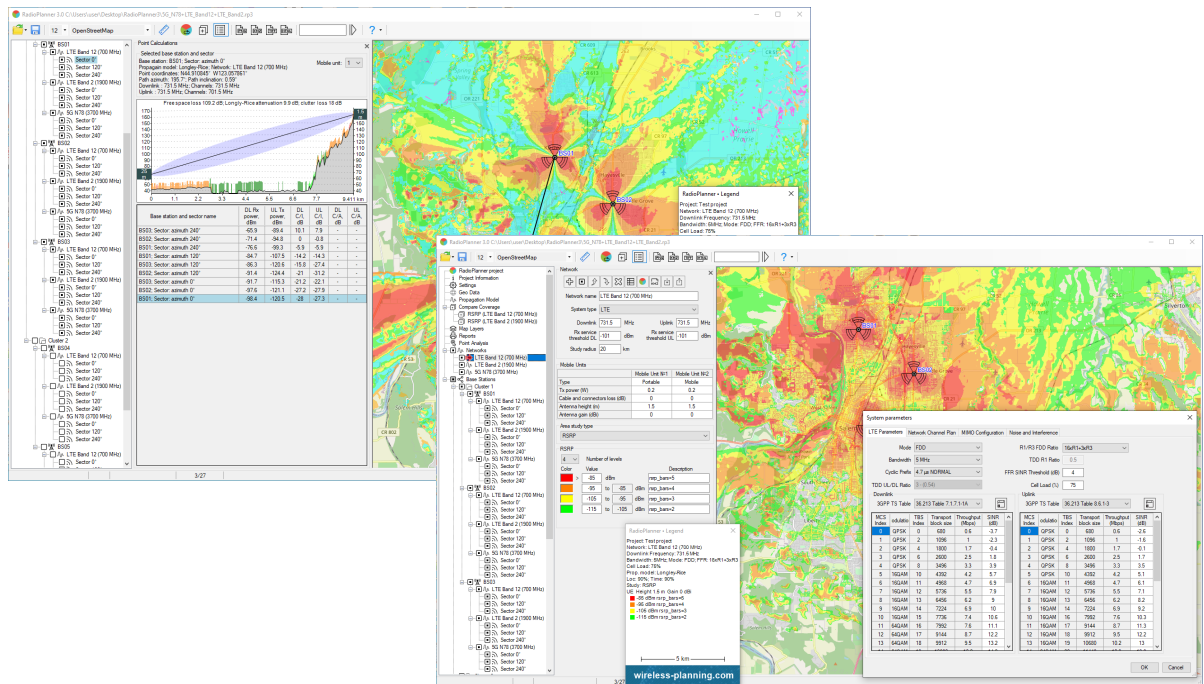


[www.wireless-planning.com](http://www.wireless-planning.com)  
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# RadioPlanner 3.0

## Mobile and Broadcast Network Planning

### User Manual



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## From the Developers

We have made every effort to create a user-friendly and intuitive application. However, we recommend taking some time to read this User Manual to fully utilize RadioPlanner's capabilities. Created by engineers with over 25 years of experience in designing radio communication and broadcasting networks, RadioPlanner is a full-featured yet simple and convenient planning tool.

## Features

RadioPlanner 3.0 is a planning tool for various types of networks, including:

- Mobile networks: 5G (NR), LTE, UMTS, GSM, GSM-R, WCDMA
- Public safety land mobile networks: P25, TETRA, DMR, dPMR, NXDN
- Wireless IoT LPWAN networks: LoRa, SigFox
- Precision agriculture systems
- Terrestrial radio and television broadcast networks: ATSC, DVB-T, DVB-T2, ISDB-T, DTMB, DAB, DAB+
- Air-to-ground communication and radio navigation systems operating in VHF, UHF, and microwave frequencies: UAV (Drone) Control, Air-to-ground radio, ADS-B, VOR, DME

RadioPlanner 3.0 uses propagation models:

- ITU-R P.1812-6
- ITU-R P.1546-6
- Longley-Rice (ITM) v1.2.2
- Okumura-Hata
- 3GPP TR 38.901
- Combined ITU-R P.528-3 + P.526-14 (for Ground-to-Air Radio only)

RadioPlanner 3.0 performs various types of area studies for mobile networks:

- Received Power
- Best Server (Strongest Server)
- C/(I+N) Ratio
- Maximum Throughput
- Maximum aggregated Throughput
- Area with Signal above Both Base and Mobile Thresholds
- Number of Servers
- Coverage Probability
- RSRP for LTE and 5G
- RSRQ for LTE and 5G
- Simulcast Delay Spread
- Received Power with Simulcast Interference
- TalckOut and TalckBack
- Field Strength

Area studies for terrestrial radio and television broadcast transmitters include:

- Field Strength at Receiver Location
- Best Server
- Simulcast Delay Spread
- FCC contours

- ITU-R P.1546-6 contours
- Population coverage
- Generation of list of localities covered by broadcasting

Area studies for Air-to-Ground radio communication systems include:

- Received power Air-to-Ground link
- Received power Ground-to-Air link
- Best Server Air-to-Ground link

RadioPlanner offers the following features:

- Work with multiple networks within a single project and view aggregate coverage predictions for maximum throughput and number of servers.
- Plan radio network frequencies while considering co-channel and adjacent channel interference.
- Display of path profiles with path losses and levels of carrier and interference on the co-channel and adjacent channels.
- Perform multipoint study of a group of CPE or IoT sensors (end devices), each with their individual parameters (antenna height, antenna gain, transmitter power, cable loss, and penetration loss) under varying deployment conditions.
- Import measured signal power level results for comparison with calculated values and adjust propagation model parameters.
- Compare multiple coverage prediction results.
- Save coverage prediction results as an interactive web page, KMZ file, PNG image, GeoTiff file, CSV file or as MIF file.
- Flexibly adjust base map layers and display custom vector layers.

GIS features:

- Default digital terrain model (DTM) with 30m plane resolution, automatically loaded worldwide (see Appendix 2 for data source details).
- Option to use custom DTM in GeoTiff format.
- Default clutter model with nine clutter types, automatically loaded worldwide. Created from OpenStreetMap ([www.openstreetmap.org](http://www.openstreetmap.org)) and Global Forest Change projects.
- Option to use custom clutter in GeoTiff format.
- Common (e.g., OpenStreetMap, OpenTopoMap, US Topo) and custom base maps.

## Installation and Activation

RadioPlanner is compatible with 64-bit Windows 10/11. The minimum computer requirements include a 64-bit Windows operating system, Core i3 CPU, 4GB RAM, 200GB HDD, video card, and monitor with support for 1366x768 resolution. For optimal performance, it is recommended to use a computer with a 64-bit Windows operating system, Core i5 CPU, 16GB RAM, 256GB SSD, video card, and monitor with support for 1920x1080 resolution. Additionally, Microsoft Excel must be installed on the computer to use all RadioPlanner features.

To access the full version of RadioPlanner, a license must be purchased. After successful purchase, an email will be sent containing a link to download the full version installation file and an Activation ID for

the license. Follow the instructions in the installation file and enter the Activation ID when prompted to activate the fully functional version of RadioPlanner.

## Software Update

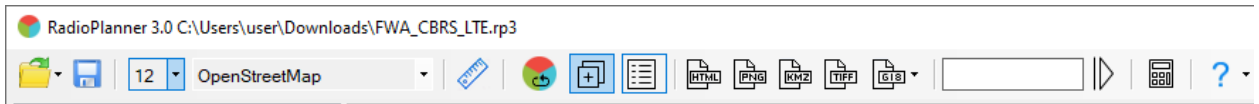
We periodically release free updates to improve the functionality and stability of RadioPlanner. The software supports both manual and automatic checking for updates and will check for available updates every time it starts. To check for updates manually, click “Help - Check for updates.” If an update is available, a window will open with information about the current and available versions. You can download the update from the provided link and install it manually. Be sure to exit RadioPlanner before installing the update.

## User Interface

After starting the program, the main panel will appear with the main menu on the left side and the base map on the right side. The size of the panels can be adjusted using the separator. The base map can display various layers, including sites, coverage, terrain and clutter layers, base map, and additional vector layers. You can choose to display one of the pre-installed base maps or customize your own base map as described in the Base map Settings section.

Navigation on the map is done using the mouse, with the mouse wheel used to zoom in and out. You can also select the desired zoom level from the drop-down list in the toolbar.

## Toolbar and Main Menu



When you hover over each of the icons, a hint appears.



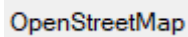
Standard tools for working with files: Create, Open, Save



Save project



The zoom of the base map



The base map



The “ruler” tool allows you to measure the distance and azimuth between any two points on the map. To use this tool, click on the ruler icon and then click on any two points on the map. The distance between the points and the azimuth from the first to the second point will be displayed. To exit the tool, right-click anywhere on the map.



Repeat previous coverage prediction



Add the coverage to compare



Show / Hide Legend



Save the map as WEB page



Save the map as an image in PNG format



Save the map as KMZ file



Save the map as GeoTiff file



Save coverage in GIS format



Search sites by the name

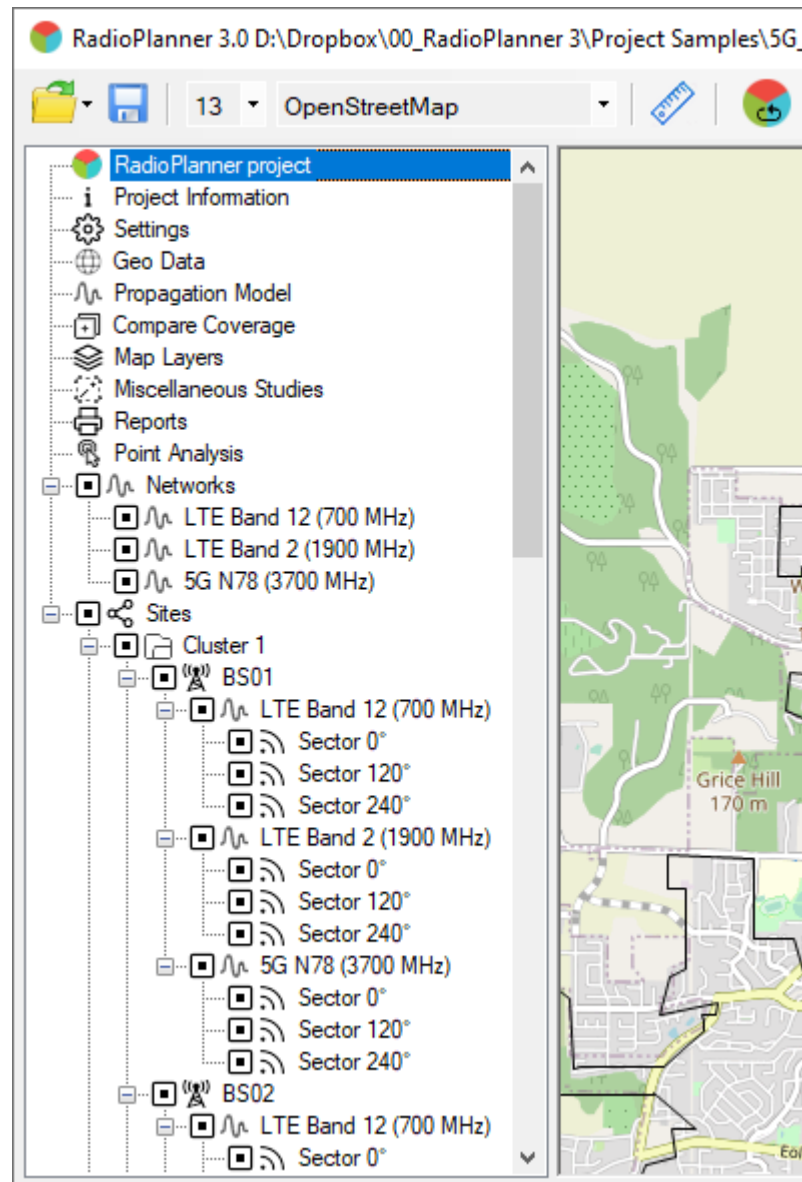


Run Noise-Adjusted Faded Performance Threshold Calculator



Help

For more detailed information about each tool, please refer to the corresponding sections in the User Manual.

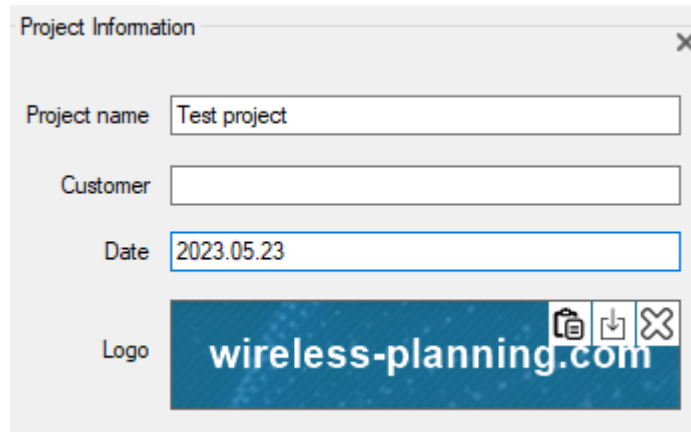


*Tree View interface*

## Project Information

A new project is automatically created when RadioPlanner is launched. The File menu contains standard buttons (New, Open, Save, Save As) for performing standard file operations. Project files can be saved with the \*.rp3 extension and contain all information about the project.

General information about the project can be specified in the project information panel.

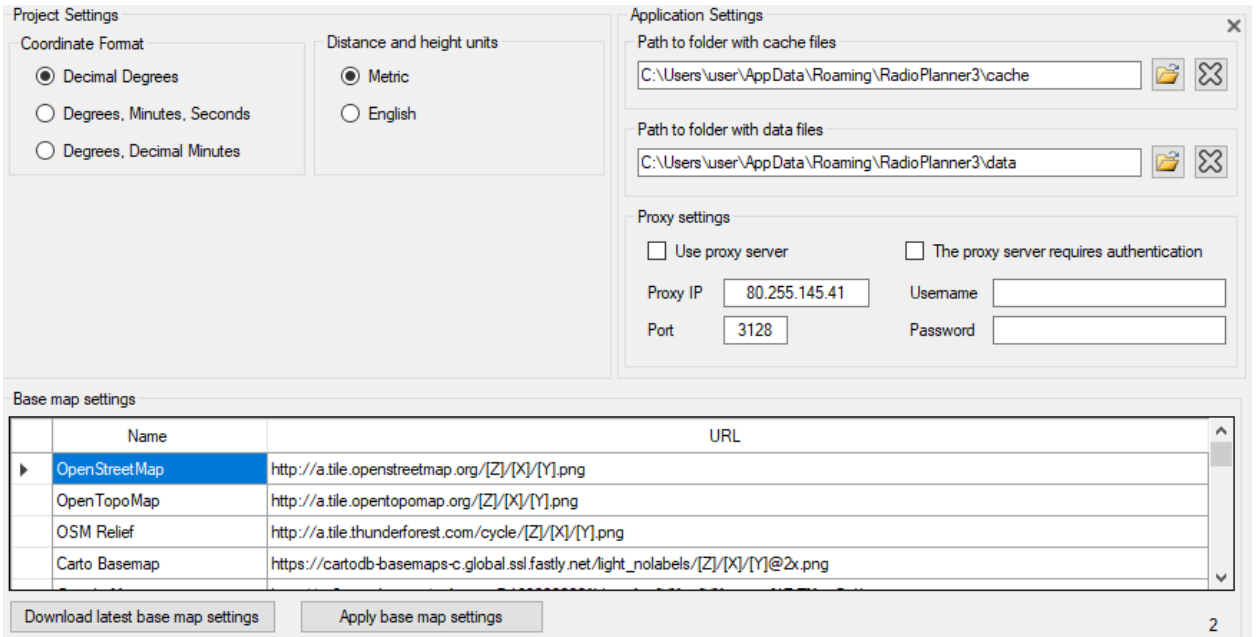


*Project Information*

Project name	Text field
Customer	Text field
Data	Text field - When creating a new project, it records the date and time of the project creation.
Logo	Your company logo. The recommended resolution is approximately 270 by 60 pixels.

## Settings

Before starting to work with the software, it is necessary to configure the settings.



*Settings*

Project Settings	
Distance and Height Units	- Metric

	<ul style="list-style-type: none"> <li>- English</li> </ul>
Coordinate Format	<ul style="list-style-type: none"> <li>- Decimal Degrees (N44.345678 W134.567893)</li> <li>- Degrees, Minutes, Seconds (N44° 34' 23.7" W134° 29' 23,4")</li> <li>- Degrees, Decimal Minutes (N44°34.2356' W134° 29.2354')</li> </ul>
<b>Application Settings</b>	
Path to Folder with Cache Files	The path to the folder where downloaded base map tiles will be saved for quick access can be specified in the settings. This folder is created automatically when the application is launched for the first time and can be changed if desired. The downloaded maps will remain on your computer and can be viewed even when you do not have an Internet connection.
Path to Folder with Data Files	The path to the folder where downloaded default Digital Terrain Model (DTM) and default clutter model files will be saved for quick access can be specified in the settings. This folder is created automatically when the application is launched for the first time and can be changed if desired. The downloaded files will remain on your computer and can be used by the application to create a terrain profile even when you do not have an Internet connection.
Proxy Settings	If you are using a proxy server to access the Internet, enter its IP address and port number in the Proxy Settings section. If the proxy server requires authentication, enter the username and password.

### Base Map Settings

You can configure your own custom base map by specifying a tile server URL. This URL encapsulates a request format specific to the map provider and consists of a text string that begins with `http://` and includes a domain name, possible parameters, and symbols that RadioPlanner substitutes with real-time tile request information when contacting the server.

The symbols that RadioPlanner accepts in the prototype URL are [X], [Y], and [Z] coordinates and zoom. Most map providers use tile coordinates of x and y, plus zoom to lookup map imagery in their database. For example, OpenStreetMap provides map imagery using x, y, and zoom. To fetch a map tile of a portion of North America, you can enter the following URL into a web browser: `http://a.tile.openstreetmap.org/3/1/2.png`. The numbers at the end of the URL represent zoom, x, and y respectively.

To create custom map types in RadioPlanner for OpenStreetMap, you can mix the known specific URLs with the symbols representing x, y, and zoom to form a custom map prototype URL. For example: `http://a.tile.openstreetmap.org/[Z]/[X]/[Y].png`. When RadioPlanner needs to fetch a map tile from a provider, it will replace the [X], [Y], and [Z] symbols with the actual coordinates and zoom for the required tile and use the resulting URL to contact the map provider's server to fetch the map tile.

To use custom maps, enter the Map Server's URL of the desired map. You can search online for local map providers' map servers' URLs. If you have more relevant or detailed cartographic data for the desired territory in the form of an image or vector map, you can create your own tile server using specialized GIS software such as MapInfo, QGIS or Global Mapper.



Download latest base map settings	Update basemap settings from our server. User tile server addresses will be removed.
Apply base map settings	Apply basemap settings after entering custom tile server address

## Geo Data

This menu allows you to specify the geodata (DTM and clutters) that will be used in calculations.

**Digital Terrain Model (DTM)**

Use default (DTM)     Use custom (DTM)

Custom DTM files

File name

**Clutter Data**

Clutter heights

Clutter type	Clutter height, m
Open/rural	0
Water	0
Trees/forest	15
Suburban	10
Urban	15
Dense urban	20
Open areas in forest	7
Open areas in suburban	5
Open areas in urban	7

Use default clutter data     Use custom clutter data

Custom clutter data files

File name

Custom clutter indices

CLC   UA   NLCD   STD   Number of Pal Idx:

Pal Idx	Clutter Type
0	Open/rural
1	Water
2	Trees/forest
3	Suburban
4	Urban
5	Dense urban
6	Open areas in forest
7	Open areas in suburban
8	Open areas in urban

Geo Data Parameters

## Digital Terrain Model (DTM)

The Digital Terrain Model (DTM) is a geographic data file (or files) representing the elevation of the ground above sea level. In RadioPlanner 3, you can use the default DTM that is automatically downloaded from our server when predicting coverage. This DTM is compiled from open geodata sources and is available worldwide. It is sufficient for most use cases.

Alternatively, you can use custom DTMs in GeoTiff format. GeoTIFF is an open format that can be used to convert elevation data from a LiDAR survey or any other DTM. This conversion can be performed using specialized GIS applications such as QGIS, Global Mapper, ArcGis, MapInfo, and others.

Use default DTM	Use default DTM
Use custom DTM	Use custom elevation DTM. Import the DTM file(s) in Geotiff format.

Custom DTM GeoTIFF files(s) must have the following format:

File Type: Int16 (Sixteen-bit signed integer)

Compression: No/LZW/Deflate (ZIP)

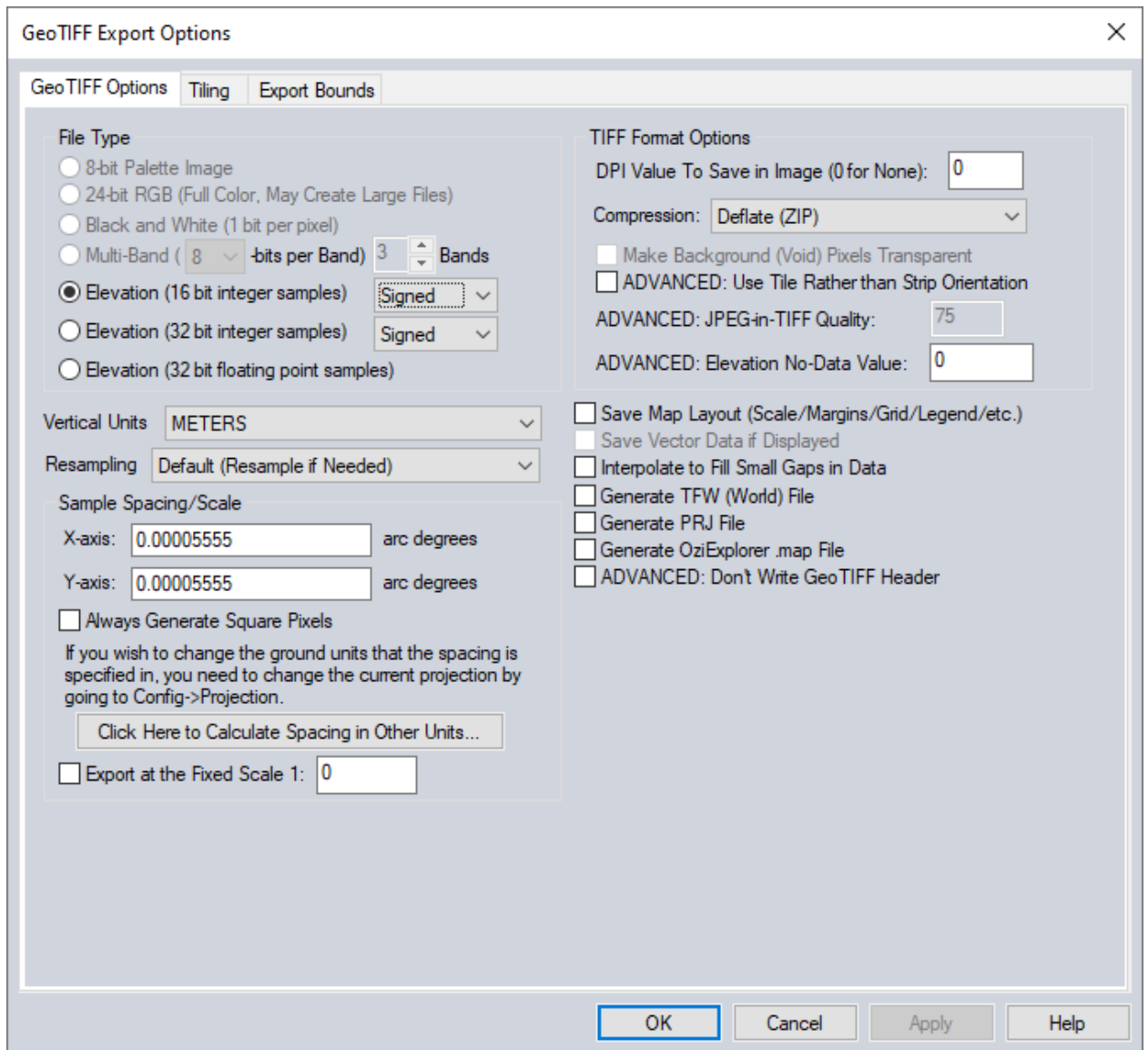
Projection: Geographic (Latitude/Longitude)

Datum: WGS84

Planar Units: ARC Degrees

Vertical Units: Meters

An example of exporting to a DEM Geo TIFF file in the Global Mapper with a resolution of 1/5 arc second (0.00005555 arc degree):



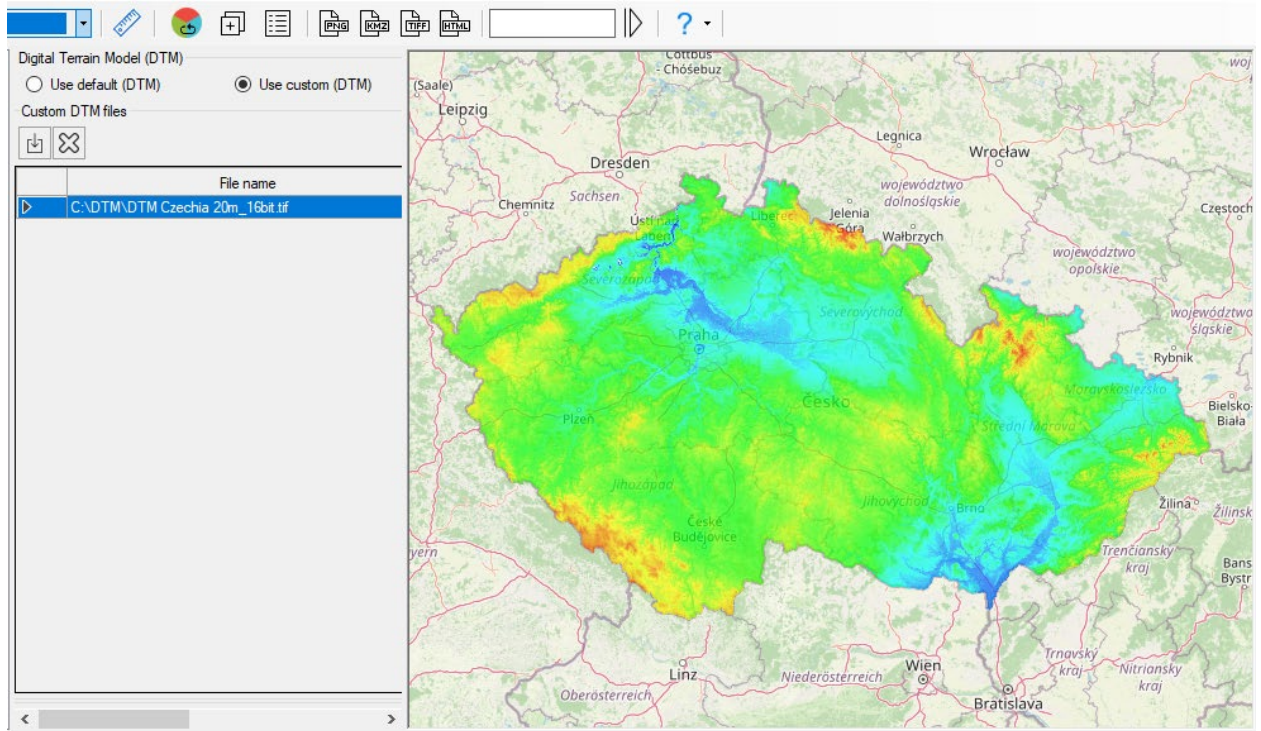
*An example of configuring DTM export settings to Geotiff*

Max Width x Height: 100 000 x 100 000 points (for 64 GB RAM and powerful CPU). For comfortable work on a computer of average performance, we do not recommend making the DEM size larger than 50,000 by 50,000 points.

Some custom DTM samples in GeoTIFF format can be found in the installation folder.

On our YouTube channel, we have posted a video on preparing custom DTM:

<https://youtu.be/yS2dQreh3Cs>



Custom DTM

## Clutter Data

The clutter data describes land cover or land use and is used by RadioPlanner to calculate signal power loss on local obstacles surrounding the mobile unit.

In RadioPlanner 3, you can use the default clutter data that is automatically downloaded from our server when predicting coverage. This data is compiled from open geodata sources (OpenStreetMap and Global Forest Change projects) and is available worldwide. It is sufficient for most use cases.

The clutter model used in RadioPlanner has 9 types of clutters:

	Clutter Type	Color	Description
1	Open / Rural		Open and rural area
2	Water		Water area
3	Trees / Forest		Forest area
4	Suburban		Suburban area
5	Urban		Urban area
6	Dense urban		Dense urban area
7	Open areas in forest		Forest roads
8	Open areas in suburban		Highways, wide roads
9	Open areas in urban		Highways, avenues, wide roads

For each clutter type, you can specify an average height (used to calculate clutter loss in the ITU-R P. 1812-6 propagation model) or directly enter the loss value (see the Propagation Model menu).

Clutter heights	The typical clutter height. This value is used in the ITU-R P.1812 and ITU-R P.1546 recommendations to calculate clutter loss.
-----------------	--

Use default clutter data	Use default clutter
Use custom clutter data	Import the clutter file(s) in Geotiff format.

You can also use custom clutter data in GeoTiff 8-bit Palette Image file format. Each pixel of this file can contain up to 256 possible clutter classes (commonly used up to 30), representing specific types of land use or landcover. Custom clutter files can be prepared from a land use database (e.g., NLCD, CORINE, ESA Global Land Cover) using specialized software (Global Mapper, QGIS, MapInfo, etc.).

Custom clutter indices	Clutter file palette indices to clutter type correspondence table  CLC - CORINE Land Cover <a href="https://land.copernicus.eu/pan-european/corine-land-cover">https://land.copernicus.eu/pan-european/corine-land-cover</a> UA – CORINE Urban Atlas <a href="https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018">https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018</a> NLCD - National Land Cover Database <a href="https://www.usgs.gov/centers/eros/science/national-land-cover-database">https://www.usgs.gov/centers/eros/science/national-land-cover-database</a> Default - Deafaul clutter indices (0,1,2,3,4,5,6,7,8)
Number of Pal Idx	Number of indexes in custom palette

After importing a custom clutter file into RadioPlanner, it is necessary to establish a correspondence between its palette indexes and the 9 clutter types used in the program. We have made lookup table presets for some standard land cover types (NLCD, CORINE Land Cover, CORINE Urban Atlas). To use these presets correctly, you need to use a special standard (for NLCD and CORINE Land Cover) or custom (for CORINE Urban Atlas) palette when exporting to GeoTiff. Some custom clutter data file samples in GeoTiff format can be found in the installation folder.

On our YouTube channel, we have posted a video on preparing custom clutter from several common landcover types:

<https://youtu.be/5QWYYGhGEdY> How to make custom clutter from National Land Cover Database (NLCD)

<https://youtu.be/pmY6YNy3elo> How to make custom clutter from CORINE Land Cover

<https://youtu.be/DwBRa2g2VIA> How to make custom clutter from Urban Atlas

Custom clutter GeoTIFF file(s) must have the following format:

File Type: 8-bit Pallette Image

Compression: No/LZW/Deflate (ZIP)

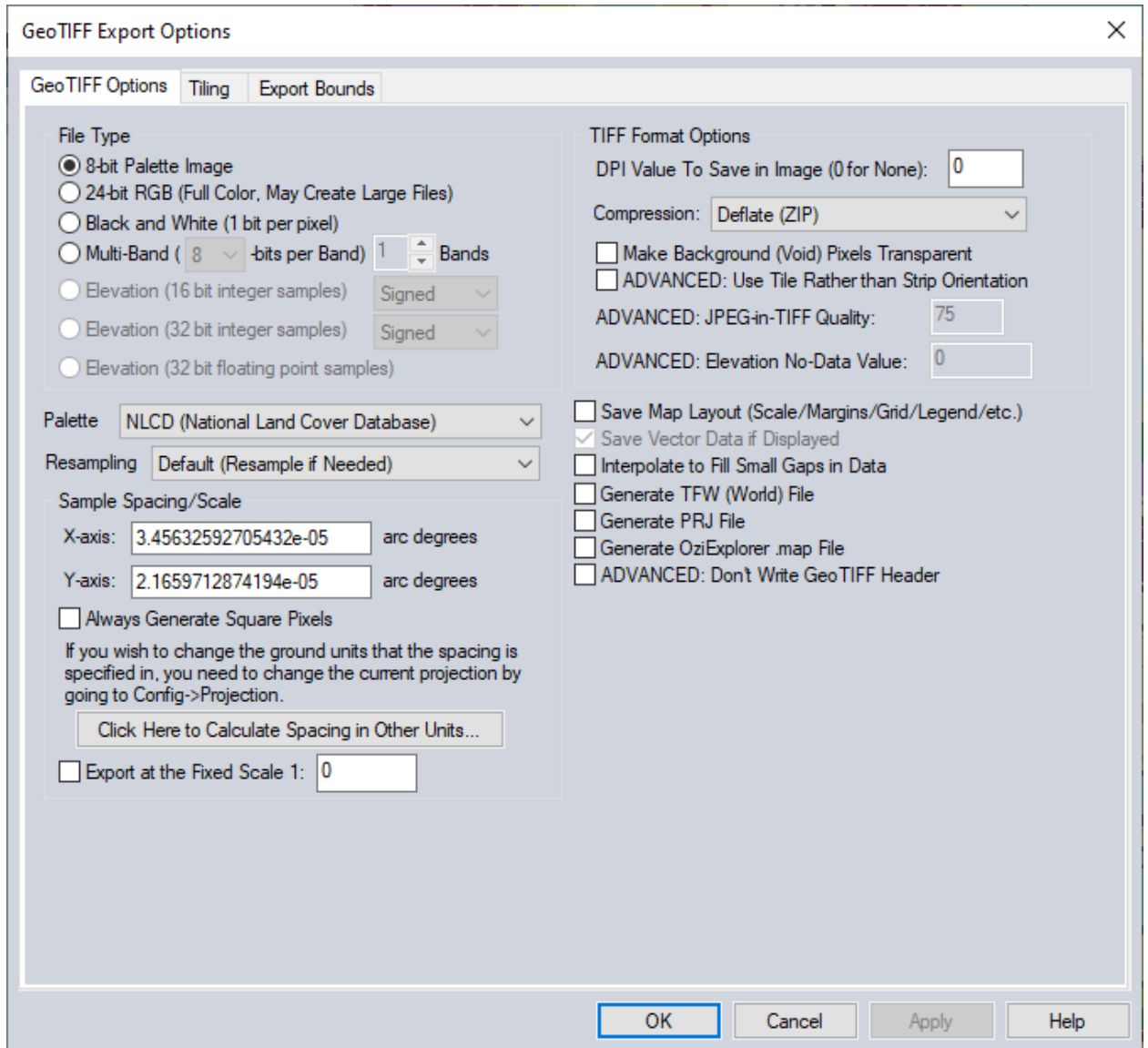
Projection: Geographic (Latitude/Longitude)

Datum: WGS84

Planar Units: ARC Degrees

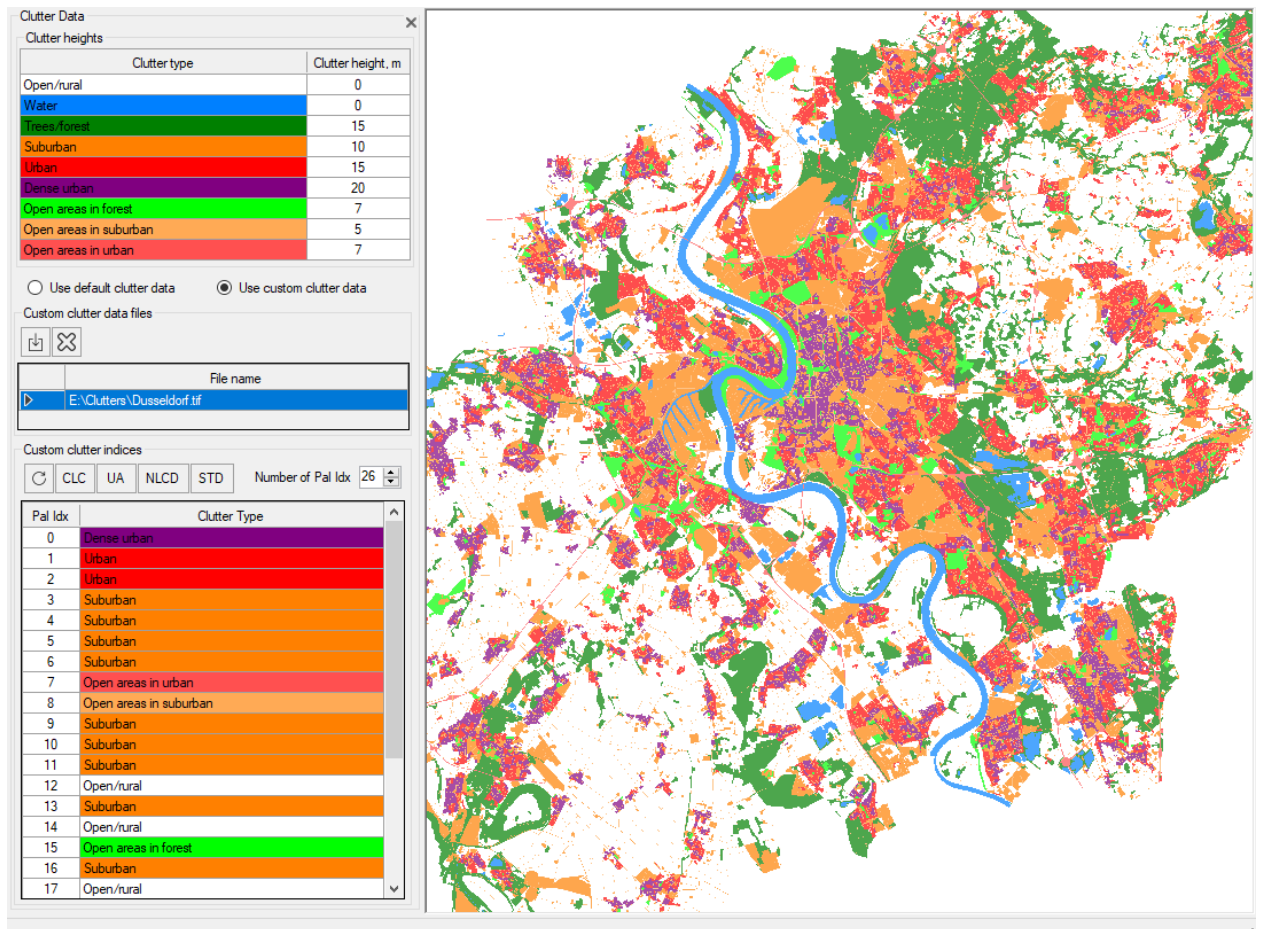
Max Width x Height: 100 000 x 100 000 points (for 64 GB RAM and powerful CPU). For comfortable work on a computer of average performance, we do not recommend making the clutter size larger than 50,000 by 50,000 points.

An example of exporting to a clutter Geo TIFF file in the Global Mapper:



*An example of configuring clutter export settings to Geotiff*





*Custom clutter*

## Map Layers

In the Map Layers menu, you can control which layers are displayed on the map. The order of the layers in the menu corresponds to their order on the map, with the base map at the bottom and sites at the top of all layers.

**Sites** ✕

Show layer


Show sites by status:

Show site names       Show sector directions

Site font style

---

Customs layers (KML, CSV files)

	Name	Show	Marker	Font	Line width	Line color
	Towers	<input checked="" type="checkbox"/>		Font	2	
▶	Pipeline	<input checked="" type="checkbox"/>	•	Font	2	

---

Routs for Rout Study

Show layer      Line width

---

CPEs

Show layer        Show links      Line width

---

Area study boundary

Show layer      Line width

---

Coverage

Show layer      Transparency (0-10)

---

Clutters

Show layer      Transparency (0-10)


---

Terrain

Show layer      Transparency (0-10)

Min. elevation (m)       Max. elevation (m)

70 m 300 m



---

Base map

Show layer

Show in grayscale      Grayscale level (0-3)

### Map Layers







## Sites

Sites are Base Stations or transmitters for TV and radio broadcasting.

Show layer	Show/hide site layer
Show site names	Show site names
Show sector directions	Show sector direction according to antenna azimuth
Site marker	Choose marker for sites
Site font style	Change font type for sites

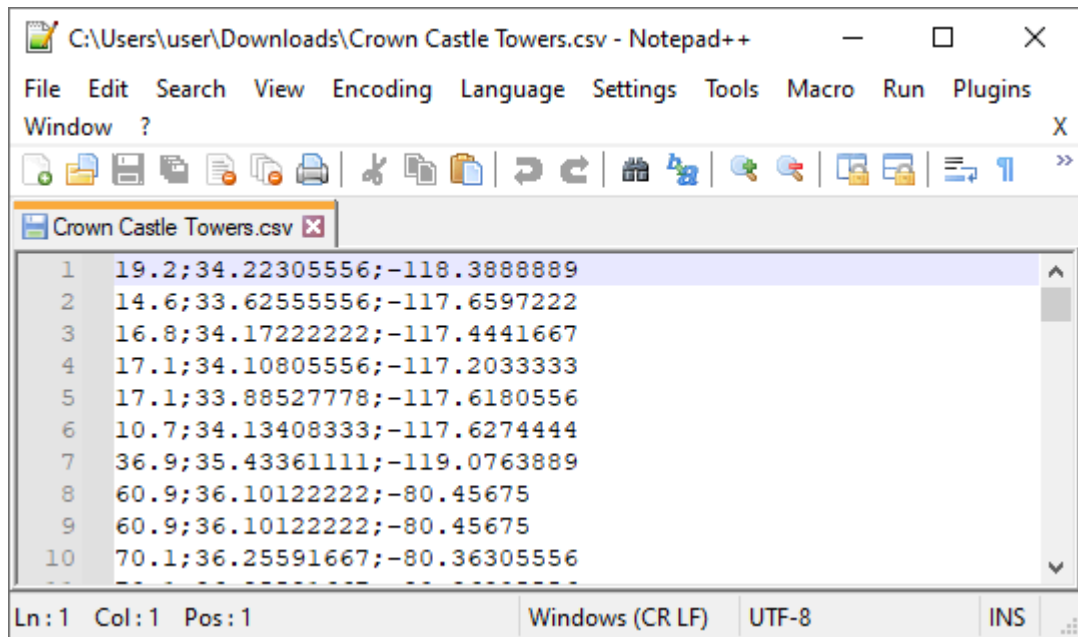
## Custom Layers (KML, CSV)

You can load and display point or linear vector objects in KML format as a layer on the map. This can include objects such as power lines, piping, and etc. Custom layers are saved in the project file.

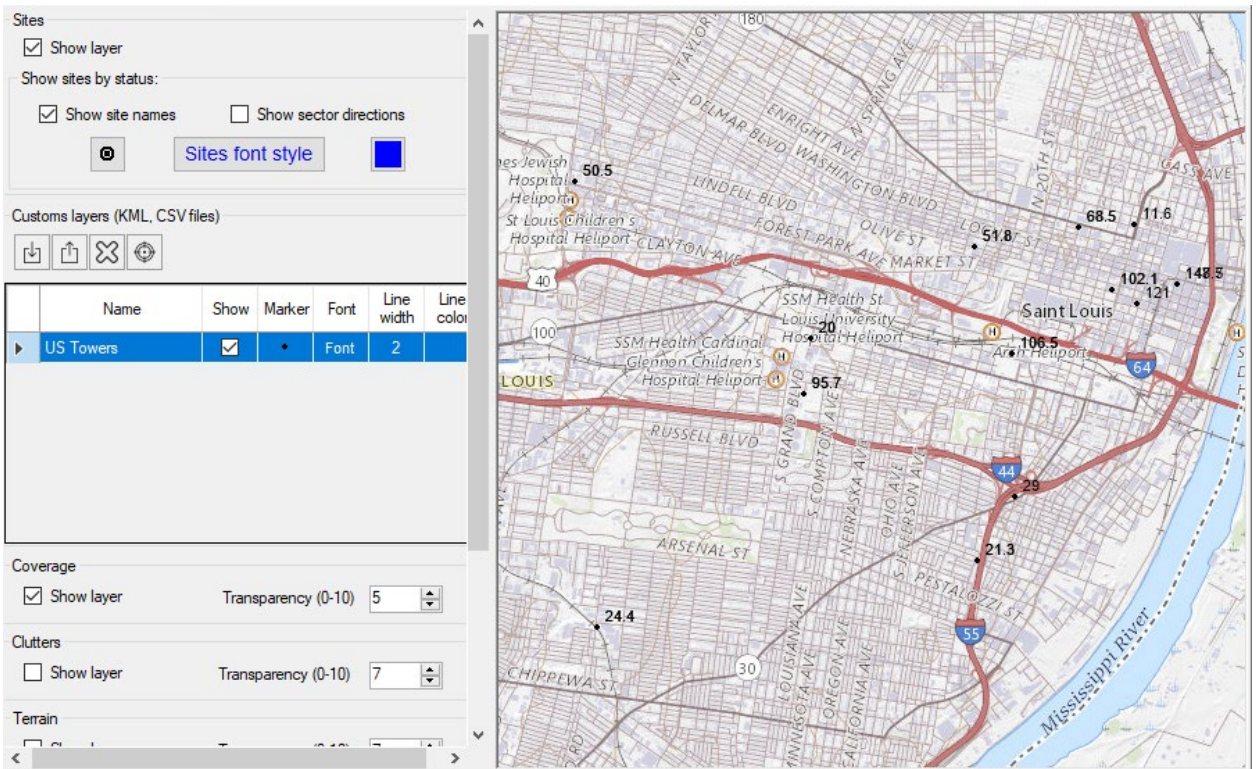
	Load a custom layer (KML, CSV file)
	Save points from the selected layer to a CSV file
	Delete selected custom layer
	Position the map on the first point of the selected layer
Name	The name of the user layer. Initially corresponds to the file name, but can be changed.
Show	Show/hide custom map layer
Marker	Select a marker for the item (only for point objects)
Line width	Specify the line width in pixels (only for line)
Line color	Specify line color (only for line)

Point objects can also be downloaded from a CSV file (text format with a semicolon separator).

