BVS Indoor Forecaster

Predictive RF In-Building
Survey Analysis for CW Signals

User Manual

Version 1.5

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Introduction to Indoor Forecaster

The Forecaster application suite is used to generate coverage analysis maps of survey areas. These survey areas will be located indoors or any other area where there is insufficient GPS coverage.

Forecaster consists of three separate applications. Indoor Projector imports an image (BMP, JPEG) of the survey area and creates a linear projection onto this area.

Forecaster Collector collects RF data within the survey area and correlates it to the projection file created with Projector. This data is collected with the BVS Coyote Receiver hardware.

This data is then input into Forecaster Analyzer, where it is then analyzed and processed into various types of reports. These reports represent the RF coverage validation and prediction over the survey area.

Quick Start

You will need the following to get started with your survey.

1. **An image file of the area to be surveyed.**
2. **Coyote hardware.**
3. **Technical information on transmitters in the survey area (if possible).**

You will perform the following steps in order to complete your survey. These steps are outlined in the sections below corresponding to the various applications.

1. **Import your image file into Indoor Projector**
2. **Create a projection based on known distances in the survey area.**
3. **Save the newly created projection file.**
4. **Copy projection file on the device where the Forecaster Collector will be running.**
5. **Import the projection file into Forecaster Collector.**
6. **Collect data points over the survey area.**
7. **Save data file.**
8. **Copy data and projection file onto device where Forecaster Analyzer will be run.**
9. **Import data and projection file into Forecaster Analyzer.**
10. **Create reports on coverage.**
11. **Save and print out reports for presentation on the coverage analysis.**

I. Indoor Projector

Introduction

The BVS Indoor Projector imports an image of an area to be surveyed and outputs a base file with information to project data onto to the image.

Projector is a Windows application that can run on any PC or tablet with a minimum of Windows XP installed. The output file is used by a "Collector" program to collect and overlay RF data points onto the survey projection.

The resulting combination of collected data and the projection is used in an "Analysis" program to show **RF coverage information in the surveyed area.**

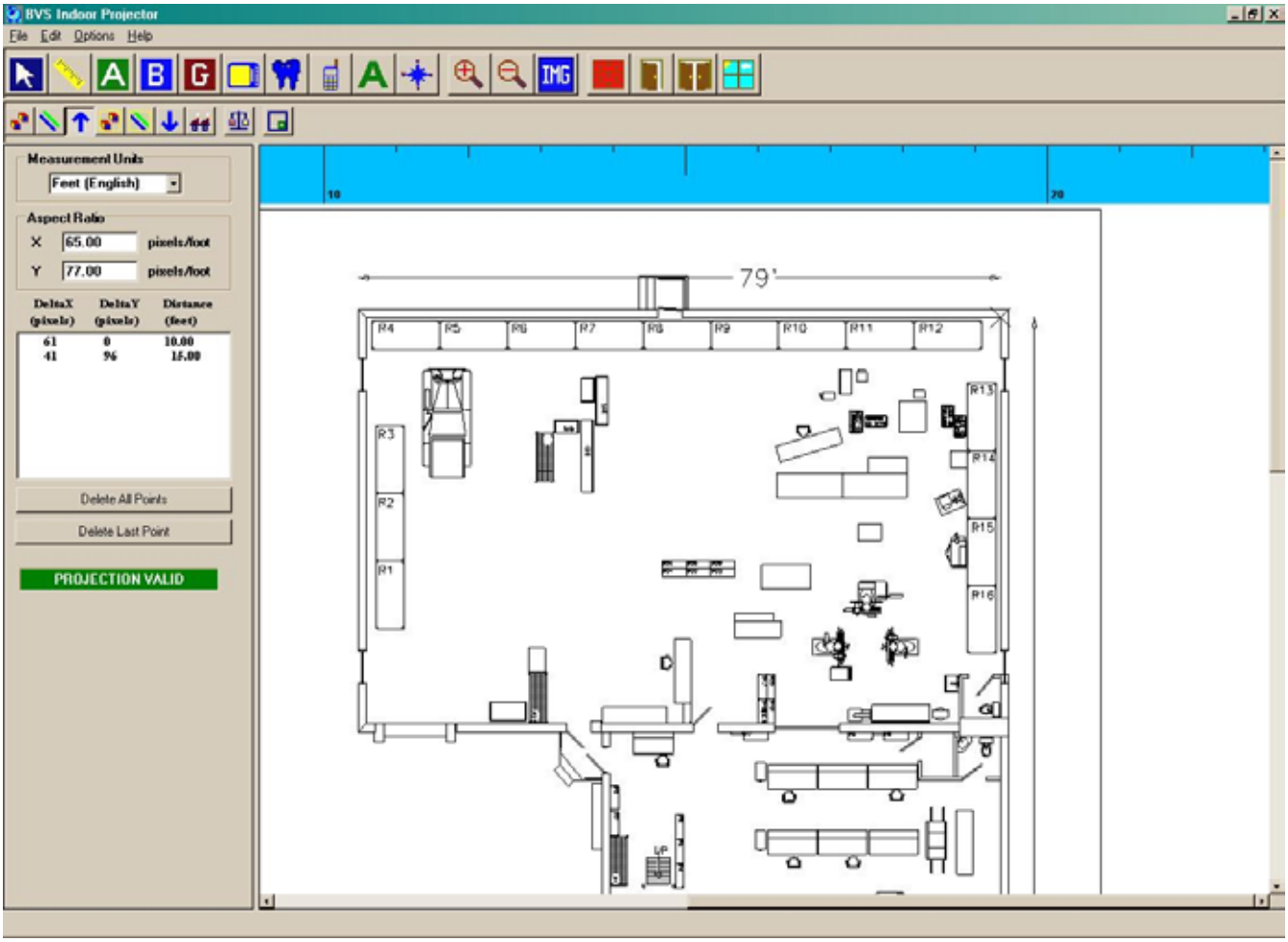


Figure 1 – Indoor Projector

Projector also allows you to add 2.4 and 5 GHz objects such as access points and interferers. Text can also be added to the floor plan.

INSTALLATION

To install the application from a CD, place the CD in the drive. Choose the Indoor Projector button. Follow the installation instructions on the screen from this point.

If you are installing from a Tablet, use the SD card provided with the USB Flash card driver. Insert the USB driver into a USB slot. The device will show up as new drive letter (i.e. D:). Run the setup or autorun program from the root of the drive. Then choose the Indoor Projector button and follow the installation instructions.

QUICK START

Creating a projection file that is ready for use with the Collector requires the following steps. See the sections below for individual explanations. Projector can import any of the following file formats: Monochrome BMP, 16-bit color BMP, 256 color BMP, 24-bit BMP, GIF, ICO, TIF, JPG and PNG.

1. **CREATE A PROJECTION**
2. **SET THE DIMENSIONS FOR THE ASPECT RATIO**
3. **ADJUST SIZE OF FLOOR PLAN IF NECESSARY**
4. **ADD STATIC OBJECTS TO FLOOR PLAN IF NECESSARY**
5. **ADD CUSTOM IMAGES AS STATIC OBJECTS**
6. **ADD WALLS, WINDOWS, AND DOORS**
7. **SAVE FILE**

CREATE A PROJECTION

Use FILE/NEW on the menu to create a new projection file. Choose a floor plan from the popup window to use as a base for your site. You may use a .bmp, .jpg, .gif etc.

SET THE DIMENSIONS FOR THE ASPECT RATIO

Click the ruler icon in the toolbox. Look for a location on the projection that you know the distance. Click on the first point of the measurement. A flag will mark the spot. Click on the second point of the measurement.

Now enter the distance and units for the measurement. Repeat steps 2 thru 4 for a second measurement. Make sure that the second measurement is in a different orientation from the first point. Keep repeating until you receive a message saying that a valid projection exists. Points used for the projection may be deleted from the listbox on the left status bar.

ADJUST THE SIZE OF THE FLOOR PLAN

There are two types of image reduction available in Projector. There are multiple algorithms used to achieve the reduction.

Scaling

Scaling the image reduces the size of the image while attempting to keep all of the features of the floor plan. In effect, the image is shrunk. Scaling the image can be done in different ways. Different interpolation modes for scaling the image are listed below. These modes use different techniques to determine how to reduce groups of pixels into one which is representative of the group.

Interpolation Modes

D is the destination image and S is the source image. Here are simple explanations of some of the interpolation modes. Trying all of the modes will give a better understanding of what changes the image will incur. Remember, the higher-quality reduction, the slower the process. The lower the quality, the faster the reduction.

Bicubic - D takes on a color value from a source matrix (S) based on a polynomial function.
Bilinear - D takes on an average of colors from the nearest region of S (for example, a 2x2 matrix)
High Quality Bicubic - D takes on a color value from a source matrix (S) based on a polynomial function.
Higher quality Bicubic (will run slower)
High Quality Bilinear - D takes on an average of colors from the nearest region of S (higher quality than simple Bilinear)
Nearest Neighbor - D simply takes on the color value of the nearest pixel in the **source.**

Cropping

Cropping the image will clip off the part of an image not specified in the new dimensions of the image.

ADD STATIC OBJECTS

A number of static objects can be permanently added to the site. Inserting each type of object is explained in the following passages.

Add an Access Point

Existing Access Points may be added to the floor plan to simply show their location. First, decide whether you want to represent an 802.11a, 802.11b, or 802.11g access point. Choose the icon from the toolbar with the correct letter on it (A,B,G). Now click on the part of the floor plan where you would like to represent the access point.

Insert Text

1. **Click on the text insertion button on the toolbox.**
2. **Click on the location where you wish to insert the text.**
3. **Enter the text.**
4. **Press OK.**

Microwave/Directional Antenna/2.4 GHz Phone/Compass

Any of these objects may be placed on the floor plan. Simply click on the desired object. Then click on the floor plan where you wish the object to be placed.

ADD CUSTOM IMAGES AS STATIC OBJECTS

Any custom bitmap may be added to the floor plan. Click on the "IMG" icon on the top toolbar. Then choose an image file. Then click on the floor plan where you would like the image.

ADD WALLS, WINDOWS, AND DOORS

Additional walls, doors, and windows can be added to the floor plan.

Walls

Click on the wall icon on the top toolbar. Then click where you would like the wall to begin.
Then click on where you want the wall to end. A new wall has now been added to the floor plan.

Doors

Click on the door on the top toolbar. Choose a single or double door using the appropriate icon. Then click on where you would like the doorway to begin. Then click on the other side of the new doorway.

NOTE: The doors will swing differently based on start and stop clicks. If the finishing click on the doorway had been the starting click, the door would then swing in the opposite direction.

Windows

Similar to the procedure for doors and walls, click on the window icon on the top toolbar. Then click where you would like the window to begin. Then click on where you want the window to end. A new window has now been added to the floor plan.

SAVE THE PROJECTION

1. **Choose FILE/SAVE from the menu.**
2. **Enter a name for your projection file.**
3. **You now have a projection file for use with the Collector.**

STATUS BAR (Left)

On the left of the screen are different statistics. They are the pixels / foot (meter) ratio. You can also adjust whether or not the measurement units are in feet or meters.

MENUS

There are 5 submenus located in the main menu at the top of the screen.

The FILE submenu lets you open or save site files.
NEW creates a new site file.
OPEN opens an existing site file.
SAVE saves a site file under the previously saved filename.
SAVE AS saves a site file under a new filename.
The EDIT submenu has editing options.
UNDO lets you undo up to 3 previous edits to the site.
The OPTIONS submenu contains system options.
SHOW GRID overlays a grid of lines on top of the site.
The SCALE submenu contains scaling options (see "Adjust the size of the floor plan")

- **Bicubic**
- **Bilinear**
- **High**
- **High Quality Bicubic**
- **High Quality Bilinear**
- **Low**
- **Nearest Neighbor**

The HELP submenu contains help options.
ABOUT pulls up the about box.

RULERS

The rulers along the vertical and horizontal planes of the projection represent a scale of the projection. These are set using the ruler toolbox option.

ZOOM MODES

There are four different modes for zooming in and out of the floor plan.

Zoom In

Click on the magnifying glass with the '+' sign. Then create a zoom rectangle by clicking-and holding on an area of the floor plan. Then drag the mouse (while holding down the mouse button) to the next point. A dashed rectangle will appear. When the zoom rectangle is the appropriate size, release the mouse button. The floor plan will now be zoomed into that rectangle.

Zoom Out

Clicking on the magnifying glass with the '-' sign will reduce the image resolution by a factor of 2, thereby making the image zoom out.

II. Coyote Collector

1. INTRODUCTION:

The Coyote Collector is a part of the BVS Indoor Forecaster and is used to collect Radio Frequency (RF) Data obtained during walk-studies of an in-building environment. An image file linear coded using the BVS Projector is imported in the Coyote Collector and the data collected is correlated to physical co-ordinates on the projected file. Data collected in this way is then analyzed using the Analyzer.

This part of the Indoor Forecaster can run on any PC which can be mobile along with the receiver for the purpose of point-to-point data collection in an in-building environment.

2. DESCRIPTION OF TOOLBAR BUTTONS:

 **When this button is clicked, the user can load a projection file. IMPORTANT: It is important to load the BVS Projection (file with extension BPF) file created using the BVS Projector before opening a Coyote Collector File (File with extension CPF).**

 **Clicking this button lets the user either Create a new Coyote Collection File OR open a previously created Coyote Collection File (File with extension CPF). This file is imported in the Analyzer portion of the Indoor Forecaster for Coverage Analysis. The process of collecting data for Coverage analysis is explained in detail later.**

 **Click this button to zoom into the current view.**

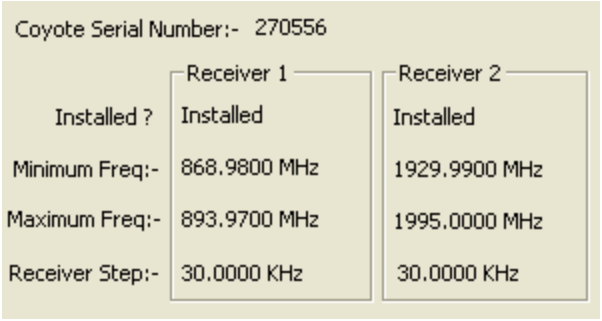
 **Click this button to fit the entire bitmap represented in the BVS Projection File within the Client area of the view.**

 **Click this button to zoom out to view a larger area of the bitmap represented by the BVS Projection File.**

 **Click this button to take a snapshot of the Client area of the window and save it as a Bitmap (BMP) or a JPEG image file.**

 **Click this button to show the Segment Data Dialog which displays information of the current segment data being collected.**

Click this button to display the Coyote Receiver information once connection has been established with the Coyote via the USB.



