RadioPlanner 2.1

Mobile and Broadcast Network Planning

User Manual
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From the Developers

We've made every effort to create a user-friendly and intuitive application. However, we recommend that you spend some time reading this User Manual to get the most out of the RadioPlanner application.

RadioPlanner was created by engineers with more than 20 years of experience in designing radio communication and broadcasting networks and is a full-featured, yet simple and convenient planning tool.
Features

RadioPlanner 2.1 is a tool for planning:

- GSM / WCDMA / CDMA / UMTS / LTE / 5G mobile networks
- TETRA / P25 / DMR / dPMR / NXDN / GSM-R / McWiLL land mobile radio networks
- Networks based on wireless IoT LPWAN technologies: LoRa, SigFox, and others
- DVB-H / DVB-T / DVB-T2 / ISDB-T / DAB / DAB+ terrestrial radio and television broadcast networks
- Air-to-ground communication systems and radio navigation operating in the VHF, UHF, and microwave frequencies: UAV (Drone) Control, Air-to-ground radio, ADS-B, VOR, DME, etc.

RadioPlanner 2.1 uses the following propagation models:

- ITU-R P.1812-4 model (for mobile and broadcasting)
- Longley-Rice (ITM) model v 1.2.2 (for broadcasting only; for mobile coming soon)
- ITU-R P.1546-6 model (for broadcasting only)
- Combined ITU-R P.528-3 + P.526-14 model (for aeronautical radio only)

RadioPlanner 2.1 performs various types of area studies for mobile networks:

- Received Power uplink/downlink
- Strongest Server (Best Server)
- C/I ratio
- Area with Signal above Both the Base and Mobile Thresholds
- Number of servers above uplink

Area studies for terrestrial radio and television broadcast transmitters:

- Field Strength at the Receiver Location
- Strongest Server (Best Server)
- FCC contours
- ITU-R P.1546-6 contours
- Calculation of the population in the coverage area based on the OpenStreetMap project database
- Generation of the list of localities covered by broadcasting

Area studies for air-to-ground communication systems:

- Received power Air-to-Ground link
- Received power Ground-to-Air link
- Strongest (most likely) Server Air-to-Ground link

RadioPlanner allows you to do:

- Frequency planning of radio networks considering co-channel and adjacent channels' interference
- Points calculation showing the profile of the path, losses, and levels of the signal and interference on co-channel and adjacent channels
- Calculation of uplink/downlink Rx levels for a set of IoT end-devices: LoRa, SigFox, and others, located in different conditions.
- Import the measurement results of the received signal power levels for comparison with calculated values and adjust propagation model parameters
- Compare two coverage study results
- Save the result of the coverage calculation as an interactive web page, as a raster image, or as a KMZ file
- Flexible adjusting of the layers on the base map and show custom vector layers

GIS features:

- SRTM-3 dataset is used as a digital terrain model. Data sources: USGS EarthExplorer site https://earthexplorer.usgs.gov
- Landcover model with the different types of clutter (dense urban, urban, suburban, open land, water, and trees/forest). The landcover model was created based on OpenStreetMap (www.openstreetmap.org), Global Forest Change (www.earthenginepartners.appspot.com) projects, and Built-in RadioPlanner. A simple and easy to use Clutter Editor will allow the user to prepare their own clutter model based on new satellite imagery.
- Any kind of base map—both common (such as OpenStreetMap, OpenTopoMap, etc.) and custom ones.

**Installation, Activation, and Registration**


The minimum computer configuration is 64-bit Windows, Core i3 CPU, 4GB RAM, 200GB HDD, video card, and monitor with support for 1366x768, although the program can be installed on a less productive computer.

The recommended computer configuration is 64-bit Windows, Core i5 CPU, 16GB RAM, 256GB SSD, video card, and monitor with support for 1920x1080. To use all RadioPlanner features, the Microsoft Excel spreadsheet editor must be installed on the computer.

To use the full version of RadioPlanner, you should purchase a license.

Once you have successfully purchased RadioPlanner, you will receive an automated email within a few seconds containing a link to download the installation file and the Activation ID for the license.

Run the installation file and follow the instructions that appear on your screen. When the installation is complete, run the application, enter the Activation ID provided to you in the order email, and click Activate.

Once you have done that, you have activated the fully functional version.
Software Update

Periodically, we release free current updates in which we improve the functionality and stability of the software.

RadioPlanner supports both manual and automatic checking for updates. The software will check for available updates every time it starts. To check for updates manually, click "Help - Check for updates." If there is an available update, a window will open with information about the current and available versions. You can download the update from the link and install it manually. Exit the RadioPlanner software before installing the update.

User Interface

RadioPlanner has three different types of projects:

- Mobile Radio
- Radio or TV Broadcasting
- Air-to-Ground Communication

The configuration of the program menu and the set of input parameters will depend on the choice of project type, so before starting, the user must select the project type in the Settings menu (see the Settings section). The general procedure for working with the software is almost the same regardless of the type of project.

This manual is divided into four parts - first, a description of the work with those program functions that are independent of the type of project, then a description of work with Mobile communications projects, then with TV and radio broadcasting projects, and finally with air-to-ground communications projects.

After the program starts, the main panel will appear with the main menu on the left side and the base map on the right side. You can change the size of the panels as needed using the separator.

Different layers can be displayed on the base map — base stations, radio coverage, various additional vector layers, etc. You can choose to display one of the pre-installed base maps or customize your base map, as described in the Base map Settings section.

Navigation on the map is carried out using the mouse. Use the mouse wheel to zoom in on the map. You can also select the desired zoom 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
- The current zoom of the base map
- The current base map
- The tool "ruler," which allows measuring the distance and azimuth between any two points. To perform a measurement, click on the ruler, then click on any two points of the map and you will see the distance between the points and the azimuth from first to second. To exit, right-click anywhere on the map.
- Perform coverage calculation
- Add coverage to compare
- Save the coverage as a web page
- Save coverage as an image in *.png format
- Save coverage in *.kmz format
- Clutter Editor
- Calculator of the Noise-Adjusted Faded Performance Threshold
- Help

More information about each of the tools is described later in the relevant sections of the manual.
Project Information

A new project is created automatically when RadioPlanner is launched.

There are standard buttons: New, Open, Save, Save As on the File menu, which allows performing standard file operations. A project file can be saved with the extension *.rplx. This file contains all of the information about the project.

You can specify the project’s general information in the project information panel.
When creating a new project, it records the date and time of the project creation.

Settings

Before you start working with the software, you must configure the settings.

**Figure 3. Settings**

<table>
<thead>
<tr>
<th>Project Settings</th>
<th>Mobile Radio Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Project</td>
<td>Radio or TV Broadcasting</td>
</tr>
<tr>
<td></td>
<td>Air-to-Ground Communication</td>
</tr>
</tbody>
</table>

Before changing the project type, save the current project, as the program will create a new project. The type of project will determine the configuration of the application menu.

**Distance and Height Units**

- Metric
- English

**Coordinate Format**

- Decimal Degrees (N44°34′23.7″ W134°29′23.4″)
- Degrees, Minutes, Seconds (N44°34′23.7″ W134°29′23.4″)
- Degrees, Decimal Minutes (N44°34.2356′ W134°29.2354″)

**Coordinate System**

- WGS-84
- SK-42
- GSK-2011
Path to Folder with Cache Files | The path to the folder where downloaded base map tiles will be saved for quick access. This will speed up the application. The downloaded maps will remain on your computer, and you will be able to view them when you do not have an Internet connection. This folder is created automatically when the application is launched for the first time. You can change this folder.

Path to Folder with Data Files | The path to the folder where the downloaded SRTM and clutter files will be saved for quick access. This will speed up the application. Moreover, the downloaded files will remain on your computer and the application will be able to use them and create a terrain profile when you don’t have an Internet connection. This folder is created automatically when the application is launched for the first time. You can change this folder.

Proxy Settings | If you are using a proxy server to access the Internet, enter its IP-address and port number. 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.

