TamoGraph® LTE and 5G Edition

Professional Software for Planning, Designing and

Visualizing Small Cellular Networks

Help Documentation

Version 1.0 Beta

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Introduction

Overview

TamoGraph LTE and 5G Edition is a design and analysis environment for planning, visualizing, and assessing the performance of LTE and 5G NR networks, with a primary focus on private deployments. Typical projects include CBRS and similar private cellular systems in campuses, industrial sites, and enterprise venues, where you control both the infrastructure and the spectrum usage. TamoGraph LTE and 5G Edition builds on the proven foundation of *TamoGraph Site Survey*, a widely used tool for Wi-Fi network planning and analysis.

Working with a virtual model of your site, TamoGraph lets you explore signal levels, coverage quality, throughput, and other key performance indicators before any hardware is installed. You can experiment with base station parameters and layouts across a wide range of scenarios, from femtocell and picocell layers to denser microcell deployments in both Sub-6 GHz and mmWave bands.

This beta version is particularly well suited for early design work: sketching out smaller deployments, comparing equipment options, and trying out different configuration ideas. Planning your network with TamoGraph at this stage can help shorten the initial rollout, guide you toward more suitable hardware choices, and reduce avoidable maintenance and upgrade costs later on.

Why Use Virtual Predictive Model in Your Cell Network Design?

Real on-site surveys provide data about the current radio environment at a given location. A virtual predictive model, by contrast, is created and adjusted entirely on your computer. In this approach, you build a representation of the physical environment and place simulated base stations; the software then predicts the resulting radio characteristics for that model. This process is often referred to as RF planning, RF predictive modeling, or RF modeling.

When you are deploying a new network, a predictive model can substantially reduce the number and scope of on-site surveys you need to perform. That, in turn, helps conserve time, budget, and engineering effort. Using TamoGraph with a virtual model, you can quickly estimate deployment costs, evaluate multiple design options, and compare different equipment configurations before any purchase decisions are made.

Even if the real site is not yet accessible, or is still at the design or construction stage, virtual-model-based planning allows you to explore how the future network is likely to behave and to refine your design while the project is still flexible.

System Requirements

TamoGraph requires a computer with the following minimal system requirements:

- Windows 10 or 11; Windows Server 2022 or 2025.
- Intel Core 2 or similar CPU. A multicore CPU such as Intel i5 or i7 is recommended.
- 16 GB of RAM.
- 400 MB of free disk space.

Trial Version Limitations

The trial of TamoGraph allows you to evaluate the software for 30 days and has the following limitations:

- Watermarks are placed on all visualizations.
- You cannot save projects or reports.

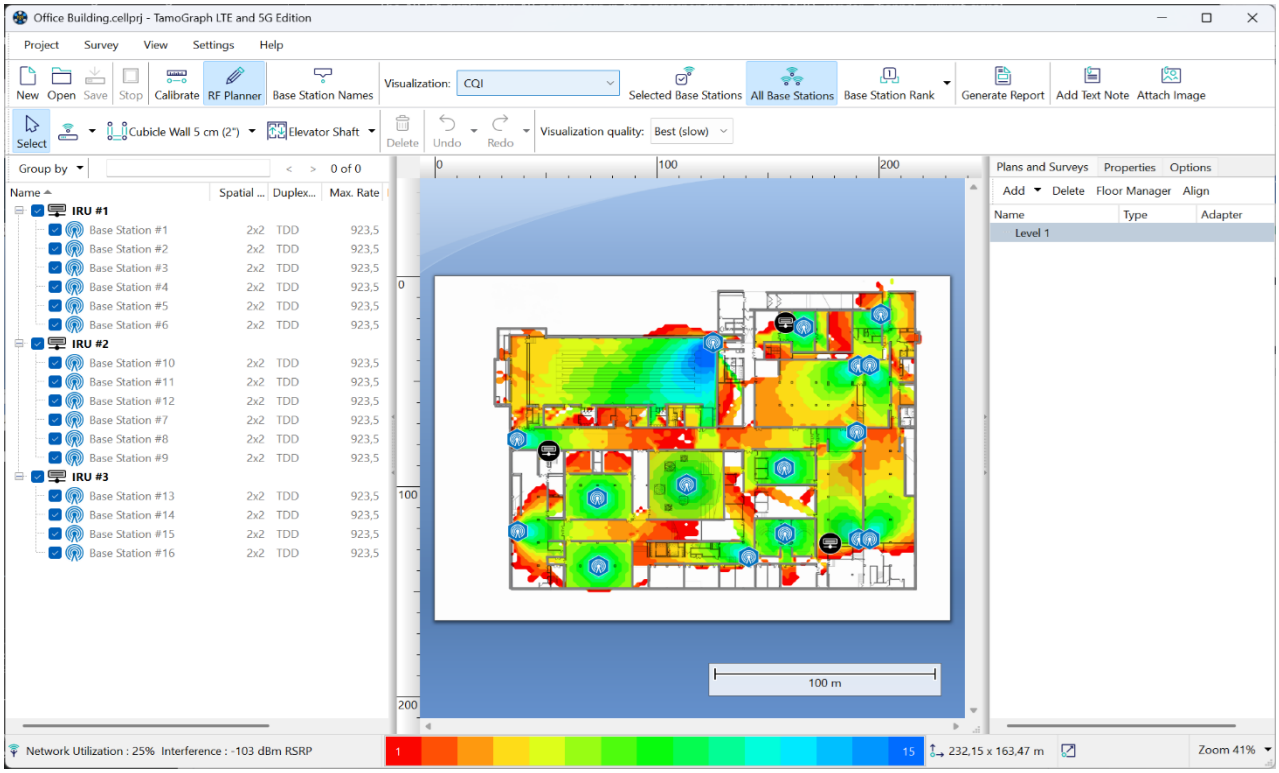
Interface Overview

The application main window includes the following elements:

- The resizable left-side panel displays a list of base stations and radio units.
- The central area is used for displaying the floor or site plan image and visualizations of analyzed data.
- The resizable right-side panel allows you to manage project floor plans, as well as to configure various project options and settings.

You can hide and show the left and right panels using the vertical splitter or through the menu commands View => Left Panel and View => Right Panel.

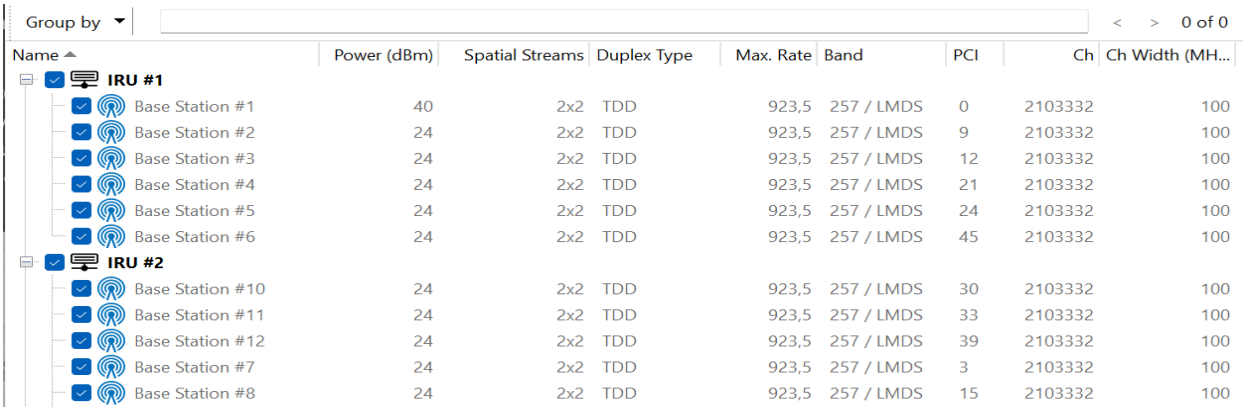
In addition to the three main elements, the application contains the main toolbar (provides quick access to frequently used commands), the **RF Planner** toolbar (used in predictive modeling for drawing virtual objects), and the status bar (provides information on Network Utilization and Interference level, current floor plan dimensions, coordinates, and zoom level, as well as the legend for the currently selected visualization).



The following chapters describe the functionality of these elements in detail.

Base Station List

The left application panel is used to display the list of base stations during predictive modeling. You can use the Group by button to group base stations by standard, channel, name, duplex type, radio unit or custom group. Grouping by Radio Unit is the best method when modeling network in DAS environment.



Name	Power (dBm)	Spatial Streams	Duplex Type	Max. Rate	Band	PCI	Ch	Ch Width (MH...
IRU #1								
Base Station #1	40	2x2	TDD	923,5	257 / LMDS	0	2103332	100
Base Station #2	24	2x2	TDD	923,5	257 / LMDS	9	2103332	100
Base Station #3	24	2x2	TDD	923,5	257 / LMDS	12	2103332	100
Base Station #4	24	2x2	TDD	923,5	257 / LMDS	21	2103332	100
Base Station #5	24	2x2	TDD	923,5	257 / LMDS	24	2103332	100
Base Station #6	24	2x2	TDD	923,5	257 / LMDS	45	2103332	100
IRU #2								
Base Station #10	24	2x2	TDD	923,5	257 / LMDS	30	2103332	100
Base Station #11	24	2x2	TDD	923,5	257 / LMDS	33	2103332	100
Base Station #12	24	2x2	TDD	923,5	257 / LMDS	39	2103332	100
Base Station #7	24	2x2	TDD	923,5	257 / LMDS	3	2103332	100
Base Station #8	24	2x2	TDD	923,5	257 / LMDS	15	2103332	100

The list displays key base stations parameters in the corresponding columns: power in dBm, spatial streams, duplex type, maximum data rate in Mbps, band, PCI, channel and channel width in MHz. You can rename a base station by right-clicking on them and selecting Rename. To restore the original name, simply delete a user-assigned name by hitting the backspace key. You can customize the columns by right-clicking on the list header or change their order by dragging them.

The icons are color-coded to reflect bands and standards they use:

	4G LTE base station
	5G base station
	Radio Unit (RU)

The check boxes next to the base station icons play a very important role: They should be used for selecting the base stations you want TamoGraph to analyze. When the **Selected Base Stations** mode is enabled on the toolbar, data visualizations include only the base stations that have checked boxes next to them.

When working with dozens of base stations, it might be difficult to find the corresponding entry on the base stations list for a given icon on the site map and vice versa. To help you with this task, two visual feedback mechanisms exist:

- When you select a base station icon on the site map, the corresponding item on the list is highlighted in grey color.
- When you double-click an item on the list, the corresponding base station icon on the site map blinks a few times (assuming that the corresponding base station icon is shown on the site map). If the base station icon is not within the site map's visible area, the site map is automatically scrolled to ensure that the icon is visible.

You can also use the **Search** function to find a base station by name or PCI. To do this, use the search field located above the base stations list and enter some text. If matches are found, they will be highlighted, and the selection line will be placed on the first match. To the right of the search field, you can see the total number of matches and the current match number. The "left" and "right" buttons can be used to navigate to the previous or next match.

Custom Groups

One of the possible base stations grouping methods is by "Custom Group". This method might be used if you have a grouping criterion that is not covered by the standard grouping methods. For example, you may want group base stations by their location. Initially, base stations are not assigned to any group. To create groups and assign base stations to them, use the **Custom Group** menu. Under this menu, you can **Add selected** to an existing or new group (by "selected," we mean the base stations that are currently checked in the base stations list) or **Clear** grouping for all or selected base stations. You can also **Manage** all groups. When you use the **Manage** command, the application displays a dialog listing all base stations and their membership in the groups. Initially, all base stations are marked as **Ungrouped**. You can create new groups, rename them, delete them, and move one or several base stations to any group via drag-and-drop. Note that a base station cannot be assigned to multiple groups; it can be assigned either to one group or to no group. Groups are project specific, which means that they exist only within a given project. You cannot create or manage groups when no project is open.

Floor Plan / Site Map

This central area of the application window is used to display the floor plan or site map on which the modeling of the site is performed by placing walls, attenuation zones, and virtual base stations:

The application status bar displays the map dimensions and your current coordinates when you hover the mouse over the map. To zoom in our out, use the mouse scroll wheel or the **Zoom** button on the status bar. To pan the map, use the vertical and horizontal scroll bars or press and hold the space bar and drag the map while holding the left mouse button. If you are using a computer with a multitouch display, you can use the two-finger pinch zoom gesture to zoom in or out and the two-finger pan gesture to pan.

When you are have completed modeling the site, you can use the **Visualization** drop-down list on the toolbar to have TamoGraph display data visualizations for your site (e.g., RSRP or coverage areas).

