

New Features in Wireless InSite 2.0

This document describes changes and new features present in Wireless InSite 2.0, including:

- New SBR based full 3D model
- Automatically set Rx bounding boxes to reduce computation time
- Calculation log window
- Global Land Cover Characteristics (GLCC) Database
- Biophysical foliage material
- Layered dielectric material
- Circularly polarized antennas
- Urban Canyon Finite-difference time-domain (UCFDTD) propagation model
- Moving Window Finite-difference time-domain (MWFDTD) propagation model
- New waveform capabilities
- 3D Antenna patterns in Project view
- Rendering Tx/Rx antenna control vectors
- Enhanced command line batch processing
- Enhancements to diagnostic files
- Raster-to-vector converter
- Plot output vs. Tx-Rx distance for some types of receiver sets

New SBR based full 3D model

A number of changes have been made to the full 3D propagation model. We have switched to entirely using an SBR (shooting and bouncing ray) approach to ray-tracing. The previous versions used both the multiple image method and the SBR method. However, it is also possible to only multiple image method by placing the character string "useSBR=no" in the long description of the study area.

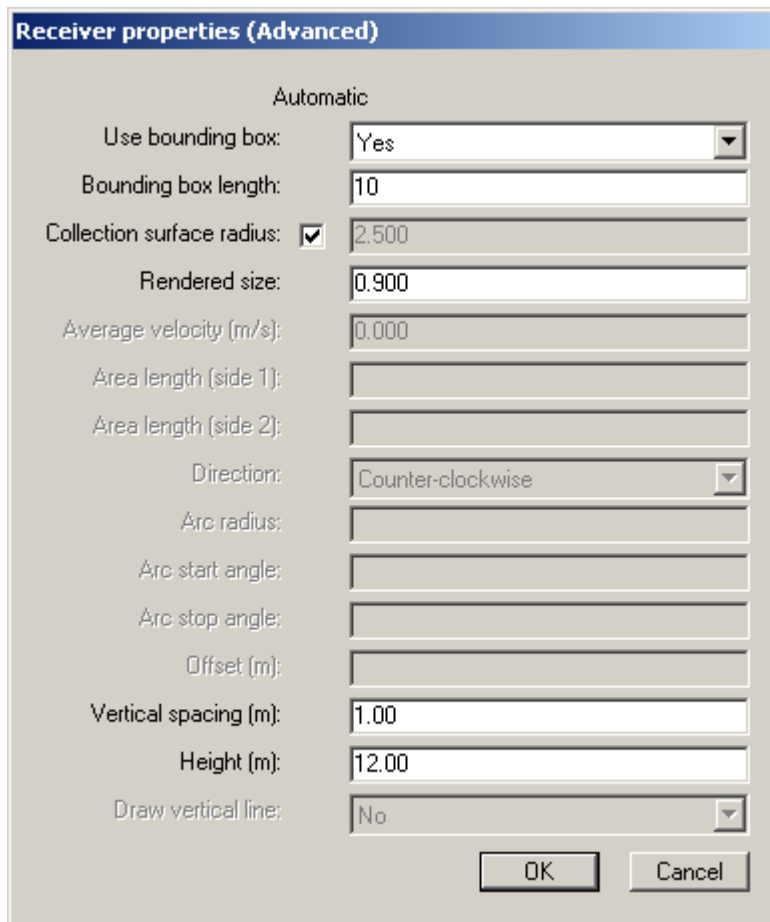
The new SBR model also constructs ray paths which propagate along a surface by multiple diffraction at facet edges. The multiple image method will not include these ray types.

Receiver bounding boxes

The receiver bounding box is used to reduce the computation time for the ray tracing by grouping receiver points within larger bounding boxes, and first considering the intersections of rays with the bounding boxes before checking for the intersection of each ray with the small collection surfaces surrounding each receiver point. The receiver bounding box is not a new feature, but some additional capabilities have been added to set the size of this box to obtain better reduction in the computation time.

