Lodz University of Technology

Institute of Electronics

Instruction for Laboratory classes on Wireless Communications

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Exercise 3. Up-link and down-link analysis

The aim of this exercise is to:

- learn about up-link and down-link coverage,
- learn how to analyse the up-link coverage with Radio Mobile software.

1. References:

1. Gordon L. Stüber, "Principles of Mobile Communication", Second Edition, Kluwer Academic Publishers, 2002
2. ETSI GSM Technical Specification, Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (GSM 05.05)
3. HELIAX® Coaxial Cables catalogue (Andrew company)

2. The scope of the exercise.

In this exercise you will learn on the differences on up-link and down-link.

In the mobile Communication systems, both the base station and the mobile unit are transmitting and receiving signals. This makes the bi-directional transmission possible and the data (speech, message, text) can get from the network to the mobile user and from the user to the network. The link from base station to mobile is called "down-link" while the link from mobile to the base station an "up-link".
In such system, the successful transmission between mobile and base station is possible when both receivers are driven with more power from the transmitters than required by their sensitivity. In the fig. 1 such case is presented.

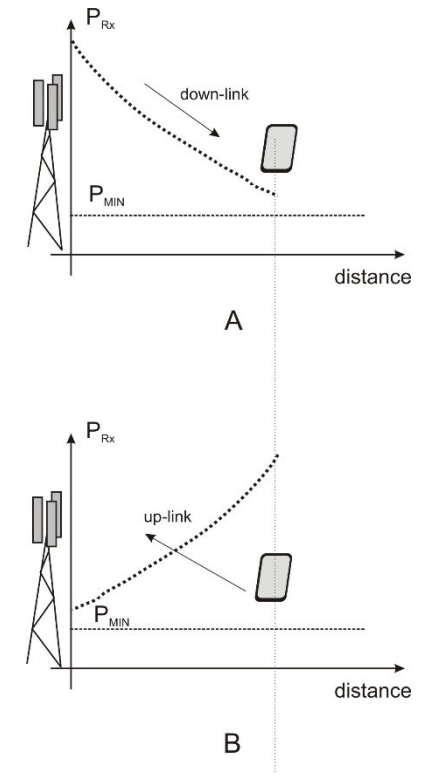


Fig.1 The successful transmission in both: A – down-link, B – up-link.

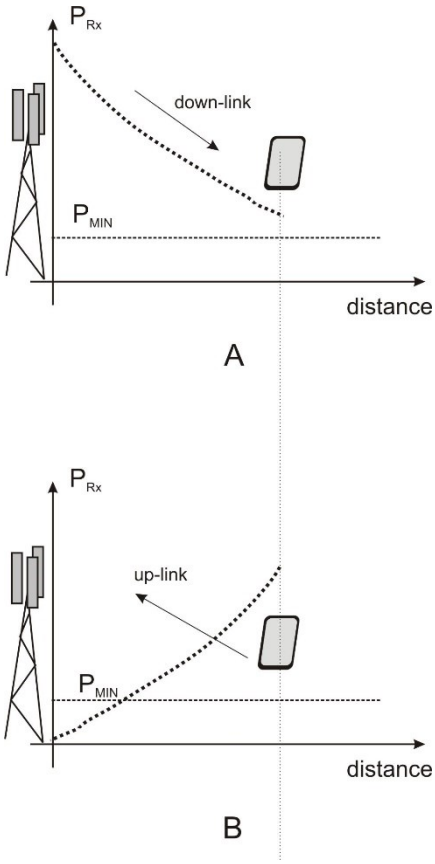


Fig.2 The successful transmission only in down-link: A – down-link, B – up-link.

Often, the parameters of base stations and mobile equipment are different from each other what may cause the differences in the system coverage in down-link and in up-link. In the fig.2 the case where mobile terminal operates with lower transmit power than the base station

is presented. For the given distance between base station and mobile terminal, in the down-link (fig. 2A) the transmission is still possible. For the up-link case, (Fig. 2B) the base station receives the power from the mobile unit that is below its sensitivity, so the transmission is not possible.

