



WaveSight

**User Manual
for Aircom Enterprise**

Company Information

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Introduction

This document provides information about using the WaveSight prediction model inside Aircom Enterprise, the leading planning tool provided by Aircom International.

Chapter 2 explains how to install WaveSight and configures all parameters needed by WaveSight. It gives also an overview of the supported buildings and terrain data formats.

Chapter 3 gives a brief description about WaveSight as a ray-tracing model.

Chapter 4 presents a list of Frequently Asked Questions by clients or partners about the WaveSight model.

Installation and configuration

Version

Component	Version information
WaveSight algorithm	3.5.2_AI_compatible
Interface COM component	2.4

Prerequisites

- a) Required platform:
 - Pentium \geq 200 MHz.
 - 30 Mbytes of free disk space for WaveSight.
 - RAM \geq 256 Mbytes (allows a prediction radius of 2 Km), 512 Mbytes is recommended.
 - Windows NT.
- b) Aircom ENTERPRISE 4.0 build 33 or later
- c) WaveSight could use up to 200MB (for a prediction area of 10X10 km) of hard disc. Make sure that they are available at the partition where Wavecall is installed.

Installation

If the installation code used by an Enterprise customer includes the relevant code to install the WaveSight model, the Enterprise Setup program installs WaveSight.

If WaveSight is not available on the installation, an updated installation code can be obtained from Aircom's support department to include WaveSight.

A "WAVESIGHT MODEL" license should be obtained in order to enable the use of WaveSight. The license should appear in the Enterprise license manager.

Parameters used by WaveSight

Parameters of the WaveSight model.

After adding WaveSight as propagation model two parameters have to be set, the frequency to be used and the receiver height. See (Figure 1).

For the *frequency* WaveSight is able to operate in a wide range of frequencies; the recommended range is 500 MHz - 5000 MHz.

For the *receiver height* there is no limit, however, for network planning, a height between 1.5 m and 2.0 m is recommended.

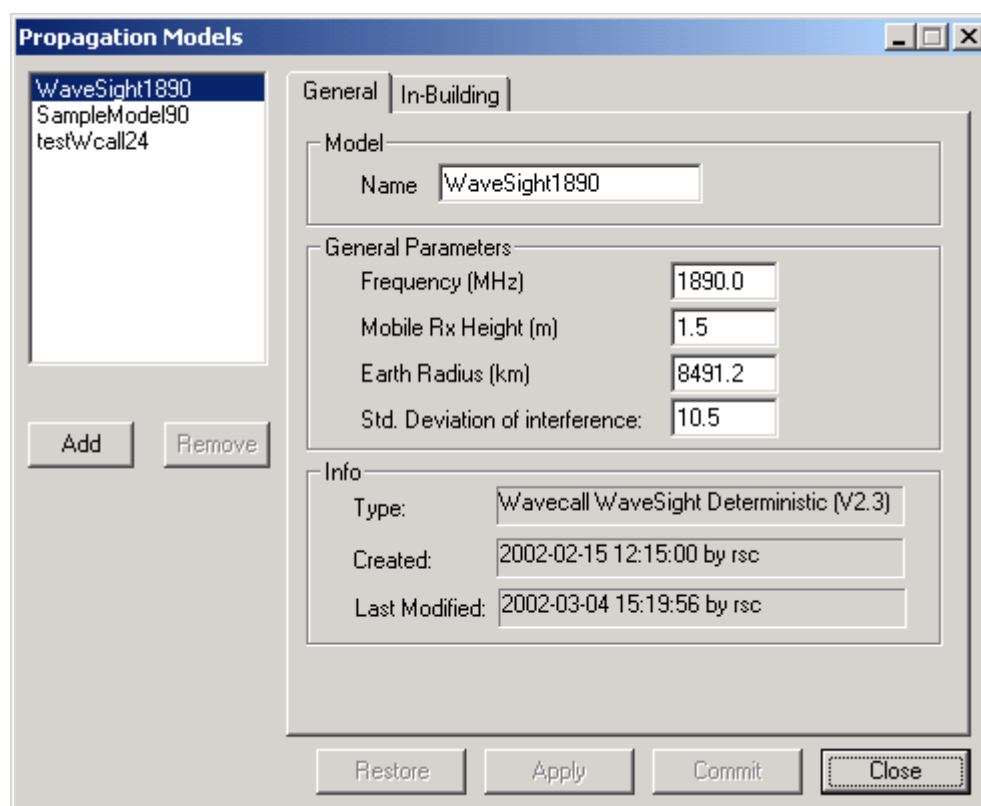


Figure 1 WaveSight propagation model

Parameters read by WaveSight from the sites setting

From the sites database window of Enterprise, WaveSight uses the following parameters to perform its prediction, below is a list of those parameters as they appear in the site cell and cells layer setting of Enterprise.

From the cell setting info:

- *Transmitter coordinates* easting, Northing and height, note that the transmitter height should be always relative to the ground not to the sea level.

- The *down tilt* in degree, considered positive if the angle below the horizon line and negative if it is above the horizon line.
- The *azimuth* in degree, 0 points to the north, 90 to the east.
- *Antenna* pattern name as listed in the antenna file given. If no antenna pattern is mentioned an isotropic pattern is assumed by default. See Figure 2.

From the cell layer setting info:

- The equivalent isotropic radiated power EIRP in dBm, See Figure 3.

