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0 Executive Summary

The purpose of this deliverable is to present the indoor radio network planning and optimisation suite of tools. This suite of tools targets designing or tuning any indoor radio network in a fast and accurate manner. Existing indoor radio network design approaches will be reviewed during the development of the platform. This tool has an easy to use Graphic User Interface (GUI). It will be able to import standard building plans. It will enable users to define a building in detail, such as modify building plans and their constituting materials. The three databases that are used to manage devices, systems and building materials are integrated. The APIs linked to radio propagation model and planning and optimisation module are implemented.

1 Introduction

It has been verified by operators that nowadays most of voice and data services using wireless communication take place indoors. In the near future, new applications with ever increasing multimedia capabilities will require higher data rates for the end users. That is why indoor network radio coverage optimization will be the main challenge for all wireless telecommunication operators in the future. Over the past few years, mobile operators used to install their base stations outdoors. Hence a high number of wireless network planning tools have been developed, to help operators to find the best parameters for their network (for example the number of base stations and their positions or the output power and the antenna tilts). However, there were very few radio network planning and optimisation tools that can be used for indoor scenarios. It is critical to the cellular operators to have such a tool to design, optimize, construct and manage their indoor cellular networks. [1]

iBuildNet is a tool which is designed to be used for indoor radio network planning and optimisation. It will not only allow wireless network engineers to design an indoor solution for different types of buildings that resolve the indoor coverage gap, but also be able to perform an automated optimisation of their current indoor networks. This suite of tools works with all the current indoor solution structures, such as Picocells, Distributed Antenna System (DAS), Repeaters, Radiating cables, BBU+RRU and also Femtocells. iBuildNet is capable of design the indoor solutions for most of current wireless communication technologies (GSM, WCDMA, CDMA2000, LTE and Wi-Fi).

iBuildNet is able to load the floor designs (saved in different formats, e.g. DXF) of a building then model the floor designs into a 3D building. With a detailed definition of building materials, the integrated 3D ray-tracing propagation models will be able to predict the path loss between the antennas and anywhere within the building. Based on the radio propagation data that obtained from propagation model, the system performance, such as Best Signal Level, Best Server etc., can be predicted. With a build-in optimisation module, it automates to connect and route the cables from the signal source to each antenna. A work flow diagram is shown in Figure 1.

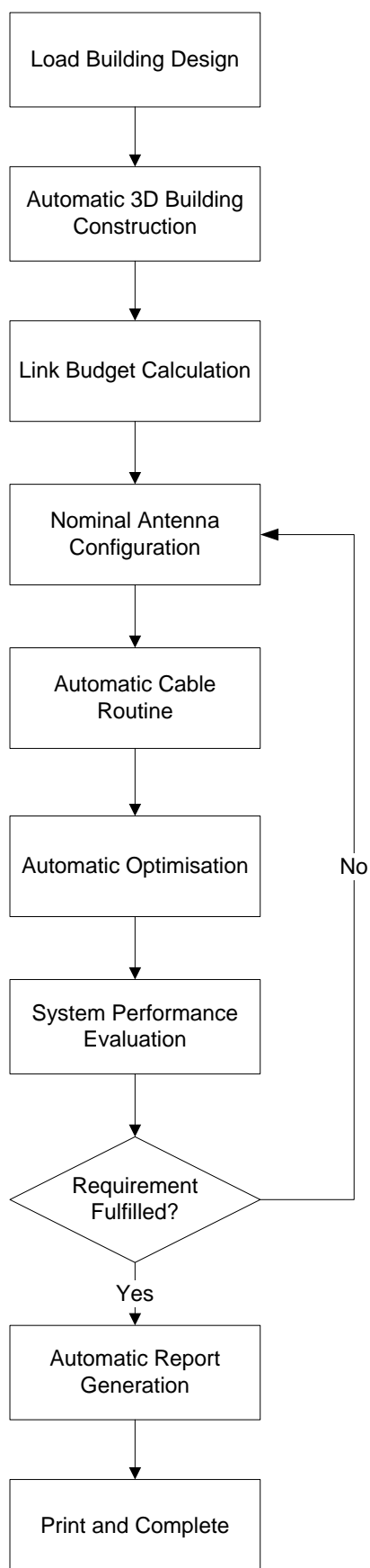


Figure 1. iBuildNet Work Flow Diagram

iBuildNet features include: [2]

- Import DXF files
- 3D Building Modelling
 - Intelligent Window Recognition
 - Intelligent Wall Merging Algorithm
 - Create, Modify, Remove Indoor Objects
 - View and Modify Building and Floor Properties
 - Draw Walls and Configure the Wall Properties
 - Draw Windows and Configure the Window Properties
 - Add Text on the Building Blueprints
 - View Building Structure in 3D
 - Building Scale and Area Computation
- Indoor Coverage Network Design
 - Add and Remove System
 - View and Modify System Properties
 - View and Modify System Device Properties
 - Cable Auto Planning
 - Mark Cables that directed through Walls
 - Import Building Blueprints
- Network Design Detection
 - Error Detection
 - Device Capability Checking
- System Evaluation
 - Best Signal Level Prediction
 - Path Loss Calculation
 - Best Server Prediction
 - Capacity Prediction
 - Hand-Offs Prediction
- Automatic Network Optimisation
- Database Editor
 - Device/System/Material Properties Editing
 - Database Importing/Exporting
- Uplink and Downlink Signal and Noise Computation
- Project Management

- Create, Copy and Save
- View and Modify Project Properties
- Blueprints and Report Printout
 - Project Summary Report
 - Antenna System Report
 - Device Report
 - Cost/Budget Report
 - Summary of Device Locations and List of Penetration Points
 - Network Structure
 - Floors Blueprint

Using iBuildNet, users are able to get benefit from:

- ✓ A friendly network design procedure based on the platform has been designed by experts.
- ✓ Predicting the network performance after design, and compare the abilities in order to obtain the best solution; and reduce the network construction cost.
- ✓ After the evaluation and analysis of the current network, the network performance can be optimized based on parameters optimisation. It is even possible to optimise indoor coverage network parameters in order to optimise outdoor network performance.
- ✓ Analyze the influence on global networks after network technology reformed. For example, iBuildNet performs many network performance simulations on different scenarios and obtains the data in the macro level. Therefore, an upgrade evaluation can be obtained in order to suggest the upgrade plan from 2G networks to 3G networks and even LTE.
- ✓ Greatly reduce the amount of time need for network design, construction and evaluation.
- ✓ An intelligent report system which includes blueprint/report generation and print, saving reports in digit format. Users can obtain concrete, uniform, readable reports.
- ✓ The management of all information by the database. This saves time when the user is designing a new network based on previous data.
- ✓ The ability to obtain the overall network project construction budget after the definition of cost of devices. This can be obtained while the network design is being completed.

2 Indoor Radio Network Design and Deployment Overview

The purpose of indoor radio network design is to plan for uniformly good coverage and appropriate capacity; and meanwhile reduce the interference within the building or emitted to outdoor as little as possible. A diagram of traditional indoor radio network design is shown in Figure 2.

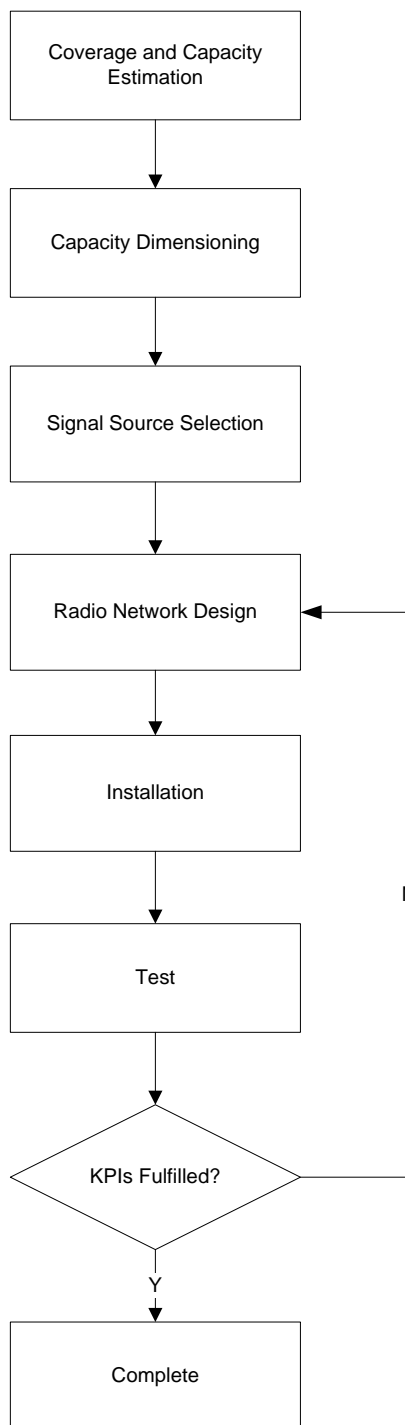


Figure 2. Traditional Indoor Radio Network Design Procedures

The buildings can be served by different types of signal distribution systems, such as passive/active Distributed Antenna System (DAS), optical fiber system and leaky cable system. A comparison of different types of distribution systems is shown in Table 1.

Distribution System Type	Advantages	Disadvantages
Passive DAS	Low cost, no need of power supply, easy to install, no noise rise	Difficult to plan, amplifiers may be required
Active DAS	Easy to plan, signal can be distributed uniformly	Restrict to device working frequency, hard to accommodate multiple system, power supply is needed, noise rise issue, expensive to deploy
Fiber Optical	Low transmission loss, easy to plan and install, capable of accommodating multiple system	Remote unit need of power supply, expensive to deploy
Leaky Cable	Signal can be distributed uniformly, capable of accommodating multiple system	Expensive to deploy, hard to install, hard to transmit for long distance

Table 1. Comparison of Different Types of Distribution Systems

2.1 Capacity Dimensioning

The first phase when designing an indoor radio network is to estimate what the capacity is required. They can be estimated in the same way as when estimating outdoor networks. In business applications, the demands are normally higher. A margin for the data service is needed, as more than 90% of data services occurred indoors.

2.2 Signal Source Selection

The signal source can be selected based on the size and shape of the building and the outcome of capacity dimensioning. There are mainly four types of signal sources for indoor solutions: Base station source, Off-air source, Femtocell and Wi-Fi.

A system database is integrated with iBuildNet. Users are able to select system technology, frequency band and also the signal source type.

2.3 Radio Network Design

The engineers will have to measure the interference levels within the building, and then the maximum path loss for desired traffic profiles can be determined. An initial antenna location placement can be obtained based on the floor plan and a rough path loss prediction. The initial antenna location will be verified according to real path loss measurement. The real path loss measurement is a time and labor consuming task. Network surveyors have to deploy signal

generator in the building in accordance with the initial antenna location plan, and measure the path loss using RF measurement tools.

With the feedbacks from the network surveyors, the network planner can move the locations of antennas. In some cases, more antennas may be required to add on to the initial plan or vice versa.

Once the locations of the antennas are verified, the network planner will connect the antennas with the signal source using suitable devices and appropriate cable routine. It will be easier to design active DAS, as the transmit power can be adjusted using active devices. But the passive DAS will be complicated to plan.

Note that, some indoor systems have to be installed before the building interior construction is completed. Since the indoor radio propagation environment is very complicated, and the building interior will seriously affect the radio propagation. In such a case, it will not be possible to obtain an accurate path loss measurement result. Moreover, it will not be easy for the indoor network planner to connect the antenna with signal source using suitable devices and appropriate cable routine. Therefore, it is critical for the network operators to have a suite of tools which can model the buildings meticulously and integrate with an accurate propagation model that is able to take consideration of these detailed building information to obtain the radio propagation result of an indoor radio network plan. An integrated planning module, which is able to automatically choose the intermediate devices and cable route, is in high demand.

2.4 Installation

Once the radio network design is approved, the network design overviews of each floor and the network system topology have to be provided for network installation engineers to deploy the network.

2.5 Test

A network test will be carried out similar to the measurement of path loss which was done during radio network design phase. But more Key Performance Indicators (KPIs) have to be monitored. If the KPIs achieve the target, the whole project can be handed over, otherwise, the network has to be re-designed and re-tested.

3 iBuildNet Working Environment

The working environment of iBuildNet integrates with a set of tools and functions that allow users to create and design any indoor radio network.

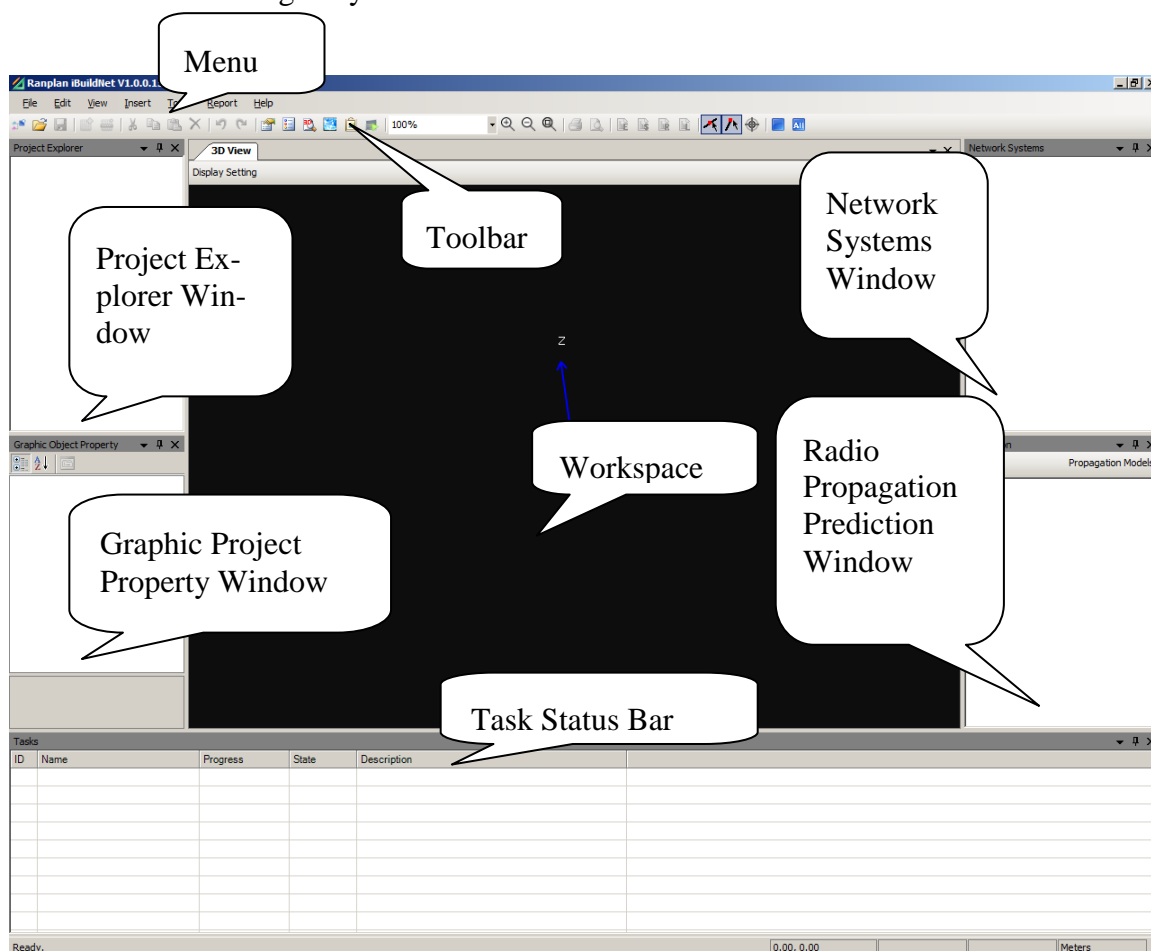


Figure 3. Main User Interface

As shown in Figure 3:

- The **Menu** is located at the top of this screen.
- The **Toolbar** is located immediately under the Menu.
- The **Workspace** is located below the Tool Bar. The users can edit objects in this area.
- The **Task Status Bar** is located under the workspace.
- The **Project Management Windows** including Project Explorer (also called as Project Structure Tree), Graphic Project Property Window, Network Systems Explorer Window and Radio Propagation Prediction Window. All these windows can be opened, closed or docked. In Figure 3, these four windows are docked around workspace. Users are able to customize the location of each window upon user preference.

3.1 The Menu

There are seven categories in the Menu as shown in Figure 4.

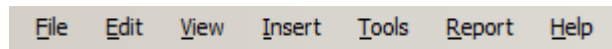


Figure 4. The Menu

File sub-menu, as displayed in Figure 5, can be used for the following features:

- Create a new Project (or Building and Floor within a current project).
- Open an existing project.
- Close a project.
- Save a project.
- Save current project to another location.
- Print to picture
- Print Preview
- Print
- View/Open recent projects
- Exit iBuildNet

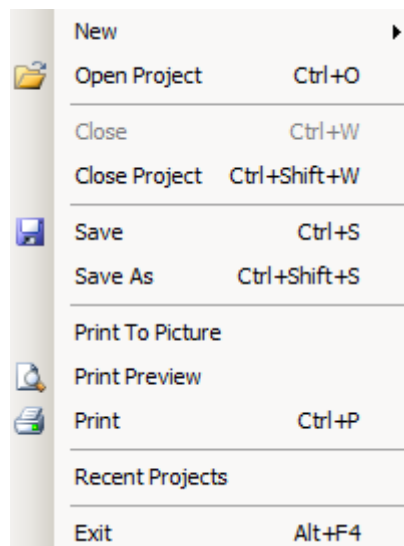


Figure 5. File Sub-Menu

Edit sub-menu, as displayed in Figure 6, can be used for the following features.

- Undo previous operation.
- Redo previous operation.
- Cut an object.
- Copy an object.

- Paste an object.
- Delete an object.
- Replace selected building material.
- Select all objects.

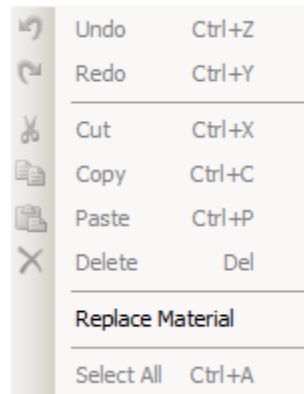


Figure 6. Edit Sub-Menu

View sub-menu, as displayed in Figure 7, can be used for the following features.

- Show Property Window.
- Show Project Explorer.
- Show 3D View.
- Show Tasks status bar.
- Show Network Systems Window.
- Show SPE Viewer.
- Zoom In/Out.

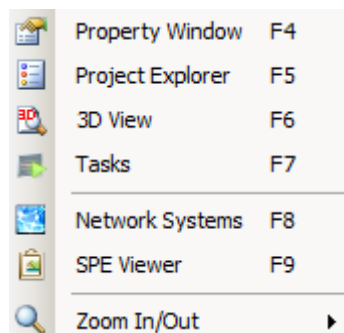


Figure 7. View Sub-Menu

Insert sub-menu, as displayed in Figure 8, can be used for the following features.

- Insert text into current project/view.
- Insert picture into current project/view.

- Import DXF file into current project.

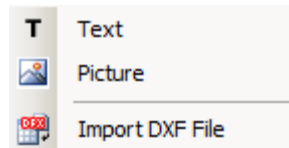


Figure 8. Insert Sub-Menu

Tools sub-menu, as displayed in Figure 9, can be used for the following features.

- Manage Material Database
- Manage System Database
- Manage Backgrounds Images
- Manage Device Database
- Customize Options

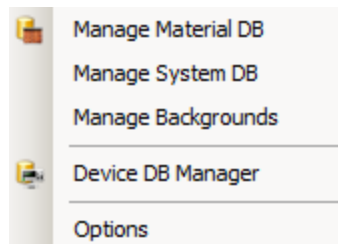


Figure 9. Tools Sub-Menu

Report sub-menu, as displayed in Figure 10, can be used for the following features.

- View and Edit Equipment List Report
- View and Edit Cost Details Report
- View and Edit Cable Routing Report
- View and Edit Layout Plan Report

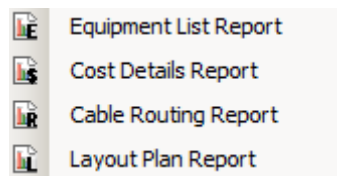
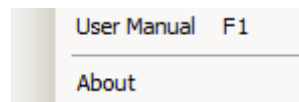


Figure 10. Report Sub-Menu

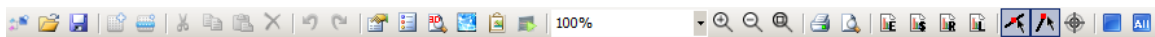
Help sub-menu, as displayed in Figure 11, can be used for the following features.




















- View User Manual
- Check iBuildNet information














**Figure 11. Help Sub-Menu**

3.2 The Toolbar

There are several shortcuts designed on the toolbar as displayed in Figure 12. These shortcuts enable the user to create and design projects more conveniently.

**Figure 12. The Toolbar**

-  Create a new project.
-  Open an existing project.
-  Save current project.
-  Create new building.
-  Create new floor.
-  Cut selected object.
-  Copy selected object.
-  Paste selected object.
-  Delete selected object.
-  Undo previous operation.
-  Redo previous operation.
-  Shown Property Window.
-  Show Project Explorer.
-  Show 3D View.
-  Show Network Systems Window.
-  Show Performance Target Window (SPE).
-  Show Task Window.
-  Zoom In/Out with a specific percentage.
-  Zoom In.

-  Zoom Out.
-  Zoom to Region.
-  Print.
-  Print Preview.
-  View Equipment List Report.
-  View Cost Details Report.
-  View Cable Routine Report.
-  View Layout Plan Report.
-  Switch On/Off Line Adsorption function.
-  Switch On/Off End Point Adsorption function.
-  Display Floor Anchor.
-  Stop Current Task.
-  Stop All Tasks.

4 Building Structure Modeling

Building Structure Modelling (BSM) is the process of modelling a building by floors. It is one of the most important procedures while planning or optimising an indoor radio network using iBuildNet. iBuildNet integrates with Ranplan's own 3D ray tracing/launching hybrid propagation module (full introduction about this module will be given in following chapters). A detailed 3D building is the basis for accurate calculation of radio propagation prediction. An example of a 3D building modelled in iBuildNet is shown in Figure 13.

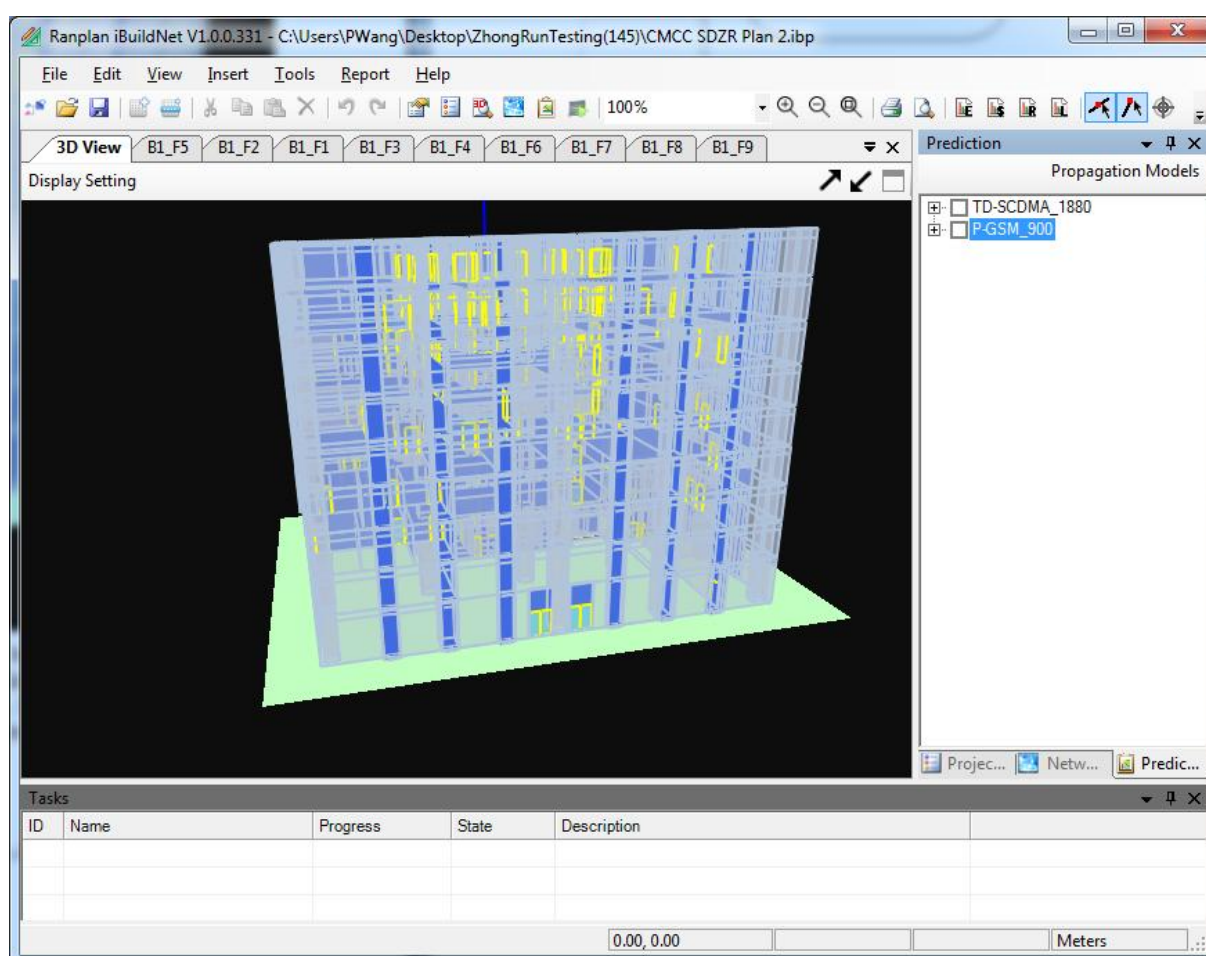


Figure 13. 3D Building Modelled in iBuildNet

First, a new building has to be created. Basic information of this building should be input. After that, each floor is modelled and assigned to the building. iBuildNet will enable users to copy a designated floor within a building or even inter-buildings. It can also create multiple floors in batch and model each floor, which includes drawing objects of the building such as walls, windows, doors etc.

