Radio Mobile

Training materials for wireless trainers

The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

Goals

- To learn how to use Radio Mobile, a free software that provides a detailed propagation model for radio. It allows to simulate a radio link and perform "what if?" scenarios, by changing the link parameters. It can also show the area coverage from a given site.
- There are two versions of the program: an on-line application and a downloadable version that runs on Windows.
- We will also describe the use of Google Earth for building elevation profiles.

Software for radio link simulation

There are many programs that can be used to simulate radio links and base station coverage, some of which cost thousands of dollars.

By using a link simulator, you can save considerable time during link planning and analysis. For example, if a link is proven to be impossible in simulation, there is little need to perform a site survey, and other options have to be considered (such as the use of repeater sites).

Radio Mobile is a free program developed for radio amateurs by Roger Coudé that is based on the well known Longley-Rice Irregular Terrain Model and predicts radio propagation, making use of several sets of freely available Digital Elevation Maps.

Windows Vs Web Radio Mobile:

On-line version (web)

Pros: runs on any machine (Linux, Mac, Tablet); does not require big downloads; saves sessions; user friendly, will fetch the elevation data automatically

Cons: requires connectivity; only certain frequencies

Windows version

Pros: runs offline; can use the GPS

Cons: runs on Windows only; requires big downloads; user must select digital elevation maps; hard to learn

It is advisable to start using the on-line version to get acquainted with the capabilities of the software and then move to the downloadable version for extra features.

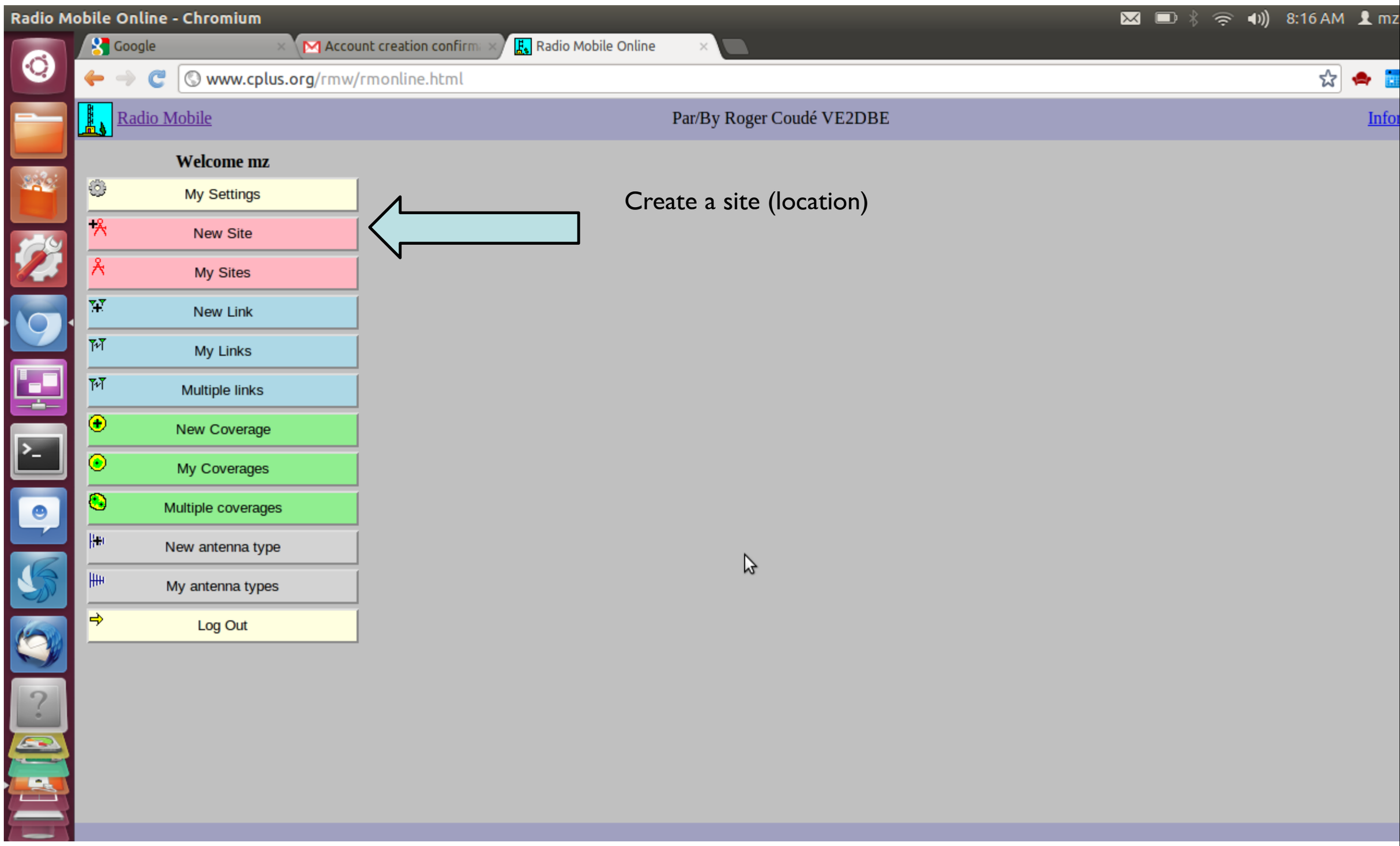
Radio Mobile On-Line

- Point your web browser to

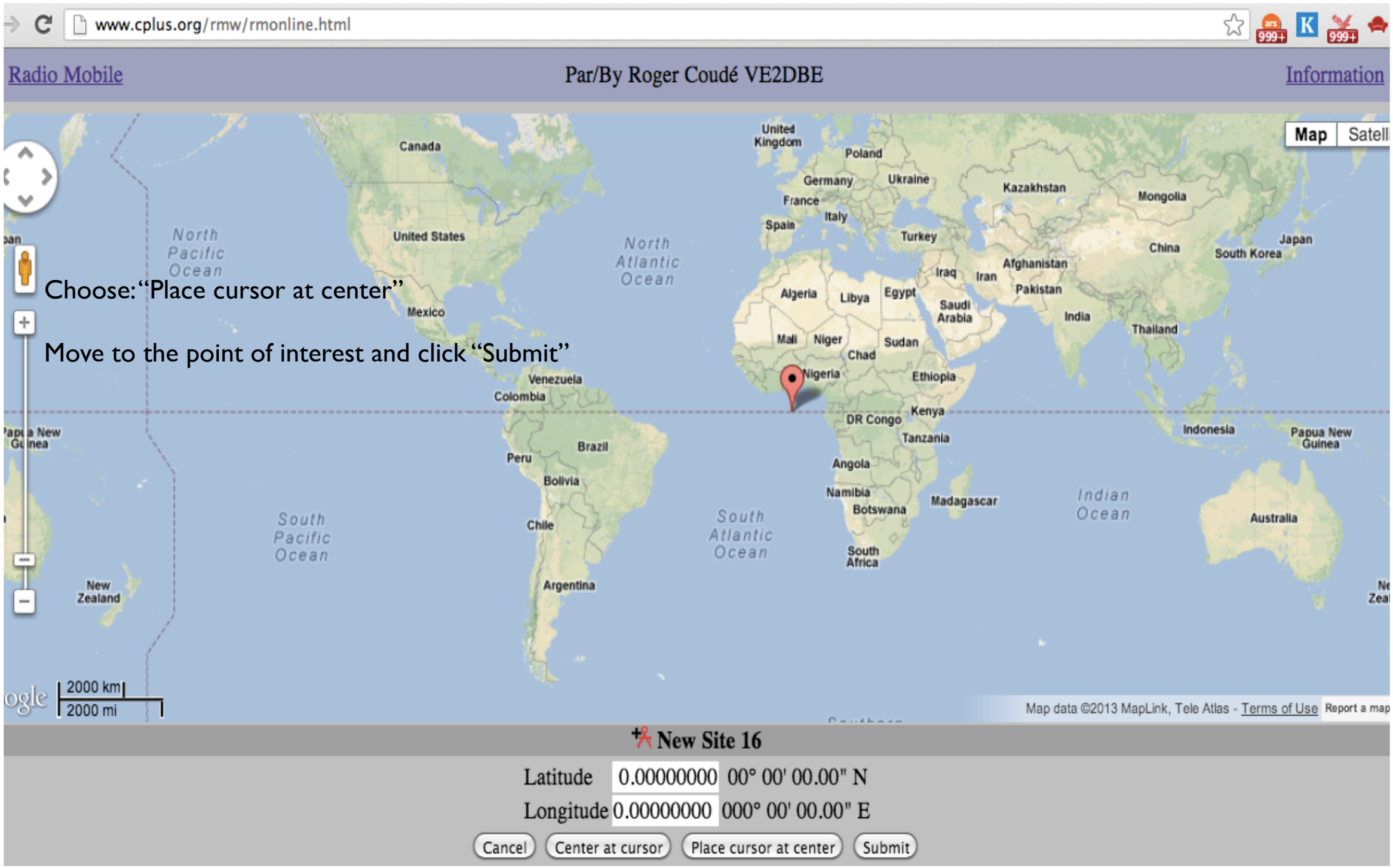
http://www.cplus.org/rmw/rmonline.html

- Register in the site (no cost) and create your account, you will receive your password in your e-mail account.
- You can then start using the program.

Web Radio Mobile



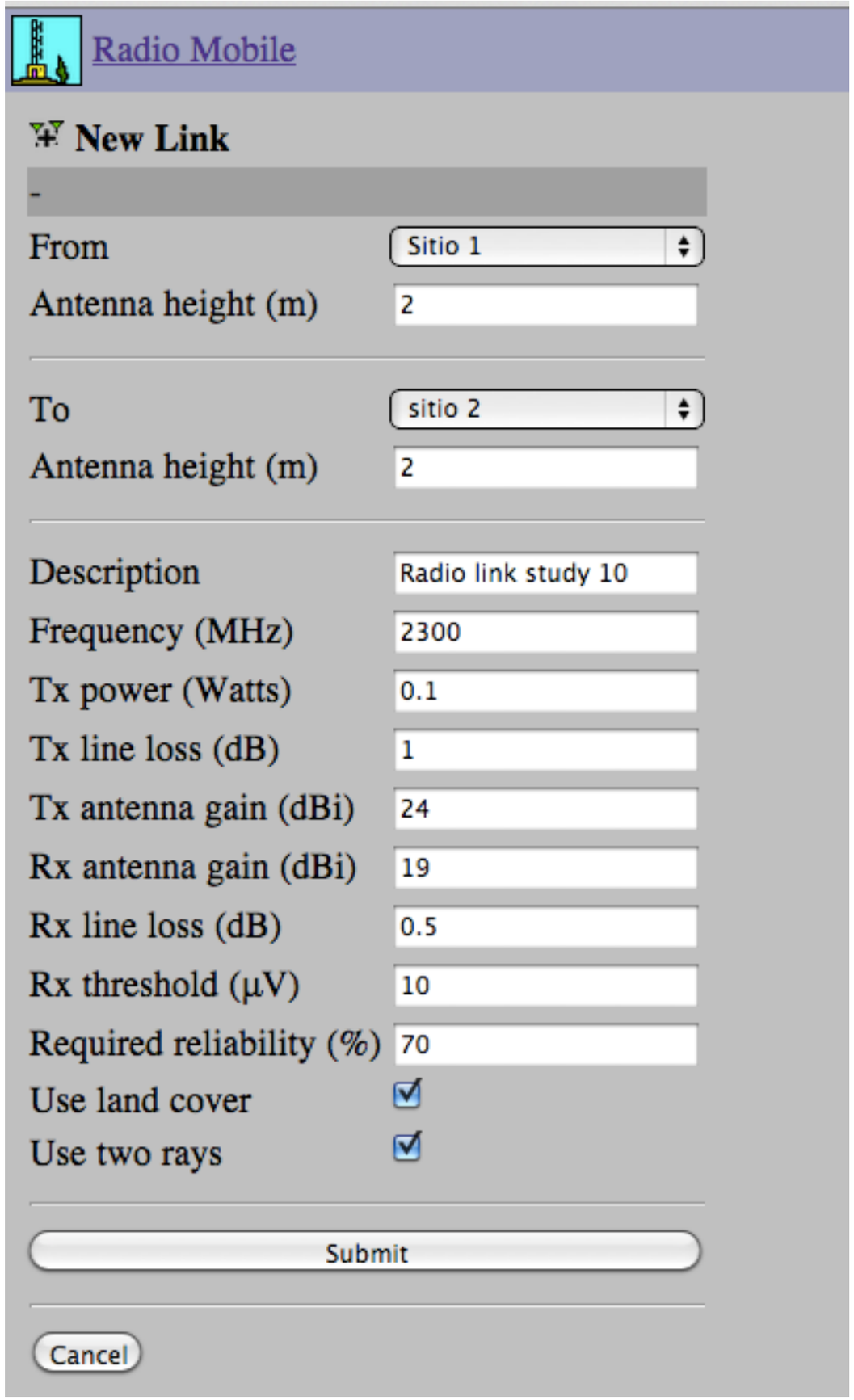
Radio Mobile On-Line



Radio Mobile on-line

If you happen to know the coordinates, you can modify the values on the screen.
Check that the elevation provided by the program is reasonable.
Assign a name to the site and click "Add to my sites"
Repeat the procedure for the second site.

