Plánovanie mobilných rádiových sietí

KIS FRI UNIZA

Vytvorené v rámci projektu **KEGA 026TUKE-4/2021**

Agenda

- Inštalácia programu
- Vytvorenie podkladovej mapy s výškovým profilom
- Konfigurácia bezdrôtovej mobilnej siete

Simulačný program Radio Mobile

- Radio Mobile je voľne dostupný simulačný nástroj na simulovanie šírenia mobilného signálu v teréne
  - Ian D. Brown, Roger Coudé
  - *“Radio Mobile is dedicated to Amateur Radio and humanitarian use. Although commercial use is not prohibited, the author cannot be held responsible for its usage or the data it provides.”*

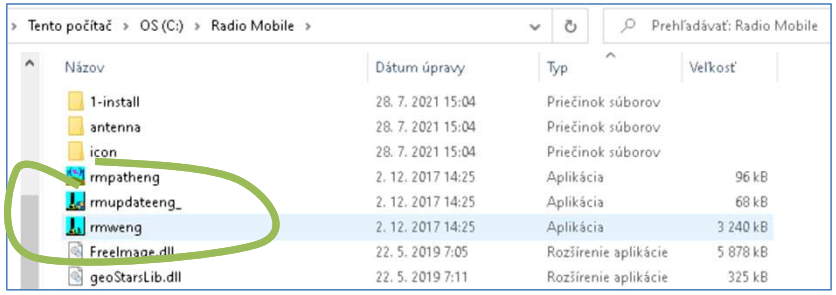
  - Longley-Rice irregular terrain model pre frekvenčný rozsah 20MHz - 20GHz
  - https://en.wikipedia.org/wiki/Longley%E2%80%93Rice_model#:~:text=The%20Longley%E2%80%93Rice%20model%20(LR,irregular%20terrain%20model%20(ITM).

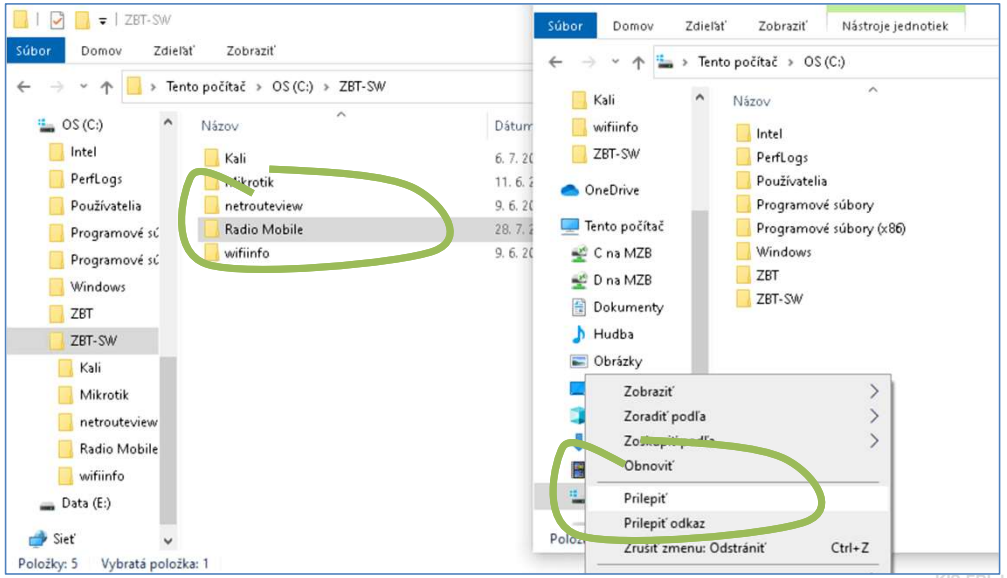
Inštalácia alebo overenie inštalácie:

- Prekopírovať adresár “Radio Mobile” z adresára “ZBT-SW” na disk C:\

Spustenie programu:

- Rmweng.exe

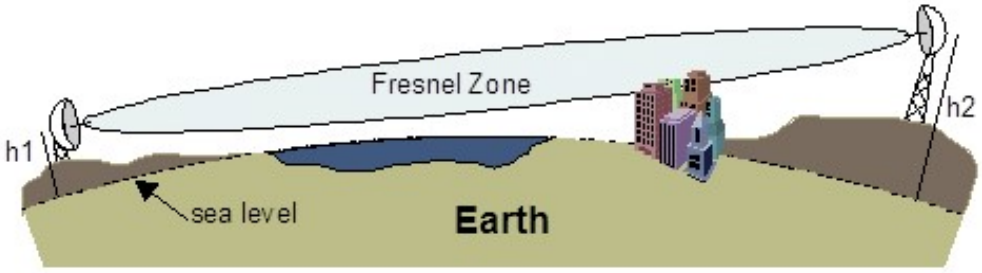


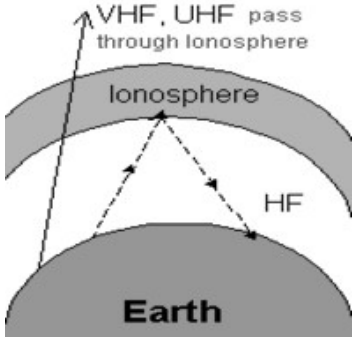


Irregular Terrain Model (ITM) Longley-Rice

- Model of radio propagation for frequencies between 20 MHz and 20 GHz
- named for Anita Longley & Phil Rice ; 1968
- predicts the median attenuation of a radio signal as a function of distance and the variability of the signal in time and in space

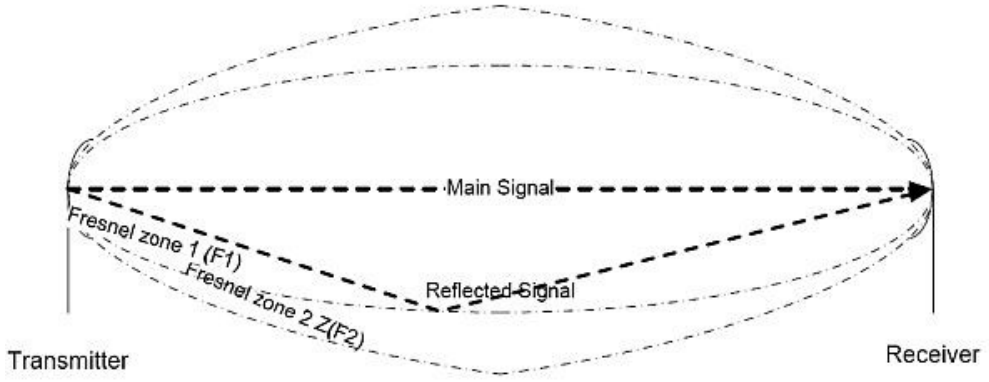
- Signal propagation is influenced by:
  - Free space loss EIRP [W], atmospheric attenuation (typicallydepends on water vapour content of the atmosphere)
  - Ground wave propagation (ground conductivity and permitivity). Diffraction around a smooth earth. Ground reflections.
  - Effect of terrain (Terrain features, trees and buildings, usually attenuate signals).
  - Tropospheric refraction (ionosphere above reflects HF radio waves (3-30MHz) back to Earth)
  - Ionospheric propagation (layer of conductive gas at heights between 70 and 400 km)
  - Diffraction over “knife edge”

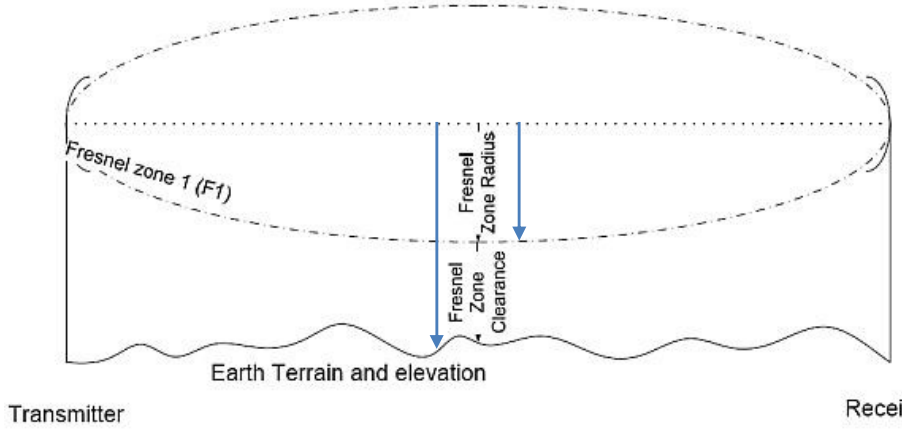




Fresnel zones

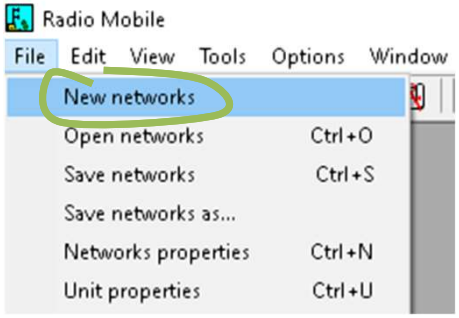
- There are an infinite number of Fresnel zones, however, only the first 3 have any real effect on radio propagation (F1, F2, F3). The size of the 3D ellipse is determined by the frequency of operation and the distance between the two sites.
- The signal can go directly between transmitter and receiver (main signal). Signal can reflect off the ground and then carry on to the distant receiver.
- F1 zone is determined by the calculation so that the difference in path length between the main signal and a reflected signal from the F1 radius distance is 180º. A reflected signal shifted by 180º of path distance plus 180º from the actual reflection point totals 360º of phase shift. The 2 signals, main and reflected, arrive at the antenna 360º apart or in phase. They will add together and not affect receiver performance.
- Fresnel zone earth clearance – the clearance between Fresnel zone cylinder (its line of sight) and the earth. Optimal clearance requires 60% or more of the first Fresnel zone (0.2F1)
  - Note: Worst Fresnel 1F1 means earth or obstacle at the edge of Fresnel Zone (FZ Clearance /FZ Radius)

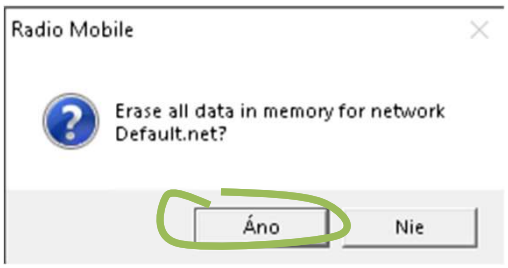


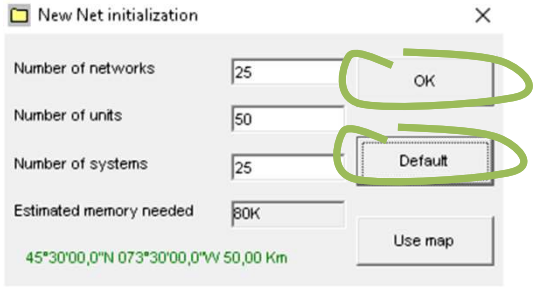


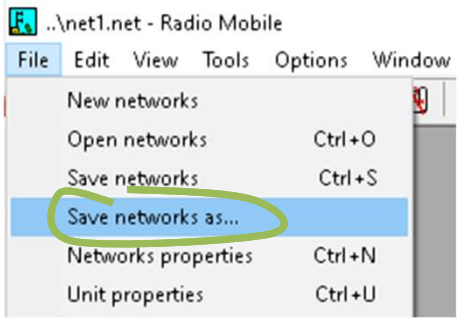
Vytvorenie podkladovej topologickej mapy