Each point object must have the required fields of Parameter, Latitude, and Longitude. Coordinates can be formatted as HEMISPHERE degrees minutes seconds (N35 23.8 36) or HEMISPHERE decimal degrees (N12.34567). The parameter can be any text that appears at the specified coordinates, such as a measurement result or the name of an object.

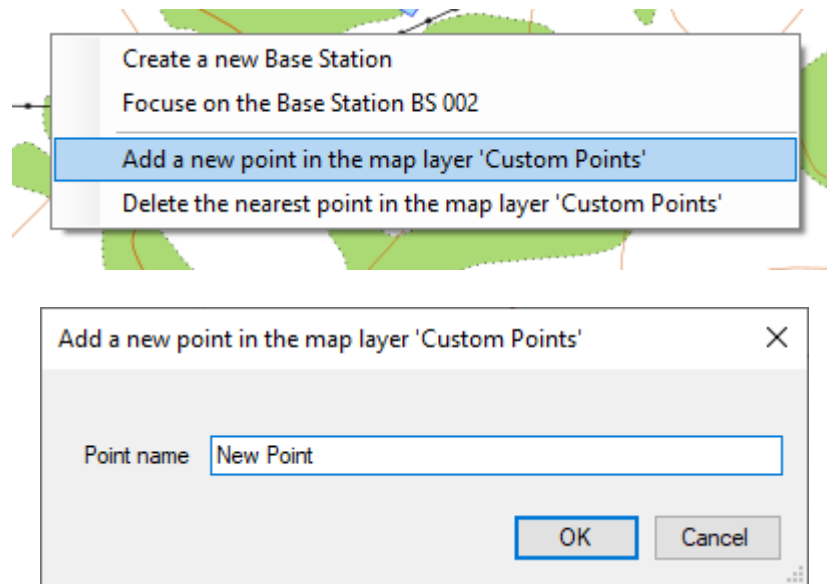


Sample CSV file with Antenna Towers



Custom Layer on the map

You can also quickly create point objects directly on the map. To do this, right-click on the desired location and select “Add a new point to the ‘Custom Points’ layer” from the context menu. Then specify the point name and it will appear on the map and be added to the “Custom Points” layer, which is automatically created when you create the first point object. You can also delete created point objects by right-clicking on the point and selecting “Delete the nearest point in the ‘Custom Points’ layer” from the context menu.



*Adding a point feature to a map*

## Routs for Route Study

Routs layer control. For more details, see the section on Miscellaneous Studies - Route Study.

Show layer	Show/hide Routs layer
Line width	Line width

## CPEs

CPE map layer control. CPE is customer premises equipment for fixed wireless access (FWA) applications or Sensors for IoT networks such as LoRaWAN, SigFox and others.

Show layer	Show/hide CPE layer
Select marker	Choose marker for CPEs
Show links	Show link to the assigned BS sector
Line width	Line width

## Area Study Boundary

The area study boundary map layer control.

Show layer	Show/hide layer
Line width	Line width

## Coverage

The coverage prediction map layer control.

Show layer	Show/hide layer
Transparency	Set layer opacity in the range from 0 (fully transparent) to 10 (not transparent)


## Clutter

The clutter map layer control.

Show Layer	Show / Hide the clutter map layer. <b>The default clutter is shown only for zoom 11 and higher. A custom clutter is shown for any zoom.</b>
Transparency	Set layer opacity in the range of 0 (fully transparent) to 10 (not transparent)

## Terrain

The Terrain map layer control.

Show Layer	Show / Hide the terrain map layer. <b>The default terrain is shown only for zoom 9 and higher. A custom terrain is shown for any zoom.</b>
Transparency	Set layer opacity in the range of 0 (fully transparent) to 10 (not transparent)
Min (Max) Elevation	Elevation legend range. All heights below the minimum (including the minimum) will be fully transparent. All heights above the maximum will be in maroon.
	Set the minimum and maximum height on the screen. Sets the height range within the minimum and maximum heights found within the screen.

## Base Map

Base map layer control

Show layer	Show/hide the layer
Show in grayscale	Show base map in grayscale
Grayscale level	Brightness from the range 0 (darker) - 3 (lighter)

## RF Planning for Mobile Networks

RadioPlanner 3.0 allows you to work with multiple networks in one project. When creating a new project, the first network is created by default.

*Networks menu*



Add a new network

Calculate Coverage (See Coverage predictions for multiple networks section)

Area Study Type	<p>Coverage predictions for multiple networks:</p> <ul style="list-style-type: none"> <li>- Number of Networks (DL)</li> <li>- Number of Networks (UL)</li> <li>- Maximum Aggregated (DL) Throughput</li> <li>- Maximum Aggregated (UL) Throughput</li> </ul> <p>See Coverage predictions for multiple networks section</p>
Area Study Resolution for all study types	<p>Coverage prediction resolution. Specifies the details of both aggregated calculations and calculations for each of the networks.</p> <ul style="list-style-type: none"> <li>- Low</li> <li>- Medium</li> <li>- High</li> </ul> <p>The resolution corresponds to one pixel of the screen for zoom = 11 (low detail), zoom = 12 (medium), and zoom = 13 (high). For a geographic latitude of 55 degrees, this is approximately 40, 20, and 10 meters, respectively.</p> <p>The higher the resolution, the longer the calculation time.</p>
Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made

## Network

The “Network” menu is used to set all parameters for the selected network, including mobile station parameters and calculation parameters. You can also perform calculations for the network using this menu.

Network
✕

+
▣
↶
↷
✕
☰
🌈
🟡
🟢
KM2
⬇️
⬆️

Network name

System type LTE

**Network parameters**

Downlink  MHz  
 Downlink Rx threshold  dBm  
 Study radius  km

Uplink  MHz  
 Uplink Rx threshold  dBm

	User Equip N°1	User Equip N°2
Type	Portable	AtomOD06H
Tx power (W)	0.2	0.2
Cable and connectors loss (dB)	0	0
Antenna height (m)	1.5	5
Antenna gain (dBi)	0	14

Use directional antenna pattern for Mobile Unit (UE)

Area study type RSRP

**RSRP for UE N°1**

4 Number of levels

Color	Value	Description
	> -85 dBm	<input type="text" value="rsrp_bars=5"/>
	-95 to -85 dBm	<input type="text" value="rsrp_bars=4"/>
	-105 to -95 dBm	<input type="text" value="rsrp_bars=3"/>
	-115 to -105 dBm	<input type="text" value="rsrp_bars=2"/>

RSRP for UE N°2

> -115 dBm









*Network menu*



Add a new network with the same parameters (copy the network)

Check/Uncheck all sectors for current network

Move the Network up

	Move the Network down
	Delete the network
	System parameters
	Calculate Coverage
	Calculate FWA Coverage taking into account the parameters of each CPE. See section "Fixed Wireless Access network"
	Calculate coverage for each active sector and save the map as a KMZ file
	Load network parameters from a template
	Save network parameters as a template

Network name	Name of network, text field
System type	System type options: <ul style="list-style-type: none"> <li>- Generic TRX</li> <li>- LTE</li> <li>- 5G</li> <li>- Terrestrial Broadcasting</li> <li>- Air-to-Ground Radio</li> </ul> <p>The selected system type will determine the set of additional system parameters, as well as the types of coverage predictions available.</p>
Downlink	Average downlink frequency, MHz
Uplink	Average uplink frequency, MHz
Downlink Rx threshold	This threshold value will limit the coverage prediction display based on whether the signal received at the mobile unit from the base station is above or below this threshold, dBm
Uplink Rx threshold	This threshold value will limit the coverage prediction display based on whether the signal received at the base station from the mobile unit is above or below this threshold, dBm
Study radius	Maximum study radius, km The larger the radius, the longer the computation time. Do not set an unnecessarily large calculation radius.

#### Mobile Units

Type	Name (model) of Mobile Unit, text field
Tx Power	Transmitter power, W
Cable and Connector Loss	Loss in cable and connectors, dB
Antenna Height	Antenna height relative to ground level, m
Antenna Gain	Antenna gain, dBi
Use directional antenna pattern for Mobile Unit (UE)	By default, the mobile units' (UE) antenna pattern is assumed to be isotropic. If you are designing a fixed wireless access (FWA) network with directional CPE antennas, you should download the antenna pattern in MSI format. It is assumed that the CPE antennas are aimed at the BS sector with the strongest signal at the CPE location. The use of directional antennas on the CPE significantly reduces interference from neighboring cells and, as a result, increases CPE throughput.



RadioPlanner allows you to predict coverage for two types of mobile devices. This is used in professional mobile radio networks, where portable and mobile stations are often used, since they differ in both power characteristics and antenna height relative to ground level. Also, coverage prediction for several types of mobile devices with different antenna heights is often necessary in fixed wireless access (FWA) networks.

## LTE System Parameters

System parameters
✕

LTE Parameters
Network Channel Plan   MIMO Configuration   Noise and Interference

Mode:

Bandwidth:

Cyclic Prefix:

TDD UL/DL Ratio:

R1/R3 FDD Ratio:

TDD R1 Ratio:

FFR SINR Threshold (dB):

Cell Load (%):

Downlink

3GPP TS Table:

MCS Index	Modulation	TBS Index	Transport block size	Throughput (Mbps)	SINR (dB)
12	64QAM	17	9144	8.7	12.2
13	64QAM	18	9912	9.5	13.2
14	64QAM	19	10680	10.2	14.2
15	64QAM	20	11448	10.9	15.2
16	64QAM	21	12576	12	16.4
17	64QAM	22	13536	12.9	17.8
18	64QAM	23	14112	13.5	19.3
19	64QAM	24	15264	14.6	21
20	256Q...	25	15840	15.1	21.5
21	256Q...	27	16416	15.7	23
22	256Q...	28	17568	16.8	24
23	256Q...	29	18336	17.5	25
24	256Q...	30	19848	18.9	27
25	256Q...	31	20616	19.7	28
26	256Q...	32	21384	20.4	29
27	256Q...	33	24496	23.4	30

Uplink

3GPP TS Table:

MCS Index	Modulation	TBS Index	Transport block size	Throughput (Mbps)	SINR (dB)
0	QPSK	0	680	0.6	-2.6
1	QPSK	2	1096	1	-1.6
2	QPSK	4	1800	1.7	-0.1
3	QPSK	6	2600	2.5	1.7
4	QPSK	8	3496	3.3	3.5
5	QPSK	10	4392	4.2	5.1
6	16QAM	11	4968	4.7	6.1
7	16QAM	12	5736	5.5	7.1
8	16QAM	13	6456	6.2	8.2
9	16QAM	14	7224	6.9	9.2
10	16QAM	16	7992	7.6	10.3
11	16QAM	17	9144	8.7	11.3
12	16QAM	18	9912	9.5	12.2
13	16QAM	19	10680	10.2	13
14	64QAM	20	11448	10.9	13.8
15	64QAM	21	12576	12	14.6
16	64QAM	22	13536	12.9	15.3

### LTE System Parameters

Mode	LTE duplex mode: <ul style="list-style-type: none"> <li>- FDD</li> <li>- TDD</li> </ul>
Bandwidth	LTE bandwidth: 1.4 MHz; 3 MHz; 5 MHz; 10MHz; 15 MHz; 20 MHz
Cyclic Prefix	LTE Cyclic Prefix: <ul style="list-style-type: none"> <li>- 4.7 μs (Normal)</li> <li>- 16.7 μs (Extended)</li> </ul>
TDD UL/DL Ratio	TDD configurations in 3GPP LTE specification:



	TDD Configuration #	UL/total ratio	DL/total ratio
	0	0.7	0.3
	1	0.5	0.5
	2	0.3	0.7
	3	0.35	0.65
	4	0.25	0.75
	5	0.15	0.85
	6	0.6	0.4
R1/R3 FDD Ratio	Type of Fractional Frequency Reuse (FFR) plan that is being used in LTE project in the R1/R3 zone Resource Blocks drop-down list		
TDD R1 Ratio	Part (from 0.1 to 1) the R1 zone subcarriers of physical resource blocks (PRB) for TDD		
FFR SINR Threshold	SINR threshold for switching between R1 and R3 zones in FFR, dB		
Cell Load	Cell Load, 0-100 % Cell Loading is considered uniform. The possibility of different cell loading by sectors and the use of subscriber density maps will be added in the future.		
Downlink and Uplink 3GPP Tables	These tables contain the MCS Index, modulation type, and transport block size (TBS) specified in the tables of 3GPP TS 36.213. Minimum C/(I+N) values for 1% SER (dB) can be specified separately for both uplink and downlink. The theoretical defaults shown in this table are from published MATLAB simulations of LTE radio link performance. The throughput for each modulation index is determined from the 3GPP tables, taking into account the transport block size. This throughput does not take into account the MIMO multiplier.		

### Network Channel Plan

In the channel table, specify all possible uplink and downlink frequencies (channels) that will be used in the network. For TDD, enter the same frequency. If the network operates on a single channel, then the frequencies in the Network Channel Plan may not be specified.

The screenshot shows the 'System parameters' dialog box with the 'Network Channel Plan' tab selected. The dialog contains four tabs: 'LTE Parameters', 'Network Channel Plan', 'MIMO Configuration', and 'Noise and Interference'. Below the tabs are three buttons: a list icon, 'dl', and 'ul'. The 'Downlink' section contains a table with two columns: 'Channel Number\*' and 'Frequency, MHz'. The first row has a right-pointing arrow in the first column, '731.5' in the second, and '731.5' in the third. The second row has an asterisk in the first column and is empty in the others. The 'Uplink' section contains a similar table with '701.5' in the second and third columns. A legend below the tables indicates '\* - optional'. At the bottom right are 'OK' and 'Cancel' buttons.

*LTE Network Channel Plan*

## MIMO Configuration

The MIMO table is fully configurable for all downlink and uplink scenarios.

System parameters

LTE Parameters Network Channel Plan **MIMO Configuration** Noise and Interference

MIMO Type	DL Coverage Gain (dB)	UL Coverage Gain (dB)	DL Throughput Multiplication Factor	UL Throughput Multiplication Factor	DL Interference Reduction (dB)	UL Interference Reduction (dB)
Diversity Rx BS antenna	0	3	1	1	0	0
MIMO-A 2x1	3	3	1	1	0	0
MIMO-A 2x2	6	6	1	1	0	0
MIMO-B 2x2	3	3	1.9	1	0	0
MIMO-A 4x2	9	9	1	1	0	0
MIMO-B 4x2	6	6	1.9	1	0	0
SDMA/Adaptive (FDD) 4x2	8	9	1.5	2	10	15
SDMA/Adaptive (TDD) 4x2	9	9	3	3	15	15
MIMO-A 4x4	12	6	1	1	0	0
MIMO-B 4x4	6	6	3.8	1	0	0
MIMO-B 8x8	9	9	8	8	0	0
SDMA/Adaptive (FDD) 8x1	8	9	1.5	2	15	20
SDMA/Adaptive (TDD) 8x1	9	9	3	3	20	20
SDMA/Adaptive (FDD) 8x2	11	12	2	2.5	15	20
SDMA/Adaptive (TDD) 8x2	12	12	4	4	20	20

OK Cancel

### LTE MIMO Configuration

## Noise and Interference

The receiver parameters in this tab are used for noise and interference calculations.

The screenshot shows a dialog box titled "System parameters" with a close button (X) in the top right corner. It has four tabs: "LTE Parameters", "Network Channel Plan", "MIMO Configuration", and "Noise and Interference" (which is selected). Inside the dialog, there is a section titled "Rx parameters" containing a table of settings for Downlink (DL) and Uplink (UL). The settings are: Rx equivalent noise bandwidth (MHz) with values 4.5 for both DL and UL; Rx noise figure (dB) with values 6 for both; Rx noise level (dB) with values -101.4 for both; and Adjacent channel rejection (dB) with values 25 for both. At the bottom right of the dialog are "OK" and "Cancel" buttons.

	DL	UL
Rx equivalent noise bandwidth (MHz)	4.5	4.5
Rx noise figure (dB)	6	6
Rx noise level (dB)	-101.4	-101.4
Adjacent channel rejection (dB)	25	25

*LTE Noise and Interference*

Rx equivalent noise bandwidth	Receiver Equivalent Noise Bandwidth, MHz In LTE systems, when using all resource blocks, the following noise bandwidths are obtained: 1.08 MHz (1.4 MHz Bandwidth) 2.7 MHz (3 MHz Bandwidth) 4.5 MHz (5 MHz Bandwidth) 9 MHz (10 MHz Bandwidth) 13.5 MHz (15 MHz Bandwidth) 18 MHz (20 MHz Bandwidth)
Rx noise figure	Receiver noise figure, dB Typically 3-4 dB for eNodeB and 6 dB for UE
Rx noise level	Receiver noise level, dB This value is used to estimate the noise on the receiving path when calculating all types of interference.
Adjacent channel rejection	Adjacent channel rejection, dB It is assumed that the receiver has a rectangular "brick wall" bandpass shape with a width equal to the equivalent noise bandwidth. Under these conditions, you can set the amount of attenuation on adjacent channels (one bandwidth above and below the desired bandwidth) by entering a value here for adjacent channel rejection.

## 5G (NR) System Parameters

System parameters

5G Parameters Network Channel Plan MIMO Configuration Noise and Interference

Mode TDD DL symbols part in TDD slot (0..1) 0.7

Configuration BW=100MHz; SCS=30kHz Cell Load (%) 75

3GPP TS Table 38.214 Table 5.1.3.1-2

MCS Index	Modulation	Target code Rate R x [1024]	DL Throughput (Mbps)	DL SINR (dB)	UL Throughput (Mbps)	UL SINR (dB)
15	64QAM	666	215.5	15.2	98.8	13.8
16	64QAM	719	232.6	16.4	106.7	14.6
17	64QAM	772	249.8	17.8	114.5	15.3
18	64QAM	822	266.0	19.3	121.9	16
19	64QAM	873	282.5	21	129.5	16.7
20	256QAM	682.5	294.4	21.5	135.0	17
21	256QAM	711	306.7	23	140.6	18
22	256QAM	754	325.3	24	149.1	19
23	256QAM	797	343.8	25	157.6	20
24	256QAM	841	362.8	27	166.3	21
25	256QAM	885	381.8	28	175.0	22
26	256QAM	916.5	395.4	29	181.3	23
27	256QAM	948	409.0	30	187.5	24

OK Cancel

### 5G Parameters

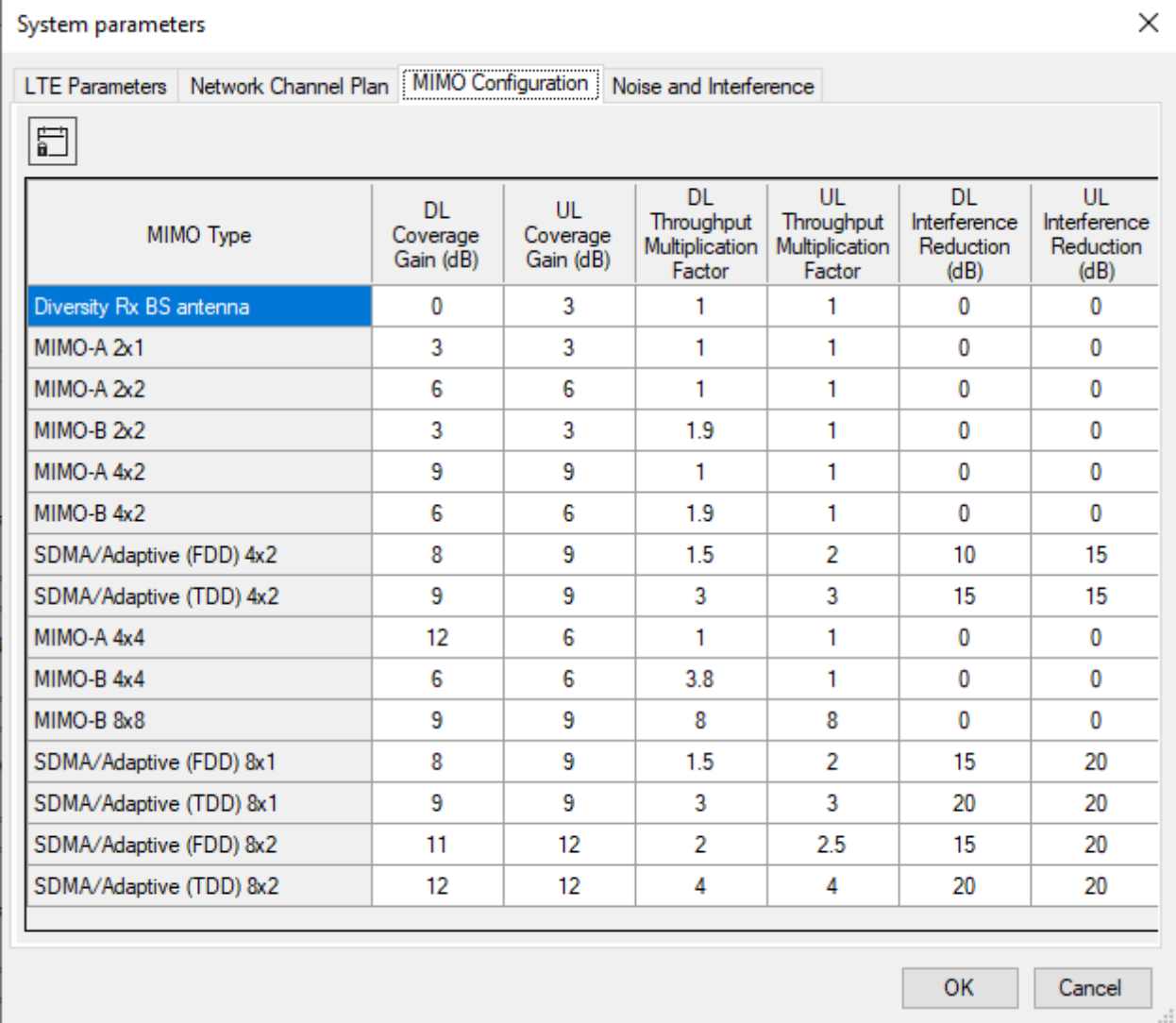
Mode	Duplex mode: - FDD - TDD
Configuration	Choice from bandwidth (BW) and Subcarrier Spacing (SCS) configurations.
Downlink and Uplink 3GPP Tables	These tables contain the MCS Index, modulation type, and Target code rate specified in the tables of 3GPP TS 36.214. Minimum $C/(I+N)$ values for 1% SER (dB) can be specified separately for both uplink and downlink. The theoretical defaults shown in this table are from published MATLAB simulations of 5G radio link performance. The throughput for each modulation index is determined from the 3GPP tables. This throughput does not take into account the MIMO multiplier.
DL symbols part in TDD slot (0..1)	Part of the TDD resource that is intended for downlink
Cell Load	Cell Load, 0-100 % Cell Loading is considered uniform. The possibility of different cell loading by sectors and the use of subscriber density maps will be added in the future.

### Network Channel Plan

In the channel table, specify all possible uplink and downlink frequencies (channels) that will be used in the network. For TDD, enter the same frequency. If the network operates on a single channel, then the frequencies in the Network Channel Plan may not be specified.

### MIMO Configuration

The MIMO table is fully configurable for all downlink and uplink scenarios.



System parameters

LTE Parameters Network Channel Plan **MIMO Configuration** Noise and Interference

MIMO Type	DL Coverage Gain (dB)	UL Coverage Gain (dB)	DL Throughput Multiplication Factor	UL Throughput Multiplication Factor	DL Interference Reduction (dB)	UL Interference Reduction (dB)
Diversity Rx BS antenna	0	3	1	1	0	0
MIMO-A 2x1	3	3	1	1	0	0
MIMO-A 2x2	6	6	1	1	0	0
MIMO-B 2x2	3	3	1.9	1	0	0
MIMO-A 4x2	9	9	1	1	0	0
MIMO-B 4x2	6	6	1.9	1	0	0
SDMA/Adaptive (FDD) 4x2	8	9	1.5	2	10	15
SDMA/Adaptive (TDD) 4x2	9	9	3	3	15	15
MIMO-A 4x4	12	6	1	1	0	0
MIMO-B 4x4	6	6	3.8	1	0	0
MIMO-B 8x8	9	9	8	8	0	0
SDMA/Adaptive (FDD) 8x1	8	9	1.5	2	15	20
SDMA/Adaptive (TDD) 8x1	9	9	3	3	20	20
SDMA/Adaptive (FDD) 8x2	11	12	2	2.5	15	20
SDMA/Adaptive (TDD) 8x2	12	12	4	4	20	20

OK Cancel

### 5G MIMO Configuration

### Noise and Interference

The receiver parameters in this tab are used for noise and interference calculations.

The screenshot shows a dialog box titled 'System parameters' with a close button (X) in the top right. It has two tabs: 'MIMO Configuration' and 'Noise and Interference'. The 'Noise and Interference' tab is active. Inside, there is a section for 'Rx parameters' with two columns: 'DL' and 'UL'. The parameters and their values are:

Parameter	DL	UL
Rx equivalent noise bandwidth (MHz)	98	98
Rx noise figure (dB)	6	6
Rx noise level (dB)	-88.1	-88.1
Adjacent channel rejection (dB)	25	25

At the bottom of the dialog are 'OK' and 'Cancel' buttons.

### 5G Noise and Interference

Rx equivalent noise bandwidth	Receiver Equivalent Noise Bandwidth, MHz In 5G, the noise band can be obtained from the formula: Rx equivalent noise BW= 12*SCS*Resource Blocks. For example, for BW=100 MHz, SCS=30 kHz Rx equivalent noise BW=12*0.03*273=98.28 MHz
Rx noise figure	Receiver noise figure, dB Typically 3-4 dB for gNodeB and 6 dB for UE
Rx noise level	Receiver noise level, dB This value is used to estimate the noise on the receiving path when calculating all types of interference.
Adjacent channel rejection	Adjacent channel rejection, dB It is assumed that the receiver has a rectangular “brick wall” bandpass shape with a width equal to the equivalent noise bandwidth. Under these conditions, you can set the amount of attenuation on adjacent channels (one bandwidth above and below the desired bandwidth) by entering a value here for adjacent channel rejection.

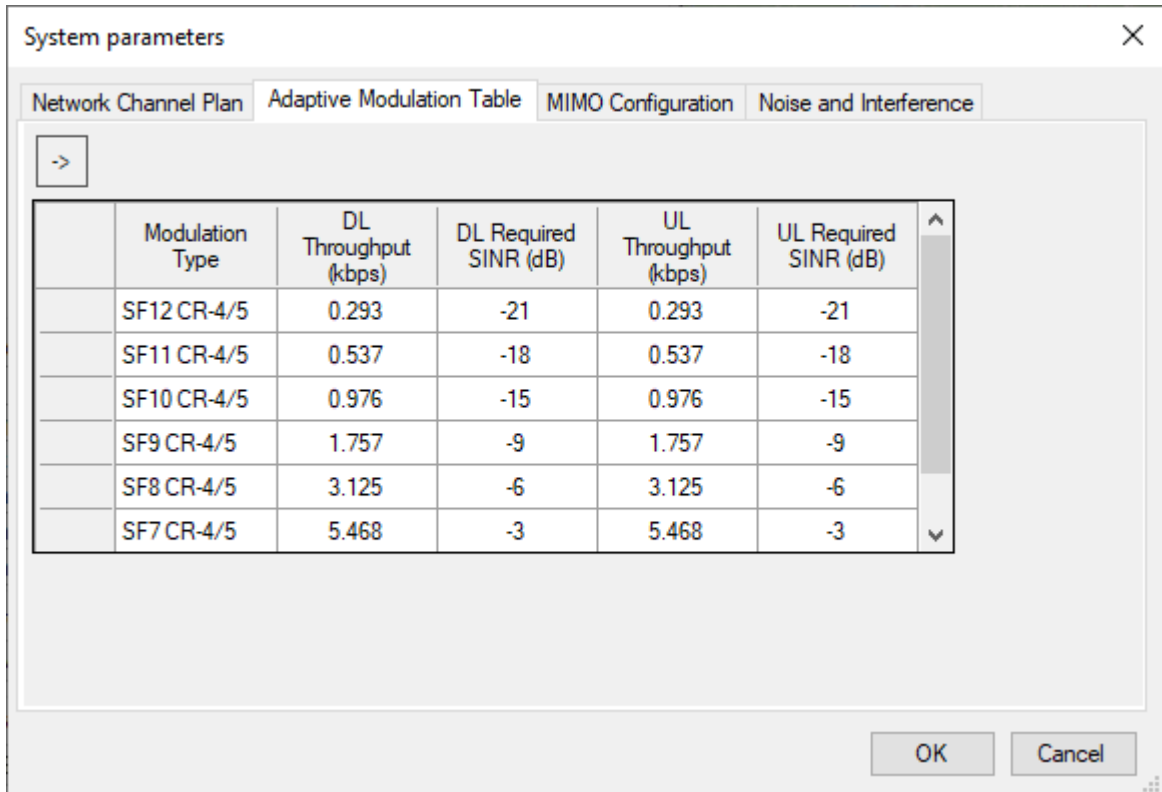
### Generic TRX System Parameters

Generic TRX in RadioPlanner includes all mobile communication systems except for LTE and 5G:

- UMTS / GSM / GSM-R / WCDMA mobile networks
- P25 / TETRA / DMR / dPMR / NXDN land mobile radio networks
- Networks based on wireless IoT LPWAN technologies: LoRa, SigFox, and others

### Adaptive Modulation Table

The adaptive modulation table is filled with SINR values and their respective throughput. This table is used to predict downlink and uplink throughput in Generic TRX. Note that LTE and 5G have separate adaptive modulation tables tied to 3GPP specifications.



*LoRaWAN Adaptive Modulation Table*

Modulation Type	Modulation Type (text field)
DL Throughput (kbps)	Downlink Throughput, kbps
DL SINR (dB)	Downlink SINR,dB
UL Throughput (kbps)	Uplink Throughput, kbps
UL SINR (dB)	Uplink SINR,dB

### Network Channel Plan

In the channel table, specify all possible uplink and downlink frequencies (channels) that will be used in the network. For TDD, enter the same frequency. If the network operates on a single channel, then the frequencies in the Network Channel Plan may not be specified.

System parameters

Network Channel Plan Adaptive Modulation Table MIMO Configuration Noise and Interference

dl ul

Downlink

	Channel Number*	Frequency, MHz
	201	770.25625
	211	770.31875
▶*		

Uplink




	Channel Number*	Frequency, MHz
	201	800.25625
	211	800.31875
▶*		

\* - optional

Channel bandwidth  MHz

OK Cancel

*Generic TRX Network Channel Plan*

-  Sort frequencies in ascending order
-  Autofill downlink frequencies
-  Autofill uplink frequencies

If your network has a large frequency grid, then you can use the autofill feature:

Channel Autofill

First channel frequency  MHz

First channel number

Step  MHz

Number of channels

OK Cancel

*Channel Autofill*

### MIMO Configuration

The MIMO table is fully configurable for all downlink and uplink scenarios.



System parameters ✕

LTE Parameters   Network Channel Plan   **MIMO Configuration**   Noise and Interference

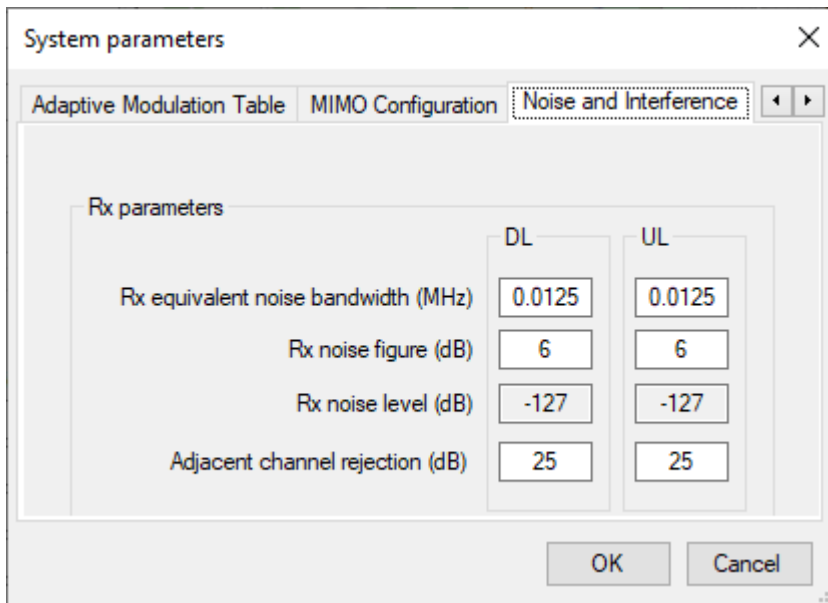
MIMO Type	DL Coverage Gain (dB)	UL Coverage Gain (dB)	DL Throughput Multiplication Factor	UL Throughput Multiplication Factor	DL Interference Reduction (dB)	UL Interference Reduction (dB)
Diversity Rx BS antenna	0	3	1	1	0	0
MIMO-A 2x1	3	3	1	1	0	0
MIMO-A 2x2	6	6	1	1	0	0
MIMO-B 2x2	3	3	1.9	1	0	0
MIMO-A 4x2	9	9	1	1	0	0
MIMO-B 4x2	6	6	1.9	1	0	0
SDMA/Adaptive (FDD) 4x2	8	9	1.5	2	10	15
SDMA/Adaptive (TDD) 4x2	9	9	3	3	15	15
MIMO-A 4x4	12	6	1	1	0	0
MIMO-B 4x4	6	6	3.8	1	0	0
MIMO-B 8x8	9	9	8	8	0	0
SDMA/Adaptive (FDD) 8x1	8	9	1.5	2	15	20
SDMA/Adaptive (TDD) 8x1	9	9	3	3	20	20
SDMA/Adaptive (FDD) 8x2	11	12	2	2.5	15	20
SDMA/Adaptive (TDD) 8x2	12	12	4	4	20	20

OK   Cancel

### *Generic TRX MIMO Configuration*

## Noise and Interference

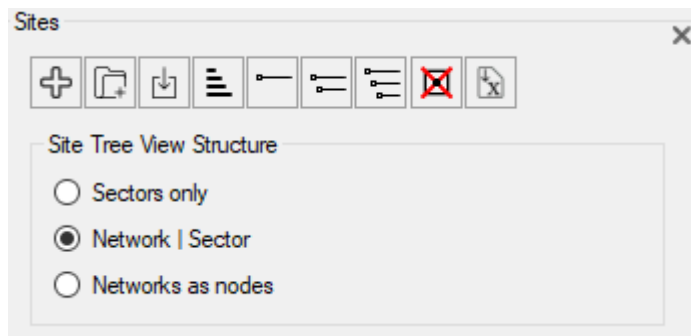
The receiver parameters in this tab are used for noise and interference calculations.












Generic TRX Noise and Interference


Rx equivalent noise bandwidth	Receiver Equivalent Noise Bandwidth, MHz
Rx noise figure	Receiver noise figure, dB Typically 3-4 dB for base station sector and 6 dB for Mobile Unit
Rx noise level	Receiver noise level, dB This value is used to estimate the noise on the receiving path when calculating all types of interference.
Adjacent channel rejection	Adjacent channel rejection, dB It is assumed that the receiver has a rectangular “brick wall” bandpass shape with a width equal to the equivalent noise bandwidth. Under these conditions, you can set the amount of attenuation on adjacent channels (one bandwidth above and below the desired bandwidth) by entering a value here for adjacent channel rejection.

## Sites



Sites

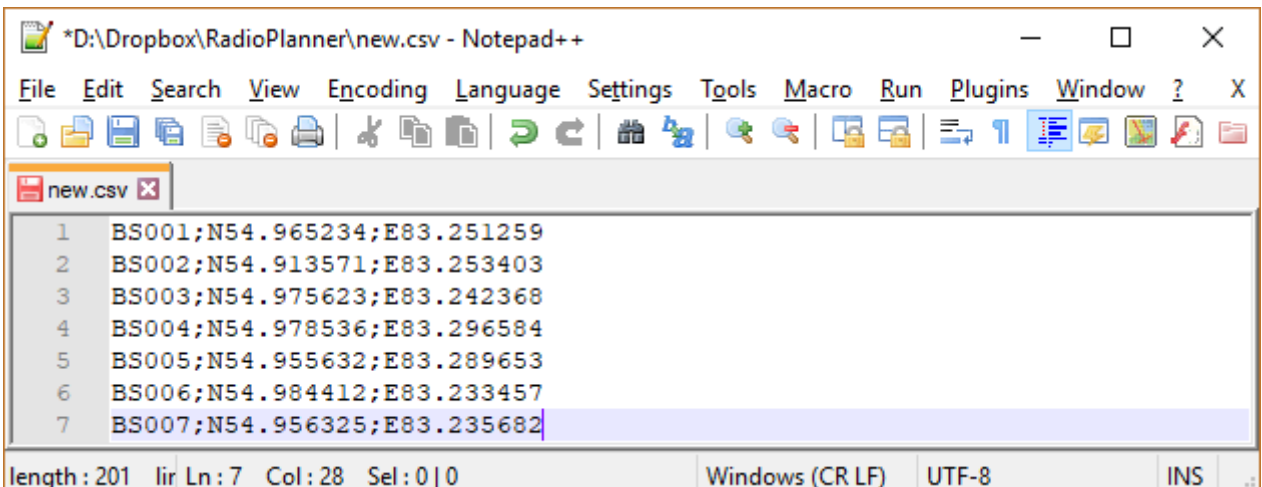
	Add a new site
	Add a new site group
	Import a site list from *.csv file
	Sort sites in alphabetical order
	Collapse of site nodes
	Collapse all network nodes
	Expand all site nodes
	Delete all selected sites
	Import site parameters from Microsoft Excel document

To create a new site, click on Sites in the Tree View interface, then click the  button in the panel that opens.

### Import sites from \*.CSV file

You can also import sites from CSV files (text format with a semicolon separator). This is a universal format that can be used to save a spreadsheet from any spreadsheet editor (Excel, LibreOffice Calc, etc.) or database. Each point object must have required fields including site name, Latitude, and Longitude. Coordinates can be formatted as HEMISPHERE degrees minutes seconds (N35 23.8 36) or HEMISPHERE decimal degrees (N12.34567).

To import sites, click on the button  (import sites from \*.CSV) and select a CSV file.



```

D:\Dropbox\RadioPlanner\new.csv - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ? X
new.csv x
1 BS001;N54.965234;E83.251259
2 BS002;N54.913571;E83.253403
3 BS003;N54.975623;E83.242368
4 BS004;N54.978536;E83.296584
5 BS005;N54.955632;E83.289653
6 BS006;N54.984412;E83.233457
7 BS007;N54.956325;E83.235682
length: 201 |ir Ln: 7 Col: 28 Sel: 0|0 Windows (CR LF) UTF-8 INS








```

*Example of a CSV file with the imported sites*

## Site Details

When clicking on a created site in the Tree View interface panel, the Site Details panel will open where you can edit details such as name, coordinates and additional text information about the site and view elevation relative to sea level.

*Site Details*

-  Add a new site as a copy of this site
-  Move this site up or down
-  Delete the site
-  Load sectors of the selected network from a template
-  Save the sectors of the selected network as a template
-  Position the map with the site at the center of the screen
-  Copy Site Parameters to all active sites

Name	Site name, text field
Latitude	The geographical latitude of the site in the format specified by the user in <b>Settings</b>
Longitude	Geographical longitude of the site in the format specified by the user in Settings
Site Elevation	Site elevation relative to sea level, m
Notes	Text box for any additional site information
Group name	Select site group. Sites can be combined into groups (clusters), allowing you to quickly include/exclude large site groups of from calculations.

## Sector Parameters

When creating a site, at least one sector of this site is automatically created. There is an activity icon next to each site and sector in the Tree View interface panel. For a sector to be calculated, it must be marked as active (a dot in the center). Clicking on the site sector will open a panel with the sector parameters.

Sector Parameters
✕

+
↶
↷
✕
≡
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📄
🚗
🌐

Network: LTE Band 12 (700 MHz)

Name:

Radio equipment: MR44EA

Set Rx antenna and transmission system to be the same as Tx:

MIMO: MIMO-B 4x2

Tx power: 40 W 46 dBm

	Tx transmission loss	Rx transmission loss
Cable type	<span>LDF4-50A 1/2"</span>	<span>LDF4-50A 1/2"</span>
Cable length	<span>5</span> m	<span>5</span> m
Cable loss	<span>0.3</span> dB	<span>0.3</span> dB
Additional loss	<span>0.2</span> dB	<span>0.2</span> dB
Total loss	<span>0.5</span> dB	<span>0.5</span> dB

	Tx antenna	Rx antenna
Antenna Height	<span>25</span> m	<span>25</span> m
Antenna gain	<span>14.5</span> dBi	<span>14.5</span> dBi
Azimuth	<span>0</span> deg.	<span>0</span> deg.
Beam tilt	<span>0</span> deg.	<span>0</span> deg.
Antenna model	<span>FFV4-65B-R3-V1_Port 1 +45_()</span>	<span>FFV4-65B-R3-V1_Port 1 +45_()</span>

Antenna patterns in relative dB:

- horizontal

- vertical

EIRP 60 dBm

Best Server Color

Каналы DL: 731.5

Каналы UL: 701.5

*Sector Parameters*

Toolbar:

Add a new sector with the same parameters

Move the sector up or down. These buttons are active for site Tree view structures "Sectors Only" and "Network | Sector"

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Delete the sector



Global Active Sector parameters change. You can replace the selected parameters for all active sectors as the current sector.



Position the map with the site at the center of the screen




Advanced sector parameters

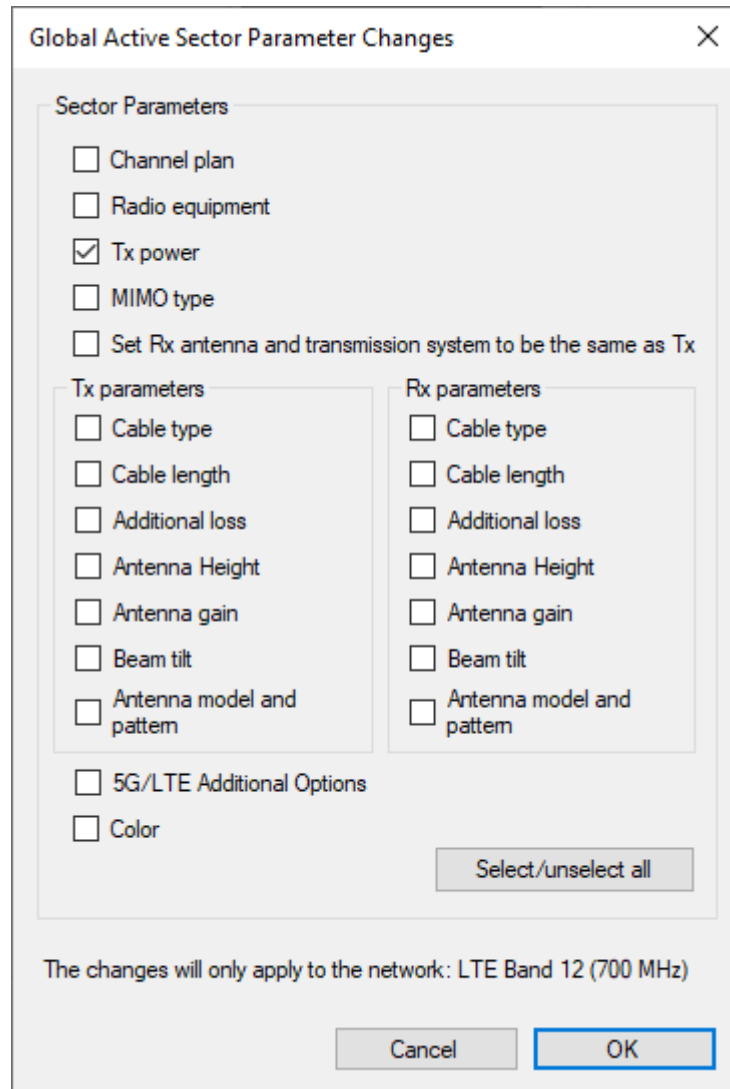


Analysis of measurements along the route. See more details in the "Measurement Results Analysis and Propagation Model Tuning" section.