Radio Mobile on-line



Input 2300 MHz as frequency when working at 2.4 GHz and 5825 MHz when working at 5 GHz, since in the on-line version they are the closest allowed frequencies. This will affect the propagation loss by a small amount.

"Rx Threshold" is the minimum received signal in microvolts, also called "Receiver sensitivity"

Click "Submit".

A word on power

Electrical power in watts is $P = v^2/R$
Telecommunication antennas have normally R = 50 ohm
In that case, $P = v^2/50$, $v = SQRT(50P)$
The received power level RP is frequently expressed in dBm:
$RP = 10Log_{10} (P/10^{-3})$, therefore $P = 10^{-3}10^{RP/10}$
So, the received voltage corresponding to RP dBm is:

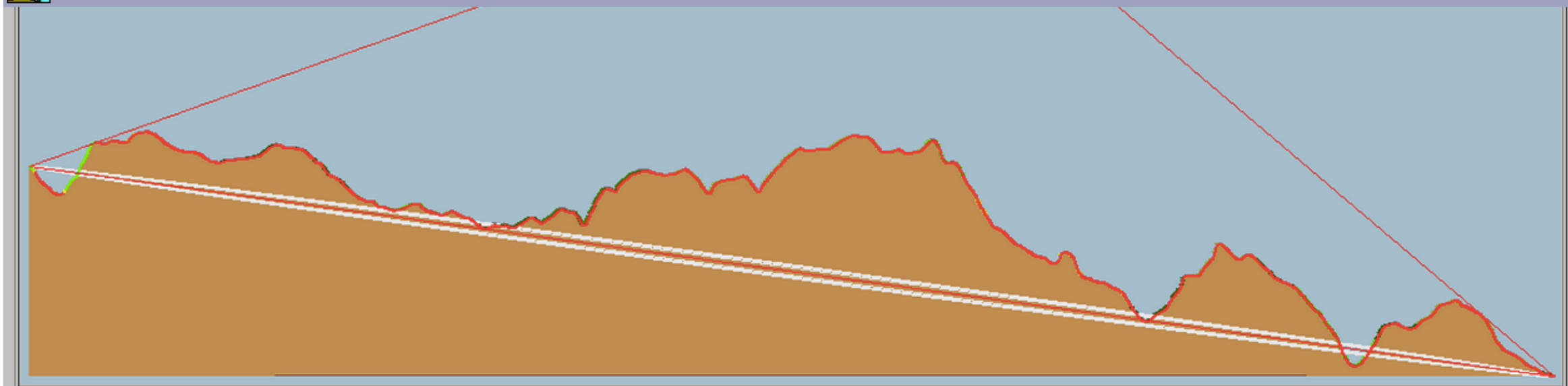
$$\mathbf{v = SQRT(0.05x10^{RP/10})}$$

Example: for RP -90 dBm, $v = SQRT(0.05x10^{-9}) = 0.00000707$

That is v = 7.07 microvolts, this the RF voltage one would measure at the antenna terminals

Radio Mobile on-line

Radio Mobile — Par/By Roger Coudé VE2DBE — Information



Radio link study 10

Sitio 1 (1)			(2) sitio 2		
Latitude	4.535356	°	Latitude	4.653080	°
Longitude	-73.666077	°	Longitude	-73.355713	°
Ground elevation	2927.1	m	Ground elevation	1082.5	m
Antenna height	2.0	m	Antenna height	2.0	m
Azimuth	69.15	°	Azimuth	249.18	°
Tilt	-3.03	°	Tilt	2.70	°

Radio system			**Propagation**		
TX power	20.00	dBm	Free space loss	130.96	dB
TX line loss	1.00	dB	Obstuction loss	117.51	dB

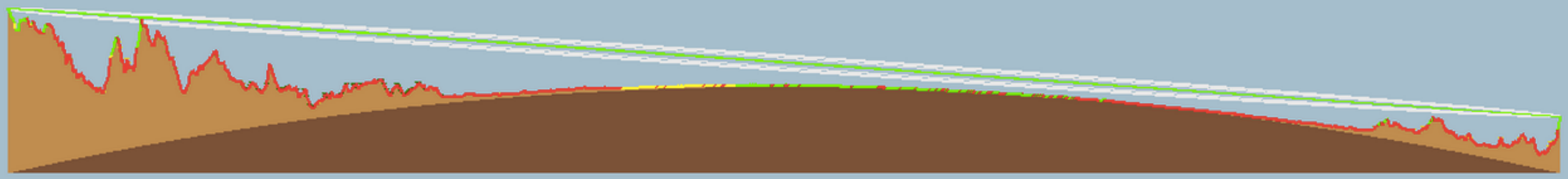
This link is not feasible because of the blocked line of sight

Radio Mobile on-line

Let's see another link:

Radio Mobile — Par/By Roger Coudé VE2DBE — Information

Return to my links | Return to main menu



Aguila-Platillon

[Aguila2012](#) (1)			(2) [Platillon](#)		
Latitude	8.829425	°	Latitude	9.859167	°
Longitude	-70.834667	°	Longitude	-67.521770	°
Ground elevation	4165.4	m	Ground elevation	1519.7	m
Antenna height	2.0	m	Antenna height	2.0	m
Azimuth	72.25	°	Azimuth	252.79	°
Tilt	-2.11	°	Tilt	-1.32	°

Radio Mobile on-line

Radio Mobile — Par/By Roger Coudé VE2DBE — Information

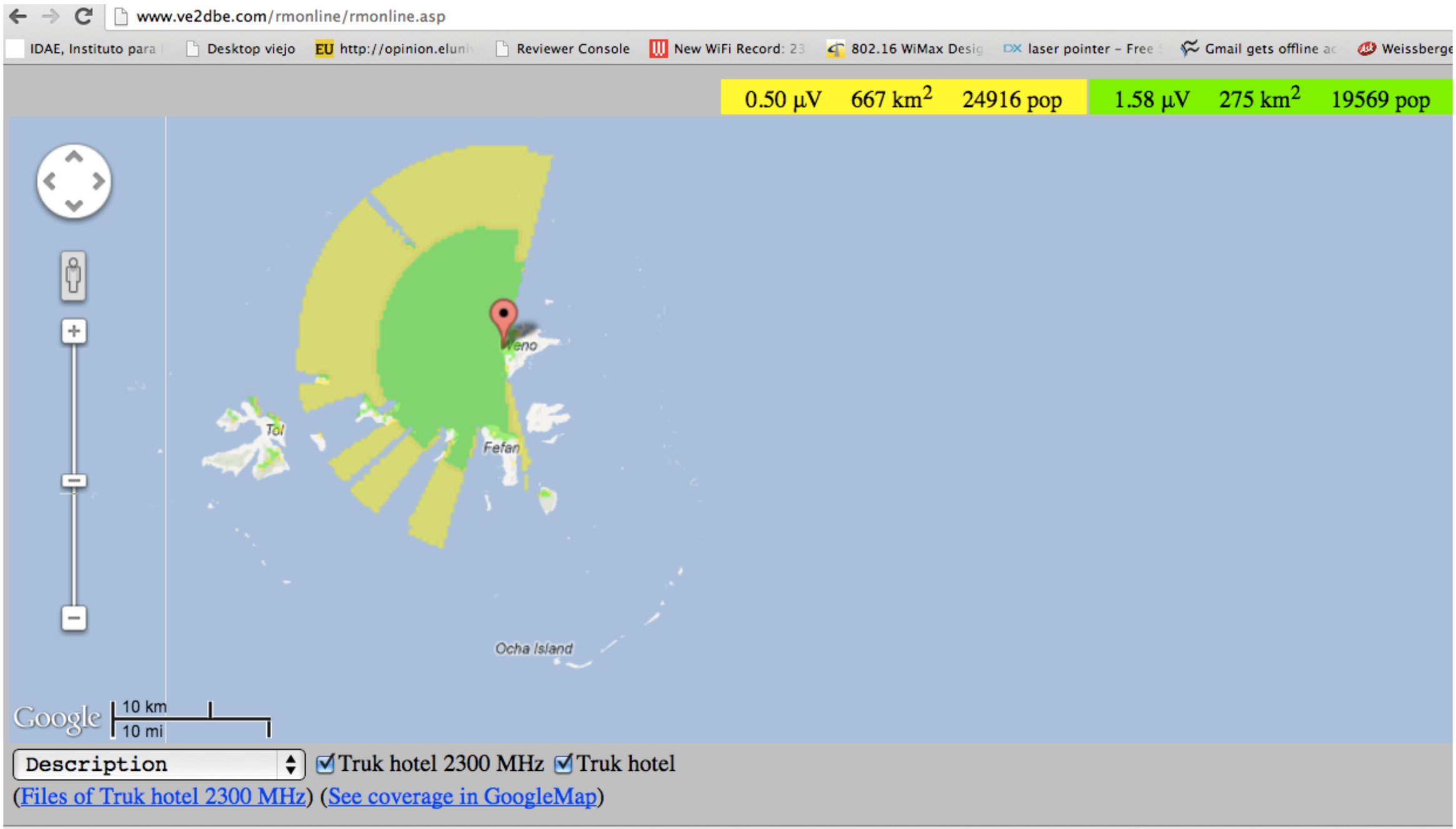
Radio system			Propagation	
TX power	20.00	dBm	Free space loss	151.26 dB
TX line loss	0.00	dB	Obstuction loss	16.58 dB
TX antenna gain	34.00	dBi	Forest loss	1.00 dB
RX antenna gain	34.00	dBi	Urban loss	0.00 dB
RX line loss	0.00	dB	Statistical loss	2.83 dB
RX sensitivity	-97.46	dBm	Total path loss	171.67 dB

Performance		
Distance	**381.091**	**km**
Precision	190.6	m
Frequency	2300.000	MHz
Equivalent Isotropically Radiated Power	251.189	W
System gain	185.46	dB
Required reliability	70.000	%
Received Signal	-83.67	dBm
Received Signal	14.68	µV
Fade Margin	**13.79**	**dB**

Radio Mobile on-line

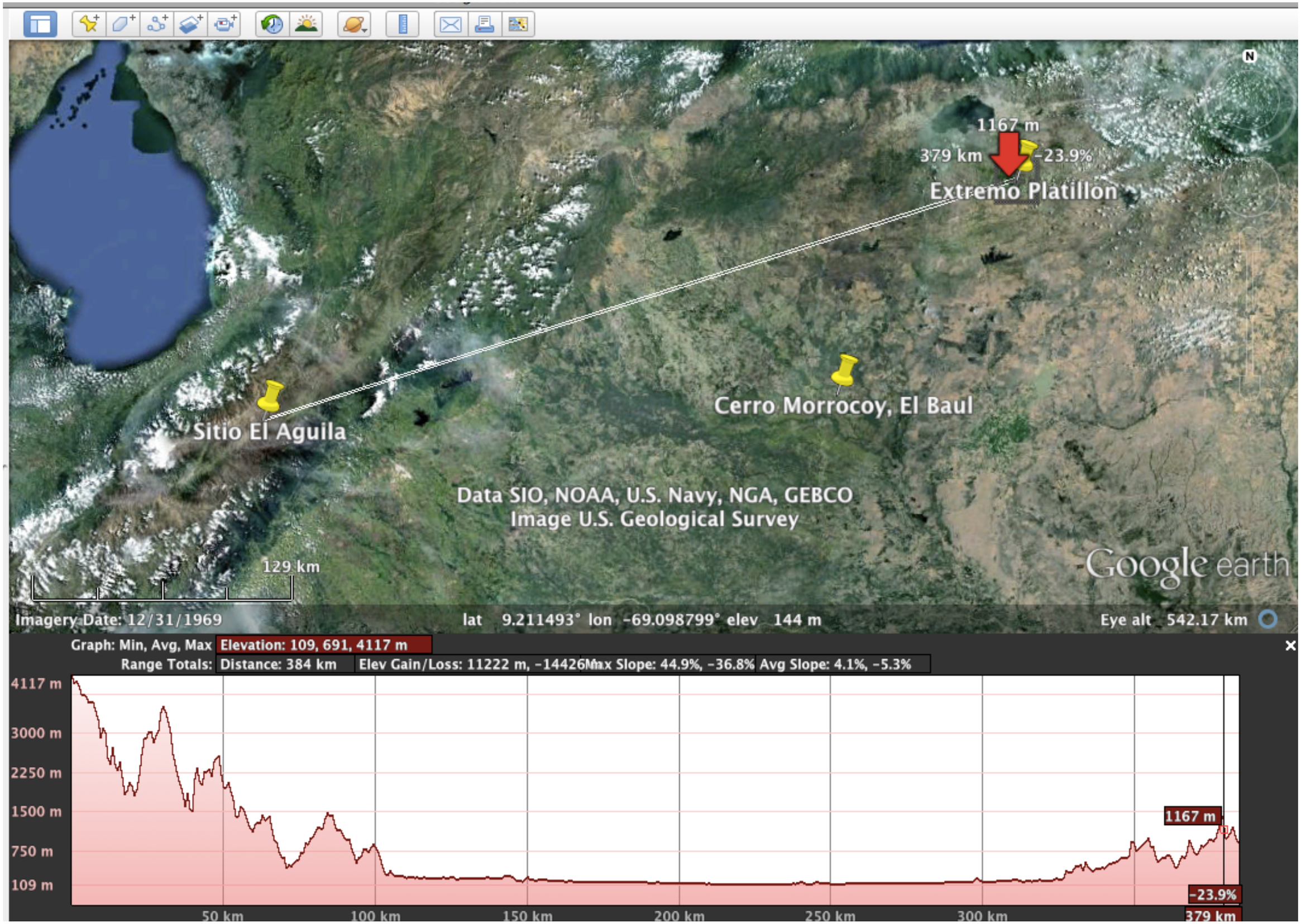
Radio Mobile on-line

Example of area coverage from another site



Elevation profiles with Google Earth

1) In the upper menu, click "Add path"
2) Click to establish the first point and then the second
3) Assign a name to the link (for instance "Longest") and click OK in the pop-up window
4) The link will show up in the menu on the left.
5) Right click in the link name ("Longest" in our example)
6) Select "Show elevation profile"
7) The elevation profile will be shown on the bottom of the screen
8) Moving along the profile, a red arrow will show the position on the map.


