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User Manual

For Forsk Atoll

<1.5>

REF: RP/WAVECALL/06-2001N01/OG

Abstract

This document describes the installation of the propagation model `WaveSight` COM component of Forsk Atoll engineering tool, and provides technical information about the data and parameters required by `WaveSight`.

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Document History

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1.2	Odeh Ghawi	October 24, 2001
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Acknowledgements

Contents

1. Introduction

This document provides information about using WaveSight prediction model inside Forsk Atoll.

The following chapters illustrate step by step how to set the parameters and data that WaveSight uses from Atoll setting.

Chapter 2 explains how to install WaveSight and configure all the parameters that WaveSight needs, including the format of buildings and terrain data supported by WaveSight, and gives a complete picture about the WaveSight during running time, which include all error and warning messages that could appear.

Chapter 3 gives a brief description about WaveSight as a ray-tracing model including the basic principle, the radio performances and running time.

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

2. Installation and configuration

2.1 Version

Component	Version information
WaveSight algorithm	3.2.0.ATOLL_COMPTIBLE
Interface COM component	2.10

This release is licensed using Wavecall's node-locked, time-bombed licensing scheme. It is necessary to obtain a license string from Wavecall to successfully run the software.

2.2 Prerequisites

1. Required platform:

- Pentium > 200 MHz.
- 30 Mbytes of free disk space for WaveSight.
- RAM > 128 Mbyte (allows a prediction radius of 2 Km), 512 Mbytes is recommended.
- Windows NT.

2. Forsk Atoll 1.6 or higher.

3. 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.

2.3 Installation

2.3.1 Installation procedure

- On Windows NT, log in with an account having administrator privileges.
- Make sure that DLL files are visible in the Windows Explorer. Select "Display all Files" in the Options dialog Figure 1.
- Expand the distribution archive into a temporary directory and run Setup.exe.

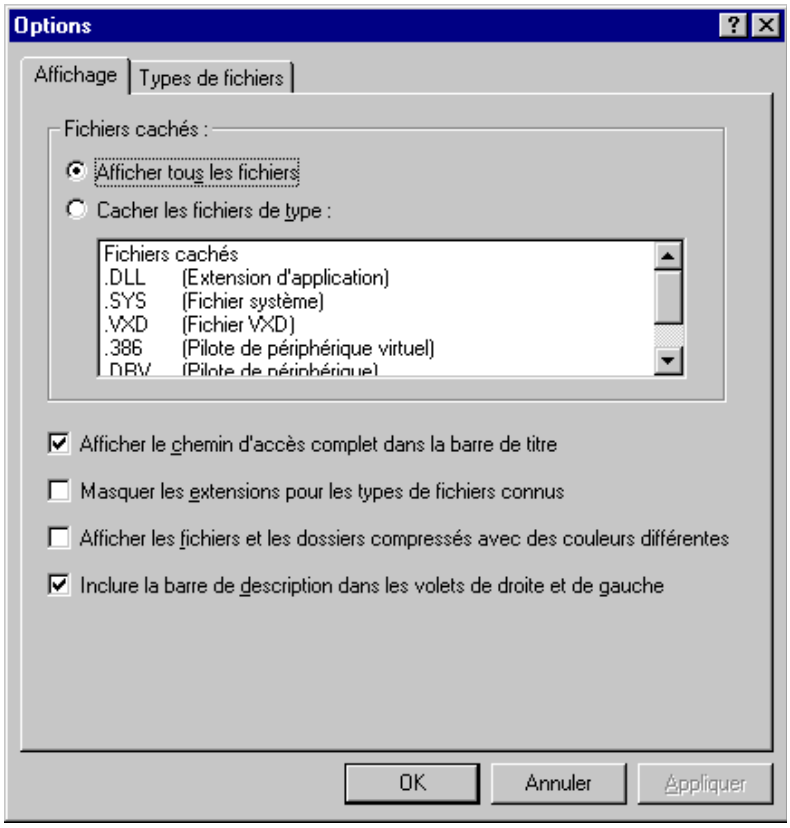


Figure 1 Make all DLL files visible (window option)

- After a welcome and a license agreement screen, the following window appears Figure 2.

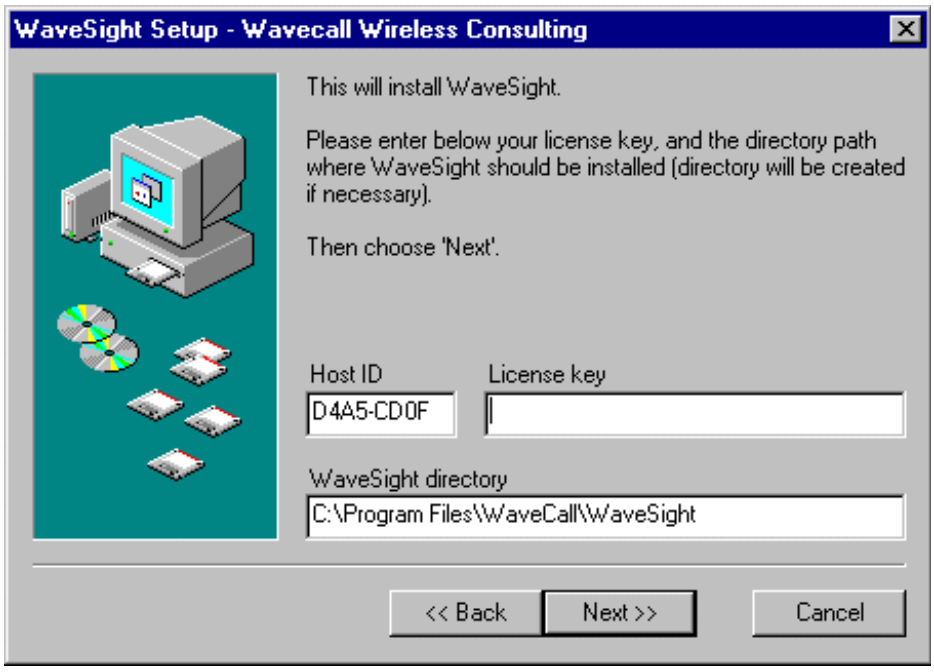


Figure 2 License key window.