Calculation of service and interference contours using FCC and ITU-R propagation curves. For more details, see the TV and Radio Broadcast Networks.

Network	The network to which the sector belongs, select from the drop-down list of networks.
MIMO	MIMO type for the sector, selection from a drop-down list of all possible MIMO configurations specified in the system parameters of this network.
Name	The name of the sector, the text field. You can specify the name of the sector in the text field. If left blank, the name "Sector azimuth" with the azimuth value specified in the sector parameters panel will be automatically displayed in the tree view panel on the left. If you specify a name in this field, it will be displayed in the tree view.
Radio Equipment	Name (model) of Radio equipment, text field
Set Rx Antenna and Transmission System to be the Same as Tx	Copying parameters' antenna-feeder transmitter path to the receive path
Tx Power	Transmitter power, W. Same value in dBm for control
Cable Type	Type of the main cable for transmission or reception path. If the required cable is not in the list, then the user can add it himself - see Appendix 1.1
Cable Length	Main cable length, m
Cable Loss	Loss in cable, dB. Calculated value
Additional Loss	Additional losses, dB - combining losses, losses in jumpers, and connectors. Any additional losses.
Total Loss	Total loss, dB. The calculated value.
Antenna Height	The antenna radiation center height relative to ground level, m
Antenna Gain	Antenna gain relative to isotropic radiator, dB
Azimuth	The azimuth of the antenna in degrees
Beam Tilt	Tilt the antenna in degrees. Down is negative; up is positive.
Antenna Model	Antenna name, text field. Automatically filled with the antenna pattern file name when selecting a pattern.
	Load MSI antenna pattern file. An antenna pattern file is a standard MSI file that can be downloaded from the antenna manufacturer's website. Antenna patterns are integrated into the project file.



*Global Active Sector parameters change*

**Global Active Sector parameters change** is a feature that allows you to instantly change the parameters of any active sectors to match those of the current sector. To perform group parameter changes, mark the sectors whose parameters need to be changed as active, set the required parameter values in the

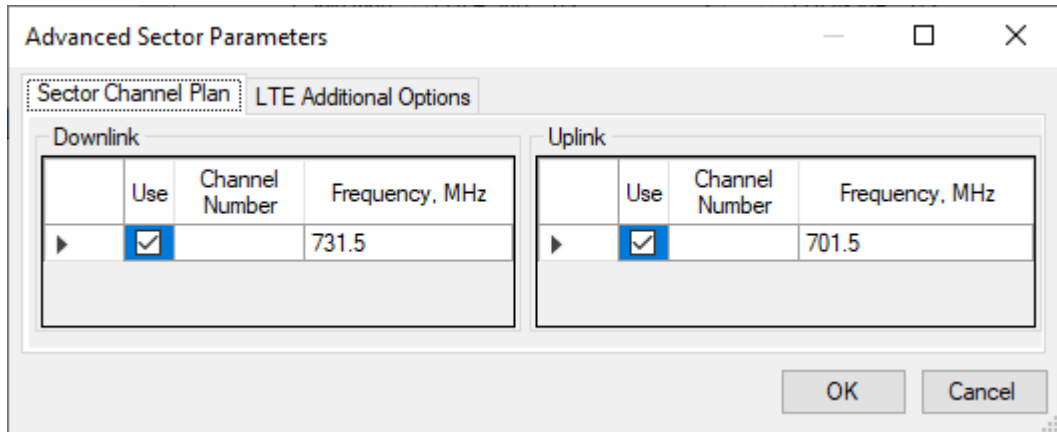
current sector, click on the button , select the parameters that need to be changed in the previously marked active sectors from the list, and click on the OK button.

### Advanced Sector Parameters

Advanced Sector Parameters include the channel plan and other parameters that differ for different types of systems.

### Sector Channel Plan

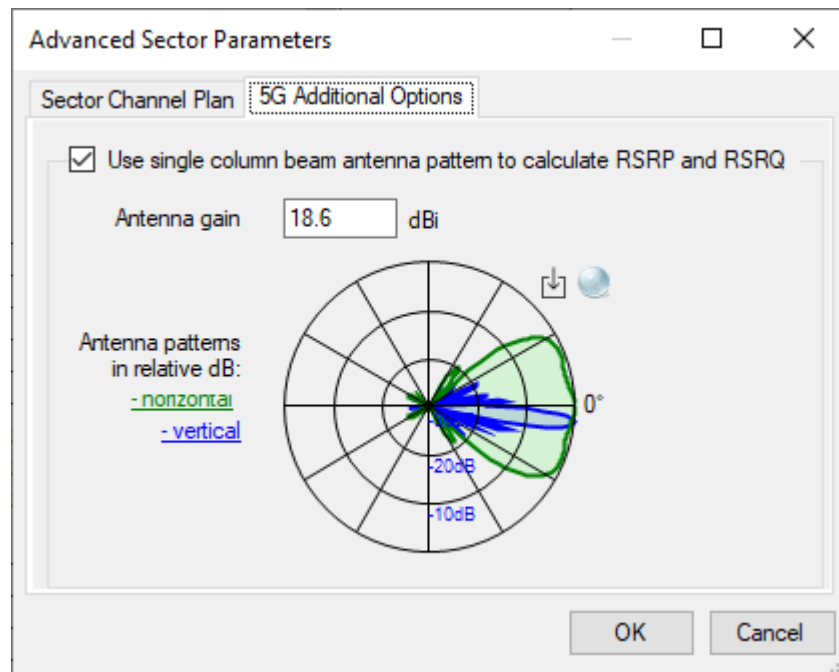
In the Sector Channel Plan, you can select specific frequencies (or channel numbers) from the entire frequency grid specified in the System Parameters of this network.



*Sector Channel Plan*

### LTE/5G Additional Options

Additional options for LTE and 5G networks include using a special antenna pattern (single column antenna pattern beam) for calculating RSRP and RSRQ.

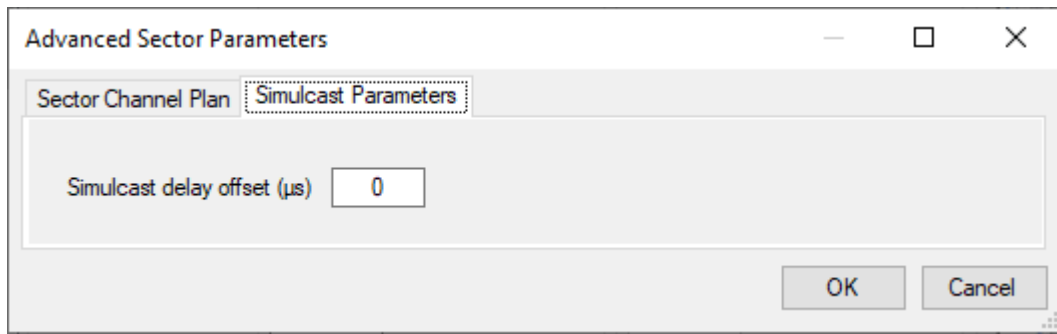


*LTE/5G Additional Options*

### Generic TRX Additional Options (Simulcast parameters)

Advanced parameters for Generic TRX include only entering the Sector simulcast delay offset, which applies only to simulcast systems where multiple transmitters share the same frequency.



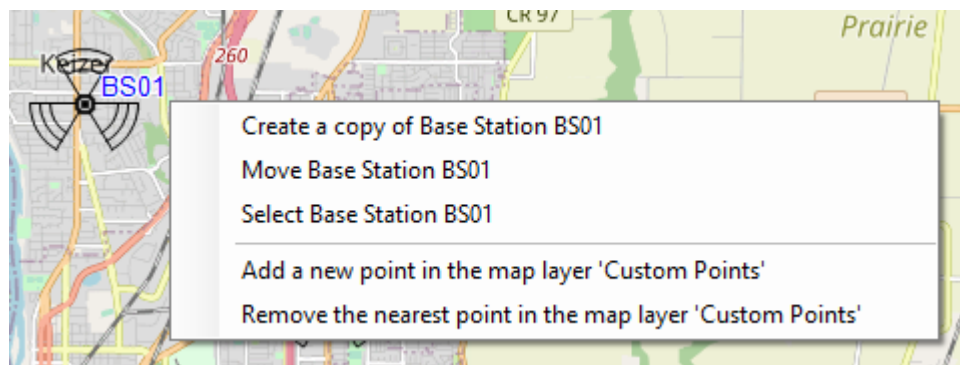


*Sector Simulcast Parameters*

Simulcast delay offset (µs)	Sector simulcast delay offset, µs
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### Context menu on the base map

When right-clicking on the base map, a context menu appears with options to create a new site at that point, move a selected site, or open the parameters of the nearest site by selecting “Select Site.”



*Context menu on the base map*

## Propagation models

In RadioPlanner 3.0, you can select from several propagation models to perform coverage predictions. You can also specify time and location variability statistics and prediction confidence margin for most models.

Available propagation models:

- ITU-R P.1812 model
- Longley-Rice (ITM) model v 1.2.2
- Okumura-Hata
- 3GPP TR 38.901
- ITU-R P.1546-6 model
- Combined ITU-R P.528-3 + P.526-14 model (for air-to-ground radio only)

The main parameters for each of the propagation models are shown in the table below.

Propagation model	Frequency Range	Use DTM	Use Clutter
ITU-R P.1812-6	30 MHz to 6 GHz	+	+
Longley-Rice (ITM) v 1.2.2	20 MHz to 20 GHz	+	+
Okumura-Hata	100 MHz to 1.5 GHz	-	+
3GPP TR 38.901	500 MHz to 100 GHz	+ <sup>1</sup>	-
ITU-R P.1546-6	30 MHz to 3 GHz	+	+
ITU-R P.528-3 + P.526-14	125 MHz to 15.5 GHz	+	+

<sup>1</sup>Used to determine LOS/NLOS path status only

### ITU-R P.1812-6 Propagation Model

The ITU-R P.1812-6 Propagation Model is described in detail in Recommendation ITU-R P.1812-6 (09/2021) “A path-specific propagation prediction method for point-to-area terrestrial services in the frequency range 30 MHz to 6 000 MHz.”

This model takes into account factors such as diffraction loss on path profile obtained from DTM data; impact of local surrounding obstacles determined by clutter model; and local and time variability of received radio signal.

**Propagation Model** ✕

Rec. ITU-R P.1812-6 ▼

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**Location and Time Variability**

Location  %       $\sigma_{LN}$   dB

Time  %       $\sigma_R$   dB

Confidence margin  dB       $\sigma_t$   dB

Fade margin  dB

---

**Clutter Loss**

Add clutter loss      Network type  ▼

Use clutter attenuation according with Rec. ITU-R P.1812

Clutter type	Mobile Unit N=1 loss, dB	Mobile Unit N=2 loss, dB
Open/rural	0	0
Water	0	0
Trees/forest	21.7	21.7
Suburban	17.9	17.9
Urban	21.7	21.7
Dense urban	24.2	24.2
Open areas in forest	14.3	14.3
Open areas in suburban	10.7	10.7
Open areas in urban	14.3	14.3

Exclude water areas from coverage

#### ITU-R P.1812-6 Propagation Model

Location, %	Location percentage (50%-99%, typically 50%, 90% or 95%) indicates that a given power level will be exceeded in at least that percentage of locations for
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	similar propagation paths. Set 50% if you want to completely exclude the influence of Location variability.
Time, %	By choosing a time percentage (50%-99%, typically 50%, 90% or 95%), the calculated received power values are the power levels that will be exceeded at least that percentage of time. Set 50% if you want to completely exclude the influence of Time variability.
Confidence margin, dB	Since the received power level calculations are estimates, the prediction margin lets you specify a safety margin in dB so that you can be more confident your signal level estimate is indeed above the specified signal level.
$\sigma_{LN}$ , dB	Lognormal large-scale (shadow) fading standard deviation, dB. This value depends on the digital terrain model (DTM) resolution and carrier frequency. Typical value 2-5 dB for modern DTMs.
$\sigma_R$ , dB	Small-scale fading (Rayleigh) standard deviation, dB. Typically 7.5 dB
$\sigma_t$ , dB	Time variability standard deviation, dB. At distances up to 50 km, the $\sigma_t$ usually varies for between 2-3 dB (Land), and up to 9 dB for the Sea. See Table 3 in Recommendation ITU-R P.1406-2 "Propagation effects relating to terrestrial land mobile and broadcasting services in the VHF and UHF bands"
Fade margin, dB	Fade margin, dB. Calculated total fade margin depending on location and time variability, as well as the confidence margin.

### Clutter loss

Clutter loss is calculated according to Recommendation ITU-R P.1812-6 and depends on factors such as antenna height of the mobile unit, frequency, typical width of streets, average height of clutter, and clutter type.

The frequency and antenna height for each of the two types of mobile units (portable and mobile) are set in the Network menu. The typical width of streets is 27m (in accordance with ITU-R P.1812-6). The clutter model determines the type of obstacles at each point.

Add clutter loss	Add clutter loss to path loss
Network type	Select the network for which the clutter loss applies
Use clutter attenuation according with Rec. ITU-R P.1812	Calculate losses in clutter using Rec. ITU-R P.1812-6 formulas

Average heights for different types of clutter are set in the Geo Data menu. The default clutter height in Rec. ITU-R P.1812-6:

	Clutter Type	Color	Clutter height (m)
1	Open / Rural		7
2	Water		0
3	Trees / Forest		15
4	Suburban		10
5	Urban		15
6	Dense urban		20
7	Open areas in forest		7
8	Open areas in suburban		5
9	Open areas in urban		7

You can also manually set clutter loss for each clutter type based on your own data by entering the losses into the table.

### ITU-R P.1546-6 Model

The model is based on recommendation ITU-R P.1546-6 (08/2019): "Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4000 MHz"

Model ITU-R P.1546-6 is empirical because it is based on experimentally obtained field strength curves versus distance for different frequencies, antenna heights, path types, and time probability. In Recommendation ITU-R P.1546-6, in addition to these curves, losses are also determined by the terrain clearance angle correction from the receiver side and the correction for the height of the clutter surrounding the receiver.

**Propagation Model** ✕

Rec. ITU-R P.1546-6 ▾

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**Location and Time Variability**

Location  %       $\sigma_{LN}$   dB

Time  %       $\sigma_R$   dB

Confidence margin  dB      Path type  ▾

Fade margin  dB

Apply terrain clearance angle correction

---

**Clutter Loss**

Add clutter loss      Network type  ▾

Use clutter attenuation according with Rec. ITU-R P.1546

Clutter type	Mobile Unit N=1 loss, dB	Mobile Unit N=2 loss, dB
Open/rural	0	0
Water	0	0
Trees/forest	21.6	21.6
Suburban	17.8	17.8
Urban	21.6	21.6
Dense urban	24.2	24.2
Open areas in forest	14.2	14.2
Open areas in suburban	10.6	10.6
Open areas in urban	14.2	14.2

Exclude water areas from coverage

*ITU-R P.1546-6 Propagation Model*

The approach to fade margin calculation, taking into account location and time variability as well as large/small-scale and time fading standard deviations, is the same as described in the ITU-R P.1812 Propagation Model.

Path Type	<ul style="list-style-type: none"> <li>- Land</li> <li>- Cold Sea</li> <li>- Warm Sea</li> </ul>
Apply Terrain Clearance Angle Correction	This uses the terrain profile to adjust the field strength at the receive point for terrain blockage on non-line-of-sight paths.
Add Clutter Loss	Add clutter loss to path loss
Use Clutter Attenuation According to Rec. ITU-R P.1546-6	Calculation of clutter losses in accordance with Rec. ITU-R P.1546-6, depending on the height of clutter. You can also manually set clutter loss for each clutter type based on your own data by entering the losses into the table.

### Longley-Rice (ITM) Propagation Model v 1.2.2

The Longley-Rice propagation model, also known as the Irregular Terrain Model (ITM), is considered the industry standard for coverage prediction in North America. RadioPlanner 3.0 uses version 1.2.2 of the Irregular Terrain Model in PTP-mode.

Propagation Model

Longley-Rice

Situation and Time Variability

Situation 95 %

Time 95 %

Margin 0 dB

Path Parameters

Refractivity 301 N-units

Conductivity 0.02 S/m

Dielectric Constant 15

Climate Zone Continental Temperate

Antenna Polarization Vertical

Clutter Loss

Add clutter loss Network type Simulcast P25 70I

Clutter type	Mobile Unit N=1 loss, dB	Mobile Unit N=2 loss, dB
Open/rural	0	0
Water	0	0
Trees/forest	18	16
Suburban	12	10
Urban	18	16
Dense urban	20	18
Open areas in forest	14	14
Open areas in suburban	10	10
Open areas in urban	10	10

Exclude water areas from coverage

*Longley-Rice Propagation Model Parameters*

Situation, %	Situation (location) percentage, (50%-99%, typically 50%, 90% or 95%) indicates that a given power level will be exceeded in at least that percentage of locations for similar propagation paths. Set 50% if you want to completely exclude the influence of Situation variability.
Time, %	Time percentage, %. By choosing a time percentage (50%-99%, typically 50%, 90% or 95%), the calculated received power values are the power levels that will be exceeded at least that percentage of time. Set 50% if you want to completely exclude the influence of Time variability.
Margin	Confidence margin. Since the received power level calculations are estimates, the prediction margin lets you specify a safety margin in dB so that you can be more confident your signal level estimate is indeed above the specified signal level.

Refractivity	Atmospheric refractivity, measured in N-Units
Conductivity (S/m)	Conductivity of the ground over which the signal propagates (Siemens per meter)
Dielectric Constant	The dielectric constant (relative ground permittivity)
Climate Zone	The following Radio Climates can be selected: <ul style="list-style-type: none"> <li>- Equatorial (Congo)</li> <li>- Continental Subtropical (Sudan)</li> <li>- Maritime Subtropical (West Coast of Africa)</li> <li>- Desert (Sahara)</li> <li>- Continental Temperate, common to large landmasses in the Temperate Zone</li> <li>- Maritime Temperate, over Land (United Kingdom and Continental West Coasts)</li> <li>- Maritime Temperate, over Sea</li> </ul>
Antenna Polarization	Antenna Polarization: Horizontal / Vertical

### Clutter Loss

In the Longley-Rice propagation model, clutter loss for are entered manually directly into the table for each network.

Add clutter loss	Add clutter loss to path loss
Network type	Select the network for which the clutter loss applies

### Okumura-Hata Propagation Model

This empirical model was developed by Hata and is based on Okumura's experimental data taken in the Tokyo urban and suburban area. When calculating coverage using this model, you must determine which category the site location area belongs to: Urban Area, Suburban Area, or Open Area. Path loss is calculated using different formulas depending on the type of area.

- **Urban Area:** Built up city or large town including buildings and houses with two or more stories, or large villages and tall trees, green lands.
- **Suburban Area:** Small town, village or highway scattered with trees and houses, some obstacles near the mobile set but not very congested and scattered industrial plants.
- **Open Area:** No tall trees or buildings in the radiowaves path, open fields, land cleared for 300–400m ahead, very low congested area, no factories such as farm lands and rice fields.

Path loss is calculated using different formulas, depending on the type of area.

Propagation Model

Okumura-Hata

Location and Time Variability

Location 90 %  $\sigma_{LN}$  5.5 dB

Time 90 %  $\sigma_R$  7.5 dB

Confidence margin 0 dB  $\sigma_t$  2 dB

Fade margin 12.2 dB

Area type By Clutter Data

Additional Clutter Loss

Network type

Clutter type	Mobile Unit N=1 loss, dB	Mobile Unit N=2 loss, dB
Open/rural	0	0
Water	0	0
Trees/forest	0	0
Suburban	0	0
Urban	0	0
Dense urban	0	0
Open areas in forest	0	0
Open areas in suburban	0	0
Open areas in urban	0	0

Exclude water areas from coverage

#### Okumura-Hata Propagation Model


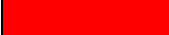




The approach to fade margin calculation, taking into account location and time variability as well as large/small-scale and time fading standard deviations, is the same as described in the ITU-R P.1812-6 Propagation Model.

Area Type	Select the area type: <ul style="list-style-type: none"> <li>- By Clutter Data</li> <li>- Open</li> <li>- Suburban</li> <li>- Urban</li> </ul>
Network type	Select the network for which the additional clutter loss applies

In RadioPlanner 3.0, you can select one of these standard Okumura-Hata area types or choose “By Clutter Data” for automatic detection of Okumura-Hata area type based on clutter type. The correspondence table between clutter type and Okumura-Hata area type is shown below. When choosing this option, you can also use additional attenuation for different types of clutter.

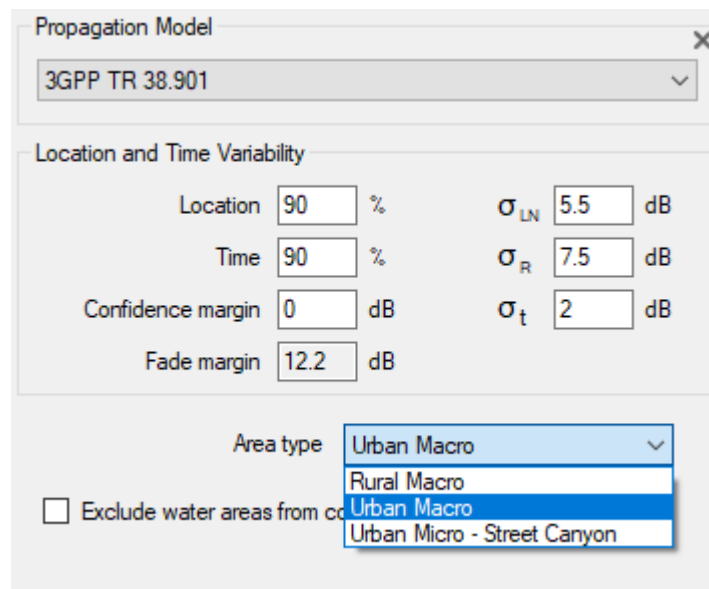
	RadioPlanner Clutter Type	Color	Okumura-Hata Area Type
1	Open / Rural		Open
2	Water		Open



3	Trees / Forest		Open
4	Suburban		Suburban
5	Urban		Urban
6	Dense urban		Urban
7	Open areas in forest		Open
8	Open areas in suburban		Suburban
9	Open areas in urban		Urban

### 3GPP TR 38.901 Propagation Model

This model is described in detail in 3GPP Technical Report 5G; Study on channel model for frequencies from 0.5 to 100 GHz (3GPP TR 38.901 version 17.0.0 Release 17; 2022-04)



*3GPP TR 38.901 Propagation Model*

The approach to fade margin calculation, taking into account location and time variability also large/small-scale and time fading standard deviations, the same as described in the ITU-R P.1812 Propagation Model.

Area Type	Select the area type: <ul style="list-style-type: none"> <li>- Rural Macro</li> <li>- Urban Macro</li> <li>- Urban Micro-Street Canyon</li> </ul>
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### Area Study (Coverage Prediction) types

RadioPlanner 3.0 performs various types of area studies:

- Received Power Uplink/Downlink
- Best Server Uplink/Downlink
- Area with Signal above Both the Base and Mobile Thresholds
- C/(I+N) Ratio Uplink/Downlink

- Maximum Throughput Uplink/Downlink
- Maximum aggregated Throughput Downlink
- Number of Servers Uplink/Downlink
- Coverage Probability Uplink/Downlink
- RSRP for LTE and 5G
- RSRQ for LTE and 5G
- Simulcast Delay Spread
- Received Power with Simulcast Interference
- Field Strength Downlink

The availability of a particular area study type is determined by the type of system chosen.

### Received power Downlink/Uplink

Received power maps show those areas where a given signal power level is present at the receiver.

	Mobile Unit N°1	Mobile Unit N°2
Type	Tait TP9461	Tait TM9400
Tx power (W)	5	50
Cable and connectors loss (dB)	0	0.5
Antenna height (m)	1.5	3
Antenna gain (dBi)	0	3

Use directional antenna pattern for Mobile Unit (UE)

Area study type  
Received Power (DL) ▾

Levels for Mobile Unit (UE) N°1

5 ▾ Number of levels

Color	Value	Description
<span style="color: red;">■</span>	> -60 dBm	
<span style="color: orange;">■</span>	-70 to -60 dBm	
<span style="color: yellow;">■</span>	-80 to -70 dBm	
<span style="color: green;">■</span>	-90 to -80 dBm	
<span style="color: cyan;">■</span>	-103 to -90 dBm	

Use co-channel interference  
 Use adj-channel interference

Interference zone color (white for transparent)  
 Required service C/(I+N) ratio  dB

Level for Mobile Unit (UE) N°2

<span style="color: blue;">■</span>	> -103 dBm	Mobile
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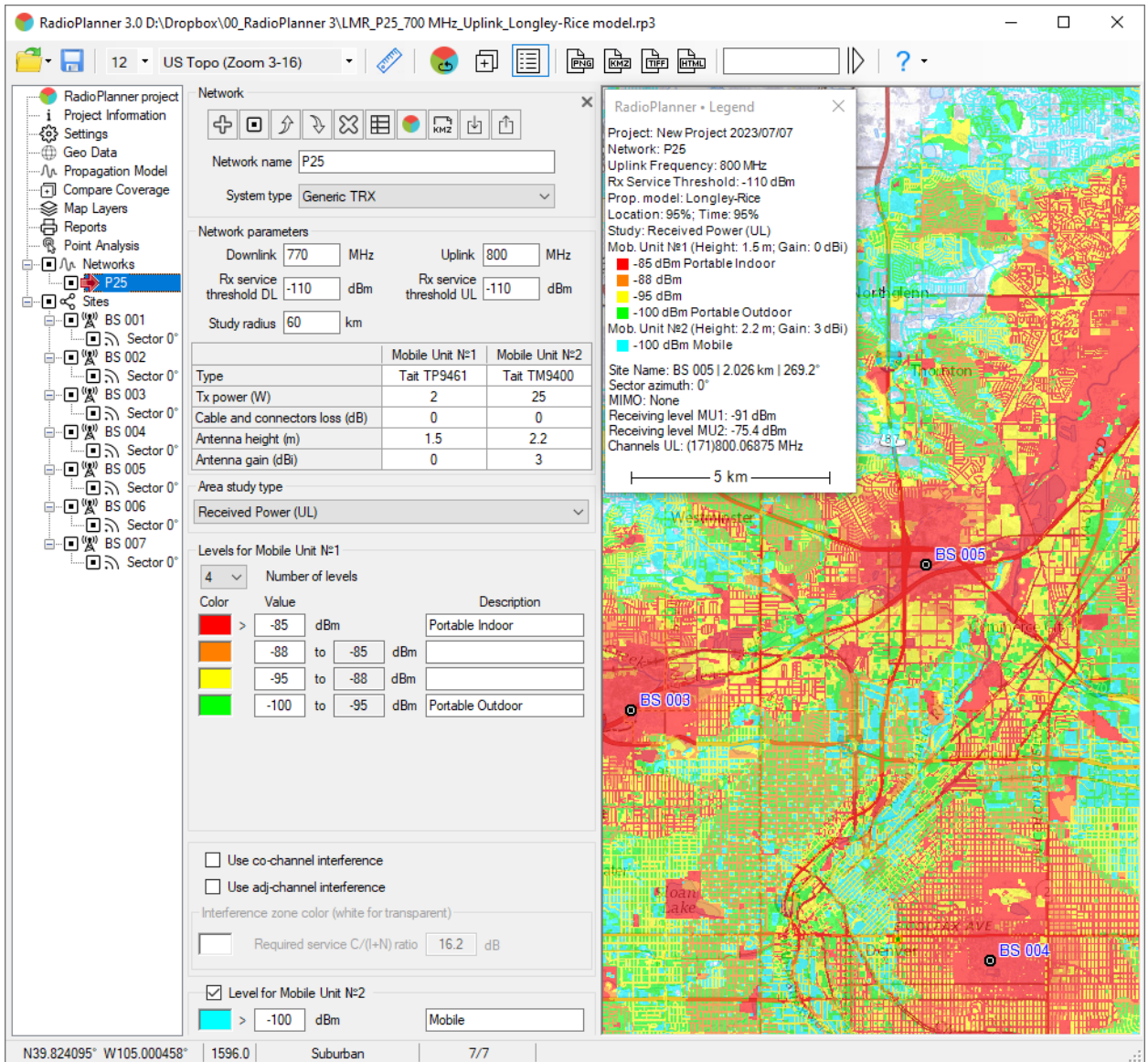
*Received Power Downlink Study Type Parameters*

Number of Levels	The number of levels (1-8)
Color	Color level
Values	Received power level, dBm
Description	Text field to describe signal level
Use co-channel interference	Perform coverage calculation taking into account co-channel interference using frequency assignments for each sector.
Use adj-channel interference	Perform coverage calculation taking into account adjacent channel interference using parameters in network settings (Channel bandwidth and Adjacent Channel rejection) as well as frequency assignments for each sector.
Required Service C/(I+N) Ratio	Required service C/(I+N) ratio, dB This is the minimum acceptable C/(I+N) ratio required by the receiver for "acceptable" performance. "Acceptable" can mean a variety of things in terms of subjective signal quality, so this number can be adjusted to represent systems of varying quality or marginal quality. An area with a C/(I+N) below the Required Service C/(I+N) ratio will be shown on the map as an interference zone.

For Mobile Unit No. 1 (portable), you can set from one to eight different levels of received signal to simulate different reception conditions (e.g., on street, inside a car, indoors).

For Mobile Unit No. 2 (mobile radio with an antenna on the roof of a car), only one signal level can be set.

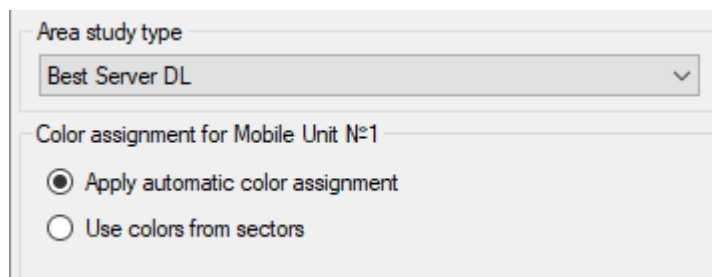
The interference calculation always takes into account the noise component, which depends on the noise bandwidth and receiver noise figure. These settings are entered in Noise and Interference in the Network system settings.



Uplink Received Power Coverage Prediction for P25 700 MHz Network

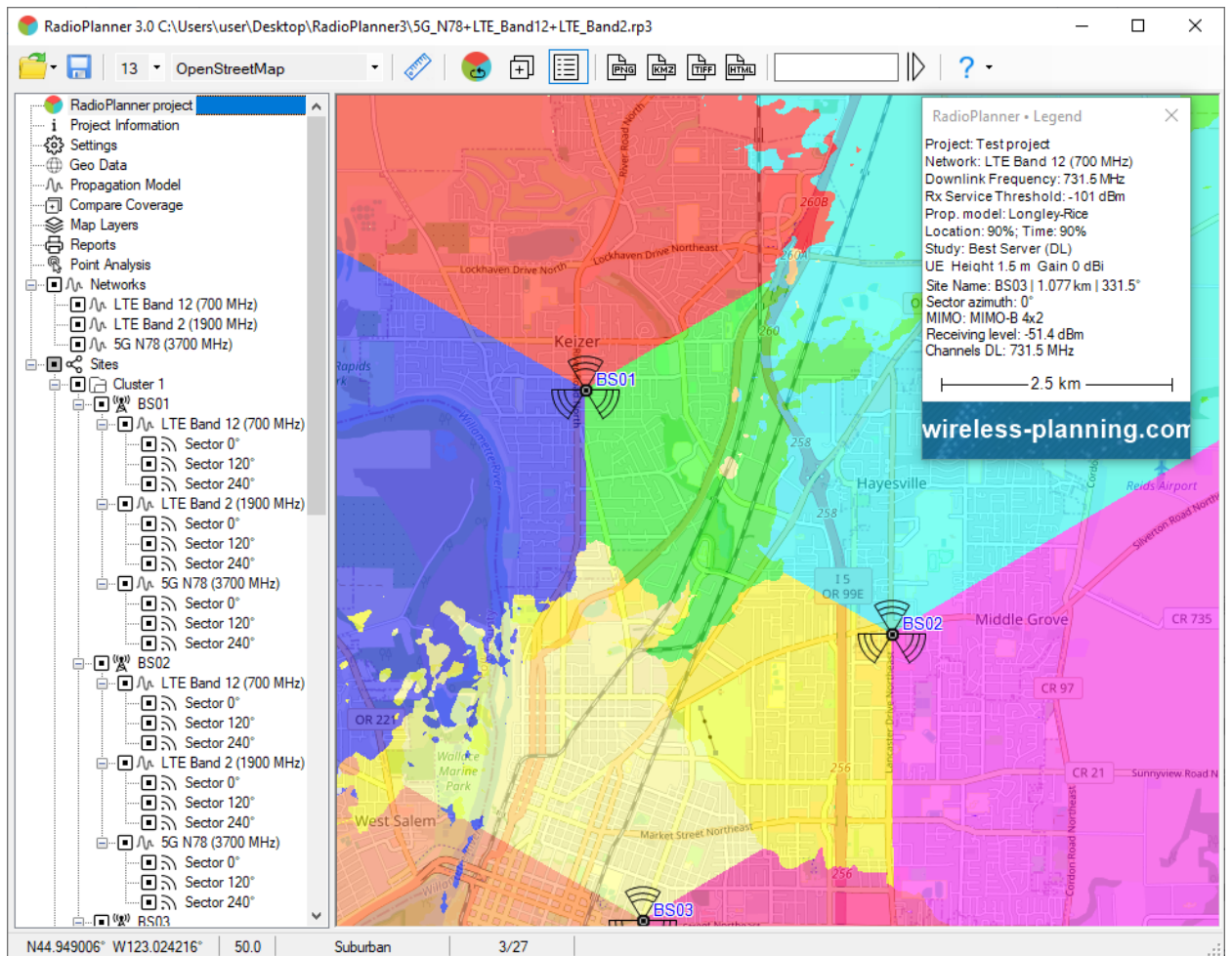
### Best Server Uplink/Downlink

The Best Server map shows the identity of the sector supplying the strongest received signal at each location. The minimum received signal level for calculating the Best Server is downlink/uplink Rx threshold. The sector color is defined in the sector parameters or can be assigned automatically.



Best Server Study Type Parameters

Apply Automatic Color Assignment	Assign colors to sectors in random order
Use Colors from sectors	Assigning colors to sectors from the sector parameters



### Best Server

#### Areas with Signal Levels Above Both the Base and Mobile Thresholds

This area study type displays a map showing locations where both the signal received by the mobile unit is above the downlink Rx threshold and where the signal received by the base station sector from the mobile is above the uplink Rx threshold. This calculation can be performed for different conditions of use of Mobile Unit No. 1 (portable radio or UE), such as indoors, outdoors, and inside a car. Each condition of use has its own color and value of loss (margin) for signal penetration indicated in this form. For Mobile Unit No. 2, only outdoor calculation is performed.




Mobile Units		
	Mobile Unit N°1	Mobile Unit N°2
Type	Portable Tait T...	Mobile Tait TM...
Tx power (W)	2	25
Cable and connectors loss (dB)	0	0.5
Antenna height (m)	1.5	3
Antenna gain (dBi)	0	3

Area study type

Areas with Signal Levels above Both the Base And Mobile Threshl ▾


Areas for Mobile Unit N°1

3 ▾ Number of levels

Color	Penetration loss	Description
	18 dB	Indoors
	10 dB	Inside a Vehicle
	0 dB	Outdoors

Area for Mobile Unit N°2

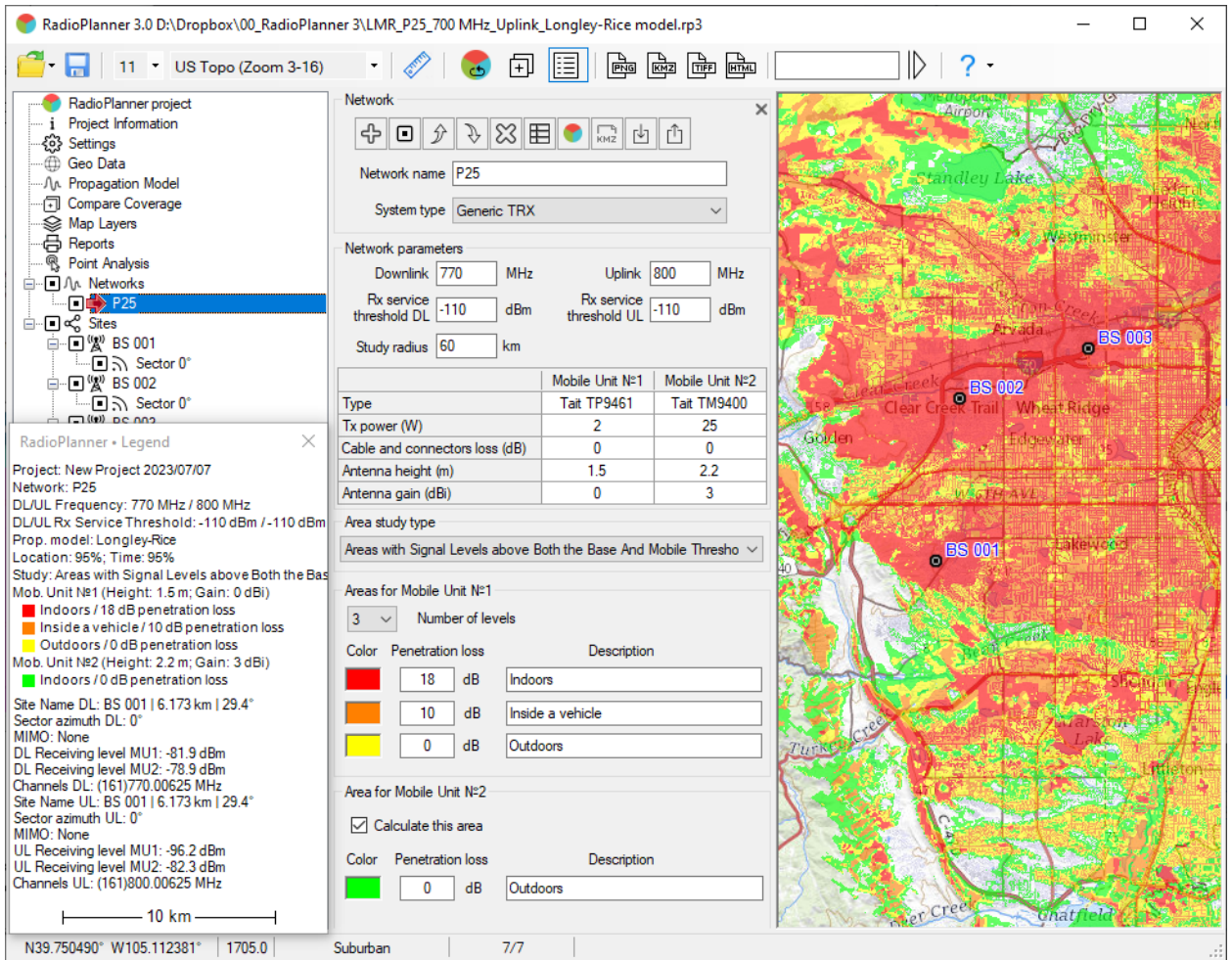
Calculate this area

Color	Penetration loss	Description
	0 dB	Outdoors

*Areas with Signal Levels Above Both the Base and Mobile Thresholds Study Type Parameters*

Number of Levels	The number of levels
Color	Color level
Penetration Loss	Penetration loss, dB
Description	Text field





*Areas with Signal Levels Above Both the Base and Mobile Thresholds for P25 700 MHz network*

## C/(I+N) Ratio Downlink/Uplink

The carrier-to-interference+noise ratio ( $C/(I+N)$ ) is an essential quantity used in assessing system performance and affecting frequency planning. RadioPlanner allows you to calculate and display areas with different downlink/uplink  $C/(I+N)$  values for interference on co-channel and adjacent channels.

Carrier-to-interference+noise ratio is calculated by first finding the strongest received signal power at each location, then calculating the sum of received signal powers from all other co-channel and adjacent sectors (taking into account adjacent channel attenuation) that also have relevant signal levels at that location. After finding the sum of interference, the carrier-to-interference+noise ratio is calculated.

The interference calculation always takes into account the noise component, which depends on noise bandwidth and receiver noise figure entered in Noise and Interference in Network system settings. The calculation of adjacent channel interference can be disabled to only take into account co-channel interference.

Area study type  
C/(I+N) Ratio (DL) v

Mobile Unit (UE) №1     Mobile Unit (UE) №2

C/(I+N) Ratio  
7 v    Number of levels

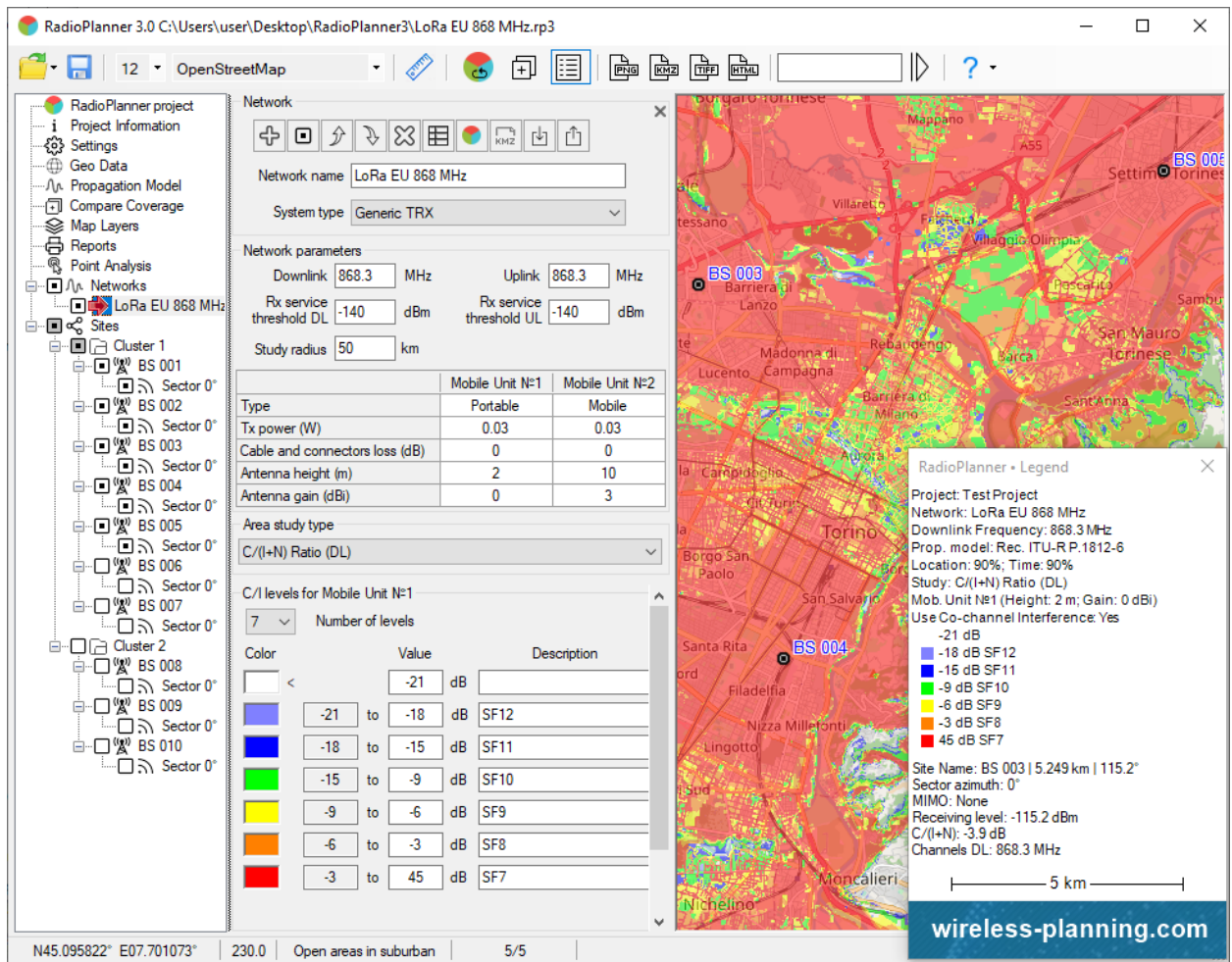
Color	Value	Description
<span style="color: cyan;">■</span> <	1 dB	
<span style="color: blue;">■</span> 1 to 5	5 dB	
<span style="color: darkblue;">■</span> 5 to 10	10 dB	
<span style="color: green;">■</span> 10 to 15	15 dB	
<span style="color: yellow;">■</span> 15 to 20	20 dB	
<span style="color: orange;">■</span> 20 to 25	25 dB	
<span style="color: red;">■</span> 25 to 45	45 dB	

Use co-channel interference  
 Use adj-channel interference

*C/(I+N) Downlink Ratio Study Type Parameters*

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Number of Levels	The number of levels
Color	Color level
Value	Carrier-to-interference+noise ratio C/(I+N), dB
Description	Text field





*C/(I+N) Downlink ratio for LoRaWAN network*

## Maximum Downlink / Uplink Throughput

This prediction type shows maximum cell throughput.

