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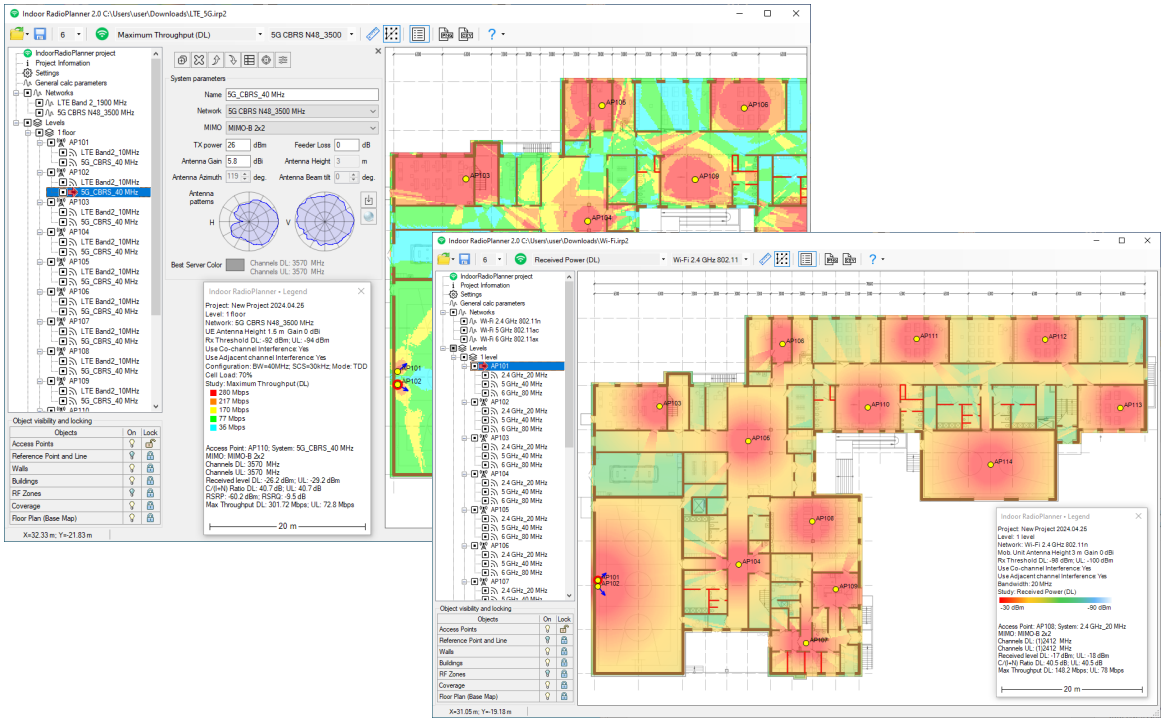
Indoor RadioPlanner 2.0

Planning tool for indoor wireless networks

User Manual



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From the Developers

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

Features

Indoor RadioPlanner is designed for planning indoor wireless networks deployed inside buildings, as well as in open local areas.

With Indoor RadioPlanner you can design any network, including:

- Wi-Fi networks in the 2.4 GHz, 5 GHz and 6 GHz bands
- Mobile networks: 5G (NR), LTE, UMTS, GSM, WCDMA
- Public safety mobile networks: P25, TETRA, DMR, dPMR, NXDN
- Wireless IoT LPWAN networks: LoRa, SigFox

Indoor RadioPlanner 2.0 uses propagation models:

- ITU-R P.1238-11 propagation model "Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range of 300 MHz to 450 GHz".

Indoor RadioPlanner 2.0 performs various prediction types:

- Received Power
- Best Server
- C/(I+N) Ratio
- Maximum Throughput
- Number of Servers
- RSRP for LTE and 5G
- RSRQ for LTE and 5G
- Maximum aggregated Throughput
- Number of Networks

In Indoor RadioPlanner 2.0, you can work with two types of projects:

1. **Indoor project:** When access points are placed inside a single- or multi-story building. In this type of project, it is possible to predict detailed coverage on different floors inside buildings, taking into account individual parameters of signal loss of internal walls, RF Zones of different rooms, as well as losses in floor slabs.
2. **Outdoor project:** When access points are placed in an outdoor local area up to 2 by 2 km in size. In this type of project, it is possible to predict coverage inside and outside buildings - along streets, in open local areas, etc. Buildings in such a project have two parameters - RF zone type (one for the entire building) and external wall type. In an outdoor project, you can use a regular base map (OpenStreetMap, etc.), or a base map based on a calibrated image.

Indoor and Outdoor projects are not compatible with each other; the user must select the project type in Settings before starting work.

Installation and Activation

Indoor RadioPlanner is compatible with 64-bit Windows 10/11. The minimum computer requirements include a 64-bit Windows operating system, Core i3 CPU, 4GB RAM, 200GB HDD, video card, and monitor with support for 1366x768 resolution. For optimal performance, it is recommended to use a monitor with support for 1920x1080 resolution.

To install Indoor RadioPlanner, run the Setup_Indoor_ RadioPlanner.exe file. Select your language and click Install to launch the installation process. Click Next to continue. To proceed with the installation, read and accept the License Agreement by checking the box next to "I accept the terms in the License Agreement" and clicking Next.

After installing Indoor RadioPlanner, you will see a new entry in the Start menu and a shortcut on your desktop.

During the 7-day trial period, you can try all of the program's features without activation (except for the option to save project files).

After the trial period has expired, you must purchase a license and activate the software to continue using it.

Note: The activation process requires an internet connection.

To purchase Indoor RadioPlanner, click Help - Purchase in the program menu. This will open the purchase page in your web browser. After completing your purchase, you will receive an activation ID code via email. To activate your software, click Help - Enter Activation ID Code in the program menu, enter your code, and click ACTIVATE.

Software Update

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

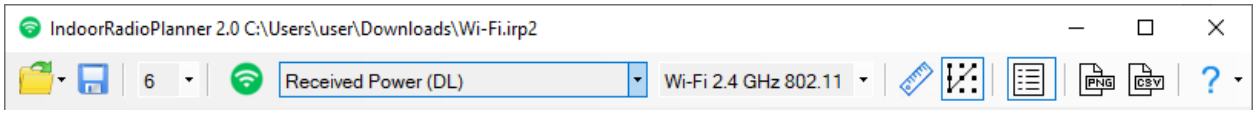
User Interface

The program window includes the following elements:

- The **main tree view menu** on the left side of the window.
- The **main toolbar**, located at the top of the window.
- The **central work area**, which displays the level (floor) plan with access points, RF zones, walls, and coverage prediction results.

- The **objects control panel**, located in the lower-left part of the window. This panel allows you to enable or disable editing of objects on the map (Access Points, Reference Points, Walls, RF Zones, Level Plans, Coverage), as well as control their visibility.

To zoom in and out, roll the mouse wheel. To move the level plan, click and drag it.



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

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

Save project

The zoom of the level plan

Calculate Coverage for current level

Received Power (DL)

Calculation type shown on display

Wi-Fi 2.4 GHz 802.11n

Network for which calculation results are displayed

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

Snap to Nodes. Enable/disable snapping to nodes when drawing walls and RF zones

Show / Hide Legend

Save the map as an image in PNG format

Save the access points and networks settings to a CSV file

Help

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

Quick start of Indoor Project

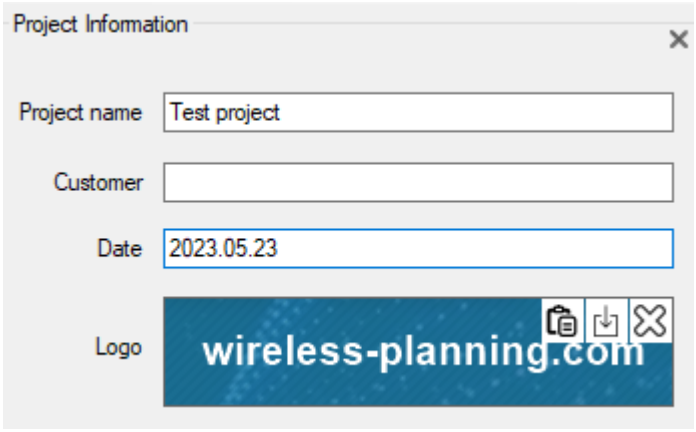
1. Make sure the project type is set to "Indoor" in the settings (this is the default).
2. **Create at least one network:** Go to “Networks – Add network”. Network settings can be loaded from a template. Templates for some networks are located in the “Templates” folder and have a *.nwirp extension.
3. **Create at least one level (floor):** Select “Levels – Add level”. Then, from the Level menu, load and scale the level image. Specify the reference point to which all other levels will be aligned.
4. **Draw RF zones and walls on the level.**
5. **Add at least one access point with one System (communication technology) to the level:** Access point parameters can be loaded from a template. Templates for some access points are located in the “Templates” folder and have a *.apirp extension. Link the access point system with the previously created network. After creating one access point and entering all its parameters, you can easily replicate it to create additional ones.
6. **Configure the calculation parameters in the network settings as needed.**
7. **To perform calculations:** Click “Calculate Coverage for current level” on the main toolbar. This will execute all types of calculations for all networks simultaneously.
8. **Select the type of calculation and the network for display:** Use the drop-down list on the main toolbar to choose the calculation type and the network for which the results will be displayed.

Tip: **To get started quickly, utilize the example project files available in the installation folder.**

A new project is automatically created when Indoor RadioPlanner is launched. The File menu contains standard buttons (New, Open, Save, Save As) for performing standard file operations. Project files can be saved with the *.irp2 extension and contain all information about the project.

Project Information

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



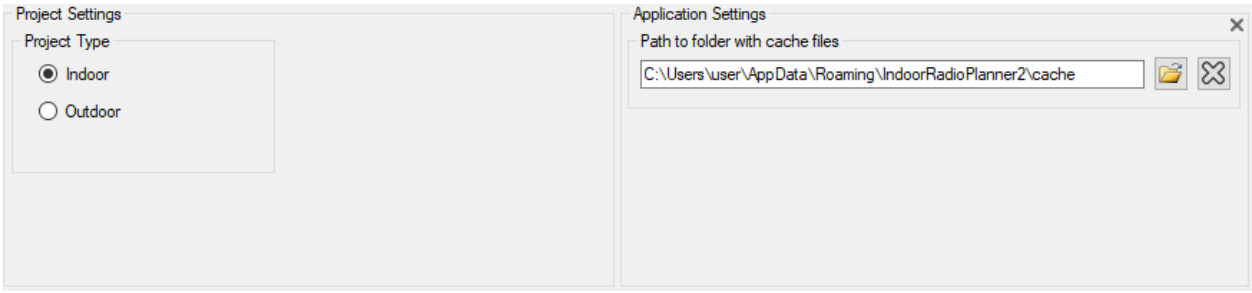
Project Information

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

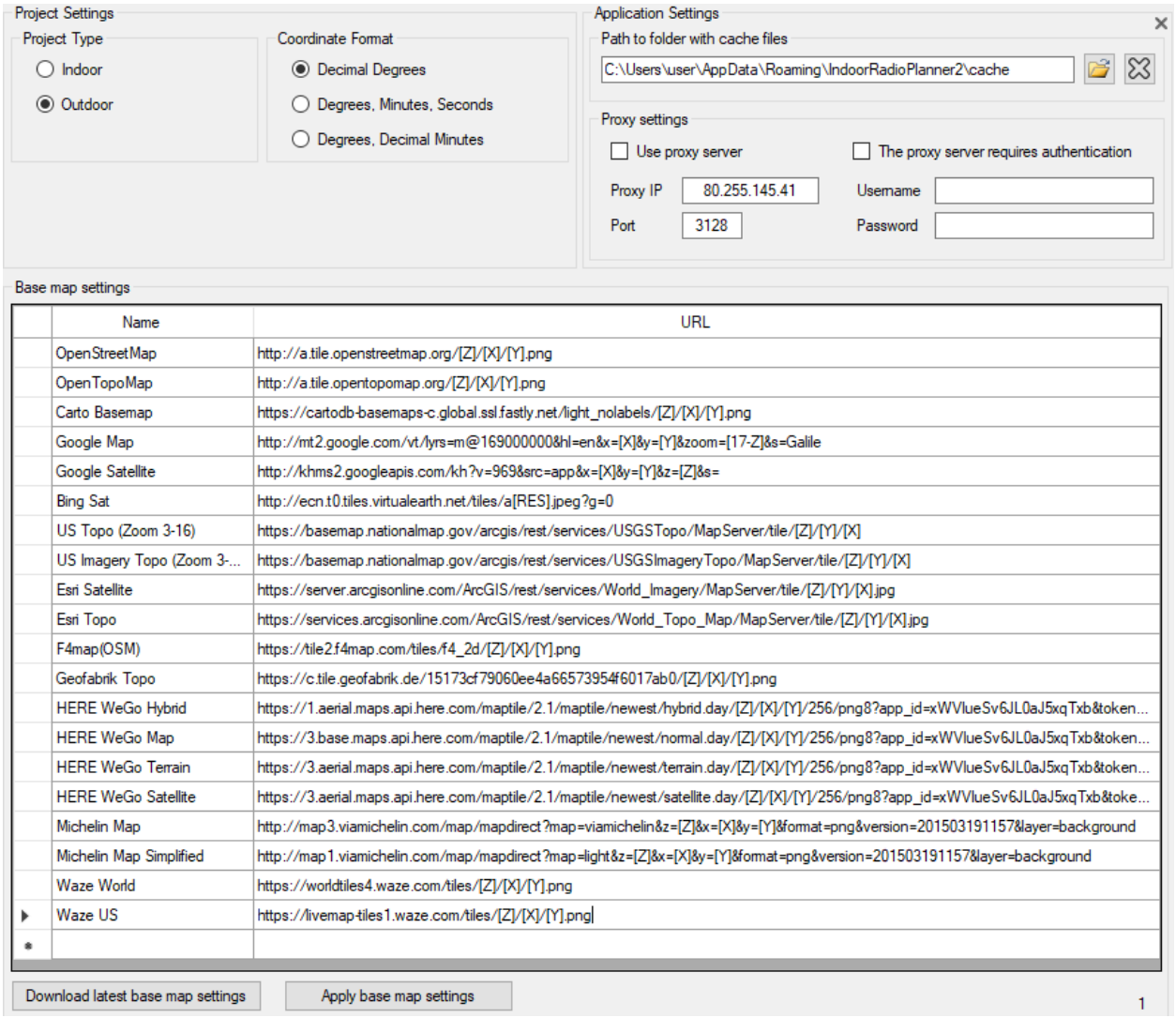
Settings

In the project settings, the user selects the project type. If the project type is **Indoor**, no additional settings are required. If you select the project type **Outdoor**, additional settings will appear.

Please note that when changing the project type, all previously entered information about wireless access points in the project will be lost!



Indoor Projects Settings



Outdoor Projects Settings

General Calc Parameters

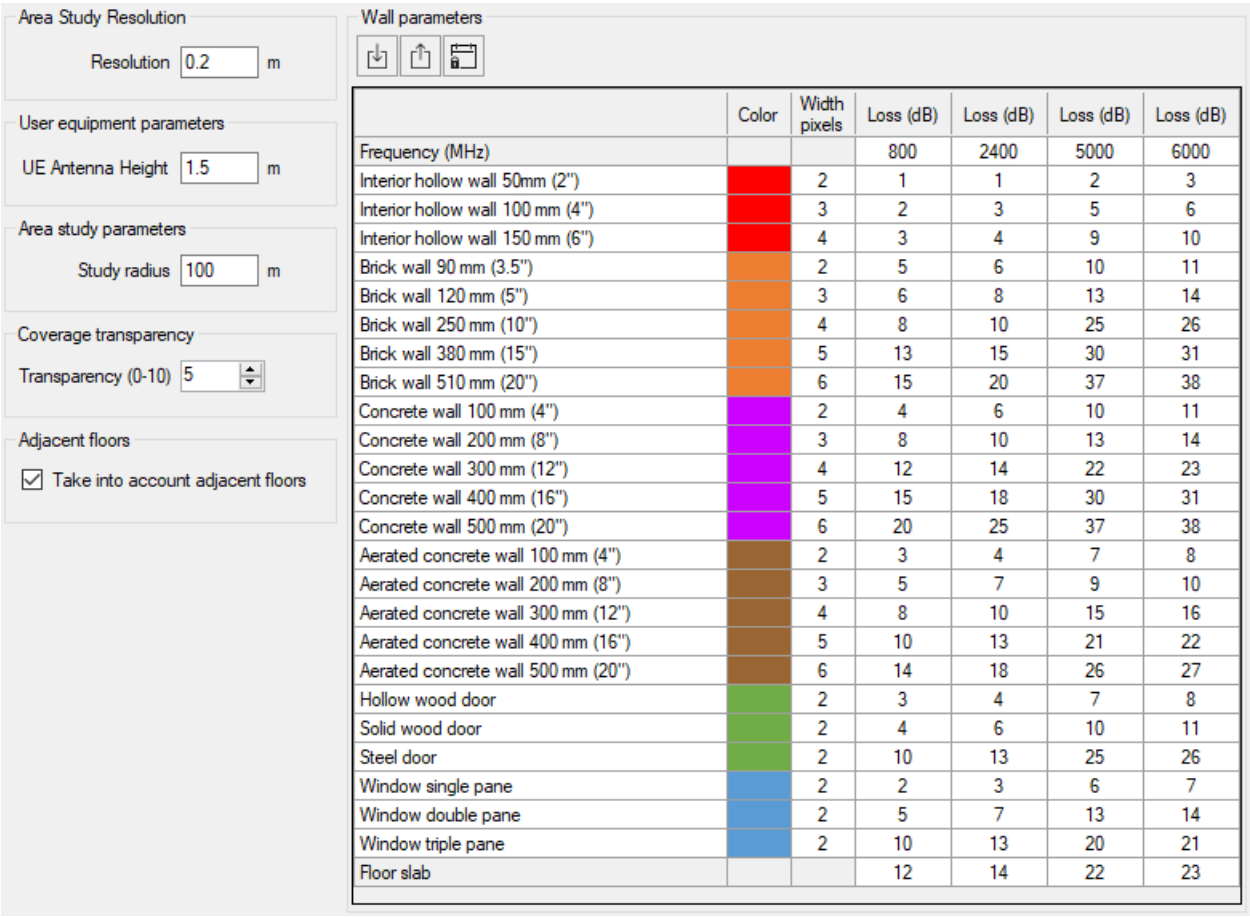
Here, a number of general calculation parameters are specified, as well as penetration losses for different wall types.

As is known, the same materials have different attenuation values for different frequencies. The default attenuation values are given for the 800 MHz, 2.4 GHz, 5 GHz and 6 GHz ranges. If a frequency outside the ranges specified above is used in the calculations, the attenuation value will be found by interpolation or extrapolation.

The user can change the penetration loss values in the default table for 24 wall types and one type of interfloor ceiling at his own discretion based on the data available to him for different frequency ranges (no more than 4 frequency ranges).

All fields in the table with a white background are editable, i.e. the user can change the name of the wall type, the frequency range and the corresponding loss value. The wall color and wall thickness in pixels affect only the display of the corresponding wall on the monitor.

The table with user-defined penetration loss data can be saved as a template in a *.wlirp file for use in other projects. It is also possible to restore the default loss data. The corresponding buttons are provided on the toolbar above the table.