4.1 Import DXF File

iBuildNet enables users to draw floor designs by importing from AutoCAD dxf files. This is one of the most convenient methods of modelling floor designs.

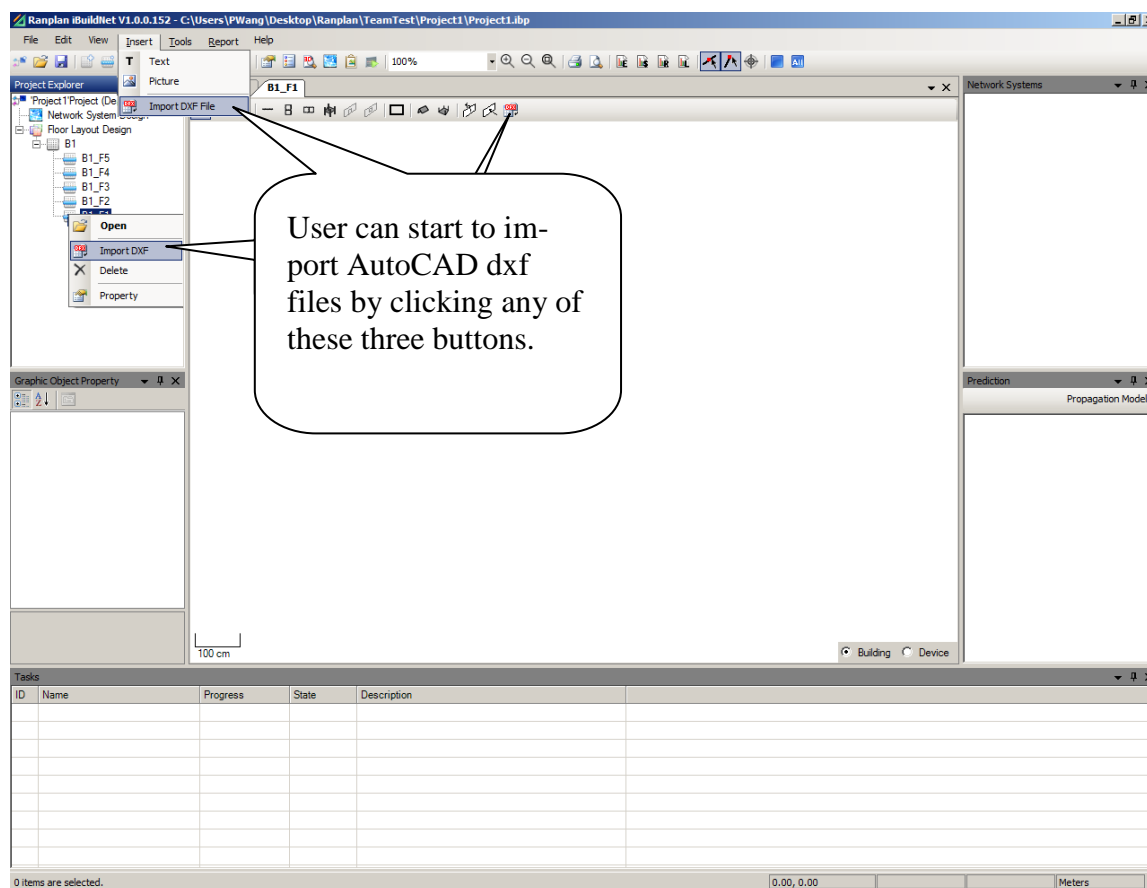


Figure 14. Import AutoCAD dxf file

4.1.1 Configure importing parameters

After the dxf file is opened, the parameters for importing a dxf file can be configured in “Import DXF” dialog as shown in Figure 15.

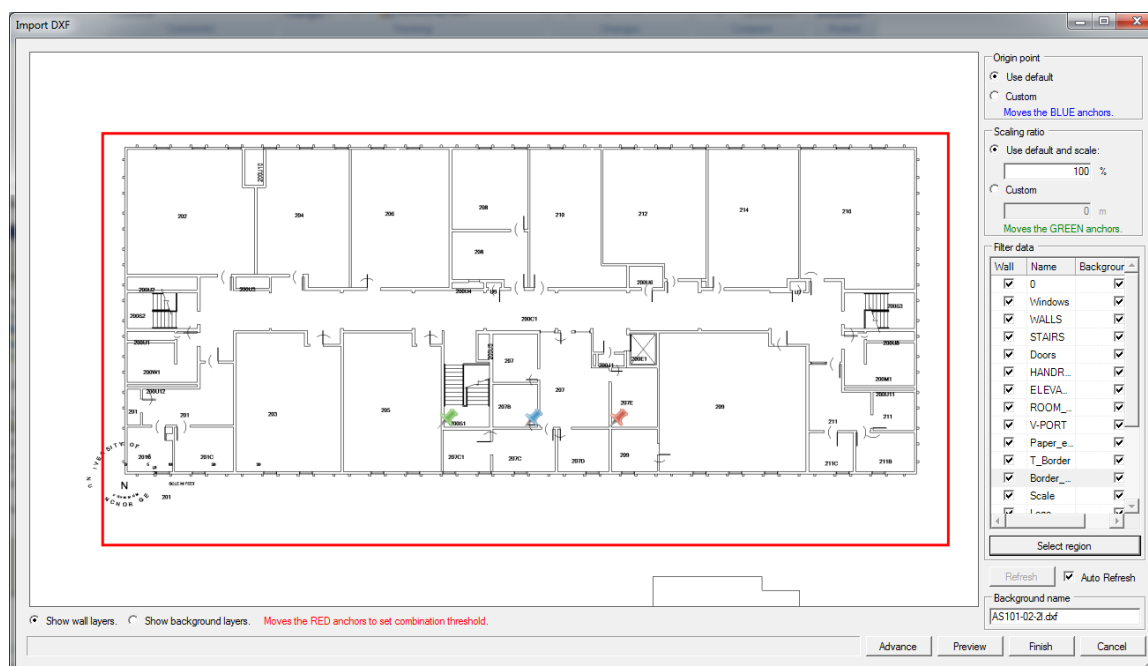


Figure 15. Import dxf Dialog

4.1.2 Configure origin point

The origin point has to be defined, either by default or customization. We recommend users to define the origin point very carefully, in particularly when designing in large dimensional buildings, i.e. a building contains several floors. Users have to ensure the origin points on each floor are exactly matched, if the floor designs were not copied from other floors. Otherwise, the buildings may suffer from offsets of each floor on the vertical plane.

4.1.3 Configure scaling ratio

The scaling ratio has to be configured. It can be defined in terms of the ratio between the actual building and the building on the dxf file. Alternatively, user can use the pair of green anchors to custom the scaling ratio. The actual distance between the two green anchors can be fed into iBuildNet; as a result, the scaling ratio can be determined.

4.1.4 Filter data layers

Most dxf files are designed with several layers on them. Some of the layers are not relevant to indoor radio network planning and optimization. In other words, they will disturb network designers while they are designing indoor networks. iBuildNet will help users to filter data layers and convert relevant data layers into a 3D building.

As shown in Figure 16, user can select a layer as a wall to be converted into 3D building or keep it as background image. Users are free to select/unselect any layer that can be recognized by iBuildNet.

In a large number of cases, several floors will be drawn on one single dxf file. Therefore, only a part of the dxf file will be used to be imported into a specific floor. User can use the “Select region” button, which is displayed in Figure 16, to select a part of the dxf file.

The image will be refreshed automatically if the “Auto Refresh” checkbox is ticked. Otherwise, users can click on the “Refresh” button to refresh the preview.

As soon as the layers to be imported such as wall and background are determined, the background image for this floor is generated. A default background name will be assigned to the background if no particular name was typed in the box as shown in Figure 16.

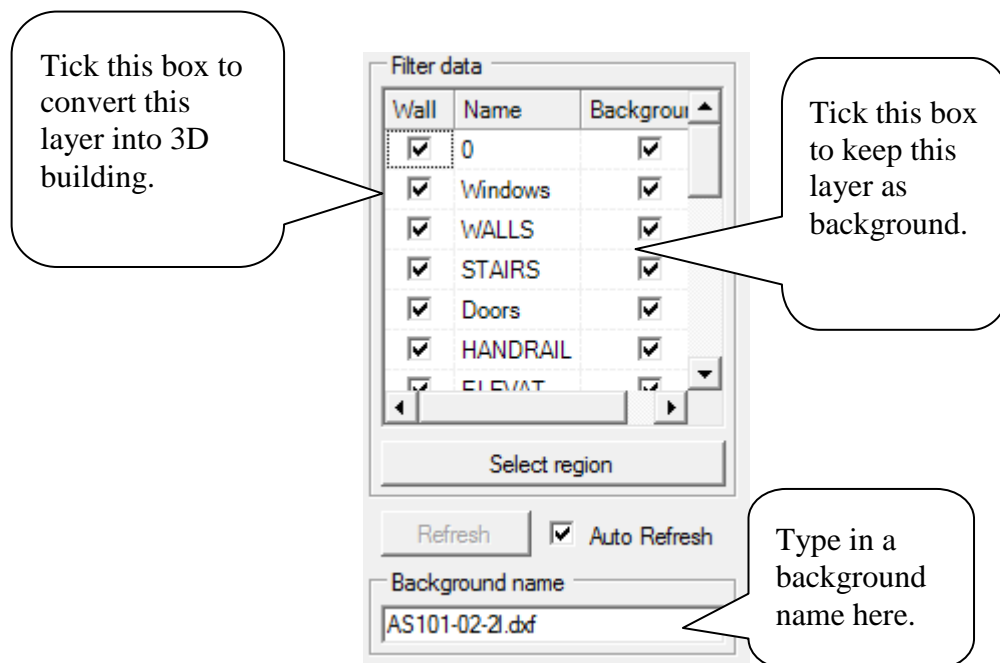
















Figure 16. Filter Data Layer

4.2 Free Style Drawing

This method does not depend on any reference. The users can use the drawing tools, as indicated in Figure 17, to draw objects based on a given scale.

- : This tool can be used to select objects.
- : This tool can be used to handle objects.
- : This tool can be used to move objects.
- : This tool can be used to draw vertical walls.
- : This tool can be used to draw doors.
- : This tool can be used to draw windows.
- : This tool can be used to draw Horizontal Walls.
- : This tool can be used to draw doors under normal view.
- : This tool can be used to draw windows under normal view.

- : This tool can be used to draw rectangle rooms.
- : This tool can be used to draw roofs.
- : This tool can be used to draw grounds.
- : This option will allow users to return to overview.
- : This option will allow users to enter normal view.

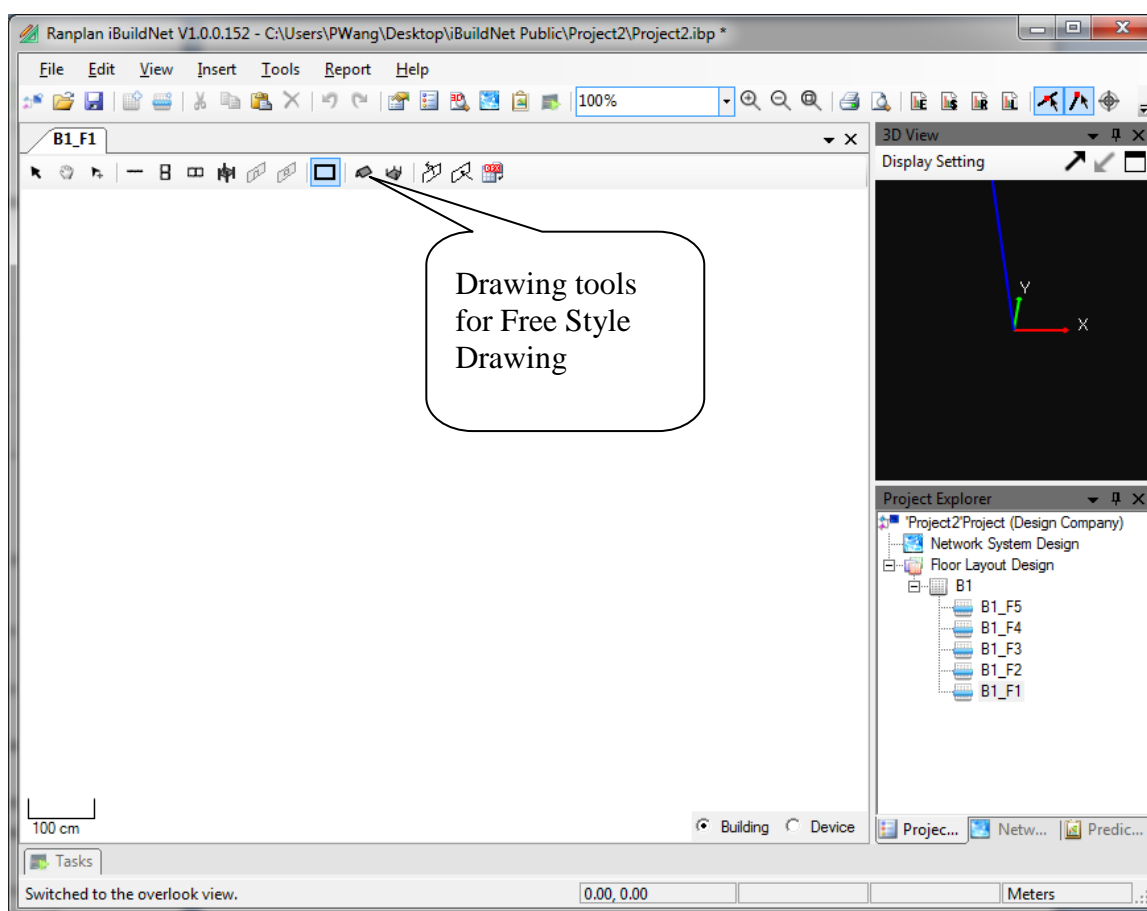


Figure 17. Drawing Tools

4.3 Drawing based on Background Pictures

This method allows the users to draw objects based on a background image. The users need to import a background image. Based on this background image, the drawing can be done similar to a free style drawing. However, background images are not only be used as a reference while drawing a floor design. They can also be used while refining a floor design after being imported from a dxf file or to check the constraints of the building while designing an indoor radio system.

4.3.1 Import background image

To import the background images of a particular floor, users have to enter the design view of the floor by a click on the name of the floor that listed in the project structure tree. Then, right click on the work space, and select “Background Image”, as shown in Figure 18.

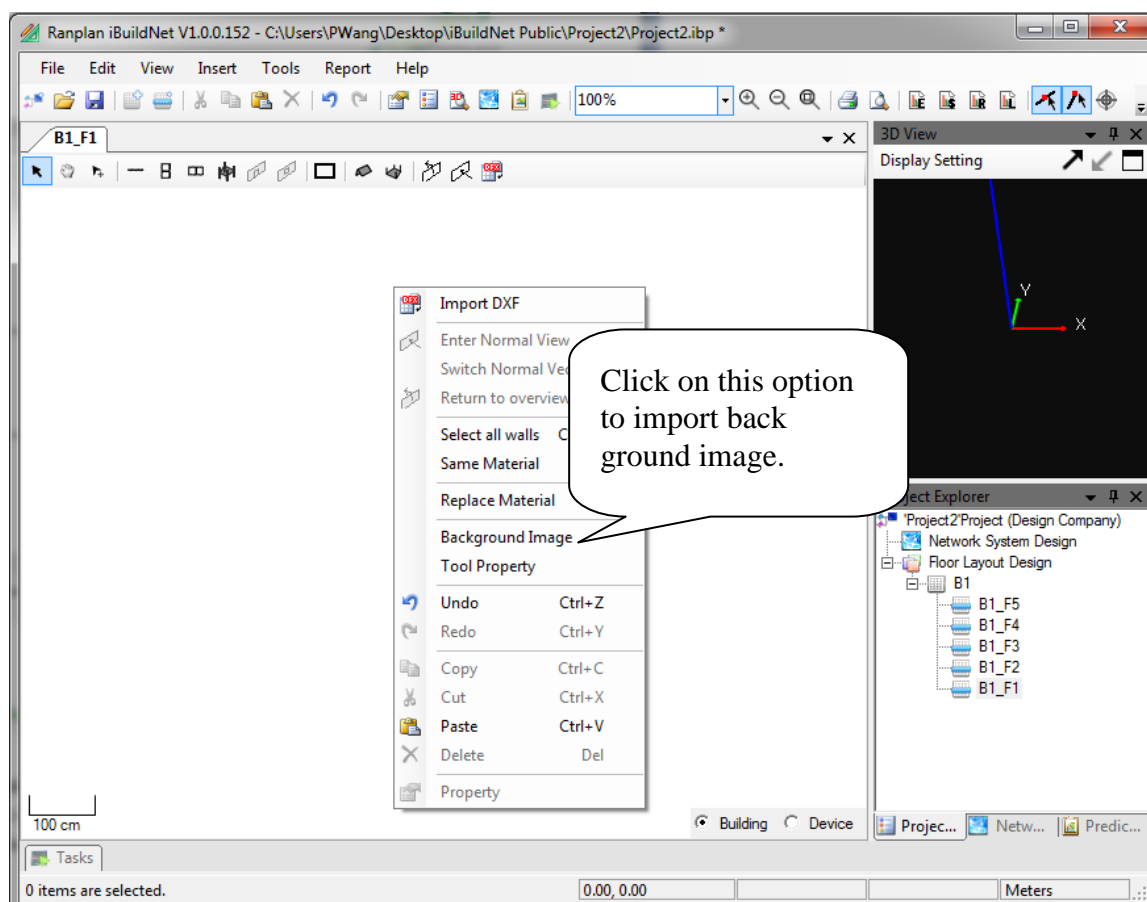


Figure 18. Import Background Image

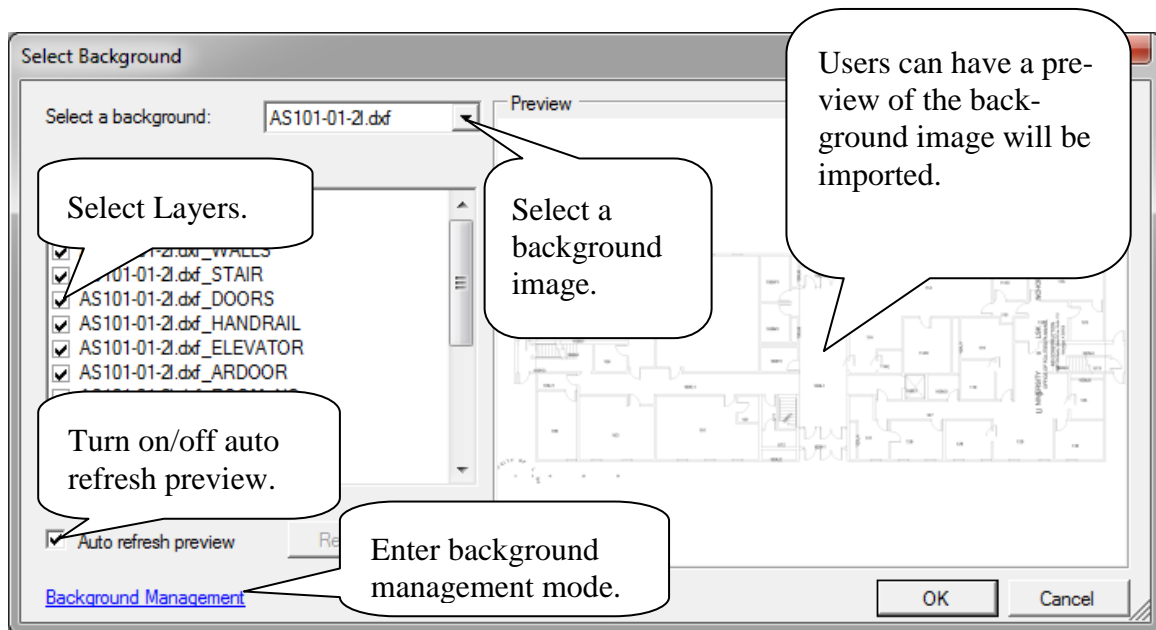


Figure 19. Background Image Import Dialog

Similar to importing dxf file to a floor, layers of the background can be selected as shown in Figure 19. The preview will be updated automatically if the “Auto refresh preview” option is turned on. An example of imported background image is shown in Figure 20.

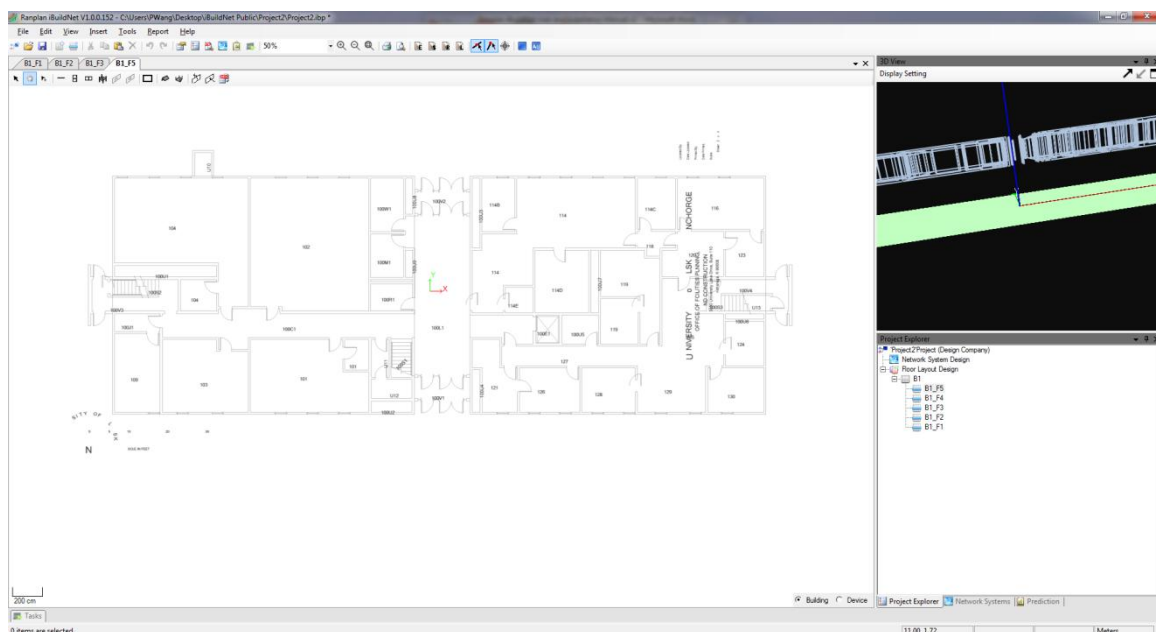


Figure 20. Import Background Image

5 Database Management

There are three individual databases integrated in iBuildNet.

- Device Database
- Material Database
- System Database

5.1 Device Database

A number of general devices are stored in the device database. Users can customize this database by adding, deleting, copying or editing any device. The devices are sorted in terms of devices types. For each device type, the devices are classified by manufactures. Figure 21 shows an example of an antenna saved in device database. All the relevant parameters are also saved, which can be loaded by the propagation model.