Note:

To obtain the **license key**, please send the shown **Host ID** to Wavecall to obtain the key.

The license key is a string of the form:

74DE5B70F23052EB333E958439362EA16D3EAE6435A9630FD3391, which needs to be entered into the **License key** field.

- A message should appear indicating that the COM component has been successfully registered.

You are now ready to configure and use WaveSight inside Atoll.

2.4 Parameters used by WaveSight

2.4.1 Parameters to be set for WaveSight deterministic Model.

WaveSight model appears among the list of propagations model in Atoll as Wavecall WaveSight deterministic Model. (Figure 3)

The parameters that should be set for WaveSight model are:

1. The path to the buildings data folder.
2. The buildings Height in the attribute file if it is relative to the ground or to sea level.
3. The area of computation: only for indoor area, only for outdoor area or both.
4. The Attenuation factor should be used when an indoor calculation is selected. It represents the signal power loss in dBm and used in the model as following:

WaveSight Computes the average field on the circumference of the building and then applies the constant penetration loss. In general, we recommend the following values for penetration loss: concrete walls: 20 dB, wooden walls: 16 dB, metallic shielded glass: 25 dB see Figure 4 Figure 5 Figure 6.

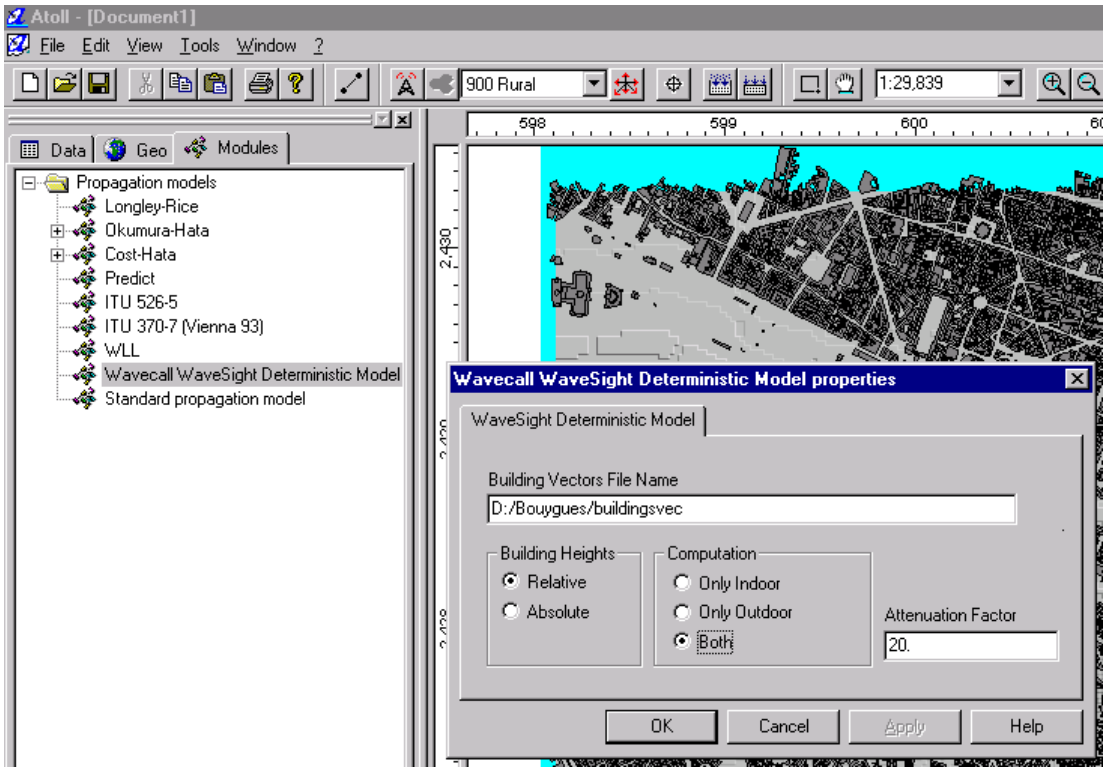


Figure 3 WaveSight propagation model

Figure 4 only indoor predictions

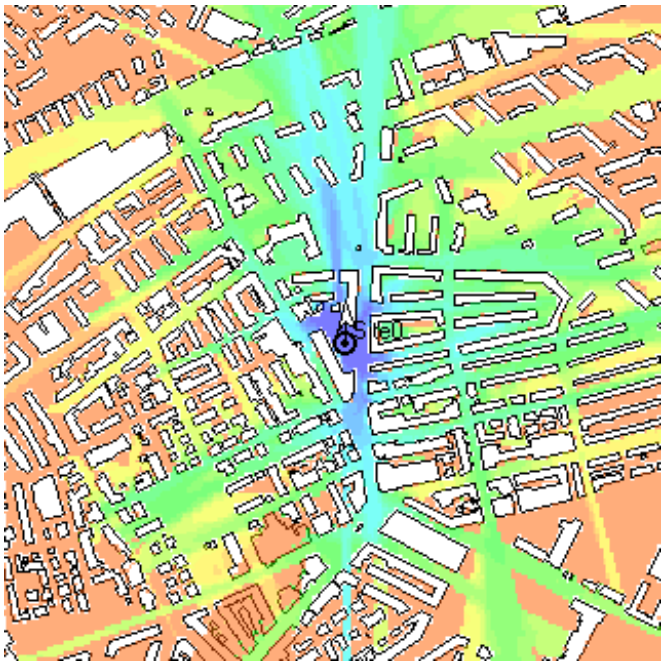


Figure 5 only outdoor predictions.

