REMCOM®

Electromagnetic Simulation Software

Time-Based Mobility of RF Systems in Wireless InSite®

New Features in Wireless InSite 4.0

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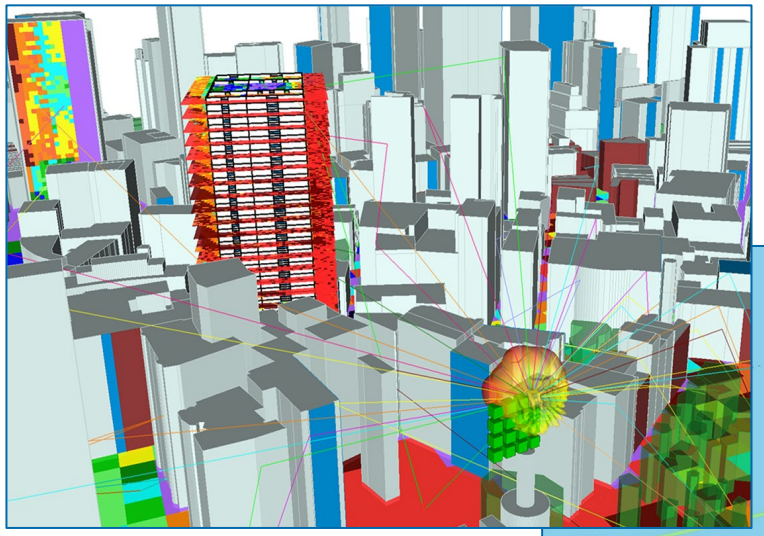
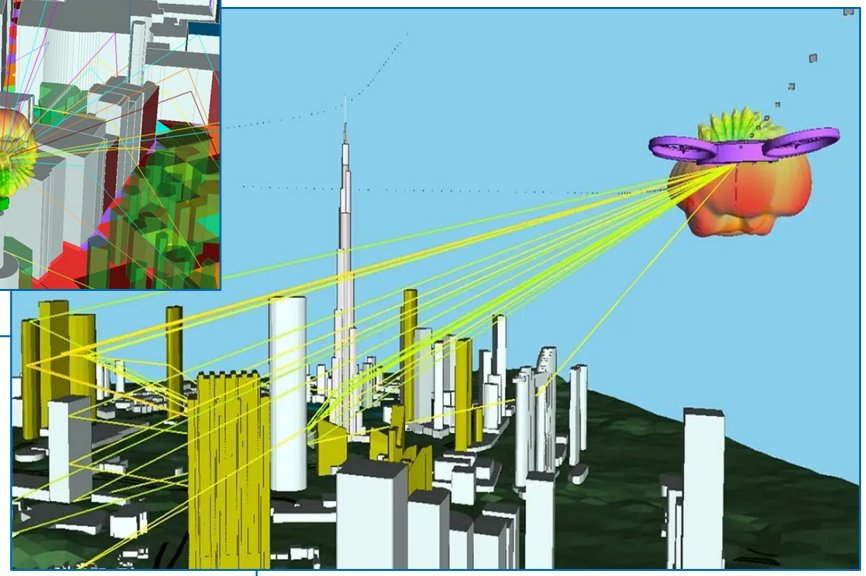
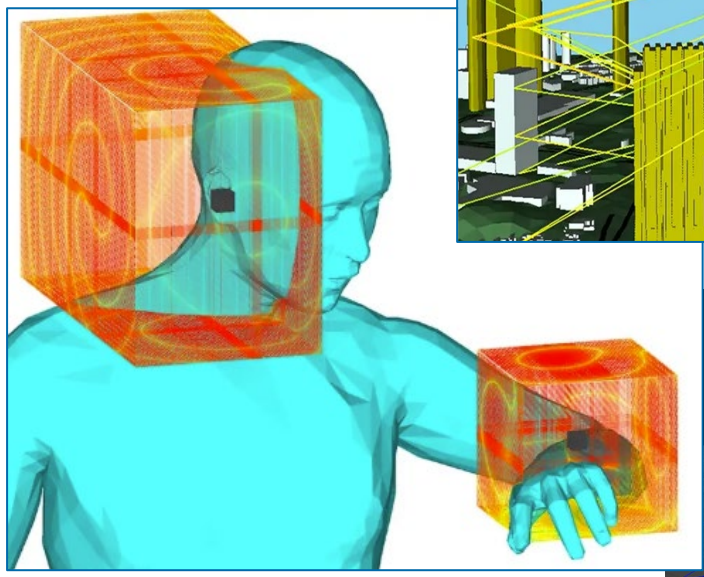
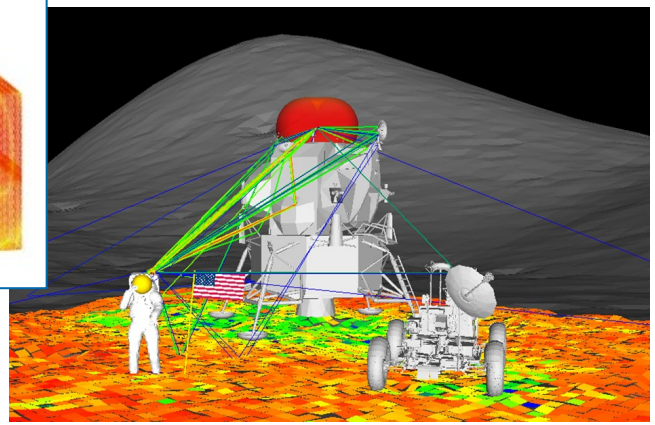
Overview

- Wireless InSite Capabilities
- Wireless Mobility
- Broadband Simulations
- Hybrid EM: Full Wave to Ray-Tracing using Huygens surfaces
- Lunar Propagation
- Questions









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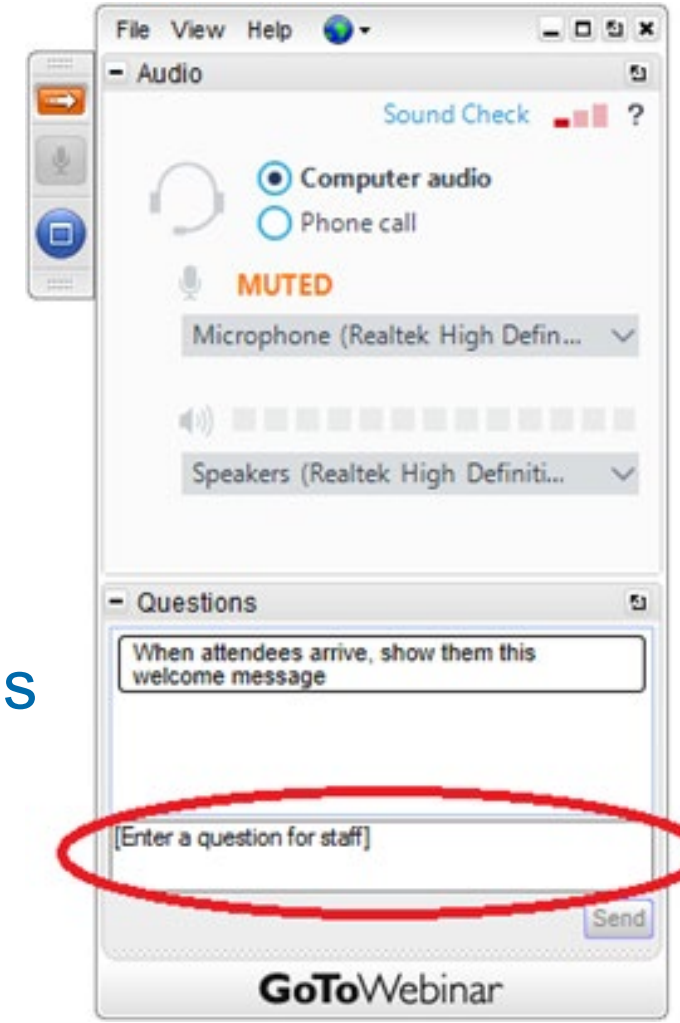


Can be undocked and expanded for easier use.