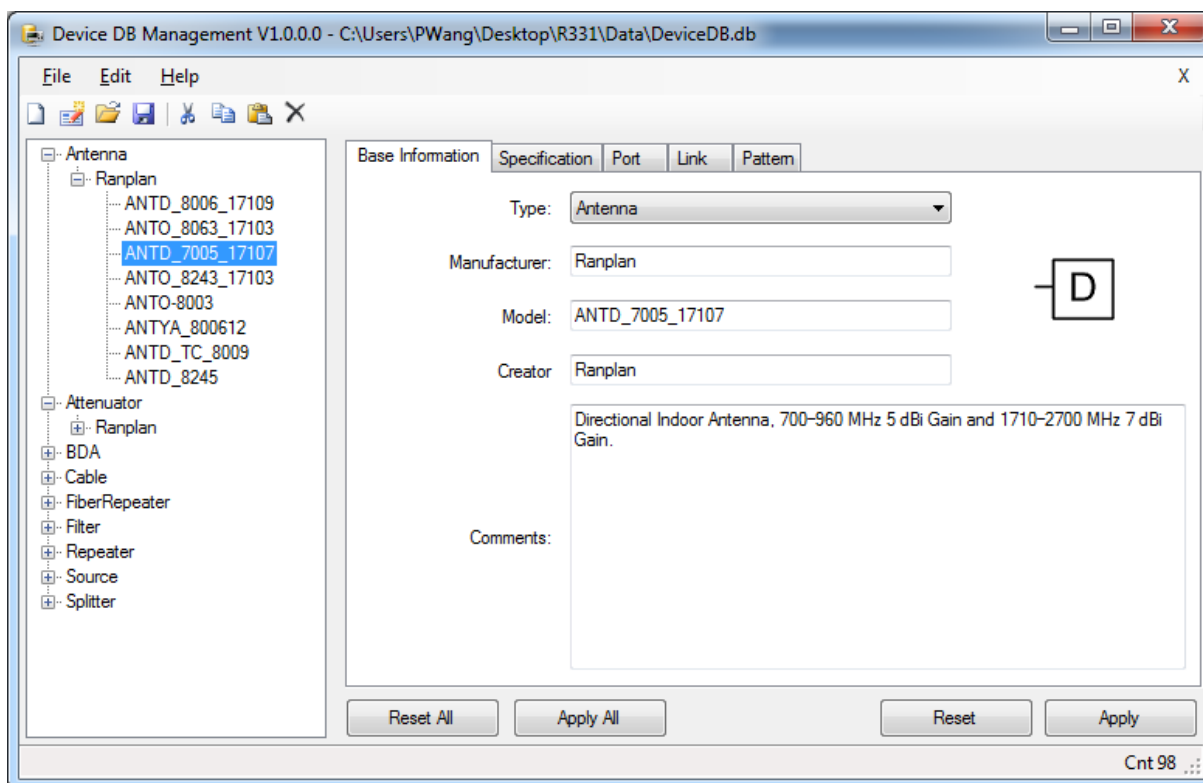
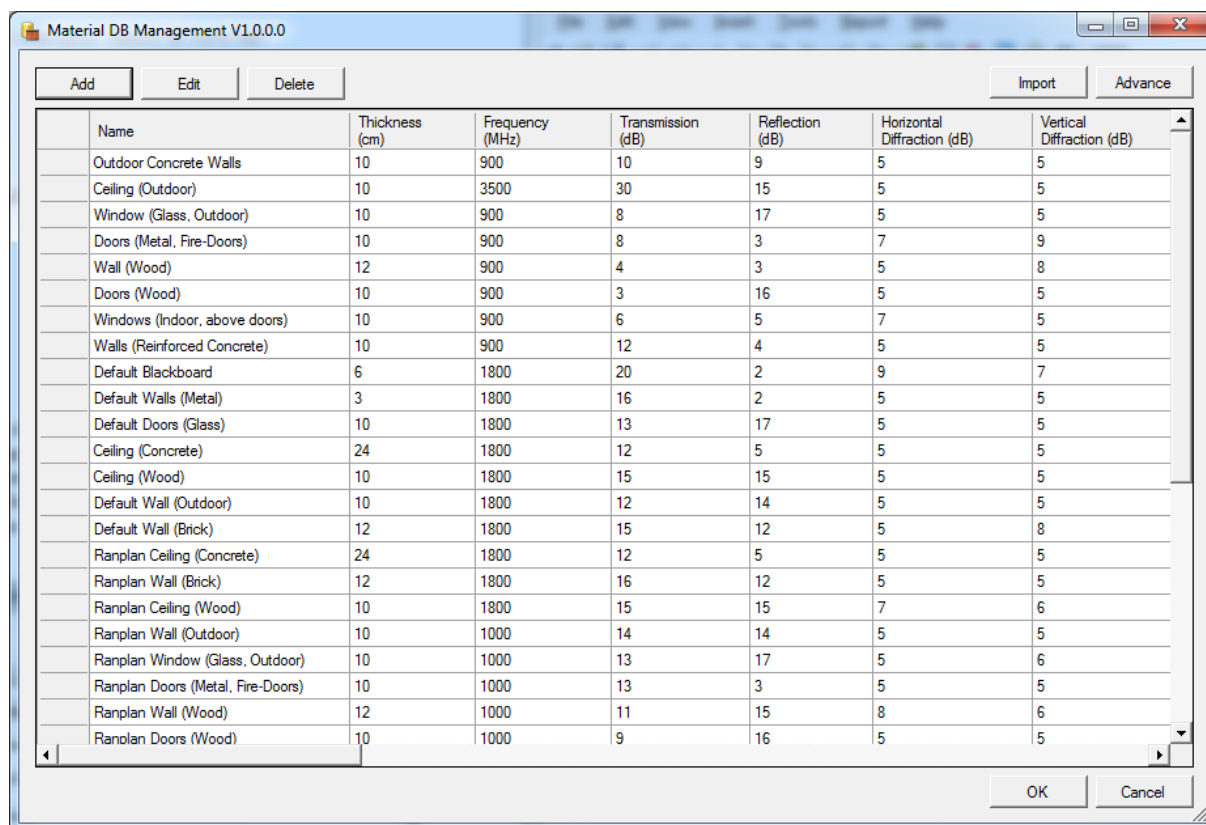


Figure 21. Example of an antenna saved in device database

5.2 Material Database

The building material plays a very important role in indoor radio propagation prediction. Different materials will have a serious affect on transmissions, reflections and diffractions of radio waves. Since iBuildNet integrates a hybrid ray-tracing/launching propagation model. It is

critical to make sure the materials of the building in which the indoor radio network will be deployed are defined as the same as the ones that will be used. iBuildNet provides a general material database, which includes basic materials for buildings. In the event that the materials used in a building do not exist in the material database. The users can add new materials or modify current ones to adapt to those needed. A screenshot of material database manager is shown in Figure 22.



The screenshot shows a window titled "Material DB Management V1.0.0.0". It has buttons for "Add", "Edit", "Delete", "Import", and "Advance". Below these is a table with the following columns: Name, Thickness (cm), Frequency (MHz), Transmission (dB), Reflection (dB), Horizontal Diffraction (dB), and Vertical Diffraction (dB). The table contains 28 rows of material data.

Name	Thickness (cm)	Frequency (MHz)	Transmission (dB)	Reflection (dB)	Horizontal Diffraction (dB)	Vertical Diffraction (dB)
Outdoor Concrete Walls	10	900	10	9	5	5
Ceiling (Outdoor)	10	3500	30	15	5	5
Window (Glass, Outdoor)	10	900	8	17	5	5
Doors (Metal, Fire-Doors)	10	900	8	3	7	9
Wall (Wood)	12	900	4	3	5	8
Doors (Wood)	10	900	3	16	5	5
Windows (Indoor, above doors)	10	900	6	5	7	5
Walls (Reinforced Concrete)	10	900	12	4	5	5
Default Blackboard	6	1800	20	2	9	7
Default Walls (Metal)	3	1800	16	2	5	5
Default Doors (Glass)	10	1800	13	17	5	5
Ceiling (Concrete)	24	1800	12	5	5	5
Ceiling (Wood)	10	1800	15	15	5	5
Default Wall (Outdoor)	10	1800	12	14	5	5
Default Wall (Brick)	12	1800	15	12	5	8
Ranplan Ceiling (Concrete)	24	1800	12	5	5	5
Ranplan Wall (Brick)	12	1800	16	12	5	5
Ranplan Ceiling (Wood)	10	1800	15	15	7	6
Ranplan Wall (Outdoor)	10	1000	14	14	5	5
Ranplan Window (Glass, Outdoor)	10	1000	13	17	5	6
Ranplan Doors (Metal, Fire-Doors)	10	1000	13	3	5	5
Ranplan Wall (Wood)	12	1000	11	15	8	6
Ranplan Doors (Wood)	10	1000	9	16	5	5

Figure 22. Material Database

5.3 System Database

The system database allows users to be able to select appropriate systems easier. It saves all the relevant information of a system, such as “Region”, “Technology”, “Frequency Band” and even the channel numbers for a specific system. Like other databases that can be integrated with this tool, system database can also be customized by users. New systems can be added into this database, and all the saved systems can be edited.

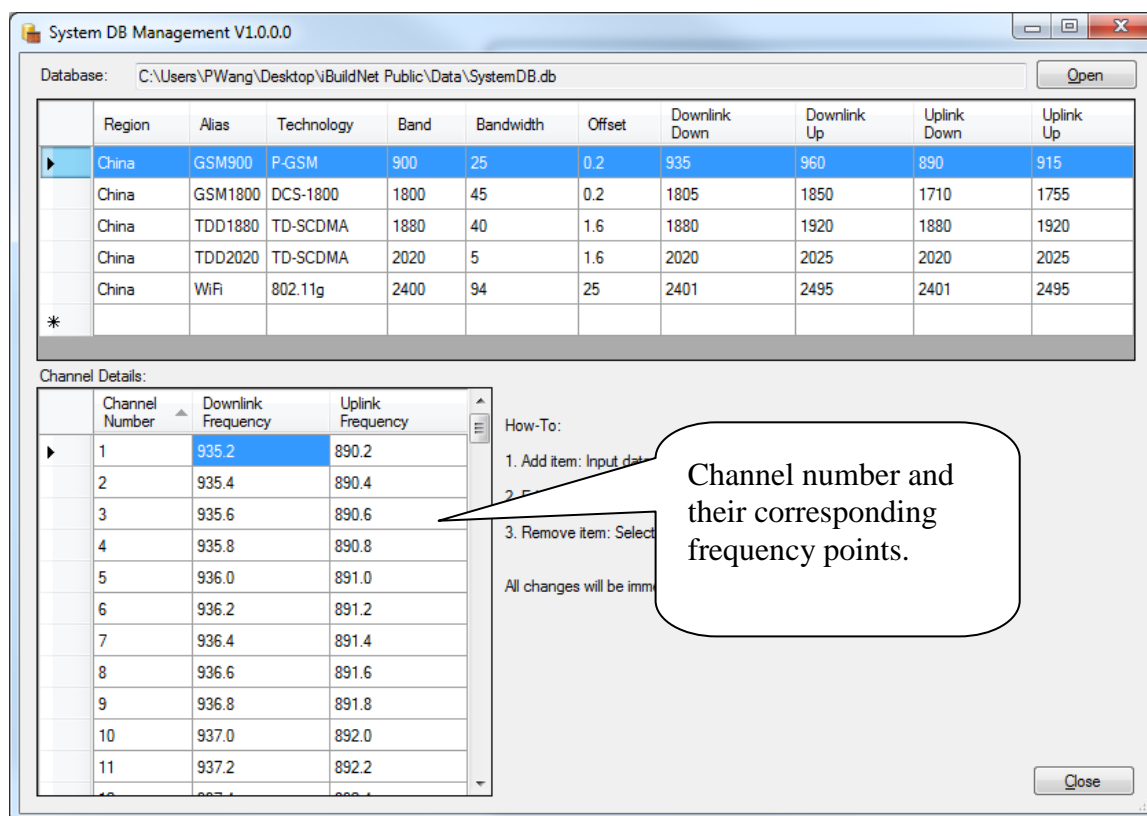


Figure 23 System Database

Add System

System color: **Select** Operator:

These two fields will be used at report and other places that need to distinguish systems.

System information

Region/Country:

The system information specifies the type of signal at the source.

Technology:

Band:

Select technology for a system

Source information

Type:

Nb. Channels:

TX Power: dBm

Noise figure: dB

Device: Not need

The source information specifies the way the signal is provided and site type.

The power and noise of this source transmits. Please note that this power does not mean the site transmits.

Select a device if this source is a femtocell source, WiFi source or off-air source. Just click the rectangle to select device.

Figure 24. Select System Technology

6 Device Layout Design















Device layout design is most important part of designing an indoor radio network. The real network planning and optimization starts from here. It is the process of determine the model, configuration and location of network devices, and connect these devices using appropriate cables.










6.1 Network System Design (NSD)

Network System Design, in short NSD, is used for constructing and designing network system. By adding different kinds of network devices to the design view, and connecting them together with different links, the logical structure and relation can be demonstrated.

6.1.1 Network System Design Toolbar

The NSD toolbar contains the following tools:

-  : Selection tool
-  : Hand tool
-  : Insert Cable
-  : Insert Antenna
-  : Insert Splitter
-  : Insert Attenuator
-  : Insert BDA
-  : Insert Fiber BDA
-  : Insert Fiber BDA Hub
-  : Insert Fiber Repeater
-  : Insert Filter
-  : Insert Device Power
-  : Insert Repeater
-  : Insert Signal Source

- : Insert Drill Hole (Between Floors)
- : Make cable be a straight line
- : Make cable be a right angled line
- : Make cable be a free style line
- : Insert Text
- : Insert Picture
- : Rotate Left
- : Rotate Right
- : Device Mirror

6.1.2 Add Devices

Users can add devices using the shortcuts listed on the NSD toolbar. The device database will be open when click on the buttons to add devices.

For instance, if an antenna is required to place into a building:

1. Click on the antenna shortcut.

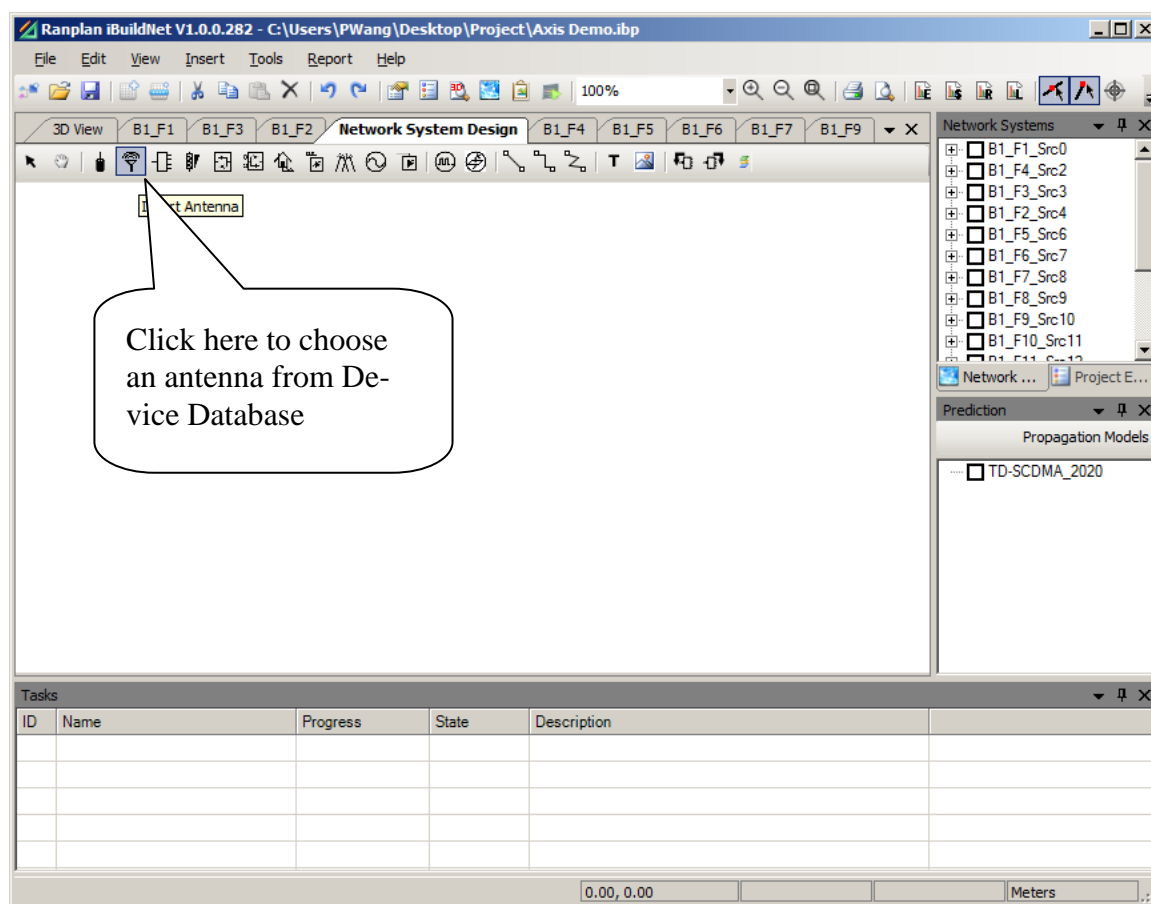


Figure 25. Start to Add an Antenna

2. “Select Device Form” will be open to choose an antenna. The antennas (also other devices) are classified by manufactures. The default database only contains the general devices created by Ranplan.

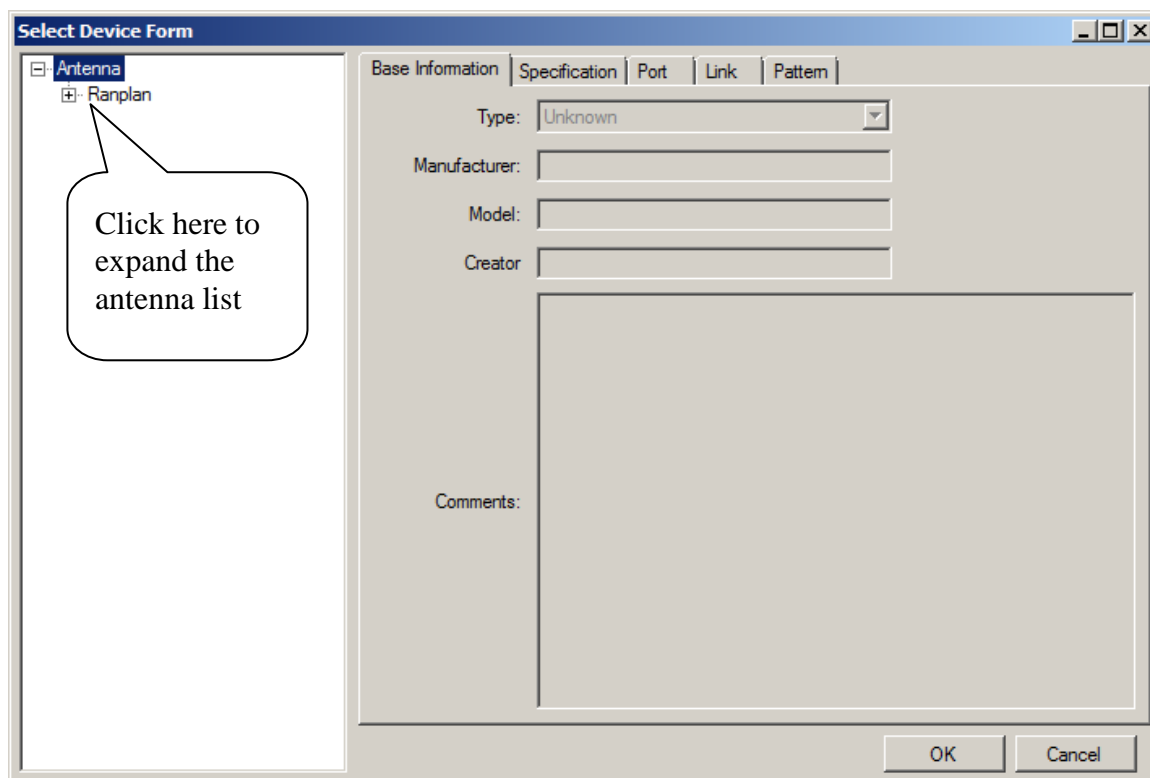


Figure 26. Select Device

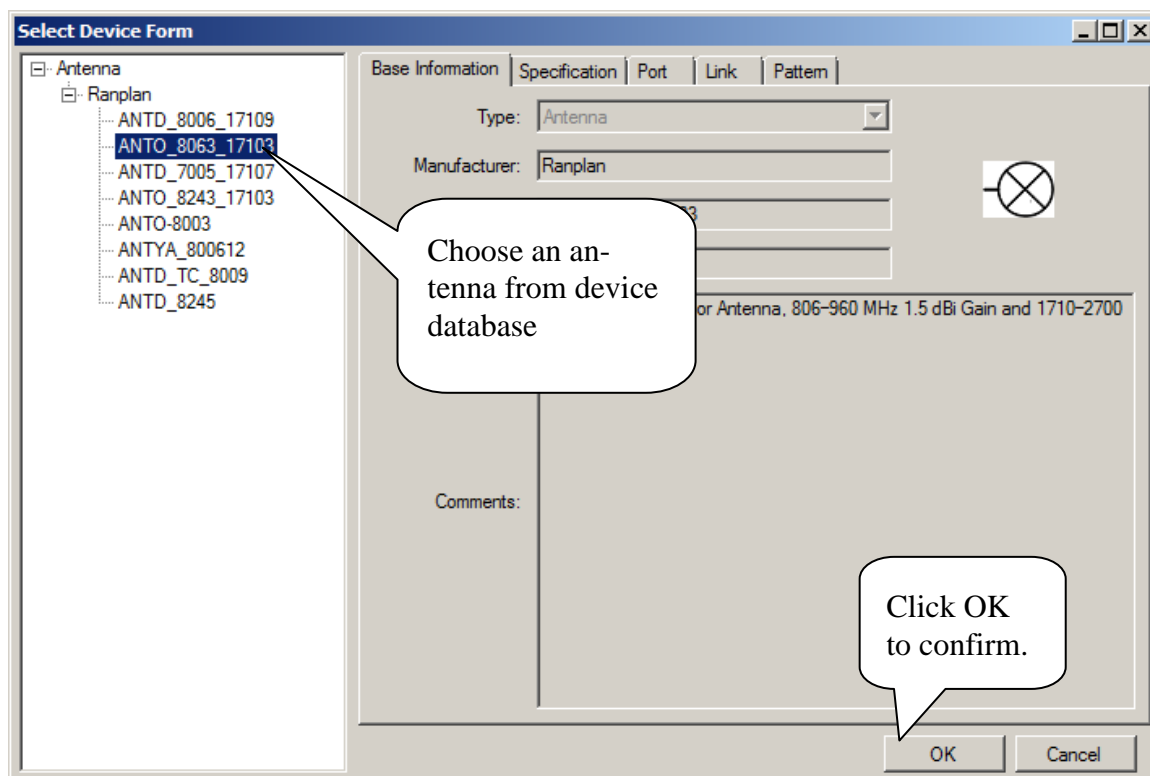


Figure 27. Choose an Antenna

An antenna icon will be displayed instead of the mouse cursor after the antenna is selected and confirmed. Users are now able to place the antenna to a desired location, as shown in Figure 28.

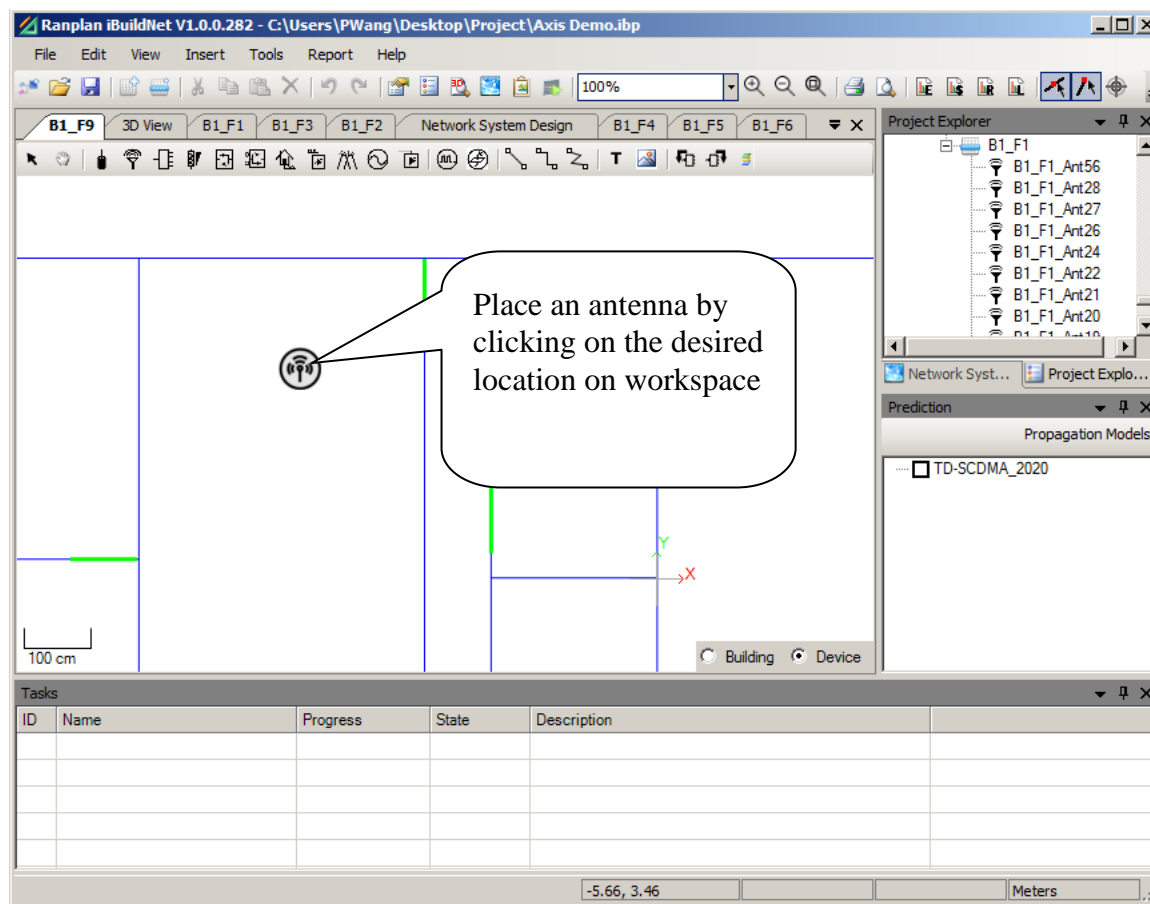


Figure 28. Place an Antenna

6.1.3 Device Properties

There are two types of properties of a device: Device Property and Device Graphic Property. The device property can only be edited in the device database, but it can be viewed in network design views. The device graphic property can be viewed and edited (mainly the height of a device) in Graphic Object Property Window.

