



**WaveSight**

**User Manual  
for Teleplan Astrix**

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## Document History

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## Introduction

This document provides information about using the WaveSight prediction model inside Teleplan Astrix.

Chapter 2 explains how to install WaveSight and configure 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               |
| Interface           | 2.0                 |

### Installation

Please follow the notes from Teleplan and Wavecall support for installing WaveSight for Astrix.

## Parameters used by WaveSight

### Parameters of the WaveSight model

The screenshot shows the 'Cell Editor' dialog box with the following parameters:

- Cell Name: T1\_X
- Cell ID:
- Site Name: T1\_X
- View: All (highlighted with a green box)
- Template: UMTS-BASESTATION
- Prediction model: WaveSight-RayTracer
- Antenna: ISOTROP
- Direction (deg): 0.0
- Tilt (deg): 0.0
- Height (m): 42.0
- Power (dBm): 22.5
- Total loss (dB): 2.5
- EIRP (dBm): 20.0
- Coverage files: (button)
- Select Cell Editor view: (All, Sites, TRX, GSM, ...)
- Buttons: Close, Apply, Cancel, Save in Situation, Update DB

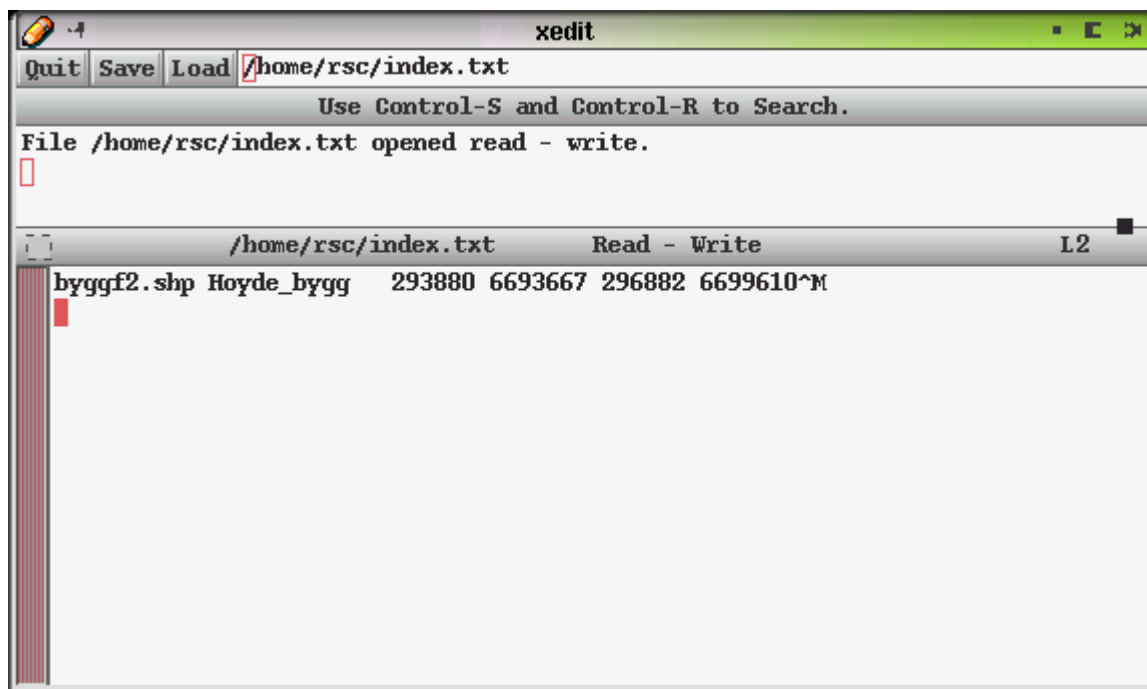
WaveSight reads all parameters it needs directly from the Cell Editor dialog:

- Frequency  
For the *frequency* WaveSight is able to operate in a wide range of frequencies; the recommended range is 500 MHz - 5000 MHz.
- Transmitter coordinates
- Azimuth and tilt
- Antenna pattern
- EIRP

## Buildings data

### Configuring the data

The data should be available in ESRI Shape file format. There can be multiple Shape building vector layers, which are referenced by an index.txt file in the following way:



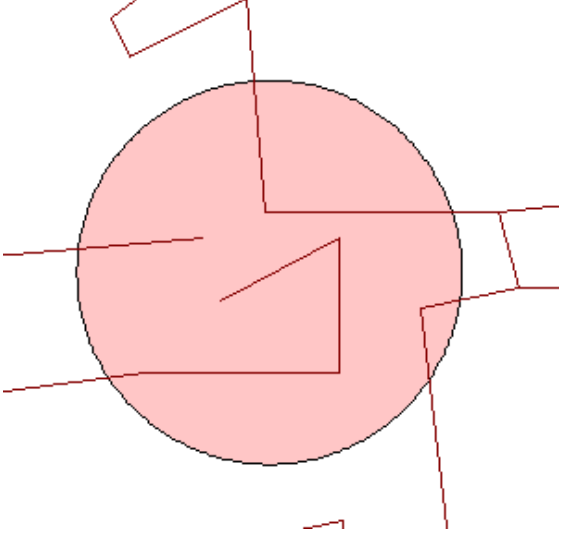
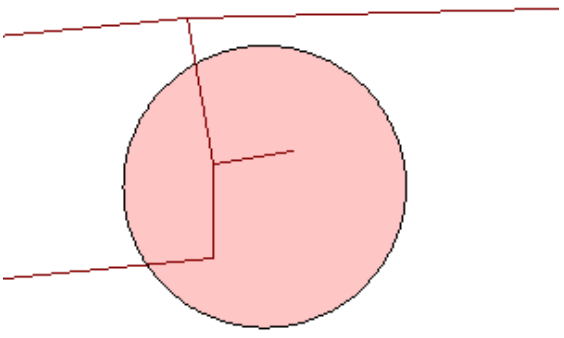
Every Shape data set (shp, shx and dbf files) take one line in the index.txt line.

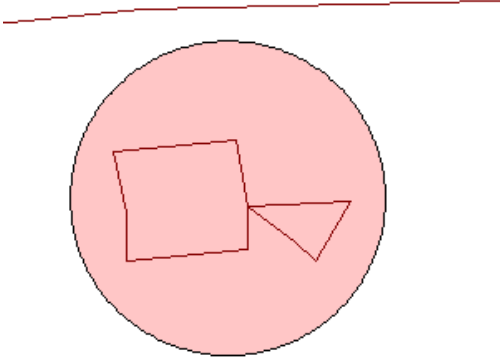
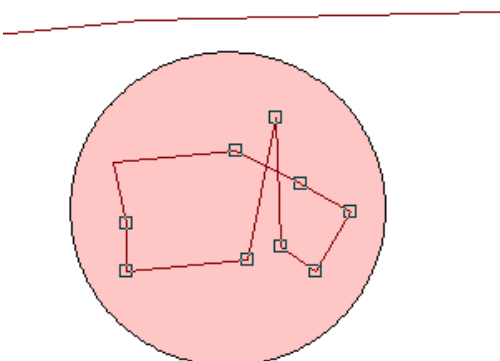
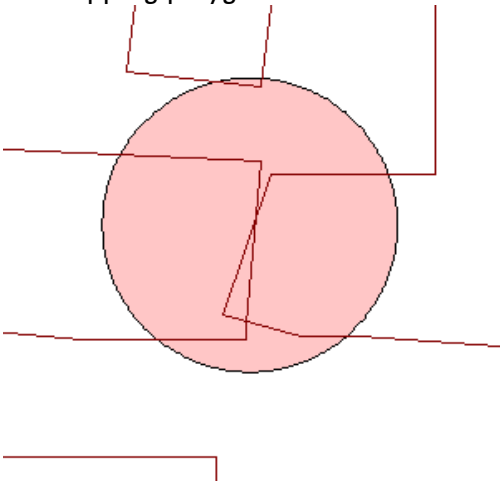
The first entry specifies the name of the Shape file, the second entry contains the name of the attribute inside the DBF file containing the height of the building. The following entries contain the bounding frame xmin ymin xmax ymax coordinates.

### 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:                |

|   |  |
|---|--|
|   |    |
| <p><b>At least 3 vertices per polygon</b></p>             | <p>The dataset should not contain one- or two-coordinate "buildings".</p>  |
| <p><b>One vertex must belong to exactly two walls</b></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><b>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.</b></p> | <p>This means that<br/>Self-intersecting polygons are not allowed.</p>  <p>Overlapping polygons are not allowed:</p>  |
|  |  |