Click this button to view, in pictorial format, the important instructions to be followed before and during data collection.

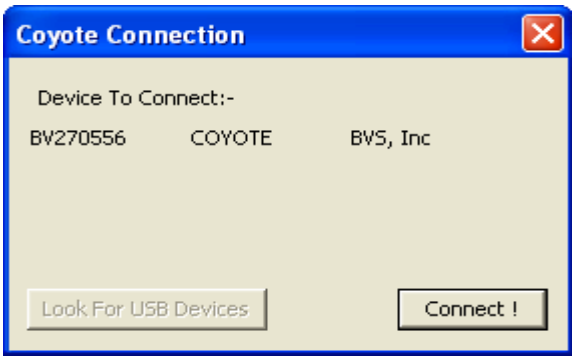
3. STEP-BY-STEP PROCEDURE FOR DATA COLLECTION:

3.1 Establishing a Connection with the receiver:

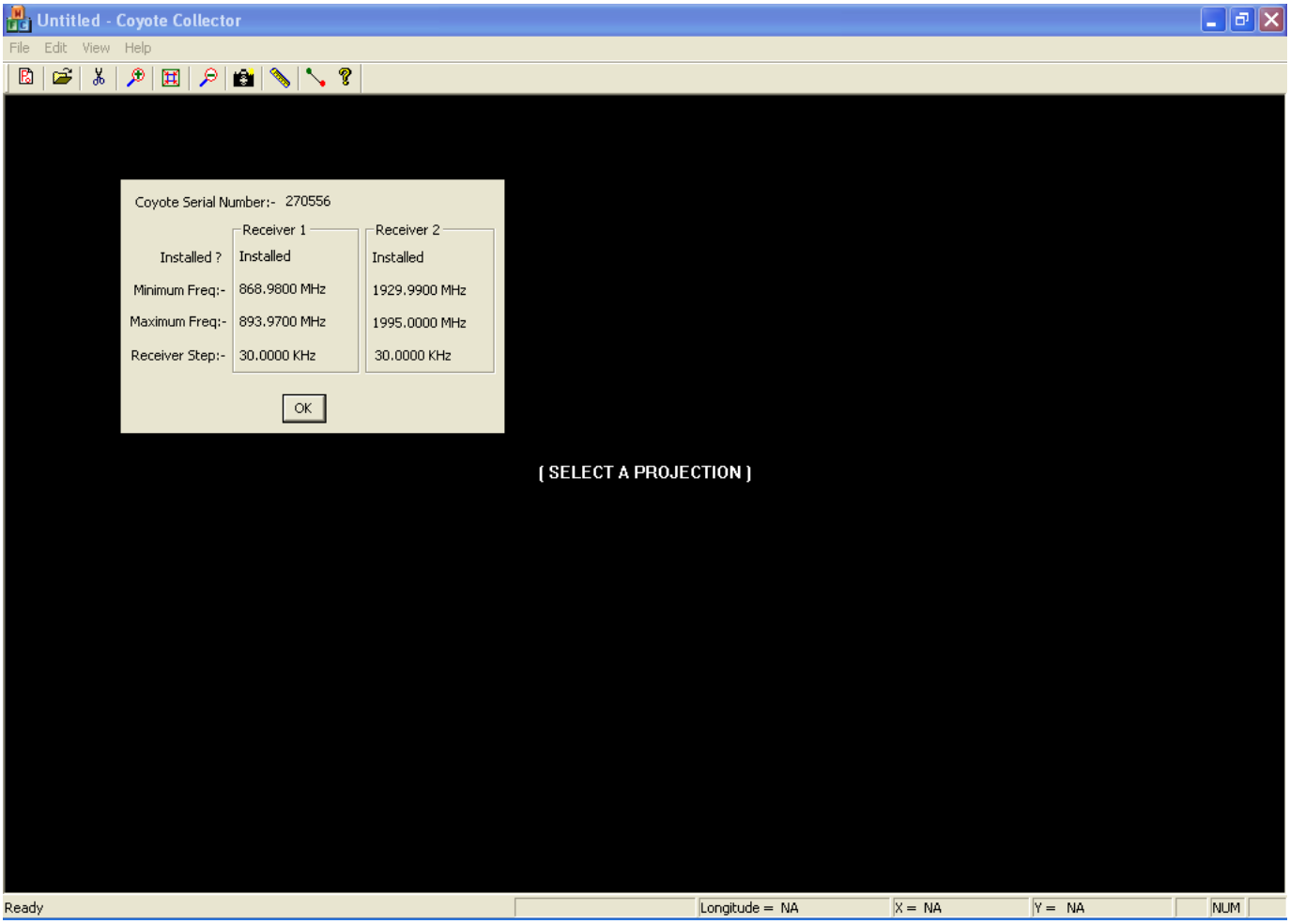
Connect the appropriate connectors of the USB cable to the Samsung Q1 UMPC and the Coyote Receivers respectively as shown:

Before starting the software, verify that the USB cable is securely connected. Make sure that the battery of the Tablet PC and the Coyote Receiver is well charged. Turn on the Coyote Receiver by pressing the "Power" button on the front panel of the Receiver.

Once all the connections seem ok, double click the Coyote Indoor Forecaster Collector Icon on the desktop. The following dialog will then pop up prompting a connection with the Coyote Receiver.



Click "Connect" for the software to establish a connection with the receiver. Upon successful connection, the Coyote Receiver characteristics will be displayed as shown:



3.2. Open the Coyote Projection File:

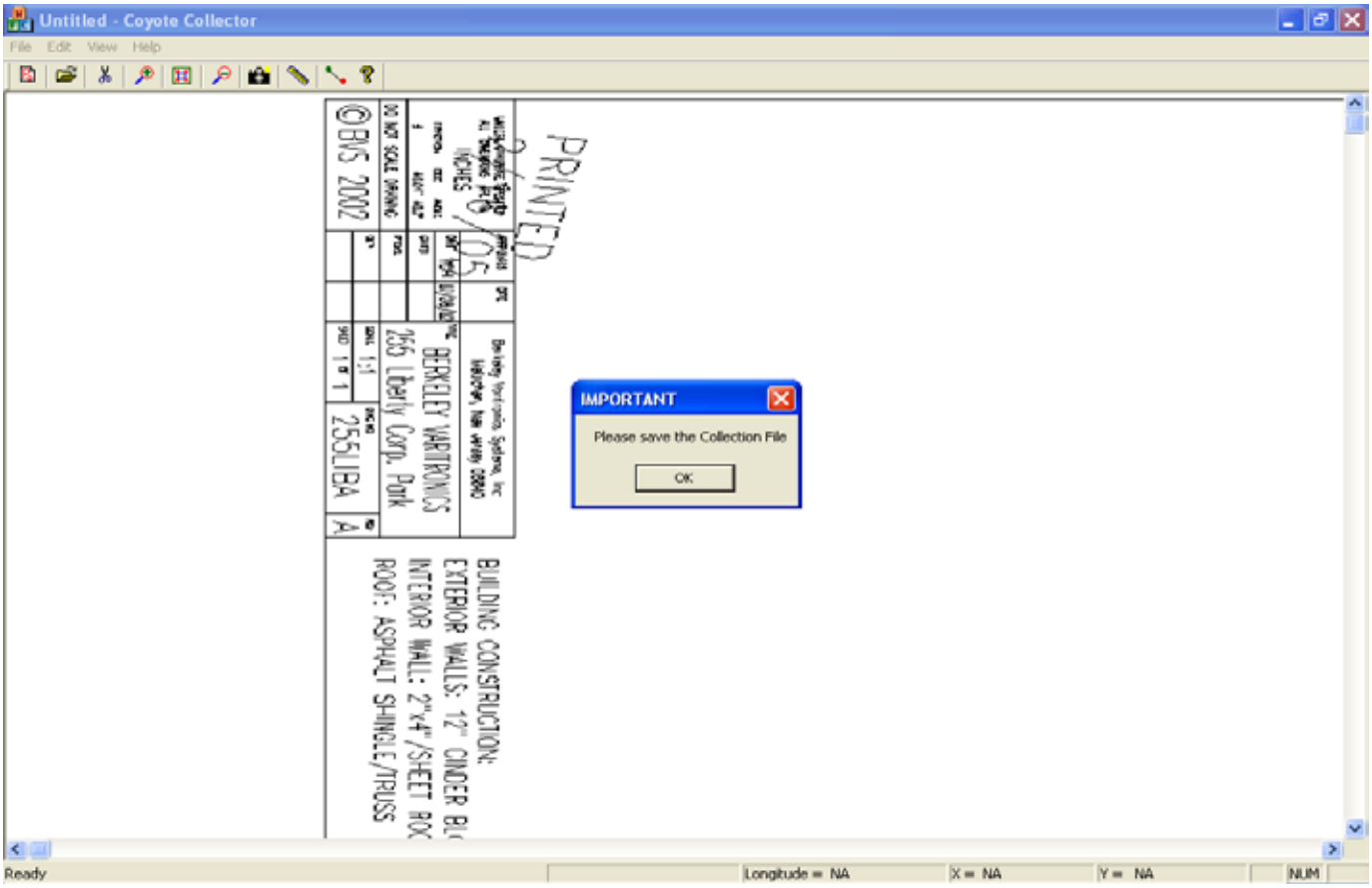
Once the connection with the Coyote receiver has been established, the Coyote Projection and Collection Files would have to be loaded before the Data Collection can begin. Click to open the Coyote Projection File (Files with extension BPF):

3.3 IMPORTANT NOTES ABOUT PROJECTION FILES:

(1). The Floor Plan in the Projection file MUST correspond to the area of Indoor Data Collection.

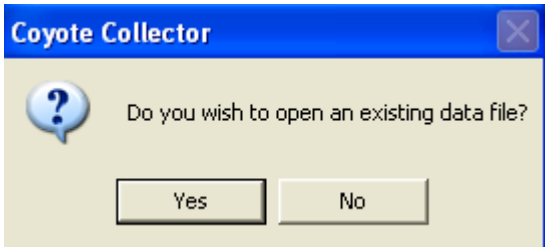
(2). It is important that the Floor Plan reflect AS ACCURATELY AS POSSIBLE, the position of furniture, doors, windows, walls, machines, plants, pillars, stairs, curves and turns in structure. This will enable the user to accurately travel straight line distances and collect accurate data.

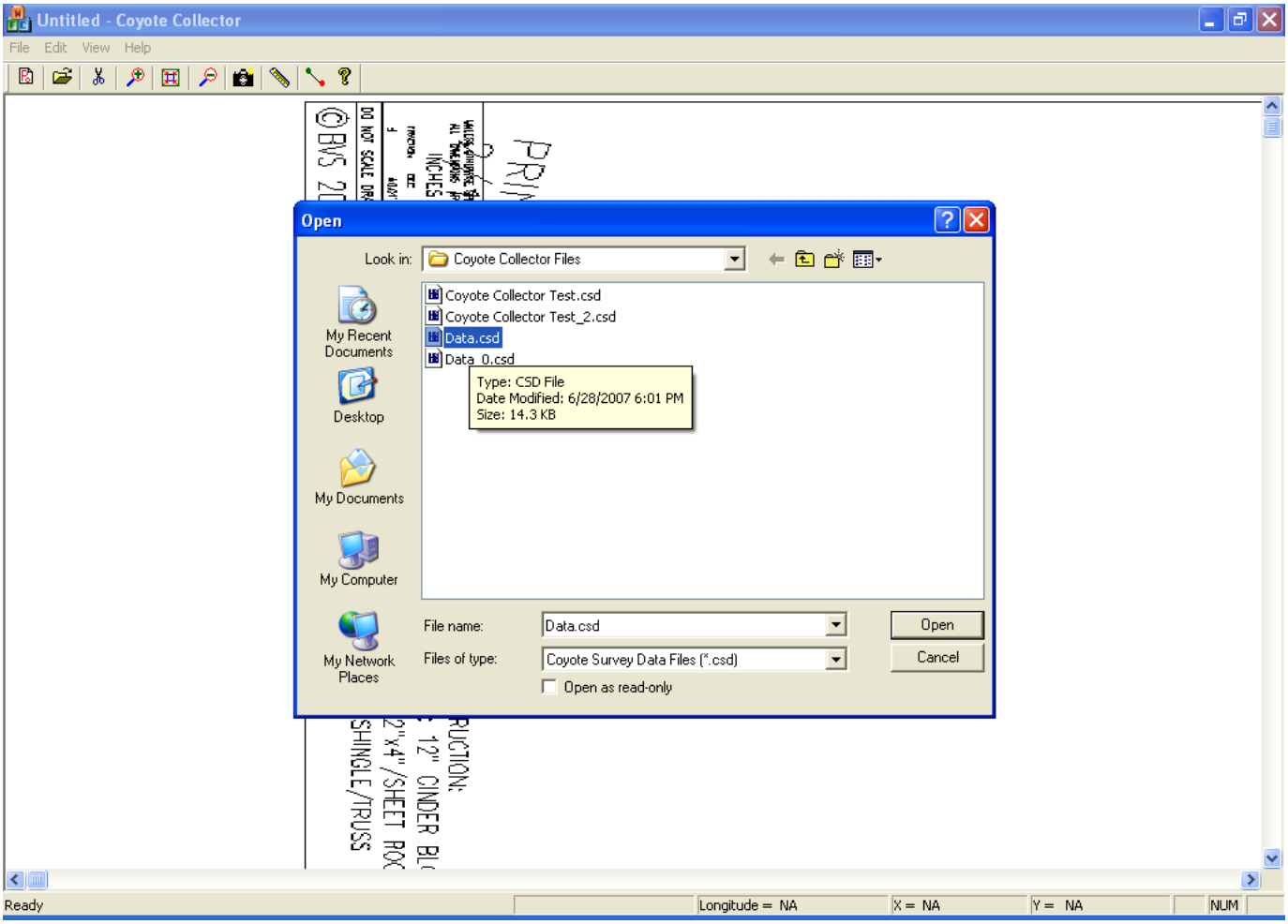
(3). It will be helpful to the user to study the Floor Plan and the actual area of walk study and Plan the Data Collection Path beforehand to avoid any mistakes during the actual process.