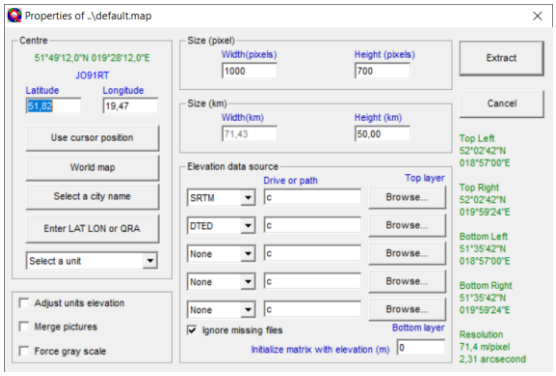
In this exercise you will analyse up-link coverage and down-link coverage of a single base station of GSM 900 system .

3. The course of the exercise

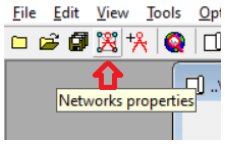
1. Create the project in Radio Mobile program

The project can be made for any city that you like. The examples are shown for Łódź city.

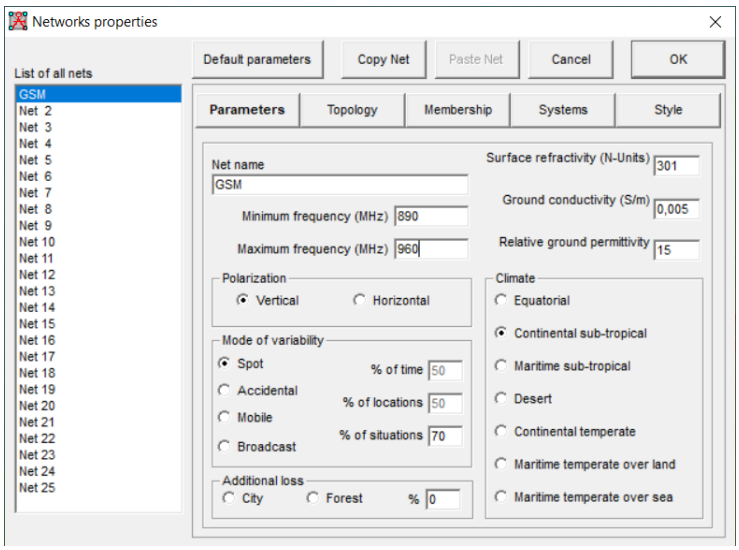
The size of the map in pixels (Size (pixel)) is set to Width = 1000, Height = 700 pixels. The map area defined in pixels can be assigned to the appropriate terrain area. We set the size of the analyzed area vertically on the map at 50 km (Size> Height> 50 km). Then press the "Extract" button.



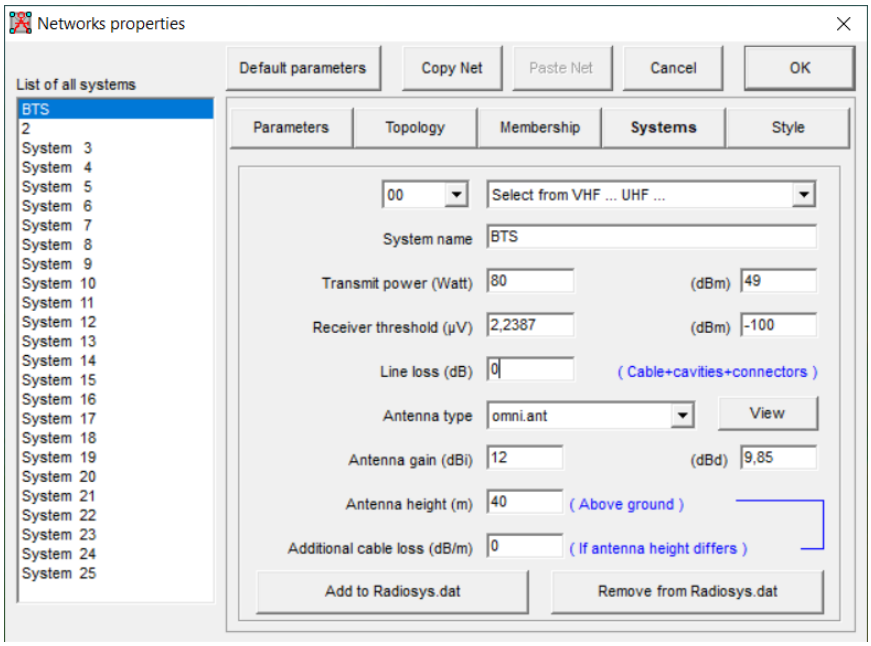
To configure GSM 900 system go to “Networks properties” window:



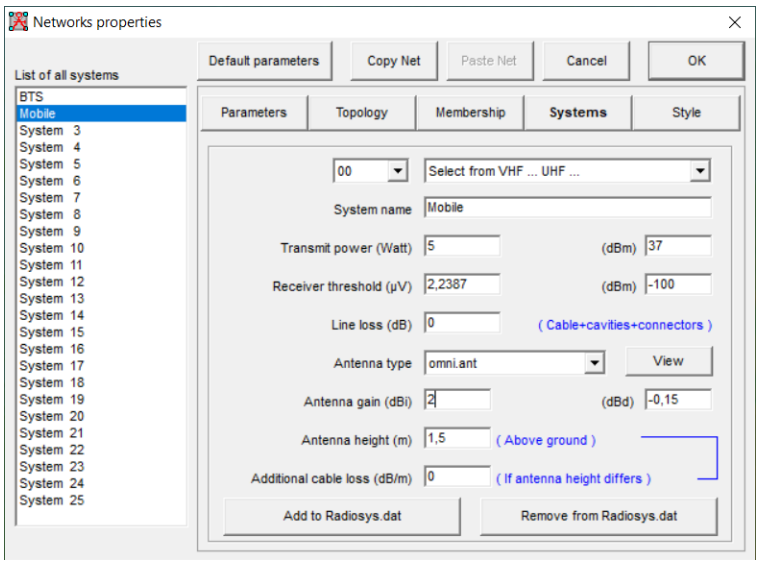
In “Parameters” tab give the name to this network “GSM”. Setup the frequency range from 890 MHz to 960 MHz.



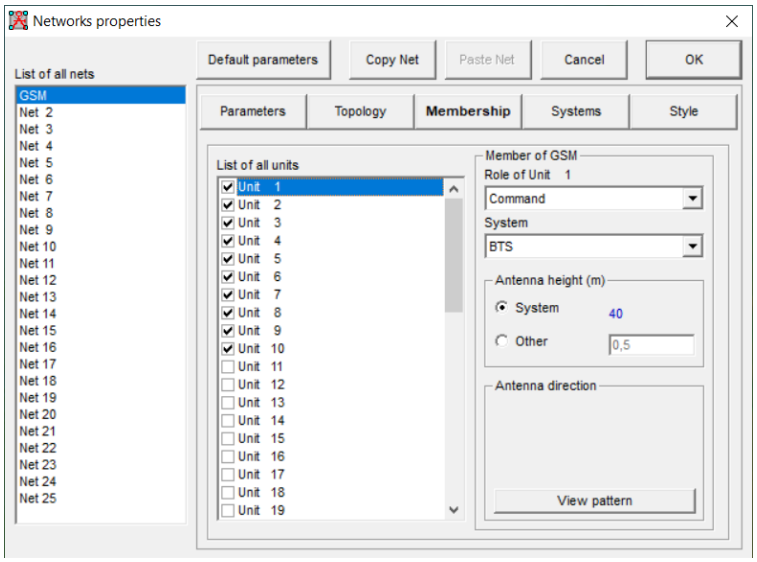
Base stations will belong to separate system. To configure this press the “Systems” button and put the following data:



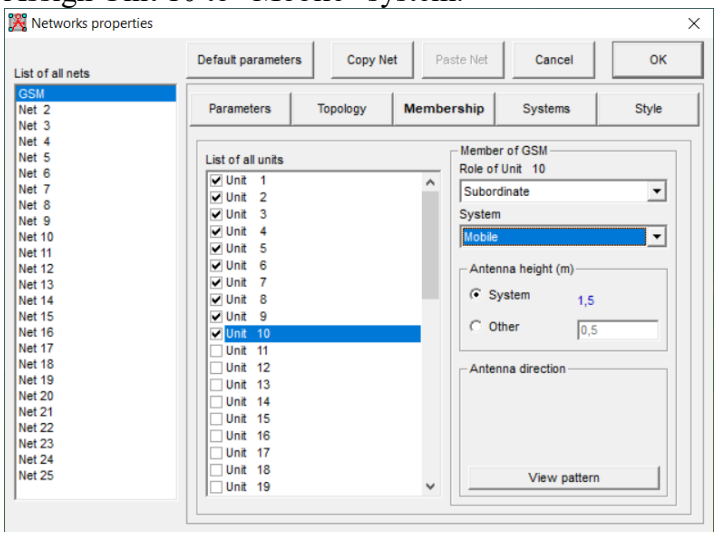
Mobile terminals will belong to separate system. To configure this press the “Systems” button and put the following data:



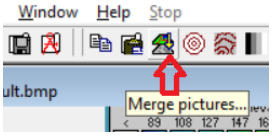
We assume that there will be 9 base stations and unit 10 will be mobile unit. Press "Membership" button and assign Unit 1 to 9 to system "BTS".



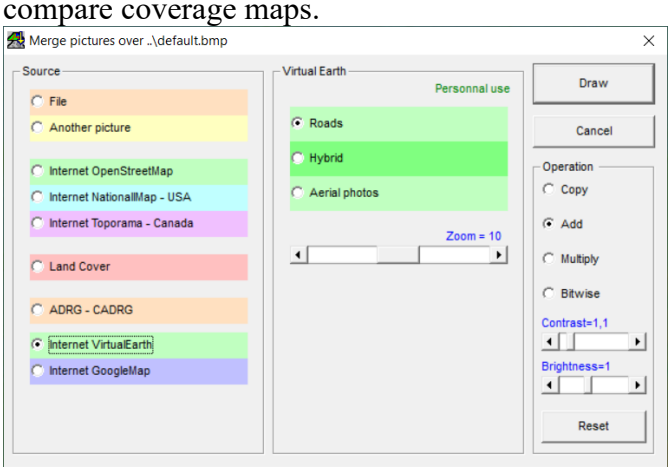
Assign Unit 10 to "Mobile" system.



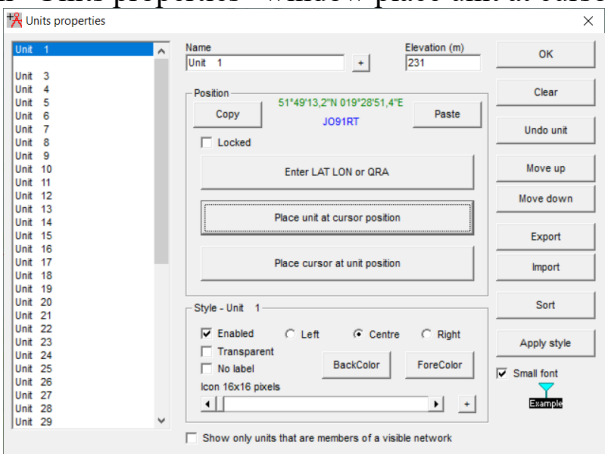
2. Place the base station

1. Go to Merge pictures window 

   And select the layer of roads to be merged with elevation map. This will help to compare coverage maps.



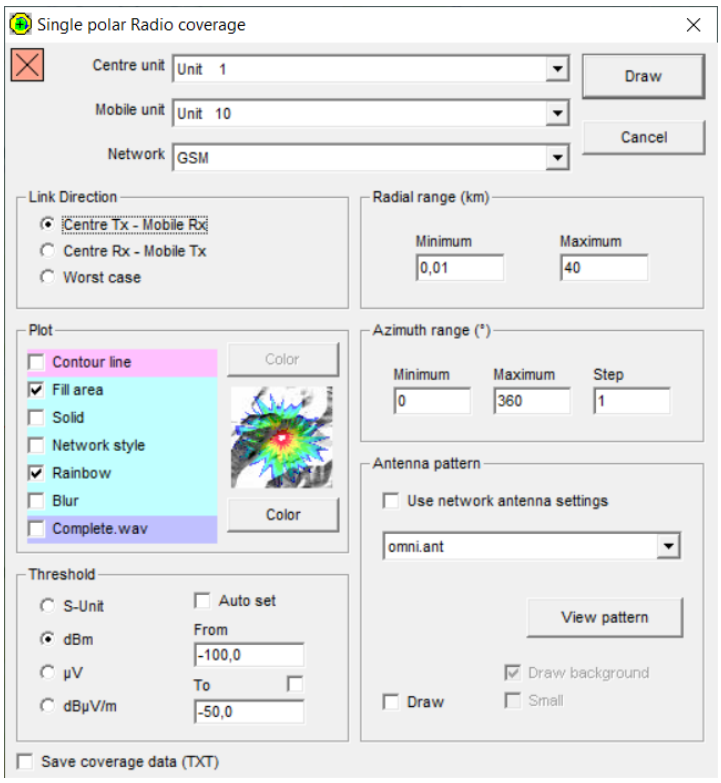
2. Point the pointer in the localization where you would like to place your base station. In “Units properties” window place unit at cursor position”