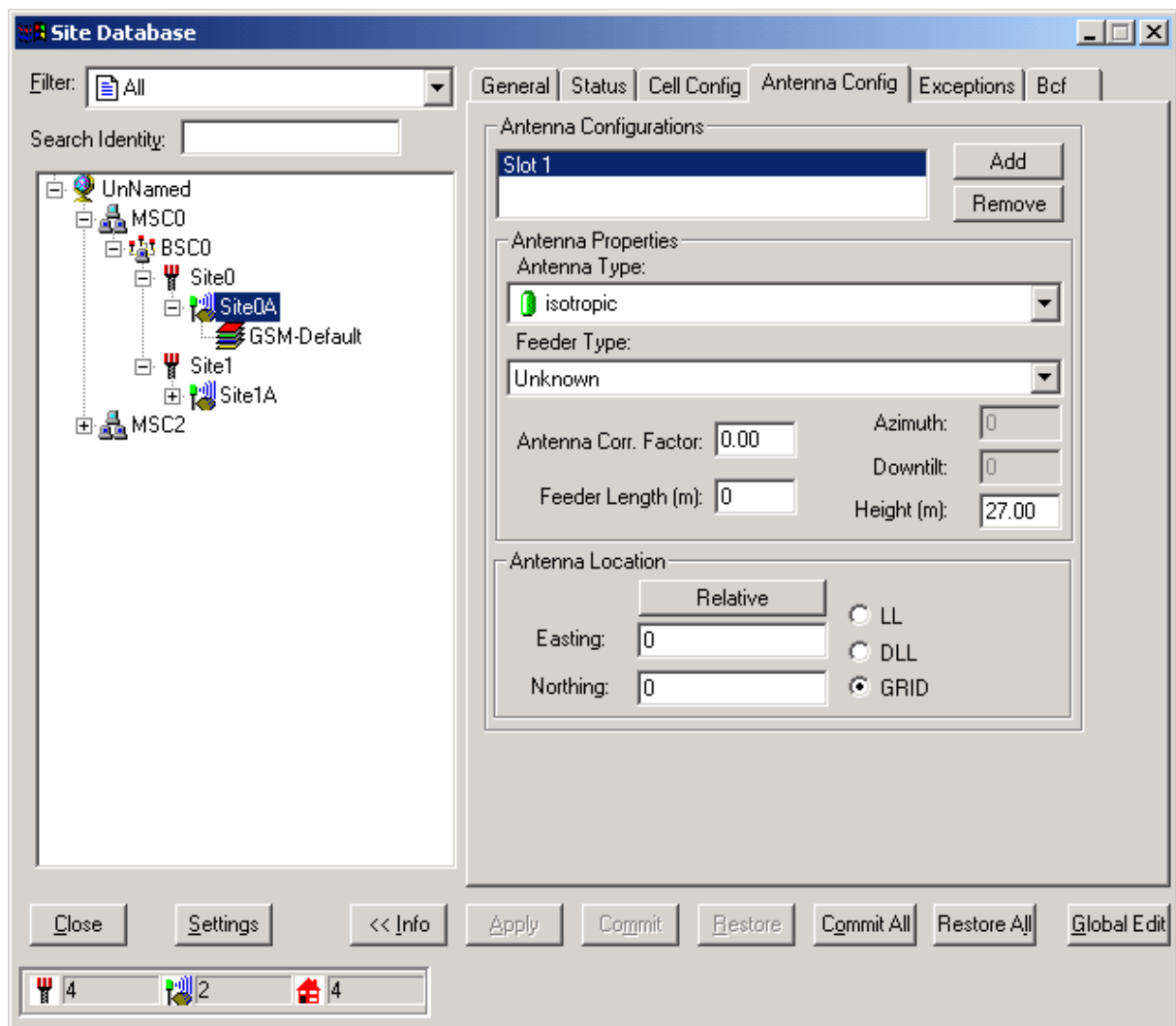


Figure 2 parameters read by WaveSight from site database.