The bounding box should be used in most situations for all receiver set types except Points, Points-on-Face, and User-Defined Files, however, even in these latter cases it may be helpful to use bounding boxes if there are a large number of points in the set (> 25). Use with user-defined sets depends on how many points are contained in the file.

Although this field is also active on the transmitter set advanced properties window, the bounding boxes are not used for transmitters at present, and this field can be ignored at this time.



The image shows a dialog box titled "Receiver properties (Advanced)". It contains several settings for a receiver set. At the top, there is a label "Automatic". Below it, the "Use bounding box:" dropdown is set to "Yes". The "Bounding box length:" text box contains the value "10". The "Collection surface radius:" checkbox is checked, and its text box contains "2.500". The "Rendered size:" text box contains "0.900". The "Average velocity (m/s):" text box contains "0.000". The "Area length (side 1):" and "Area length (side 2):" text boxes are empty. The "Direction:" dropdown is set to "Counter-clockwise". The "Arc radius:", "Arc start angle:", and "Arc stop angle:" text boxes are empty. The "Offset (m):" text box is empty. The "Vertical spacing (m):" text box contains "1.00". The "Height (m):" text box contains "12.00". The "Draw vertical line:" dropdown is set to "No". At the bottom right, there are "OK" and "Cancel" buttons.

Property	Value
Automatic	Automatic
Use bounding box:	Yes
Bounding box length:	10
Collection surface radius:	<input checked="" type="checkbox"/> 2.500
Rendered size:	0.900
Average velocity (m/s):	0.000
Area length (side 1):	
Area length (side 2):	
Direction:	Counter-clockwise
Arc radius:	
Arc start angle:	
Arc stop angle:	
Offset (m):	
Vertical spacing (m):	1.00
Height (m):	12.00
Draw vertical line:	No

Receiver bounding boxes properties can be set in the **Receiver properties (Advanced)** window. To define a bounding box around a receiver set, first set **Use bounding box** to **Yes**. The size of the bounding box is set by the value entered in the **Bounding box length** field.

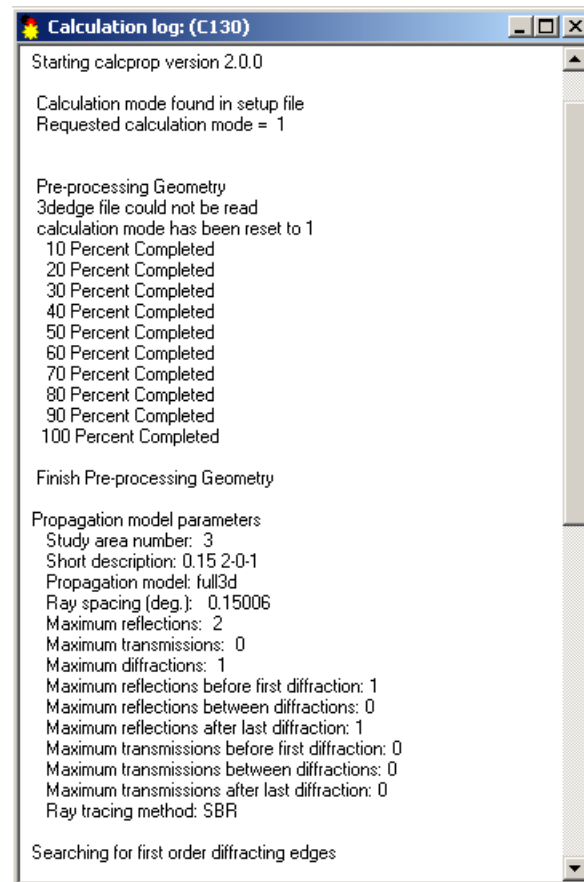
At present the default size of the bounding box is 100 m. This size was selected because it usually worked well for calculations in high-rise urban environments. Unfortunately, this size will not work well for smaller areas, and may even lead to longer run times than if the bounding boxes were not used at all. In the future we plan on adding an "automatic" checkbox to this field so that a good size can be set by the calculation engine. As a temporary work around we suggest using the following rules of thumb:

- For xy grid, vertical surface, polygon, circular cylinder set bounding box size to 10 times the spacing between points.
- For linear routes and arc set the box size to 20 times the spacing
- For points set the box size so that each one encloses roughly 25 points.