The prototype URL encapsulates a request format that is specific to the map provider and it varies from map provider to map provider. It consists of a text string that begins with http://, has a domain name and possible parameters, plus some symbols that RadioPlanner substitutes with real-time tile request information when actually contacting the server.

Below is a detailed explanation of how prototype URLs are constructed. The possible symbols that RadioPlanner accepts in the prototype URL are: \([X]\), \([Y]\), and \([Z]\) coordinates and zoom.

To lookup map imagery in their database, most map providers use tile coordinates of \(x\) and \(y\), plus zoom. As an example, the OpenStreetMap provides map imagery using \(x\), \(y\), and zoom. We can test-fetch a map tile of a portion of North America by typing 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. The OpenStreetMap fetches the map tile corresponding to \(x = 1\), \(y = 2\), and zoom = 3.

In order for RadioPlanner to properly fetch tiles from a map provider, a generalized prototype URL scheme must be furnished. This generalized URL scheme will be used by RadioPlanner to fetch any tile, at any coordinate, with any zoom. To accomplish this, the symbols "\([X]\)" , "\([Y]\)" , and "\([Z]\)" (without the quotes) are inserted in the place of explicit coordinates.

For example, creating custom map types in RadioPlanner for OpenStreetMap can be accomplished by mixing the known specific URLs above with the symbols representing \(x\), \(y\), and zoom to form a custom map prototype URL (try these in the custom maps setup screen):

http://a.tile.openstreetmap.org/[Z]/[X]/[Y].png
When RadioPlanner needs a map tile fetched from a provider, it will replace the 
"[X]," "[Y]," and "[Z]" symbols with the actual coordinates and zoom for the tile required and 
then 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 required map. There are some 
examples listed below. Search online for local map providers' map servers' URLs.

Example:

OCM Transport:

http://a.tile2.opencyclemap.org/transport/[Z]/[X]/[Y].png

If the user has more relevant or more detailed cartographic data for the desired territory in the form of 
an image or vector map, he can create a tile server by himself in specialized GIS MapInfo, QGIS, Global Mapper.
Map Layers

In the Map Layers menu, the user can control layers that are displayed on the map. The order of the layers in the menu corresponds to the order on the map (the base map is below all of the layers, sites are on top of all of the layers).

Sites

Sites are base stations or transmitters for TV and radio broadcasting, depending on the type of project.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show layer</td>
<td>Show/hide site layer</td>
</tr>
<tr>
<td>Show all sites</td>
<td>Show all sites</td>
</tr>
<tr>
<td>Show only active sites</td>
<td>Show only active sites</td>
</tr>
<tr>
<td>Show site names</td>
<td>Show site names</td>
</tr>
<tr>
<td>Show sector directions</td>
<td>Show sector direction according to antenna azimuth</td>
</tr>
<tr>
<td>Site marker</td>
<td>Choose marker for sites</td>
</tr>
</tbody>
</table>
Custom Layers (KML, CSV)

The user can load and display as a layer on the map any point or linear vector objects in KML format. This may be, for example, power lines, piping, and the results of measurements of signal levels.

Point objects can also be downloaded from a CSV file (text format, where the separator is a semicolon).

This is a universal format in which you can save a spreadsheet from any spreadsheet editor (Excel, LibreOffice Calc, and others), as well as databases.

The required fields for each point object are Parameter, Latitude, and Longitude. Format coordinates - HEMISPHERE degrees minutes seconds (N35 23.8 36) or HEMISPHERE decimal degrees (N12.34567). As a parameter, there can be any text that appears at the point with the specified coordinates. This may be, for example, the measurement result or the name of the object.

![Figure 5. Sample CSV file with measurement results](image)

*Figure 5. Sample CSV file with measurement results*
The user also can quickly create point objects on the map. To do this, right-click on the point location and in the context menu that appears, select "Add a new point to the 'Custom Points' layer," and then specify the point name. The point will appear on the map and it will also be added to the "Custom Points" layer, which will be automatically created when the user creates the first point object. The created point objects can also be deleted - to do this, right-click on the point and select "Delete the nearest point in the 'Custom Points' layer."

---

*Figure 6. An example of the display of measurement results on the map*
Custom layers are saved in the project file.

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Load" /></td>
<td>Load a custom layer (KML, CSV file)</td>
</tr>
<tr>
<td><img src="#" alt="Delete" /></td>
<td>Delete selected custom layer</td>
</tr>
<tr>
<td><img src="#" alt="Position" /></td>
<td>Position the map on the first point of the selected layer</td>
</tr>
<tr>
<td><img src="#" alt="Save" /></td>
<td>Save points from the selected layer to a CSV file</td>
</tr>
<tr>
<td>Name</td>
<td>The name of the user layer. Initially corresponds to the file name, but can be changed.</td>
</tr>
<tr>
<td>Show</td>
<td>Show/hide custom map layer</td>
</tr>
<tr>
<td>Marker</td>
<td>Select a marker for the item (only for point objects)</td>
</tr>
<tr>
<td>Line width</td>
<td>Specify the line width in pixels (only for line)</td>
</tr>
<tr>
<td>Line color</td>
<td>Specify line color (only for line)</td>
</tr>
</tbody>
</table>

**Coverage**

Controlling the layer with the result of the calculation of the radio coverage.

<table>
<thead>
<tr>
<th>Show layer</th>
<th>Show/hide layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency</td>
<td>Set layer opacity in the range from 0 (fully transparent) to 10 (not transparent)</td>
</tr>
</tbody>
</table>

**Clutter**

Control the landcover layer. The landcover layer is displayed starting with Zoom = 11.
Figure 8. Clutter map

Colors that show clutter:

- No color
- Open land
- Water
- Trees/Forest
- Suburban
- Urban
- Dense urban

<table>
<thead>
<tr>
<th>Show layer</th>
<th>Show/hide layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Show layer icon]</td>
<td>Download landcover within the screen area. This command will be required if the calculation of radio coverage in this area has not been performed yet.</td>
</tr>
<tr>
<td>Transparency</td>
<td>Layer opacity in the range from 0 (fully transparent) to 10 (not transparent)</td>
</tr>
</tbody>
</table>

**Base Map**

Base map layer control

<table>
<thead>
<tr>
<th>Show layer</th>
<th>Show/hide the layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show in grayscale</td>
<td>Show base map in grayscale</td>
</tr>
<tr>
<td>Grayscale level</td>
<td>Brightness from the range 0 (darker) - 3 (lighter)</td>
</tr>
</tbody>
</table>
Saving the Result of Coverage Calculation

The result of the calculation of any type of radio coverage can be saved as an interactive web page, an image file, or KMZ file.

**Save the coverage as a webpage** - Save the result of the calculation as an interactive webpage. The application allows the user to select the location and the name of the directory in which the result is saved. The index.html file (this is the page script), the bs.png file (base station icon), and the folder with the radio coverage tile pyramid \( \text{ZOOM} / \{X\} / \{Y\} \) will be saved to the specified directory. To open a web page, open the index.html file using your browser (Google Chrome, Mozilla Firefox, Internet Explorer, etc.). The specified folder with the script and the pyramid of tiles can be archived and forwarded to the customer.

Also, the resulting webpage can be placed on a web server for viewing in any browser and on any of the operating systems (Windows, Mac, IOS, Android, and Linux).

This webpage allows you to:

- Choose a base map from four different base maps
- Change zoom
- View basic data from the legend
- Display the scale and current coordinates of the cursor

For the operation of the web page, you'll need access to the Internet, since the base maps are downloaded from the corresponding resources.

A folder with a pyramid of tiles can be used for more than just this script. For example, it can be connected to any GIS that supports working with tiles, which will allow you to demonstrate the result of the calculation of radio coverage as a layer on any GIS (QGIS, MapInfo, ArcGIS, SAS.Planet, and others).
Figure 9. Example of the interactive web page

Saved the coverage as an image - Save the result of coverage calculation as an image file in *.png format.

Before saving the image, the user can select the area of the saved coverage using the appearing frame (in this case, you can move both the border of the frame and the map itself).