	Color	Width pixels	Loss (dB)	Loss (dB)	Loss (dB)	Loss (dB)
Frequency (MHz)			800	2400	5000	6000
Interior hollow wall 50mm (2")		2	1	1	2	3
Interior hollow wall 100 mm (4")		3	2	3	5	6
Interior hollow wall 150 mm (6")		4	3	4	9	10
Brick wall 90 mm (3.5")		2	5	6	10	11
Brick wall 120 mm (5")		3	6	8	13	14
Brick wall 250 mm (10")		4	8	10	25	26
Brick wall 380 mm (15")		5	13	15	30	31
Brick wall 510 mm (20")		6	15	20	37	38
Concrete wall 100 mm (4")		2	4	6	10	11
Concrete wall 200 mm (8")		3	8	10	13	14
Concrete wall 300 mm (12")		4	12	14	22	23
Concrete wall 400 mm (16")		5	15	18	30	31
Concrete wall 500 mm (20")		6	20	25	37	38
Aerated concrete wall 100 mm (4")		2	3	4	7	8
Aerated concrete wall 200 mm (8")		3	5	7	9	10
Aerated concrete wall 300 mm (12")		4	8	10	15	16
Aerated concrete wall 400 mm (16")		5	10	13	21	22
Aerated concrete wall 500 mm (20")		6	14	18	26	27
Hollow wood door		2	3	4	7	8
Solid wood door		2	4	6	10	11
Steel door		2	10	13	25	26
Window single pane		2	2	3	6	7
Window double pane		2	5	7	13	14
Window triple pane		2	10	13	20	21
Floor slab			12	14	22	23

General Calc Parameters

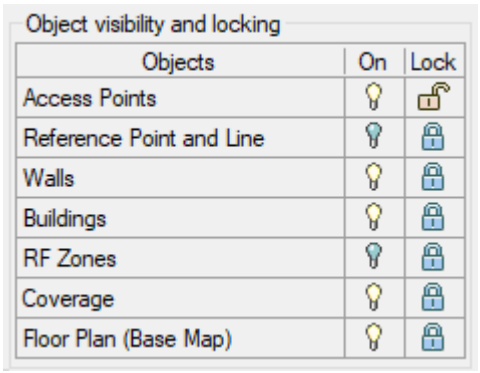
Area Study Resolution	Coverage prediction resolution, m The recommended value for Indoor projects is 0.2-0.3 meters. For Outdoor projects - 0.5m-1m.
UE Antenna Height	User Equipment antenna height, m
Study radius	Maximum study radius from access point, m The larger the radius, the longer the computation time. Do not set an unnecessarily large calculation radius.
Coverage Transparency	Set coverage opacity in the range from 0 (fully transparent) to 10 (not transparent)
Take into account adjacent floors	Indoor RadioPlanner takes into account the penetration of useful signal and interference only from access points located on adjacent floors, i.e. one floor above and one floor below.
Outdoor RF Environment	RF Environment for outdoor spaces (for Outdoor project type only)
Wall parameters:	
	Load wall parameters from a template

	Save wall parameters as a template
	Fill the table whith default values
Color	Wall color on screen
Width (pixels)	Wall thickness on screen in pixels

Objects visibility and locking Panel

The **Objects Visibility and Locking Panel** is located in the lower-left part of the program window. This panel enables you to:

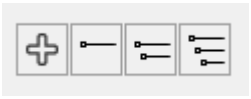
- Control the visibility of objects on the map, such as Access Points, Reference Points, Walls, Buildings (for outdoor project types), RF Zones, Floor Plan (base map for outdoor project), and Coverage, by toggling them on or off.
- Lock or unlock layers to permit or restrict editing.



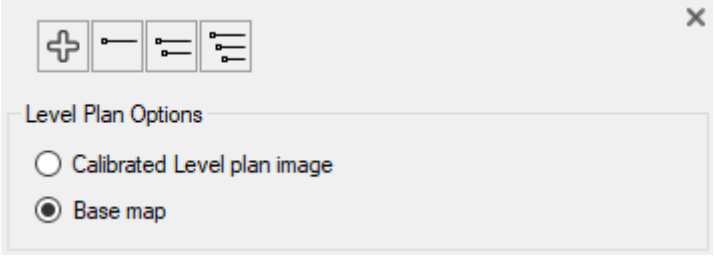
Visibility and locking of objects are managed by clicking on the icons located opposite the corresponding objects in the list. To edit objects, they must be both visible and unlocked. This is achieved by setting the icons to the  .

Levels

In Indoor projects, you can create buildings with an unlimited number of levels (floors). In outdoor projects, you can only create one level.



Levels menu for Indoor project

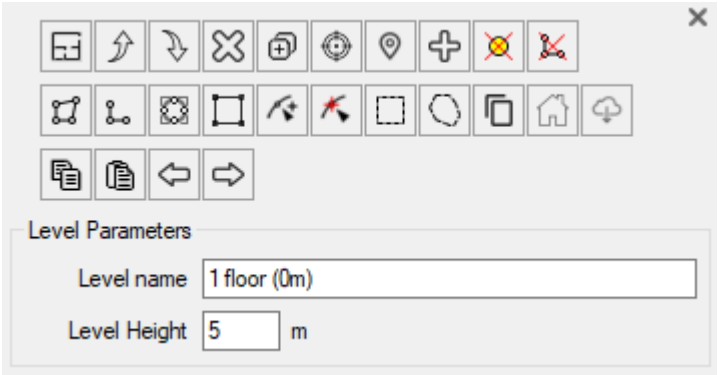


Levels menu for Outdoor project

Add a new level
Collapse all level nodes
Collapse all AP nodes
Expand all AP nodes

Level plan options	Calibrated image or base map (for outdoor project only)

Level



Level menu

Level plan image
Move the Level up
Move the Level down
Delete Level
Add a new Level with the same parameters (duplicate the Level)

Position the plan with Reference Point at the screen center

Move the reference point and the line to the screen center

Add a new Access Point

Delete all APs from the Level

Delete all walls from the Level

Add new RF Zone

Add new wall

Add wall or building like as circle or rectangle

Square corners of selected objects

Add a node. Select an object (RF zone or wall) and click in the desired location to create a node.

Delete node. Select an object (RF zone or wall) and click on the node you want to delete.

Select walls, RF Zones, Buildings inside square area

Select walls, RF Zones, Buildings inside area

Duplicate selected objects (walls, RF Zones, buildings)

Add a new building

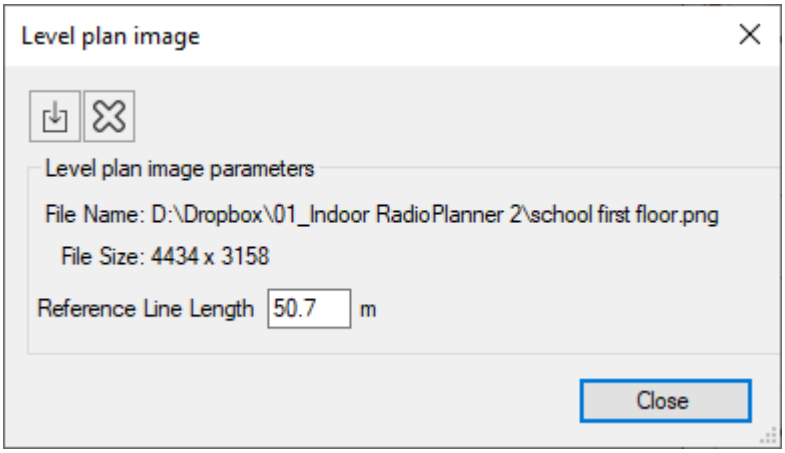
Import buildings from OpenStreetMap database

Copy selected object to clipboard

Paste objects from clipboard

Undo

Redo



Import Level plan

Import level plan image

Delete level plan image

Creating a RF Environment Model

The basic propagation model ITU-R P.1238-11 takes into account two parameters related to the propagation environment:

$$L_{total} = L(d_o) + N \log_{10} \frac{d}{d_o} + L_f(n) \quad \text{dB}$$

N: Power loss over distance (RF propagation parameter) shows how much the signal level drops in dB when the distance from the signal source changes by a factor of 10 (per decade).

Lf, dB: Floor slab or wall penetration loss factor (in dB) for floor slabs or walls located between the access point and the subscriber terminal (UE).

In Indoor RadioPlanner 2.0, different approaches to forming an RF environment model are used for indoor and outdoor projects.

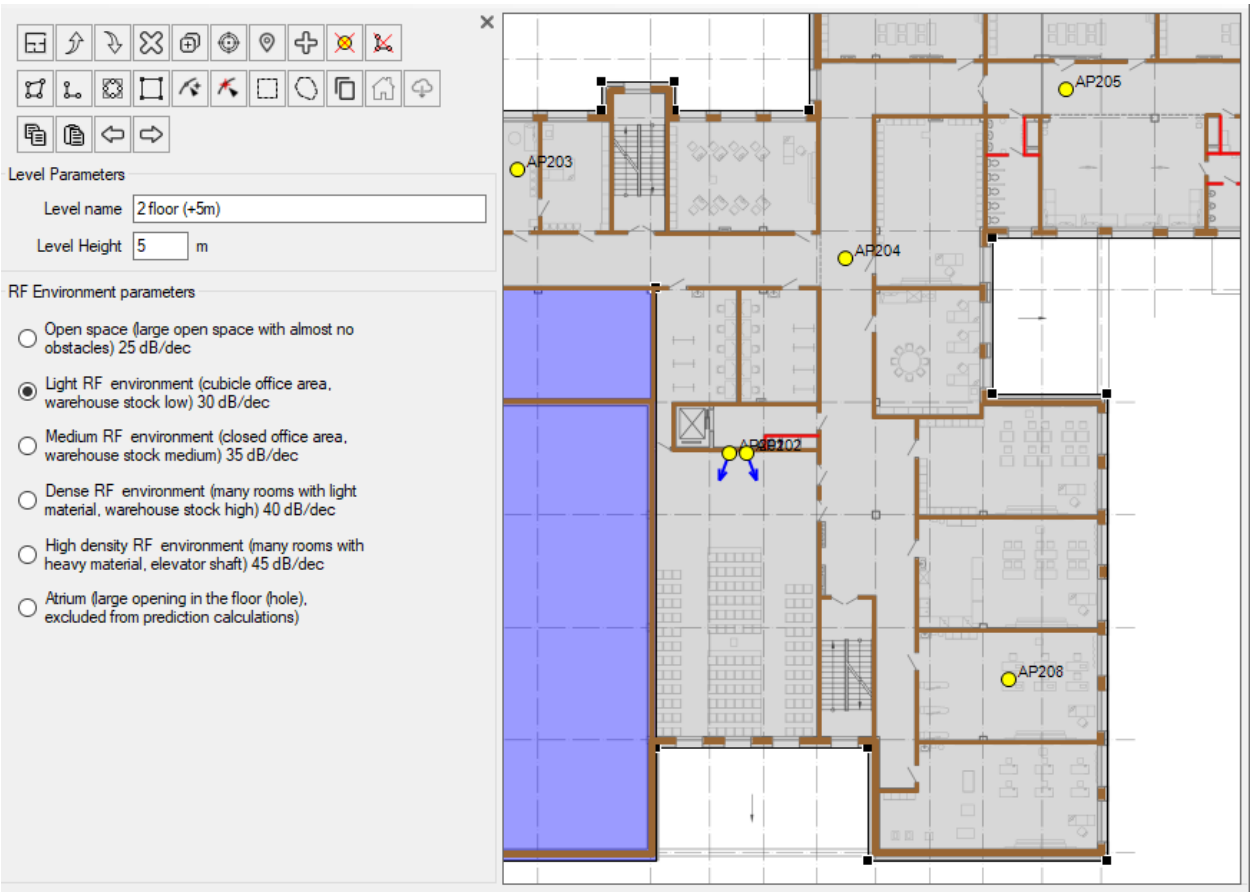
In the Indoor project, a model of a single- or multi-story building is created with the ability to specify individual loss parameters for each wall and RF Zone of individual rooms.

For Outdoor projects, buildings are created with their own RF Zone (one type per building) and the external wall (also one type per building). And one type of RF Zone is also specified for the external environment.

Indoor Projects

RF Environment (RF Zones)

To create RF environment model inside a building, you need to draw different RF zones and walls with corresponding loss parameters.



RF Zone parameters

You can draw the following RF environment types on the floor plan:

- Open Space (large open space with almost no obstacles) - 25 dB/dec
- Light RF Environment (cubicle office area, low warehouse stock) - 30 dB/dec
- Medium RF Environment (closed office area, medium warehouse stock) - 35 dB/dec
- Dense RF Environment (many rooms with light material, high warehouse stock) - 40 dB/dec
- High-Density RF Environment (many rooms with heavy material, elevator shaft) - 45 dB/dec
- Atrium - large opening in the floor (hole), excluded from prediction calculations

Working with RF Zones

Before drawing RF zones, ensure the object layer is unlocked for editing.

Adding an RF Zone:

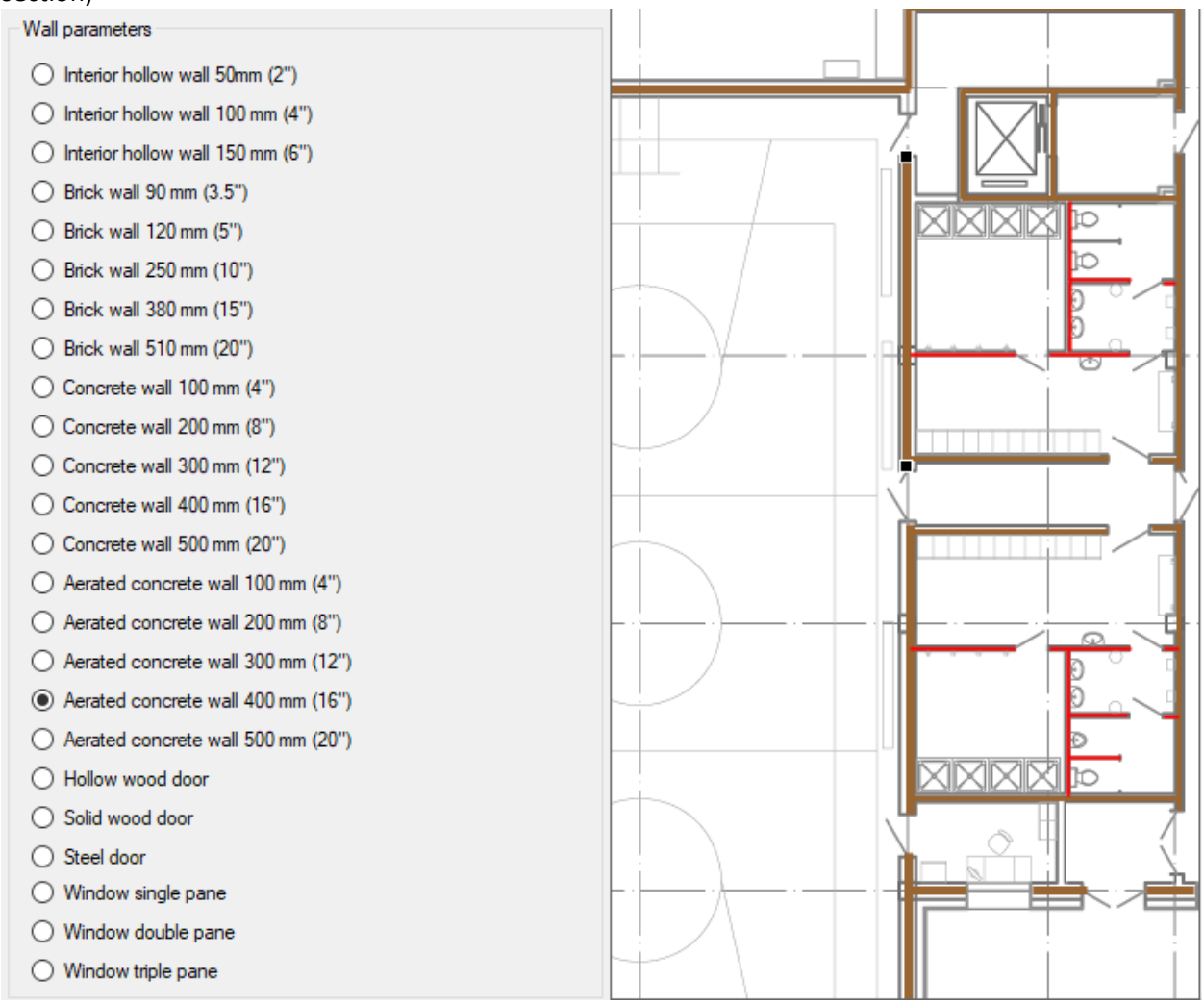
1. Click on the **RF Zone tool** in the level toolbar.
2. Draw a polygon to represent the RF environment using the mouse (right-click to complete the polygon).
3. Select the **RF environment coefficient** from the list that appears.
4. Press **Esc** or select another tool from the toolbar to complete your entry.
5. For added convenience, use the **Snap to Nodes** tool on the main toolbar.

Operations on RF Zones:

- **Edit Shapes:** Drag the nodes of polygons to modify their shape.
- **Move Polygons:** Click and drag to reposition entire polygons.
- **Delete Polygons:** Select a polygon and press Delete to remove it.
- **Cancel Drawing:** Press the **Esc** key to cancel the current RF zone drawing. Pressing **Esc** again will exit the RF zone drawing mode.

Walls

The user can draw on the plan and take into account in the calculation the walls whose parameters are specified in the **Calculation parameters** panel – **Wall parameters**. You can use the default wall parameters or set your own by editing the Wall parameters table at your discretion (see the Calculation parameters section)



Wall parameters

Drawing Walls

Before drawing walls, ensure the object layer is unlocked for editing.

To Add a Wall:

1. Click on the **Wall tool** on the level toolbar.
2. Use the mouse to draw the wall (right-click to finish).
3. Select the **wall type** from the list that appears.
4. Press **Esc** or select another tool from the toolbar to complete your entry.
5. For more convenient work, use the **Snap to Nodes** tool on the main toolbar.

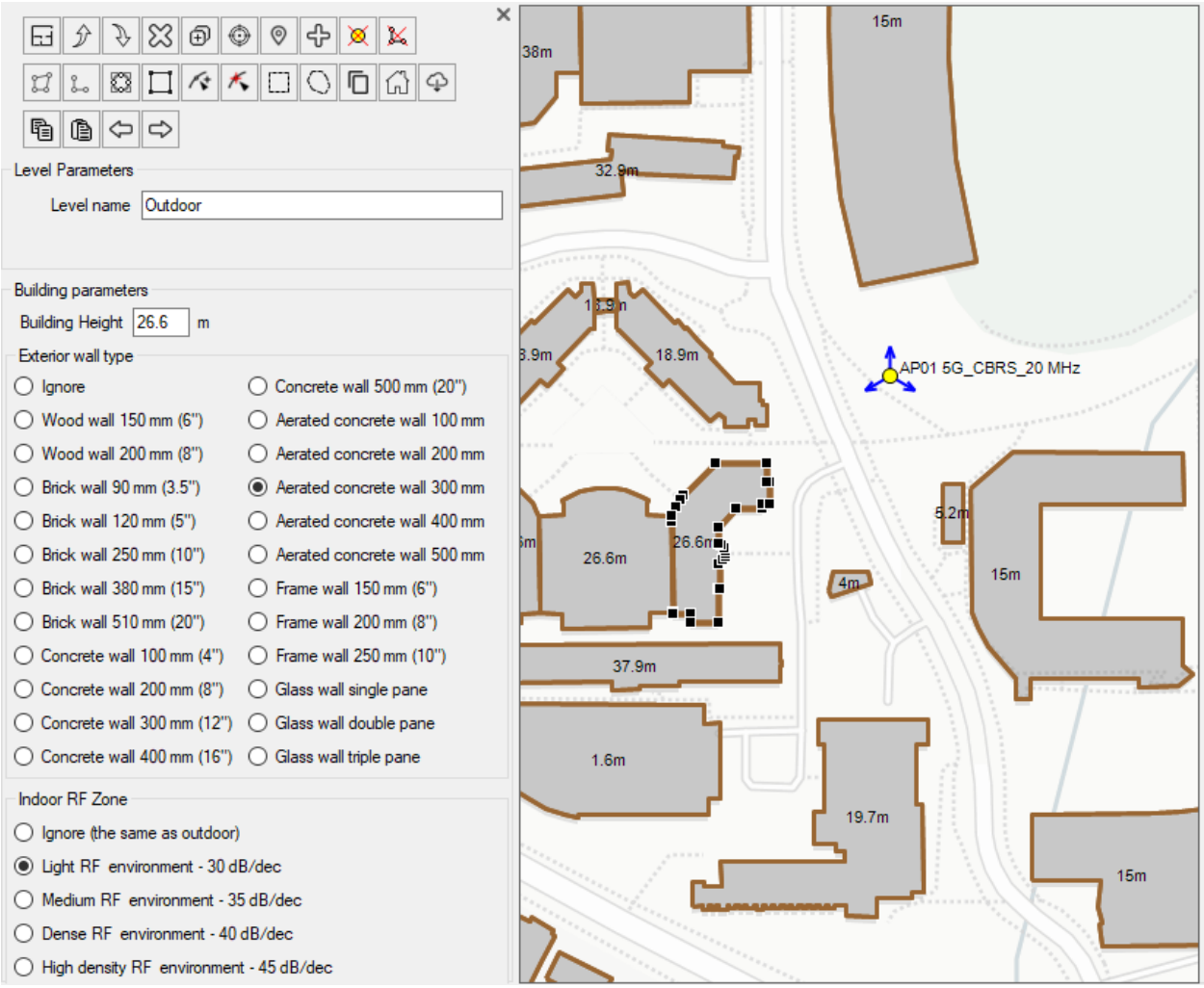
Operations on Walls:

- **Edit Shapes:** Drag the nodes of walls to modify their shape.
- **Move Walls:** Click and drag to reposition entire walls.
- **Delete Walls:** Select a wall and press **Delete** to remove it.
- **Cancel Drawing:** Press the **Esc** key to cancel the current wall drawing. Pressing **Esc** again will exit the wall drawing mode.