1167 m
379 km
-23.9%
Extremo Platillon
Cerro Morrocoy, El Baul
Sitio El Aguila
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image U.S. Geological Survey
129 km
Google earth
Imagery Date: 12/31/1969
lat 9.211493° lon -69.098799° elev 144 m
Eye alt 542.17 km
Graph: Min, Avg, Max
Elevation: 109, 691, 4117 m
Range Totals:
Distance: 384 km
Elev Gain/Loss: 11222 m, -14426
Max Slope: 44.9%, -36.8%
Avg Slope: 4.1%, -5.3%
4117 m
3000 m
2250 m
1500 m
750 m
109 m
1167 m
-23.9%
50 km
100 km
150 km
200 km
250 km
300 km
379 km

Exercise

We want to establish a link between GGH-ICTP and ISMAR (a research institution in Trieste downtown), with WiFi and with TVWS equipment.

1) GGH-ICTP		2) ISMAR	
Latitude	45.70348900	Latitude	45.64337000
Longitude	13.72081800	Longitude	13.75378700
Latitude	045° 42' 12.56"N	Latitude	045° 38' 36.13"N
Longitude	13° 43' 14.94"E	Longitude	13° 45' 13.63”E

Is the link feasible? What equipment would you use? What antenna gain do you need? What antenna height?

Why use downloadable Radio Mobile?

Radio Mobile runs in Windows but it can be used in Linux or Mac OS by means of emulators.

It provides all sort of details for point to point links, including expected signal level at any point along the path, including diffraction losses due to obstacles.

Radio Mobile automatically builds a profile between two points on the digital map, showing Fresnel zone and earth curvature clearance, as well as required antenna heights. It is a wonderful tool for exploring "what if?" scenarios.

Download Radio Mobile

Download Radio Mobile here:

http://www.cplus.org/rmw/english1.html

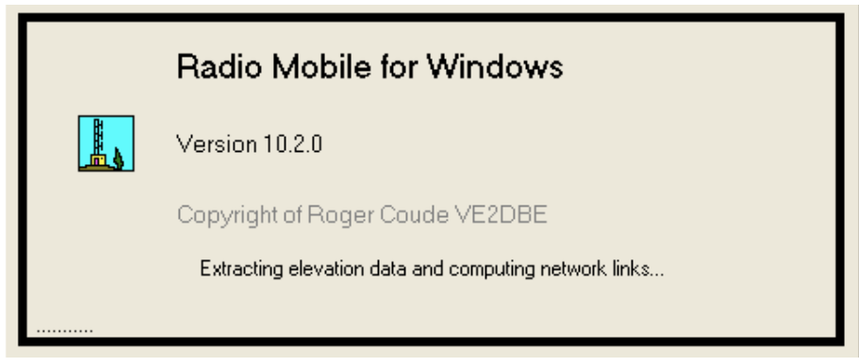
Instructions are provided for how to download the digital elevations maps for your area of interest.

Digital elevation maps come in one degree longitude, X degree latitude tiles so you might need to download a few tiles for your application. Resolution of 30 and 3 arc seconds (or better!) are available for all regions of the world.

Once you have downloaded the maps, you no longer need Internet access (unlike using Google Earth).

Using Radio Mobile

- Let's assume Radio Mobile is already correctly installed on your computer (installation instructions are provided in the download page). We will now review the procedure to simulate a simple wireless network composed of a few nodes
- We will then use Radio Mobile to perform some simple link budget calculations, coverage analysis and "what if?" simulations

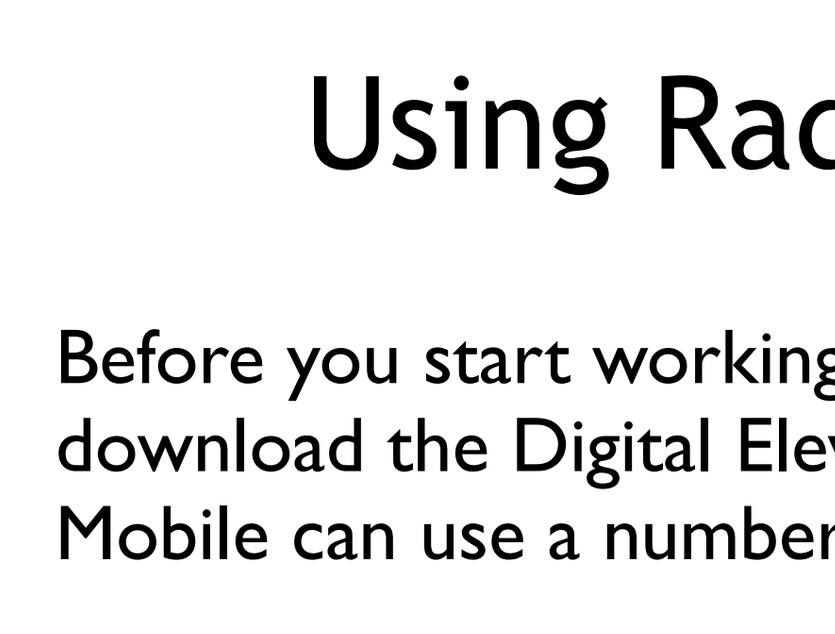


Using Radio Mobile: example

- We will use Radio Mobile to simulate a few radio links around the city of Trieste (Italy).Coordinates of some locations are (approx.):
  - The Miramare Campus: N 45°42'15" E 13°43'13"
  - The Church (Muggia): N 45°36'10" E 13°45'10"
  - The Castle (San Giusto): N 45°38'51" E 13°46'21"
  - The Hotel (Grado): N 45°40'32" E 13°23'17"

Using Radio Mobile: DEMs

- Before you start working with Radio Mobile, you may want to download the Digital Elevation Maps of your area of interest. Radio Mobile can use a number of formats including SRTM.

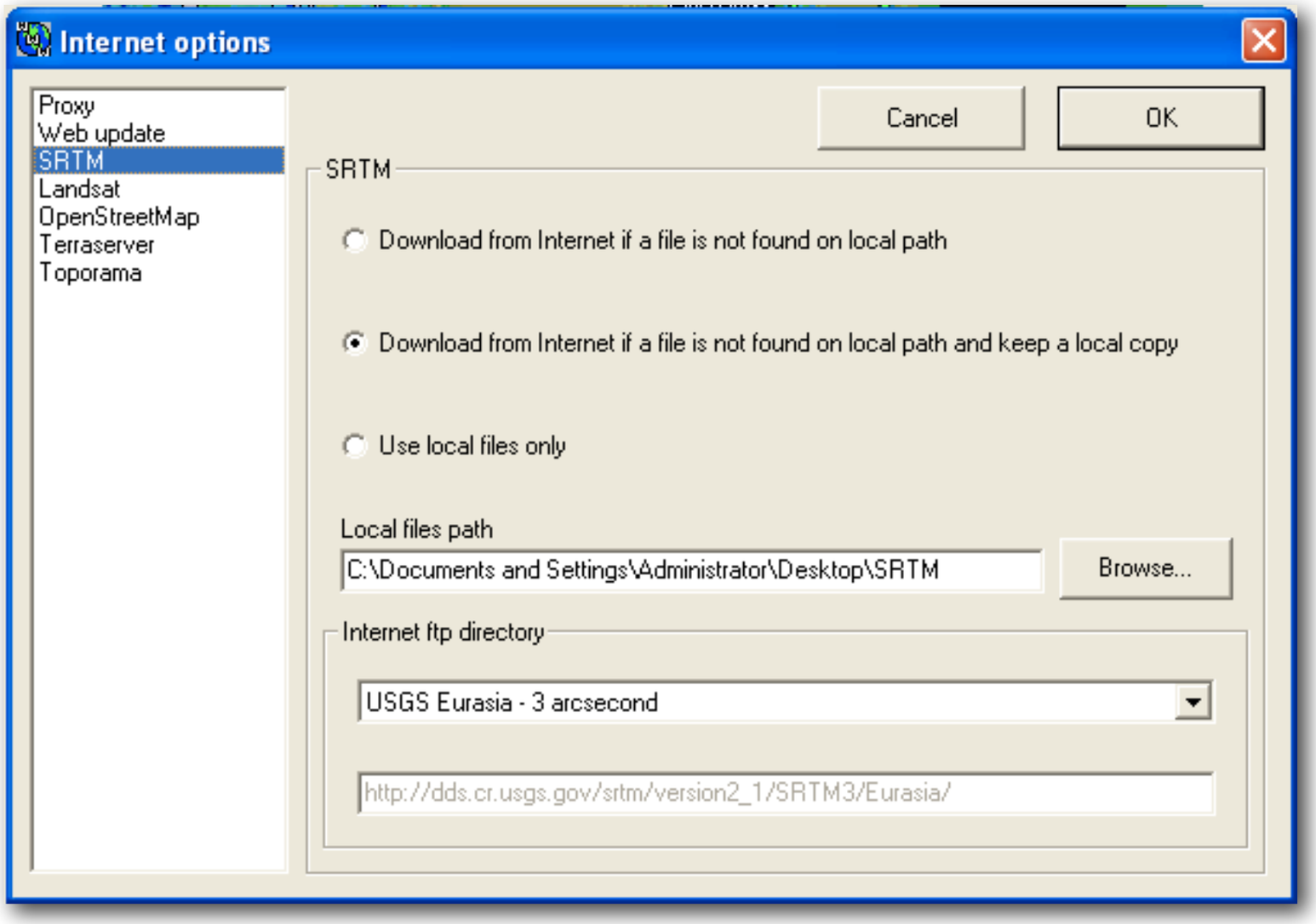


Radio Mobile screenshot

http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30_info

Using Radio Mobile: DEMs

- The simplest way to get elevation data is to let Radio Mobile download it automatically when needed. It will also store the data locally for future use.