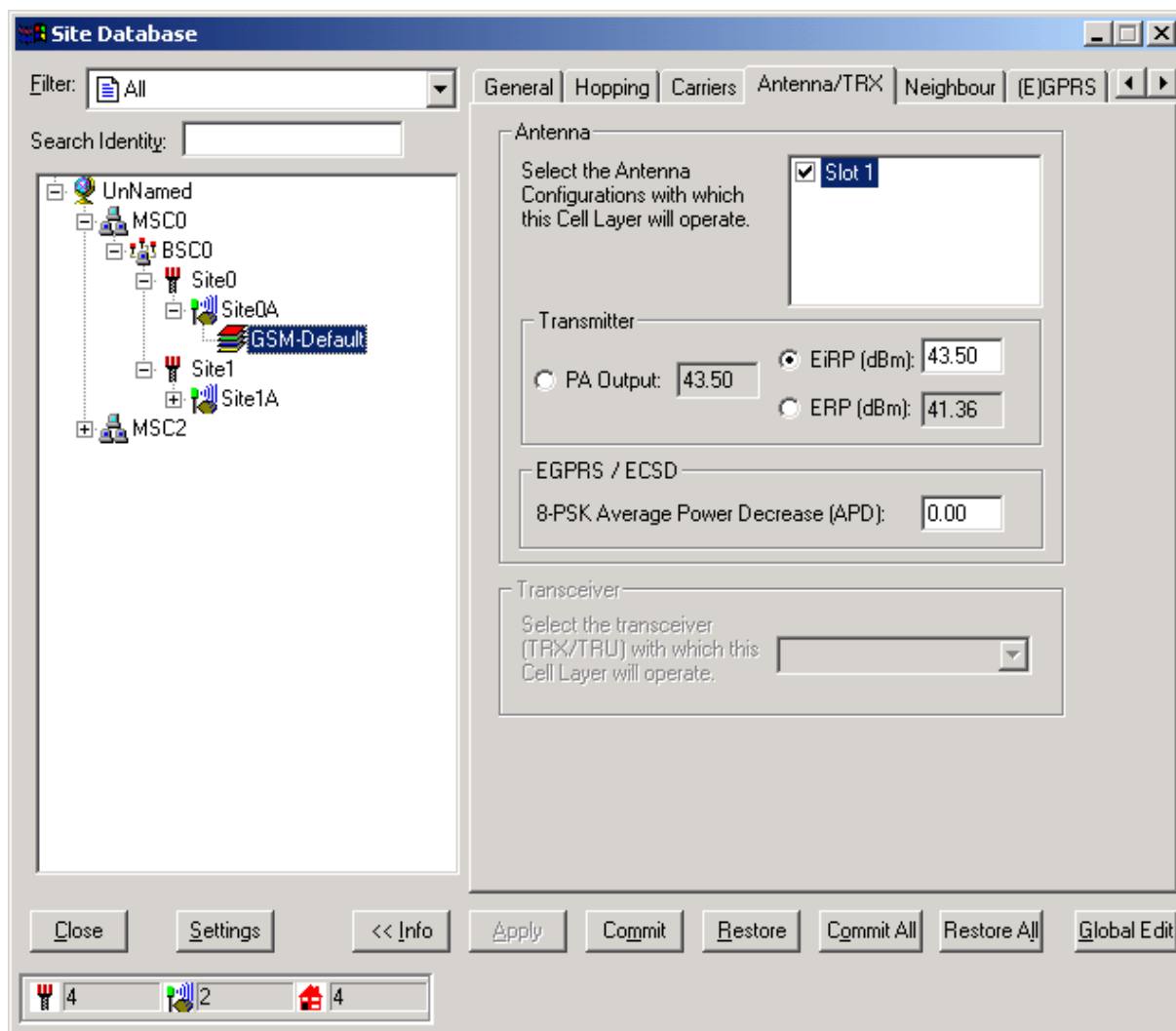


Figure 3 Antenna power read by WaveSight.

Building data

Configuring the data

The Building vector data used by WaveSight should be added to the Enterprise project, from the "Modify Project" window, in the map data directories. The path to the folder that contains the building data should be identified in the field *Building vector data*, as shown below in Figure 4.

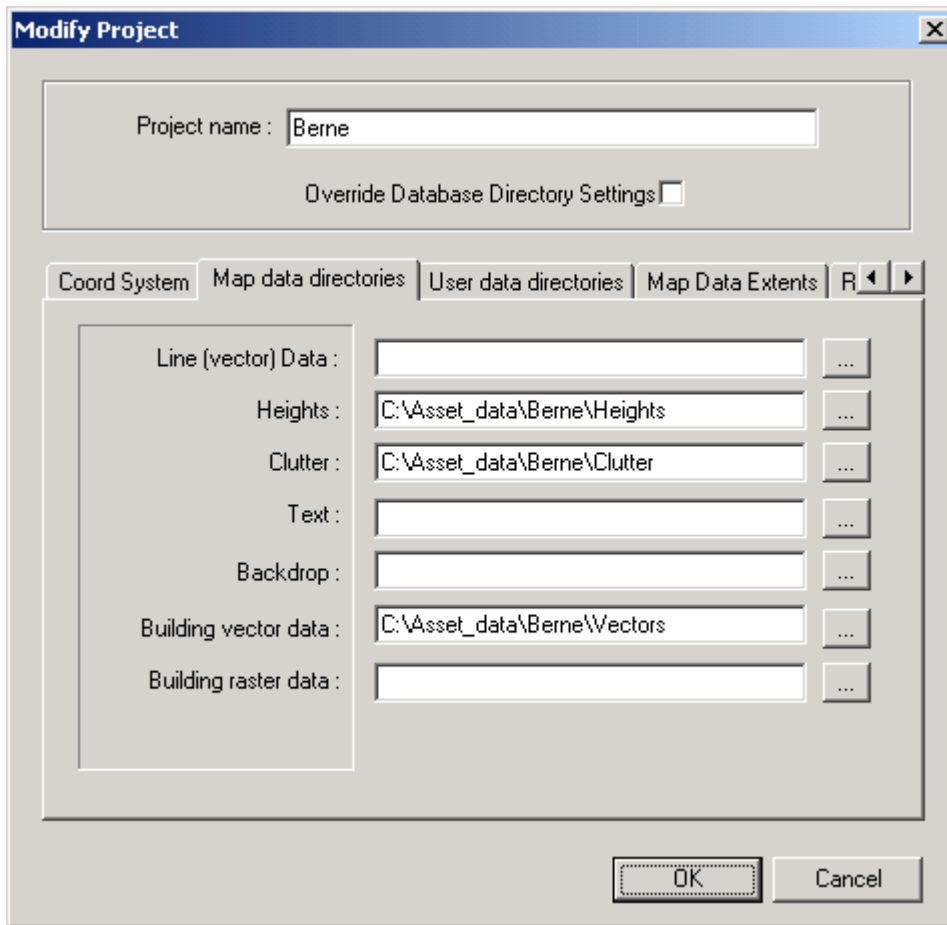


Figure 4 adding the building vector data to the Enterprise project.