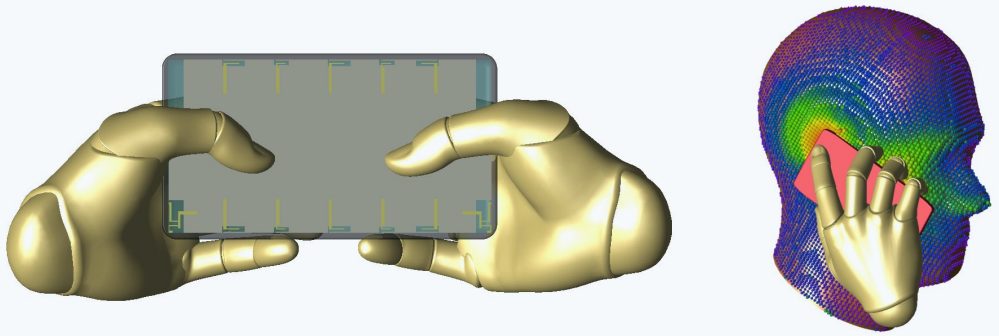
Questions may be entered into the dialogue on the webinar panel

Wireless InSite Capabilities

Remcom Products

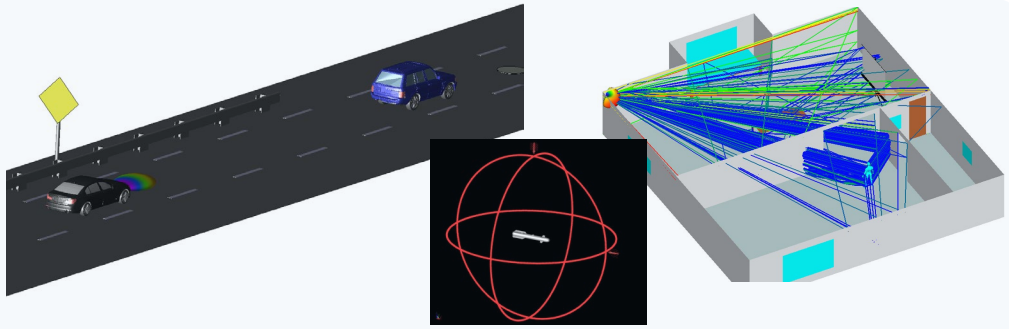
XFdtd®

3D GPU Full-Wave Solver: Antennas, RF, EM Scattering, BioEM, RCS; Enterprise HPC Enabled for NN Datasets



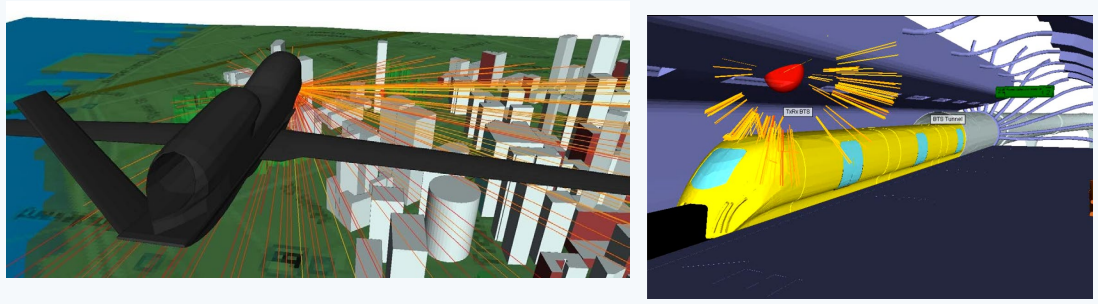
WaveFarer®

3D GPU EM Ray Casting: Mobile Sensing Scenarios for RADAR and RCS; HPC enabled for NN for Sensing



Wireless InSite®

3D GPU EM Ray Tracing: Mobile platforms for broadband propagation analysis; HPC Enabled for NN Dataset for Comms



Wireless InSite: 3D Wireless Prediction

3D Wireless Prediction Software

- Suite of propagation models and comms post-processing (MIMO/throughput)
- Validated, deterministic models
  - GPU-accelerated, 3D ray-tracing in complex urban and indoor environments
  - 2D (long-range) and real-time alternatives
- 5G/MIMO beamforming, spatial multiplexing, diversity
- Extensions for mmWave, diffuse scatter

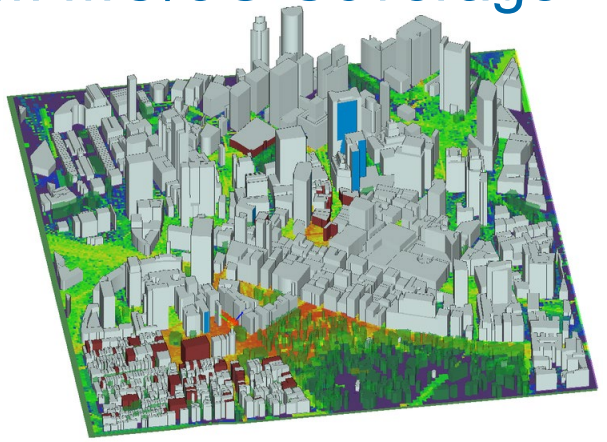
Applications

- 5G/6G Coverage (SINR, throughput) in dense urban outdoor, indoor, out-to-in
- WiFi or BT coverage in complex indoor
- Multipath fading, mobility

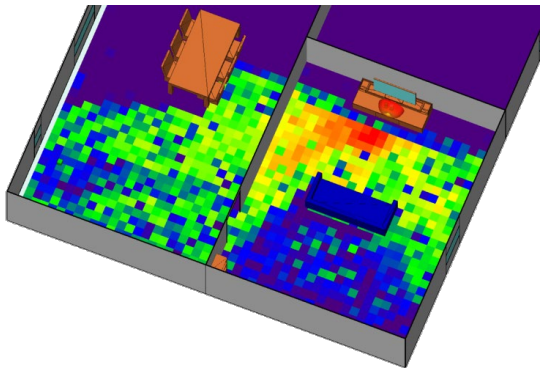
Digitize RF System analysis

- Replace need for measurement
- Channel Emulation
- Generate synthetic data for ML

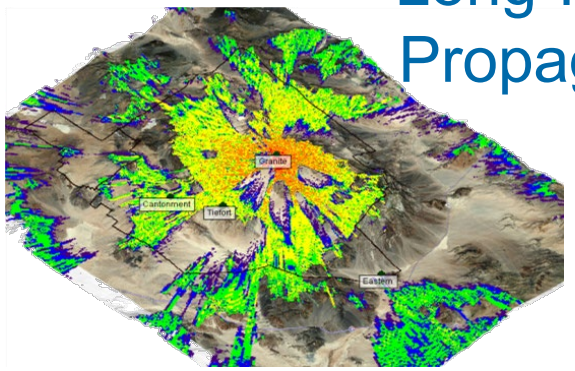
MIMO/5G Coverage

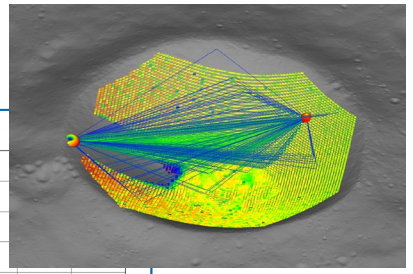


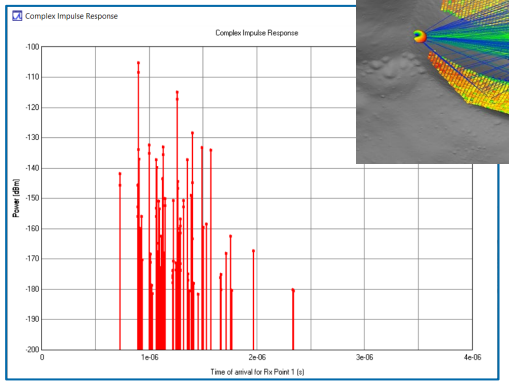
Indoor WiFi



Long-Range Propagation







Detailed Path Data

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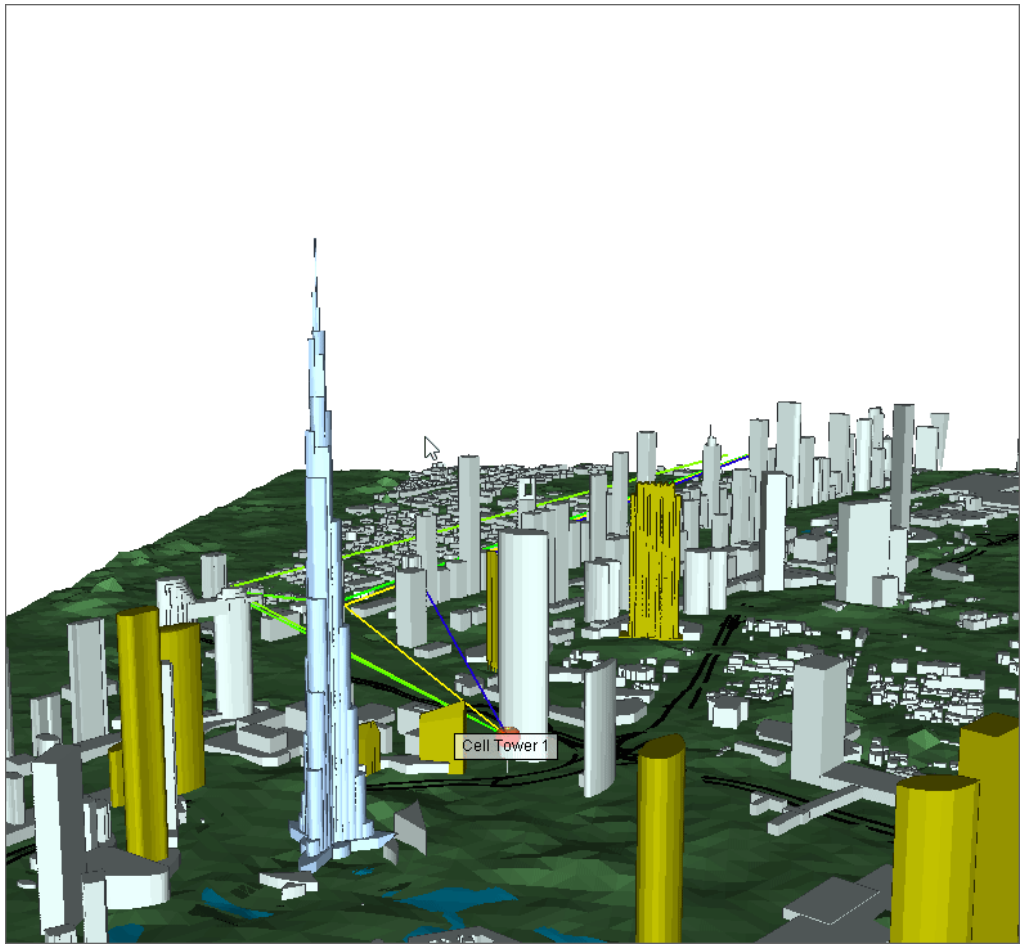
Wireless Mobility