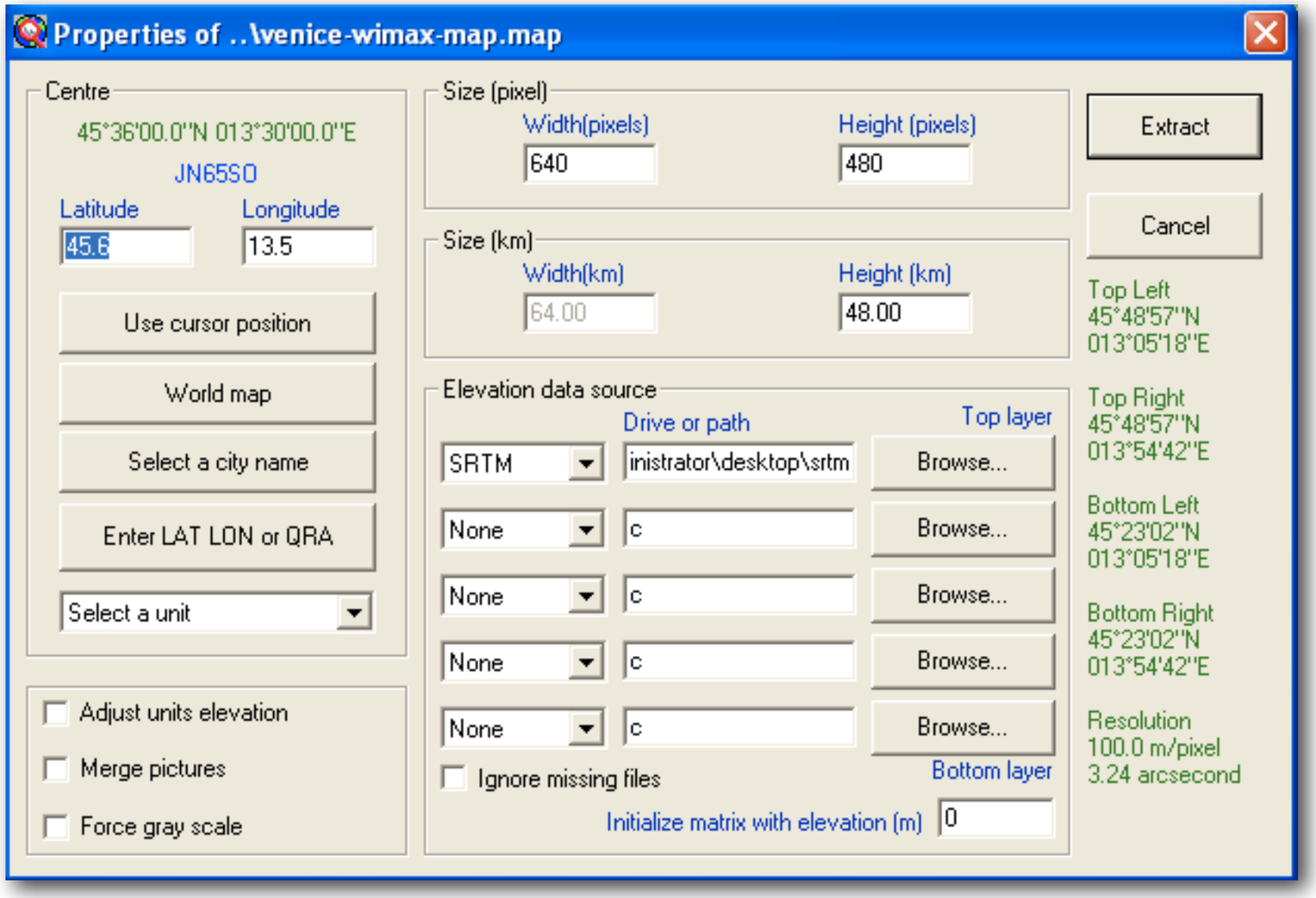
Radio Mobile screenshot

Using Radio Mobile: create map

- Menu “File”, select item “Map properties”
- Insert coordinates (center of map) and dimensions of the map
- We use:

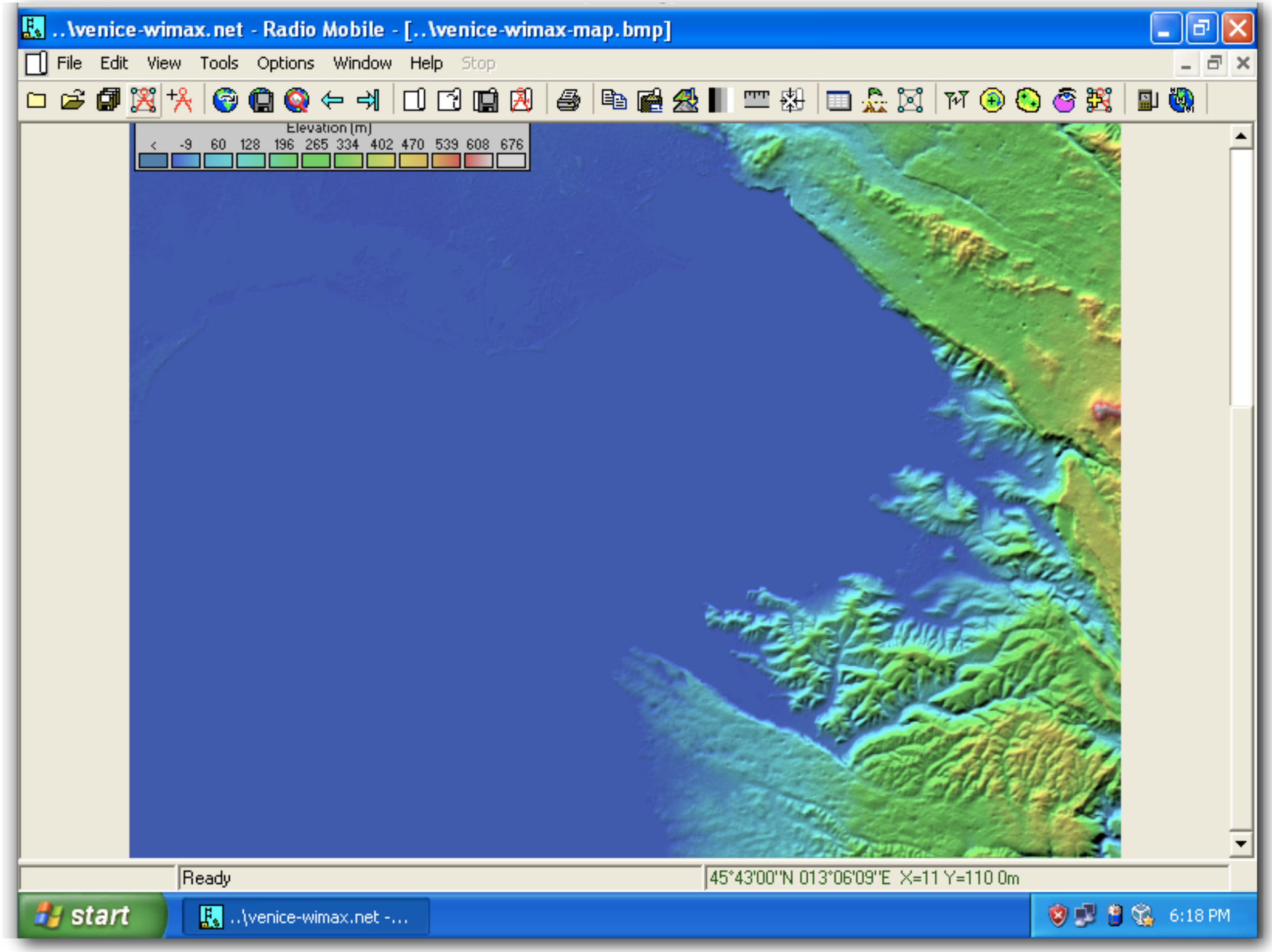
N 45.6 - E 13.5
640x480 pixels
64x48 km

- “Extract”



Radio Mobile screenshot

Using Radio Mobile: the map



Using Radio Mobile: add map

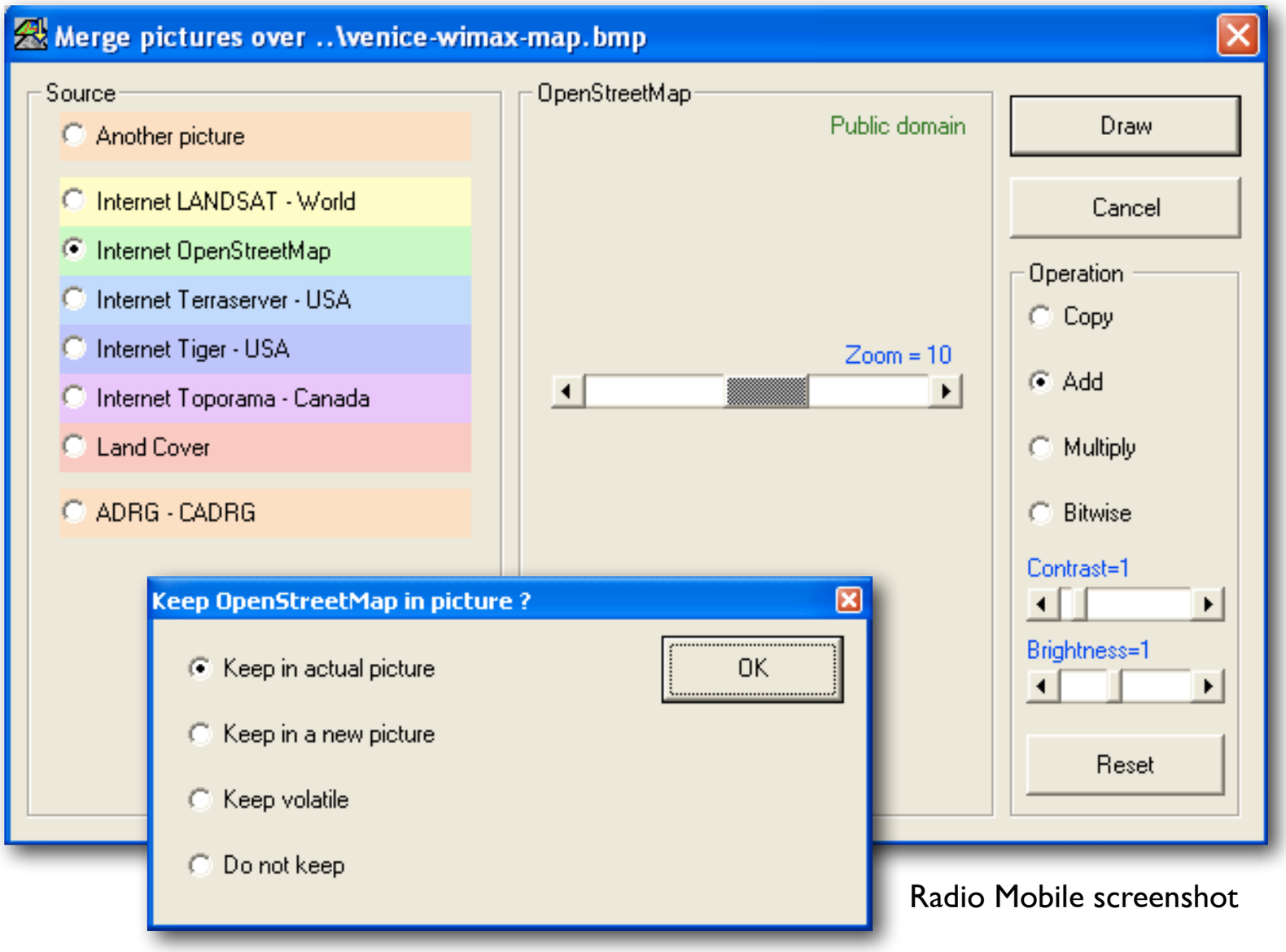
- We can add road details using this procedure: menu "Edit" select item "Merge pictures..."
- Then select

OpenStreetMap

with Zoom=10

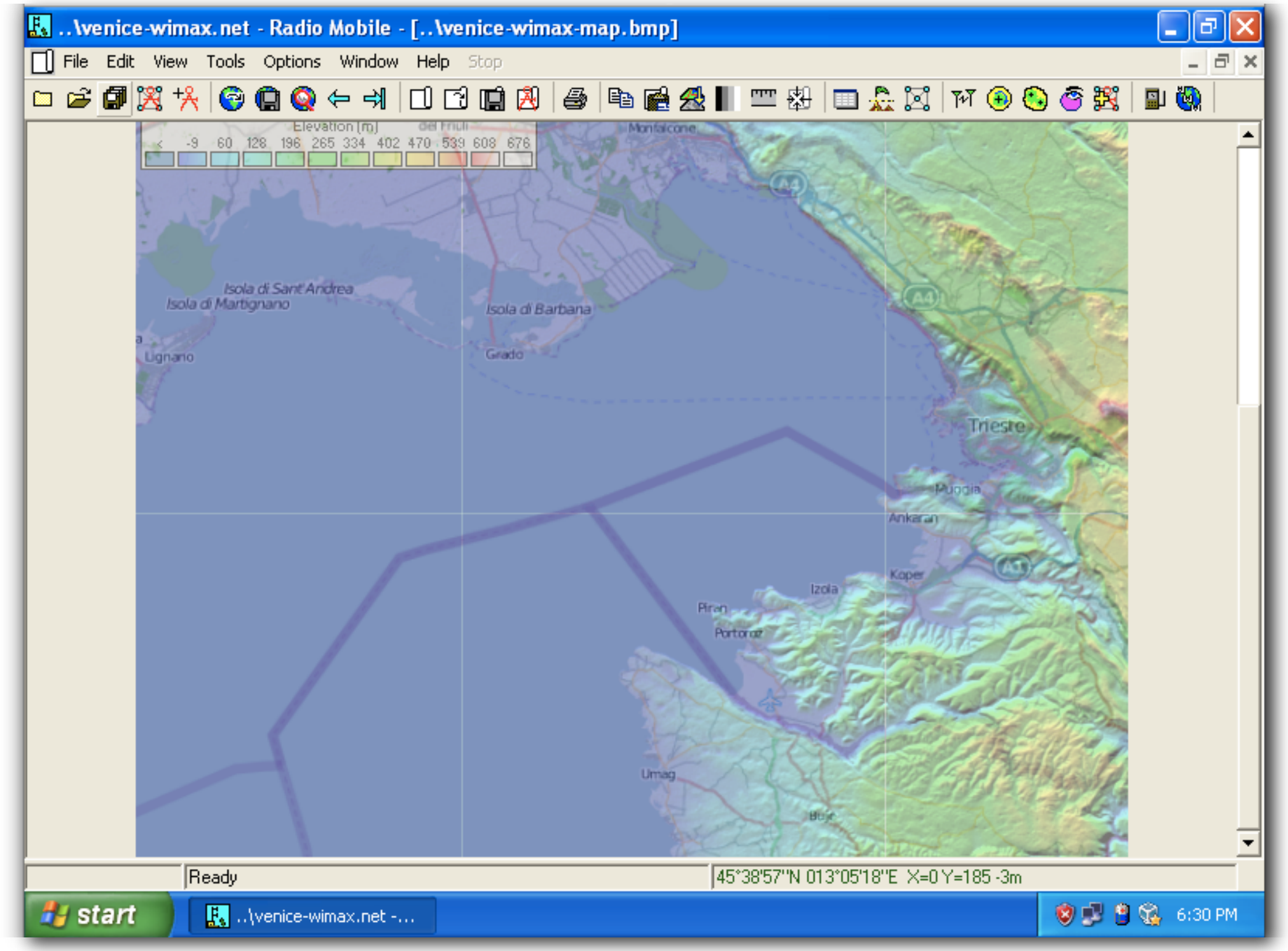
Operation: Add

- click on "Draw"
- "Keep in picture"