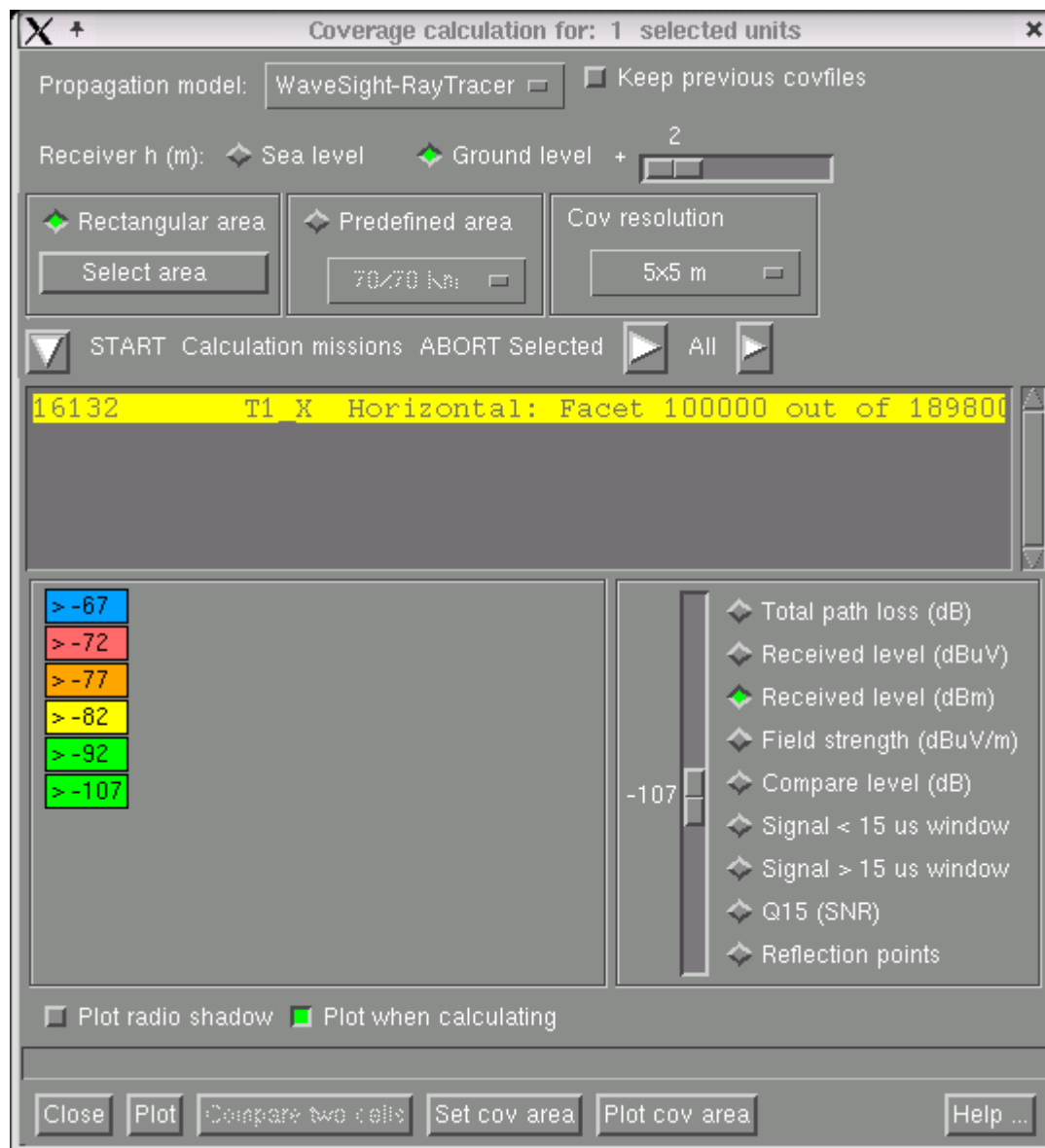
|   |  |
|---|--|
| <b>All heights must be above local ground.</b>                                      | It is not permitted to model "holes" as buildings below the terrain height level.  |
| <b>An accuracy 1 m in building corner position is required</b>                      | The paper [2] contains a discussion of the influence of the database accuracy on prediction results. It is available on Wavecall's web site. |
| <b>There should not be repeated vertices.</b>                                       | This restriction applies to the versions before 2.2.19 of the WaveSight algorithm.   |
| <b>It is important to set the frame coordinates correctly in the file index.txt</b> | WaveSight only reads the buildings inside these coordinates.   |

### Terrain data

Digital Terrain Model information is read directly from ASTRIX. Please consult ASTRIX documentation for details.