Wireless Mobility

Create dynamic scenarios and simulate how movement of devices and vehicles affects multipath, coverage, and wireless communications

- Mobile platforms model assemblies of objects and transceivers as they move through a scene
- Visualize the multipath within views of the scenario
- Evaluate how time-varying shadowing and fading impact communication link performance
- Plot or view time-based outputs and automatically generate animations
- Generate accurate path data for each timestep



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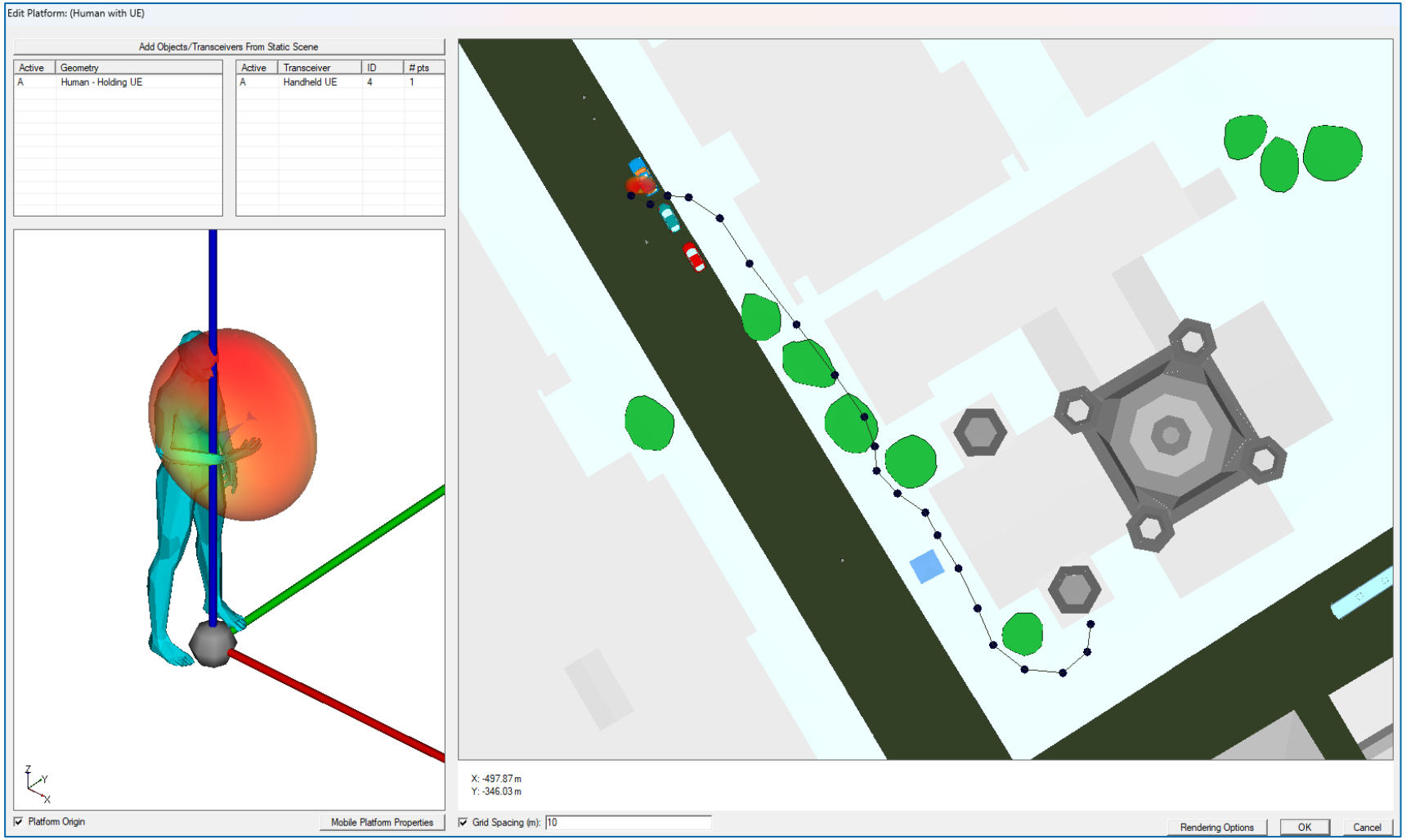
Mobile Platforms

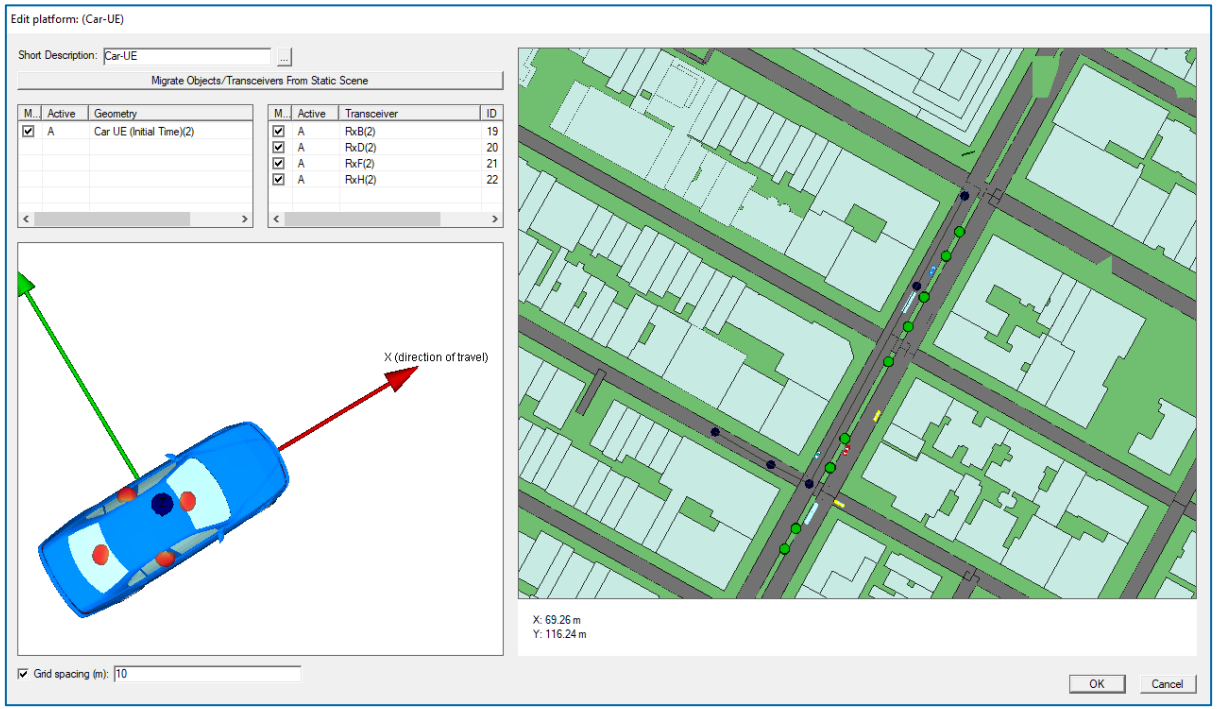
- Position transceivers and geometry relative to one another
- Maintain relative positions as the platform moves through the environment