Radio Mobile screenshot

Using Radio Mobile: new map

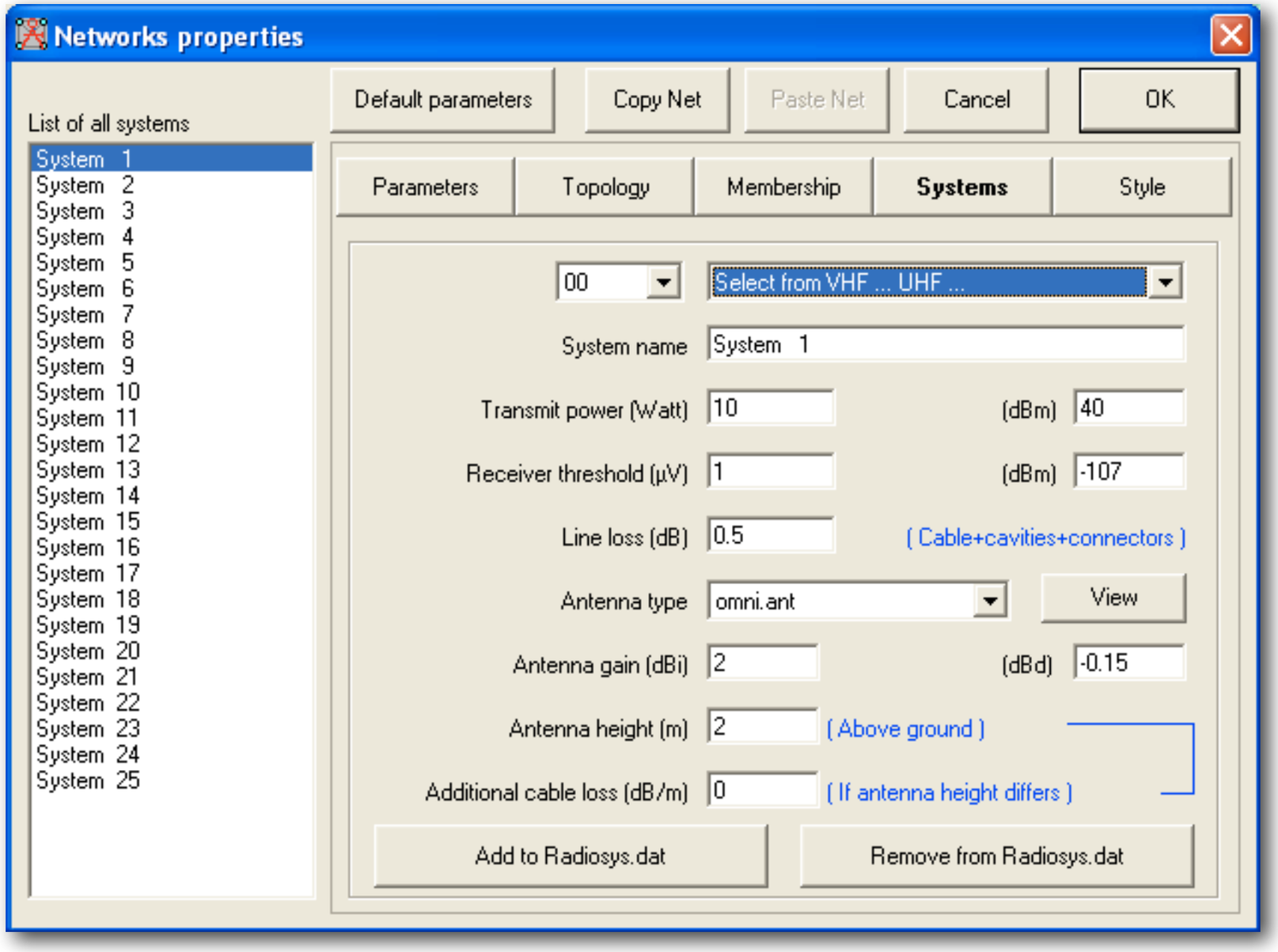


Using Radio Mobile: terminology

- Radio Mobile has its own special terminology. In order to create radio links we need to learn a few new terms:
  - a **system**: a particular choice of radio and antenna (TX power, gain, radiation pattern, ...)
  - a **unit**: a system installed in a particular location (coordinates, height of antenna, ...)
  - a **network**: a set of units, part of the same radio network (all at the same frequency)

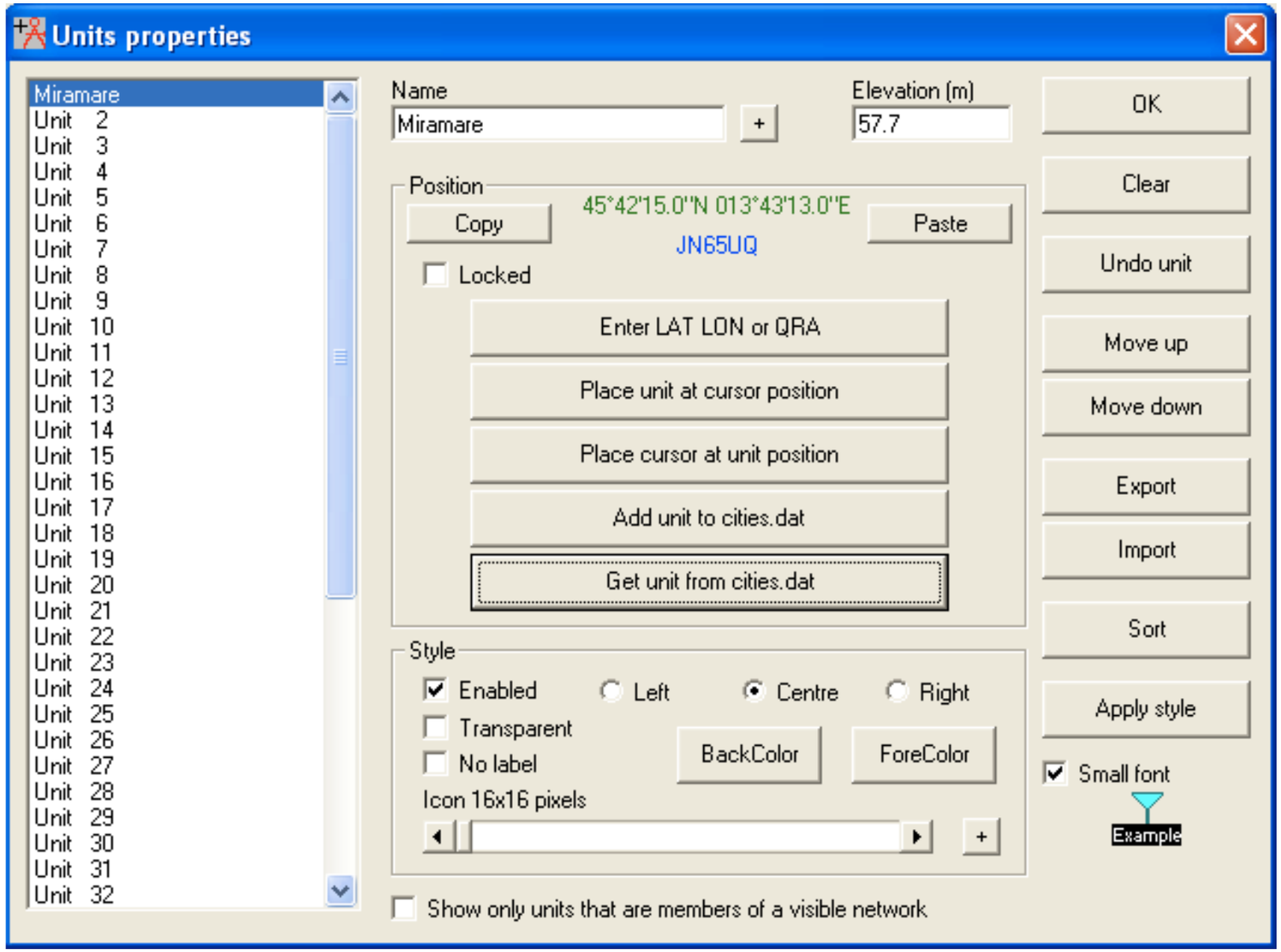
Using Radio Mobile: systems

- Let's create two different systems (WiFi@2.4GHz):
- SmallRadio:
  P_{TX}=16dBm
  S_{RX}=-90dBm
  omni 8dBi
- BigRadio:
  P_{TX}=20dBm
  S_{RX}=-96dBm
  dish 24dBi
- other: default



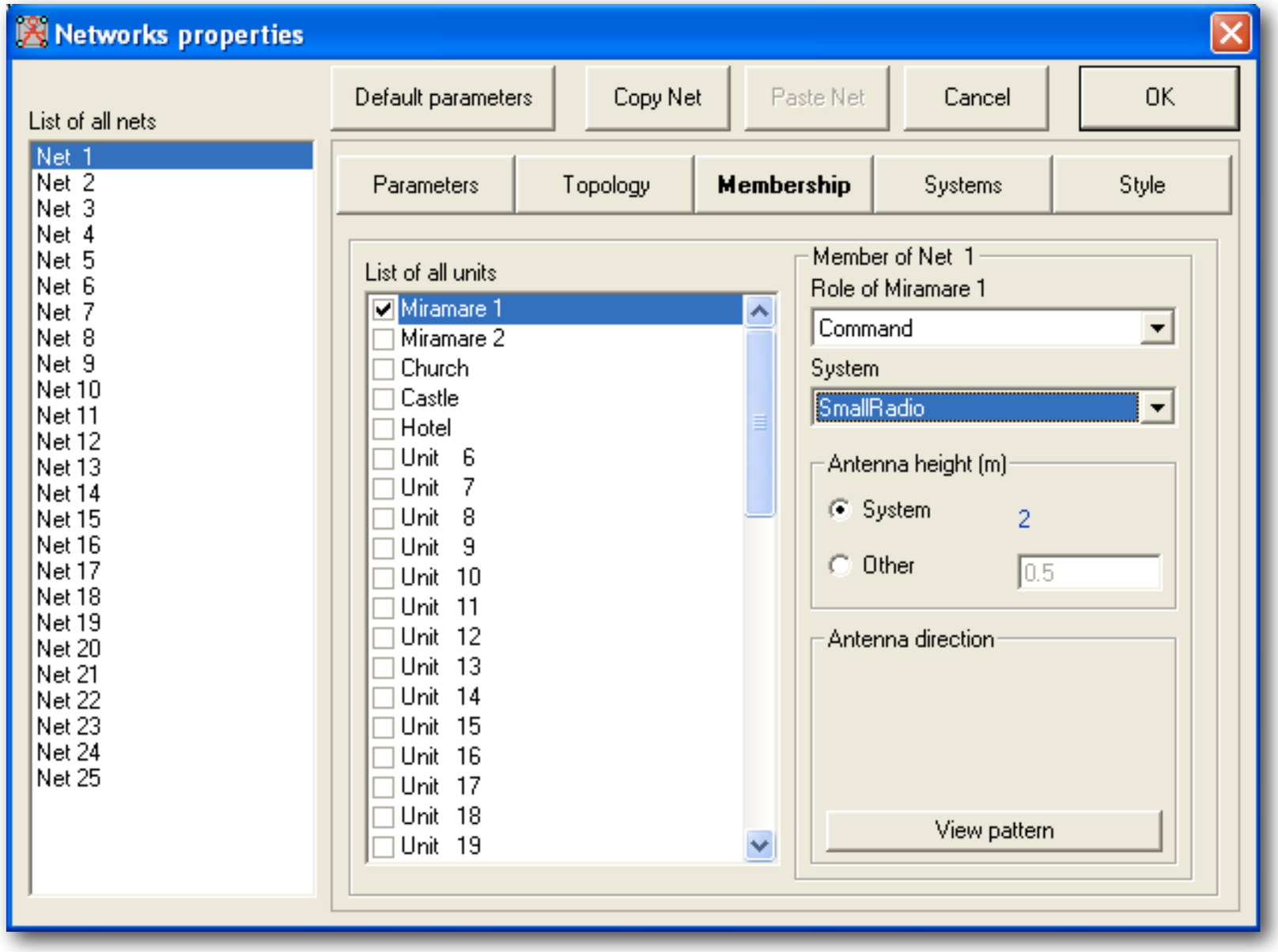
Using Radio Mobile: units

- Let's create 5 new units, located in the 4 sites:
- *Miramare 1*
- *Miramare 2*
- *Church*
- *Castle*
- *Hotel*