6.1.3.1 View Device Property

In order to view device property, the target device has to be selected by double clicking on it. Device property window will be displayed. For example, for an antenna device property window shows below:

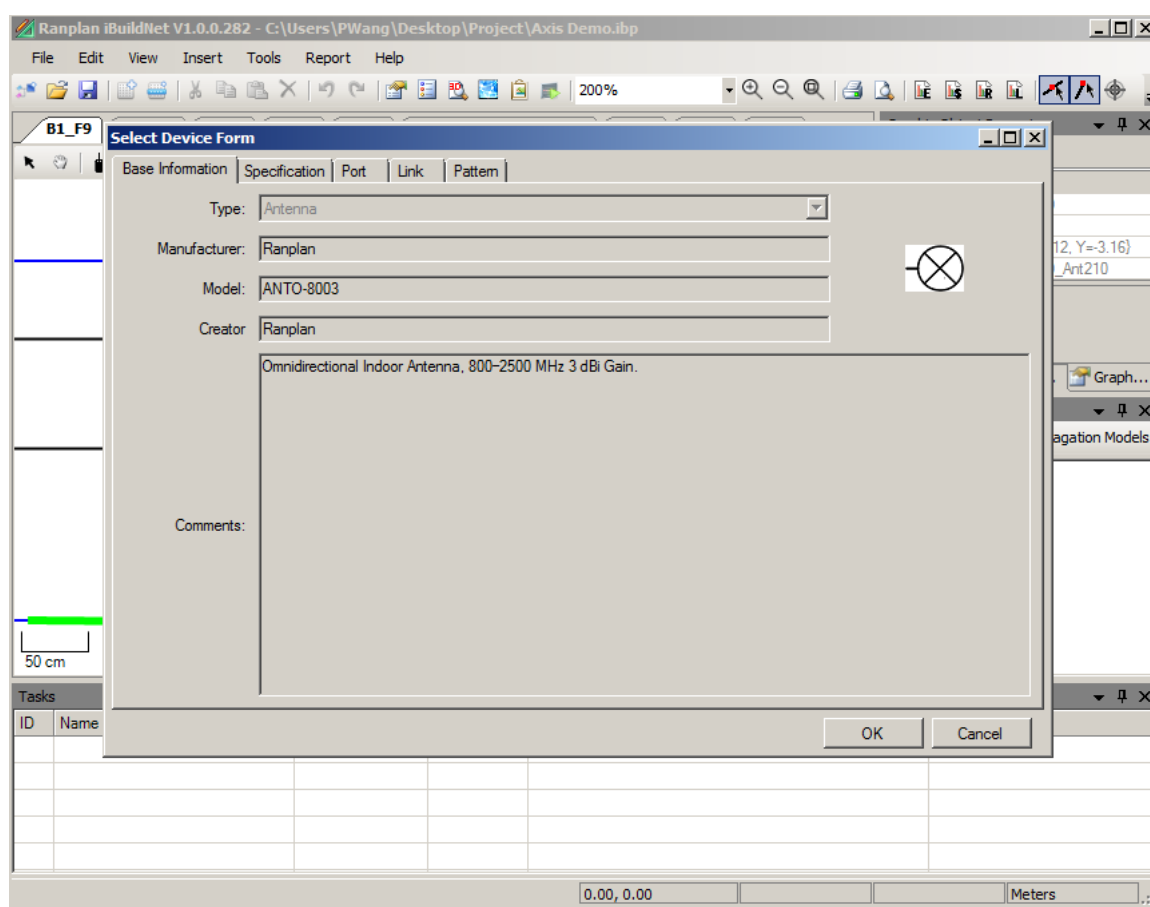


Figure 29. View Device Property

6.1.3.2 View and Edit Device Graphic Property

The device graphic property can be viewed and edited in the graphic object property window. This window can be opened by right clicking on a device, then choose “Show Property”, as shown in Figure 30.

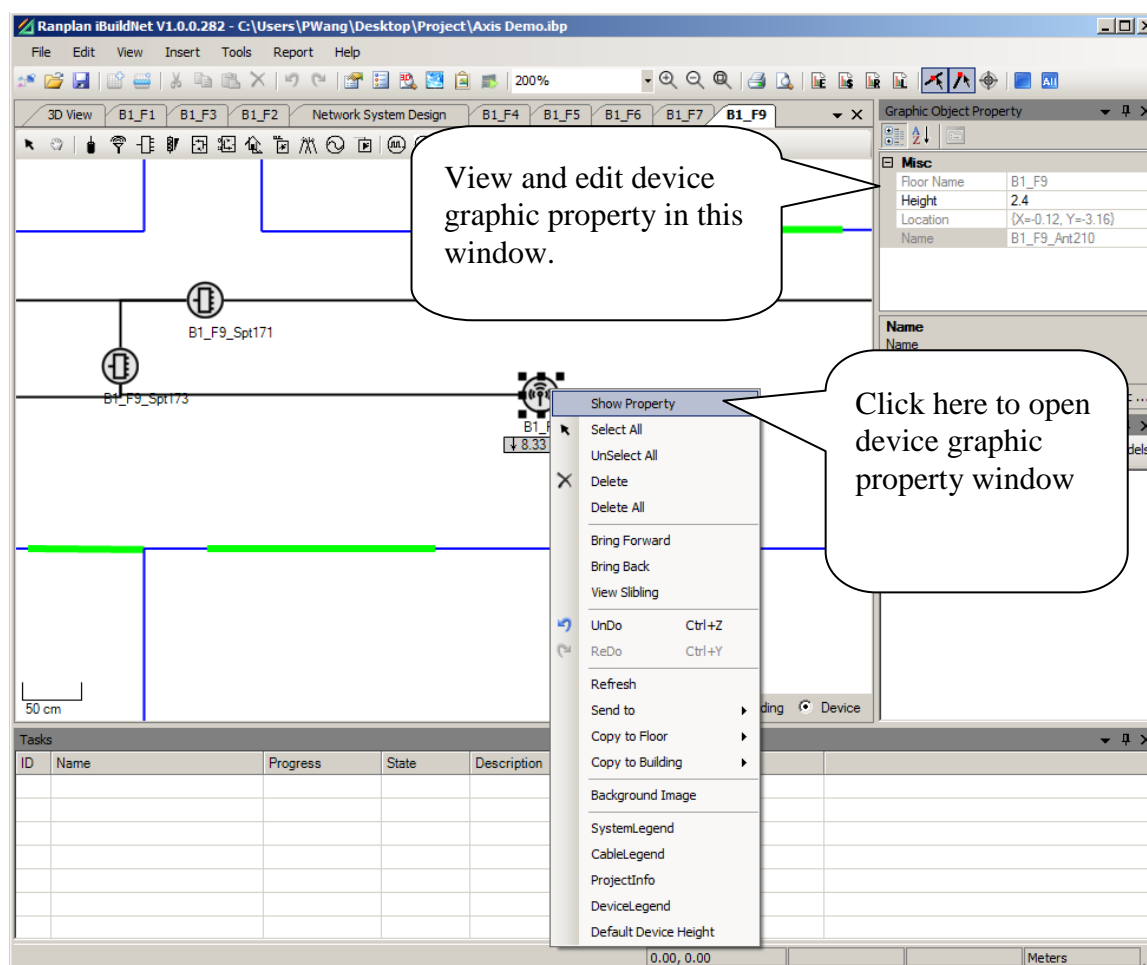


Figure 30. Open Graphic Object Property Window

6.1.4 Delete Devices

In order to delete a device, users have to select the target device, right click on it and choose "delete". Figure 31 shows an example of deleting an antenna.

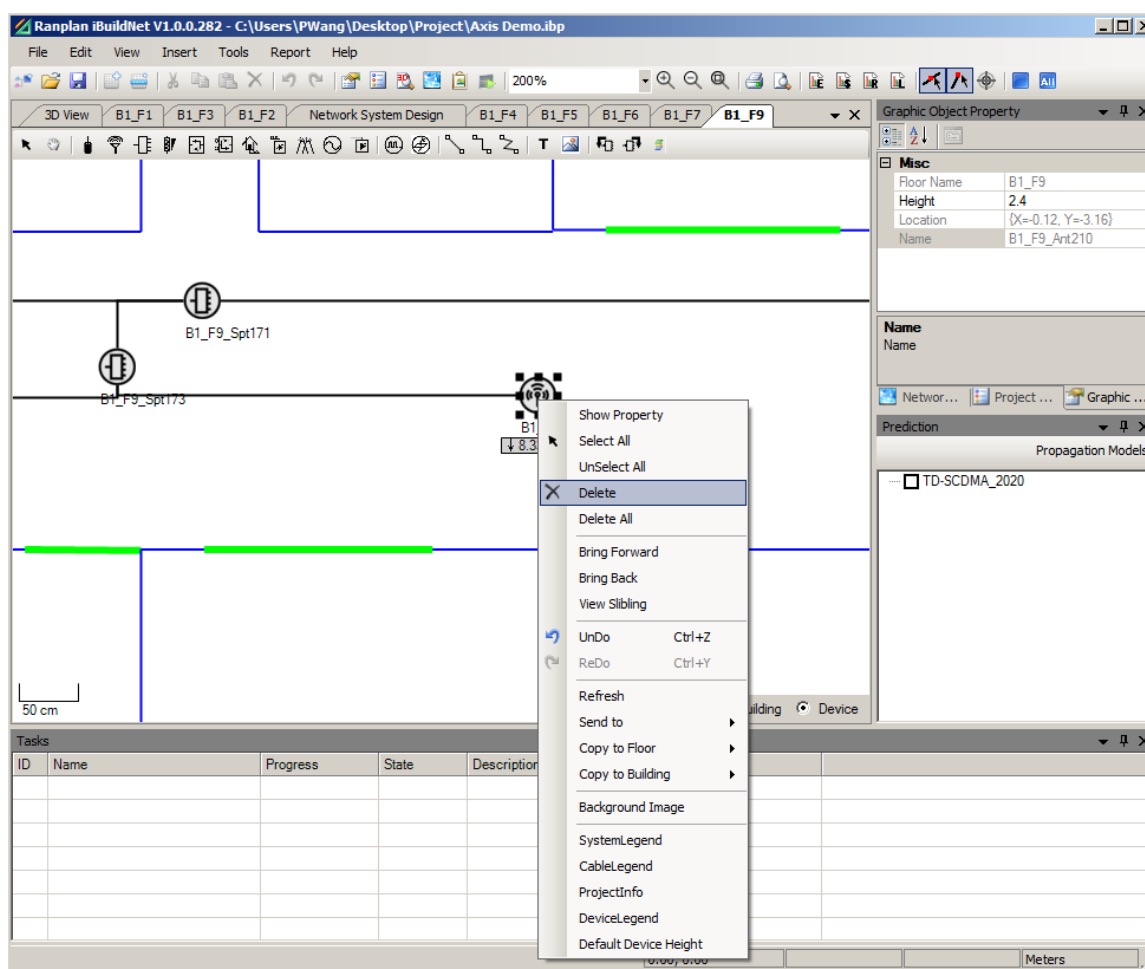


Figure 31. Delete a Device

6.1.4.1 Send Devices

Users can send target device to specified floor in network system design interface. The target device has to be selected using select tool, and right click on the device. Users now are able to select “Send to” from the right click menu, and then choose the building and floors that the device will be sent to. Figure 32 shows an example of sending a splitter to another floor.

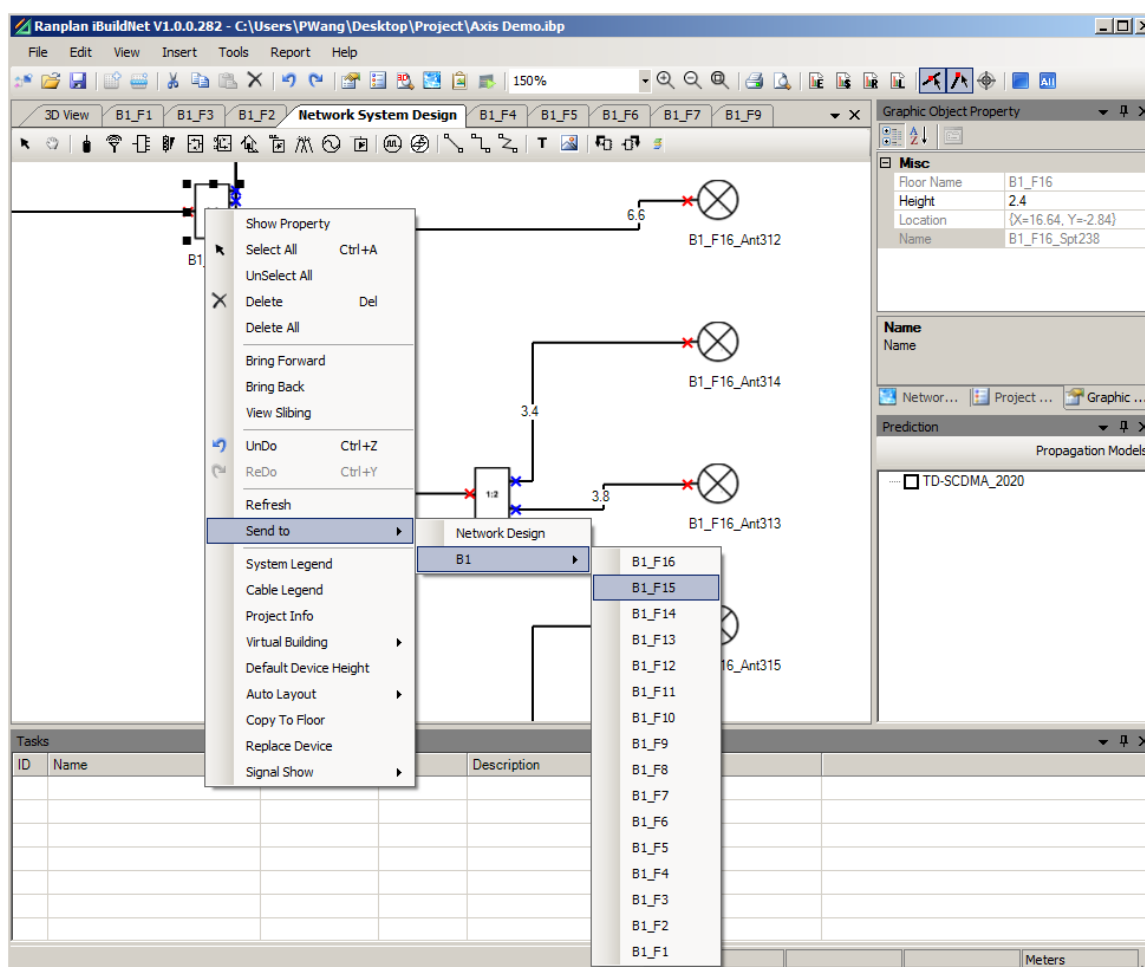


Figure 32. Send Device

6.1.4.2 Connect Device

Appropriate devices can be connected using network cables. Click on the “Cable” shortcut from device toolbar. Connect the devices using cables whose properties are compatible with both of the two devices. Figure 33 shows an example of choosing a cable. The instruction of connecting devices is shown in Figure 34 and Figure 35.

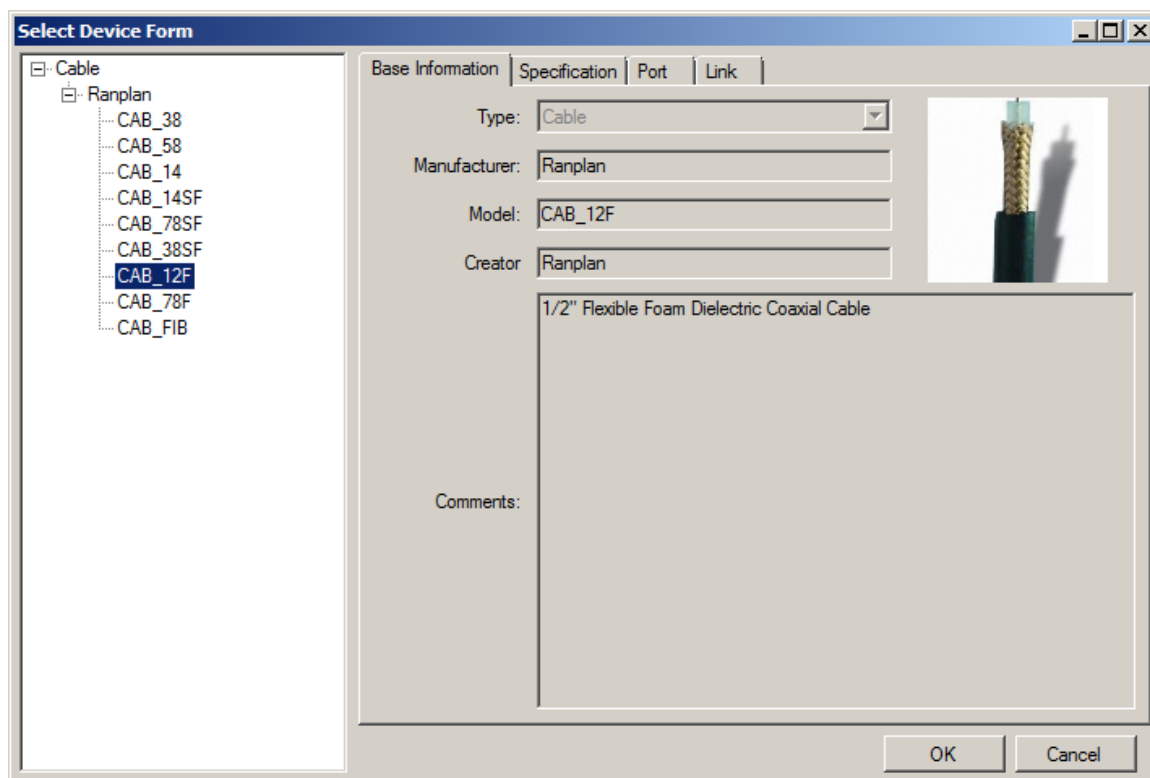


Figure 33. Choosing Cable

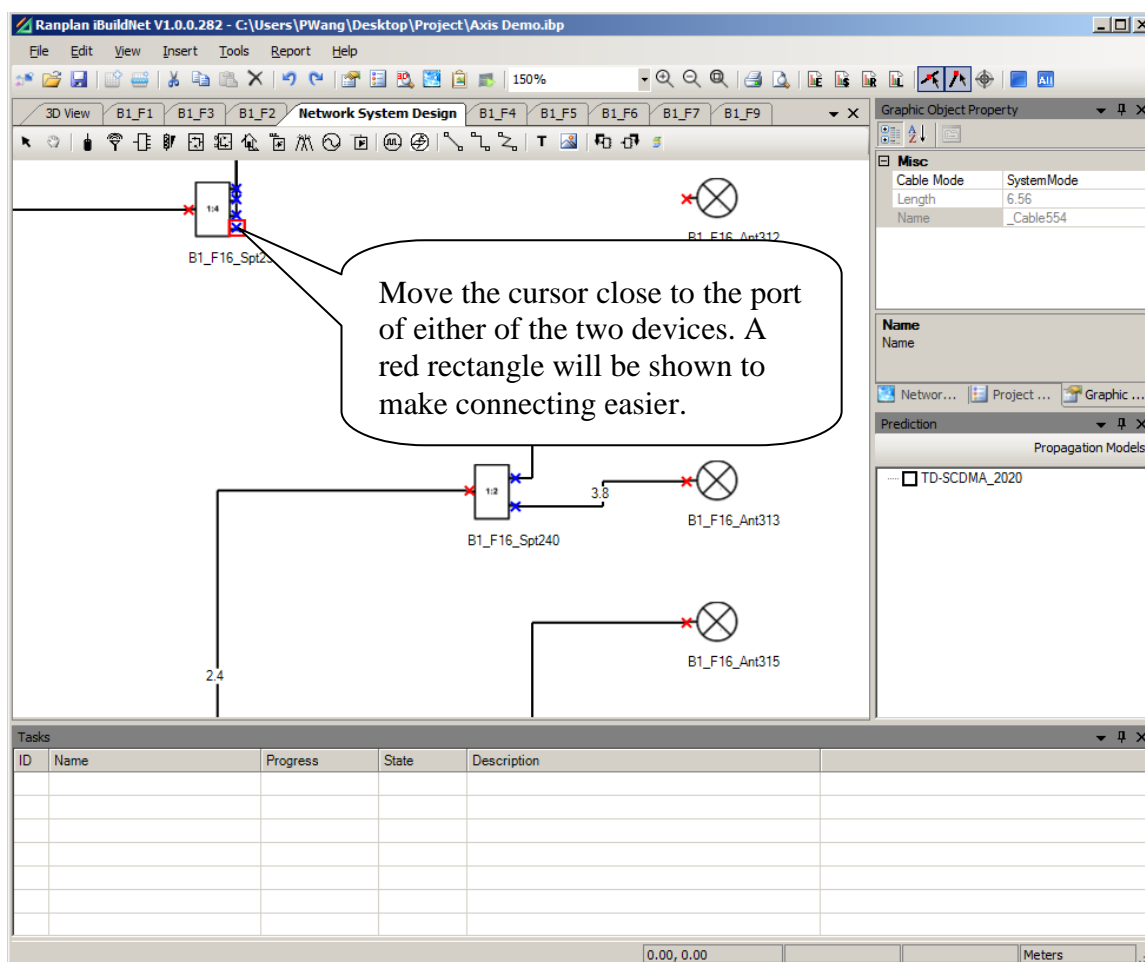


Figure 34. Connect Devices I

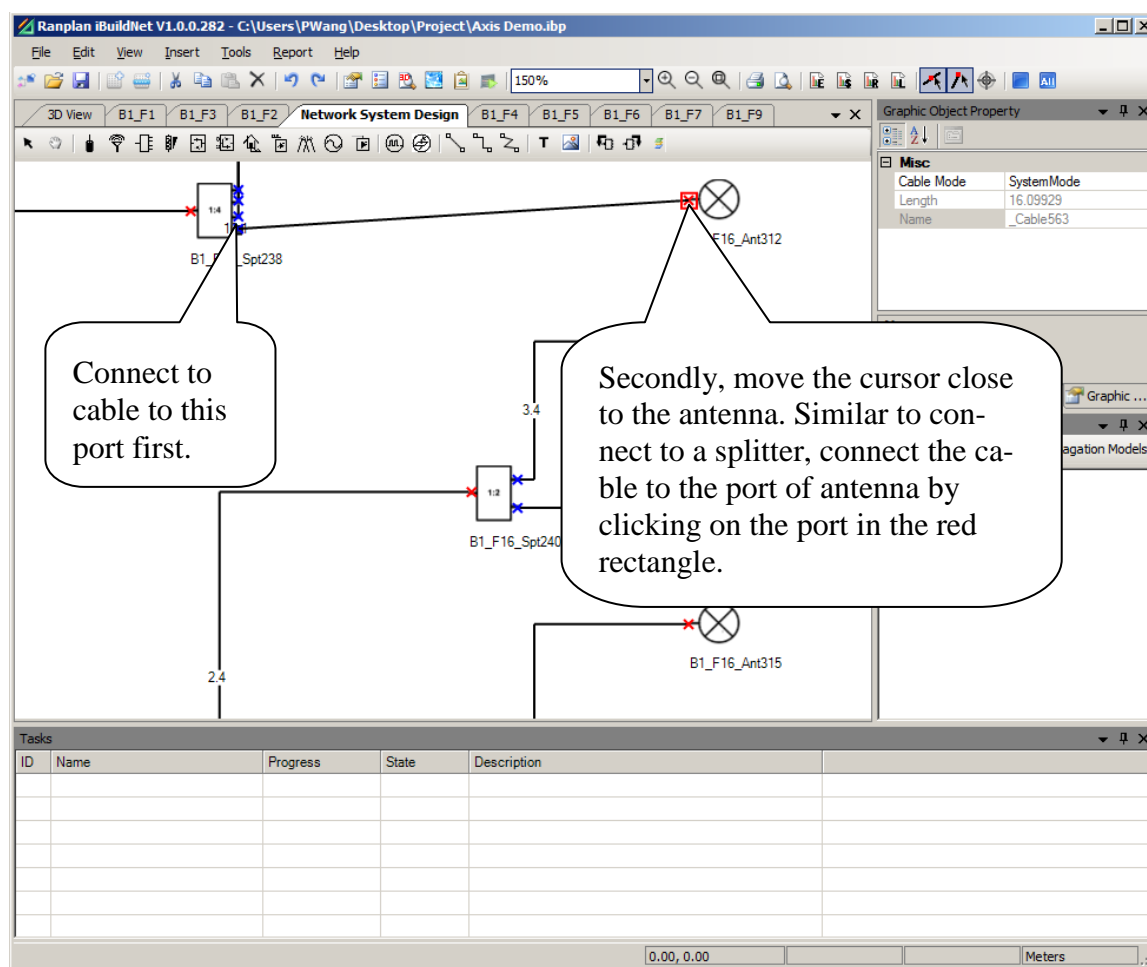


Figure 35. Connect Devices II

If the port is already being used by another cable, a message will be pop out as shown in Figure 36.

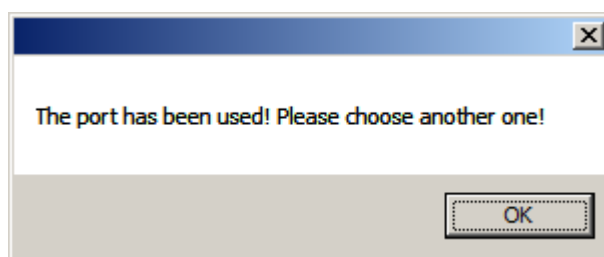


Figure 36. Port has been used

6.1.4.3 Cable Routing

There are three cable routing style: Straight Line, Right Angled Line and Free Style Line, as shown in Figure 37.

