MLinkPlanner 2.0

Point-to-Point and Point-to-Multipoint Microwave Link Planning Software

User Manual

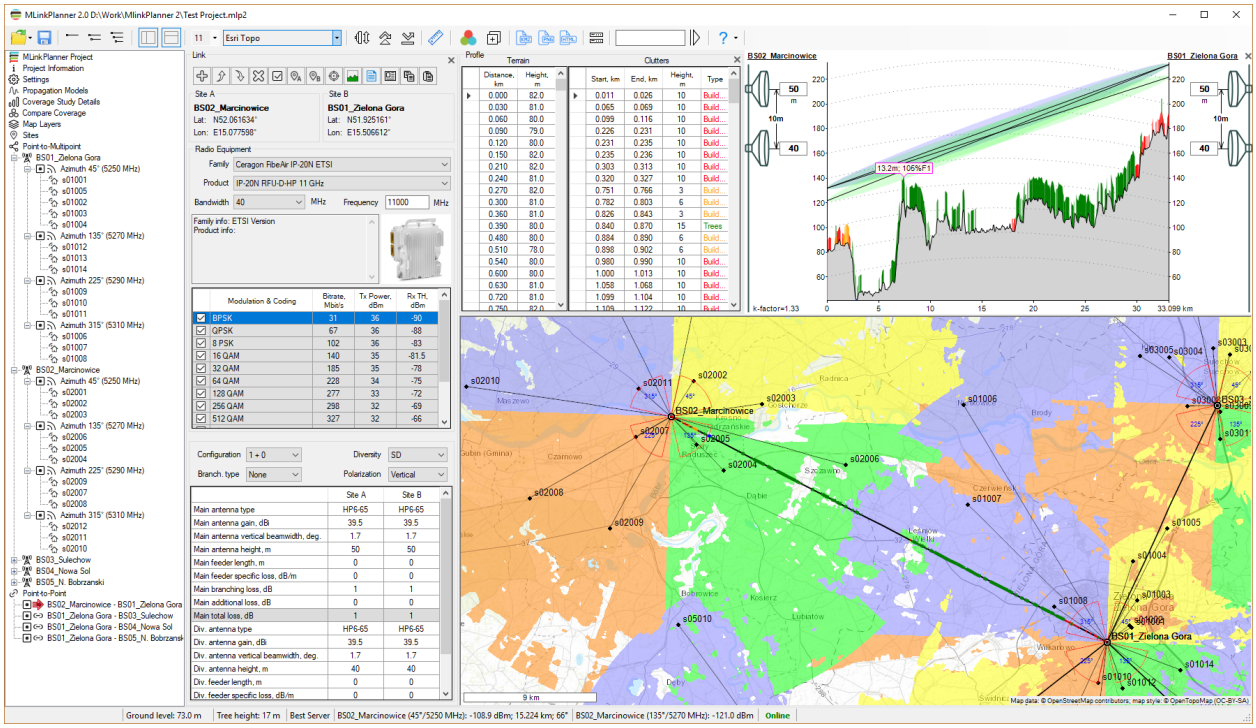


Table of Contents

From the Developers

We have 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 MLinkPlanner.

About MLinkPlanner

MLinkPlanner is a powerful and user-friendly tool for designing microwave point-to-point (PtP) and point-to-multipoint (PtMP) links. MLinkPlanner was created by engineers with many years of experience in designing microwave links, from single-hop access links to high-power long-haul trunk lines.

MLinkPlanner has demonstrated its effectiveness in designing many links that are operating successfully in various climate zones and topographical conditions from plains and marshlands to highlands.

Special focus was placed on devising a convenient user interface, the incorporation of adaptable and easy to use link path profiles in the design process, and the automation of all key calculations.

Main Features

Path profile generation with terrain elevation, tree height, and height of buildings based on:

- **Terrain elevation data 2-30 m plane resolution** (Default DEM). For more details on data sources see Appendix 1. "Terrain Elevation Data". It is also possible to use custom DEM in GeoTIFF format with any plane resolution.
- **Global tree cover 1 arc sec (about 30 m) resolution data with information about tree height** Data sources: High-Resolution Global Maps of 21st-Century Forest Cover Change Published by Hansen, Potapov, Moore, Hancher et al. Department of Geographical Sciences University of Maryland https://earthenginepartners.appspot.com and Jet Propulsion Laboratory California Institute of Technology https://landscape.jpl.nasa.gov
- **Global 3D building data from OpenStreetMap project database.** Data source: Our buildings database, which synchronizes with the global OpenStreetMap database.

All of these types of geodata are automatically downloaded to the required area as needed; there is no need to worry about preloading the geodata.

You can also edit an existing path profile or create a new one manually.

The application allows you to use standard basemaps (such as OpenStreetMap, OpenTopoMap, US Topo etc.) and custom ones.

MLinkPlanner 2.0 can perform the calculation and optimization of PtP and PtMP microwave link parameters, including:

- Path profile analysis (evaluate different clearance criteria, obstruction loss, reflection geometry)
- Multipath fade probability prediction (Rec. ITU-R P.530-17 method; Vigants-Barnett method)
- Rain fade estimation (Rec. ITU-R P.530-17 method; Crane method)
- Diversity improvement calculation (frequency, space, and quad diversity)
- Co-channel operation
- Error performance and availability prediction (Rec. ITU-R F.1668, Rec. ITU-R F.1703)
- Reflection analysis (Rec. ITU-R P.530-17)

- Diffraction loss analysis (Rec. ITU-R P.526-15 Complete Bullington method or Diffraction over multiple cylinders method; Deygout principle method with correction ITU-R-P.526-11; Epstein-Peterson method)
- Gaseous attenuation (Rec. ITU-R P.676-11)
- Attenuation in vegetation (Rec. ITU-R P.833-9)

MLinkPlanner 2.0 can perform coverage prediction for PtMP and outdoor Wi-Fi with the different area study methods:

- Received Power Studies at subscriber stations (downlink)
- Best Server
- Carrier-to-interference + noise ratio C/(I+N) at subscriber stations

MLinkPlanner 2.0 allows you to do:

- Use the large set of radio equipment specifications that come with the software.
- Save the result of the coverage prediction as an interactive web page, as a PNG image, GeoTIFF, or as a KMZ file.
- Compare the coverage prediction results performed for different conditions.
- Flexibly adjust the layers on the base map and show custom vector layers
- Use metric or English measurement systems

Installation, Activation, and Registration

MLinkPlanner 2.0 supports Windows 7/8/8.1/10/11.

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.

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

Once you have successfully purchased MLinkPlanner, you will receive an 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.

MLinkPlanner 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 MLinkPlanner software before installing the update.

User Interface

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. At the top is the main toolbar. When you hover over each of the icons, a hint appears.

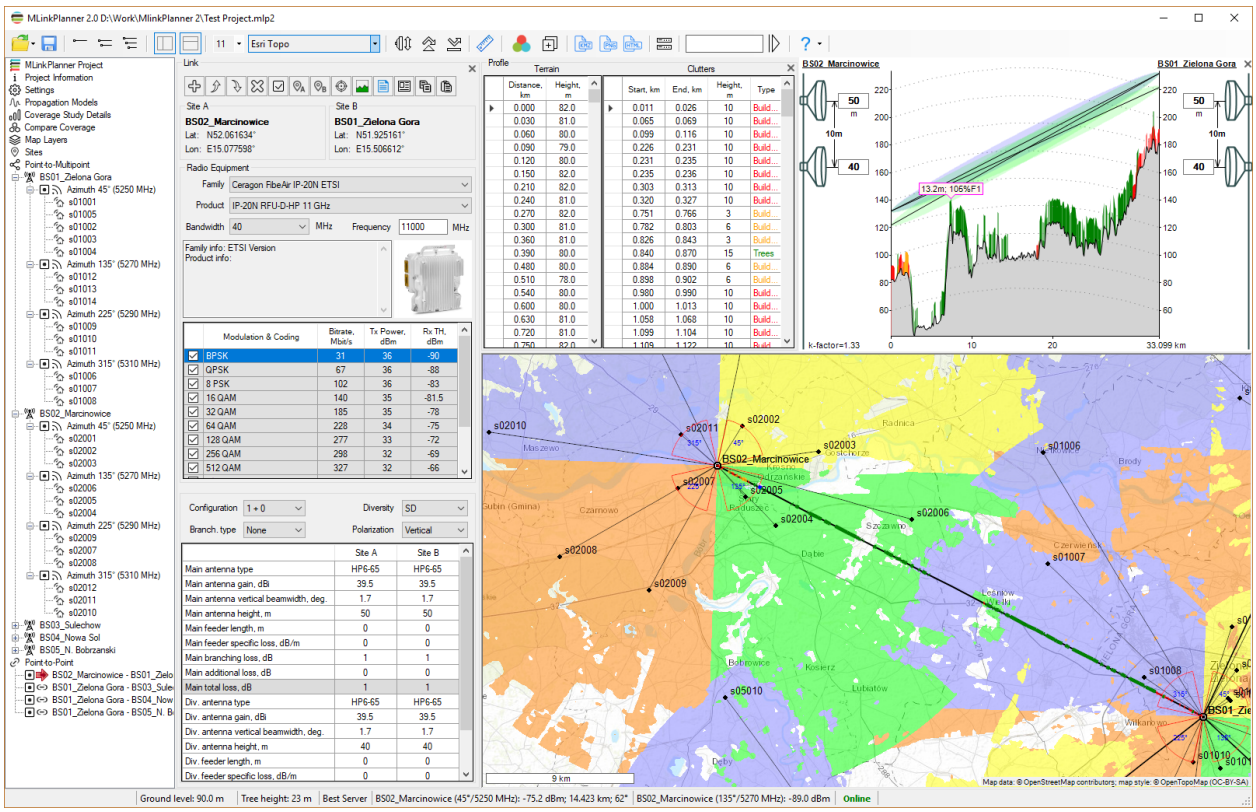


Figure 1. MLinkPlanner 2.0 interface

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

- Save the project.

- Collapse all PtMP base stations in the main menu.

- Expand PtMP base stations to the sector level in the main menu.

- Expand PtMP base stations in the main menu to the subscriber station level.

- Show / Hide the left panel for subscriber stations and links. By default, this tool is deactivated, but it can be activated in Settings.

- Show / Hide the panel with a path profile. By default, this tool is deactivated, but it can be activated in Settings.

11 - The current base map zoom

TopoCTT - The current base map

- Antenna height optimization

- Diffraction analysis

- Reflection analysis

- Perform coverage prediction for PtMP base stations.

- Add the coverage to compare

- 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.

- Save PtMP base station coverage as a webpage.

- Save PtMP base station coverage as an image in *.png format.

- Save PtMP base station coverage as a GeoTIFF file in the Web Mercator projection

- Save coverage, sites and links as a KMZ file.

- Equipment Editor

- Search for base stations, subscriber stations, and links by name.

- Help

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

As in the main user menu, the program uses a multi-level tree interface. When you select one of the menu items, the corresponding panel opens next to it.

MLinkPlanner also has a context menu on the base map. You can use them to quickly perform various actions. The options for this context menu directly depends on selected main menu items.

Different layers can be displayed on the base map — sites, microwave PtP links, PtMP base and subscriber stations, PtMP coverage, various additional custom 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.

Map navigation performs with a mouse. Use the mouse wheel to zoom the map in or out. You can also select the required zoom from the drop-down list in the toolbar.

When the map zooms into level 12 or higher, the application begins to download SRTM elevation data and tree cover data. The status bar displays the pointer's geographic coordinates and the information about the elevation above sea level and the height of the tree canopy. Usually, loading of the necessary data sets (terrain, elevation, and tree cover) takes place in a few seconds.

Quick Start

Point-to-Multipoint Link Availability Prediction

1. Create at least two sites (see **Creating Sites**).
2. Using the , (add a new product family) button in the **Point-to-Multipoint** menu, connect the product family with the PtMP equipment you need to the project (see the **PtMP base stations** section). If such equipment was not in the set of specifications supplied with the program, then first create the equipment specification (see Section **Equipment Editor**).
3. Using the one of the previously created sites, in the **Point-to-Multipoint** menu, create a new base station (see the **PtMP base stations** section). When creating a BS, its first sector is created automatically.
4. In the created BS sector, from the drop-down lists, select the family and product (equipment model), bandwidth, carrier frequency, and also specify the antenna and feeder parameters, also choose the antenna pattern file (see the **PtMP base stations** section).
5. In the created BS sector, click on the button (add a new subscriber station) and select the site on the basis of which this subscriber station will be created.
6. In the panel of the created subscriber station, click the (generate path profile) button to automatically create the path profile (see **Creating the Path Profile with GIS** section). From the drop-down list, select the product (equipment model), and specify the antenna and feeder parameters.
7. In the panel of the subscriber station, click (Report) to display the link availability report.

Point-to-Point Link Performance and Availability Prediction

1. Create at least two sites (see **Creating Sites**).
2. Using the (add a new product family) button in the **Point-to-Point** menu, connect the product family with the PtP equipment you need to the project (see the **PtP links** section). If such equipment was not in the set of specifications supplied with the program, then first create the equipment specification (see **Equipment Editor**).
3. Using the previously created sites, in the **Point-to-Point** menu, create a new microwave PtP link (see the **Creating PtP link** section).
4. In the panel of the created PtP link, click the (generate path profile) button to automatically create the path profile (see **Creating the Path Profile with GIS** section).
5. From the drop-down list, select the family and product (equipment model), bandwidth, and carrier frequency.
6. In the table that appears, mark the types of modulations and coding for which the calculation will be performed. Next, specify the required configuration of the microwave link, redundancy and diversity reception, parameters of antennas and feeders, as well as antenna heights (antenna heights can also be changed directly on the path profile diagram).
7. Click (Report) to display the link performance and availability report.

Coverage Study for Point-to-Multipoint

1. Create at least one site (see **Creating Sites**).
2. Using the (add a new product family) button in the **Point-to-Multipoint** menu, connect the product family with the PtMP equipment you need to the project (see the **PtMP base stations** section). If such equipment was not in the set of specifications supplied with the program, then first create the equipment specification (see Section **Equipment Editor**).
3. Using the one of the previously created sites, in the **Point-to-Multipoint** menu, create a new base station (see the **PtMP base stations** section). When creating a BS, its first sector is created automatically.
4. In the created BS sector, from the drop-down lists, select the family and product (equipment model), bandwidth, carrier frequency, the antenna and feeder parameters, and also choose the antenna pattern file (see the **PtMP base stations** section).
5. Fill in the form **Coverage Study Details** with the calculation parameters (see **Coverage Study**).
6. Click **Calculate Coverage** on the top toolbar to display a coverage map.

Projects

MLinkPlanner project files have a *.mlp2 extension. Each file contains information about the project, including path profiles and parameters of microwave equipment. A new project is created automatically each time the application is run. On the lower left panel, enter the Project Information.

The import of projects from the previous version is also provided.

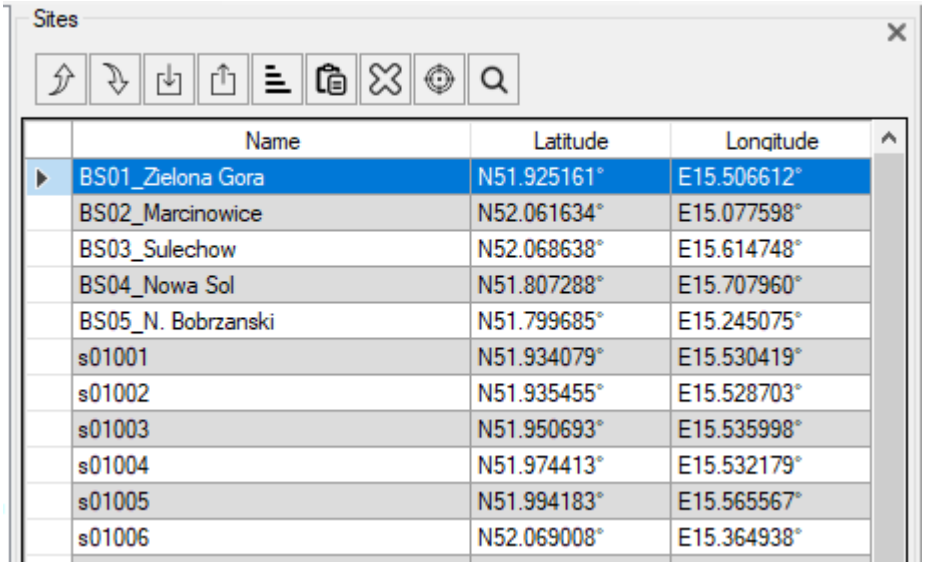
The installation file comes with several test projects from which you can start working in MLinkPlanner.

Sites

Before creating microwave point-to-point links, point-to-multipoint base stations or subscriber stations links, you must first create sites. Sites are locations that can be connected via point-to-point or point-to-multipoint links. A site has only three characteristics - name, latitude, longitude.

Creating Sites

To work with sites, go to the **Sites** menu item in the left menu.



Name	Latitude	Longitude
BS01_Zielona Gora	N51.925161°	E15.506612°
BS02_Marcinowice	N52.061634°	E15.077598°
BS03_Sulechow	N52.068638°	E15.614748°
BS04_Nowa Sol	N51.807288°	E15.707960°
BS05_N. Bobrzanski	N51.799685°	E15.245075°
s01001	N51.934079°	E15.530419°
s01002	N51.935455°	E15.528703°
s01003	N51.950693°	E15.535998°
s01004	N51.974413°	E15.532179°
s01005	N51.994183°	E15.565567°
s01006	N52.069008°	E15.364938°

Figure 2. Sites menu

Toolbar:

 - Move this site up.

 - Move this site down.

 - Import sites from *.csv or *.kml files.

 - Export sites to Microsoft Excel.

 - Sort sites in alphabetical order.

 - Add sites from the clipboard.

 - Delete all sites.

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

 - Find and select a site in the table.

MLinkPlanner provides several ways to create sites:

1. Enter the name and coordinates of the site in the table.

2. Use the context menu when clicking on the base map.

3. Import sites from a CSV or KML file.

4. Copy from spreadsheets via the clipboard.

Table Entry

Enter the site name and its geographic coordinates in the relevant fields. The geographic coordinates are specified as Point of compass, degrees, minutes, and decimal seconds (e.g., N35 36 23.8). The numbers should be separated by a space. After pressing ENTER, the coordinates will be automatically converted to the format specified in the **Settings** menu. Alternatively, you can enter coordinates as Point of Compass and Decimal degrees (N12.34567). After pressing ENTER, they will also be converted to the selected format. The site icon will be displayed on the base map. If you do not specify a hemisphere, then the northern hemisphere will be set by default.

Use the Context Menu

You can also create a site by right clicking on a location on the base map. Being in the main menu item **Sites**, right-click on a location within the basemap and select **Create a new site** from the context menu; you can rename it later. The new site will be added to the map and appended to the bottom of the site table.

Please note that the context menu with the line "**Create new site**" appears on the base map only when you are in the **Sites** main menu.

Import Sites from a CSV or KML File

You can import sites into MLinkPlanner from any spreadsheet by exporting the sheet as a CSV file (separator – ";"). The required fields for each site are Name, Latitude, and Longitude. Geographic coordinates should be specified as Point of compass, degrees, minutes, and decimal seconds (N35 36 23.8). The numbers must be separated by a space. Point of Compass and Decimal degrees (N12.34567) is also an acceptable format.

To import from CSV: save the spreadsheet as a CSV file (separator – ";") and then click  (Import sites from *.CSV, *.KML).

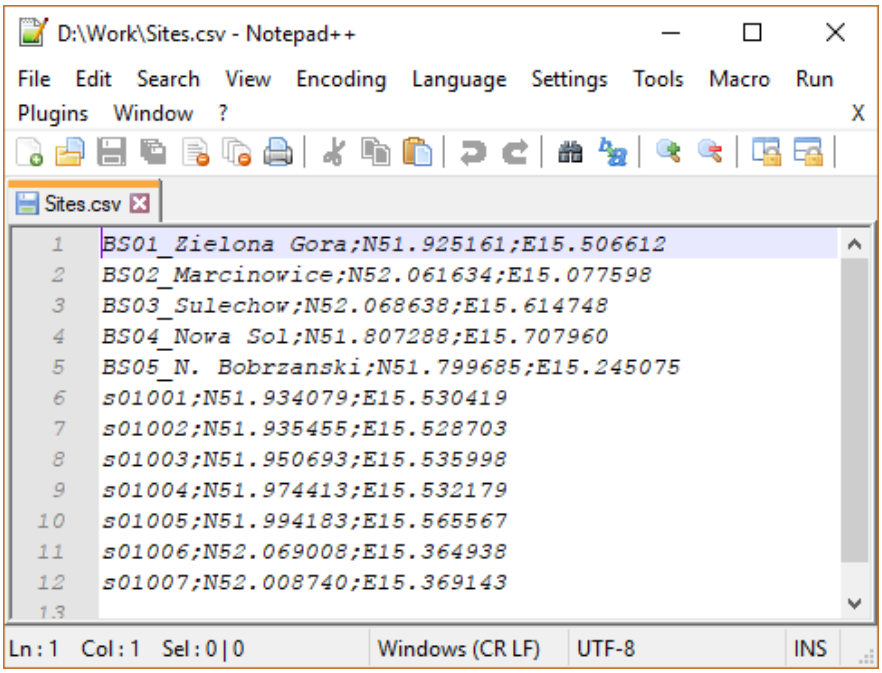


Figure 3. Example of CSV file with sites to be imported

The program also allows you to import sites from KML files that can be prepared using the Google Earth application. To import sites, click the button and select the * .KML file, while all point features from the KML file will be imported as sites.

Imported sites are added to existing ones.

Copy from Spreadsheets via Clipboard

Copy the cells with the names of the sites and their coordinates in the Excel or Word spreadsheet to the clipboard and then click on the toolbar, after which the corresponding sites will appear in the table.

Working with Sites

To delete one or several sites, select the corresponding rows in the table and press the Delete key. Deleting a site will not lead to the deletion of PtP microwave links already created on the basis of this site, as well as the base or subscriber station PtMP.

By double-clicking on the row with the site in the table, this site will be shown on the base map in the center of the screen.

You can move the site using the right mouse button - select the site in the Sites table, then right-click on the location on the base map, and select **Move site** in the context menu.

You can quickly find a site in a table using the tool .

Equipment Editor

MLinkPlanner 2.0 uses special format equipment files with the extension * .eqt. These files contain specifications of different types of Point-to-Point and Point-to-Multipoint equipment.

The software comes with a set of such files for a wide range of modern Point-to-Point and Point-to-Multipoint equipment. Therefore, in most cases, the user does not need to search for detailed specifications for the main radio equipment. It is enough to choose equipment from the supplied set. One such file may contain specifications for a whole family of products. The common parameters for this Family are modulation and coding parameters, as well as a set of bandwidths.

An example of such a family for Point-to-Multipoint equipment is the popular airMax family by Ubiquiti Networks, which includes many products of base stations and subscriber stations that are compatible with each other. Equipment for Point-to-Point example family is FibeAir IP-20N by Ceragon, which includes a set of external placement of different modules (RFU) on different frequency bands.

We are constantly updating the files with equipment parameters, the current set can be downloaded from our website https://www.wireless-planning.com/equipment. These specifications are taken from open sources and are supplied "as is;" we carefully check it, but we do not guarantee the reliability.

If the file with the necessary equipment was not included in the supplied set, the program provides a tool, Equipment Editor, with which the user can prepare the specification file.

To start the equipment editor, click on the icon on the top toolbar.

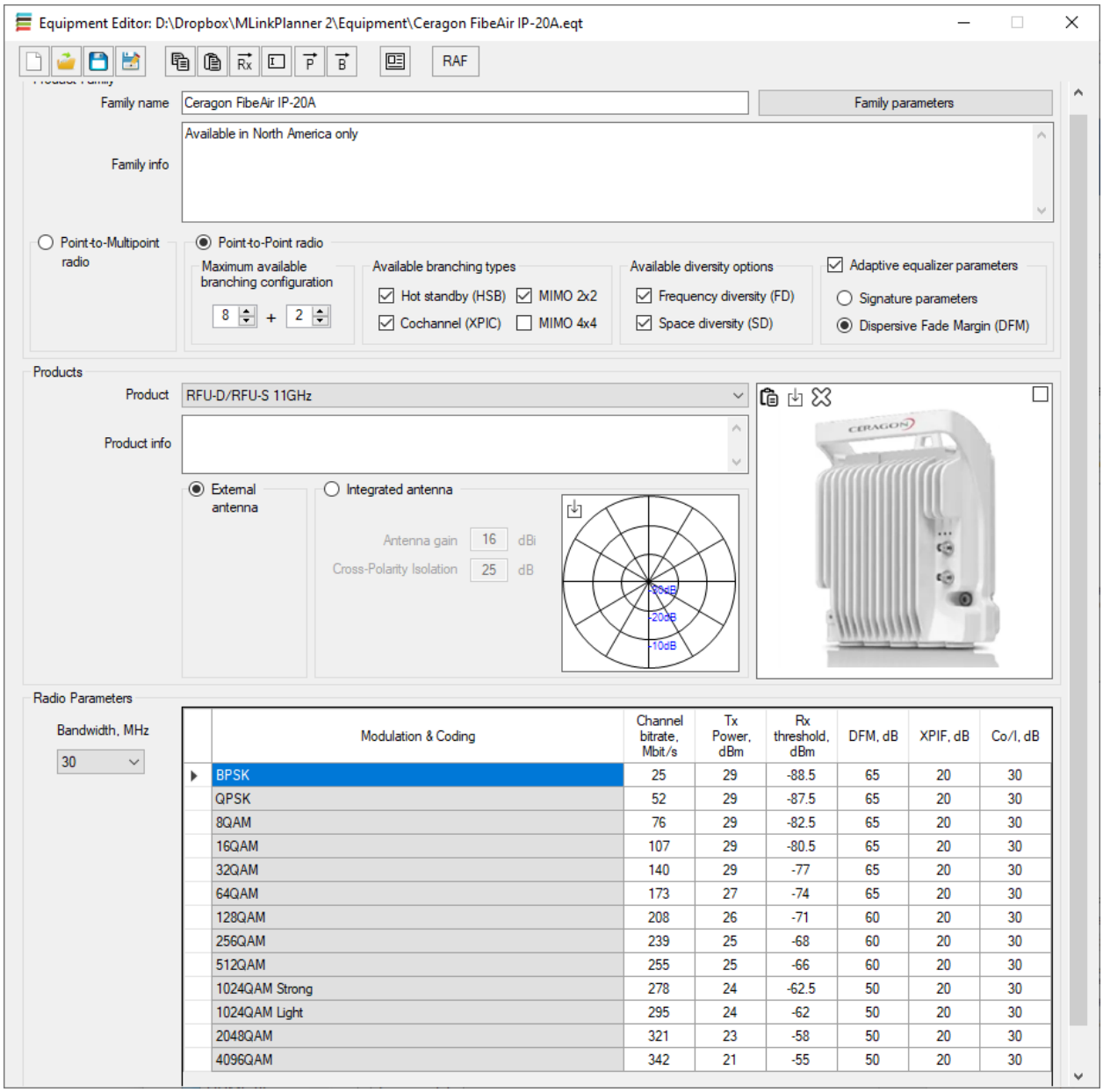


Figure 4. Equipment Editor

Standard File Tools:

 - New

 - Open

 - Save

 - Save as

Family Name	Family name
Family Info	General information about the equipment family; information text field
Family Parameters	
Products	The list of products (equipment models) included in the family
Bandwidth, MHz	List of all bandwidths supported by the equipment family
Modulation @ Coding	A list of all types of modulations and coding supported by the equipment family
Point-to-Multipoint Radio	Select for the PtMP family
Point-to-Point Radio	Select for the PtP family
Maximum Available Branching Configuration	The maximum number of main and standby trunks available in the equipment family (PtP only)
Available Branching Types	Available branching types: Hot Standby (HSB) / Co-channel (XPIC)/ MIMO 2x2/MIMO 4x4. PtP only.
Available Diversity Options	Diversity reception methods available for the equipment family (PtP only)
Adaptive Equalizer Parameters	Choosing the type of adaptive equalizer parameters: signature parameters or DFM (Dispersive Fade Margin) PtP only
Product	Selected product (equipment model)
Product Info	General product information (equipment models); information text field
External Antenna	Select if an external antenna is used with this product.
Integrated Antenna	Select if **only** an integrated antenna is used with this product.
Antenna Gain, dBi	Integrated antenna Gain, dBi
Antenna Pattern (in MSI format)	Antenna pattern of the integrated antenna. To download the antenna pattern file in MSI format, click in the upper left corner.
Product Image	Photo or graphic image of the product. You can download the image from a file or through the clipboard, using the tools above the image. If one picture is used for all products, then indicate this using the check box in the upper right corner, this will significantly reduce the size of the file with the specification.
Bandwidth, MHz	Selected bandwidth, MHz
Modulation @ Coding	A list of all types of modulations and coding supported by the equipment family
Channel Bitrate, Mbit/s	Maximum channel speed for the corresponding type of modulation and coding, Reference Information, Mbps
Tx Power, dBm	Transmitter power for the appropriate type of modulation and coding, dBm
Rx Threshold, dBm	The threshold sensitivity of the receiver for the corresponding type of modulation and coding, dBm
Signature Width, MHz	Signature width, MHz (PtP only)
Signature Depth min Phase, dB	Signature depth min phase, dB (PtP only)
Signature Depth non min Phase, dB	Signature depth non min phase, dB (PtP only)

DFM, dB	Dispersive Fade Margin, dB (PtP only)
XPIF, dB	Cochannel Improvement Factor, dB (PtP only)
Co/I, dB	Carrier-to-interference ratio for a reference BER, dB (PtP only)

The procedure for creating the specification file:

1. Fill in the Family field and the Family information field (if necessary; this is just an information field).

2. Go to the Family Parameters panel. Fill in all the products in the Family. Fill in all the frequency bands which are available for the Family. Fill in all the Modulation and Coding which are available for the Family. After filling in, click OK, this panel will close, and the entered information will appear in the Products, Frequency Bands, as well as in the Modulation and Coding table of the main panel of the Equipment Editor.