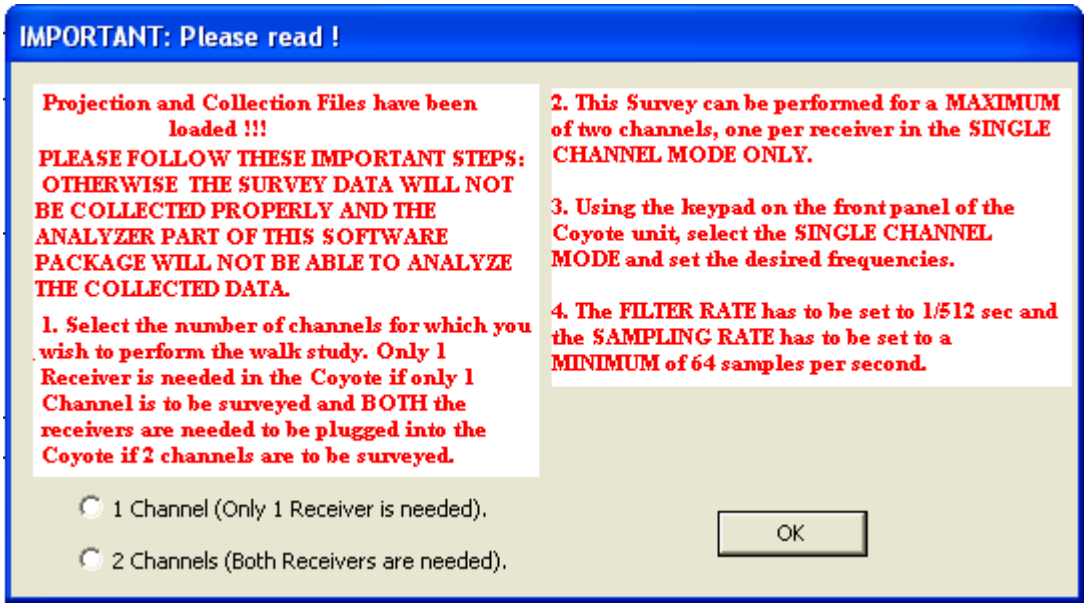
3.4 Opening the Collection Files:

Once the Projection File has been loaded, the software prompts the user to open/save the Collection File (Files with extension CSD). This can be done by clicking on the main Tool-bar. Previously collected Collection files can be opened as well as new ones can be created:





Once the collection and projection files have been loaded, dialog box containing VERY IMPORTANT INSTRUCTIONS to be followed before data collection will pop up: Please carefully read and understand these instructions before beginning any further data collection.



3.5 IMPORTANT INSTRUCTIONS TO BE FOLLOWED BEFORE BEGINNING THE DATA COLLECTION:

Please follow these important steps otherwise the survey data will not be collected properly and the analyzer part of this software package will not be able to analyze the collected data:

(1). Select the number of channels for which the walk study is to be performed. Only ONE receiver needs to be installed in the Coyote if only 1 channel is to be surveyed. BOTH the receivers need to be installed in the Coyote if TWO channels are to be surveyed.

(2). This Survey can be performed for a MAXIMUM of two channels, ONE per receiver in the SINGLE CHANNEL MODE of the Coyote.

(3). Using the keypad on the front panel of the Coyote, select the SINGLE CHANNEL MODE and then set the desired frequencies.

(4). The FILTER RATE has to be set to 1/512 second and the SAMPLING RATE has to be set to a MINIMUM of 64 samples per second.

Once the above instructions have been observed, select whether the walk study is intended for a single channel or for two channels and then click OK. Carefully open the lid on which the

Tablet PC is mounted and using the keys on the front panel of the Coyote receiver, begin Single Channel Measurement.

Close the lid once the measurements begin. The unit is now ready for indoor coverage prediction data collection. Close the Receiver Cover and put the locks in place so that the Lid does not accidentally open during the walk study.

3.6 IMPORTANT PRINCIPLES TO UNDERSTAND BEFORE BEGINNING THE DATA COLLECTION:

(1). The software is designed to collect data segment-wise, meaning that the user has to walk in a straight line between two points to form a data segment.

(2). On the floor plan loaded in the form of a linear coded projection file, the user selects the start point and the stop point of the segment he wishes to traverse. The Start and the stop points on the floor plan have to co-incide with the actual start and stop locations in the building.

(3). Once the start and stop points have been set, the user has to walk from the START point to the STOP point in a STRAIGHT LINE and at CONSTANT SPEED. It is very important to strictly observe this point for greater accuracy of data analysis.

3.7 STEPS TO FOLLOW FOR USEFUL DATA COLLECTION:

(1). Click "New Segment" button on the Segment Data Dialog, which pops up after you close the Pre-Data Collection Instructions Dialog.

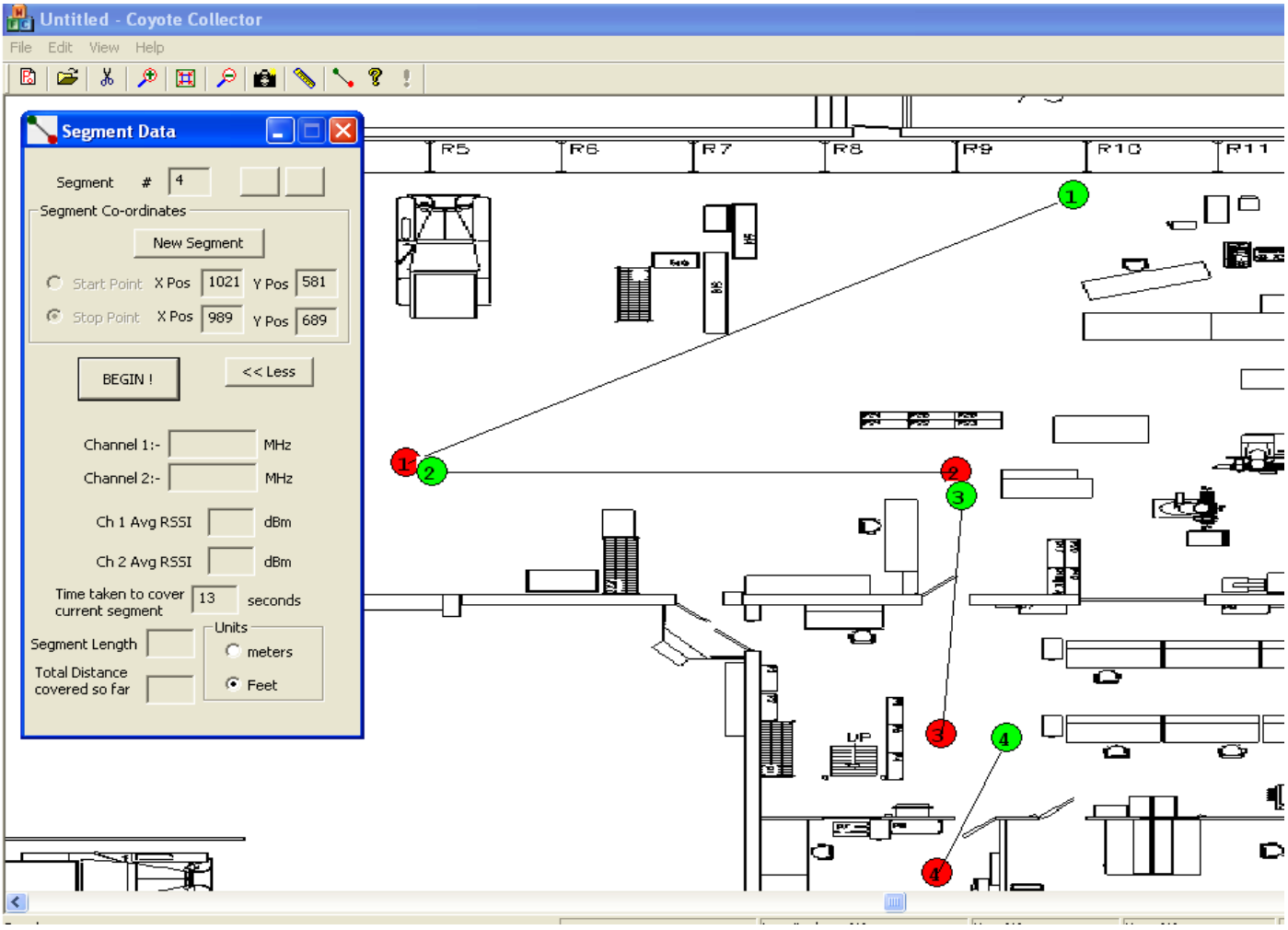
(2). Select Start Point on the Segment Data Dialog and tap the Start Point on the projection file, corresponding to the actual position of the user on the Projection File.

(3). Select Stop Point on the Segment Data Dialog and do the same as 2.

(4). Ensure that a straight line can be traversed between the Start and the Stop points selected before clicking the "Start" button. If it is not possible to traverse a straight line between the start and the stop points, change the stop point position on the projection to enable a straight line traversal.

(5). Once it is ensured that a straight line between the Start and the Stop Point is traversable, click the "BEGIN !!!" button. Walk the distance between the START and the STOP Points in a STRAIGHT LINE and at a CONSTANT SPEED.

(6). Once the Stop Point is reached, click STOP. Data is no longer collected in the Collection file after this. Repeat Steps 1 to 6 for all other segments. Data collected in this way can be used in the Forecaster Analyzer for further analysis.



III. Forecaster Analyzer

1. INTRODUCTION

Forecaster Analyzer is the analysis component of Forecaster software package for Coyote receivers. It provides analysis of coverage, reliability, channel reuse and more.

2. GETTING STARED WITH FORECASTER ANALYZER

Table 1 gives the descriptions of the buttons in the Tool Bar to control the graph view.

Table 3.1. Buttons In The Tool Bar

Button	Name	Description
	Zoom In Tool	After clicking this hot button, the cursor changes to a magnifying glass.
	Zoom Out Tool	After clicking this hot button, the cursor changes to a zoom-out glass.
	Fit to Window	Pressing this hot key fits the image to the current size of the graph window.
	Fit to Map	Show the graph image with the whole map.
	Show Directions	Show the GPS directions of the view. (**Disabled for indoor survey study**)
	Show Map	Show/Hide the map
	Information Window	Show information as mouse hovers
	Legend Window	Show legend for the graph
	Move Base Station	Move base stations on the map
	Ruler	Measure distance
	KML report	Create a KML report (**GPS data only**: **Disabled for indoor survey study**)
	HTML report	Create a HTML report

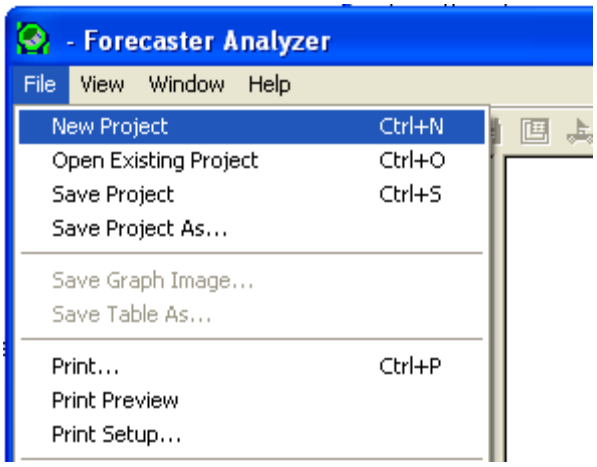
Forecaster Analyzer uses a linear projected map from the Projector and data files recorded with Coyote Collector.

The Projector generates a Projection File (*bpf) that contains the map of the survey.
The Coyote Collector produces a data file (*.csd) that contains the collected data.

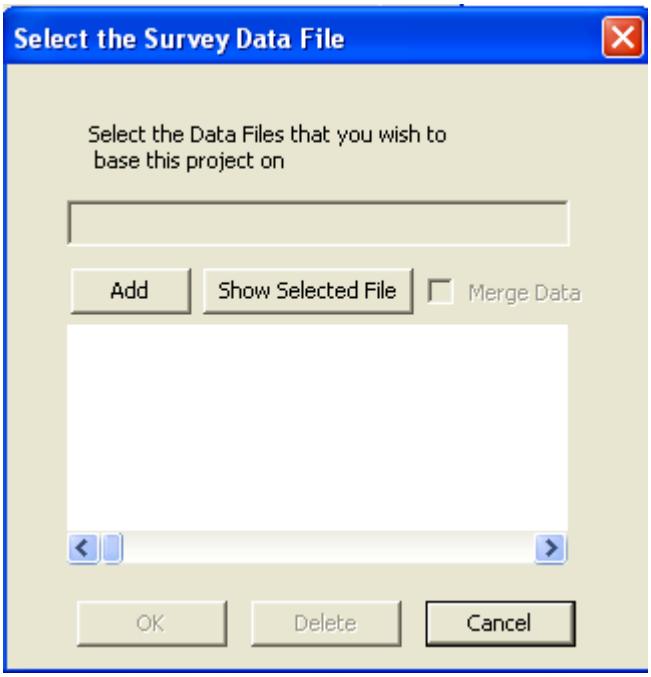
2.1 Creating New Projects

The Forecaster is project based. To begin using the Forecaster, a projection file is first generated (Please see the manual for the Projector). Click on the  hotkey located in the toolbar near the top of the screen. The Projection File dialog box then appears. Open the projection file (map) you wish to use.

Then the data files must be loaded to create a project. The Forecaster Analyzer can process multiple data files. To create a new project, select "New Project" from the File menu or the Hotkey from the Toolbar.