Plans and Surveys, Properties, and Options Panel

This panel gives you access to virtually all the application and project settings. Using this panel, you can manage floor plans, configure requirements for your cellular network, select color schemes for your visualizations, etc. For a detailed description of these functions, refer to the Configuring TamoGraph chapter.

Main Menu

The application menu commands are described below.

Project

- **New** – launches a new project wizard.
- **Open** – opens a previously saved project.
- **Save** – saves the current project.
- **Save As** – saves the current project under a different name.
- **Close** – closes the current project.
- **Generate Report** – opens the report generation dialog.
- **Save Current Visualization** – saves the currently selected visualization and legend to an image file.
- **Clear Recent List** – clears the list of recently opened project files.
- **Exit** – closes the application.

Plan / Map

- Calibrate – allows you to set the map dimensions.

View

- **Left Panel** – shows or hides the left panel.
- **Right Panel** – shows or hides the right panel.
- **Main Menu** – shows or hides the main application menu. To show it again, press ALT or use the View context menu on the central pane.
- **Main Toolbar** – shows or hides the toolbar in the main application window.
- **RF Planner Toolbar** – shows or hides the toolbar for editing virtual objects used in predictive modeling.
- **Status Bar** – shows or hides the application status bar.
- **Full Screen** – expands the main application window and hides all other applications. To exit full screen mode, press F11 or use the View context menu on the central pane.
- **Vertical Ruler** – shows or hides the vertical ruler.
- **Horizontal Ruler** – shows or hides the horizontal ruler.
- **Legend** – shows or hides the legend on the map.
- **Base Stations** – shows or hides base stations' icons.
- **Virtual Objects** – shows or hides virtual objects (walls, attenuation areas and floor areas) that were created as part of predictive modeling.
- **Media Objects** – shows or hides icons that represent images that you added to the project.

Settings

- **Interface Font** – allows you to change the interface font.

Help

- **Contents** – displays help documentation.
- **Contents (PDF)** – displays help documentation in PDF format.
- **Check for updates** – connects to the TamoSoft website and checks whether a newer application version is available.
- **Activation** – activates your registration key.
- **About** – displays information about the application.

Creating a New Project

To plan an LTE/5G network for your site, you need to:

- Create a new project with the help of the Project Wizard.
- Calibrate the floor plan or site map.
- Configure the program options and network requirements.
- Create a virtual environment. See the chapter on modeling for more information.

The following chapters describe these steps in detail.

New Project Wizard

To create a new project, click **Project** => **New**. A wizard window will appear.

Step 1

Specify the **Name**, **Description** (optional), and **Project path**. The name you give to the project is used as the file name under which your project will be saved in the folder specified in the **Project path** field.

Step 2

In this step, you should **Select an environment**. The Environment panel allows you to configure some of the very important project parameters that affect the way data visualizations are computed. Because different environments have different characteristics in terms of signal attenuation, diffraction, reflection, etc., you are asked to select the environment that best describes the site you plan to survey.

Select the primary frequency band that will be used at your site. The program can combine base stations operating in different bands, but the primary band will be used by default.

Finally, the **Measurement units** control can be used to choose the preferred units (feet or meters) for displaying distances and coordinates throughout the application. See the Environment chapter for more information.

Step 3

In the final step, you should add an image file that contains the floor plan or site map of the facility or area where you want to deploy your cellular network (you will be able to add more images if your project includes several zones or floors later.) A floor plan or site map is required for accurate data analysis. If no image file is available, you may want to scan a plan, if it exists on paper, create one using a drawing program, such as CorelDraw, or even make a sketch using a ruler and pencil and then scan the sketch (be sure to follow the proportions). The image file should be between 250 and 2,500 pixels on a side (naturally, this applies to raster formats only; vector images, such as DWG, do not have pixel dimensions). Larger images will slow down the application. The following image file formats are supported on Windows: BMP, PNG, JPG, GIF, WMF, TIFF, PDF, DWG, DXF, and SVG.

If you add an AutoCAD image (DWG or DXF), an additional import settings dialog is displayed. This dialog allows you to select a layout to be used (if the file contains multiple layouts) and include or exclude specific layers. For example, you may want to exclude the plan legend. You can also crop the floor plan to define a specific zone to be used for surveying.

The application also supports PDF files. When you use a PDF file, an additional import settings dialog is displayed. This dialog allows you to select a page to be used (if the file contains multiple pages). Alternatively, you can use any of the images embedded into the PDF file; such images are listed on a separate tab. You can also rotate or crop the floor plan to define a specific zone to be used for surveying.

You can also import a map from one of the online map services. Click **Load Street Map** to open a new map loader dialog. Once the initial map view is loaded (the application will try to guess your location based on the Wi-Fi environment), you can navigate to the area you want to survey, using the map controls or the **Navigation** frame, in which you can enter your coordinates or your address. Click **Go to Location** to load the map of the corresponding area. When you are satisfied with the area selection and zoom level, click **Use Map**. Note that the application will use the map image as you see it, with the selected zoom level and size in pixels as in the map loader window (the window can be resized). Be sure to select the area correctly and to set a zoom level that meets your needs, as you will not be able to resize the map or zoom in/out at a later time.

Calibration

Once the project has been created, you will be prompted to calibrate the floor plan or site map. Calibration is the process by which you "tell" the application about the map dimensions.

To calibrate the map, you need to know the distance between two points on the map. That can be the distance between two walls or windows. Click on the first point of the distance, and move the mouse pointer to the second point while holding down the left mouse button. Release the left mouse button when the mouse pointer is over the second point. A red line indicating the distance will be shown. At the bottom of the screen, enter the length of the red line and click **Apply**.

Configuration

Before you begin working on your network model, you may want to configure some of the application settings and project properties, although this is not mandatory. Available settings and options are described in the Configuring TamoGraph chapter. Specifically, it is recommended that you configure network requirements. This is helpful for a quick and easy evaluation of the overall health of your network and detection of potential issues.

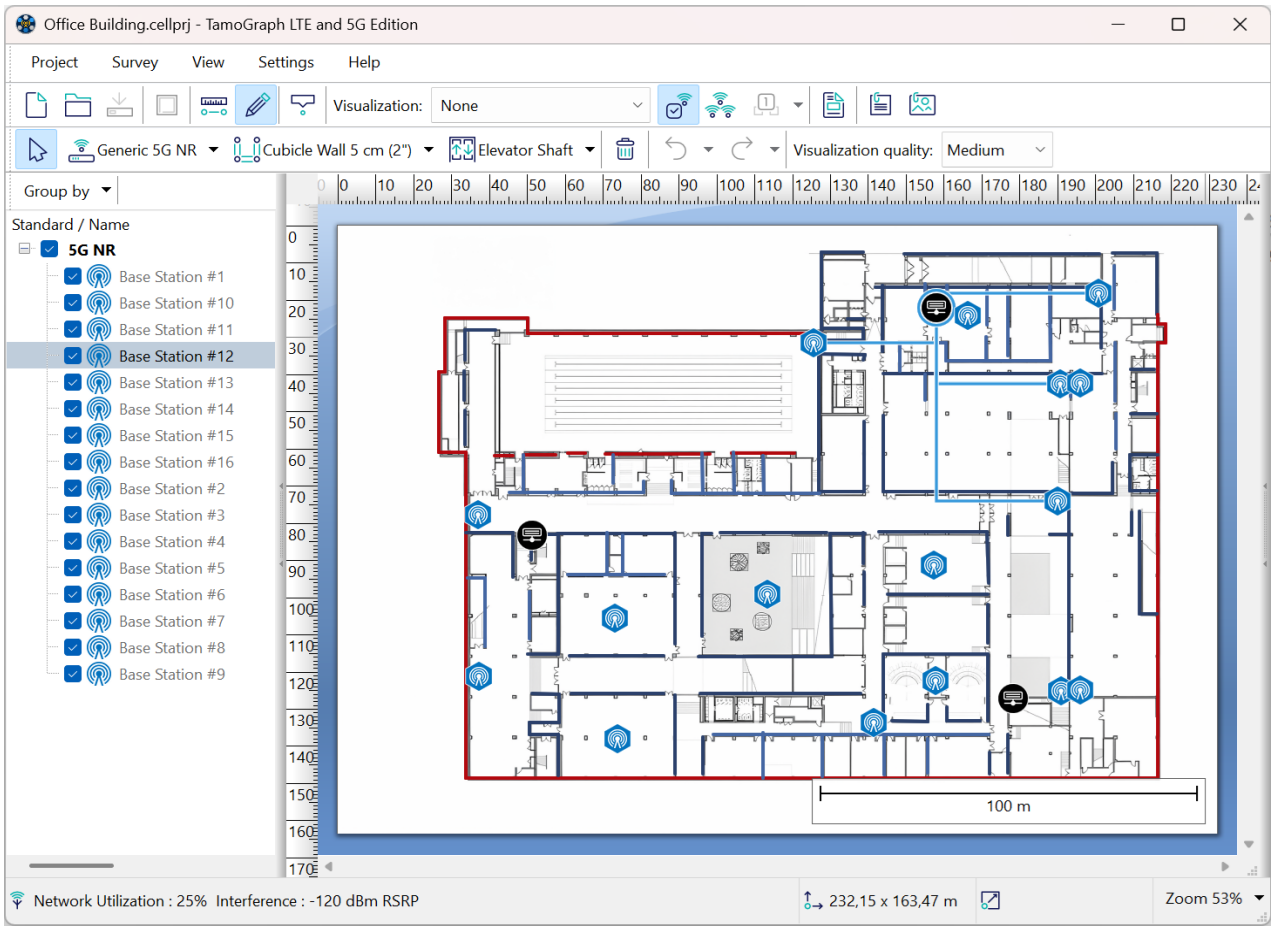
Modeling Your Cellular Network

TamoGraph is a tool for planning and analyzing the performance of 4G/LTE and 5G/NR networks that are yet to be deployed at a site. To achieve this, TamoGraph uses a virtual model of the site and radio equipment to simulate radio coverage. This process is called “RF predictive modeling” or “RF planning” (“RF” stands for Radio Frequency), since the characteristics of the future network are determined according to the virtual environment defined by the user. The virtual model includes walls and other obstructions, as well as virtual base stations placed by the user. In other words, it is a computer simulation. No on-site measurements are required.

> Simulating a cellular network is a computationally intensive process. A high-performance multi-core CPU and/or discrete GPU are recommended for improved performance.

Before you begin modeling, create a new project as described in this chapter if you haven’t already done so.

To create a virtual model of the environment, the user needs to “tell” the application about the position, size, and type of the physical objects that affect radio wave propagation. Typically, walls and other obstructions, such elevator shafts, are already shown on floor plans; however, these are merely lines and dots that are meaningless to the application. The user has to draw such physical objects on top of the floor plan and define their characteristics.



Before you begin, ensure that the RF Planner toolbar is visible (press the **RF Planner** button to unhide it). Now you are ready to start creating a virtual model.

It is recommended to begin by drawing walls. Once the walls have been drawn, you can place base stations on the floor plan, decide how many base stations you need to provide adequate coverage, select the best positions for them, and configure their parameters.

Once you have completed this process, you can analyze data. If you are a novice in cellular network design, we also suggest that you read about Best Practices, Tips, and Tricks at the end of this chapter.

Remember that the accuracy of your results depends on the data you enter into the model. Ensure that you collect full business and technical requirements before you begin RF modeling. Know what types and numbers of client devices will be used, where and what applications they will use, and whether there are any mission-critical client devices that you need to consider. In addition, consider possible future changes and upgrades.