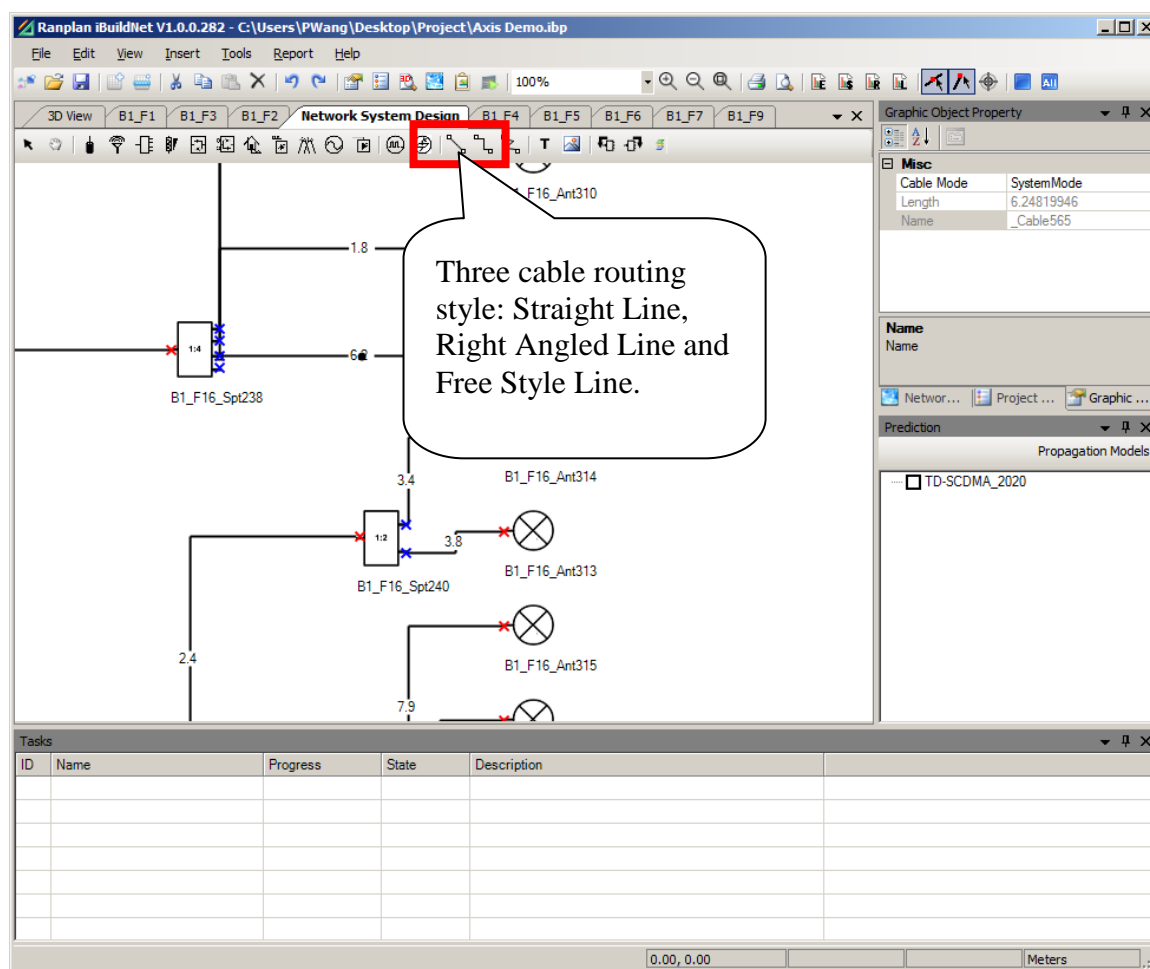


Figure 37. Cable Routing Style

6.1.5 Auto Layout

Users can use auto layout function to organize devices in NSD view. There are two types of auto layout style (Free Style and Floor Style) can be used as shown in Figure 38.

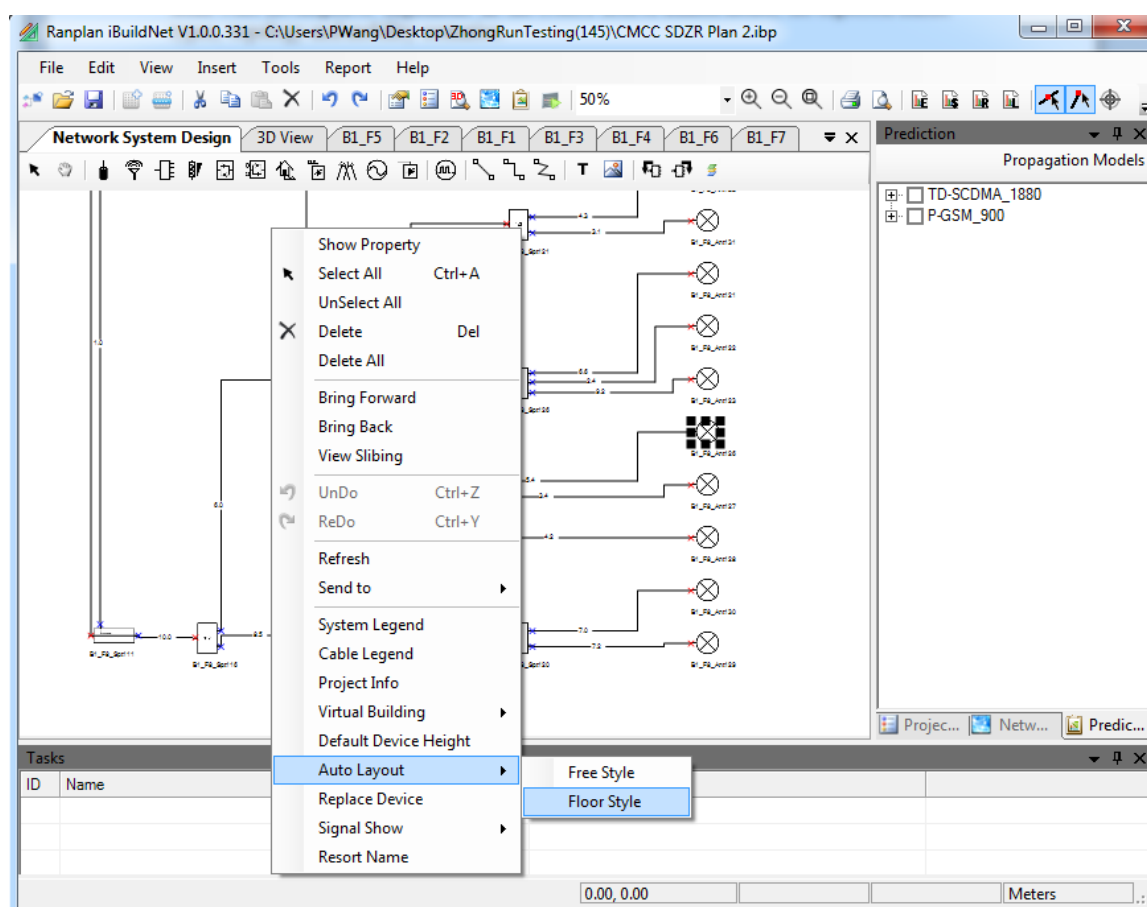


Figure 38. Auto Layout

6.2 Floor Layout Design (FLD)

6.2.1 Send Devices from FLD

As stated in previous sections, users can send one device to one floor (FLD) from NSD. This operation can also be done from FLD as well. Figure 39 shows an example of sending device to other floors from FLD.

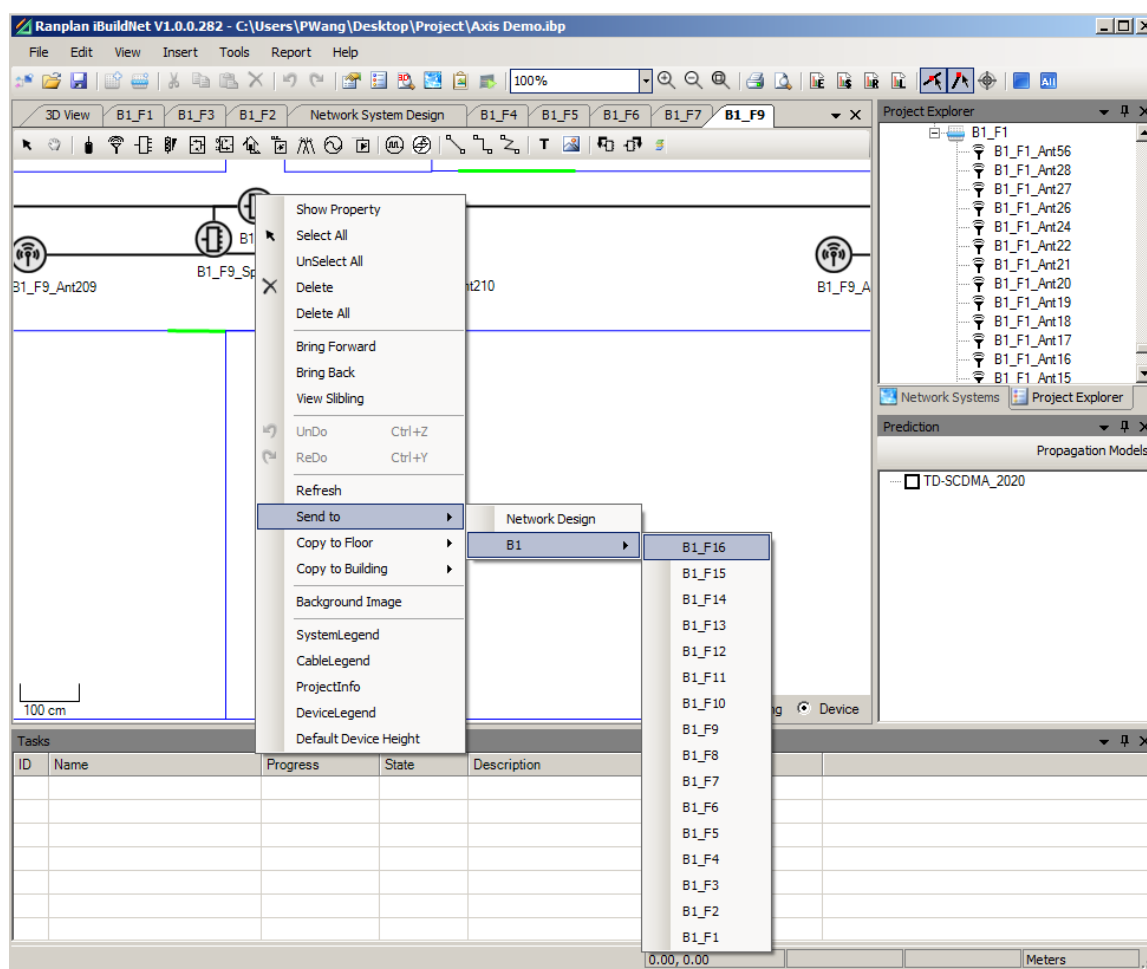


Figure 39. Send Device to Other Floors from FLD

6.2.2 Design Floor Layout

For the device that adds in floor layout design, only the category icon is used to represent the device. All the devices that add to FLD will be added to the NSD accordingly, the operation of adding devices in FLD is similar to the operation in NSD. The detailed device operation in FLD can be referred to in NSD.

7 System Performance Evaluation (SPE) and 3D Display

7.1 SPE Introduction

System performance evaluation (SPE) is a special module of iBuildNet. SPE algorithm is based on full 3D Ray Tracing and Ray Launching technique. It is able to provide accurate performance evaluation in a short period of time. It includes path loss calculation, signal strength calculation and best cell calculation.

SPE is one of the key evaluation indexes in indoor wireless network planning and optimization. The result of planning and optimization relies heavily on the performance of SPE. SPE has to achieve a relatively accurate prediction in a short period of time. RRPS (Ranplan Radiowave Propagation Simulations) is also integrated in Ranplan iBuildNet. [4] RRPS is a powerful 3D ray tracing model engine. 3D multi-path data and path loss matrix can be obtained within a short period of time. Furthermore, the RRPS engine also contains many sophisticated empirical model and semi-empirical model, such as Multi-Wall Model. RRPS is able to accomplish a full 3D signal calculation of one antenna within several seconds, with an accuracy rate of around 7 dB. Ranplan iBuildNet also has one built-in propagation model which was developed by our company. This will greatly improve work efficiency and save costs.

7.2 Configure Propagation Models

As stated in previous chapters, RRPS is integrated in iBuildNet, therefore several propagation models can be used for system performance evaluation.

Users are able to configure the propagation model to meet different user requirements. In order to configure the propagation model, users should click on the “Propagation Models” button on SPE viewer window (Press F9 to open SPE viewer window). The “Ranplan Radiowave Propagation Engine” configuration window will pop up, as shown in Figure 40. The propagation model configuration window contains 6 tabs. Relevant parameters can be configured on them.

The screenshot shows the 'Ranplan Radiowave Propagation Engine - Configuration [RELEASE]' window with the 'General' tab selected. The window contains several input fields and a status bar. The fields are as follows:

Field Name	Value
Name	Ranplan Radiowave Propagation Simulator Module
Version Major	2
Version Minor	597
Area Type	C_AREA_NOT_DEFINED = 0;
Upper Limit of Path Loss in dB	165.00000
Lower Limit of Path Loss in dB	0.00000
Global Adjustment	0.00000
DLL Path	C:\Users\PWang\Desktop\R282\RPMLib.dll
Language File	(Empty field with Browse and Apply buttons)

At the bottom of the window, the status bar displays: 'IUtility: 1.68 - FastMM: 4.97 - TimeStamp: 11/02/2011 11:31:08 DLL: 2.597.0.105'. Below the status bar are buttons for 'OK', 'Cancel', 'Reset', and 'Apply'.

Figure 40. Propagation Model Configuration Window

7.2.1 General Parameters

The “General” tab, as shown in Figure 40, contains the following information:

- Name: Name of this module.
- Version Major: This number will only be changed if new core algorithm is applied and tested.
- Version Minor: As this module keeps updating. The minor version keeps changing accordingly.
- Area Type: This is used to define the radio propagation scenario, such as indoor, dense urban, urban etc. Users do not need to configure this parameter if the project is only involved in indoor radio network design. It is set to indoor scenario by default.

- Upper Limit of Path Loss in dB: Maximum path loss threshold that configured for simulation.
- Lower Limit of Path Loss in dB: Minimum controlled path loss threshold that configured for simulation
- Global Adjustment: The value to shift for all predictions after simulation.
- Language File: Specifies a language for this propagation model configuration window.

7.2.2 Scenario Parameters

The “Scenario” tab, as shown in Figure 41, contains the following information:

The screenshot shows the 'Scenario' tab of the 'Ranplan Radiowave Propagation Engine - Configuration [RELEASE]' window. The window has a title bar with standard Windows controls. Below the title bar is a tabbed interface with tabs for 'General', 'Scenario' (selected), 'Network', 'Emitter', 'Miscellaneous', and 'Computation'. The 'Scenario' tab contains several input fields and buttons:

- Discrete Database (*.vc)**: A text input field with a 'Browse' button to its right.
- Path Loss (*.ecb)**: A text input field with a 'Browse' button to its right.
- Scale**: A text input field containing the value '1.00000'.
- Distance Coefficient (LOS)**: A text input field containing the value '20.00000'.
- Path Loss Constant**: A text input field containing the value '32.44000'.
- Distance Coefficient (NLOS)**: A text input field containing the value '20.00000'.
- Frequency Coefficient**: A text input field containing the value '20.00000'.
- Max Delay (ns)**: A checkbox that is currently unchecked.
- Filter**: A checkbox that is currently unchecked.
- Clutter Index File (*.txt)**: A text input field with a 'Browse' button to its right.
- DEM Index File (*.txt)**: A text input field with a 'Browse' button to its right.

At the bottom of the window are four buttons: 'OK', 'Cancel', 'Reset', and 'Apply'.

Figure 41. Propagation Model Configuration Window - Scenario Tab

- Discrete Database (*.vc): The file path for storing the building data. It will be automatically set in iBuildNet during runtime.
- Path Loss (*.ecb): The file path for storing the path loss (automatically set in iBuildNet during runtime).
- Scale: e.g. set the scale to 1000 if the base unit used is km.
- Distance Coefficient (LOS): Line-of-sight path loss coefficient.
- Path Loss Constant: i.e. $20 * \log_{10}(f) + 20 * \log_{10}(d) + 32.45$.
- Distance Coefficient (NLOS): None-line-of-sight path loss coefficient.
- Frequency Coefficient: i.e. $20 * \log_{10}(f) + 20 * \log_{10}(d) + 32.45$
- Max Delay (ns): Whether each ray is limited to have max delay (ns).
- Filter: Filter the result after simulation (average surround 1 pixel).
- Clutter Index File (*.txt): Used in outdoor simulation for storing clutter data.
- DEM Index File (*.txt): Used in outdoor simulation for storing DEM data.

7.2.3 Network Parameters

The “Network” tab, as shown in Figure 42, contains the following information:

Ranplan Radiowave Propagation Engine - Configuration [RELEASE]

General | Scenario | **Network** | Emitter | Miscellaneous | Computation

Reflection Loss (dB)
5.00000

Transmission Loss (dB)
11.00000

Diffraction Loss (dB)
7.00000

Roof-top Diffraction Loss (dB)
7.00000

Maximum Reflection
4

Maximum Transmission
5

Maximum Diffraction
2

Maximum Roof-top Diffraction
3

Maximum Iteration
10

OK Cancel Reset Apply

Figure 42. Propagation Model Configuration Window - Network Tab

- Reflection Loss (dB): Default reflection loss if material is not available.
- Transmission Loss (dB): Default transmission loss if material is not available.
- Diffraction Loss (dB): Default diffraction loss if material is not available.
- Roof-top-diffraction Loss (dB): Default vertical diffraction loss if material is not available
- Maximum Reflection: The maximum reflection each ray can travel.
- Maximum Transmission: The maximum transmission each ray can travel.
- Maximum Diffraction: The maximum diffraction each ray can travel.
- Maximum Roof-top-Diffraction: The maximum vertical diffraction each ray can travel.
- Maximum Iteration: The maximum combination (reflection diffraction etc) that each ray can travel.

7.2.4 Emitter Parameters

The “Emitter” tab, as shown in Figure 43, contains the following information:

The screenshot shows a software window titled "Ranplan Radiowave Propagation Engine - Configuration [RELEASE]". It has a tabbed interface with tabs for "General", "Scenario", "Network", "Emitter", "Miscellaneous", and "Computation". The "Emitter" tab is selected. The window contains several input fields and a checkbox:

- Cubic Position X: -1
- Cubic Position Y: -1
- Cubic Position Z: -1
- Frequency (GHz): 0.00000
- Bearing: 0.00000
- M-Tilt: 0.00000
- E-Tilt: 0.00000
- Power (dBm): 0.00000
- ☐ Force No Antenna Pattern

At the bottom of the window are four buttons: "OK", "Cancel", "Reset", and "Apply".

Figure 43. Propagation Model Configuration Window - Emitter Tab

- Force No Antenna Pattern: No antenna pattern will be used in calculation.
- All others are read-only fields that are intended for displaying information about current emitter being computed.

7.2.5 Miscellaneous Parameters

The “Miscellaneous” tab, as shown in Figure 44, contains the following information:

The screenshot shows the 'Miscellaneous' tab of the 'Ranplan Radiowave Propagation Engine - Configuration [RELEASE]' window. The window has a title bar with standard Windows controls. Below the title bar are tabs for 'General', 'Scenario', 'Network', 'Emitter', 'Miscellaneous' (selected), and 'Computation'. The 'Miscellaneous' tab contains several input fields and a button:

- 'Original Map Lowest-X': A text box containing '0.00000'.
- 'Original Map Lowest-Y': A text box containing '0.00000'.
- 'Original Map Lowest-Z': A text box containing '0.00000'.
- 'Post VC': A text box containing '0'.
- 'Post_PL': A text box containing '0.00000'.
- 'Image Scale': A text box containing '1.00000'.
- 'Multithreading': A dropdown menu showing '7'.
- 'Thread Priority': A dropdown menu showing '3 = Normal'.
- 'Paths': A text box with a 'Browse' button next to it.

At the bottom of the window are four buttons: 'OK', 'Cancel', 'Reset', and 'Apply'.

Figure 44. Propagation Model Configuration Window - Miscellaneous Tab

- Original Map Lowest-X: Stores the original map coordinate X.
- Original Map Lowest-Y: Stores the original map coordinate Y.
- Original Map Lowest-Z: Stores the original map coordinate Z.
- Post-VC: Cubic Flag to control after simulation.
- Post-PL: Set the Post-VC bit to pre-defined path loss after simulation.
- Image Scale: The image scale to generate pictures.
- Multithreading: The number of threads to be used in simulation.
- Thread Priority: Thread priority of the threads.
- Path: Multipath file location.

7.3 System Performance Calculation

SPE is the one of most important modules of Ranplan iBuildNet. The operations of SPE include:

- New performance index evaluation
- Refresh existing performance index evaluation
- Re-evaluate performance index
- Deleting existing performance index
- View performance index evaluation
- 3D view display
- Print

7.3.1 Create New Performance Index Evaluation

Every system is able to create a number of SPE indexes. In order to create, from the SPE window (can be displayed by pressing F9) right click on a system and then click on “New”, see Figure 45. Different systems have to be evaluated separately.

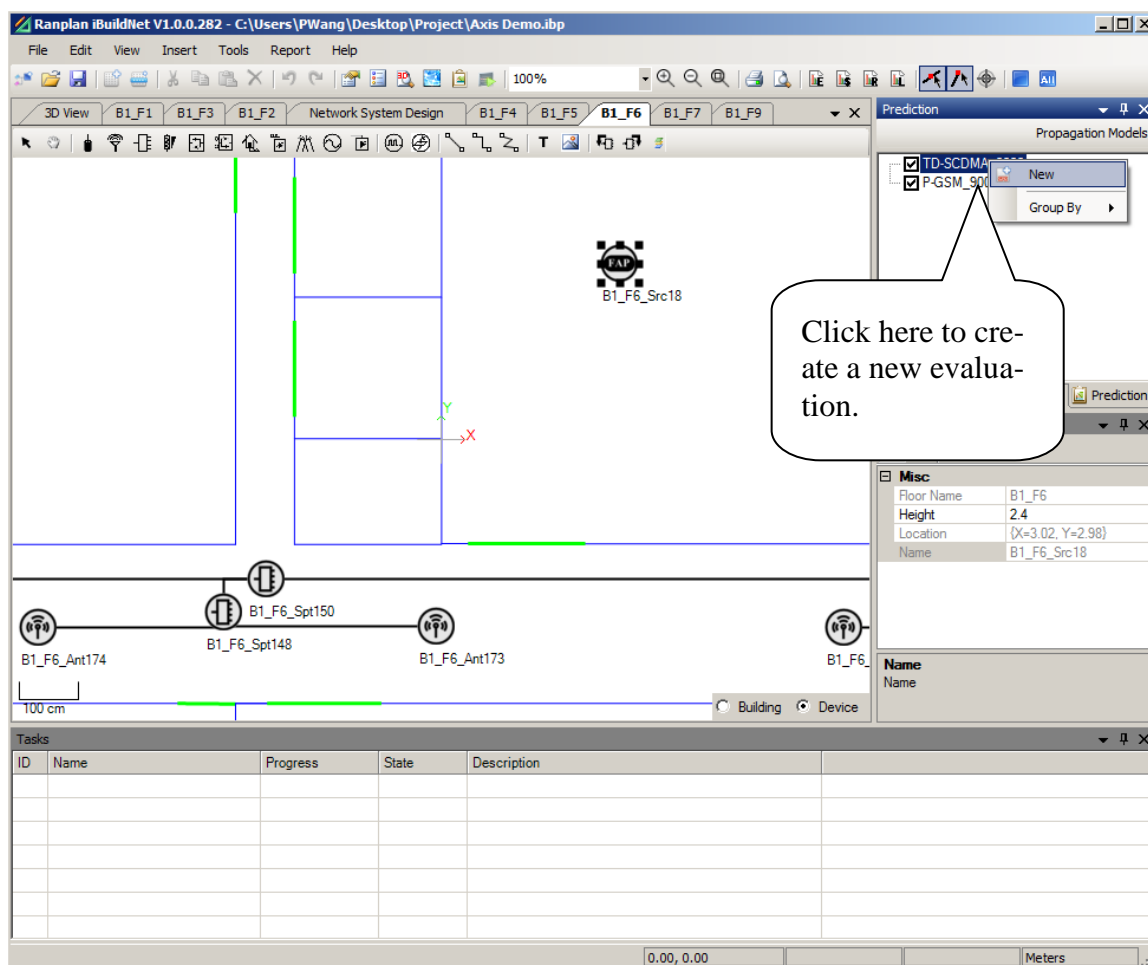


Figure 45. Create a New Evaluation

A pop-up window will be displayed, from where users can choose different prediction type, such as Path Loss, Signal Level, Best Signal Level and Best Server. As the propagation model setting may be reused for other projects. The settings can be saved for future use, as shown in Figure 46.

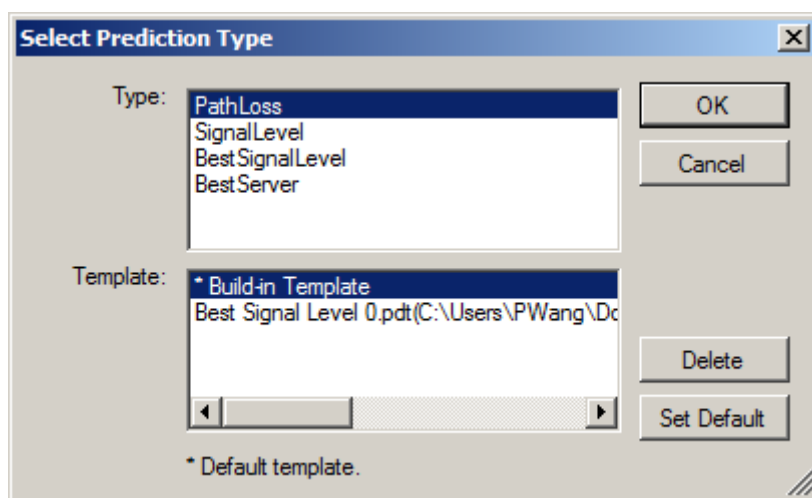


Figure 46. Choose a Prediction Type

The corresponding prediction will be created after a calculation has been selected. The configuration dialog for this prediction will be displayed as shown in Figure 47.