It is also possible to have the size of the bounding box be set by the calculation engine by placing the text string **useAutoBoundingBox=yes** in either the project long description or the long description of a receiver set. In the first case, the bounding box size will be set automatically for all receiver sets using bounding boxes, but in the latter case the bounding box size will only be set automatically for that specific receiver set. The size of the bounding box will be written to the receiver section of the diag file.

Calculation log window

The Calculation log window can now be viewed at any time by selecting **View>Calculation log** in the Main window. This window records all information generated while performing simulations, including the time and date the calculation starts and finishes, as well as the elapsed time.



Global Land Cover Characteristics (GLCC) Database

Geo-referenced foliage information can be imported from data in the GLCC database, which is available for download at the Land Processes Distributed Active Archive Center (LPDAAC) http://edcdaac.usgs.gov/glcc/globe_int.asp. This database has information on **Seasonal Land Cover Regions (SLCR)**, which has a resolution of 1x1 km.

To run the importer, select **Project>Import>Foliage** in the Main window and choose GLCC as the import option. The imported foliage is modeled using the **Biophysical** material type, which is described below.

Biophysical foliage material

The effective permittivity of a region containing foliage can be approximated by modeling the foliage as a dielectric slab containing randomly oriented leaves and branches which act to scatter and attenuate the propagating field. The effective permittivity is determined from the biophysical characteristics of the tree, such as leaf area, leaf density, branch size, branch density, etc. The Biophysical foliage material type also takes the permittivity of the leaves and branches into account when determining the effective permittivity of the foliage. There is also an option for adjusting the effective permittivity to agree with a measured attenuation at a particular frequency, polarization and incidence angle.

Biophysical properties

Short description: Dense Deciduous Forest, In Leaf ...

Theta: 90.0000

Input

Data type: Tree parameters

Leaf radius: 0.0500

Leaf thickness: 0.0005

Leaf density: 250.0000

Leaf angle 1: 0.0000

Leaf angle 2: 180.0000

Branch radius: 0.0190

Branch length: 0.5000

Branch density: 2.5000

Branch angle 1: 0.0000

Branch angle 2: 90.0000

Permittivity model

Model: Frequency Dependent

Branch conductivity: 0.3900

Branch static permittivity: 20.0000

Leaf conductivity: 0.3900

Leaf static permittivity: 26.0000

Waveform: [2412 MHz] - IEEE 802.11b, channel

Effective permittivity (V): 1.0276 - j 0.0101

Effective permittivity (H): 1.0274 - j 0.0093

Attenuation (V) (dB/m): 0.9084

Attenuation (H) (dB/m): 0.8375

Recalculate

Color: [Green]

Plot

OK Cancel Apply

Layered dielectric material

Wireless InSite now includes a layered dielectric material type which can be defined with an unlimited number of adjacent dielectric layers. This material type replaces the “one-layer” and “two layer” material types. Any materials defined using the discontinued material types will automatically be changed to the new type when the feature file is saved. The old one and two layer definitions are also still recognized by the calculation engine. Each dielectric layer is defined by its permittivity, conductivity, thickness, and roughness. The first layer is the outermost layer, the second is the one below that, and so on. The angle and frequency dependent reflection and transmission coefficients include the effects of interactions at the internal dielectric boundaries. Only the roughness of the first layer is currently used in the calculations.

Layered dielectric properties

Short description: ...