3. Down-link coverage calculations

In the menu: Tools> Radio coverage select Single polar. Using this menu, we will simulate the coverage of a transmitter. In the "Single Polar radio coverage" window, select "Center Unit" as "Unit 1", mobile unit should be “Unit 10”. The "Threshold" parameter is set in dBm from -100 (sensitivity of terminals) to 50.

In downlink analysis select link direction: Centre Tx – Mobile RX



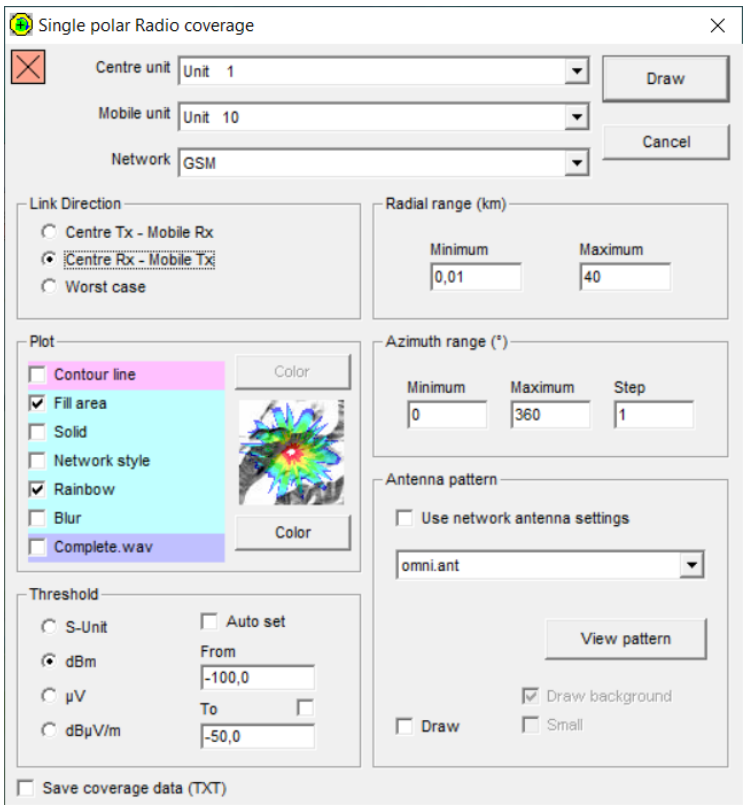
Confirm with ‘Draw’ button

On the project map you will see the results of coverage simulations presented in different colours that code the received power around the transmitter.
Save the coverage map that presents now the coverage in the down-link.

4.Up-link coverage

Get back to the map with roads, and no coverage on it. Having this map selected, in the menu: Tools> Radio coverage select again Single polar. Using this menu, we will simulate the coverage of a transmitter. In the "Single Polar radio coverage" window, select "Center Unit" as "Unit 1", mobile unit should be “Unit 10”. The "Threshold" parameter is set in dBm from -100 (sensitivity of terminals) to 50.

In up-link analysis select link direction: Centre Rx – Mobile TX

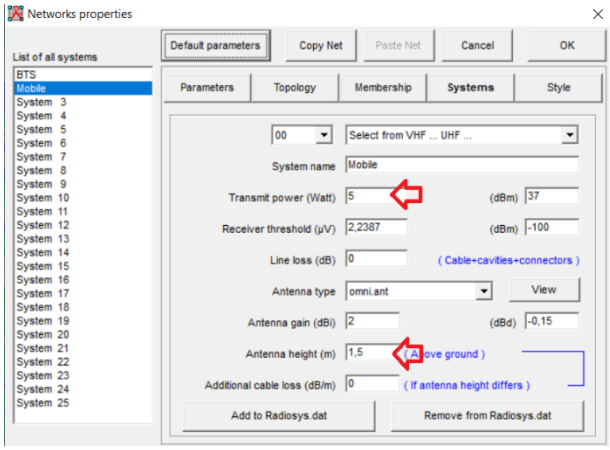


Save the coverage map that presents now the coverage in the up-link.