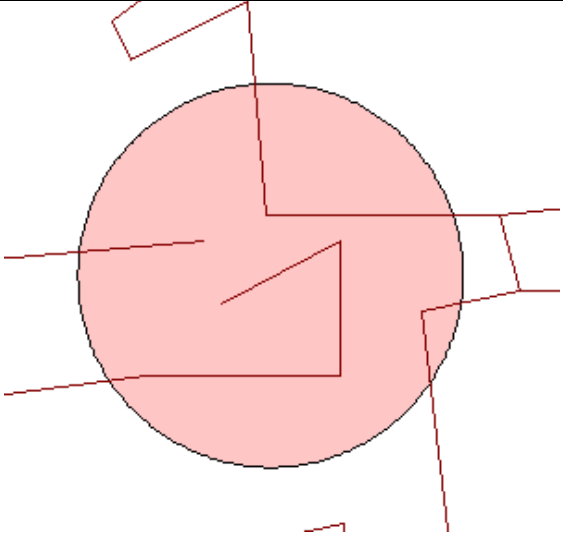
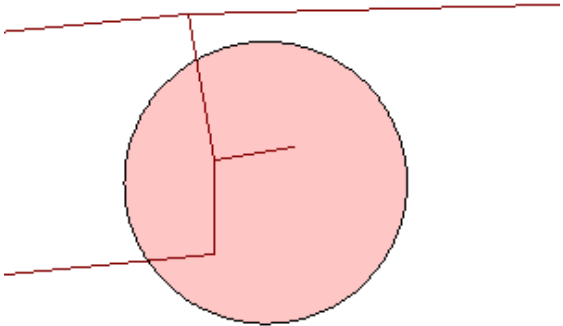
Building vector data is stored in ASCII format and requires three types of input files - a vector data file, an attributes file and an index file. The index file is similar to a normal vector index file. Each line describes: a vector data file name, an attribute file name, Easting Northing coordinates representing a bounding box around that feature and the feature name itself.

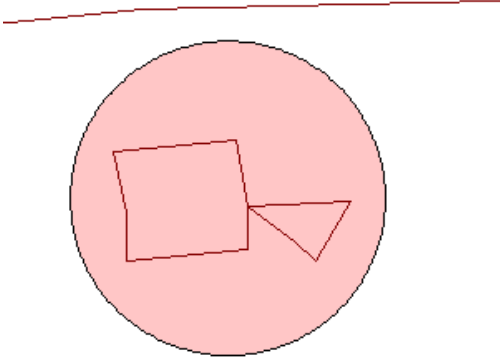
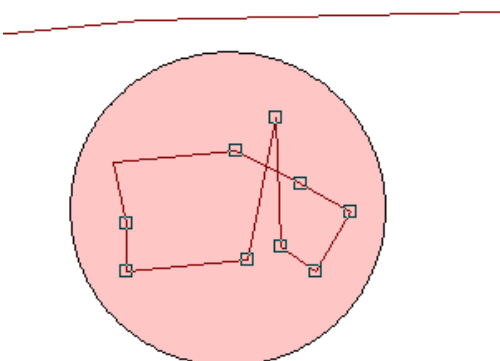
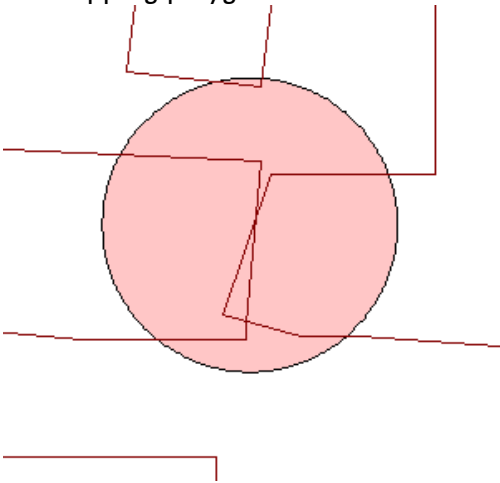
Please note that the format described above is different from the one used in Enterprise, however, Enterprise is able to convert that format and import it into the Enterprise database. Careful management of the vector map data is required, as both data sets need to remain synchronized.

Data requirements

The building data used by WaveSight model the buildings' footprint and the buildings' height. The building data should comply with the following requirements:

Requirement	Explanation
Identical polygons are not accepted	The dataset must not contain the same building twice. This is the very idea of a set.
Polygons must be closed. The first and the last	Open "polygons" are not accepted:

<p>point in each polygon must be identical.</p>	
<p>At least distinct 3 vertices per polygon. Also the three vertices must not be on a straight line.</p>	<p>The dataset must not contain one- or two-coordinate "buildings".</p>
<p>One vertex must belong to exactly two walls</p>	<p>This requirement means that "Spikes" (the building outline contains a vertex which comes back on a previous vertex) are not permitted in the outline:</p>  <p>"8-shaped buildings" (the building outline actually contains two buildings, touching each other at one coordinate) are not permitted:</p>

	
<p>Each two walls can only intersect if they are successive walls belonging to the same polygons. In such a case the intersection forms the vertex.</p>	<p>This means that Self-intersecting polygons are not allowed.</p>  <p>Overlapping polygons are not allowed:</p> 

All heights must be above local ground.	It is not permitted to model "holes" as buildings below the terrain height level.
An accuracy 1 m in building corner position is required	The paper [2] contains a discussion of the influence of the database accuracy on prediction results. It is available on Wavecall's web site.
Any given vertex must not occur more than once.	This restriction applies to the versions before 2.2.19 of the WaveSight algorithm.
The heights should be given with respect to local ground not to sea level. ENTERPRISE-SPECIFIC	Heights in the attributes file must be with respect to ground. This is a limitation of the current Enterprise-WaveSight interface (version 2.4) and will be removed in the future, since data is delivered often with respect to sea level as well.
The index file must contain the string "building" ENTERPRISE-SPECIFIC	Only the entries containing the "building" string are read by WaveSight.
The building vectors must contain one (and only one) string between the id and the number of vertices ENTERPRISE-SPECIFIC	This does not comply with the Genamap19 specification in Enterprise's user manual and is a bug.
It is important to set the frame coordinates correctly in the file index.txt	WaveSight only reads the buildings inside these coordinates.