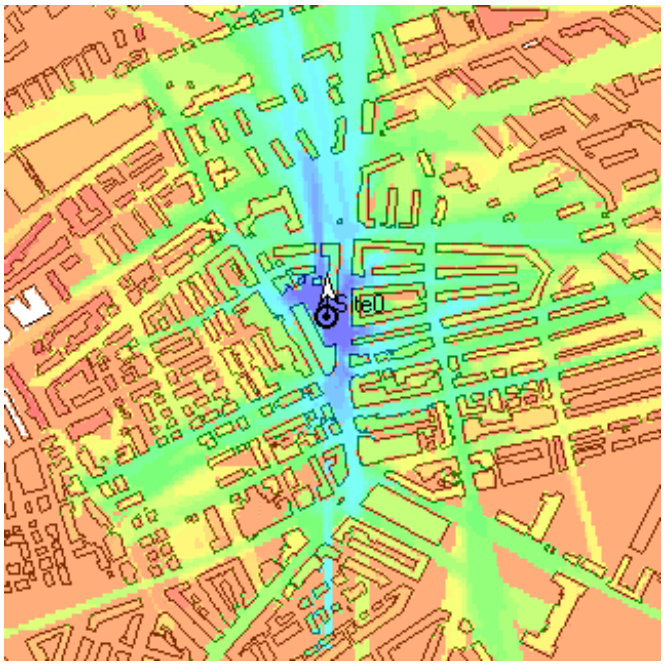


Figure 6 Both (indoor and outdoor)

2.4.2 Parameters read by WaveSight from the transmitters setting

From the transmitters database window of Atoll, WaveSight uses the parameters shown below as they appear in the properties of the transmitters folder.

From the transmitters properties info:

- WaveSight uses the frequency defined under the frequencies option Modify, the frequency is given in MHz, Figure 7

In General, WaveSight is able to operate in a wide range of frequencies; the recommended range is 500 MHz - 5000 MHz.

From the site properties info:

- WaveSight uses the site location coordinate X, Y. If the cell location is not at the same place, WaveSight considers the relative position in the cell properties, see Figure 8.

From the transmitter properties info:

- WaveSight uses the equivalent isotropic radiated power (EIRP) in dBm.
- The antenna pattern, WaveSight uses both horizontal and vertical pattern.
- The antenna height in m.
- The antenna down tilt in degree.
- The antenna direction or azimuth in degree.
- The calculation radius in m Figure 10 (Note: the prediction model selected in this window is the one that would be used for the propagation).

2.4.3 From the predictions properties:

- WaveSight uses the calculation resolution in m Figure 11.
- The receiver height in m, from the receiver option Figure 12.