Outdoor Projects

Buildings

As already mentioned, for Outdoor projects only buildings are created. Each building has only three parameters - attenuation of the internal RF Zone, losses of the external wall, and building height. Also in the General Calc Parameters, it is necessary to specify the type of RF Zone for the external environment. The user can draw buildings or import them from the OpenStreetMap database.



Building parameters

The wall type and penetration loss parameters for different frequency ranges are specified in the Wall Parameters table in the Calculation Parameters panel. You can use the default parameters or specify your own parameters (for more information, see the Calculation Parameters section).

Working with Buildings

Before drawing Buildings, ensure the object layer is unlocked for editing.

Add Buildings manually:

1. Click on the **Add a new Building** in the level toolbar.
2. Draw a polygon to represent the building using the mouse (right-click to complete the polygon).
3. Specify building height.
4. Select the exterior wall type from the list
5. Select the indoor RF Zone from the list.
6. Press **Esc** or select another tool from the toolbar to complete your entry.

Import buildings from OpenStreetMap database (Only for outdoor projects with basemap):

1. Click Import buildings from OpenStreetMap database on the level toolbar.
2. Mark the area on the map where the buildings will be imported (no more than 2 by 2 km).

3. In the form that appears, specify the parameters of the heights and floors of the buildings if there is no information about them in the database.
4. Specify the RF Zone type and the type of external walls for all buildings at once or separately for each building.

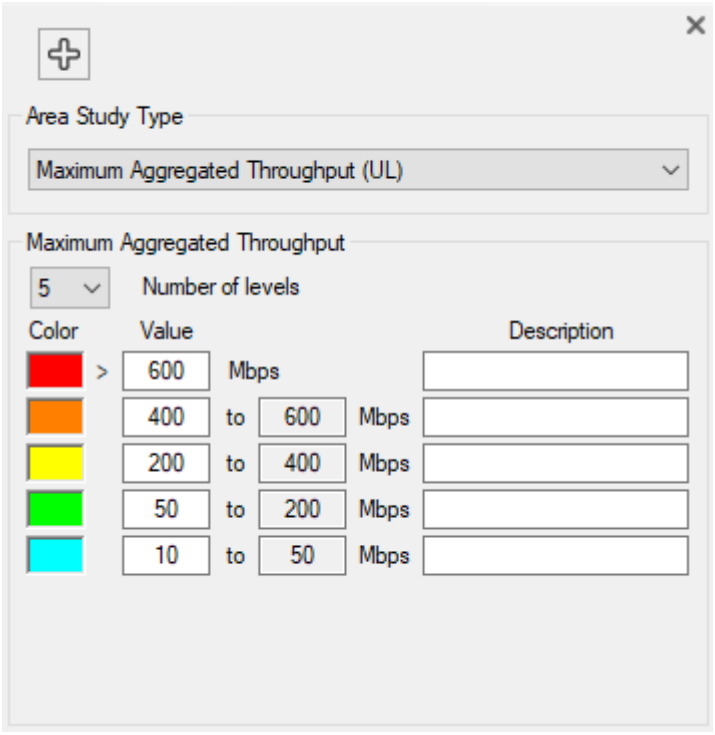
Buildings imported in this way can then be edited manually.

Operations on Buildings:

- **Edit Shapes:** Drag the nodes of polygons to modify their shape.
- **Move Polygons:** Click and drag to reposition entire polygons.
- **Delete Polygons:** Select a polygon and press Delete to remove it.
- **Cancel Drawing:** Press the **Esc** key to cancel the current RF zone drawing. Pressing **Esc** again will exit the Buildings drawing mode.

Networks

Indoor RadioPlanner 2.0 allows you to work with multiple networks in one project. When creating a new project, the first network is created by default.

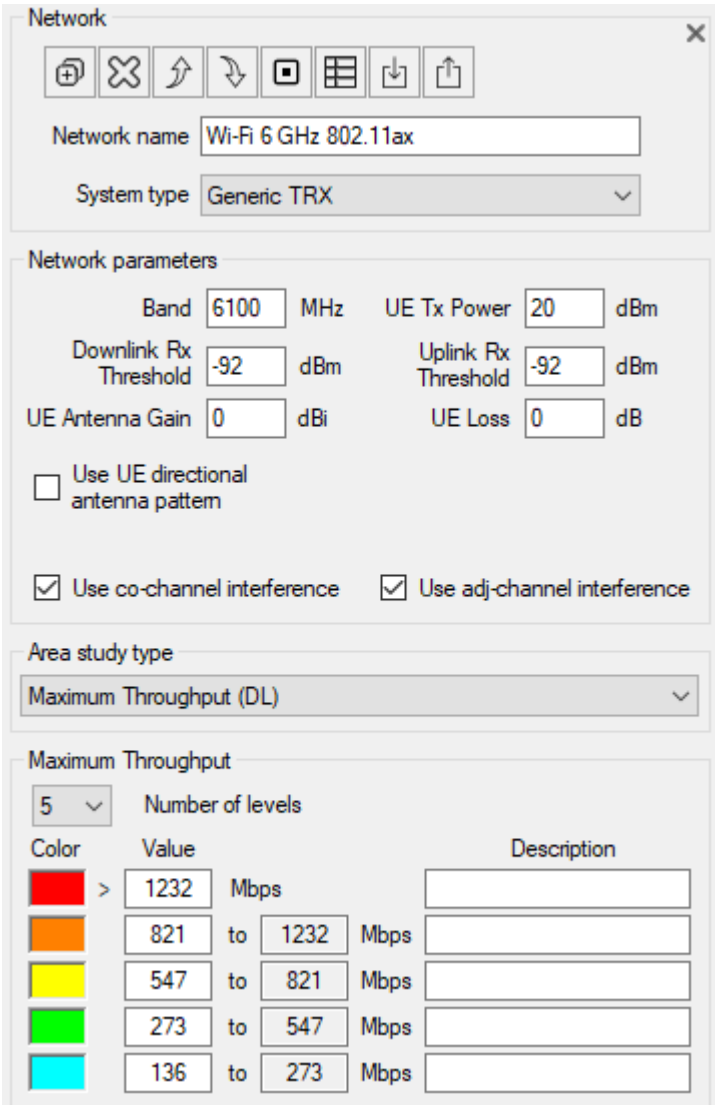


Networks menu

Add a new network

Area Study Type	Coverage predictions for multiple networks: - Number of Networks (DL) - Number of Networks (UL) - Maximum Aggregated (DL) Throughput - Maximum Aggregated (UL) Throughput See Coverage predictions for multiple networks section

The “Network” menu is used to set all parameters for the selected network and calculation parameters.



Network menu

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

Delete the network

Move the Network up

Move the Network down

Activate/Deactivate all systems for current network

System parameters

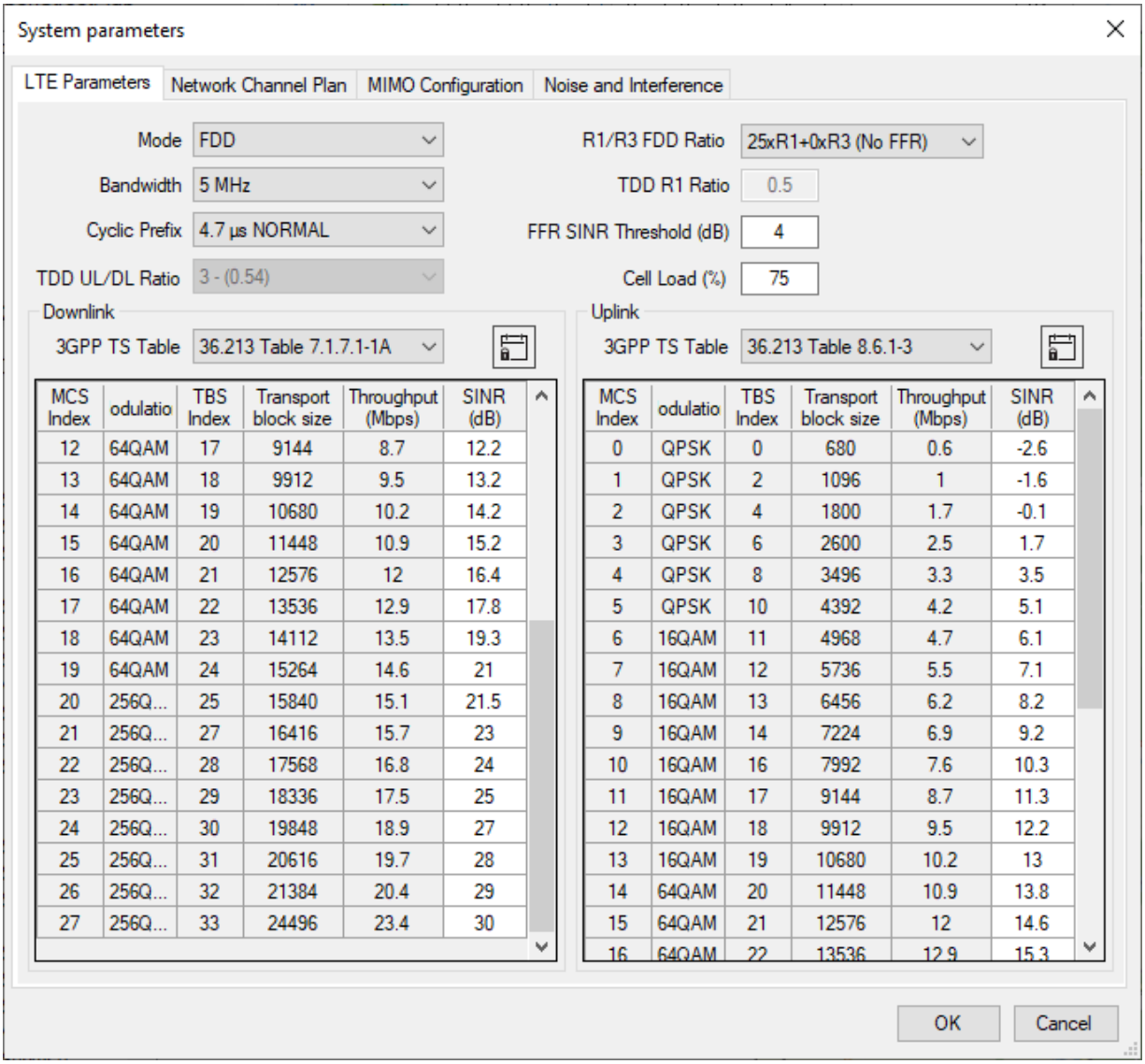
Load network parameters from a template

Save network parameters as a template

Network name	Name of network, text field
System type	System type options: - Generic TRX (including Wi-Fi) - LTE

	- 5G The selected system type will determine the set of additional system parameters, as well as the types of coverage predictions available.
Band	Average band frequency, MHz
UE Tx Power	User Equipment (mobile unit) transmitter power, dBm
Downlink Rx threshold	This threshold value will limit the coverage prediction display based on whether the signal received at the UE from the access point is above or below this threshold, dBm
Uplink Rx threshold	This threshold value will limit the coverage prediction display based on whether the signal received at the access point from UE is above or below this threshold, dBm
UE Antenna Gain	User Equipment antenna gain, dBi
UE Loss	User Equipment cable loss, dB
Use UE directional antenna pattern	Use the antenna pattern at the UE. By default, the UE antenna pattern is assumed to be isotropic. The use of directional antennas on the UE significantly reduces interference from neighboring cells and, as a result, increases throughput.
Use co-channel interference	Perform coverage calculation taking into account co-channel interference using frequency assignments.
Use adj-channel interference	Perform coverage calculation taking into account adjacent channel interference using parameters in network settings (Channel bandwidth and Adjacent Channel rejection) as well as frequency assignments.

LTE System Parameters



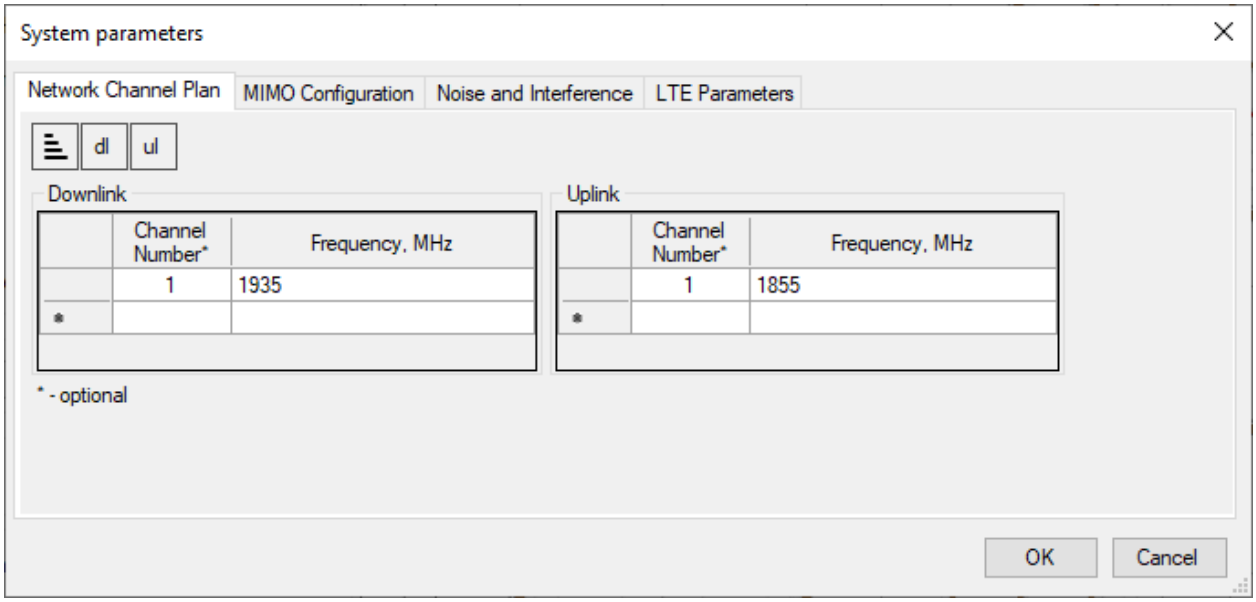
LTE System Parameters

Mode	LTE duplex mode: - FDD - TDD
Bandwidth	LTE bandwidth: 1.4 MHz; 3 MHz; 5 MHz; 10MHz; 15 MHz; 20 MHz
Cyclic Prefix	LTE Cyclic Prefix: - 4.7 µs (Normal) - 16.7 µs (Extended)
TDD UL/DL Ratio	TDD configurations in 3GPP LTE specification: TDD Configuration # UL/total ratio DL/total ratio 0 0.7 0.3 1 0.5 0.5 2 0.3 0.7 3 0.35 0.65 4 0.25 0.75 5 0.15 0.85 6 0.6 0.4

R1/R3 FDD Ratio	Type of Fractional Frequency Reuse (FFR) plan that is being used in LTE project in the R1/R3 zone Resource Blocks drop-down list
TDD R1 Ratio	Part (from 0.1 to 1) the R1 zone subcarriers of physical resource blocks (PRB) for TDD
FFR SINR Threshold	SINR threshold for switching between R1 and R3 zones in FFR, dB
Cell Load	Cell Load, 0-100 % Cell Loading is considered uniform.
Downlink and Uplink 3GPP Tables	These tables contain the MCS Index, modulation type, and transport block size (TBS) specified in the tables of 3GPP TS 36.213. Minimum C/(I+N) values for 1% SER (dB) can be specified separately for both uplink and downlink. The theoretical defaults shown in this table are from published MATLAB simulations of LTE radio link performance. The throughput for each modulation index is determined from the 3GPP tables, taking into account the transport block size. This throughput does not take into account the MIMO multiplier.

Network Channel Plan

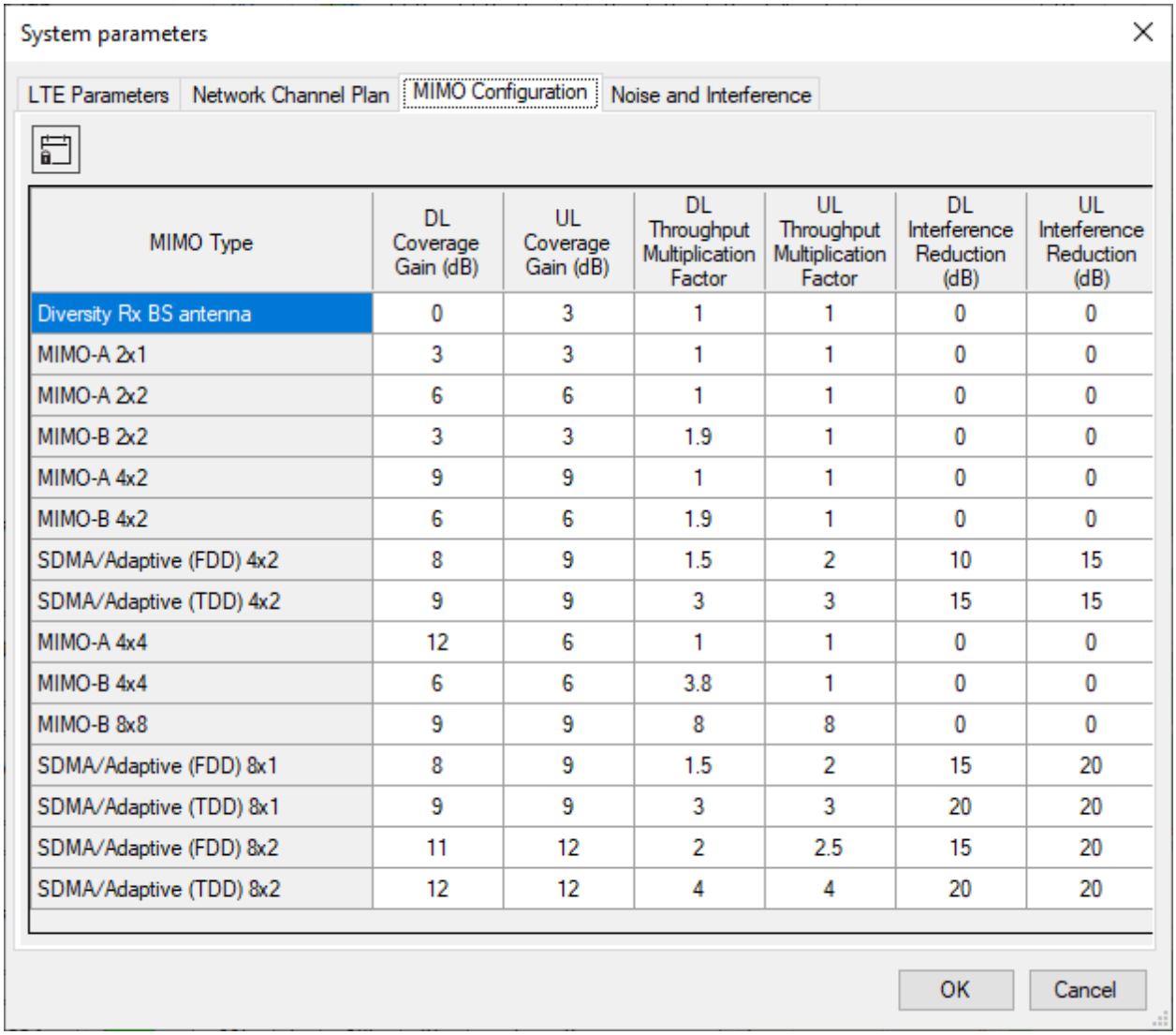
In the channel table, specify all possible uplink and downlink frequencies (channels) that will be used in the network. For TDD, enter the same frequency. If the network operates on a single channel, then the frequencies in the Network Channel Plan may not be specified.