Dielectric layers:

Layer #	Description	Permittivity	Conductivity	Thickness
1 [Front]	Drywall	2.800	0.001000	0.01300
2	Air	1.000	0.0000	0.08900
3 [Back]	Drywall	2.800	0.001000	0.01300

Color: Plot

OK Cancel Apply

Circularly polarized antennas

In addition to vertical and horizontal polarization, left-hand circular and right-hand circular polarization are now available for isotropic, omni-directional, directional, and helical antennas. Circularly polarized patterns can also be imported through Wireless InSite's user-defined format by including the phase of the field components. The file format is described in Chapter 7 of the user's manual. The effect of the circular polarization is calculated by means of the relative phase between the theta and phi components. For a pure right-circularly polarized field, the phase of the phi component will exceed that of the theta component by 90 degrees, and theta will lead phi by 90 degrees for a pure left-hand circularly polarized field. Circularly polarized patterns can also be imported from the far zone cuts generated by Remcom's XFDTD software. The importation of XFDTD calculated pattern data is described in Chapter 7.

Urban Canyon Finite-difference time-domain (UCFDTD) propagation model

(licensed separately)

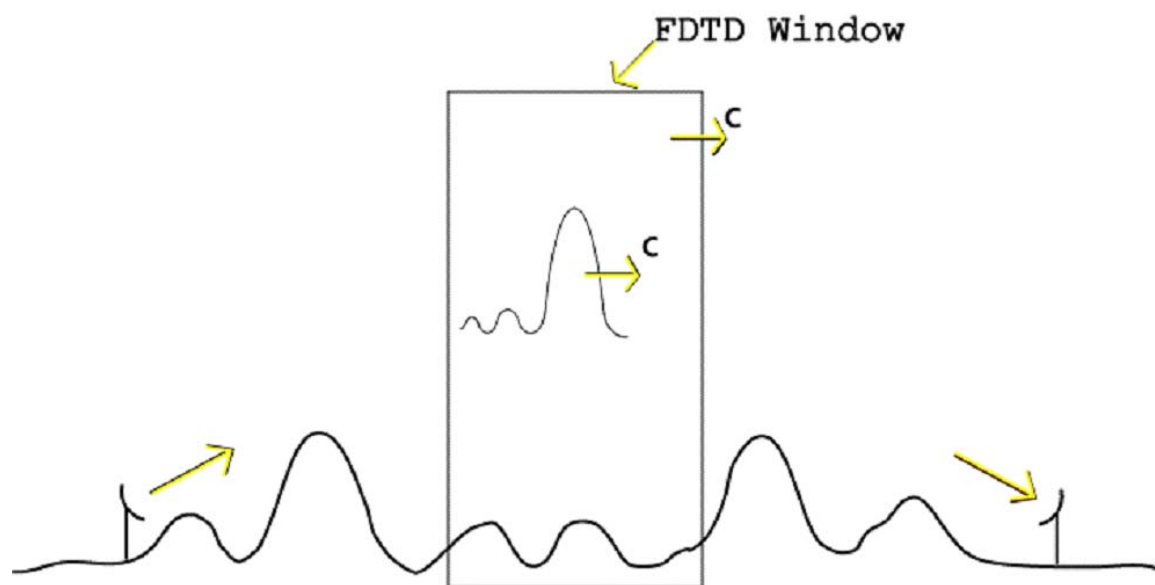
The Urban Canyon FDTD model is intended for high-rise urban environments where the transmitting and receiving antennas are located close to the ground relative to the building heights. For these situations the buildings can be approximated as being infinitely tall, and the interactions with the buildings are entirely determined by the 2D ground level perimeters, or footprints, of the buildings. Urban Canyon FDTD simulates the radio wave propagation by using the finite-difference time-domain (FDTD) method to directly solve Maxwell's equations after projecting the urban building layout onto a rectangular grid consisting of evenly spaced grid points in the x-y plane.

Moving Window Finite-difference time-domain (MWFDTD) propagation model

(licensed separately)

The Moving Window FDTD model is a propagation model based on the 2-D finite-difference time-domain method. Unlike the Urban Canyon FDTD model, the 2-D geometry is found from the intersection of the 3-D geometry with the vertical plane rather than the horizontal plane. This model is used to simulate the propagation of radio waves at UHF and VHF frequencies over irregular terrain.