3. Select the type of equipment family - Point-to-Multipoint or Point-to-Point. For the Point-to-Point family, fill in the information about the maximum available branching configuration, available branching types, available diversity options, and the type of adaptive equalizer parameters. All of this information will be taken into account in the future when configuring PtP microwave links based on this product family.

4. Now you can enter information about each product:

4.1 Select your product from the drop-down list.

4.2 Fill in the Product Information Field (if necessary; this is just a text field).

4.3 If an external antenna is used with this model of equipment, select this. If an antenna is built into the equipment, as is often the case for PtMP base and subscriber stations, select the Integrated Antenna, enter its gain, and download the antenna pattern file in MSI format.

4.4 Insert a photo or graphic image of the product. You can download the image from a file or through the clipboard, using the tools above the image. If one picture is used for all products, then indicate this using the checkbox in the upper right corner; this will significantly reduce the size of the file with the specification.

4.5 From the bandwidth drop-down list, select the required product bandwidth. Fill in the columns Channel bitrate, Tx Power, and Rx threshold for each modulation type. For Point-to-Point equipment, it may be necessary to additionally fill in the adaptive equalizer parameters for each modulation type and if the equipment family supports Co-channel mode, then XPIF and Co/I parameters.

4.6 Repeat the steps in clause 4.5 for all bandwidths supported by the product

5. After filling in the information for each product, save the specification file (extension * .eqt).

For convenience and reducing time when filling out specifications, several tools are provided here, and copying and pasting groups of cells from spreadsheets are also supported.

Toolbar:

- Copy all parameters of the product modulation table to the clipboard (used to create new products based on existing ones).

- Paste modulation table parameters from the clipboard (used to create new products based on existing ones).

- Automatically fill receiver threshold sensitivity values for all bandwidths based on the values of the first bandwidth. This tool can be used for an approximate assessment of threshold sensitivity when accurate data is not available for all bandwidths. The tool is based on the fact that the threshold sensitivity of the receiver decreases in proportion to the increase in bandwidth. For example, when the bandwidth is doubled, the threshold sensitivity decreases by 3 dB.

- Rename products (replace the combination of any letters / numbers / symbols in the product name).

- Apply selected parameters in the table for all products with this bandwidth.

- Apply selected parameters in the table for all bandwidths for this product.

- Display the product specifications for the selected bandwidth in the form of a datasheet, which can be saved in PDF, Word, or Excel formats.

- Load product data from Pathloss RAF file PL50_ASCII_RADIO_SPEC_03/04 with ADMOD

Propagation Models for PtP and PtMP links

In this menu, the user can select a method, which will be used to calculate the microwave link performance, as well as some parameters of this method.

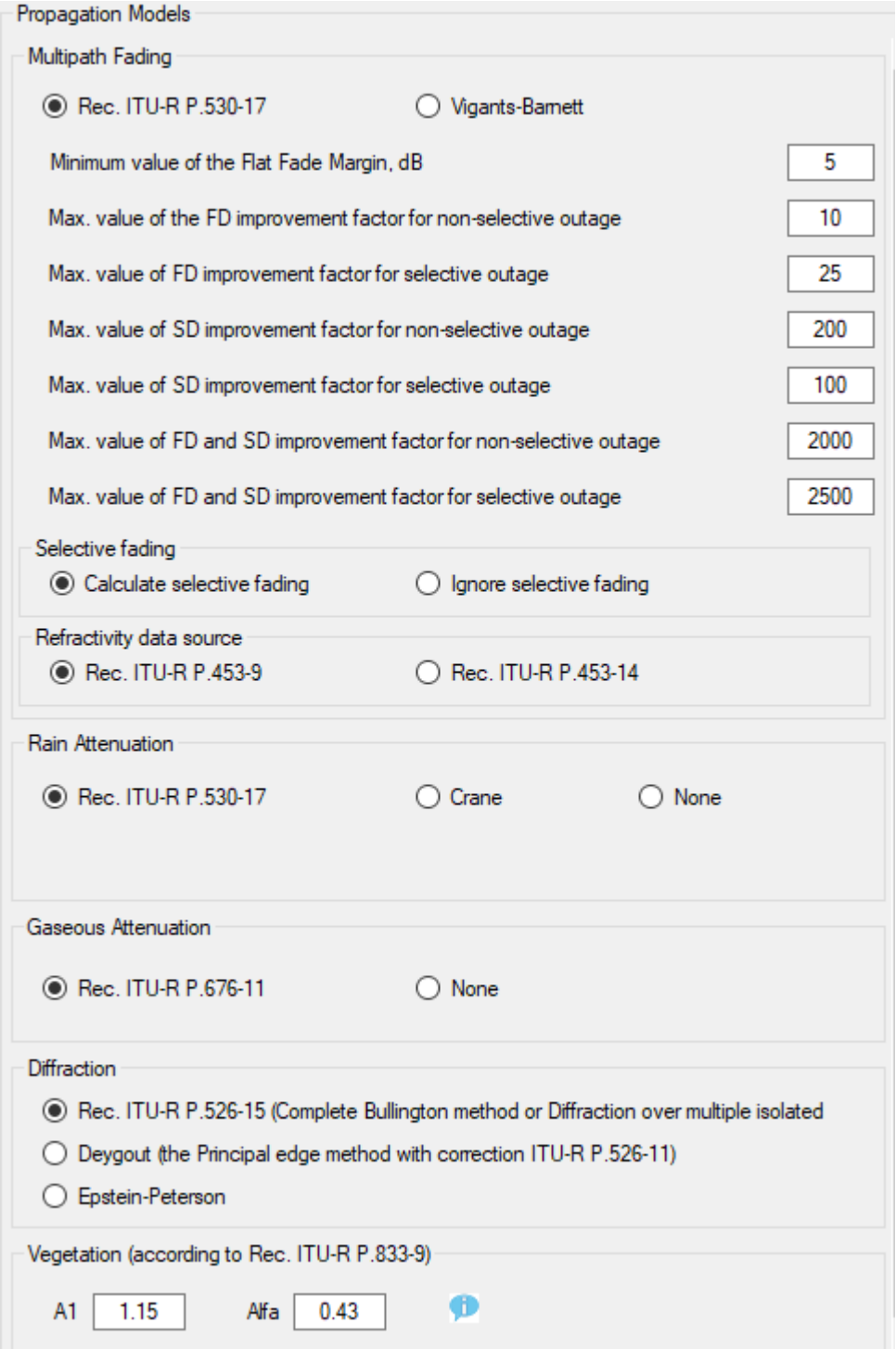


Figure 5. Propagation Models

ITU-R P.530-17 Multipath Fading Model	
Minimum value of the Flat Fade Margin, dB	The minimum allowable fade margin, dB If the fade margin is less than this value, the calculation will be stopped (dashes will appear in the report in place of the calculated values).
Maximum value of the frequency diversity improvement factor for non-selective outage probability	Limiting the maximum value of the frequency diversity improvement factor for non-selective outage probability

Maximum value of the frequency diversity improvement factor for selective outage probability	Limiting the maximum value of the frequency diversity improvement factor for selective outage probability
Maximum value of the space diversity improvement factor for selective outage probability	Limiting the maximum value of the space diversity improvement factor for selective outage probability
Maximum value of the space and frequency diversity (four receivers) improvement factor for non-selective outage probability	Limiting the maximum value of the space and frequency diversity (four receivers) improvement factor for non-selective outage probability
Maximum value of the space and frequency diversity (four receivers) improvement factor for selective outage probability	Limiting the maximum value of the space and frequency diversity (four receivers) improvement factor for selective outage probability
Calculate selective fading	Calculate selective fading
Ignore selective fading	Ignore selective fading
Rec. ITU-R P. 453-9	Use Rec. ITU-R P. 453-9 refractive gradient data
Rec. ITU-R P. 453-14	Use Rec. ITU-R P. 453-14 refractive gradient data
Vigants-Barnett Multipath Fading Model	
Minimum value of the Flat Fade Margin, dB	The minimum allowable fade margin, dB If the fade margin is less than this value, the calculation will be stopped (dashes will appear in the report in place of the calculated values).
Rain Attenuation	
Rec. ITU-R P.530-17	Rain attenuation estimation in accordance with Recommendation ITU-R P.530-17
Crane - Select Crane 1996 rain region	Rain attenuation estimation according to the Crane method, taking into account 1996 rain regions. To view rain regions for the US and World, press I.
None	Do not calculate rain attenuation.
Gaseous Attenuation	
Rec. ITU-R P.627-11	Calculate of gaseous attenuation according to recommendation ITU-R P.627-11
None	Do not calculate gaseous attenuation.
Diffraction	
Rec. ITU-R P.526-15 (Complete Bullington method or Diffraction over multiple isolated cylinders method)	Calculation of diffraction attenuation by the Rec. ITU-R P.526-15 (complete Bullington method or Diffraction over multiple isolated cylinders method)
Deygout (the principle edge method with correction Rec. ITU-R P.526-11)	Calculation of diffraction attenuation by the Deygout (the principle edge method with correction Rec. ITU-R P.526-11)
Epstein-Peterson	Calculation of diffraction attenuation by the Epstein-Peterson method
Vegetation (according to Rec. ITU-R P.833-9)	
A1 and Alfa parameters	Parameters A1 and Alfa for calculating attenuation in vegetation in accordance with ITU-T Rec. ITU-R P.833-9. Press i for information.

Planning Point-to-Point Links

Creating PtP Link

When sites have been created, you can create one or several microwave links.

To start working with point-to-point links, open the **Point-to-Point** item on the main menu.

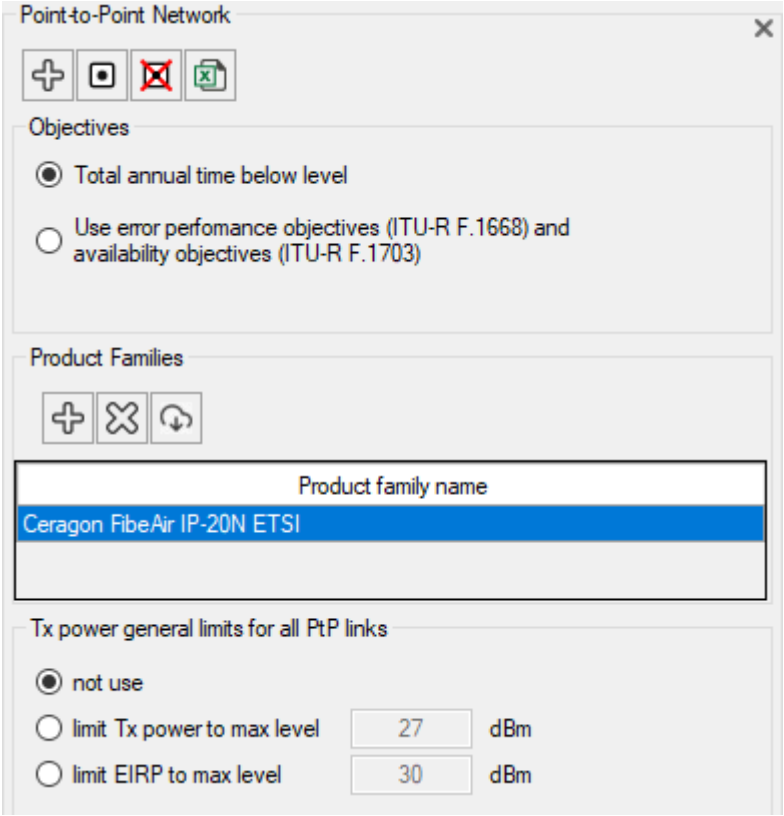


Figure 6. Point-to-Point main menu

First, it is necessary to include the specification file of the equipment family that is supposed to be involved in the project.

Click on the  **Add a new product family** button in the Point-to-Point menu to include the product family to your project. To download the product family files from our website, click on the **Download product family files** button, and a link will open in the browser. We are continually updating the files with equipment parameters, but if such equipment not on our website, then first create the equipment specification file (see **Equipment Editor**).

Toolbar for PtP:

 - Create a new PtP link.

 - Select / Deselect all PtP links.

 - Delete all selected PtP links.

 - Summary report for all active PtP links in Microsoft Excel

Tx power general limits for all PtP links	
not use	not use general limits
limit Tx power to max level, dBm	Maximum Tx power for transmitters of all PtP links in this project, dBm From the general limit that is set in this menu and the limit that is set in a particular link, the most stringent limit is selected during the calculation.
limit EIRP to max level, dBm	Maximum EIRP for transmitters of all PtP links in this project, dBm From the general limit that is set in this menu and the limit that is set in a particular link, the most stringent limit is selected during the calculation.

To create a PtP link, click on the  button at the top of the Point-to-Point menu, and the program will prompt you to select the link ends, Site A and Site B, from the sites created before. Then this link will appear in a point-to-point tree and a panel will open with its parameters.

So that in the future the software can automatically calculate the length of a line consisting of several PtP links (this is necessary to distribute the objectives by intervals - see the Objectives section), you need to choose the link direction in such a way that to make it easy to build a line. For example, if there are sites A, B, C, D, E, then the PtP links should be named as A-B, B-C, C-D, D-E (and not E-D, for example). Then, when specifying the beginning and end of the line, for example, A-E or B-D, the program will determine its topology and correctly take into account the length of all PtP links in the whole line. The same applies to the branches of the main line.

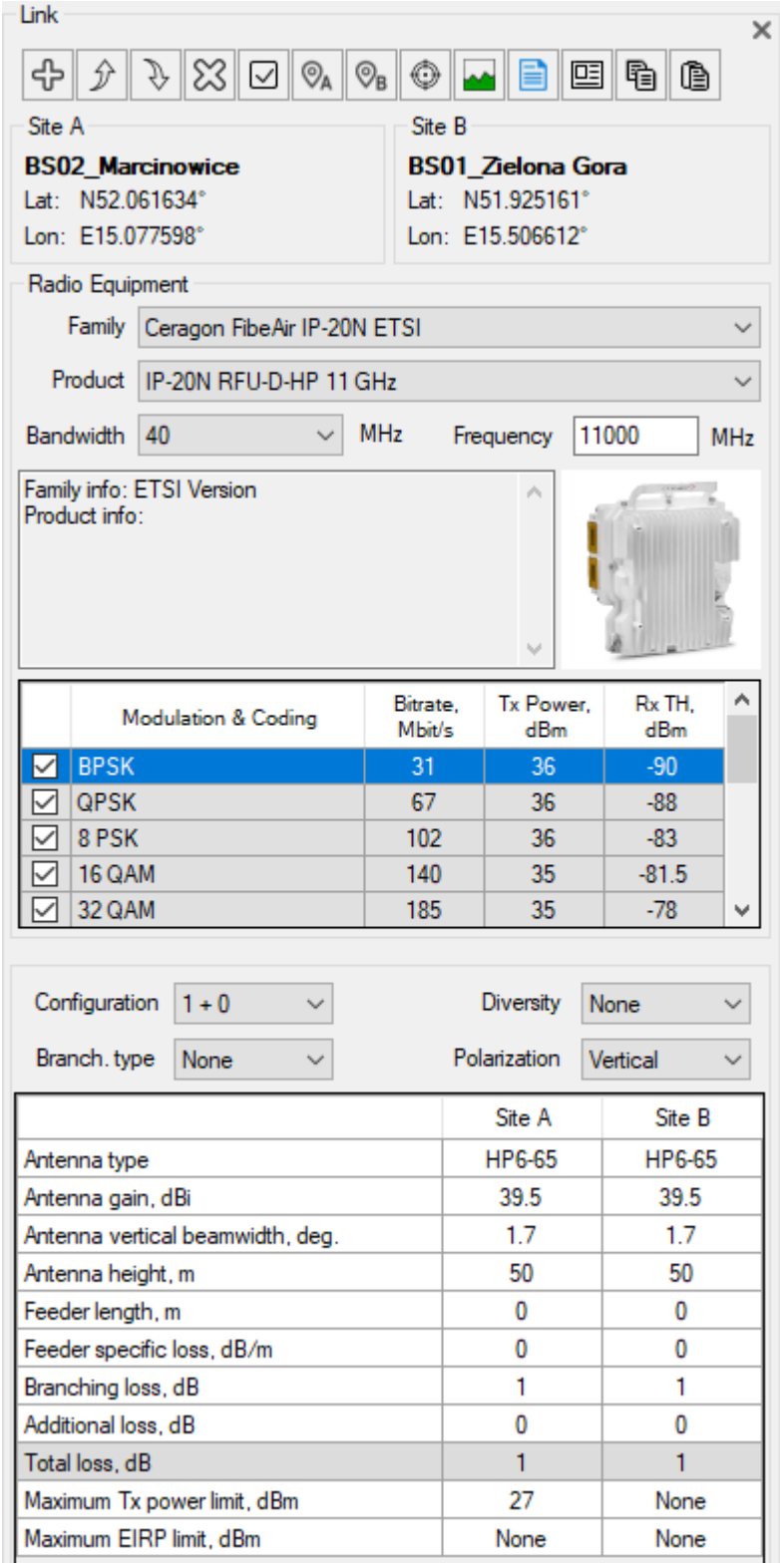


Figure 7. PtP link parameters

PtP Link Toolbar:

 - Create a new PtP link with the same parameters.

- Move this link up.
- Move this link down.
- Delete this link.
- Select / deselect all types of modulation and coding.
- Change the site A.
- Change the site B.
- Position the map with the link at the center of the screen.
- Generate the path profile for the link.
- Link report.
- Display the product specifications for the selected bandwidth in the form of a datasheet, which can be saved in PDF, Word, or Excel formats.
- Copy link parameters to the clipboard
- Paste link parameters from the clipboard

The required link can be selected from the list in the **Point-to-Point** menu or by double-clicking on it on the base map.

Path Profile

A path profile is a vertical sectional view of the terrain created by a plane passing through both ends of the link. The path profile includes terrain elevation data, building and tree heights, and boundaries of water bodies.

MLinkPlanner creates path profiles using the following GIS data:

- **Terrain elevation data 2-30 m plane resolution** (Default DEM). For more details on data sources see Appendix 1. "Terrain Elevation Data". It is also possible to use custom DEM in GeoTIFF format with any plane resolution. In order to use custom DEM, specify the path to it in the Settings menu and check the corresponding box. File format requirements are outlined in Appendix 2 "Custom DEM Format".
- **Global tree cover 1 arc sec (about 30 m) resolution data with information about tree heights.** Data sources: High-Resolution Global Maps of 21st-Century Forest Cover Change Published by Hansen, Potapov, Moore, Hancher et al. Department of Geographical Sciences University of Maryland https://earthenginepartners.appspot.com and Jet Propulsion Laboratory California Institute of Technology https://landscape.jpl.nasa.gov/
- **Global 3D buildings data from OpenStreetMap project database.** Data sources: Our buildings database, which synchronizes with the global OpenStreetMap (OSM) database.

All of these types of geodata are downloaded for the desired area automatically as needed; there is no need to worry about preloading the geodata.

Creating the Path Profile with GIS

In the created link, click the button **Generate path profile**. A warning dialog box will appear indicating that the path profile data will be changed. You should specify the average building floor height (typically 3 m) in this window. The OSM project database usually contains information about the number of floors of the buildings rather than their height in meters. Building height in the path profile will usually be based on the number of floors and floor height. You will also have to specify the height of the buildings for which OSM project database does not have information. Such buildings will be highlighted in red in the path profile.

If a building affects the qualitative characteristics of the path profile as a critical obstruction, check the building's height with third party sources to verify its exact height. The user can override the forest height information obtained from the **Global Forest Change** records and set a new value to be used in a path profile.

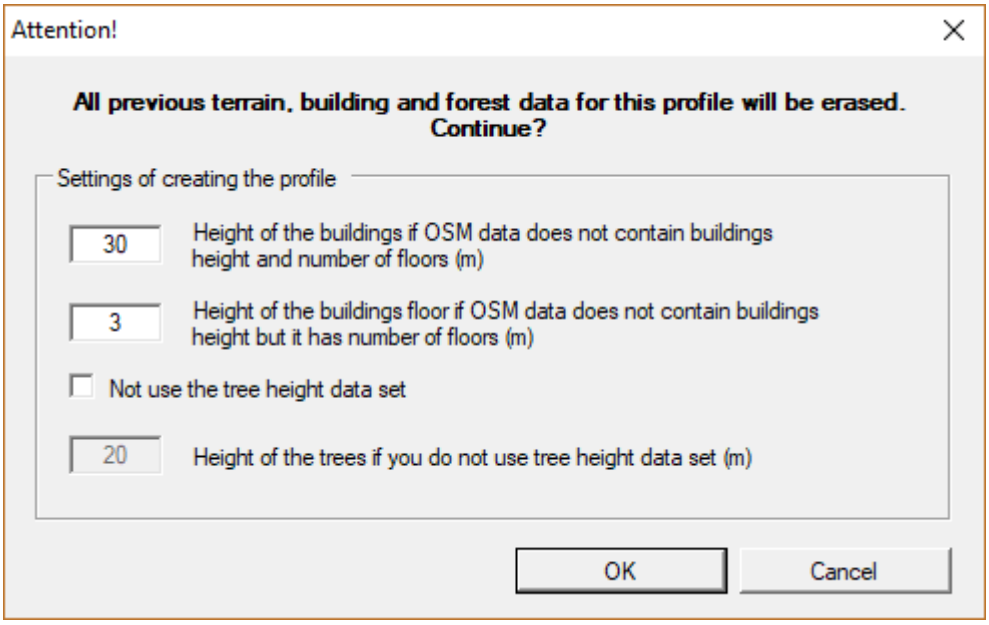


Figure 8. Path Profile Creating Settings

Click **OK,** and after a couple of seconds, the information about terrain elevation and clutter characteristics along the path profile will appear in the table cells. The view of the path profile will be displayed at the top right panel.

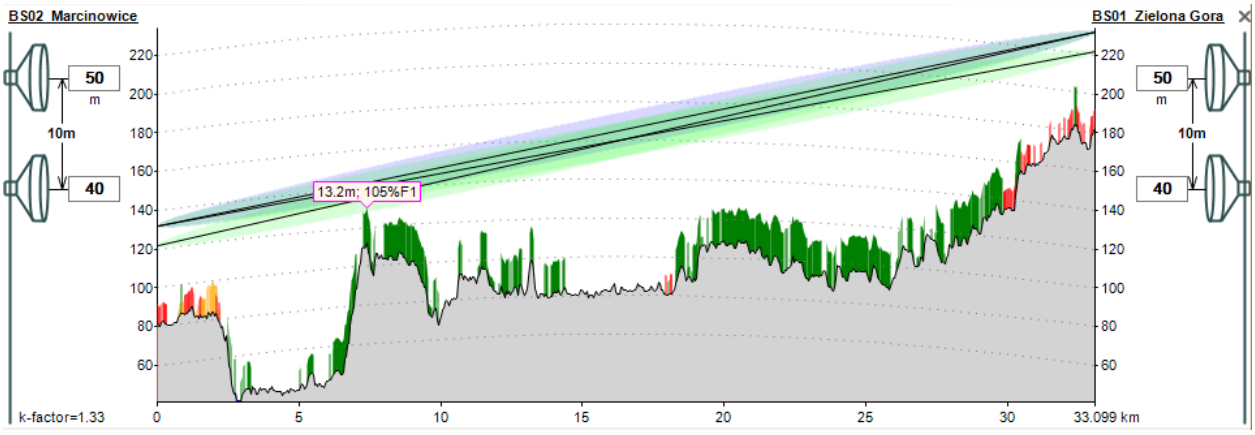


Figure 9. Path Profile

Clutter:
Green: *trees*
Orange: *buildings whose height or number of floors can be found in the OpenStreetMap database*
Red: *buildings whose height and a number of floors are missing in the OpenStreetMap database*

Editing the Path Profile

Terrain elevations can be edited manually in the corresponding cells of the elevation table. To edit terrain elevations for multiple cells, select the required cells and enter a new value. The new elevation will be saved to all selected cells, and the information about old elevations will be automatically removed. Only end values of this range will remain. To delete an entire row in the table, click on the triangle icon at the beginning of the row to select either a single row or multiple rows (by dragging the mouse or holding the **Shift** key and using the up or down arrow keys) and press **Delete**.

If you highlight a segment on the path profile by clicking and dragging the left mouse button, the segment will also be highlighted in the terrain elevation table, clutter table, and on the base map. Likewise, if you select rows in the elevation or clutter table, it will highlight the corresponding section in the path profile view and on the base map.

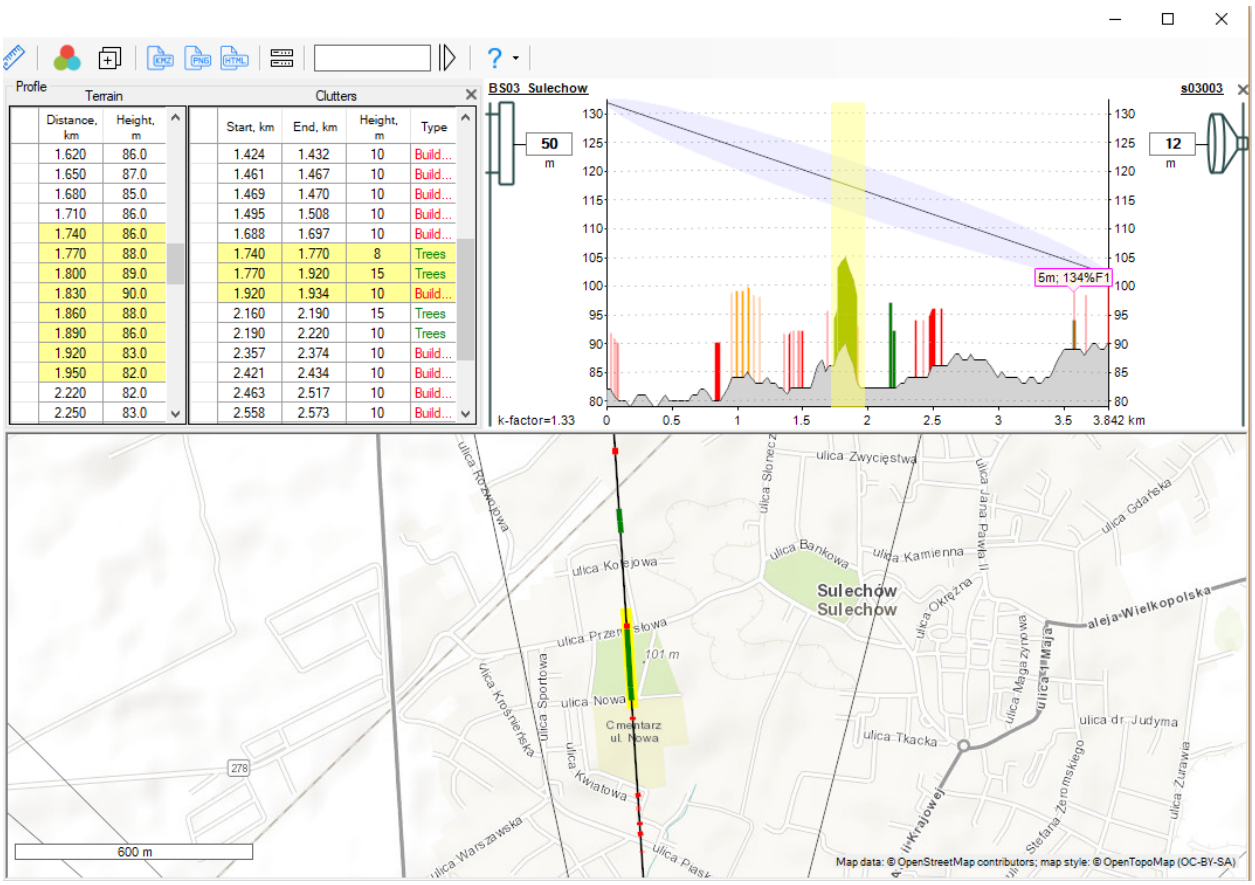


Figure 10. Highlighting the path profile segment

The clutter also can be edited manually in the corresponding cells of the clutter table. To delete an entire row in the table, click on the triangle icon at the beginning of the row to select either a single row or multiple rows (by dragging the mouse or holding the **Shift** key and using the up or down arrow keys) and press **Delete**.