LTE Network Channel Plan

MIMO Configuration

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

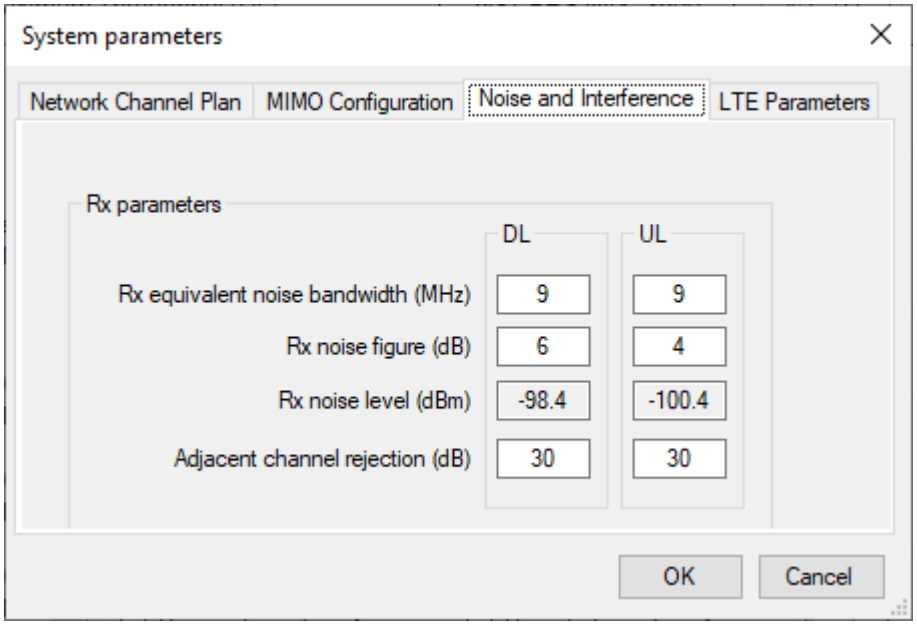


MIMO Type	DL Coverage Gain (dB)	UL Coverage Gain (dB)	DL Throughput Multiplication Factor	UL Throughput Multiplication Factor	DL Interference Reduction (dB)	UL Interference Reduction (dB)
Diversity Rx BS antenna	0	3	1	1	0	0
MIMO-A 2x1	3	3	1	1	0	0
MIMO-A 2x2	6	6	1	1	0	0
MIMO-B 2x2	3	3	1.9	1	0	0
MIMO-A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

LTE MIMO Configuration

Noise and Interference

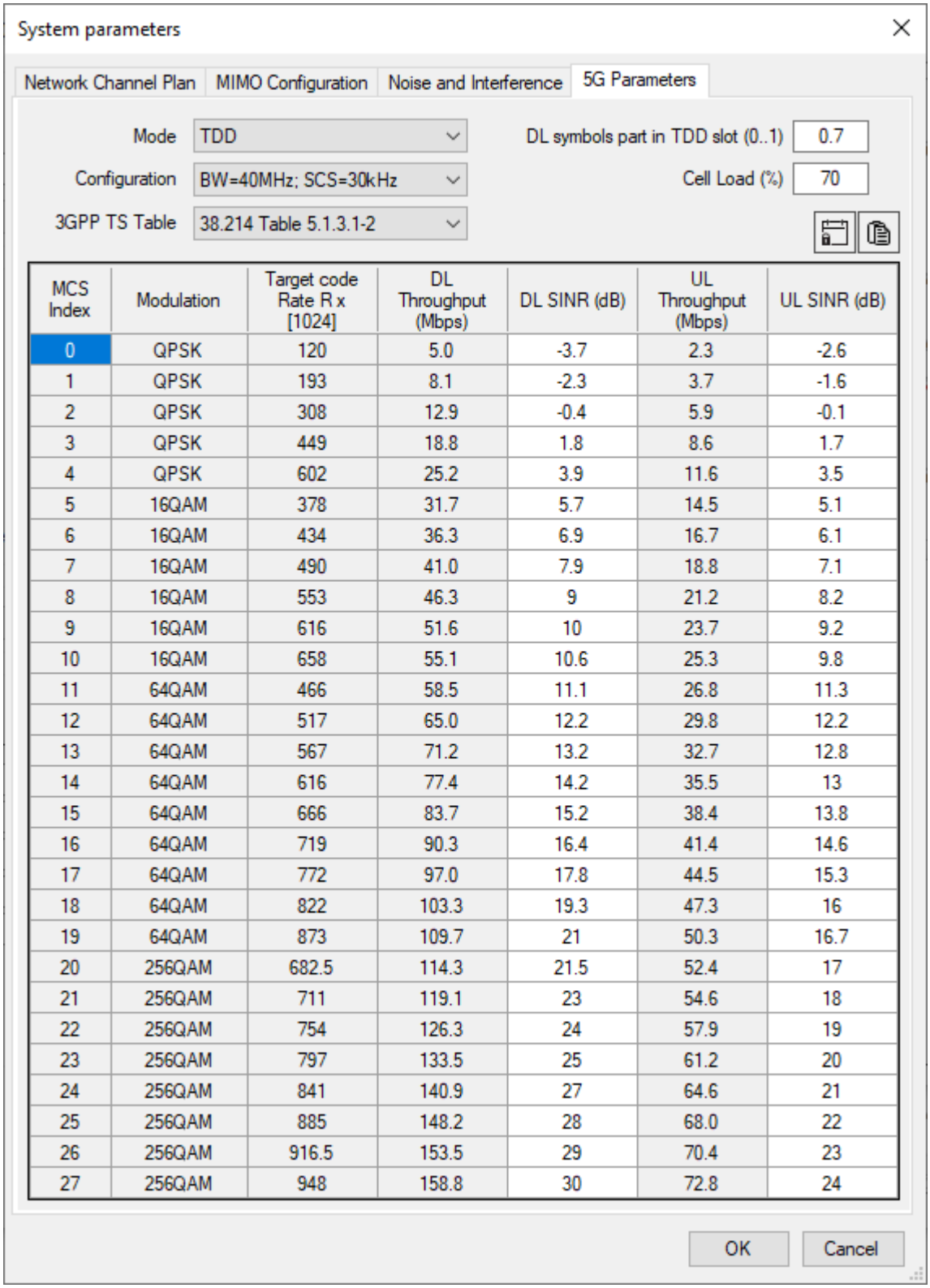
The receiver parameters in this tab are used for noise and interference calculations.



LTE Noise and Interference

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

5G (NR) System Parameters



MCS Index	Modulation	Target code Rate R x [1024]	DL Throughput (Mbps)	DL SINR (dB)	UL Throughput (Mbps)	UL SINR (dB)
0	QPSK	120	5.0	-3.7	2.3	-2.6
1	QPSK	193	8.1	-2.3	3.7	-1.6
2	QPSK	308	12.9	-0.4	5.9	-0.1
3	QPSK	449	18.8	1.8	8.6	1.7
4	QPSK	602	25.2	3.9	11.6	3.5
5	16QAM	378	31.7	5.7	14.5	5.1
6	16QAM	434	36.3	6.9	16.7	6.1
7	16QAM	490	41.0	7.9	18.8	7.1
8	16QAM	553	46.3	9	21.2	8.2
9	16QAM	616	51.6	10	23.7	9.2
10	16QAM	658	55.1	10.6	25.3	9.8
11	64QAM	466	58.5	11.1	26.8	11.3
12	64QAM	517	65.0	12.2	29.8	12.2
13	64QAM	567	71.2	13.2	32.7	12.8
14	64QAM	616	77.4	14.2	35.5	13
15	64QAM	666	83.7	15.2	38.4	13.8
16	64QAM	719	90.3	16.4	41.4	14.6
17	64QAM	772	97.0	17.8	44.5	15.3
18	64QAM	822	103.3	19.3	47.3	16
19	64QAM	873	109.7	21	50.3	16.7
20	256QAM	682.5	114.3	21.5	52.4	17
21	256QAM	711	119.1	23	54.6	18
22	256QAM	754	126.3	24	57.9	19
23	256QAM	797	133.5	25	61.2	20
24	256QAM	841	140.9	27	64.6	21
25	256QAM	885	148.2	28	68.0	22
26	256QAM	916.5	153.5	29	70.4	23
27	256QAM	948	158.8	30	72.8	24

5G Parameters

Mode	Duplex mode: - FDD - TDD
Configuration	Choice from bandwidth (BW) and Subcarrier Spacing (SCS) configurations.

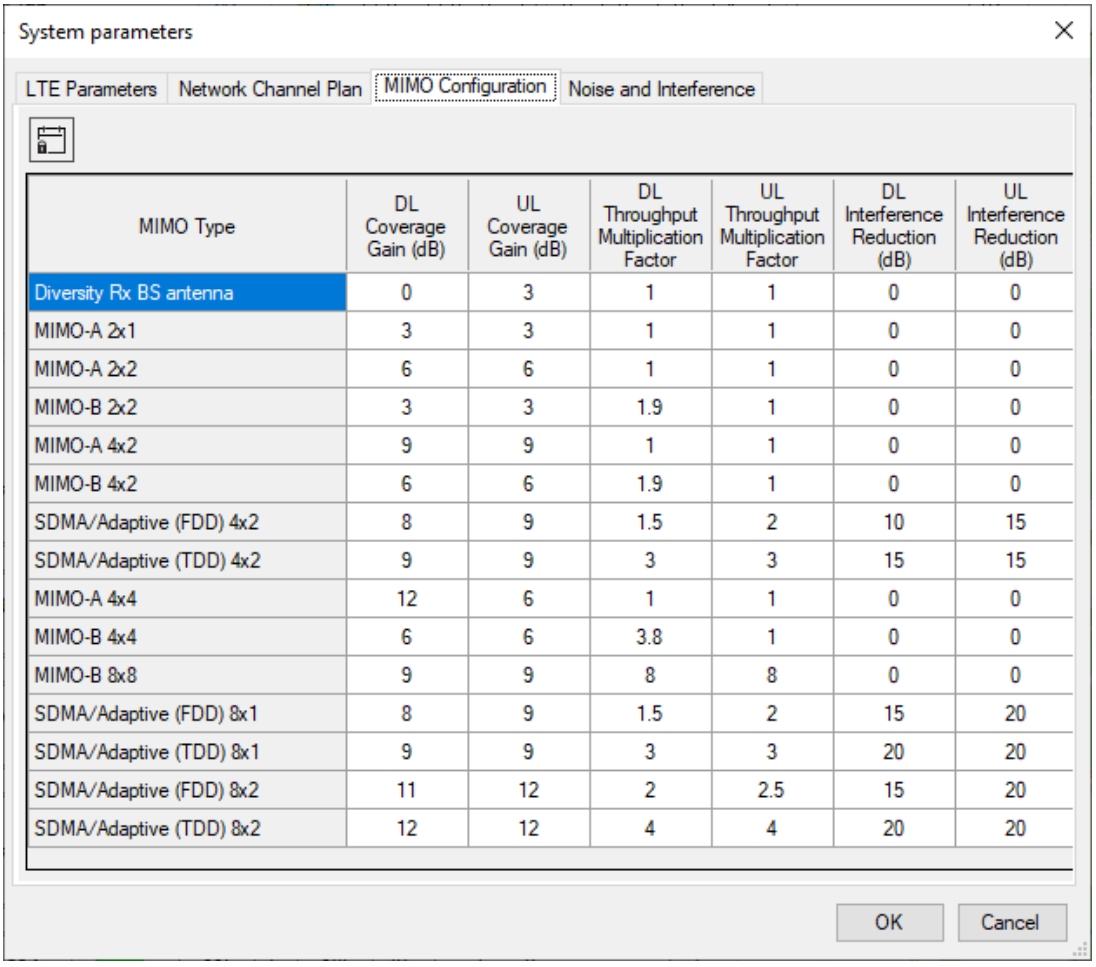
Downlink and Uplink 3GPP Tables	These tables contain the MCS Index, modulation type, and Target code rate specified in the tables of 3GPP TS 36.214. Minimum C/(I+N) values for 1% SER (dB) can be specified separately for both uplink and downlink. The theoretical defaults shown in this table are from published MATLAB simulations of 5G radio link performance. The throughput for each modulation index is determined from the 3GPP tables. This throughput does not take into account the MIMO multiplier.
DL symbols part in TDD slot (0..1)	Part of the TDD resource that is intended for downlink
Cell Load	Cell Load, 0-100 % Cell Loading is considered uniform.

Network Channel Plan

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

MIMO Configuration

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

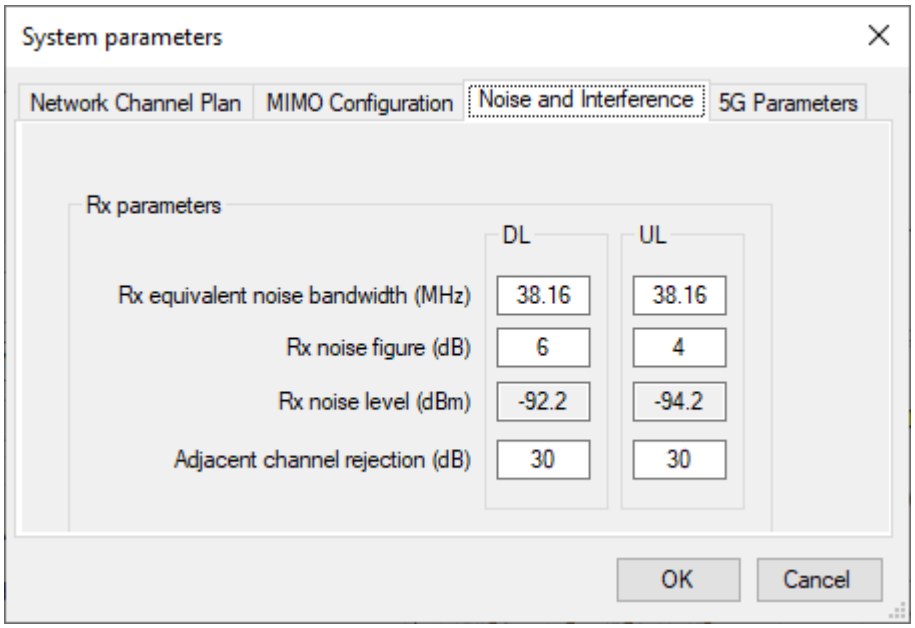


MIMO Type	DL Coverage Gain (dB)	UL Coverage Gain (dB)	DL Throughput Multiplication Factor	UL Throughput Multiplication Factor	DL Interference Reduction (dB)	UL Interference Reduction (dB)
Diversity Rx BS antenna	0	3	1	1	0	0
MIMO-A 2x1	3	3	1	1	0	0
MIMO-A 2x2	6	6	1	1	0	0
MIMO-B 2x2	3	3	1.9	1	0	0
MIMO-A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

5G MIMO Configuration

Noise and Interference

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



5G Noise and Interference

Rx equivalent noise bandwidth	Receiver Equivalent Noise Bandwidth, MHz In 5G, the noise band can be obtained from the formula: Rx equivalent noise BW= 12*SCS*Resource Blocks. For example, for BW=100 MHz, SCS=30 kHz Rx equivalent noise BW=12*0.03*106=38.16 MHz
Rx noise figure	Receiver noise figure, dB Typically 3-4 dB for gNodeB and 6 dB for UE
Rx noise level	Receiver noise level, dB This value is used to estimate the noise on the receiving path when calculating all types of interference.
Adjacent channel rejection	Adjacent channel rejection, dB It is assumed that the receiver has a rectangular “brick wall” bandpass shape with a width equal to the equivalent noise bandwidth. Under these conditions, you can set the amount of attenuation on adjacent channels (one bandwidth above and below the desired bandwidth) by entering a value here for adjacent channel rejection.

Generic TRX System Parameters

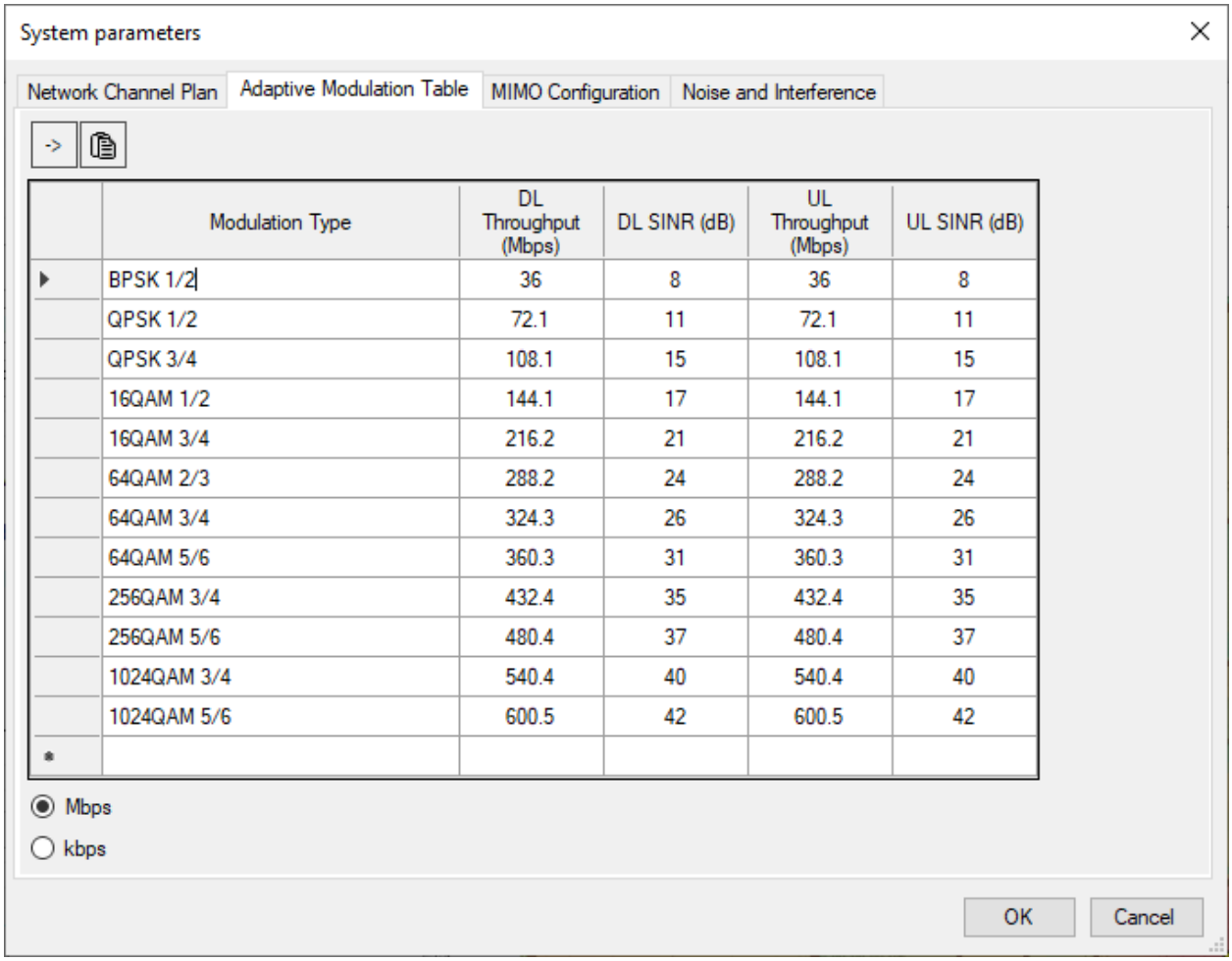
Generic TRX in Indoor RadioPlanner includes all mobile communication systems except for LTE and 5G:

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

Adaptive Modulation Table

The adaptive modulation table is filled with SINR values and their respective throughput for one spatial stream (no MIMO). This table is used to predict downlink and uplink throughput in Generic TRX.