Drawing Walls and Other Obstructions

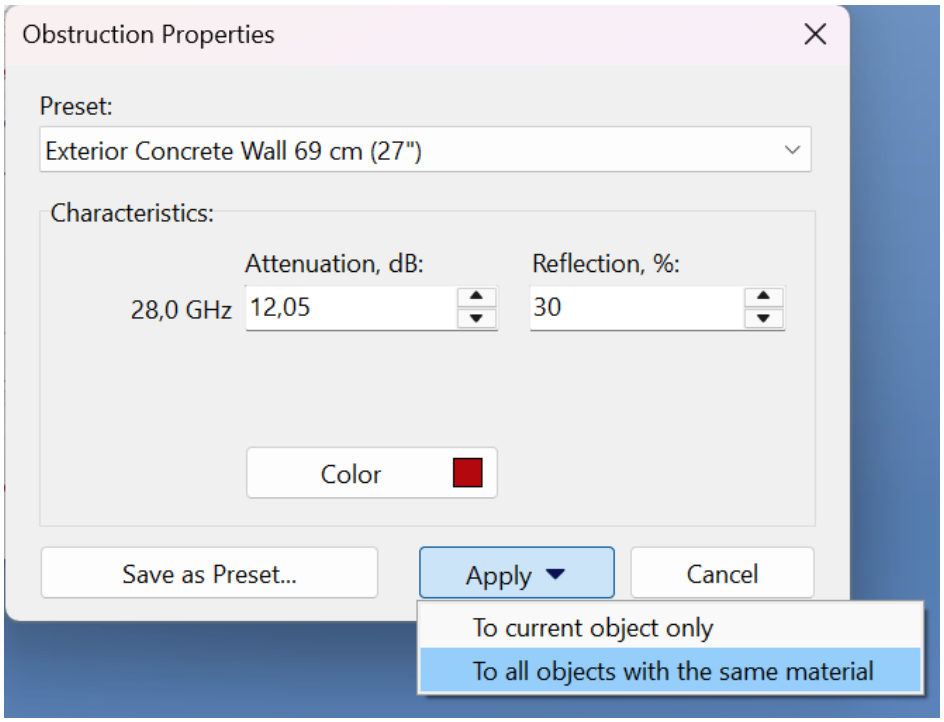
To draw a wall or other obstructions (e.g., doors or windows) on the floor plan, press the wall drawing tool button and select one of the pre-defined wall types, for example "Brick wall" or "Interior office window." You should select the type that best matches the actual wall you are going to draw. You can also select one of the two drawing modes: **Line** or **Polygonal path**. If you selected the **Line** mode, left-click on the floor plan to start a new wall and left-click once again in a new location to finish the wall. A straight line representing the wall will be drawn. If you selected the **Polygonal path** mode, left-click on the floor plan to start a new wall and left-click every time you need to start a new line segment. This will draw a connected series of line segments. If you hold the **Ctrl** key while drawing walls, the line is drawn in orthogonal mode (0, 90, 180, or 270 degrees). If you need to cancel the previous move, right-click on the shape and select **Undo Last Segment** in the context menu. To finish the wall, click on the last point or press the ESC key. You can move or resize the walls that you have drawn. To move a wall, select it and drag it with the left mouse button to a new position. To resize a wall or wall segment, select it, move the mouse over the vertex (shown as a white circle), click on it, and drag it with the left mouse button to a new position.

Please note that there is no need to redraw similar obstructions manually; you can simply copy and paste objects individually or in groups. For example, you can copy a set of walls, doors, and windows from one room and paste it to another. See Copying, Pasting, and Deleting Multiple Objects for more information

After the wall has been drawn, you can change its properties in the **Obstruction Properties** dialog. To display this dialog, double-click on a wall or select the **Properties** context menu item. In the dialog window, you can change the obstruction type by selecting one of the existing presets or modify obstruction characteristics such as attenuation, reflection, or color. **Attenuation** is a drop in strength measured in dB that the RF signal experiences when it passes through the obstruction. Because materials might attenuate differently at different frequencies, you may need to specify the obstacle material properties for other frequency bands. Note that by default, the material characteristics are defined using the frequency of the project's selected main band (Main band). You can change the project's main band in the **Properties -> Environment** panel. You can enter a custom attenuation value. **Reflection** is a percentage of signal strength that is reflected by the obstruction at the 90° angle. **Color** is an arbitrary color used to show the obstruction on the floor plan. If you prefer obstructions to appear colorless (i.e., grayscale), you can configure the application to grayscale them in the Visualization Settings panel. When you have edited obstruction properties, you can save the current configuration for future use by clicking the **Save as Preset** button at the bottom of the dialog window.

You can also select an existing preset, modify it, and click **Save** to save it under the same name. To save it under a different name, change the preset name before clicking **Save**. Click **New** to create a new preset from scratch. To delete an existing preset, click **Delete**.

Consider creating separate custom presets for each wall or door type in your project even if they match existing presets. This allows you to change the values or colors of all similar objects with a few clicks, as shown below:



Drawing Attenuation Zones

An attenuation zone is an area where the signal strength drops over distance. This makes it different from walls and other obstructions, where the drop occurs only one time, when the signal passes through a specific object, and where the object thickness is negligible. To draw an attenuation zone on the floor plan, press the attenuation zone drawing tool button and select one of the pre-defined attenuation zone types; for example “Elevator shaft” (there is also a zone type titled “Floor Area” that is not an attenuation zone per se; we will talk about this in the Working with Multi-floor Sites chapter). You should select the type that best matches the actual attenuation zone you are going to draw. You can also select one of the two drawing modes: **Rectangle mode** or **Polygon mode**. A rectangle is defined by its top left and bottom right corners; it is aligned vertically/horizontally and cannot be rotated. Polygons consist of multiple line segments, allowing more complex shapes to be created. If you selected **Rectangle mode**, left-click on the floor plan to start a new zone, drag the mouse to form a rectangle, and release the left mouse button to finish. If you selected **Polygon mode**, left-click on the floor plan to start a new zone and left-click every time you need to start a new line segment. This will draw a connected series of line segments. If you hold the **Ctrl** key while drawing, the line is drawn in orthogonal mode (0, 90, 180, or 270 degrees). If you need to cancel the previous move, right-click on the shape and select **Undo Last Segment** in the context menu. To finish the zone, click on the last point, or press the ESC key, or click **Done** on the info panel below the floor plan. You can move or resize the zone borders that you have drawn. To move a zone, select it and drag it with the left mouse button to a new position. To resize a zone or zone segment, select it, move the mouse over the vertex (shown as a circle), click on it, and drag it with the left mouse button to a new position.

After the zone has been drawn, you can change its properties in the **Attenuation Zone Properties** dialog. To display this dialog, select a zone and double-click on it, or select the **Properties** context menu item. In the dialog window, you can change the zone type by selecting one of the existing presets or modify zone characteristics such as attenuation or color. **Attenuation** is a drop in strength measured in dB per meter (or

foot, depending on the measurement units of your project) that the RF signal experiences when it moves across the zone. Because materials might attenuate differently at different frequencies, you may need to specify the obstacle material properties for other frequency bands. Note that by default, the material characteristics are defined using the frequency of the project's selected main band (Main band). You can change the project's main band in the **Properties -> Environment** panel. You can enter a custom attenuation value. **Color** is an arbitrary color used to show the zone on the floor plan. If you prefer zones to appear colorless (i.e., grayscale), you can configure the application to grayscale them in the Visualization Settings the panel. When you have edited zone properties, you can save the current configuration for future use by clicking the **Save as Preset** button at the bottom of the dialog window.

As with the material presets, you can select an existing preset, modify it, and click **Save** to save it under the same name. To save it under a different name, change the preset name before clicking **Save**. You can also click **New** to create a new preset from scratch. To delete an existing preset, click **Delete**.

Copying, Pasting, and Deleting Multiple Objects

While working on your RF model, you can copy multiple virtual objects and paste them to the current or a different floor plan. To select multiple objects, hold the **Ctrl** and left-click on each object you would like to add to the selection. Another click on the selected object removes the selection from the given object. Clicking anywhere outside the selection unselects all objects. Alternatively, multiple objects can be selected by drawing a frame, i.e. pressing and holding the left mouse button and dragging the mouse.

If multiple objects of different type are selected (e.g., base stations, walls), an additional panel is displayed below the floor plan. Using the checkboxes on that panel, users can control which type(s) of objects should be included in the selection. By default, all types of objects are included.

Once the objects have been selected, you can copy them to clipboard by pressing **Ctrl + C** or by using the **Edit => Copy** context menu item. Copied objects can be pasted to the same floor plan, a different floor plan within the same project, or even to a floor plan in a different project. To paste objects, use **Ctrl + V** or the **Edit => Paste** context menu item. You may need to adjust the pasted objects' positions after pasting.

To delete multiple objects, select them as described above and press the **Del** key.

Undo and Redo

TamoGraph keeps track of all the changes that you make to your RF model as you work. This allows you to roll back your model to any previous state within the current editing session. This function is useful if you make a mistake and want to undo a certain action.

To access this functionality, you can use the **Redo last operation** and **Undo last operation** buttons on the RF planner toolbar. These buttons contain drop-down menus that list all previously performed editing operations. You can also use the context menu commands, **Edit => Undo and Edit => Redo**, as well as the keyboard shortcuts: **Ctrl + Z** and **Ctrl + Y**.

Placing and Configuring Base Stations

To place a base station on the floor plan, press the base station drawing tool button and select one of the pre-defined base station types; for example, “Generic 5G NR” or “Generic Cat.A LTE Adv.” Click on the floor plan to place a base station in a desired location. After that, you can change its properties by double-clicking on the base station or by selecting the **Properties** context menu item. The **Base Station Properties** dialog can be used for loading base station characteristics from one of the presets, assigning a unique name to a base station, or for customizing base station characteristics.

To customize a base station, you can use two **Radio** tabs. Both radios can be either configured independently and use different standard and bands, or share the same band and/or standard. These tabs allow you to turn on and off these radios independently (using the **Radio enabled** check box) and configure the following characteristics for each of the two radios:

- **Standard**. Use this drop-down list to select one of the cell network standards.
- **Band**. Choose the appropriate frequency band that will be used by this radio.
- **Tx Power.** Opens the drop-down list for selecting the base station transmit power. The typical power of LTE base stations usually falls within the 20–30 W range. 5G base stations have a much wider range of power levels — from a few hundred milliwatts for small cells up to 120 W for large macro cells installed on outdoor towers and using MIMO antenna arrays. Since the transmit power depends heavily on the specific equipment used, refer to its documentation to set this parameter correctly.
- **Channel Width.** This parameter defines the channel width, and the available values depend on the selected **Standard** and **Band**. For LTE, the maximum available width is 20 MHz. For 5G, carrier aggregation can provide channel widths of up to 100 MHz in Sub-6 GHz bands and up to 400 MHz in the mmWave band.
- **Subcarrier Spacing.** Defines the subcarrier spacing in kilohertz. For LTE, this value is fixed at 15 kHz. For 5G, seven possible values are used depending on the selected frequency band. In the mmWave range, a spacing of 120 kHz or higher may be required.
- **CID.** Cell ID, a unique identifier of a specific cell on a cellular network.
- **TX/RX Streams**. Allows you to select the number of MIMO streams that can be used for transmission (TX) or reception (RX) by the base station equipment.

The **Duplex Mode** frame allows you to set a number of parameters the availability of which depends on the duplex mode for the given band: Frequency Division Duplex (FDD) or Time Division Duplex (TDD). This frame includes the following controls:

- **DL/UL Configuration** (available for TDD only). Sets the pattern that defines which symbols/slots are

used for downlink, uplink, or flexible. The available values are 0-6 for LTE and 0-55 for 5G.

- **DL/UL Channel** (available for TDD only). Sets the channel number to be used.
- **Flexible Symbol Policy** (available for 5G TDD only). Defines what flexible (F) slots are used for.
- **Subframe Configuration** (a.k.a DwPTS–GP–UpPTS configuration, available for LTE TDD only). It defines how Subframe 1 is split between DwPTS, GP, and UpPTS.
- **DL Channel, UL Channel** (available for FDD only). Sets the downlink (RX) and uplink (TX) channel numbers to be used.

The **PCI** frame allow setting the PCI identifier that is calculated using the formula PCI = (3 x SSS) + PSS, where:

- **PSS** (Primary Synchronization Signal) – the synchronization signal used for the initial detection of the base station. The value range is 0–2.
- **SSS** (Secondary Synchronization Signal) – used for final synchronization and obtaining the full cell identity. The value range is 0–335.

The **Advanced 5G** Settings frame allows setting some additional parameters of 5G networks:

- **SSB (Synchronization Signal Block) Beams**. Sets the number of directional broadcast beams that carry synchronization and system information (the SSB).
- **Max. phased array beamforming gain**. This parameter defines the signal gain achieved by using multiple antennas as a single phased array. The gain is directly dependent on the number of antennas used. Typical values for base stations in the Sub-6 GHz range are 8–10 dB. For mmWave, the gain can reach up to 22 dB. Experimental prototypes in this range demonstrate a gain of 26 dB when using a 32×10 array. Leave the value at 0 dB if this technology is not used.
- **3GPP 38.306 scaling factor**. Set the multiplier used for calculating a User Equipment's maximum data rate. It accounts for the difference between the maximum supported number of MIMO layers and modulation order and the actual configuration, ensuring a more realistic average data rate is calculated for a given band or band combination. It can take values of 1, 0.8, 0.75, and 0.4.
- **3GPP 38.214 table**. Sets the specific MCS table to be used.