**For LTE/5G System Types**, this study calculates MCS Index for each point based on predicted C/(I+N) from LTE/5G system parameters tab of Network. Throughput associated with MCS is determined using 3GPP specified formulas and tables.

**For Generic TRX System Type**, this study calculates Throughput for each point based on predicted C/(I+N) from Adaptive Modulation Table in system parameters tab of Network.

Area study type  
 Maximum Throughput (DL) v

Mobile Unit (UE) №1     Mobile Unit (UE) №2

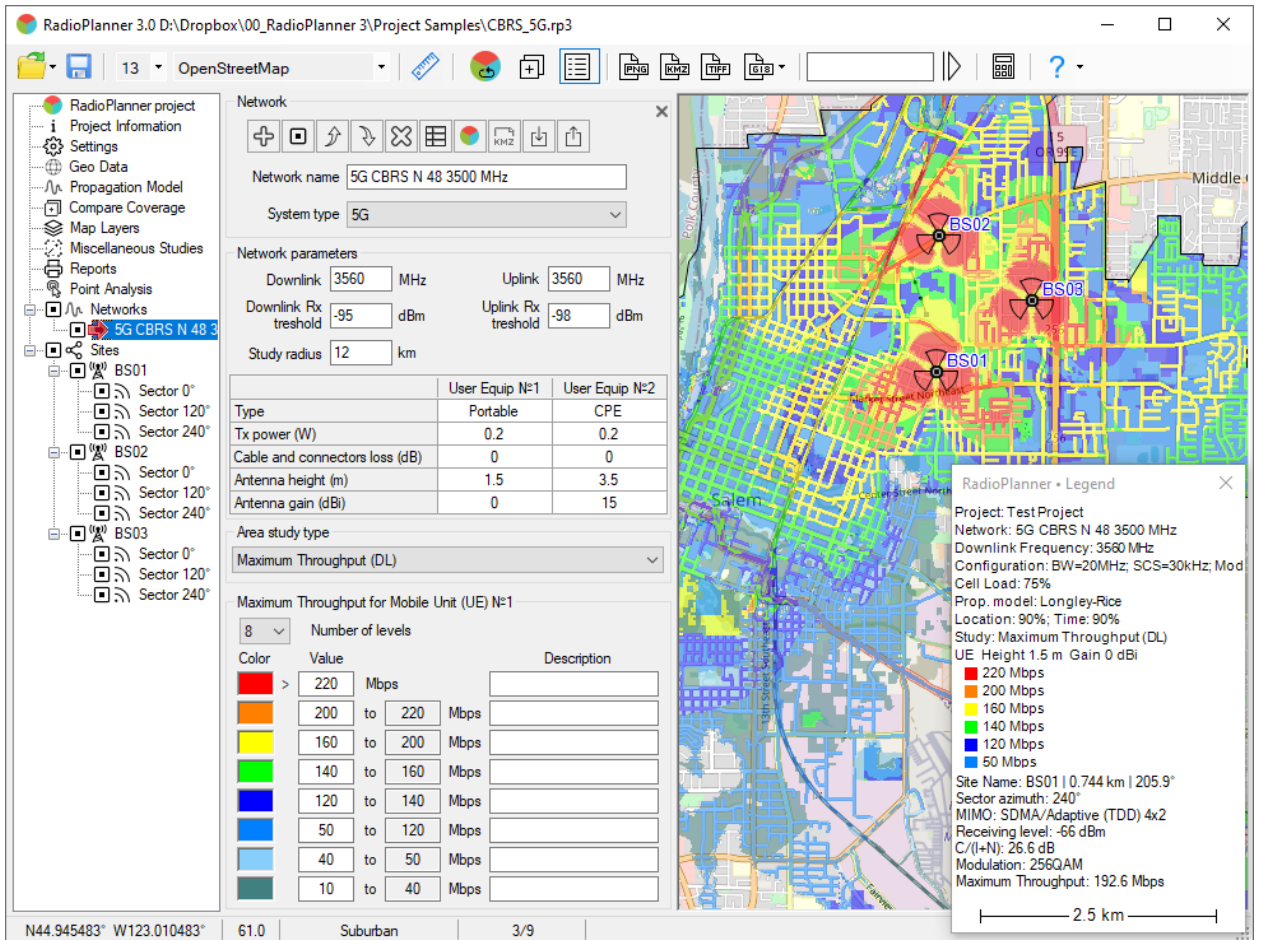
Maximum Throughput

8 v    Number of levels

Color	Value	Description
<span style="color: red;">■</span>	> 80 Mbps	<input type="text"/>
<span style="color: orange;">■</span>	70 to 80 Mbps	<input type="text"/>
<span style="color: yellow;">■</span>	60 to 70 Mbps	<input type="text"/>
<span style="color: green;">■</span>	50 to 60 Mbps	<input type="text"/>
<span style="color: blue;">■</span>	40 to 50 Mbps	<input type="text"/>
<span style="color: cyan;">■</span>	30 to 40 Mbps	<input type="text"/>
<span style="color: magenta;">■</span>	20 to 30 Mbps	<input type="text"/>
<span style="color: grey;">■</span>	10 to 20 Mbps	<input type="text"/>

*Maximum Downlink Throughput Study Type Parameters*

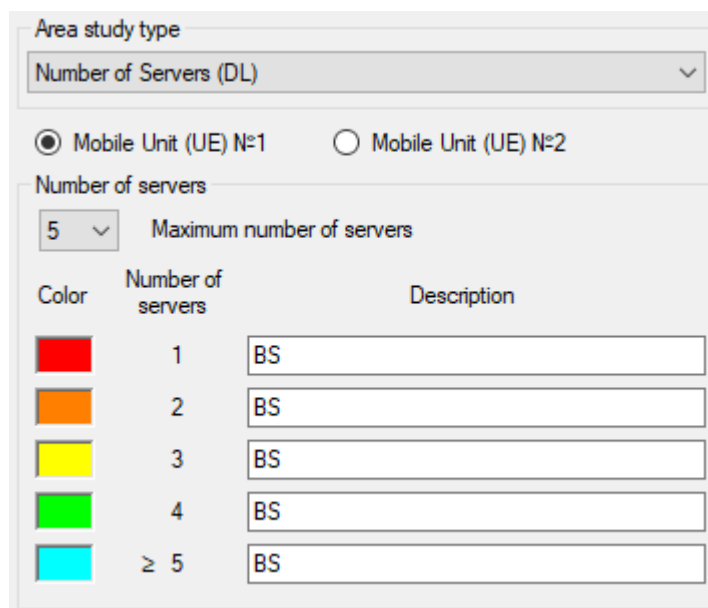
Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Maximum Throughput, Mbps
Description	Text field



Maximum Downlink Throughput Coverage Prediction for 5G CBRS N48 (3500 MHz) Network

### Number of Servers Uplink/Downlink

This study indicates total number of sectors that provide a signal above Rx threshold at each location. This study type is often required when planning networks based on wireless IoT technologies such as LoRaWAN.



Number of Servers Above Downlink Study Type Parameters

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Maximum Number of Sectors	Maximum number of displayed servers above uplink
Color	Color indicating the appropriate number of sectors
Description	Text field

The screenshot displays the RadioPlanner 3.0 interface for a LoRa EU 868 MHz network. The main window shows the following configuration:

- Network name:** LoRa EU 868 MHz
- System type:** Generic TRX
- Network parameters:**
  - Downlink: 868.3 MHz
  - Uplink: 868.3 MHz
  - Rx service threshold DL: -140 dBm
  - Rx service threshold UL: -140 dBm
  - Study radius: 50 km
- Mobile Unit Parameters:**

Type	Mobile Unit №1	Mobile Unit №2
Type	Portable	Mobile
Tx power (W)	0.03	0.03
Cable and connectors loss (dB)	0	0
Antenna height (m)	2	10
Antenna gain (dBi)	0	3
- Area study type:** Number of Servers (DL)
- Number of servers for Mobile Unit №1:** 3 (Maximum number of sectors)
- Color Legend:**

Color	Number of sectors	Description
Green	1	BS
Yellow	2	BS
Red	≥ 3	BS

The map on the right shows the coverage area over a city (Torino), with colors indicating the number of servers above the downlink threshold at each location. A legend box in the bottom right corner provides details for a specific site (BS 004):

- Project: TestProject
- Network: LoRa EU 868 MHz
- Downlink Frequency: 868.3 MHz
- Rx Service Threshold: -140 dBm
- Prop. model: Rec. ITU-R P.1812-6
- Location: 90%; Time: 90%
- Study: Number of Servers (DL)
- Mob. Unit №1 (Height: 2 m; Gain: 0 dBi)
- Site Name: BS 004 | 4.786 km | 245.3°
- Sector azimuth: 0°
- Receiving level: -123.1 dBm
- Number of Servers: 2

The bottom status bar shows coordinates (N45.025495° E07.608719°), a scale of 256.0, and a zoom level of 5/5.

*Number of Servers Above Downlink for LoraWAN Network*

## Coverage Probability Uplink/Downlink

This area study shows the availability of service based on a Gaussian (“normal”) distribution in dB. The calculation determines the “fade margin” at each study location based on the received signal strength with respect to a receiver threshold. The percent reliability is then a lognormal distribution of the fade margin in dB. Interference and noise are not taken into account in the calculation. The values of standard deviations in the calculation are taken from the “Coverage Probability” parameters, while standard deviation values in propagation model parameters are ignored.

Area study type  
Coverage Probability (DL) ▾

Mobile Unit (UE) №1     Mobile Unit (UE) №2

Coverage Probability

$\sigma_{LN}$   dB     $\sigma_R$   dB     $\sigma_t$   dB

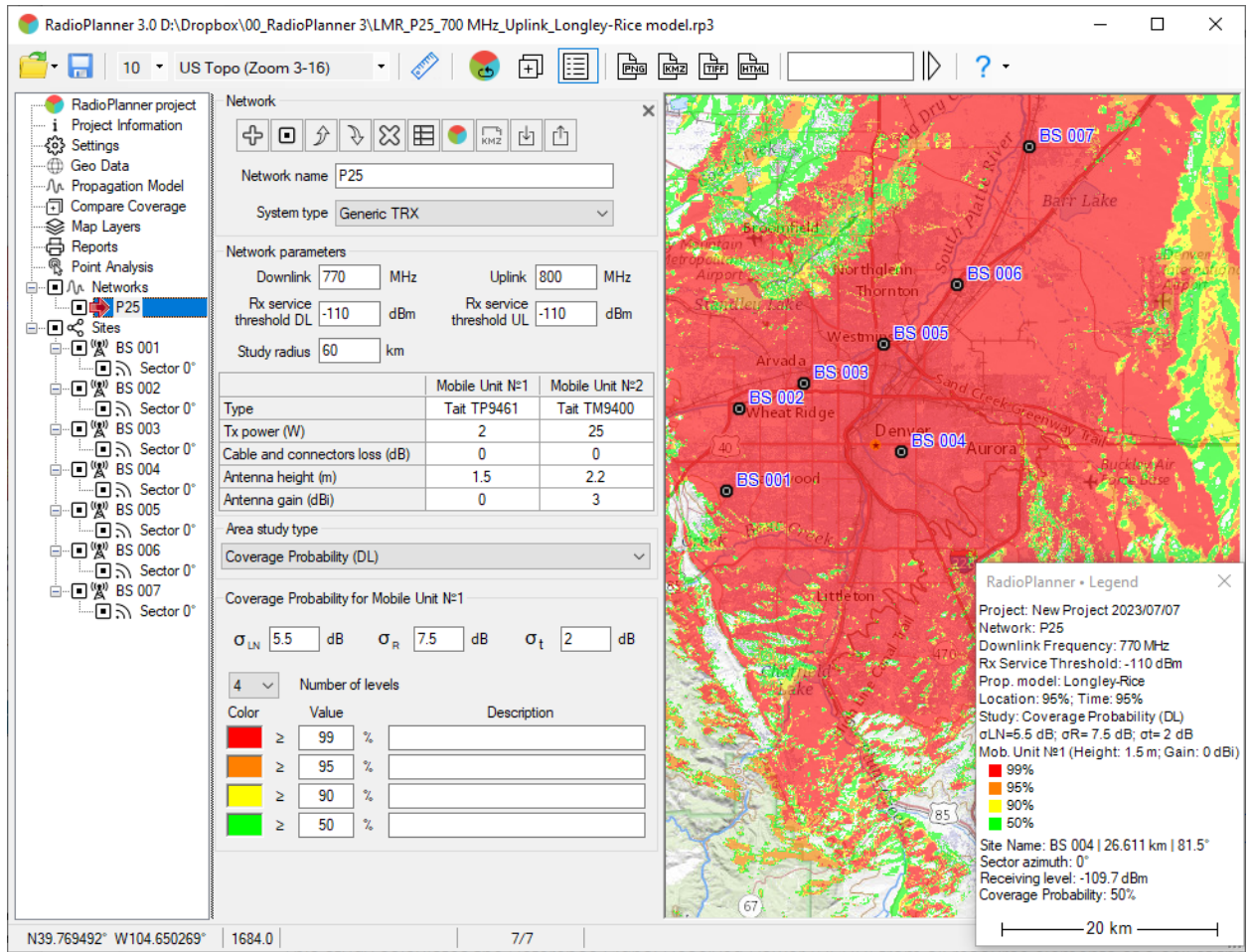
▾    Number of levels

Color	Value	Description
<span style="color: red;">■</span>	≥ <input type="text" value="99"/> %	<input type="text"/>
<span style="color: orange;">■</span>	≥ <input type="text" value="95"/> %	<input type="text"/>
<span style="color: green;">■</span>	≥ <input type="text" value="90"/> %	<input type="text"/>
<span style="color: cyan;">■</span>	≥ <input type="text" value="50"/> %	<input type="text"/>

Coverage Probability Study Type Parameters

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
$\sigma_{LN}$ , dB	Lognormal large-scale (shadow) fading standard deviation, dB. This value depends on the digital terrain model (DTM) resolution and carrier frequency. Typical value 2-5 dB for modern DTMs.
$\sigma_R$ , dB	Small-scale fading (Rayleigh) standard deviation, dB. Typically 7.5 dB
$\sigma_t$ , dB	Time variability standard deviation, dB. At distances up to 50 km, the $\sigma_t$ usually varies for between 2-3 dB (Land), and up to 9 dB for the Sea. See Table 3 in Recommendation ITU-R P.1406-2 "Propagation effects relating to terrestrial land mobile and broadcasting services in the VHF and UHF bands"
Number of Levels	The number of levels
Color	Color level
Value	Probability, %
Description	Text field





Coverage Probability Coverage Prediction for P25 700 MHz Network

### Reference Signal Received Power (RSRP)

This study calculates the Reference Signal Received Power (RSRP) from all resource elements of a cell at the remote UE receiver using system parameters of LTE and 5G networks (bandwidth, subcarrier spacing). The calculation can use a single-column antenna pattern for a sector if selected in LTE/5G sector Additional Options.

Area study type  
RSRP

RSRP for UE N=1

4 Number of levels

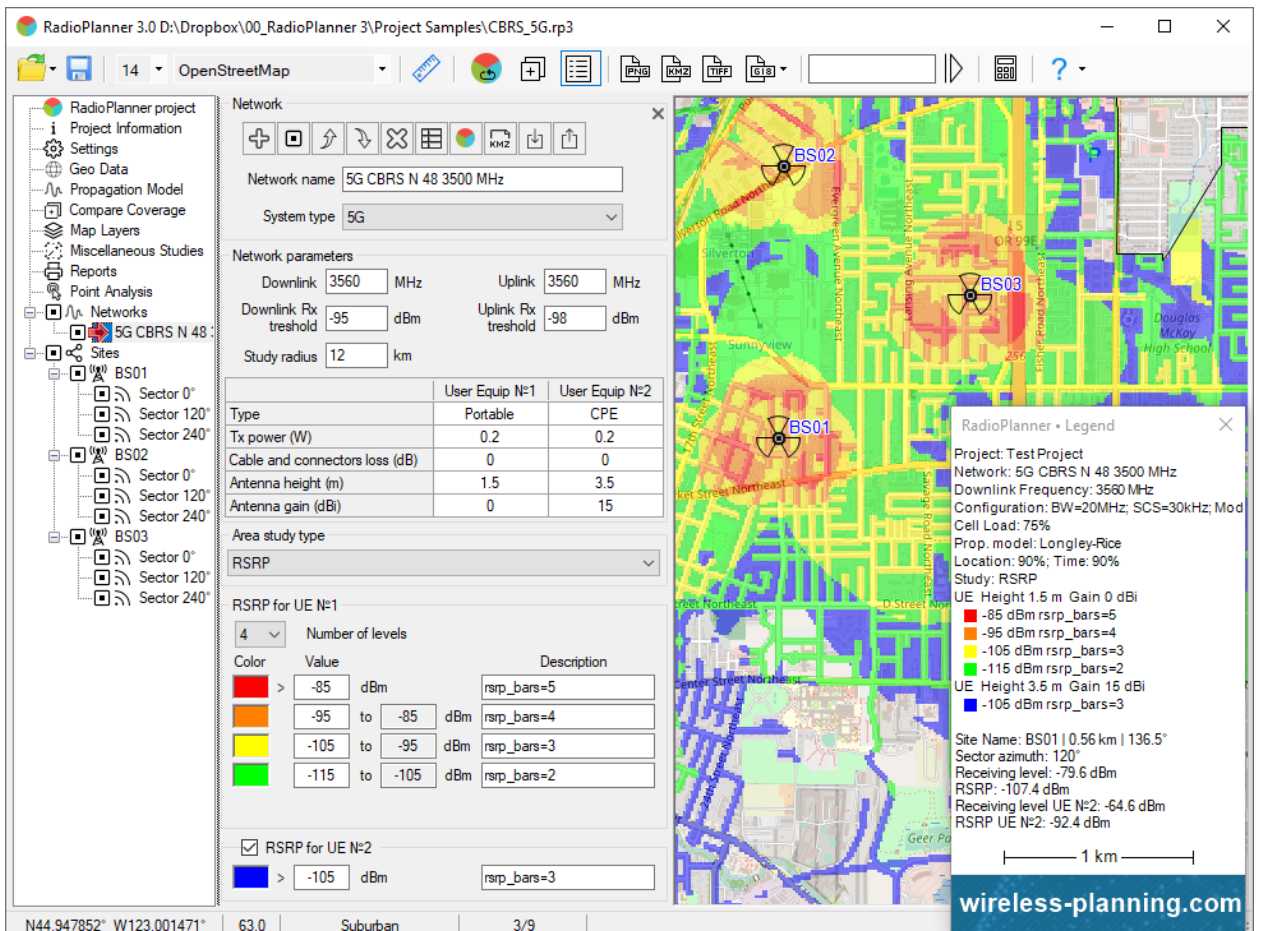
Color	Value	Description
Red	> -85 dBm	rsrp_bars=5
Orange	-95 to -85 dBm	rsrp_bars=4
Yellow	-105 to -95 dBm	rsrp_bars=3
Green	-115 to -105 dBm	rsrp_bars=2

RSRP for UE N=2

Cyan	> -105 dBm	rsrp_bars=3
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RSRP Study Type Parameters

Number of Levels	The number of levels (1-8)
Color	Color level
Values	Reference Signal Received Power (RSRP), dBm
Description	Text field to describe RSRP level



RSRP coverage prediction for 5G CBRS N48 (3500 MHz) Network

## Reference Signal Received Quality (RSRQ)

This study calculates the Reference Signal Received Quality (RSRQ) from all resource elements at the remote UE receiver using system parameters of LTE and 5G networks (bandwidth, subcarrier spacing, cell load, and C/(I+N) ratio). The calculation can use a single-column antenna pattern for a sector if selected in LTE/5G sector Additional Options.

Area study type  
RSRQ

Mobile Unit (UE) N°1     Mobile Unit (UE) N°2

RSRQ for UE N°1

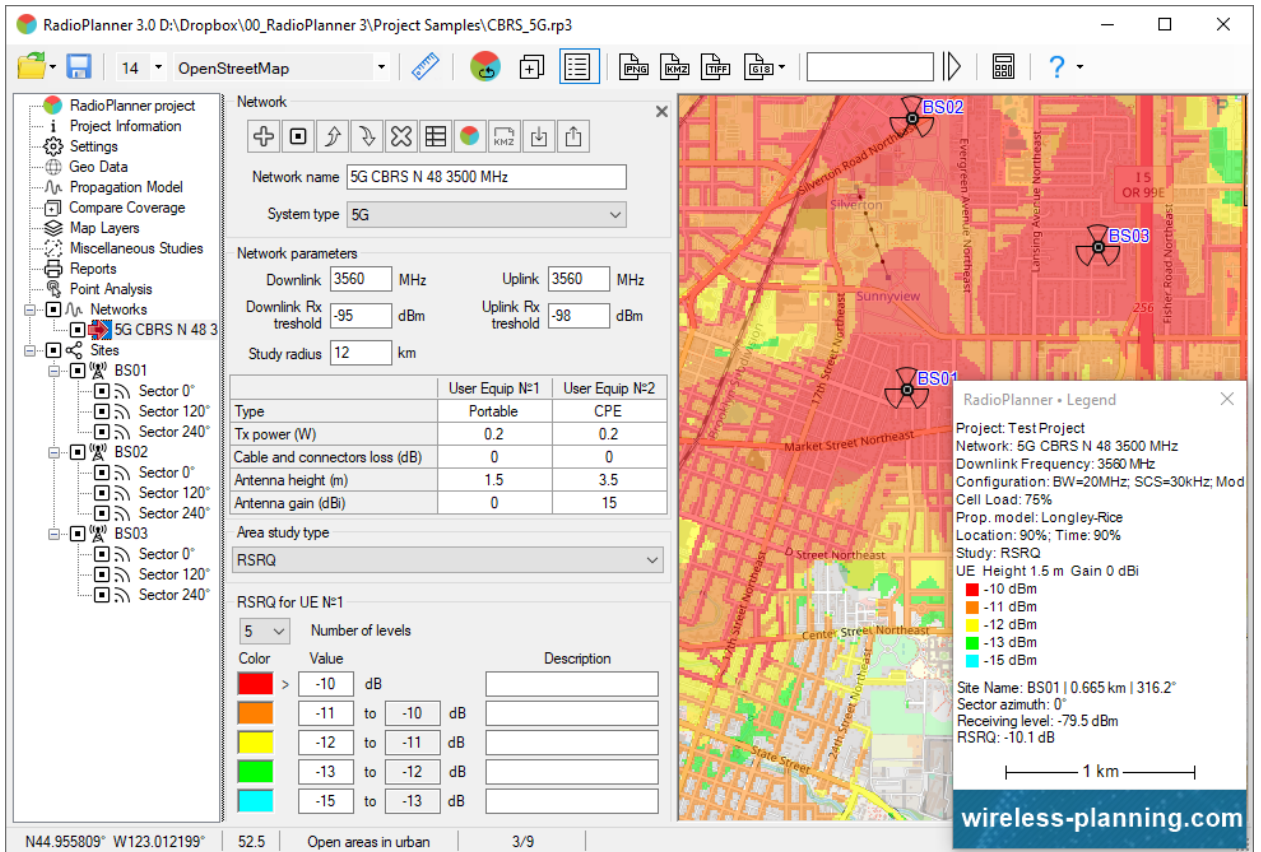
5 Number of levels

Color	Value	Description
Red	> -11 dB	
Orange	-12 to -11 dB	
Yellow	-13 to -12 dB	
Green	-14 to -13 dB	
Blue	-20 to -14 dB	

*RSRQ Study Type Parameters*

Mobile Unit (UE) N°1/N°2	Select the mobile device for which the calculation will be made
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Reference Signal Received Quality (RSRQ), dB
Description	Text field to describe RSRQ level

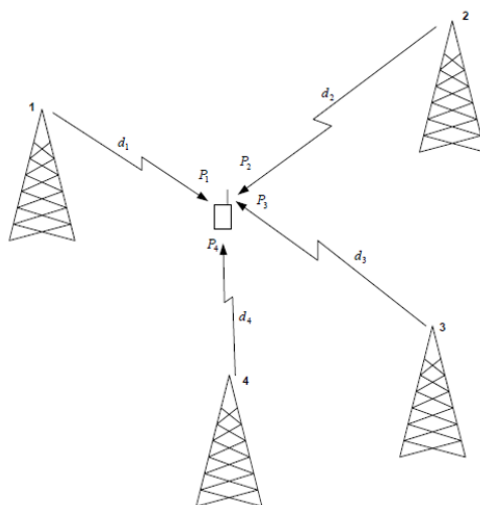




RSRQ coverage prediction for 5G CBRS N48 (3500 MHz) Network

### Simulcast Delay Spread

This prediction is used for simulcast systems that transmit signals from multiple locations simultaneously on the same channel. Interference in the receiver will occur under certain conditions related to delay time between signals arriving at a given location and their relative power. The simulcast delay spread is calculated as follows:



$$T_m = 2 \sqrt{\frac{\sum_{i=1}^N P_i d_i^2}{\sum_{i=1}^N P_i} - \frac{\left(\sum_{i=1}^N P_i d_i\right)^2}{\left(\sum_{i=1}^N P_i\right)^2}}$$

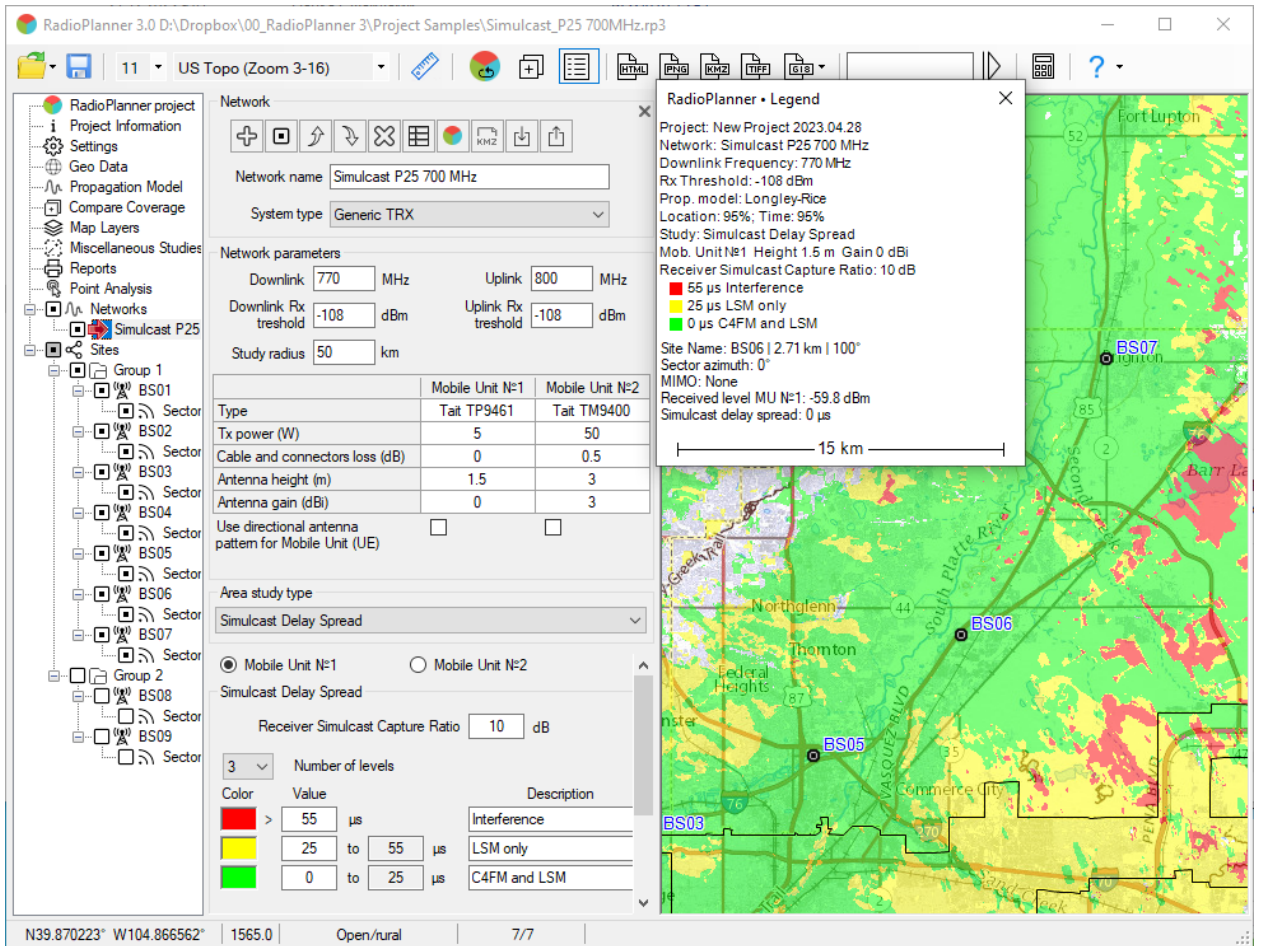
- $T_m$  Multipath Spread (twice the RMS delay spread)
- $P_i$  Power arriving at a terminal antenna from transmitter *i*
- $d_i$  Time of flight from transmitter *i* to antenna terminal

The simulcast delay spread is calculated by considering only the six strongest signals at any grid analysis location. The results of the calculation are displayed in  $\mu\text{s}$  on the map.

*Simulcast Delay Spread Study Type Parameters*

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Receiver Simulcast Capture Ratio	For delay spread studies, the delay is calculated and displayed only when the power of the strongest received signal and the power of the second strongest received signal are within the capture ratio of each other. Typical value 7-15 dB.
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Simulcast Delay Spread, $\mu\text{s}$
Description	Text field to describe Simulcast Delay Spread value

To reduce interference between simulcast transmitters, it can be useful to artificially delay the signal transmitted from a given location using Simultaneous Delay Offset entered in Advanced Sector Parameters. By carefully assigning offsets to different sectors, some control can be exercised over where interference occurs in simulcast system.



Simulcast Delay Spread Prediction for P25 700 MHz Simulcast Network

### Received Power Downlink with Simulcast Interference

Received power maps show areas where a given signal power level is present at mobile unit receiver. This prediction also takes into account interference due to simulcast.

Area study type  
 Received Power with Simulcast Interference (DL) v

Mobile Unit №1     Mobile Unit №2

Received Power

Receiver Simulcast Capture Ratio  dB

v Number of levels

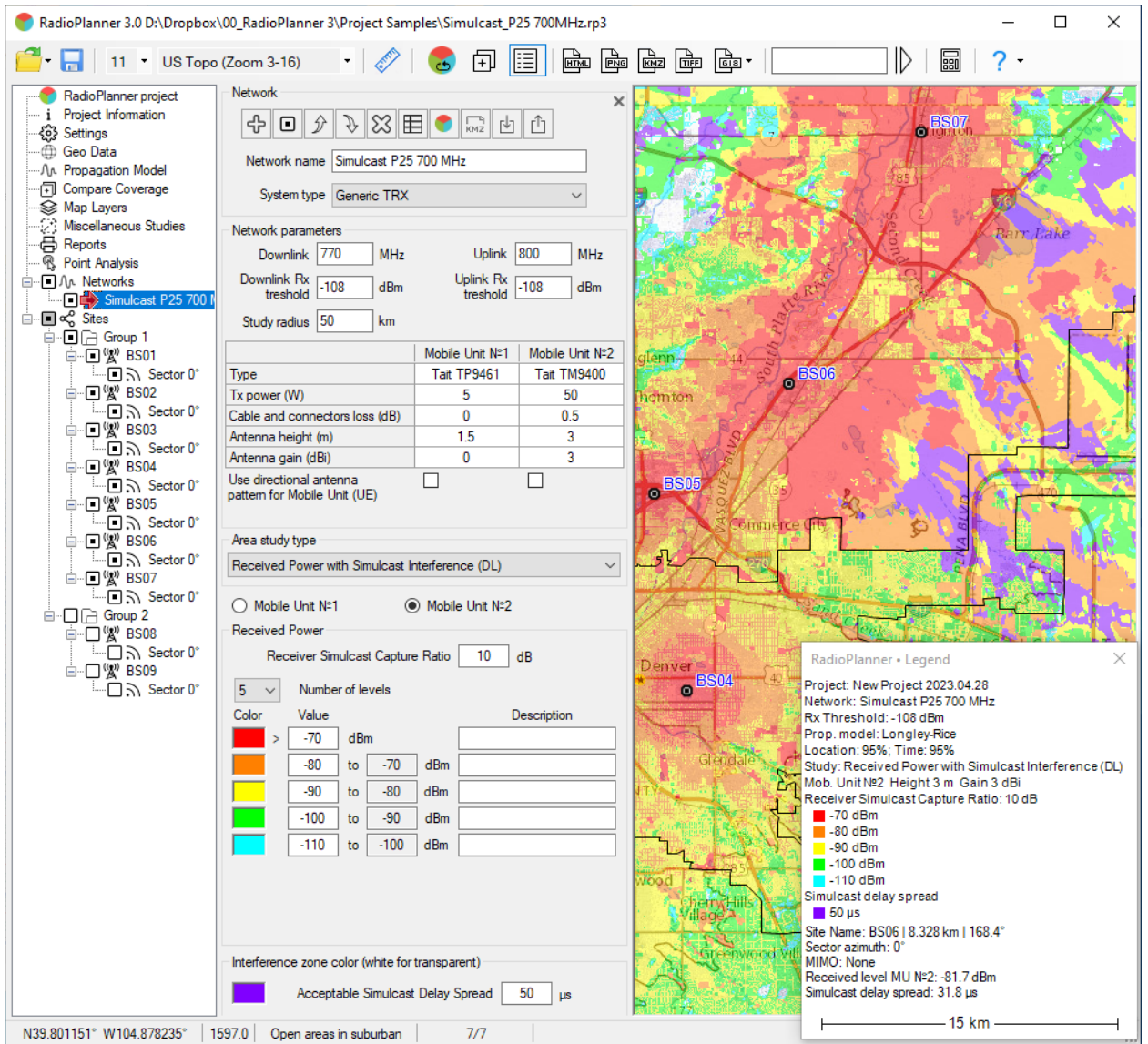
Color	Value	Description
<span style="color: red;">■</span>	> <input type="text" value="-70"/> dBm	<input type="text"/>
<span style="color: orange;">■</span>	<input type="text" value="-80"/> to <input type="text" value="-70"/> dBm	<input type="text"/>
<span style="color: yellow;">■</span>	<input type="text" value="-90"/> to <input type="text" value="-80"/> dBm	<input type="text"/>
<span style="color: green;">■</span>	<input type="text" value="-100"/> to <input type="text" value="-90"/> dBm	<input type="text"/>
<span style="color: cyan;">■</span>	<input type="text" value="-110"/> to <input type="text" value="-100"/> dBm	<input type="text"/>

Interference zone color (white for transparent)

■ Acceptable Simulcast Delay Spread   $\mu$ s

*Received Power with Simulcast Interference Downlink Study Type Parameters*

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Receiver Simulcast Capture Ratio	For delay spread studies, the delay is calculated and displayed only when the power of the strongest received signal and the power of the second strongest received signal are within the capture ratio of each other. Typical value 7-15 dB.
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Received power level, dBm
Acceptable Simulcast Delay Spread, $\mu$ s	An area with a Simulcast Delay Spread higher of the acceptable one will be shown on the map as an interference zone. The interference zone can be painted with any color on the map, or made transparent by selecting white for it.
Description	Text field



Received Power with Simulcast Interference Prediction for P25 700 MHz Simulcast Network

### Field Strength Downlink

Field Strength maps show areas where a given field strength level is present at receiver point. Note that field strength is not a function of receive antenna parameters.



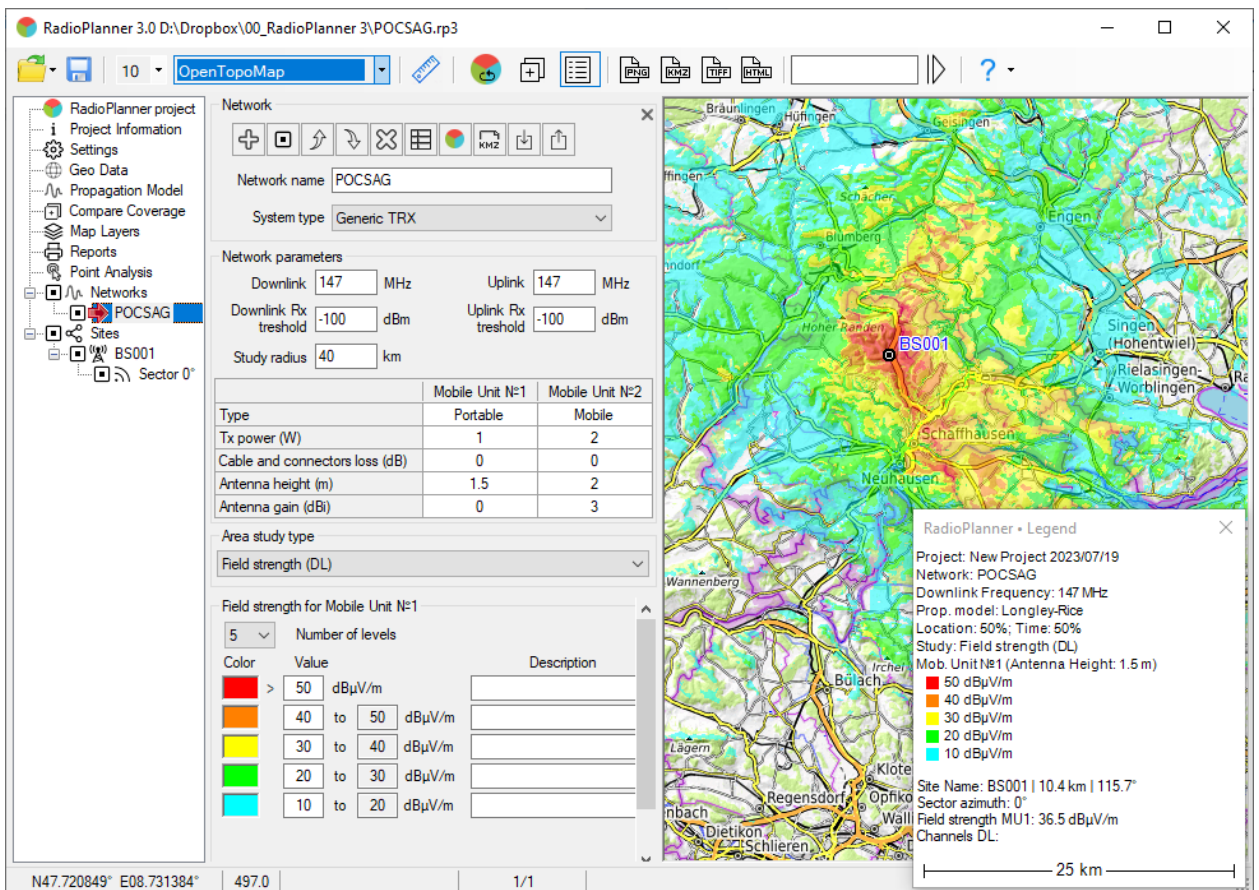
Area study type  
Field strength DL

Field strength for Mobile Unit №1  
5 Number of levels

Color	Value	Description
Red	> 60 dB $\mu$ V/m	
Orange	50 to 60 dB $\mu$ V/m	
Yellow	30 to 50 dB $\mu$ V/m	
Green	20 to 30 dB $\mu$ V/m	
Cyan	10 to 20 dB $\mu$ V/m	

Field Strength Study Type Parameters

Number of Levels	The number of levels (1-8)
Color	Color level
Values	Downlink Received Field Strength, dB $\mu$ V/m
Description	Text field



Field Strength Prediction for POCSAG Pager Network

### TalckOut and TalckBack

This area study type displays a map with the talk-out and talck-back (two-way) locations, talk-out only (downlink), talk-back only (uplink), and no coverage locations for mobile unit №1.

Area study type  
 TalkOut and TalkBack

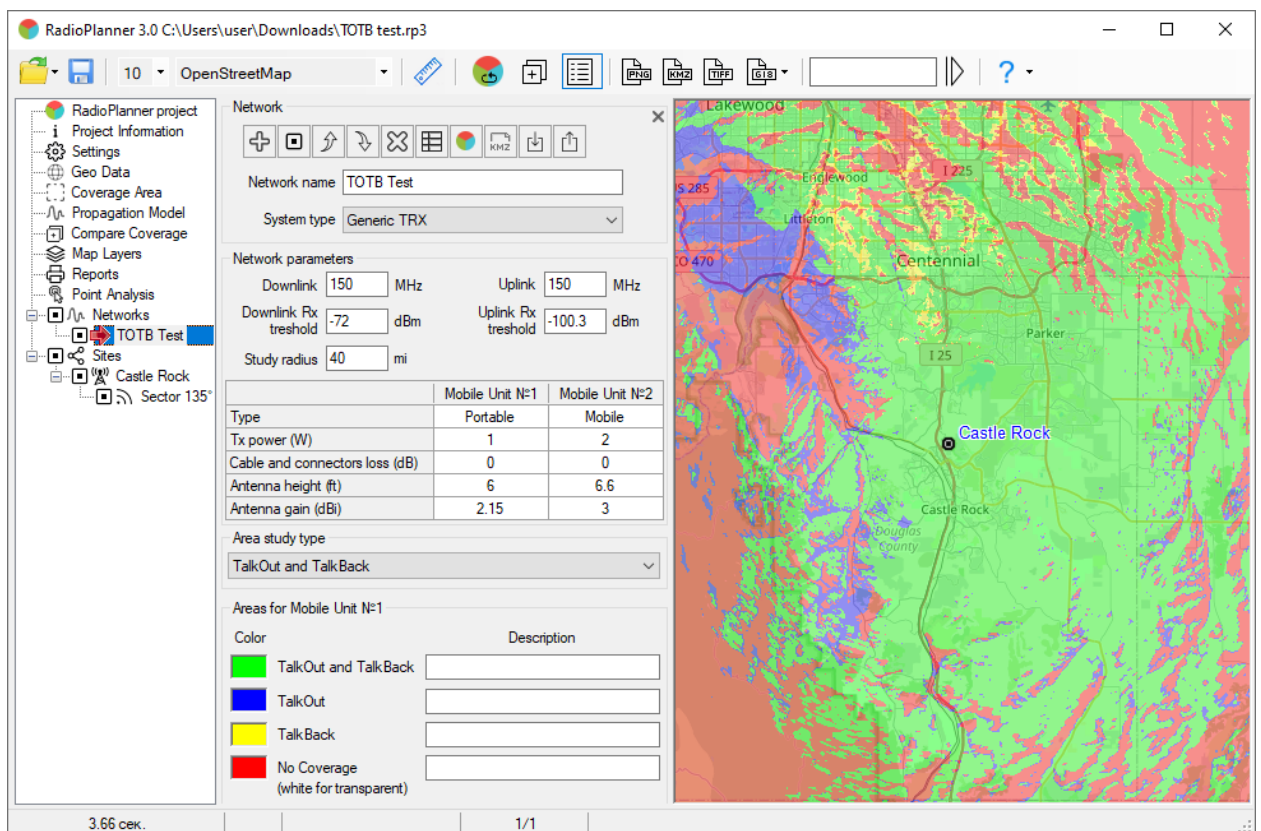
Mobile Unit (UE) №1     Mobile Unit (UE) №2

Areas TalkOut and TalkBack

Color	Description
<span style="color: green;">■</span> TalkOut and TalkBack	<input type="text"/>
<span style="color: blue;">■</span> TalkOut	<input type="text"/>
<span style="color: red;">■</span> TalkBack	<input type="text"/>
<span style="color: white;">■</span> No Coverage (white for transparent)	<input type="text"/>

*TalckOut and TalckBack Study Type Parameters*

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Color	Color
TalkOut and TalckBack	Downlink and uplink coverage
TalkOut	Downlink coverage only
TalckBack	Uplink coverage only
No Coverage	No Coverage (white color for transparent)
Description	Text field



*TalckOut and TalckBack Coverage Prediction*

## Coverage predictions for multiple networks

### Number of Networks Downlink / Uplink

This prediction shows number of networks providing service at each calculation point for downlink or uplink. Calculation is performed for respective thresholds Rx of each network taken into account in calculation.