When saving an image, the user also selects its resolution. Resolution may correspond with the current size or be two or four times larger. The better the resolution, the larger the size of the saved file. The maximum size of the bitmap image is approximately 5400x4400 pixels; the file size in the *.png format is about 10 MB.

A scale bar appears in the lower-left corner of the saved image.
Save the calculation result as a KMZ file - Save the calculation result as a KMZ file, which can be opened in Google Earth.

Two Coverage Calculation Comparison

RadioPlanner allows you to visually compare the results of the current coverage calculation with the calculation result previously added for such a comparison. Thus, it is possible to estimate the impact on the coverage due to changes in various parameters of the BS, the propagation model, etc.

To add the performed calculation to the comparison, click the Add Coverage to Compare button on the top toolbar. Now, when you go to the Compare coverage menu of the main toolbar, this calculation result will be located on the left side of the screen. Whereas on the right side of the screen, the result of the current coverage calculation will be displayed. Now, for example, you can change the height of the sector or sectors of active BSs, and after performing the coverage calculation, you can see how these changes were reflected in the result compared to the previous calculation.

Manage maps in the left and right panels (map shift and zoom) independently of each other. It is convenient to perform this operation with the mouse by dragging and rotating the wheel. By controlling the maps in this way, one can compare in small details the two results of coverage calculating.
Figure 11. Two coverage calculation comparison
Reports

In the Report menu, you can create several types of equipment reports - short, complete, for all base stations, or for only active base stations.

The project report shows the results of calculating the coverage area in square kilometers for the corresponding Rx levels.

Using the toolbar, which is located above the report, you can print it as well as save it in PDF, Microsoft Word, or Excel formats.

![Figure 12. Text report](image-url)
Mobile networks

Frequency planning for a mobile network is a complex iterative process that is influenced by many factors. In practice, it is carried out by drawing up a frequency plan for the initial approximation network taking into account the requirements for coverage, number, and distribution of subscribers, communication quality, available frequency bands, features of the standard used, and other conditions. Then, the radio coverage of the network is calculated taking into account the co-channel, and adjacent channels' interference for the selected frequency plan and the optimization of the parameters of the base stations. The frequency plan is performed in order to reduce the influence of the interference on the network coverage.

The purpose of this user manual is not to educate users on the principles and features of frequency planning of mobile networks. A sufficient number of books have been published on this topic.

A general blog diagram of the mobile network planning algorithm is shown in the figure below.
Figure 13. General algorithm for working with RadioPlanner

Start

Choice of project type mobile/broadcast

Specifying Propagation Model Parameters

Specify the number and location of base stations

Specifying the BS sector configuration (number, direction, types and heights of antennas, cable types, LNA, etc.)

Coverage calculation

Does the coverage without interference meet the requirements?

Yes

Frequency planning required?

Yes

Frequency assignment (initially - with a minimum number of frequency groups)

No

No

Calculation of coverage with regard to interference on the co-channel and adjacent channels

Analyzed all possible BS configurations?

Yes

Specifying the number and location of base stations

Analyzed all variants of frequency assignments?

Yes

Does it meet the requirements?

Yes

No

Stop

Report output
**Mobile Units**

The mobile units' characteristics in the Mobile Units menu.

![Figure 14. Mobile Units](image)

<table>
<thead>
<tr>
<th>Type</th>
<th>Name (model) of Mobile Unit, text field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx Power</td>
<td>Transmitter power, W</td>
</tr>
<tr>
<td>Rx Threshold</td>
<td>Receiver threshold sensitivity, dBm</td>
</tr>
<tr>
<td>Cable and connector loss</td>
<td>Loss in cable and connectors, dB</td>
</tr>
<tr>
<td>Antenna Height</td>
<td>Antenna height relative to ground level, m</td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>Antenna gain, dBi</td>
</tr>
</tbody>
</table>

This parameter is taken into account when performing the calculation of the radio coverage "Areas with signal levels above both the base and mobile thresholds," as well as Point Calculations.

The application allows calculating radio coverage for two types of mobile units, since, for example, in professional wireless networks portables and mobiles subscriber stations are often used, which differ in both energy characteristics and antenna height relative to ground level.

**Base Stations**

The characteristics of the radio equipment of the base stations in the Base Station Network menu. After creating a new project, the list of base stations is empty.
Figure 15. Base stations

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Center of frequency band, MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study radius</td>
<td>Maximum radius of calculation from base stations, km. The larger the radius, the longer the calculation time.</td>
</tr>
</tbody>
</table>

- Create a new base station
- Import sites from *.csv file
- Sort base stations in alphabetical order
- Delete all active base stations
- Import base station parameters from Microsoft Excel document
- Export active base station to Microsoft Excel

Creating a Base Station

To create a new base station, click on Base Station Network in the Tree View interface, then click the button in the panel that opens, then select the template from which the new base station will be created. You can then create the template yourself.
Import sites from *.CSV file

You can also import sites from CSV files (text format, where the separator is a semicolon).

This is a universal format in which you can save a spreadsheet from any spreadsheet editor (Excel, LibreOffice Calc, and others), as well as databases.

The required fields for each point object are BS name, Latitude, and Longitude. Format coordinates - 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, then select a template from which new base stations will be created with coordinates of imported sites.

![Example of a CSV file with the imported sites](image)

*Figure 17. Example of a CSV file with the imported sites*

Import/Export BS Parameters to Excel Spreadsheet

The program can export the parameters of the base stations to the Microsoft Excel spreadsheet, as well as import data from this spreadsheet. This function can accelerate the loading of source data for a network with a large number of base stations, as well as simplify the exchange of source data between the user and the customer. The format of the table can be found by exporting the parameters of base stations for one of the test examples.
When importing/exporting a spreadsheet, the following should be considered:

1. Export to a spreadsheet is performed only for active base stations

2. When importing from a spreadsheet, the imported base stations will be added to the existing BS of the current project. That is, if you need to completely replace the information on base stations, then before performing the import, you should remove the existing base stations from the project.

3. When importing from a spreadsheet, the antenna pattern file must be in the folder with the Excel file.

4. If in the base station sector, the antenna-feeder transmission and reception path are the same, then when preparing the table, you can fill in the antenna-feeder path parameters for the transmit path only and do not fill in the receive path parameters - just leave the corresponding cells of the spreadsheet empty.

When clicking in the Tree View interface panel on the created base station, the Base Station Details panel will open, where you can edit the name, coordinates, specify additional text information about the base station, and find out the elevation of the base station relative to sea level.
Using the tools on the **Base Station Details** panel, you can do the following:

- Create a new base station as a copy of this base station
- Move this base station up or down
- Delete base station
- Load the base station parameters from the template
- Save the parameters of the base station (including the parameters of all its sectors) as a template
- Position the map with the base station at the center of the screen

<table>
<thead>
<tr>
<th>Name</th>
<th>Base station name, text field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>The geographical latitude of the base station in the format specified by the user in <strong>Settings</strong></td>
</tr>
<tr>
<td>Longitude</td>
<td>Geographical longitude of the base station in the format specified by the user in <strong>Settings</strong></td>
</tr>
<tr>
<td>Site Elevation</td>
<td>Site elevation relative to sea level, m</td>
</tr>
<tr>
<td>Other Information</td>
<td>Text box for any additional base station information</td>
</tr>
</tbody>
</table>

When creating a base station, at least one sector of this base station is automatically created.

There is an activity icon in the Tree View interface panel next to each base station and sector. For the sector to be calculated, this sector must be marked as active (a dot in the center of the icon).