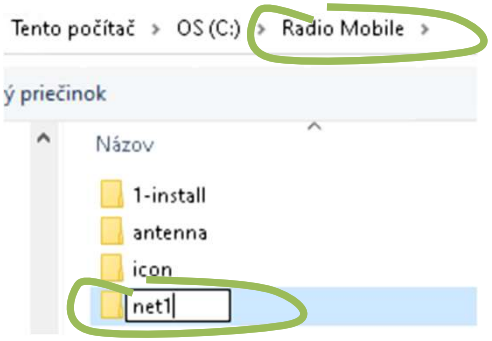
Vytvorenie a uloženie nového projektu

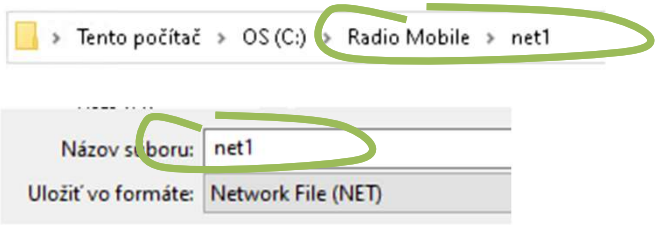






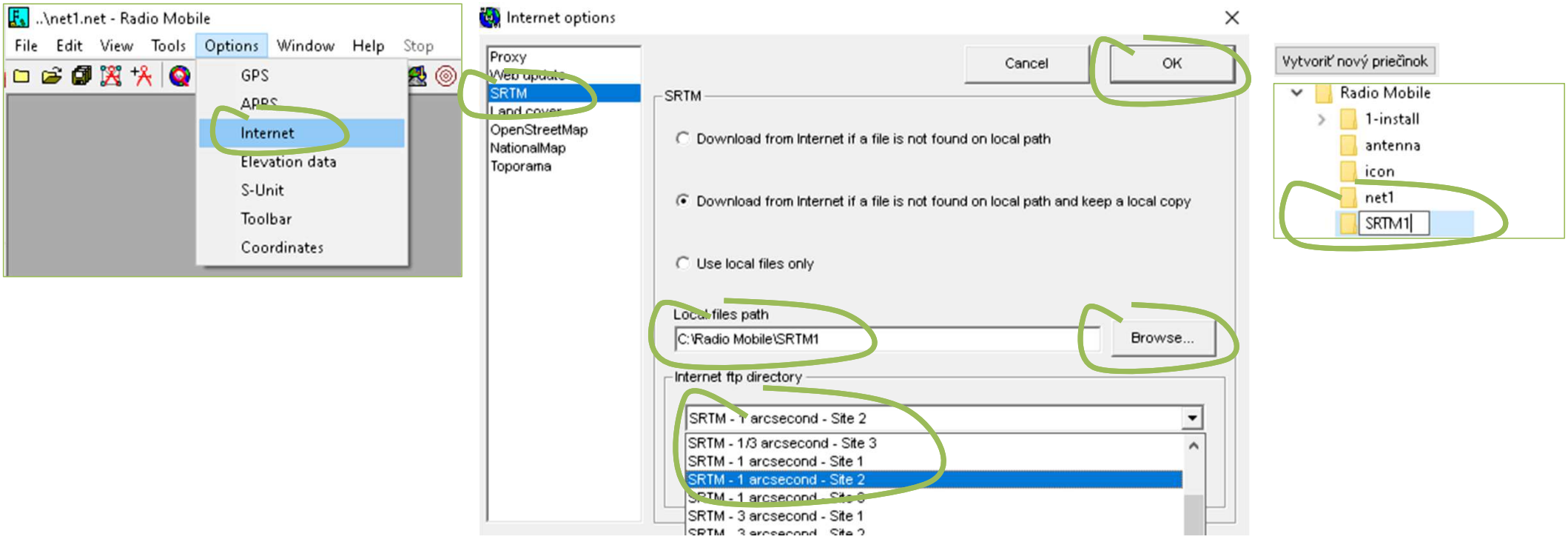






- New project NET1 saved in new directory C:\Radio Mobile\net1\

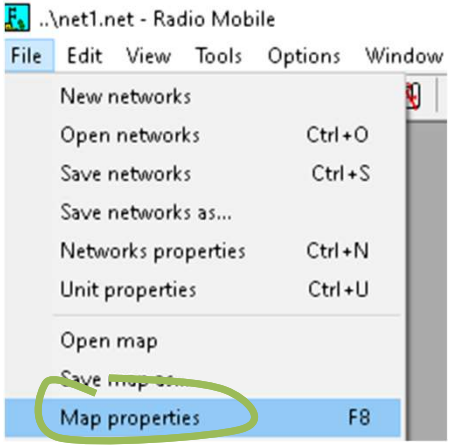
Nastavenie internetovej konektivity na stiahnutie výškových profilov



- The Shuttle Radar Topography Mission (SRTM) is an international research effort that obtained digital elevation models, relevant files need to be downloaded from Internet for the selected region (region definition on the next slide)

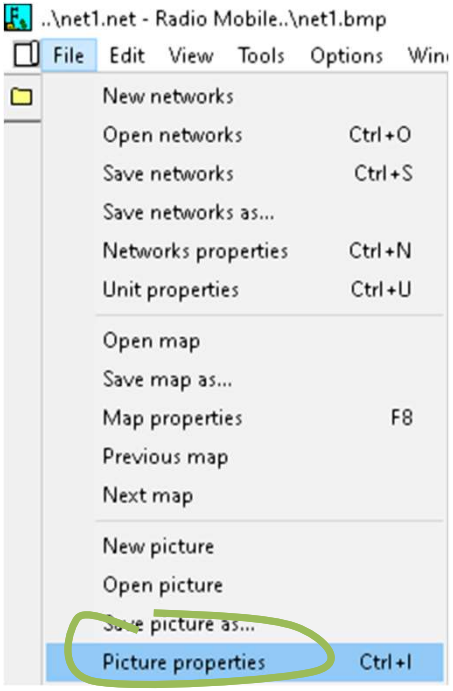
- Downloaded files locally stored in the C:\Radio Mobile\SRTM1\ directory

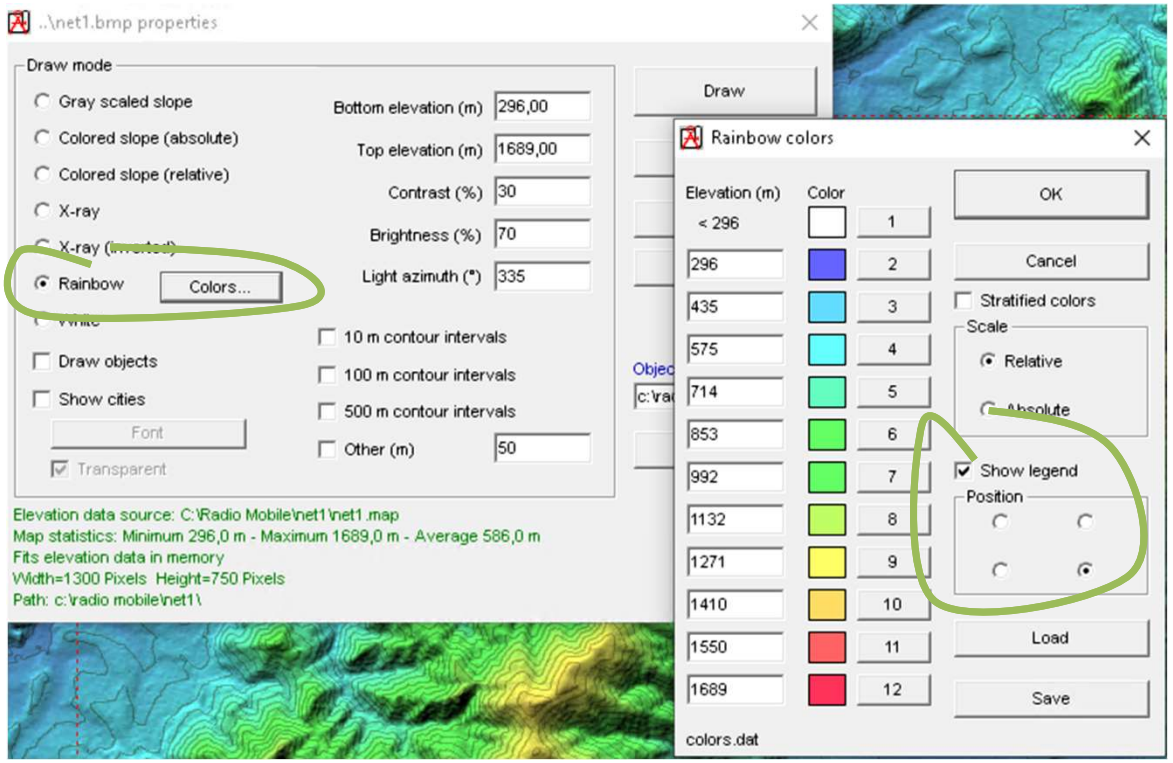
Definovanie vytváranej podkladovej mapy s výškovým profilom pre zvolený región – GPS coord

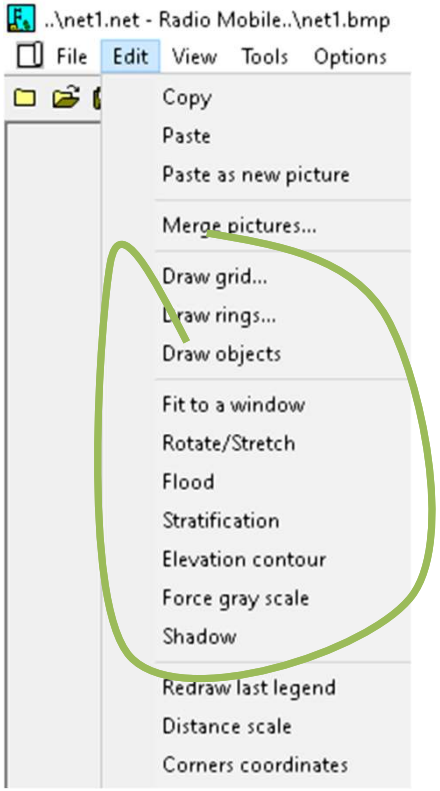


- New SRTM based map will be merged with topographic information

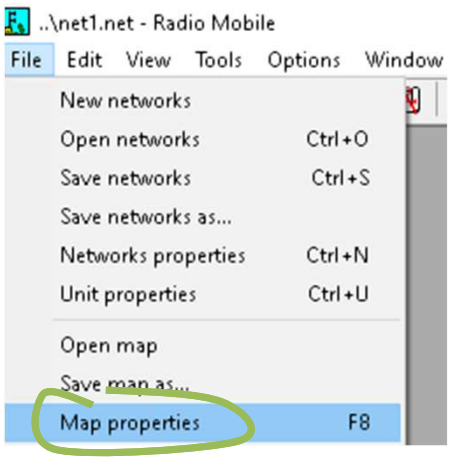
Úprava zobrazovania podkladovej mapy s výškovým profilom a pozícia legendy; ďalšie voliteľné úpravy mapového obrazu .BMP

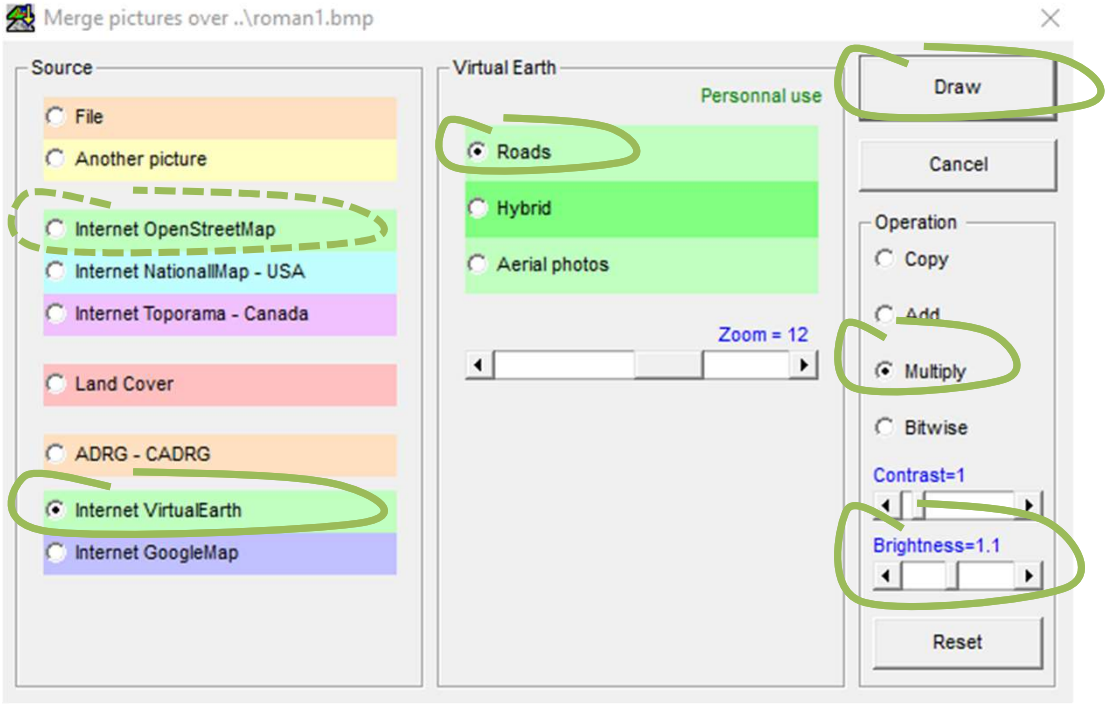






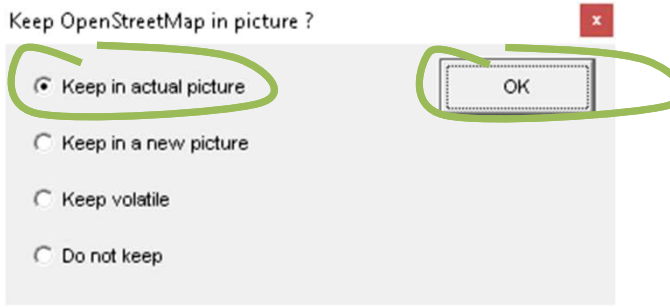
Spojenie topografických informácií s podkladovou mapou s výškovým profilom