Creating the Path Profile Manually

The application allows you to create a path profile by manually specifying all elevations on the path.

The information about forest, buildings, and water bodies can be entered based on the base maps, which you can open right in the application. Many online services allow you to view cartographic materials. They all differ in such parameters as map scale, coverage, and displayed objects. Depending on the specific area where the link is located, you may find one or several services useful. It is also important to select a proper scale of the map. More information about using custom base maps can be found in the application.

After analyzing the basemap along the line of the path profile, you can enter boundaries of forests, buildings, and water bodies. To do that, on the base map, right-click on the point on the link path where you want to enter the start of a clutter object segment. A context menu will open where you can select corresponding types of the segment. When the ends of a segment are marked, a number field will appear that you must fill in to indicate forest or building height. On the path profile, the forest is highlighted in green, building in orange, and water area in blue. Table entries for clutter and water information will be created automatically. You can delete any segment by right-clicking on it and selecting the corresponding action in the context menu that appears.

Start a Building Segment	Specify the beginning of the building segment on the path profile.
Start a Tree Segment	Specify the beginning of the tree segment on the path profile.

Start a Water Segment	Specify the beginning of the water segment on the path profile.
End Segment	Specify the end of any segment.
Delete the Nearest Segment	Delete any nearest segment.
Move Site A	Move site A to the specified location.
Move Site B	Move site B to the specified location.

The following must be observed when creating a path profile manually:

1. The first elevation point must have a zero distance.
2. The path profile must have at least two points.
3. A clutter object must not extend beyond the last terrain point.

For more information about creating a path profile of microwave links, visit our YouTube channel.

Entering Parameters of PtP Links

In the drop-down lists, select the product family from those previously connected to the project then select the equipment model (product), channel bandwidth, and frequency band. After that, general information about the selected equipment, its image, channel bitrates, and basic energy parameters for each type of modulation supported by the equipment will appear below.

Below is the description of all input parameters that may be necessary to specify. The required input parameters are determined by the application automatically based on the equipment configuration and calculation requirements.

Frequency, MHz	Mean frequency of the microwave link, MHz
Configuration	The number of working and reserve trunks
Diversity	Diversity configurations (None, Space Diversity, Frequency Diversity, Comb-4Rx)
Branching Type	Hot Standby (HSB) /XPIC (Cochannel)/HSB+XPIC/MIMO 2x2
Polarization	Polarization type (Vertical or Horizontal)
Frequency Spacing, MHz	The frequency spacing between TX channels for frequency diversity. Required if frequency or combined diversity is selected.

Antenna, feeder, and branching parameters for the Main and Diversity paths (when using space diversity):

Antenna Type	Antenna model; information only
Antenna Gain, dBi	Antenna gain, dBi
Vertical Antenna Beam Width, Degrees	Antenna 3 dB beam width in a vertical plane; use only for reflection analysis. The default value is 3 degrees.
Antenna Height, m	Antenna installation height relative to ground level, m. You can also change the antenna height in the profile window.
Feeder Length, m	Feeder length to the primary antenna; the default value is 0 m.
Feeder Specific Loss, dB/m	Feeder specific loss; default value is 0 dB/m.
Branching Loss, dB	Branching loss at Tx and Rx (if any); the default value is 0 dB.
Additional Loss, dB	Additional loss; default value is 0 dB.
Total loss, dB	Total loss, dB. The calculated value.
Maximum Tx power limit, dBm	Maximum Tx power for transmitters of this link, dBm

	From the general limit that is set in the PtP menu and the limit that is set in a particular link, the most stringent limit is selected during the calculation. To remove the maximum limit, highlight the value and press the Delete key, then the inscription "None" will appear.
Maximum EIRP limit, dBm	Maximum EIRP for transmitters of this link, dBm From the general limit that is set in the PtP menu and the limit that is set in a particular link, the most stringent limit is selected during the calculation. To remove the maximum limit, highlight the value and press the Delete key, then the inscription "None" will appear.

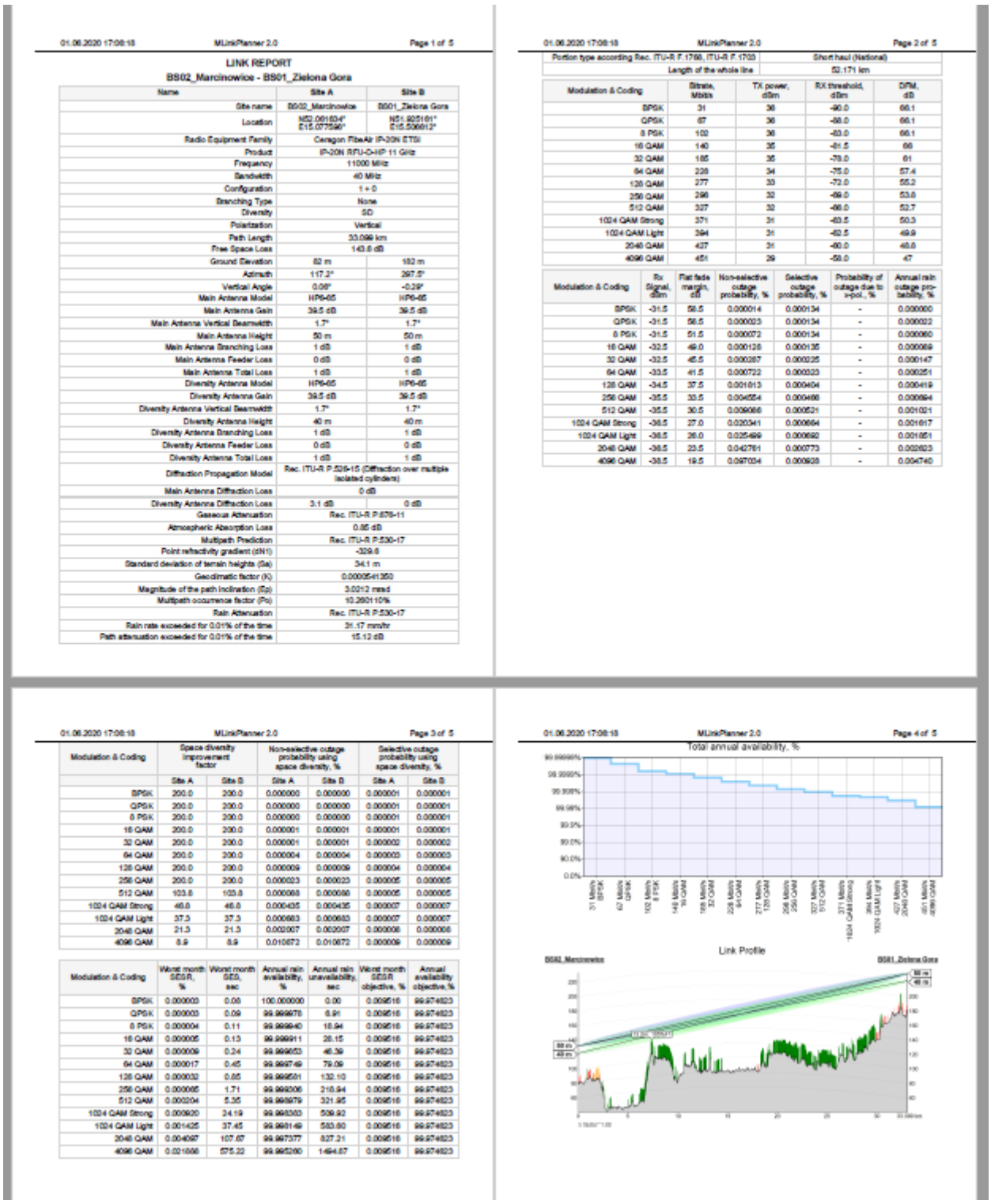
PtP Link Error Performance and Availability Prediction

To do the link performance prediction, click the **Report** button. The calculation will be performed only for those types of modulation that are marked in the table as active - ☑

You can switch between the short report view and the full report view.

The short report displays only calculation results; the full report displays input parameters, calculation results, path profile drawing, and path profile diagram on the map.

You can print the report or save it as PDF, Microsoft Word, or Excel.



01.06.2020 17:06:18 MLinkPlanner 2.0 Page 1 of 5

LINK REPORT

BS02_Marcinowice - BS01_Zielona Gora

Name	Site A	Site B
Site name	BS02_Marcinowice	BS01_Zielona Gora
Location	N52.061634° E15.077596°	N51.925161° E15.506612°
Radio Equipment Family	Ceragon FibeAir IP-20N ETSI	
Product	IP-20N RFU-D-HP 11 GHz	
Frequency	11000 MHz	
Bandwidth	40 MHz	
Configuration	1 + 0	
Branching Type	None	
Diversity	SD	
Polarization	Vertical	
Path Length	33.099 km	
Free Space Loss	143.6 dB	
Ground Elevation	82 m	182 m
Azimuth	117.2°	297.5°
Vertical Angle	0.06°	-0.29°
Main Antenna Model	HP6-65	HP6-65
Main Antenna Gain	39.5 dB	39.5 dB
Main Antenna Vertical Beamwidth	1.7°	1.7°
Main Antenna Height	50 m	50 m
Main Antenna Branching Loss	1 dB	1 dB
Main Antenna Feeder Loss	0 dB	0 dB
Main Antenna Total Loss	1 dB	1 dB
Diversity Antenna Model	HP6-65	HP6-65
Diversity Antenna Gain	39.5 dB	39.5 dB
Diversity Antenna Vertical Beamwidth	1.7°	1.7°
Diversity Antenna Height	40 m	40 m
Diversity Antenna Branching Loss	1 dB	1 dB
Diversity Antenna Feeder Loss	0 dB	0 dB
Diversity Antenna Total Loss	1 dB	1 dB
Diffraction Propagation Model	Rec. ITU-R P.526-15 (Diffraction over multiple isolated cylinders)	
Main Antenna Diffraction Loss	0 dB	
Diversity Antenna Diffraction Loss	3.1 dB	0 dB
Gaseous Attenuation	Rec. ITU-R P.676-11	
Atmospheric Absorption Loss	0.85 dB	
Multipath Prediction	Rec. ITU-R P.530-17	
Point refractivity gradient (dN1)	-329.6	
Standard deviation of terrain heights (Sa)	34.1 m	
Geoclimatic factor (K)	0.000054 1350	
Magnitude of the path inclination (Ep)	3.0212 mrad	
Multipath occurrence factor (Po)	10.280110%	
Rain Attenuation	Rec. ITU-R P.530-17	
Rain rate exceeded for 0.01% of the time	31.17 mm/hr	
Path attenuation exceeded for 0.01% of the time	15.12 dB	

01.06.2020 17:06:18 MLinkPlanner 2.0 Page 2 of 5

Portion type according Rec. ITU-R F.1766, ITU-R F.1703	Short haul (National)
Length of the whole line	52.171 km

Modulation & Coding	Bitrate, Mbit/s	TX power, dBm	RX threshold, dBm	DFM, dB
BPSK	31	36	-90.0	66.1
QPSK	67	36	-88.0	66.1
8 PSK	102	36	-83.0	66.1
16 QAM	140	35	-81.5	66
32 QAM	185	35	-78.0	61
64 QAM	228	34	-75.0	57.4
128 QAM	277	33	-72.0	55.2
256 QAM	296	32	-69.0	53.8
512 QAM	327	32	-66.0	52.7
1024 QAM Strong	371	31	-63.5	50.3
1024 QAM Light	394	31	-62.5	49.9
2048 QAM	427	31	-60.0	48.8
4096 QAM	451	29	-58.0	47

Modulation & Coding	Rx Signal, dBm	Flat fade margin, dB	Non-selective outage probability, %	Selective outage probability, %	Probability of outage due to x-pol., %	Annual rain outage probability, %
BPSK	-31.5	58.5	0.000014	0.000134	-	0.000000
QPSK	-31.5	56.5	0.000023	0.000134	-	0.000002
8 PSK	-31.5	51.5	0.000072	0.000134	-	0.000060
16 QAM	-32.5	49.0	0.000128	0.000135	-	0.000069
32 QAM	-32.5	45.5	0.000287	0.000225	-	0.000147
64 QAM	-33.5	41.5	0.000722	0.000323	-	0.000251
128 QAM	-34.5	37.5	0.001813	0.000404	-	0.000419
256 QAM	-35.5	33.5	0.004554	0.000488	-	0.000694
512 QAM	-36.5	30.5	0.009066	0.000521	-	0.001021
1024 QAM Strong	-38.5	27.0	0.020341	0.000664	-	0.001617
1024 QAM Light	-38.5	26.0	0.025499	0.000692	-	0.001851
2048 QAM	-38.5	23.5	0.042761	0.000773	-	0.002623
4096 QAM	-38.5	19.5	0.097034	0.000928	-	0.004740

01.06.2020 17:06:18 MLinkPlanner 2.0 Page 3 of 5

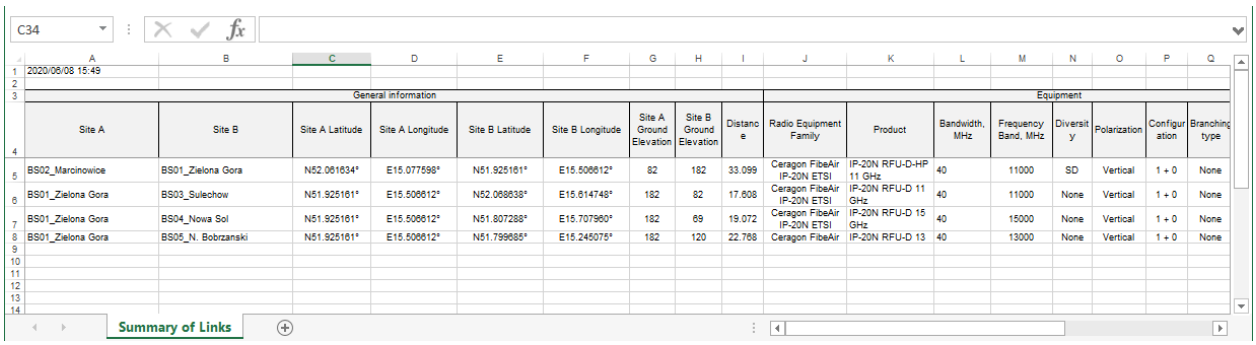
Modulation & Coding	Space diversity improvement factor		Non-selective outage probability using space diversity, %		Selective outage probability using space diversity, %	
	Site A	Site B	Site A	Site B	Site A	Site B
BPSK	200.0	200.0	0.000000	0.000000	0.000001	0.000001
QPSK	200.0	200.0	0.000000	0.000000	0.000001	0.000001
8 PSK	200.0	200.0	0.000000	0.000000	0.000001	0.000001
16 QAM	200.0	200.0	0.000001	0.000001	0.000001	0.000001
32 QAM	200.0	200.0	0.000001	0.000001	0.000002	0.000002
64 QAM	200.0	200.0	0.000004	0.000004	0.000003	0.000003
128 QAM	200.0	200.0	0.000009	0.000009	0.000004	0.000004
256 QAM	200.0	200.0	0.000023	0.000023	0.000005	0.000005
512 QAM	103.8	103.8	0.000068	0.000068	0.000005	0.000005
1024 QAM Strong	46.8	46.8	0.000435	0.000435	0.000007	0.000007
1024 QAM Light	37.3	37.3	0.000683	0.000683	0.000007	0.000007
2048 QAM	21.3	21.3	0.002007	0.002007	0.000008	0.000008
4096 QAM	8.9	8.9	0.010672	0.010672	0.000009	0.000009

Modulation & Coding	Worst month SESR, %	Worst month SES, sec	Annual rain availability, %	Annual rain unavailability, sec	Worst month SESR objective, %	Annual availability objective, %
BPSK	0.000003	0.06	100.000000	0.00	0.009516	99.974923
QPSK	0.000003	0.09	99.999978	6.91	0.009516	99.974923
8 PSK	0.000004	0.11	99.999940	18.94	0.009516	99.974923
16 QAM	0.000005	0.13	99.999911	28.15	0.009516	99.974923
32 QAM	0.000009	0.24	99.999653	46.39	0.009516	99.974923
64 QAM	0.000017	0.45	99.999749	79.09	0.009516	99.974923
128 QAM	0.000032	0.85	99.999501	132.10	0.009516	99.974923
256 QAM	0.000065	1.71	99.999306	210.94	0.009516	99.974923
512 QAM	0.000204	5.35	99.999979	321.95	0.009516	99.974923
1024 QAM Strong	0.000920	24.19	99.998303	509.92	0.009516	99.974923
1024 QAM Light	0.001425	37.45	99.998149	583.80	0.009516	99.974923
2048 QAM	0.004097	107.67	99.997377	827.21	0.009516	99.974923
4096 QAM	0.021668	575.22	99.995290	1494.87	0.009516	99.974923

01.06.2020 17:06:18 MLinkPlanner 2.0 Page 4 of 5

Figure 11. Full PtP Link Report

You can also save summary information for all Point-to-Point links in an Excel spreadsheet. Click the "Summary Report" button on the Point-to-Point main menu and an Excel spreadsheet will open.



2020/06/08 15:49

General information									Equipment							
Site A	Site B	Site A Latitude	Site A Longitude	Site B Latitude	Site B Longitude	Site A Ground Elevation	Site B Ground Elevation	Distance	Radio Equipment Family	Product	Bandwidth, MHz	Frequency Band, MHz	Diversity	Polarization	Configuration	Branching type
BS02_Marcinowice	BS01_Zielona Gora	N52.061634°	E15.077598°	N51.925161°	E15.506612°	82	182	33.099	Ceragon FibeAir IP-20N ETSI	IP-20N RFU-D-HP 11 GHz	40	11000	SD	Vertical	1 + 0	None
BS01_Zielona Gora	BS03_Sulechow	N51.925161°	E15.506612°	N52.068638°	E15.614748°	182	82	17.608	Ceragon FibeAir IP-20N ETSI	IP-20N RFU-D 11 GHz	40	11000	None	Vertical	1 + 0	None
BS01_Zielona Gora	BS04_Nowa Sol	N51.925161°	E15.506612°	N51.807288°	E15.707960°	182	69	19.072	Ceragon FibeAir IP-20N ETSI	IP-20N RFU-D 15 GHz	40	15000	None	Vertical	1 + 0	None
BS01_Zielona Gora	BS05_N. Bobrzanski	N51.925161°	E15.506612°	N51.799685°	E15.245075°	182	120	22.768	Ceragon FibeAir	IP-20N RFU-D 13	40	13000	None	Vertical	1 + 0	None

Summary of Links

Figure 12. MS Excel Summary Report for Point-to-Point links

Objectives

The objectives for PtP links are set in the Point-to-Point main menu item. Here, you need to specify your approach to determining the reliability of the microwave link, and, if necessary, enter additional link parameters to calculate the performance and availability objectives.

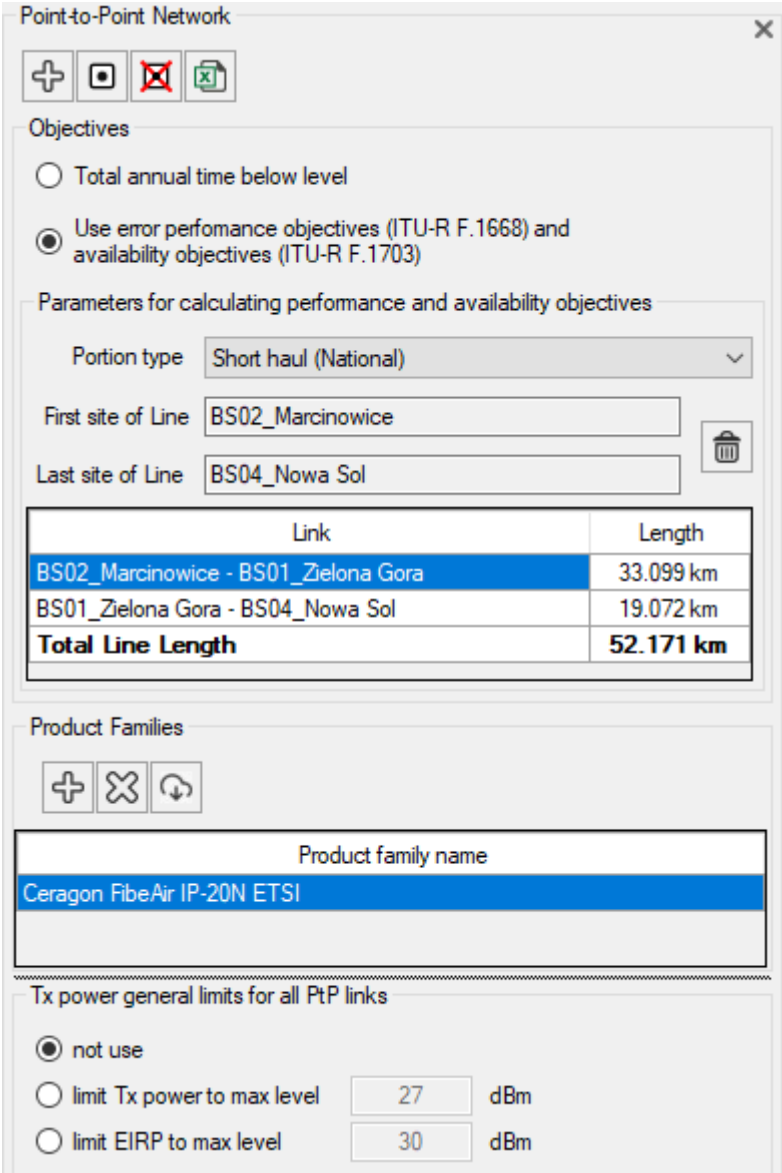


Figure 13. Objectives

Total Annual Time Below Level

Outage times are reported for the worst month and annually without considering the fade duration. The annual rain outage is simply added to the annual multipath outage for the total annual outage. This assumes that the conditions for high-intensity rain and severe multipath fading are different and the two fading mechanisms do not occur at the same time. Outage probabilities can be expressed as availability (99.95%) or unavailability (sec).

Use of Error Performance Objectives (ITU-R F.1668) and Availability Objectives (ITU-R F.1703)

In this case, Severely Errored Seconds are calculated for the worst month as a ratio (SESR) and in seconds (SES). Availability is reported as a ratio per year; unavailability is reported in seconds per year. It is assumed that a rain fade will always last longer than 10 consecutive seconds, and therefore, the rain outage is always classed as unavailability.

For the objectives calculation, you have to specify if the link is part of an International or National Link and select among the relevant subcategories—Long Haul, Short Haul, Access. If the line consists of several links, for the distribution of the objective in accordance with the ratio of the length of the link to the total length of the line, specify the first and last sites of the line. The program will calculate the total length of the line, taking into account its topology, and when calculating the objective, will be distributed among the links in proportion to their length.

Optimizing Antenna Heights

MLinkPlanner can calculate the height of main and diversity antennas using different clearance criteria.

To calculate antenna heights, select the desired link, then click the  icon on the top toolbar.

Figure 14. Antenna height optimization panel

The general procedure for determining the minimum required antenna heights on a link is to verify the required clearance of the first Fresnel zone for various expected values of the ratio of the equivalent Earth radius to the real radius (k-factor). Different methods have different requirements for the clearance and for the k-factor value.

Optimizing Antenna Heights According to Rec. ITU-R P.530-17

Climate	Temperate climate Tropical climate
Type of Obstruction	Obstruction is extended along a portion of the path Single isolated path obstruction
Criteria	Standard Less conservative criteria. May be necessary for frequencies less than about 2 GHz to avoid unacceptably large antenna heights.
Standard k-factor	The median value of the k-factor (equivalent Earth radius factor) for standard atmosphere. Can be modified by the designer.
Extreme k-factor	The lowest expected (minimum) value of the k-factor, computed from ITU-R Rec. P.530-17, as a function of path length. Can be modified by the designer.
Part of Fresnel Radius	Part of the First Fresnel ellipsoid that is required to be free of any obstruction for the appropriate value of the k-factor. Is automatically determined depending on the Type of Climate, Type of the Obstruction, and Criteria from above, but can be modified by the designer.

In a space diversity configuration, the minimum heights of secondary antennas are calculated without taking into account climate and extreme k-factor, as per Rec. ITU-R P.530-17.

Minimum antenna height is calculated with consideration for clutter (forest and buildings) located on the path profile.

Once the required preferences are selected, click **Optimize** and the minimum antenna height will appear on the left. The height of the response antenna will be fixed at the current value. The path profile image will display the criterion used to calculate the antenna height. Click **Apply** to change the antenna height according to the calculated value. To discard the calculated value, click **Cancel**.

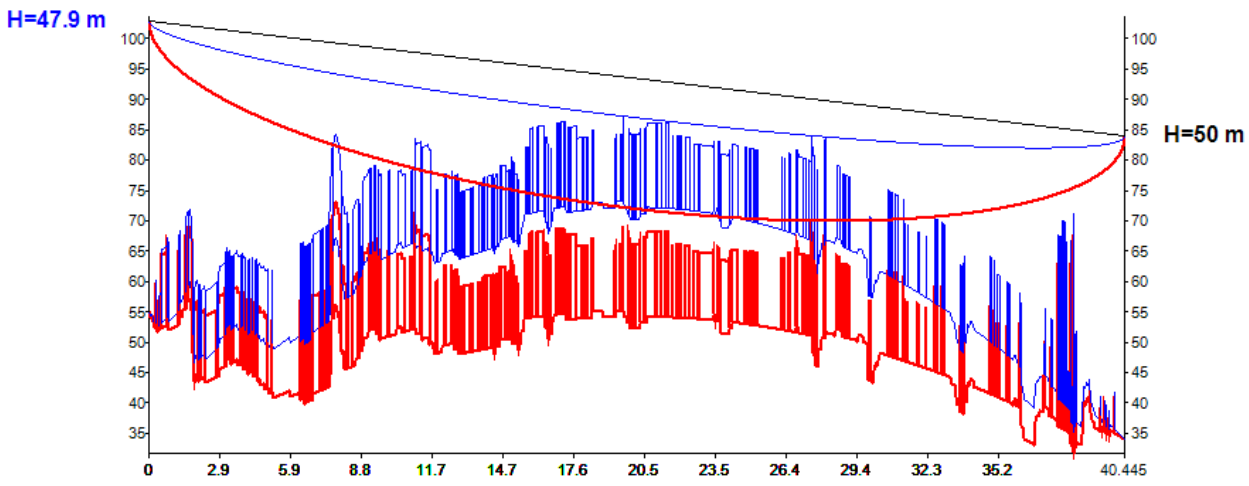


Figure 15. Path profile showing a triggered criterion

Reflection Analysis

Reflection analysis allows the user to identify possible specular reflection points on the link path profile and evaluate the application of various specular reflection reduction methods.