Waypoints and Platform Properties

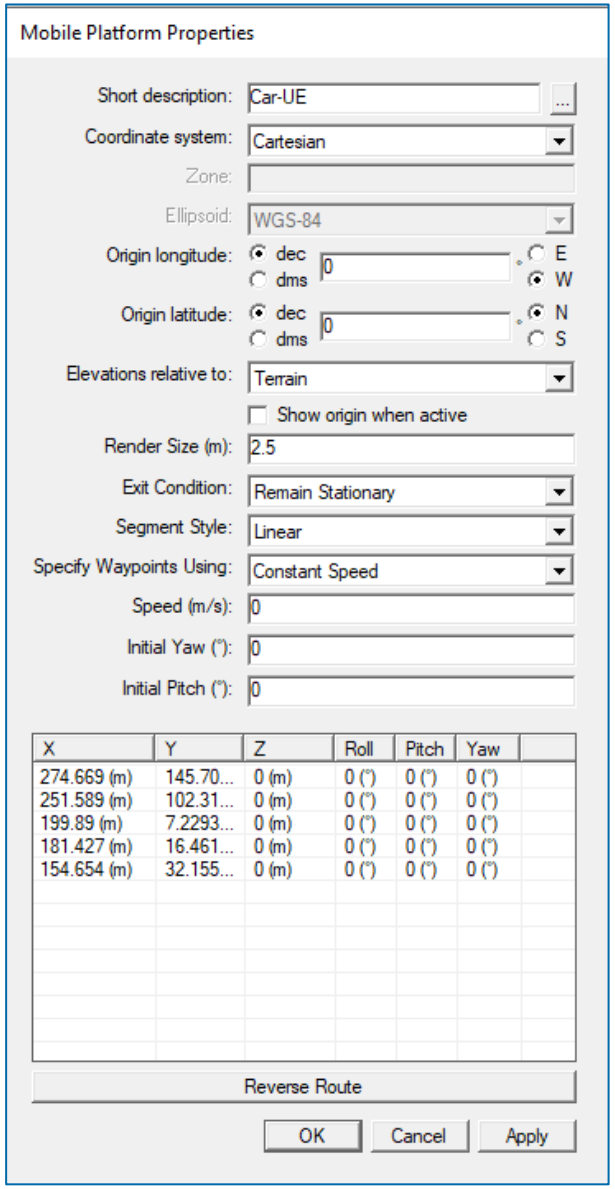
In Platform Editor

- Add waypoints graphically by clicking in 2D view



In Mobile Platform Properties

- Edit waypoints
- Define segment style (Linear or Spline)
- Define Constant speed vs. Time-based waypoints
- Define Exit condition (Remain stationary vs. Exit)



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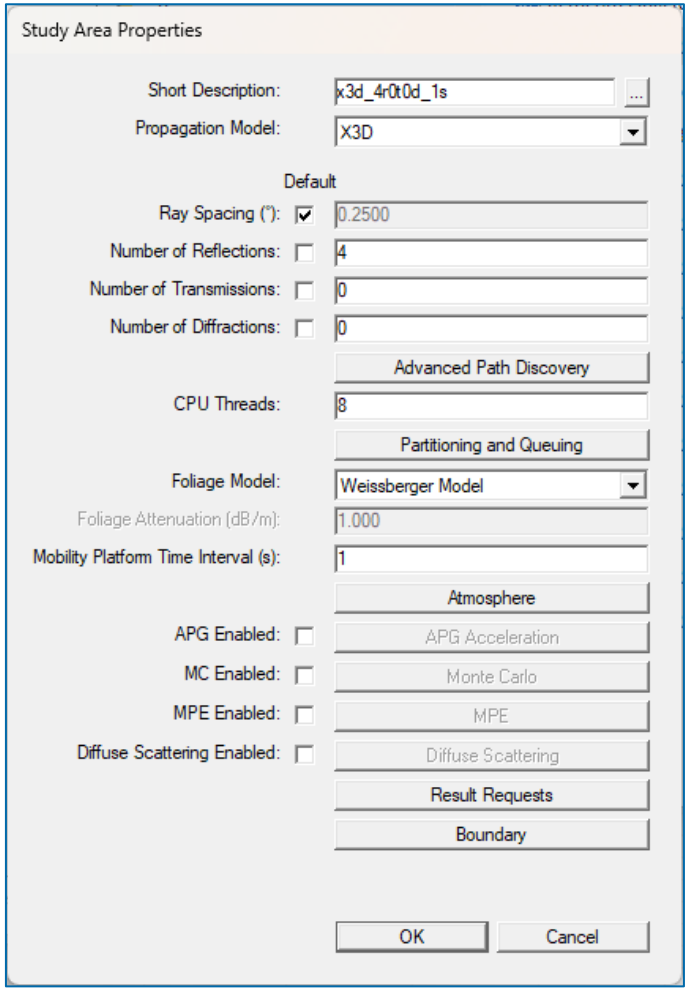
Sampling Rate

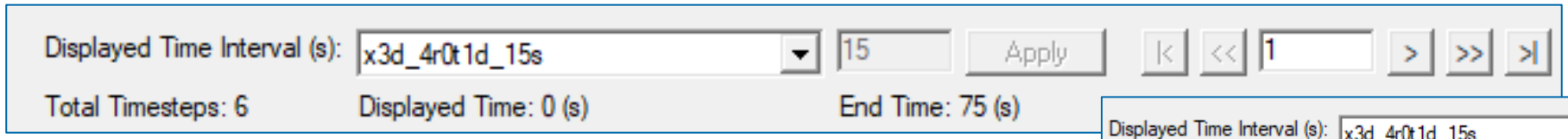
Study Area Property:

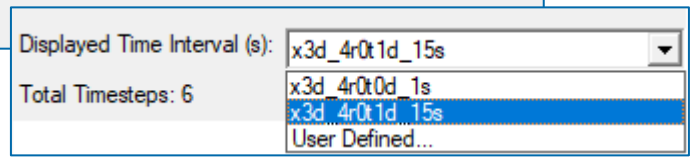
- Mobility Platform Time Interval

Platform Tab:

- Displayed Time Interval
  - Per study-area or custom
- Preview Total Timesteps
- Preview Position in Geometry view



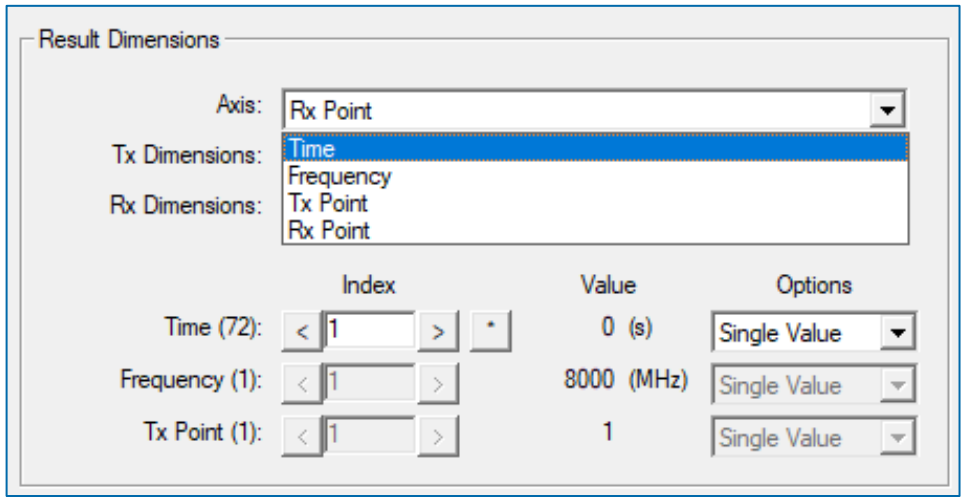


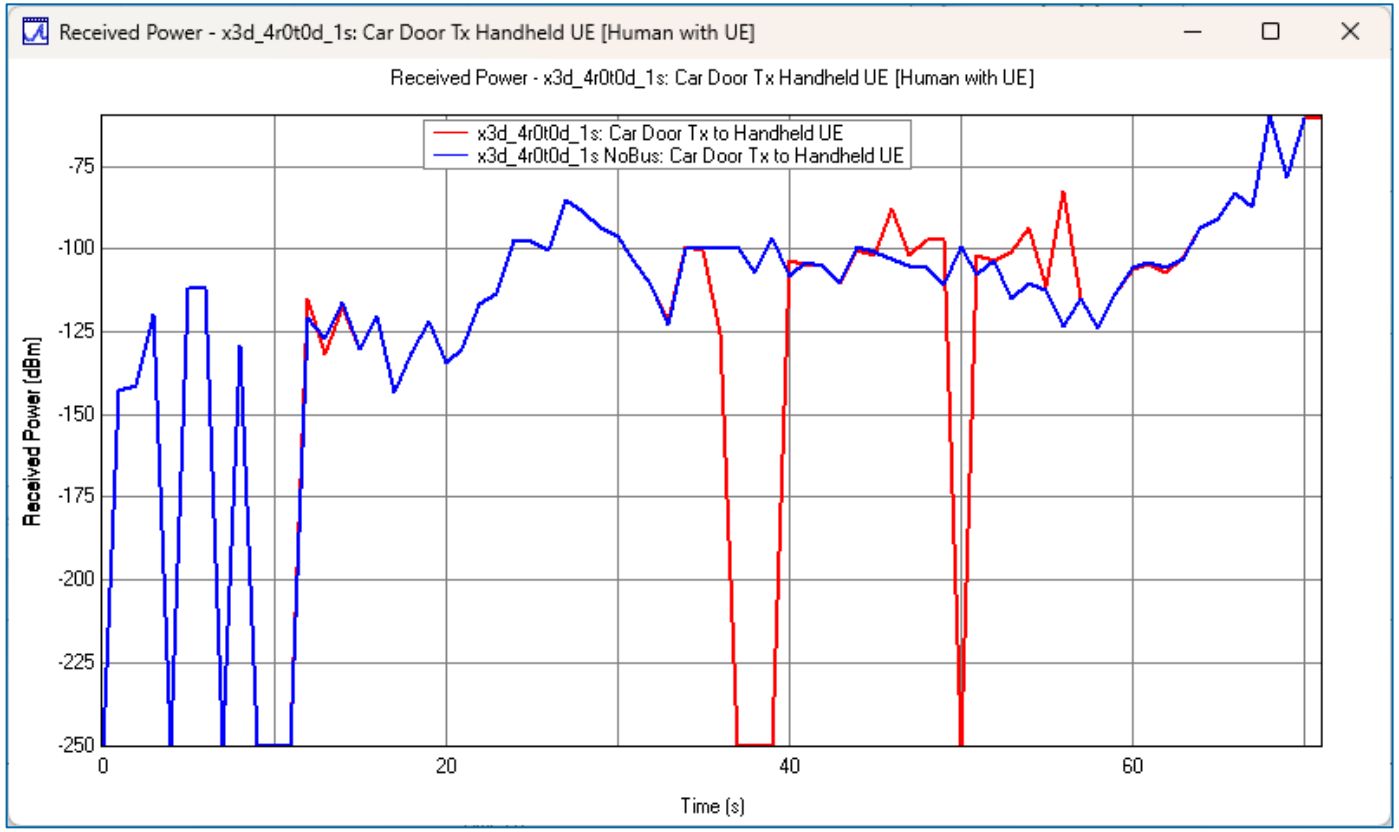


Plotting Results vs. Time

Result browser offers several options for defining the plot's independent variable:

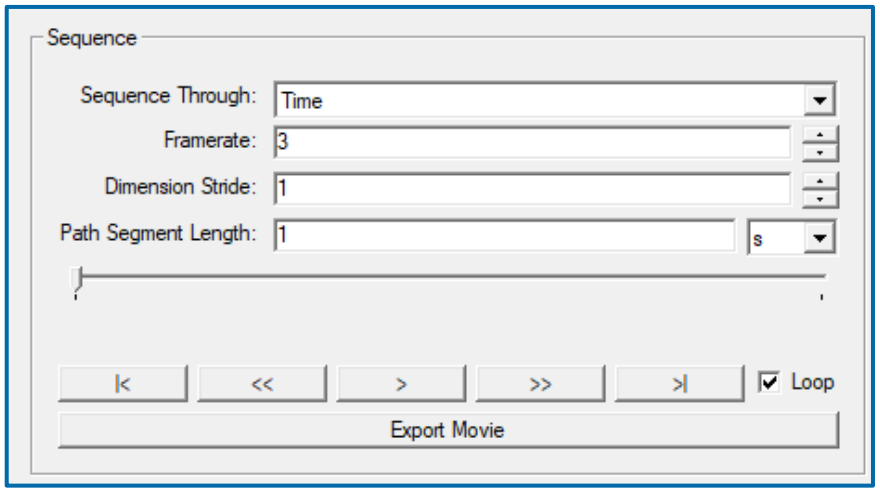
- Vs. Rx point
- Vs. Time
- Vs. Frequency
- Vs. Tx point

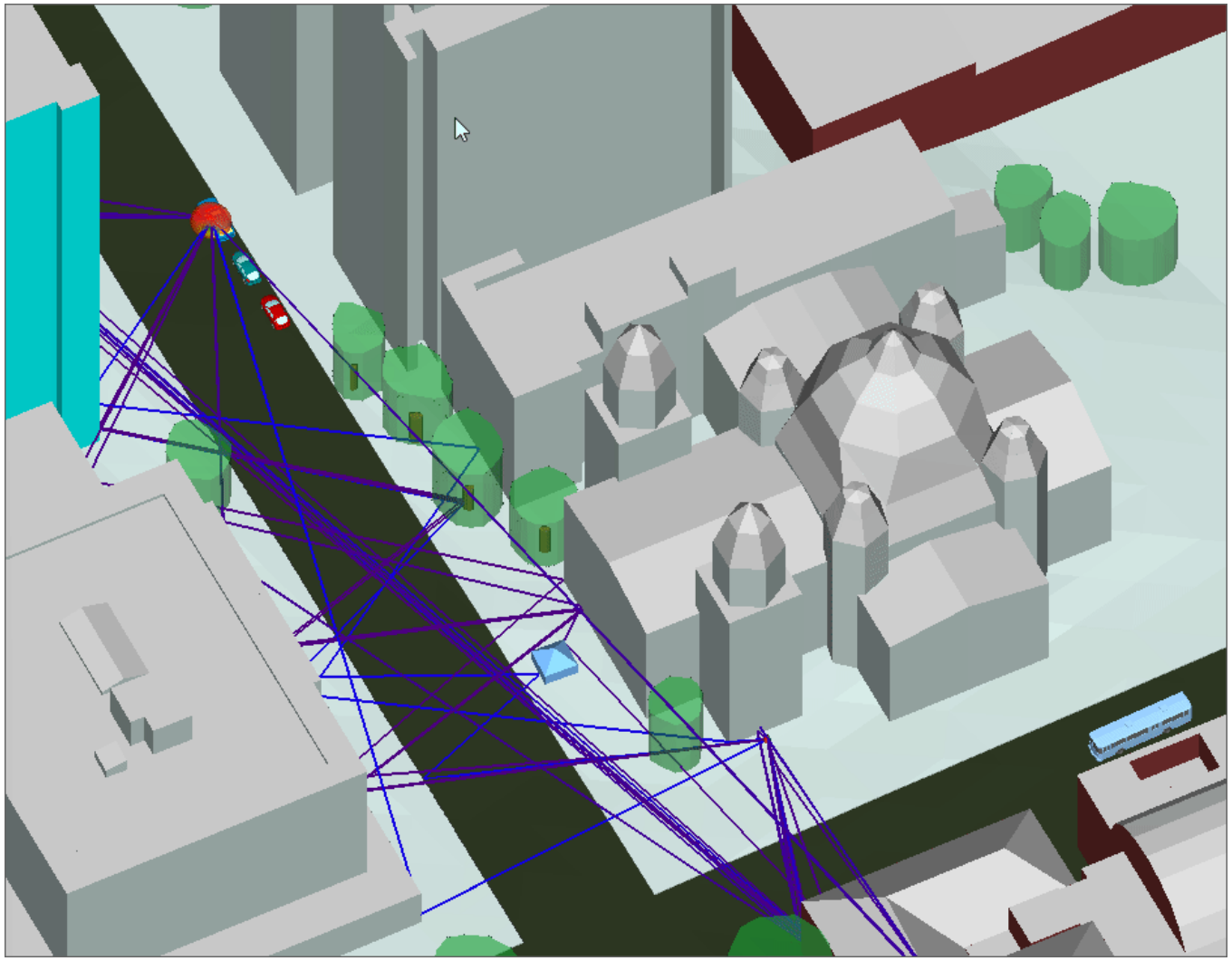




Received Power vs. Time: (Red) with bus; (Blue) without bus

Viewing Results vs. Time





Sequence through time

- Render in geometry view
- Control frame rate

Analyze path interactions in dynamic scene

Multi-Frequency & Broadband Simulations

Multi-Frequency & Broadband Analysis

Multi-frequency definitions: define a single project for multiple bands

- Multi-frequency antennas
- Frequency-based atmospheric effects
- Multi-frequency materials
- Multi-frequency MIMO S-parameters

Optimized frequency-sweep simulation

- Ray-trace once to find paths, then only recalculate field results for each frequency
- **Key benefits**: adjusts antenna gains and material properties for each frequency in the sweep – improves accuracy while simplifying setup (single project rather than project for each frequency band) and reducing runtime

Broadband Analyzer Post-Processing Utility

- Calculate frequency spectrum, broadband CIR

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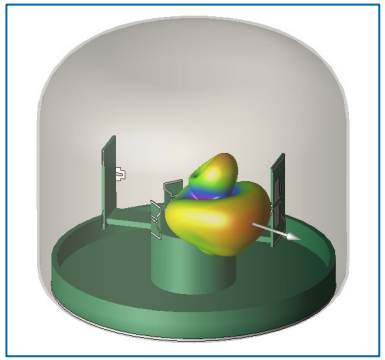
Multi-Frequency Antenna Patterns

Import multi-frequency antenna gain patterns from full-wave or measured data:

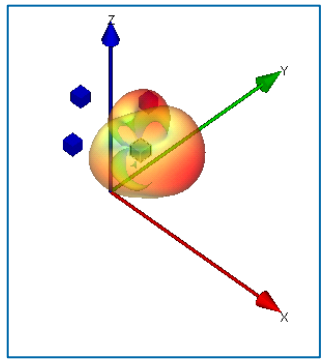
- MIMO antennas, including radiation patterns, and element positions
- Frequency-specific radiation patterns across 1 or more bands
- Codebooks (beamforming weights)
- Multi-port S-parameters (touchstone file)

Includes direct import from XFdtd®; benefits:

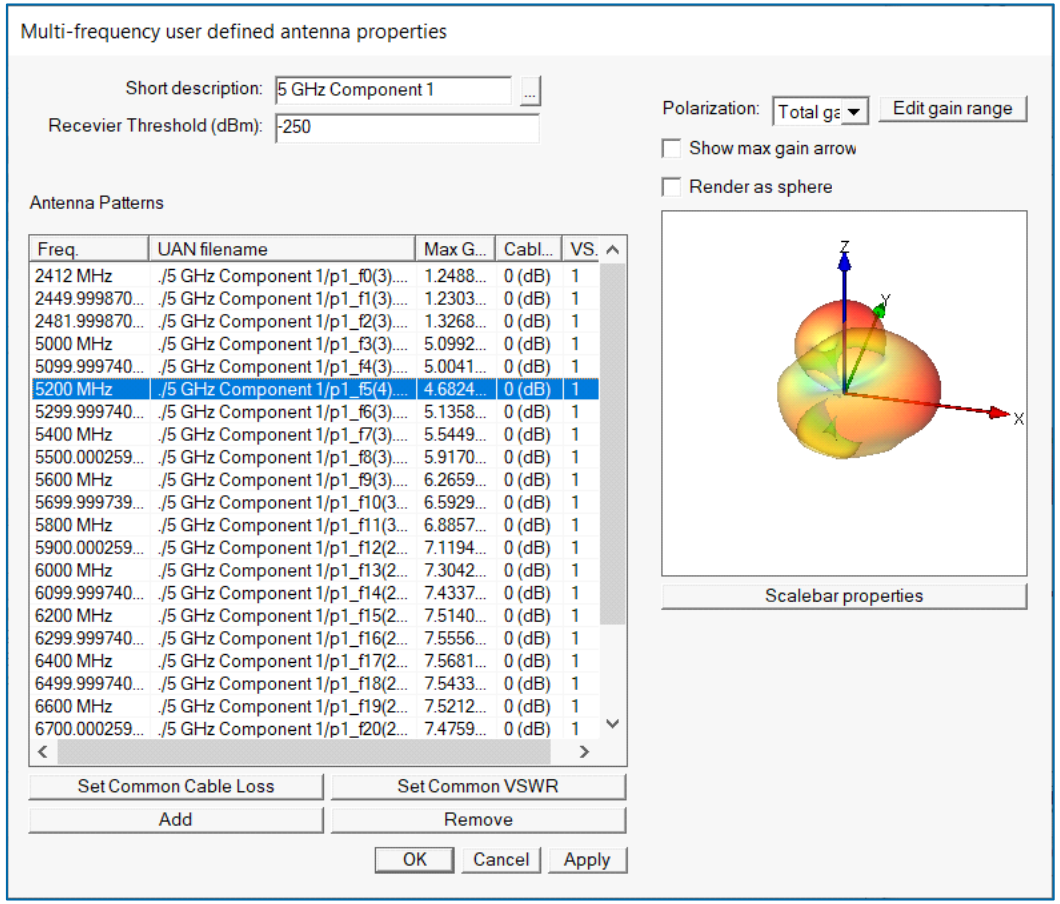
- Easy to load, and saves time by automatically setting up MIMO arrays and antenna patterns
- Realistic patterns and tuned beamforming coefficients to match



Antenna Sim in XFdtd®



Antenna Imported Into Wireless InSite



Frequency-Specific Patterns

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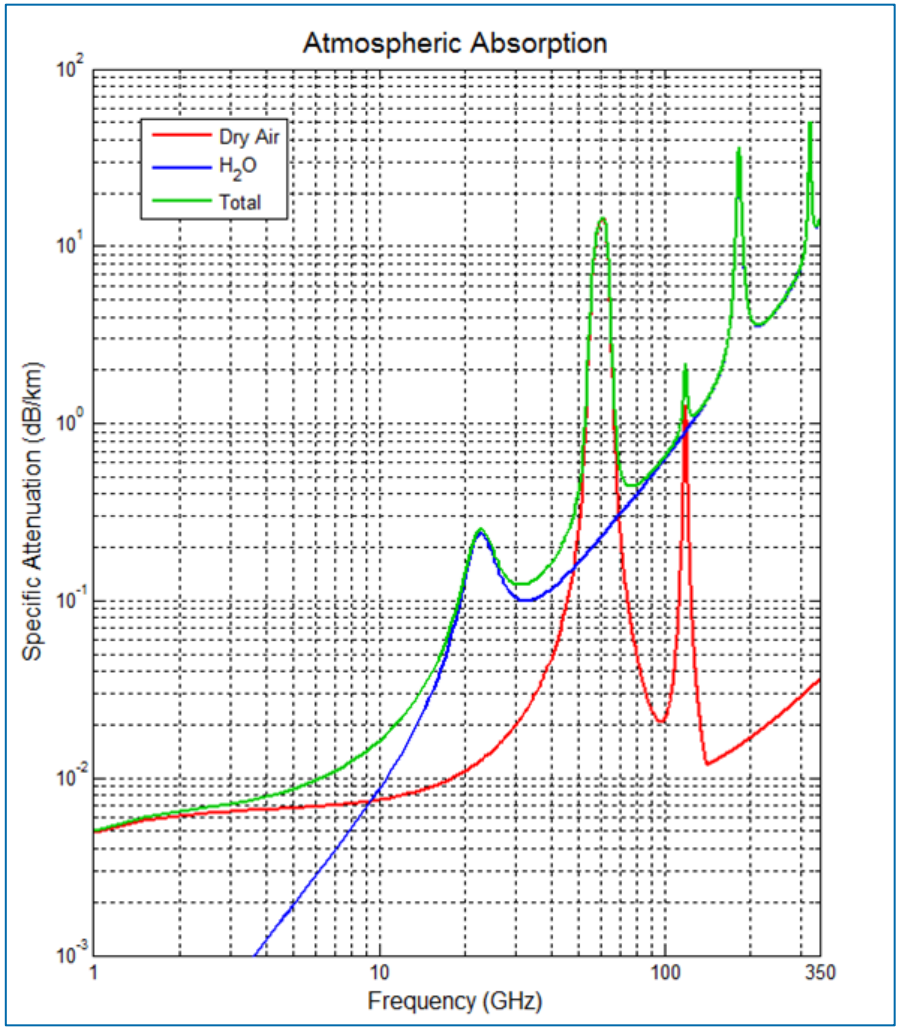
Atmospheric Absorption

- Define temperature, pressure and humidity
- Wireless InSite incorporates key absorption bands due to oxygen and water vapor resonances
  - Examples: 22, 60 GHz, etc.
- Absorption is defined up to 1 THz, allowing for LOS calculations (direct path only) above mmW



Specific Attenuation as predicted by Wireless InSite's X3D

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Multi-Frequency Material Definitions

Material properties can be defined per facet

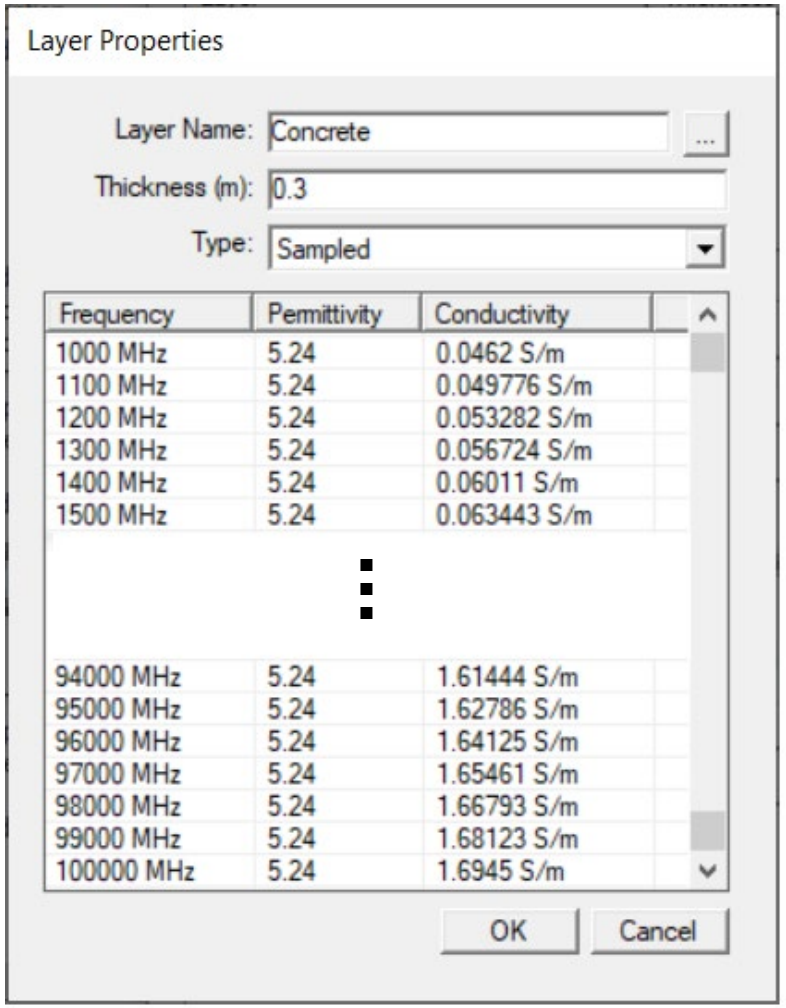
Database provides ground and wall materials from ITU recommendations and other references

Modeled via electrical & physical properties

- Electrical properties:
  - Permittivity and conductivity
  - Reflection/transmission coefficients; can vary with frequency and angle
- Physical properties:
  - Thickness: half-spaces (ground), finite-thickness (walls) or multilayer materials (e.g. 2-pane glass)
  - Roughness: specular or diffuse scattering