5. Experiments on Up-link and Don-link coverage

Please compare the up-link and down-link coverage keeping BTS parameters unchanged and for different uplink coverage parameters ("Network properties" > Systems > Mobile):

- Transmit power: 40W, 20W, 10W, 1W, 0.5W
- Antenna height: 1.5m, 5m, 40 m



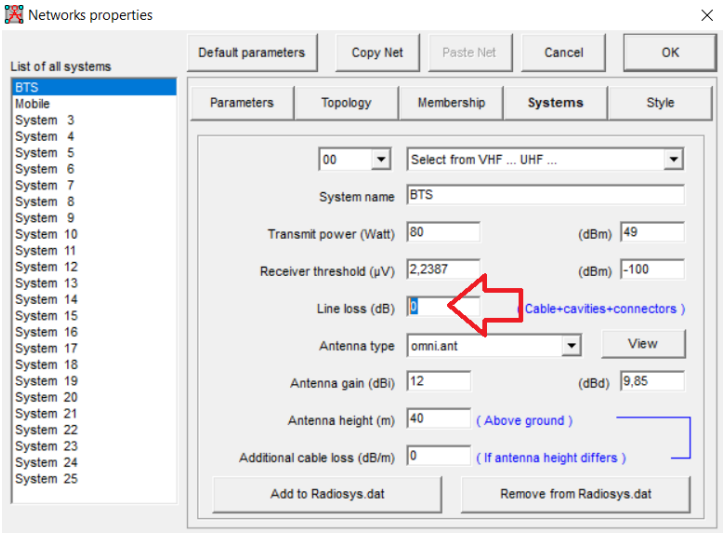
6. Compensate the loss of BTS feeding cable

The height of BTS antenna is 40m. You need a coaxial cable to connect the antenna to the transceiver that is located beneath the antenna mast.

Please browse in the Internet to see what cables you may use for this. Select one and learn what is its unit loss (given in dB/1m or dB/100m).

Calculate the loss introduced by this cable to the BTS signal.

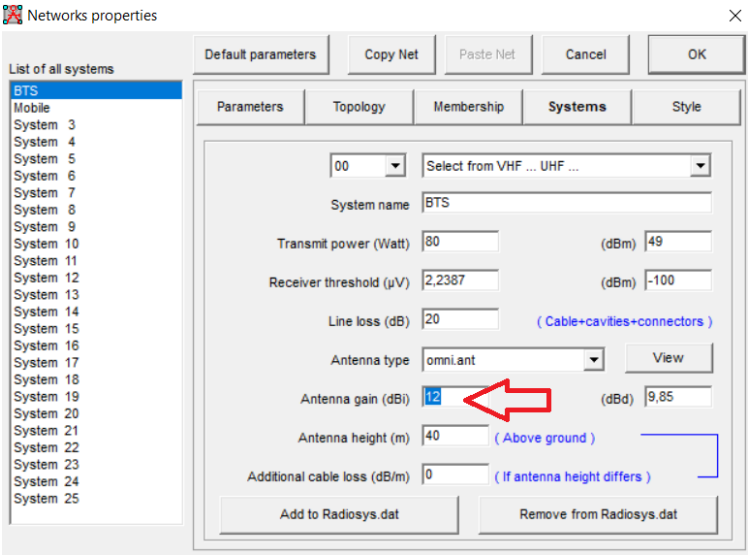
Now put this value into the properties of base station and make the simulations of uplink and downlink.



Assuming that the transmit power of mobile unit (TX radiated power) is 5W, what should be the transmit power of BTS to have the similar coverage in uplink and downlink?

7. Analyse up-link and down-link for different antenna gains

Change the BTS antenna gain and check how does it influence the up-link and down-link. Use gain equal to 2, 5, 15 dBi.



Compare the obtained results.

THE END