The **Antenna** frame Use this frame to specify the kind of antenna used by the base station. The **Select** button opens the antenna selection dialog (overviewed below). With the **Rotation** control, you can specify the angle (in degrees) relating to the horizontal positioning of the antenna. With the **Elevation** control, you can specify the angle (in degrees) above the horizon, i.e., the angle by which the antenna is tilted up or down in relation to the theoretical horizon. With the **Tilt** control, you can specify the angle (in degrees) relating to the vertical axis, i.e., the angle by which the antenna is tilted sideways. The **Height** control can be used to specify the height of the base station above the floor level. The **Advanced** dialog provides top, front, right, and 3D views of the selected antenna diagram and can be used to adjust the antenna orientation either by rotating the diagram top, front, or right views or by entering numeric values.

When you have edited base station properties, you can save the current configuration for future use by clicking

the **Save as Preset** button at the bottom of the dialog window.

Antenna Selection

When you click **Select** in the **Antenna frame**, an antenna selection dialog is displayed. Using this dialog, you can choose from a variety of antenna models by a number of cellular network equipment vendors or one of the generic antenna types. Each listed antenna has a name, vendor name, and gain. By default, the available antennas are grouped as follows:

- **Recently Used** – antennas that you have recently used in your projects. Initially, this group is empty.
- **Generic Antennas** – standard antenna types that are not associated with a specific vendor.
- **Vendor Antennas** – antennas manufactured by major cell network equipment vendors.

Checking the **Group by Vendor** checkbox re-groups the list by vendor name. You can use the Quick search field to find antennas that match the search string. Note that the search is performed only for vendor antennas; recently used and generic antennas are always displayed.

Advanced users may want to add their own antenna patterns or edit existing ones by clicking the **New antenna** and **Edit current antenna** buttons, respectively. This will open the **AntEditor** utility. Please note that this is an experimental tool, and we do not provide official support for it. Please watch Using TamoSoft Antenna Editor to learn how to use this utility.

In addition, if you want to add a new antenna pattern for a specific base station and you cannot or do not want to do this yourself, just contact our technical support and we will add your antenna pattern to TamoGraph in a matter of days. Just ensure that the antenna radiation patterns (in graphical or numerical format) are publicly available (or available to you, in which case you should send them to us).

Adjusting Horizontal Antenna Orientation

Once a base station has been placed on the floor plan, you can change its horizontal antenna orientation without opening additional dialogs. To do that, select a base station with a mouse click; you will see a ring that surrounds the base station icon and a triangle-shaped marker that shows the direction of the antenna's main lobe. To modify the direction, hover the mouse over the triangle and, while holding the left mouse button pressed, drag the triangle to change the antenna's main lobe direction.

Naturally, this operation is advisable only if you are working with directional antennas, such as sector antennas. For omnidirectional antennas, rotating the antenna is not needed at all.

Creating Vendor-Specific Base Station Presets

As described in the previous chapter, TamoGraph allows for full customization of all virtual base station parameters. This functionality makes it possible to create virtual station presets that match actual hardware from major cellular equipment vendors.

Before we explain this procedure, we would like to answer one of the most frequently asked questions:

Why do you not add vendor-specific base station presets yourselves?

Indeed, TamoGraph includes only a few generic base station presets, because real-world hardware has many configurable parameters and only you know how your base station is or will be configured. It is impossible to cover the full variety of base station parameter configuration combinations in ready-made presets. Therefore, you, the network administrator, should create unique base station presets in accordance with your unique configurations. This is very easy. All base station presets consist of two parts:

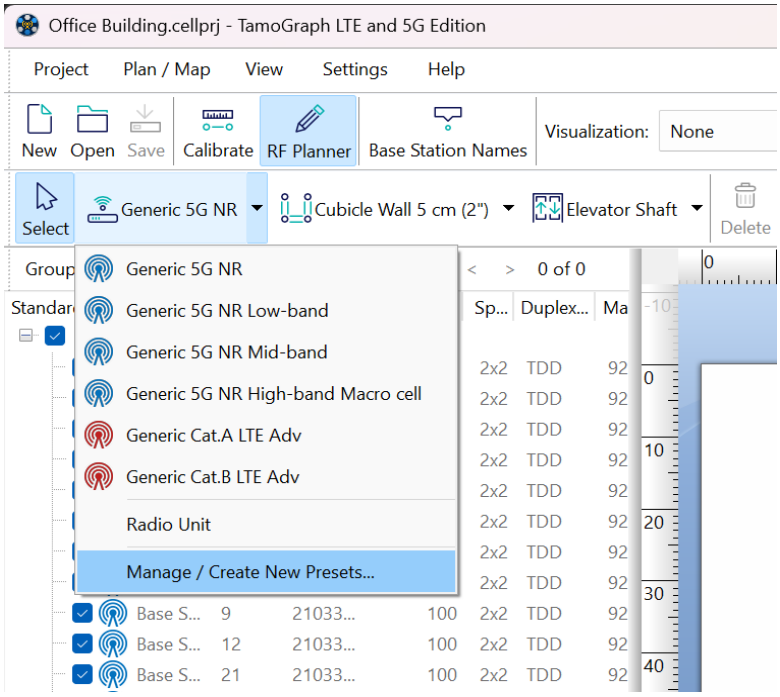
1. Base station configuration parameters (power, channel, installation height and angles, etc.)
2. Antenna preset.

This can be expressed by a simple formula:

`Base Station Preset = Base Station Parameters + Antenna Preset`

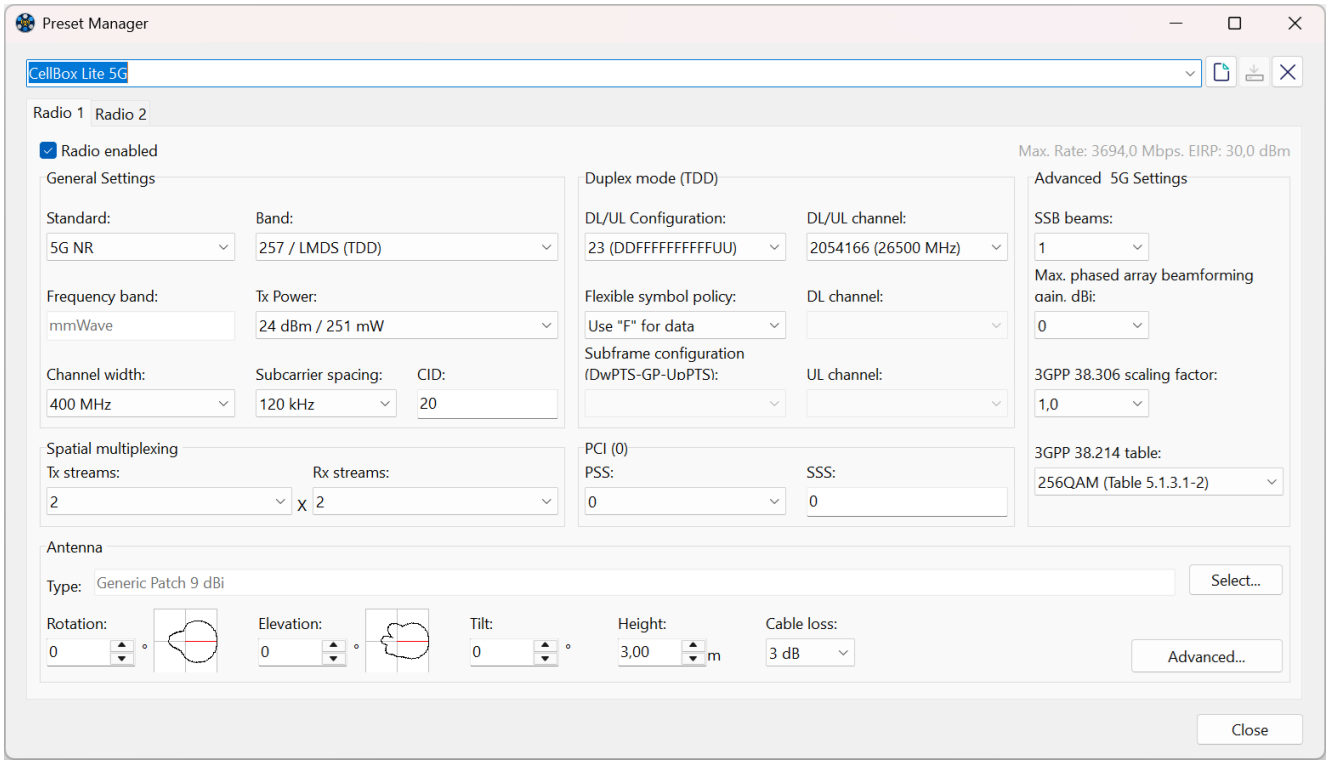
Yet another reason we do not add vendor-specific base station presets is that many outdoor base station models do not have integrated antennas. Instead, the user can select from a number of external antennas, which means that the same base station model may have multiple antenna options and, therefore, multiple presets.

To illustrate the process, suppose we want to create a preset for an indoor small-cell base station — for example, something like the Microamp CellBox Lite 5G operating in the mmWave band. First, click on the **Virtual Base Stations** button on the toolbar and select **Manage / Create New Presets**:



This opens the **Preset Manager** where you can modify all the base station parameters and change the antenna type. Select the **Generic 5G NR High-band cell** as the base on which we are going to build a preset

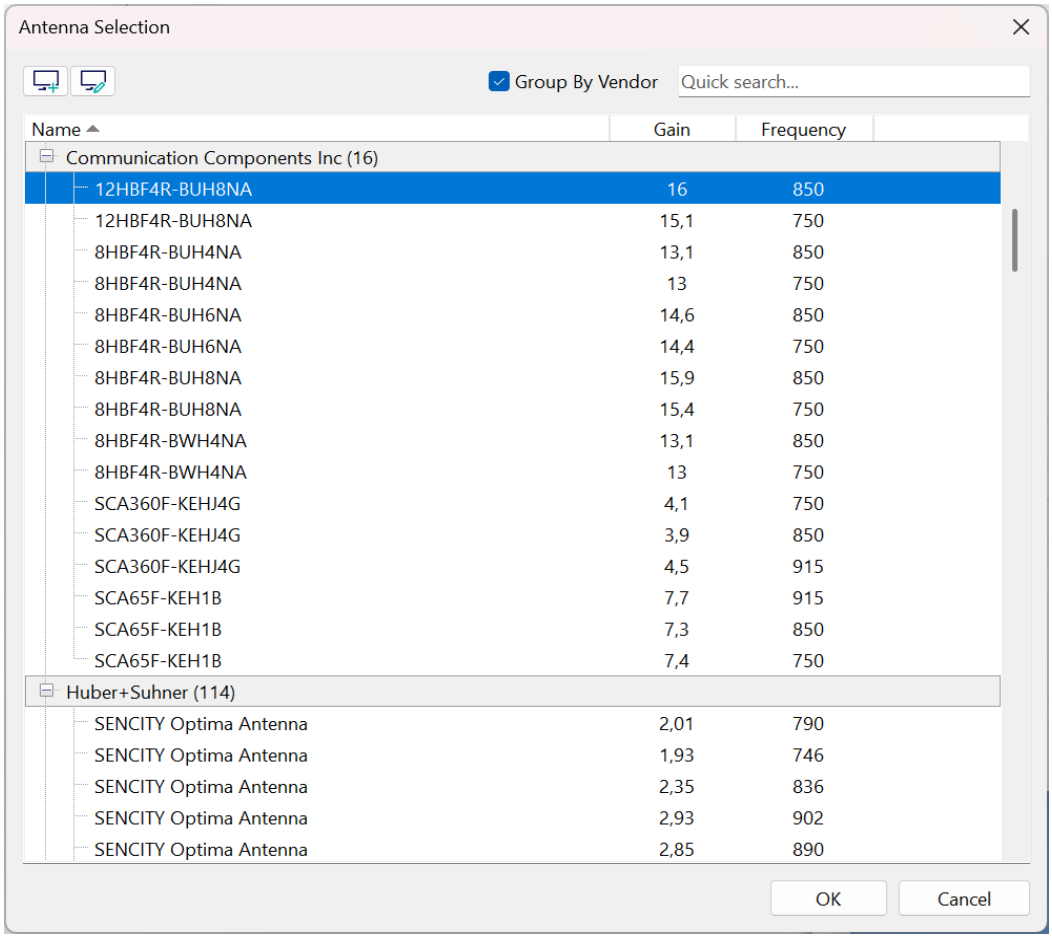
for the specific base station. The screenshot below illustrates a few changes we made to the default values for the radio to ensure that the virtual base station matches the real-world **CellBox Lite 5G** that we plan to deploy:



The following changes have been made:

- The Preset Name is changed to CellBox Lite 5G.
- The Tx Power set to 24 dBm.
- The channel width was set to 400 MHz according to specs.