Clicking on the base station sector will open a panel with the parameters of this sector.
Figure 20. BS Sector parameters

Toolbar:

- Create a new sector as a copy of this sector
- Move this sector up or down
- Delete sector
- Group change of active sector parameters based on current sector parameters
- Position the map with the base station at the center of the screen
<table>
<thead>
<tr>
<th>Name</th>
<th>The name of the sector, the text field. If this field is left blank, the name &quot;Sector azimuth&quot; with the azimuth value specified below in the sector parameters panel will be automatically displayed on the left in the tree view panel. If you specify the name in this field, it will be displayed in the tree view.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Group</td>
<td>Frequency group to which this sector belongs, f01-f12</td>
</tr>
<tr>
<td>Radio Equipment</td>
<td>Name (model) of Radio equipment, text field</td>
</tr>
<tr>
<td>Tx Power</td>
<td>Transmitter power, W</td>
</tr>
<tr>
<td>Rx Threshold</td>
<td>Receiver threshold sensitivity, dBm. This parameter is taken into account when performing the calculation of the radio coverage &quot;Areas with signal levels above both the base and mobile thresholds,&quot; as well as Point Calculations.</td>
</tr>
<tr>
<td>Diversity Gain</td>
<td>Gain due to the use of diversity reception, dB</td>
</tr>
<tr>
<td>Set Rx Antenna and Transmission System to be the Same as Tx</td>
<td>Copying parameters’ antenna-feeder transmit path to the receive path.</td>
</tr>
<tr>
<td>Cable Type</td>
<td>Type of 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</td>
</tr>
<tr>
<td>Cable Length</td>
<td>Main cable length, m</td>
</tr>
<tr>
<td>Cable Loss</td>
<td>Loss in cable, dB Calculated value.</td>
</tr>
<tr>
<td>Additional Loss</td>
<td>Additional losses, dB - combining losses, losses in jumpers, and connectors. Any additional losses.</td>
</tr>
<tr>
<td>Total Loss</td>
<td>Total loss, dB. The calculated value.</td>
</tr>
<tr>
<td>Antenna Height</td>
<td>The height of the center of radiation of the antenna relative to ground level, m</td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>Antenna gain relative to isotropic radiator, dB</td>
</tr>
<tr>
<td>Azimuth</td>
<td>The azimuth of the antenna in degrees</td>
</tr>
<tr>
<td>Beam Tilt</td>
<td>Tilt the antenna in degrees. Down is negative; up is positive.</td>
</tr>
<tr>
<td>Antenna Model</td>
<td>Antenna name, text field. Automatically filled with the antenna pattern file name when selecting a pattern.</td>
</tr>
<tr>
<td>Measurement File</td>
<td>The file with the results of the measured signal downlink level in this BS sector. See more details in the &quot;Import measurement results and adjustment of the propagation model&quot; section.</td>
</tr>
</tbody>
</table>

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.

**Group change of active sector parameters based on the parameters of the current sector** is a useful feature that allows you to instantly change the parameters of any sectors following the parameters of the current sector.

The procedure for performing group parameter changes:

1. Mark sectors as active whose parameters need to be changed.
2. Set the required parameter values in the current sector.

3. Click the button , select in the list the parameters that need to be changed in the previously marked active sectors, and click the OK button.

**Context menu on the base map**

When you right-click on the base map, the context menu appears, in which you can:

1. Create a new base station at this point
2. Change the location of the current (selected) base station
3. Open the parameters of the nearest base station (focus on …)

![Figure 21. Context menu](image)

**Propagation models**

RadioPlanner 2.1 uses the following propagation models:

- ITU-R P.1812-4 model (for mobile and broadcasting)
- Longley-Rice (ITM) model v 1.2.2 (for broadcasting only; for mobile coming soon)
- ITU-R P.1546-6 model (for broadcasting only)
- Combined ITU-R P.528-3 + P.526-14 model (for aeronautical radio only)

**ITU-R P.1812-4 model**

This model is described in detail in the recommendation ITU-R P.1812-4 (07/2015) *A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands.*

The following main factors which affect propagation are taken into account:

- Diffraction loss on the path profile obtained from the SRTM data
- The impact of local surrounding obstacles that exist in the landcover model
- Temporal and spatial instability of the received radio signal (slow and fast fading)
You may select three parameters that determine the time, location, and prediction confidence margin of the calculation results:

**Percentage of time** (usually 90-95%). 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.

**Percentage of location** (usually 90-95%). The location percentage indicates that a given power level will be exceeded in at least that percentage of locations for similar propagation paths. The percentage of location can vary from 1% to 99%. The model is not valid for a percentage of locations less than 1% or more than 99%.

*Figure 22. ITU-R P.1812-4 propagation model*
Margin 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 your signal level estimate is indeed above the specified signal level.

Specify the location of the Mobile units:

- Mobile units with antennas below clutter height in urban or suburban environments
- Mobile units with rooftop antennas near the clutter height
- Mobile units in rural areas

Clutter loss

RadioPlanner calculates the signal power loss on local obstacles surrounding the Mobile unit using the landcover model with the different types of clutter (dense urban, urban, suburban, open land, water, and trees/forest). The landcover model was created based on OpenStreetMap (www.openstreetmap.org) and Global Forest Change (www.earthenginepartners.appspot.com) projects.

Losses are calculated following Recommendation ITU-R P.1812-4; they depend on the following parameters:

- Antenna height of the Mobile unit
- Width of the streets
- Average (typical) height of clutter
- Type of clutter

The frequency range is set in the Base station Network menu, the antenna height for each of the two types of Mobile units (usually portable and mobile) in the Mobile Units menu, the typical width of streets is 27m (in accordance with ITU-R P.1812-4), and the landcover model determines the type of obstacles at each point.

To determine the loss according to ITU-R P.1812-4, the user should select Calculate the loss in rec. ITU-R P.1812-4 and specify in the table the average height of the obstacles of each type based on local conditions. Default data in Rec. ITU-R P.1812-4:

<table>
<thead>
<tr>
<th>Clutter type</th>
<th>Clutter height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water/sea</td>
<td>0</td>
</tr>
<tr>
<td>Open/rural</td>
<td>10</td>
</tr>
<tr>
<td>Tree/forest</td>
<td>15</td>
</tr>
<tr>
<td>Suburban</td>
<td>10</td>
</tr>
<tr>
<td>Urban</td>
<td>15</td>
</tr>
<tr>
<td>Dense urban</td>
<td>20</td>
</tr>
</tbody>
</table>

The user can also set clutter loss manually for each type of obstacle based on their own data - to do this, simply enter the losses into the table.
Clutter data

**Use default clutter data** or **Use custom clutter data** - The choice of the clutter data that will be used for calculations - the default clutter or the custom clutter. Custom clutter is created in the Clutter Editor (see the section Clutter Editor).

**Area Study Details**

In this panel, the user selects the type of calculation and sets its parameters.

For projects of the "Mobile Radio" type, you can select the following types of calculations:

- Received power Downlink
- Received power Uplink
- Areas with signal levels above both the base and mobile thresholds
- Strongest (most likely) Server Downlink
- C/I Downlink ratio using channel plan
- Number of servers above Uplink

**Received power Downlink/Uplink**

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

- Low
- Medium
- High

It's the resolution of the result of the calculation. 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.

Number of Levels

The number of levels (1-8)

Figure 23. Area study type Received Power Uplink menu
For Mobile Unit No. 1 (portable), you can set from one to eight different levels of the received signal and thus simulate different reception conditions (for example, on the street, inside the car, indoors, etc.) or different data transfer rates.

For Mobile Unit No. 2, which is supposed to be a mobile subscriber station with an antenna on the roof of the car, only one signal level can be set.

In the calculations, you can also take into account interference on the co-channel and adjacent channels. For this, there are corresponding check-boxes at the bottom of the panel. In this case, the zones where the interference on the co-channel and/or adjacent channels exceeds the amount allowable, one will be excluded from the coverage area. A useful signal is a signal with the maximum level at a given point.

To take into account interference, it is necessary to specify the maximum permissible levels of interference on the co-channel (C/I) and adjacent (C/A) channels.

To calculate interference on adjacent channels, you must specify the channel bandwidth and the exact channel frequencies (these parameters are entered into the Channel Plan menu).

<table>
<thead>
<tr>
<th>Color</th>
<th>Color level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>Received power level, dBm</td>
</tr>
<tr>
<td>Description</td>
<td>Text field to describe signal level</td>
</tr>
<tr>
<td>Consider RX threshold level</td>
<td>Exclude from coverage the areas with a level that is less than the threshold of mobile stations receivers for the downlink or threshold of base stations receivers for the uplink</td>
</tr>
</tbody>
</table>

**Figure 24. Received Power Uplink for P25 800 MHz network**
To calculate co-channel interference, it is sufficient to specify the frequency group in the sector parameters.