Analytically include multipath between multiple layers to predict resonances

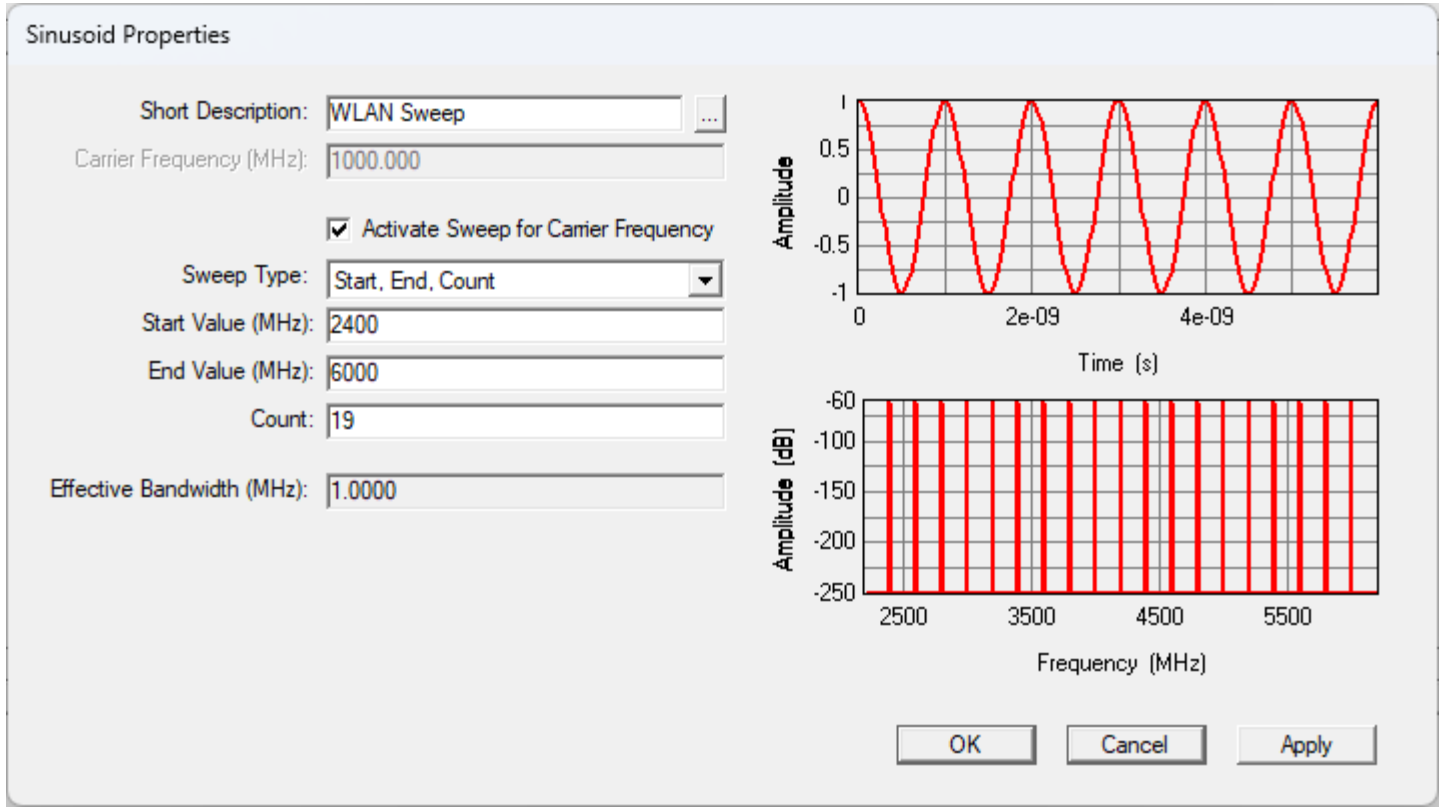
Example: Concrete (1-100 GHz)



Frequency Sweeps

Define waveform with a frequency sweep

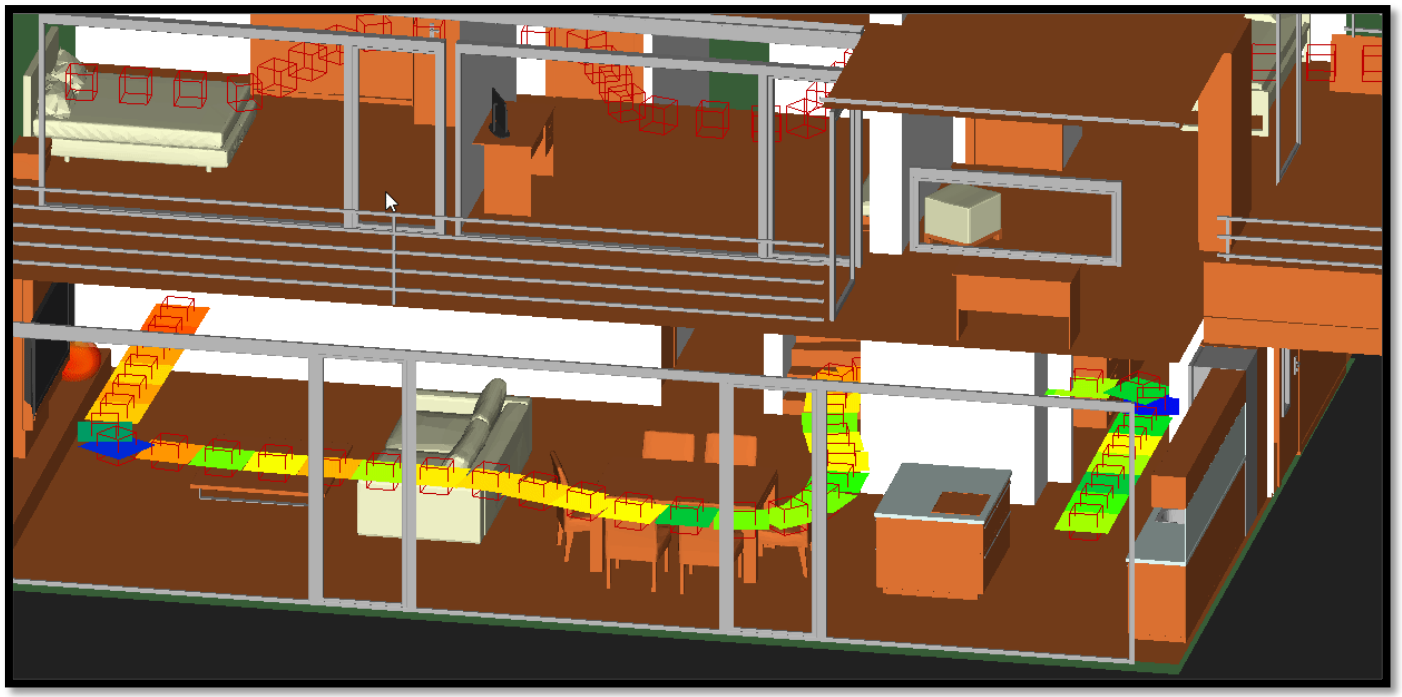
- Start, End, Count
- Start, Increment, Count

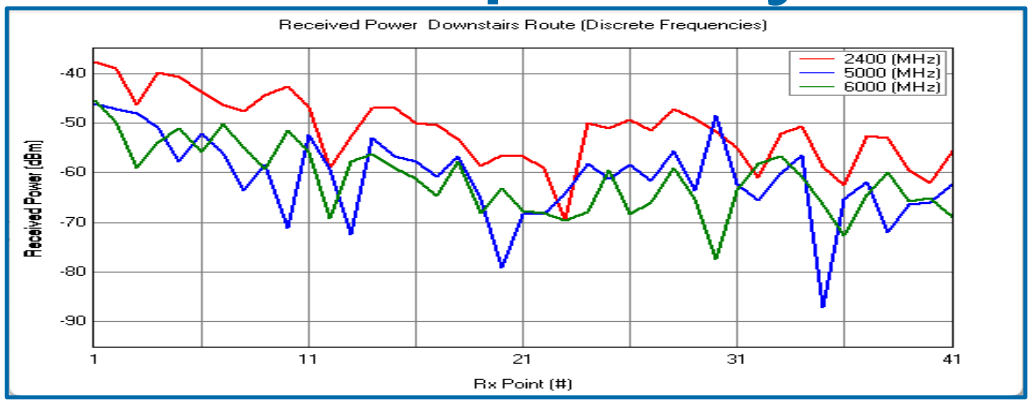


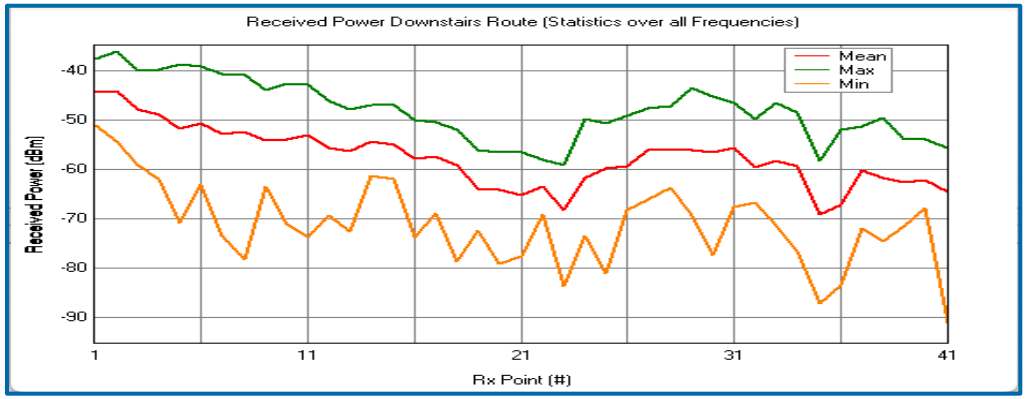
Plotting and Viewing Results vs. Frequency