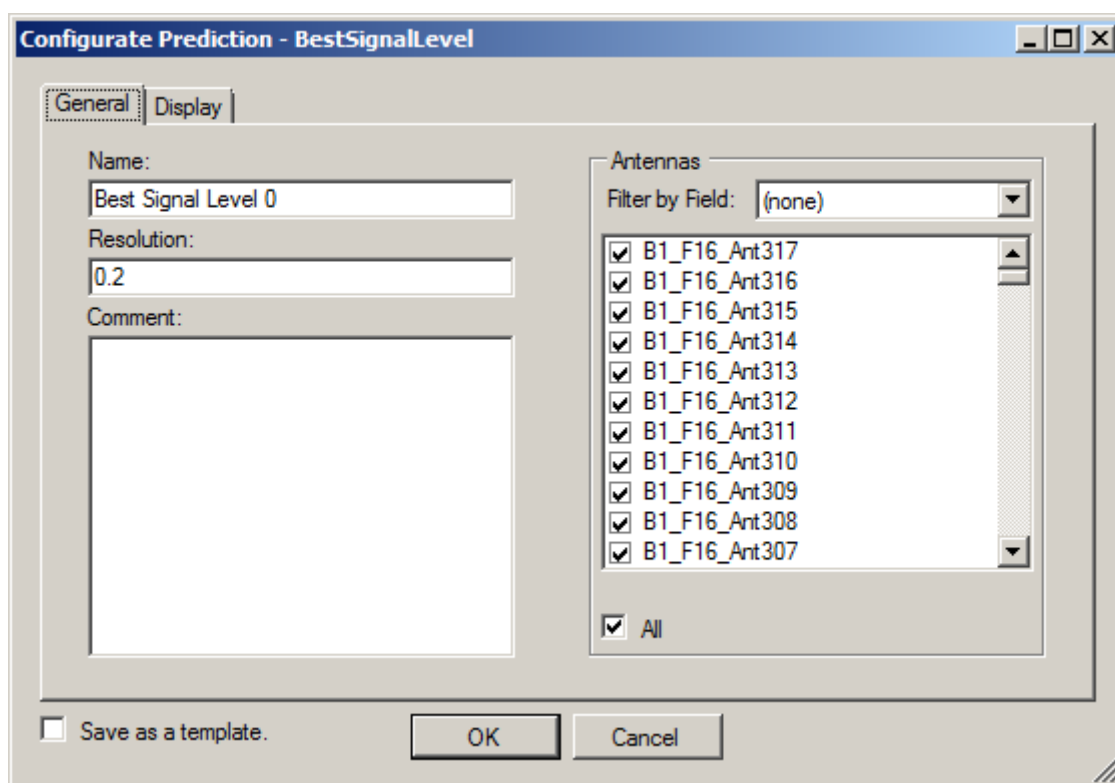


Figure 47. Configure Prediction

7.3.1.1 Configure General Parameters

There are two configuration tabs, General and Display, on this dialog window. From the General tab, users are able to define the name of the current prediction, the resolution of the prediction, record a comment and choose the antennas to be active in this prediction. The resolution is a very important parameter to a prediction. It will decide how accurate the prediction is. The unit of this parameter is the same as the unit of the building, such as Metre or Feet. The antennas can be chosen one by one or use the select all checkbox that is provided on the window. Moreover, users can use the filter to choose antennas, such as choose a floor, a building and so on. See Figure 48.

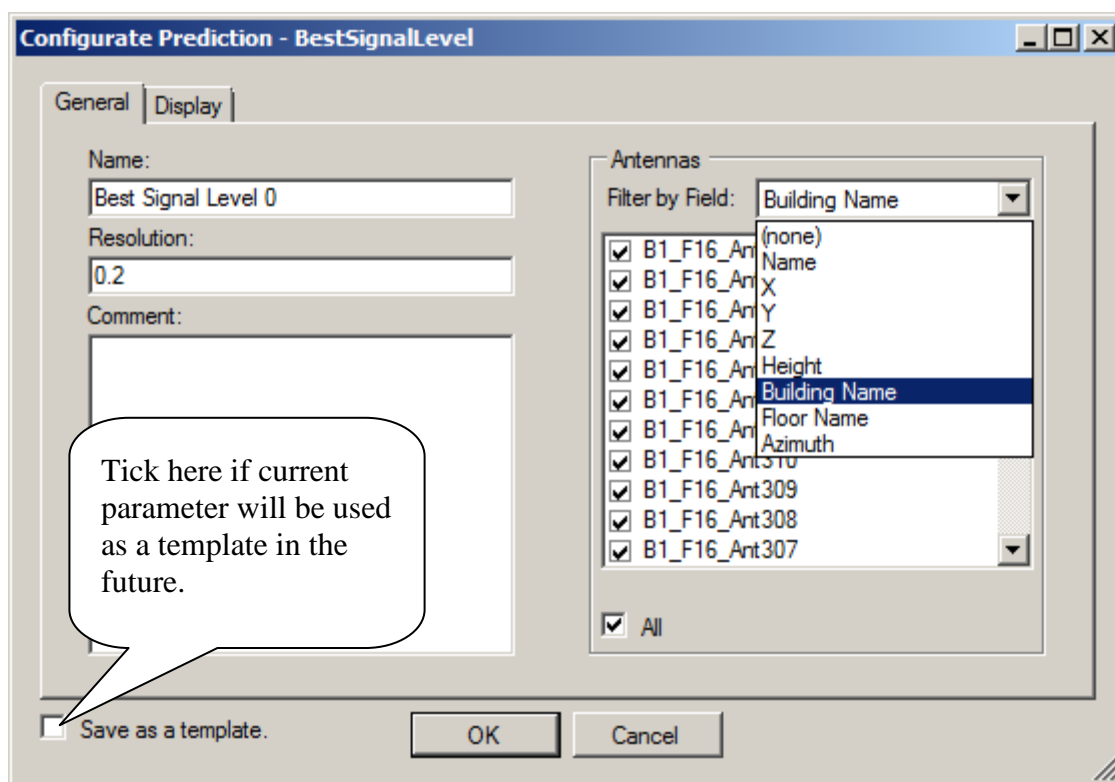


Figure 48. Choose Antennas Filtered by Field

7.3.1.2 Configure Display Parameters

The display parameters including: Signal Height, Display Type, Display Transparency and Display Legend, as shown in Figure 49.

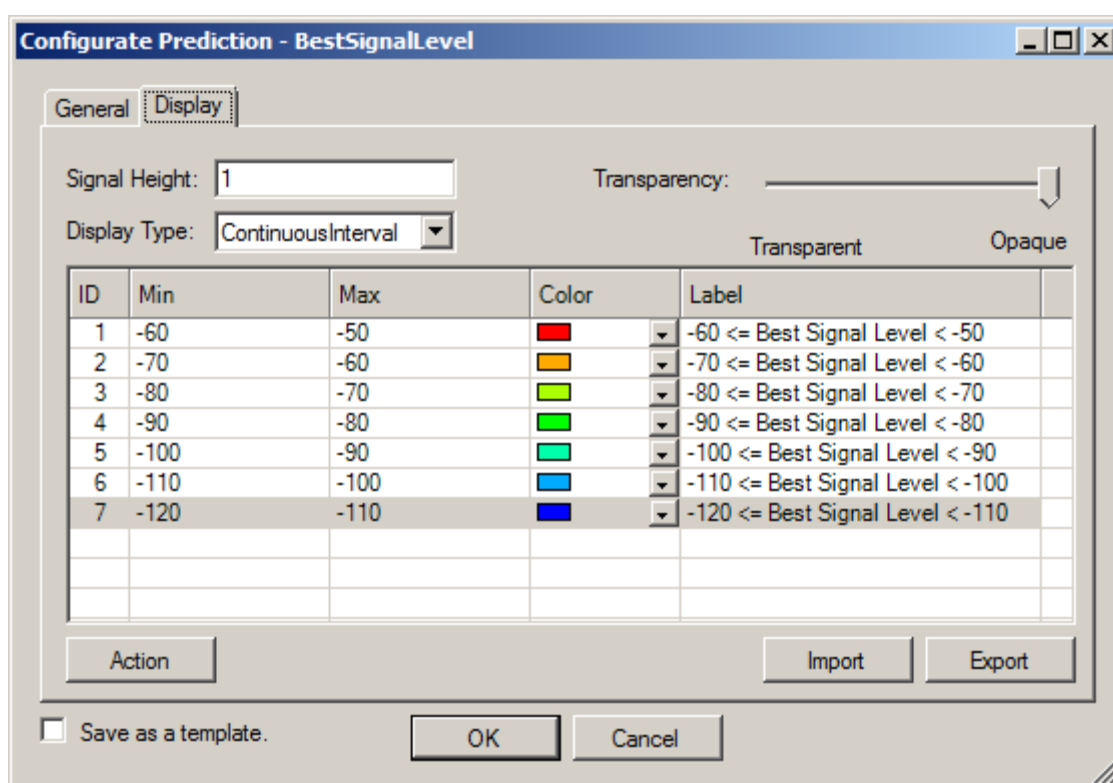


Figure 49. Configure Display Parameters

As the system performance prediction is carried out in full 3D calculation. There is a propagation result corresponding to a space point of a building. The size of the space point is determined by the resolution that configured in General tab. For instance, if the unit of the building is metres; and the resolution is configured as 0.2. Then each space point will be a cube with the size of 0.2*0.2*0.2 (Metre). The Signal Height to be configured here will determine the height of the signal prediction result that used to display in FLD or 3D view. Users are able to define the transparency of SPE results. There are two types, Continuous Interval and Continuous, of display style can be applied.

Legend can be edited by changing, adding or removing a step. The colour of the step can also be customized. The “Auto Colour” function enables users to configure colours of steps automatically, as shown in Figure 50. It is recommended that the default colour is used whenever the legend is edited.

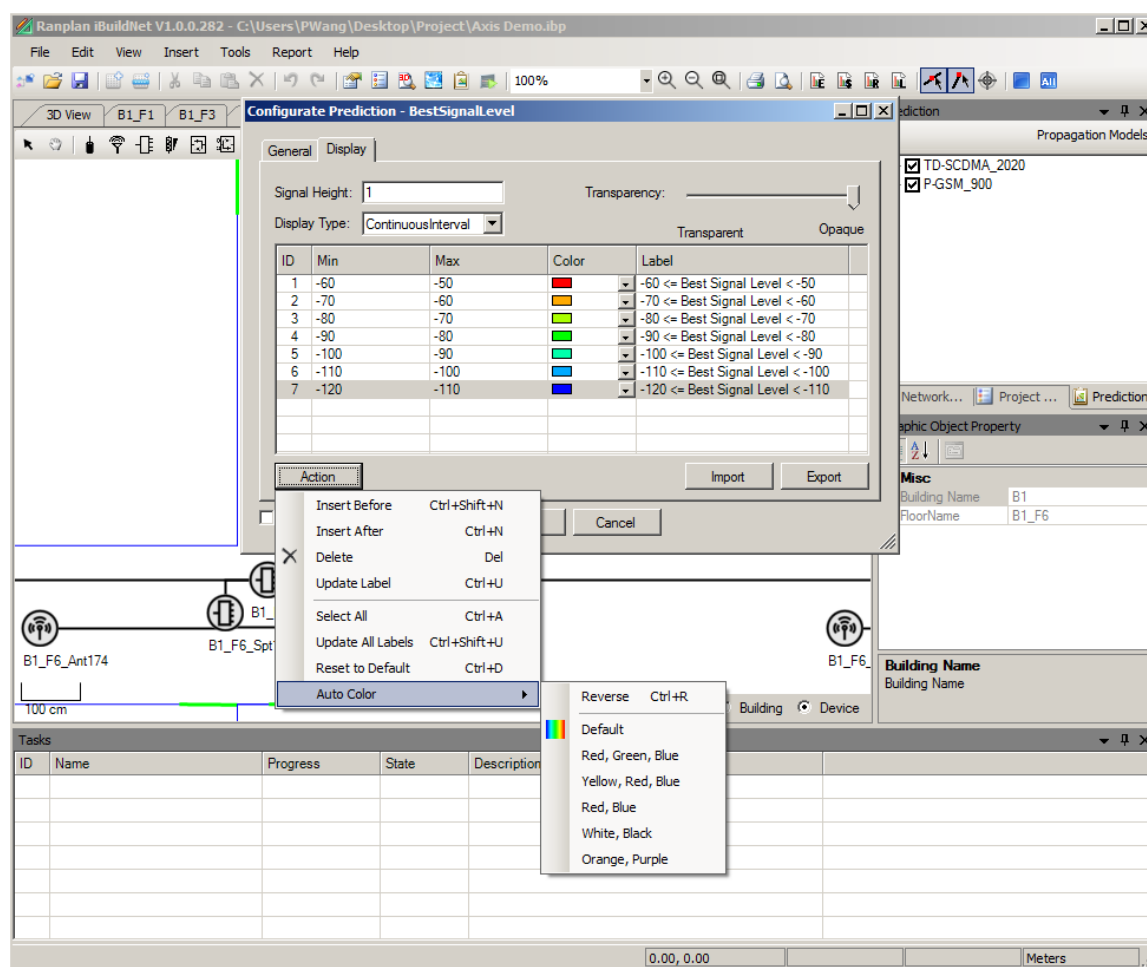


Figure 50. Auto Define Legend Colour

Any legend can be imported into the current prediction. A configured prediction can also be exported. The exported legend will be saved in .cfg format.

7.3.2 Start Calculation

After a new prediction is created, users are able to calculate by right clicking on the prediction and choose “Calculate”.

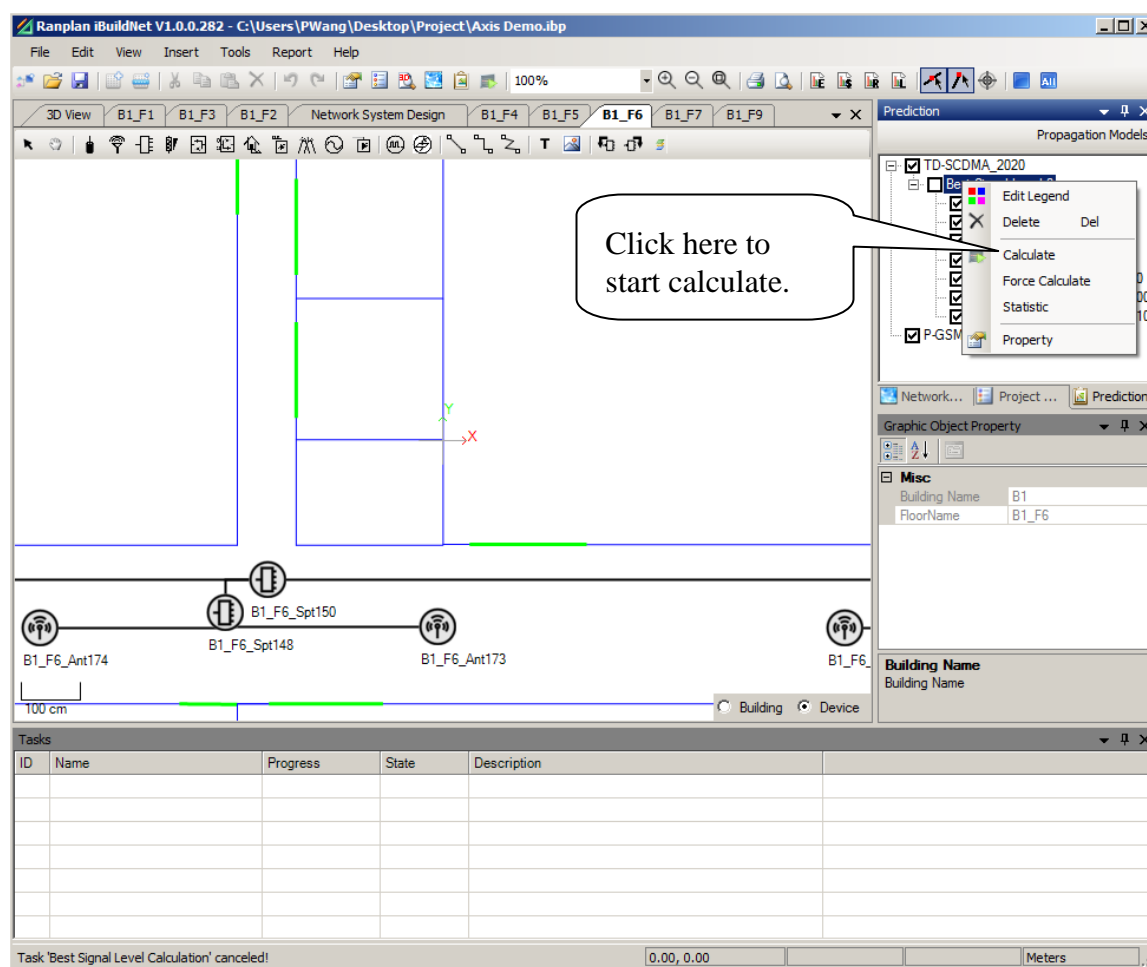


Figure 51. Start to Calculate a Prediction

7.3.3 End Calculation

When a calculation is started, the progress of the calculation can be viewed on the task bar as shown in Figure 52. The calculation can be ended by clicking on the “Stop” button that is indicated in Figure 52.

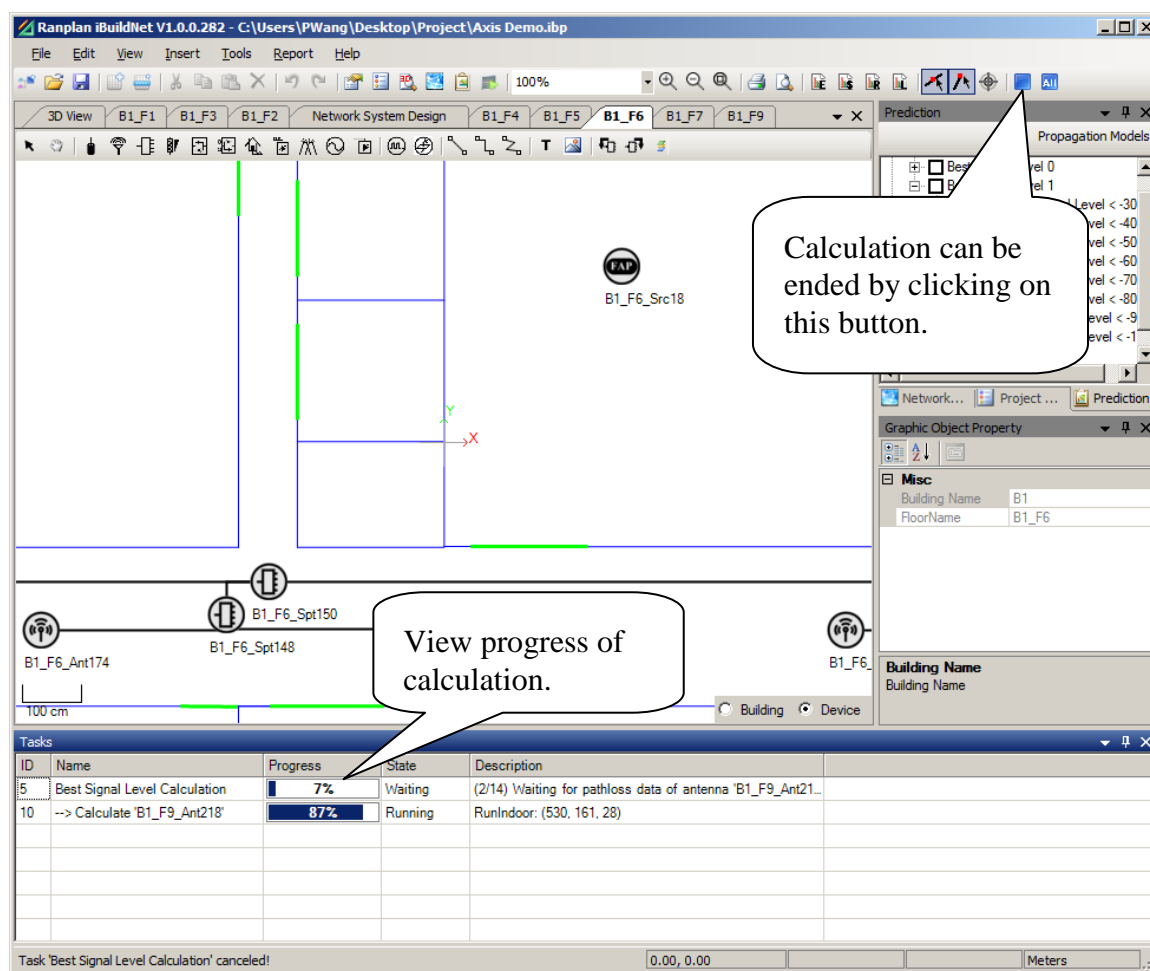
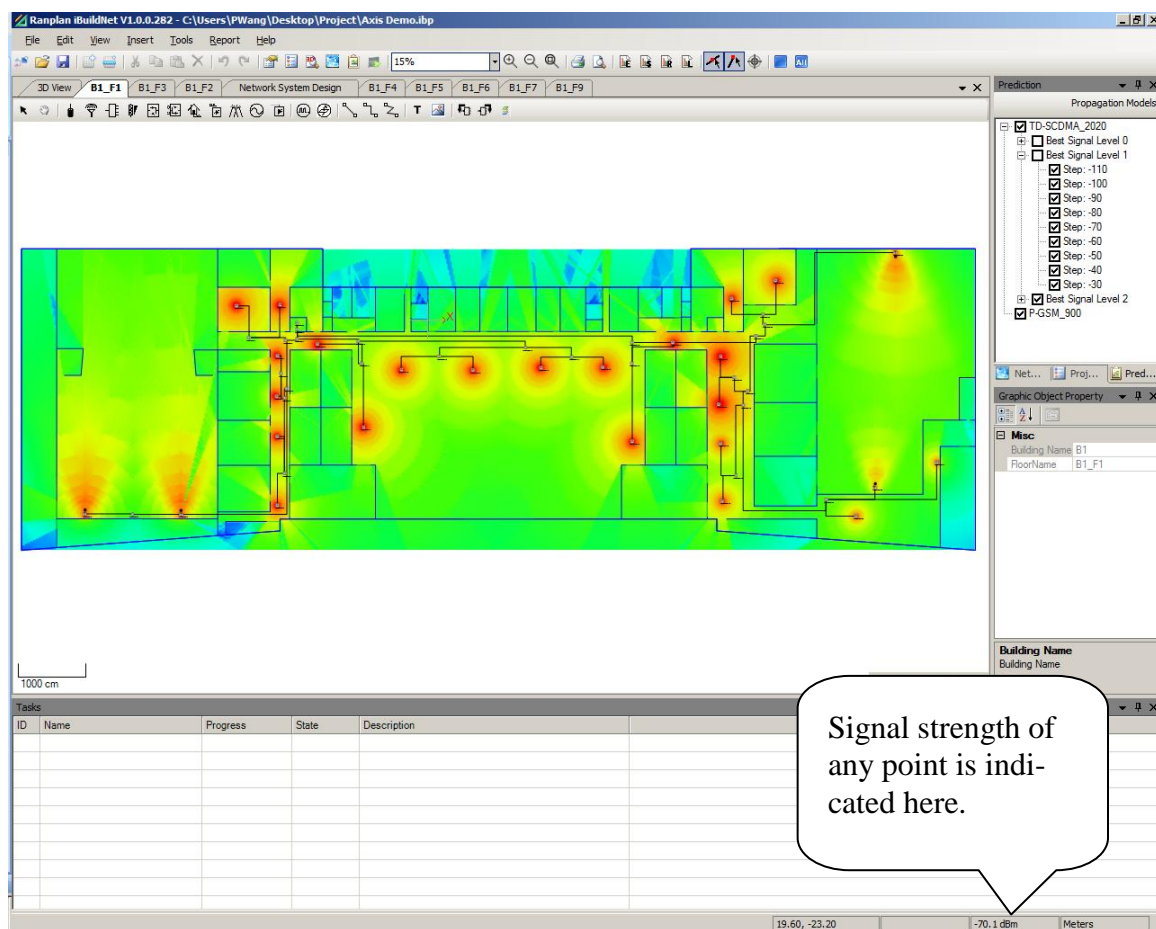


Figure 52. Check Calculation Progress in Task Bar

7.3.4 View SPE Result

Users are able to check the SPE result once the calculation is completed. The result can be viewed in FLD (2D) and 3D view. The signal level (in dBm) of any point in the building can be viewed in FLD mode. The signal level is stated on the status bar as shown in Figure 53.

3D view window contains Building Structure modelling (BSM), Floor Layout Design (FLD) and System Performance Evaluation (SPE). There are three display modes: docked, floated and maximized. Under floated mode, users can easily compare between 2D view and 3D view. When users editing FLD or NSD, it is not necessary to see 3D in real time, in this case users can set the mode to docked mode. The default 3D mode of the system is docked mode. Maximized mode can display 3D view more accurate and with a wider view, so it helps users to change the detail of the 3D view.



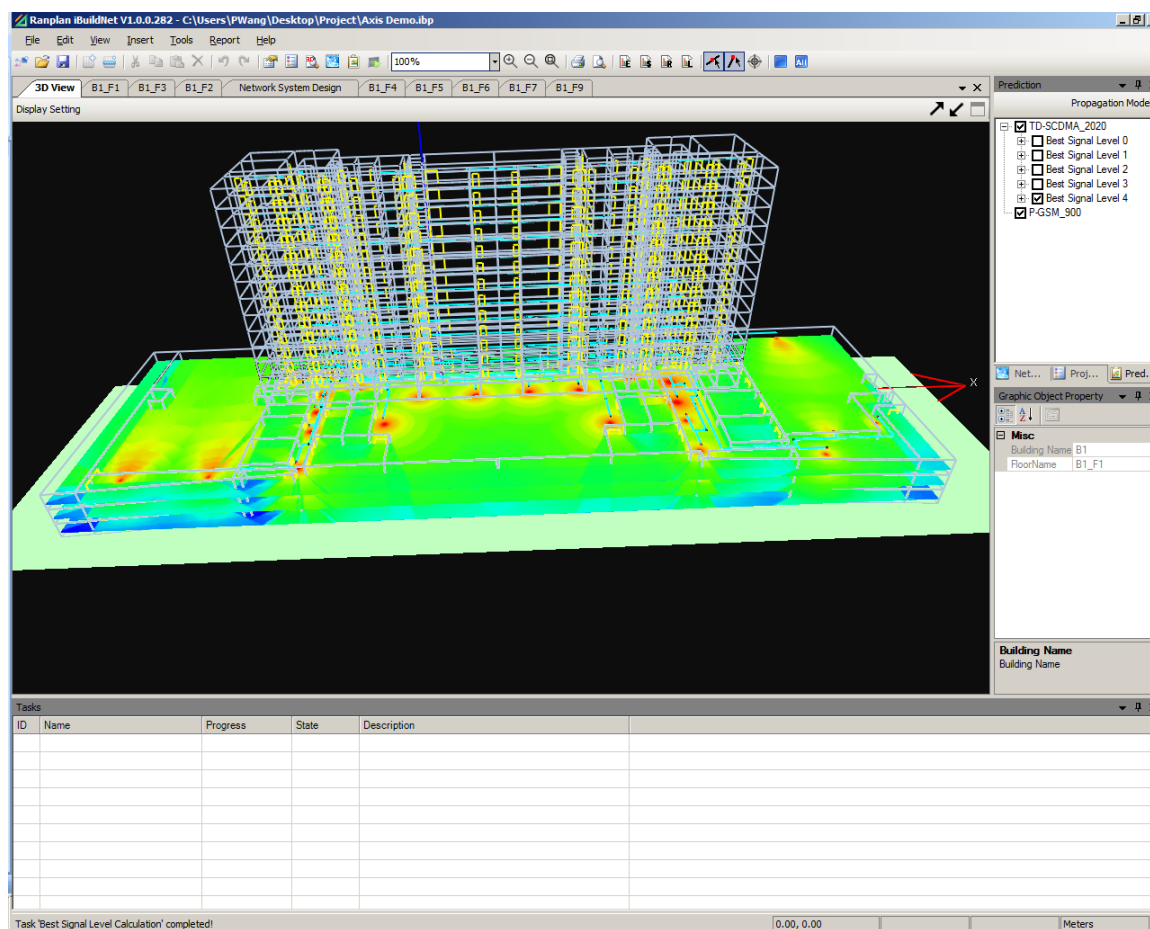


Figure 54. View SPE Result in 3D Mode

7.3.4.1 Configure Display Setting of SPE Result in 3D View

The display setting of SPE result in 3D view can be configured by clicking on “Display Setting” as shown in Figure 55.