The calculation of interference is performed only for one type of subscriber station – Mobile Unit No. 1.

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

This area study type displays a map showing those grid locations where both the signal received by the mobile unit is above the remote receiver threshold and from where the signal received by the base station from the mobile is above the base threshold.

The calculations use the parameters of antennas, losses, transmitter power, and receiver sensitivity for the base and subscriber stations specified in the relevant menus.

This type of calculation can be performed for different conditions of use of Mobile Unit No. 1 (portable). For example, indoors, outdoors, and inside the car. Each condition of use has its own color and its own value of loss (margin) for signal penetration, which is indicated in this form.

For Mobile Unit No. 2, only outdoor calculations are performed.

![Figure 25. Areas with Signal Levels Above Both the Base and Mobile Thresholds Menu](image-url)
### Table

<table>
<thead>
<tr>
<th><strong>Number of Levels</strong></th>
<th><strong>The number of levels</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color</strong></td>
<td><strong>Color level</strong></td>
</tr>
<tr>
<td><strong>Penetration Loss</strong></td>
<td><strong>Penetration loss, dB</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td><strong>Text field to describe condition of use</strong></td>
</tr>
<tr>
<td>Consider RX threshold level</td>
<td>Exclude from coverage the areas with a level that is less than the threshold of mobile stations receivers for the downlink or threshold of base stations receivers for the uplink</td>
</tr>
</tbody>
</table>

![RadioPlanner 2.1 Diagram](image)

**Figure 26. Areas with Signal Levels Above Both the Base and Mobile Thresholds for P25 800 MHz network**

**Strongest (Most Likely) Server Downlink**

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

Sector colors can be assigned automatically or by the table of frequency groups.
Required Service Threshold | The minimum threshold level of the received signal to calculate Strongest (Most likely) Server, dBm
---|---
Apply Automatic Color Assignment | Assigning colors to BS sectors is performed automatically in random order.
Use Colors from the Table | Assigning colors to BS sectors is done from the table according to color frequency groups.
Consider RX threshold level | Exclude from coverage the areas with a level that is less than the threshold of mobile stations receiver

*Figure 27. Strongest Server menu*
C/I Downlink Ratio Using Channel Plan

The carrier-to-interference ratio, C/I, is one of the essential quantities used in assessing system performance and affecting frequency planning.

RadioPlanner allows you to calculate and display areas with different C/I values for interference on co-channel and adjacent channels at the input of a mobile unit receiver.

Carrier-to-interference ratio is calculated by first finding the strongest received signal power from any BS sector at each location. Then it calculates the sum of the received signal powers from all other co-channel sectors and adjacent sectors (taking into account adjacent channel attenuation), which also have relevant signal levels at a location. After the sum of the interference is found, the carrier-to-interference ratio is calculated.

The calculation of adjacent channel interference can be turned off, in which case only co-channel interference will be taken into account.
Figure 29. C/I Downlink ratio using channel plan menu

<table>
<thead>
<tr>
<th>Required Service Threshold</th>
<th>The minimum threshold level of the received signal to calculate carrier-to-interference ratio, dBm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Levels</td>
<td>The number of levels</td>
</tr>
<tr>
<td>Color</td>
<td>Color level</td>
</tr>
<tr>
<td>Value</td>
<td>Carrier-to-interference ratio C/I, dB</td>
</tr>
<tr>
<td>Description</td>
<td>Text field to describe carrier-to-interference ratio</td>
</tr>
<tr>
<td>Consider RX threshold level</td>
<td>Exclude from coverage the areas with a level that is less than the threshold of mobile stations receiver</td>
</tr>
</tbody>
</table>

To calculate co-channel interference, in the BS sector parameters, set the frequency group of the sector and set the C/I value. To calculate interference on adjacent channels, it is necessary to fill in the table of frequency groups with exact frequencies and set the channel bandwidth and C/A value (see section Channel Plan).
Number of Servers Above Uplink

When performing this study, the base map displays the areas of possible location of subscriber stations with the number of BS sectors with a received power level above the threshold.

This study type is often required when planning networks based on wireless technologies IoT LPWAN – LoRa, and others.
Figure 31. Number of servers above uplink

<table>
<thead>
<tr>
<th>Area Study Resolution</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>It's the resolution of the result of the calculation. 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Service Threshold</th>
<th>The minimum threshold level of the received signal, dBm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Number of Sectors</td>
<td>Maximum number of displayed servers above uplink</td>
</tr>
<tr>
<td>Color</td>
<td>Color indicating the appropriate number of sectors</td>
</tr>
<tr>
<td>Description</td>
<td>Text field</td>
</tr>
<tr>
<td>Consider RX threshold level</td>
<td>Exclude from coverage the areas with a level that is less than the threshold of BS Rx</td>
</tr>
</tbody>
</table>
Figure 32. Number of servers above uplink for LoRa network
Channel Plan

In the Channel Plan menu, you can set frequencies for frequency groups. Also, there are several other parameters that affect interference.

![Figure 33. Channel Plan (GSM-900)](image)

**Typical C/I and C/A values for some wireless standards:**
- GSM C/I=9 dB, C/A=-9dB
- TETRA (π/4-DQPSK modulation) C/I=19 dB, C/A=-40dB

**Point Calculations**

In this panel, the user can see detailed results of the calculation of the received signal power in the "down" and "up" directions at any point, as well as the levels of interference on the co-channel and adjacent channels.
You can change the current point on the map by clicking the mouse on the place you want. The path profile is a vertical section of the terrain between the base station and the mobile unit with information about land elevations, forests, and buildings. The colors that mark the various obstacles on the profile correspond to the colors of the landcover model.

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

The BS sector is selected on the left side of the panel in the general network Mobile Network. Find the BS sector you need and click on it with the mouse (don't be confused with the activity tag), after which information on this sector will appear above the path profile.

You can also select a mobile unit (No. 1 or No. 2), the parameters of which will be taken into account in the calculations.

Under the path profile, a table appears with the results of calculating the power levels "down" and "up" for the selected sector (it is highlighted in the table in color) and for sectors of other BS. Only sectors that are marked as active are accepted for calculation. In addition, in order for a sector to appear in the table, it is necessary for it to fulfill one of the following conditions: the threshold sensitivity level of the receiver of the selected type of mobile unit must be bigger than the "down" level or the threshold sensitivity level of the BS sector receiver must be higher than the "up" level. Rows in the table can be sorted by frequency groups and received power levels "down" or "up." Also, using the drop-down list located below the table, you can display the results for only one frequency group.

The selected BS sector is considered to be a sector with a useful signal; signals from sectors with the same frequency group are considered to be co-channel interference and signals from sectors where there are frequencies adjacent to a selected sector are adjacent channel interference. Based on this, below are the
calculated values of interference levels along the co-channel and adjacent channels for the "down" and "up" directions.

**Group Point Analysis**

RadioPlanner 2.1 allows you to calculate the RX uplink/downlink power for a group of points with a set of parameters. It is a useful tool for estimating the uplink/downlink when placing LoRa, SigFox, and other IoT end-devices in different conditions.

The end-devices parameters can be loaded into RadioPlanner as a spreadsheet in Microsoft Excel format or as a CSV text file. The calculation result can also be obtained in two versions - either in the form of a Microsoft Excel spreadsheet (to use this function, the Microsoft Excel spreadsheet editor must be installed on the computer) or in the form of a CSV file. It is more convenient to work with Excel tables, in addition, the results report in the form of a Microsoft Excel table is more visual (see the figure below). However, the work with the CSV file is much faster, and the format of the output CSV file is more convenient for further analysis of the result in various GIS.