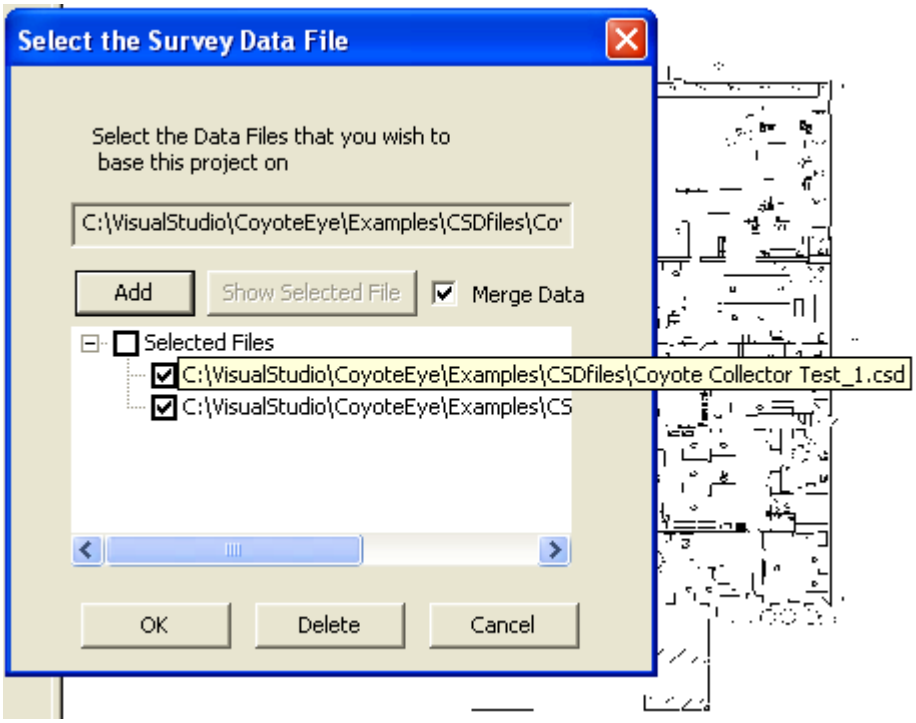


The data log file selection dialog then appears.



In the data log file selection dialog press the "Select" button and browse for the *.csd files you wish to work with.

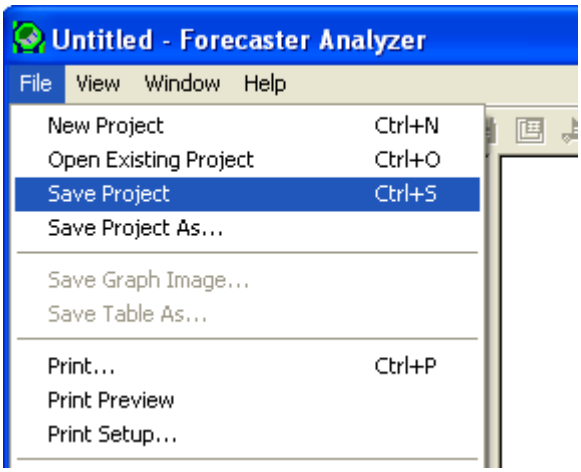
More files can be selected by clicking on the "Add" button. If you wish to use two or more files that you have collected, the data in these files can be merged to process by checking the box before "Merge Data". If a file is added in by mistake, check the box before the file and then press the "Delete" button. All selected files will be deleted. Click the "OK" button to load the data in the files.



Note that the "Merge File" means merging the data in the files in the process. It does not mean that multiple files are merged into one file.

2.2 Saving A Forecaster Project

At anytime after a project has been created it can be saved to a file. The current settings including state of controls and graph (map, bitmap and analysis) are saved in a project file and can be recalled later. To save a project select Save or Save as… from the File menu or the hotkey from the Toolbar.



If the project has previously been saved the Save option will overwrite the existing file while the Save as… will allow a new file name to be selected.

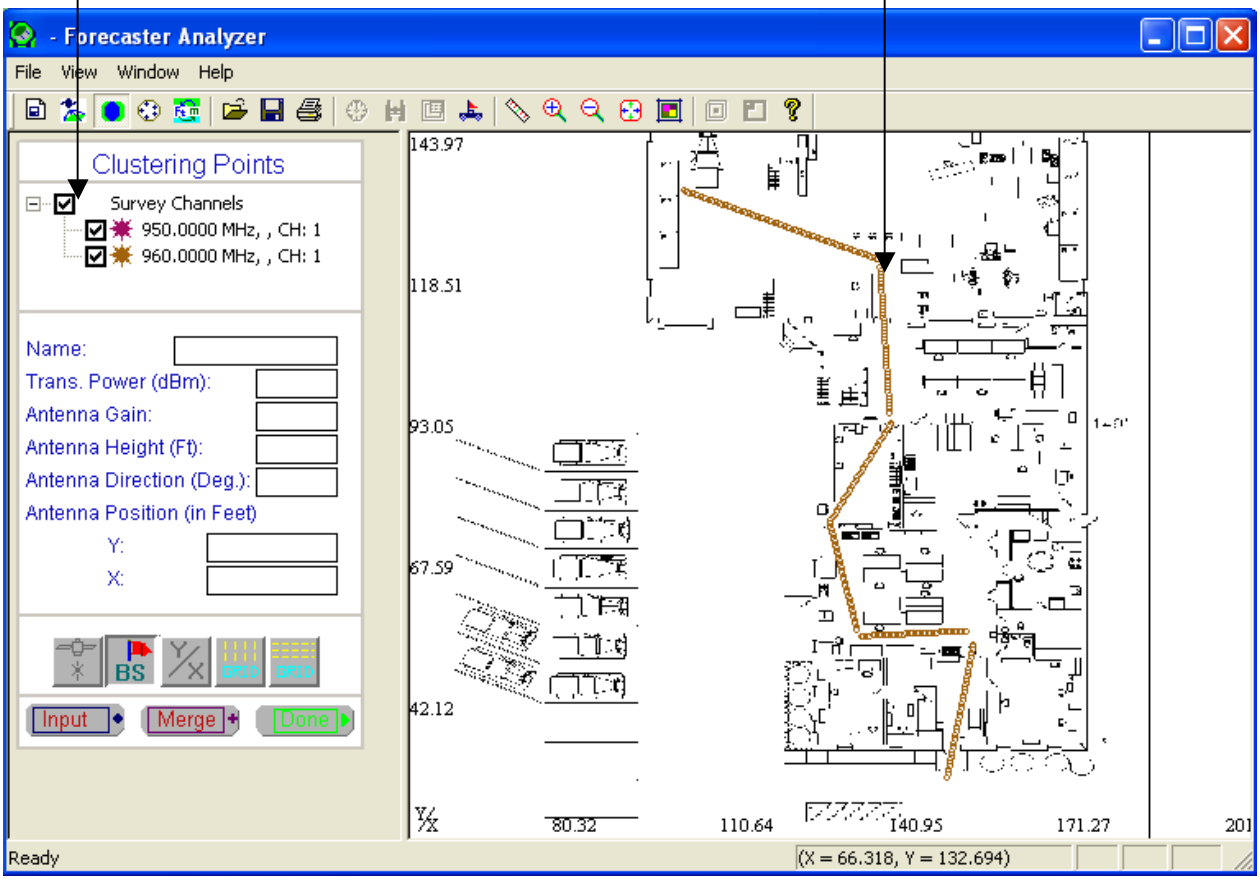
2.3 Opening An Existing Forecaster Project

To open an existing Forecaster Project, select Open Existing Project from the File menu or the Hotkey from the Toolbar. A dialog box will appear to allow the selection of the project file (*.fws).

The Forecaster Analyzer screen is displayed in two sections:

The left pane of the display contains the Control Window used for Clustering Points, View Options, Channel Selection, and Reliability Analysis.

The right pane contains the graph and the map from the Projector.

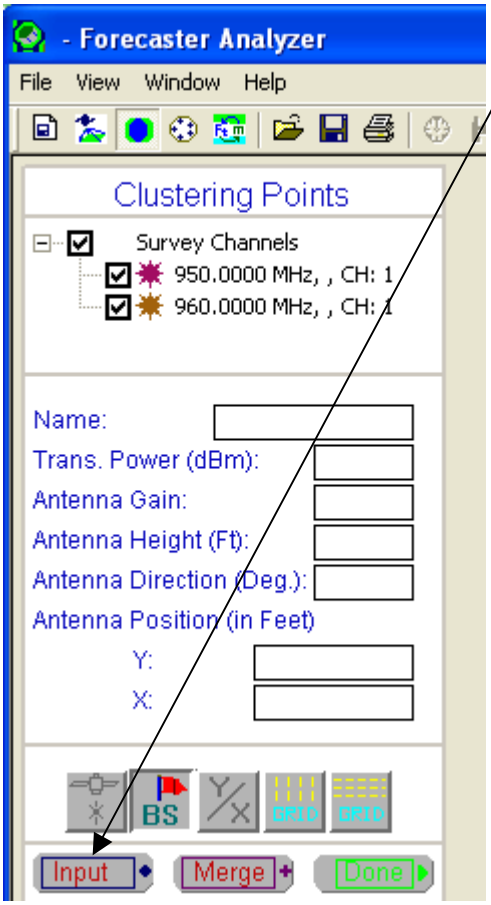


3. Survey Data Analysis

3.1 Clustering Points

After loading the data files, the interface for clustering points is shown. This is used to separate the data with same frequency, but they are received from different base stations (BS). The automatic clustering has been done when this interface is shown. To further separate the points manually, click the Hotkey, left click and hold on the graph to start the clustering. As the mouse is up, the points within the rectangular will be grouped. To merge two groups (channels) with the same frequency, check the boxes before them and then click Button Merge.

When a channel is selected (the box is checked), the parameters for the BS antenna are shown. Please type in the parameters if they are known. Press the Input button to input the information.



After base station antenna's position is input, the BS marker will be shown on the graph. To move the BS marker, click , left click at the center of the BS icon, hold on the graph and move it to the correct location. Table 3.2 gives the descriptions of the buttons to cluster points.

Table 3.2. Buttons In Control Window For Clustering Points

Button	Name	Description
	GPS Status	Show GPS status by black circles. 3D fix: No black circles; 2D fix: small black circles; No fix: big black circles. **(GPS only: disabled for indoor study)**
	Show/Hide Base Stations	Show or Hide base stations on the map
	Y/X or Lat/Lon	Y/X: Use linear distance (feet or meter) in the axis Lat/Lon: Use Lat/Lon (decimal degree) in the axis **(Only Y/X coordinates for indoor study)**
	Vertical Grid Lines	Show vertical grid lines
	Horizontal Grid Lines	Show horizontal grid lines
	Input Parameters	Input the parameters for base stations and antennas
	Merge Groups	Merge multiple groups with the same frequency into one.
	Finish Clustering	Process the data after clustering is done

After the clustering is finished, click the  **button to proceed to the next step of post processing.**

3.2 Measurement Data Analysis

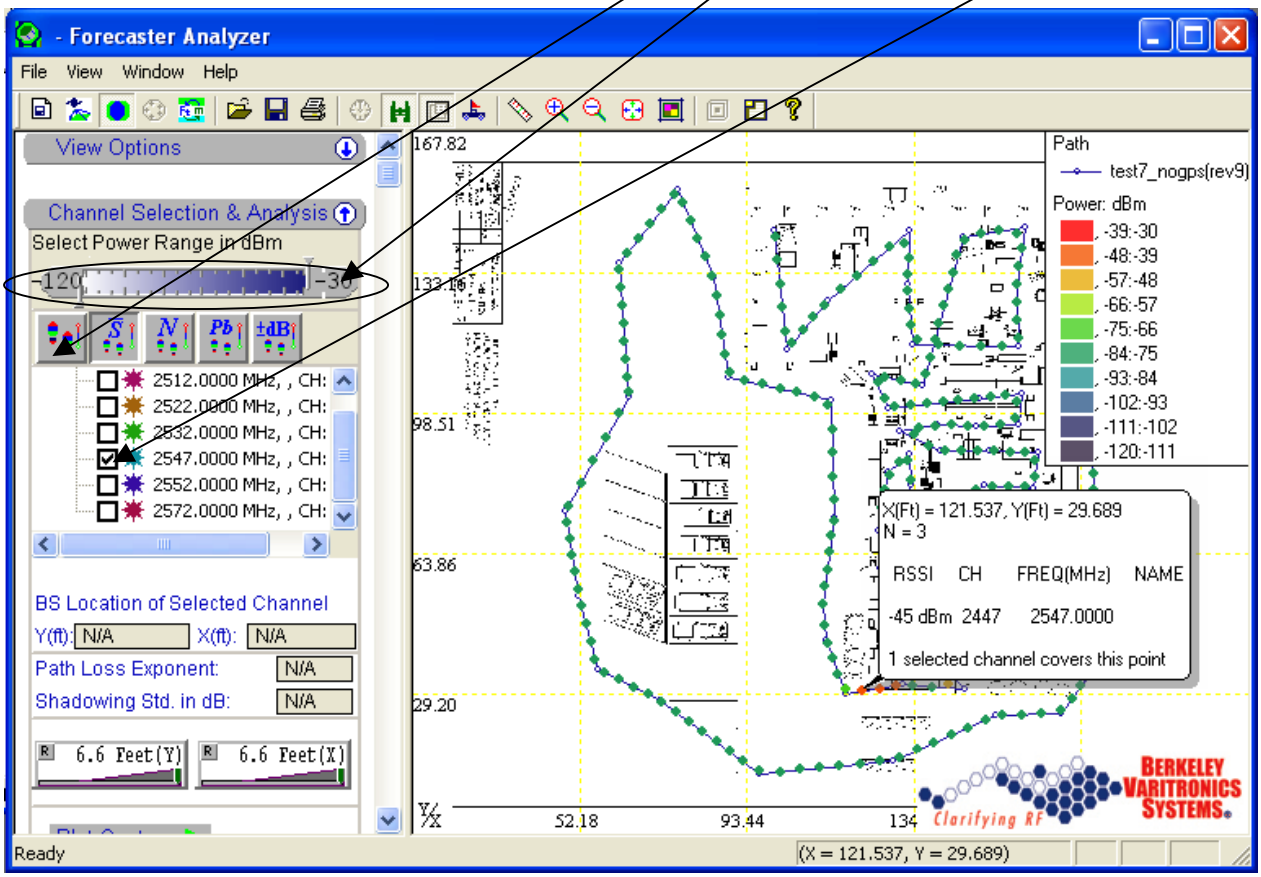
Table 3 shows the descriptions of the buttons used in the control window to analyze the data.