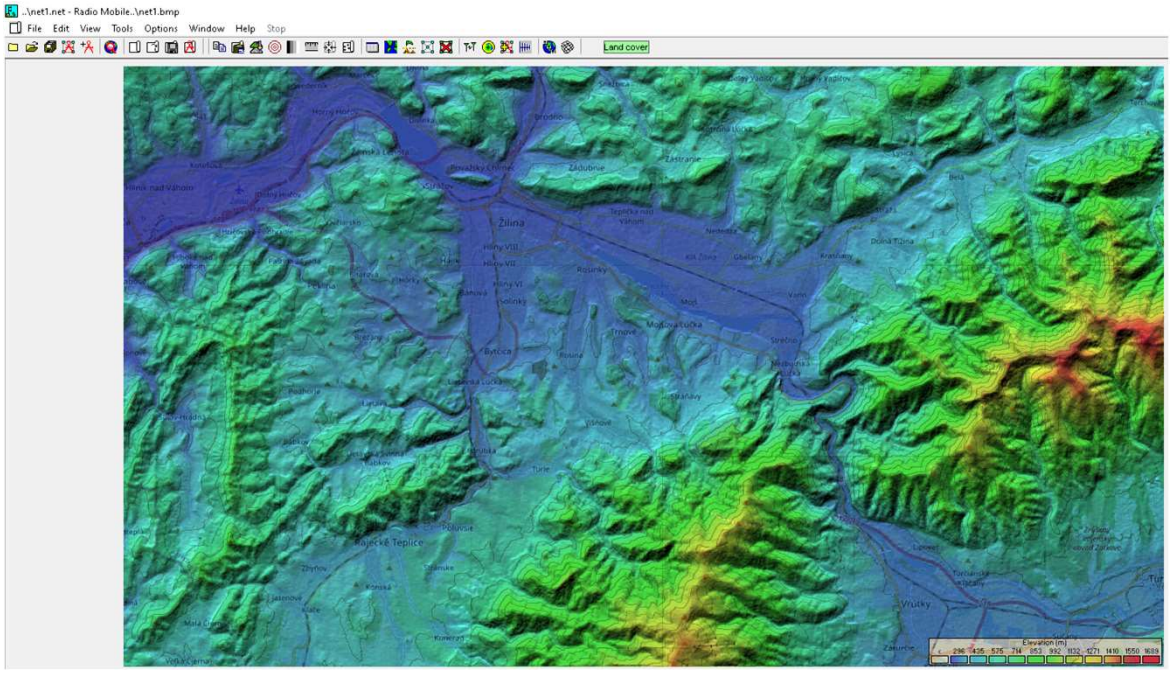


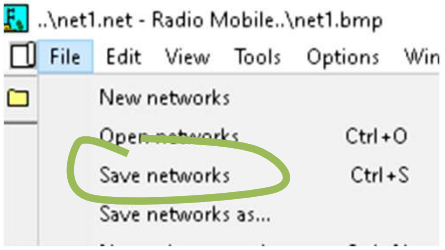
Povoliť v súbore “Map_Link.txt” MS mapy alebo zvoliť v menu OpenStreetMap

```
Radio Mobile restricted merge sources (this line for alternate OSM style server)
virtualearth.net
'
```



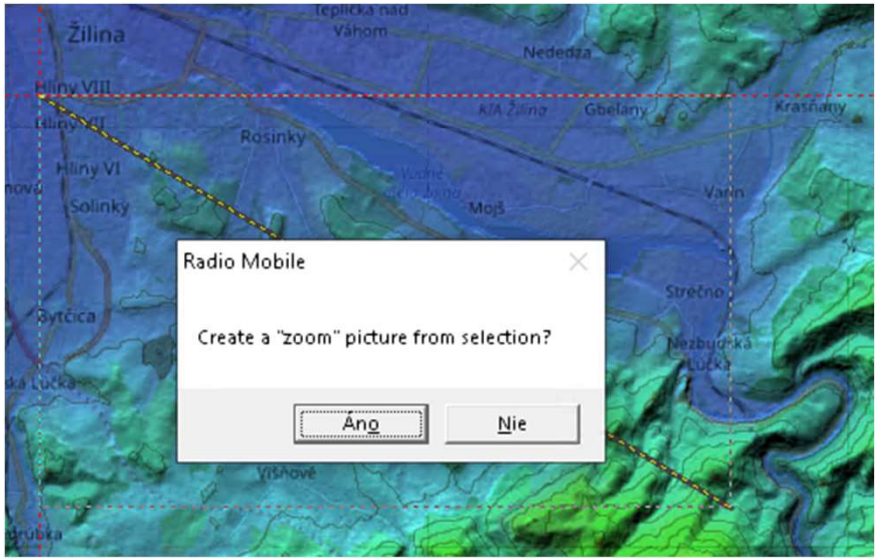
Príklad finálnej podkladovej mapy; uloženie atribútov mapy, BMP obrazového súboru a sieťových prvkov do adresára C:\Radio Mobile\net1\





Zoom – možnosť vytvorenia nového obrazu z výberu

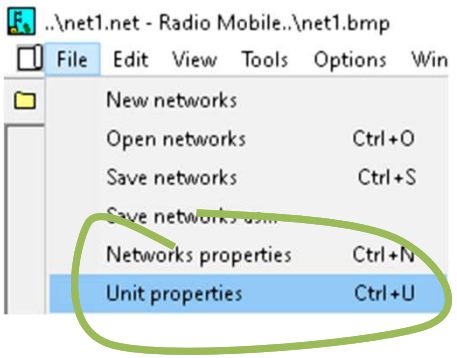
- Right-click na obrazový súbor a potiahnutím zvoliť výsek pôvodného podkladu
- Right-click na výber spustí proces vytvorenia nového obrazového súboru

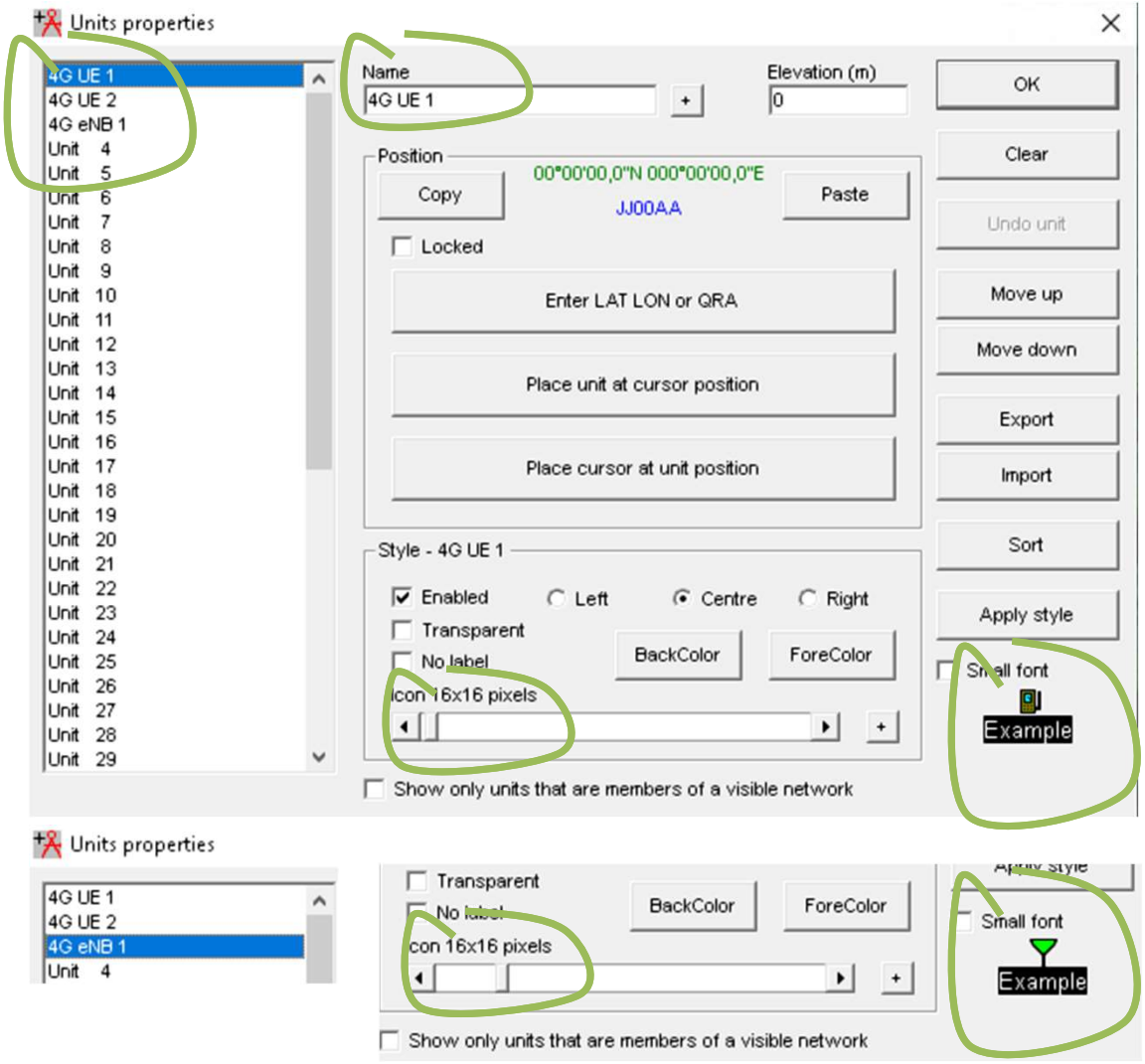


- Novovytvorený obrazový súbor je možné kedykoľvek uložiť alebo zavrieť bez uloženia

Konfigurácia bezdrôtovej mobilnej siete

Konfigurácia jednotlivých prvkov mobilnej komunikácie - 4G/LTE základňovej stanice eNB a 2x koncového zariadenia UE (User Equipment)

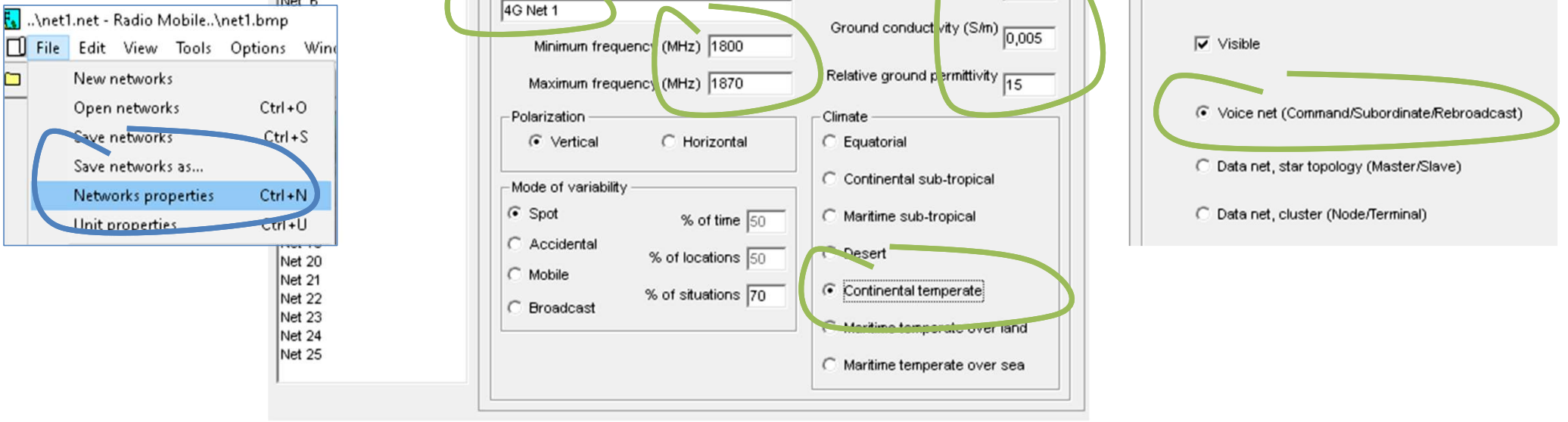




eNB (Evolved Node B) - 4G (or LTE) hardware that is connected to the mobile phone network that communicates wirelessly with mobile handset or user equipment (**UE**)