To open the Reflection Analysis window, click the  button on the main window. The left-hand part of the panel will be disabled; to exit this mode, use the main menu.

k-factor	k-factor, for which the reflection points are searched It is recommended that reflection points be determined for large k-factor values (at least 10).
Polarization	Vertical Horizontal To reduce the effect of the reflected wave, it is recommended to select vertical polarization.
Reflecting Surface Type	Sea water Fresh water Wet ground Very dry ground Ice The type of surface from which the reflection occurs. Each of the above surface types have their own values of Relative dielectric constant and Electrical conductivity.
Relative Dielectric Constant	Relative dielectric constant is a dimensionless parameter. It's automatically determined depending on the Reflecting surface type from above, but can be modified by the designer.
Electrical Conductivity	Electrical conductivity [ohm-1 m-1]. It's automatically determined depending on the Reflecting surface type from above, but can be modified by the designer.
Consider Clutter on the Reflected Paths	If this check-box is active, then when the incident or reflected rays intersect with ground obstacles (forest or trees), these rays will be screened.

The path profile will display all possible direct and ground-reflected rays for the Main-Main paths and in a space diversity configuration for the Main-Diversity and Diversity-Main paths. The table below will show the distances to and clearance at each of the reflection points.

You can view Relative Rx Power vs. k-factor chart for any reflection point and any of the Main-Main, Main-Diversity, or Diversity-Main paths by clicking on the desired point in the table. Note that you need to specify the beam width for each of the antennas in Site A and Site B to calculate Relative Rx Power vs. k-factor chart.

In addition to Relative Rx Power vs. k-factor, you can also display Time Delay vs. k-factor chart. On this plot, the relative signal delay in nanoseconds between the direct and reflected signal is displayed for each of the Main–Main, Main–Diversity or Diversity–Main paths. If the reflected signal delay is greater than 10-20 nanoseconds, performance problems on high capacity systems can occur.

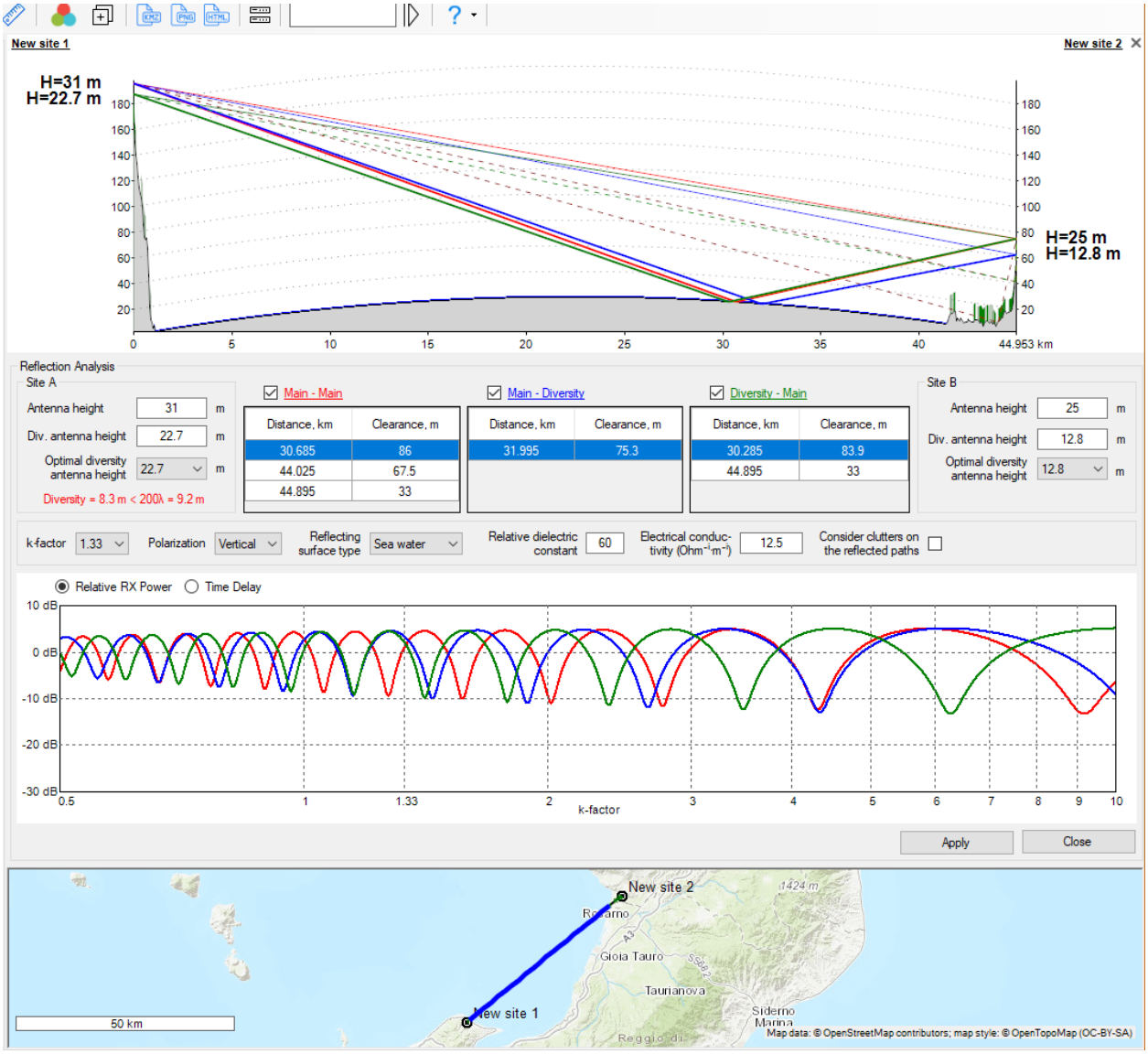


Figure 16. Reflection analysis

Estimation of Specular Reflection Reduction without Using Space Diversity

If there is specular reflection along the path and you are not going to use space diversity, the application can estimate the effectiveness of the following methods for reducing the effect of the reflected ray on the resulting signal for systems without space diversity recommended in Rec. ITU-R P.530-17:

- Increase of path inclination
- Shielding of the reflection point
- Moving of the reflection point to poorer reflecting surface
- Reduction of path clearance
- Choice of vertical polarization

In most cases, these methods (except for the last one) are limited to selecting the primary antenna height on the right or left.

Estimation of Specular Reflection Effect with Space Diversity

The most efficient way to eliminate the effect of specular reflection is to use space diversity techniques. The most often used technique is vertical space diversity. MLinkPlanner allows you to determine receive antenna heights with enough spacing to maintain an uncorrelated direct and reflected signal, so that when the received signal level for the primary antenna is zero (in fade), the signal is near the peak for the diversity antenna and vice versa.

The right-hand part of the window displays the heights of diversity antennas determined based on optimum antenna spacing as per Rec. ITU-R P.530-17. I.e. the case when received signal levels at the primary and secondary antennas must display a maximum difference (maximum and minimum) across the full range of the k-factor to minimize the effect of specular reflection on the received signal level.

To estimate the effect of space diversity, perform the following steps:

1. Select a space diversity configuration for both Site A and Site B.
2. Select a reflection point for each path using the mouse button.
3. Select one of the optimum heights of the secondary antenna from the series in the right section of the window using the mouse button.

You will then view the received signal level for each antenna on the chart. By changing the antenna height, you can see how the received signal level will change.

In a space diversity configuration, if the vertical spacing between antennas is less than 200 times the wavelength (which is a common rule for reducing the effect of multipath propagation on the performance indicators), a warning will appear next to the spacing on the profile and its value in meters (i.e., 200 times the wavelength) will be displayed.

To determine heights of primary and secondary antennas in a space diversity configuration, the following conditions must be met:

1. The maximum difference between the received signal levels of the primary and secondary antennas must be observed across the full range of k-factor to eliminate the effect of specular reflection (if any).

2. The primary and secondary antennas must be at least 200 times the wavelength to eliminate the effect of multipath propagation.

The primary and secondary antennas must satisfy the clearance criteria described in Rec. ITU-R P.530-17.

Diffraction Analysis

Diffraction analysis allows the user to estimate diffraction losses due to obstacles on the path profile.

Strictly speaking, diffraction losses at the link should be avoided, especially in the high-frequency ranges where the accuracy of the path profile is comparable to the size of the first Fresnel zone.

Diffraction losses may be due to the inability to meet the clearance criteria as per Rec. ITU-R P.530-17, especially in the relatively low-frequency ranges (up to 2-4 GHz).

In MLinkPlanner 2.0, you can choose one of the following diffraction methods:

- Rec. ITU-R P.526-15 (Complete Bullington method or Diffraction over multiple cylinders method)
- Deygout principle method with correction ITU-R-P.526-11
- Epstein-Peterson method

The method for calculating diffraction losses is selected in the **Propagation Model** menu.

To begin the analysis of diffraction loss on the link, select the required link and click on the  button in the upper toolbar.

Enter the heights of the antennas, as well as the K-factor for which you want to calculate the diffraction loss (after entering, press Enter), after which the result of calculating the diffraction loss on the path profile and the intermediate parameters will appear in the information window in accordance with the selected method. In order to take into account the obtained results, click the Apply button. After this, the antenna heights in link parameters will change in accordance with the applied values.

Diffraction losses are calculated for a single path (by default, for the Main–Main path). If you want to estimate diffraction losses for other paths (Main–Diversity or Diversity–Main paths), you'll need to change the height of the corresponding antennas.

When you calculate performance characteristics, diffraction losses are calculated automatically for each path based on the antenna heights and other parameters. These parameters are saved in the project file and can be defined for each path individually.

Parameters of Diffraction Analysis	
K-factor	k-factor for Diffraction Analysis
Value of K exceeded for 99.9% (k_e)	Value of k-factor exceeded for approximately 99.9% of the worst month for the path profile according to Figure 2 in Rec. ITU-R P.530-17
Consider vegetation according to Rec. ITU-R P.833-9	In this case, the forest on the track profile is excluded from the diffraction calculation and the attenuation in

	the forest is calculated in accordance with Rec. ITU-R P.833-9 "Attenuation of signals by vegetation."

Figure 17. Bullington Diffraction Loss Analysis Rec. ITU-R P.526-15

Parameters for the Bullington Method of Rec. ITU-R P.526-15	
Bullington Point	Bullington Point location
Luc, dB	Knife-edge loss for the Bullington point, dB
Lb, dB	Bullington diffraction loss for the path, dB
Lbs, dB	Bullington diffraction loss for the smooth path, dB
Lsph, dB	Spherical-earth diffraction loss, dB
L, dB	The diffraction loss for the general path, dB

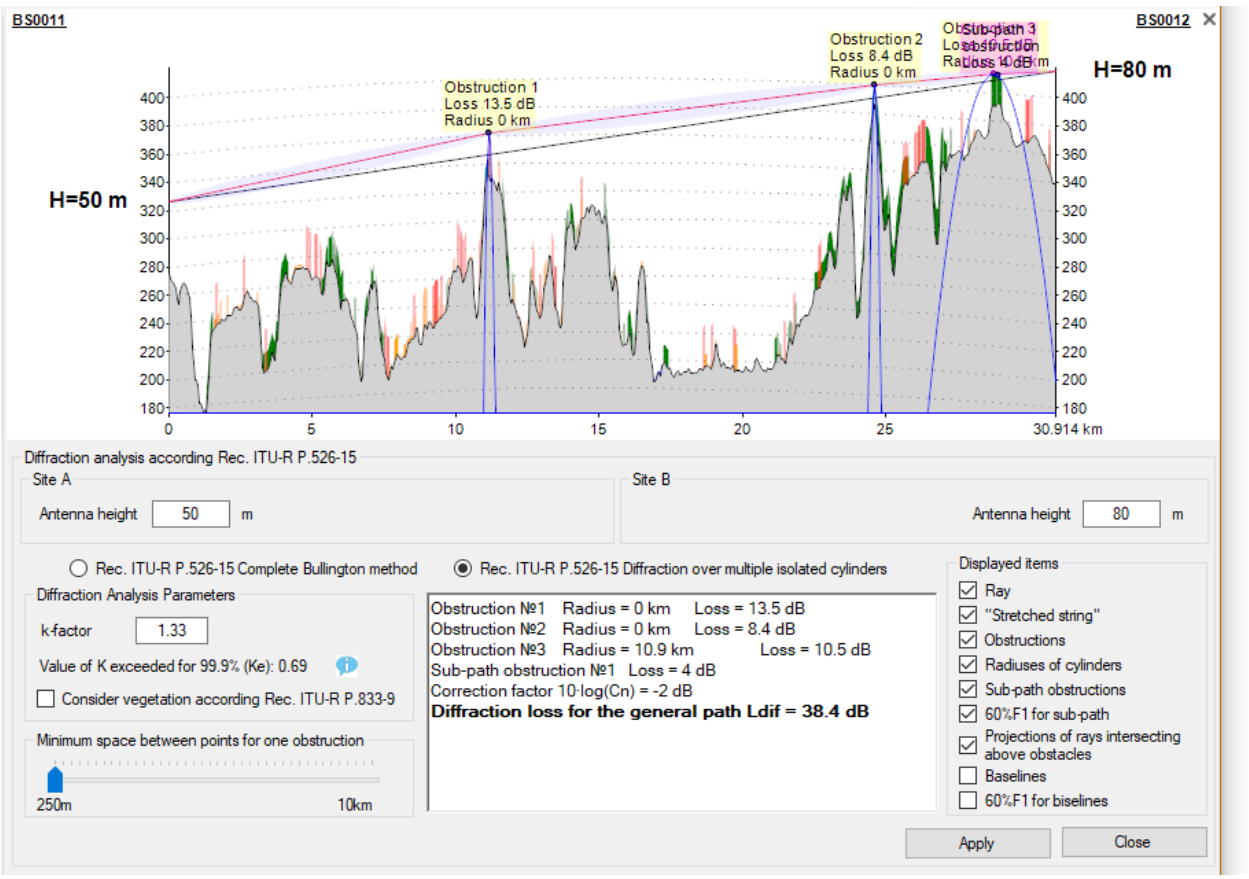


Figure 18. Analysis of diffraction losses by the method of isolated cylinders according to Rec. ITU-R P.526-15

Displayed items for the method of isolated cylinders according to Rec. ITU-R P.526-15	
Ray	Show the ray line between antennas.
Stretched String	Show line **Stretched string**. This identifies the sample points which would be touched by a string stretched over the profile from the transmitter to receiver.
Obstructions	Show obstruction identifiers. The obstruction identifier numbers are shown in figures on a yellow background.
Radiuses of the Cylinders	Show Radius equal to the radius of curvature at the obstacle top.
Sub-path Obstructions	Show obstruction numbers on the Sub-path. The obstruction numbers on the Sub-path are shown on a blue background.
60%F1 for Sub-path	Show 60 % of the first Fresnel zone.
Projections of Rays Intersecting above Obstacles	Show Projections of rays intersecting above obstacles.
Baselines	Show Baselines.
60%F1 for Baselines	Show 60% of the first Fresnel zone for baselines.
Minimum Space Between Points for One Obstruction	This parameter can be adjusted within 250 m–10 km for more accurate approximation of obstruction.
Obstruction No.	Identifier Number of Obstruction
Sub-path Obstruction No.	Identifier Number of Obstruction on the Sub-path
Correction Factor Cn	Correction factor Cn according to Rec. ITU-R P.526-15
Location, km	Location of Obstruction, km
Clearance, m	Clearance at the Obstruction, m

V	Single dimensionless parameter according to Rec. ITU-R P.526-15
Radius, km	The radius of the Obstruction, km
Loss, dB	Diffraction losses at each obstruction, dB
Total, dB	Total Loss, dB

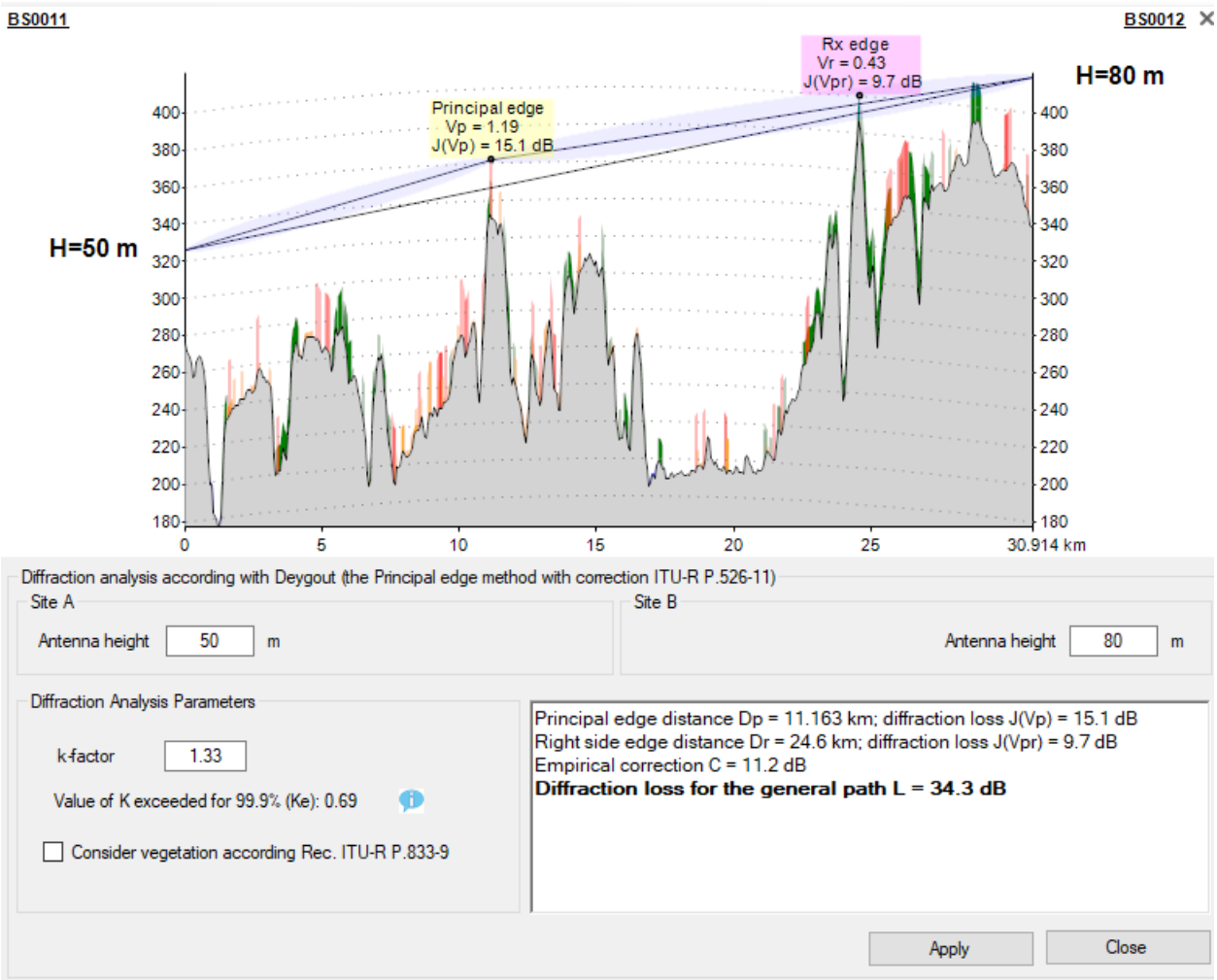


Figure 19. Deygout Diffraction Loss Analysis Rec. ITU-R P.526-11

Displayed items for Deygout principle method with correction Rec. ITU-R-P.526-11	
Dp, km	Distance to the main knife-edge obstacle, km
Dt, km	Distance to the knife-edge obstacle from the Tx side, km
Dr, km	Distance to the knife-edge obstacle from the Rx side, km
J(Vp), dB	Loss on the main knife-edge obstacle, dB
J(Vt), dB	Loss on the Tx knife-edge obstacle, dB
J(Vr), dB	Loss on the Rx knife-edge obstacle, dB
C, dB	Empirical correction, dB
L, dB	Diffraction losses, dB

Figure 20. Epstein-Peterson diffraction method

Displayed items for the Epstein-Peterson diffraction method	
Obstruction №	Identifier Number of Obstruction
Distance, km	Distance to the knife-edge obstacle, km
V	The Diffraction Parameter
Loss, dB	Diffraction losses at each obstruction, dB
L, dB	Diffraction losses, dB

Planning Point-to-Multipoint Networks

Planning point-to-multipoint network in MLinkPlanner, you can do:

1. Different coverage study types for PtMP Base Stations
2. Availability prediction for Base Station - Subscriber Station links

To calculate radio coverage, it is sufficient to enter the parameters of the base station(s) and the typical parameters of the subscriber station - “subscriber station installation,” which can be located anywhere in the study area.

For the point-to-multipoint link availability prediction (see Point-to-Multipoint Links Availability Prediction), it is also necessary to specify the location of each of the subscriber stations, specify to which

base station each subscriber station relates, and enter all necessary detailed parameters of base stations and subscriber stations.

Base Stations

PtMP base stations are created based on previously created sites (see the Sites section).

To get started, open the **Point-to-Multipoint** item on the main menu.

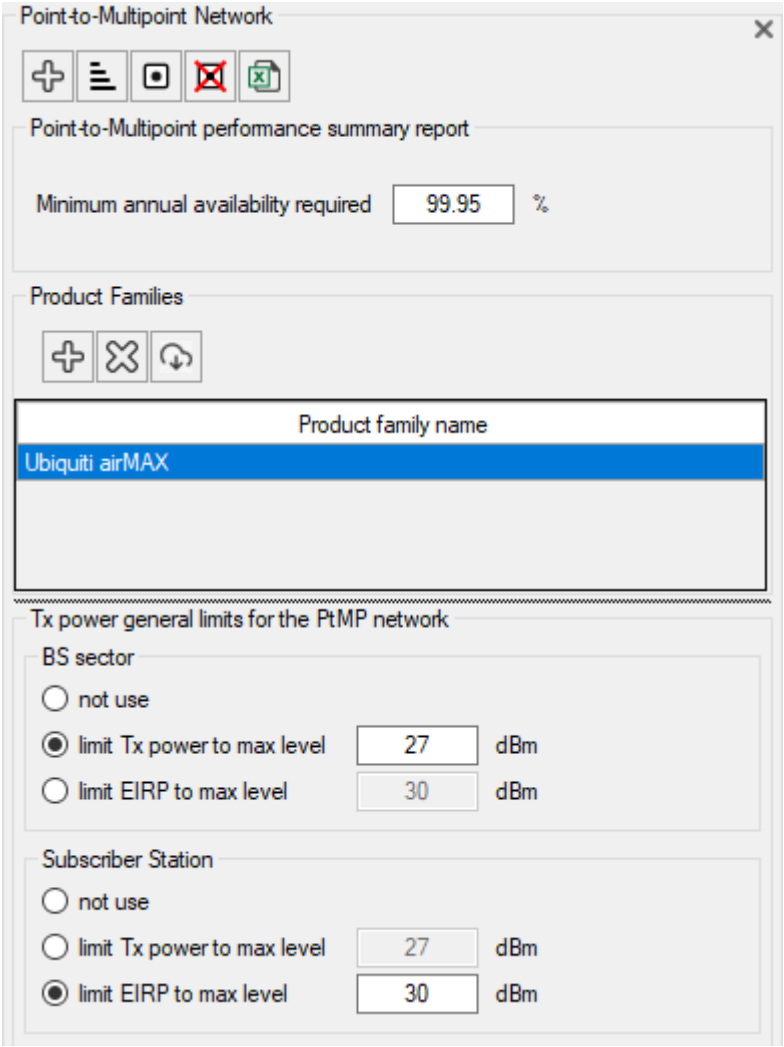


Figure 21. PtMP Network menu

First, it is necessary to include the specification file of the equipment family that is supposed to be involved in the project.

Click on the  **Add a new product family** button in the Point-to-Multipoint menu to include the product family to your project. To download the product family files from our website, click on the **Download product family files** button, and a link will open in the browser. We are continually updating the files with

equipment parameters, but if such equipment not on our website, then first create the equipment specification file (see **Equipment Editor**).

Toolbar:

- Create a new PtMP base station
- Sort the base stations in alphabetical order
- Select / Unselect all BS sectors
- Delete all selected sectors; if all sectors of the BS are selected, that BS will also be deleted.
- Summary Report for all active Point-to-Multipoint links in MS Excel. Click the "Summary Report" button and an Excel spreadsheet will open. Only active base stations will be listed in the spreadsheet.

Tx power general limits for the PtMP network

BS Sector	
not use	not use general limits for BS sector
limit Tx power to max level, dBm	Maximum Tx power for all BS Sectors in this project, dBm From the general limit that is set in this menu and the limit that is set in a particular BS Sector, the most stringent limit is selected in the calculations.
limit EIRP to max level, dBm	Maximum EIRP for all BS Sectors in this project, dBm From the general limit that is set in this menu and the limit that is set in a particular BS Sector, the most stringent limit is selected in the calculations.
Subscriber Station	
not use	not use general limits for Subscriber Station
limit Tx power to max level, dBm	Maximum Tx power for all Subscriber Stations in this project, dBm From the general limit that is set in this menu and the limit that is set in a particular Subscriber Station, the most stringent limit is selected during the calculation.
limit EIRP to max level, dBm	Maximum EIRP for all Subscriber Stations in this project, dBm From the general limit that is set in this menu and the limit that is set in a particular Subscriber Station, the most stringent limit is selected during the calculation.

To create a base station, click on the **Add button** at the top of the Point-to-Multipoint menu, then select a site from the list that appears. After that, the Base Station will appear on the map, as well as the width of the angular sector and its direction. When creating a BS, one BS sector is always automatically created. You can add as many sectors for the BS as you need, just click the button.

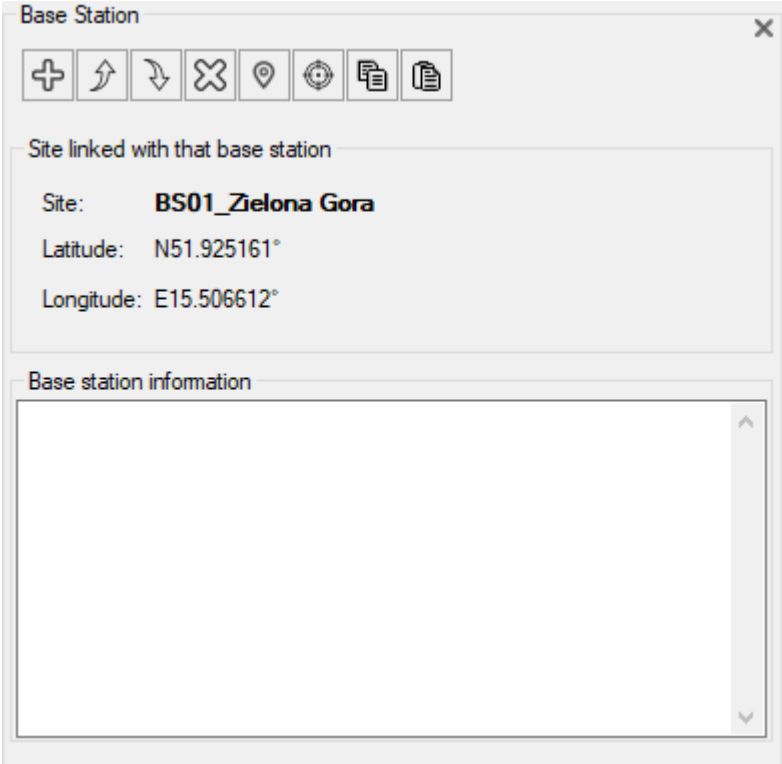


Figure 22. PtMP BS Parameters

Toolbar:

 - Add a new base station with the same parameters. You can select any number of sites at once and thus create any number of BS at once.

 - Move this BS up.

 - Move this BS down.

 - Delete the base station.

 - Change the site.

 - Position the map with the base station at the center of the screen.