Data format

An example of the building format, with all conditions as indicated above, is shown below:

Vector file

Header Record	
Easting	Northing
Easting	Northing
Easting	Northing
Easting	Northing
Easting	Northing
Header Record	
Easting	Northing
Easting	Northing
Easting	Northing

The final row is terminated by a carriage return.

The format of the header record is as follows:

Field	Position	Description
1	1-5	Record Identifier (used to identify building segment in attributes file)
2	6-15	Blanks
3	16-47	32 Character description (not used, same as feature name field in index file entry)
4	48-50	Blanks
5	51-55	Record Count

00001	buildings	00005
725777.00	5031472.00	
725775.00	5031468.00	
725778.00	5031467.00	
725780.00	5031471.00	
725777.00	5031472.00	
00002	buildings	00005
725783.00	5031472.00	
725781.00	5031468.00	
.....		

The final row is terminated by a carriage return.

Vector Index File

An ASCII text file called index.txt contains positional information about the vector file. This file must be in the same directory as the vector data.

Each row contains the following variables separated by a space:

Field	Description
Data filename	Filename of vector data file
Attribute filename	Filename of building attributes (heights) file
Eastmin	Minimum Easting value (metres)
Eastmax	Maximum Easting value (meters)
Northmin	Minimum Northing value (meters)
Northmax	Maximum Northing value (meters)
Feature Name	Name of the feature stored in the vector data file, for WaveSight this name should contain a string called "building" included in the feature name.

For example:

buildings_vec.txt buildings_atr.txt 1627764 1630022 6579401 6582574 buildings

The final row is terminated by a carriage return.

Vector Attributes File

An ASCII text file, named in the index file contains height information about the building segments contained in the vector data file.

Each row contains a record, as follows:

Field	Position	Description
1	1-5	Record Identifier (used to identify building segment in vector data file)
2	6	Delimiter <space>
3	7-19	12 Character vector segment description (not used)
4	20	Delimiter <space>
5	21-26	Vector segment height (floating point, two decimal places)

00001 buildings	010.00
00002 buildings	007.00
00003 buildings	011.00
00004 buildings	010.00
00005 buildings	006.00
00006 buildings	006.00
....	

Terrain data

The terrain data should be added to the Enterprise project, from the window "modify project", in the map data directories, where the path to the folder that contains the terrain data should be identified in the field Heights, as shown above in Figure 4.

1. Digital Terrain Height Data (DTM)

The digital terrain height data (DTM) needed is stored in a binary format where each element of the data represents the height above sea level in meters for a square area of, for example, 50m x 50m. Each element is two bytes in size and the most significant byte is stored first.

The elements are stored in one continuous array such that the size of the array in the following example would be 500 (wide) x 500 (high) x 2 (bytes per element) = 500,000 bytes.

If there are pixels within the file that are outside the limits of the map, the value -9999 is stored at that location.

An ASCII text file called index.txt contains positional information about each binary height file. This file must be in the same directory as the height data.

The file contains one row describing each height file. Each row contains the following variables separated by a space:

Field	Description
Filename	Filename of DTM Height file
Eastmin	Minimum Easting value (metres)
Eastmax	Maximum Easting value (meters)
Northmin	Minimum Northing value (meters)
Northmax	Maximum Northing value (meters)
Square Size	Size of each element of the height data (meters)

For example:

file1.bin	100000 125000 50000 75000 50
file2.bin	125000 150000 50000 75000 50

The final row is terminated by a carriage return.

Running WaveSight

From the main menu of Enterprise select predictor. From the window shown in Figure 5 WaveSight use two parameters:

- The radius of calculated area.
By clicking on a site in the tree view of the Site Database Dialog it is possible to select the "Misc" tab. This allows the configuration of the desired Prediction Radius for the site. This value is used when performing a prediction and the override site-defined radius checkbox is not checked in the Coverage Predictor dialog.
- The Calculation resolution.