BTS (Base Transceiver Station) is an equivalent to eNB but in 2G (GSM) technology

Konfigurácia parametrov mobilnej siete a typov komunikačných prvkov



Zisk antény a súvislosť s vysielacím výkonom

Effective Isotropic Radiated Power (EIRP)

- The hypothetical power that would have to be radiated by an isotropic antenna to give the same (or "equivalent") signal strength as the actual source antenna in the direction of the antenna's strongest beam

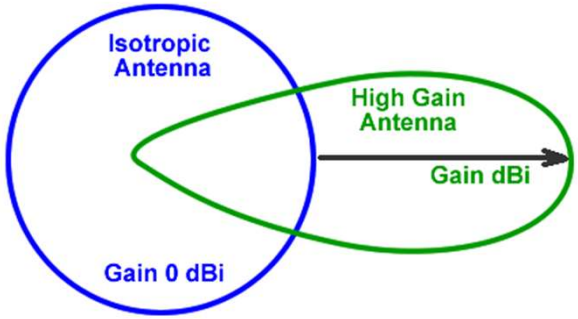
$$EIRP = P_T - L_C + G_a$$

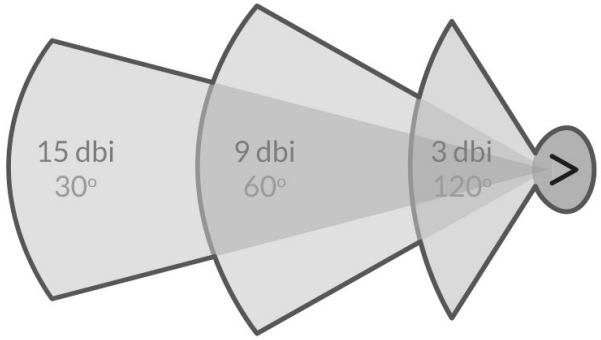
P_T = Output power of the transmitter (dBm)

L_C = Cable Loss (dB)

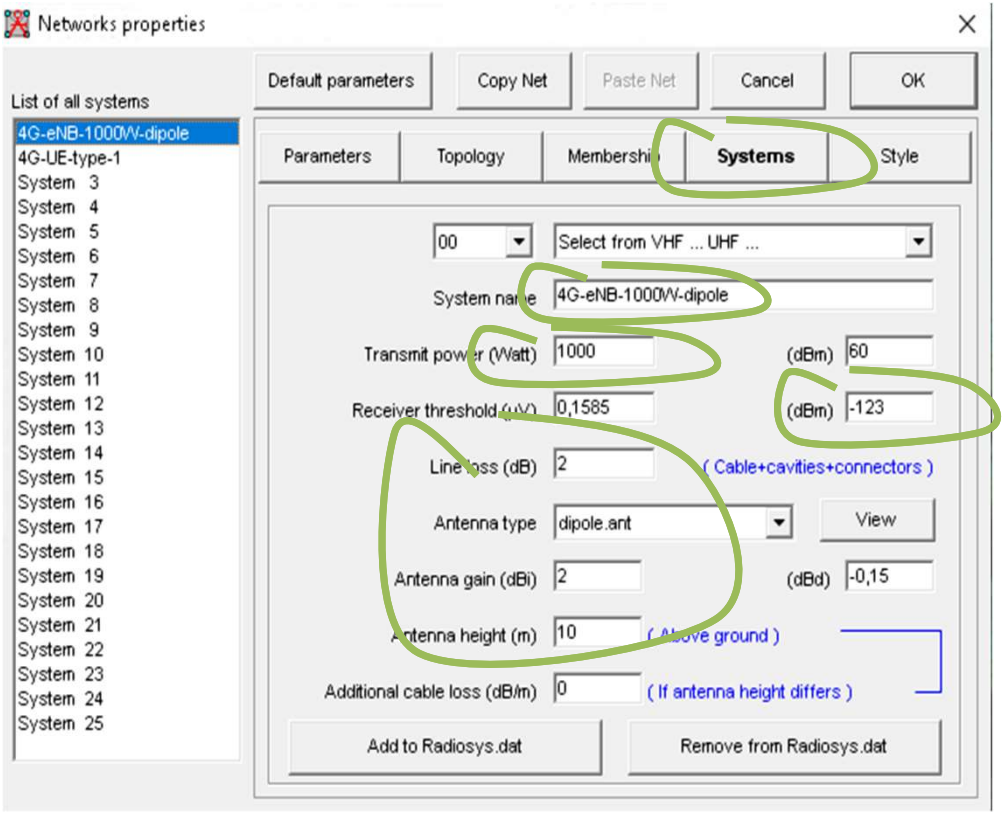
G_a = Antenna Gain (dBi)

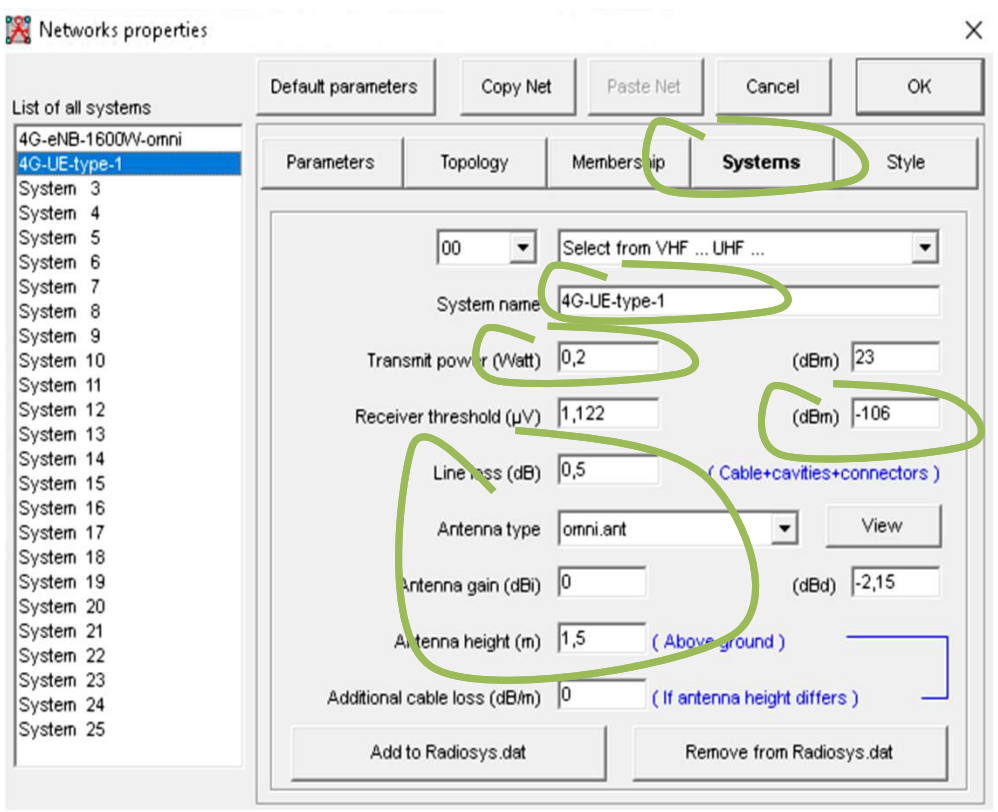
	Omni	Dipole	Yagi (60°)	
Tx Power	1600	1000	200	W
Tx Power	62.0	60.0	53.0	dBm
Ant. gain	0	2	9	dBi
Cable loss	2	2	2	dBm
EIRP	60.0	60.0	60.0	dBm
EIRP	1009.5	1000.0	1002.4	W
dBm = 10 log P_1/1mW				
P_1= 1mW*10$^{dBm/10}$				



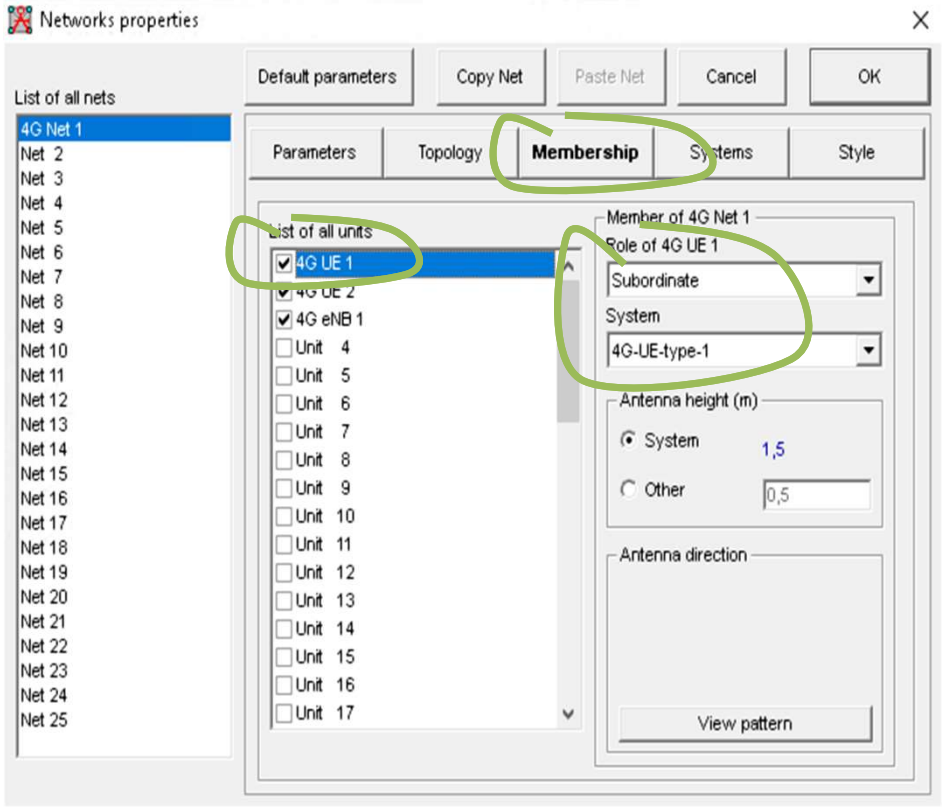


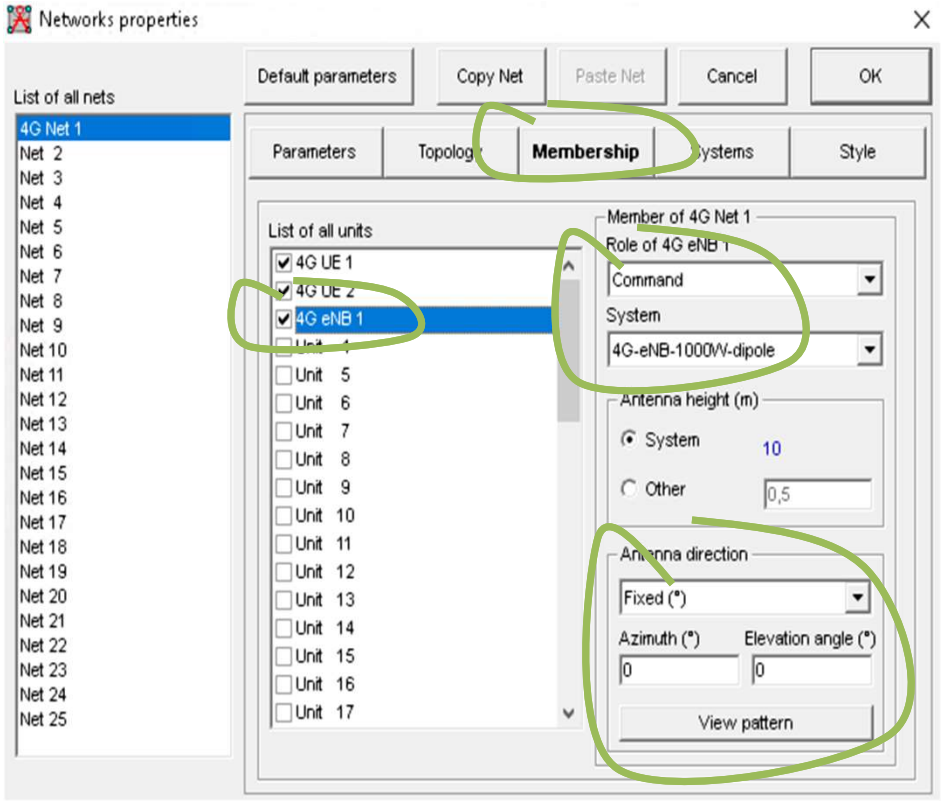
eNB a UE prvky; nastavenie anténnych a vysielacích charakteristík, citlivosť prijímača