 - Copy base station parameters to the clipboard

 - Paste base station parameters from the clipboard

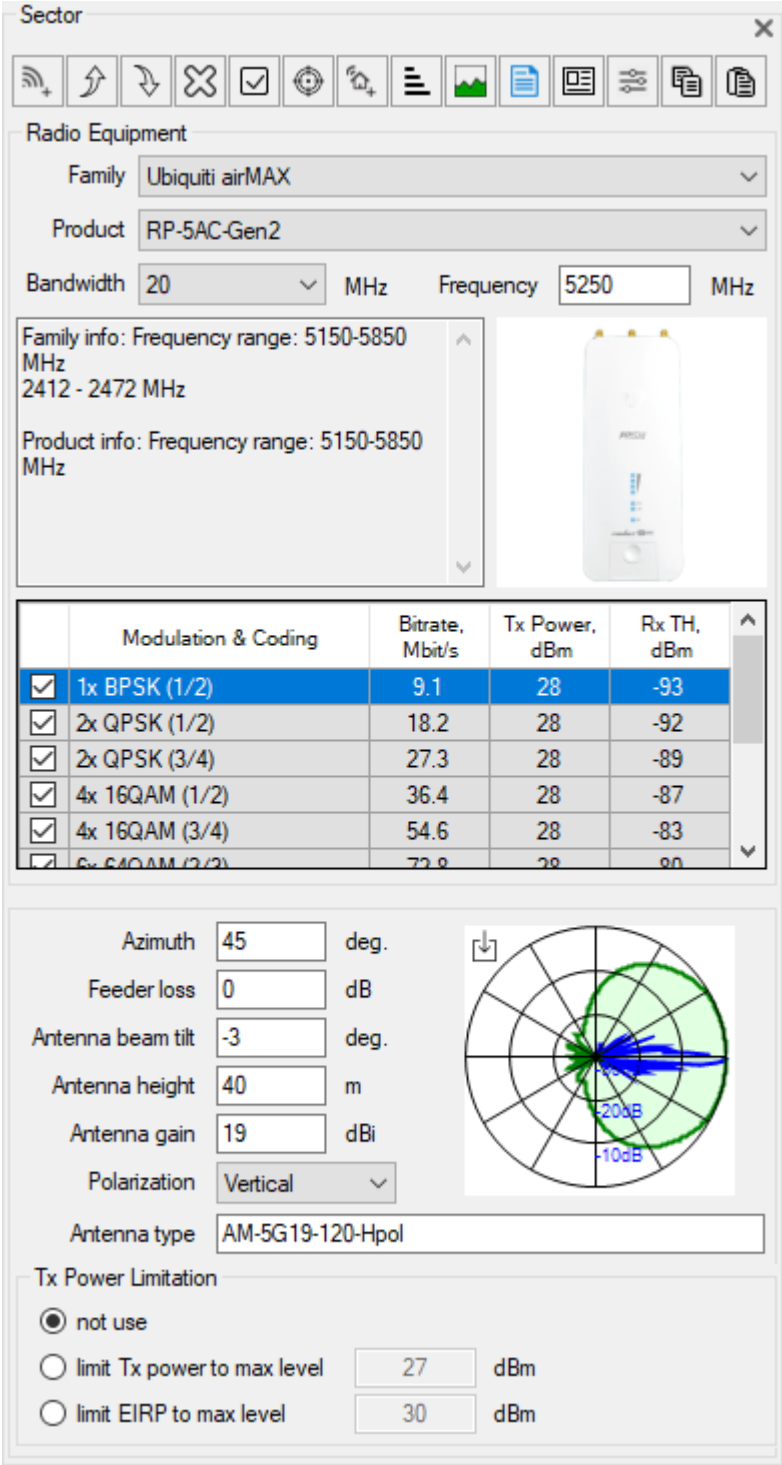


Figure 23. Base Station Sector Parameters

Toolbar for BS Sector:

 - Add a new sector with the same parameters.

 - Move the sector up.

- Move the sector down.

- Delete the sector.

- Select / Unselect all modulations and coding rows.

- Global active sectors parameter change - a feature that allows you instantly change the parameters of any base station in accordance with the parameters of the current sector.

- Position the map with the base station at the center of the screen.

- Add a new subscriber station for this sector.

- Sort the list of subscriber stations in the sector in alphabetical order.

- Generate the path profiles for all subscriber stations of the sector.

- BS Sector Performance Summary provides a summary of the performance of all the subscriber stations of the selected base station sector including the maximum usable modulation modes of all the PtMP Links that meet the required minimum flat fade margin setting and minimum annual availability setting.

- Display the product specifications for the selected bandwidth in the form of a datasheet, which can be saved in PDF, Word, or Excel formats.

- Copy sector parameters to the clipboard

- Paste sector parameters from the clipboard

In the drop-down lists, select the product family from those previously included to the project then select the equipment model (product), channel bandwidth, and frequency band. After that, general information about the selected equipment, its image, channel bitrates, and Tx power and Rx parameters for each supported modulation type will appear below.

Frequency, MHz	Frequency of the BS sector, MHz
Azimuth, deg	Antenna azimuth, degree
Feeder loss, dB	Feeder loss, default value is 0 dB
Antenna Beam Tilt, deg	Antenna beam tilt, degree. A negative value is a downward beam tilt, a positive value - upward beam tilt.
Antenna Height, m	Antenna installation height relative to ground level, m. You can also change the antenna height in the profile window
Antenna Gain, dBi	Antenna gain, dBi
Polarization	Antenna polarization, Vertical/Horizontal. Used for estimating interference zones C / (I + N) only.
Antenna Type	Antenna model; information only.
Antenna Pattern	To select antenna pattern, click the button next to the entered antenna model code and load the file in the *.msi or *.nsma format.

Tx Power Limitation

not use	not use Tx power max limit

Maximum Tx power limit, dBm	Maximum Tx power for this BS sector, dBm From the general limit that is set in the PtMP menu and the limit that is set in this BS sector, the most stringent limit is selected during the calculation.
Maximum EIRP limit, dBm	Maximum EIRP for this BS sector, dBm From the general limit that is set in the PtMP menu and the limit that is set in this BS sector, the most stringent limit is selected during the calculation.

Global active sectors parameter change - this is a very convenient feature that allows you instantly change the parameters of any base station sectors in accordance with the parameters of the current sector.

The procedure for performing group parameter changes on Multiple Base Station sectors:

1. Mark as active two or more base station sectors whose parameters need to be changed by clicking on the checkbox located to the left of the Base Station sector name.

2. Set the required parameter values in the current BS sector.

3. Click the button  to display the Global active sectors parameter change pop-up menu. Select the parameters that need to be copied to the previously marked active BS sectors by clicking on the checkboxes in the sector parameter list. Click the **OK** button and the selected parameters will be copied to all base station sectors marked as active.

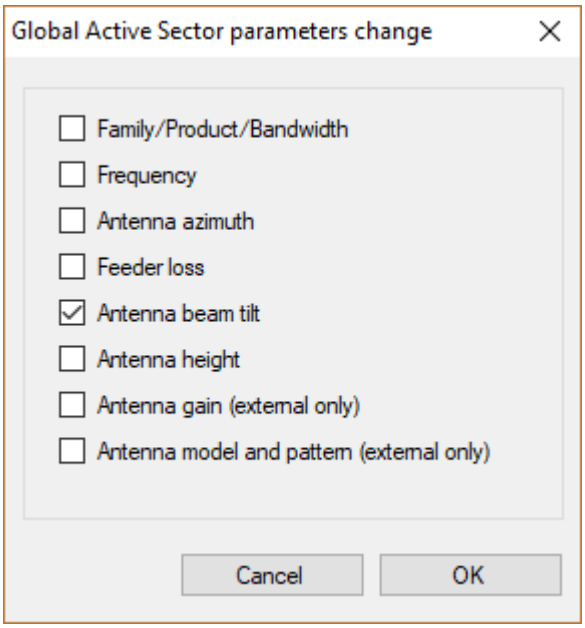


Figure 24. Global active base station sectors parameter change

Coverage Study

The coverage study calculates the estimated coverage of the base stations – i.e., the study approximately determines the areas where the subscriber stations can be located and gives a rough estimate of the achievable link capacity in this location. To ensure the correctness of the decision to place the subscriber station in a particular location, and to determine the exact height and type of the subscriber station antenna for the required link capacity, it is necessary to perform a detailed link availability prediction.

Coverage study is performed under the following conditions:

1. The parameters entered for each of the base station sectors are used for the coverage prediction.
2. A typical "Subscriber station installation" is used in the calculations for predicting coverage in the entire study area. The typical subscriber station parameters are entered into the Coverage Study Details menu.
3. The calculations do not take into account the excess path loss due to clutter loss (buildings and trees).

Before starting a coverage area study, you must first specify the parameters of the base station sectors that will be involved in the study and set those base station sectors to Active. Refer to Base Stations section for information on setting base station parameters. Please note that the coverage study for base station sectors will only be carried out if the checkbox, located to the left of the base station sector name, is active.

To configure the Coverage Study options, go to the **Coverage Study Details** menu.

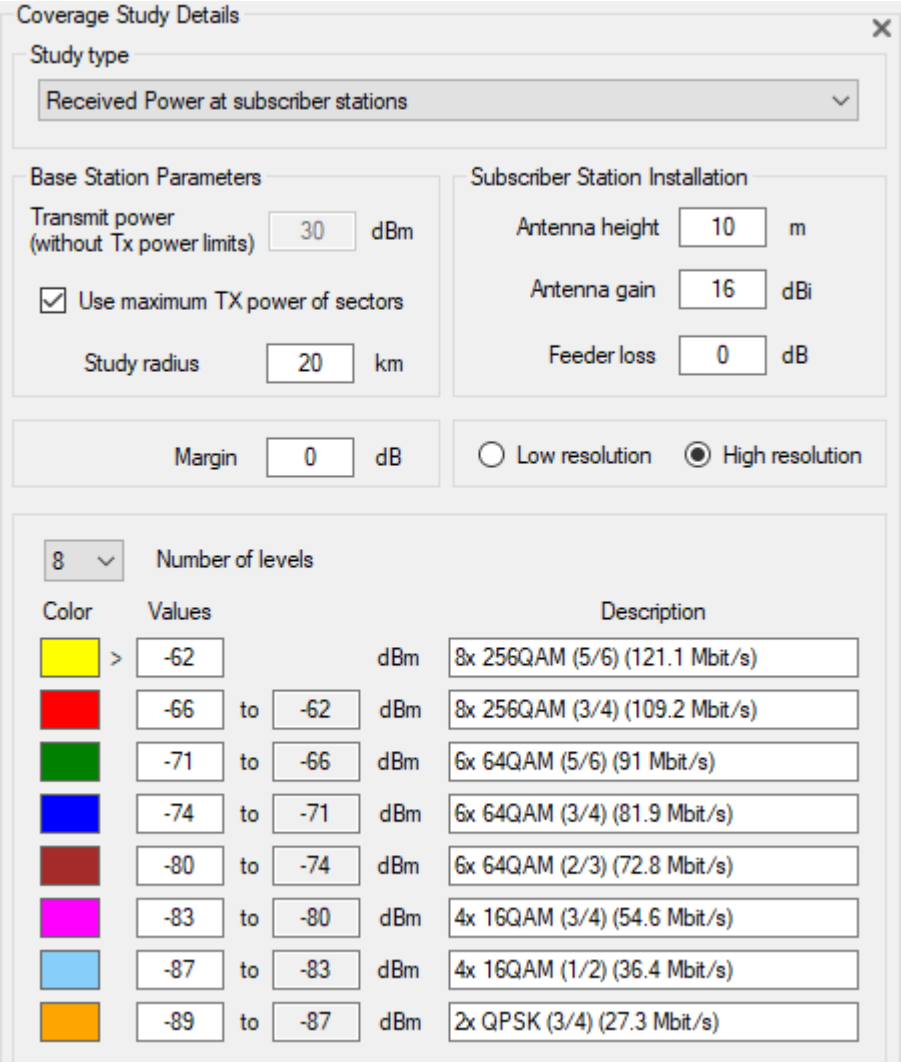


Figure 25. Coverage Study Details for Received Power at subscriber stations study

Coverage study Details	
Area Study Type	Received Power at subscriber stations Strongest (Most likely) Server C/I+N at subscriber stations
Base Station Parameters	
Transmit Power, dBm	One power value for all base stations, dBm
Use BS Transmitter Power Data	Use the power settings for each of the base stations specified in the Base Station sector menu.
Study Radius, km	Maximum study radius from Base Station, km
Subscriber Station Installation	
Antenna Height, m	Antenna installation height relative to ground level, m.
Antenna Gain, dBi	Antenna gain, dBi
Feeder Loss, dB	Feeder loss, default value is 0 dB
Margin, dB	Prediction confidence margin of the calculation results for area study, dB
Low Resolution	Low-resolution calculation (less computation time)
High Resolution	High-resolution calculation (more computation time)

Received Power at Subscriber Stations

Received power map shows those areas where a given signal power level is present at the subscriber station's receiver (downlink).

Number of Levels	The number of signal levels from 1 to 8
Color	The color of the signal level
Values, dBm *	Received power level, dBm
Description	The text field as an annotation on each signal level; for example, 256-QAM 5/6 400 Mbit/s

* To automatically fill these fields with subscriber station parameters, go to the panel of the characteristics of the subscriber station and click on the  button. Then the threshold levels are copied to the Levels field and information about the selected modulation modes is copied to the Description field.

To perform the coverage study, click the  button.

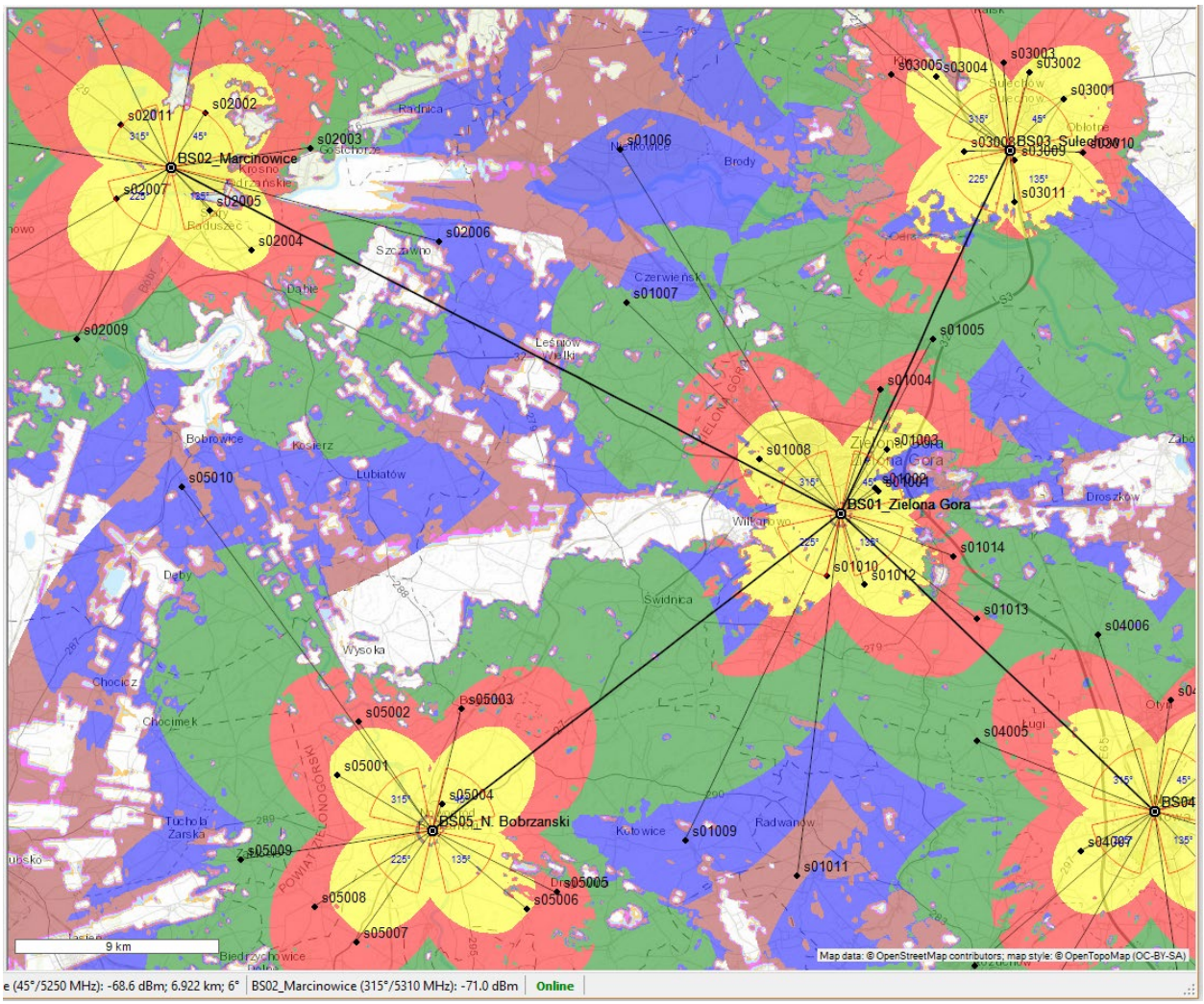


Figure 26. Received Power at subscriber stations coverage

Best Server

Best server map display is a map showing the base station supplying the strongest received signal at all locations on the base map.

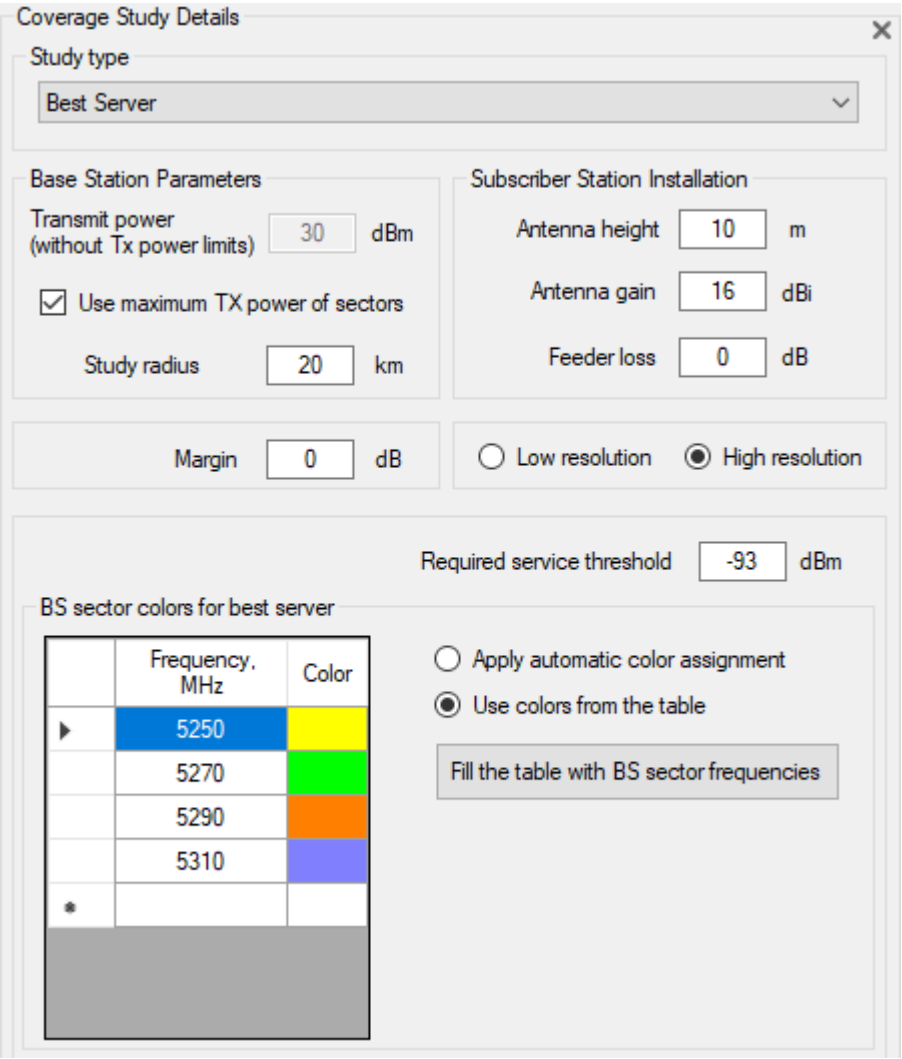


Figure 27. Coverage Study Details for Best Server study

Required Service Threshold, dBm	This is the minimum acceptable signal strength required by the receiver.
Apply Automatic Color Assignment	The program automatically assigns colors to the base stations in the study and then color fills the map according to these color assignments.
Use Colors from the Table	The colors for the base stations will be assigned in accordance with the frequency table.
Fill the Table with Frequencies of BS	Fill the table with the frequencies specified in the parameters of the base stations.

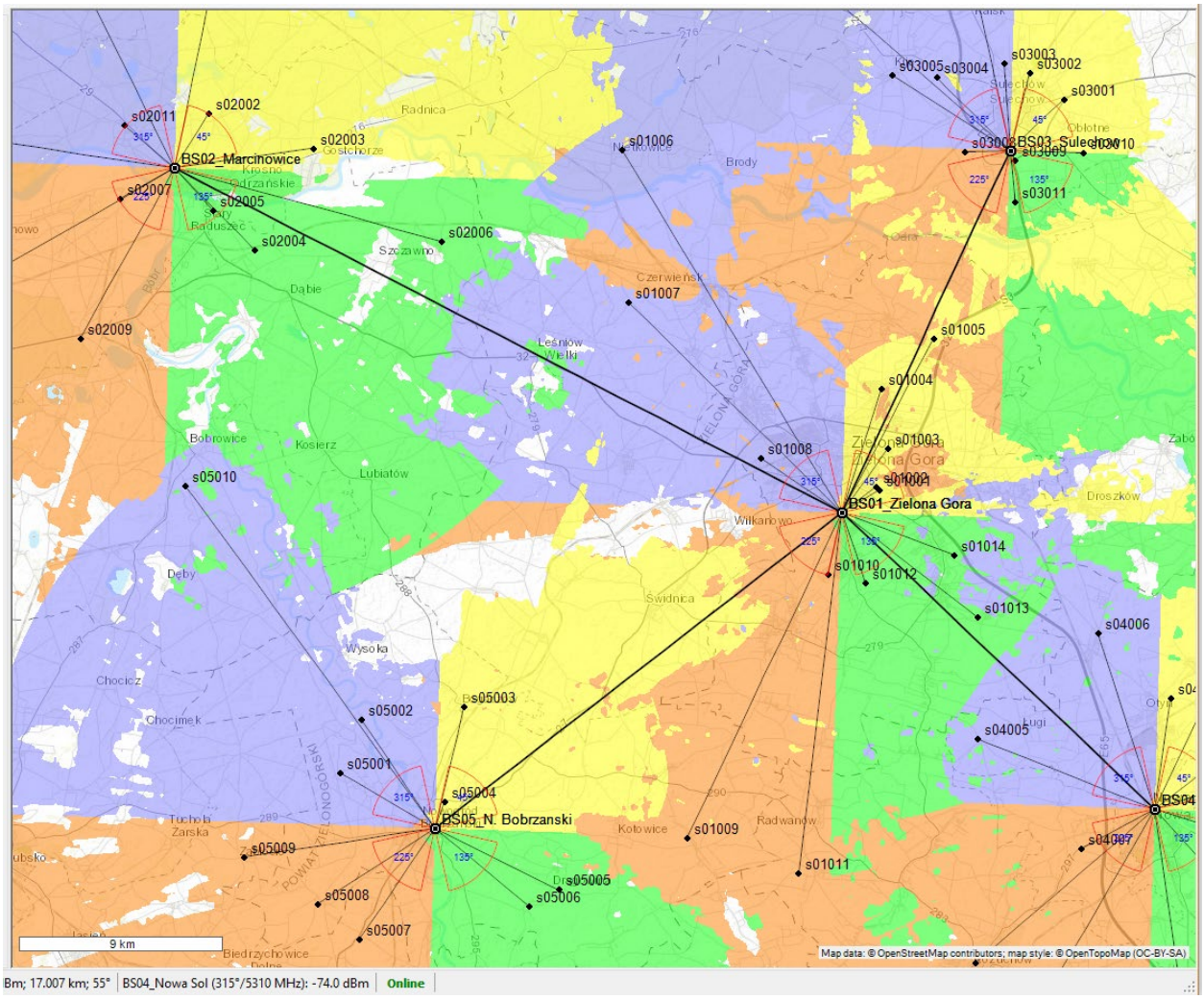


Figure 28. Best Server study

To perform the coverage study, click the  button.

C/(I+N) at Subscriber Stations

The carrier-to-interference + noise ratio, C/(I+N) or *CIR*, is one of the most important quantities used in assessing system performance. The quantity CIR is more completely written as:

$$CIR=\frac{C}{(\sum_{k=1}^{K} I_k+N_R)}$$

where C is the power of the signal from the strongest server at a location, I_k is the power of each of the other k signals at that location, N_R is the receiver noise power, and K is the total number of transmitters which cause interference at this location. I_k is only computed for transmitters that are using a co-channel or adjacent channel. If the closest channel in use by the interference sector is an adjacent channel, then the interference contribution by the sector is reduced in amplitude by the adjacent channel rejection factor.

Channels are defined as adjacent if the difference between the center frequencies of the channels is less than or equal to one bandwidth.

Channels are defined as co-channels if the difference between the center frequencies of the channels is zero.

The receiver noise power is calculated by multiplying the receiver effective noise bandwidth by the power noise density as represented by the receiver noise figure.

CIR is calculated by first finding the strongest received signal power from any transmitter at each location. It then calculates the sum of the received signal powers from all of the other transmitters which also have relevant signal levels at the location. After the sum of the interference is found, the noise power is calculated and the ratio is found.

Note that once the strongest signal has been identified, the directional received antenna at each location is assumed to be pointed toward the transmitter from which the strongest signal is received. The received signal from the other (interference) transmitters is then found using the off-axis gain of the received antenna, assuming an orientation toward the strongest signal transmitter.

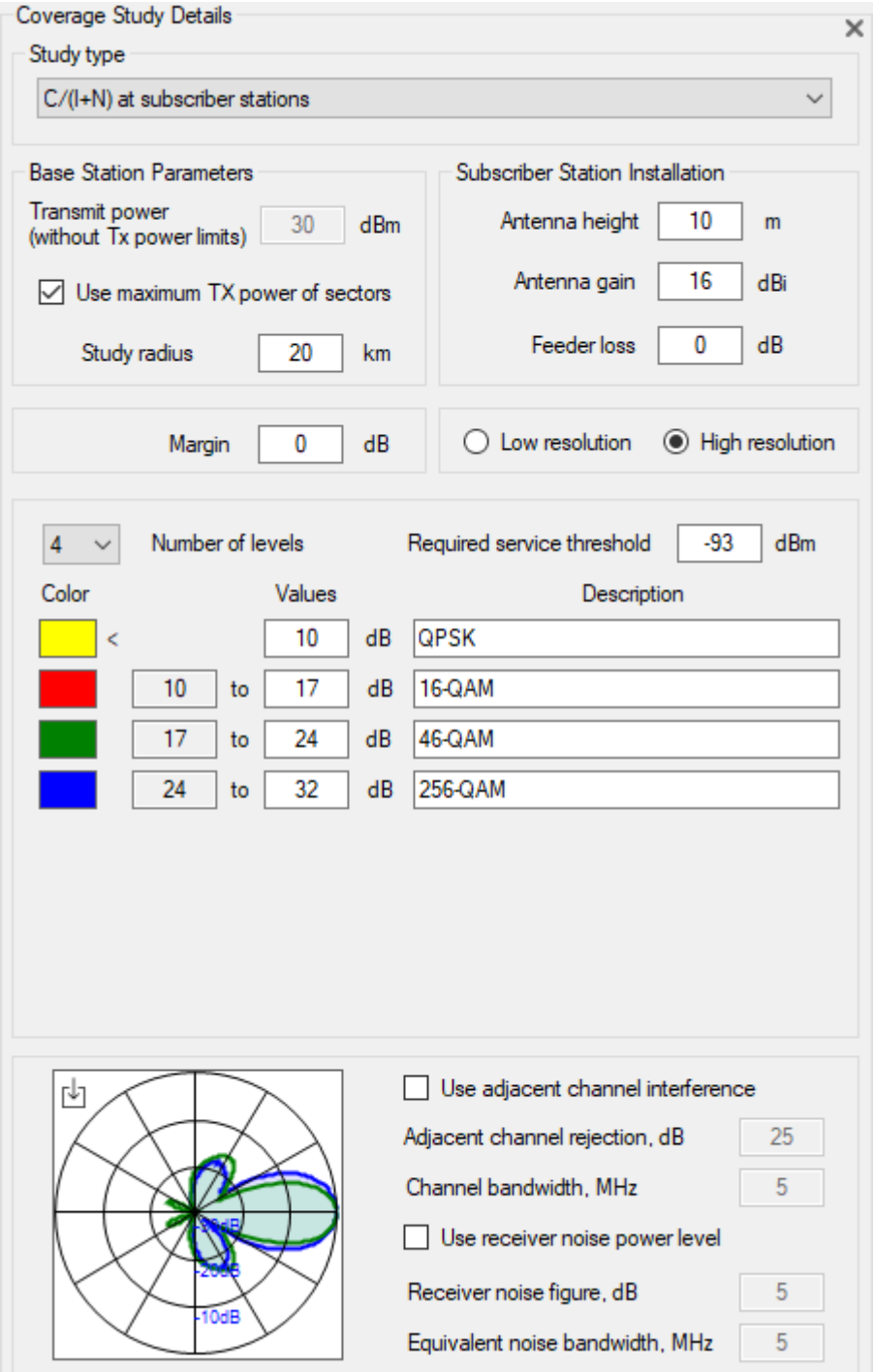


Figure 29. Coverage Study Details for C/(I+N) at subscriber stations study

Required Service Threshold, dBm	This is the minimum acceptable signal strength required by the receiver.
Browse MSI or NSMA	Choose the antenna pattern file for Subscriber Station Installation in MSI or NSMA format.
Use Adjacent Channel Interference	If the checkbox is active, the calculation will take into account the contribution of adjacent channels to interference.
Adjacent Channel Rejection, dB	Adjacent channel rejection, dB
Channel Bandwidth, MHz	Channel bandwidth, MHz
Use Receiver Noise Power Level	If the checkbox is active, the calculation will take into account the power of receiver noise.
Receiver Noise Figure, dB	Receiver noise figure, dB
Equivalent Noise Bandwidth, MHz	Equivalent noise bandwidth, MHz

If the checkboxes "Use adjacent channel interference" and "Use receiver noise power level" are not active, the calculations will take into account only the co-channel interference.