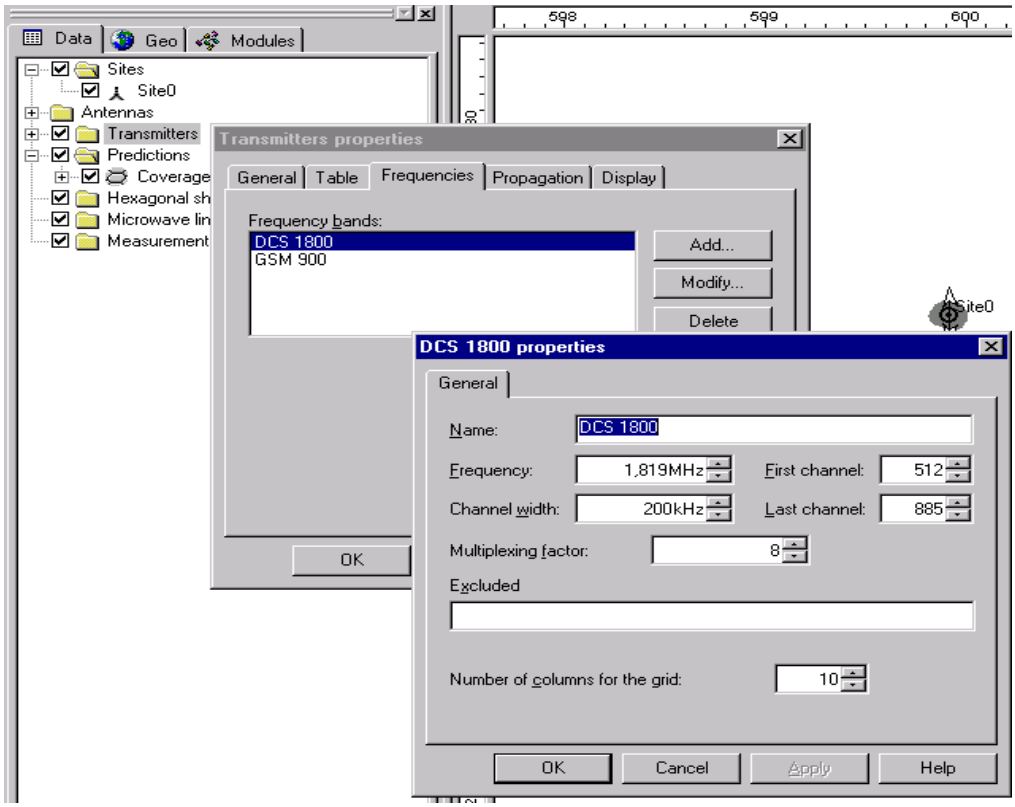


Figure 7 frequency used by WaveSight

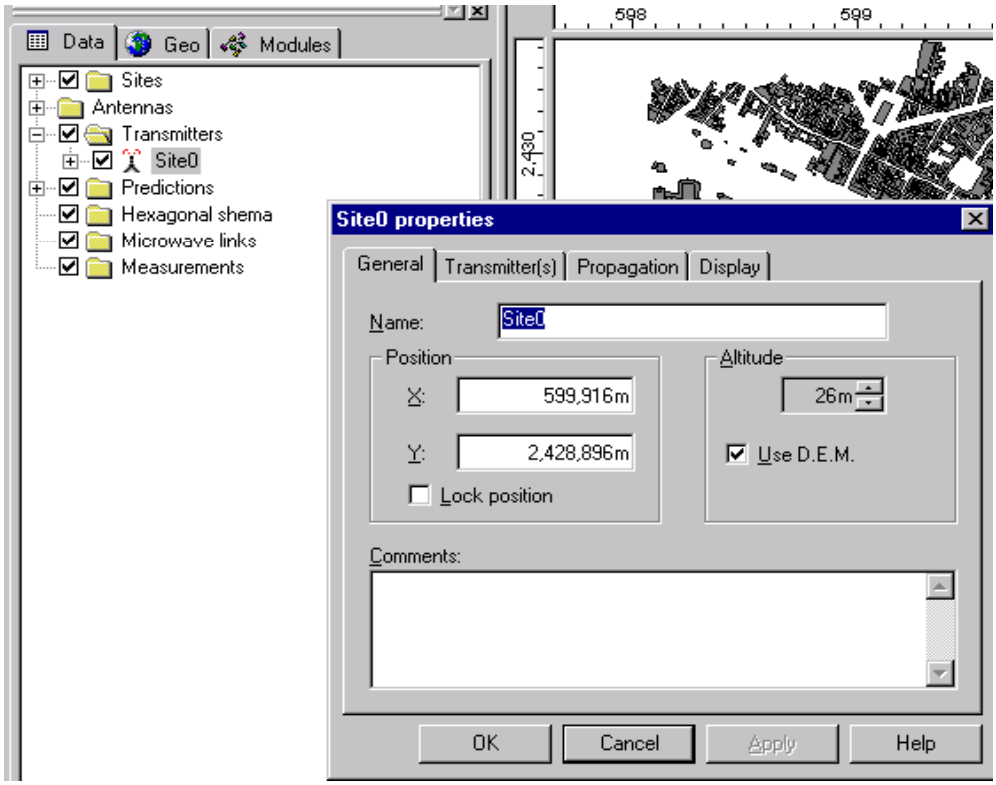


Figure 8 Setting base station location used by WaveSight

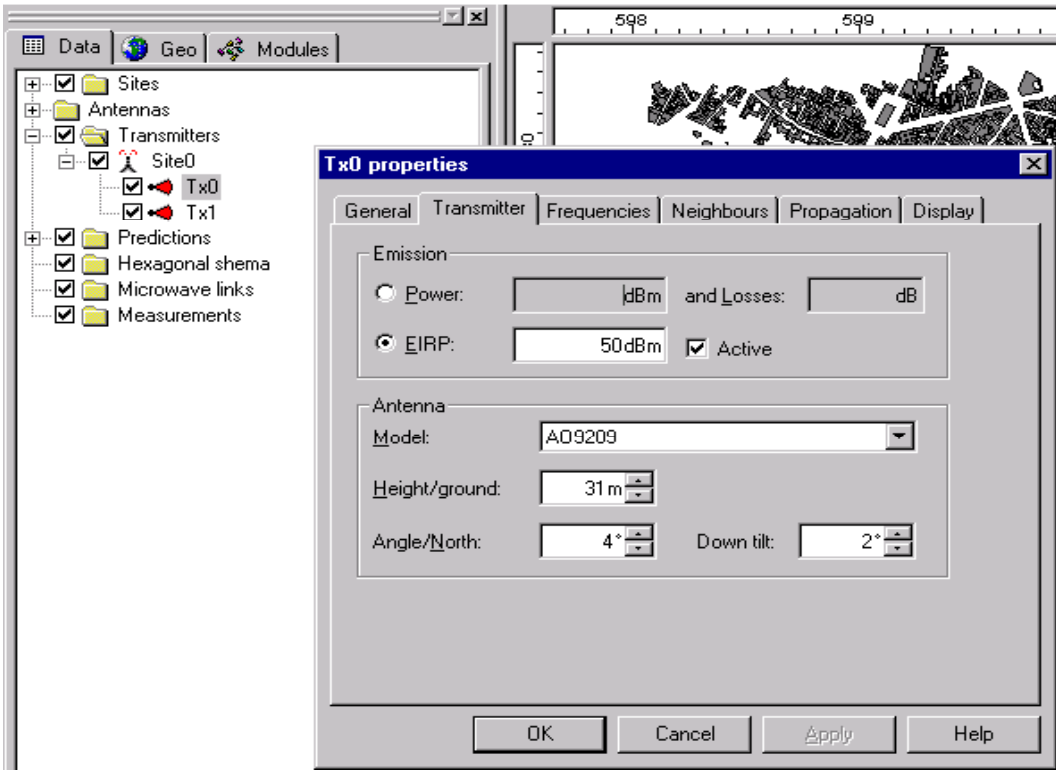