Table 3.3. Button In View Options Of Control Window

Buttons	Name	Description
	Walk/Drive Path	Show/Hide Walk/Drive Path
	Path Width	Change the Width of Walk/Drive Path
	GPS Status	**Show GPS status by black circles. 3D fix: No black circles; 2D fix: small black circles; No fix: big black circles. (GPS only: disabled for indoor study)**
	**Show/Hide Base Stations**	**Show/Hide Base Stations** on the Map
	Coordinates Selection	**Y/X: Use the linear distance in the axis Lat/Lon: Use Lat/Lon (decimal degree) in the axis (Only Y/X coordinates for indoor study)**
	**Horizontal Grid Lines**	Show/Hide grid lines in X direction
	**Vertical Grid Lines**	Show/Hide grid lines in Y direction
 	Number of Grid Lines **Plot RSSI Along Path**	Change the number of lines in the grid **Plot the measured RSSI along the survey path.**
	**Plot Averaged RSSI Along Path**	**Plot the averaged RSSI along the survey path.**
	**Plot The Averaging Number Along Path**	**Plot the number of RSSI for 40-lambda averaging along the survey path.**
	**Plot Reliability Along Path**	**Plot the reliability of averaged RSSI along survey path**
	**Plot Variation Along Path**	**Plot the Variation of Averaged RSSI Along Survey Path**

3.2.1 Plot RSSI Along Survey Path

To plot the raw RSSI along the survey path, click on the  button and then select the channel. A colorful drive path is shown below. The range in the map is from -30 dBm to –120 dBm. To change the range of RSSI, please move the sliders above.



3.2.2 Plot the Averaged RSSI Along Survey Path

To plot the averaged RSSI along the survey path, click on the  button and then select the channel. A colorful drive path is shown. If none of the channels is selected, a dialog will pop up to ask for selecting channels. The range of RSSI can also be changed by moving the sliders above.

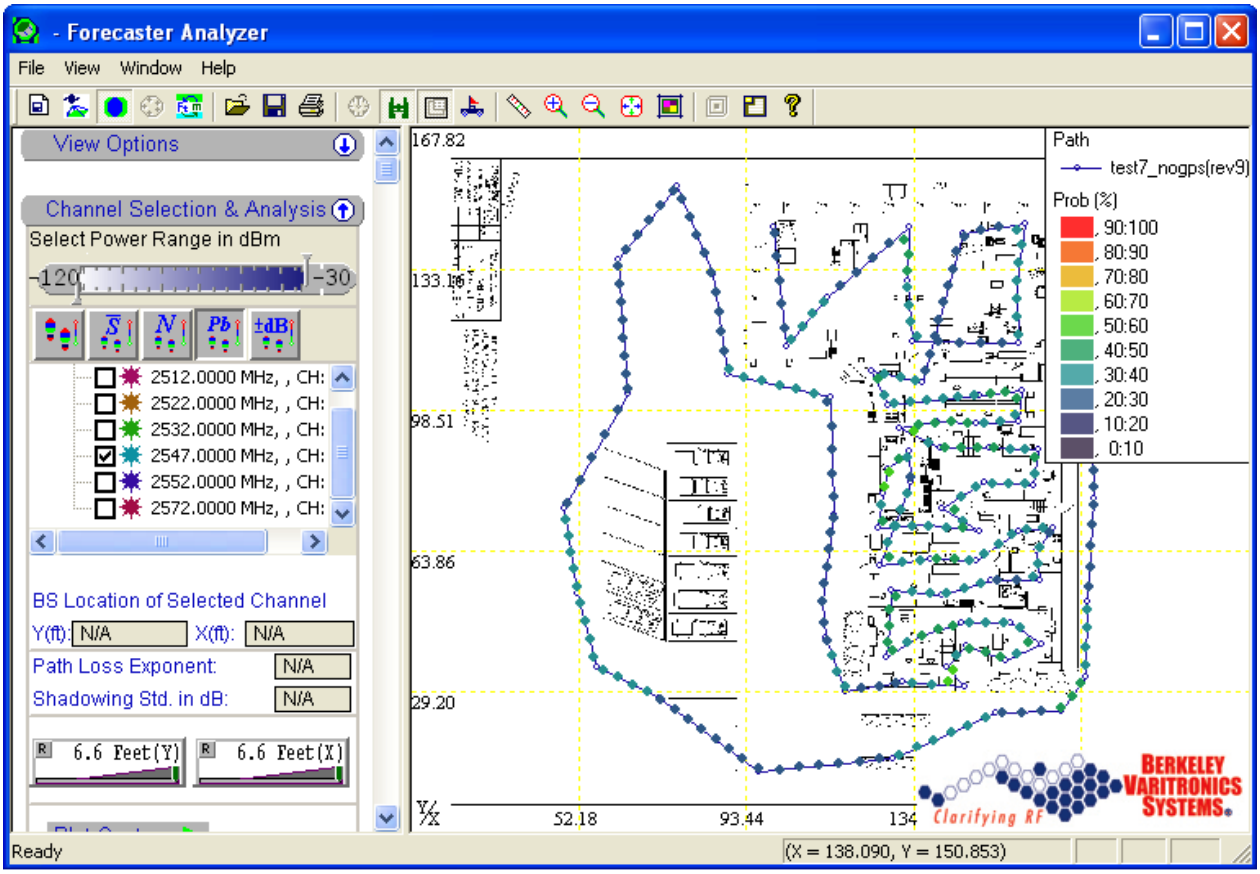
3.2.3. Plot the Number of Points For Averaging Along Survey Path

The number of the points, which are used for averaging, can also be plotted along the walk/drive path. Click on the  button under "Channel Selection and Analysis". A dialog will be popped up to take the range for the numbers.

3.2.4 Plot the Reliability of Averaged RSSI Along Survey Path

To plot the reliability of averaged RSSI along the walk/drive path, click on the button  under "Channel Selection and Analysis". A dialog will be popped up to take the range for the reliability. The default value of RSSI variation to calculate the reliability is 1dB. For example, if the reliability is 90%, it means that the possibility that the averaged RSSI is within ± 1dB of the real mean value is 90%. The accuracy of the averaged RSSI to the real mean value increases with the reliability. Assuming the number of points is *N*, the reliability is *p*, the standard variation is σ, the equation to calculate the reliability is[1]

This figure showing the reliability of averaged data is show below.



[1] Please refer to the book – "The Mobile Radio Propagation Channel", David Parsons, John Wiley & Sons, New York, 1992.

3.2.5 Plot the Variation of Averaged RSSI Along Survey Path

To plot the averaged RSSI along the walk/drive path, click on the button  **under "Channel Selection and Analysis". A dialog will be popped up to take the range for the variation. The default value of the reliability to calculate the reliability is 90%. The accuracy of the averaged RSSI to the real one decreases with an increasing standard variation. Assuming the number of points is *N*, the reliability is *p*, the standard variation is σ, the equation to calculate σ is**

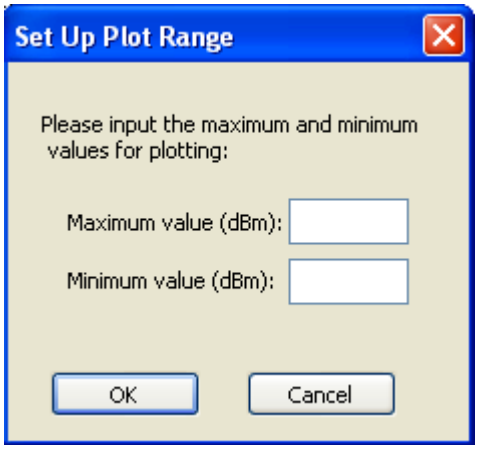
$$\sigma(p) = \frac{5.57 erf^{-1}(p)}{\sqrt{N/2}}$$

3.3 Coverage Analysis and Prediction

3.3.1 Plot Contours

The detailed coverage analysis and prediction with contours can be shown by pressing the 

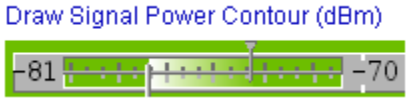
button. A dialog will be shown to ask for the minimum and maximum values for contours.



Either the signal strength or the number of channels (*N*) in the coverage area can be shown by clicking the  **(signal strength) or the**  **(number of channels) button.**

3.3.2 Draw Controls

The range of the power (or number of channels) is shown in the following range control diagram. Move the sliders on the range control by clicking and holding the sliders to the desired value and the contours for the two values will be displayed in the graph window.

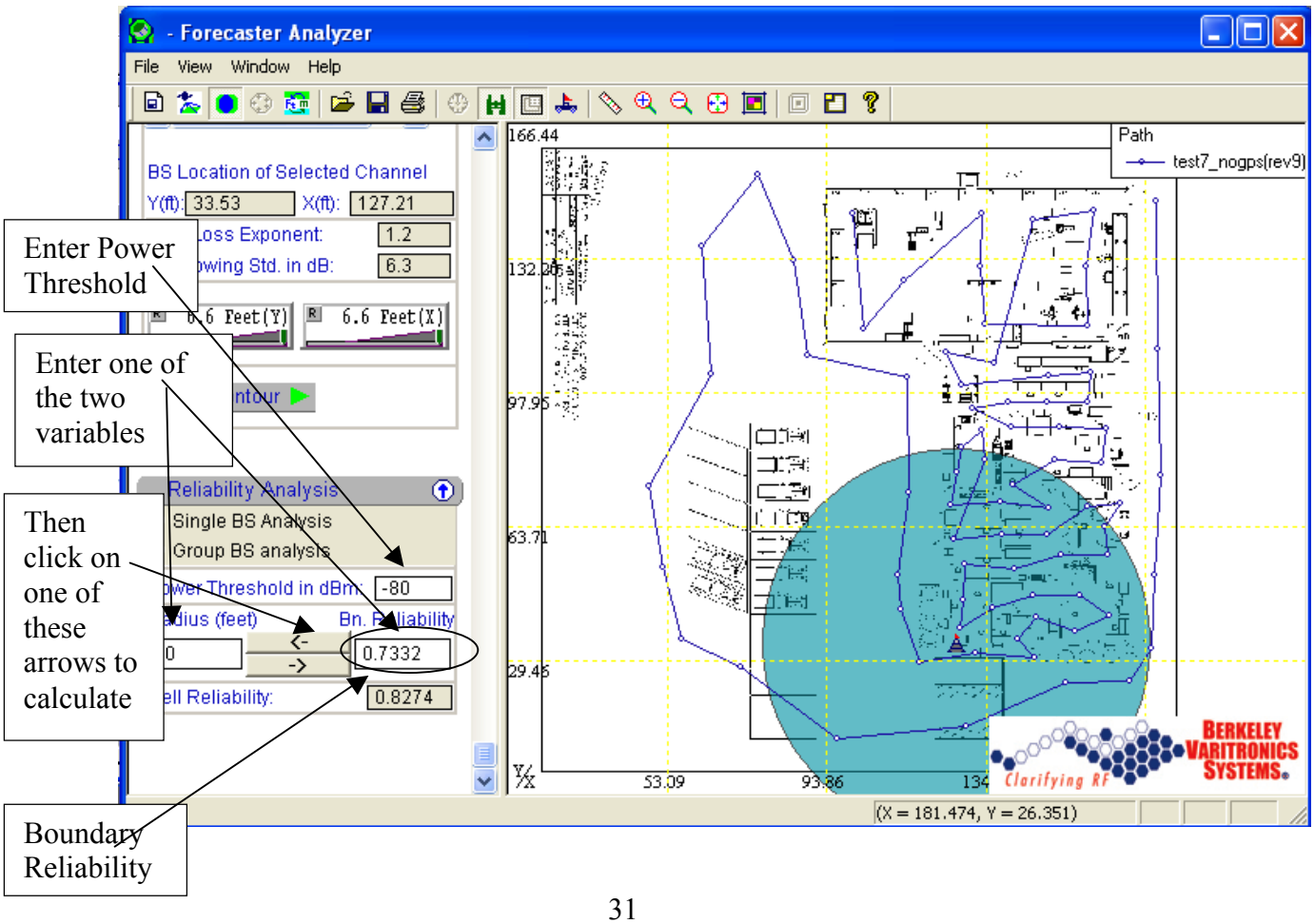


3.4 Reliability Analysis

Reliability Analysis **shows the radius, boundary reliability, cell reliability and power threshold of the channel(s). The user can input numbers via the keyboard and calculate the coverage reliability in the control panel.**

Channel(s) selected for Reliability Analysis is done with the channel selection list. After selecting the channel(s) use the buttons in the control pane to calculate reliability analysis. To do single channel analysis select "Single Analysis" and the last selected channel is analyzed. Click on the "Reliability Analysis" button and input Power Threshold and Radius. Click  **and the boundary reliability for this channel is shown under "Bn. Reliability" and the cell reliability is also calculated and shown. The coverage of the last selected channel with the radius is shown as a circle on the graph window. The reliability represents the probability that the received signal's strength is larger than the threshold value. The boundary reliability stands for the probability of the signal received at the boundary of the cell to be greater than the threshold, the cell reliability stands for the probability of the signal received within the cell to be greater than the threshold. On the other hand if power threshold and probability (boundary reliability) are known click**  **and the radius and cell reliability will be shown. If "Group Analysis" is selected then all the selected channels will be analyzed with the same input data.** **An example is shown below where the transmission power is 1W and the antenna height is 2 meter.**

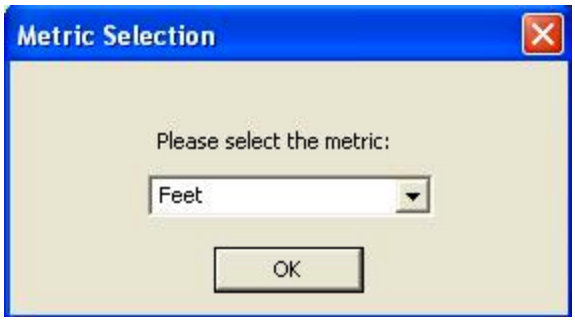
Note: If the "Reliability Analysis" is open then the software is set to this mode. To see the coverage of the selected channel(s) click the "Reliability Analysis" again to pull up the interface and close this mode.