**Figure 35. Group Point Analysis**

| Input file | File with data on points (end-devices) in Microsoft Excel or CSV format. Sample data set files SensorInputData.xlsx and SensorInputData.csv are located in the Sample Data folder |
| Rx threshold, dBm | The minimum threshold level that will be taken into account when filling out the table with the calculation results, dBm |
| Add map layer | Add end-devices from the source table as a custom point layer to the map |
| to Excel | Perform the calculation and open Microsoft Excel with the calculation result |
| to CSV | Calculate and save the result as a CSV file |

**Figure 36. Microsoft Excel spreadsheet with source data**
Name | End-device name or ID
---|---
Lat | The geographic latitude of the terminal in any of the formats that RadioPlanner allows (see the Setup menu).
Lon | Geographic longitude of the terminal in any of the formats that RadioPlanner allows (see the Setup menu).
Type | Type (model) of end-device
Tx power, W | End-device transmitter power, W
Ant. height, m | End-device antenna height relative to ground level, m
Ant. gain, dBi | End-device antenna gain, dBi
Cable loss, dB | End-device cable loss, dB
Penetration loss, dB | Penetration loss into the building where the end-device is installed, dB

The calculation is carried out in accordance with the parameters set in the "Propagation model" menu. If the calculation takes into account clutter losses in accordance with Recommendation ITU-R P.1812-4, then the value of these losses is determined for each end-device, taking into account its antenna height above ground level. The calculation can additionally take into account the building penetration loss for each end-device. The output report for each end-device will show the uplink and downlink Rx powers for base stations that exceed the threshold set in this menu.

![Figure 37. Output Microsoft Excel spreadsheets](image)
The user can import the results of measurements of the received signal power levels and compare with the calculated values and then adjust the parameters of the propagation model.

Operating procedure:

1. Prepare separate files of received power levels for each of the necessary sectors of base stations.

The measurement file is a CSV format file, each of the lines of which contains three parameters: the level of the measured signal from one BS sector 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).
2. Upload measurement files to the appropriate BS sectors in "Mobile Network" - "Sector Settings."

Here, using the button, you can view the downloaded measurement data for the BS sector and, if necessary, perform the preliminary processing:
Figure 40. Pre-processing of measurement results in the BS sector

<table>
<thead>
<tr>
<th>Measurement Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
</tr>
<tr>
<td>0026</td>
</tr>
<tr>
<td>0027</td>
</tr>
<tr>
<td>0028</td>
</tr>
<tr>
<td>0029</td>
</tr>
<tr>
<td>0030</td>
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<td>0031</td>
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<td>0045</td>
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<tr>
<td>0046</td>
</tr>
<tr>
<td>0047</td>
</tr>
<tr>
<td>0048</td>
</tr>
<tr>
<td>0049</td>
</tr>
<tr>
<td>0050</td>
</tr>
<tr>
<td>0051</td>
</tr>
</tbody>
</table>

**Signal level**
- **Minimum/Maximum Level**: Limit the points that will be included in the comparison by received power level from the base station.

**Distance to Base Station**
- **Minimum/Maximum Distance**: Limit the points that will be included in the comparison by distance from the base station.

**Sector from Base Station**
- **Minimum/Maximum Angle**: Limit the points that will be included in the comparison by azimuth from the base station.

**Gap**
- **Minimum Gap**: Perform averaging of the power level within a given segment.

**Add New Layer with Measurement Points**
- **Minimum Gap**: Add a custom measurement layer to the map with averaging within the specified minimum distance. The data in the table does not change. The resulting layer will appear among the user layers; the layer name will correspond to the BS name and sector direction.

3. In the "Measurement Analysis" menu, the results of the comparison of the measured and calculated levels for each of the sectors for different clutter types will appear - the average error and the standard deviation of the error. Also, the recommended loss values for different clutter types, for which the average error will be zero, will also be indicated. On the graph, you can see the distribution of measured and calculated signal level values for different clutter types.
4. Now, based on the analysis of the results obtained for different clutter types, a decision is made regarding the need to tune the values of the previously used clutter losses in the propagation model.

Calculator of the Noise-Adjusted Faded Performance Threshold

The influence of man-made noise cannot be ignored in the frequency bands where most of the professional mobile radio communication systems operate (136-174 MHz and 403-470 MHz).

The calculator built into the software determines the Noise-Adjusted Faded Performance Threshold for various environmental conditions and frequencies.

The calculations take into account Delivered Audio Quality (DAQ) according to the methodology described in the TIA TSB-88.1 recommendation. The typical parameters of the receiver-demodulator of all land mobile radio systems are built into the calculator - data is taken from Table A1 "Projected VCPC Parameters for Different DAQs" TIA TSB-88.1-D.

Next, a Noise-Adjusted Faded Performance Threshold is calculated, taking into account one of the three research reports for different categories of land cover:

1. Recommendation ITU-R P.372-13 "Radio noise" (50-250 MHz)
2. OFCOM MMN measurement (AY4119) 2003 (50-1000 MHz)
3. Data from TIA TSB-88.2-D Part 2: Propagation and Noise (162 MHz)
To calculate the Noise-Adjusted Faded Performance Threshold, the user must specify:

1. Reference receiver sensitivity in dBm or µV - 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 system

3. DAQ required, usually DAQ = 3.0 or 3.4

4. Select the research report on which the calculation will be based and the category of land cover.

5. Specify the carrier frequency.

Figure 42. Man-made noise calculations
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.
Radio and TV Broadcast

RadioPlanner 2.1 performs the coverage calculation for the transmitters of television and radio broadcast, as well as automatically determines the population in the coverage area based on the OpenStreetMap project base. Based on the results of the calculation, a list of localities covered by broadcasting is formed, indicating the population in each locality and the total population in the coverage area.

Broadcast Network

The characteristics of the radio equipment of the base stations are set in the Broadcasting Network menu. After creating a new project, the list of transmitters is empty.

![Broadcast network](image)

**Figure 42. Broadcast network**

**Toolbar:**

- Create a new transmitter
- Import sites from *.csv file
- Sort transmitters in alphabetical order
- Delete all active transmitters

<table>
<thead>
<tr>
<th>Study Radius</th>
<th>The maximum radius of calculation from transmitters, km. The larger the radius, the longer the calculation time.</th>
</tr>
</thead>
</table>

To create a new transmitter, click on Broadcast Network in the Tree View interface, then click the button in the panel that opens, then select the template from which the new transmitter will be created.

You can also import sites from CSV files (text format, where the separator is a semicolon).

This is a universal format in which you can save a spreadsheet from any spreadsheet editor (Excel, LibreOffice Calc, and others), as well as databases.

The required fields for each point object are the transmitter name, the Latitude, and the Longitude. Format coordinates - 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, then select a template based on which new base stations will be created with coordinates of imported sites.

![Image of CSV file sample]

**Figure 43. CSV file sample**

When clicking in the Tree View interface panel on the created transmitter, the Transmitter Details panel will open, where you can edit the name, coordinates, specify additional text information about the transmitter, and find out the elevation of the transmitter relative to sea level.

Using the tools on the Transmitter Details panel, you can do the following:

- Create a new transmitter as a copy of this transmitter
- Move transmitter up or down
- Delete transmitter
- Load the transmitter parameters from a template
- Save the parameters of the transmitter as a template
- Position the map with the transmitter at the center of the screen
### Transmitter Details

**Name**
Transmitter name, text field

**Other Information**
The text box for any additional transmitter information

**Latitude**
The geographical latitude of the base station in the format specified by the user in Settings

**Longitude**
Geographical longitude of the base station in the format specified by the user in Settings

**Site Elevation**
Site elevation relative to sea level, m

**Radio Equipment**
Type (model) of Radio equipment, text field

**Frequency**
Transmitter carrier frequency, MHz

**Tx Power**
Transmitter power, W

---

**Figure 44. Transmitter Details**
### Cable Type
Main cable type. 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
Main cable loss, 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 height of the center of radiation of the antenna 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 of 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.

### FCC contour parameters
The value of the field strength, dB(μV/m) for calculating the contours according to the FCC propagation curves. For more details, see the section FCC contours.