Figure 9 Setting base station parameters used by WaveSight

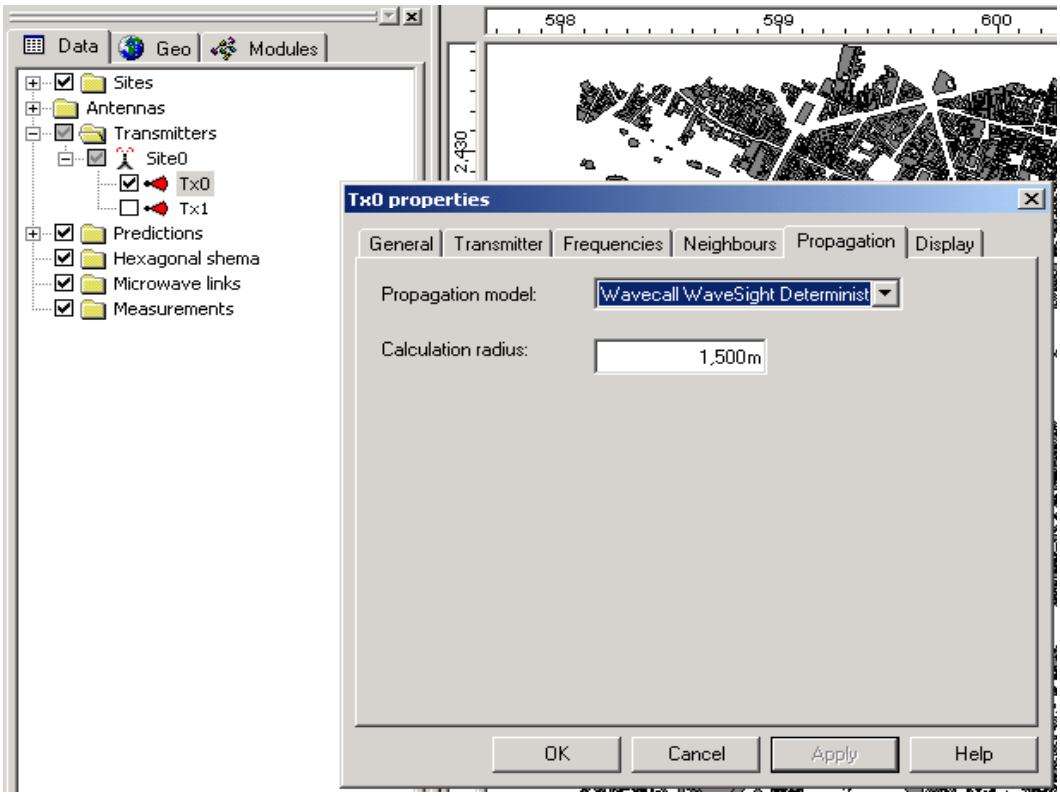


Figure 10 Setting WaveSight calculation radius

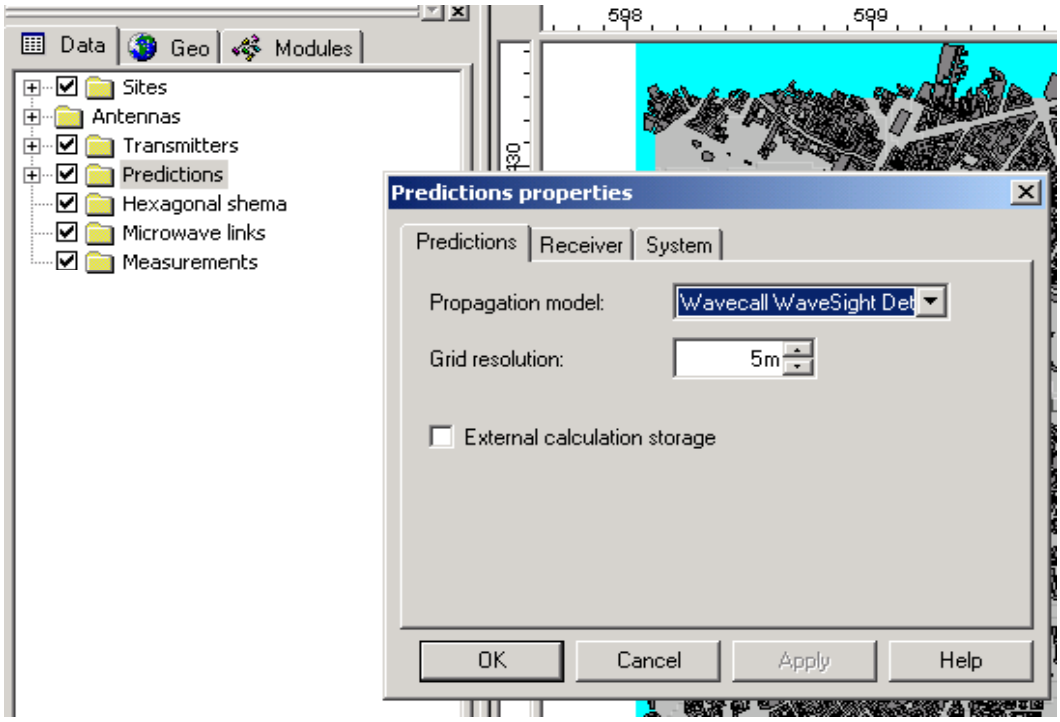


Figure 11 Setting WaveSight prediction resolution.