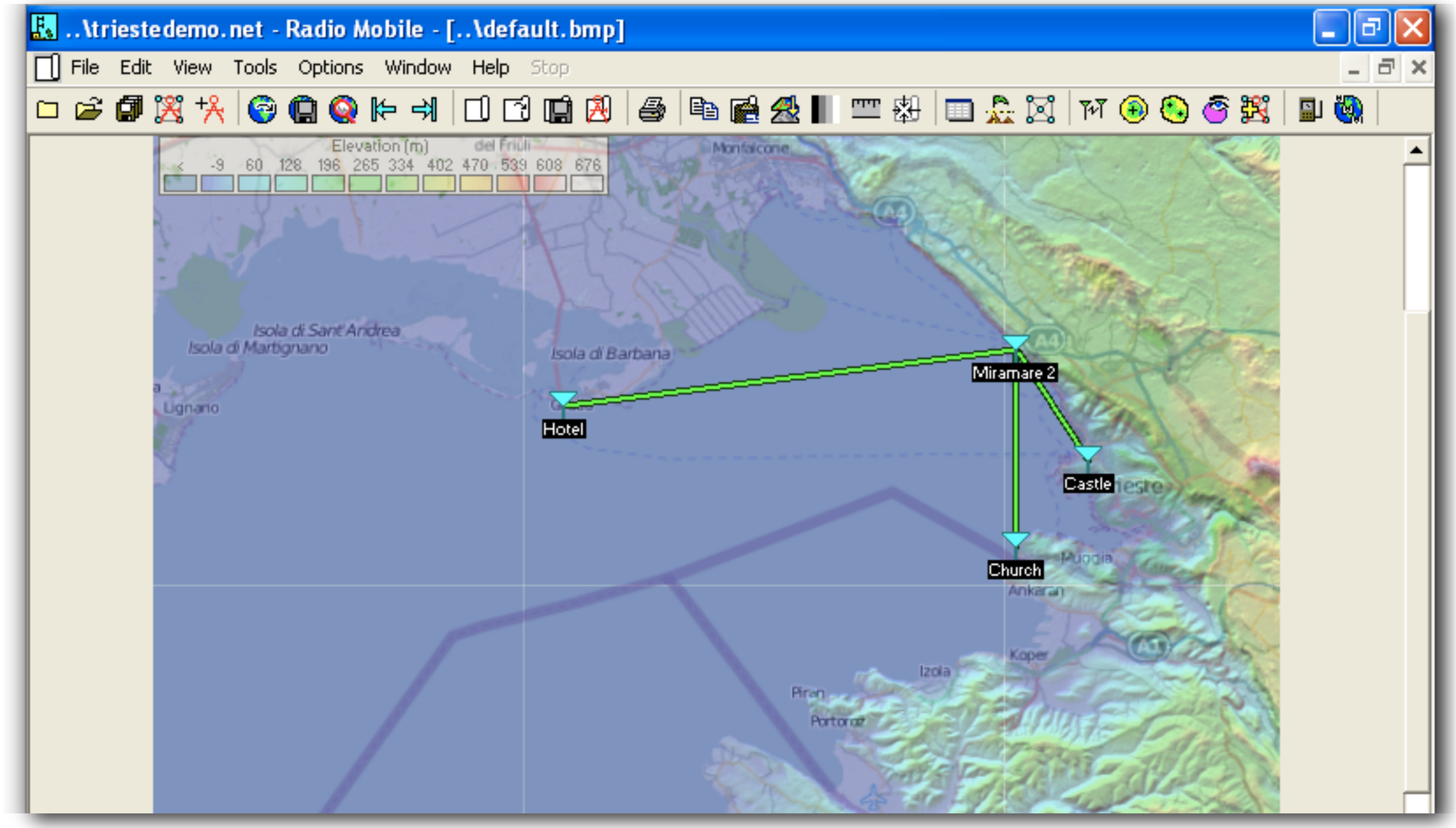
Using Radio Mobile: units

- After creation, you should assign the proper system to each unit:
- *Miramare 1*
- *Church*
- *Castle* are all "SmallRadio"
- *Miramare 2*
- *Hotel* are both "BigRadio"



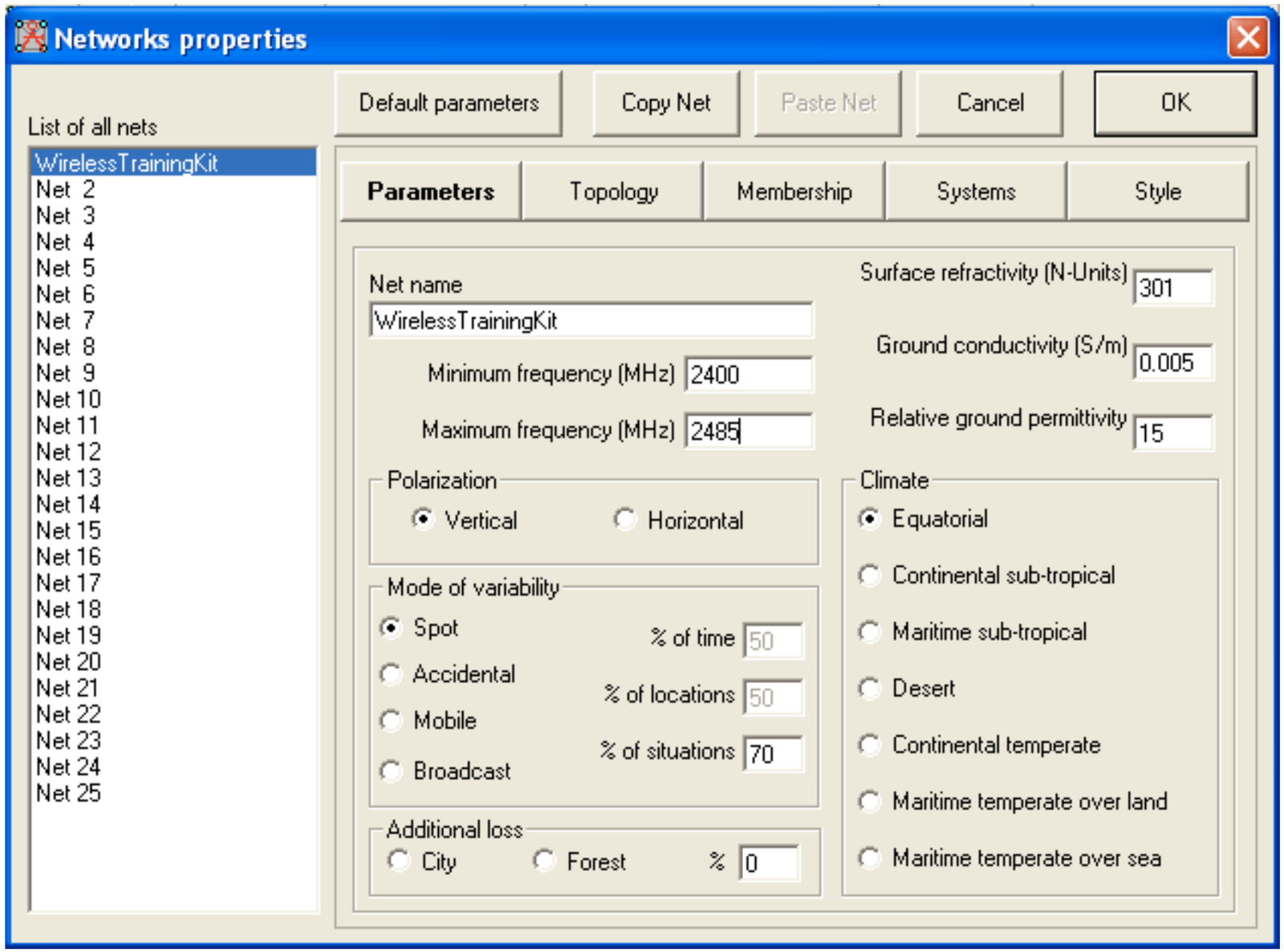
Using Radio Mobile: network

- To view your network on the map, just select "View" →"Show networks"→"All"



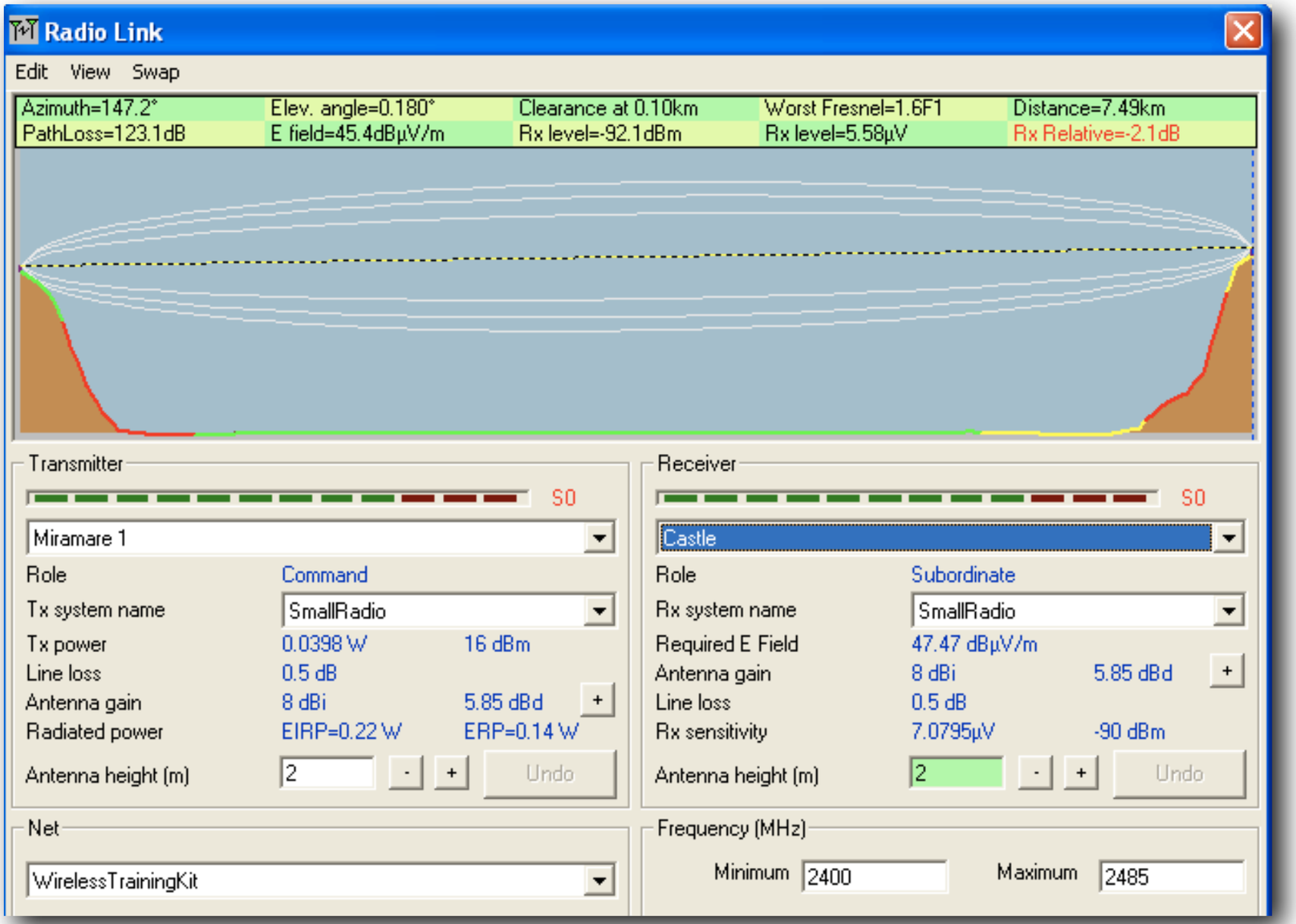
Using Radio Mobile: network

- To be able to correctly calculate the loss due to propagation, you should set the correct frequency.
- We are using the 2.4GHz band, so let's set the range 2400-2485.