### Curve
FCC curve from set F (50.50); F (50.10); F (50.90). For more details, see the section FCC contours.

### Add Map Layer
Adding a contour with selected parameters to the map as a layer

### ITU-R P.1546-6 contour parameters
The value of the field strength, dB(μV/m) for calculating the contours according to the ITU-R P.1546-6 propagation curves. For more details, 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

### Color for Strongest (Most Likely) Server
The color that will be used to indicate the coverage for this transmitter when calculating the zones of maximum field strength at the receiving point (Strongest Server)

The 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.

### Propagation Models for Radio and TV Broadcasting Projects

When working with TV and radio broadcasting projects, the user can choose from the following propagation models:

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

This propagation model is described in detail in the Mobile Networks section. The model parameters for TV and broadcast projects are similar.

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 obstacles surrounding the receiver. These corrections are determined by the features of the terrain and obstacles in a particular territory.
**Figure 45. ITU-R P.1546-6 Propagation Model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Time, %</td>
<td>The procedures deliver the field strength exceeded for this percentage of time. A value of 1% is used to calculate interference; 50% is used to calculate service areas.</td>
</tr>
<tr>
<td>Percentage of Location, %</td>
<td>The procedures deliver the field strength exceeded for this percentage of locations.</td>
</tr>
<tr>
<td>Margin, dB</td>
<td>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 your signal level estimate is indeed above the specified signal level.</td>
</tr>
</tbody>
</table>
| Path Type                | - Land  
- Cold Sea  
- Warm Sea |
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

Take into account the clutter loss. The user can manually set the clutter loss for each type of clutter, based on third-party data on the amount of loss. For this, you need to specify Add clutter loss and enter the corresponding losses into the table.

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.

Clutter Data

Use default clutter data or Use custom clutter data - The choice of the clutter data that will be used for calculations - the default clutter or the custom clutter. Custom clutter is created in the Clutter Editor (see the section Clutter Editor).

Longley-Rice (ITM) Model v 1.2.2

The Longley-Rice propagation model is also known as the Irregular Terrain Model (ITM). RadioPlanner 2.1 uses version 1.2.2 of the Irregular Terrain Model in PTP-mode. This propagation model is considered the industry standard for calculating radio coverage in North America.

Figure 46. Longley-Rice propagation model parameters
Conductivity, S/m  Conductivity of the ground over which the signal propagates (Siemens per meter)

Dielectric Constant  The dielectric constant (relative ground permittivity)

Refractivity  Atmospheric refractivity, measured in N-Units

Climate Zone  The following Radio Climates can be selected:
- Equatorial (Congo)
- Continental Subtropical (Sudan)
- Maritime Subtropical (West Coast of Africa)
- Desert (Sahara)
- Continental Temperate, common to large landmasses in the Temperate Zone
- Maritime Temperate, over land (United Kingdom and Continental West Coasts)
- Maritime Temperate, over sea

Antenna Polarization  Antenna Polarization
Horizontal / Vertical

Time Variability, %  Time variability, %

Situation Variability, %  Situation variability, %

**Area Study Details**

In this panel, the user selects the type of calculation and sets its parameters.

For broadcast networks, the field strength (dBµV/m) of the radio signal at the receiving site is usually calculated.

For projects "radio or TV broadcasting," you can choose the following types of calculations:

- Field Strength at Remote;
- Strongest (Most Likely) Server

**Field Strength at Remote**

The base map displays areas with different colors, where the corresponding level of radio signal strength is present at the reception point.
The resolution with which the result of the calculation will be presented. 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.

<table>
<thead>
<tr>
<th>Area Study Resolution</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Levels</th>
<th>The number of field strength levels (1-8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Color level</td>
</tr>
<tr>
<td>Values</td>
<td>field strength (dBµV/m)</td>
</tr>
<tr>
<td>Description</td>
<td>Text field to describe signal level</td>
</tr>
<tr>
<td>Rx Antenna Height</td>
<td>Rx antenna height relative to ground level, m</td>
</tr>
</tbody>
</table>
Strongest (Most Likely) Server

The strongest server map is a map showing the identity of the transmitter supplying the strongest received signal at each grid location. The colors that show coverage from different transmitters can be assigned to each transmitter or can correspond to a group of transmitters with the same frequencies.
The resolution with which the result of the calculation will be presented. 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.

- **Rx Antenna Height**
  Rx antenna height relative to ground level, m

- **Required Service Threshold**
  Required service threshold for Strongest Server calculation, dBuV/m

- **Use Colors Assigned to each Transmitter**
  Color assignment to the transmitter is performed by the color specified in the "Transmitter Parameters" menu.

- **Use Colors from the Table**
  The color assignment will be performed according to the table depending on the frequency of the transmitter.
RadioPlanner 2.1 allows you to calculate service and interference contours from FCC propagation curves. These contours are used in North America in accordance with FCC rules, as well as in some countries as a recommendation when planning television and FM broadcast stations.

FCC contour calculation is performed in the parameters menu of the transmitter for which the contour is calculated. Enter the required value of the electromagnetic field strength and also select the type of FCC propagation curve:

- F (50,50) - Curve of the service contour for FM broadcasting and analog television
- F (50,10) - Curve of the interference contour
- F (50,90) - Curve of the service contour for digital television

After clicking the Add map layer button, the FCC contour appears on the base map as a vector layer. The name of this layer displays information about the name of the transmitter, 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 you wish; working with it is no different from working with other vector layers on the map.

Figure 51. FCC Contours + Longley-Rice coverage

**ITU-R P.1546-6 Contours**

ITU-R P.1546-6 contour calculation is performed in the parameters menu of the transmitter for which the contour is calculated. To calculate, set the value of the electromagnetic field strength, the type of path, and the percentage of places and times for which the calculation will be made.

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

- (50.50) - service circuit 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 appears on the base map as a vector layer. The name of this layer displays information about the name of the transmitter, 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 you wish; working with it is no different from working with other vector layers on the map.
Point Calculations

The user can see results of the calculation of the field strength at any point in this panel.

You can change the current point on the map by clicking the mouse on the place you want. The path profile is a vertical section of the terrain between the transmitter and the receiver with information about land elevations, forests, and buildings. The colors that mark the various obstacles on the profile correspond to the colors of the landcover model.

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

The transmitter is selected on the left side of the panel in the general network Broadcast Network. Find the transmitter you need and click on it with the mouse (not to be confused with the activity tag), after which information on this sector will appear above the path profile.

![Point Calculations](image)

*Figure 52. Point Calculations*

Under the path profile, a table appears with the results of calculating the field strength.

Calculation of the Population Covered by Television and Radio Broadcasting

RadioPlanner 2.1 allows you to automatically determine the population in the coverage area based on the OpenStreetMap project base. Based on the results of the calculation, 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 the population, you first need to calculate the coverage area from the transmitter (or several transmitters). Calculation of the population will be performed for the very minimum field strength level from the **Area Study Details** menu. To display the calculation results, go to the **Report** menu and click on the **Population Coverage** button, after which a table will appear listing the settlements covered by the broadcast. The total area of coverage in square kilometers is indicated under the table, as well as the average coverage radius (only when calculating coverage from one transmitter).

![Population Coverage Report](image)

*Figure 53. Population Coverage Report*
Air-to-Ground Communication

RadioPlanner 2.1 calculates coverage areas for ground-to-air and radio navigation aeronautical systems operating in the VHF, UHF, and microwave frequency bands.

Before starting work, you should select the project type "Air-to-Ground Communication" in the Settings menu (see the Settings section).

The set of parameters for the base station of the mobile aeronautical service is completely similar to that of the mobile communication network (See Section Mobile Networks - Base Stations).

The set of equipment parameters for the mobile aeronautical service station is similar to the set of parameters for the mobile communication network (See Section Mobile Networks - Mobile Stations), except for the antenna height, which is not specified here (the height of the mobile station for the mobile aeronautical service is used as a parameter in the menu "Area study details"). In addition, in the Air-to-Ground Communication projects, parameters are specified for only one type of subscriber station.