Area Study Type

Area Study Resolution for all study types  
 Low     Medium     High

Mobile Unit (UE) №1     Mobile Unit (UE) №2

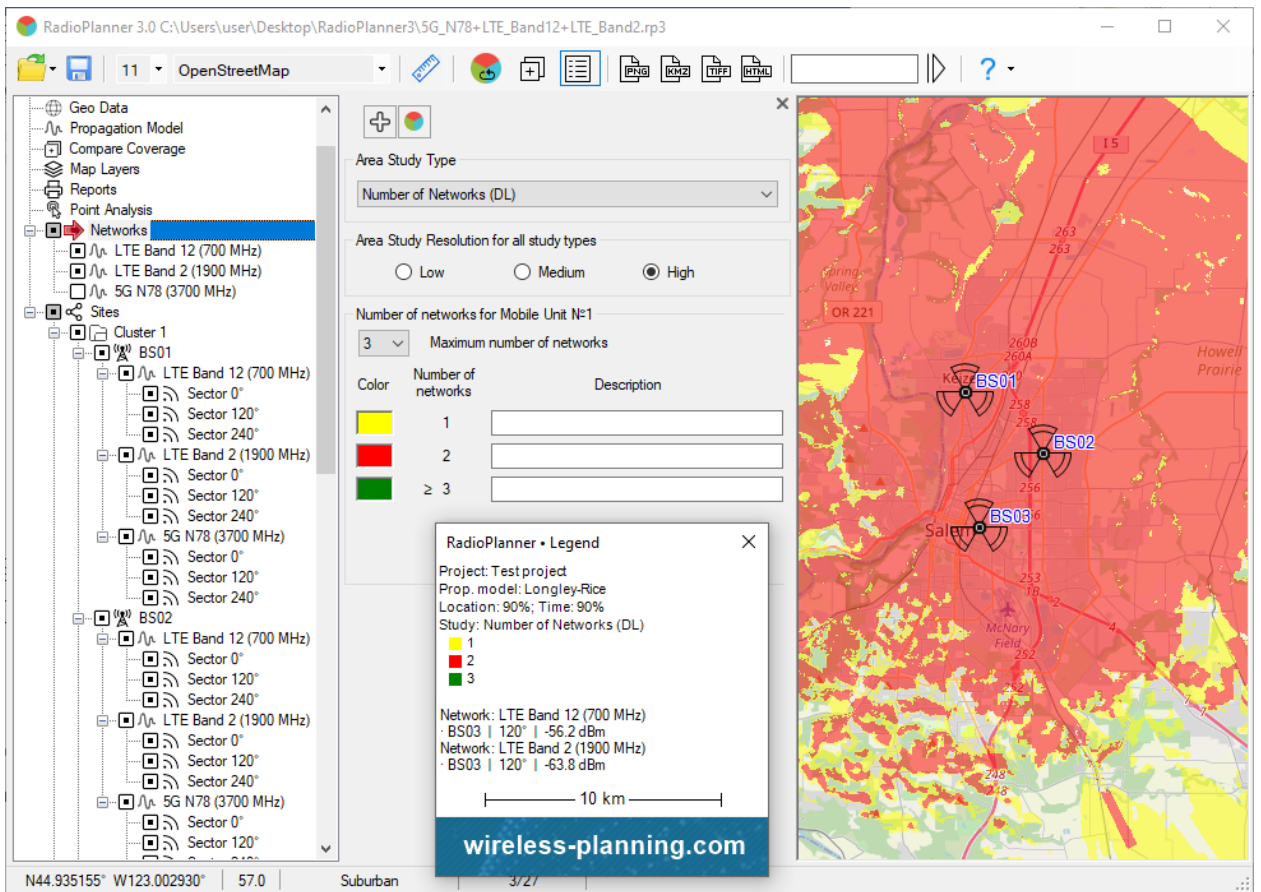
Number of networks  
 Maximum number of networks

Color	Number of networks	Description
	1	<input type="text"/>
	2	<input type="text"/>
	≥ 3	<input type="text"/>

*Number of Networks Downlink Study Type Parameters*

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Maximum Number of Networks	Maximum number networks
Color	Color indicating the number of networks
Description	Text field





Number of Networks Downlink Coverage Prediction for LTE Band 12 and Band 2

### Maximum Aggregated Downlink / Uplink Throughput









This prediction type shows the total throughput at each point for all networks involved in the calculation.

Area Study Type  
 Maximum Aggregated Throughput (DL) ▾

Area Study Resolution for all study types  
 Low  Medium  High

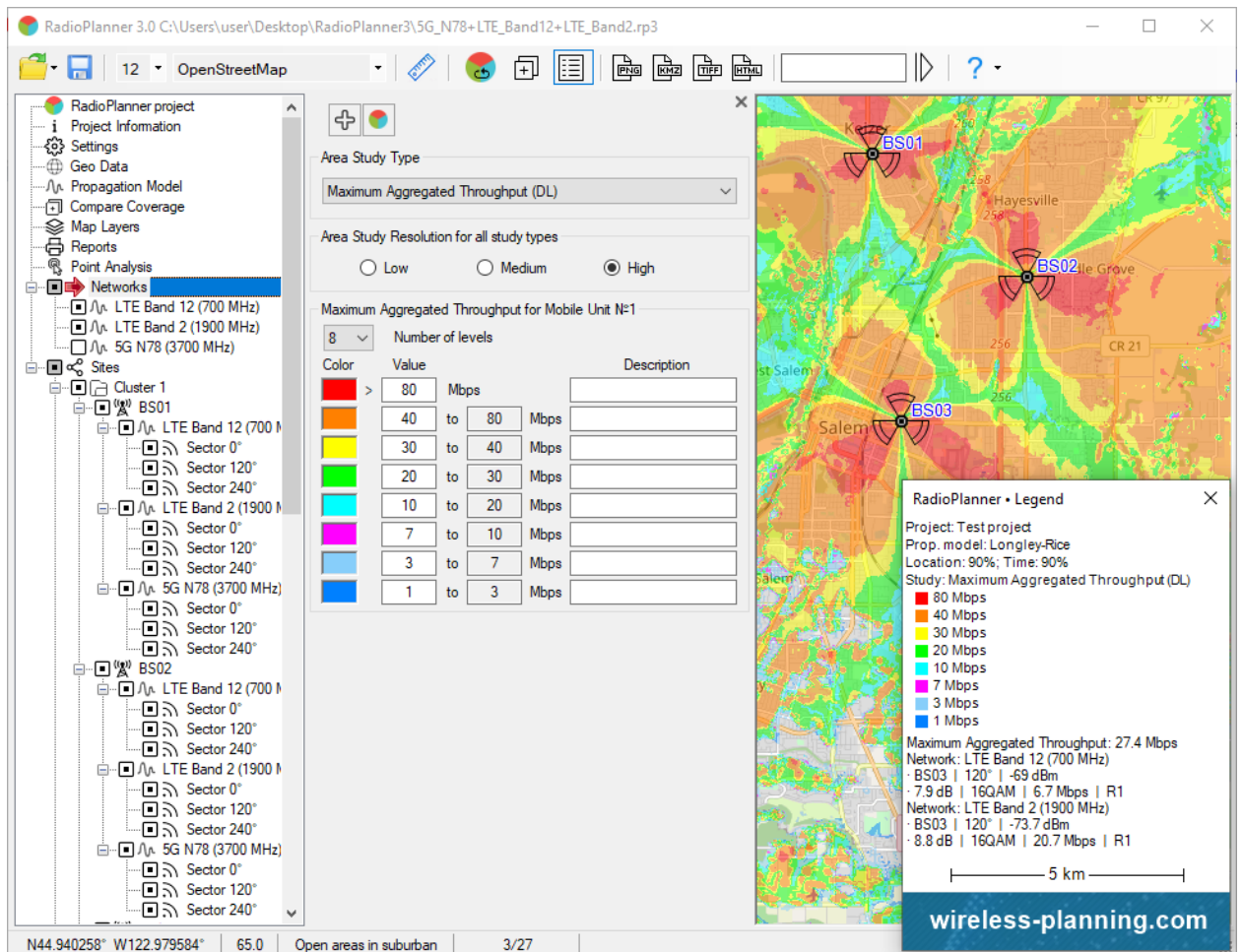
Mobile Unit (UE) №1  Mobile Unit (UE) №2

Maximum Aggregated Throughput  
 8 ▾ Number of levels

Color	Value	Description
	> 1000 Mbps	<input type="text"/>
	800 to 1000 Mbps	<input type="text"/>
	150 to 800 Mbps	<input type="text"/>
	100 to 150 Mbps	<input type="text"/>
	80 to 100 Mbps	<input type="text"/>
	40 to 80 Mbps	<input type="text"/>
	20 to 40 Mbps	<input type="text"/>
	5 to 20 Mbps	<input type="text"/>

*Maximum Aggregated Downlink Throughput Study Type Parameters*

Mobile Unit (UE) №1/№2	Select the mobile device for which the calculation will be made
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Maximum Aggregated Throughput, Mbps
Description	Text field



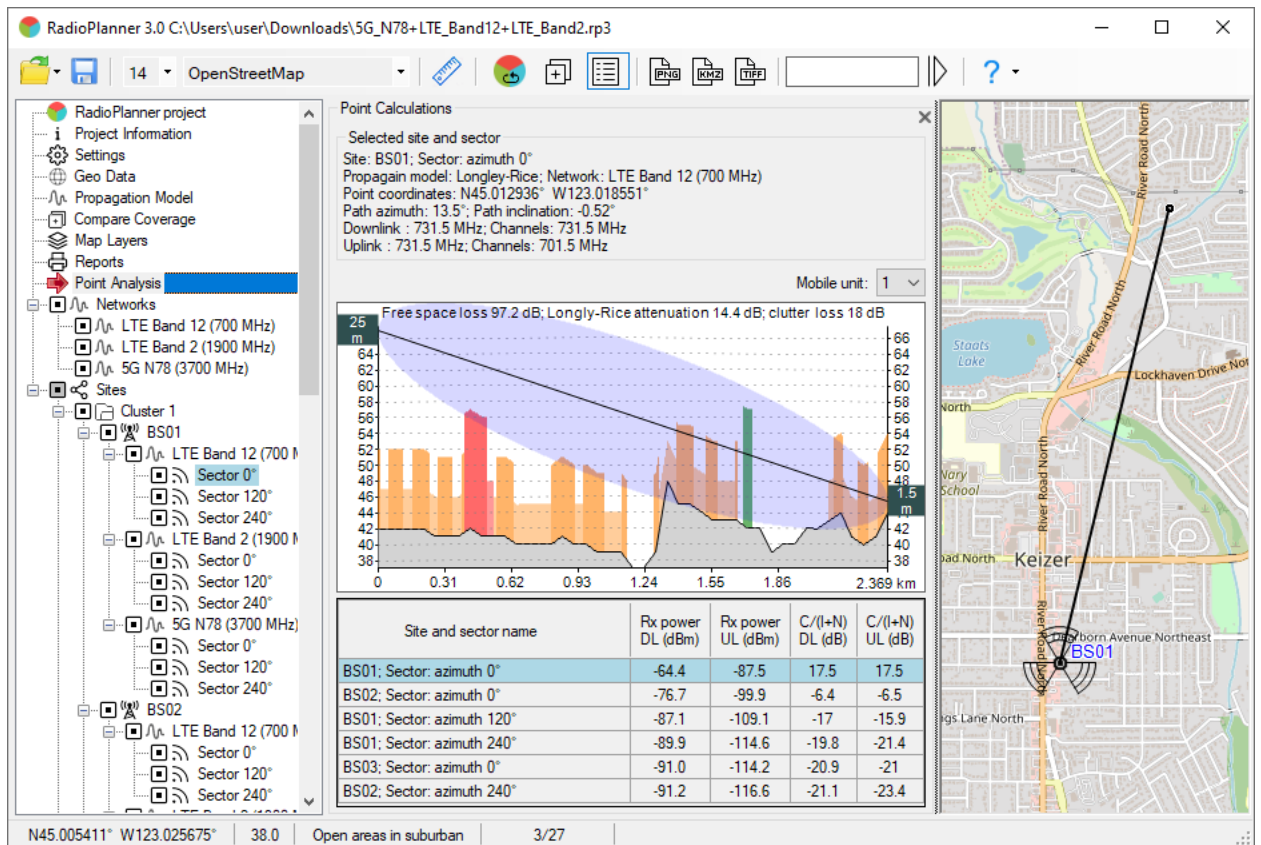
Maximum Aggregated Downlink Throughput Coverage Prediction for LTE Band 12 and Band 2

## Point Analysis

In this panel, you can see detailed results of received signal power downlink and uplink calculation at any point as well as interference levels on co-channel and adjacent channels. The path profile is a vertical section of terrain between site and mobile unit with elevations and clutter information. Clutter height in path profile is determined by height for each clutter type set in Geo Data menu.

Click on “Point Analysis” and then find the required sector in the interface tree and click on it (do not confuse it with the activity tag). A path profile from the sector to the current point on the map will appear. You can change the current point on the map by clicking on the desired location.

The path profile shows the height of the antenna radiation center of the selected sector and mobile unit, as well as the Fresnel zone for the radio beam, loss in free space, diffraction loss due to terrain, and loss on clutter surrounding mobile unit.



### Point Analysis

You can select a mobile unit (No. 1 or No. 2) whose parameters will be taken into account in calculations.

Under the path profile, a table appears with results of calculating power levels of downlink and uplink channels for selected sector (highlighted in color in table) and other sectors. Only sectors marked as active are included in calculation. For a sector to appear in table, received signal level must be greater than corresponding downlink or uplink Rx Threshold (see Network menu). Values in table can be sorted in ascending or descending order by clicking on corresponding field in table header.

The selected sector is considered to have a useful signal; signals from sectors with same frequency are considered co-channel interference, and signals from sectors whose frequencies are adjacent to selected sector are considered interference from adjacent channels. With this in mind, the table shows the calculated values of the interference level, taking into account noise and interference in the co-channel and adjacent channel.

## Fixed Wireless Access

RadioPlanner 3.0 allows you to plan Fixed Wireless Access (FWA) and Internet of Things (IoT) networks such as LoRa, SigFox, and others.

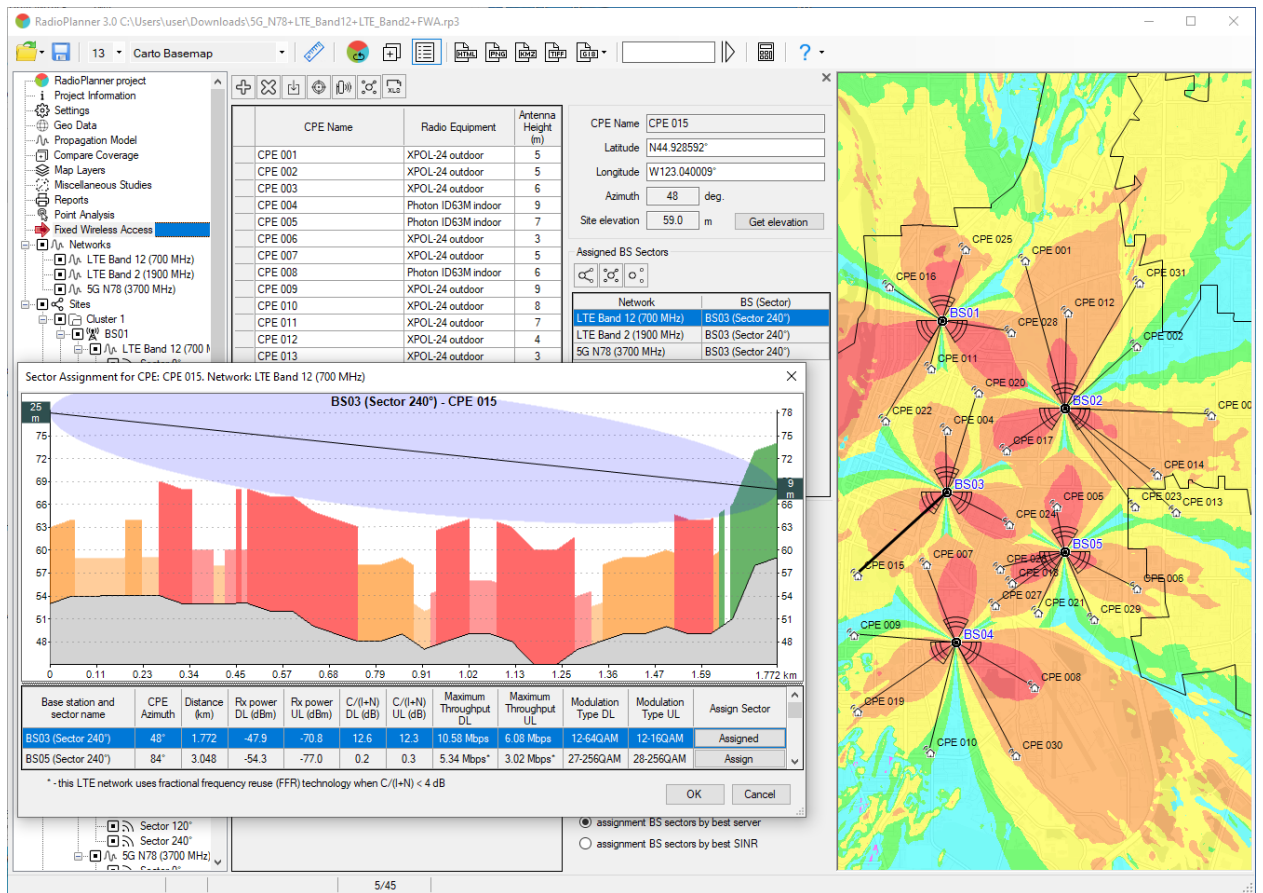
Users can perform calculations for multiple Customer Premises Equipment (CPEs) or IoT sensors, each with their own individual parameters (antenna height, antenna gain, antenna pattern, transmitter power, cable loss, and penetration loss).

In the Fixed Wireless Access panel, users can:

1. Import CPEs/Sensors from a CSV file or manually create new CPEs/Sensors on the map.


2. Use multiple types of CPE/Sensor equipment.
3. Adjust the antenna height for an individual CPE/Sensor or multiple CPEs in the table.
4. Manually or automatically assign CPEs/Sensors to Base Station (BS) sectors based on various criteria.
5. View path profiles from the selected CPEs/Sensors to nearby base stations.
6. Generate a single network report or an aggregate throughput summary report for CPEs/Sensors in Excel.

To display the CPE and the link to the assigned BS on the base map, a separate layer has been created in 'Map Layers'. Here, users can modify the CPE icon and line width. This layer can be saved in HTML, PNG, and KMZ coverage files.



Fixed Wireless Access panel

	Add a CPE site as a copy of selected one
	Remove selected CPE site (full row has to be selected)
	Import a list of CPE sites from CSV file
	Position the map with CPE site at the center of the screen
	Edit CPE Equipment
	Automatic BS assignment for all CPEs. The selection criterion is defined in the lower right part of the panel.

	Excel reports: <ul style="list-style-type: none"> <li>- Full report on the selected network in Excel</li> <li>- Aggregate Bandwidth Summary Report in Excel (LTE/5G only)</li> </ul>
CPE Name	CPE (End-device) name or ID
Latitude	CPE latitude in any of the formats that RadioPlanner allows (see the Setup menu)
Longitude	CPE longitude in any of the formats that RadioPlanner allows (see the Setup menu)
Azimuth	CPE antenna direction azimuth
Site elevation	Site elevation

**CSV file format with CPE input data:**

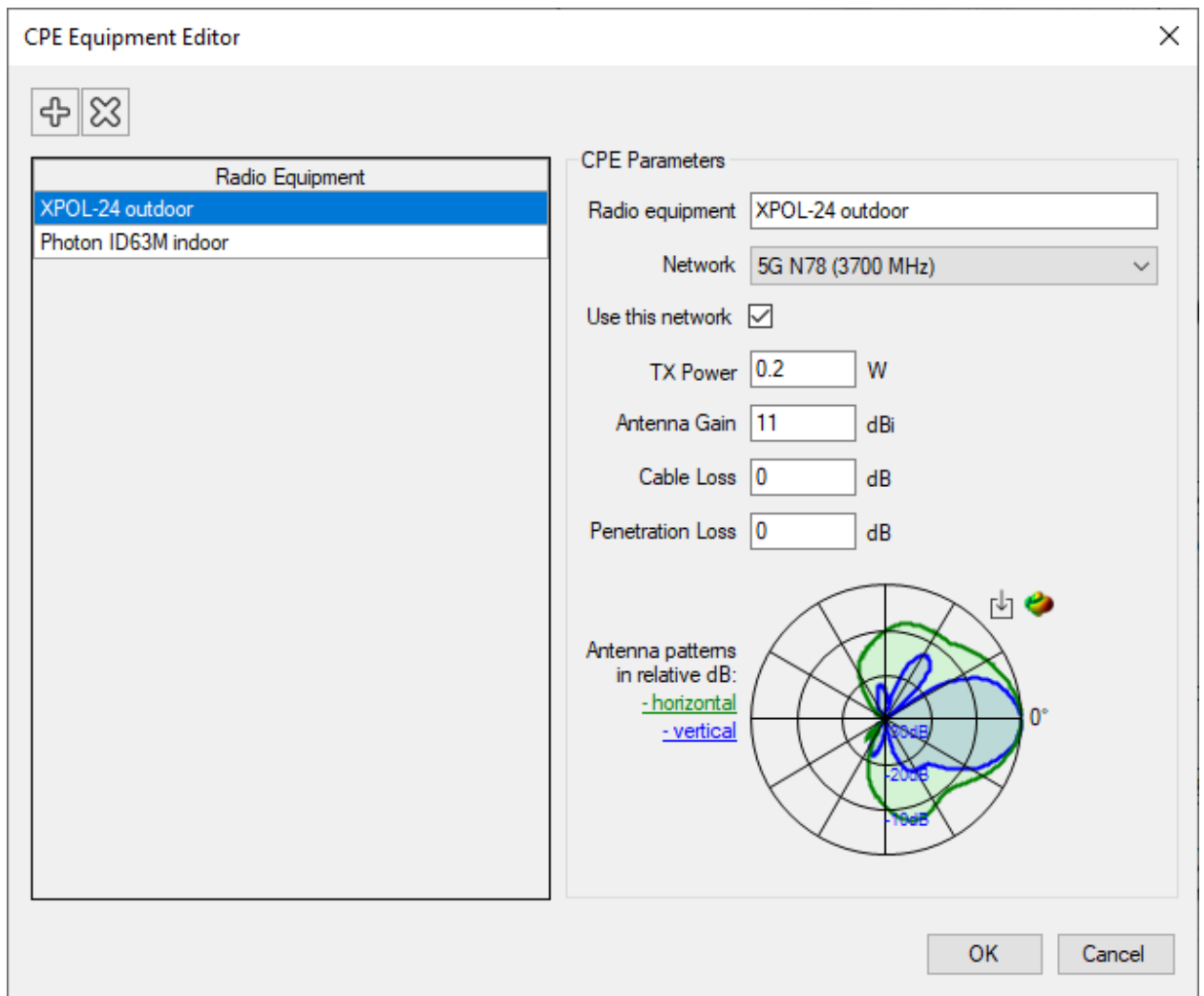
CPE/Sensor;Lat;Lon; Ant. height, m

for example:

CPE 001;44.96965602;-123.0091095;1.5





.....

CPE 007;44.93005057;-123.0273056;3

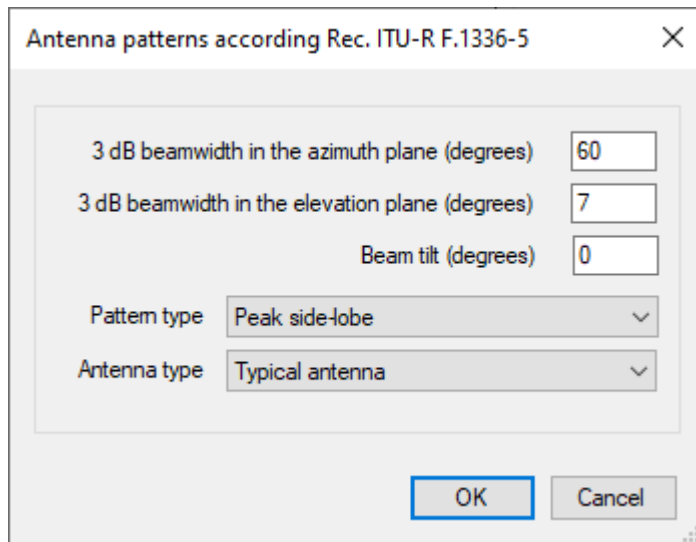


CPE Equipment Editor






	Add a new CPE type with the same parameters as selected CPE
	Remove the CPE
Radio equipment	CPE Type (model)
Network	Network
Use this network	Select the checkbox if the CPE supports the selected network
Tx power, W	CPE transmitter power, W
Ant. gain, dBi	CPE antenna gain, dBi
Cable loss, dB	CPE cable loss, dB
Penetration loss, dB	Penetration loss into the building where the CPE is installed, dB
	Load MSI antenna pattern file
	Create antenna pattern using a reference model in accordance with Rec. ITU-R F.1336-5

The CPE equipment editor allows you to synthesize an antenna pattern using a reference model in accordance with Rec. ITU-R F.1336-5.



*Creation of antenna pattern using a reference model in accordance with Rec. ITU-R F.1336-5*

3 dB beamwidth in the azimuth plane (degree)	3 dB beamwidth in the azimuth plane (degree)
3 dB beamwidth in the elevation plane (degree)	3 dB beamwidth in the elevation plane (degree)
Beam tilt (degree)	Beam tilt (degree)
Pattern Type: <ul style="list-style-type: none"> <li>- Peak side-lobe</li> <li>- Average side-lobe</li> </ul>	Type of antenna pattern approximation: <ul style="list-style-type: none"> <li>- on the peaks (maximums) of the side lobes</li> <li>- the average level of the side lobes</li> </ul>
Antenna Type <ul style="list-style-type: none"> <li>- Typical antenna</li> <li>- Improved side-lobe performance antenna</li> </ul>	Antenna Type <ul style="list-style-type: none"> <li>- Typical antenna</li> <li>- Improved side-lobe performance antenna</li> </ul>

	Assign BS sector manually
	Automatic BS assignment for selected CPE in below selected network. The selection criterion is defined in the lower right part of the panel.
	Reset sector assignments

Assignment BS sectors by Best Server	Assignment of BS sectors according to the Best Server criterion
Assignment BS sectors by best SINR	Assignment of BS sectors based on the best SINR criterion

The calculation of CPE - BS links is carried out according to the parameters specified in the "Propagation Model" menu.

If you use the ITU-R P.1812/1546 propagation model for FWA calculations, then the **clutter loss will always take into account the clutter height**; these losses are determined for each end device taking into account the height of its antenna above ground level.

The calculation can also take into account building penetration losses for each CPE/end device. The output report for each CPE or end device will display the received downlink/uplink power,  $C/(I+N)$  ratio, modulation type, maximum throughput, and other parameters.

#### General Procedure for Working in the Fixed Wireless Access Menu:

1. Load a list of CPEs from a CSV file or create a CPE manually using the right mouse button in the context menu. The CSV file format is described above. If you already have CPEs in your table, then when importing from a CSV file, new ones will appear at the end of the table.
2. Create one or more types of CPE equipment in the "Edit CPE Equipment" menu. Please note that for one type of CPE equipment, parameters for different networks can be specified.
3. Specify the type of equipment for each CPE in the table. To do this, point to the desired cell with the equipment and select the required equipment from the list that appears. You can select several cells in the table at once and set one type of equipment for them.
4. If your CSV file did not include data on antenna heights, or you created the CPE manually on the map, then indicate the antenna heights in the appropriate cells of the table. Here, it is also possible to select several cells at once and enter the same height for these cells.
5. If you want to assign BS sectors for all CPEs at once automatically, then select the criterion by which the assignment will be made - best server or best SINR - and click on the "Assign BS sectors for all CPE" button. After this, you will be asked to select a network for which the calculation and assignment of BS sectors will be carried out, and then automatic assignment will be performed. If there is only one network in the project, then automatic assignment will occur immediately. Please note that even if the CPE operates in different networks, it can be assigned and directed only to one BS site (the sectors are, of course, different). CPEs that do not have an assigned BS sector are displayed in the table in faded font.
6. If you want to view the path profile from the CPE to the BS sector or manually assign/reassign the BS sector, then first select the CPE you need in the main table, then select the desired network on the right and click on the "Assign BS Sector Manually" tool. In the window that opens with the path profile, you can select the sector you need, view the main calculation results, and assign/reassign the selected BS sector.
7. After the sector assignments have been completed for all CPEs, you can obtain the calculation results in Excel "*Full report on the selected network in Excel*" for one network or for several networks "*Aggregate Bandwidth Summary Report in Excel (LTE/5G only)*". Only those networks that are marked in the main left menu "Networks" will be taken into account.
8. If the calculation results do not satisfy you, then change the parameters of the CPE (antenna height, equipment type, etc.) and perform the calculation again, and so on, until you get the desired result.



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
CPE	Lat	Lon	Radio Equipment	Tx power (W)	Ant. height (m)	Ant. gain (dBi)	Cable loss (dB)	Penetration loss (dB)	Clutter Type	Clutter loss (dB)	Assigned Site	Assigned Sector	Distance to site (km)	Direction to Site	Received power DL (dBm)	Received power UL (dBm)	C/I(+N) Ratio DL (dB)	C/I(+N) Ratio UL (dB)	Maximum Throughput DL (Mbps)	Maximum Throughput UL (Mbps)
CPE 001	N44.969656°	W123.009110°	XPOL-24 outdoor	0.2	5	8.5	0	0	Suburban	13.5	BS02	Sector 0°	2.244	165.0°	-48.7	-71.8	14.2	13.8	11.552	6.528
CPE 002	N44.958482°	W122.988510°	XPOL-24 outdoor	0.2	5	8.5	0	0	Open areas	6.9	BS02	Sector 0°	1.379	228.0°	-43.4	-65.4	9.4	9.8	7.5392	4.416
CPE 003	N44.949492°	W122.974777°	XPOL-24 outdoor	0.2	6	8.5	0	0	Open areas	3.7	BS02	Sector 120°	2.111	272.0°	-40.3	-63.2	13.0	12.8	10.5792	6.08
CPE 004	N44.947548°	W123.023529°	Photon ID63M indoor	0.2	9	6	0	10	Urban	15	BS03	Sector 0°	0.920	179.0°	-54.3	-77.0	10.9	10.6	8.9984	4.864
CPE 005	N44.937585°	W123.003273°	Photon ID63M indoor	0.2	7	6	0	10	Urban	17.4	BS05	Sector 0°	0.690	169.0°	-54.5	-77.4	12.9	12.6	10.5792	6.08
CPE 006	N44.926891°	W122.988510°	XPOL-24 outdoor	0.2	3	8.5	0	0	Urban	20.7	BS05	Sector 120°	1.150	297.0°	-86.1	-88.7	14.2	11.5	11.552	5.568
CPE 007	N44.930051°	W123.027306°	XPOL-24 outdoor	0.2	5	8.5	0	0	Open areas	0	BS04	Sector 0°	1.234	159.0°	-30.7	-53.9	16.7	16.8	14.592	9.344
CPE 008	N44.914006°	W123.007393°	Photon ID63M indoor	0.2	6	6	0	10	Suburban	11.7	BS04	Sector 120°	1.291	300.0°	-53.9	-76.7	13.2	12.6	10.5792	6.08
CPE 009	N44.920113°	W123.040695°	XPOL-24 outdoor	0.2	9	8.5	0	0	Open areas	0	BS04	Sector 240°	1.507	95.0°	-35.0	-57.5	7.7	7.9	5.715199	3.52
CPE 010	N44.905496°	W123.026199°	XPOL-24 outdoor	0.2	6	8.5	0	0	Suburban	6.9	BS04	Sector 240°	1.631	14.0°	-44.5	-66.6	8.9	9.1	6.688	3.968
CPE 011	N44.955566°	W123.026447°	XPOL-24 outdoor	0.2	7	8.5	0	0	Open areas	0	BS01	Sector 240°	0.699	15.0°	-30.0	-52.2	14.3	14.4	12.4032	6.976
CPE 012	N44.962855°	W123.011213°	XPOL-24 outdoor	0.2	4	8.5	0	0	Suburban	15	BS02	Sector 0°	1.407	181.0°	-45.5	-68.2	19.1	19.2	15.6864	10.752
CPE 013	N44.936856°	W122.981300°	XPOL-24 outdoor	0.2	3	8.5	0	0	Suburban	16.2	BS02	Sector 120°	2.182	313.0°	-51.8	-74.7	12.1	11.7	9.241599	5.568
CPE 014	N44.941716°	W122.964734°	XPOL-24 outdoor	0.2	5	8.5	0	0	Urban	19.2	BS02	Sector 120°	1.629	306.0°	-51.1	-73.7	15.0	14.9	12.4032	7.68
CPE 015	N44.928592°	W123.040009°	XPOL-24 outdoor	0.2	9	8.5	0	0	Trees/forest	15.5	BS03	Sector 240°	1.772	48.0°	-47.9	-70.8	12.6	12.3	10.5792	6.08
CPE 016	N44.966255°	W123.034172°	XPOL-24 outdoor	0.2	10	8.5	0	0	Suburban	0	BS01	Sector 0°	0.938	123.0°	-34.9	-56.8	7.6	7.7	5.715199	3.52
CPE 017	N44.944875°	W123.012543°	XPOL-24 outdoor	0.2	4	8.5	0	0	Open areas	3.7	BS02	Sector 240°	1.050	55.0°	-31.6	-54.4	22.2	22.6	18.3616	13.056
CPE 018	N44.927620°	W123.011513°	XPOL-24 outdoor	0.2	8	8.5	0	0	Suburban	6.9	BS05	Sector 240°	0.896	61.0°	-33.5	-56.2	20.4	20.2	16.416	11.2
CPE 019	N44.910845°	W123.040009°	XPOL-24 outdoor	0.2	6	8.5	0	0	Suburban	11.7	BS04	Sector 240°	1.753	56.0°	-52.0	-74.9	10.7	10.7	8.9984	4.864
CPE 020	N44.952408°	W123.017693°	XPOL-24 outdoor	0.2	9	8.5	0	0	Open areas	0	BS03	Sector 0°	1.527	197.0°	-32.3	-54.9	11.1	11.3	8.9984	4.864
CPE 021	N44.923731°	W123.006706°	XPOL-24 outdoor	0.2	5	8.5	0	0	Suburban	13.5	BS05	Sector 240°	0.956	25.0°	-44.5	-67.1	12.8	12.8	10.5792	6.08
CPE 022	N44.948763°	W123.034859°	XPOL-24 outdoor	0.2	7	8.5	0	0	Suburban	9.6	BS01	Sector 240°	1.661	30.0°	-44.4	-67.4	15.2	15.3	12.4032	7.68
CPE 023	N44.937585°	W122.988853°	XPOL-24 outdoor	0.2	10	8.5	0	0	Open areas	0	BS02	Sector 120°	1.726	325.0°	-34.5	-57.2	9.3	9.2	7.5392	3.968
CPE 024	N44.935276°	W123.012028°	XPOL-24 outdoor	0.2	10	8.5	0	0	Suburban	0	BS03	Sector 120°	0.998	297.0°	-27.5	-50.2	21.8	22.0	18.3616	12.608
CPE 025	N44.971113°	W123.020996°	XPOL-24 outdoor	0.2	10	8.5	0	0	Suburban	0	BS01	Sector 0°	1.103	197.0°	-29.5	-52.1	13.1	13.3	10.5792	6.528
CPE 026	N44.929443°	W123.013744°	XPOL-24 outdoor	0.2	10	8.5	0	0	Suburban	0	BS05	Sector 240°	0.968	77.0°	-28.5	-51.1	16.1	16.0	15.6864	9.664
CPE 027	N44.924703°	W123.014603°	XPOL-24 outdoor	0.2	10	8.5	0	0	Suburban	0	BS05	Sector 240°	1.277	54.0°	-29.6	-52.5	16.7	16.4	14.592	8.639999
CPE 028	N44.960304°	W123.011884°	XPOL-24 outdoor	0.2	10	8.5	0	0	Open areas	0	BS01	Sector 120°	0.968	279.0°	-28.9	-52.0	19.5	20.0	16.416	11.2
CPE 029	N44.922880°	W122.996407°	XPOL-24 outdoor	0.2	10	8.5	0	0	Urban	13.5	BS05	Sector 120°	1.043	337.0°	-45.7	-68.1	9.9	10.0	7.5392	4.416
CPE 030	N44.905131°	W123.010826°	XPOL-24 outdoor	0.2	10	8.5	0	0	Urban	13.5	BS04	Sector 120°	1.834	332.0°	-49.7	-72.3	14.7	14.0	12.4032	6.976
CPE 031	N44.966741°	W122.987995°	XPOL-24 outdoor	0.2	10	8.5	0	0	Urban	13.5	BS02	Sector 0°	2.127	210.0°	-50.7	-73.3	10.0	10.0	7.5392	4.416

Full report on the selected network in Excel

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
CPE	Lat	Lon	Radio Equipment	Ant. Height (m)	Assigned Site	Direction to Site	Distance to site (km)	Network	Assigned Sector	Received power DL (dBm)	Received power UL (dBm)	C/I(+N) Ratio DL (dB)	C/I(+N) Ratio UL (dB)	Maximum Throughput DL (Mbps)	Maximum Throughput UL (Mbps)	
CPE 001	N44.969656°	W123.009110°	XPOL-24 outdoor	5	BS02	165.0°	2.244	LTE Band 12 (700 MHz)	Sector 0°	-48.7	-71.8	14.2	13.8	11.552	6.528	
								LTE Band 2 (1900 MHz)	Sector 0°	-57.6	-85.8	10.2	6.7	25.650	9.500	
								SG N78 (3700 MHz)	Sector 0°	-75.7	-88.8	12.4	1.2	669.200	60.800	
								<b>Max Aggregated Throughput (Mbps)</b>						<b>706.402</b>	<b>76.828</b>	
CPE 002	N44.958482°	W122.988510°	XPOL-24 outdoor	5	BS02	228.0°	1.379	LTE Band 12 (700 MHz)	Sector 0°	-43.4	-65.4	9.4	9.8	7.539	4.416	
								LTE Band 2 (1900 MHz)	Sector 0°	-54.1	-78.2	6.2	5.8	15.960	8.400	
								SG N78 (3700 MHz)	Sector 0°	-65.3	-78.5	22.6	11.6	1177.600	276.400	
								<b>Max Aggregated Throughput (Mbps)</b>						<b>1201.099</b>	<b>289.216</b>	
CPE 003	N44.949492°	W122.974777°	XPOL-24 outdoor	6	BS02	272.0°	2.111	LTE Band 12 (700 MHz)	Sector 120°	-40.3	-63.2	13.0	12.8	10.579	6.080	
								LTE Band 2 (1900 MHz)	Sector 120°	-46.7	-76.1	12.6	5.6	33.250	8.400	
								SG N78 (3700 MHz)	Sector 120°	-62.6	-75.7	25.3	14.3	1375.200	395.200	
								<b>Max Aggregated Throughput (Mbps)</b>						<b>1419.029</b>	<b>409.680</b>	
CPE 004	N44.947548°	W123.023529°	Photon ID63M indoor	9	BS03	179.0°	0.920	LTE Band 12 (700 MHz)	Sector 0°	-54.3	-77.0	10.9	10.6	8.998	4.864	
								LTE Band 2 (1900 MHz)	Sector 0°	-65.9	-94.1	12.0	3.4	29.830	4.900	
								SG N78 (3700 MHz)	Sector 0°							
								<b>Max Aggregated Throughput (Mbps)</b>						<b>38.828</b>	<b>9.764</b>	
CPE 005	N44.937585°	W123.003273°	Photon ID63M indoor	7	BS05	169.0°	0.690	LTE Band 12 (700 MHz)	Sector 0°	-54.5	-77.4	12.9	12.6	10.579	6.080	
								LTE Band 2 (1900 MHz)	Sector 0°	-65.9	-94.1	13.3	4.6	35.910	6.600	
								SG N78 (3700 MHz)	Sector 0°							
								<b>Max Aggregated Throughput (Mbps)</b>						<b>46.489</b>	<b>12.680</b>	
CPE 006	N44.926891°	W122.988510°	XPOL-24 outdoor	3	BS05	297.0°	1.150	LTE Band 12 (700 MHz)	Sector 120°	-86.1	-88.7	14.2	11.5	11.552	5.568	
								LTE Band 2 (1900 MHz)	Sector 120°							
								SG N78 (3700 MHz)	Sector 120°							
								<b>Max Aggregated Throughput (Mbps)</b>						<b>11.552</b>	<b>5.568</b>	
CPE 007	N44.930051°	W123.027306°	XPOL-24 outdoor	5	BS04	159.0°	1.234	LTE Band 12 (700 MHz)	Sector 0°	-30.7	-53.9	16.7	16.8	14.592	9.344	
								LTE Band 2 (1900 MHz)	Sector 0°	-35.5	-63.0	21.6	16.6	57.380	27.000	
								SG N78 (3700 MHz)	Sector 0°	-49.6	-62.8	37.7	27.2	1636.000	750.000	
								<b>Max Aggregated Throughput (Mbps)</b>						<b>1707.972</b>	<b>786.344</b>	
CPE 008	N44.914006°	W123.007393°	Photon ID63M indoor	6	BS04	300.0°	1.291	LTE Band 12 (700 MHz)	Sector 120°	-53.9	-76.7	13.2	12.6	10.579	6.080	
								LTE Band 2 (1900 MHz)	Sector 120°	-65.4	-93.6	13.3	4.2	35.910	6.600	
								SG N78 (3700 MHz)	Sector 120°							

Aggregate Bandwidth Summary Report in Excel (LTE/5G only)

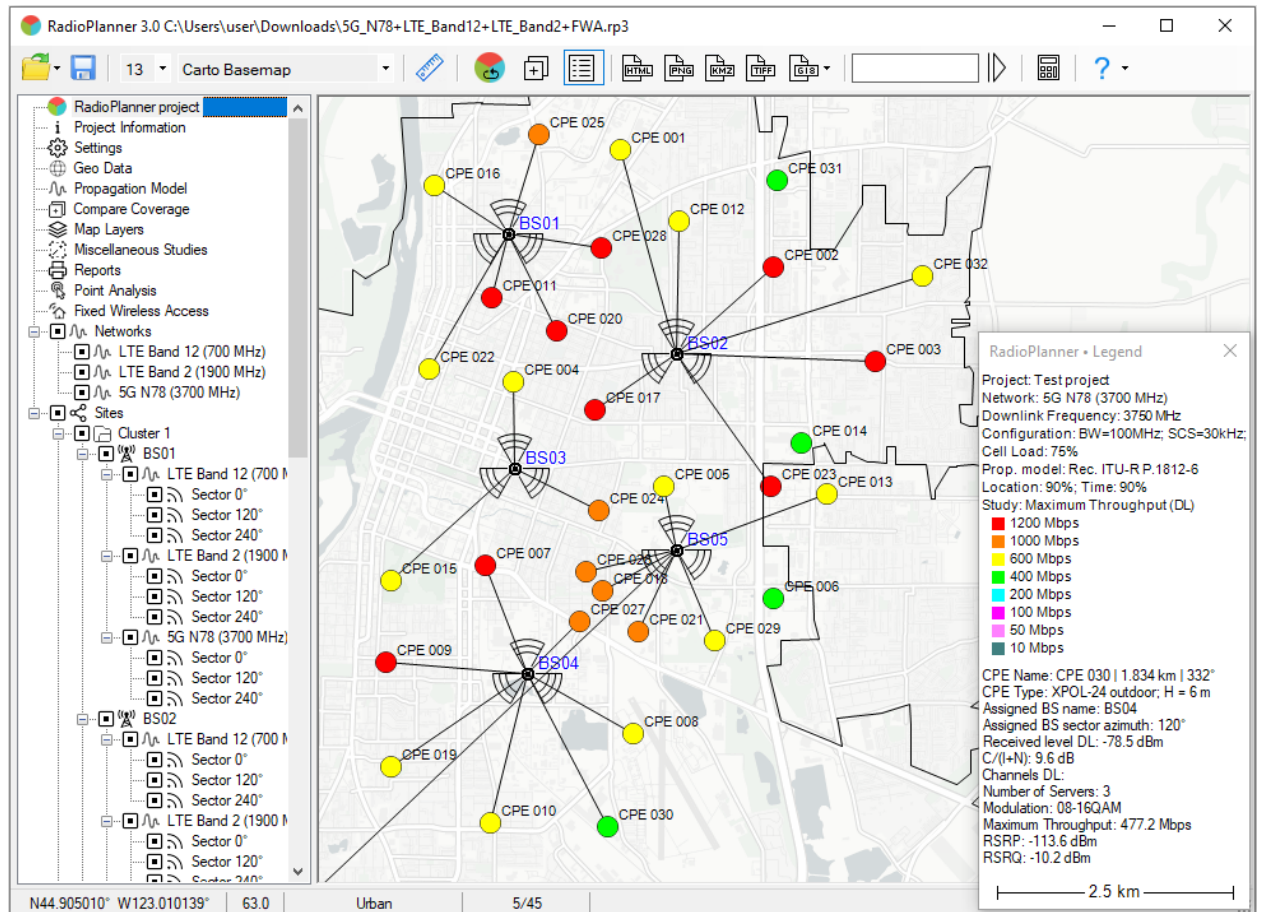
### Coverage prediction for Fixed Wireless Access network

RadioPlanner 3.0 enables the display of coverage predictions for a Fixed Wireless Access (FWA) network or an IoT network (such as LoRaWAN) on a map. The algorithm used to calculate coverage for CPEs or IoT sensors differs from the one used for mobile units. This difference stems from the fact that while calculating mobile network coverage, the characteristics of one of two typical mobile units (UE1 or UE2) are considered. However, when calculating FWA coverage, the individual characteristics of each CPE or sensor are taken into account. These include antenna height, antenna gain, antenna pattern, transmitter power, losses in the cable, and building penetration losses. As a result, coverage prediction results are more accurate.