Since we are typically interested in propagation over relatively long distances (thousands or tens of thousands of wavelength), the amount of computer memory and computation time needed to perform FDTD on the entire propagating path is prohibitive. In MWFDTD, we take advantage of the fact that the propagating radio pulse is limited in spatial extent and create a computational grid only wide enough to include the pulse. Then as the pulse propagates along the terrain, we move the computational mesh to follow along with the pulse so that the radio wave pulse is always within the computational grid. In this way, we ensure that at each time step, we only calculate the field values in the area where field is nonzero. The MWFDTD method is illustrated below.



New waveform capabilities

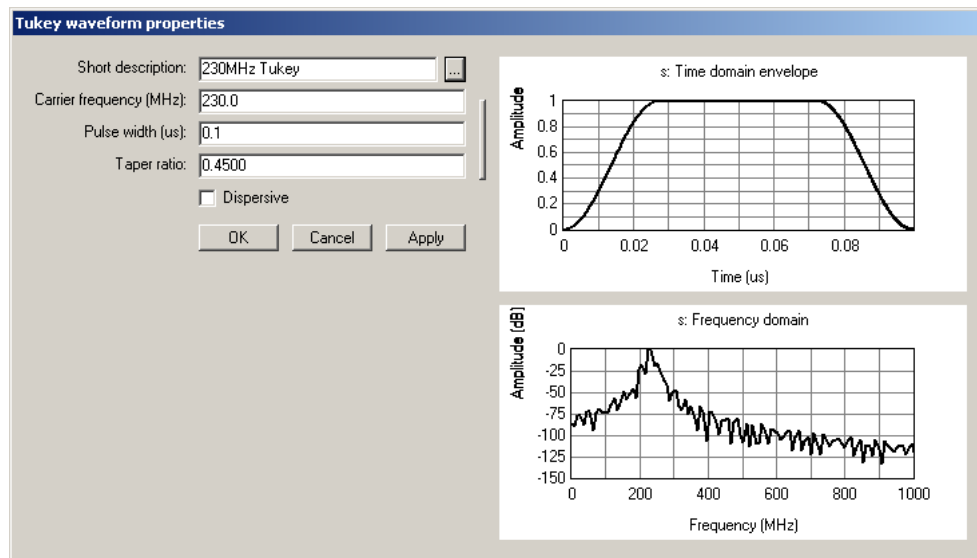
Two types of waveforms were allowed for in Wireless InSite v1.5.2 and earlier. One type was called a “narrowband waveform” and the other was called a “wideband waveform”. The terms referred to whether frequency dispersion was included in analysis. The narrowband waveform did not include frequency dispersion in the analysis, but used a bandwidth parameter to account for some effects of having a finite width waveform. The wideband waveform was limited to a frequency domain waveform specified through an external file produced by the user.

The term wideband was used to refer to the ability to perform UTD calculations at multiple frequencies with carrier amplitudes specified in the user-defined file, and the ability to inverse Fourier transform the frequency domain results to create the time domain response. Even when a wideband waveform was assigned to a transmitter, some output was still only evaluated at a single frequency.

Wireless InSite 2.0 includes the following new waveform pulse shapes: Gaussian and Gaussian derivative pulses, Blackman, Hamming, Hanning, and Tukey time-domain envelopes, and raised-cosine and root raised-cosine pulses. Previously defined narrowband waveforms are now labeled as sinusoidal waveforms. The user defined waveform can now be specified as either a function of time or frequency. The format of the file is described in Chapter 9 of the user’s manual.

Each waveform type has its own properties window for setting the waveform parameters. The parameters for each waveform are described in Chapter 9 of the user’s manual. Plots of the

waveform in both the time- and frequency-domains are displayed on the right-hand side of the properties window. Larger plots with the full set of graph properties are available through the context menu accessed by right-clicking on the waveform entry in either the main window or the project hierarchy window.