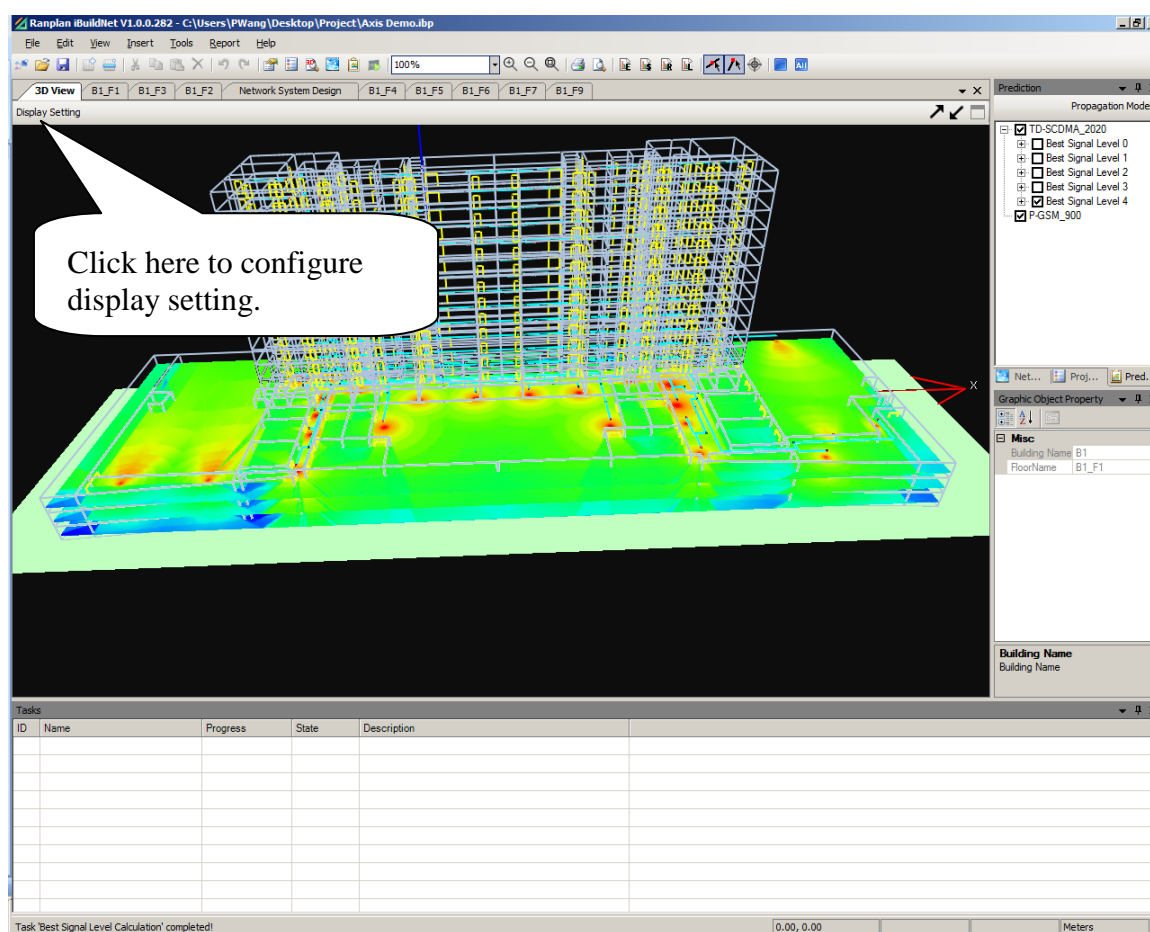


Figure 55. Configure Display Setting

The “3D View Display Setting” dialog will be displayed, as in Figure 56. Users are able to choose whether to display devices, building outline and its surface, and signal (SPE results). The colour of cable and ground can also be configured here.

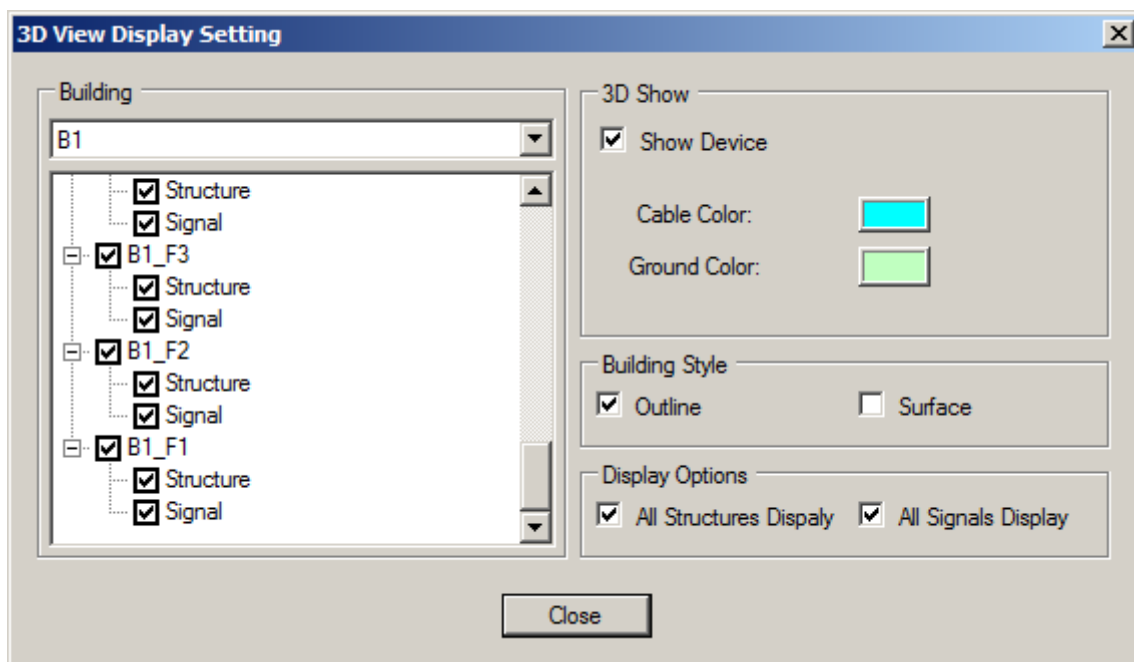


Figure 56. 3D View Display Setting

7.3.5 Re-use Current Path loss Data for Other Predictions

When anyone of the four prediction type has been calculated, the path loss data of all the antennas of current network design are obtained. Other prediction types can be calculated base on the path loss data, if there is no modification on the current network design. Therefore it will be time efficient to re-use the path loss data to generate other performance indicators. In order to re-use the path loss data, users can create a new prediction type, and then choose “Calculate” in the SPE right click menu, see Figure 57.

If there is no available previous prediction result, the SPE engine will calculate the selected system as a new calculation.

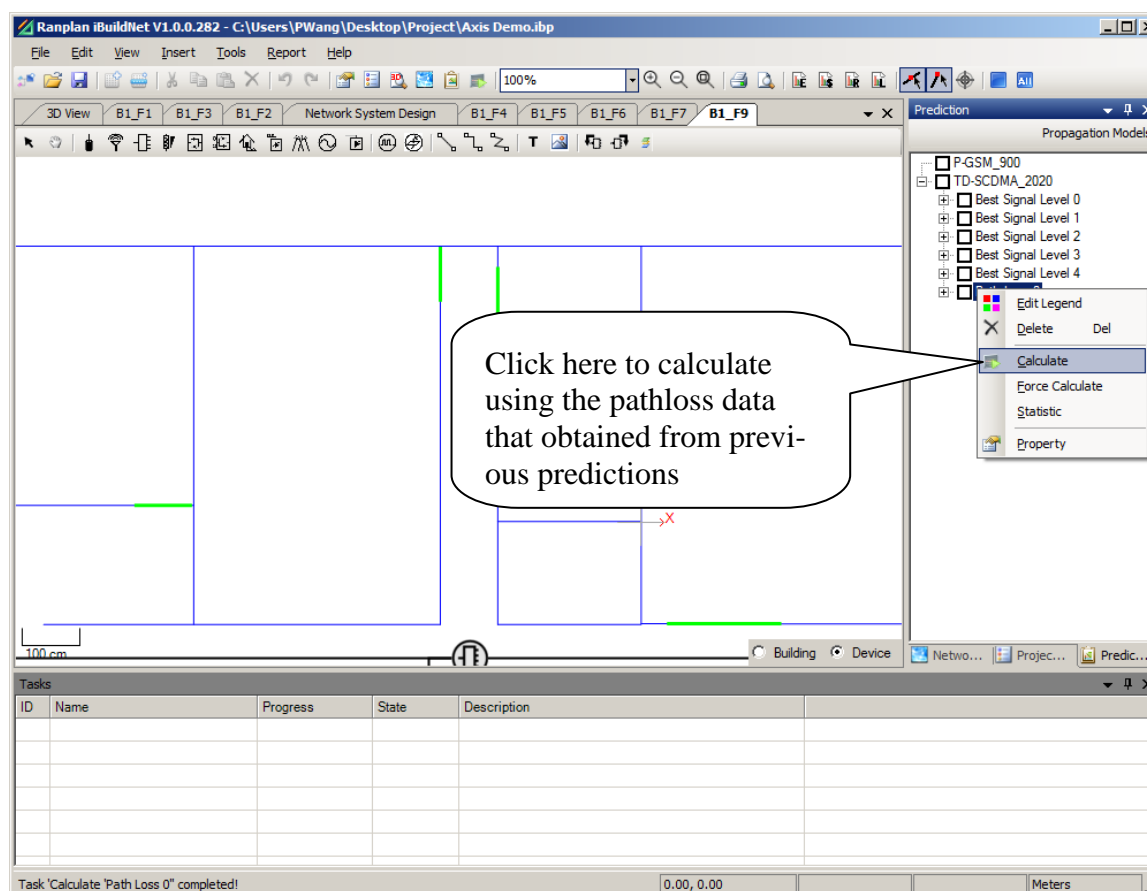


Figure 57. Calculate New Prediction Base on Previous Result

7.3.6 Force Calculate Prediction

In the case that users do not prefer to re-use the previous prediction result, the “Force Calculate” function, as shown in Figure 58, can start a new calculation for this prediction rather than re-use the previous prediction result.

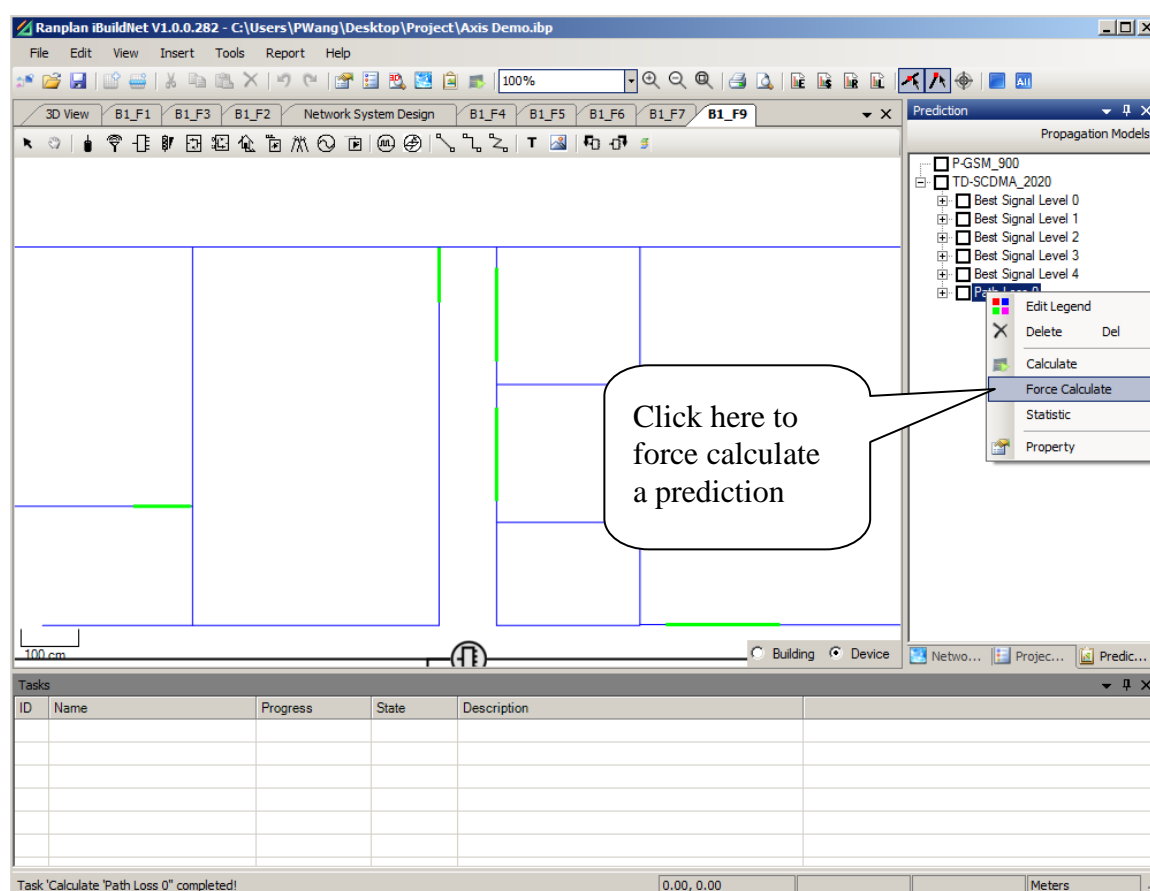


Figure 58. Force Calculate

7.3.7 Edit Legend

As mentioned in previous sessions, the legend of calculation result can be defined when creating a new prediction. But, as the prediction results have not been obtained, users may find that the legend that was defined before is no longer suitable. Therefore, editing legend after a prediction result is obtained is necessary. This can be done by a right click on a prediction result and choose “Edit Legend”, as shown in Figure 59.

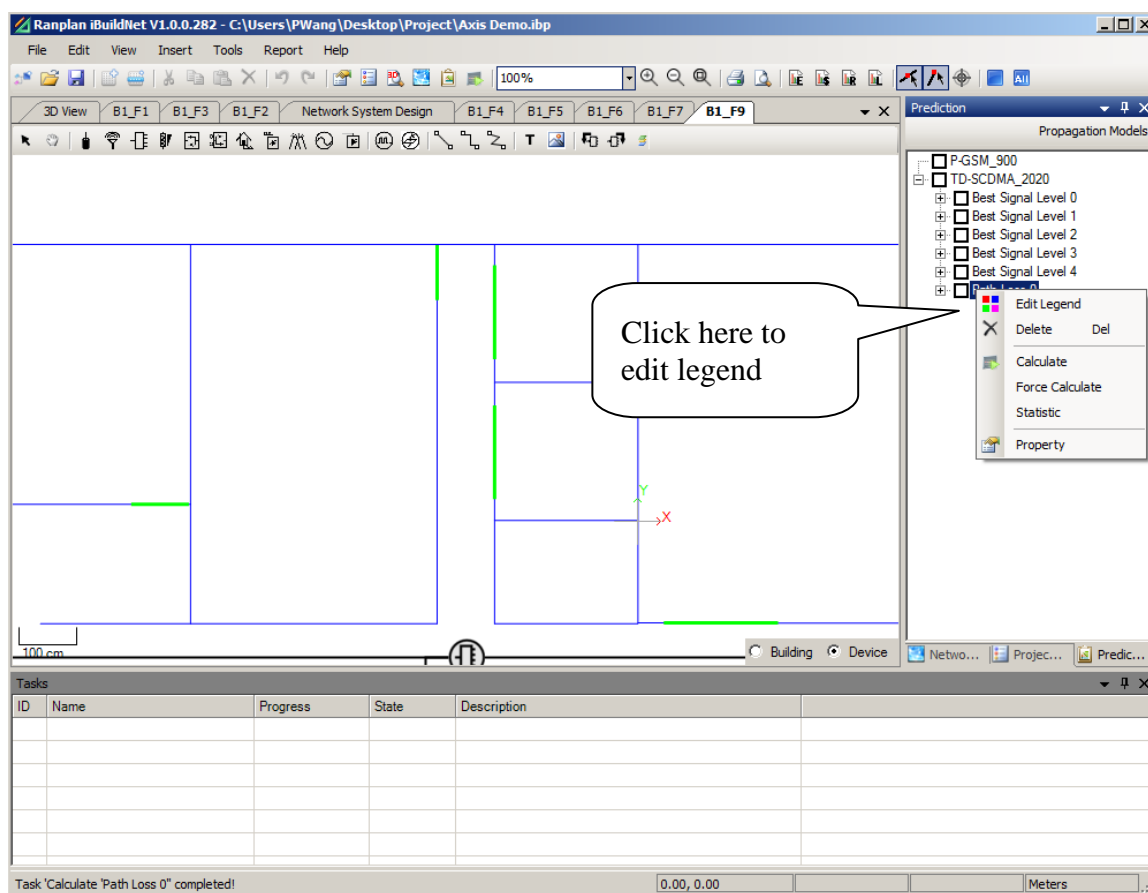


Figure 59. Edit Legend

7.3.8 Obtain Statistic Information

Statistic Information is very important to network engineers, as the optimize plans are often obtained in according with the statistic information. The statistic information can be viewed and exported from Statistic dialog, which can be opened by right click on a prediction result and choose “Statistic”, see Figure 60.

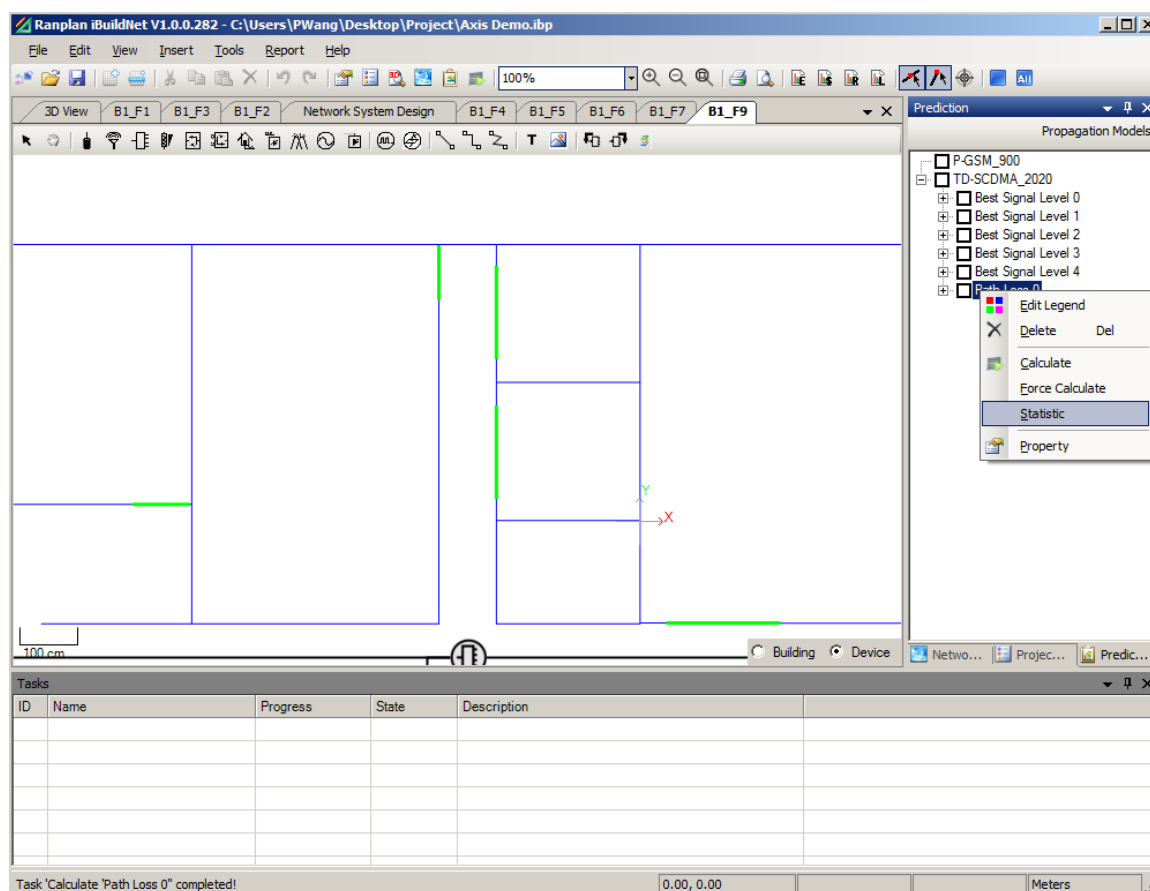


Figure 60. Open Statistic Dialog

The statistic information can be presented in terms of percentage and area. There are a number of chart types can be applied with, such as Column, Point, Pie, Bar, Radar etc. Users are able to customize the statistic chart and export the chart.

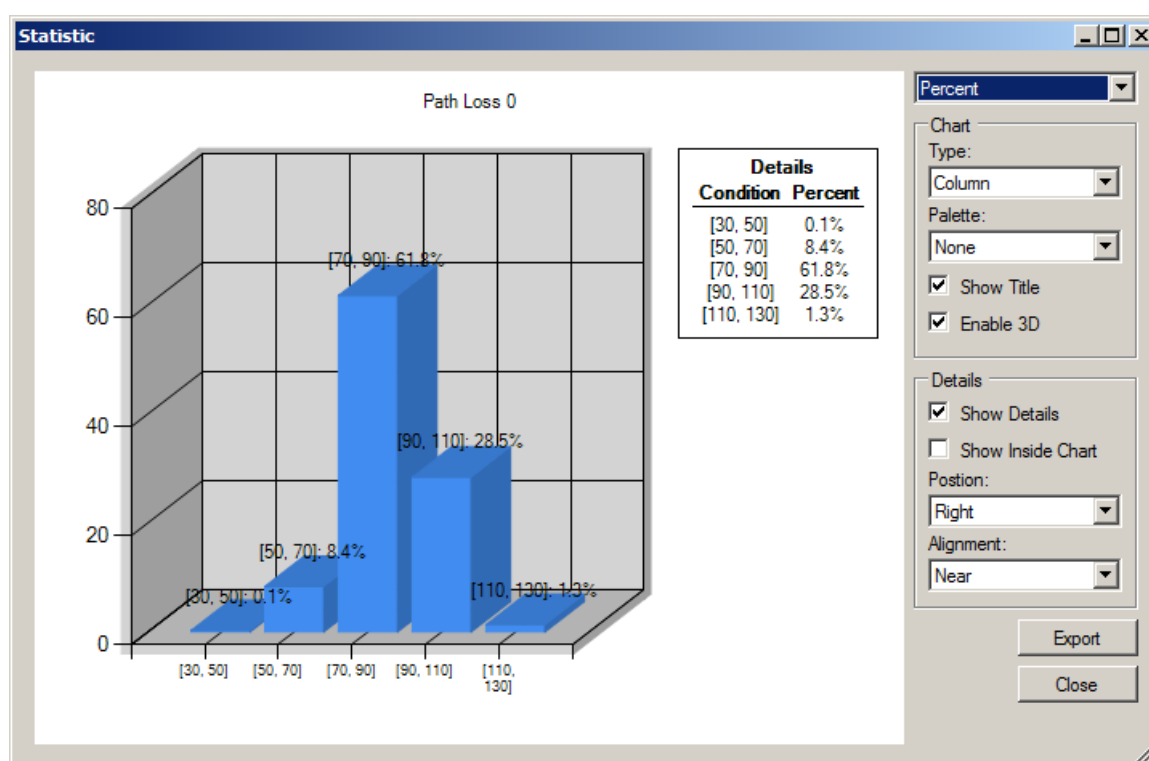


Figure 61. Statistic Information

7.4 Printing

Users can use print function to print including FLD, BSM, NSD view printing.

7.4.1 Generate image

From menu, click "File" then "Print To Picture".