- Forecaster Analyzer
File View Window Help
BS Location of Selected Channel
Y(ft): 33.53
X(ft): 127.21
Loss Exponent: 1.2
owing Std. in dB: 6.3
6.6 Feet(Y)
6.6 Feet(X)
ntour
Reliability Analysis
Single BS Analysis
Group BS analysis
ower Threshold in dBm: -80
dius (feet)
Bn. Reliability
0
<-
->
0.7332
ell Reliability: 0.8274
166.44
132.20
97.95
63.71
29.46
53.09
93.86
134
Path
test7_nogps(rev9)
Clarifying RF
BERKELEY VARITRONICS SYSTEMS
(X = 181.474, Y = 26.351)
Enter Power Threshold
Enter one of the two variables
Then click on one of these arrows to calculate
Boundary Reliability

4. SOME FUCNTIONS IN THE ANALYZER

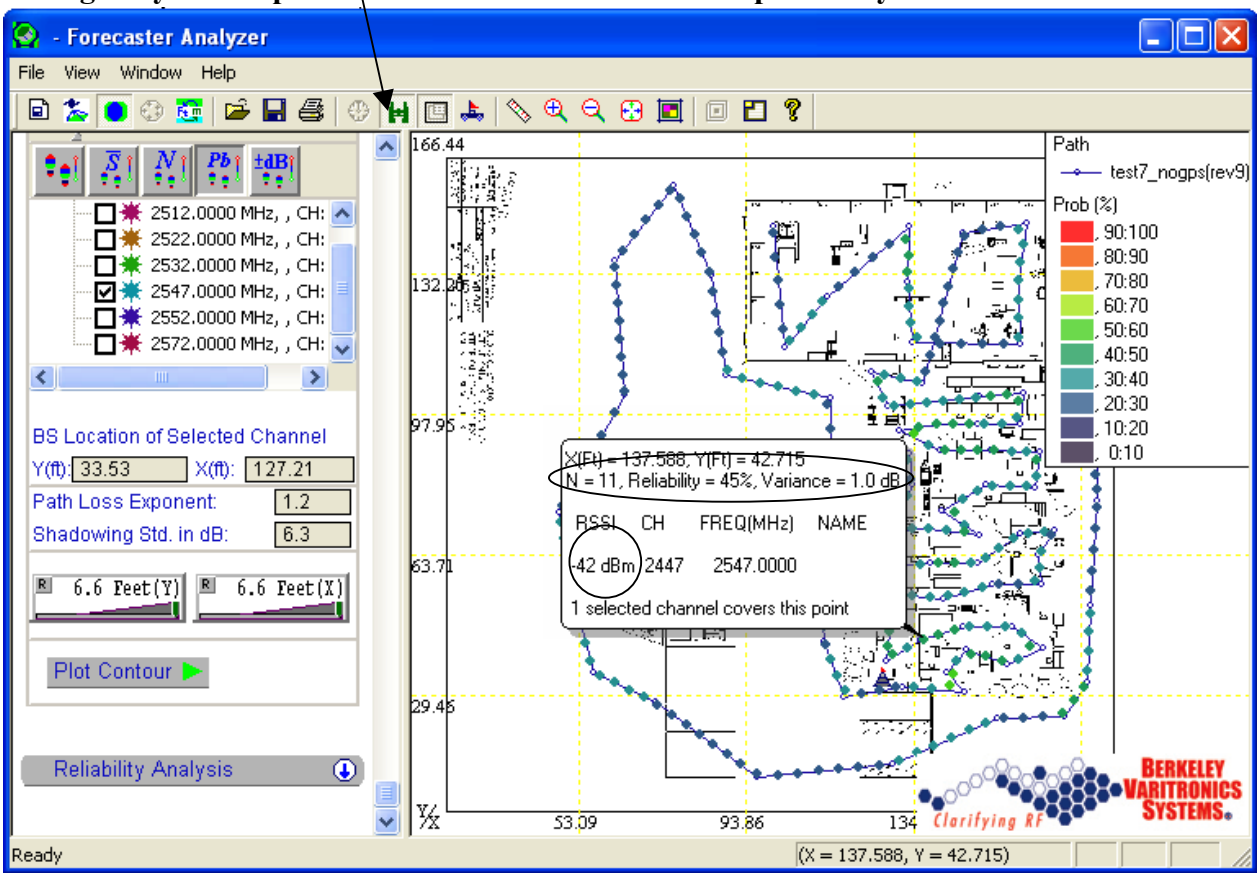
4.1 Metric Selection

Measurement information can be displayed in feet or meter. The default setting is feet. To select the metric use the Hotkey located on the top toolbar. Left click on the hotkey and the metric selection dialog box appears.



4.2 Information Window

The following figure shows the analysis of measurement data by using the information window. Click on the hotkey and then move the mouse to the point to be analyzed. Stay at the point for a second and the information window will be shown. The information window in this figure shows that the averaged value at this point is –80 dB, which is averaged by 48 samples. The real mean value has 79% possibility within -80±1 dB.



4.3 Channel Selection

Select the channels or group of channels you wish to work with in the control window under "Channel Selection". The Channel Selection tool contains a list of all channel(s) that are present in the log files. Checking the box next to the frequency includes the channel(s) in the analysis. As the channel is selected, its coverage graph will be shown in the graph window.

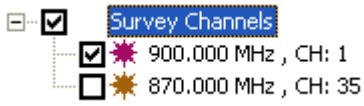
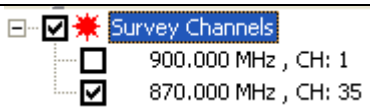
4.4 Color Selection

The color indicator between the frequency and the check box has two functions:

One is to select the color used to graph signal strength from that channel(s). To change the color for a selected channel(s) right click on the color indicator. A color selection dialog box will appear.

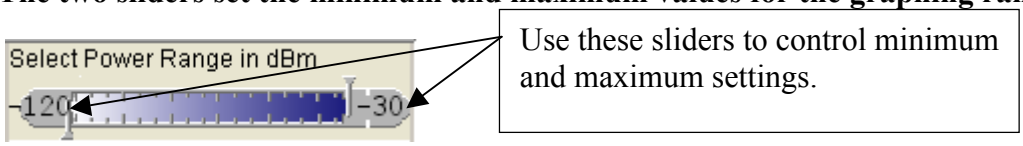
The other is to select how channels are grouped for analysis. After checking the channel, the RF coverage of that channel will be shown if it is not in the Reliability Analysis mode. If it is in the Reliability mode the area with certain reliability is shown. Reliability Analysis is explained in the next section. There are two conditions the user can choose from as shown in the following table:

Example Grouping Description

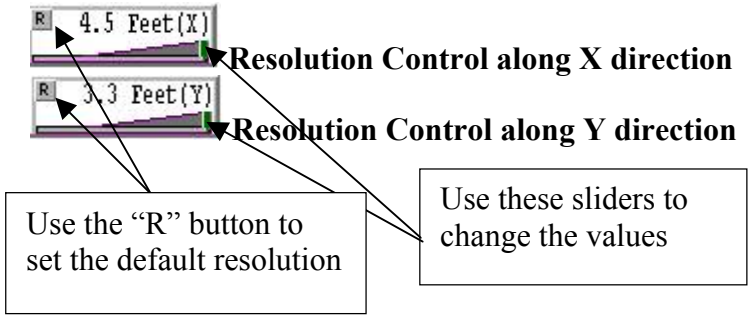
Example	Grouping	Description
	Individual	Each selected channel is graphed in its own color indicated by the color of the star.
	Group Selection	The best coverage for all channels is shown using the group color.

4.5 Range Control

This feature allows users to control how the signal strength is represented using a graph. The two sliders set the minimum and maximum values for the graphing range.



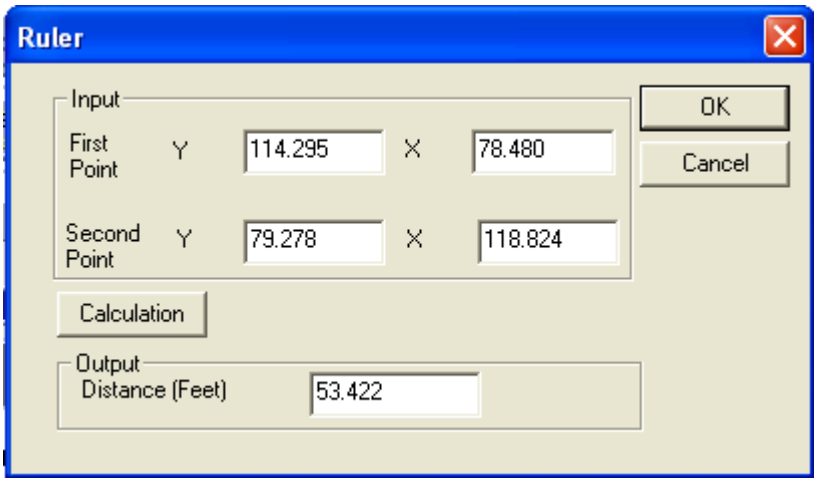
4.6 Resolution Control



The resolution control shows the size of the points calculated. Setting the control for low resolution will reduce the calculation time and decrease the resolution. The button R resets the control to a reasonable default setting.

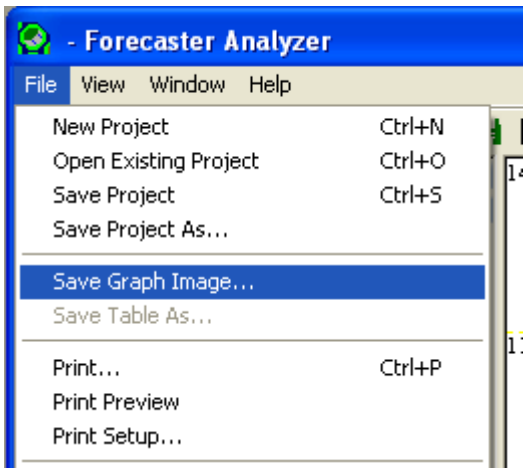
4.7 Measuring Distances

Distance measurements can be made on a graph by using the ruler tool. To measure distances use the hotkey. Left click and hold on the graph to start the measurement. By releasing the button the distance is displayed by a distance dialog box.



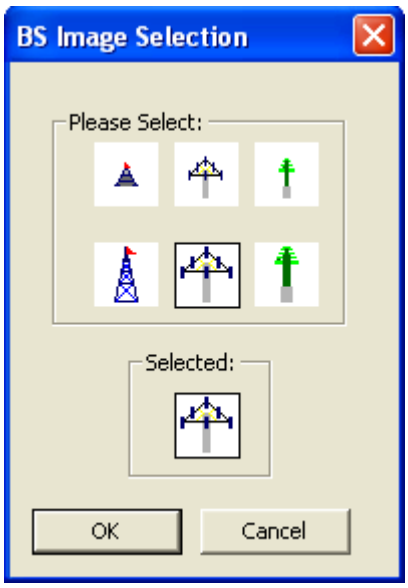
4.8 Saving Coverage Graph

The current coverage graph can be saved as a bitmap. Select Save Graph Image… from the File menu.



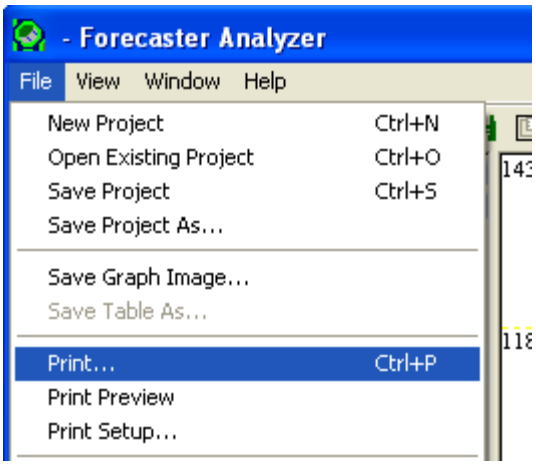
4.9 Change Base Station Icons

Right click on the base station, a dialog to select base station image is shown. Click on the desired image, press "OK" Button.



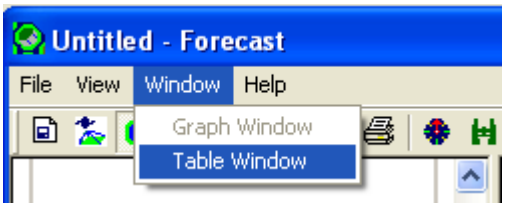
4.10 Printing

The standard Windows printing selections Print, Print Preview and Print Setup are available from the File menu.