## Running WaveSight

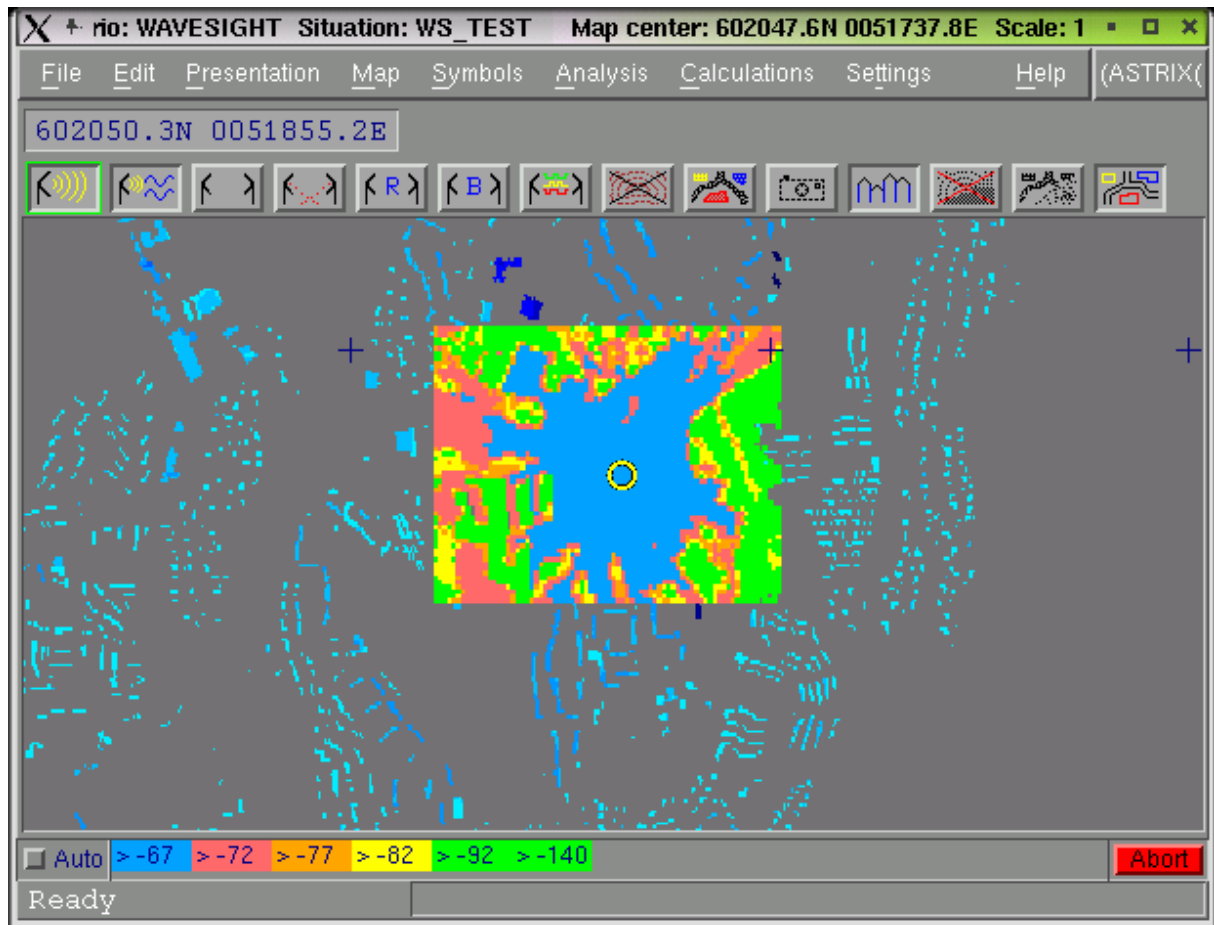
From the main menu of ASTRIX select Calculations - Radio Coverage.



The Coverage calculations dialog allows to perform WaveSight predictions.

- Select WaveSight - Ray Tracer
- Select the Receiver Height
- Define a Rectangular area for the extent of the prediction. To do this, click on the *Select area* button and draw an area around the transmitter with the mouse in the Main window.
- Determine a calculation resolution (Cov. resolution). A resolution of 5 m is recommended for WaveSight.
- Click on the Start button to start a WaveSight prediction.

When finished, the coverage map can be displayed in the main window:





## WaveSight ray tracing model

### 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.

### 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.

### 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.

### 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 1 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 1 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</p>                         |

|  |   |
|--|---|
|  | keywords in infiles.txt   |
| WSERR3: hori directory not found   | In the WaveSight directory a sub directory named hori must exist.<br><br>On PC platform this directory is created automatically<br><br>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.   |

## 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<br><br>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   |

|  |   |
|--|---|
| buildings  | WaveSight removed because they were not a part of the horizontal calculations, since they are covered by other buildings.<br><br>No action needed for this warning. |
| WSERR3: Assertion failed when reading the buildings database.                        | Points to buildings errors that WaveSight can cope with. For instance in the case of two repeated vertices, WaveSight just skip one of them.                        |
| WARNG: A building with two or less vertices was encountered, and it will be skipped. | If a buildings has less than three vertex, WaveSight would ignore this buildings  |
| WARNG: xxx undefined terrain height points   | This message doesn't show any error, but the numbers of pixel where the terrain height is not defined (-999).   |

## 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.