Note that LTE and 5G have separate adaptive modulation tables tied to 3GPP specifications.

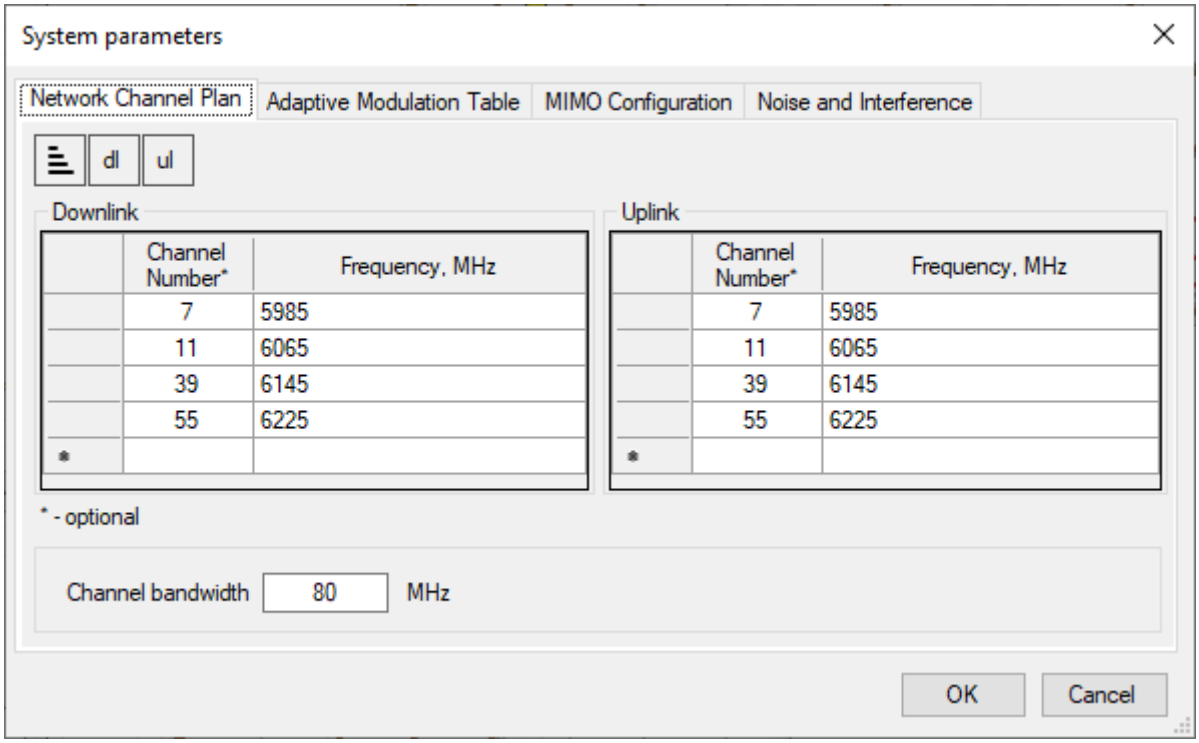


Wi-Fi 6 GHz 802.11ax Adaptive Modulation Table for BW 80 MHz

Modulation Type	Modulation Type (text field)
DL Throughput	Downlink Throughput, Mbps or kbps
DL SINR (dB)	Downlink SINR,dB
UL Throughput	Uplink Throughput, Mbps or kbps
UL SINR (dB)	Uplink SINR,dB
Mbps or kbps	Select Throughput Units

Network Channel Plan

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



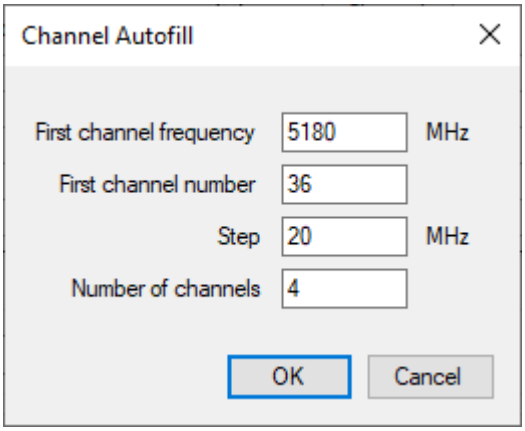
Wi-Fi 6 GHz 802.11ax Channel Plan for BW 80 MHz

Sort frequencies in ascending order

Autofill downlink frequencies

Autofill uplink frequencies

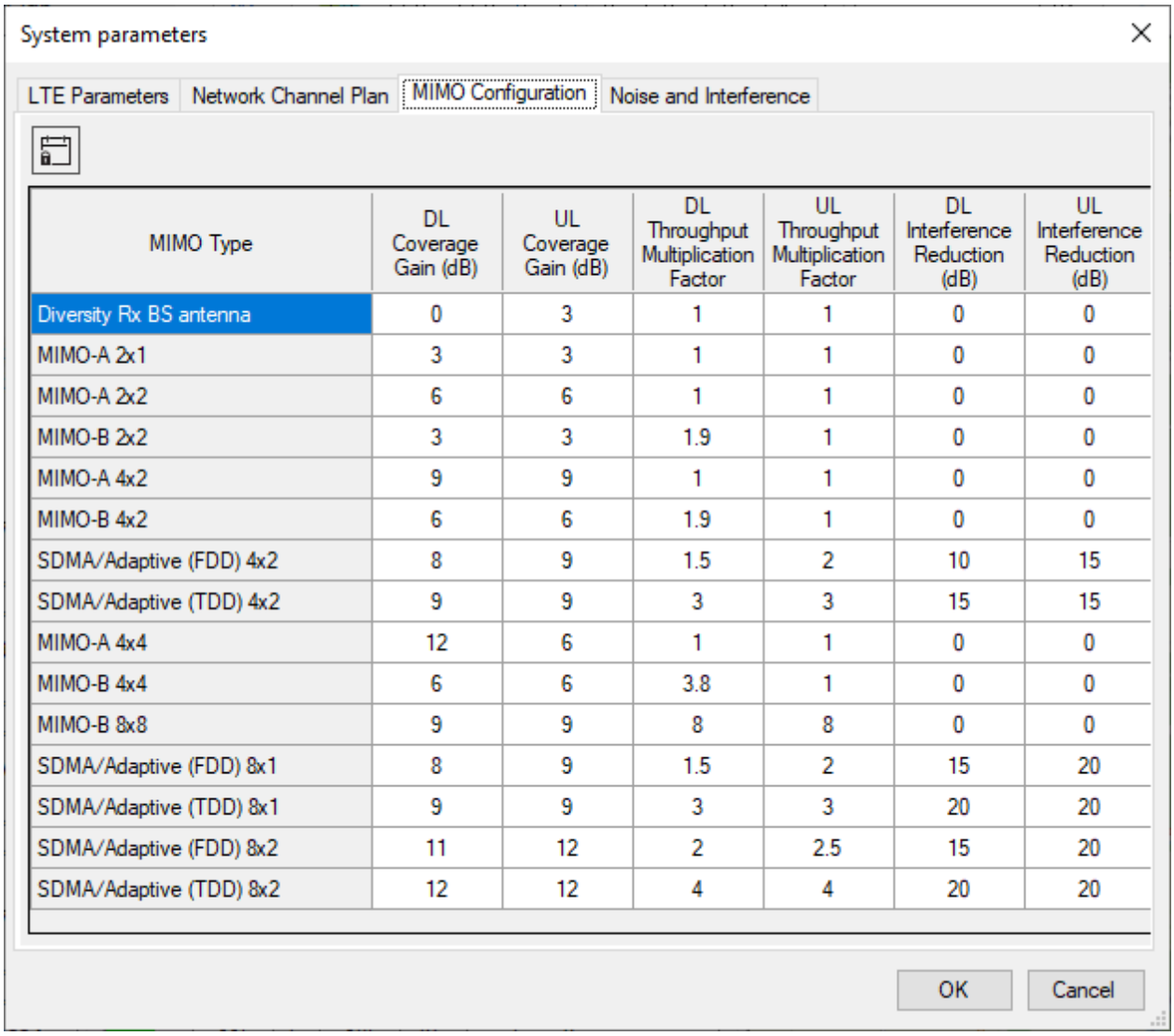
If your network has a large frequency grid, then you can use the autofill feature:



Channel Autofill

MIMO Configuration

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

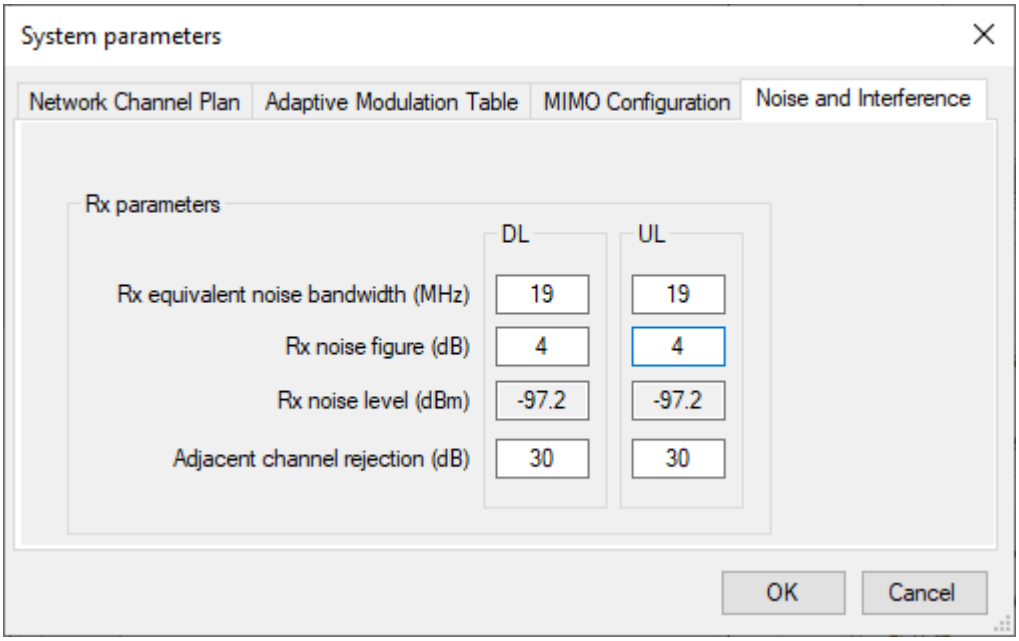


MIMO Type	DL Coverage Gain (dB)	UL Coverage Gain (dB)	DL Throughput Multiplication Factor	UL Throughput Multiplication Factor	DL Interference Reduction (dB)	UL Interference Reduction (dB)
Diversity Rx BS antenna	0	3	1	1	0	0
MIMO-A 2x1	3	3	1	1	0	0
MIMO-A 2x2	6	6	1	1	0	0
MIMO-B 2x2	3	3	1.9	1	0	0
MIMO-A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

Generic TRX MIMO Configuration

Noise and Interference

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



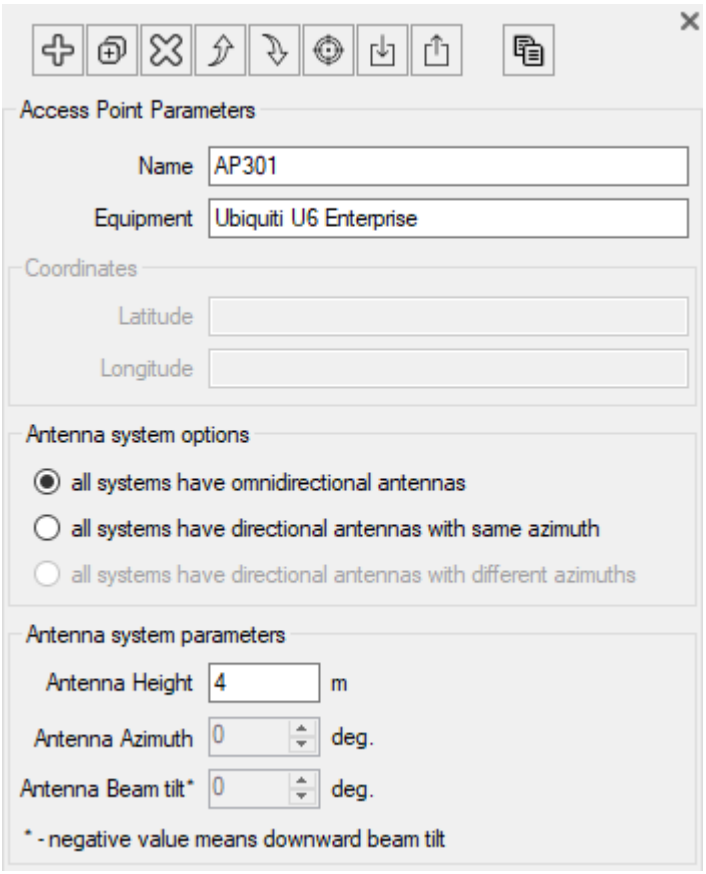
Generic TRX Noise and Interference

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

Access Points

An access point within Indoor RadioPlanner is a device that can encompass one or more systems (technology standards). For instance, a Wi-Fi access point might support multiple frequencies such as 2.4 GHz, 5 GHz, and 6 GHz. In the program, each technology standard is referred to as a “System.”

To create a first Access Point, click on Level in the Tree View interface, then click the  "Add a new Access Point" button in the panel that opens. Subsequently, it is efficient to generate additional access points based on the first one created.



Access Point Parameters

Add a new system

Add a new Access Point with the same parameters (Duplicate)

Delete this Access Point

Move Access Point up or down

Position the plan with the Access Point at the center of the screen

Load Access Point parameters from a template

Save Access Point parameters as a template

Copy this AP to clipboard

Name	AP name, text field
Equipment	Name (model) of AP equipment, text field
Latitude	Latitude (only for outdoor projects with Basemap underlay)
Longitude	Longitude (only for outdoor projects with Basemap underlay)

The antenna configuration at one Access Point can be of three options:

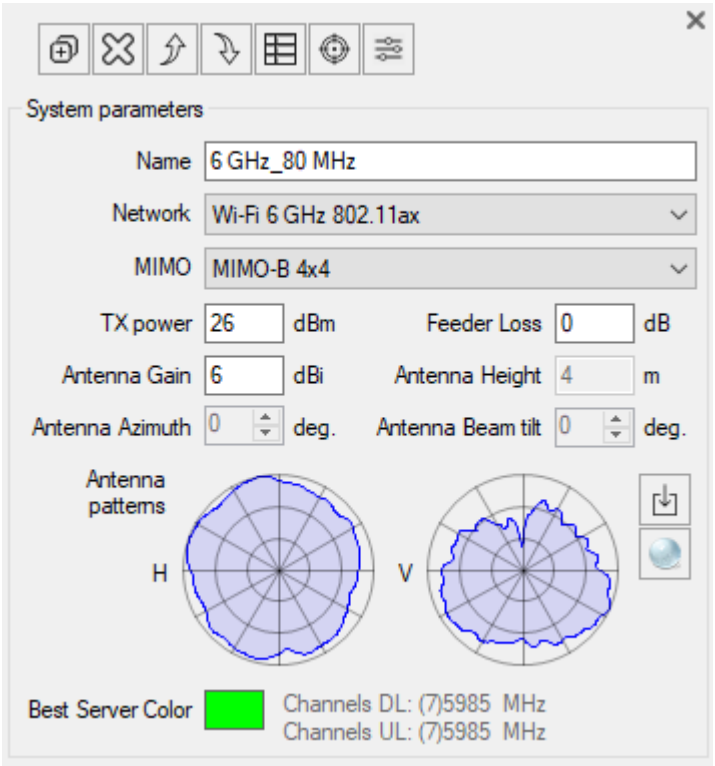
- All systems have omnidirectional antennas
- All systems have directional antennas with same azimuth

- All systems have directional antennas with different azimuths (for outdoor projects only)

Antenna parameters depend on system configuration options and may be specified here or in specific system parameters.

Systems

There is an activity icon next to each access point and system in the tree view of the interface. For a system to be calculated, it must be marked as active (the dot in the center). When you click on a system, a panel with its parameters will open.



System Parameters

Toolbar:


Add a new System with the same parameters


Delete the System

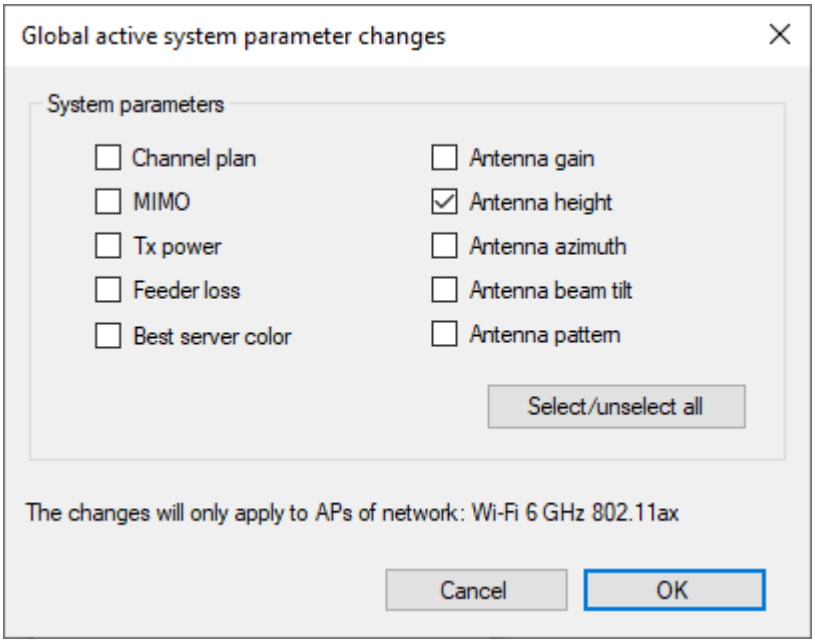

Move the System up or down


Channel Plan


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


Global Active System parameters change. You can replace the selected parameters for all active Systems as the current System.