To finish creating the preset, use **Select…** to choose an appropriate antenna. The program includes a large database of external antennas, primarily those used for outdoor deployments. In this case, our base station has a built-in antenna system that can be modeled by selecting the standard Generic Patch 9 dBi antenna. For base stations that use external antennas, you can choose the required model from the list provided, grouped by manufacturer:



If you cannot find a matching antenna, please refer to Antenna Selection, which lists a few options available to users.

You may want to click **Advanced…** to examine 3D views of the selected antenna diagram and to adjust the antenna orientation either by rotating the diagram views or entering numeric values.

Finally, clicking **OK** confirms the antenna selection.

Clicking **Save** saves the new preset. The preset is now available alongside the generic presets in the drop-down list. Managing base station presets is similar to managing walls or attenuation zone presets. You can select an existing base station preset, modify it, and click **Save** to save it under the same name. To save it under a different name, change the preset name before clicking **Save**. You can also click **New** to create a new preset from scratch. To delete an existing preset, click **Delete**.

DAS and Placing a Radio Unit (RU)

A Distributed Antenna System (DAS) is a network of antennas or RRUs (Remote Radio Units) connected to a single signal source (such as a mobile operator's base station) and deployed throughout a facility—such as a building, stadium, or airport—to distribute radio coverage evenly. This topology offers several significant advantages over traditional networks, including:

- **Improved coverage and signal quality**. Especially important inside buildings, in dense urban areas, underground structures, elevators, and parking garages. It eliminates "dead zones" where a standard operator signal is unavailable.
- **High capacity**. Supports a large number of simultaneous device connections without degrading performance.
- **Flexible placement**. Antennas can be positioned exactly where signal enhancement is needed, enabling flexible coverage design.
- **Scalability**. The system can be easily expanded as coverage requirements or facility size grow.

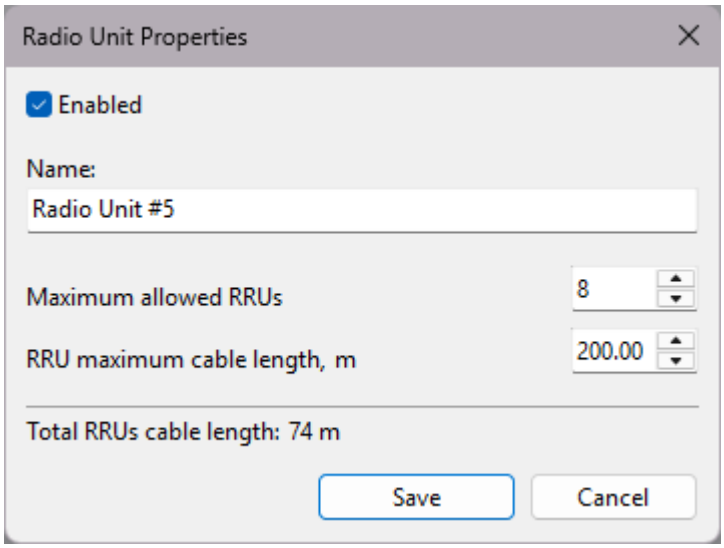
If your planned network uses any type of **DAS** architecture, you can model such a system in TamoGraph. To do this, add RU devices to the virtual model and place them on the map or floor plan. Click the arrow on the **Virtual Base Stations** button on the toolbar and choose **Radio Unit**. This activates RU placement mode, and by clicking on the map you can place one or more Radio Units.

When you are done placing Radio Units, click on the arrow button on the toolbar to finish the placement process.

You can then connect the previously placed base station units to specific RUs. To do this, right-click the desired RU and select **Add/Remove RRU**… The program will switch to the RRU add/remove mode. Then click on the base stations located near the RU to connect them. In this way**, a base station connected to the RU becomes one of its Remote Radio Units in DAS terminology**. Clicking the station again disconnects it from the RU.

For base stations connected to an RU, the program displays the possible cable routing path and calculates the minimum required cable length. Two cable-length calculation methods are available: **Shortest route** (straight line) and **Orthogonal** (routing along walls). You can choose the calculation method in **Properties → Environment → Cable laying method**. In the same panel, you can enable or disable **Cable length** control. This function prevents connecting stations to an RU if they are located farther than the maximum allowed cable length.

You can configure the maximum cable length and the maximum number of RRUs that can be connected in the properties of a Radio Unit. To do this, right-click the desired RU and select **Properties**. In the dialog shown below, you will also be able to rename the radio unit and check or uncheck the **Enabled** box. Unchecking the box excludes all the connected RRUs from visualizations.



Working with Presets

Presets are pre-configured sets of values for base stations, walls, and attenuation zones (and, additionally, for floors/ ceilings, if you work with multi-floor sites). Presets can be accessed via the **Manage Presets** menu item available in the corresponding drop-down menus for each of the three object types. At the top of the preset management dialog, you can see a drop-down list populated with existing presets. You can select an existing preset, modify it, and click **Save** to save it under the same name. To save it under a different name, change the preset name before clicking **Save**. You can also click **New** to create a new preset from scratch or delete an existing preset by clicking **Delete**.

Working with Multi-floor Sites

When a cellular network for a multi-floor building is being designed, the virtual model must take into consideration signal "leak" from the adjacent floors. This is important for two reasons. First, it is a common practice to provide connectivity to the adjacent floor by means of the base stations that are deployed one floor below or above. Second, if providing connectivity by this method is not planned, it is important to make sure that the signal that penetrates the floors does not cause interference. With TamoGraph, you can create and analyze multi-floor models as explained below.

Creating a Multi-floor Project

To create a multi-floor project, you should first follow the same steps that you follow to create a standard project; you must add a floor plan to the project and calibrate it. You can begin with the first floor. Once a standard project with a single floor plan has been created, you can use the Plans and Surveys tab on the right panel to manage floors and define their characteristics. Floors define the building's vertical structure. Floor maps within each floor contain images of the floor plans. Click **Add => Floor** to create a new floor level. If this is the first time you have added a floor to the project and the project already contains previously added floor plans, you will be prompted to move the existing floor plans to the newly created floor. You can also do this later, by dragging the floor plans to the new floor.

After that you can click **Add => Floor** again to create a new floor level. If the floor plans are identical for all the floors in your model, you can duplicate floors after drawing walls and other obstructions on the first floor plan and placing alignment points; this is described in detail below. If the floors are not identical, you should add individual floor plans images in one of the supported graphic formats for every floor by selecting the corresponding floor and using the **Add => Plan**… command. New floor plans must then be calibrated. Note that for each floor, you can add multiple floor plans that might have different scale and orientation.

Once the floors have been created and the corresponding floor plans have been added and calibrated, you should specify floor heights and a few other characteristics. New floors are added with default floor materials and heights; to specify correct values for your building, right-click on any of the floor items and select **Properties** or click on the **Floor Manager** button. You can also use this dialog to rearrange floors.

Use the **Add Roof** button to add a roof on top of all floors. You can specify the material reflection and attenuation of the roof in the **Floor/Ceiling Properties** window accessible via the **Modify…** button. Once you have defined the floor and roof properties, address floor plan alignment as explained below.

Aligning Floors

When you work with a multi-floor site model, TamoGraph can analyze radio signals that come from the adjacent floors. To be able to take advantage of this functionality, you need to perform floor alignment. Floor plan alignment is necessary because floor plans might have different scale, orientation, or offset. While floor alignment is not mandatory, TamoGraph will use only the data from the current floor unless you perform floor alignment. To perform it, please do the following:

- Right-click on the first-floor plan and select **Align Floor Plan**.
- Choose a few locations on the floor plan that will be easily identifiable on the plans of other floors. This could be elevator shaft corners, building corners, staircase corners, or anything else that you can easily find on all the floor plans that you use in the project.
- Click **Add point** to place a new marker on the floor plan, and then move the marker to one of these locations. Create at least two markers. Each marker is assigned a unique number. If you made a mistake, click **Delete point** or **Clear all**.
- Once you have placed two or more alignment markers, click **Apply**.
- Repeat this operation for all the floor plans that you would like to have aligned. The markers must be positioned exactly below or above the corresponding markers on the adjacent floor. For example, if marker #2 on the 5th floor is placed in the bottom right corner of the building, marker #2 must be also placed in the bottom right corner of the building on the floor plan of the 6th floor.

To check the current floor alignment status, select **Properties** or click on the **Floor Manager** button. The floors that are properly aligned are marked with a green checkbox. The floors that have not been aligned yet are marked with a yellow exclamation mark. Just like map calibration, floor alignment must be done only once.

Floor Duplication

If the floor plans are identical for some or all the floors in your model, you can simply right-click on the first floor and select **Duplicate Floor** to create a copy of the first floor with exactly the same floor plan. If the walls and other obstructions, their placement, and materials are identical for all floors, you can calibrate a single floor plan, draw walls, perform floor alignment as described above, and then use the **Duplicate Floor** command; that way, you will not need to recreate the same virtual floor model for every floor or align the floors, because duplication includes the walls and alignment points. You can select which object types should be copied to the new duplicate. By default, all objects except base stations will be copied.

Dealing with Complex Floor Structures

When you use a floor manager to specify the materials that separate floors, you assume that each floor is a contiguous piece of material that covers the entire floor plan area. However, there are cases that are more complex. For example, one can find buildings that have "holes" in the floors that span one or several stories. To deal with such virtual models, you should use the "Floor Area" drawing tool; it is grouped together with attenuation zones and can be found in the corresponding drop-down list on the RF Planner toolbar, next to the "Elevator shaft" or "Filing cabinet" items. Floor areas are drawn just like other attenuation zones, using **Rectangle** or **Polygon** mode. As soon as you have drawn the first-floor area on a given floor, the application will assume that the floor has a non-standard geometry and only those areas that are covered with "Floor area" contain floor material; areas that are not covered are considered free from any obstructions.

To avoid unnecessary clutter, floor areas are hidden by default. Their visibility can be turned on and off in the **View => Virtual Objects => Floor Areas** menu. We recommend hiding floor areas once you have completed the design of your virtual model. Additionally, for the sake of clarity, it should be mentioned that when you edit floor areas, you are editing the floor below your feet, not above your head. It should also be mentioned that the floor material and its properties are configured on the **Floor Manager**, as discussed in the previous chapters.

Zero Attenuation Obstruction Material

A special radio-transparent floor/ceiling material can be assigned to a floor to create additional levels where you need to visualize coverage but that do not have a physical floor or ceiling. Such levels can be useful when you have obstructions like storage shelves or partial walls whose height is lower than the ceiling, or when you need to analyze coverage at multiple levels above the floor in a tall warehouse.

Multi-floor Site Data Analysis

Data analysis for multi-floor sites is similar to data analysis methods for single-floor predictive models; they are described in the Analyzing Data chapter. However, there are some peculiarities that should be noted. In

addition to the signals from the base stations located on the floor being analyzed, TamoGraph will also analyze the signals that penetrate from the base stations located on the adjacent floors, taking into account their position, height above the floor, and the material of the ceilings. The base stations located on the adjacent floors are displayed on the base stations list (the left pane of the main TamoGraph window), but the names of such base stations are shown using a light gray font color. This allows you to identify the base stations that do not belong to the current floor. Note that you cannot change the properties of such base stations or delete them. If you want to change properties of a base station or delete it, first select the floor to which it belongs using the **Plans and Surveys** tab.

Best Practices, Tips, and Tricks

Designing cellular networks is a complex task that requires a solid understanding of the underlying technologies and design principles. That said, we would like to highlight a few simple guidelines and practical tips. This list is not intended to be comprehensive.

- Setting the base station's maximum available transmit power is not always justified. You should consider not only the capabilities of the base station itself, but also those of the client devices that will connect to it. These may be limited, low-power devices whose weak uplink signal the base station will not be able to receive reliably. Even if such devices can hear the base station well, stable communication will still be impossible. Another important factor is signal leakage beyond the intended service area. Excessive transmit power may be wasted "lighting up" adjacent sectors or even areas served by completely different networks, where your coverage is not planned. This does not improve the performance of your own network; on the contrary, it harms neighboring systems by creating unnecessary interference. Therefore, power selection should always be thoughtful and justified.

- Remember that even if your particular deployment prioritizes coverage over performance, channel selection still matters. A base station may only be able to output maximum power on specific channels—typically those near the center of the band.