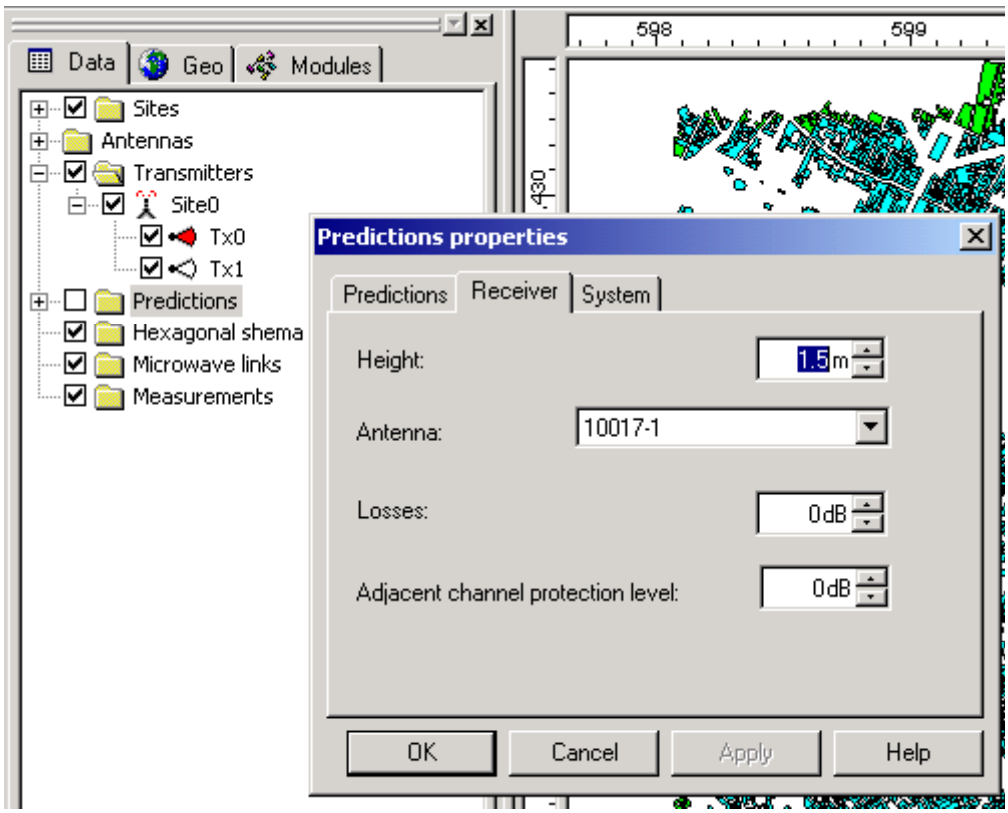


Figure 12 Setting receiver height

2.5 Buildings data

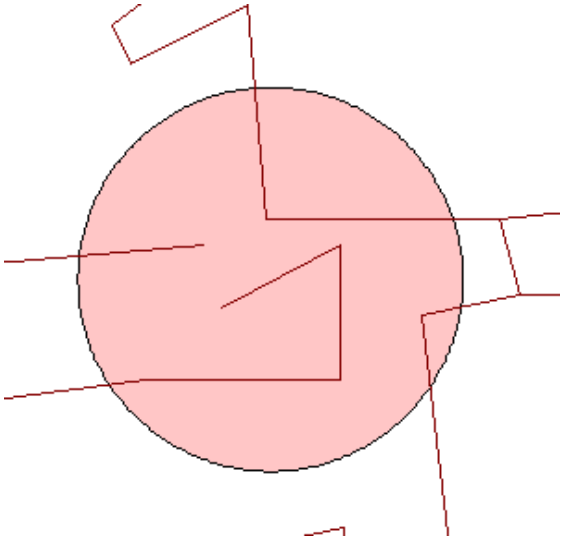
2.5.1 Configuring the data

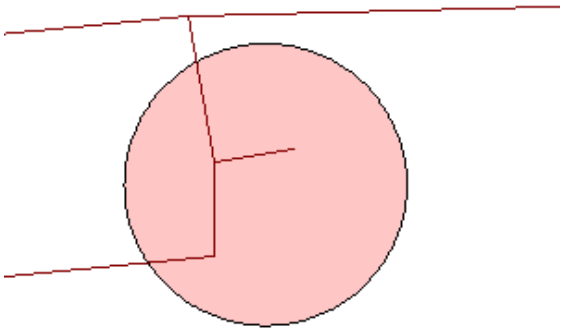
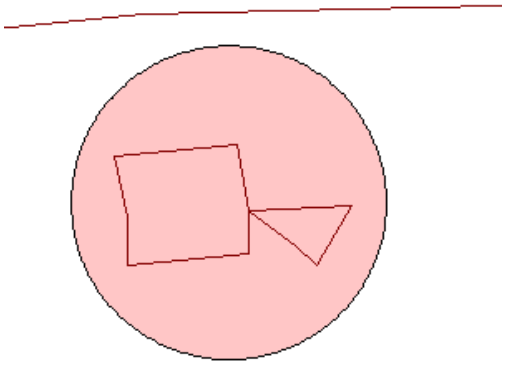
The Buildings vector data used by WaveSight should be added to Atoll project as mentioned in paragraph 2.4.1 Figure 3.

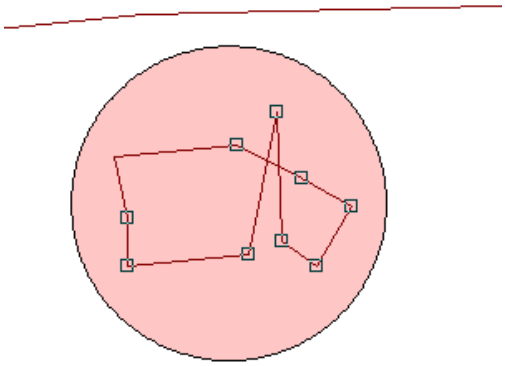
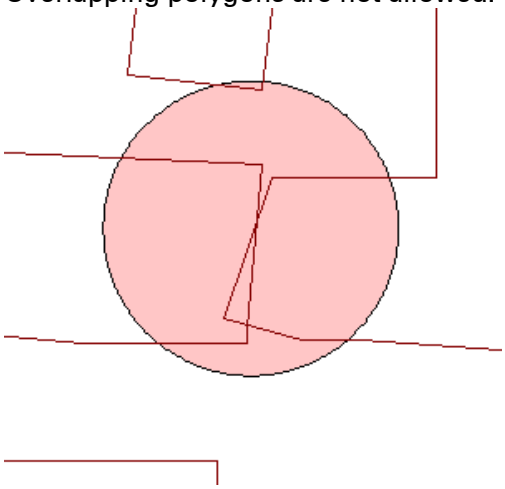
Building vector data is stored in ASCII format and requires three types of input file - a vector data file, an attribute file and an index file. The index file is similar to a normal vector index file. Each line describes: a vector data file name, an attribute file name, Easting Northing co-ordinates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

2.5.2 Data requirements

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

Requirement	Explanation
Identical polygons are not accepted	The dataset should not repeat the same building.
Polygons must be closed. The first and the last point in each polygon must be identical.	Open "polygons" are not accepted: 
At least 3 vertices per polygon	The dataset should not contain one or two coordinate "buildings".
One vertex must belong to exactly two walls	This requirement means that "Spikes" (the building outline contains a vertex which comes back on a previous vertex) are not permitted in the outline:

	 "8-shaped buildings" (the building outline actually contains two buildings, touching each other at one coordinate) are not permitted: 
Each two walls can only intersect if they are successive walls belongings to the same polygons. In such a case the intersection forms the vertex.	This means that Self-intersecting polygons are not allowed. 