Propagation Model for Air-to-Ground Communication

The propagation model is a hybrid model based upon 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 applicable 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 digital elevation model SRTM
- Variation of the received radio signal due to multipath fading

In the used hybrid model, rain fading is not taken into account; therefore, the frequency range of its applicability is limited to 7000 MHz (100 MHz-7000 MHz).

![Propagation Model](image)

*Figure 55. Propagation model for Air-to-Ground Communication*

<table>
<thead>
<tr>
<th>Time Availability, %</th>
<th>Percentage of time (usually 95%). 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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Margin, dB</td>
<td>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.</td>
</tr>
</tbody>
</table>

**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
- Strongest (most likely) Server Air-to-Ground link

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

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

After the calculation is completed, the level of received power at the current point for different heights will also be displayed in the status bar.
It's the resolution of the result of the calculation. The resolution corresponds to one pixel of the screen for zoom = 7 (low detail), zoom = 8 (medium), and zoom = 9 (high). For a geographic latitude of 55 degrees, this is approximately 720, 360, and 180 meters, respectively.

The higher the resolution, the longer the calculation time.

| Area Study Resolution | - Low  
|                       | - Medium  
|                       | - High  
| Description          | It's the resolution of the result of the calculation. The resolution corresponds to one pixel of the screen for zoom = 7 (low detail), zoom = 8 (medium), and zoom = 9 (high). For a geographic latitude of 55 degrees, this is approximately 720, 360, and 180 meters, respectively.
| Required Service Threshold | The minimum threshold level of the received signal, dBm  
| Mobile Antenna Height Reference | - Sea level  
|                                  | - Ground level  
| Number of Levels | Number of altitude levels  
| Color | Color level  
| Height | The value of the level height of the mobile station for which the coverage area is displayed, m  
| Description | Text field  

*Figure 56. Received power Air-to-ground link*
**Strongest (Most Likely) Server Air-to-Ground Link**

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

Sector colors can be assigned automatically or by the table of frequency groups.

![Figure 57. Strongest Server menu](image)

| Area Study Resolution | - Low  
|                       | - Medium  
|                       | - High  

<table>
<thead>
<tr>
<th>Channel group</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>f01</td>
<td></td>
</tr>
<tr>
<td>f02</td>
<td></td>
</tr>
<tr>
<td>f03</td>
<td></td>
</tr>
<tr>
<td>f04</td>
<td></td>
</tr>
<tr>
<td>f05</td>
<td></td>
</tr>
<tr>
<td>f06</td>
<td></td>
</tr>
<tr>
<td>f07</td>
<td></td>
</tr>
<tr>
<td>f08</td>
<td></td>
</tr>
<tr>
<td>f09</td>
<td></td>
</tr>
<tr>
<td>f10</td>
<td></td>
</tr>
<tr>
<td>f11</td>
<td></td>
</tr>
<tr>
<td>f12</td>
<td></td>
</tr>
</tbody>
</table>
It's the resolution of the result of the calculation. The resolution corresponds to one pixel of the screen for zoom = 7 (low detail), zoom = 8 (medium), and zoom = 9 (high). For a geographic latitude of 55 degrees, this is approximately 720, 360, and 180 meters, respectively. The higher the resolution, the longer the calculation time.

<table>
<thead>
<tr>
<th>Required Service Threshold</th>
<th>The minimum threshold level of the received signal to calculate Strongest (Most likely) Server, dBm</th>
</tr>
</thead>
</table>
| Mobile Antenna Height Reference | - Sea level  
- Ground level |
| Apply automatic color assignment | Assigning colors to BS sectors is performed automatically in random order. |
| Use Colors from the Table | Assigning colors to BS sectors is done from the table according to color frequency groups. |
Point Calculations for Air-to-Ground Communication

This menu displays the terrain profile from the selected base station to any point at the height of the mobile station. The current point on the map can be changed with a mouse click. The profile is a vertical section of the terrain between the base station and the mobile station with information about elevations.

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

The height of the mobile station 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 the Area Study Details - Received Power Air-to-Ground link.

Some features of calculating coverage areas for aeronautical radio communications are given in Appendix 1.
Clutter Editor

RadioPlanner allows you to create custom clutters using the built-in Clutter Editor. The custom clutter model is formed by replacing the user-corrected areas in the default clutter model. A base map with actual satellite images is used as a data source for the custom clutter.

To start Clutter Editor, click the button on the main program panel.

![Figure 59. Clutter Editor](image)

Menu commands are designed as a toolbar. When you hover over each of the icons, a hint appears.

- Standard tools for working with files of clutter polygons *.plg Create, Open, Save
- Base map zoom
- Base map
- Exit from polygon drawing mode
- Draw Open/Rural polygon
- Draw Water polygon
- Draw Trees/Forest polygon
- Draw Suburban polygon
- Draw Urban polygon
- Draw Dense Urban polygon
- Delete polygon. To delete a polygon, select this tool and then click with the mouse on the polygon (polygons) to be deleted.
- Delete all polygons; removes all user-drawn polygons. This action can be undone using the Undo button.
- Undo
- Redo
- Convert Polygons to a Custom Clutter
- Show Base map
- Show Default Clutter
- Show Custom Clutter Polygons
- Show Custom Clutter
- Download Default Clutter within the screen area

- Delete Custom Clutter within the screen area

The current map zoom can be changed by scrolling the mouse wheel. The display of the default and custom clutter on the map starts with a Zoom of at least 11. Navigation on the map is performed using the left mouse button while pressing the button. In polygon drawing mode, the map can be moved by clicking on the mouse wheel.

The procedure for preparing a custom clutter consists of two stages:

1. **Drawing polygons for various clutter categories on the base map**

   In order to draw a clutter polygon of the desired category, click on the corresponding toolbar icon; the mouse pointer will change at the crosshairs. Click all vertices of the polygon with the mouse; to finish drawing the polygon, click on the right mouse button. Then you can proceed to draw the next polygon of the selected category. To change the clutter category - click on the desired icon on the toolbar. Using the toolbar, you can delete individual polygons or all polygons at once, as well as cancel or return up to ten actions in the editor.

   When drawing polygons, their hierarchy should be taken into account, which is enhanced by looking at the category icons in the toolbar from left to right. For example, inside the Open/Rural polygon, you can draw any of the polygons and inside the Trees/Forest polygon, you can draw Urban polygons, etc. It is convenient to start the adjustment of the default clutter by drawing Open/Rural polygons, inside which others polygons are then drawn.

   Polygons can be saved in a file with *.plg extension.

2. **Conversion of polygons to the Custom Clutter**

   To convert drawn polygons into a Custom Clutter, click the button on the toolbar, after which the program converts polygons into a Custom Clutter matrix. Elements of the Custom Clutter matrix are stored in the cache along with the Default Clutter matrix.

   You can choose a clutter model, Default or Custom, which will be taken into account in the calculations and displayed as a layer on the map, which is carried out in the "Propagation model" menu in RadioPlanner.

   Using the corresponding buttons of the Clutter Editor toolbar, you can turn on/off the showing of the base map, drawn polygons, as well as the Default and Custom clutters.

   When adjusting the clutter model, it should be noted that the ITU-R P.1812-4 propagation model used in the program assumes that the clutter model is detailed with a resolution of tens of meters. Accordingly, it makes no sense to outline the individual buildings and trees; it is enough to draw building blocks and forests.
Appendix 1. File formats

1.1 Cable attenuation file

A text file **feeders.txt** with information about frequency-dependent attenuation in cables is included in the folder where RadioPlanner is installed. The user can add information about the required cables to this file.

The feeders.txt file has a 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 need not be the same.
Appendix 2. Some Features of Coverage Calculating for Air-to-Ground Radio

For a certain combination of data (heights of the base and mobile stations, 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 BS).

This means that in this zone, the mobile station (aircraft) will be in the area of the 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 the 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, within 5-7 percent reduction, 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 the additional margin for fading within 5-7 dB.

After which, the calculation result for the example considered above will look like this:
Appendix 3. Examples of Calculations for Various Wireless Networks and Broadcasting Networks

There are several project examples for various wireless and broadcast networks in the software package.