- Although RSRP provides a more accurate picture of signal quality than RSSI, it does not, by itself, fully describe the network's quality or availability. This metric primarily reflects signal penetration and can be reported down to –140 dBm. However, the actual communication quality is determined largely by the signal-to-noise ratio, and in most cases, you will not achieve stable service where RSRP is below –110 dBm. When analyzing the network, make sure to use additional visualizations, such as SINR to assess interference, and Uplink/Downlink Rate to evaluate performance in conjunction with the selected client equipment.

- It is common practice to deploy base stations with multiple radios operating in different bands, and TamoGraph can model such configurations. When placing them on the plan and using visualizations, ensure that you select the intended stations for display. With equal transmit power, a radio operating

in a lower-frequency band will have wider coverage. Since most visualizations display the strongest base station, the signal from a second radio configured for a higher-frequency band may not appear on the map. To evaluate the coverage of radios operating in higher-frequency bands, temporarily exclude the others from the visualization.

- If in doubt, you can create several copies of the same floor using different base stations and antenna models and see which results best suit your requirements and budget.

Analyzing Data

When you have created a virtual environment model, the application is ready to display a number of network data visualizations that will help you determine important characteristics of your cellular network, such as signal coverage, and detect potential performance problems.

Selecting Data for Analysis

Three key interface elements affect what data will be analyzed and how. These elements are overviewed below.

The **Plans and Surveys** tab on the right panel defines what data the application will visualize. This tab is organized as a hierarchical tree. First of all, you need to select the floor plan to be analyzed. This floor plan will be displayed in the central area of the program, and you will be able to overlay various visualizations on it. You can add a custom comment to each plan or map, which will be shown in the Comments column of the tree.

The **Visualization** drop-down box on the toolbar defines what type of analytical tool will be applied to the selected site plan. A visualization is a graphical representation of cellular network characteristics displayed as an overlay on top of the floor plan. The available visualization types will be described below. To select a visualization, simply select the corresponding item from the drop-down list. To clear all visualizations, select **None**.

The **Selected Base Stations** / **All Base Stations** buttons on the toolbar, along with the base station list, determine which subset of listed base stations is used for visualizations. The default mode is **Selected Base Stations**, in which TamoGraph analyzes only the signals originating from the base stations you selected in the list on the left panel.

Base Station Rank and Secondary Coverage

Modern cellular networks are usually designed to meet stringent capacity, flexibility, and fault tolerance requirements. One of the most widely used methods of ensuring fault tolerance and, at the same time, increasing capacity, is providing secondary coverage. In 5G networks, this is often a 4G connection that acts as a secondary node alongside a primary 5G node, providing wider coverage and control while the 5G node adds capacity. Base stations are positioned so that in case of failure or overload, no client is left without connection, as nearby base stations can service the zone. An additional benefit is fast and more reliable roaming.

To facilitate analyzing non-primary coverage, TamoGraph offers the **Base Station Rank selector** that can be found on the application main toolbar. By clicking the **Base Station Rank button**, you switch the visualization from the primary coverage (the strongest base station) to the secondary (the second strongest) and then to the tertiary (the third strongest) coverage. For example, to see the signal level provided by the second-strongest base station in a given location, you need to select the **RSRP** visualization and click the **Base Station Rank** button once, so that the square “2” is highlighted. If you click the **Base Station Rank** button repeatedly, the rank is switched cyclically, i.e. 1-2-3-1…, and so on. If you need to select a specific rank without going through the full cycle, use the menu that can be invoked by clicking on the arrow to the right of the button.

Visualization Quality

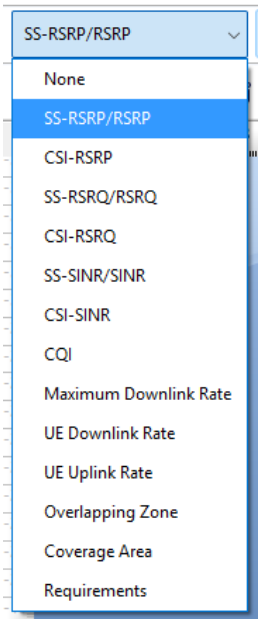
You can control the **Visualization quality** by using the corresponding control on the toolbar. Visualization quality is an important parameter that defines how precise the calculations are. High-precision calculations come at a cost: the higher the precision, the longer the computation time. The application offers four quality presets: **Low, Medium, Good,** and **Best**. They differ in grid size and in applying advanced RF propagation effects, such as reflection and Fresnel zones. We suggest that you use **low** or **medium** visualization quality while you design your cellular network and make adjustments to your design. When the design is ready, you can use **good** or **best** visualization quality for the final verification and/or report generation.

> Calculating RF propagation is a very CPU-intensive task that might take a long time for large floor plans with many base stations. A high-performance multi-core CPU and/or discrete GPU are recommended for improved performance. It is also recommended that you split large floor plans into smaller parts if computing visualizations takes too long.

Visualization Types

The following chapters describe different visualization types and the configuration settings that affect them. They will also help you interpret the data and suggest solutions to problems with cellular network coverage and performance.

Understanding Difference Between SS and CSI Visualizations



For analyzing 5G networks, two sets of **RSRP, RSRQ**, and **SINR** visualizations are available: **SS** and **CSI**. The **SS (Synchronization Signal)** set applies to the broadcast synchronization signals from a cell, used for initial cell discovery and basic mobility. In contrast, the **CSI (Channel State Information)** visualizations apply to CSI-RS, which are more flexible and configurable signals used for advanced features such as beam management and accurate throughput estimation, as they can be adapted to reduce interference. Essentially, SS is a general indicator of a cell's signal, while CSI provides a more specific, quality-focused measure of the channel.

For 4G networks, there are no separate SS and CSI metrics; i.e. there is only one RSRP rather than SS-RSRP and CSI-RSRP. So the "**SS-RSRP/RSRP**" visualization displays **SS-RSRP** for 5G networks and **RSRP** for 4G networks.

RSRP

RSRP, or Reference Signal Received Power, is a measure of the power of the reference signal from a cell tower in cellular networks. It indicates the strength of the signal received by a device and is measured in dBm, where a higher number (closer to zero) means a stronger signal. A higher RSRP leads to better network quality, faster speeds, and a more stable connection.

Higher value means better service quality. A value closer to -44 dBm or above is a very strong signal, while a value closer to -140dBm is a very weak signal.

Signal strength is affected by the distance: The closer the measuring point is to a base station, the stronger the RSRP will be. Obstructions such as buildings, trees, and other physical obstacles can weaken the signal, leading to a lower RSRP. A higher number of users on the network (high network load) can also impact signal quality.

Double-clicking on the RSRP legend on the status bar allows you to configure the color scheme and change its value range.

Suggested Solutions

When low signal areas are discovered, the following solutions are suggested:

- Change base stations' locations: You should minimize the number of obstructions between the base station and the low RSRP zone. Additionally, the material of the obstructions plays an important role; for example, the attenuation factor of a brick wall far exceeds that of a cubicle wall or window.
- Add more base stations: Sometimes repositioning base stations does not provide the desired effect, and the option becomes installing additional base stations in the problematic areas.
- Use a different antenna: A high-gain antenna (if your base station supports the use of such antennae) directs radio signal in the desired direction, thereby increasing the signal level in some zones and decreasing it in the others.
- Increase output power: Adjust the power output of base station radio if possible.

RSRQ

RSRQ, or Reference Signal Received Quality, is a cellular signal metric that measures the quality of the signal, indicating the level of interference and noise relative to the desired signal from the cell tower. It is calculated using the received signal strength from the reference signal (RSRP) and the total received signal power (RSSI). It is measured in decibels (dB), with values closer to 0 dB representing a higher quality and stronger signal, while more negative values indicate poorer quality. An excellent RSRQ is typically greater than -10 dB, while a poor RSRQ is less than -20 dB and can lead to connection loss.

While RSRP measures signal strength, RSRQ provides a more complete picture by factoring in interference and noise from neighboring cells and other sources.

Double-clicking on the RSRQ legend on the status bar allows you to configure the color scheme and change

its value range.

Suggested Solutions

To improve low RSRQ, you either clean up interference (tilt, power, azimuth, reuse, extra sites) or relieve load (offload traffic, add capacity) so that the UE sees a strong serving signal with less “garbage” in the same bandwidth.

- Reduce interference from neighboring cells. Interference is the most common cause of poor RSRQ. Improve it by adjusting antenna tilts or azimuths so sectors do not overshoot or overlap aggressively. If a particular sector is the dominant interferer, slightly reducing its transmit power can noticeably clean up RSRQ in the affected area. Using different carriers or bands for congested or overlapping sectors also helps.
- Fix coverage holes and imbalanced footprints. Poor RSRQ often appears where coverage is weak and the UE is “hanging on” to a far cell. Adding small cells, indoor systems, or repositioning antennas gives users a stronger, cleaner serving signal.
- Reduce cell load and PRB utilization. Even with good RF design, high utilization in a cell degrades RSRQ because the UE sees more interference across the full bandwidth.

SINR

SINR, or Signal-to-Interference-plus-Noise Ratio, is a cellular metric that measures the quality of a received signal by comparing its power to the combined power of all interfering signals and background noise. A higher SINR value indicates a stronger, clearer signal and better data speeds, while a low or negative value (below -10) suggests that the signal is poor or nonexistent, leading to slow speeds and potential disconnections. This is calculated as the ratio of the desired signal power (S) to the sum of interference power (I) and noise power (N).

SINR directly affects achievable data rates. It tells you how well the UE can decode data, factoring in both signal and interference.

Double-clicking on the SINR legend on the status bar allows you to configure the color scheme and change its value range.

Suggested Solutions

When low SINR areas are discovered, consider the following:

- Increase Signal Strength: Proper antenna positioning, deploying additional cells, and boosting transmit power can enhance the desired signal.
- Reduce Interference: Use interference management techniques (e.g., ICIC, beamforming, interference cancellation), optimize network planning, and reduce cell overlap.
- Reduce Noise: Implement noise reduction strategies and optimize power control to minimize

environmental noise.

- Advanced Antenna Systems: Utilize MIMO, beamforming, and adaptive antenna systems to improve spatial separation and reduce interference.

CQI

CQI stands for Channel Quality Indicator, a value reported by a user's device to a cellular network's base station to describe the quality of the wireless channel. This feedback helps the base station optimize data transmission by selecting the most efficient modulation and coding scheme (MCS) to balance speed and reliability. A higher CQI value signifies better channel quality and allows for a higher data rate, while a lower value indicates poorer conditions that require more robust, but slower, transmission settings.

The UE converts this quality into a specific CQI value, typically on a scale from 1 to 15. CQI is crucial for optimizing data throughput and reliability in modern cellular systems.

Double-clicking on the CQI legend on the status bar allows you to configure the color scheme and change its value range.

Suggested Solutions

When low CQI areas are discovered, consider the following:

- Increase signal strength (RSRP) by optimizing coverage, deploying small cells, and improving antenna designs.
- Reduce interference through proper cell planning, interference coordination, and advanced techniques like eICIC and beamforming.
- Improve SNR by using adaptive power control and noise reduction techniques.
- Leverage advanced antenna technologies like MIMO and beamforming.
- Improve modulation and coding schemes for higher data rates and better CQI.

Maximum Downlink Rate

Maximum Downlink Rate refers to the highest data transfer rate that can be achieved in the downlink (from the base station to the mobile device) in a cellular network. This rate is a key indicator of network performance, particularly for users consuming data-intensive applications like video streaming, file downloads, or web browsing.

The maximum downlink rate depends on a combination of factors, including standard (e.g., LTE, 5G), available bandwidth, signal quality, available modulation schemes, coding schemes, and network load. The rate is expressed in megabits per second (Mbps).

This metric depends only on base station capabilities. It does not take into account UE. If you need to analyze throughput depending on specific user equipment, choose **UE Downlink Rate** or **UE Uplink Rate** visualizations.

Double-clicking on the Maximum Downlink Rate legend on the status bar allows you to configure the color scheme and change its value range.

Suggested Solutions

When low expected PHY rate areas are discovered, you should focus on:

- Increasing available bandwidth (via Carrier Aggregation or moving to mmWave band with huge channel width).
- Leveraging advanced MIMO techniques (like massive MIMO and beamforming).
- Optimizing modulation and coding schemes for higher efficiency.
- Reducing interference by managing channel assignment.
- Improving network load management with load balancing and small cells.