	 Overlapping polygons are not allowed: 
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.
There should not be repeated vertices.	This restriction applies to the versions before2.2.19 of the WaveSight algorithm.
The index file must contain the string "building"	Only the entries containing the "building" string are read by WaveSight.
It is important to set the frame coordinates correctly in the file index.txt	WaveSight only reads the buildings inside these coordinates.

2.5.3 Data format

An example of the buildings 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 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 (metres)
Northmin	Minimum Northing value (metres)
Northmax	Maximum Northing value (metres)
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
....
```

2.6 Terrain data

The recommended terrain resolution for WaveSight is 5-10 m.

WaveSight reads all terrain data supported and loaded by Atoll including Tiff, Bil, Dis(Ing), IST (Istar) and Planet format.

2.7 Running WaveSight

Running WaveSight follows the same procedures as running any other prediction tool in Atoll.

The recommended calculation resolution for WaveSight is 5-10 m, this would give accurate results precision. Using resolution of more than 10 m would make WaveSight run faster but the accuracy will be sacrificed, using a resolution of less than 5 m, would increase the calculation time and RAM needed.

2.7.1 WaveSight progress window

After starting WaveSight, a progress window (WinSight) appears as shown in Figure 13. This window shows the calculation progress, starting with reading the terrain and buildings data, continuing with performing the vertical profile calculation and finishing with the horizontal profile calculation.

The verbose field shows all-important messages during WaveSight running time. A list of error messages that may appear is listed in Appendix I. Those errors cause WaveSight to stop running, and must be corrected.

Some warning messages also could appear which in any case would not cause WaveSight to stop running, however, some of those warnings need to be checked such as the error in buildings database. A list of warning messages is listed in Appendix II.

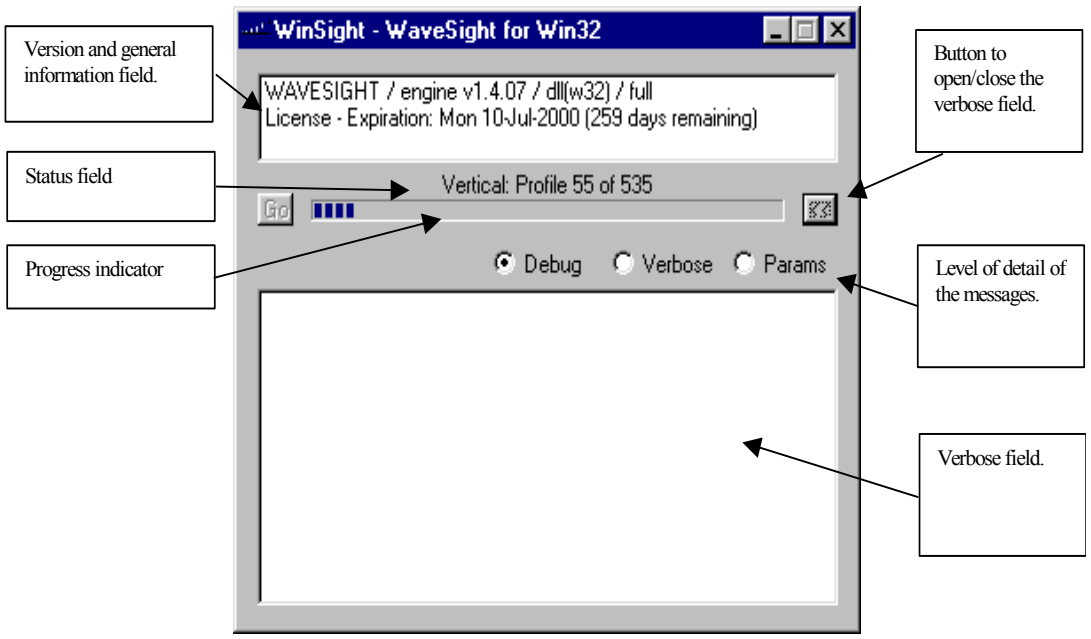


Figure 13 WaveSight progress window.

2.8 Comparing WaveSight results with measurements.

Comparing WaveSight results with measurements route follows the same procedure as for any other prediction model.

From the measurements route properties, select WaveSight Deterministic Model from the prediction menu Figure 1, press calculate to lunch WaveSight prediction for the route file.

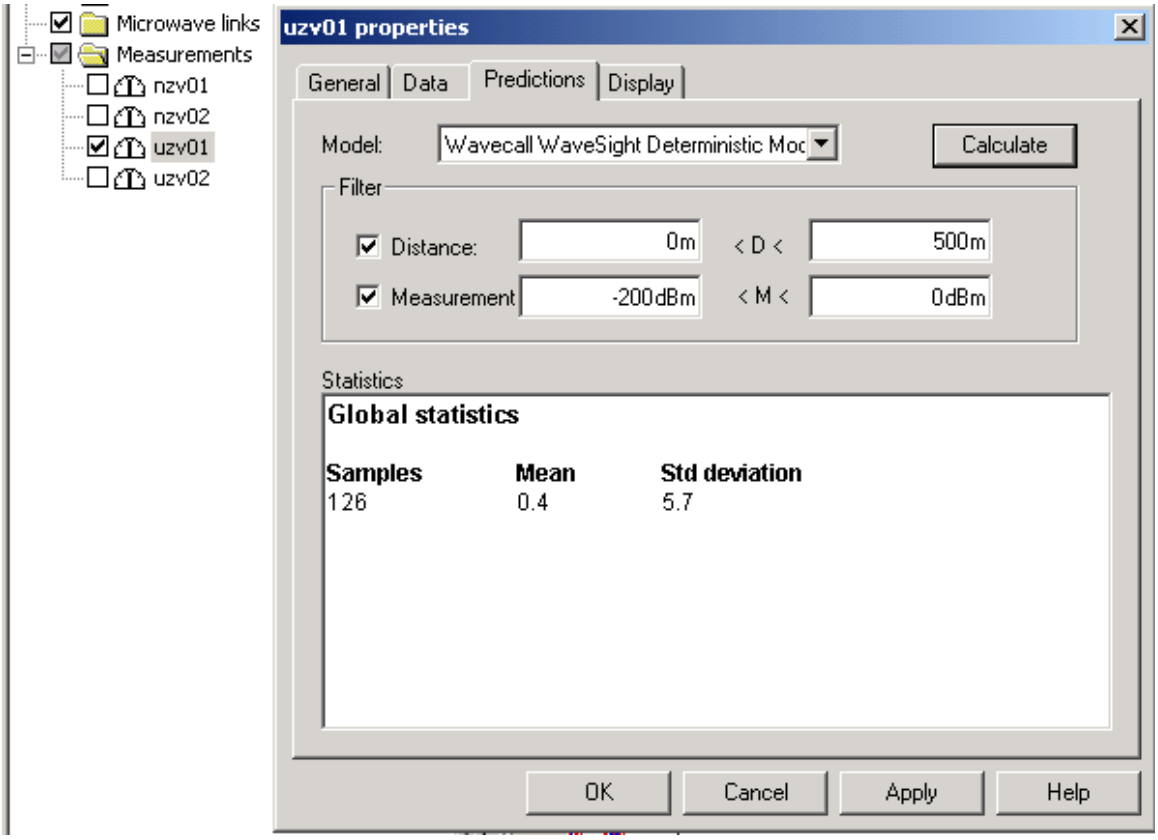


Figure 1 comparing WaveSight prediction with measurements

For WaveSight calculation the frame selected to cover the measurements route will be drawn around the measurements route with an area of 100m from the measurement routes edges.

The defaults calculation resolution value would be 5m, no matter what the prediction resolution has been set in the predictions properties.

3. WaveSight ray tracing model

3.1 Background

WaveSight is the result of more than eight 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.

3.2 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 individual building foot prints and heights, as well as the terrain profile into account 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 no need for calibration or measurement on the field. The domains of application include Wireless mobile, UMTS, Wireless Internet and fixed Wireless

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

3.3 Accuracy