To perform the coverage study, click the  button.

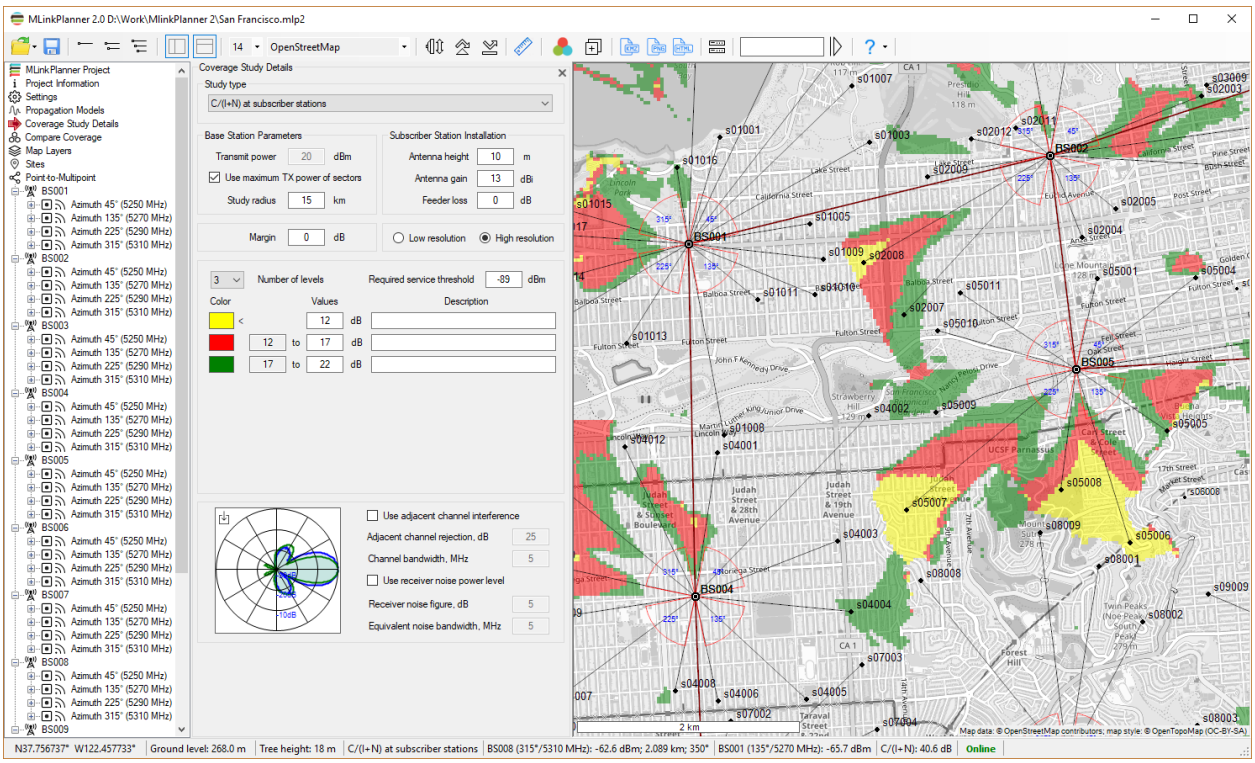


Figure 30. C/(I+N) study

Coverage Prediction for Outdoor Wi-Fi Networks

In MLinkPlanner, it is possible to predict the coverage of a city-wide Wi-Fi network, taking into account the characteristics of the propagation environment along the streets and the parameters of buildings. This feature allows you to design outdoor Wi-Fi networks with public access on a city scale, large-scale corporate outdoor Wi-Fi networks, Smart City networks, and so on.

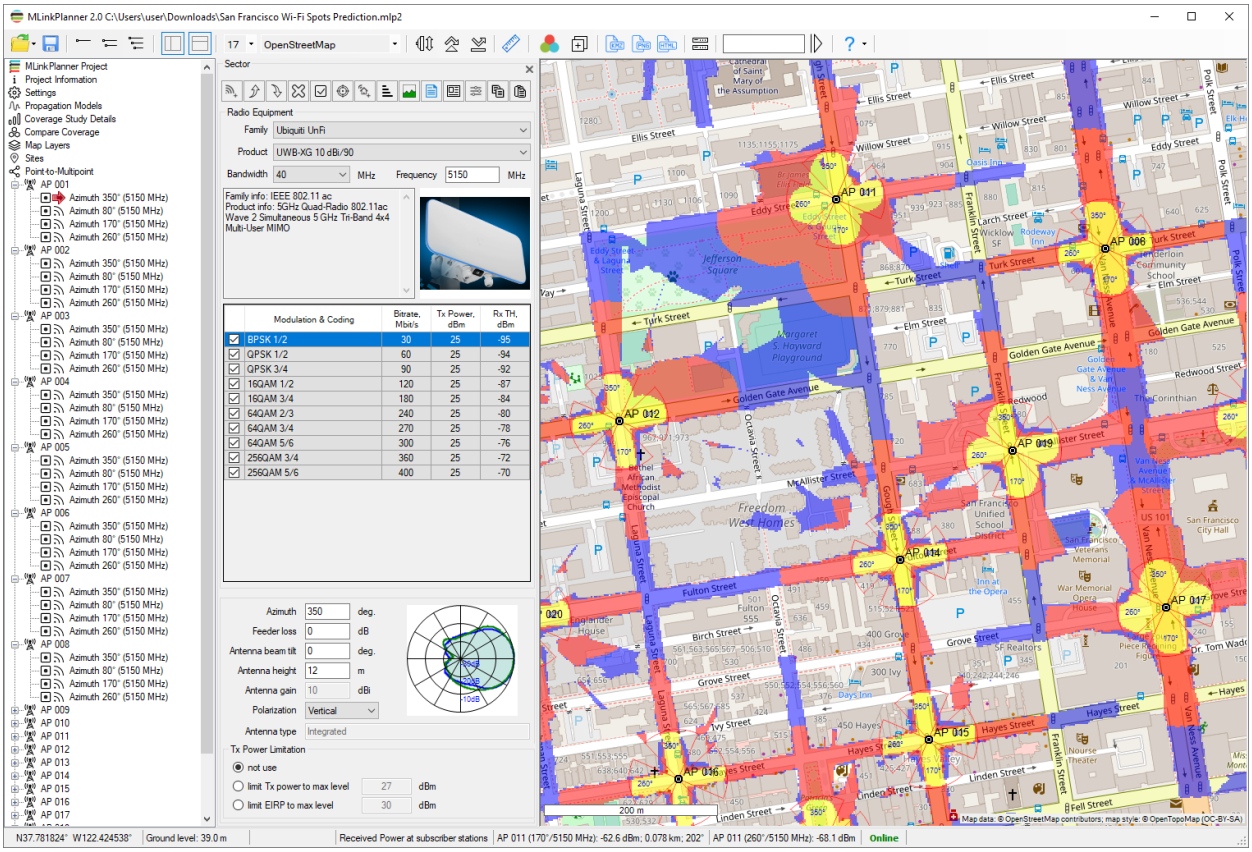


Figure 31. Coverage Prediction for Outdoor Wi-Fi Networks

The coverage prediction is based on the combined propagation model ITU-R P.1238-11 + Diffraction. The Bullington model is adopted as the diffraction model.

This combined propagation model takes into account the following factors:

- Outdoor signal attenuation according to the selected outdoor environment
- Indoor signal attenuation according to indoor propagation environment for buildings
- Power loss when the signal penetrates inside buildings
- Diffraction loss on terrain roughness
- Building heights

The ITU-R P.1238-11 propagation model, based on the use of different distance power loss coefficients for different propagation environments and signal penetration losses through walls, is mainly used for planning indoor radiocommunication systems. However, the same approach is entirely appropriate for a simplified simulation of the radio wave propagation along the streets. The user can customize the propagation model by selecting different environmental parameters for the street and buildings and taking into account penetration losses by choosing the material of the outer walls.

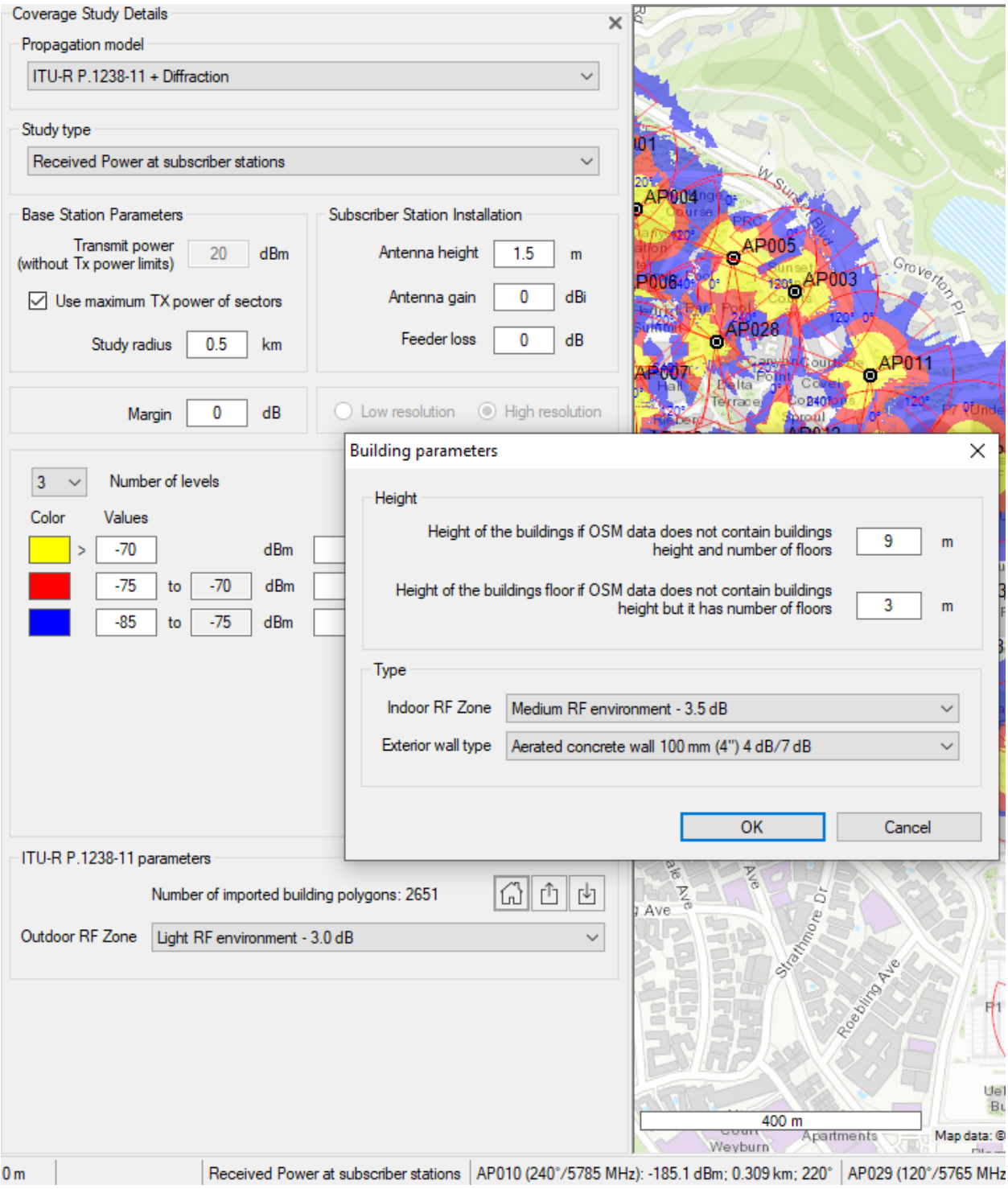


Figure 32. ITU-R P.1238-11 + Diffraction model parameters

The procedure for estimating coverage for outdoor Wi-Fi is basically the same as for estimating PtMP coverage (see the previous section). Still, it has some differences since the calculation takes into account the parameters of surrounding buildings:

1. Go to the " Coverage Study Details " menu and select the ITU-R P.1238-11 + Diffraction propagation model. For outdoor Wi-Fi networks, use only this model.
2. Specify the study type you need (Received Power or Best Server)

3. Set the base stations parameters (the maximum study radius from the BS here is 1 km, the calculation is performed only with high resolution) and the parameters of the subscriber station installation. You should not specify too large study radius; this will significantly slow down the calculation. Specify the actual radius of 200-400 meters.
4. Set the required received power levels.
5. Click on the "Import building polygons from OSM data for active BS"  Then, in the form that appears, specify the building's heights and floor heights for those buildings that do not have this information in the OpenStreetMap database.
6. Specify the propagation environment type for streets (Outdoor RF Zone)
7. Specify the propagation environment type for buildings (Indoor RF Zone), as well as the building walls material
8. Click on the "Calculate coverage" button

The user can import and export building polygons in KML format using the tools 
When exporting to KML, the name of each building polygon will contain information about the building height, RF Zone inside the building, and the walls type in the format: Height, m; Indoor RF Zone Index; Exterior Wall Type Index (see screenshot below). The user can change these parameters Google Earth individually for each building, then save and import this file into MLinkPlanner. The user can also change the buildings geometry in Google Earth or add new buildings to the plan.

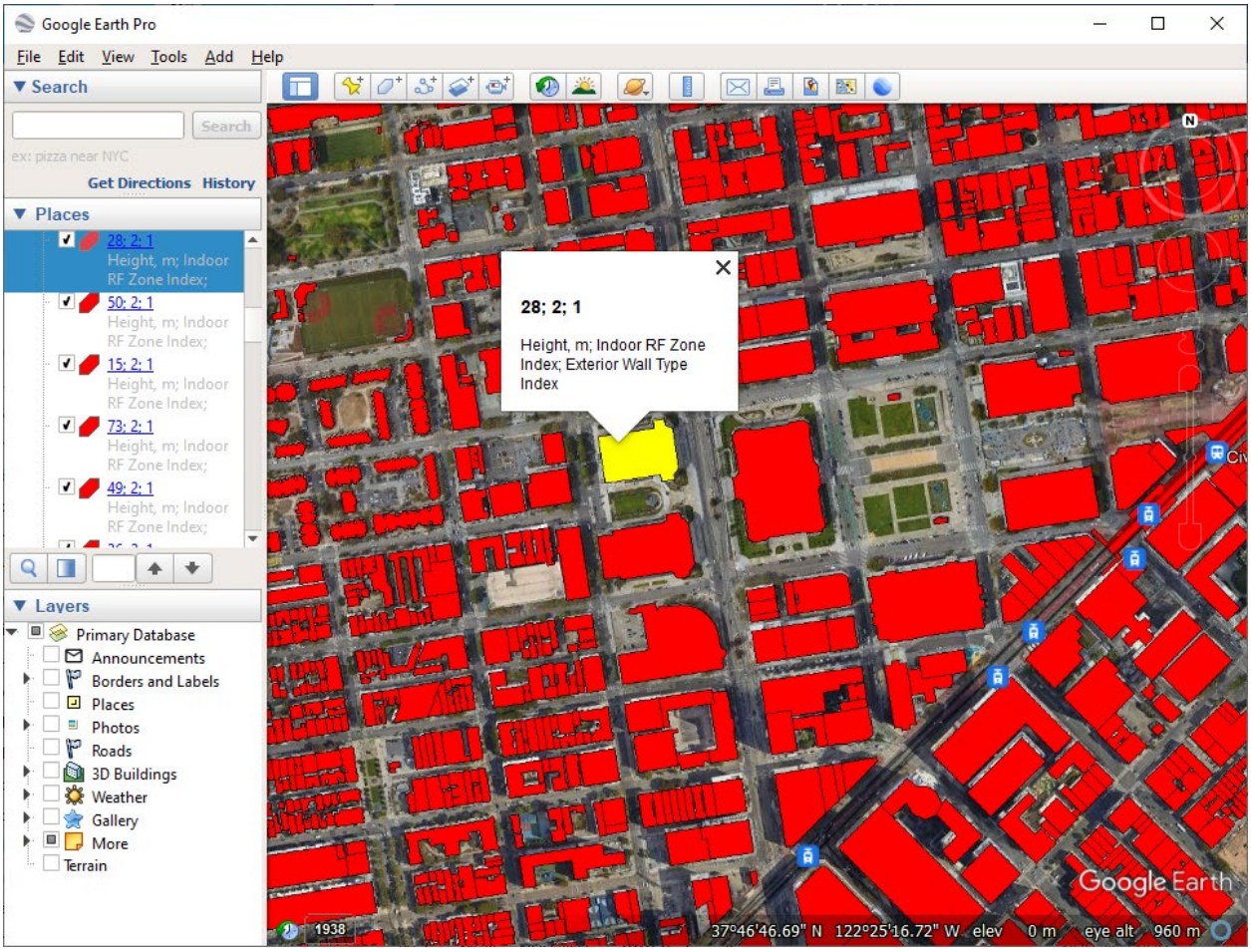


Figure 33. KML file in Google Earth Pro

RF Zone Index

Index	Indoor RF Zone
0	Ignore (the same as outdoor)
1	Light RF environment - 3.0 dB
2	Medium RF environment - 3.5 dB
3	Dense RF environment - 4.0 dB
4	High density RF environment - 4.5 dB

Exterior Wall Type Index

Index	Exterior Wall Type
0	Ignore 0 dB
1	Brick wall 90 mm
2	Brick wall 120 mm
3	Brick wall 250 mm
4	Brick wall 380 mm
5	Brick wall 510 mm
6	Concrete wall 100 mm
7	Concrete wall 200 mm
8	Concrete wall 300 mm
9	Concrete wall 400 mm
10	Concrete wall 500 mm
11	Aerated concrete wall 100 mm
12	Aerated concrete wall 200 mm
13	Aerated concrete wall 300 mm
14	Aerated concrete wall 400 mm
15	Aerated concrete wall 500 mm

There is an outdoor Wi-Fi project sample based on Ubiquiti Unifi UWB-XG outdoor access points among the project file samples.

Creating a Coverage Report

Coverage reports can be saved as an interactive web page, an image file, or a KMZ file.

Save the coverage as a webpage – Saves as a webpage. The index.html file (this is a page script), the bs.png file (the base station icon), and the folder of the coverage tile pyramid in the format {Z} / {X} / {Y} will be saved to the folder selected by the user. To view the result, open the index.html file in any web browser. This page can also be placed on a web server for viewing in any browser and on any of the operating systems (Windows, Mac, iOS, Android, Linux).

The webpage allows you to:

- Choose a base map from four different base maps

- Change the map zoom

- Display the legend

- Display the map zoom and the map scale and current coordinates of the cursor (in the decimal system and DMS)

To view an interactive webpage, you need an Internet connection.

The folder with the pyramid of tiles can be connected to any GIS that supports working with tiles (i.e.: QGIS, ArcGIS, MapInfo), which will demonstrate the result of calculating the radio coverage as a layer on any GIS.

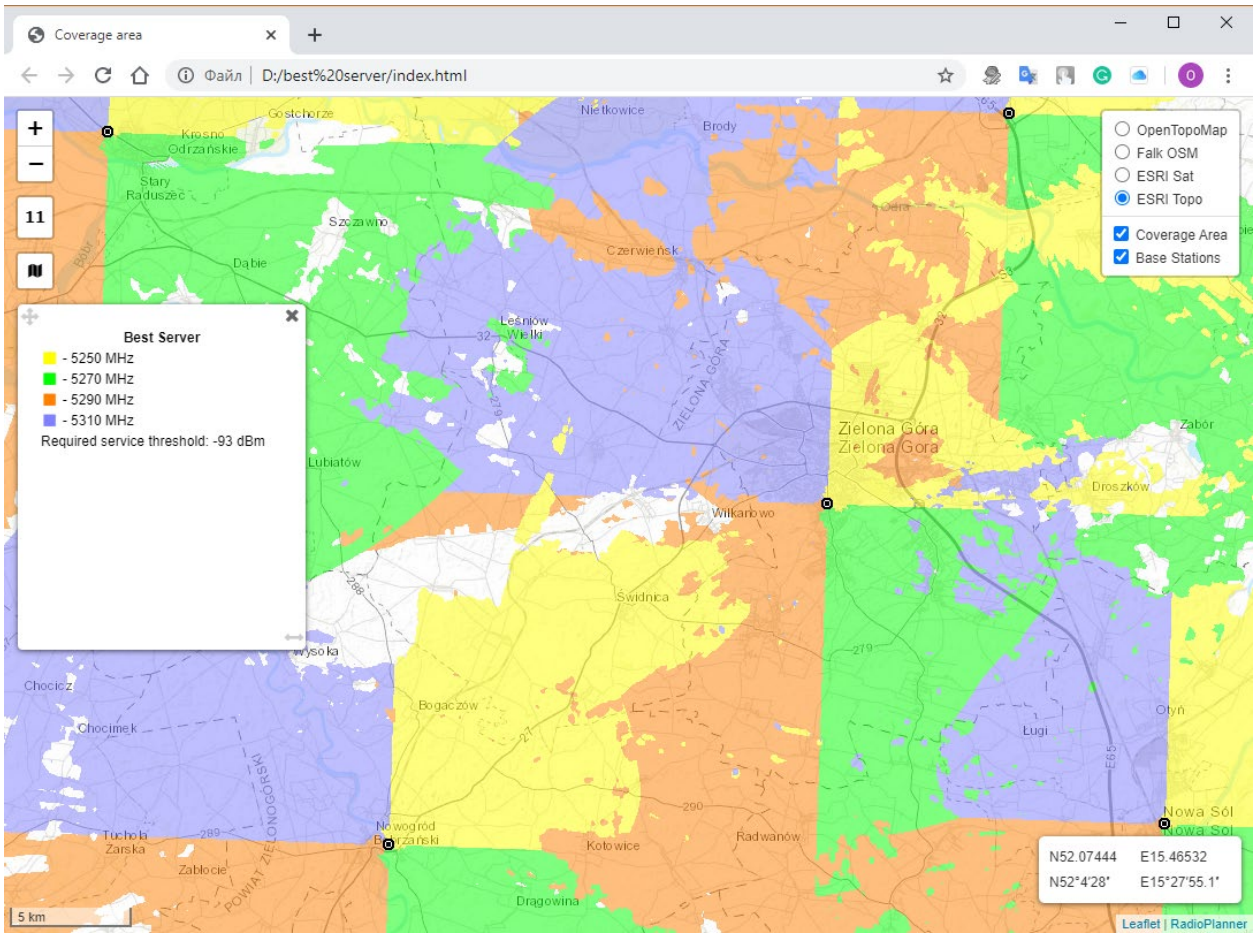


Figure 34. Example of the interactive webpage

Save the coverage as an image - Saves the result of coverage prediction 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.

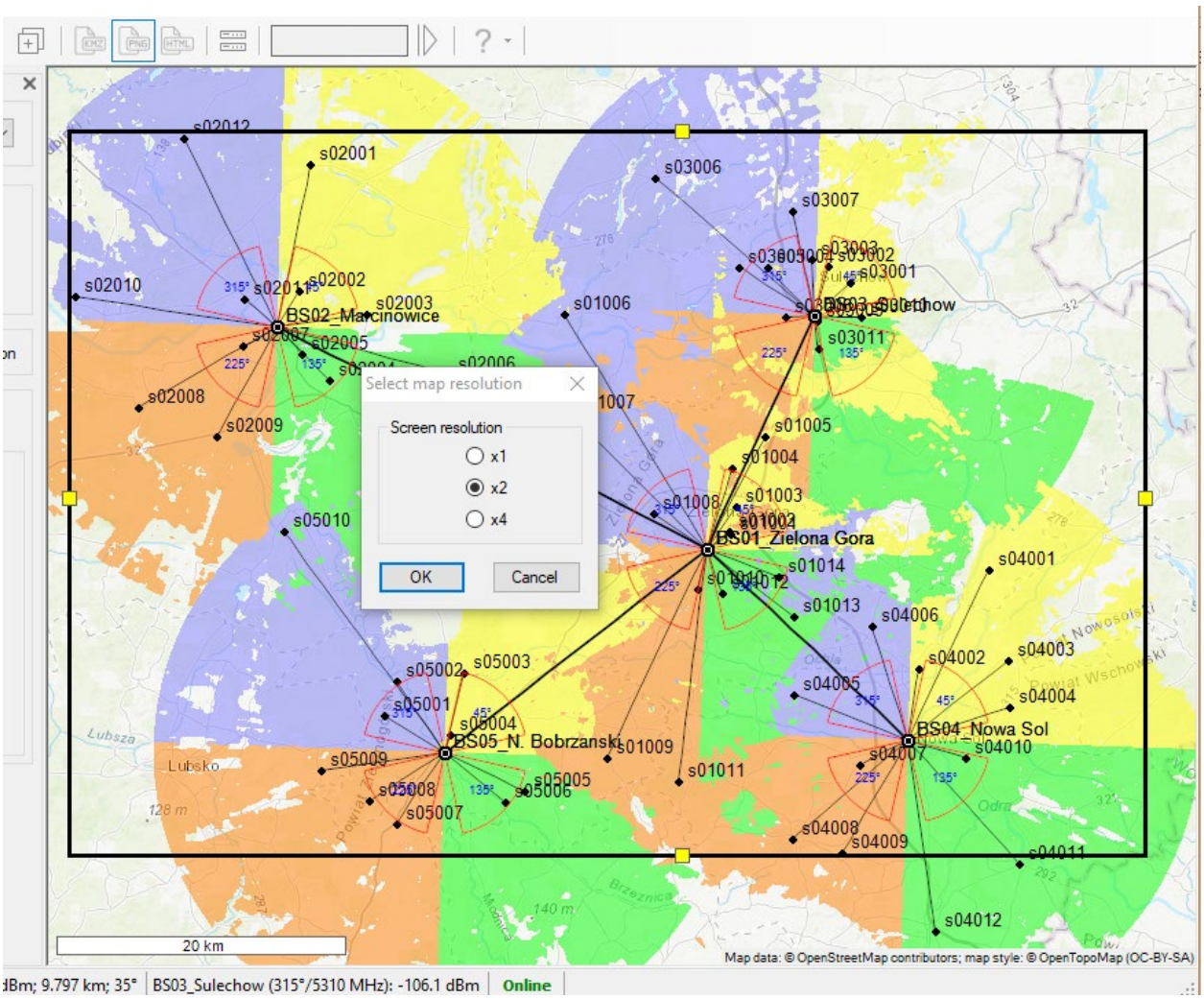


Figure 35. Save the coverage as an image

Save the coverage as a GeoTIFF file - Saves the result of coverage prediction as save the PtMP coverage as a GeoTIFF file in the Web Mercator projection. For further work with the coverage file in third-party GIS.

Save coverage, sites, and links as a KMZ file - Saves the coverage, sites as well as Point-to-Point and Point-to-Multipoint links as a KMZ file, which can be opened in Google Earth.