The distinction between a wideband pulse and a narrowband pulse has been eliminated from the software. Instead the user will be able to designate waveforms as being “dispersive” or “non-dispersive”. The dispersive option is disabled for some waveform types. Waveforms which use the sinusoid pulse shape are always non-dispersive, and waveforms using the Gaussian derivative pulse shape and user-defined waveforms are always dispersive.

The calculation of some output types will depend on the dispersion setting but other output may not. By selecting the dispersive option, the calculation of electric field versus time and power versus time include the effects of dispersion on the broadband waveform pulse as it propagates. The electric field is also calculated as a function of frequency. The e-field vs. time, power vs. time (power delay spread) and e-field vs. frequency are only available for receiver sets of type points and points-on-face.

The user-defined waveform was just assumed to give a real valued time domain pulse and no check was performed to make sure the waveform satisfied this requirement. A check was performed on the frequency increment to make sure it was sufficiently small.

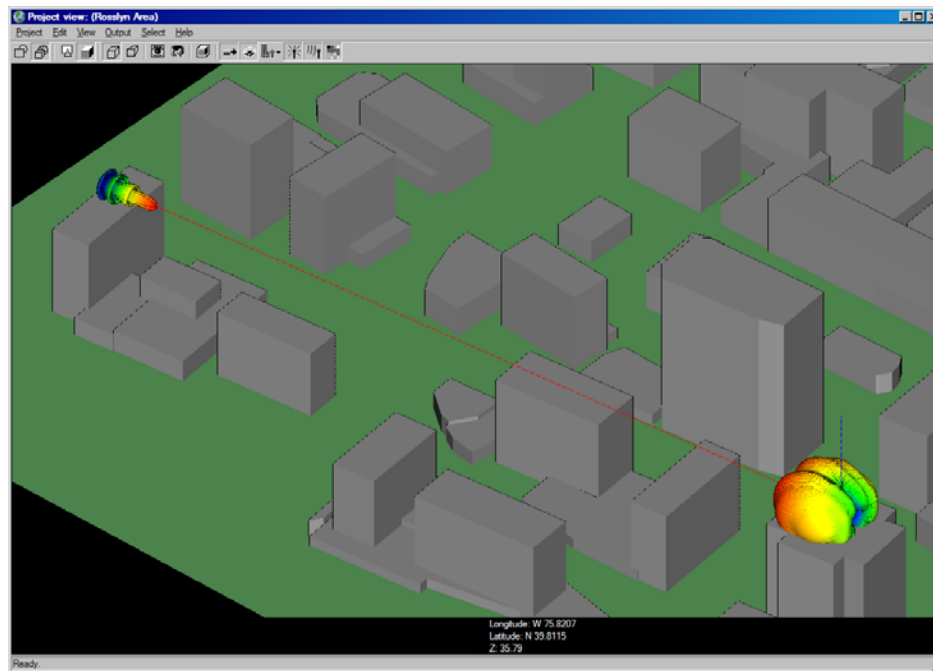
The purpose of waveforms in Wireless InSite will be to allow the user to input parameters which describe the signal which is radiated from the transmitting antenna, and to act as a kind of bandpass filter at the receiver.

Any output involving phase is inherently only meaningful at a single frequency. Output types in this category include: Total Electric Field, Complex Electric Field, and Complex Impulse Response. Even when a waveform is designated as dispersive, these output types will still be evaluated only at a single frequency. The carrier frequency, or center frequency for a Gaussian derivative or user-defined waveform, will be used in these cases.

The addition of dispersive calculations is also an important addition when used with UTD propagation models. By selecting the **Dispersive** waveform option, the calculation of E-field versus time and power versus time include the effects of dispersion on the broadband waveform pulse as it propagates.