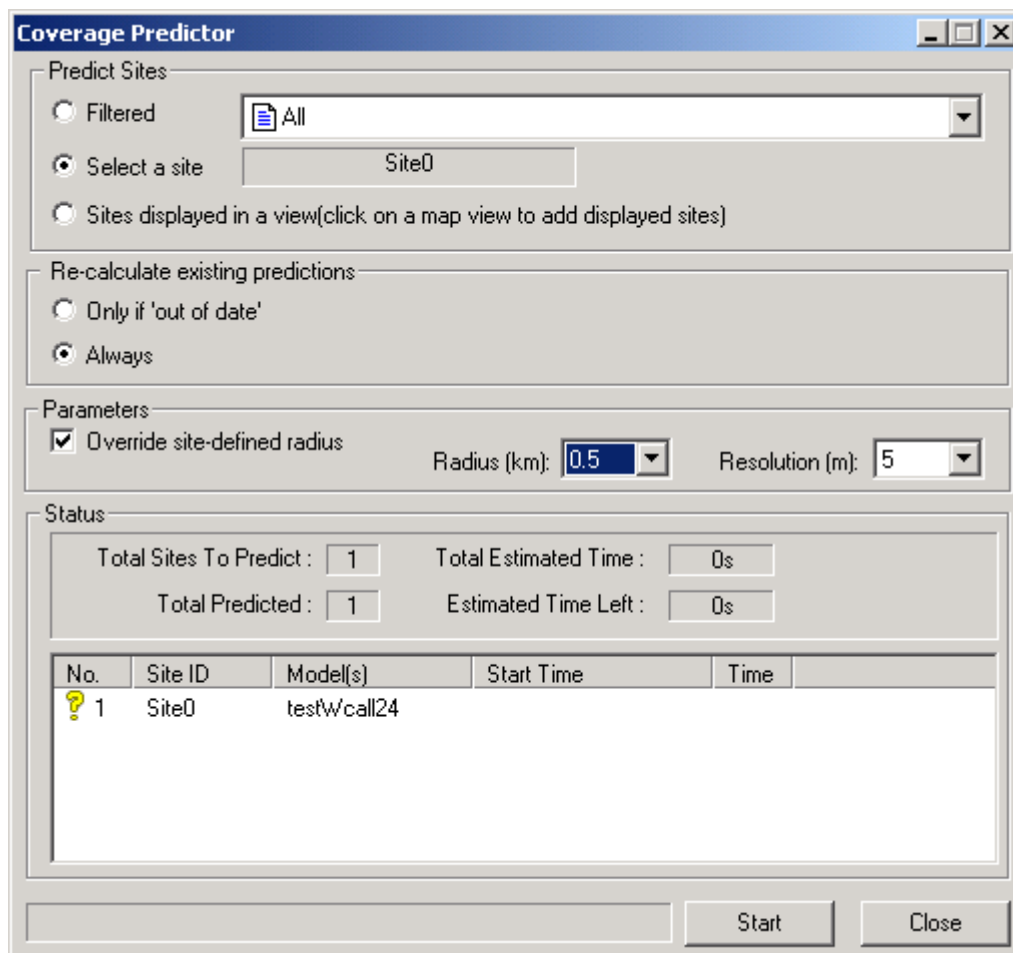


Figure 5 Running WaveSight.

WaveSight progress window

After starting WaveSight a progress window (WinSight) appears as shown in Figure 6. This window shows the calculation progress, starting with reading the terrain and building data,

continuing with performing the horizontal profile calculation and finishing with the vertical profile calculation.

The verbose field shows all the important messages while WaveSight is running. A list of error messages that may appear is shown in Appendix I.

Some warning messages also could appear and those warning messages would not cause WaveSight to stop running, some of those warnings should be checked such as error in building database. A list of warning messages is shown in Appendix II.

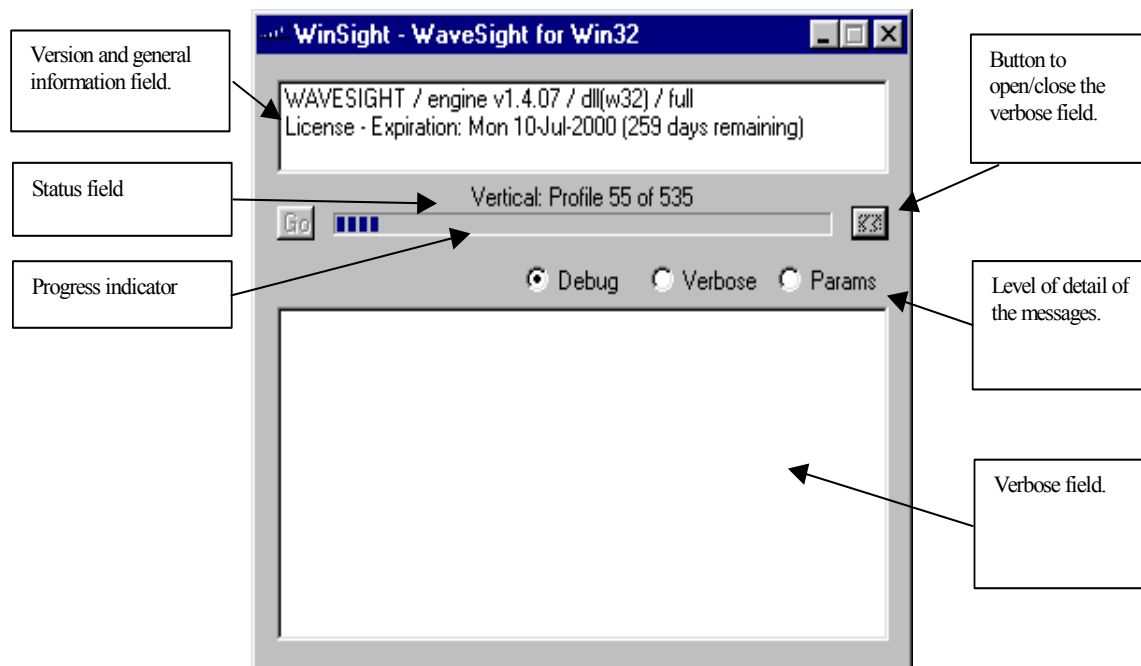


Figure 6 WaveSight progress window.

Comparing WaveSight results with measurements.

Comparing WaveSight results with measurement routes follows the same procedure as for any other prediction model.

From the Tools menu select CW measurements... import the route file(s) you want to calculate by pressing the button add, then select the prediction model you want to use from the options menu Figure 7.

To run the calculation press the analyze button, WaveSight's progress window should appear and start the calculation, the result file will be created at the end of the calculation.

Important Note: Please note that the frequency and the receiver height values are taken from WaveSight properties in the propagation Model Editor option and not from the values in the CW measurements info.