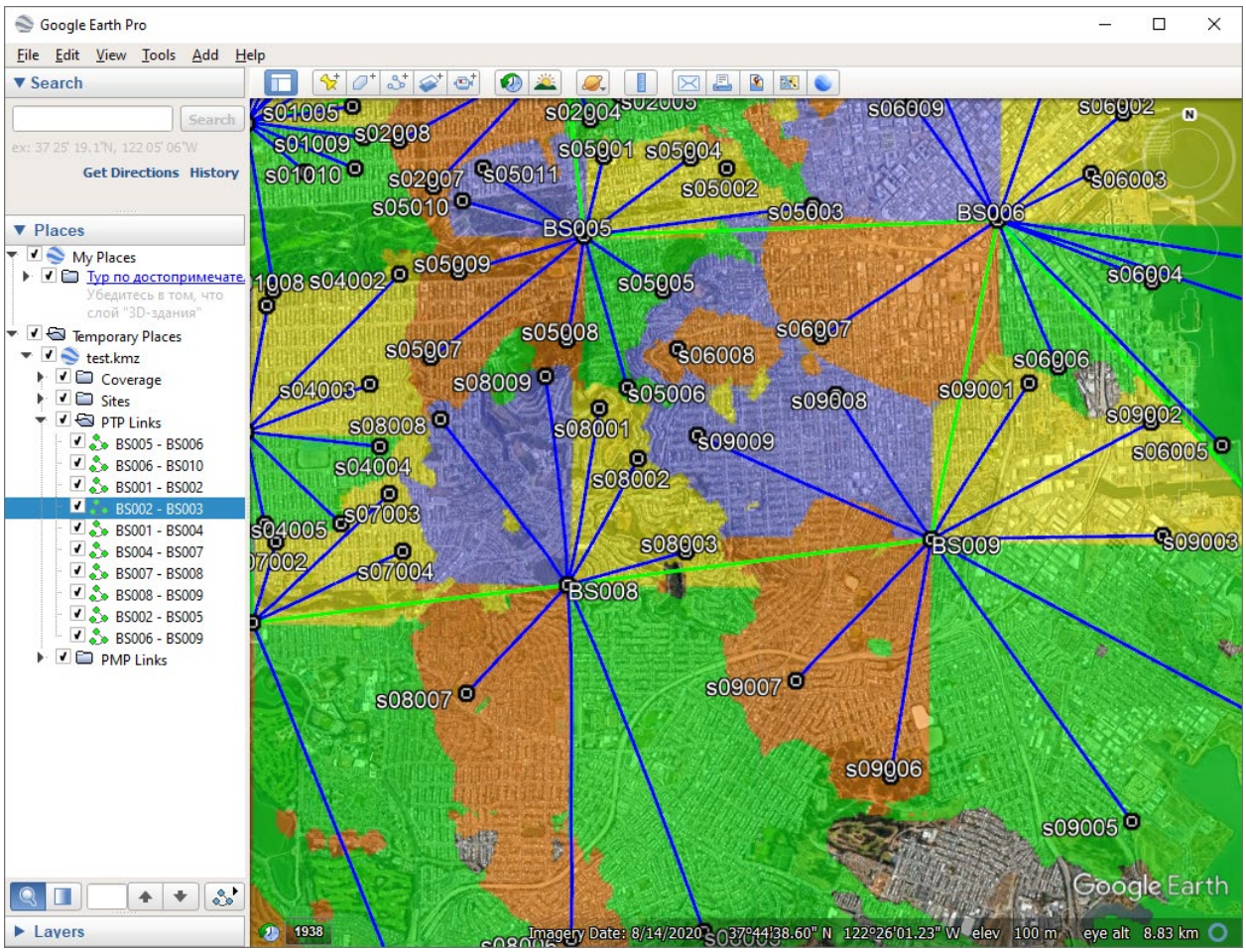


Figure 36. View KMZ file in Google Earth

Two Coverage Prediction Comparison

MLinkPlanner allows you to perform a visual comparison of the two coverage prediction results. Therefore, you can evaluate the effect on coverage of a change in various parameters of the base and subscriber stations of the PtMP network.

To add the performed prediction 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 will be displayed. Now, for example, you can change the height of the sector or sectors of active BSs, and after performing the coverage prediction, you can see how these changes were reflected in the result compared to the previous one.

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.

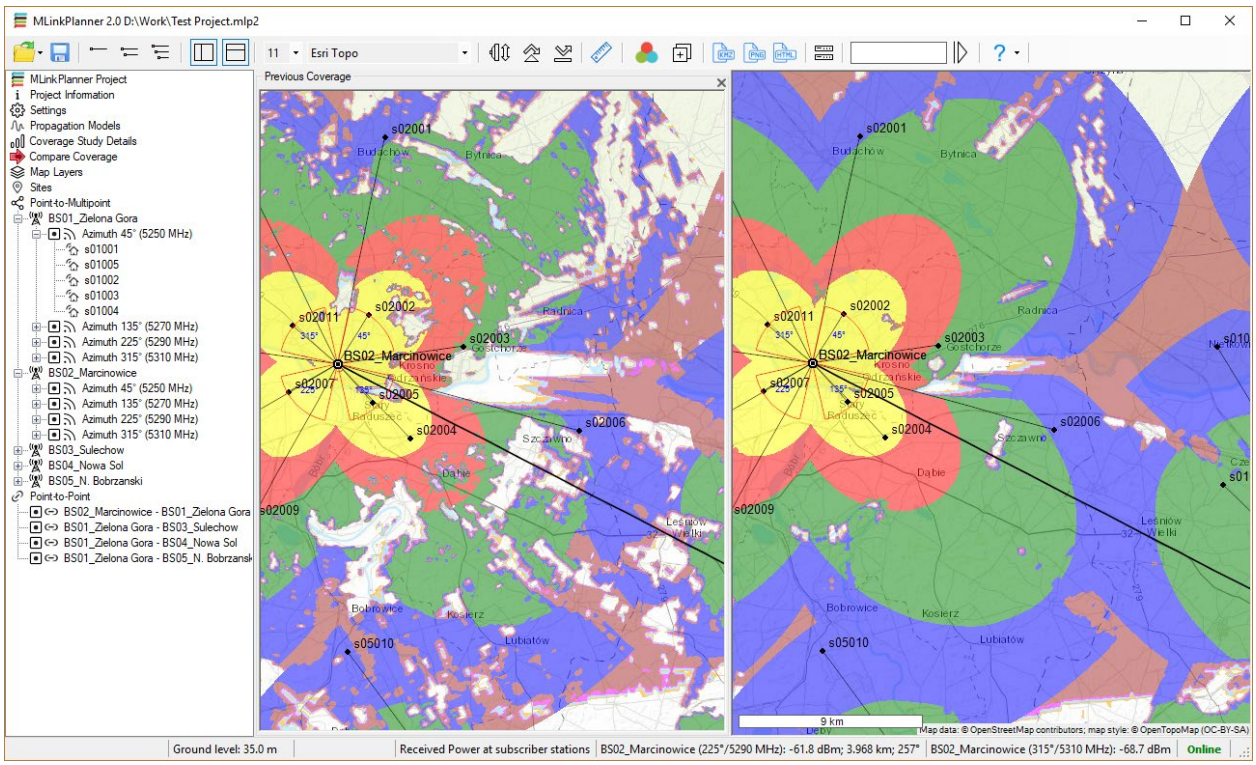


Figure 37. Two coverage prediction comparison

PtMP Subscriber Stations

For each of the Base Stations, you can set its Subscriber Stations.

To create a subscriber station, click on the  **Add subscriber station** button in the sector to which it will be linked. Then select the site from the list. After that, the subscriber station panel will open.

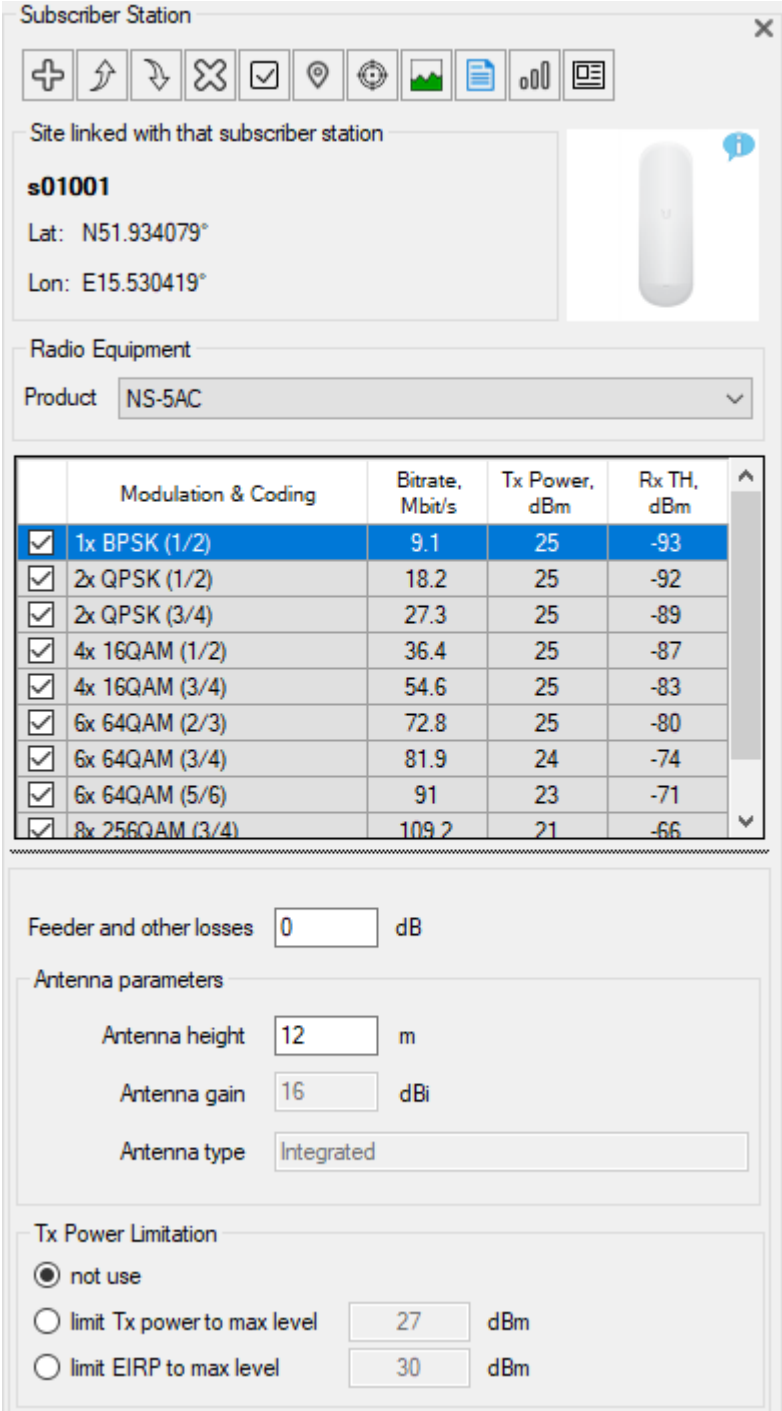


Figure 38. Subscriber station parameters

Toolbar:

 - Add a new subscriber station with the same parameters.

 - Move the subscriber station up.

 - Move the subscriber station down.

 - Delete the subscriber station.

 - Select / Unselect all modulations and coding rows.

 - Change the site.

 - Position the map with the subscriber station at the center of the screen.

 - Generate the path profile to the a base station.

 - Link report

 - Copy selected Rx thresholds to Coverage Study Levels.

 - Display the product specifications for the selected bandwidth in the form of a datasheet, which can be saved in PDF, Word, or Excel formats.

In the drop-down list, select the equipment model (product). The equipment family for the subscriber station is the same as the Family specified for the BS sector. Below you will see general information about the selected equipment, its image, channel bitrates, Tx power and Rx parameters for each modulation type.

Feeder and Other Losses, dB	Feeder and connector losses; default value is 0 dB.
Antenna Height, m	Antenna installation height relative to ground level, m. You can also change the antenna height in the profile window.
Antenna Gain, dBi	Antenna gain, dBi
Antenna Type	Antenna model; information only.

Tx Power Limitation

not use	not use Tx power max limit
Maximum Tx power limit, dBm	Maximum Tx power for this Subscriber Station, dBm From the general limit that is set in the PtMP menu and the limit that is set in this Subscriber Station, the most stringent limit is selected during the calculation.
Maximum EIRP limit, dBm	Maximum EIRP for this Subscriber Station, dBm From the general limit that is set in the PtMP menu and the limit that is set in this Subscriber Station, the most stringent limit is selected during the calculation.

The antenna pattern for a subscriber station is not specified since it is always directed strictly in the direction of the BS sector to which it is linked. The frequency also coincides with the BS sector frequency.

It is also convenient to create subscriber stations using the context menu on the base map. To do this, follow these steps:

1. In the main menu, select the BS sector to which the new subscriber station will be linked. You can also select the BS sector directly on the map by double-clicking on the degree designation of the desired BS sector.

2. Right-click on the site for the subscriber station and select “Create Subscriber Station Site Name” in the context menu.

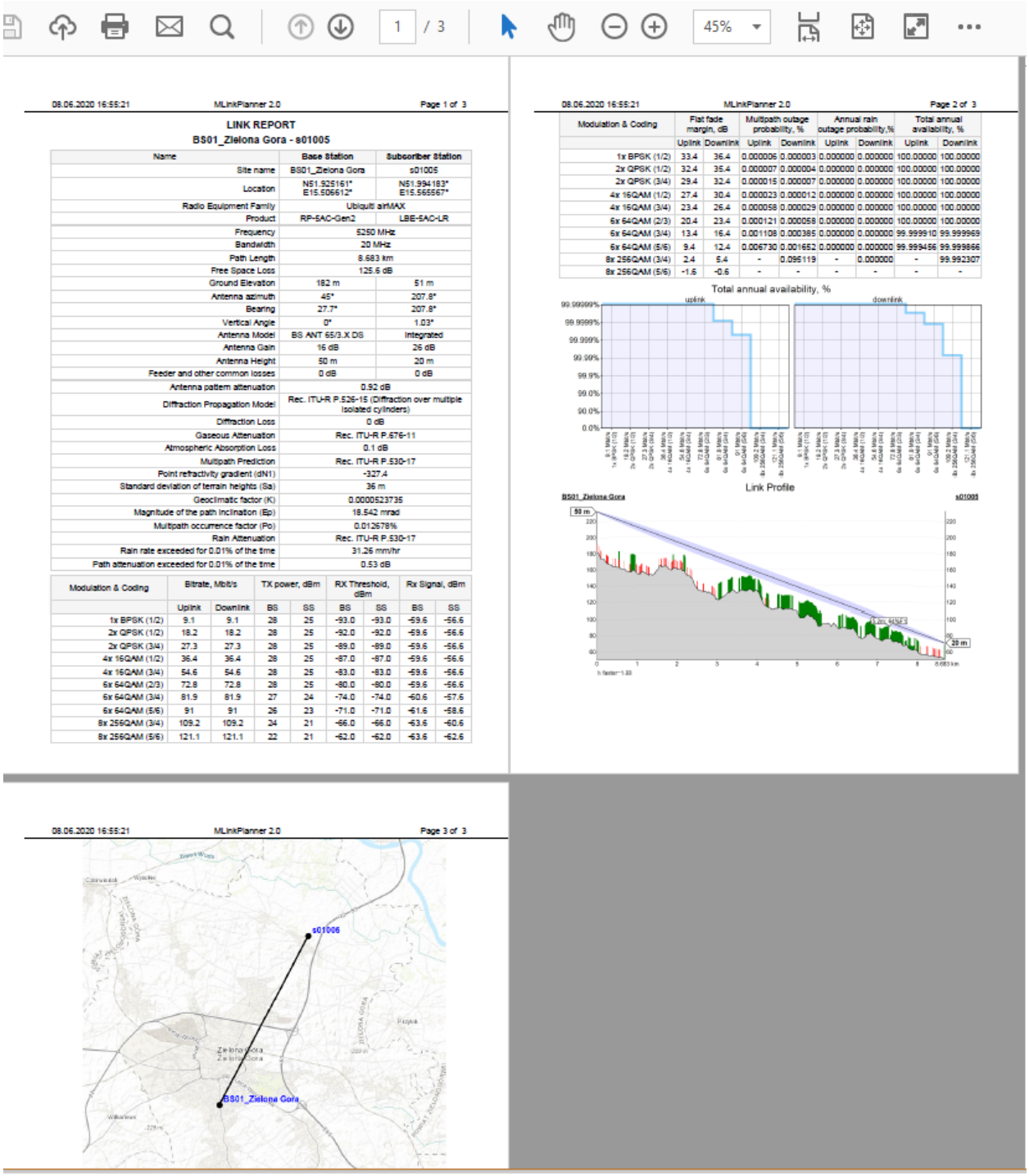
3. If you right-click on a subscriber station that has already been created, an additional line will appear in the context menu: “Delete all subscriber stations associated with the Site Name site,” with which you can delete a subscriber station. Notice that you delete only the subscriber station, not the site that connected to it.

Point-to-Multipoint Link Availability Prediction

For each of the Base Station - Subscriber station links can be performed availability prediction with a detailed consideration of all clutters along with the path profile. This prediction enables you to choose the parameters of the antennas and equipment for each link.

To generate a report:

1. Create a Base and Subscriber Station (see the relevant sections).
2. In the parameters panel of the corresponding subscriber station, use the  button to create a path profile between the base and subscriber stations. All of the possibilities when working with the path profile for PtMP are the same as when working with the profile for point-to-point links.
3. Use the  button to create a report; in this case, you can select the required report type - **Short report** or **Full report**.



08.06.2020 16:55:21 MLinkPlanner 2.0 Page 1 of 3

LINK REPORT

BS01_Zielona Gora - s01005

Name	Base Station	Subscriber Station
Site name	BS01_Zielona Gora	s01005
Location	N51.925161° E15.506612°	N51.994183° E15.565567°
Radio Equipment Family	Ubiquiti airMAX	
Product	RP-5AC-Gen2	LBE-5AC-LR
Frequency	5250 MHz	
Bandwidth	20 MHz	
Path Length	8.683 km	
Free Space Loss	125.6 dB	
Ground Elevation	182 m	51 m
Antenna azimuth	45°	207.8°
Bearing	27.7°	207.8°
Vertical Angle	0°	1.03°
Antenna Model	BS ANT 65/3.X DS	Integrated
Antenna Gain	16 dB	26 dB
Antenna Height	50 m	20 m
Feeder and other common losses	0 dB	0 dB
Antenna pattern attenuation	0.92 dB	
Diffraction Propagation Model	Rec. ITU-R P.526-15 (Diffraction over multiple isolated cylinders)	
Diffraction Loss	0 dB	
Gaseous Attenuation	Rec. ITU-R P.676-11	
Atmospheric Absorption Loss	0.1 dB	
Multipath Prediction	Rec. ITU-R P.530-17	
Point refractivity gradient (dN1)	-327.4	
Standard deviation of terrain heights (Sa)	36 m	
Geoclimatic factor (K)	0.0000523735	
Magnitude of the path inclination (Ep)	18.542 mrad	
Multipath occurrence factor (Po)	0.012678%	
Rain Attenuation	Rec. ITU-R P.530-17	
Rain rate exceeded for 0.01% of the time	31.26 mm/hr	
Path attenuation exceeded for 0.01% of the time	0.53 dB	

Modulation & Coding	Bitrate, Mbit/s		TX power, dBm		RX Threshold, dBm		Rx Signal, dBm	
	Uplink	Downlink	BS	SS	BS	SS	BS	SS
1x BPSK (1/2)	9.1	9.1	28	25	-93.0	-93.0	-59.6	-56.6
2x QPSK (1/2)	18.2	18.2	28	25	-92.0	-92.0	-59.6	-56.6
2x QPSK (3/4)	27.3	27.3	28	25	-89.0	-89.0	-59.6	-56.6
4x 16QAM (1/2)	36.4	36.4	28	25	-87.0	-87.0	-59.6	-56.6
4x 16QAM (3/4)	54.6	54.6	28	25	-83.0	-83.0	-59.6	-56.6
6x 64QAM (2/3)	72.8	72.8	28	25	-80.0	-80.0	-59.6	-56.6
6x 64QAM (3/4)	81.9	81.9	27	24	-74.0	-74.0	-60.6	-57.6
6x 64QAM (5/6)	91	91	26	23	-71.0	-71.0	-61.6	-58.6
8x 256QAM (3/4)	109.2	109.2	24	21	-66.0	-66.0	-63.6	-60.6
8x 256QAM (5/6)	121.1	121.1	22	21	-62.0	-62.0	-63.6	-62.6

08.06.2020 16:55:21 MLinkPlanner 2.0 Page 2 of 3

Modulation & Coding	Flat fade margin, dB		Multipath outage probability, %		Annual rain outage probability,%		Total annual availability, %	
	Uplink	Downlink	Uplink	Downlink	Uplink	Downlink	Uplink	Downlink
1x BPSK (1/2)	33.4	36.4	0.000006	0.000003	0.000000	0.000000	100.00000	100.00000
2x QPSK (1/2)	32.4	35.4	0.000007	0.000004	0.000000	0.000000	100.00000	100.00000
2x QPSK (3/4)	29.4	32.4	0.000015	0.000007	0.000000	0.000000	100.00000	100.00000
4x 16QAM (1/2)	27.4	30.4	0.000023	0.000012	0.000000	0.000000	100.00000	100.00000
4x 16QAM (3/4)	23.4	26.4	0.000058	0.000029	0.000000	0.000000	100.00000	100.00000
6x 64QAM (2/3)	20.4	23.4	0.000121	0.000058	0.000000	0.000000	100.00000	100.00000
6x 64QAM (3/4)	13.4	16.4	0.001108	0.000385	0.000000	0.000000	99.999910	99.999969
6x 64QAM (5/6)	9.4	12.4	0.006730	0.001652	0.000000	0.000000	99.999456	99.999866
8x 256QAM (3/4)	2.4	5.4	-	0.095119	-	0.000000	-	99.992307
8x 256QAM (5/6)	-1.6	-0.6	-	-	-	-	-	-

08.06.2020 16:55:21 MLinkPlanner 2.0 Page 3 of 3

Figure 39. PtMP link full report in PDF

Link Report

Full Report Short Report

1 of 1 100% Find | Next

16.07.2020 17:39:28 MLinkPlanner 2.0 Page 1 of 1

Point-to-Multipoint Performance Summary

Minimum Annual Availability Required 99.95%

BS001 N37.780149° W122.492430°

Ubiquiti airMAX LAP-120 Antenna Integrated/16dBi/66°/40m/45°

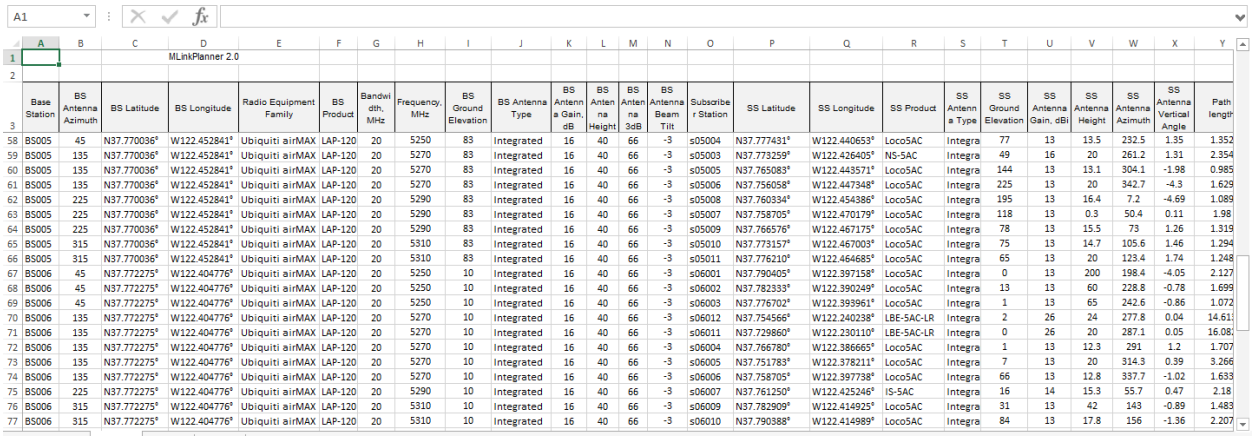
Subscriber stations	Latitude Longitude	Radio equipment	Antenna	Path lenght	Diffraction loss
s01001	N37.788794° W122.489233°	Loco5AC	Integrated/13dBi/10.7 m Azimuth 196°	1.003 km	0.0 dB
s01004	N37.806970° W122.476530°	IS-5AC	Integrated/14dBi/14.5 m Azimuth 205°	3.297 km	0.0 dB
s01006	N37.827930° W122.489995°	LBE-5AC-Gen2	Integrated/23dBi/11 m Azimuth 182°	5.323 km	0.0 dB
s01007	N37.792897° W122.475758°	NS-5AC	Integrated/16dBi/20 m Azimuth 226°	2.041 km	0.0 dB
s01002	N37.796458° W122.476401°	IS-5AC	Integrated/14dBi/20 m Azimuth 218°	2.299 km	0.0 dB
s01003	N37.788353° W122.473955°	IS-5AC	Integrated/14dBi/12 m Azimuth 241°	1.864 km	0.0 dB
s01005	N37.781807° W122.480049°	Loco5AC	Integrated/13dBi/9.6 m Azimuth 260°	1.105 km	0.0 dB

	Uplink				Downlink			
Subscriber stations	Rx power, dBm	Fade margin, dB	Max usable mode	Capacity, Mbit/s	Rx power, dBm	Fade margin, dB	Max usable mode	Bitrate, Mbit/s
s01001	-59.7	6.3	8x 256QAM (3/4)	109.2	-59.7	6.3	8x 256QAM (3/4)	109.2
s01004	-65.5	5.5	6x 64QAM (5/6)	91	-65.5	5.5	6x 64QAM (5/6)	91
s01006	-64.1	6.9	6x 64QAM (5/6)	91	-64.1	6.9	6x 64QAM (5/6)	91
s01007	-60.1	5.9	8x 256QAM (3/4)	109.2	-60.1	5.9	8x 256QAM (3/4)	109.2
s01002	-61.7	9.3	6x 64QAM (5/6)	91	-61.7	9.3	6x 64QAM (5/6)	91
s01003	-60.0	11.0	6x 64QAM (5/6)	91	-60.0	11.0	6x 64QAM (5/6)	91
s01005	-61.0	5.0	8x 256QAM (3/4)	109.2	-61.0	5.0	8x 256QAM (3/4)	109.2

Close

Figure 40. BS Sector Performance Summary

BS Sector Performance Summary provides a summary of the performance of all the subscriber stations of the selected base station sector including the maximum usable modulation modes of all the PtMP Links that meet the required minimum flat fade margin setting and minimum annual availability setting.