Upon calculation, a small circle will appear at the location of each CPE or sensor. The color of this circle will correspond to the result of the selected study type. The study type can be chosen from the menu of the corresponding network, and the calculation can be initiated there using a special tool 'Calculate FWA Coverage'.

If a CPE/Sensor has an assigned BS sector, then the coverage calculation will be performed for this BS sector. If the CPE/Sensor does not have an assigned BS sector, then the coverage calculation will be performed for the sector with the best power at the receiver (Best Server).

When you hover your mouse over the CPE circle, the equipment parameters and calculation results will be displayed on the Legend.



Coverage prediction for Fixed Wireless Access network

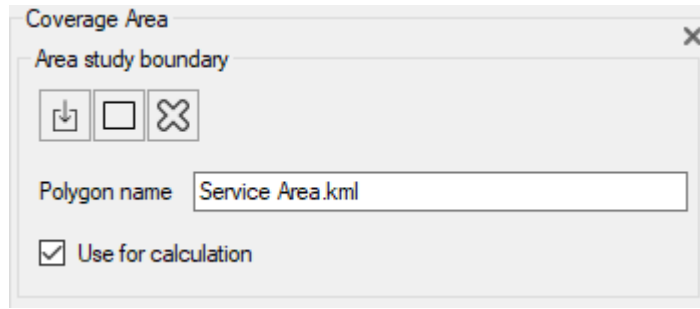
## Miscellaneous Studies

### Area study boundary

You can specify the area on which the coverage area will be cropped. The boundaries of a rectangular area can be set manually, or you can upload an arbitrary area in KML format.

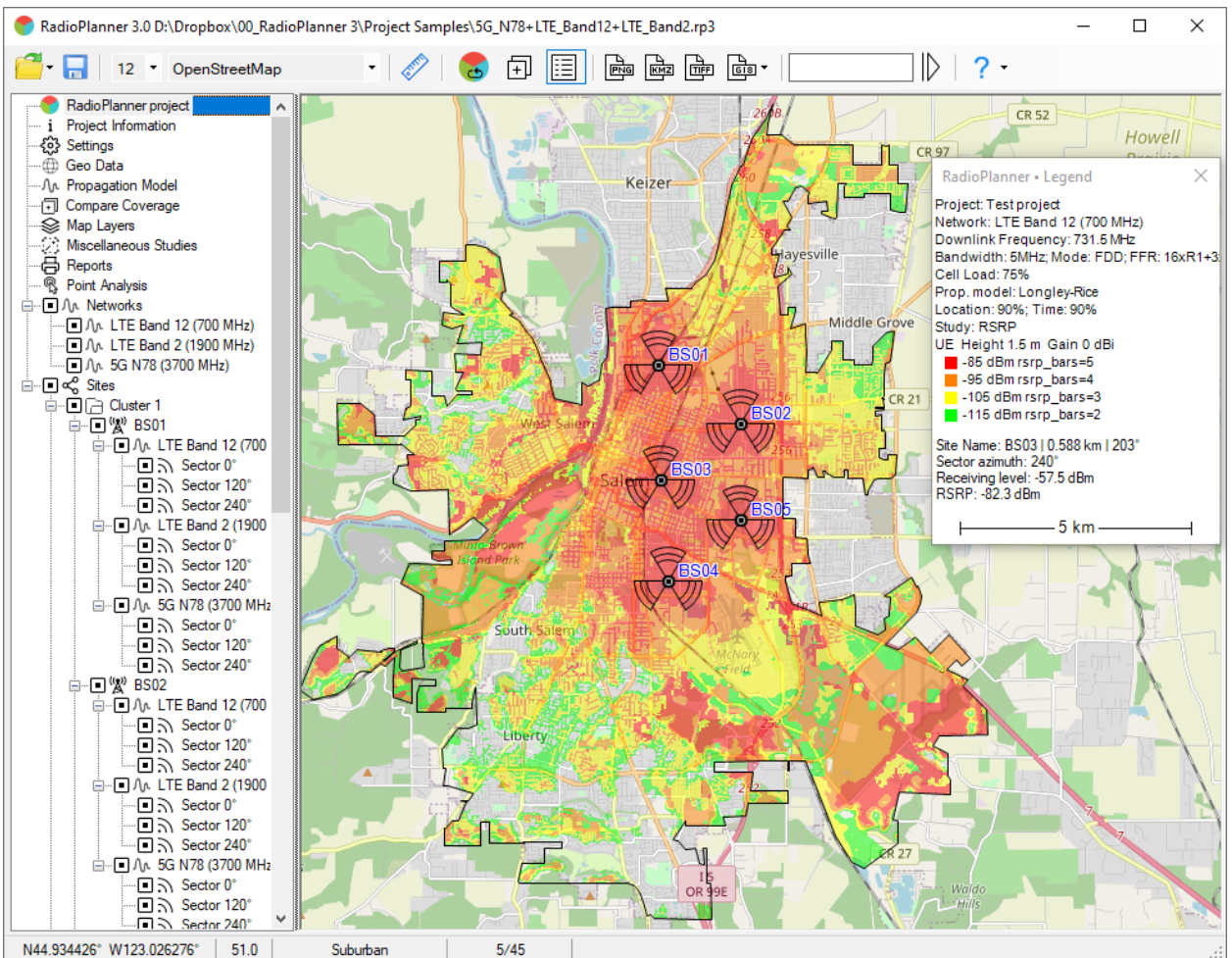
U.S. community and county boundary in KML format is available on FCC website

<https://www.fcc.gov/media/radio/us-community-boundary-overlays-kml>



Area study boundary

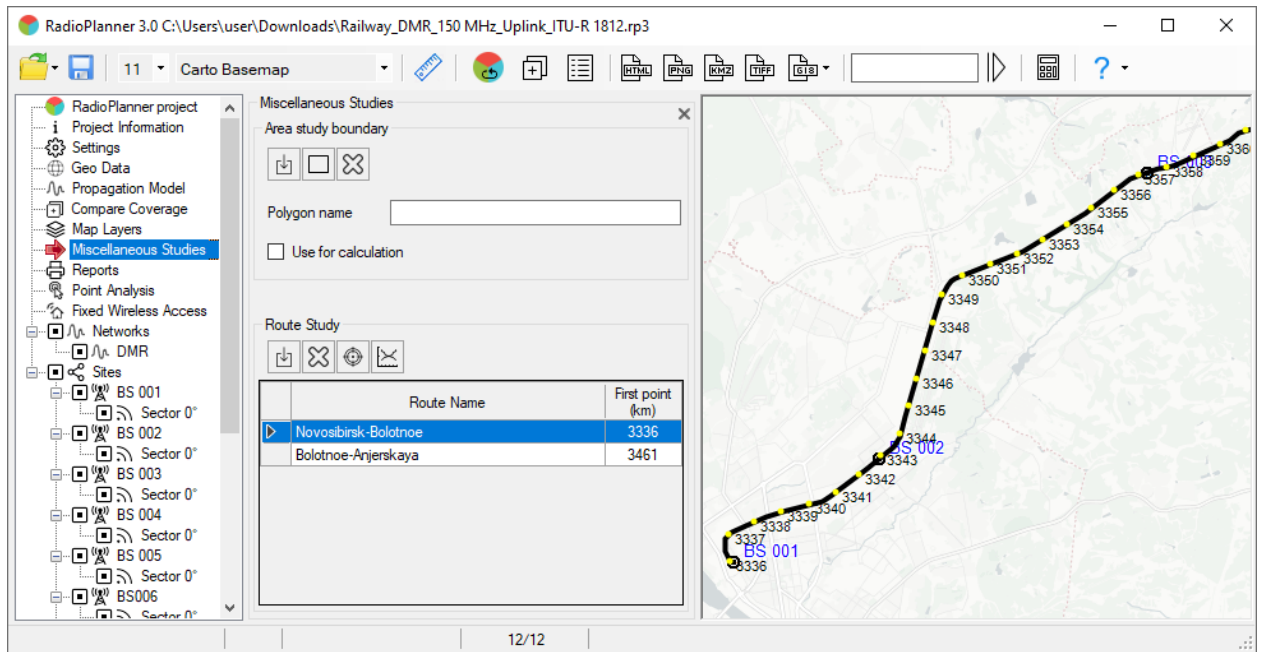
	Import polygon from KML file
	Define area as a rectangle
	Delete polygon
Use for calculation	Crop the coverage at the area boundary



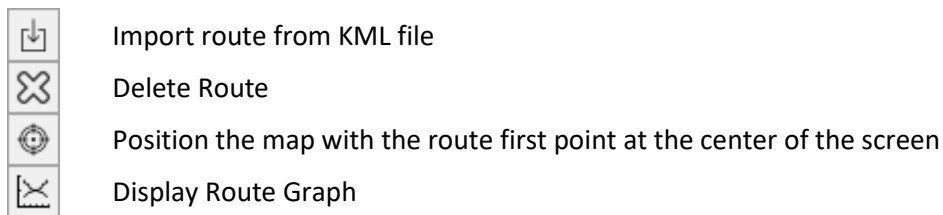
Coverage prediction based on area study boundaries

### Route Study

The Route Study feature allows you to construct graphs of received power levels,  $C/(I+N)$ , or a throughput graph along any extended object such as a pipeline, railway, or highway, etc.

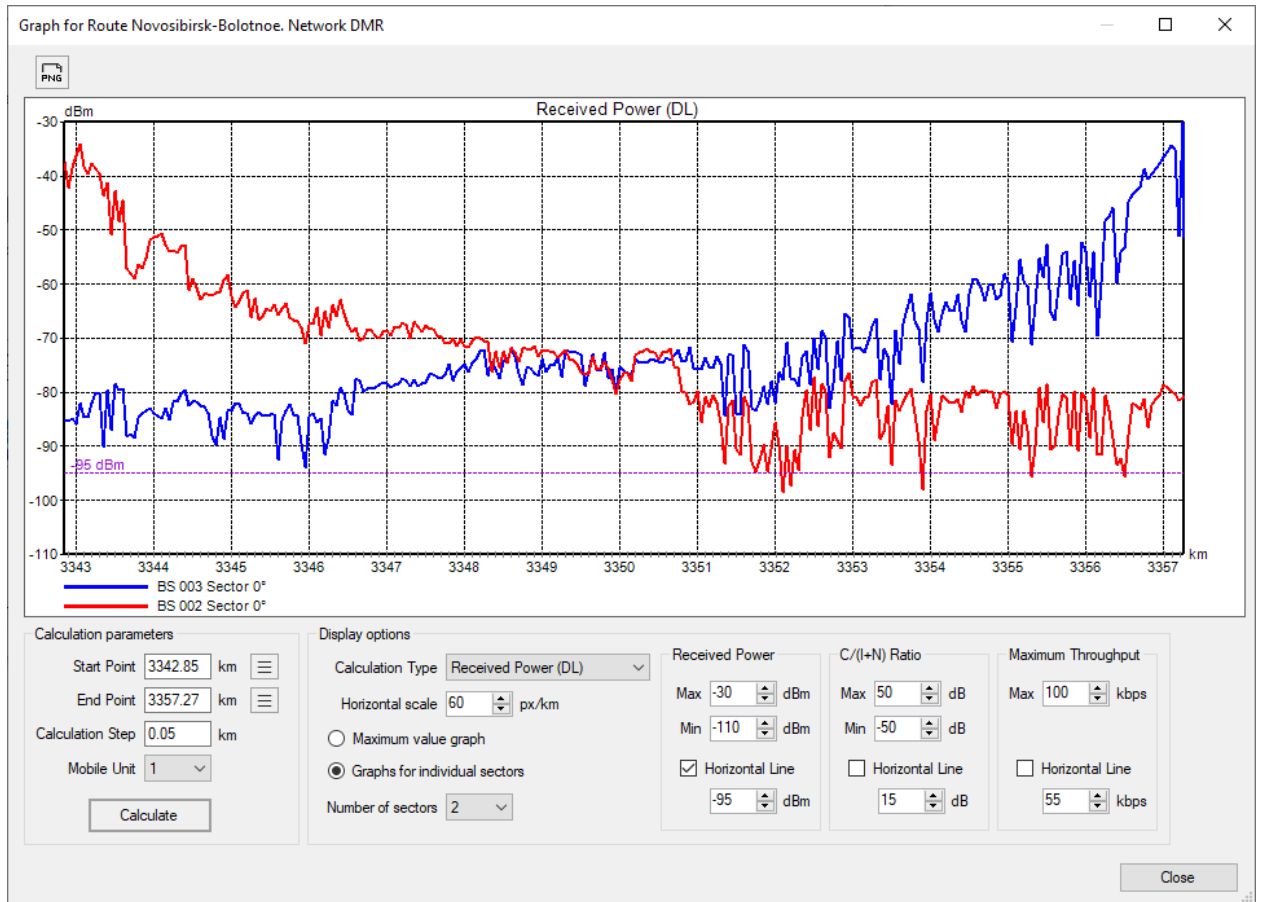


Route Study menu



The route for which the calculation will be performed is loaded from a KML file. This file can be prepared in any third-party software, for example, Google Earth. There can be multiple routes. You can specify any desired value as the marker for the first point of a linear section. The remaining kilometer markers will be placed on the map along the route automatically. To construct graphs, double-click on the desired route or use the 'Display Route Graph' tool.



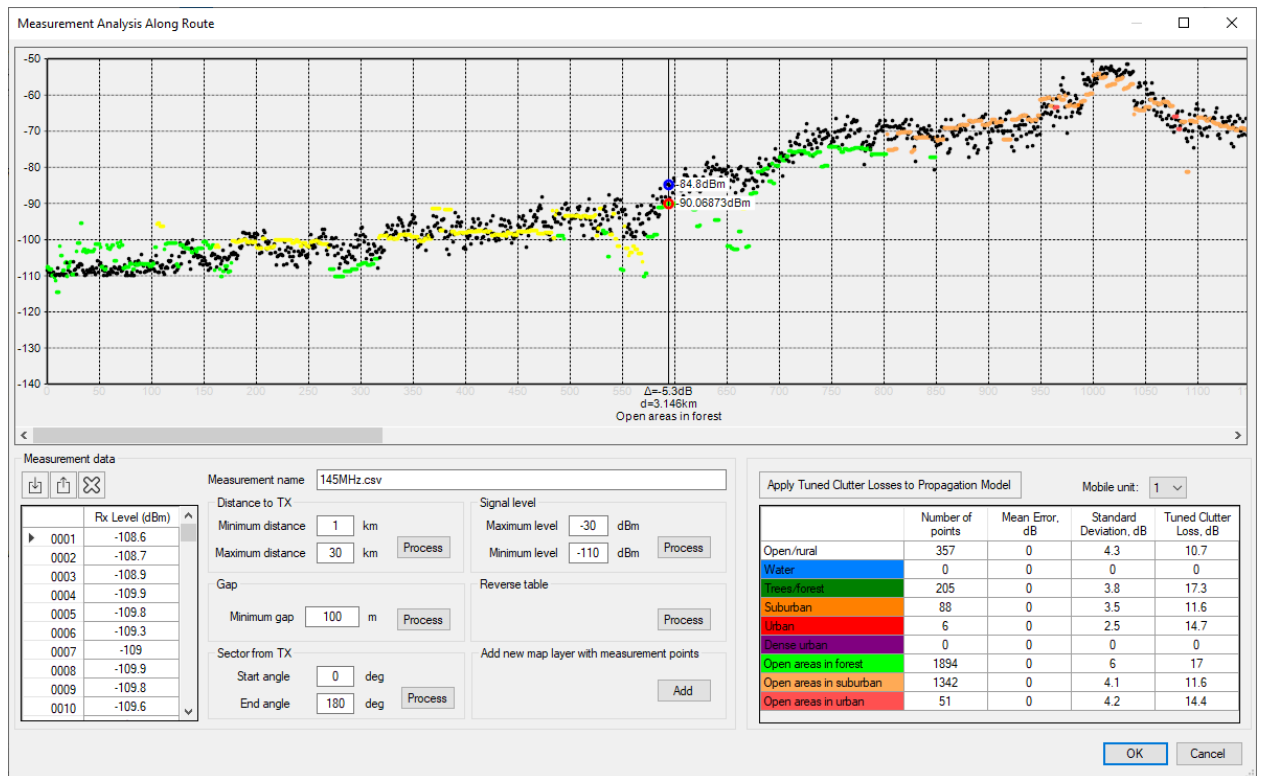


Route Graph

	Save the graph in PNG format. The original size will remain
Start Point	Starting point of the graph
End Point	End point of the graph
	Determine the point with the minimum distance from the selected BS to the route
Calculation Step	Calculation step. Minimum step 20m.
Mobile unit	Mobile unit (UE)
Calculate	Perform calculation
Calculation Type	Calculation Type
Horizontal scale	Horizontal scale of the graph in pixels per kilometer
Maximum value graph	Maximum value graph
Graphs for individual sectors	Display a graph for individual sectors. This feature allows you to display a graph for individual sectors. The sectors displayed on the graph are determined automatically based on the maximum level of the integral reception Rx power on a given section of the route. If the algorithm for automatically determining sectors does not function (which happens very rarely), it is recommended to manually select the necessary BS sectors for calculation in the main left menu.
Number of sectors	Number of displayed sectors. Maximum 5 BS sectors.
Received Power	Set the maximum and minimum reception level values on the graph
C/(I+N) Ratio	Set the maximum and minimum values of C/(I+N) on the graph
Maximum Throughput	Set maximum and minimum throughput values on the graph
Horizontal Line	Display a horizontal line with the specified value on the graph

## Measurement Results Analysis and Propagation Model Tuning

RadioPlanner 3.0 allows you to tune clutter loss for a propagation model by comparing measurements with predicted Rx power values. Loading, preprocessing and analysis of measurement file for each sector is performed in Sector parameters panel.



*Measurement Analysis Along Route*



Import of measurement data from a CSV file

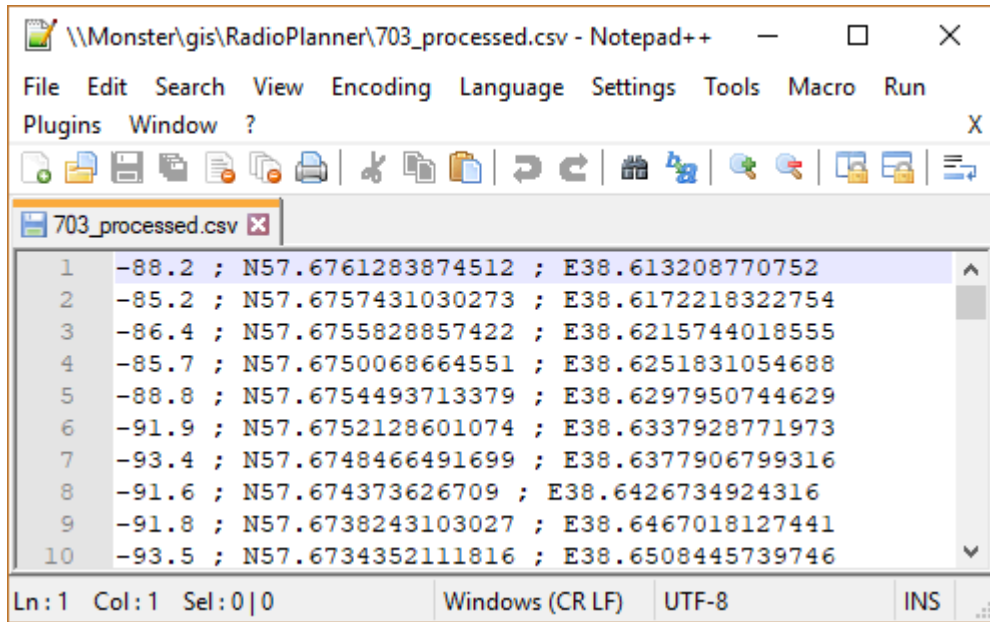


Export of measurement data to a CSV file



Delete all measurement points

First prepare a file of received power levels for required site sector. The measurement file is a CSV format file with each line containing three parameters: level of measured signal from one sector in dBm; geographical latitude; geographic longitude. The separator of parameter values is semicolon. Formats for representation of geographic coordinates are Hemisphere Degrees SECOND MINUTES (N35 36 23.8) or HEM DECIMAL DEGREES (N12.34567).



*Sample Measurement File*

Upload measurement file to appropriate sector and perform preliminary processing if necessary:

Signal level Minimum/Maximum Level	Limit the measurement points by received power level from the site
Distance to TX Minimum/Maximum Distance	Limit the measurement points by distance from the site
Sector from Site Minimum/Maximum Angle	Limit the measurement points by azimuth from the site
Gap Minimum Gap	Perform measurement points power level averaging within a given distance
Reverse table	Change the order of measurement points in the route (the last point becomes the first, the penultimate point becomes the second, and so on)
Add New Layer with Measurement Points	Add a custom measurement layer to the map. The resulting layer will appear among the user layers; the layer name will determinate to the site name and sector direction.

On the results scatter-plot, measurement levels are indicated in black, while predicted values are indicated in a color corresponding to the clutter type at a given point (e.g., yellow for open space). The x-axis displays the waypoint numbers. When hovering the cursor over the graph, calculated and measured levels, level difference, distance to the site (in kilometers), and clutter type are displayed. When you click on the plot, a context menu appears, in which you can delete a point with the measurement result.

Below the plot is a table that displays the number of points, mean error, standard deviation of error, and recommended loss values for different clutter types that will result in an average error of zero. Clicking the "Apply Tuned Clutter Losses to Propagation Model" button changes the clutter loss values in the "Propagation Model" menu and recalculates the plot point values based on the tuned loss values. To assess the impact of the new clutter loss values on coverage calculation results, coverage must be recalculated.

A decision is made regarding the need to tune previously used clutter loss values in the propagation model based on an analysis of results obtained for different clutter types and sectors.

## Saving the Coverage Calculation Result

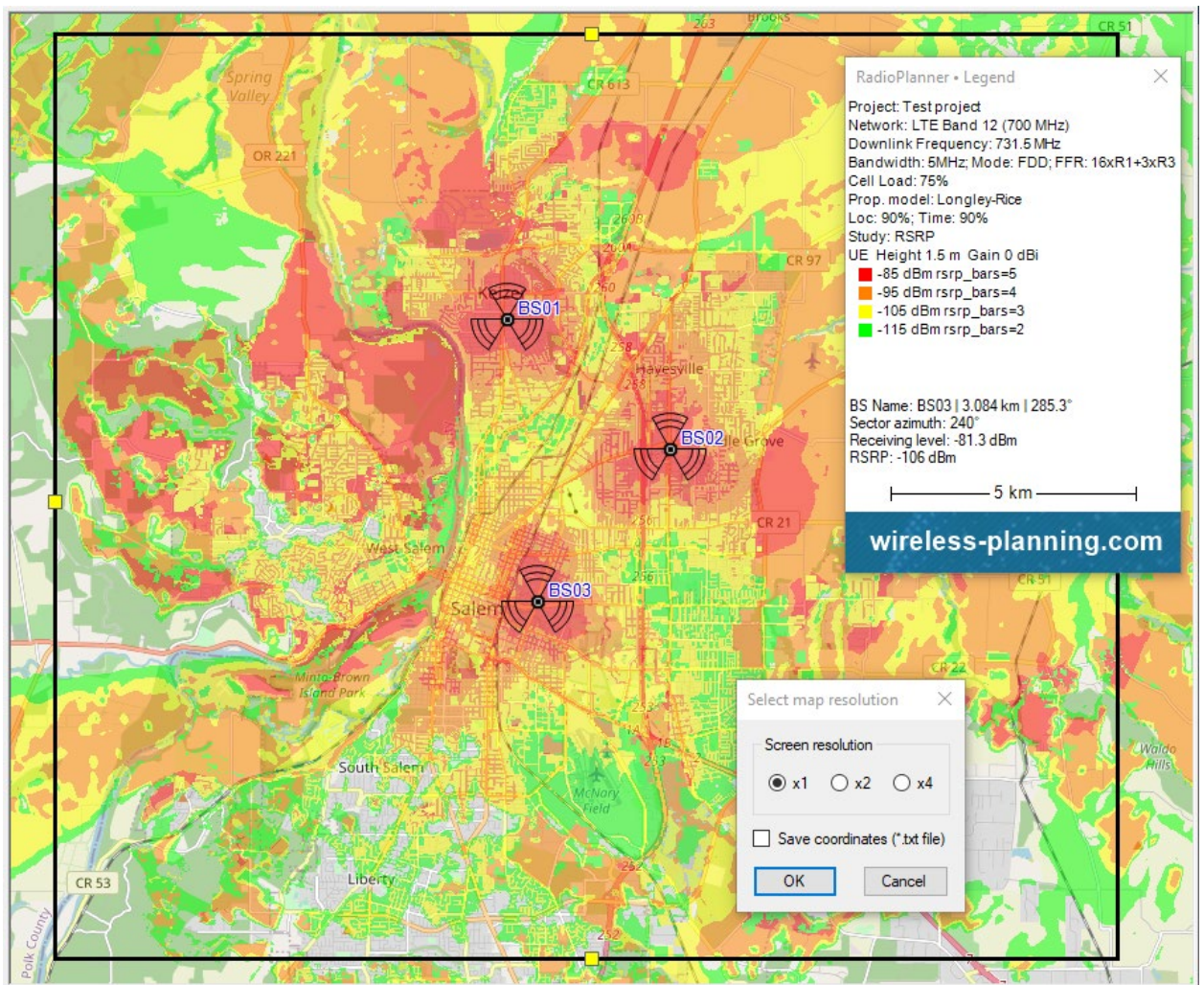
Coverage prediction result can be saved as:

- Image file in PNG format
- Interactive web page in HTML format
- KMZ file
- Image file in GeoTiff format
- Text CSV file - a set of points with coordinates and a received power / a field strength
- Exchange file MapInfo (MIF + MID) - a set of squares with the attribute as received power / a field strength




**Save the map as a PNG image** - Save result of coverage calculation as image file in \*.png format. Before saving image, you can select area of saved coverage using frame (you can move both border of frame and map itself). When saving image, you also select its resolution. Resolution may correspond with current size or be two or four times larger. The better resolution, larger size of saved file.

Maximum size of bitmap image is approximately 5400x4400 pixels; file size in \*.png format is about 10 MB. If Legend is active, it will appear in upper left corner of saved image. Save coordinates (\*.txt file): Saves text file with same name as image file. Coordinates of corners of image are written into text file.



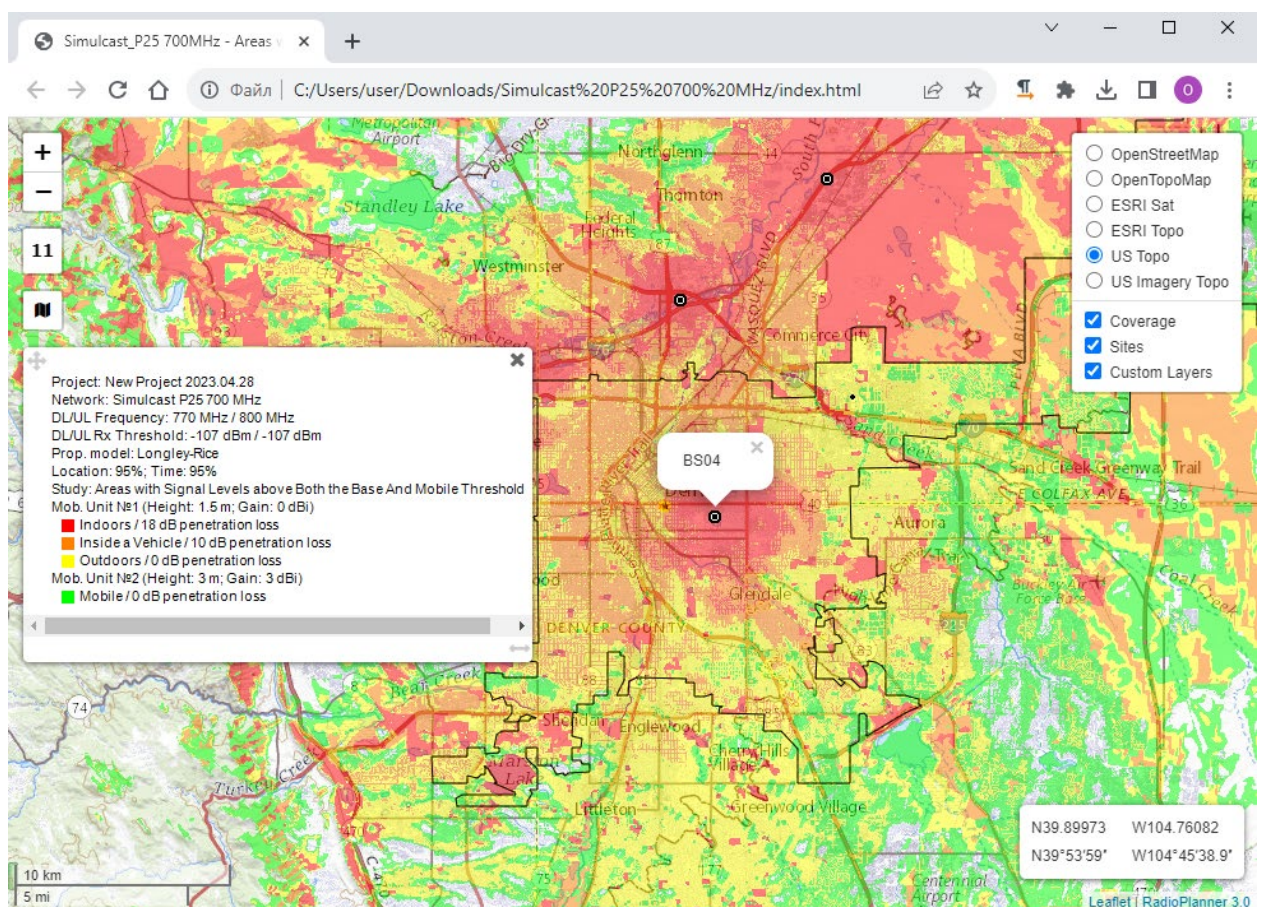
*Selecting the area and resolution of the saved image*




 **Save the map as a WEB page** - Save result of calculation as interactive webpage. Application allows user to select location and name of directory where result is saved. The index.html file (page script), bs.png file (site icon), and folder with radio coverage tile pyramid {ZOOM}/{X}/{Y} will be saved to specified directory. To open webpage, open index.html file using browser (Google Chrome, Mozilla Firefox, Internet Explorer, etc.). Specified folder with script and tile pyramid can be archived and forwarded to customer.

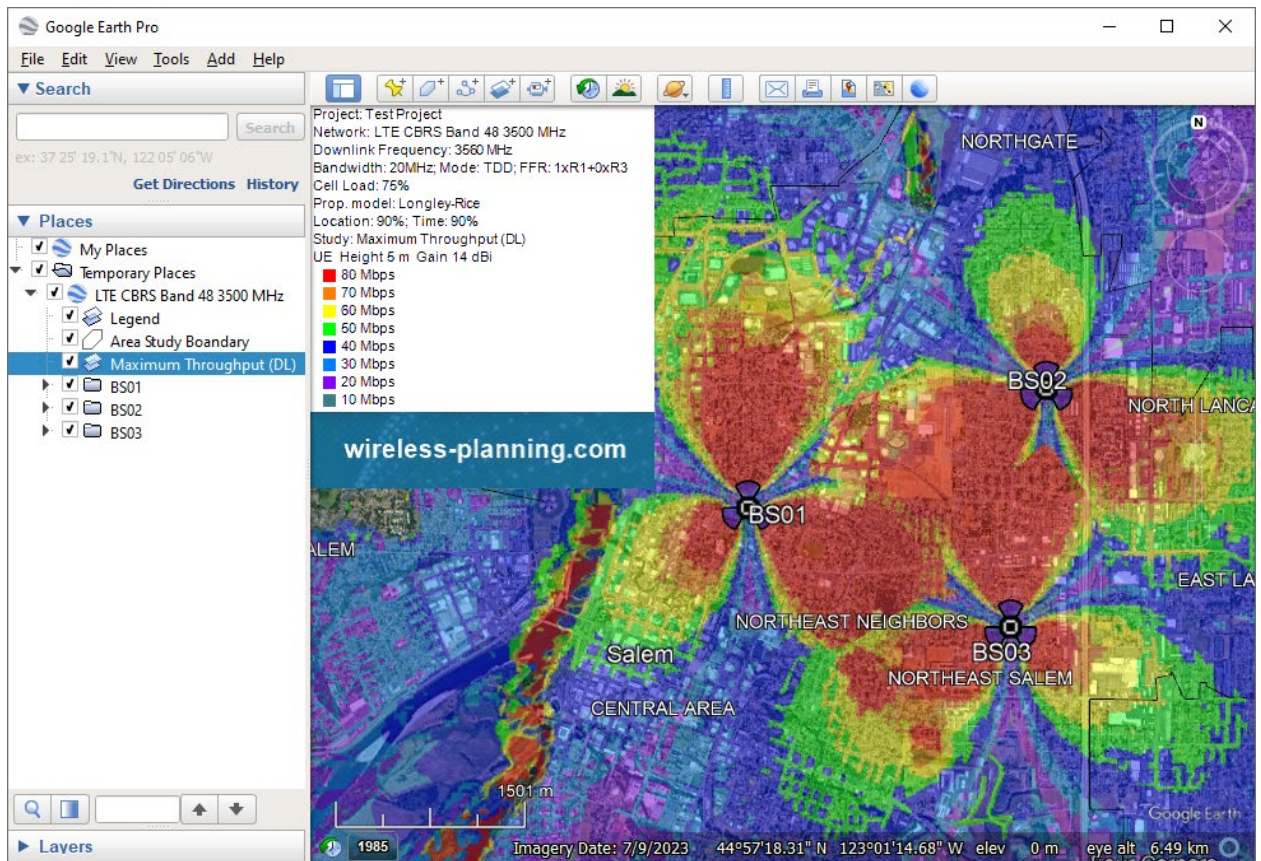
Resulting webpage can also be placed on web server for viewing in any browser and operating system (Windows, Mac, IOS, Android, Linux). This webpage allows you to choose base map from different base maps; change zoom; view basic data from legend; display scale and current coordinates of cursor.

For the webpage to function, you'll need access to the internet as base maps are downloaded from corresponding resources. A folder with a tiles pyramid can be connected to any GIS that supports working with tiles, allowing you to demonstrate coverage as a layer on any GIS (QGIS, MapInfo, ArcGIS, SAS.Planet, etc.).





*Calculation result in the form of HTML page*

 **Save the map as a KMZ file** - Save calculation result as structured KMZ file for Google Earth. If Legend is active, it will appear in upper left corner of Google Earth.



*Calculation result in the form of KMZ*

 **Save the map as a GeoTIFF file** - Save calculation result without a base map as a georeferenced file in geotiff format

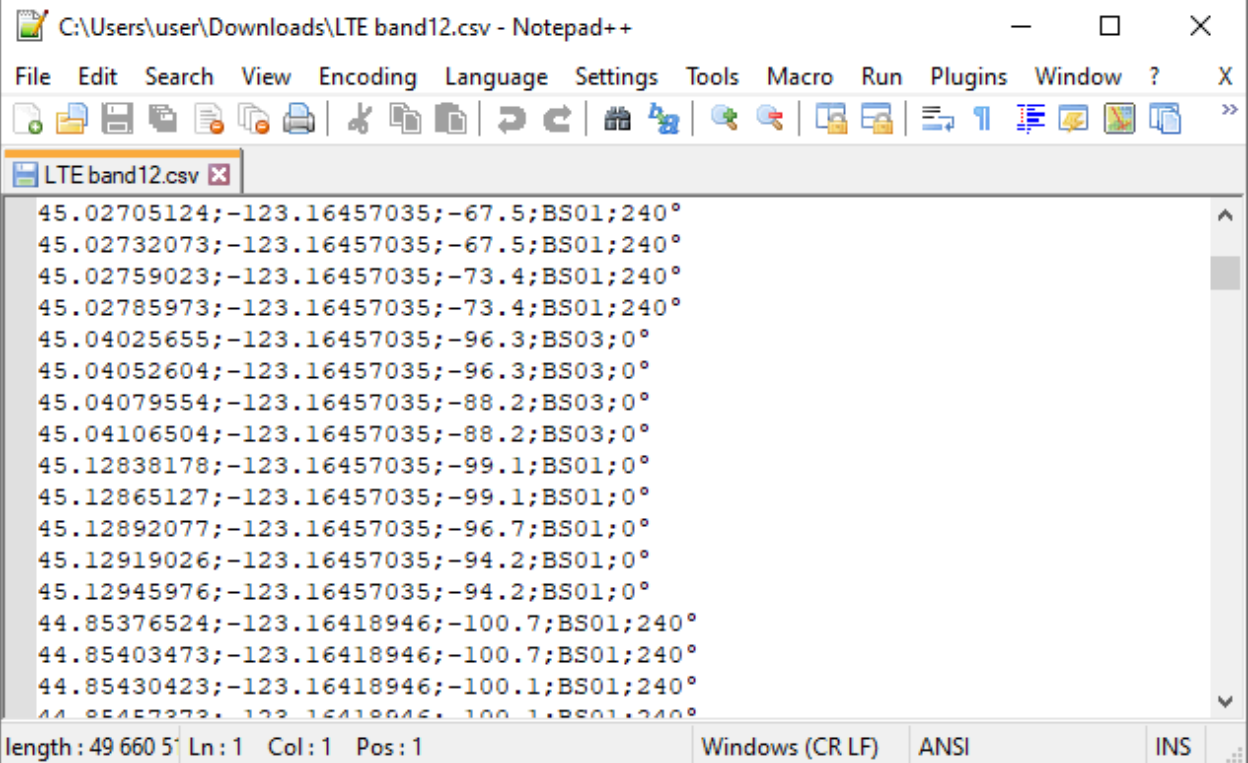
 **Save the coverage in GIS format** – Save the coverage in Text CSV file or Exchange file MapInfo (MIF + MID). Coverage export to these vector formats is necessary for those users who use the coverage for further analysis in various GIS applications.

When saving the file, you will need to specify the space grid with which the result will be saved.

### CSV file format

Each line contains three parameters: geographical latitude; geographic longitude; strongest signal level (Rx power level or field strength); site name; sector azimuth. The separator of parameter values is a semicolon. Formats for geographic coordinates: Degrees Minutes Second (35 36 23.8) or Decimal Degrees (12.34567).





```

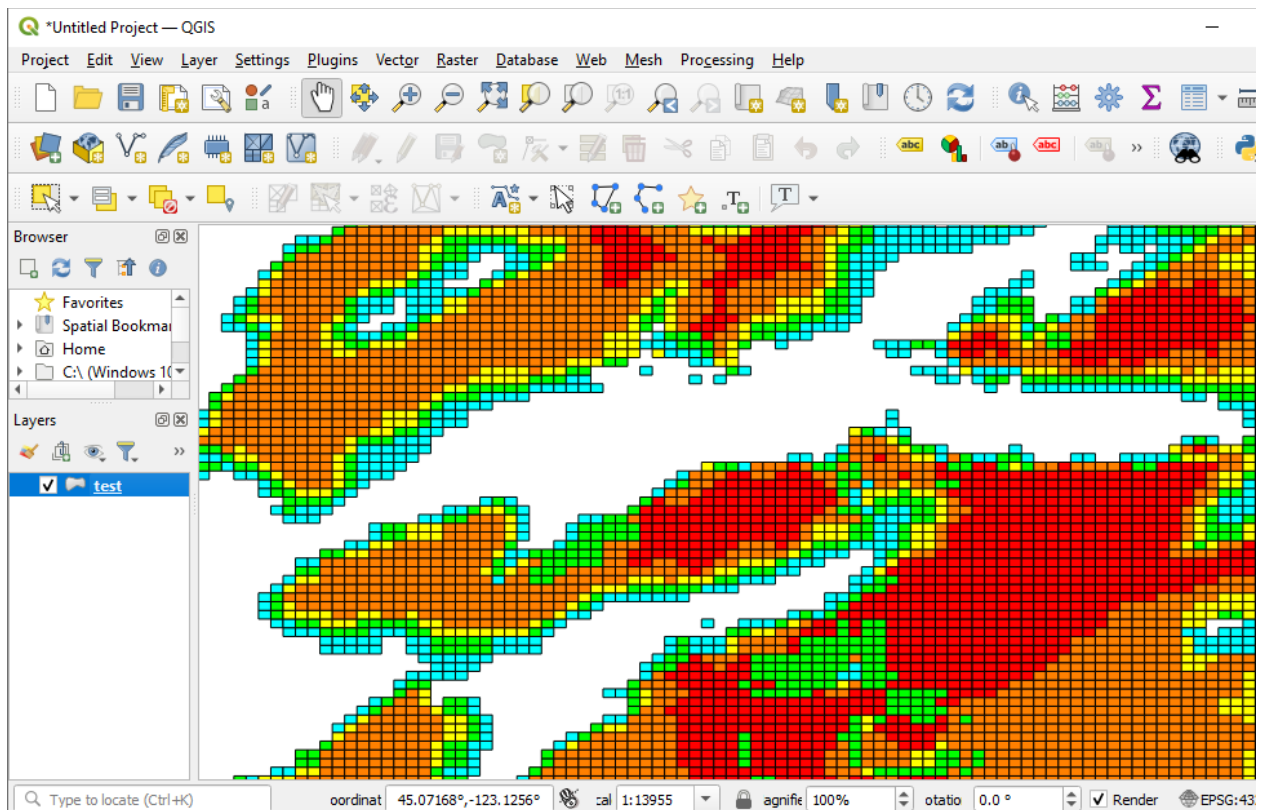
C:\Users\user\Downloads\LTE band12.csv - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ? X
LTE band12.csv x
45.02705124;-123.16457035;-67.5;BS01;240°
45.02732073;-123.16457035;-67.5;BS01;240°
45.02759023;-123.16457035;-73.4;BS01;240°
45.02785973;-123.16457035;-73.4;BS01;240°
45.04025655;-123.16457035;-96.3;BS03;0°
45.04052604;-123.16457035;-96.3;BS03;0°
45.04079554;-123.16457035;-88.2;BS03;0°
45.04106504;-123.16457035;-88.2;BS03;0°
45.12838178;-123.16457035;-99.1;BS01;0°
45.12865127;-123.16457035;-99.1;BS01;0°
45.12892077;-123.16457035;-96.7;BS01;0°
45.12919026;-123.16457035;-94.2;BS01;0°
45.12945976;-123.16457035;-94.2;BS01;0°
44.85376524;-123.16418946;-100.7;BS01;240°
44.85403473;-123.16418946;-100.7;BS01;240°
44.85430423;-123.16418946;-100.1;BS01;240°
44.85457373;-123.16418946;-100.1;BS01;240°
length: 49 660 5 Ln: 1 Col: 1 Pos: 1 Windows (CR LF) ANSI INS

```

*CSV file sample*

### MIF MapInfo file

MIF coverage file is a standard MapInfo exchange file that can be opened in any GIS application.