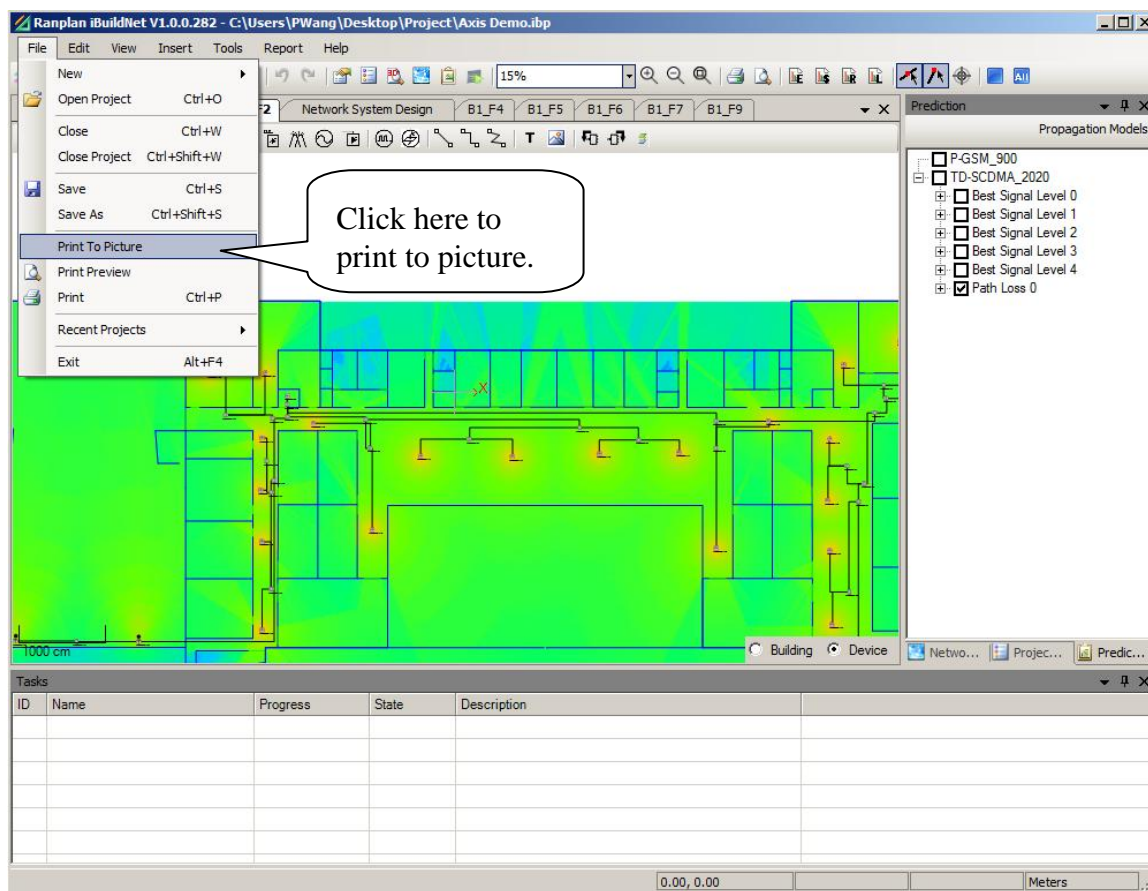


Figure 62. Print to Picture

7.4.2 Print Preview

In order to preview the print, users should go to menu bar, then click "File" and choose "Print preview", a window pops up as shown in Figure 63. Users are able to adjust the size of the target image by using the zoom button. The size of images can be quickly adjusted by selecting "One Page", "Two Pages" and so on.



Figure 63. Print Preview

7.4.3 Print

Similar to print to picture, users can go to menu bar and click “File” then choose “Print”. Also Ctrl + P is the shortcut provided for printing.

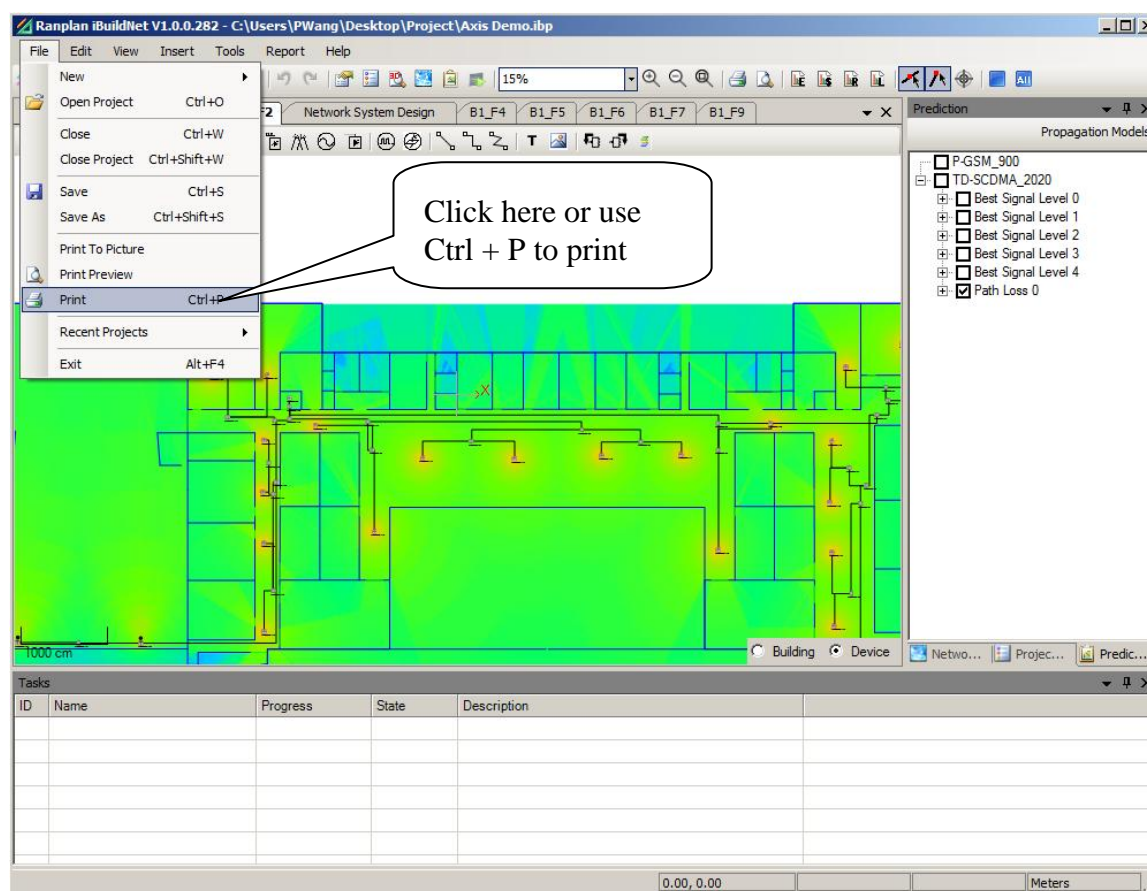


Figure 64. Print

7.5 Conclusion

Ranplan iBuildNet provides several built-in propagation models. They are able to quickly and effectively evaluate the performance of the wireless signal for existing buildings and network systems. The generated SPE performance evaluation can be displayed, analyzed, and printed in both 2D and 3D. Different systems in a same building can be simulated by Ranplan iBuildNet; the SPE can be compared and analyzed horizontally. In doing so, the engineer can deploy indoor antennas according to requirement and based on the result of current topology, make a comparison and analysis between real data and simulation data. Finally obtain an optimized indoor wireless network design solution.

8 Project Report

Users are able to generate different kinds of reports which will be of a great convenience to system designers, constructors, project estimators, project supervision and related personnel. The current version of iBuildNet is able to generate four kinds of reports: equipment list report, cost details report, cable routing report and layout plan report.

8.1 Generate Report

There are two ways to generate reports:

- From toolbar.
- From menu bar.

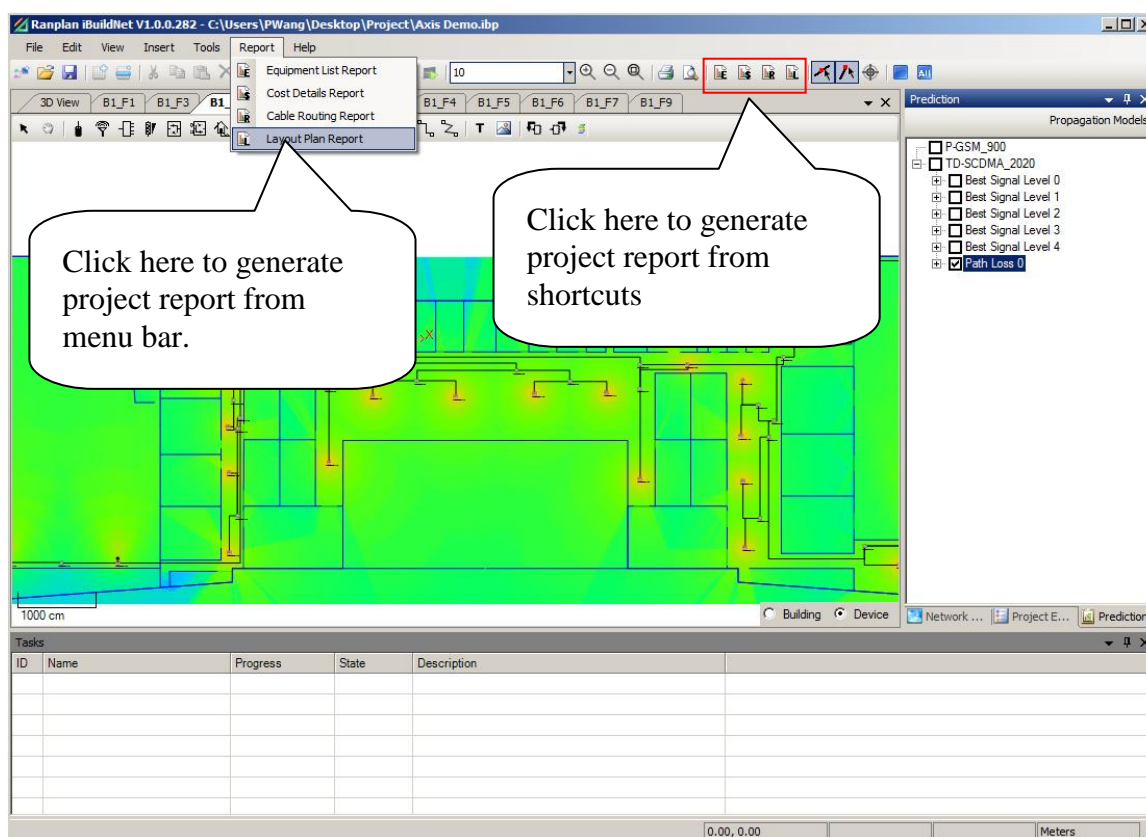


Figure 65. Generate Project Report

8.1.1 Equipment List Report

All the devices in Network System Design and Floor Layout Design are included in the equipment list report. In order to open the equipment list report, users can click on "Equip-

ment List Report" icon from tool bar. Alternatively, go to the menu bar, then click on "Report" and choose "Equipment List Report".

The equipment list report will provide a summer of all the devices. Users are able to check the following properties of devices:

- Type: The type of devices, such as Antenna, Cable, Splitter and so on.
- Manufacturer: The manufacturer of devices.
- Model: The model of devices.
- Comments: General comments of devices.
- Quantity: The quantity of devices that used in this project.

An example of equipment list report can be found in Figure 66.

Equipment List Report

Type	Manufacturer	Model	Comments	Qty
Antenna	Ranplan	ANTD_S245	Directional Indoor Antenna (Ceiling Mounted). 824 MHz - 2500 MHz 4.5 dBi Gain.	4
Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount). GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	141
Cable	Ranplan	CAB_12F	1/2" Flexible Foam Dielectric Coaxial Cable	1294.96 m
Splitter	Ranplan	FS-02C-NFA	2-Way High Power Cavity Splitter - 800-2500 MHz - N-Female Connectors - Standard	59
Splitter	Ranplan	T-07C-NFA	7 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	34
Splitter	Ranplan	T-06C-NFA	6 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	15
Splitter	Ranplan	T-05C-NFA	5 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	8
Splitter	Ranplan	FS-03C-NFA	3-Way High Power Cavity Splitter - 800-2500 MHz - N-Female Connectors - Standard	4
Splitter	Ranplan	T-10C-NFA	10 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	15

Figure 66. Example of Equipment List Report

8.1.2 Cost Detail Report

The cost details report includes device cost, construction cost and other costs. In order to open the equipment list report, users can click on "Cost Detail Report" icon from tool bar. Alternatively, go to the menu bar, then click on "Report" and choose "Cost Detail Report".

The cost detail report contains the following information:

- Type: The type of devices, such as Antenna, Cable, Splitter and so on.
- Manufacturer: The manufacturer of devices.
- Model: The model of devices.
- Comments: General comments of devices.
- Quantity: The quantity of devices that used in this project.

- **Unit Cost:** The unit price of the device. The unit price is set as 0 by default. As the price of equipment is vary from suppliers. Users are able to define it in device database.
- **Equipment Cost:** The total cost of this device. (Equipment Cost = Unit Cost * Quantity)
- **Construction Cost:** The total cost to install this device. The construction cost is set as 0 by default. Users are able to define it in device database.

An example of cost detail report can be found in Figure 67. In this example, all the prices are set to be zero, as the price will be vary from project to project.

Cost Details Report

Type	Manufacturer	Model	Comments	Qty	Unit Cost	Equipment Cost	Construction Cost
Antenna	Ranplan	ANTD_S245	Directional Indoor Antenna (Ceiling Mounted). S24 MHz - 2500 MHz 4.5 dBi Gain.	4.00	0.00	0.00	0.00
Antenna	Ranplan	ANTO_S245_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	141.00	0.00	0.00	0.00
Cable	Ranplan	CAB_12F	1/2" Flexible Foam Dielectric Coaxial Cable	1294.96 m	0.00	0.00	0.00
Splitter	Ranplan	PS-02C-NFA	2-Way High Power Cavity Splitter - 800-2500 MHz - N Female Connectors - Standard	59.00	0.00	0.00	0.00
Splitter	Ranplan	I-07C-NFA	7 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	34.00	0.00	0.00	0.00
Splitter	Ranplan	I-08C-NFA	8 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	18.00	0.00	0.00	0.00
Splitter	Ranplan	I-05C-NFA	5 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	8.00	0.00	0.00	0.00
Splitter	Ranplan	PS-03C-NFA	3-Way High Power Cavity Splitter - 800-2500 MHz - N Female Connectors - Standard	4.00	0.00	0.00	0.00
Splitter	Ranplan	I-10C-NFA	10 dB Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	15.00	0.00	0.00	0.00
Sub Total						0	0
Total						0	0

Figure 67. Example of Cost Detail Report

8.1.3 Cable Routing Report

The cable routing report contains all the information about the routing of the cables as well as the detail of the devices to which they are connected. In order to open the cable routing report, users can click on "Cable Routing Report" icon from tool bar. Alternatively, go to the menu bar, then click on "Report" and choose "Cable Routing Report".

The cable routing report contains the following information:

- **ID:** Device ID
- **Cable From (Source Side):**
 - **Part Type:** Type of devices.
 - **Part Conn:** The port of a device to be used for this connection.

- Floor: The location of the device.
- Cable To (Mobile Side):
 - Part Type: Type of devices.
 - Part Conn: The port of a device to be used for this connection.
 - Floor: The location of the device.
- Cable Type: Cable type can be coaxial or optical.
- Cable Model: Model of the cable.
- Cable Mfg: Manufacture of the cable.
- Length:
 - Estimated: The length of cable estimated by iBuildNet
 - Real: Real length of cable that used in a project.

An example of cost detail report can be found in Figure 68.

Cable Routing Report

ID	Cable From (Source Side)			Cable To (Mobile Side)			Cable Type	Cable Model	Cable Mfg	Length	
	PartType	PartConn	Floor	PartType	PartConn	Floor				Estimated	Real
0	Splitter	P1	B1_F2	Splitter	P2	B1_F3	Coaxial	CAB_12F	Ranplan	4.68 m	0 m
1	Splitter	P1	B1_F3	Splitter	P3	B1_F3	Coaxial	CAB_12F	Ranplan	1.04 m	0 m
2	Base Station	output	B1_F9	Splitter	In	B1_F9	Coaxial	CAB_12F	Ranplan	3.60 m	0 m
3	Splitter	In	B1_F8	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	6.58 m	0 m
4	Antenna	Ant	B1_F9	Splitter	P3	B1_F9	Coaxial	CAB_12F	Ranplan	6.98 m	0 m
5	Antenna	Ant	B1_F9	Splitter	P2	B1_F9	Coaxial	CAB_12F	Ranplan	4.58 m	0 m
6	Splitter	P1	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	5.94 m	0 m
7	Antenna	Ant	B1_F9	Splitter	Coupling	B1_F9	Coaxial	CAB_12F	Ranplan	1.04 m	0 m
8	Splitter	In	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	3.44 m	0 m
9	Antenna	Ant	B1_F9	Splitter	Coupling	B1_F9	Coaxial	CAB_12F	Ranplan	5.30 m	0 m
10	Splitter	In	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	1.60 m	0 m
11	Antenna	Ant	B1_F9	Splitter	P3	B1_F9	Coaxial	CAB_12F	Ranplan	1.32 m	0 m
12	Antenna	Ant	B1_F9	Splitter	P2	B1_F9	Coaxial	CAB_12F	Ranplan	2.14 m	0 m
13	Splitter	P1	B1_F9	Splitter	Coupling	B1_F9	Coaxial	CAB_12F	Ranplan	15.38 m	0 m
14	Splitter	In	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	24.06 m	0 m
15	Antenna	Ant	B1_F9	Splitter	P2	B1_F9	Coaxial	CAB_12F	Ranplan	6.66 m	0 m
16	Antenna	Ant	B1_F9	Splitter	P3	B1_F9	Coaxial	CAB_12F	Ranplan	10.22 m	0 m
17	Splitter	P1	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	2.72 m	0 m
18	Antenna	Ant	B1_F9	Splitter	Coupling	B1_F9	Coaxial	CAB_12F	Ranplan	7.62 m	0 m
19	Splitter	In	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	2.56 m	0 m
20	Antenna	Ant	B1_F9	Splitter	Coupling	B1_F9	Coaxial	CAB_12F	Ranplan	0.67 m	0 m
21	Splitter	In	B1_F9	Splitter	Through	B1_F9	Coaxial	CAB_12F	Ranplan	7.12 m	0 m
22	Antenna	Ant	B1_F9	Splitter	P2	B1_F9	Coaxial	CAB_12F	Ranplan	6.90 m	0 m

Figure 68. Example of Cable Routing Report

8.1.4 Layout Plan Report

The layout plan report is used to record the detailed information of devices as well as their locations. In order to open the layout plan report, users can click on "Layout Plan Report" icon from tool bar. Alternatively, go to the menu bar, then click on "Report" and choose "Layout Plan Report".

The layout plan report contains the following information:

- ID: The device ID generated by iBuildNet
- Type: The type of devices, such as Antenna, Cable, Splitter and so on.
- Manufacturer: The manufacturer of devices.
- Model: The model of devices.
- Comments: General comments of devices.
- Plan: The floor that the device will be installed.

An example of layout plan report can be found in Figure 69.

Cross Reference Report

ID	Type	Manufacturer	Model	Comments	Plan
Bi_F1_Ant0	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant1	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant10	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant2	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant3	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant4	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant5	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant6	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant7	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant8	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F1_Ant9	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F1
Bi_F2_Ant11	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant12	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant13	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant14	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant15	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant16	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant17	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant18	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant19	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant20	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F2_Ant21	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F2
Bi_F3_Ant22	Antenna	Ranplan	ANTO_S243_17103	Omnidirectional Antenna (Ceiling Mount), GSM/CDMA/WiFi (2.4 GHz) - 3 dBi Gain	Bi_F3

Figure 69. Layout Plan Report

8.2 Print Report

In order to print report, users should click on the printer icon from the toolbar on the report viewer, as shown in Figure 70.

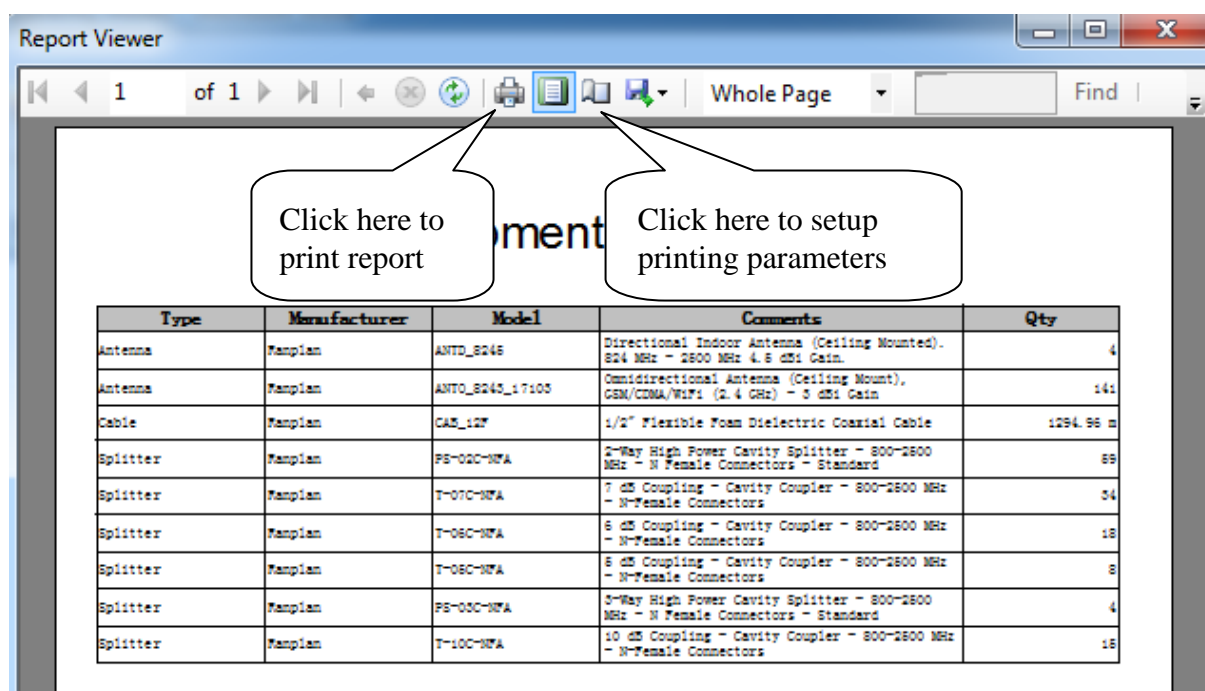


Figure 70. Print Report

8.3 Export Report

In order to export the report, users should click on the disk icon from the toolbar on the report viewer, as shown in Figure 71. Reports can be exported and saved in Acrobat pdf, Microsoft Word or Microsoft Excel format.

Report Viewer

1 of 1 | Whole Page | Find

Equipment Report

Click here to export report

Type	Manufacturer	Model	Comments	Qty
Antenna	Fanplian	ANTD_S24E	Directional Indoor Antenna (Ceiling Mounted). 824 MHz - 2500 MHz 4.8 dBi Gain.	4
Antenna	Fanplian	ANTO_S24E_17100	Omnidirectional Antenna (Ceiling Mount). GSM/CDMA/WiFi (2.4 GHz) - 5 dBi Gain	141
Cable	Fanplian	CAB_12F	1/2" Flexible Foam Dielectric Coaxial Cable	1294.96 m
Splitter	Fanplian	PS-02C-WFA	2-Way High Power Cavity Splitter - 800-2500 MHz - N-Female Connectors - Standard	89
Splitter	Fanplian	T-07C-WFA	7 dBi Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	34
Splitter	Fanplian	T-06C-WFA	6 dBi Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	18
Splitter	Fanplian	T-08C-WFA	8 dBi Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	8
Splitter	Fanplian	PS-03C-WFA	3-Way High Power Cavity Splitter - 800-2500 MHz - N-Female Connectors - Standard	4
Splitter	Fanplian	T-10C-WFA	10 dBi Coupling - Cavity Coupler - 800-2500 MHz - N-Female Connectors	15

Figure 71. Export Report

9 Conclusions

In this deliverable, an indoor radio network planning and optimisation suite of tools is defined and developed. This suite of tools is not only able to plan new indoor networks, but also optimise deployed systems. It will help the network operators to reduce the time and cost of planning and optimising indoor projects. A large part of design work can be done automatically by this suite of tools. Since an intelligent 3D ray tracing indoor propagation model is integrated, an accurate system evaluation result can be obtained in a short time. The reporting module will assist project managers to manage the budget of projects. Automatic system topology generation will deliver a clear overview of the network structure to the network installation engineers. The intelligible 2D and 3D network design plot will help to make sure the location of devices can be installed accurately.

10 Reference

- [1] Morten Tolstrup, "Indoor Radio Planning A Practical Guide for GSM, DCS, UMTS and HSPA", John Wiley & Sons Ltd, 2008
- [2] www.ranplan.co.uk
- [3] "DXF Reference", Autodesk, Inc, 2011
- [4] "Ranplan Radiowave Propagation Simulator: The User Manual", Ranplan Wireless Network Design Ltd., 2011

11 Glossary of Terms

2D – Two Dimension

2G – Second Generation

3D - Three Dimension

3G – Third Generation

4G – Fourth Generation

BBU - Base Band Unit

BSM – Building Structure Modelling

CDMA – Code Division Multiple Access

DAS – Distributed Antenna System

dB – Decibel

FLD – Floor Layout Design

FP7 – Seventh Framework Programme

GHz - Gigahertz

GSM – Global System for Mobile communications

GUI- Graphic User Interface

Hz – Hertz

ID – Identity

KPI – Key Performance Indicator

LTE - Long Term Evolution

Mbps – Megabits Per Second

MHz – Megahertz

NLOS – Non Line of Sight

NSD – Network System Design

RAN – Radio Access Network

RF – Radio Frequency

RRPS – Ranplan Radio Propagation Simulator

RRU- Radio Remote Unit

SPE - System Performance Evaluation

UMTS – Universal Mobile Telecommunications System

WCDMA – Wideband CDMA