MLinkPlanner 2.0

	Base Station	BS Antenna Azimuth	BS Latitude	BS Longitude	Radio Equipment Family	BS Product	Bandwidth, MHz	Frequency, MHz	BS Ground Elevation	BS Antenna Type	BS Antenna Gain, dB	BS Antenna Height	BS Antenna 3dB	BS Antenna Beam Tilt	Subscriber Station	SS Latitude	SS Longitude	SS Product	SS Antenna Type	SS Ground Elevation	SS Antenna Gain, dBi	SS Antenna Height	SS Antenna Azimuth	SS Antenna Vertical Angle	Path length
58	BS005	45	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5250	83	Integrated	16	40	66	-3	s05004	N37.777431°	W122.440653°	Loco5AC	Integra	77	13	13.5	232.5	1.35	1.352
59	BS005	135	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5270	83	Integrated	16	40	66	-3	s05003	N37.773259°	W122.426405°	NS-5AC	Integra	49	16	20	261.2	1.31	2.354
60	BS005	135	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5270	83	Integrated	16	40	66	-3	s05005	N37.765083°	W122.443571°	Loco5AC	Integra	144	13	13.1	304.1	-1.98	0.985
61	BS005	135	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5270	83	Integrated	16	40	66	-3	s05006	N37.756058°	W122.447348°	Loco5AC	Integra	225	13	20	342.7	-4.3	1.629
62	BS005	225	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5290	83	Integrated	16	40	66	-3	s05008	N37.760334°	W122.454386°	Loco5AC	Integra	195	13	16.4	7.2	-4.69	1.089
63	BS005	225	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5290	83	Integrated	16	40	66	-3	s05007	N37.758705°	W122.470179°	Loco5AC	Integra	118	13	0.3	50.4	0.11	1.98
64	BS005	225	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5290	83	Integrated	16	40	66	-3	s05009	N37.766576°	W122.467175°	Loco5AC	Integra	78	13	15.5	73	1.26	1.319
65	BS005	315	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5310	83	Integrated	16	40	66	-3	s05010	N37.773157°	W122.467003°	Loco5AC	Integra	75	13	14.7	105.6	1.46	1.294
66	BS005	315	N37.770036°	W122.452841°	Ubiquiti airMAX	LAP-120	20	5310	83	Integrated	16	40	66	-3	s05011	N37.776210°	W122.464685°	Loco5AC	Integra	65	13	20	123.4	1.74	1.248
67	BS006	45	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5250	10	Integrated	16	40	66	-3	s06001	N37.790405°	W122.397158°	Loco5AC	Integra	0	13	200	198.4	-4.05	2.127
68	BS006	45	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5250	10	Integrated	16	40	66	-3	s06002	N37.782333°	W122.390249°	Loco5AC	Integra	13	13	60	228.8	-0.78	1.699
69	BS006	45	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5250	10	Integrated	16	40	66	-3	s06003	N37.776702°	W122.393961°	Loco5AC	Integra	1	13	65	242.6	-0.86	1.072
70	BS006	135	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5270	10	Integrated	16	40	66	-3	s06012	N37.754566°	W122.240238°	LBE-5AC-LR	Integra	2	26	24	277.8	0.04	14.61
71	BS006	135	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5270	10	Integrated	16	40	66	-3	s06011	N37.729860°	W122.230110°	LBE-5AC-LR	Integra	0	26	20	287.1	0.05	16.08
72	BS006	135	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5270	10	Integrated	16	40	66	-3	s06004	N37.766780°	W122.386665°	Loco5AC	Integra	1	13	12.3	291	1.2	1.707
73	BS006	135	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5270	10	Integrated	16	40	66	-3	s06005	N37.751783°	W122.378211°	Loco5AC	Integra	7	13	20	314.3	0.39	3.266
74	BS006	135	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5270	10	Integrated	16	40	66	-3	s06006	N37.758705°	W122.397738°	Loco5AC	Integra	66	13	12.8	337.7	-1.02	1.633
75	BS006	225	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5290	10	Integrated	16	40	66	-3	s06007	N37.761250°	W122.425246°	IS-5AC	Integra	16	14	15.3	55.7	0.47	2.18
76	BS006	315	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5310	10	Integrated	16	40	66	-3	s06009	N37.782909°	W122.414925°	Loco5AC	Integra	31	13	42	143	-0.89	1.483
77	BS006	315	N37.772275°	W122.404776°	Ubiquiti airMAX	LAP-120	20	5310	10	Integrated	16	40	66	-3	s06010	N37.790388°	W122.414989°	Loco5AC	Integra	84	13	17.8	156	-1.36	2.207

Figure 41. MS Excel Summary Report for Point-to-Multipoint links

Click the "Summary Report" button on the PtMP menu and an Excel spreadsheet will open. Only active base stations will be listed in the spreadsheet.

For point-to-multipoint links, the same path profile analysis features as for the point-to-point path profile available:

- Antenna minimum height estimation
- Reflection Analysis
- Diffraction Analysis

Map Layers

In the Map Layers menu, the user can control the layers that are displayed on the map - enable/disable the display of layers and change their style. The base map is always below the other layers, followed by the DEM layer and then the coverage layer. The order of other layers can be changed.

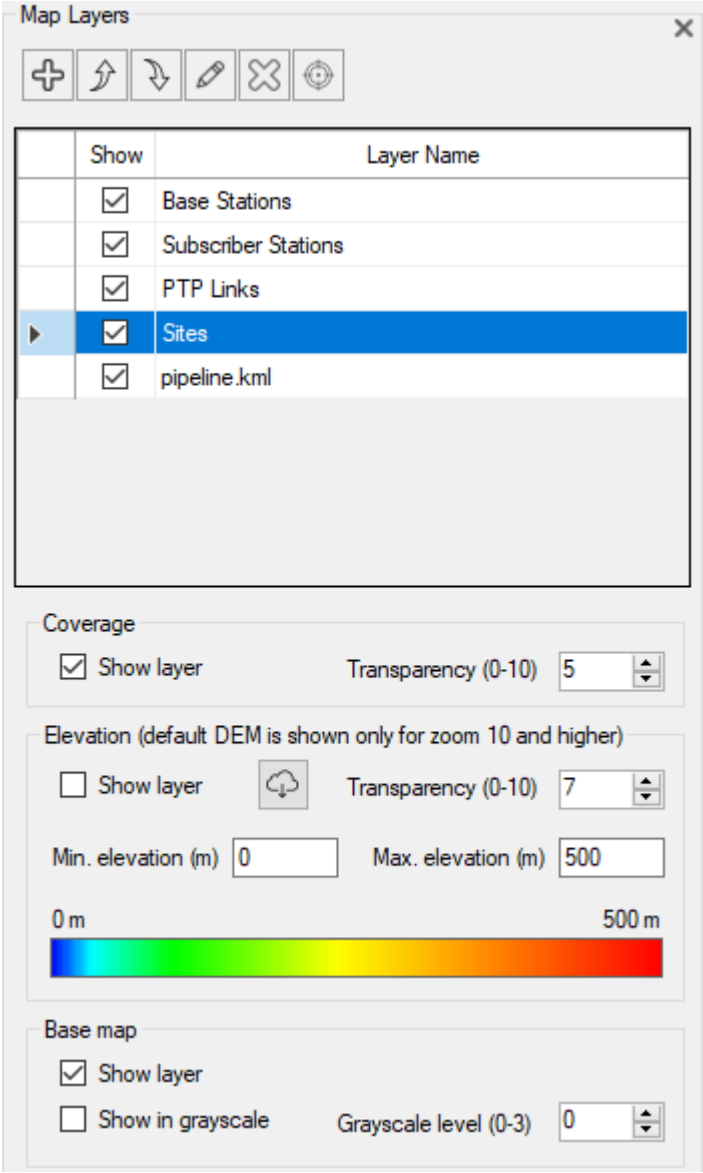


Figure 42. Map Layers

Toolbar:

 - Add a new custom layer from KML or CSV file.

 - Move the selected layer up.

 - Move the selected layer down.

 - Change the style of the selected layer (or double click on the selected layer).

 - Delete custom layer.

 - Show the first point of the selected user layer in the center of the screen.

By default, the following layers are always present: sites, PtP links, PtMP base stations, subscriber stations. The user can change their order, turn on / off, and change the style of the layers, but it is impossible to delete them.

Coverage Layer

Show Layer	Show / Hide coverage layer
Transparency	Set layer opacity in the range of 0 (fully transparent) to 10 (not transparent)

Elevation (DEM) Layer

Show Layer	Show / Hide the DEM map layer. The Default DEM is shown only for zoom 10 and higher. Custom DEM is shown for any zoom.
	Download and refresh custom DEM data within the screen (Only for zoom 10 and higher)
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.

Base Map Layer

Show Layer	Show / Hide the base map layer
Show in Grayscale	Show base map in grayscale
Grayscale Level	Brightness from the range 0 (darker) - 3 (lighter)

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, pipelines, and other infrastructure objects.

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.

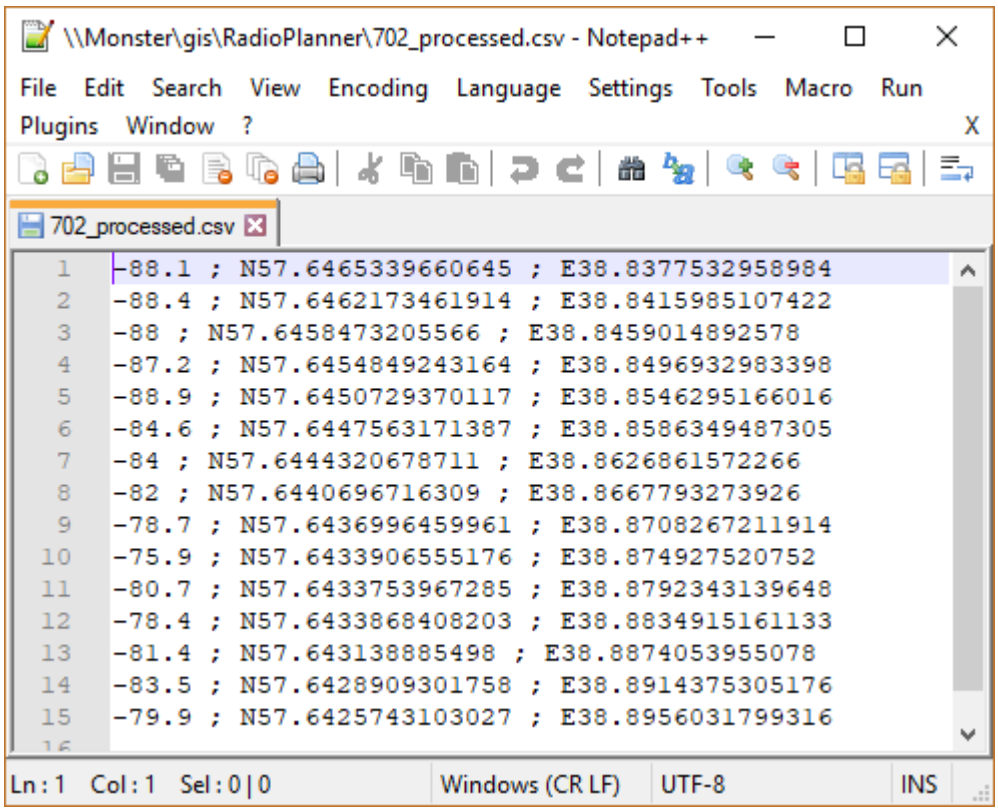


Figure 43. Sample CSV file with measurement results

Edit Custom Layer Styles

Site Layer Style

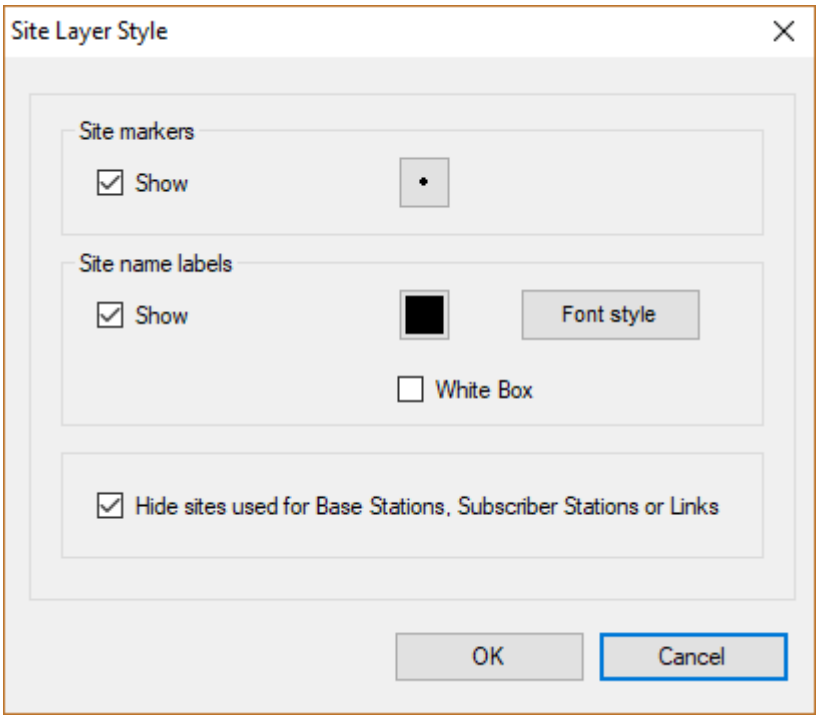


Figure 44. Site Layer Style

Show	Show / hide
Site Markers	Select a marker for sites from the standard set.
Site Name Labels	Choose font type, style, and color for site names.
White Box	Place the label on a white box
Hide Sites used for Base Stations, Subscriber Stations, or Links	Hide sites that are already used to host Base Stations, Subscriber Stations, or Links. Only empty sites will be shown on the base map.

PtP Link Layer Style

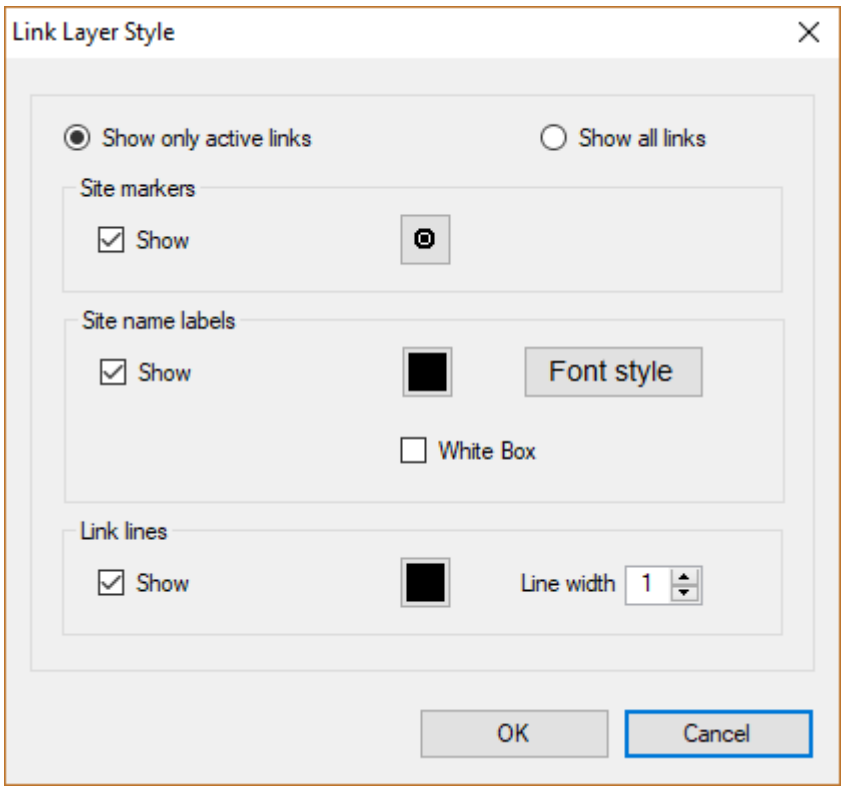


Figure 45. PtP Link Layer Style

Show only Active Links	Show only active links.
Show all Links	Show all links.
Site Markers	Show / hide, as well as select a marker for the ends of the link from the standard set.
Site Name Labels	Show / hide the name of the ends of the link, as well as choose the font style and color.
White Box	Place the label on a white box
Link Lines	Show / hide the link, as well as select the color and line thickness.

PtMP Base Stations Layer Style

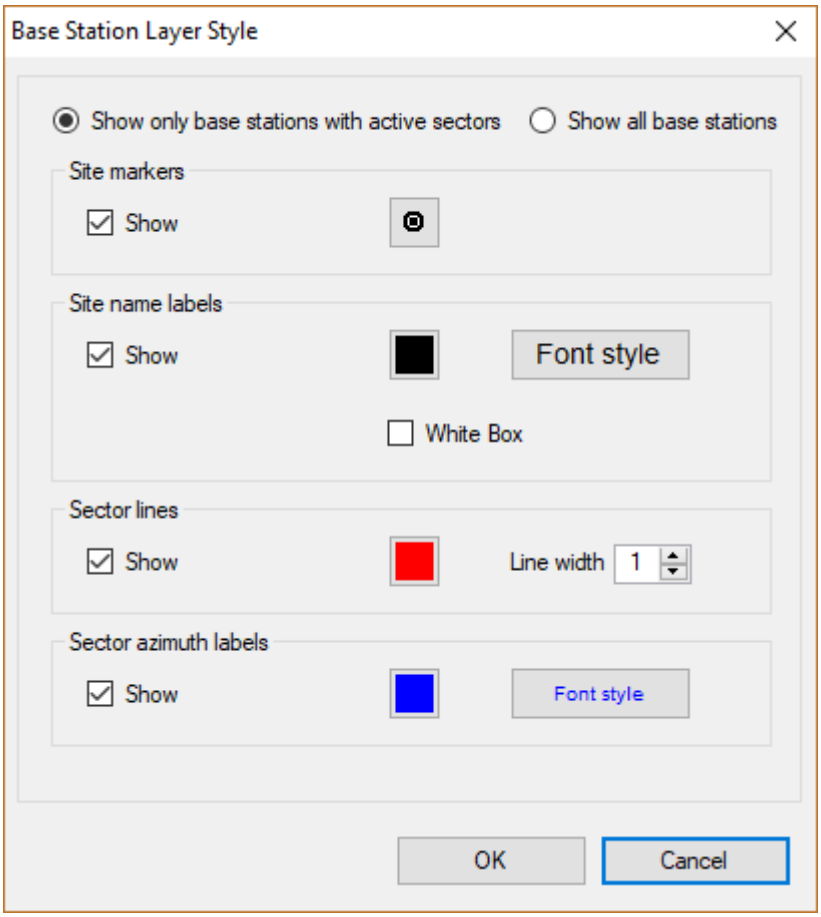


Figure 46. PtMP Base Stations Layer Style

Show only Base Stations with Active Sectors	Show only base stations with active sectors.
Show all Base Stations	Show all base stations.
Show / Hide Site Markers	Show / Hide and also select the marker for the base station from the standard set.
Show / Hide Site Name Labels	Show / Hide base station label, as well as select font style and color.
White Box	Place the label on a white box
Show / Hide Sector Lines	Show / Hide base station sector designation, as well as select color and line thickness.
Show / Hide Sector Azimuth Labels	Show / Hide sector labels, as well as select font styles and colors for them.

Subscriber Station Layer Style

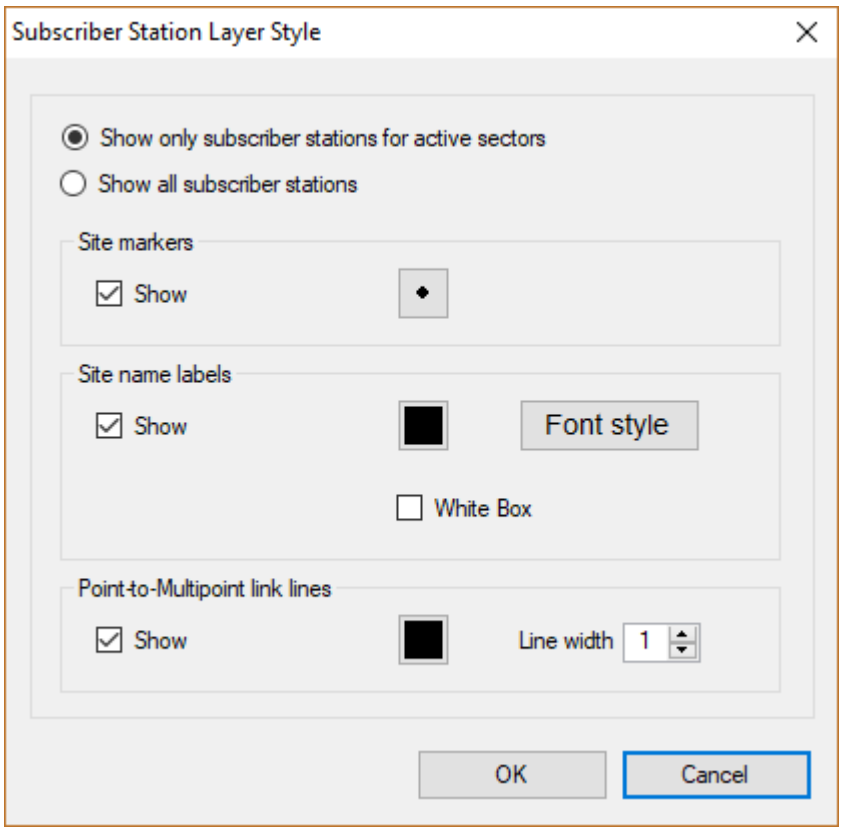


Figure 47. Subscriber Station Layer Style

Show only Subscriber Stations for Active Sectors	Show only Subscriber stations for active sectors.
Show all Subscriber Stations	Show all subscriber stations.
Show / Hide Site Markers	Show / Hide and also select the marker for the subscriber station from the standard set.
Show / Hide Site Name Labels	Show / Hide subscriber station label, as well as select font style and color.
White Box	Place the label on a white box
Show / Hide Point-to-Multipoint Link Lines	Show / Hide the point-to-multipoint link lines, as well as select their colors and line thickness.

Custom Layer Style

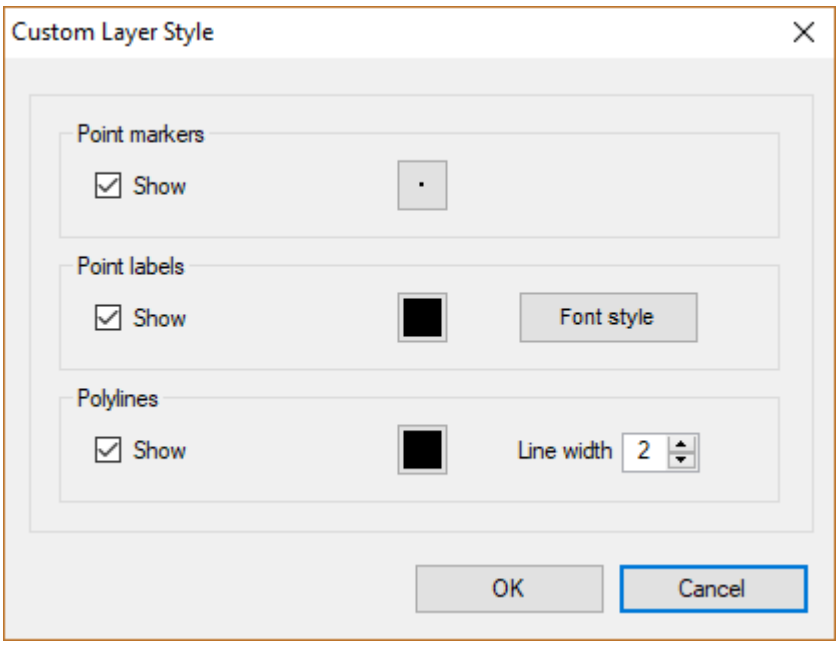


Figure 48. Custom Layer Style

Point Markers	Show / Hide and also select the marker of point features from the standard set.
Point Labels	Show / Hide the point features label and also select the font style and color.
Polylines	Show / Hide polylines, as well as select the colors and thickness of polylines.

Settings

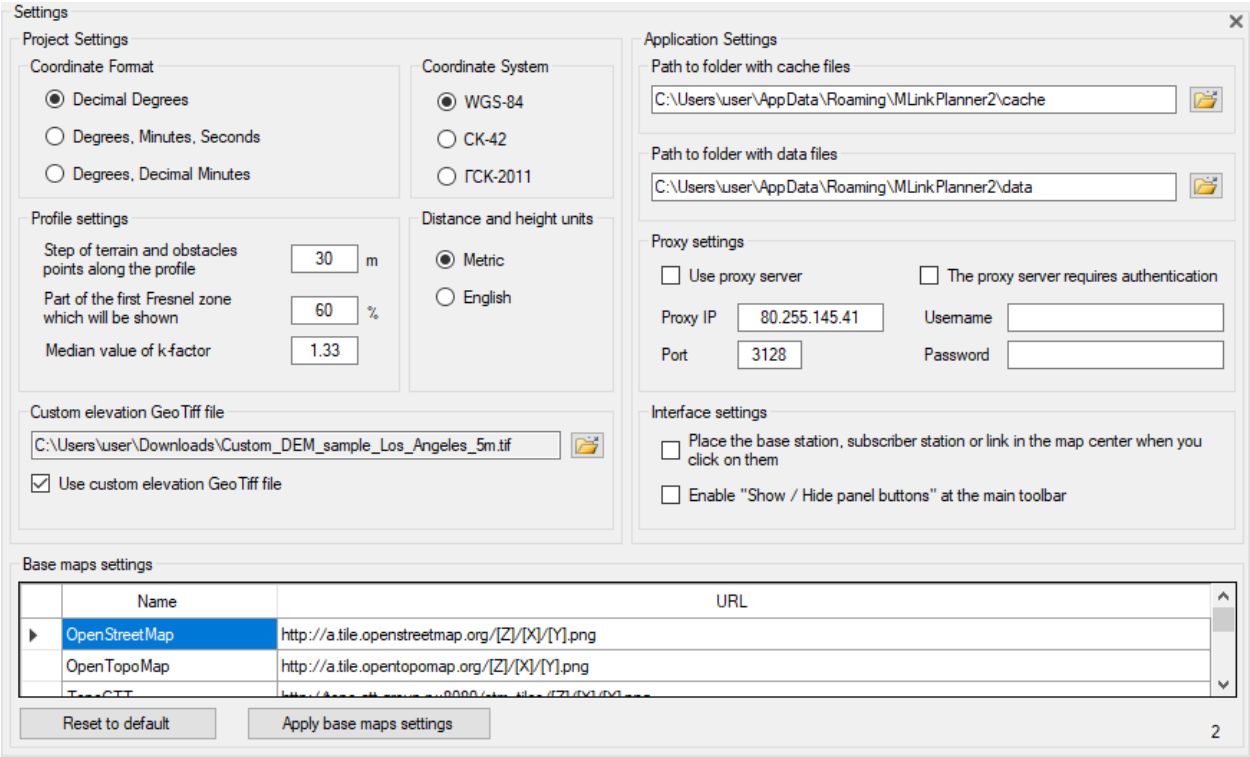


Figure 49. Settings

Coordinate Format	Geographic coordinate format: - Decimal Degrees (N44.345678 W134.567893) - Degrees, Minutes, Seconds (N44° 34’ 23.7’’ W134° 29’ 23,4’’) - Degrees, Decimal Minutes (N44° 34.2356’ W134° 29.2354’)
Coordinate System	Coordinate System: - WGS-84 - СК-42 (Russia) - ГСК-2011 (Russia)
Step of Terrain and Obstacle Points along the Profile, m	The step of terrain and obstacle points along the profile for automatic creation of the path profile. For SRTM-1, the minimum step for creation of the path profile is 30 m. A lower value makes no sense since it will not increase the accuracy.
Part of first Fresnel Zone which will be Shown, %	A part of the first Fresnel zone which will be shown when the path profile is displayed.
Median Value of K-factor	The median value of the k-factor that will be used to create the link path profile and determine clearance
Distance and Height Units	Distance and Height Units: - Metric (kilometers, meters) - English (miles, feet)

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 forest data 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.
Custom elevation GeoTiff file	In order to use custom DEM, specify the path to it in the Settings menu and check the "Use custom elevation Geo Tiff file" box. File format requirements are outlined in Appendix 2 "Custom DEM Format".
Place the Base Station, Subscriber Station, or Link in the Map Center when you Click on them	Place the base station, subscriber station, or link in the map center when you click on them.
Enable "Show / Hide Panel Buttons" in the Main Toolbar	Enable "Show / Hide panel buttons"  and  in the main toolbar.

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 MLinkPlanner 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 MLinkPlanner 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 MLinkPlanner to properly fetch tiles from a map provider, a generalized prototype URL scheme must be furnished. This generalized URL scheme will be used by MLinkPlanner 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 place of explicit coordinates.

For example, creating custom map types in MLinkPlanner for OpenStreetMap can be accomplished by mixing the known explicit 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 in MLinkPlanner):

http://a.tile.openstreetmap.org/[Z]/[X]/[Y].png

When MLinkPlanner 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.

Appendix 1. Terrain Elevation Data

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)
- Denmark (DTM 1.6 meters)
- Estonia (DTM 10 meters)
- Finland (DTM 10 meters)
- France (DTM 5-10 meters)
- Germany (DTM 2-25 meters)
- Iceland (DTM 10 meters)
- Italy (DTM 2-10 meters)
- Latvia (DTM 20 meters)
- Liechtenstein (DTM 10 meters)
- Luxembourg (DTM 5 meters)
- Netherlands (DTM 5 meters)
- Norway (DTM 10 meters)
- Slovakia (DTM 10 meters)
- Slovenia (DTM 1 meters)
- Spain (DTM 2-5 meters)
- Sweden (DTM 50 meters)
- Switzerland (DTM 2 meters)
- United Kingdom (DTM 2-50 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, Czechia, Greece, Hungary, Kosovo, Lithuania, Malta, Montenegro, North Macedonia, Poland, Portugal, Romania, 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 2. Custom DEM Format

In MLinkPlanner 2.1, starting from update 221121, the user can use his own DEM in Geo TIFF format. Geo TIFF is an open format to which elevation data from a LiDAR survey or any other DEM can be converted. Such transformation can be performed in specialized GIS applications such as QGIS, Global Mapper, ArcGis, MapInfo, and others.

A Custom DEM must consist of a single Geo TIFF file (not tiles) with the following settings:

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

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 DEM samples in Geo TIFF format can be found in the installation folder.

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