Name	System name, text field
Network	The network to which the System belongs, select from the drop-down list of networks.
MIMO	MIMO type for the System, selection from a drop-down list of all possible MIMO configurations specified in the parameters of this network.
Tx Power	Transmitter power, dBm
Cable Loss	Loss in cable, dB
Antenna Gain	Antenna gain, dBi
Azimuth	The azimuth of the antenna in degrees
Antenna Height	The antenna height, m
Antenna Beam Tilt	Tilt the antenna in degrees. Down is negative; up is positive.
	Load MSI antenna pattern file. An antenna pattern file is a standard MSI file that can be downloaded from the antenna manufacturer's website. Antenna patterns are integrated into the project file.
	Select OMNI antenna pattern

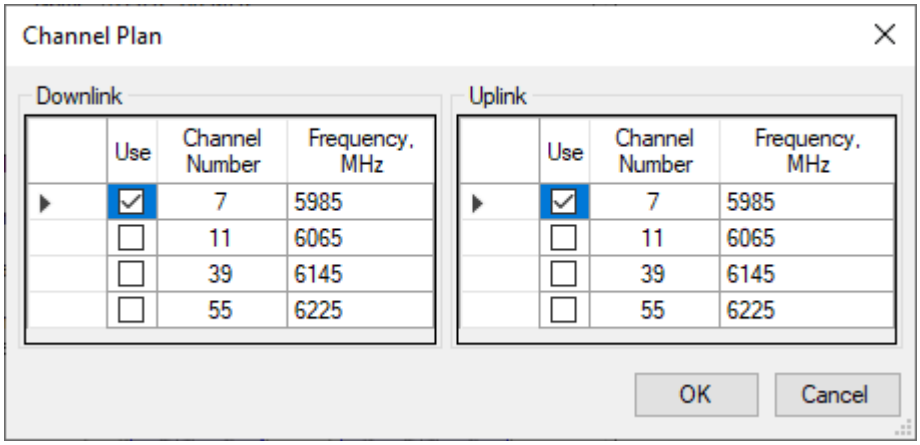


Global Active Systems parameters change

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

Channel Plan

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



System Channel Plan

Area Study (Coverage Prediction) types

Indoor RadioPlanner 2.0 performs various types of area studies:

- Received Power Uplink/Downlink
- Best Server Uplink/Downlink
- C/(I+N) Ratio Uplink/Downlink
- Maximum Throughput Uplink/Downlink
- Number of Servers Uplink/Downlink
- RSRP for LTE and 5G
- RSRQ for LTE and 5G
- Maximum aggregated Throughput Uplink/Downlink
- Number of Networks Uplink/Downlink

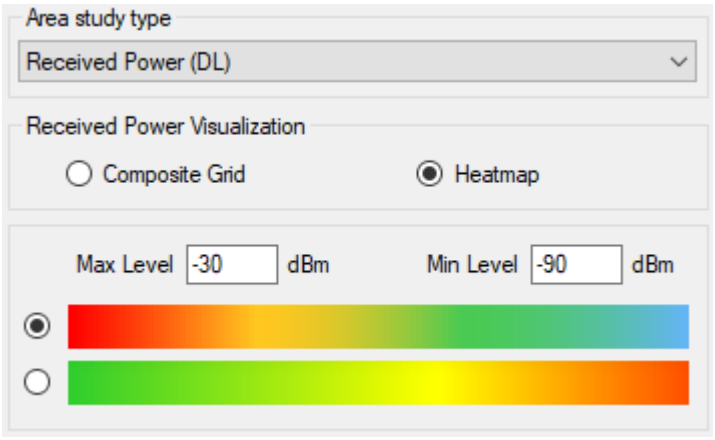
The availability of a particular area study type is determined by the type of system chosen.

When you click the "Calculate Coverage for Current Level" button on the main toolbar, all prediction types are performed at once. The prediction displayed on the screen can then be selected from the main toolbar.

Received power Downlink/Uplink

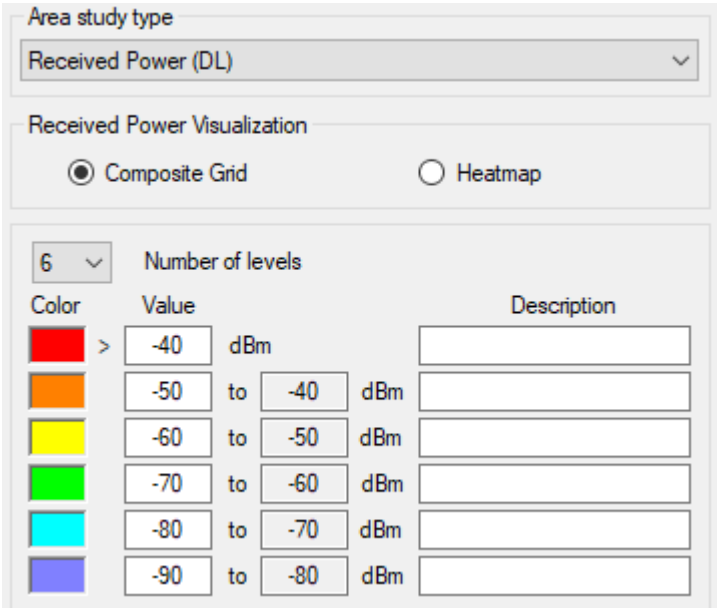
Received power maps show those areas where a given signal power level is present at the receiver.

You can choose prediction visualization as a heat map or a composite grid.



Received power as a heatmap visualization

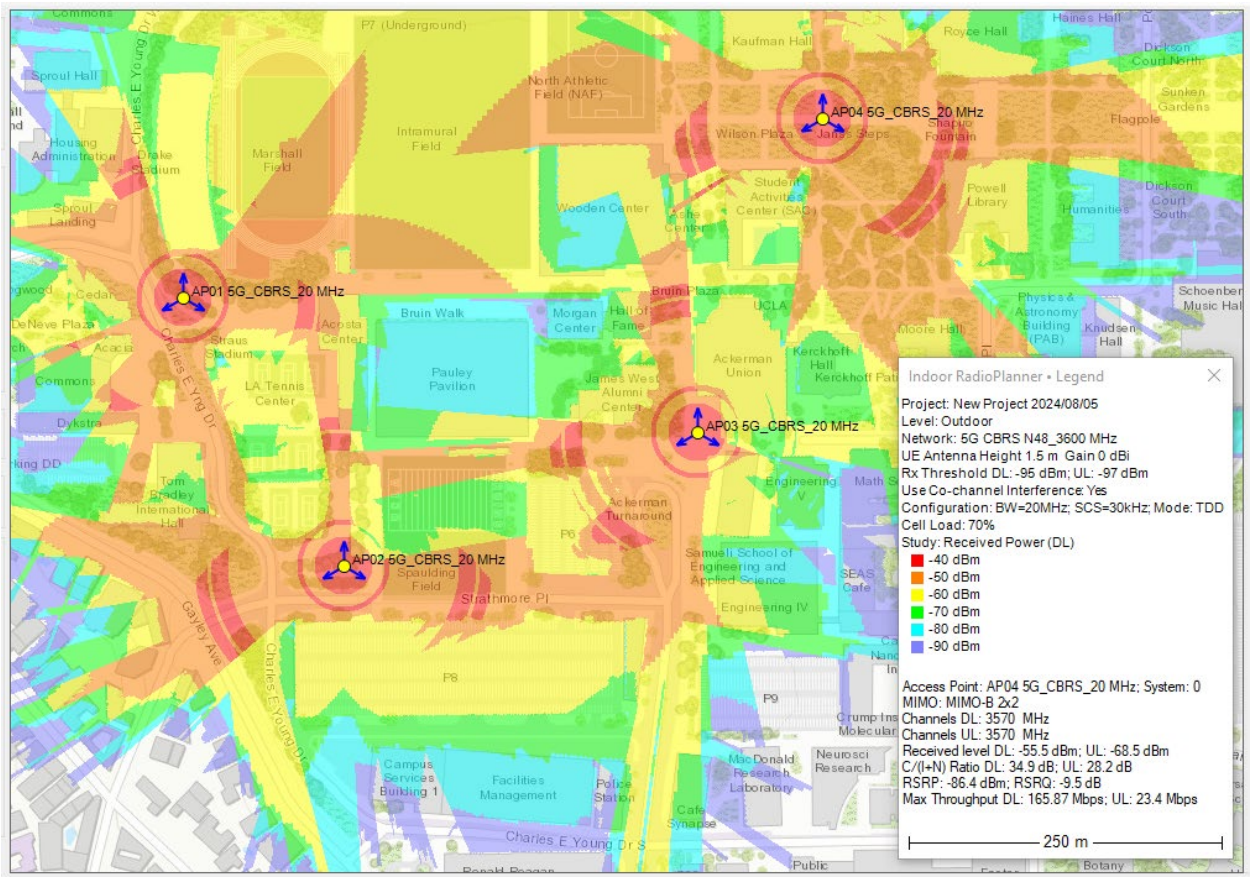
Max Level	Max visualization level, dBm
Min Level	Min visualization level, dBm



Received power as a composite grid visualization

Number of Levels	The number of levels (1-8)
Color	Color level
Values	Received power level, dBm
Description	Text field to describe signal level

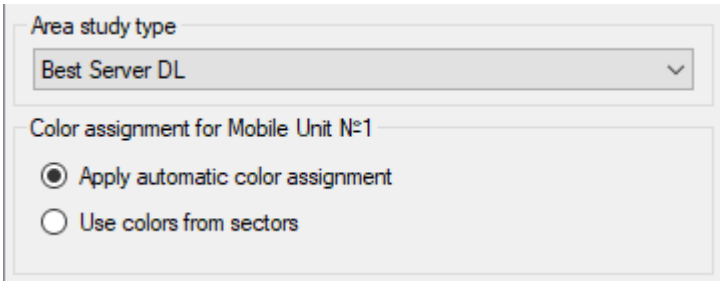
Indoor Uplink Received Power Coverage Prediction



Outdoor Downlink Received Power Coverage Prediction

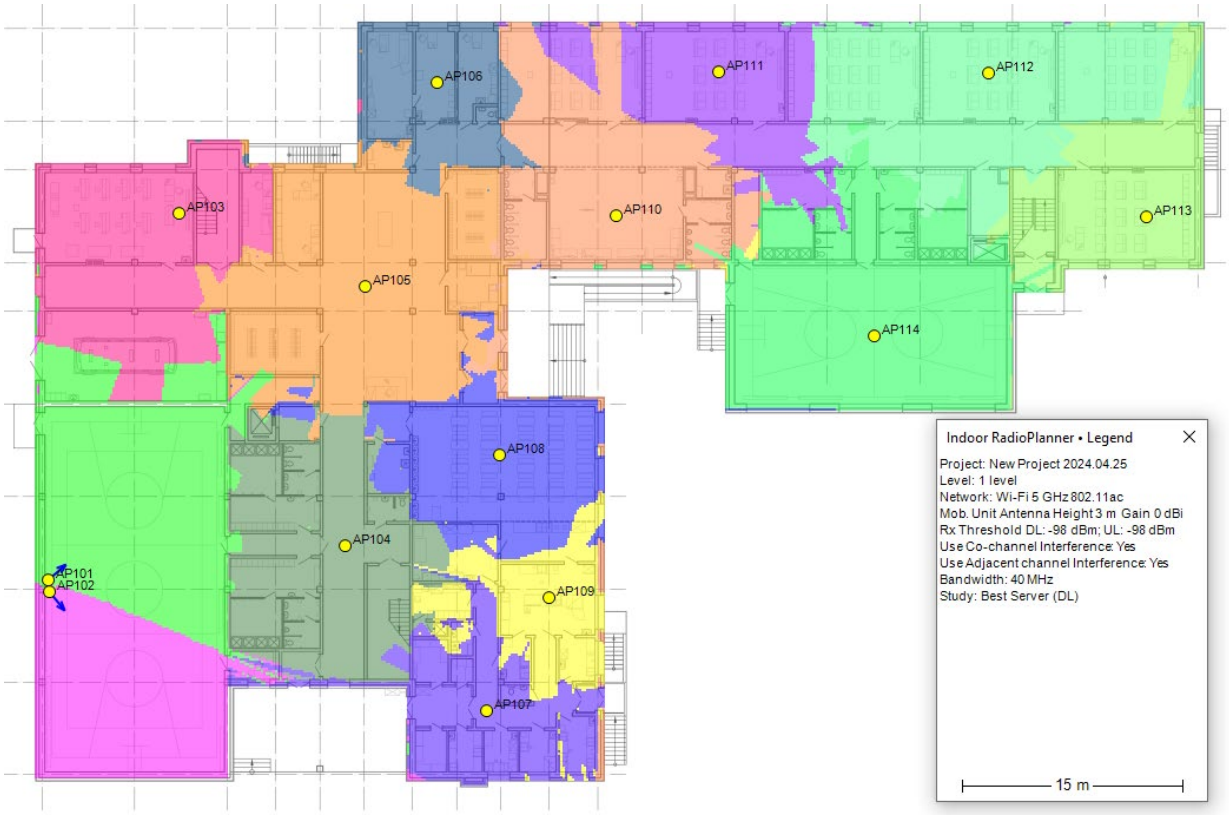
Best Server Uplink/Downlink

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

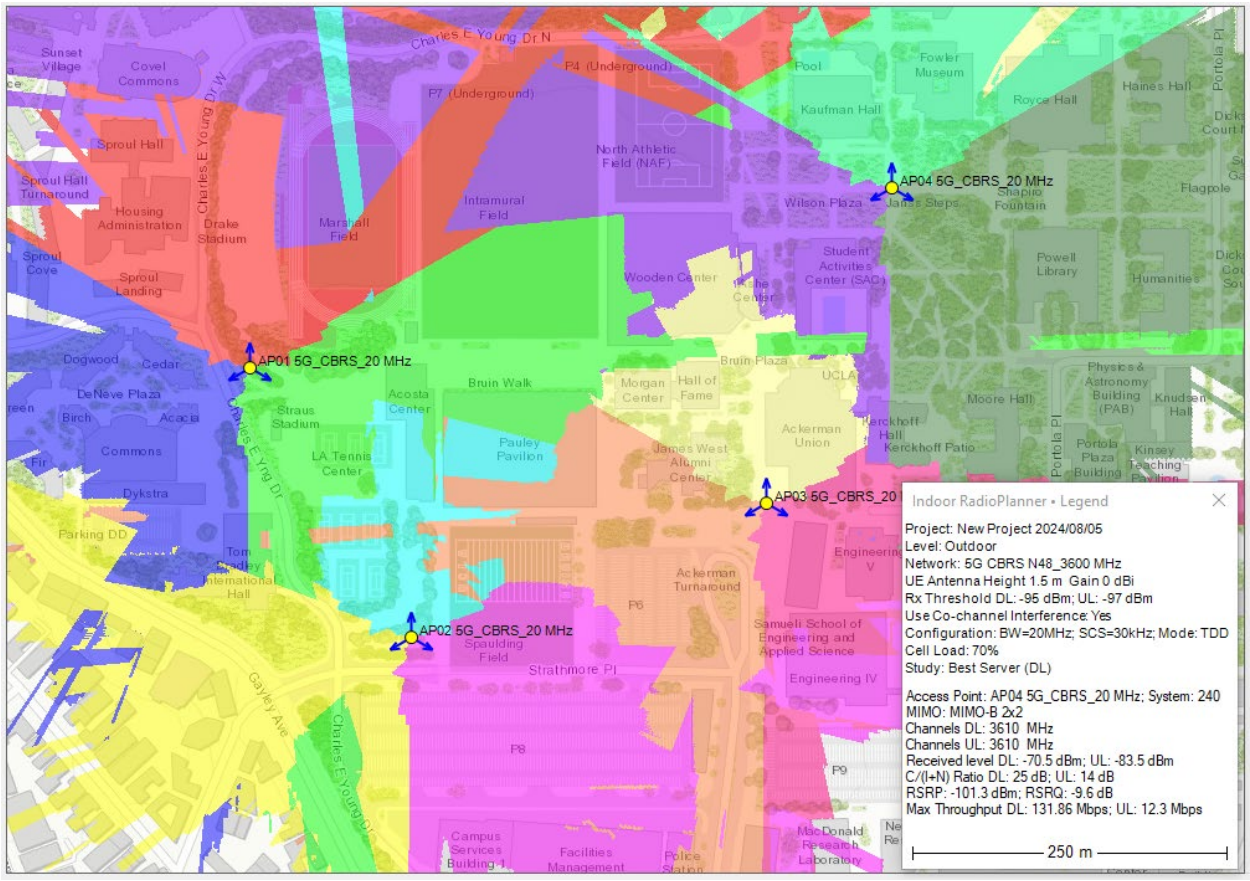


Best Server Study Type Parameters

Apply Automatic Color Assignment	Assign colors to sectors in random order
Use Colors from System parameters	Assigning based on colors specified in system parameters



Best Server Indoor



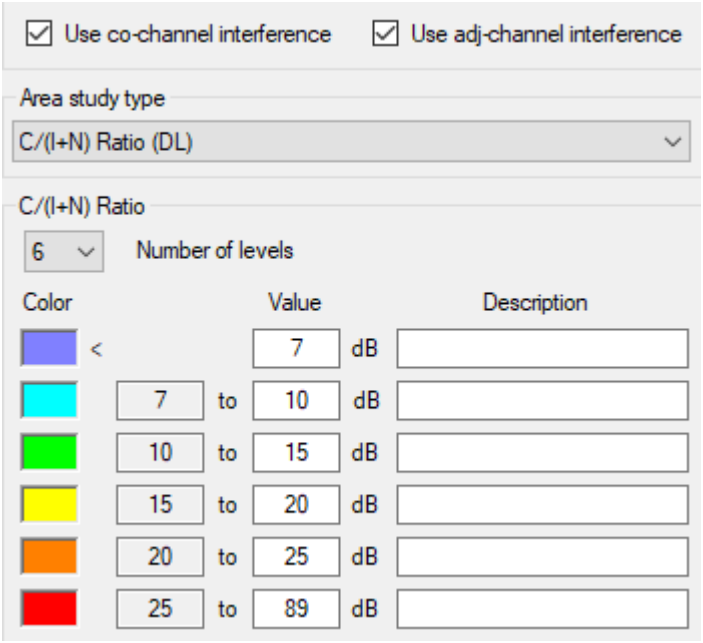
Best Server Outdoor

C/(I+N) Ratio Downlink/Uplink

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

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

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



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

Number of Levels	The number of levels
Color	Color level
Value	Carrier-to-interference+noise ratio C/(I+N), dB
Description	Text field

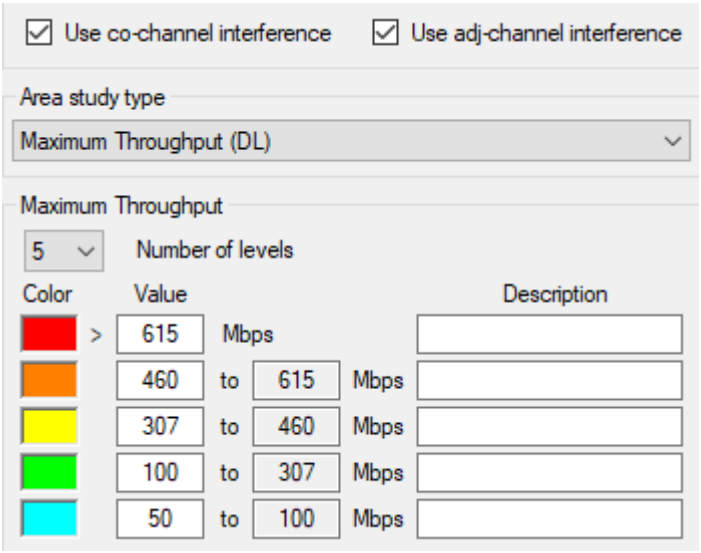
C/(I+N) Downlink

Maximum Downlink / Uplink Throughput

This prediction type shows maximum cell throughput.