UE Downlink/Uplink Rate

The UE (User Equipment) Downlink/Uplink rate refers to the data transfer rate that the user device (such as a smartphone, tablet, or IoT device) can achieve when receiving data from the cellular network. This rate is a critical performance metric that directly impacts the end-user experience in terms of network activities like video streaming, web browsing, downloads, and other data-intensive tasks.

The rate is expressed in megabits per second (Mbps) and depends on both: base station and UE capabilities and network conditions.

> When calculating UE rates, TamoGraph relies on the UE Capabilities settings, which may be more limited than the base station's capabilities. If the UE's capabilities are inferior, for example, if certain MIMO modes or modulation schemes are not supported, the maximum data rate supported by the base station will not be achievable. Please refer to the description of UE Capabilities for more information.

Double-clicking on the UE Downlink/Uplink Rate legend on the status bar allows you to configure the color scheme and change its value range.

Suggested Solutions

When low UE Downlink/Uplink areas are discovered, first consider recommendations given for the Maximum Downlink Rate visualization and also consider:

- Upgrade your clients to ensure the UE supports modern features like higher MIMO modes, 5G,

mmWave band and advanced modulations for maximum performance.

Overlapping Zone

Overlapping zone represents the areas where the coverage from multiple base stations or cells overlaps. This occurs when the coverage areas of two or more neighboring base stations extend into the same geographic area. This is common behavior because it ensures continuous coverage as users move between cells, supporting handover between cells to maintain a seamless connection. Overlapping zones play a key role in managing network capacity. If one base station is overloaded, the network can offload some of the traffic to the neighboring base station, improving overall network performance.

However, the overlapping area also introduces some challenges, such as potential interference and the need for coordination between the cells to optimize user experience.

In TamoGraph, the Overlapping Zone visualization shows how many base stations provide coverage at each point on the map. It takes into account the PCI assigned to each base station, allowing you to assess how these overlaps will be perceived by client devices.

Suggested Solutions

If you discover unwanted coverage overlaps or, conversely, want to expand such overlap zones in locations where additional capacity is important, try the following:

- Experiment with the placement of base stations on the floor plan and with their installation height.
- Use directional antennas instead of dipole antennas. This allows you to fine-tune the coverage sector more precisely.
- Evaluate the required base-station transmit power. This is a case where reducing power can help you manage overlap zones more effectively.
- Check the assigned PCI identifiers. They determine how UEs distinguish signals from different stations within an overlap area.

Coverage Areas

This visualization shows the areas covered by the base stations. An area is considered covered if the signal is strong enough for the clients to communicate to the base station. You can select and deselect one or several of the base stations to see individual or group coverage areas. Coverage areas are color-coded: For each base station, a small colored square is shown next to the base station icon. The corresponding color is used to display the coverage area contour or fill.

The definition of "strong enough" is rather subjective because certain signal strength might be sufficient for low data rates, but insufficient for the high data rates required for performance demanding applications. Additionally, UE vary in sensitivity, and some clients might be able to provide good connectivity in zones where others fail to connect altogether.

The following options on the Visualization Settings panel (located on the Options tab of the right-side panel) affect the way coverage areas are analyzed and visualized:

- **Base station coverage areas** – this allows you to change the color-coding method used for displaying coverage areas. In **No fill, contours only** mode, the application draws contours of the coverage areas without filling the areas with colors. In **Fill and mix colors** mode, base station coverage areas are filled with colors; when areas overlap, the application draws a striped pattern, alternating the colors of the respective base stations. In **Fill, the strongest base station on top** mode, base station coverage areas are filled with colors; when areas overlap, the application draws the color of the strongest base station. In **Fill, the weakest base station on top** mode, base station coverage areas are filled with colors; when areas overlap, the application draws the color of the weakest base station.

Requirements

This visualization shows what requirements set by the user are met. The Requirements panel (located on the Properties tab of the right-side panel) allows the user to set thresholds for key cellular network parameters:

- Minimum RSRP (shown as **RSRP** on the legend)
- Minimum RSRQ (shown as **RSRQ** on the legend)
- Minimum SINR (shown as **SINR** on the legend)
- Minimum CQI (shown as **CQI** on the legend)
- Minimum base station downlink rate (shown as **BS**↓ on the legend)
- Minimum UE downlink rate (shown as **UE**↓ on the legend)
- Minimum UE uplink rate (shown as **UE**↑ on the legend)

The zones where the requirement is not met are marked with the corresponding legend color. If more than one requirement is not met, only one color will be used (priority is given to the requirements closer to the top of the list). If multiple base stations are required, the strongest base station will be checked against the requirement list. If all the requirements are met, no color overlays will be displayed.

The meaning of the requirements listed above is explained in detail in the preceding sections of the Analyzing Data chapter.

Double-clicking on the "Requirements" legend on the status bar allows you to configure the color scheme and change its value range.

Reporting and Printing

After performing a site survey and viewing its results in the main application window, you can create a report that contains all the information and visualizations related to your survey. To configure the report options and generate a report, click Project => Generate Report in the main application menu.

The report generation dialog allows you to configure the following report options:

- **Plans and Surveys**. This frame lists the available floor plans to be included in the report. By default, the selection of floor plans is the same as in the main application window. At the bottom of this frame, you can also see the indication of the **Current Base Station selection mode**, which tells you if the report will be generated for all or for only the selected base stations. Again, the selection is the same as in the main application window. If you want to change the base station selection mode, close the report dialog and change the mode, using the corresponding buttons on the toolbar of the main window.
- **Project information**. Use the **Surveyor**, **Location**, and **Description** fields to specify additional information about your project.
- **Visualizations**. This list allows you to select which visualizations you would like to see in the report by checking or unchecking the corresponding boxes. Check **Map with no visualizations** if you would like to have the original site map / floor plan included. **Add per-BS visualizations** is an important option that allows you to add additional visualizations for each of the selected base stations. For example, if you want to create a report for five base stations and include the **RSRP** visualization with the **Add per-BS visualizations** option, the report will contain one cumulative **RSRP** visualization for all the five base stations and, additionally, five separate visualizations for each of the base stations. Without the **Add per-BS visualizations** option, the report will contain only one cumulative signal level visualization that includes data on all the five base stations.

  You can also add visualizations for secondary and tertiary coverage, i.e., coverage provided by the second- and third-strongest BS. To do that, you should click on the rectangle to the right of the visualization type. The rectangle displays the **BS rank(s)** to be included into the report: **1** for the default, standard visualization, where the metrics are shown for the strongest base station, **1+2** for the strongest and second-strongest base station, and **1+3** for the strongest and third-strongest base station. For more information, see Base Station Rank and Secondary Coverage.
- **Additional items to include**. Check the corresponding boxes to include additional information pertaining to your site survey. Checking **Base station list** will add the table that lists all the base stations and if a DAS architecture is used, the table will also include an estimate of the required cable lengths for connecting each base station; checking **Map descriptions** will add the descriptions (if any) of the floor plan(s) entered by the user; checking **Virtual Obstructions** will display virtual obstructions, such as walls or attenuation areas, on the floor plan. Checking **Media Objects** will add images and notes you might have added to the project.
- **Output settings**. Use the **Format** drop-down list to select the report format. You can choose between **PDF**, **ODT** (OpenDocument Text format that you can edit in **Microsoft® Word** or **OpenOffice**), **HTML**, **HTML (single file).** The difference between the **HTML** and **HTML (single file)** is that in the former, images are stored in a separate subfolder, whereas in the latter, images are embedded into a single

.MHT file, which can be natively viewed only in Microsoft Internet Explorer. The **Paper size** drop-down list can be used to specify the size of the report pages: **A4**, **A3**, or **Letter**. You can also select a **Page orientation**: **Portrait** or **Landscape**. If you generate reports in **PDF** format, you can control the **JPEG quality** (the higher the quality is, the larger the file size will be) and the **Embed fonts** option. Embedding fonts increases the output file size considerably, but ensures that the file looks correct on any system, even if the fonts used in that file are not installed.

- **Object size factor.** Depending on the floor plan dimensions and report page size, the objects in the report, such as base station icons, may appear too small or too large. Although the application tries to compute the best icon size for the given combination of plan dimensions and page size, you may want to adjust the object size manually by using this control.
- **Language.** This control allows selecting the report language that does not necessarily match the language of the application user interface. For example, if the TamoGraph UI is English, you can generate a report in German. Currently, only English is supported.

Once you have configured all the options, you may want to customize its look (fonts, colors, logos, etc.) by clicking **Customize** and then clicking **Save** to select the file name and have TamoGraph generate the report. Check the **Open report after generation** box to have the file opened by the associated viewer upon generation. If you would like to print the report without saving it to a file, click **Print**. Alternatively, you can first save the report and then print it from the associated viewer (Adobe Acrobat in the case of PDF files or your favorite browser in the case of HTML files).

Customizing Reports

The report customization dialog can be accessed by clicking the **Customize** button and checking the **Enabled report customization** box. By using the customization functionality, you can change text colors, fonts, logos, or add additional text to PDF or HTML reports.

The following customization elements are available:

- **Heading #1** and **Heading #2** – use these fields to modify the default report heading and subheading on the first report page.
- **Footer** – use this field to modify the default footer text that is placed at the bottom of every report page except the first one.
- **Additional summary row** and **Additional summary text** – use these fields to add a row to the report summary located on the first page.
- **Logo** – this element allows you to replace the default logo on the first page. You can select an image in any common graphic format.
- **Colors** – use this frame to set custom colors. #1 is for the heading on the first page; #2 is for other headings; #3 is for the background of the tables; #4 is for the table heading text color; #5 is for the main text color.
- **Fonts** – use this frame to modify the default fonts. #1 is for the heading font; #2 is for the main text font.

Additionally, you may want to **Add a page before the report** and/or **Add a page after the report** by checking the corresponding boxes. Clicking **Edit** opens an editor window where you can enter and format any text and specify the headings for the additional pages.

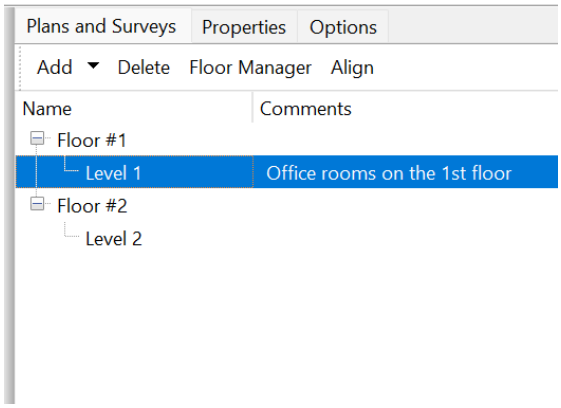
To apply the new settings, click **OK**. To restore the default settings, click **Default**.

Configuring TamoGraph

Virtually all of the application and project settings can be configured using the right-side panel (if the panel is hidden, click **View => Right Panel** or click on the central part of the right splitter to have it displayed). This panel includes three tabs whose functionality is described below in detail.

Plans and Surveys

This tab displays a hierarchical list of the project floor plans or site maps, as shown below.



This list is an important tool that allows you to add, rename, or delete floors (for multi-floor projects) and floor plans / site maps. The project hierarchy consists of floors, floor plans. The top hierarchy level is a floor, which contains one or several floor plans. Adding a floor is optional. Your project does not necessarily have to have the top-level floor node; when you create a new project, a floor level is not automatically created, and your floor plan becomes the top-level node. To add a new floor, click **Add => Floor**. To add a new plan, select the floor you want to add the plan to and click **Add => Plan** or **Add => Street map**, if you want to import a map from one of the online map services. To move a plan and related surveys to a newly created floor, simply select the plan with the mouse and drag it to the corresponding floor node. You can also use the context menu commands to Rename or Delete floors and floor plans.

You can use the **Comments** column to add or modify comments for floor plans. The **Floor Manager** is a tool that may be used in multi-floor predictive models; more information can be found in the Working with Multi-Floor Sites chapter.

Properties

Using this tab, you can configure the project properties. It includes the following panels: **Plan / Map**, **Environment**, **UE Capabilities**, and **Requirements**. You can collapse or expand panels by clicking on the arrow button on the right-hand side of the panel.

Plan / Map

The **Plan / Map** panel can be used for editing the floor plan **Map name**, adding **Description/Comments** to the plan, and adjusting the image brightness and contrast, if the floor plan is too bright, too dark, or lacks contrast. If the floor plan image is colored, you may want to check the **Discard color information** box to convert it to grayscale, as grayscale images give you a clearer picture when overlaid with data visualizations.

Environment

The **Environment** panel allows you to configure some of the very important project parameters that affect the way data visualizations are computed.