*MIF Mapinfo Coverage file as a layer in QGIS*

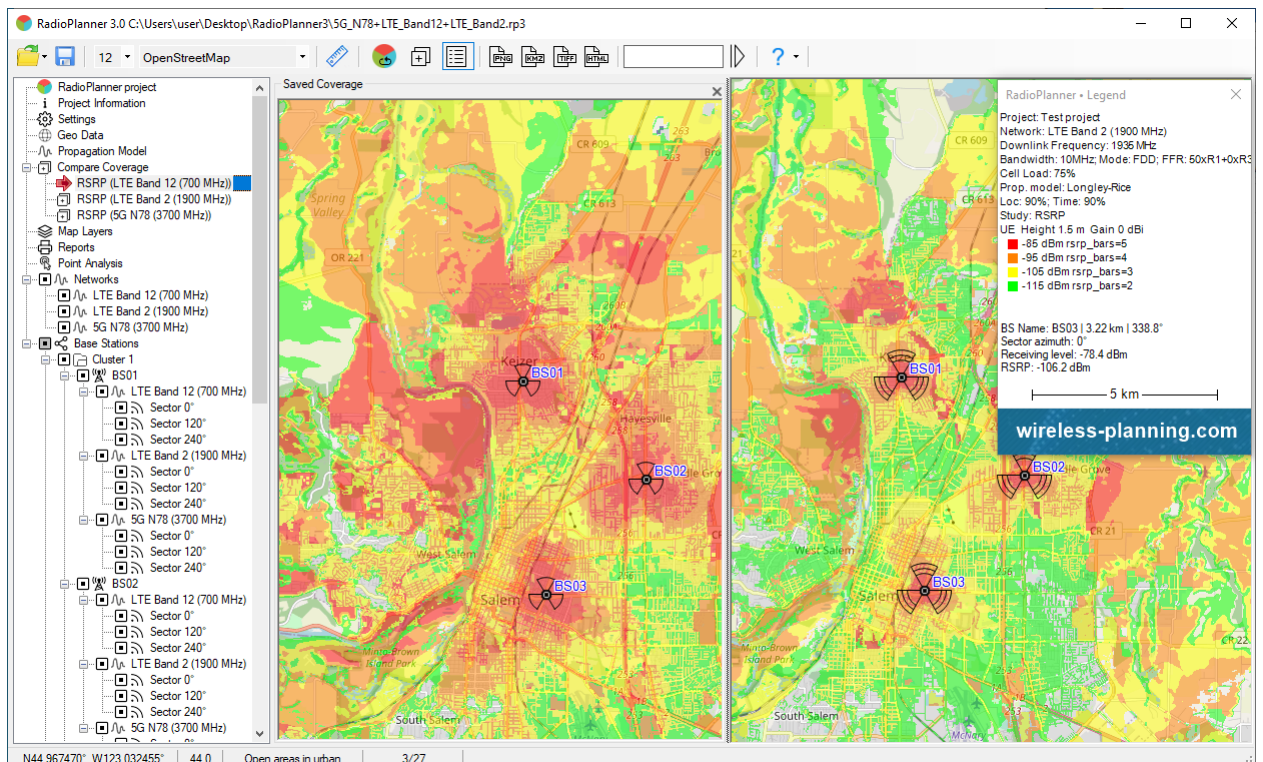
<Feature Name>	<Feature Type>	STRONGEST_SIGNAL	BS_NAME	SECTOR_NAME	<Feature Description>	<Feature Layer Name>	<Index ir
<UNNAMED FE...	Unknown Are...	-87.90	BS03	240°	Unknown Area Type	test.mif	12143
<UNNAMED FE...	Unknown Are...	-89.10	BS03	240°	Unknown Area Type	test.mif	12144
<UNNAMED FE...	Unknown Are...	-90.10	BS03	240°	Unknown Area Type	test.mif	12145
<UNNAMED FE...	Unknown Are...	-90.90	BS03	240°	Unknown Area Type	test.mif	12146
<UNNAMED FE...	Unknown Are...	-90.90	BS03	240°	Unknown Area Type	test.mif	12147
<UNNAMED FE...	Unknown Are...	-90.20	BS03	240°	Unknown Area Type	test.mif	12148
<UNNAMED FE...	Unknown Are...	-89.60	BS03	240°	Unknown Area Type	test.mif	12149
<UNNAMED FE...	Unknown Are...	-89.10	BS03	240°	Unknown Area Type	test.mif	12150

MIF Attribute Table

## Coverage Prediction Comparison

RadioPlanner 3.0 allows you to compare results of current coverage prediction with previously performed predictions. This allows you to evaluate the impact on coverage by changing various site parameters, propagation model, etc.

To add a performed calculation to comparison, click on the  **Add Coverage to Compare button** on top toolbar. When you go to Compare Coverage menu of main toolbar, this calculation result will be located on left side of screen while result of current coverage calculation will be displayed on right side. If Legend is enabled, it will display calculation parameters that mouse pointer is currently over.



### *Coverage Prediction Comparison*

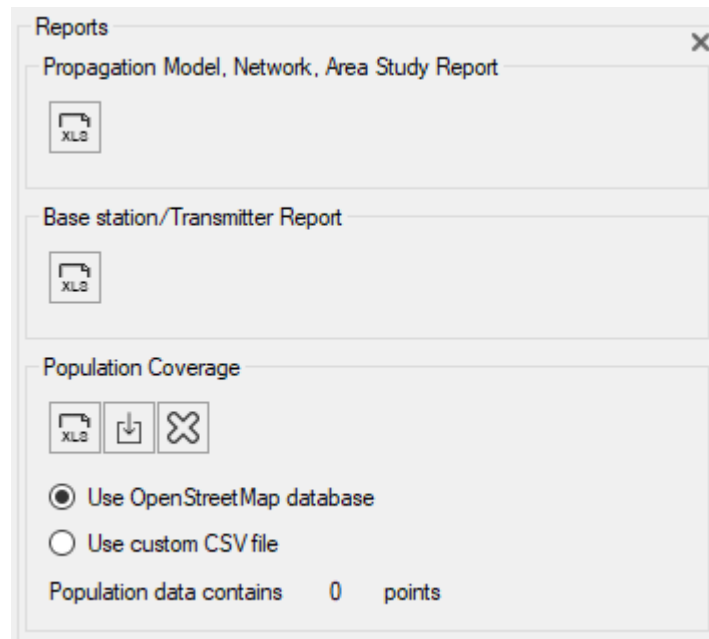
You can add multiple calculations to comparison and their names will appear in tree-view interface under Compare Coverage. When adding a calculation to comparison, RadioPlanner saves all calculation matrices so for large calculations it can take a long time and take up a lot of hard disk space. Manage maps in left and right panels (map shift and zoom) independently of each other. This allows you to compare two results of coverage calculation in detail. To rename a calculation in tree-view interface, double-click on it and rename it. To delete an unnecessary calculation, click on it and press Delete button on keyboard. When closing RadioPlanner, calculations added to comparison are not saved.

## Reports

In the "Reports" menu, you can create different types of project reports - network configuration report, propagation model report, area survey type, and active sites configuration report.

You can also create a report on population coverage (currently only for broadcasting - see the corresponding section of this User Manual).

All types of reports open directly in Excel.



*Reports menu*

Propagation Model, Network, Area Study Report



Open report in Microsoft Excel

	A	B	C	D	E	F	G	H
4	Project Name	Test project						
5	Customer							
6	Data							
7								
8	<b>Network</b>							
9	Name	LTE Band 12 (700 MHz)						
10	System Type	LTE						
11	Downlink	731.5 MHz						
12	Uplink	701.5 MHz						
13	Downlink Rx treshold	-101 dBm						
14	Uplink Rx treshold	-103 dBm						
15	Study radius	20 km						
16								
17	<b>User Equipment (UE)</b>							
18		UE №1	UE №2					
19	Type	Portable	Mobile					
20	Tx Power	0.2 W	0.2 W					
21	Cable and connector loss	0 dB	0 dB					
22	Antenna height	1.5m	1.5m					
23	Antena gain	0 dBi	0 dBi					
24								
25	<b>Propagation Model</b>							
26	Type	Longley-Rice						
27	Situation	90%						
28	Time	90%						
29	Margin	0 dB						
30	Refractivity	301 N-units						
31	Conductivity	0.02 S/m						
32	Dielectric Constant	15						
33	Climate Zone	Continental Temperate						
34	Antenna Polarization	Vertical						
35	Add Clutter Loss	Yes						
36								
37	<b>Area Study</b>							
38	Type	RSRP						
39	UE №1		Description					
40		-85 dBm	rsrp_bars=5					
41		-95 dBm	rsrp_bars=4					
42		-105 dBm	rsrp_bars=3					
43		-115 dBm	rsrp_bars=2					
44								

*Report in Microsoft Excel*

Base station/Transmitter report



Open active site configuration in Microsoft Excel





**Noise-Adjusted Faded Performance Threshold Calculator**

**Receiver parameters**

Reference Sensitivity  $\frac{2}{}$  -119 dBm

Reference Sensitivity  $\frac{2}{}$  0.25  $\mu$ V

Receiver Type  $\frac{2}{}$  ETSI DMR 2 slot TDMA (AMBE +2) (12.5 kHz)  $\downarrow$

Delivered Audio Quality  $\frac{2}{}$  DAQ-3.4  $\downarrow$

Static Carrier to Noise Ratio  $C_s/N$   $\frac{2}{}$  5.3 dB BER = 5 %

Faded Carrier to Noise Ratio  $C_f/N$   $\frac{2}{}$  15.6 dB BER = 2 %

Equivalent Noise Bandwidth  $\frac{2}{}$  7 kHz

Receiver Noise Figure  $\frac{2}{}$  11.2 dB

Faded Performance Threshold  $\frac{2}{}$  -108.7 dBm

**Man-made noise**

Rec. ITU-R P.372-13 Radio noise (50 - 250 MHz)

OFCOM MMN measurement (AY4119) 2003 (50 - 1000 MHz)

TIA TSB-88.2-D Part 2: Propagation and Noise (162 MHz)

Frequency  $\frac{2}{}$  162 MHz

Category  $\frac{2}{}$  Major Metro - Developed, Medium Intensity (23)  $\downarrow$

Man-made Noise (Fam or Nr)  $\frac{2}{}$  16.1 dB

**Result**

Noise-Adjusted Faded Performance Threshold  $\frac{2}{}$  -102.6 dBm

### *Noise-Adjusted Faded Performance Threshold Calculation*

To calculate the Noise-Adjusted Faded Performance Threshold, the user must specify:

1. Reference receiver sensitivity in dBm or  $\mu$ V - This is usually given in the technical specification as receiver sensitivity with 12 dB SINAD for analog systems or with BER = 5% for digital systems.
2. Type of land mobile radio
3. DAQ required, usually DAQ = 3.0 or 3.4
4. Select the research report on which the calculation will be based and the environmental category
5. Specify the carrier frequency.

After changing any field of source data, the calculation is performed automatically. If an empty field appears as a result of the calculation, this means that incorrect data has been entered on receiving equipment (not physically feasible) or man-made noise graphs are beyond the frequencies at which the studies were performed.

## TV and Radio Broadcast Networks Planning

RadioPlanner 3.0 performs broadcast coverage prediction and determines the population in the coverage area based on the OpenStreetMap project database or user data in CSV format. Based on the results of the prediction, a list of settlements covered by broadcasting is formed, indicating the population in each settlement and the total population in the coverage area.

RadioPlanner 3.0 allows you to work with multiple TV or Radio networks in one project. When creating a new project, the first network is created by default.

*Networks menu*



Add a new network

Calculate Coverage (See Coverage predictions for multiple networks section)

Area Study Type	Coverage predictions for multiple networks: - Number of Networks (DL) See Coverage predictions for multiple networks section
Area Study Resolution for all study types	Coverage prediction resolution. Specifies the details of both aggregated calculations and calculations for each of the networks. - Low - Medium - High The resolution corresponds to one pixel of the screen for zoom = 11 (low detail), zoom = 12 (medium), and zoom = 13 (high). For a geographic latitude of 55 degrees, this is approximately 40, 20, and 10 meters, respectively. The higher the resolution, the longer the calculation time.

## Network

The "Network" menu is used to set all parameters for the selected network and calculation parameters. To design television and radio broadcasting networks, you must select the system type "Terrestrial Broadcasting".

Network

Network name: RTRS Multiplex I

System type: Terrestrial Broadcasting

Network parameters

Band: 538 MHz

Study radius: 70 km

Rx antenna height: 10 m

Area study type: Field strength (DL)

Field strength for Mobile Unit N:1

4 Number of levels

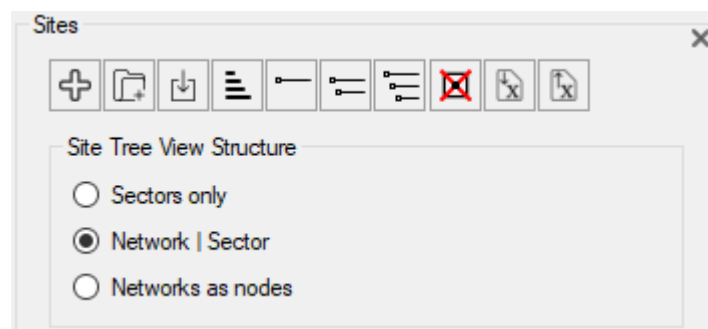
Color	Value	Description
Red	> 58 dB $\mu$ V/m	256 QAM 4/5 PP4 64800
Yellow	53 to 58 dB $\mu$ V/m	64 QAM 4/5 PP4 64800
Green	47 to 53 dB $\mu$ V/m	16 QAM 4/5 PP4 64800
Cyan	41 to 47 dB $\mu$ V/m	QPSK 4/5 PP4 64800

Network menu











	Add a new network with the same parameters (copy the network)
	Check/Uncheck all sectors for current network
	Move the Network up
	Move the Network down
	Delete the network
	Calculate Coverage
	Calculate coverage for each active transmitter and save the map as a KMZ file
	Load network parameters from a template
	Save network parameters as a template


Network name	Name of network, text field
System type	<p>System type options:</p> <ul style="list-style-type: none"> <li>- Generic TRX</li> <li>- LTE</li> <li>- 5G</li> <li>- Terrestrial Broadcasting</li> <li>- Air-to-Ground Radio</li> </ul> <p>The selected system type will determine the set of additional system parameters, as well as the types of coverage predictions available.</p>
Band	Average network frequency, MHz Used only to calculate clutter loss in the ITU-R P.1812 and ITU-R P.1546 propagation models
Rx antenna height	Rx antenna height, m
Study radius	Maximum study radius, km The larger the radius, the longer the computation time. Do not set an unnecessarily large calculation radius.

## Sites




Sites

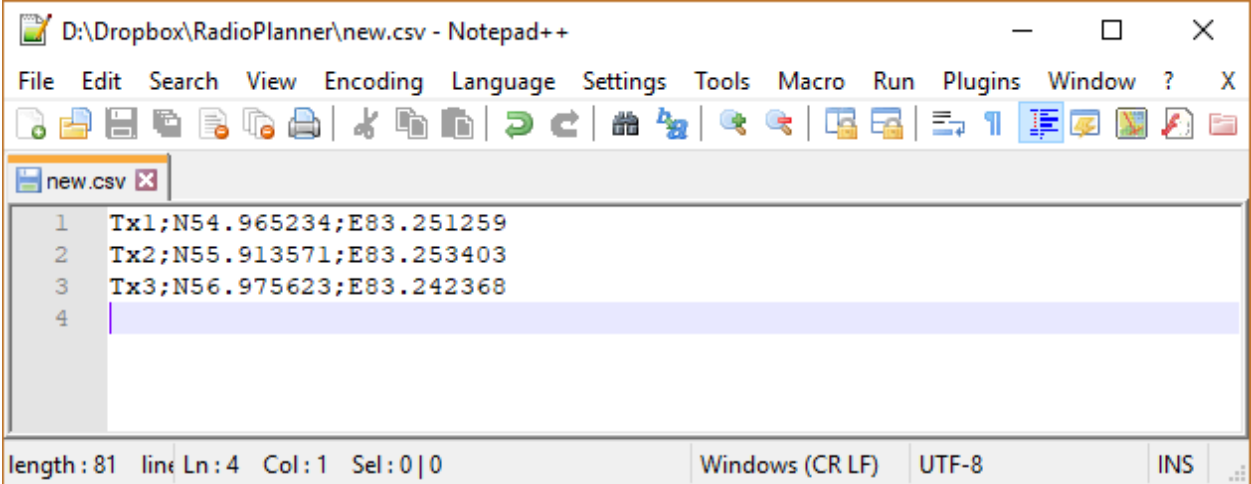
-  Add a new site
-  Add a new site group
-  Import a site list from \*.csv file
-  Sort sites in alphabetical order
-  Collapse of site nodes
-  Collapse all network nodes
-  Expand all site nodes
-  Delete all selected sites
-  Import sites parameters from Microsoft Excel document
-  Export active sites to Microsoft Excel

To create a new site, click on Sites in the Tree View interface, then click the  button in the panel that opens.

### Import sites from \*.CSV file

You can also import sites from CSV files (text format with a semicolon separator). This is a universal format that can be used to save a spreadsheet from any spreadsheet editor (Excel, LibreOffice Calc, etc.) or database. Each point object must have required fields including site name, Latitude, and Longitude. Coordinates can be formatted as HEMISPHERE degrees minutes seconds (N35 23.8 36) or HEMISPHERE decimal degrees (N12.34567).

To import sites, click on the button  (import sites from \*.CSV) and select a CSV file.

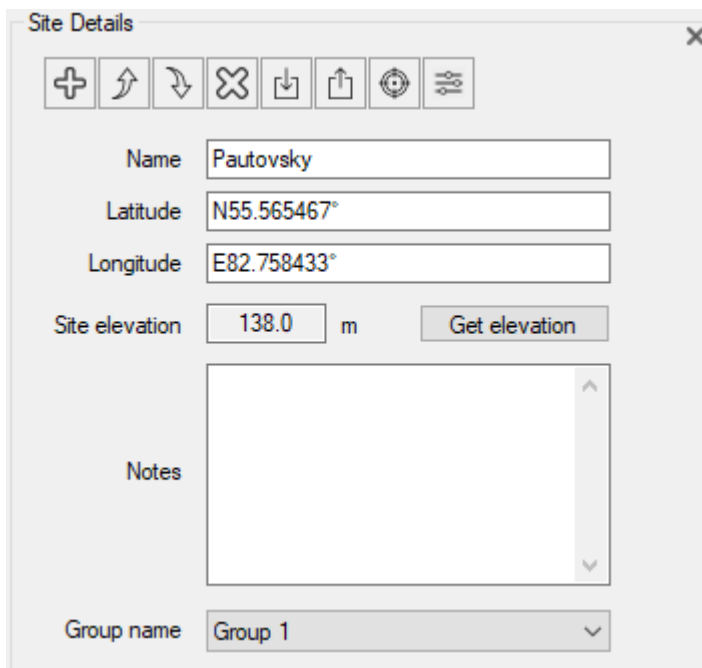


```
D:\Dropbox\RadioPlanner\new.csv - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ? X
new.csv x
1 Tx1;N54.965234;E83.251259
2 Tx2;N55.913571;E83.253403
3 Tx3;N56.975623;E83.242368
4
length: 81 line Ln: 4 Col: 1 Sel: 0|0 Windows (CR LF) UTF-8 INS
```








*CSV file sample*

### Site Details

When clicking on a created site in the Tree View interface panel, the Site Details panel will open where you can edit details such as name, coordinates and additional text information about the site and view elevation relative to sea level.



Site Details

-  Add a new site as a copy of this site
-  Move this site up or down
-  Delete the site
-  Load site sectors of the selected network from a template
-  Save the sectors of the selected network as a template
-  Position the map with the site at the center of the screen
-  Copy Site Parameters to all active Sites

Name	Site name, text field
Latitude	The geographical latitude of the site in the format specified by the user in Settings
Longitude	Geographical longitude of the site in the format specified by the user in Settings
Site Elevation	Site elevation relative to sea level, m
Notes	Text box for any additional site information
Group name	Select site group. Sites can be combined into groups (clusters), allowing you to quickly include/exclude large groups of site from calculations.

## Transmitter Parameters

When creating a site, one transmitter of this site is automatically created. There is an activity icon next to each site and sector in the Tree View interface panel. For a transmitter to be calculated, it must be marked as active (a dot in the center). Clicking on the transmitter will open a panel with its parameters.

**Transmitter Parameters** ✕

+ ↶ ↷ ✕ ≡ 📍 🚗 📶

Network:

Name:

Radio equipment:

---

Frequency:  MHz

Tx power:  W

Minimum field strength:  dBμV/m

Best Server Color:

Tx power: 57 dBm

**Tx antenna**

Antenna Height:  m

Antenna gain:  dBi

Azimuth:  deg.

Beam tilt:  deg.

Antenna model:

---

**Tx transmission loss**

Cable type:

Cable length:  m

Cable loss:  dB

Additional loss:  dB

Total loss:  dB

---

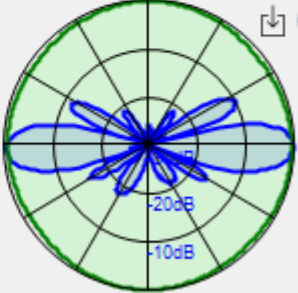
**Simulcast parameters**

Simulcast delay offset:  μs

Antenna patterns in relative dB:

- horizontal

- vertical



EIRP: 65.5 dBm

*Transmitter Parameters*



Add a new transmitter with the same parameters to selected site



Move the transmitter up or down



Delete the transmitter



Global Active Transmitter parameters change. You can replace the selected parameters for all active transmitters as the current transmitter.



Position the map with the transmitter at the center of the screen




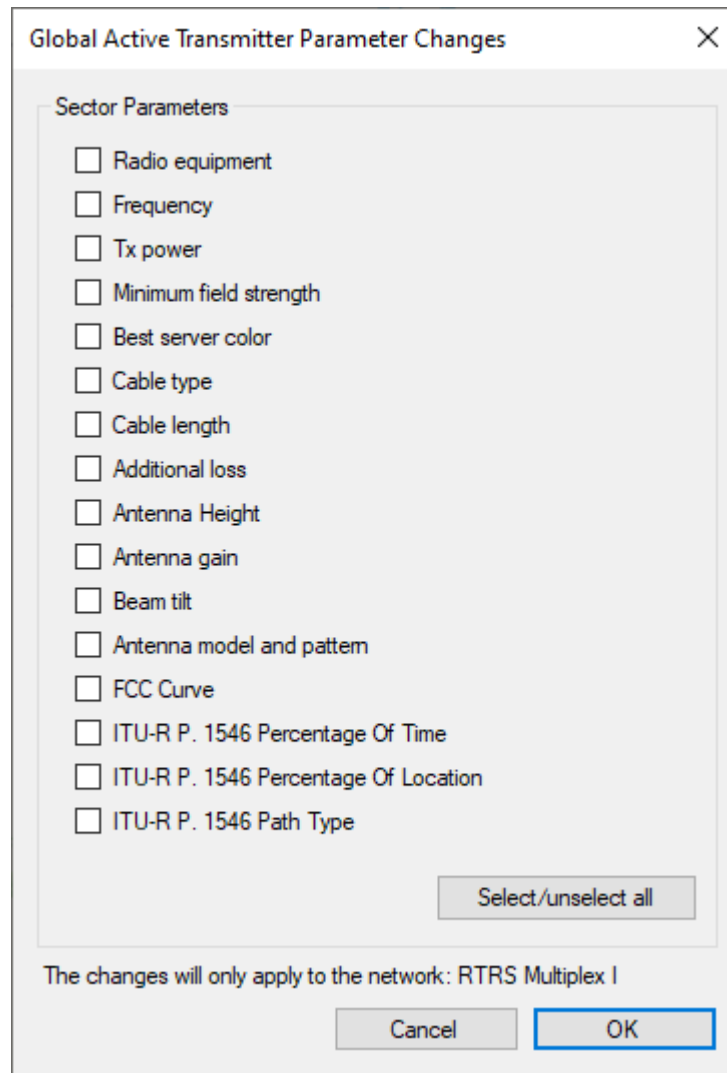
Analysis of measurements along the route. See more details in the "Import Measurement Results and Propagation Model Tuning for TV and Radio Broadcasting Projects" section.




Calculation of service and interference contours using FCC and ITU-R propagation curves.



Network	The network to which the transmitter belongs, select from the drop-down list of networks.
Name	The name of the transmitter, the text field. If left blank, the name "Sector azimuth" with the azimuth value specified in the transmitter parameters panel will be automatically displayed in the tree view panel on the left. If you specify a name in this field, it will be displayed in the tree view.
Radio Equipment	Name (model) of Radio equipment, text field
Frequency	Transmitter carrier frequency, MHz
Tx Power	Transmitter power, W. Same value in dBm for control
Min. field strength, dBuV/m	Minimum field strength required for reception, dBuV/m. An area with a field strength less than the specified value will be excluded from transmitter coverage. This feature is useful for displaying the total coverage area for a network of transmitters operating in different frequency bands or with different modulation levels. Since such transmitters have different minimum field strength required for reliable reception. This value is also used in FCC and ITU-R 1546 contours calculations.
Best Server Color	The color that will be used to indicate the coverage for this transmitter when calculating the Best Server coverage prediction
Cable Length	Main cable length, m
Cable Loss	Loss in cable, dB. Calculated value
Additional Loss	Additional losses, dB - combining losses, losses in jumpers, and connectors. Any additional losses.
Total Loss	Total loss, dB. The calculated value.
Antenna Height	The antenna radiation center height relative to ground level, m
Antenna Gain	Antenna gain relative to isotropic radiator, dBi
Azimuth	The azimuth of the antenna in degrees
Beam Tilt	Tilt the antenna in degrees. Down is negative; up is positive.
Antenna Model	Antenna name, text field. Automatically filled with the antenna pattern file name when selecting a pattern.
	Load MSI antenna pattern file. An antenna pattern file is a standard MSI file that can be downloaded from the antenna manufacturer's website. Antenna patterns are integrated into the project file.
Simulcast delay offset (µs)	Transmitter simulcast delay offset, µs



*Global Active Transmitter Parameter Changes*

**Global Active Transmitter parameters change** is a feature that allows you to instantly change the parameters of any active transmitters to match those of the current transmitter. To perform group parameter changes, mark the transmitters whose parameters need to be changed as active, set the required parameter values in the current transmitter, click on the button , select the parameters that need to be changed in the previously marked active transmitters from the list, and click on the OK button.

## Propagation Models for Radio and TV Broadcasting

When working with television and radio broadcasting projects, one of the following propagation models is usually used:

- ITU-R P.1812-4
- ITU-R P.1546-6
- Longley-Rice (ITM) v 1.2.2

For more information about these models, see the Propagation Models for mobile section.

## Area Study Types

For terrestrial broadcasting systems, you can choose the following types of coverage prediction:

- Field Strength
- Best Server





### Field Strength (DL)

The base map displays areas with different colors, where the corresponding level of radio signal strength is present at the reception point.

Area study type  
Field strength (DL) ▾

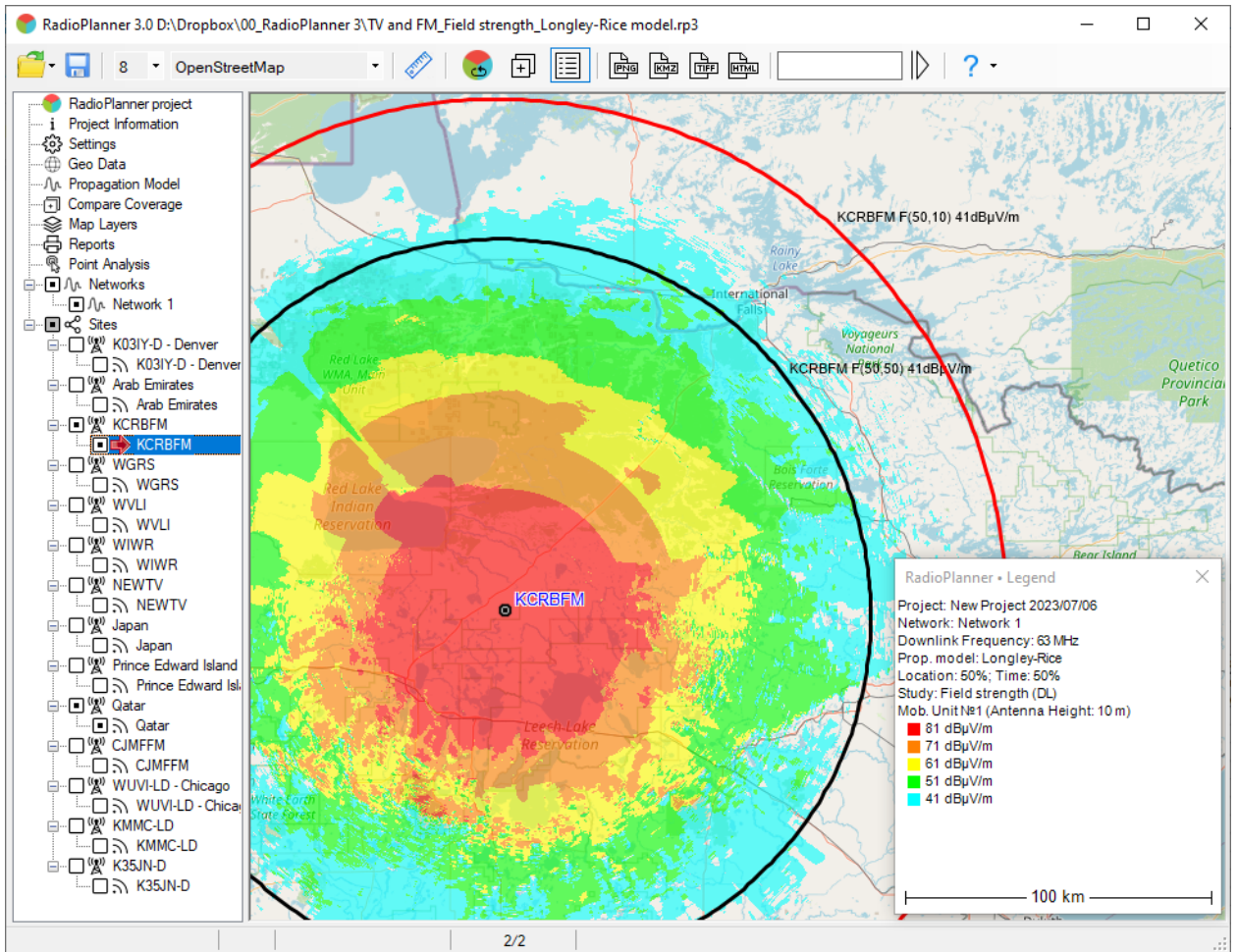
Field strength for Mobile Unit N°1

4 ▾ Number of levels

Color	Value	Description
	> 58 dB $\mu$ V/m	256 QAM 4/5 PP4 64800
	53 to 58 dB $\mu$ V/m	64 QAM 4/5 PP4 64800
	47 to 53 dB $\mu$ V/m	16 QAM 4/5 PP4 64800
	41 to 47 dB $\mu$ V/m	QPSK 4/5 PP4 64800

*Field Strength (DL) menu*

Number of Levels	The number of field strength levels (1-8)
Color	Color level
Values	Field strength, dB $\mu$ V/m
Description	Text field to describe signal level



FM Transmitter Field Strength Coverage

### Best Server (DL)

The Best Server map shows the identity of the transmitter supplying the strongest received signal at each location. The required service threshold for calculating the Best Server is Min. field strength, dBuV/m.

Area study type

Best Server DL

---

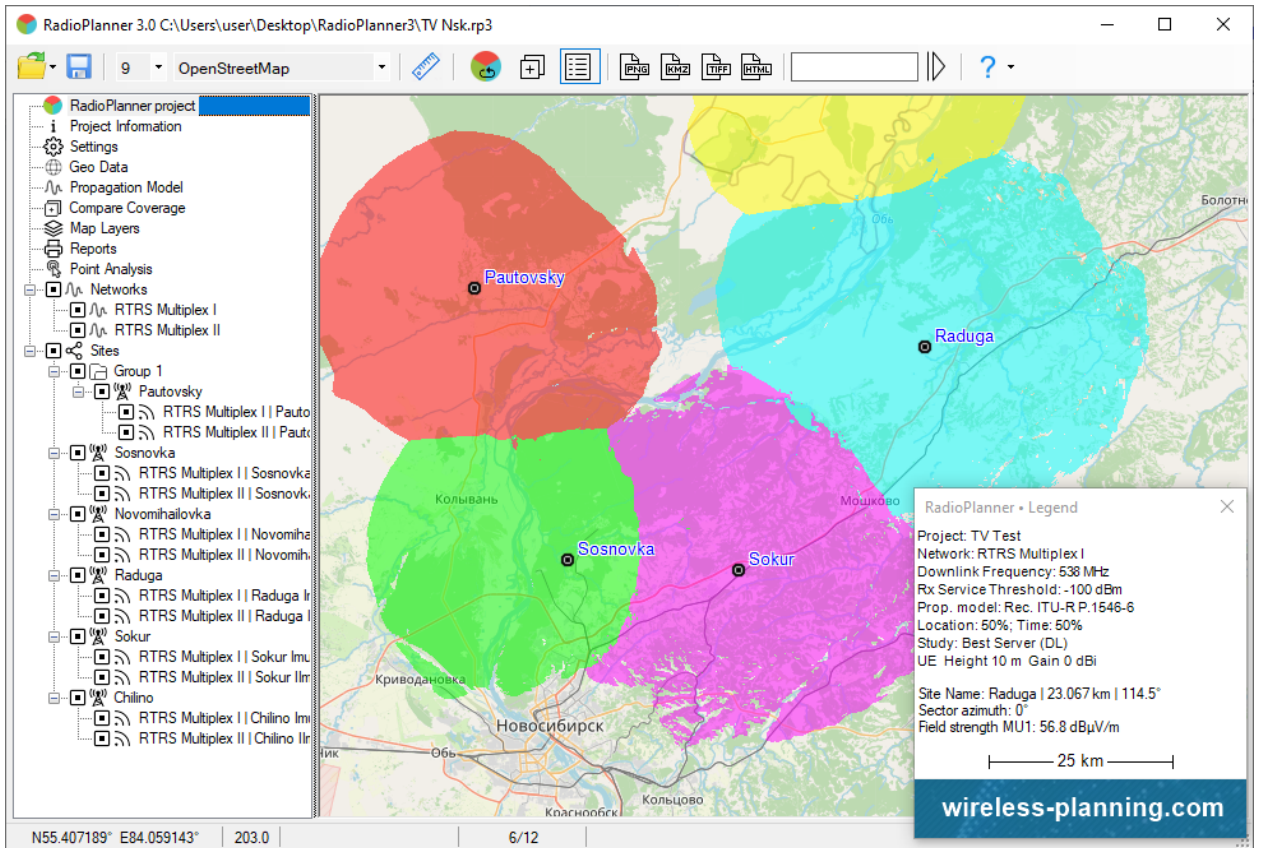
Color assignment for Mobile Unit №1

Apply automatic color assignment

Use colors from sectors

Best Server Study Type Parameters

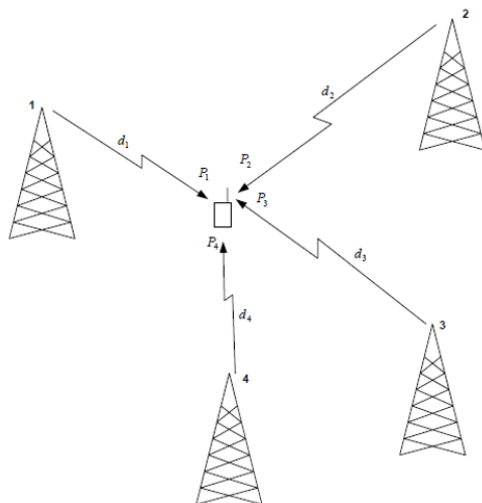
Apply Automatic Color Assignment	Assign colors to transmitters in random order
Use Colors from sectors	Assigning colors from the transmitters parameters



Best Server for TV DVB-T2 network

### Simulcast Delay Spread

This prediction is used for single-frequency network (SFN). Inter symbol interference in the receiver will occur under certain conditions related to delay time between signals arriving at a given location and their relative power. The simulcast delay spread is calculated as follows:



$$T_m = 2 \sqrt{\frac{\sum_{i=1}^N P_i d_i^2}{\sum_{i=1}^N P_i} - \left( \frac{\sum_{i=1}^N P_i d_i}{\sum_{i=1}^N P_i} \right)^2}$$

- $T_m$  Multipath Spread (twice the RMS delay spread)
- $P_i$  Power arriving at a terminal antenna from transmitter  $i$
- $d_i$  Time of flight from transmitter  $i$  to antenna terminal

The simulcast delay spread is calculated by considering only the six strongest signals at any grid analysis location. The results of the calculation are displayed in  $\mu\text{s}$  on the map.

*Simulcast Delay Spread Parameters*

Receiver Simulcast Capture Ratio	For delay spread studies, the delay is calculated and displayed only when the power of the strongest received signal and the power of the second strongest received signal are within the capture ratio of each other.
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Simulcast Delay Spread, $\mu\text{s}$
Description	Text field to describe Simulcast Delay Spread value

To reduce interference between simulcast transmitters, it can be useful to artificially delay the signal transmitted from a given location using Simultaneous Delay Offset entered in Transmitter Parameters. By carefully assigning offsets to different transmitters, some control can be exercised over where interference occurs.

## FCC Contours

RadioPlanner 3.0 allows you to calculate service and interference contours using FCC propagation curves. These contours are used in North America in accordance with FCC rules and are also recommended for use when planning television and FM broadcast stations in some countries.

*FCC and ITU-R Contours*

<b>FCC contour parameters</b>	See the section FCC contours
Curve	FCC curve from set F (50.50); F (50.10); F (50.90).
Add Map Layer	Adding a contour with selected parameters to the map as a layer
<b>ITU-R P.1546-6 contour parameters</b>	See the section ITU-R P.1546-6 Contours
Percentage of time	Percentage of time for which the contour will be calculated (50%, 10% or 1%)
Percentage of location	Percentage of location (receivers) for which the contour will be calculated (50% -99%)
Path type	Land, Cold sea or Warm sea
Add Map Layer	Adding a contour with selected parameters to the map as a layer

To calculate an FCC contour, go to the parameters menu of the transmitter for which you want to calculate the contour. Enter the required value for the electromagnetic field strength (Minimum field strength) and select the type of FCC propagation curve:

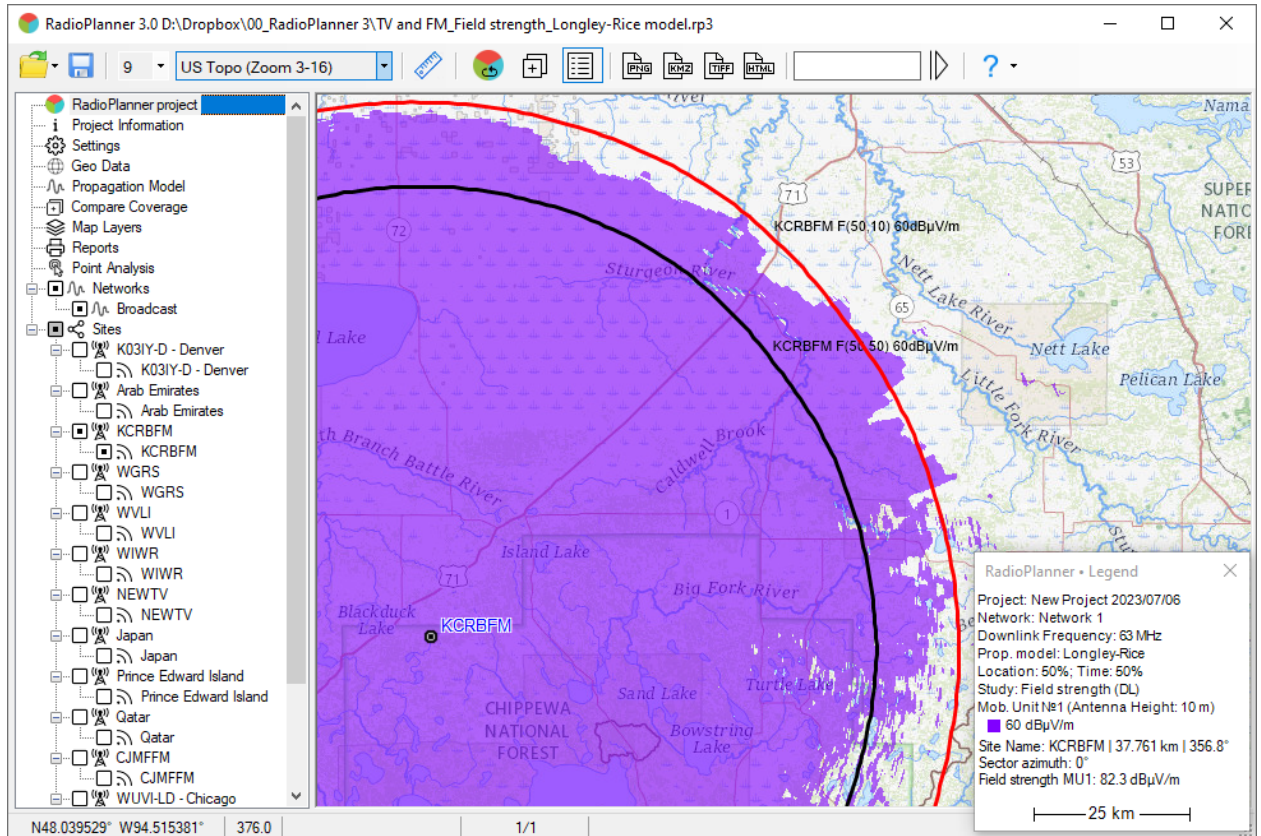
- F (50,50) - Service contour curve for FM broadcasting and analog television
- F (50,10) - Interference contour curve
- F (50,90) - Service contour curve for digital television

After clicking the “Add map layer” button, the FCC contour will appear on the base map as a vector layer. The name of this layer displays information about the transmitter’s name, the type of curve, and the field strength level. By default, service contours are displayed in black and interference contours in red. You can change the display settings of this layer as desired; working with it is no different from working with other vector layers on the map.

The calculation uses the frequency specified in the “Band” item in the “Network” menu.



For more information on designing broadcast stations using FCC curves, see <https://recnet.com/faq-contours> or <https://www.fcc.gov/media/radio/fm-and-tv-propagation-curves-graphs>.



*FCC Contours + Longley-Rice coverage*

## ITU-R P.1546-6 Contours

To calculate an ITU-R P.1546-6 contour, go to the parameters menu of the transmitter for which you want to calculate the contour. Set the value of the electromagnetic field strength (Minimum field strength), select the type of path, and enter the percentage of locations and times for which you want to perform the calculation.

The following contours are commonly used (percentage of locations, percentage of time):

- (50.50) - Service contour for FM broadcasting and television
- (50.10) and (50.1) - Interference contours

After clicking the “Add map layer” button, the ITU-R P.1546-6 contour will appear on the base map as a vector layer. The name of this layer displays information about the transmitter’s name, the type of curve, and the field strength level. By default, all contours are displayed in black. You can change the display settings of this layer as desired; working with it is no different from working with other vector layers on the map.

## Point Analysis in Terrestrial Broadcasting

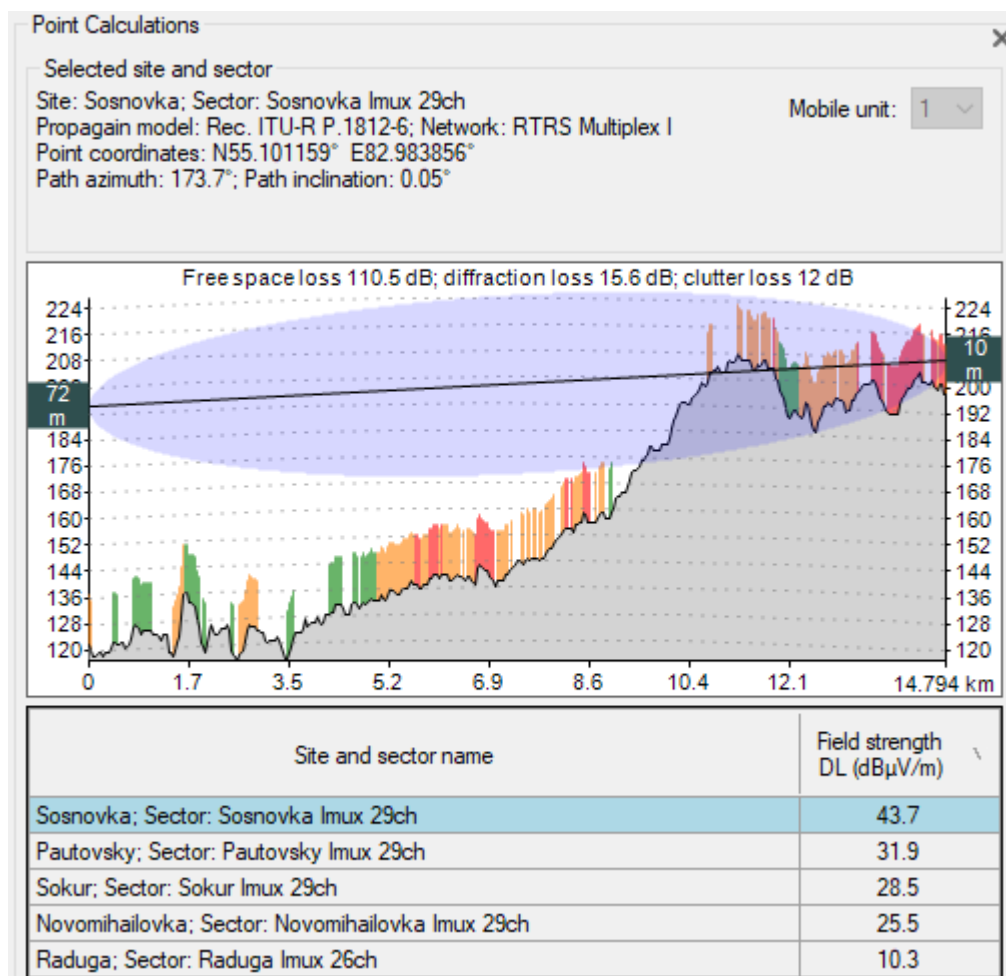
In this panel, you can see results of field strength calculations at any point on the map.

You can change the current point on the map by clicking on a new location with your mouse. The path profile is a vertical section of terrain between transmitter and receiver that shows information about elevations and clutter. The colors that mark various obstacles on the profile correspond to those used in the clutter model.

The path profile shows antenna radiation center heights for both transmitter and receiver as well as Fresnel zone for radio beam, free space loss, diffraction loss due to terrain and clutter surrounding the receiver.