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

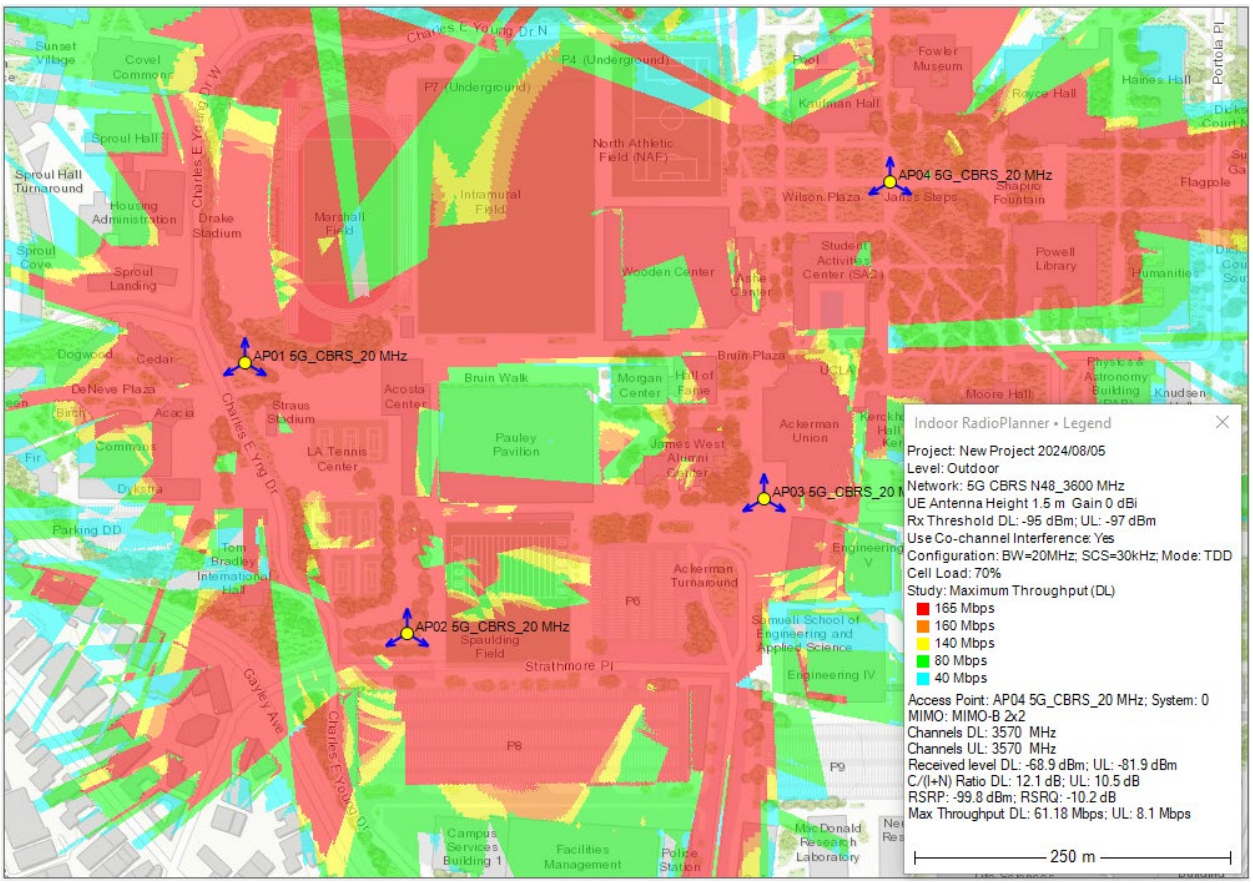
For Generic TRX System Type (including Wi-Fi), this study calculates Throughput for each point based on predicted C/(I+N) from Adaptive Modulation Table in system parameters tab of Network.



Maximum Downlink Throughput Study Type Parameters

Number of Levels	The number of levels (1-8)
Color	Color level
Values	Maximum Throughput, Mbps
Description	Text field

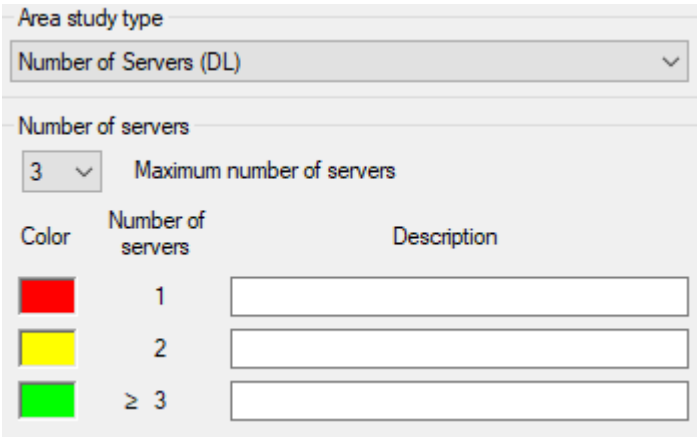
Maximum Downlink Throughput Coverage Prediction for indoor 5G CBRS N48 (3500 MHz) Network



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

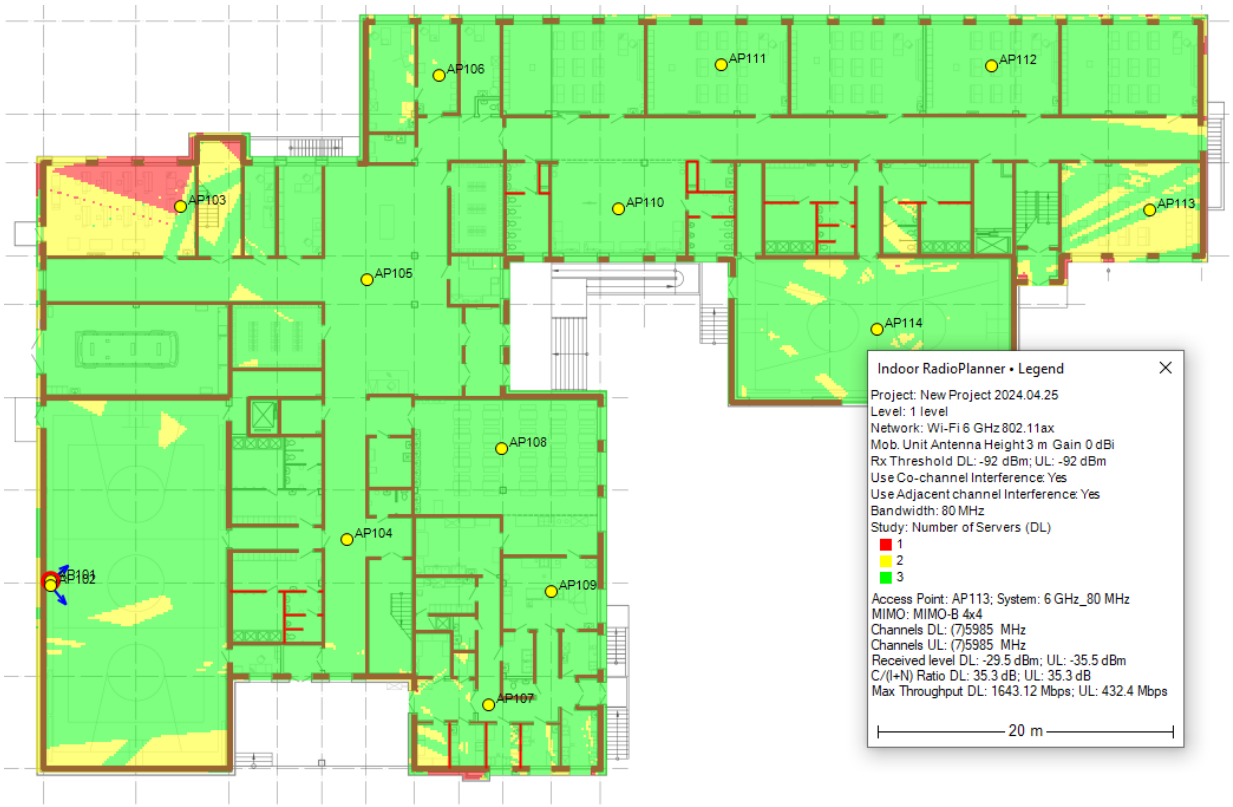
Number of Servers Uplink/Downlink

This study indicates total number of systems that provide a signal above Rx threshold at each location.



Number of Servers Above Downlink Study Type Parameters

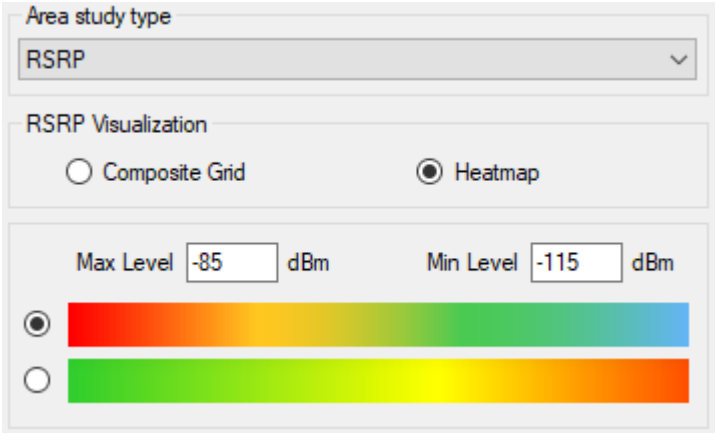
Maximum Number of Sectors	Maximum number of displayed servers above uplink
Color	Color indicating the appropriate number of systems
Description	Text field



Number of Servers Above Downlink for Wi-Fi

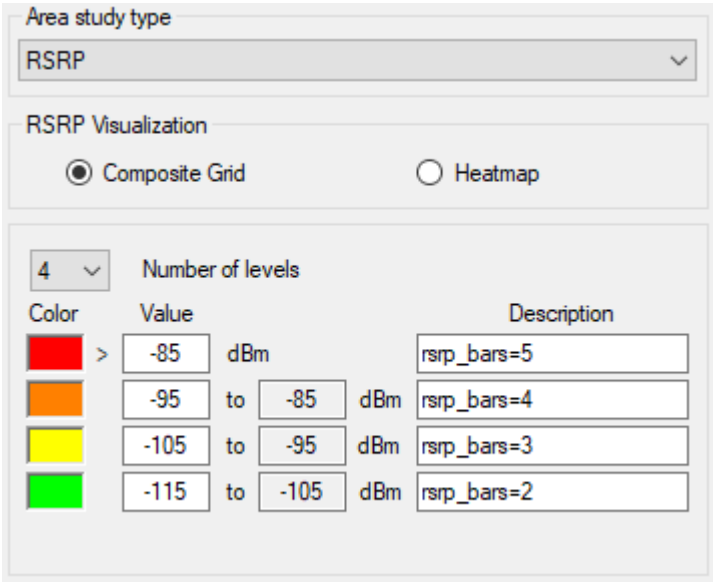
Reference Signal Received Power (RSRP)

This study calculates the Reference Signal Received Power (RSRP) from all resource elements of a cell at the remote UE receiver using system parameters of LTE and 5G networks (bandwidth, subcarrier spacing). You can choose prediction visualization as a heat map or a composite grid.



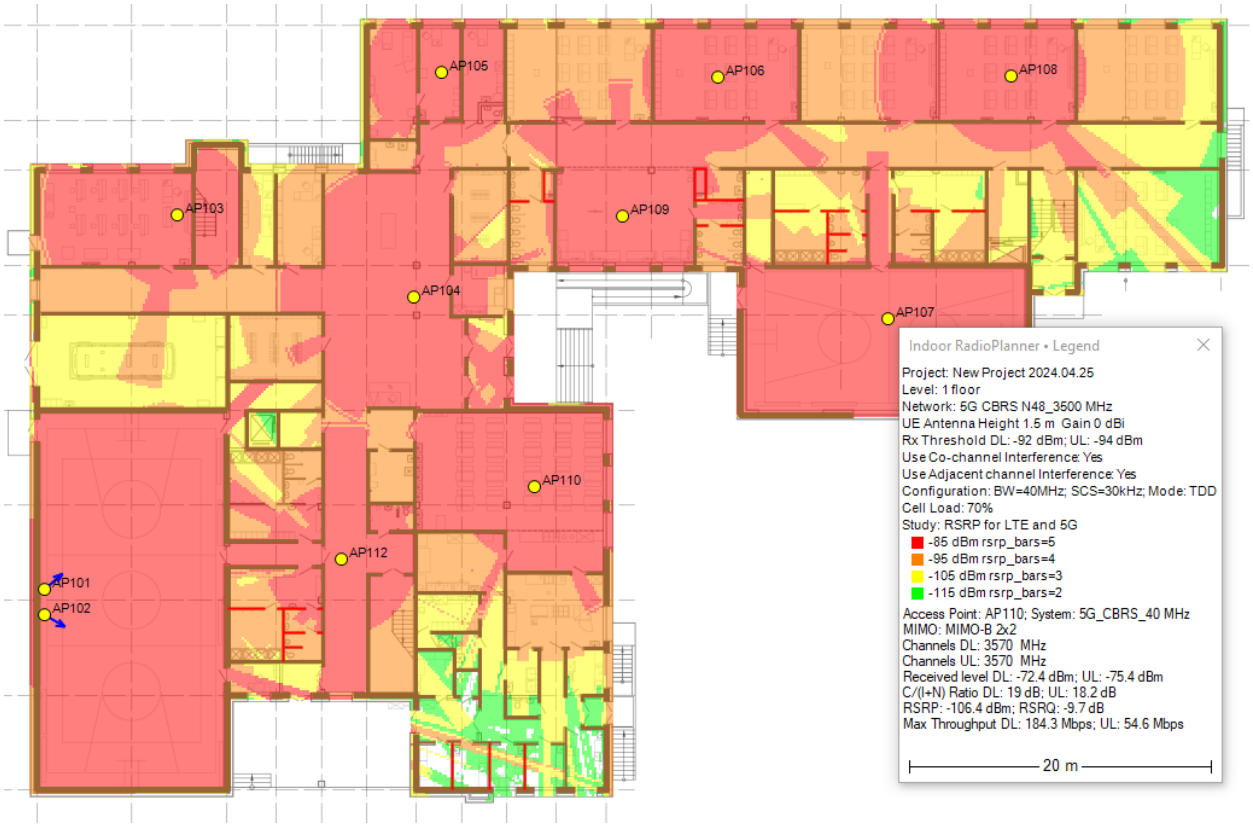
RSRP as a heatmap visualization

Max Level	Max visualization level, dBm
Min Level	Min visualization level, dBm

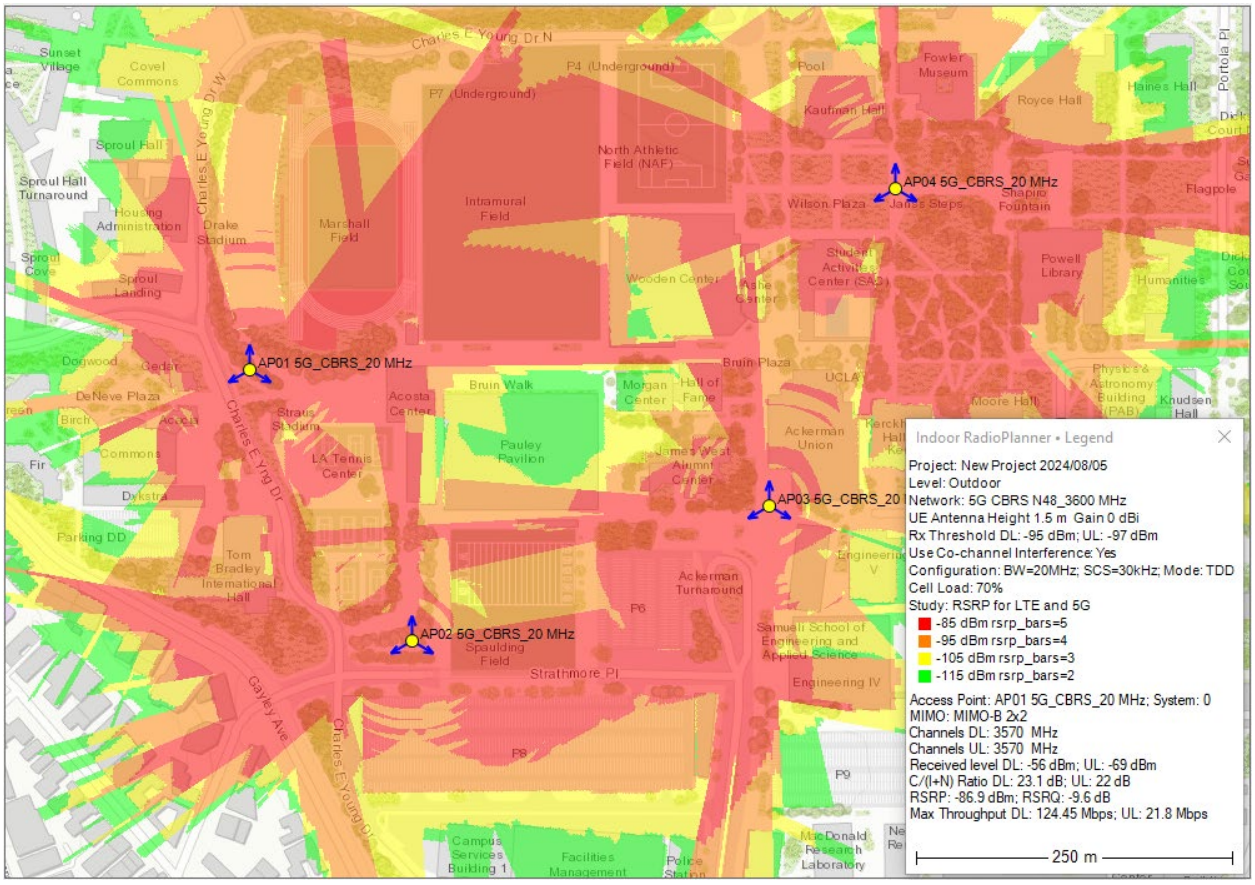


RSRP as a composite grid visualization

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



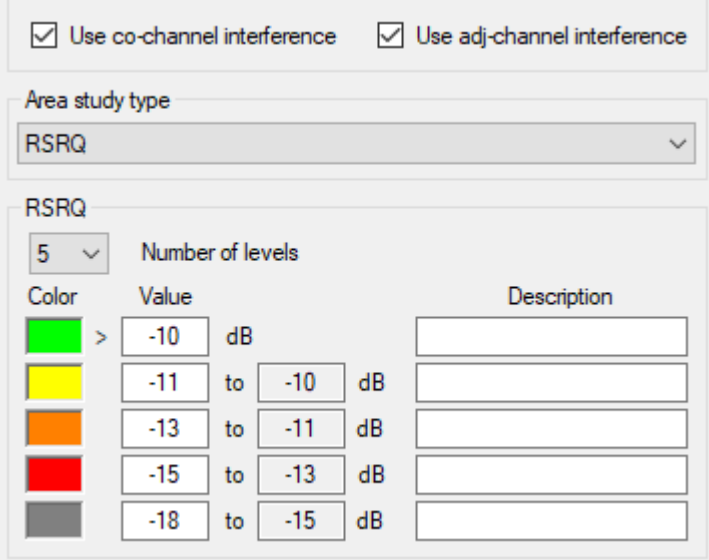
RSRP coverage prediction for indoor 5G CBRS N48 (3500 MHz) Network



RSRP coverage prediction for outdoor 5G CBRS N48 (3600 MHz) Network

Reference Signal Received Quality (RSRQ)

This study calculates the Reference Signal Received Quality (RSRQ) from all resource elements at the remote UE receiver using system parameters of LTE and 5G networks (bandwidth, subcarrier spacing, cell load, and C/(I+N) ratio).