As it is impossible to obtain a sufficiently detailed description of the propagation environment to solve the electromagnetic problem in a rigorous manner, i. e. solve Maxwell's equations, some assumptions had to be made in WaveSight to compute the propagation path loss. Even if the detailed description were available, the computation time needed to obtain a rigorous solution would be a limiting obstacle. In the absence of such a rigorous solution, the only way to test the validity of the WaveSight model is the comparison with measurements.

Therefore validations against measurement are a fundamental component of the model. Wavecall performed a large number of validations of WaveSight against measurements. The validations included comparisons over 1000 km of measurement routes in 100 cells located in a dozen of European and American cities. These comparisons showed that the WaveSight model achieves increased prediction accuracy in comparison with the classical models.

3.4 Computing time

WaveSight uses one of the most comprehensive methods to compute the 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 are innovative and original. They make use of numerous geometrical and electromagnetic tricks to minimize the computing time. Figure 14 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 make the computation time 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 14 WaveSight computing time with relation to the area of study.

5. Appendix I

(WaveSight error messages)

Errors	Explanations
WSERR1: You cannot have an IndexTerrDir and a TerrainFile. Please check infiles.txt	IndexTerrDir is a key word in infiles.txt that indicates the directory of a specific type of terrain format. TerrainFile is a key word in infiles.txt that indicates the path for the file WaveSight type of terrain. Therefore it is not possible to have both keywords in infiles.txt
WSERR2: You cannot have an IndexBldgDir and a BldgFile. Please check the inputs.txt file	IndexBldgDir is a key word in infiles.txt that indicates the directory of specific type of building format. BldgFile is a key word in infiles.txt that indicates the path for the file WaveSight format of buildings. Therefore it is not possible to have both keywords in infiles.txt
WSERR3: hori directory not found	In the WaveSight directory a sub directory named hori must exist. On PC platform this directory is created automatically On UNIX platform this directory must be created manually
WSERR4: Insufficient memory	
WSERR5: This version cannot handle full 3D	The CompType in comp.txt is set to 2.
WSERR6: The antenna pattern is given with a resolution higher than half degree	
WSERR7: The pattern of the specified antenna is not listed in the antenna file	The file which contains all antenna patterns, (it is specified via the keyword AntFile in infiles.txt) does not contains 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 contains 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 >= upper 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.

6. 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 above in the buildings data specifications. The action needed is to correct these error listed in the file mapcheck.txt
WSERR2: Removed xxx buildings	This message doesn't shows any error, but the numbers of buildings that WaveSight removed because they were not a part of the horizontal calculations, since they are covered by other buildings. No action needed for this warning.
WSERR3: Assertion failed	Error in buildings database, The causes of this error are listed above in the buildings data specifications.

7. 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] Atoll RF Planning Software, user manual.