Konfigurácia konkrétnych komunikačných zariadení

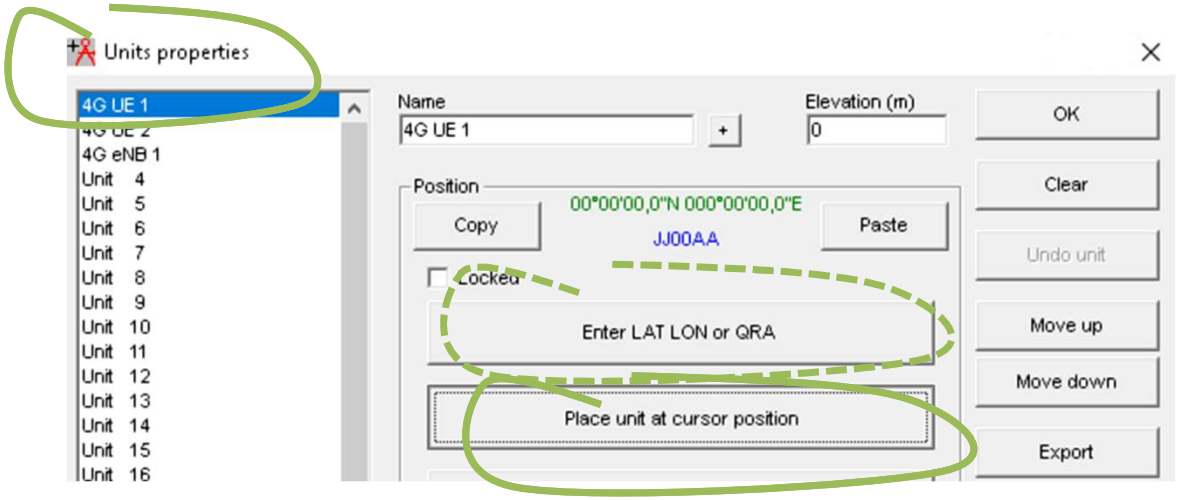




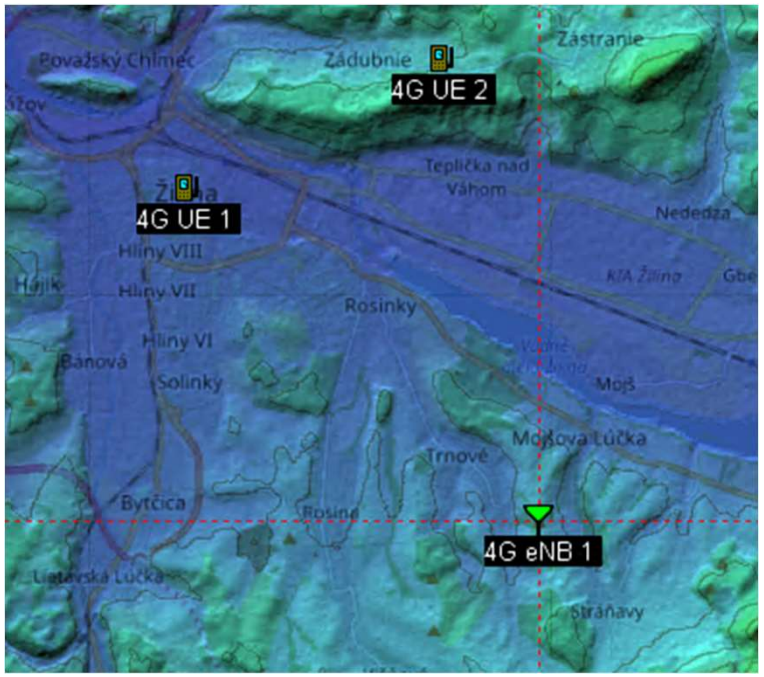
- Voľba zariadení, ktoré patria do konfigurovanej mobilnej siete
- eNB základňová stanica je nastavená do módu Command, hand-held zariadenie je v móde Subordinate
- Priradenie predkonfigurovaných charakteristík konkrétnemu zariadeniu

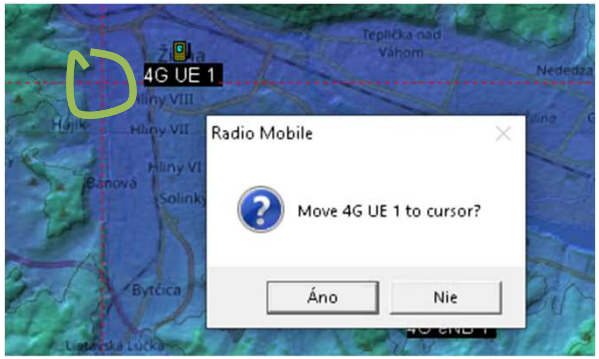
Umiestnenie zvolených zariadení do topologickej mapy

Umiestnenie komunikačných prvkov do vytvorenej topologickej mapy



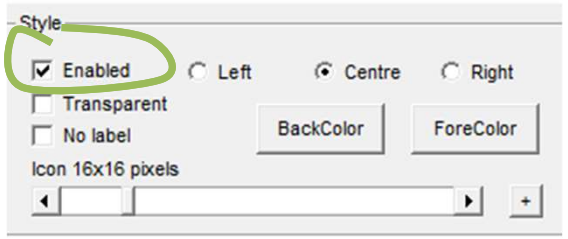
- Left-click na mapový podklad, kam chcem umiestniť zariadenie (resp. zadať súradnice)
- File - Unit Properties - Place unit at cursor position
- Viacero možností modifikovať pozíciu na mape; jedna možnosť je označiť novú pozíciu left-clickom a right-click na ikonu zariadenia





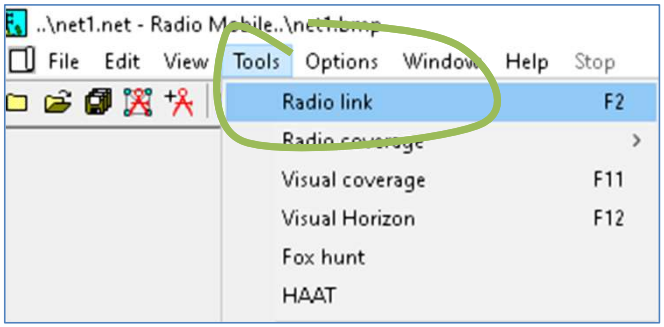
eNB: 49.18293 N , 18.80587 E
UE1: cca centrum Žiliny

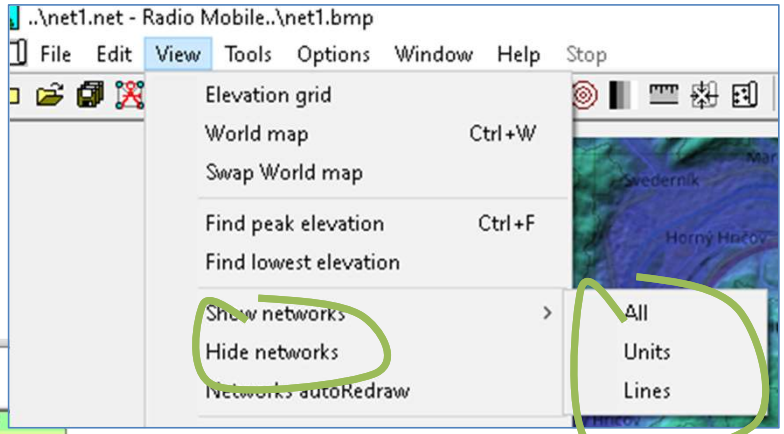
Možnosť aktivovať/deaktivovať zariadenie:

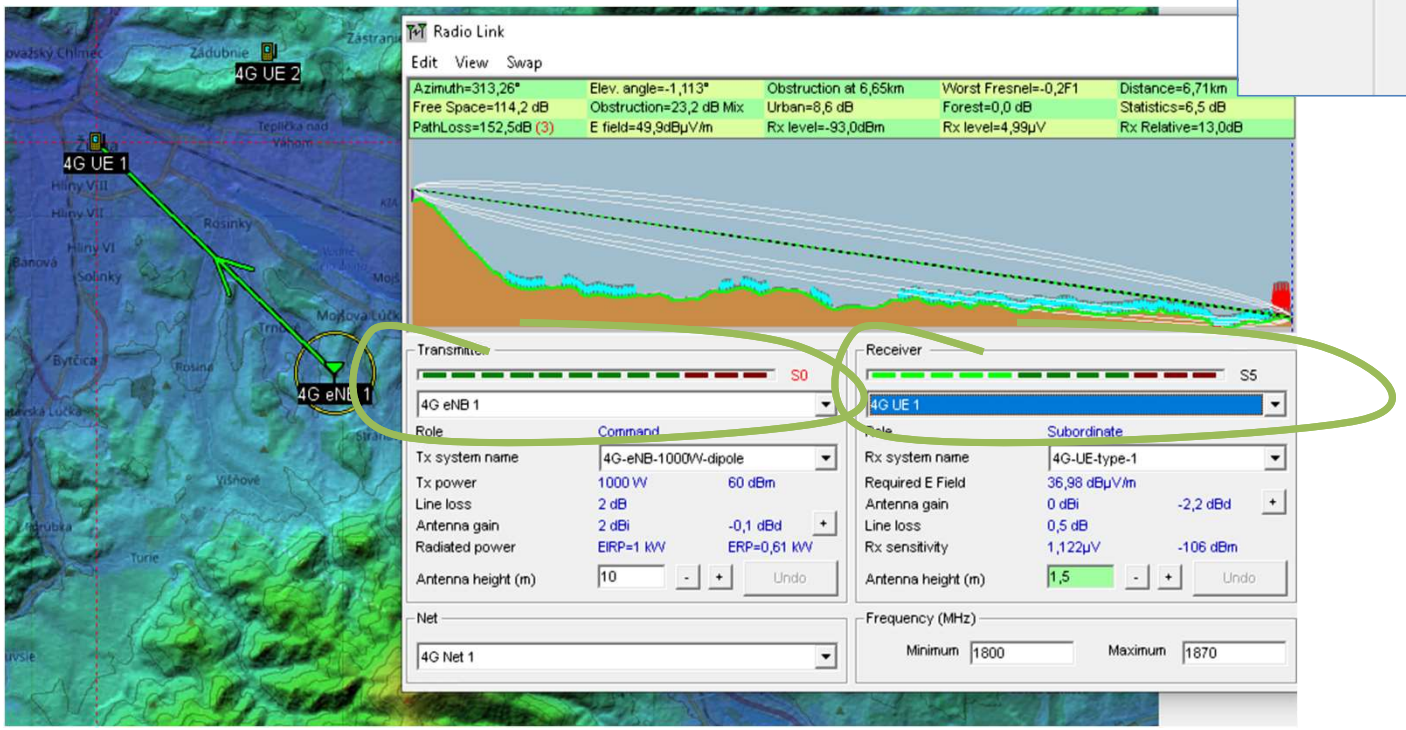


Radio Link
Charakteristika bezdrôtovej rádiovej linky

Radio Link - zobrazenie charakteristiky spojenia medzi eNB a zvoleným UE



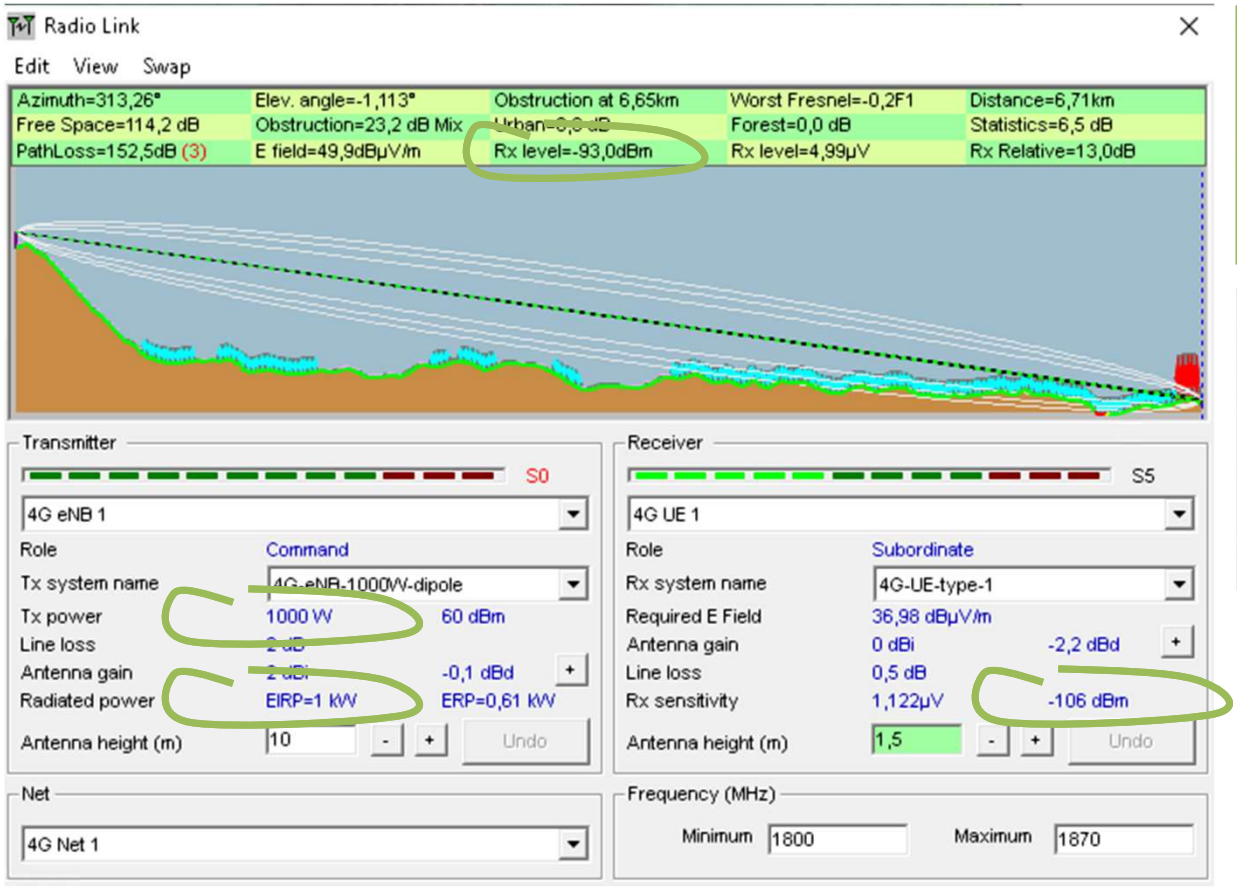


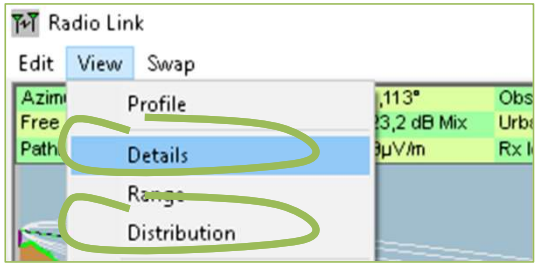


Signal level; S-Units:

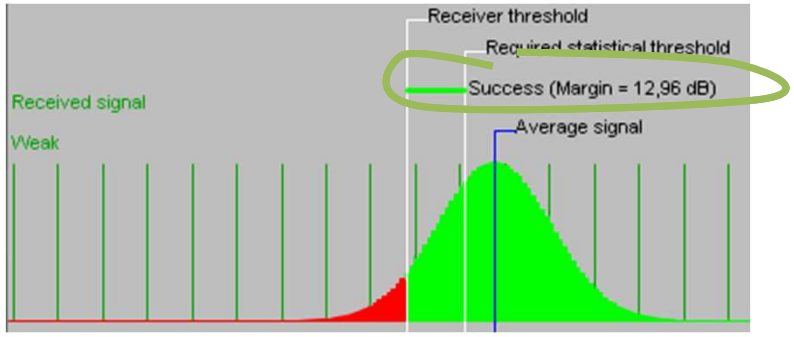
- S9 level is 5,01 uV (-93 dBm at 50 ohm, 0dBd)
- 3 dB per S-point
- Nižšia hodnota, slabší signál

Radio Link parameters: 4G eNB -> 4G UE 1



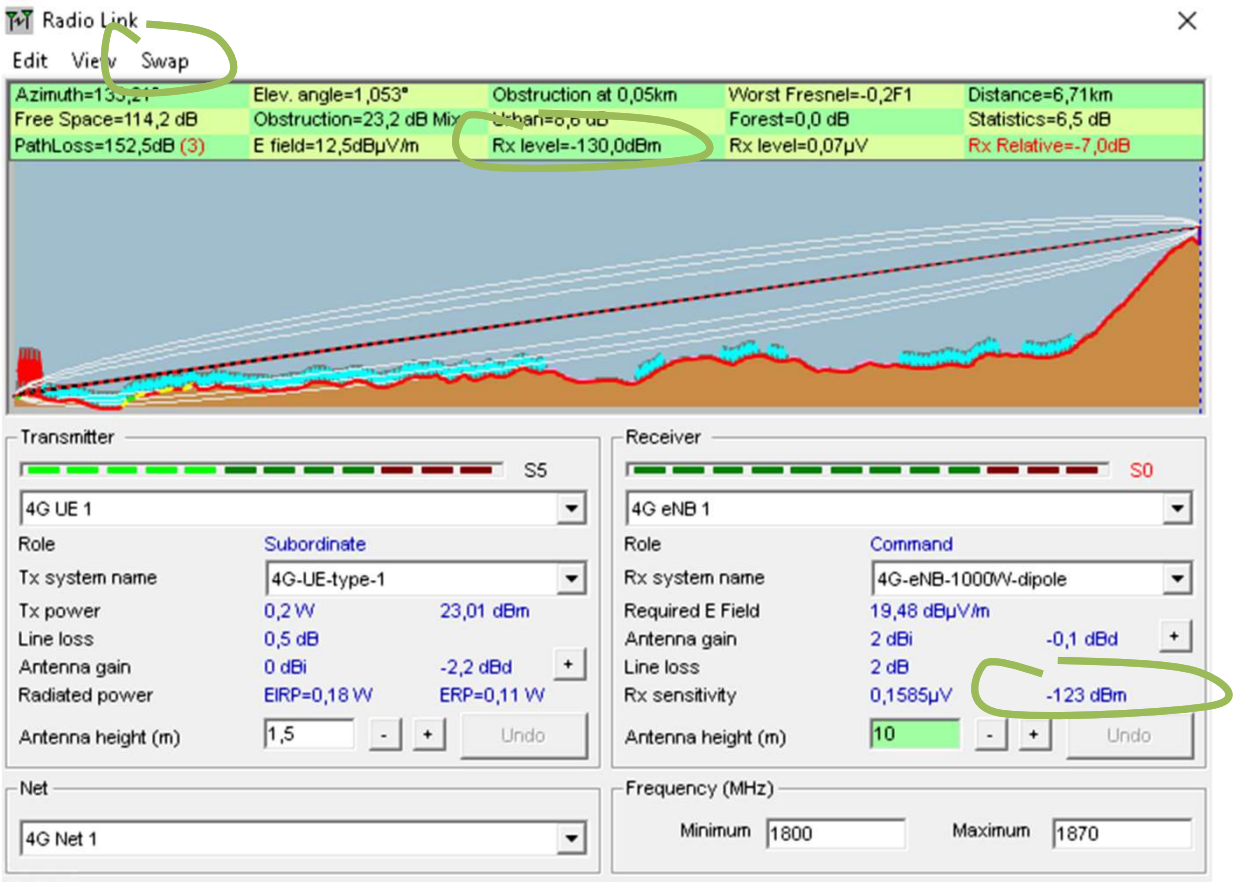


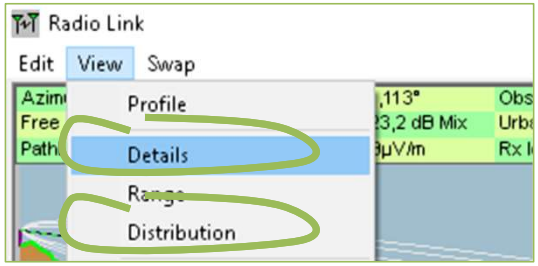
Distance between 4G eNB 1 and 4G UE 1 is 6,7 km (4,2 miles)
True North Azimuth = 313,26°, Magnetic North Azimuth = 308,14°, Elevation angle = -1,1134°
Terrain elevation variation is 113,8 m
Propagation mode is diffraction, single obstruction, 0,2F1 at 6,7km
Average frequency is 1835,000 MHz
Free Space = 114,2 dB, Obstruction = 23,2 dB Mix, Urban = 8,6 dB, Forest = 0,0 dB, Statistics = 6,5 dB
Total propagation loss is 152,5 dB
System gain from 4G eNB 1 to 4G UE 1 is 165,5 dB (dipole.ant at 313,3 °-1,11° gain = 2,0 dBi)
System gain from 4G UE 1 to 4G eNB 1 is 145,5 dB
Worst reception is 7,0 dB below the required signal to meet
70,000% of situations



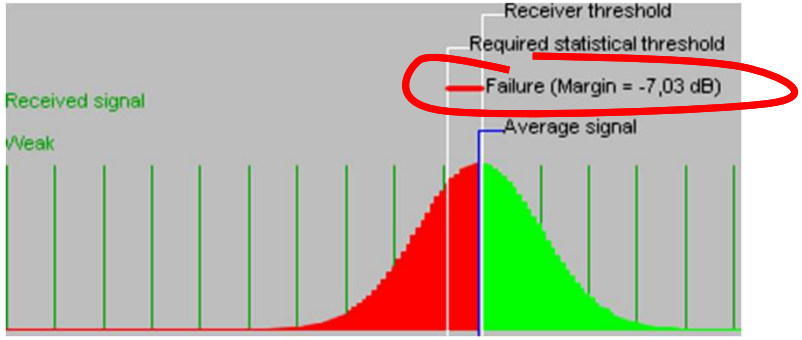
60 (EIRP) -114.2 (free space) -23.2 (obstruction) -0 (forest) -8.6 (urban) -6.5 (stat) -0.5 (UE line loss) = -93 dBm

