 W 20 dBm
Line loss	1 dB
Antenna gain	32 dBi 29,85 dBd
Radiated power	EIRP=125,89 W ERP=76,76 W
Antenna height (m)	<input type="text" value="80"/> <input type="button" value="Apply"/>

Receiver

[Progress bar] S6

Cerro el toro

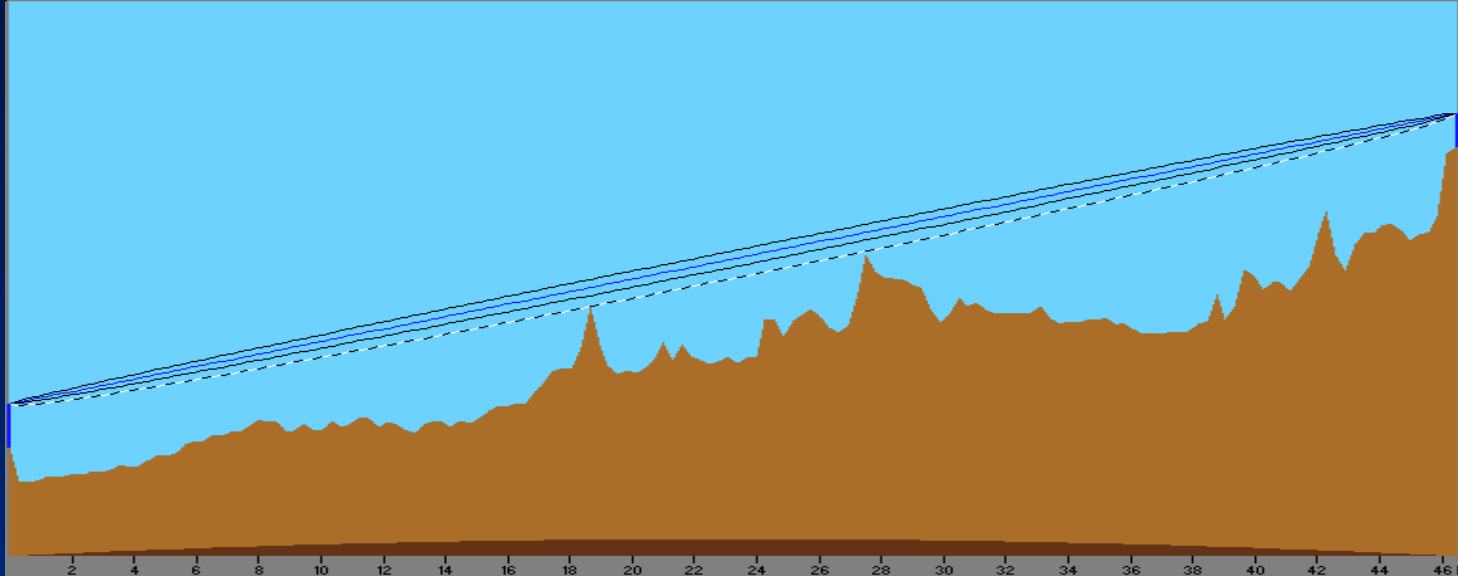
Role	Command
Rx system name	System 1
Required E Field	55,94 dB μ V/m
Antenna gain	32 dBi 29,85 dBd
Line loss	1 dB
Rx sensitivity	125,89 μ V -65 dBm
Antenna height (m)	<input type="text" value="60"/> <input type="button" value="Apply"/>

Net

Net 1

Frequency (MHz)

Minimum	Maximum	<input type="button" value="Apply"/>
<input type="text" value="5400"/>	<input type="text" value="5500"/>	



-
- Distance between Hito Luminico and Cerro el Toro is 46,5 km (28,9 miles)
- True North Azimuth = $136,1^\circ$, Elevation angle = $0,4606^\circ$
- Terrain elevation variation is 615,0 m
- Propagation mode is line-of-sight, minimum clearance 1,4F1 at 18,6km
- Average frequency is 5450,000 MHz
- Free Space = 140,5 dB, Obstruction = 3,8 dB, Urban = 0,0 dB, Forest = 0,0 dB, Statistics = -0,1 dB
- Total propagation loss is 144,2 dB
- System gain from Hito Luminico to Cerro el toro is 147,0 dB
- System gain from Cerro el toro to Hito Luminico is 147,0 dB
- Worst reception is 2,8 dB over the required signal to meet 50,0% of time, 50,0% of locations, and 50,0% of situations

From theory to practice....



The site survey is always required!

From theory to practice....



The site survey is always required!

More Info.

- [Radio Mobile Yahoo Group](#)
- [G8GTZ how to get started guide](#)
- [G3TVU Quick start guide](#)
- [Greg Bur alternative source of documentation](#)
- [Merging pictures](#)
- [Find best sites - Basics](#)
- [Find best sites - A field experience from Ian G3TVU](#)
- [Google Earth](#)