Find the required transmitter and click on it with your mouse (not to be confused with activity tag). Information about selected sector will appear above path profile.

Below path profile is a table displaying results of field strength calculations.



Point Analysis

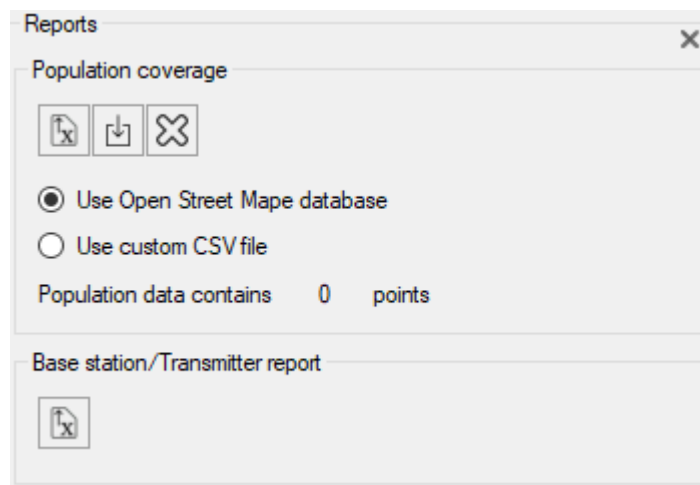
## Calculation of the Population Covered by Television and Radio Broadcasting

RadioPlanner allows you to determine the population in the coverage area. Based on the calculation results, a list of localities covered by broadcasting is formed, indicating the population in each locality and the total population in the coverage area.

To calculate population covered, you first need to calculate the downlink field strength coverage for the transmitter (or several transmitters). The population covered will be made for the lowest field strength level used in the calculation.

The population and list of localities covered by the broadcast can be obtained from the OpenStreetMap project data or a local dataset (CSV file). In both cases, the population covered is counted according to the following algorithm. In the center of each settlement, there is a point, the entry of which into the coverage area with a given field strength is the basis for including the entire population of this settlement into the coverage area. If the OpenStreetMap database is used for the calculation (in this case, a copy of the database located on our server is accessed), then these points are point objects - settlements with the tag place = city; town; village; hamlet, and the corresponding population tag.

To calculate the population covered, go to the "Report" menu and select the calculation method - using OpenStreetMap database or a custom CSV file. If you have selected the OpenStreetMap database, then click on the "Open Report" tool and a spreadsheet will appear with the population and the list of settlements covered by the broadcast. This spreadsheet will also show the total area of coverage in square kilometers, as well as the average coverage radius (only when calculating coverage from a single transmitter).



*Reports panel*



Open population coverage report in Microsoft Excel



Import population data from CSV file



Delete population data

	A	B	C	D	E	F	G
1	Locality	Population		Coverage area, km <sup>2</sup>	Average radius of coverage, km		
2	Québec	530168		16809.8	73.1		
3	Lévis	143414					
4	Trois-Rivières	134413					
5	Saint-Augustin-de-Desmaures	18820					
6	L'Ancienne-Lorette	16543					
7	Saint-Boniface	4832					
8	Boischatel	4751					
9	Château-Richer	3527					
10	Saint-Maurice	3286					
11	Saint-Isidore	3017					
12	L'Ange-Gardien	2946					
13	Sainte-Anne-de-Beaupré	2775					
14	Wendake	2134					
15	Sainte-Anne-de-la-Pérade	2072					
16	Vallée-Jonction	1972					
17	Champlain	1742					
18	Saint-Joachim	1489					
19	Sainte-Agathe-de-Lotbinière	1200					
20	Saint-Norbert-D'Arthabaska	1166					
21	Saint-Rosaire	843					
22	Saint-Séverin	281					
23	<b>TOTAL</b>	<b>881391</b>					

### Population Coverage Report

If you want to use custom population data to calculate population coverage, prepare a text CSV file in the format described below.

1	Ureysk;50.298889;113.217222;907
2	Dorozhnoye;50.314722;113.176667;168
3	Ulacha;50.403333;113.272778;365
4	Mogoty;50.352500;113.832500;802
5	Tokhtor;50.079167;113.354444;411
6	Narasun;50.088611;112.979722;1013
7	Karulga;50.118056;112.761944;418

Sample CSV text file with population data

Required data for each locality: The name of the settlement; Latitude; Longitude; Population

The data separator is the semicolon character.

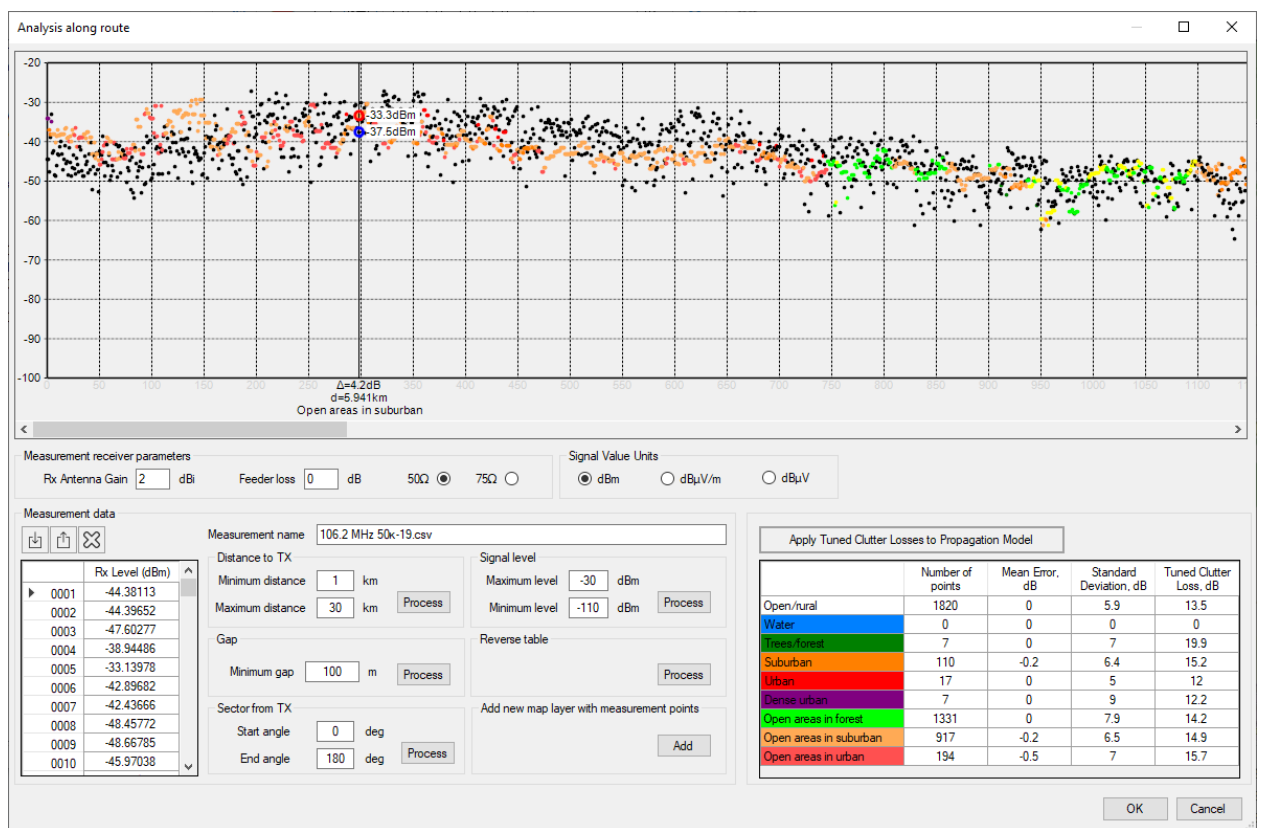
Coordinate presentation formats - HEMISPHERE DEGREES MINUTES SECOND (N35 36 23.8) or HEMISPHERE DECimal DEGREES (N12.34567).

To import data on population from a CSV file, click on the button "Import population data from CSV file" and select file, after which the program will show the total number of settlements with data on the


population. Click on the "Open Report" tool and a spreadsheet will appear with the population and the list of settlements covered by the broadcast.


## Import Measurement Results and Propagation Model Tuning for TV and Radio Broadcasting Projects


RadioPlanner 3.0 allows you to tune clutter loss for a propagation model by comparing measurements with predicted Rx power values. Loading, preprocessing and analysis of measurement file is performed in transmitter panel.



### Measurement Analysis Along Route for FM

 Import of measurement data from a CSV file

 Export of measurement data to a CSV file

 Delete measurement data

Rx Antenna Gain  dBi Measurement receiver antenna gain, dBi

50Ω  75Ω  System type, Ohm

Feeder loss  dB Antenna cable loss, dB

Signal Value Units  
 dBm  dBμV/m  dBμV  
 Select signal units to display

#### Tools for preliminary processing:

Distance to TX Minimum/Maximum Distance	Limit the points that will be included in the comparison by distance from the transmitter
Signal level Minimum/Maximum Level	Limit the points that will be included in the comparison by received power level from the transmitter
Gap Minimum Gap	Perform averaging of the power level within a given segment
Sector from TX Minimum/Maximum Angle	Limit the points that will be included in the comparison by azimuth from the transmitter
Reverse table	Change the order of points in the route (the last point becomes the first, the penultimate point becomes the second, and so on)
Add New Layer with Measurement Points	Add a custom measurement layer to the map. The resulting layer will appear among the user layers; the layer name will correspond to the transmitter and antenna direction.

#### Measurement file in CSV format

Each of the lines in this file contains three parameters: the level of the measured signal from transmitter in dBm; geographical latitude; geographic longitude

The separator of parameter values is a semicolon.

Formats for the representation of geographic coordinates are Hemisphere Degrees SECOND MINUTES (N35 36 23.8) or HEM DECIMAL DEGREES (N12.34567).

```

1 -88.2 ; N57.6761283874512 ; E38.613208770752
2 -85.2 ; N57.6757431030273 ; E38.6172218322754
3 -86.4 ; N57.6755828857422 ; E38.6215744018555
4 -85.7 ; N57.6750068664551 ; E38.6251831054688
5 -88.8 ; N57.6754493713379 ; E38.6297950744629
6 -91.9 ; N57.6752128601074 ; E38.6337928771973
7 -93.4 ; N57.6748466491699 ; E38.6377906799316
8 -91.6 ; N57.674373626709 ; E38.6426734924316
9 -91.8 ; N57.6738243103027 ; E38.6467018127441
10 -93.5 ; N57.6734352111816 ; E38.6508445739746
  
```

Measurement file in CSV format

**Operating procedure:**

1. Based on the results of field measurements, prepare a file with the measurements results.
2. Specify the antenna gain, cable loss and impedance for the measuring receiver path. The height of the receiving antenna is set in the network parameters.
3. Upload measurement files to the transmitter. The results of the measured and calculated receiving levels along the route will appear. Measurement levels are indicated in black, calculated levels - in a color that corresponds to the clutter type at a given point (yellow - open space). The abscissa shows the route point numbers. Hovering over the plot displays the calculated and measured levels, the difference in levels, the distance to the site in kilometers, and the clutter type. If necessary, perform the preliminary processing. When you click on the plot, a context menu appears, in which you can delete a point with the measurement result.

The table below the plot will indicate the number of points, the average error, the standard deviation of the error, as well as the recommended loss values for different clutter types, at which the average error will be zero. When you click on the button "Apply Tuned Clutter Losses to Propagation Model", the values for the points of the plot will be recalculated taking into account the tuned values, as well as the loss values in the "Propagation Model" menu will be changed. To assess how the new obstacle loss values will affect the coverage calculation result, you need to re-calculate the coverage.

4. Now, based on the analysis of the results obtained for different clutter types and for different transmitters, a decision is made regarding the need to tune the values of the previously used clutter losses in the propagation model.



## Air-to-Ground Communication Coverage Prediction

RadioPlanner 3.0 can predict coverage for Air-to-ground communication and radio navigation systems operating in VHF, UHF, and microwave frequencies: UAV (Drone) Control, Air-to-ground radio, ADS-B, VOR, DME.

The system type must be set to Air-to-Ground Radio. The set of parameters for the Site and Mobile Unit is similar to that of the mobile communication network.

### Network

The “Network” menu is used to set all parameters for the selected network, including mobile station parameters and calculation parameters. You can also perform calculations for the network using this menu.

Network
✕

+ □ ↶ ↷ ✕ ☰ 🌈 KMZ ↓ ↑

Network name

System type Air-to-Ground Radio ▾

**Network parameters**

Ground-to-air  MHz      Air-to-ground  MHz

Aircraft Rx threshold  dBm      Ground Rx threshold  dBm

Study radius  km

	Mobile Unit №1
Type	Icom IC-A220
Tx power (W)	8
Cable and connectors loss (dB)	0
Antenna height (m)	1500
Antenna gain (dBi)	0

Area study type

Received Power Air-to-Ground Link ▾

Mobile antenna height reference

Sea level       Ground level

**Mobile antenna heights**










5 ▾ Number of levels

Color	Height	Description
	<input type="text" value="300"/> m	<input type="text"/>
	<input type="text" value="500"/> m	<input type="text"/>
	<input type="text" value="1500"/> m	Robinson R44 cruise altitude
	<input type="text" value="3000"/> m	<input type="text"/>
	<input type="text" value="4250"/> m	Robinson R44 max altitude

Network menu for Air-to-Ground Radio



Add a new network with the same parameters (copy the network)

	Check/Uncheck all sectors for current network
	Move the Network up
	Move the Network down
	Delete the network
	System parameters
	Calculate Coverage
	Calculate coverage for each active sector and save the map as a KMZ file
	Load network parameters from a template
	Save network parameters as a template

Network name	Name of network, text field
System type	System type options: <ul style="list-style-type: none"> <li>- Generic TRX</li> <li>- LTE</li> <li>- 5G</li> <li>- Terrestrial Broadcasting</li> <li>- Air-to-Ground Radio</li> </ul> <p>The selected system type will determine the set of additional system parameters, as well as the types of coverage predictions available.</p>
Ground-to-Air	Carrier frequency towards aircraft, MHz
Air-to-Ground	Carrier frequency to ground, MHz
Aircraft Rx threshold	This threshold value will limit the coverage prediction display based on whether the signal received at the aircraft from the ground base station is above or below this threshold, dBm
Ground Rx threshold	This threshold value will limit the coverage prediction display based on whether the signal received at the ground base station from the aircraft is above or below this threshold, dBm
Study radius	Maximum study radius, km The larger the radius, the longer the computation time. Do not set an unnecessarily large calculation radius.

#### Mobile Units

Type	Name (model) of Mobile Unit, text field
Tx Power	Transmitter power, W
Cable and Connector Loss	Loss in cable and connectors, dB
Antenna Height	Antenna height relative to ground level, m
Antenna Gain	Antenna gain, dBi

### Propagation Model for Air-to-Ground Radio

The propagation model is a combined model based on the recommendation ITU-R P.528-3 (02/2012), "Propagation curves for aeronautical mobile and radio navigation services using the VHF, UHF, and SHF bands" and the recommendation ITU-R P. 526-14 "Propagation by Diffraction."

The hybrid model takes into account the following factors affecting the propagation of radio waves along the air-to-ground path:

- Free space loss
- Diffraction loss along the path taking into account the curvature of the Earth and the terrain profile extracted from the DTM
- Variation of the received radio signal due to multipath fading

*Propagation model for Air-to-Ground Communication*

Time Availability, %	By choosing a particular time percentage, the calculated received power values are the power levels that will be exceeded at least that percentage of time.
Margin, dB	Prediction confidence margin. Since the received power level calculations are estimates, the prediction margin lets you specify a safety margin in dB so that you can be more confident that your signal level estimate is indeed above the specified signal level.

## Area Study Types for Air-to-Ground Communication

For the Air-to-Ground Communication project, you can choose one of the following area study types:

- Received power Air-to-Ground link
- Received power Ground-to-Air link
- Best Server Air-to-Ground link

The area study resolution for air-to-ground calculations corresponds to one screen pixel for magnification = 7 (Low), magnification = 8 (Medium), and magnification = 9 (High). For a geographic latitude of 55 degrees, this is approximately 720, 360 and 180 meters, respectively. The higher the resolution, the longer it takes to calculate.

### Received Power Air-to-Ground/Ground-to-Air Link

In these types of calculations, the map displays different colors of coverage areas for different heights of the Mobile Unit (aircraft). You can set from one to eight different altitude levels.

Area study type  
 Received Power Air-to-Ground Link

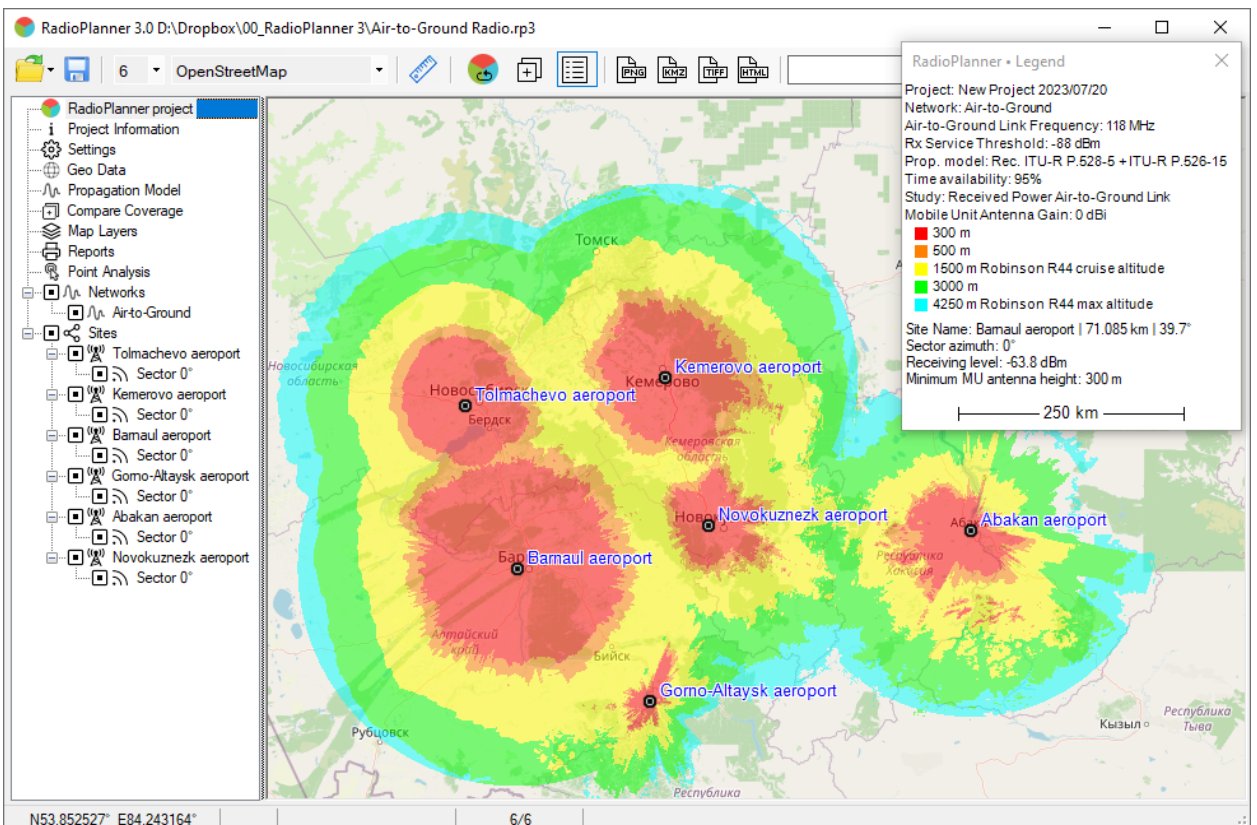
Mobile antenna height reference  
 Sea level  Ground level

Mobile antenna heights  
 5 Number of levels

Color	Height	Description
<span style="color: red;">■</span>	300 m	
<span style="color: orange;">■</span>	500 m	
<span style="color: yellow;">■</span>	1500 m	Robinson R44 cruise altitude
<span style="color: green;">■</span>	3000 m	
<span style="color: cyan;">■</span>	4250 m	Robinson R44 max altitude

Received power Air-to-ground link

Mobile Antenna Height Reference	- Sea level - Ground level
Number of Levels	Number of altitude levels
Color	Color level
Height	The value of the height of the mobile unit for which coverage area is displayed in meters.
Description	Text field



Air-to-Ground Radio Coverage

### Best Server Air-to-Ground Link

The Best Server map is a map showing the identity of the sector supplying the strongest received signal at each grid location.

**Area study type**

Best Server Air-to-Ground Link ▼

---

**Mobile antenna height reference**

Sea level
  Ground level

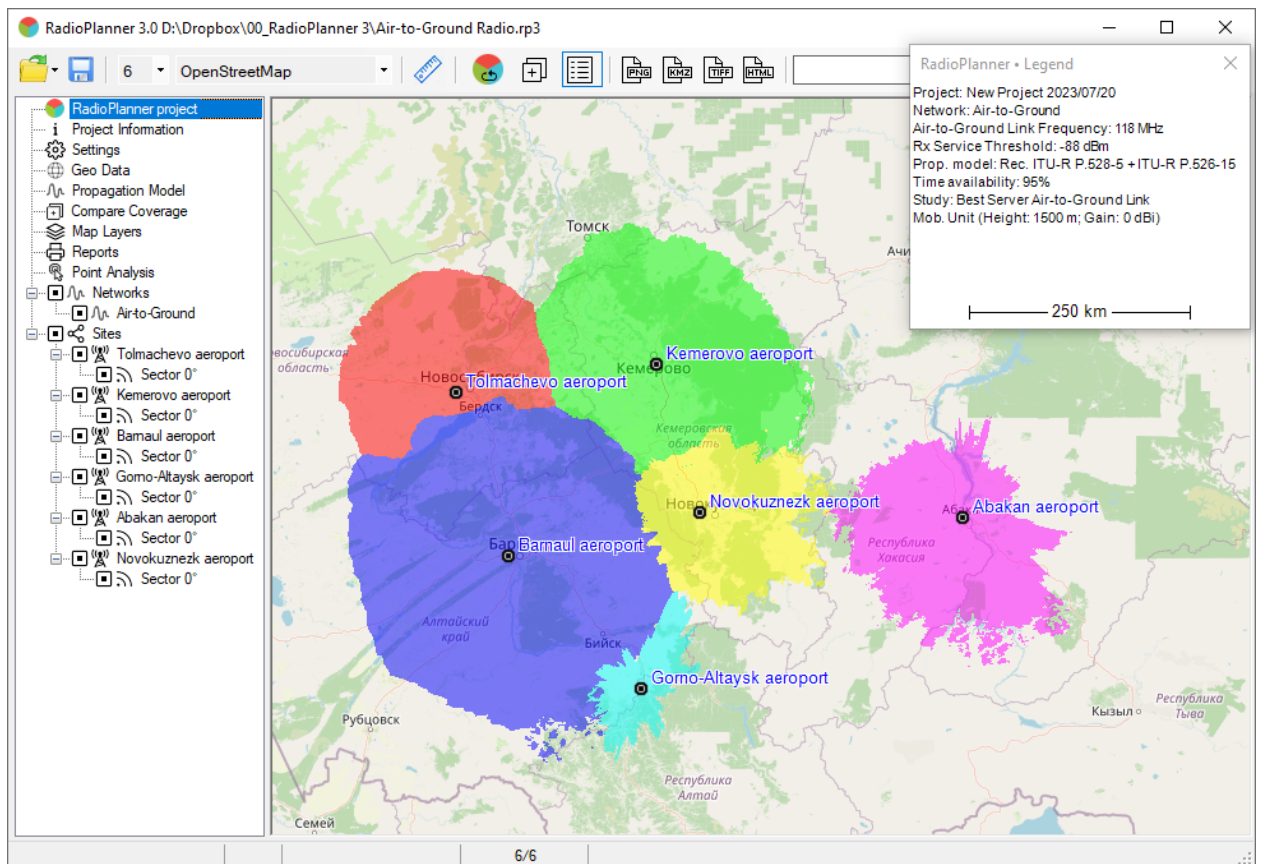
---

**Color assignment**

Apply automatic color assignment
  Use colors from sectors

*Best Server menu*

Mobile Antenna Height Reference	- Sea level - Ground level
Apply Automatic Color Assignment	Assign colors to sectors in random order
Use Colors from sectors	Assigning colors to sectors from the sector parameters



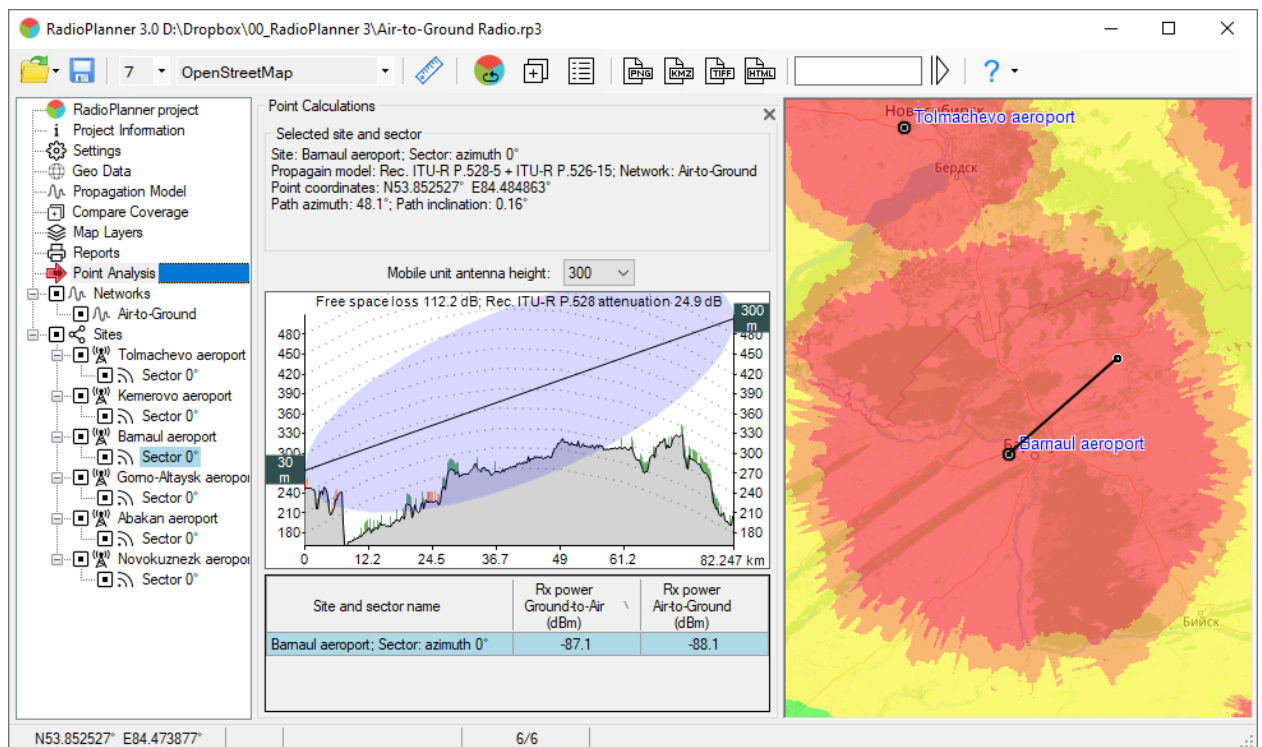
*Best Server Air-to-Ground Radio Coverage*

## Point Analysis for Air-to-Ground Communication

This menu displays the terrain profile from the selected site to any point at the height of the mobile unit. The current point on the map can be changed with a mouse click.

The terrain profile shows the heights of the radiation centers of the antennas of the site and mobile unit, as well as the 60% Fresnel zone for the radio beam, free space loss, and diffraction loss due to the terrain. The site for which the profile will be shown is selected in the left part of the panel in the general sites tree. Click on the required site sector (not to be confused with the activity icon), after which information on this sector will appear above the terrain profile.

The height of the mobile unit is selected in the drop-down list on the right above the terrain profile from the set of heights specified for calculating coverage areas in Area Study Details - Received Power Air-to-Ground link. The maximum path profile length is limited by the Study Radius parameter in the Network menu.

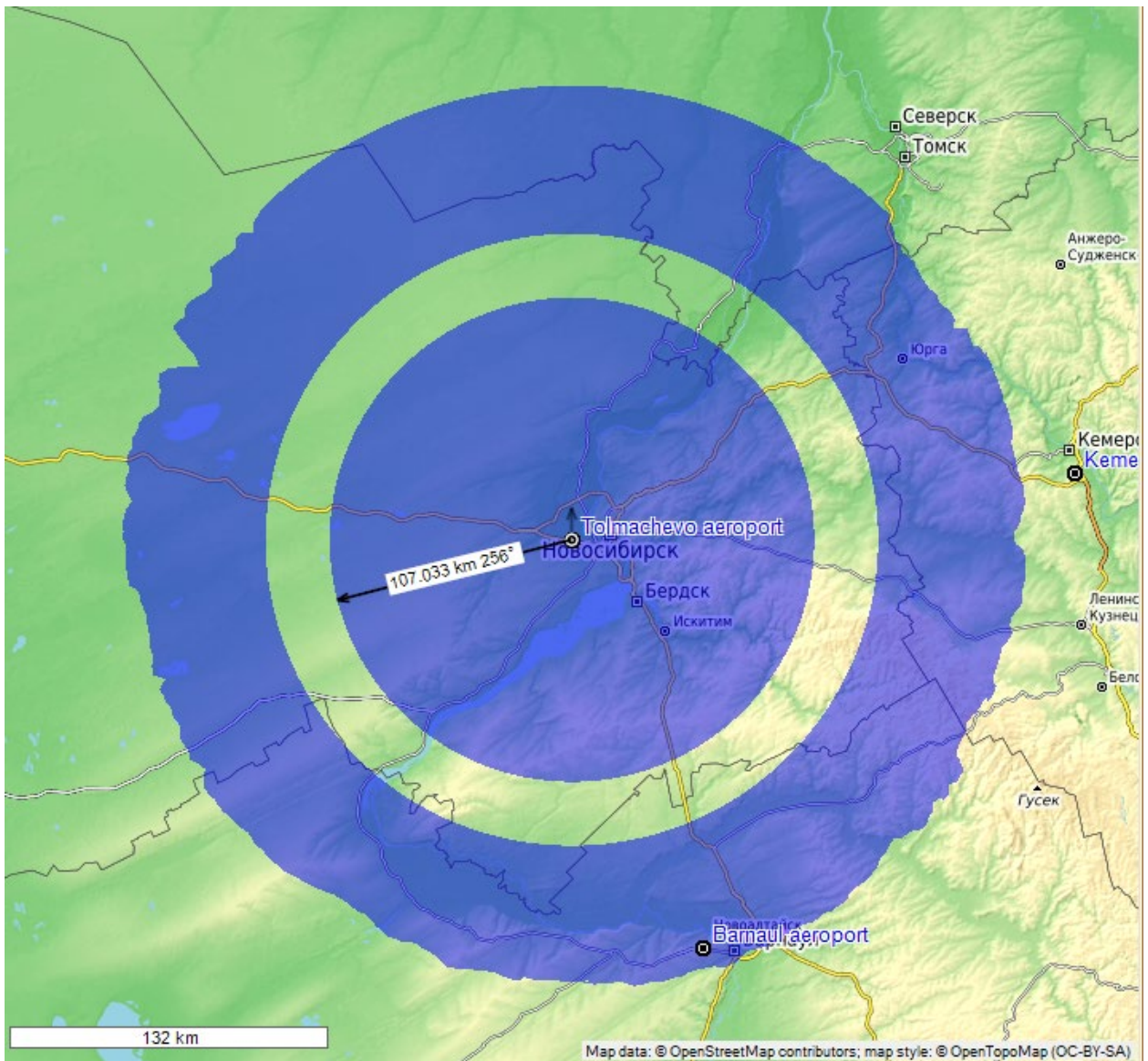


*Point Analysis*

## Some Features of Coverage Calculating for Air-to-Ground Radio

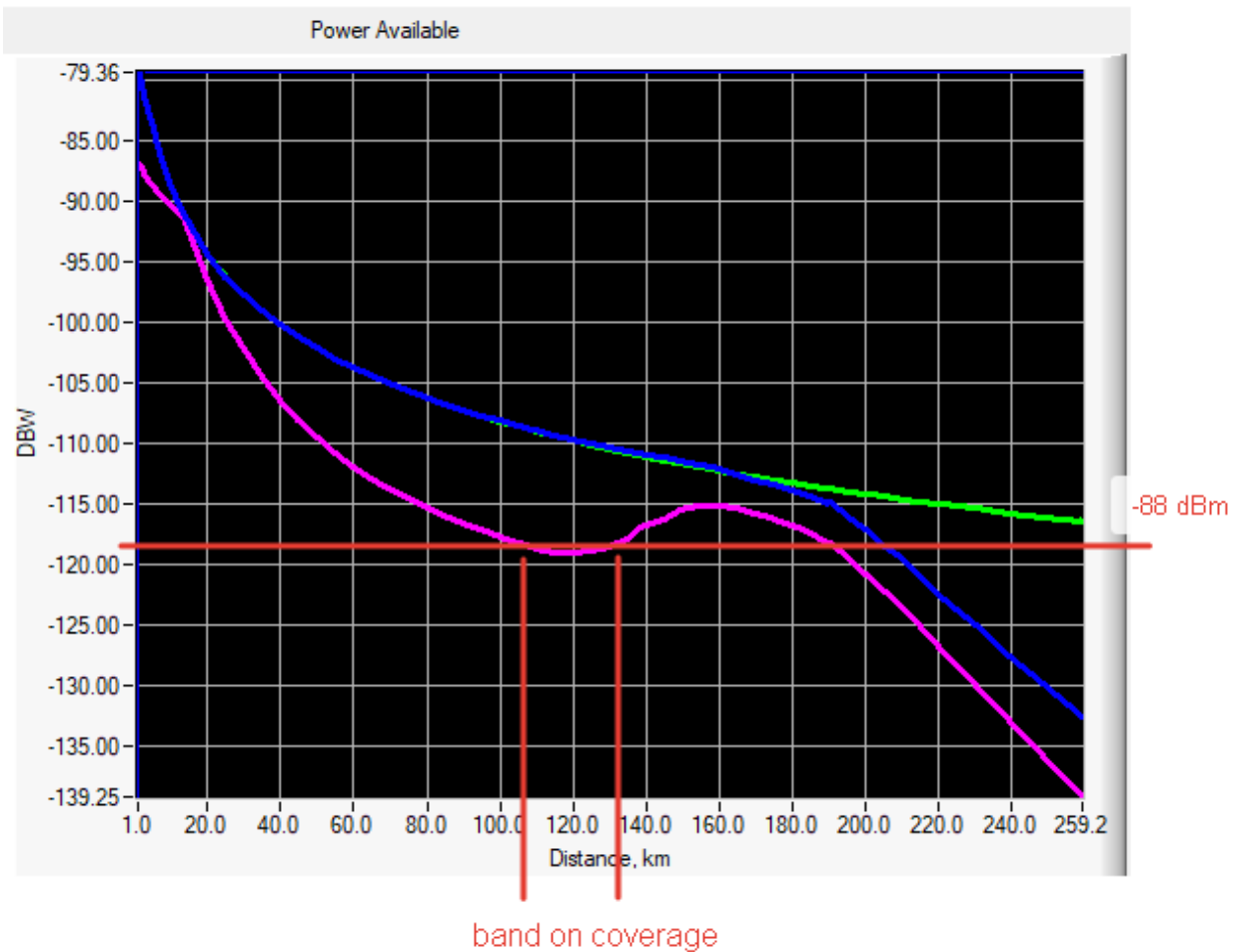
For a certain combination of data (heights of the site and mobile unit, frequency, power, service threshold, and time availability), a band may appear on the radio coverage area indicating lack of communication (in the example below, such a band is present at a distance of 107-134 km in the radial direction from the base station).





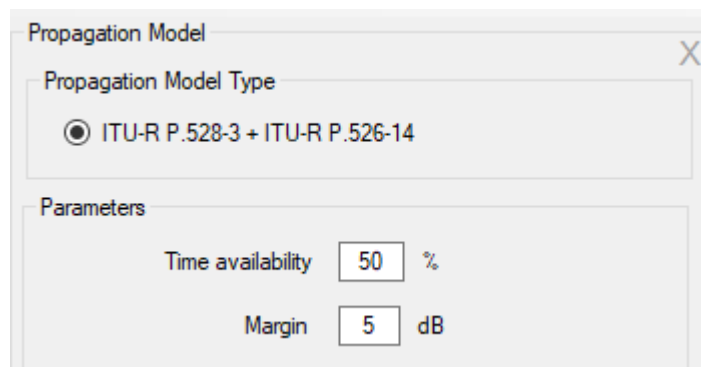
This means that in this zone, the mobile unit (aircraft) will be in the area of strong influence of multipath due to reflection from the Earth's surface and time availability will decrease. Model ITU-R P.528-3 (02/2012), which is based on the IF-77 Electromagnetic Wave Propagation Model by M.E. Johnson and G.D. Gierhart, specially designed for aeronautical radio communications, takes this effect into account. A plot of received power versus distance for the example in question is shown below. It shows that at a time availability of 95% for the level of -88 dBm (-118 dBW), the curve has a bend, which determines the dip in received power and the corresponding band in the coverage area.



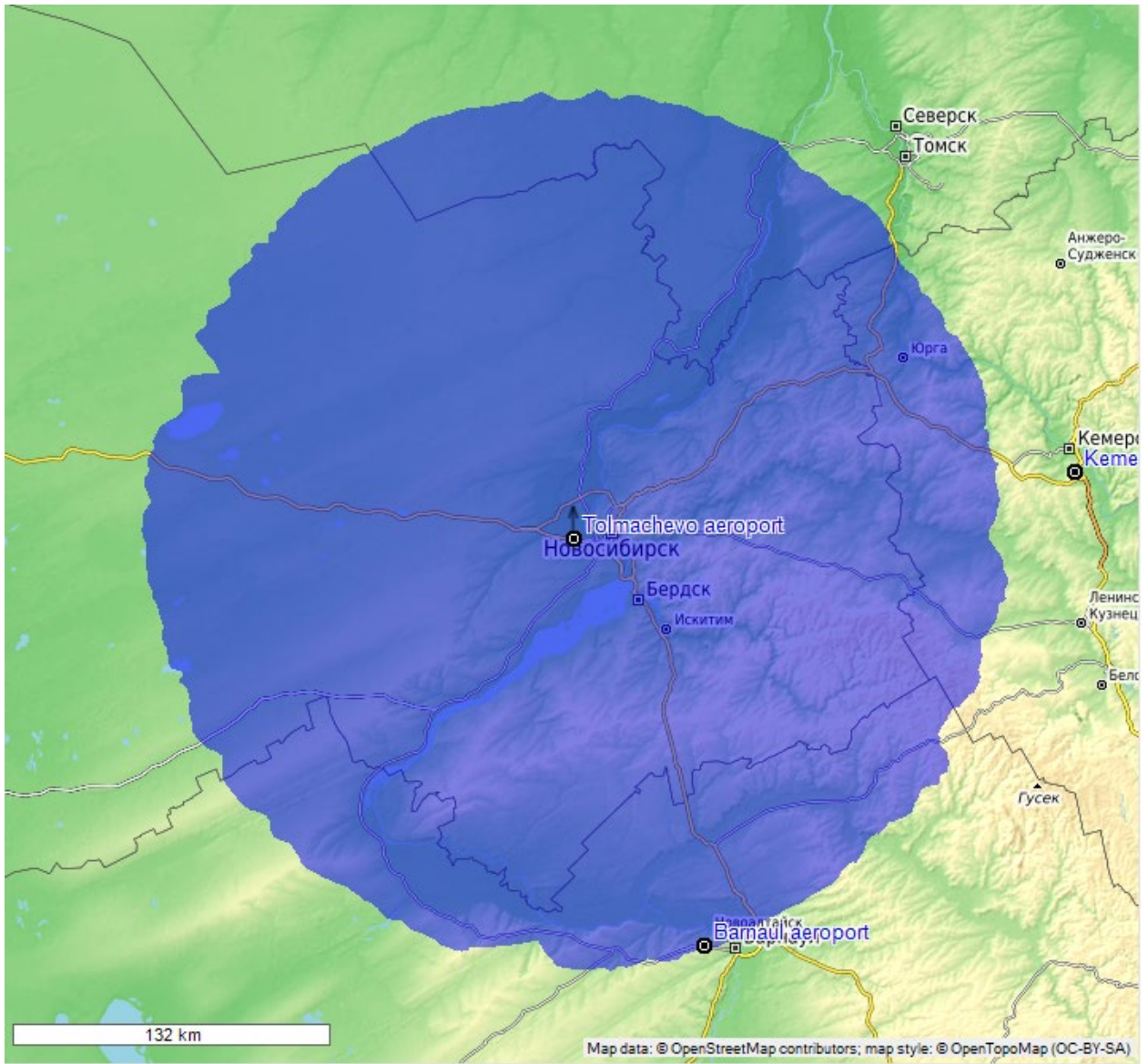


In fact, the appearance of such a band in the coverage area does not mean a significant reduction (within 5-7 percent) in time availability in this area. In practice, such a decrease in time availability in a small area within the coverage area can be considered acceptable.

In order to take this assumption into account, a calculation should be made for the average power of the received signal (time availability 50%), taking into account an additional margin for fading within 5-7 dB.



After which, the calculation result for the example considered above will look like this:



## Appendix 1. File formats

### 1.1 Cable attenuation file

A text file named **feeders.txt**, containing information about frequency-dependent attenuation in cables, is included in the RadioPlanner installation folder. Users can add information about required cables to this file.

The **feeders.txt** file has the simple format:

```
-  
FSJ1-50A 1/4"  
30    3.22  
100   5.94  
450   12.9  
1000  19.7  
2000  28.6  
6000  53.2  
10000 71.5  
-  
LCF12-50J D=1/2"  
0.5   0.15  
100   2.16  
200   3.1  
300   3.8  
450   4.71  
900   6.8  
1500  8.97  
1800  9.91  
2300  11.35  
3000  13.2  
4000  15.5  
8800  24.6
```

where:

FSJ1-50A 1/4" – the cable name that will appear in the cable list box.

30 – frequency in MHz.

3.22 – attenuation in dB per 100 meters at this frequency.

The number of frequency/attenuation pairs for each line in the feeders.txt file does not need to be the same. A TAB character should be used as a separator between frequency and attenuation values.

## Appendix 2. Default Digital Terrain Model (DTM)

### North America

*1 Arc-second Digital Elevation Model USGS National Map 3DEP*

Coverage: USA, Canada, Mexico.

Source: <https://data.usgs.gov/datacatalog/data/USGS:35f9c4d4-b113-4c8d-8691-47c428c29a5b>

### Europe

We use open digital terrain models (DTM) from national geoservices for the following European countries:

- Austria (DTM 5-10 meters)
- Belgium (DTM 5-10 meters)
- Czech (DTM 1 meter)
- Denmark (DTM 2 meter)
- Estonia (DTM 10 meters)
- Finland (DTM 10 meters)
- France (DTM 5-10 meters)
- Germany (DTM 2-10 meters)
- Iceland (DTM 10 meters)
- Ireland (DTM 2 meter)
- Italy (DTM 2-10 meters)
- Latvia (DTM 20 meters)
- Lithuania (DTM 5 meters)
- Liechtenstein (DTM 10 meters)
- Luxembourg (DTM 0.5 meter)
- Netherlands (DTM 5 meters)
- Norway (DTM 10 meters)
- Poland (DTM 1 meters)
- Portugal (DTM 0.5-10 meters)
- Romania (DTM 1 meter)
- Slovakia (DTM 1 meter)
- Slovenia (DTM 1 meters)
- Spain (DTM 2-5 meters)
- Sweden (DTM 50 meters)
- Switzerland (DTM 2 meters)
- United Kingdom (DTM 2 meters)

For the rest of Europe, we use the *European Digital Elevation Model (EU-DEM), version 1.1*.

Coverage: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Greece, Hungary, Kosovo, Malta, Montenegro, North Macedonia, Serbia, Turkey.

Source: <https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=metadata>

### Australia

*SRTM-derived 1 Second Digital Elevation Models Version 1.0 (DEM-S)*.

Coverage: Australia

Source: <https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/72759>

### New Zealand

*New Zealand National Digital Elevation Model a 25-meter resolution.*

Coverage: New Zealand

Source: <https://lris.scinfo.org.nz/layer/48131-nzdem-north-island-25-metre/>

**South America, Africa, Asia, Middle and Far East regions**

ALOS World 3D - 30m (AW3D30) by the Japan Aerospace Exploration Agency's (JAXA).

Source: <https://www.eorc.jaxa.jp/ALOS/en/aw3d30/>

<https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLIII-B4-2020/183/2020/isprs-archives-XLIII-B4-2020-183-2020.pdf>

## **Appendix 3. Project Samples for Various Wireless Networks and Broadcasting Networks**

The software package includes several project samples for various wireless and broadcast networks. These projects are fully prepared for calculation; simply open the project and click the “Calculate coverage” button.