RSRQ Study Type Parameters

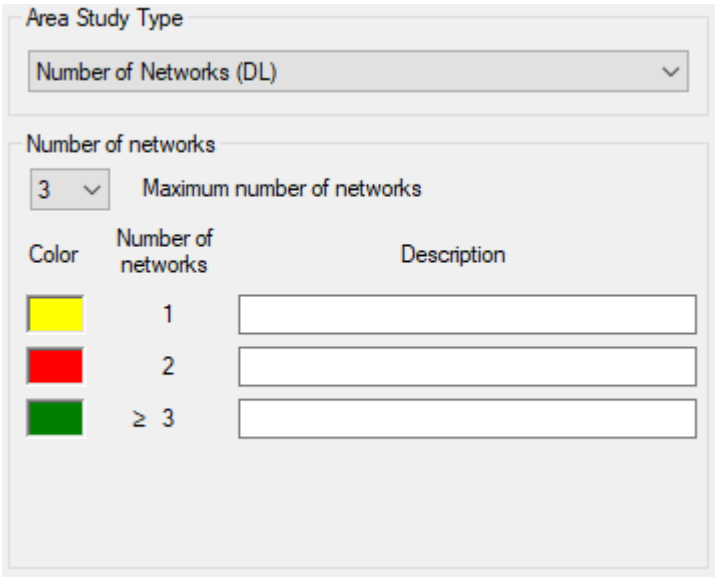
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Reference Signal Received Quality (RSRQ), dB
Description	Text field to describe RSRQ level

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

Coverage predictions for multiple networks

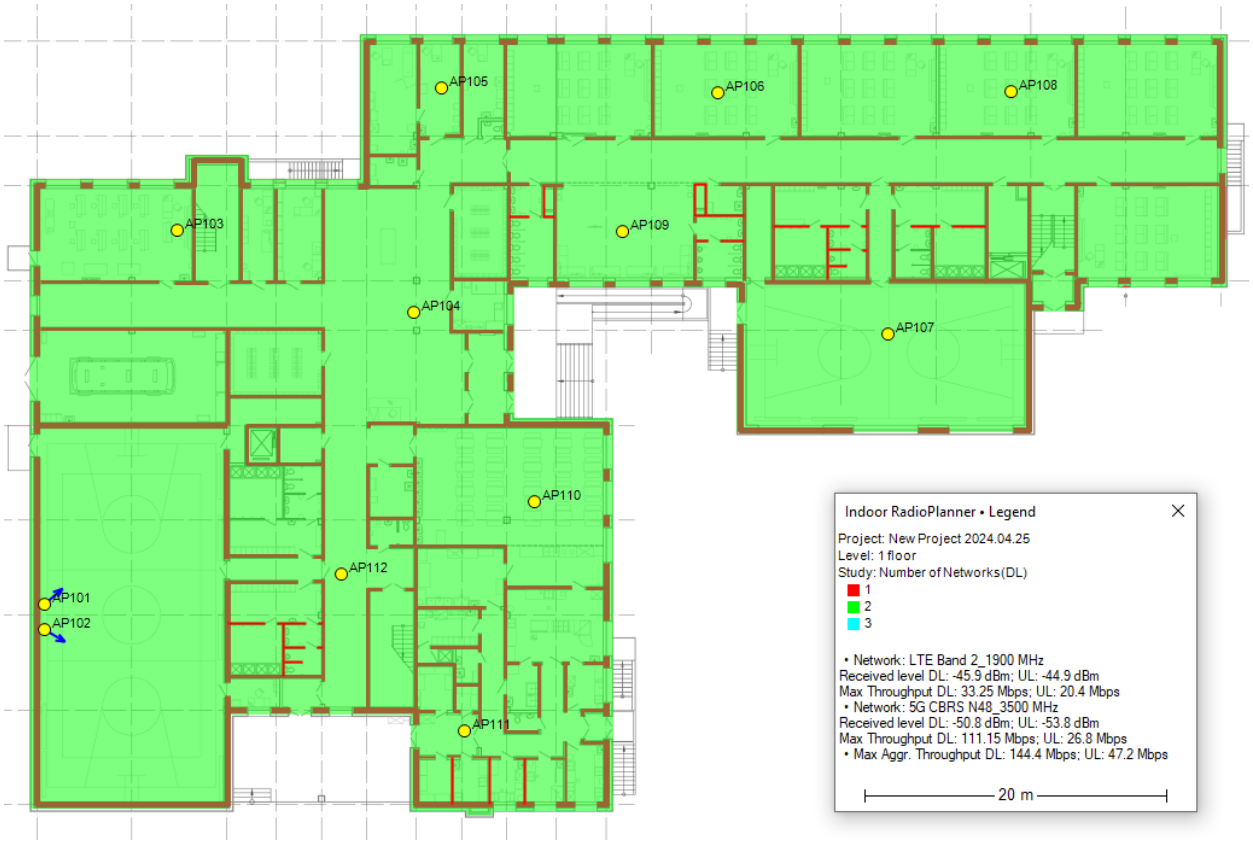
Number of Networks Downlink / Uplink

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



Number of Networks Downlink Study Type Parameters

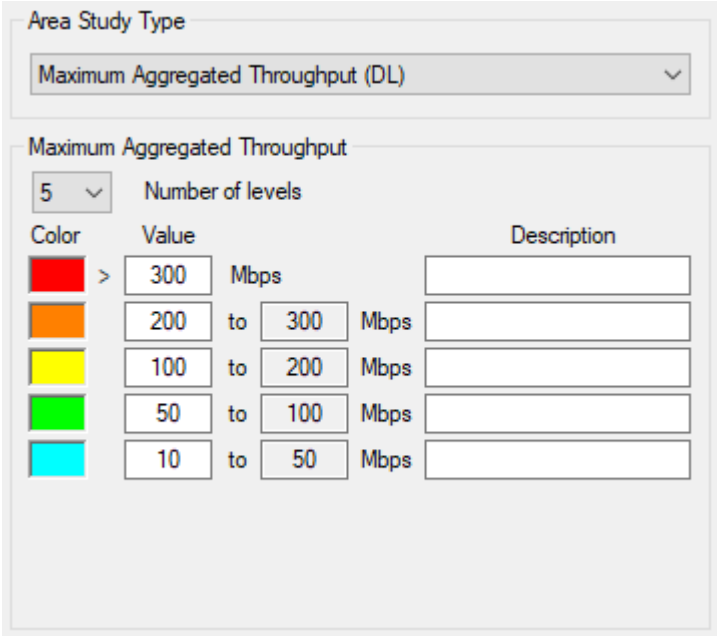
Maximum Number of Networks	Maximum number networks
Color	Color indicating the number of networks
Description	Text field



Number of Networks Downlink Coverage Prediction for indoor LTE Band 12 and 5G N48

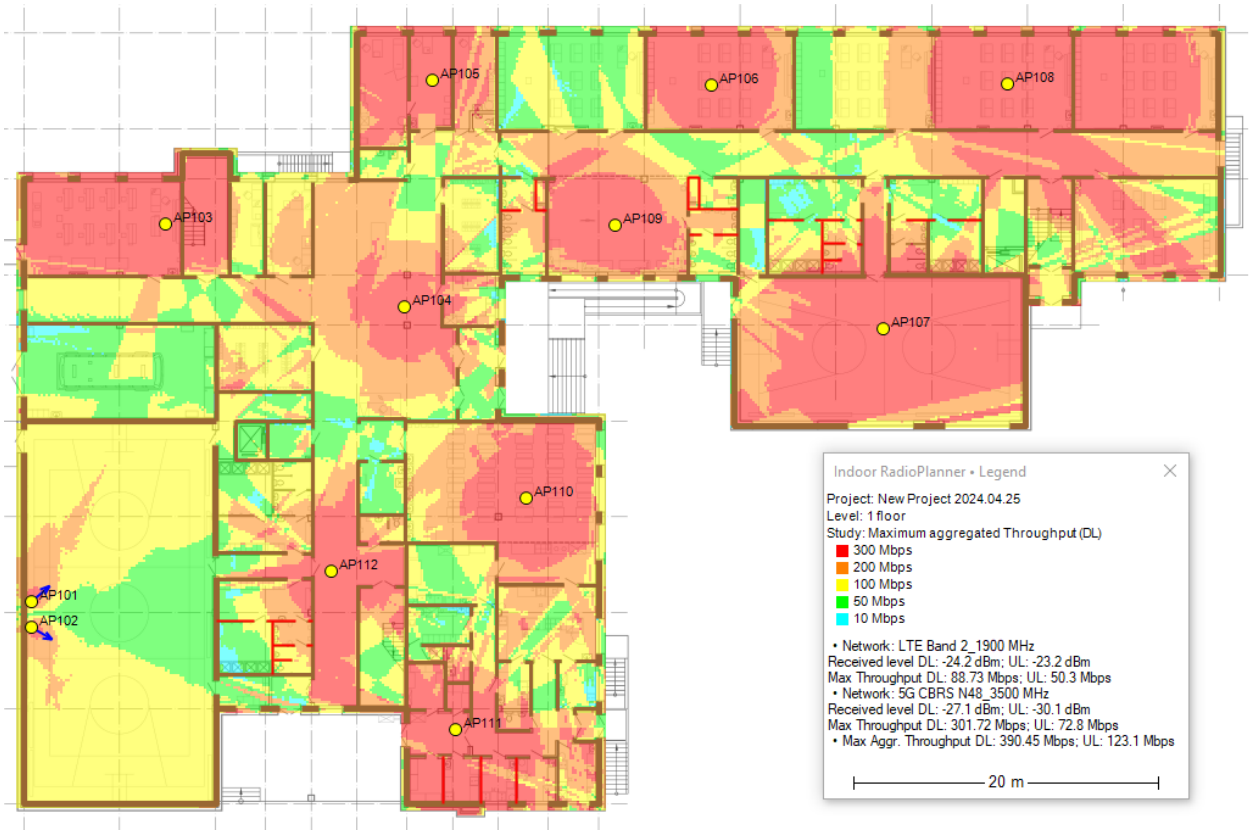
Maximum Aggregated Downlink / Uplink Throughput

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



Maximum Aggregated Downlink Throughput Study Type Parameters

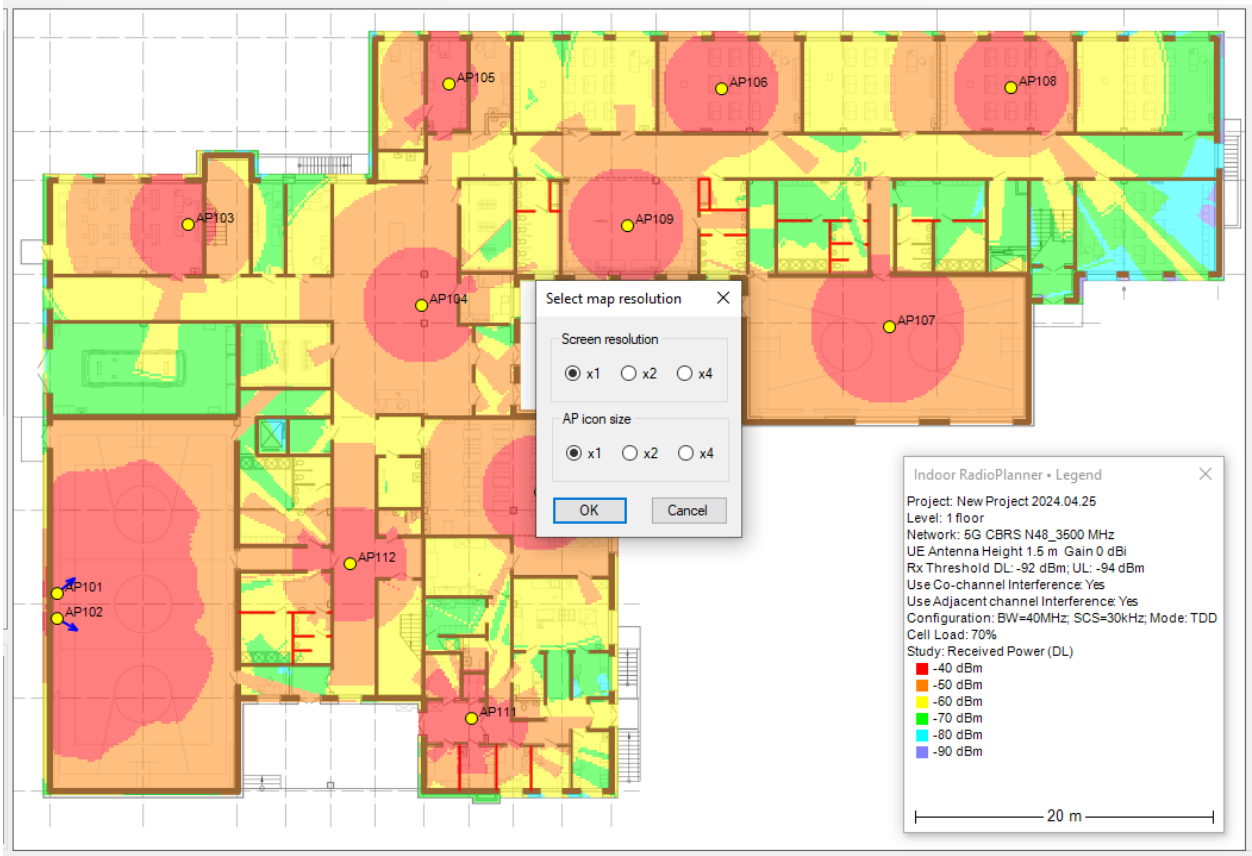
Number of Levels	The number of levels (1-8)
Color	Color level
Values	Maximum Aggregated Throughput, Mbps
Description	Text field



Maximum Aggregated Downlink Throughput Coverage Prediction for indoor LTE Band 2 and 5G N48

Saving the Coverage Prediction Result

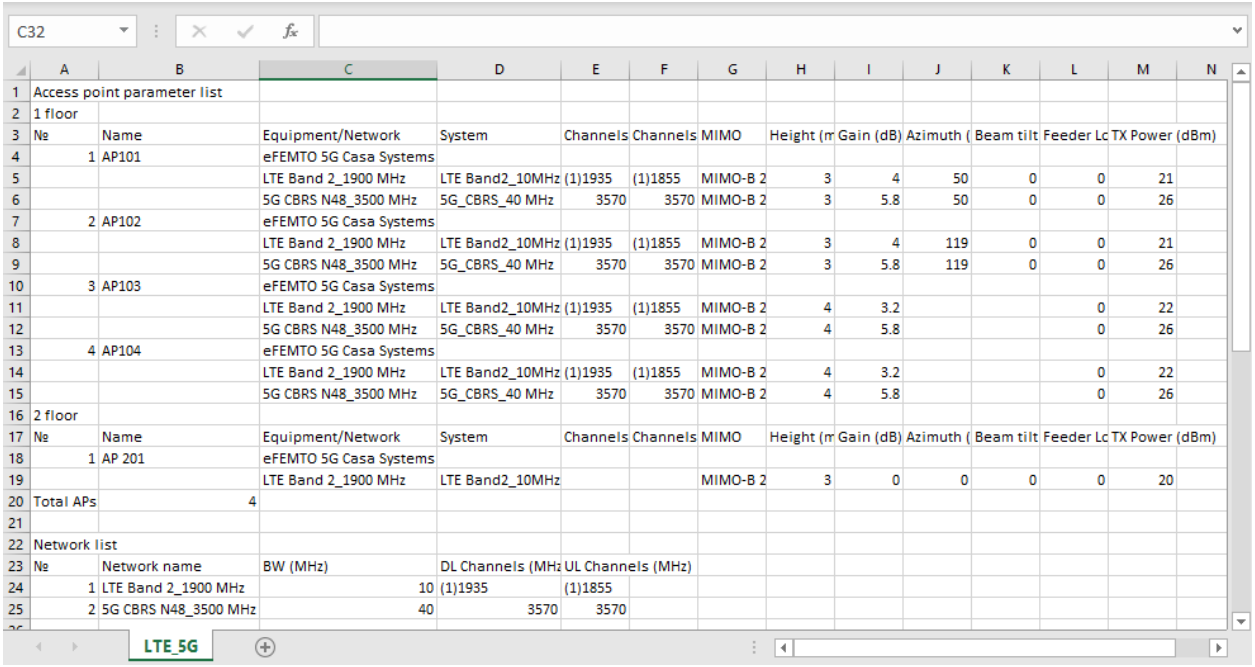
Save the level plan as a PNG image - Save the result of the coverage calculation as an image file in *.png format. The saved image will include the same area and Legend placement as currently displayed on the screen. You can select the image resolution and the size of the access point icons. The resolution can match the current size or be two or four times larger. The better the resolution, the larger the saved file size.



Save the level plan as a PNG image

Report

Using the "Save Access Point Settings List as CSV" button on the main toolbar, you can save a configuration report of all access points and networks. This CSV file can then be opened in Excel.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Access point parameter list													
2	1 floor													
3	№	Name	Equipment/Network	System	Channels	Channels	MIMO	Height (m	Gain (dB)	Azimuth (	Beam tilt	Feeder Lo	TX Power (dBm)	
4	1	AP101	eFEMTO 5G Casa Systems											
5			LTE Band 2_1900 MHz	LTE Band2_10MHz	(1)1935	(1)1855	MIMO-B 2	3	4	50	0	0	21	
6			5G CBRS N48_3500 MHz	5G_CBRS_40 MHz	3570	3570	MIMO-B 2	3	5.8	50	0	0	26	
7	2	AP102	eFEMTO 5G Casa Systems											
8			LTE Band 2_1900 MHz	LTE Band2_10MHz	(1)1935	(1)1855	MIMO-B 2	3	4	119	0	0	21	
9			5G CBRS N48_3500 MHz	5G_CBRS_40 MHz	3570	3570	MIMO-B 2	3	5.8	119	0	0	26	
10	3	AP103	eFEMTO 5G Casa Systems											
11			LTE Band 2_1900 MHz	LTE Band2_10MHz	(1)1935	(1)1855	MIMO-B 2	4	3.2			0	22	
12			5G CBRS N48_3500 MHz	5G_CBRS_40 MHz	3570	3570	MIMO-B 2	4	5.8			0	26	
13	4	AP104	eFEMTO 5G Casa Systems											
14			LTE Band 2_1900 MHz	LTE Band2_10MHz	(1)1935	(1)1855	MIMO-B 2	4	3.2			0	22	
15			5G CBRS N48_3500 MHz	5G_CBRS_40 MHz	3570	3570	MIMO-B 2	4	5.8			0	26	
16	2 floor													
17	№	Name	Equipment/Network	System	Channels	Channels	MIMO	Height (m	Gain (dB)	Azimuth (	Beam tilt	Feeder Lo	TX Power (dBm)	
18	1	AP 201	eFEMTO 5G Casa Systems											
19			LTE Band 2_1900 MHz	LTE Band2_10MHz			MIMO-B 2	3	0	0	0	0	20	
20	Total APs	4												
21														
22	Network list													
23	№	Network name	BW (MHz)	DL Channels (MHz	UL Channels (MHz)									
24	1	LTE Band 2_1900 MHz	10	(1)1935	(1)1855									
25	2	5G CBRS N48_3500 MHz	40	3570	3570									

Report in Microsoft Excel