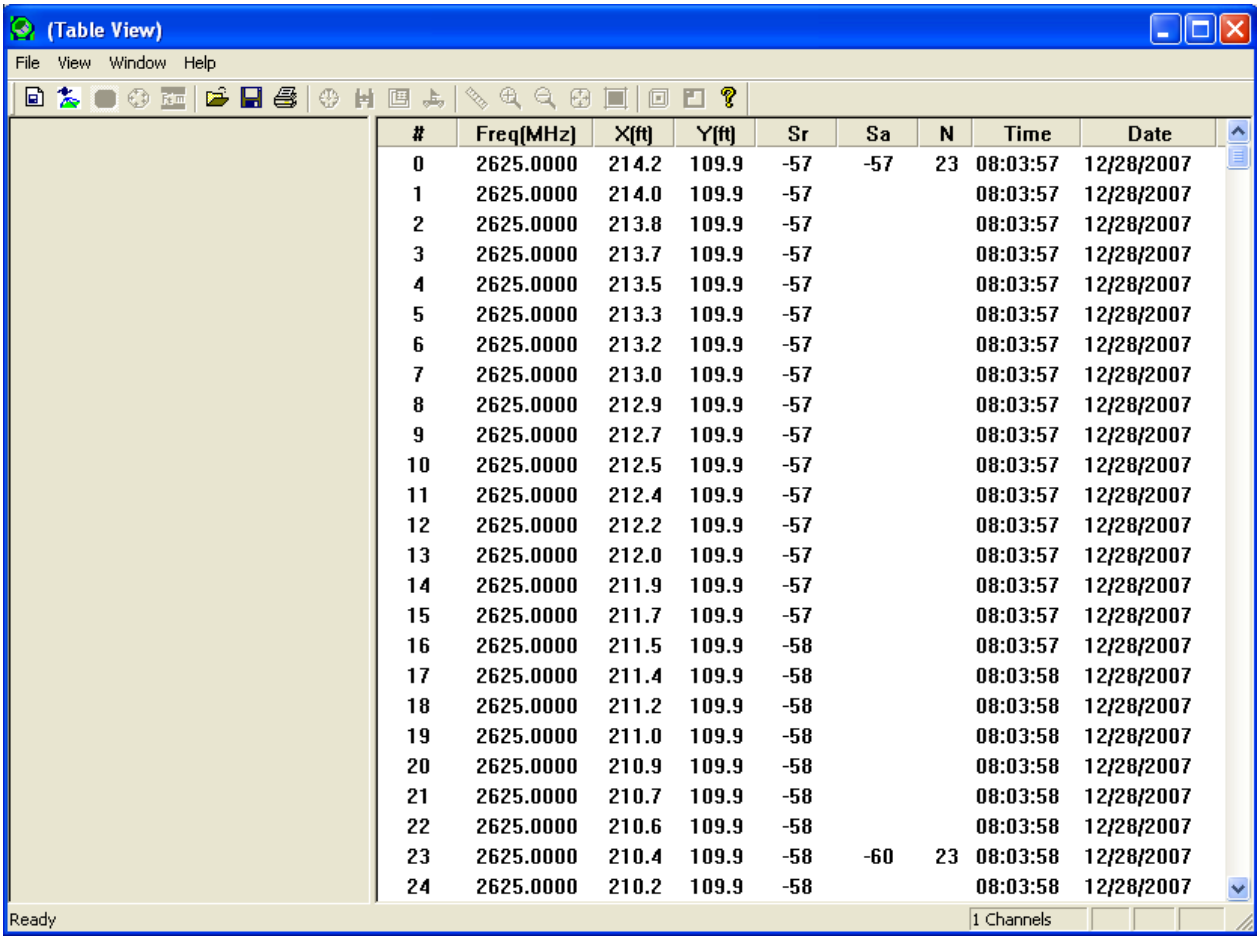


4.11 Table View

To view the data point in tabular form select Table Window from the Window menu.



An example of a table view follows on the next page.

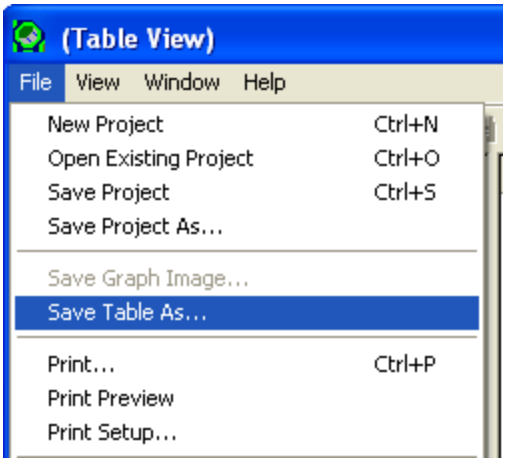


#	Freq(MHz)	X(ft)	Y(ft)	Sr	Sa	N	Time	Date
0	2625.0000	214.2	109.9	-57	-57	23	08:03:57	12/28/2007
1	2625.0000	214.0	109.9	-57			08:03:57	12/28/2007
2	2625.0000	213.8	109.9	-57			08:03:57	12/28/2007
3	2625.0000	213.7	109.9	-57			08:03:57	12/28/2007
4	2625.0000	213.5	109.9	-57			08:03:57	12/28/2007
5	2625.0000	213.3	109.9	-57			08:03:57	12/28/2007
6	2625.0000	213.2	109.9	-57			08:03:57	12/28/2007
7	2625.0000	213.0	109.9	-57			08:03:57	12/28/2007
8	2625.0000	212.9	109.9	-57			08:03:57	12/28/2007
9	2625.0000	212.7	109.9	-57			08:03:57	12/28/2007
10	2625.0000	212.5	109.9	-57			08:03:57	12/28/2007
11	2625.0000	212.4	109.9	-57			08:03:57	12/28/2007
12	2625.0000	212.2	109.9	-57			08:03:57	12/28/2007
13	2625.0000	212.0	109.9	-57			08:03:57	12/28/2007
14	2625.0000	211.9	109.9	-57			08:03:57	12/28/2007
15	2625.0000	211.7	109.9	-57			08:03:57	12/28/2007
16	2625.0000	211.5	109.9	-58			08:03:57	12/28/2007
17	2625.0000	211.4	109.9	-58			08:03:58	12/28/2007
18	2625.0000	211.2	109.9	-58			08:03:58	12/28/2007
19	2625.0000	211.0	109.9	-58			08:03:58	12/28/2007
20	2625.0000	210.9	109.9	-58			08:03:58	12/28/2007
21	2625.0000	210.7	109.9	-58			08:03:58	12/28/2007
22	2625.0000	210.6	109.9	-58			08:03:58	12/28/2007
23	2625.0000	210.4	109.9	-58	-60	23	08:03:58	12/28/2007
24	2625.0000	210.2	109.9	-58			08:03:58	12/28/2007

where

Freq: **Frequency.**
X(ft): **The coordinates of the point along X in the map in feet.**
Y(ft): **The coordinates of the point along Y in the map in feet.**
Sr: **First stage filtered data.**
Sa: **10 lambda averaged data.**
N: **The number of points for 10-lambda averaging.**
Time: **Record time.**
Date: **Survey date.**

To save the table in a form that can be used by spreadsheet applications and other programs, select Save Table as… from the File menu. The output is 40-lambda averaged data. Please check Appendix A for the data processing algorithms.



The save table options dialog then appears.

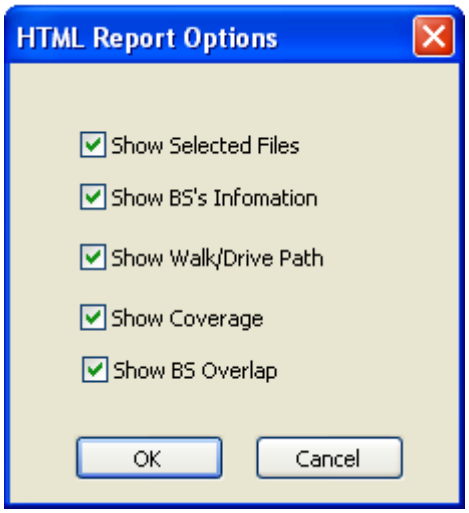
The output is an ASCII file that can be customized for easier conversion to a specific program.

5. CREATING REPORTS

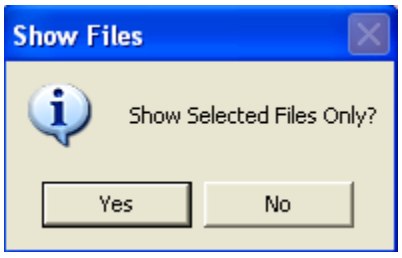
5.1 HTML Report

HyperText Markup Language (HTML) files can be opened by Internet Explorer and can contain formatted text and graphics. Forecaster Analyzer can create a HTML report that has the information about the data survey files, the selected channels, the coverage of signal power and the number of channels per location.

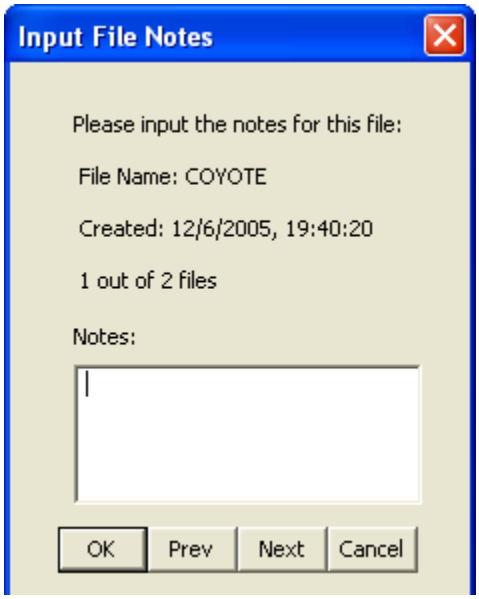
To use this feature select  **Hotkey. Select a file name to store the file when the dialog box appears. A dialog box for HTML report options will be shown. If no "Plot Contour" is implemented, the button "Show Coverage" and "Show BS Overlap" will be disabled.**



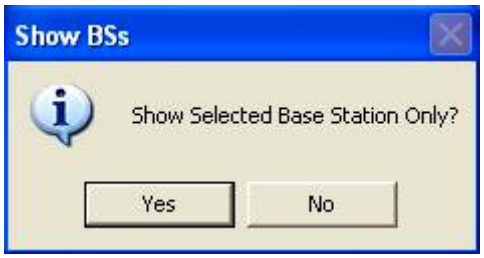
If "Show Selected Files" is checked a message box will appear asking if the selected files are to be displayed in the report. If "No" is clicked, all the files will be displayed in the report.



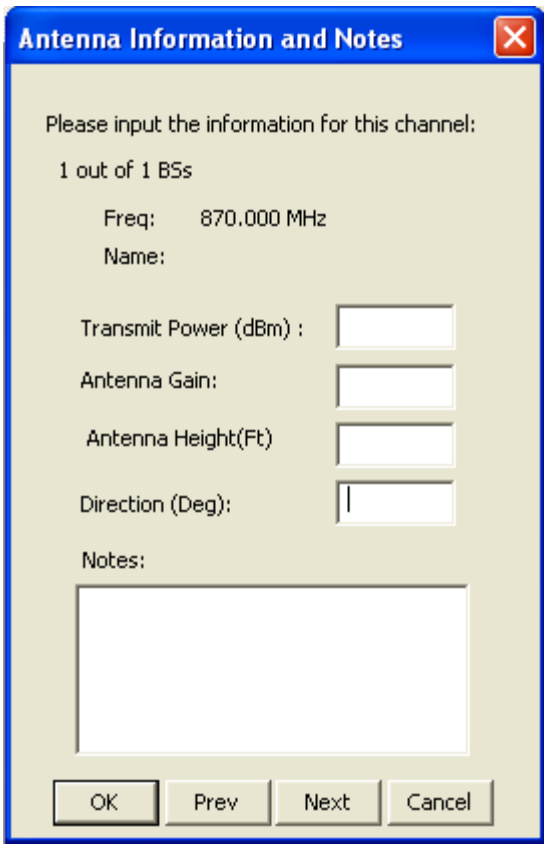
Then a dialog appears to take the notes for the selected file. Enter the notes for the different files by clicking the "Prev" or "Next" buttons. After entering the notes for all the files then click "OK". All notes will be stored and displayed in the report.



If "Show BS's Information" is checked in the dialog for HTML report options, a message box will appear asking if only selected base stations are shown in the report. If "No" is selected then all of the base stations will be displayed in the report.



Then a dialog box appears to take the parameters and notes for the selected base stations or channels. The parameters input at the interface for clustering points are shown here. Modify the parameters and notes for individual BSs by clicking the "Prev" or "Next" buttons. After entering the notes for all BSs click "OK". All notes will be stored and displayed in the report.


Antenna Information and Notes
Please input the information for this channel:
1 out of 1 BSs
Freq: 870.000 MHz
Name:
Transmit Power (dBm) :
Antenna Gain:
Antenna Height(Ft)
Direction (Deg):
Notes:
OK
Prev
Next
Cancel

Appendix I: Indoor Site Survey Study

I. Rayleigh Fading and Terrain Based Fading

There are two types of fading that are relevant to performing coverage measurements, fast fading, also know as Rayleigh fading, and terrain based fading due to obstructions and propagation loss. The goal of coverage measurement is to measure the local signal strength in presence of terrain based fading.

Rayleigh fading is due to close in reflections. It produces drops in signal strength that are only a fraction of a wavelength in size (often on the scale of inches). These fades always exist and are only of interest in the sense that coverage measurements must be made in a manner that rejects Rayleigh fading, so that accurate measurements of terrain-based fading can be made.

II. Reject Rayleigh Fading

It is important to realize that Rayleigh fading is a spatial phenomenon not a time one. The averaging is intended to be done over a certain distance, which can be optimal in rejecting Rayleigh fading and keeping terrain information. In an outdoor environment, the location information during a drive study can be achieved through GPS, which updates every second. Therefore, sufficient measurements can be collected quickly and easily for outdoor measurement.

There is no positioning system for most indoor environments, such as hospital, shopping malls, office building, and so on. It increases the difficulty to collect sufficient data to reject the Rayleigh fading. There are three collection methods [1],

1) **Manual collection. In this method, one measurement of the signal power with its location is recorded. However, the signal power can vary from a few dB to 20 dB in several inches due to Rayleigh fading. Therefore, this method provides the inaccurate measurement data since it cannot effectively reject Rayleigh fading. Furthermore, it needs a large amount of measurement not to distort terrain based fading.**
2) **Spinning antenna method. At a fixed measurement location, the antenna moves along a circle orbit and the collected data is averaged and saved. This method can remove the Rayleigh fading in the measurement. However, similar to the first method, it also needs a large amount of data to keep terrain based fading. Furthermore, the possibility of averaging correlated data reduces the accuracy of the measurement.**
3) **Linear averaging method. In this method a test engineer walks along a straight line and the measurement tool records the signal strength during the walk. In post processing, the software will select the independent points and then average them to get the local mean power. This is the most efficient method and it provides the most accurate measurement. For example, people can walk 100 feet in 1 minute. Assuming the carrier frequency is 2.5GHz. So the wavelength will be 0.4 feet. If the first or second method is used, the test engineer needs to measure 250 times for each wavelength or 25 times every 10 wavelength. It obviously takes much more time than the linear averaging method.**

This linear averaging method is used in Indoor Forecaster software and the data is collected in this way,

a. **The test engineer taps the start point and end point on the map,**
b. **The test engineer presses the button to start the measurement and then walk straight with a constant speed toward the end point,**
c. **The test engineer presses the button to end the collection when he arrives at the end point.**

III. Data Processing Algorithms

The position of each sample is interpolated from the start and stop point. This is done assuming a constant velocity during the walk. The interpolation equation is

$$P_{0,i} = \frac{(P_1 - P_0)i}{N} + P_0, \text{ Where } P_0 \text{ and } P_1 \text{ are the start and stop positions and } i = 0,1...N \quad (1)$$

There will be two stages in processing the data, which are shown in Figure A1. The first stage is to filter out the correlated/redundant data. To eliminate the bias in estimating the local mean power, the spatially independent data have to be used for averaging. The spacing used in the software is 0.38λ, which is the minimum independent distance for Rayleigh fading. The filtered data will be shown in the Forecaster Analyzer as the "raw data". The second stage is to average the data. Due to the complexity of indoor environments, a window length 10λ is used in averaging to remove Rayleigh fading and to keep terrain based fading. Therefore, there will be about 10λ/0.38λ = 26 independent samples for averaging. The averaging with 26 samples indicates that the measured local mean power has 90% possibility to be within ±1.8 dB of the real value [2]. Table A1 shows the reliability of averaging 26 independent samples. Figure A2 shows the table report of the data, where *N* represents the number of samples used for averaging within 10 lambda.