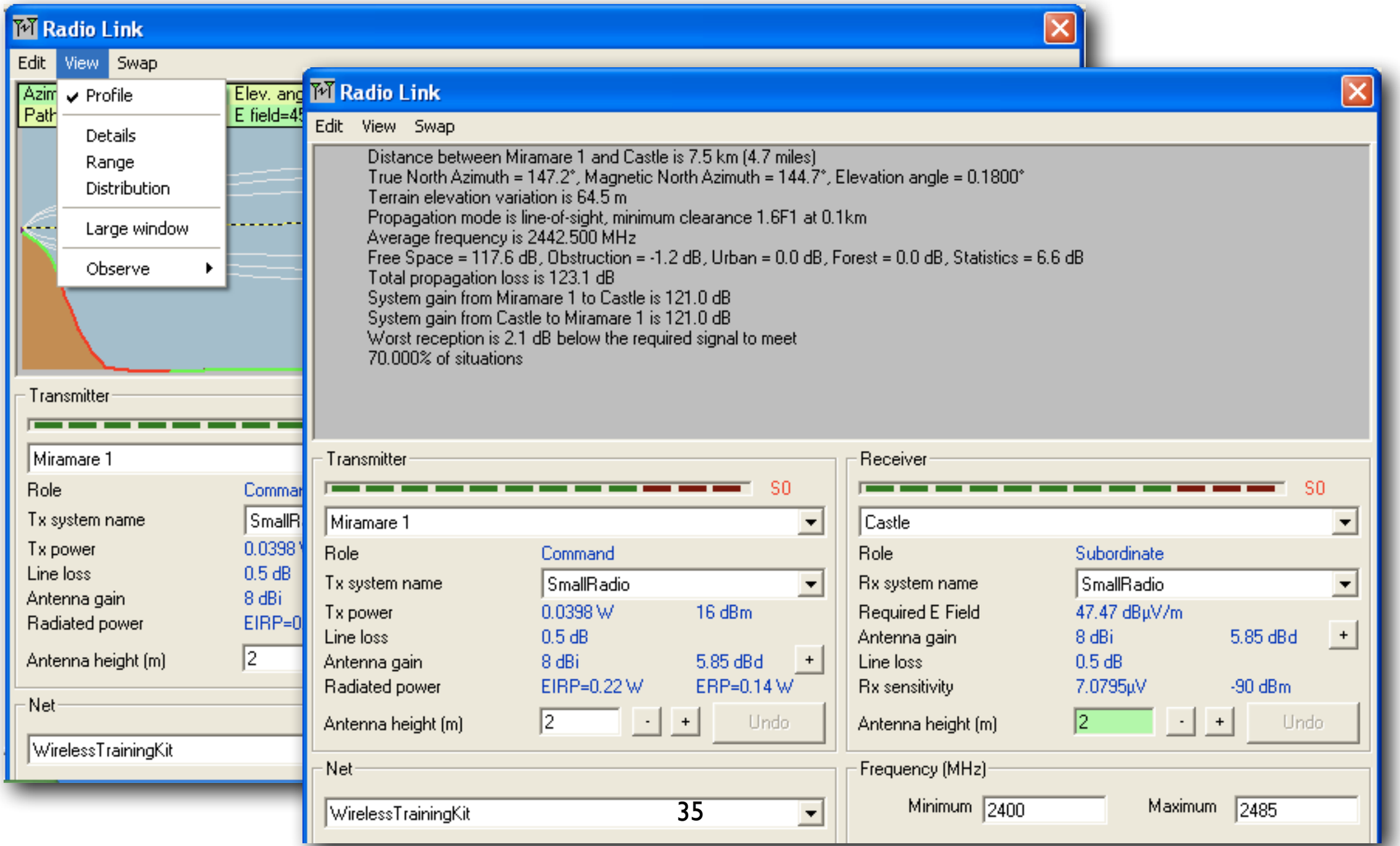
Using Radio Mobile: results

- Now that we have set our scenario, let's calculate the link budget for our links: "Tools" → "Radio link"



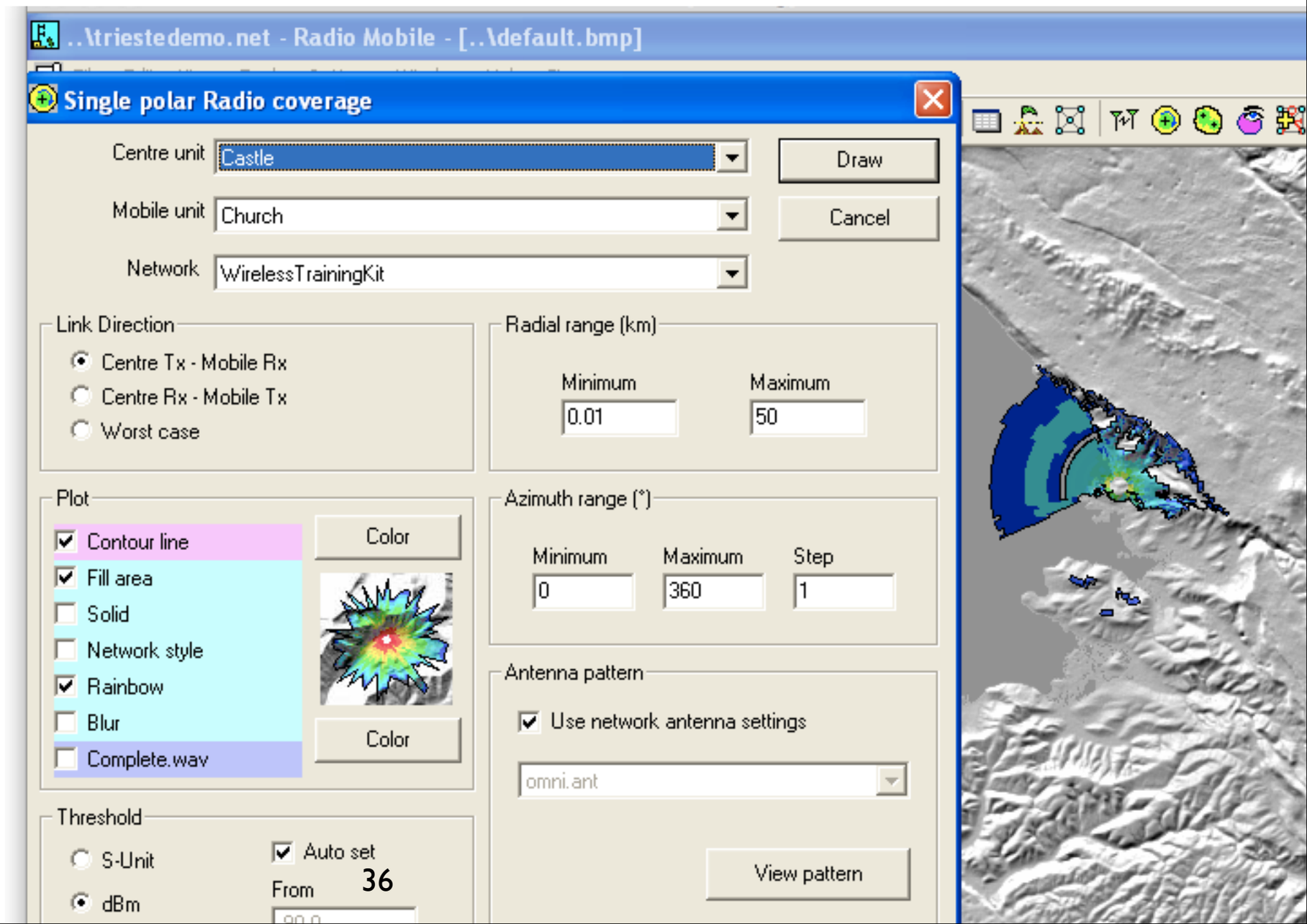
Using Radio Mobile: results

- You can switch to the detailed view, that gives you a textual description of the output of the simulation



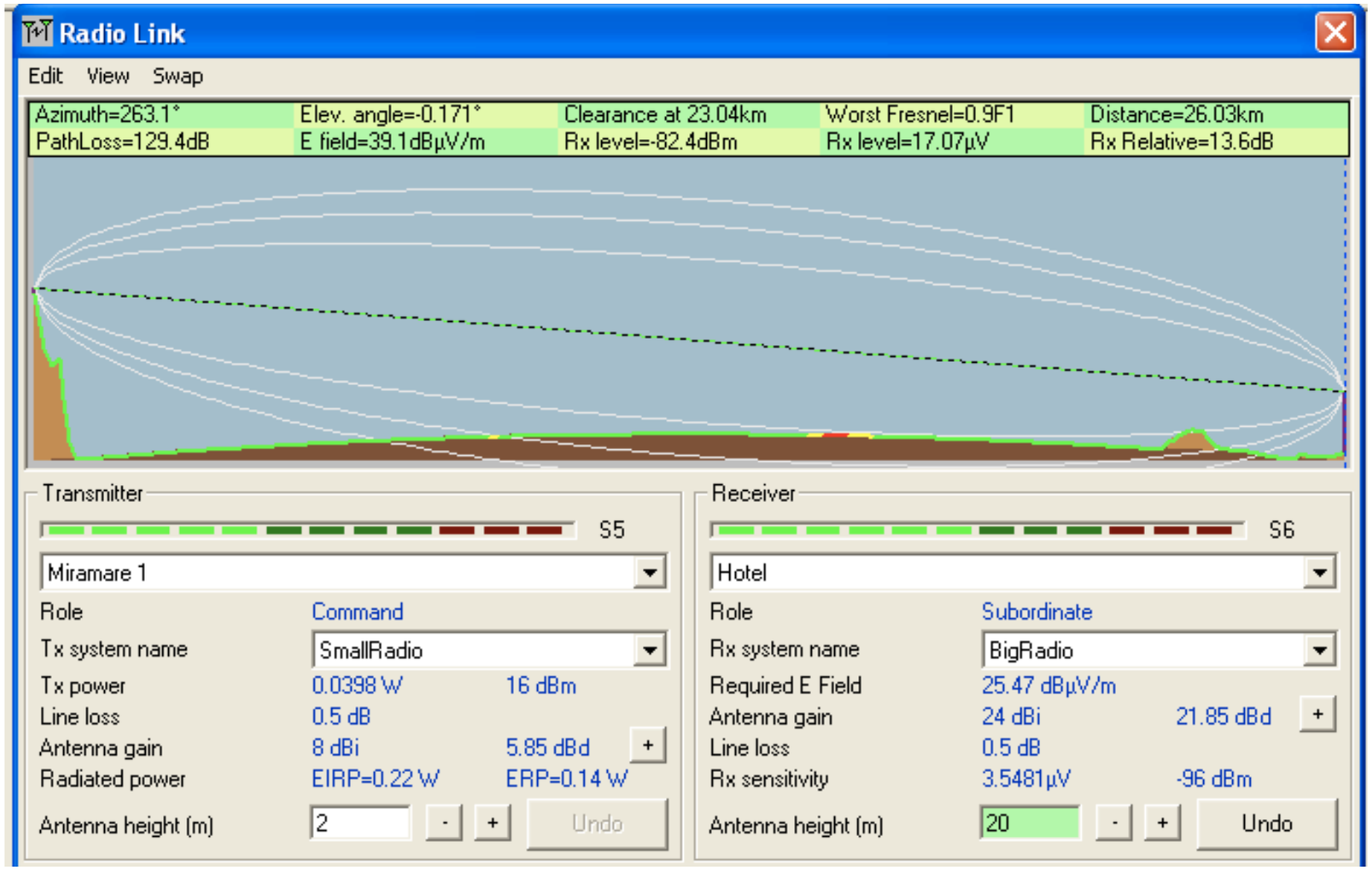
Using Radio Mobile: coverage

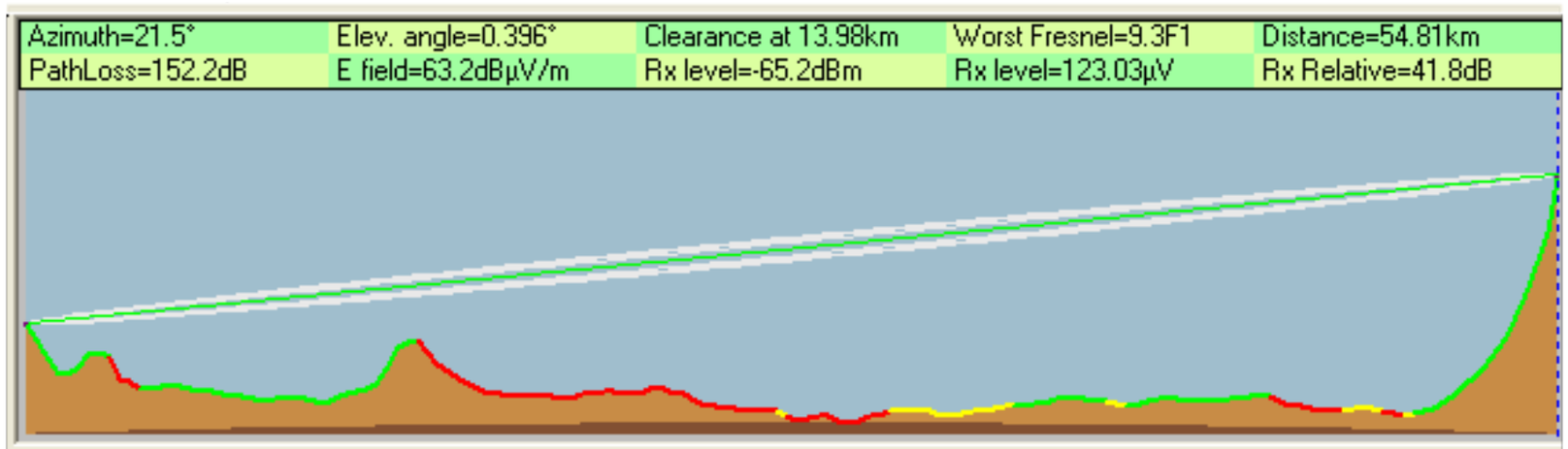
- "Tools" → "Radio coverage" → "Single polar"
- This will start the calculation of the coverage area of a selected station in your net.