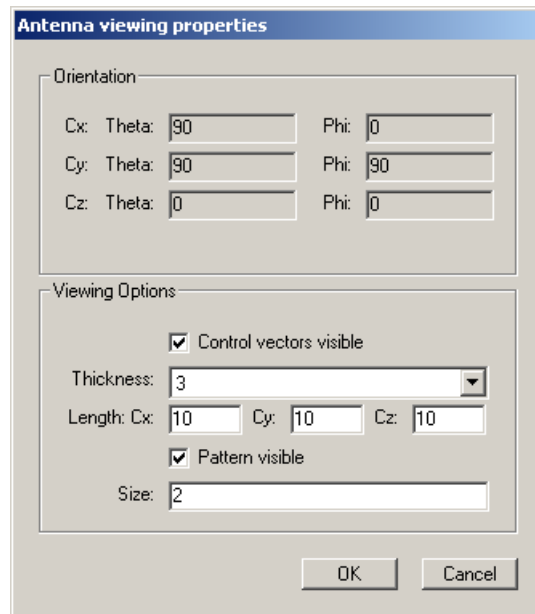
3D Antenna patterns in Project view

To facilitate the orientation of transmitter or receiver antennas, the ability to view the rotated antenna pattern in the Project view is now possible as shown in the figure below. The display of the antenna pattern is enabled for each transmitter or receiver set through the “Antenna viewing options” button in the transmitter or receiver properties window. The antenna pattern display is disabled by default. To avoid lengthy initial rendering time, all pattern displays will be turned off when a project is initially loaded.



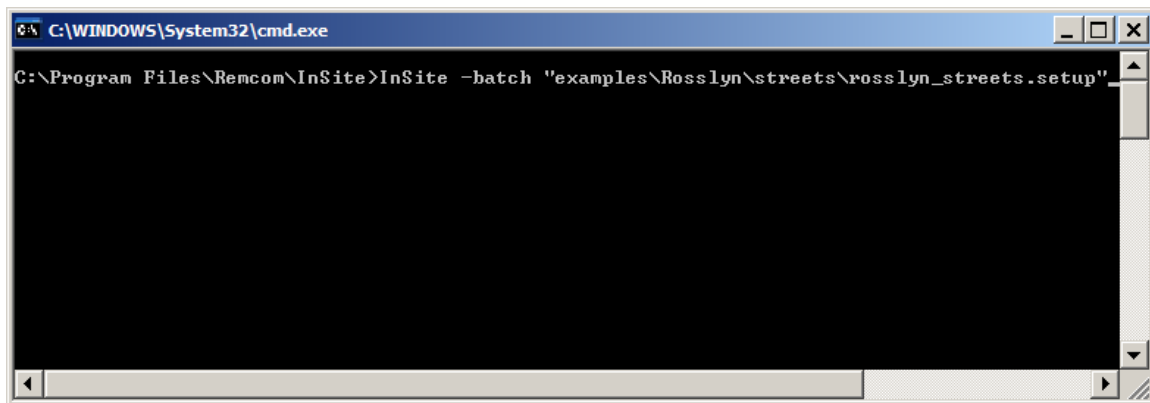
Rendering Tx/Rx antenna control vectors

In addition to viewing the antenna pattern, the final orientation of the antenna after application of the Tx/Rx rotations can now be visualized through the display of a set of orthogonal control vectors rendered in the Project view. All rotations applied to the antenna pattern are also applied to these vectors. The figure above shows these vectors drawn for the directional antenna on the left. The red dashed line is along the boresight of the antenna, and the blue vector shows the polarization along the boresight. The antenna viewing options can be accessed through the “**Antenna viewing options**” button in the transmitter or receivers properties windows.



Enhanced command line batch processing

It is also possible to run the calculation engine from a DOS window or as a batch job. Batch jobs can be accomplished by using the *-batch* option when running Wireless InSite from the command line. Using quotes around the setup file is recommended. An example command for a batch run is shown below.