Opačný smer: 4G UE 1 -> 4G eNB





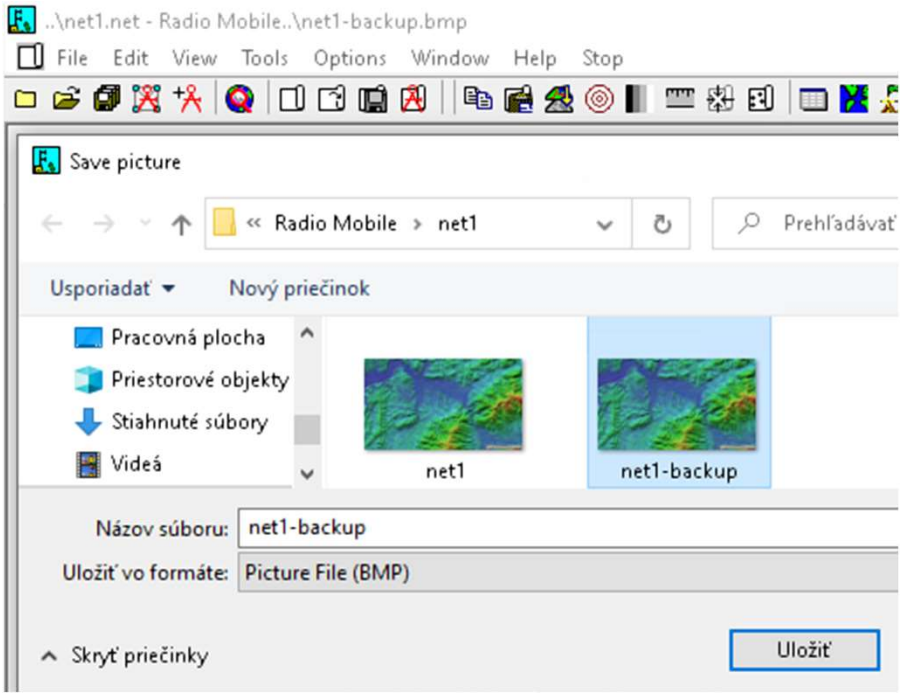
Distance between 4G UE 1 and 4G eNB 1 is 6,7 km (4,2 miles)
True North Azimuth = 133,21°, Magnetic North Azimuth = 128,10°, Elevation angle = 1,0530°
Terrain elevation variation is 113,8 m
Propagation mode is diffraction, single obstruction, 0,2F1 at 0,1km
Average frequency is 1835,000 MHz
Free Space = 114,2 dB, Obstruction = 23,2 dB Mix, Urban = 8,6 dB, Forest = 0,0 dB, Statistics = 6,5 dB
Total propagation loss is 152,5 dB
System gain from 4G UE 1 to 4G eNB 1 is 145,5 dB
System gain from 4G eNB 1 to 4G UE 1 is 165,5 dB (dipole.ant at 313,3 °-1,11° gain = 2,0 dBi)
Worst reception is 7,0 dB below the required signal to meet
70,000% of situations

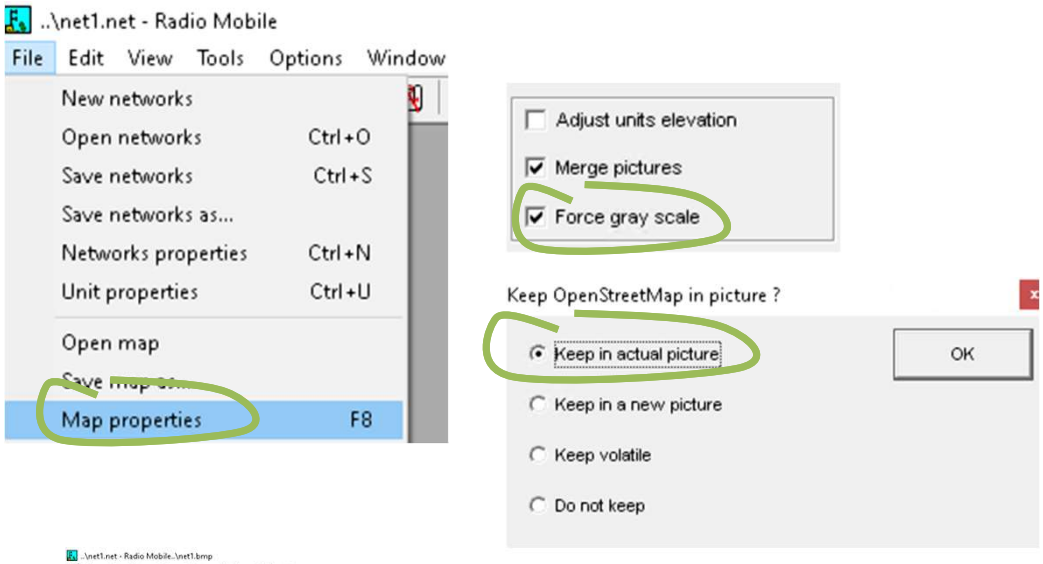


22.5 (EIRP) -114.2 (free space) -23.2 (obstruction) -0 (forest) -8.6 (urban) -6.5 (stat) -2 (UE line loss) + 2 (ant.gain) = -130 dBm

Radio Coverage
Simulácia pokrytia zvoleného územia mobilným signálom

Vytvorenie novej podkladovej mapy; výškový profil v odtieni šedej farby



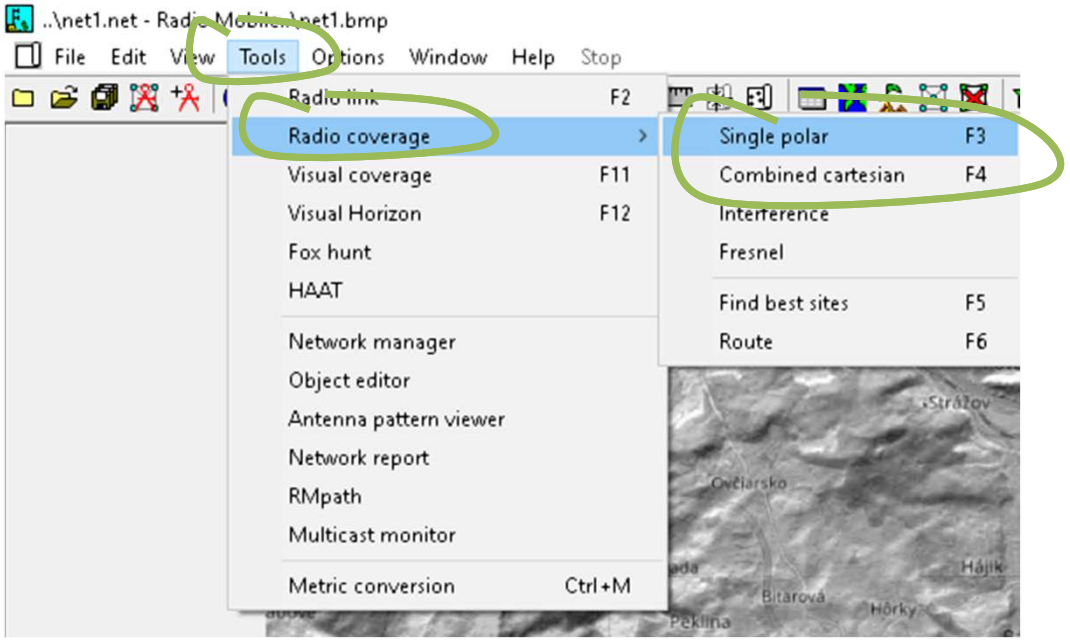


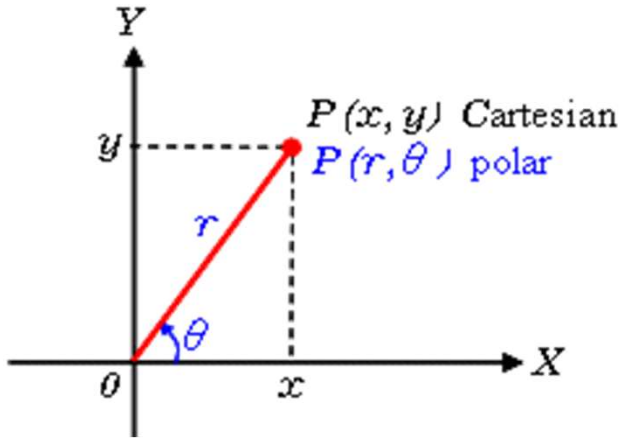
1. Záloha originálneho podkladového obrázku
2. Vytvorenie šedej verzie podkladovej mapy vo formáte BMP
3. Spojenie s topografickou mapou
4. Uložiť BMP súbor do pôvodného názvu “net1.BMP”

“Polar” coverage plot versus “Cartesian” coverage plot

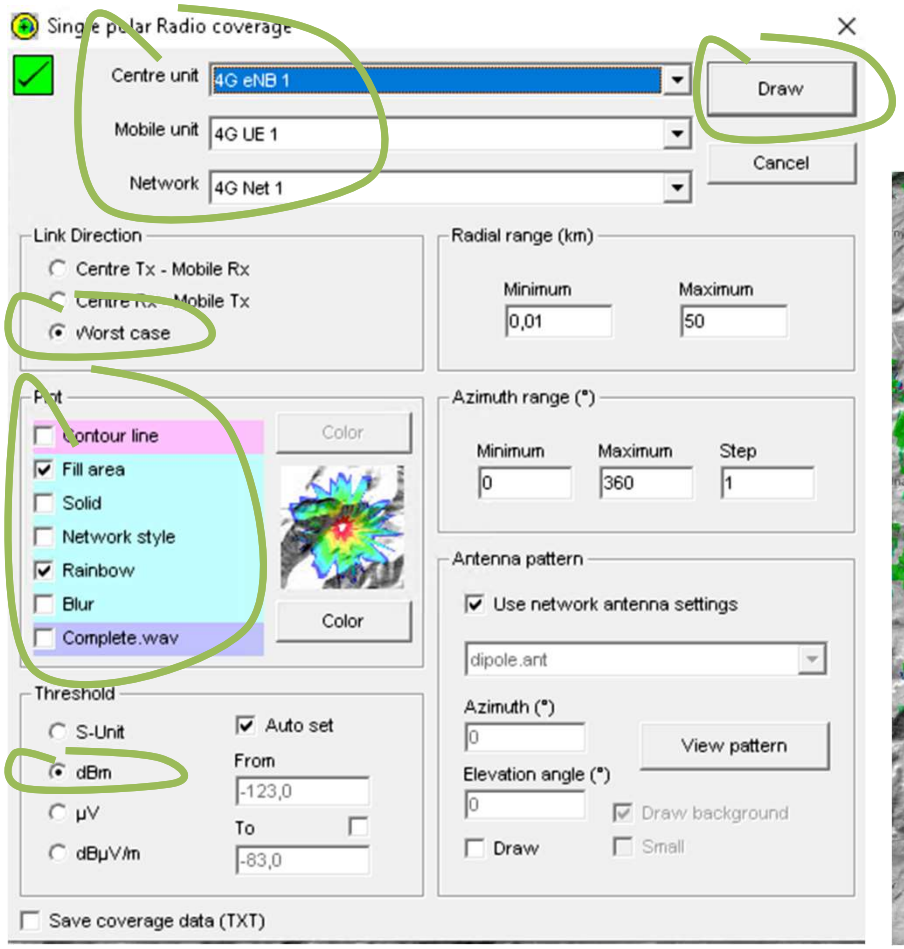
- A Polar plot has been seen to be a very useful tool capable of producing rapid coverage data for a single central unit to or from a specified moving mobile unit
- Poorer accuracy plot simulations towards the outside of the plot (greater distance from the central unit)

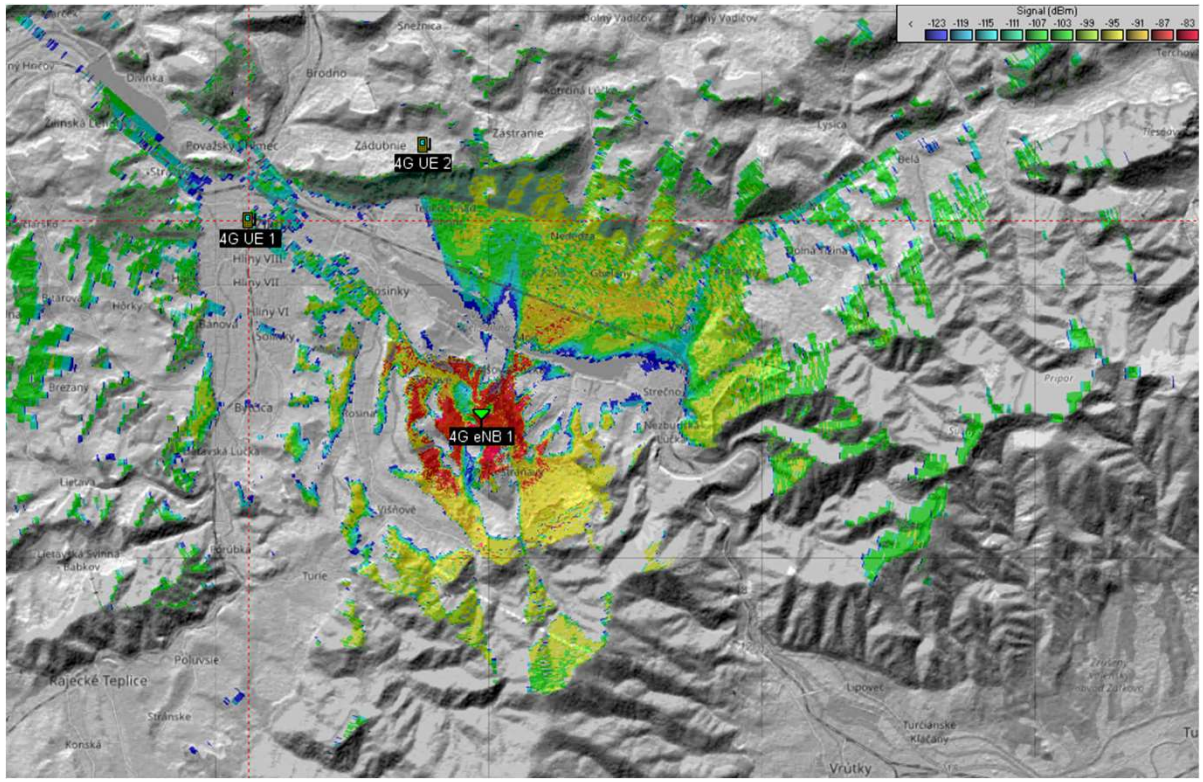
- With Cartesian plot the whole map area is covered by defined ’square pixel’ areas for signal evaluation