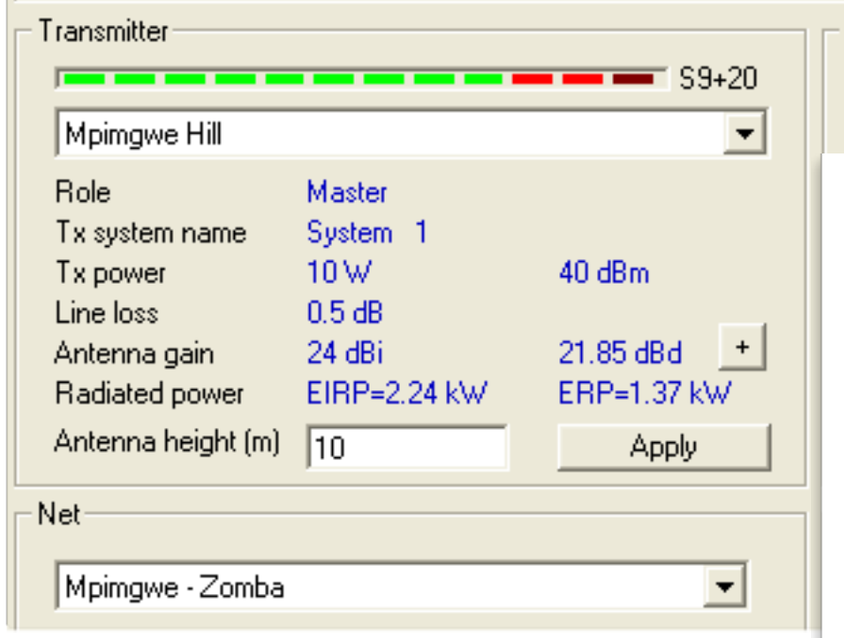


Using Radio Mobile: “what if?”

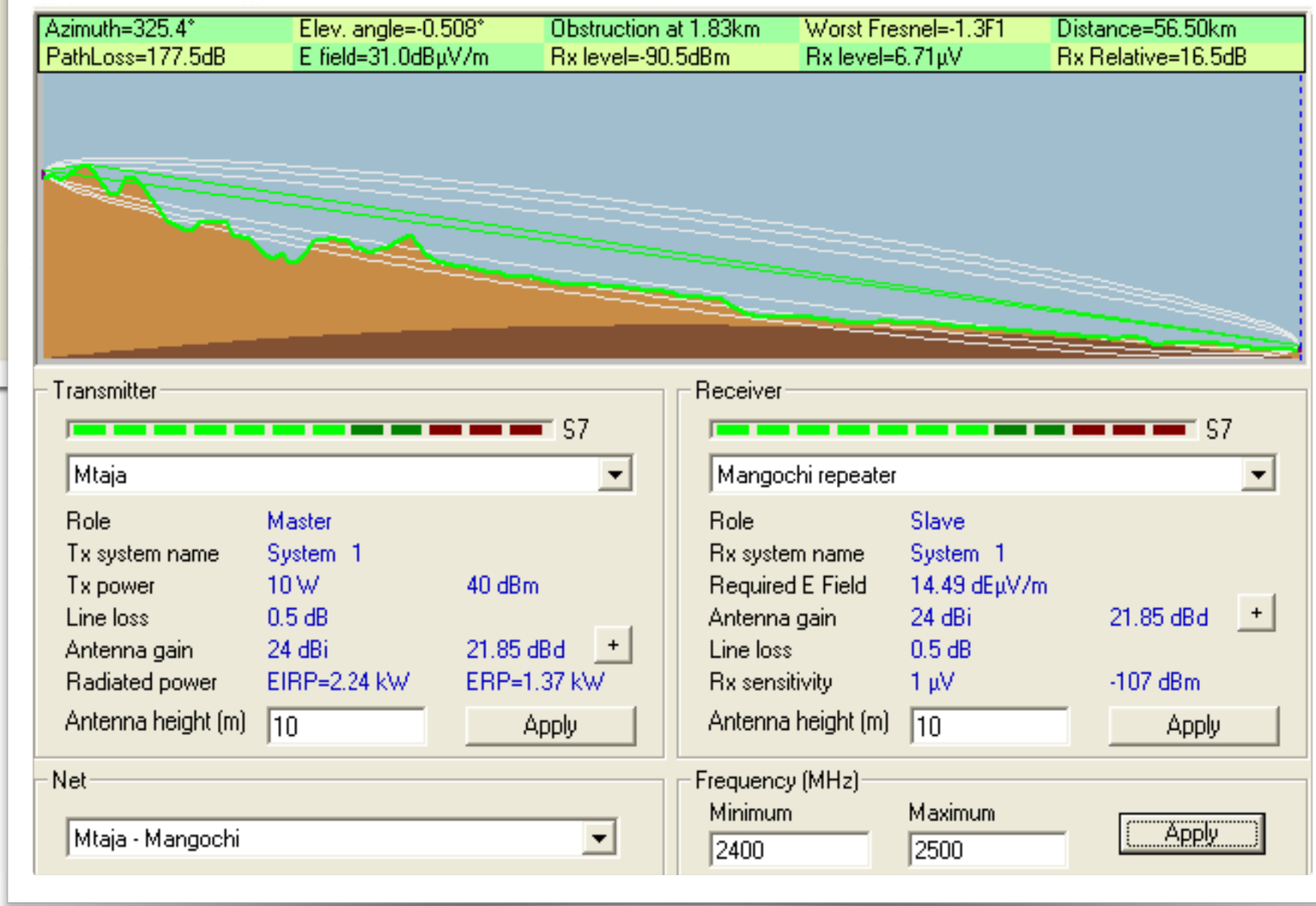
- With the help of Radio Mobile is very easy to simulate different scenarios, or just different values of the antenna height and/or gain, TX power, etc...





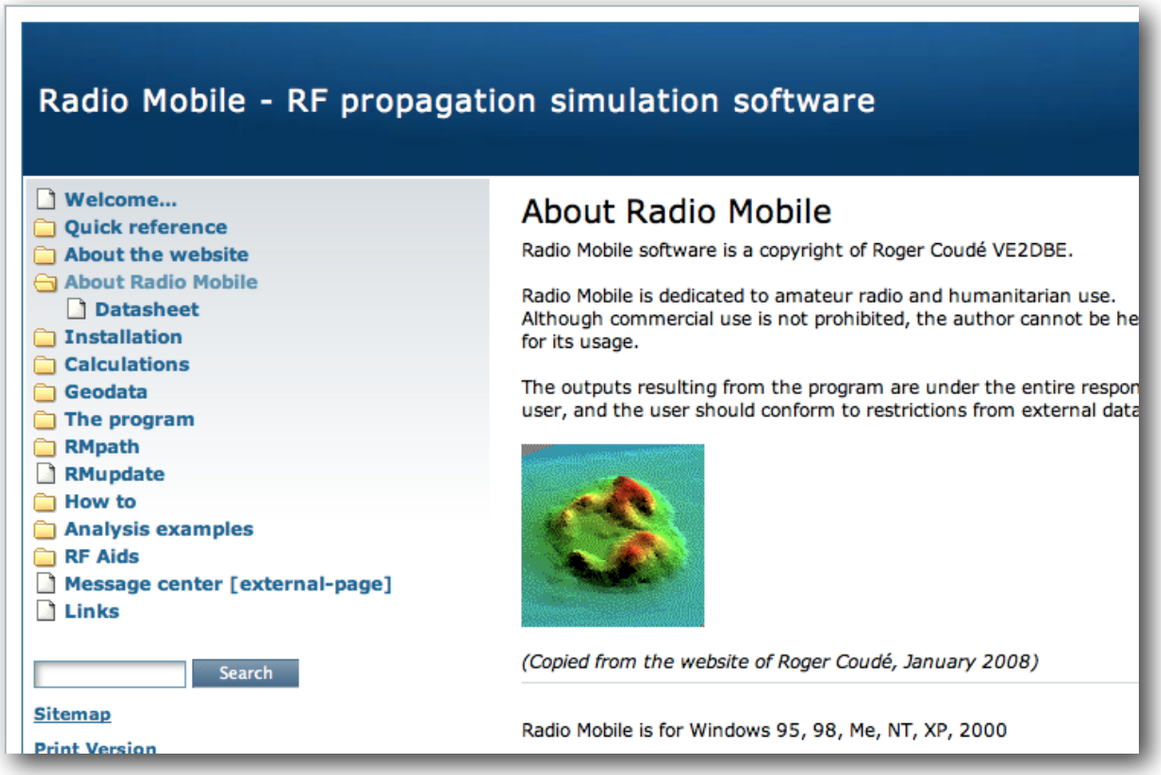


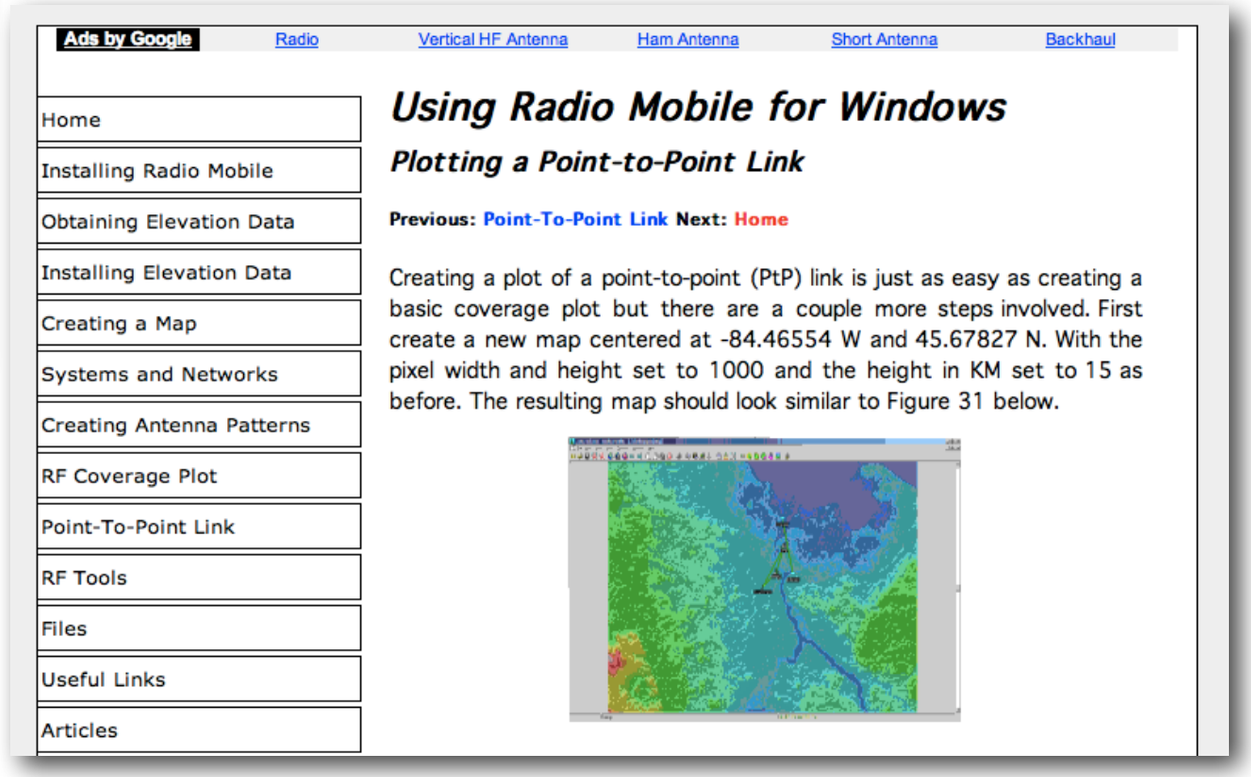
Other examples
(Malawi)



Links

http://radiomobile.pe1mew.nl/?About_Radio_Mobile





http://www.pizon.org/radio-mobile-tutorial/point-to-point-link.html

Conclusions

- Radio Mobile makes it possible to simulate one or more radio links and perform "what if?" simulations, changing various link parameters
- While it cannot prove that a link is 100% possible, Radio Mobile can prove that a link is not possible (or would be very difficult).
- By combining DEM data and free overlay maps, it is possible to make very informative reports about coverage, link quality, and other radio parameters.

Thank you for your attention

For more details about the topics presented in this lecture, please see the book ***Wireless Networking in the Developing World***, available as free download in many languages at:

http://wndw.net/