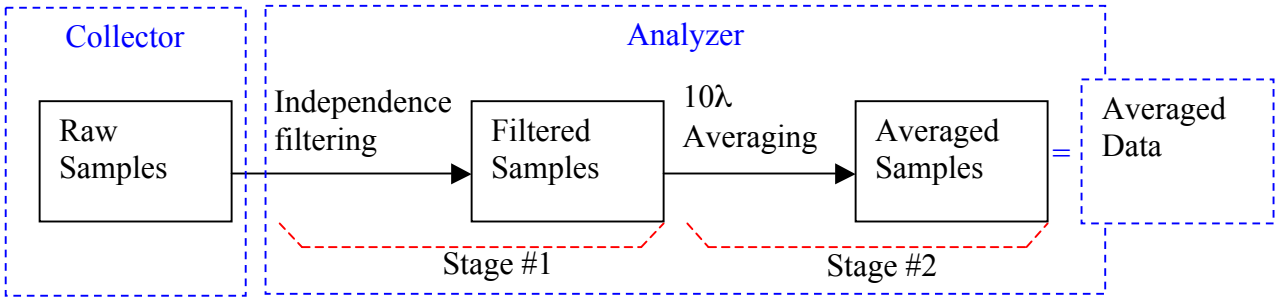


Figure A1: 10 Lambda averaging process

Table A1. Measurement reliability with respect to the number of independent samples

N	Reliability (%)	±σ dB
26	99	2.8
26	90	1.8
26	64	1

Figure A3 demonstrates the first-stage filtering procedure. For 0.38λ independent spacing, sample at $P_{0,2}$ will be selected and the one at $P_{0,1}$ will be deleted. The next selected one will be at $P_{0,4}$. Thus there will be totally 26 samples selected for averaging ($P_{0,i}$, i =0, 2, … 50) and 25 samples will be filtered out ($P_{0,i}$, i =1, 3, … 49) in 10 Lambda from P_0 to P_1. However, if the spacing between each adjacent samples is 0.25λ, there will be totally 21 samples ($P_{0,i}$, i =0, 2, … 40) selected for averaging.

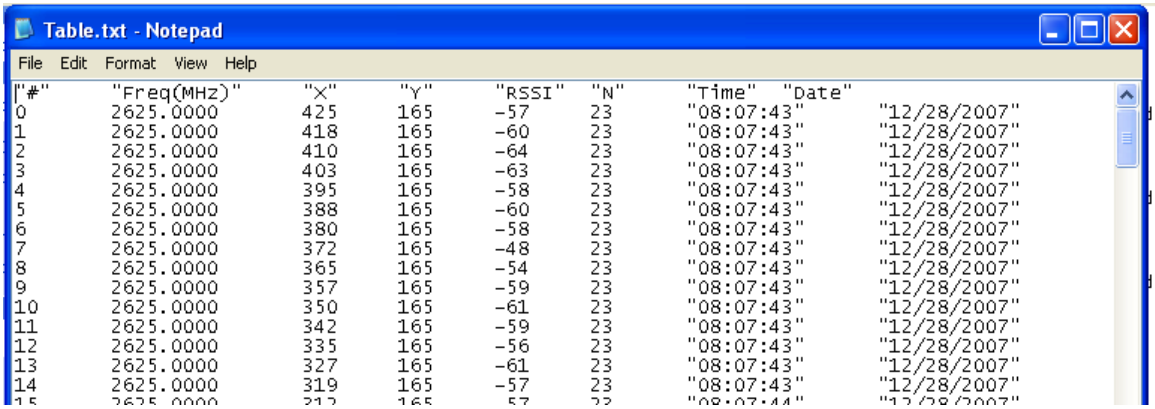


Figure A2. Table report of indoor site survey data.

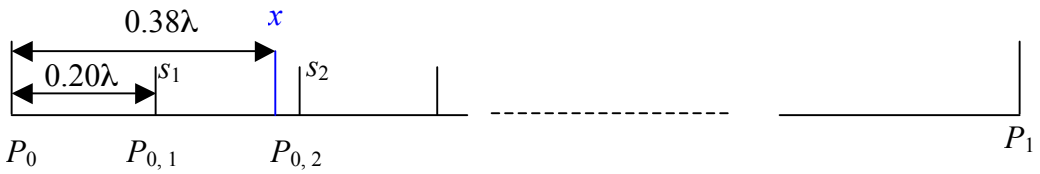


Figure A3. First stage filtering demonstration.

III. Indoor Forecaster Site Survey Software

Indoor Forecaster software will provide the analysis for averaged data, coverage validation, prediction, and reliability. Indoor Forecaster software provides two stages of analysis. The first stage is the analysis of averaged data. The software will filter out the redundant data and average the samples using 10λ window to keep the terrain based fading. The software can show the signal strength of independent data and averaged data on the map. The software can also shows the reliability analysis based on the number of independent samples for averaging. The reliability of the averaged data is related to the number of samples for averaging [2]. Secondly, the Forecaster software can provide the analysis for coverage validation, prediction, and reliability. Based on the measured signal strength and locations, the cell radius with a certain outage probability or the cell reliability with a certain radius can be estimated through a robust method [3]. Figure A4 shows the averaged signal strength along walk path. The place with yellow color has signal strength from –48 dBm to -39 dBm. It indicates that the high data rate can be achieved at this

location. Fig. A5 shows the RF coverage for survey area, where the signal range is from –75 dBm to –30 dBm.

References:

[1]. R. A. Valenzuela, O. Landron, and D. L. Jacobs, "Estimating Local Mean Signal Strength of Indoor Multipath Propagation", *IEEE Trans. On Vehicular Technology*, vol. 46, no. 1, Feb. 1997.

[2] David Parsons, The Mobile Radio Propagation Channel, John Wiley &Sons, New York, 1992.

[3] P. Bernardin and K. Manoj, "The postprocessing resolution required for accurate RF coverage validation and prediction," *IEEE Transactions on Vehicular Technology*, vol. 49, no. 5, Sep. 2000, pp. 1516 - 1521.

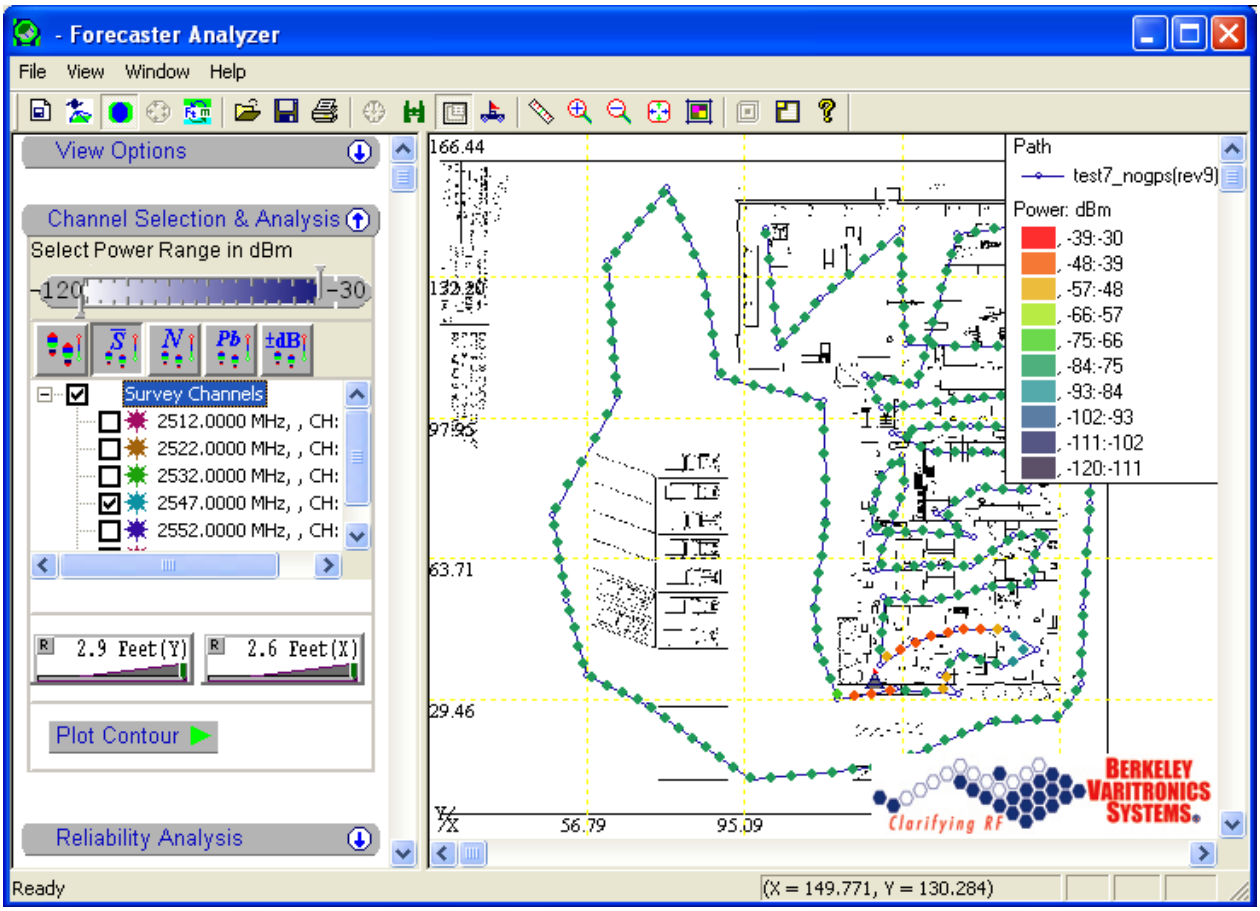


Figure A4. The averaged data along walk path.

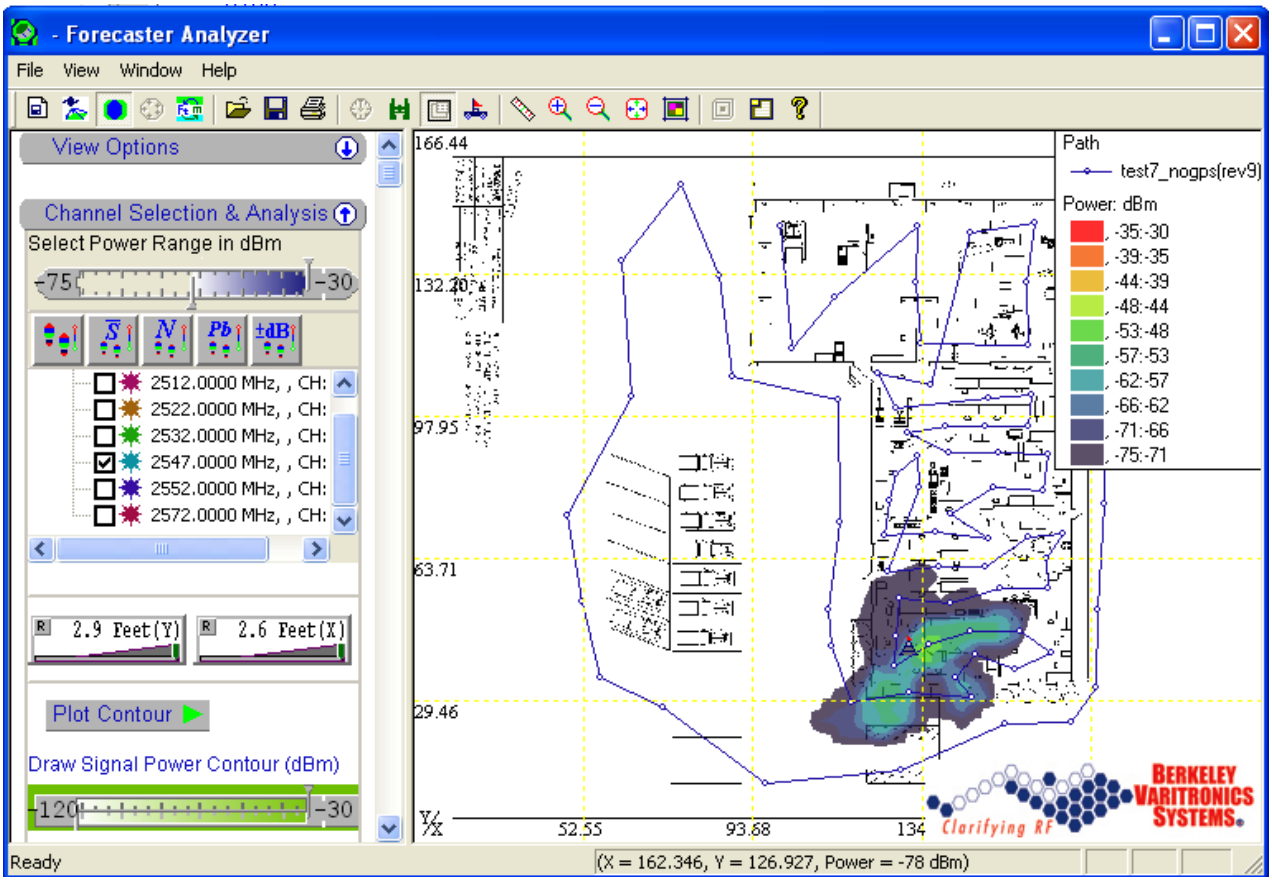


Figure A5. RF coverage for an indoor floor plan.