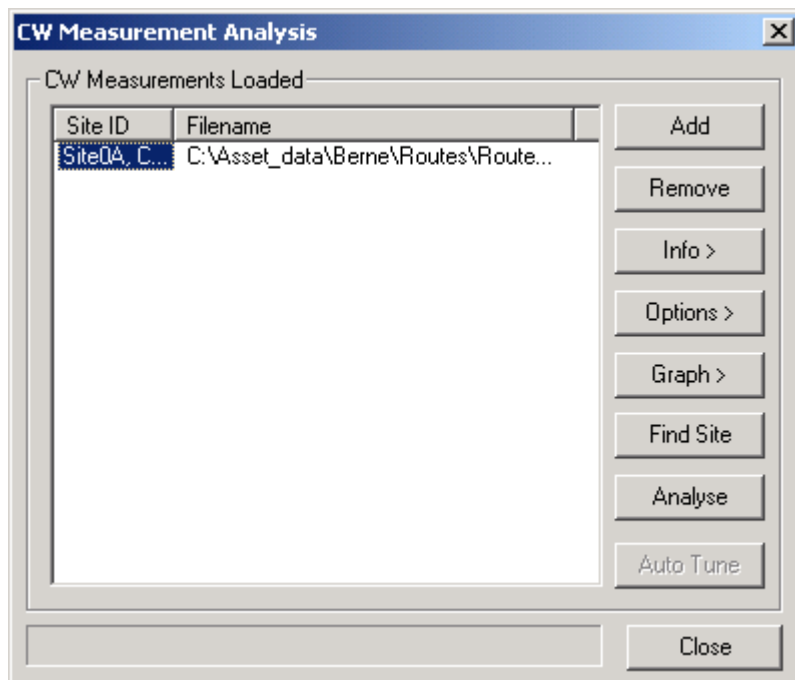
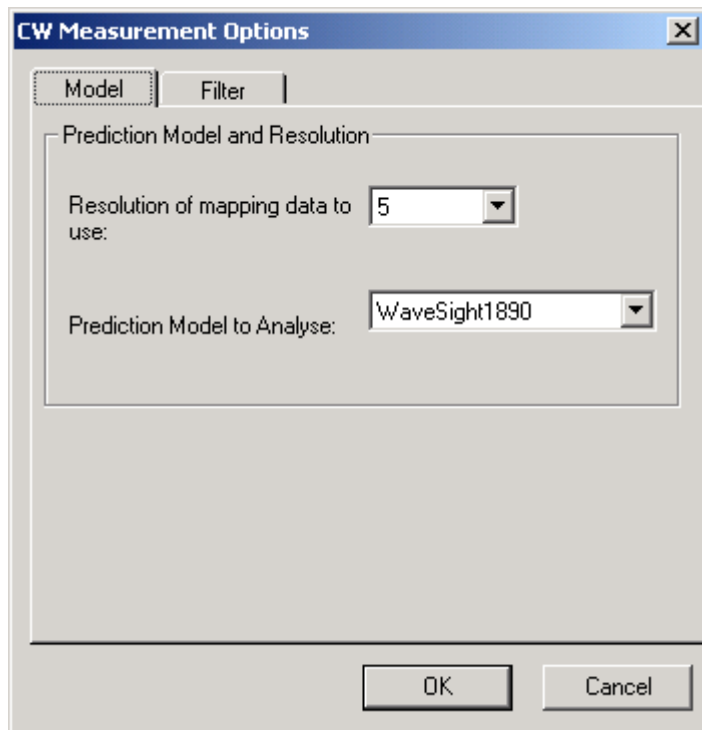


Figure 7 comparing WaveSight results with measurements routes.



WaveSight ray tracing model

Background

WaveSight is the result of more than eleven years of research and development. The foundations of WaveSight are inspired from a five years Ph.D. thesis fully sponsored by well-established industrials in the domain of telecommunication such as Swisscom, KPN and Lucent technology. A strong team of renowned researchers continue working on extending the range of applicability of the model and increasing its performance. Wavecall research team has published more than 50 technical papers in the domain of propagation and can be considered as a world leading think tank in radio wave propagation.

WaveSight feature overview

WaveSight uses a combination of deterministic ray tracing in the vertical plane and the horizontal plane. Based on the uniform theory of diffraction (UTD) and ray-tracing, its algorithms take into account individual building foot prints and heights, as well as the terrain profile, and accurately predict the signal power at every point of the area covered.

Its innovative implementation permits for unprecedented computing efficiency. The algorithm enables the simulation of a micro cell with a computation time of around 1 minute and a macro cell with a computation time around 5 minutes on a Pentium II 300 MHz machine. Speed and accuracy are thus no longer contradictory.

Because the method is fully deterministic, there is in general no need for calibration or measurements in the field. The domains of application include wireless mobile, UMTS, outdoor wireless Internet and fixed wireless

It applies to urban areas for any transmitter and receiver heights.

Computing time

WaveSight uses one of the most comprehensive methods to compute propagation, that is ray tracing. This method is well known not only for its superior accuracy but also for being computing time demanding. The ray tracing implementation in WaveSight is innovative and original. It is making use of numerous geometrical and electromagnetic tricks to minimize the computing time. Figure 8 shows an example of the calculation time with relation to the area of study. Note that the calculation time for the area of 8X8km, with a resolution of 5m is very high. This is because the machine RAM is low, in this case WaveSight is swapping, i.e. using the hard disk as memory, which makes the computation very slow.

It is highly recommended to use 512 Mbytes of RAM when the studied area is more than 4x4 km.