“Single Polar” zobrazenie pokrytia signálom jednou základňovou stanicou



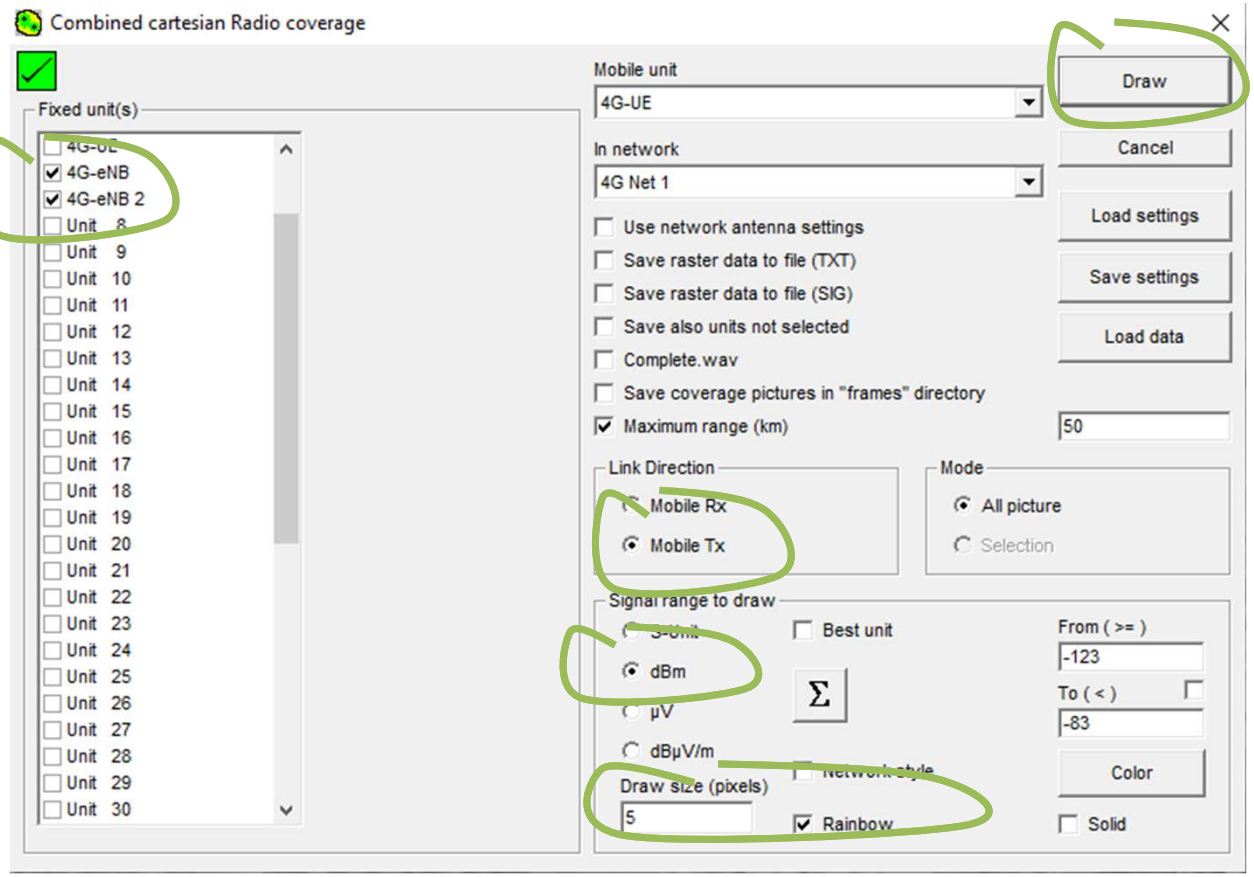


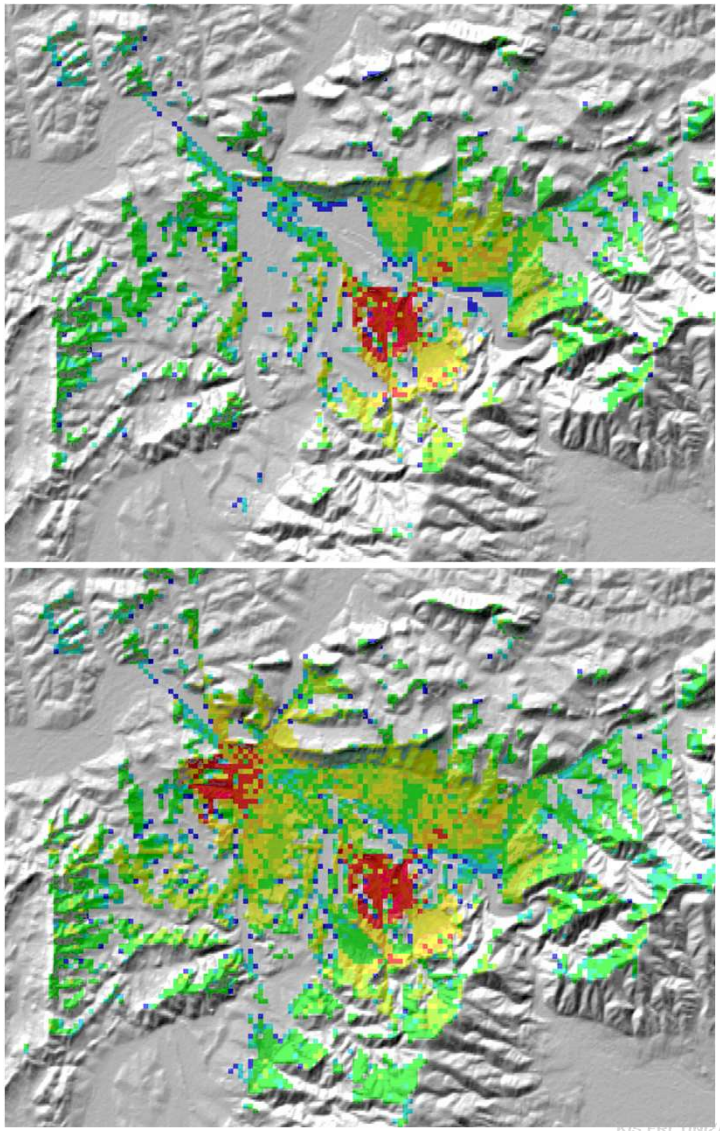
“Worst Case” knob - two way communication performance has to be used for the plots

“Mobile unit” – na vykreslenie pokrytia použije parametre zvoleného UE

“Combined Cartesian” zobrazenie pokrytia signálom jednou alebo viacerými základňovými stanicami

- Fixed unit(s) – voľba, ktoré základňové stanice budú použité na vykreslenie pokrytia
- Vysielací výkon UE je zvyčajne limitujúci (Mobile Tx)





Úlohy

A. Základňová stanica 4G eNB so smerovou anténou 60 stupňov

1. Vytvoriť nový typ základňovej stanice
   - 4G eNB charakteristika
     - Transmit power 50W ~~1000W~~
     - Receiver threshold -123dBm
     - Yagi (60 st)
     - High 10m
     - Line loss 2dB

2. Zistiť a zdôvodniť
   - Vysielací výkon v dBm jednotkách
   - Zisk antény
   - EIRP

3. Porovnať pokrytia všesmerovej a smerovej vysielacej stanice
   - “Single Polar” zobrazenie, “Worst Case”
   - Súradnice: 49.18293 N , 18.80587 E
   - Smerovanie antény na mesto alebo na UE (Network properties, Membership, Antenna direction)

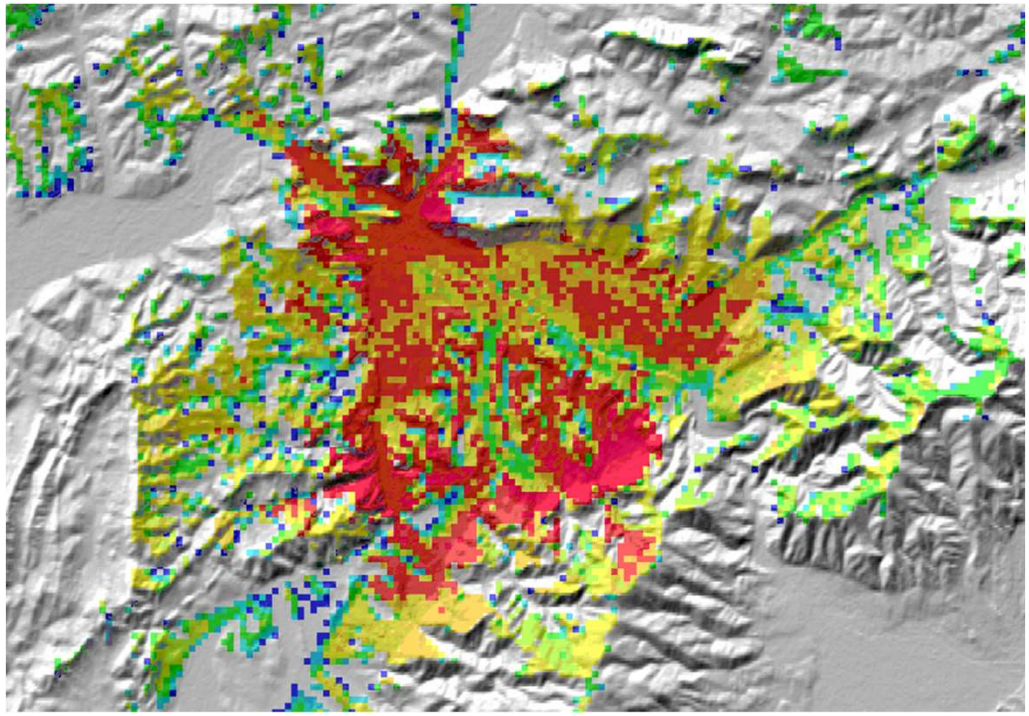
4. Zhodnotiť

B. Vytvorte čo najlepšie pokrytie žilinskej kotliny mobilným signálom

1. Vytvorte novú 2G sieť
   - min a max freq 930 a 960 MHz

2. Použite 3x 2G BTS a nájdite pre ne najvhodnejšie umiestnenie
   - 2G BTS charakteristika
     - Transmit power 1000W (60dBm)
     - Receiver threshold -114dBm
     - Dipole
     - High 20m
     - Line loss 2dB
   - 2G UE charakteristika
     - Transmit power 1W (30dBm)
     - Receiver treshold -104dBm
     - Omni
     - High 1.5m
     - Line loss 3dB

3. Porovnať s už vytvorenou 4G sieťou
   - Doplniť chýbajúce eNB
   - Použiť nájdené lokality pre eNB
   - Vytvoriť mapu pokrytia



C. Radio link

1. Porovnajte charakteristiky Fresnelových zón pre nakonfigurované 2G a 4G frekvencie
    1. 2G a 4G základňové stanice - súradnice: 49.18293 N , 18.80587 E
    2. 2G a 4G UE - súradnice: 49.2130 N , 18.7789 E

2. Aký je “The worst case Fresnel” parameter? Vysvetlite.
3. Aký je mód šírenia signálu? Priamy alebo difrakčný?
4. Aká je vypočítaná hodnota signálu vysielaného UE zariadením v mieste základňovej stanice? Je ešte nad úrovňou citlivosti prijímača? Uveďte vplyv a hodnoty v dBm jednotlivých komponentov, okolia a prenosového média.

Ďakujem za pozornosť.

- Vytvorené v rámci projektu KEGA 026TUKE-4/2021