Because different environments have different characteristics in terms of signal attenuation, diffraction, reflection, etc., you are asked to **Select an environment** from the list. You should select the environment that best describes the site being surveyed.

The **Main Band** parameter specifies the frequency band that will be used by default when working with this project.

The **Interference** slider sets the level of external interference at the site. This is used to account for noise not directly related to the network being designed.

The **Network Utilization** slider defines the average network load. The percentage should correspond to typical, not peak, load conditions.

The **Measurement units** control can be used to choose the preferred units (feet or meters) for displaying distances and coordinates throughout the application.

Finally, **Cable laying method** determines how the required cable length for base stations is calculated. The **Cable length control** switch enables or disables the function that prevents placing base stations at a distance that clearly exceeds the maximum allowable cable length.

UE Capabilities

This section of settings is used to define the characteristics of the client equipment (formally referred to as user equipment, UE). These characteristics determine the client's capabilities and are primarily used for the **UE Downlink/Uplink Rate** visualizations, as well as in the **Requirements** visualization.

Client equipment does not always support all the features provided by the base station. This may relate to supported modulation schemes or, for example, the number of MIMO streams. All of this affects the maximum performance available to the client. The **Capabilities** section is designed to simulate such client equipment. This allows you to view network performance from your clients' perspective and potentially identify bottlenecks in both base-station configuration and placement.

You can save UE settings as presets for future use. To do this, assign a name to the settings and click **Save preset**. Later, the saved preset can be loaded by selecting it from the drop-down list.

Because the 4G/LTE and 5G standards differ significantly in configuration options and the variety of client devices, TamoGraph provides two separate sets of UE Capabilities settings—one for each standard.

UE Capabilities 4G LTE

Tx/Rx streams specifies the number of supported MIMO streams for transmission and reception, respectively.

Max transmit power defines the maximum transmit power of the client radio.

The three switches at the bottom of the panel specify the client's ability to support modern modulation schemes such as **64QAM** and **256QAM**

UE Capabilities 5G NR

The UE Capabilities panel for 5G has two sections for the Sub-6 GHz (FR1) and mmWave (FR2) bands. The set of available parameters is identical for both sections:

Tx/Rx streams define the number of MIMO streams supported for transmission and reception, respectively.

Max. DL/UL BW specifies the channel bandwidth in MHz for each transmission direction.

EIRP sets the transmit power of the client radio.

As in 4G, both bands share a set of switches that control support for modern modulation schemes such as 256QAM.

Finally, at the bottom of the panel, the user can specify the **Beamforming gain**. This parameter defines the amount of signal gain achieved through directional phased-array transmission toward the receiver (not supported by all equipment).

Requirements

Using the **Requirements** panel, you can configure the requirements that your cellular network should meet. The configuration that you create will be used for displaying the Requirements visualization. This visualization is helpful for a quick and easy evaluation of the overall health of your network and detection of potential issues. You can set thresholds for the following parameters (click on the links for the detailed description of the corresponding items):

- Minimum RSRP
- Minimum RSRQ
- Minimum SINR
- Minimum CQI
- Minimum BS downlink rate

- Minimum UE downlink rate
- Minimum UE uplink rate

To facilitate requirements configuration, three presets are available: **Basic** (for basic, low throughput connectivity), **Medium**, and **Advanced** (for high throughput, redundant connectivity). You can select a preset from the drop-down list, adjust the values, or create your own by clicking on the **New** button, typing a preset name, and then clicking the **Save** button. You can also delete presets by clicking on the **Delete** button.

Options

This tab allows you to configure the application options. It includes the following panels: Colors and Value Ranges, Visualization Settings, Tips, Computations, and Miscellaneous. You can collapse or expand panels by clicking on the arrow button on the right-hand side of the panel.

Colors and Value Ranges

Using this tab, you can configure color schemes, drawing styles, and value ranges used in visualizations overlaid on top of the floor plan or site map.

You can also choose between several **Visualization schemes** that will be used for visualizations, such as RSRP or Link Rate. Checking the **Smooth colors** box makes the transition between colors smooth. Checking the **Invert colors** box inverts the colors in the selected visualization scheme. If you would like to see the contours between areas of different color, check the **Contour** box.

Using the **Value Ranges** section, you can configure the range of values represented by the selected color scheme for the **RSRP, RSRQ, SINR, CQI, BS downlink rate, UE downlink rate, UE uplink rate** visualizations. For example, if you selected the color scheme that ranges from red to blue and a RSRP value range from -130 dBm to -50 dBm, any area where the signal level is equal to or below -130 dBm will be shown in red, and any area where the signal level is equal to or above -50 dBm will be shown in blue. Additionally, you can adjust the Steps value (i.e., the number of distinct colors to be used). Using the same example, the entire value range from -130 to -50 dBm would be 80 dBm; setting the Steps value to 10 would mean that every 8 dBm, a new color would be used to display the RSRP level and the total number of distinct colors zones would be 10. Setting the Steps value to 20 would double the number of distinct colors, making the color overlay much smoother.

Click the **Reset** button below the value ranges to revert to the default range settings.

Visualization Settings

The following settings affect the way TamoGraph displays some visualizations:

Base station coverage areas – This setting allows you to change the color-coding method used for displaying coverage areas. In **No fill, contours only** mode, the application draws contours of the coverage areas without

filling the areas with colors. In **Fill and mix colors** mode, the base stations' coverage areas are filled with colors; when areas overlap, the application draws a striped pattern, alternating the colors of the respective base stations. In **Fill, the strongest base station on top** mode, base station coverage areas are filled with colors; when areas overlap, the application draws the color of the strongest base station. In **Fill, the weakest base station on top** mode, base stations' coverage areas are filled with colors; when areas overlap, the application draws the color of the weakest base station. This setting is applicable to the following visualization: Coverage Areas.

Grayscale obstructions – This setting controls whether virtual objects are displayed in color or grayscale mode. Available options are **Always**, **When applying visualizations**, and **Never**.

Tips Panel

The tips panel is a small panel that is shown at the bottom of the application window; it displays useful tips and tricks that help you perform certain tasks. You can control whether to show tips when performing **RF Planning** and **Selecting multiple obstruction objects** by checking or unchecking the corresponding checkboxes. Experienced users may want to turn off tips altogether to free more space for the floor plan. By default, all tips are enabled.

Computations

The following settings affect the way TamoGraph performs heavy computational tasks needed for predictive RF models:

Use GPU for faster computations – Check this box if you want TamoGraph to use the computational resources of your graphics processing unit (also known as "video card"). If your computer is equipped with a modern, fast GPU (preferably a discrete, dedicated one), selecting this option will make computations of complex RF models much faster. Note that this option is disabled if your GPU is not supported or if you are running a 32-bit TamoGraph version.

Allow background computations – This option is turned off by default. Check this box if you want TamoGraph to conduct computations in the background. For example, if this option is turned on, once you have opened a project with a predictive model, TamoGraph will start computing the model before you select any visualization. These saves time when you actually select a visualization to work with the model. Please turn on this option **only if you running TamoGraph on a very powerful computer** to ensure that other tasks are not slowed down due to the background computations.

Miscellaneous

The following miscellaneous options are available:

Load last opened project at startup – Check this box if you want TamoGraph to automatically load the last project you worked on (if any) when the application starts.

Autosave a project backup – Check this box if you want to save a separate backup copy of the project whenever potentially risky or time-consuming operations are performed on the open project. You can specify

the location for saving these backup copies and define how many of the most recent copies should be kept. Set the value to “0” for an unlimited number of copies. Note: this function is disabled by default.

Custom base station names are used globally – Check this box if you want TamoGraph to use custom base station names throughout all the projects that you work with on a given computer. When this box is not checked, custom BS names are project-specific.

Show base station labels on the map – Check this box if you want TamoGraph to display a small label with the base station name next to each base station on the floor plan.

Ignore multitouch features – Check this box if you want TamoGraph to ignore the fact that you are running it on a computer with a multitouch display. When TamoGraph detects a multitouch display, it makes certain changes to the interface elements to make them more convenient to use. For example, pane splitters become wider, and so on. If you do not need these changes, you can use this option to force TamoGraph to use a standard user interface. Enabling or disabling this option requires a restart.

Smart map scrolling – Select when you want TamoGraph to use smart map scrolling. Smart map scrolls the map automatically whenever you click or tap next to the map edge, eliminating the need to scroll the map as you move along your path.

Enable automatic updates – Check this box if you want TamoGraph to connect to the TamoSoft and see whether a new TamoGraph version is available. When this option is enabled, TamoGraph checks for updates once a week.

Command-Line Options and Configuration Settings for Advanced Users

A few command-line options are available for customizing the application's behavior.

Those commands are intended for advanced users; please do not modify the registry or edit configuration files unless you know exactly what you are doing or unless you have been asked to do that by our technical support team.

/debug – turns on writing debug information to a log file and writing captured packets to a capture file. Our technical support team may request these files for troubleshooting complex problems. The output file name is *debug.log* and it is located on the Windows Desktop folder.

/gpu_force_bench – forces TamoGraph to re-evaluate OpenCL compatibility of the connected GPU devices and to re-run benchmark tests for them in order to check their performance.

Certain advanced TamoGraph configuration settings cannot be accessed via the user interface; such settings can be edited in the registry.

Close TamoGraph before editing these settings!

The parameters listed below are located under the following registry branch:

```
HKEY_CURRENT_USER\SOFTWARE\TamoGraph LTE and 5G Edition
```

BSLabelTemplate – defines the format of information displayed on base station labels. A base station label is a line of text that can include one or several of the following variables:

%n – base station ordinal number according to the base station list on the left application panel.
%m – base station name
%b - Band
%c – Channel(s)
%r – base station maximum downlink rate

If the parameter is empty, the labels will show only base station names. Note that this parameter affects only the base station labels; it does not affect the base station names saved as part of the project.

MinZoomPercent / MaxZoomPercent – defines the minimum and maximum zoom factor in percent for the floor plans displayed by TamoGraph.

SaveVisAPIconFactor – this parameter controls the magnification in percent of base station icons when you use the **Save Visualization As**… function. If you want to make base station icons larger, specify a value > 100. To make them smaller, specify a value below 100.

RFPlanner\FloorNeighborhoodDepth – defines how many floors above and below the specific floor are taken into consideration when computing signals in predictive models. By default, this value equals 1, which means that signals from base stations located one floor above and one floor below are computed. Note that increasing the value of this parameter slows down calculations.

Some user settings and presets are stored as separate files. These files can be manually edited. All the files that are listed below use UTF-16 encoding.

These files are located in:

```
C:\ProgramData\TamoSoft\TamoGraph LTE and 5G Edition
```

areas.user – custom attenuation area presets (applicable to predictive RF Modeling).
floor_ceiling.user – custom floor/ceiling material presets (applicable to predictive RF Modeling).
obstructions.user – custom walls and doors presets.
stations.user – custom base station presets (they include antenna information + base station-specific values of band, rate, power, etc.)

Frequently Asked Questions

Q1. Does TamoGraph support multi-floor projects?

A. Yes, you can create projects with multiple floors in TamoGraph. If you perform predictive modeling, simply add new floors in Floor Manager, add floor plans for each floor, define floor height and material, and then align the floors.

Q2. It appears that there are very few virtual base station templates and all of them are for generic base stations. How do I create a virtual base station that simulates a specific model by a major cellular equipment vendor?

Virtual base stations can be constructed like Lego. For example, if you want to simulate a specific base station, start with a suitable Generic Base Station template. Place the base station on the floor map, double-click it, configure its properties to match the physical unit you plan to deploy (e.g., channel width or output power), and then select the antenna type. TamoGraph includes many vendor-specific external antennas in its database. In other words, you assemble Lego-like building blocks to create a model that matches the real base station. You can then save this configuration as a new template and reuse it in future projects. Naturally, it's impossible to include every antenna in our database, so if there is a specific antenna you would like us to add and its radiation patterns are publicly available, just let us know and we'll include it in TamoGraph.

Sales and Support

At TamoSoft, we want you to be happy with your purchase. That is why we encourage you to try our products and technical support free of charge for 30 days before you make a decision regarding your purchase. By making the most of these free evaluations, you can fully test the software and make sure that it does everything you need. When you are ready to buy, we welcome you to https://www.tamos.com/order to order directly from us or through our partners and resellers.

As a registered user, you will receive:

- A fully functional, unrestricted copy of the software.
- Free updates that will be released within one year from the date of purchase.
- Information on updates and new products.
- Free technical support.

Prices, terms, and conditions are subject to change without notice. Please check our website for the latest product offerings and prices.

For technical support, please visit https://www.tamos.com/support.