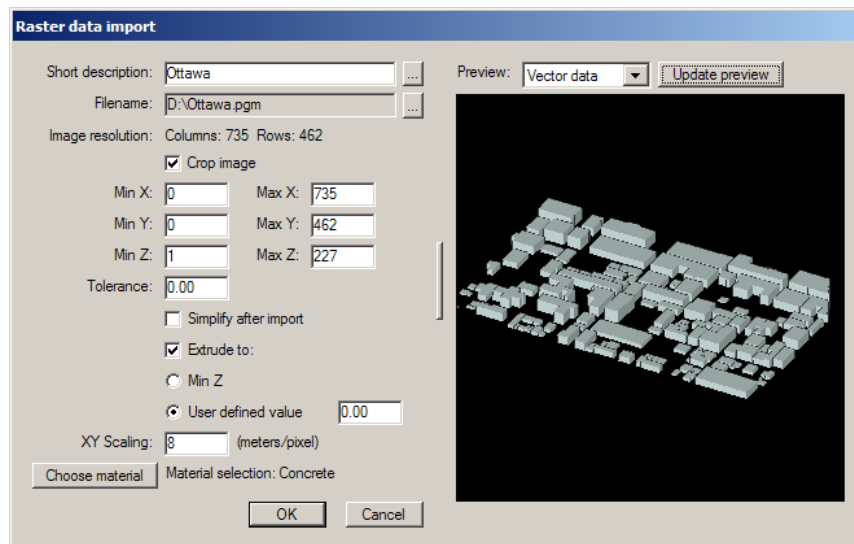
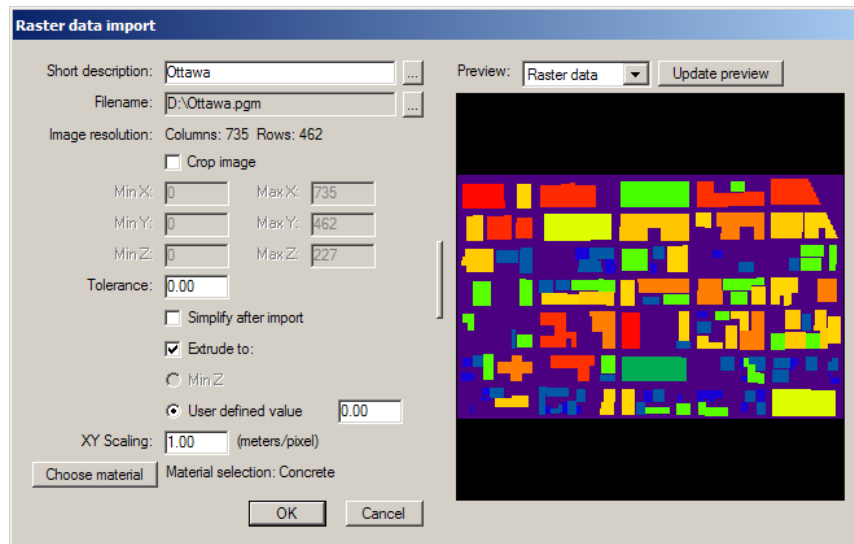


Enhancements to diagnostic files

More diagnostic information is now written to the *.diag file during the calculation. Additional files are also written to the diag folder when "diagnostic information" is a requested output type.

Raster-to-vector converter

Wireless InSite can now import city data in raster format and convert it to vector format for use with all propagation models. By interpreting values in the raster data as heights, the raster-to-vector converter can detect regions of similar height and form buildings by extruding these regions to the ground. The file formats currently supported include ARC ASCIIGrid and Portable Gray Map (.PGM) raster images. To import raster data select **Project>Import>Raster data**.



Plot output vs. Tx-Rx distance for some types of receiver sets

In the past all line plots of output vs. distance, the distance was the accumulated distance in going from one receiver point to the next. While this was a good way of displaying results along a receiver route or arc, it was not useful for xy grid receiver sets, or other receiver sets covering an area, such as cylinders, vertical surfaces and polygons. For the latter set types we have changed the distance in the output file to be the transmitter to receiver distance. The default line type for these plots is still “lines”, but this can be changed to “points” to create a more useful graph. For receiver sets of type points, points-on-face, and user-defined sets, the distance is still the accumulated distance in going from one receiver point to the next.