Test for the calculation time of WaveSight version 2.2.17

Machine:	Pentium III, 650 MHz
RAM:	196 MB
City:	Torino
Antenna:	Isotropic
Frequency	1890 Mhz
Receiver Height:	1.5m

Area of study	1x1 km	2x2 km	4x4 km	8x8 km
Resolution	Calculation time	Calculation time	Calculation time	Calculation time
5	1 min 12 s	4 min 57 s	16 min 15 s	104 min 15 s
10	1 min 4 s	4 min 21 s	13 min 50 s	24 min 49 s
20	1 min 2 s	4 min 14 s	13 min 10 s	21 min 20 s

Figure 8 WaveSight computing time with relation to the area of study.

Appendix I (WaveSight error messages)

Errors	Explanations
WSERR1: You cannot have an IndexTerrDir and a TerrainFile. Please check infiles.txt	<p>IndexTerrDir is a key word in infiles.txt that indicates the directory of a specific type of terrain format.</p> <p>TerrainFile is a key word in infiles.txt that indicates the path for the file WaveSight type of terrain.</p> <p>Therefore it is not possible to have both keywords in infiles.txt</p>
WSERR2: You cannot have an IndexBldgDir and a BldgFile. Please check the inputs.txt file	<p>IndexBldgDir is a key word in infiles.txt that indicates the directory of specific type of building format.</p> <p>BldgFile is a key word in infiles.txt that indicates the path for the file WaveSight format of buildings.</p> <p>Therefore it is not possible to have both keywords in infiles.txt</p>
WSERR3: hori directory not found	<p>In the WaveSight directory a sub directory named hori must exist.</p> <p>On PC platform this directory is created automatically</p> <p>On UNIX platform this directory must be created manually</p>
WSERR4: Insufficient memory	
WSERR6: The antenna pattern is given with a resolution higher than half degree	
WSERR7: The pattern of the specified antenna is	The file which contains all antenna patterns, (it is specified via the keyword

not listed in the antenna file	AntFile in infiles.txt) does not contain the antenna pattern specified in transmitter
WSERR8: An antenna file name must be provided	The AntPtrn key word in the transmitter file indicates a pattern, but infiles.txt does not contain the path to the file where this pattern can be found
WSERR9: Buildings elevation is relative to ground and there is no terrain file	
WSERR10: No frame file is given	It is mandatory to indicate in the infiles.txt a frame file with the key word FrameFile
WSERR11: Error in frame file: east x >= west x	The frame file indicated by the key word FrameFile in infiles.txt, must contain the x of the south east corner, the y of the south east corner, then the x of north west, and then the y of the north west corner.
WSERR12: Error in frame file: south y >= north y	The frame file indicated by the key word FrmFile in infiles.txt, must contain the x of southeast corner, the y of the southeast corner, then the x of northwest, and then the y of the northwest corner.
WSERR13: Error in the index file: east x >= west x	The index file of terrain heights of specific format indicated by the key word IndexTerrDir, must contain the x of south east corner, the y of the south east corner, then the x of north west, and then the y of the north west corner
WSERR14: Error in the index file: south y >= north y	The index file of terrain heights of specific format indicated by the key word IndexTerrDir, must contain the x of south east corner, the y of the south east corner, then the x of north west, and then the y of the north west corner
WSERR15: No index directory for terrain is given	The index file of terrain heights of specific format indicated by the key word IndexTerrDir must be given in infiles.txt. Buildings are by default assumed to be given relative to ground level, except if the flag Is2Ground is set to 1 in comp.txt
WSERR16: This version can only handle Profile or Horizontal propagation	In comp.txt CompType was set to a value different from 1 (horizontal computation) or 3 (combination of vertical and horizontal plane

	computation)
WSERR17: No Tx file is given	For propagation prediction a transmitter file must be given in infiles.txt using the key word TxFile
WSERR18: No index directory for buildings is given	When running with a specific type of buildings, the directory that contains the index.txt file must be given in infiles.txt via the key word IndexBldgDir
WSERR19: Null sized segment: ...	It indicates that a null sized segment was encountered in the course of the execution. For instance, this message occurs when reading the building files and a null sized wall exists in the building file.

Appendix II (WaveSight warning messages)

Warning	Action needed
WARNG: data base error, see mapcheck.txt	Error in buildings database, this error could cause bad prediction on the line between the transmitter and the error. The causes of this error are listed in paragraph 0 The action needed is to correct these error listed in the file mapcheck.txt
WSERR3: Assertion failed when reading the buildings database.	Hints at building errors that WaveSight can cope with. For instance in the case of two repeated vertices, WaveSight just skips one of them.
WARNG: A building with two or less vertices was encountered, and it will be skipped.	If a building has less than three vertices, WaveSight will ignore this building
WARNG: xxx undefined terrain height points	This message doesn't show any error, but the numbers of pixels where the terrain height is not defined (-9999).

Bibliography

- [1] Karim Rizk: [Propagation in microcellular and small cell urban environment](#), Thesis #1710 (1997), Swiss Federal Institute of Technology of Lausanne

- [2] K. Rizk, J.F. Wagen, F. Gardiol: [Influence of database accuracy on two-dimensional ray-tracing-based prediction in urban microcells](#), IEEE Trans. Veh. Technol., vol. 49, no. 2, March 2000, pp. 631-642.
- [3] Francisco Gil, Ana R. Claro, José M. Ferreira, Carlos Pardelinha and Luís M. Correia. "A 3-D Interpolation Method for Base Station Antennas' Radiation Patterns". *IEEE Antennas and Propagation Magazine*, Vol. 43, No. 2, Apr. 2001, pp. 132-137.