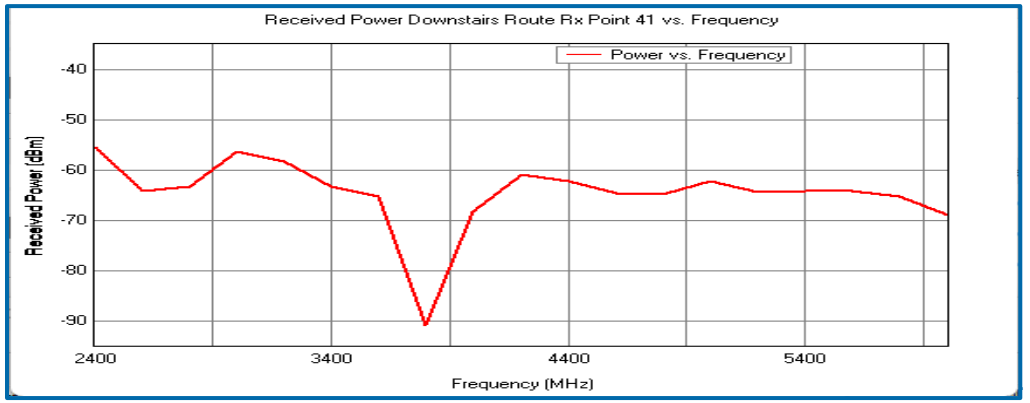
View and Plot results:

- For specific frequencies
- For statistics aggregated over frequency
- vs. frequency









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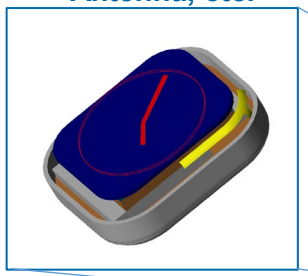
Hybrid EM: Full Wave to Ray-Tracing using Huygens surfaces

Huygens Equivalence Principle & Reciprocity

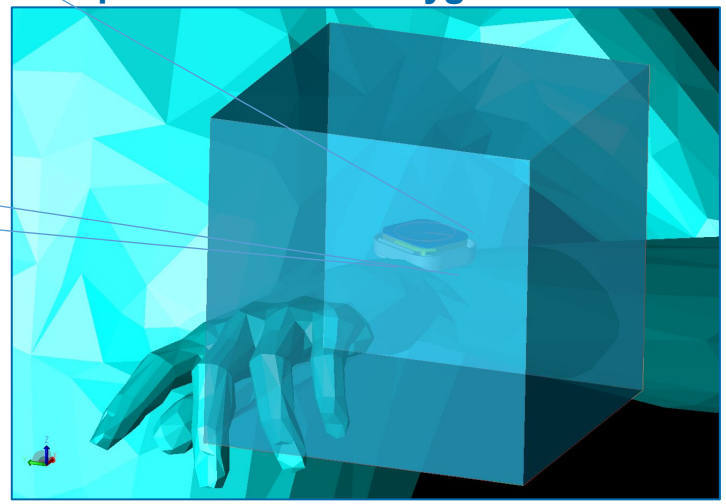
Christiaan Huygens (1629-1695)

Tangential components of E & H Fields on a closed surface are used to find the power transmitted from (Tx) and/or to (Rx) antenna systems that are modeled inside the respective Huygens surfaces.

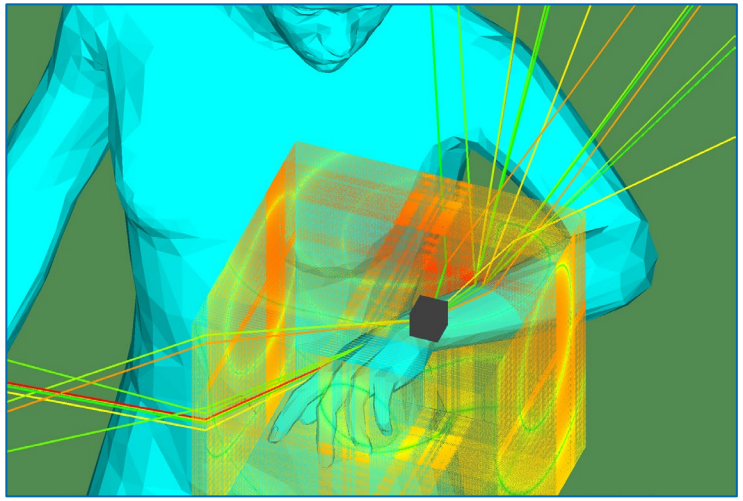
CAD with PCB, Antenna, etc.



Full wave simulation in XFdtd® to capture Fields on Huygens surface



Huygens Antenna in Wireless InSite®



- Huygens Principle (1690)
- Huygens – Fresnel Principle (1819)
- Lorentz Reciprocity Theorem (1896)
- Stratton & Chu Formulation (1936)

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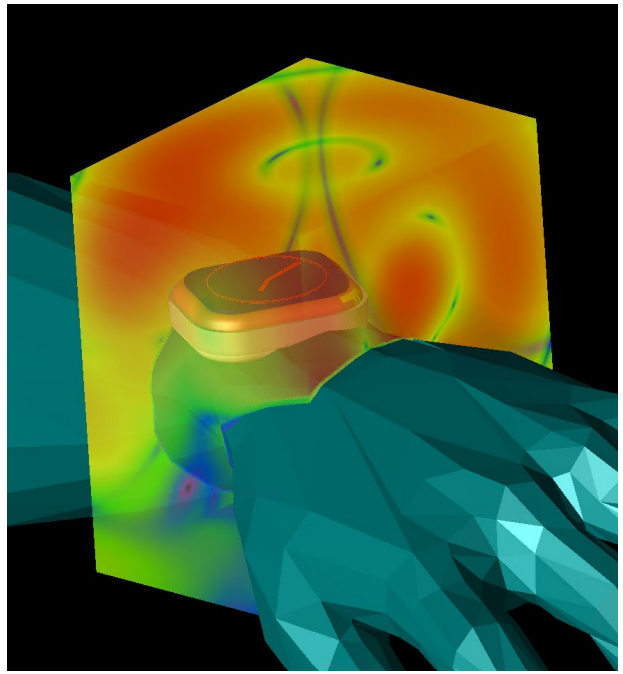
Full wave Near-field to 3D Ray-trace Environment

Capture near-field effects on Huygens surface

XFdtd®



Capture multipath from larger environment

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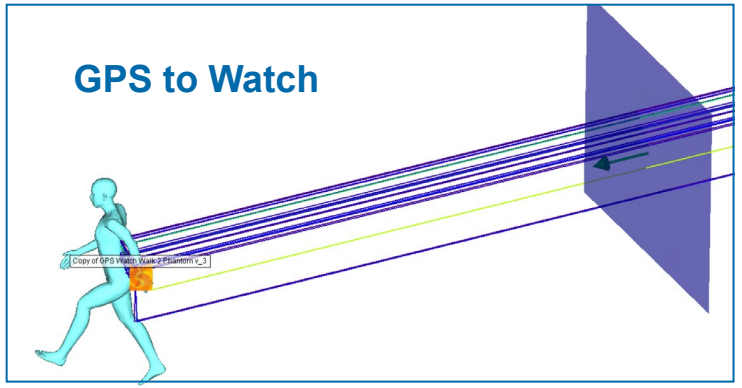

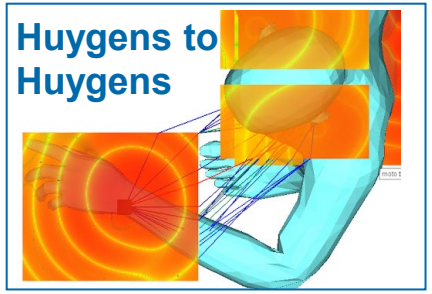

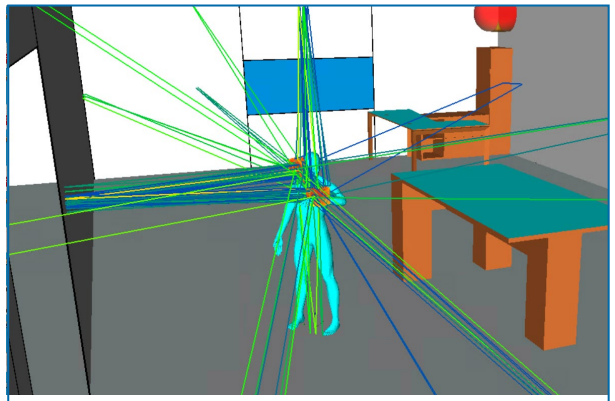

Access Point to On-Body Devices

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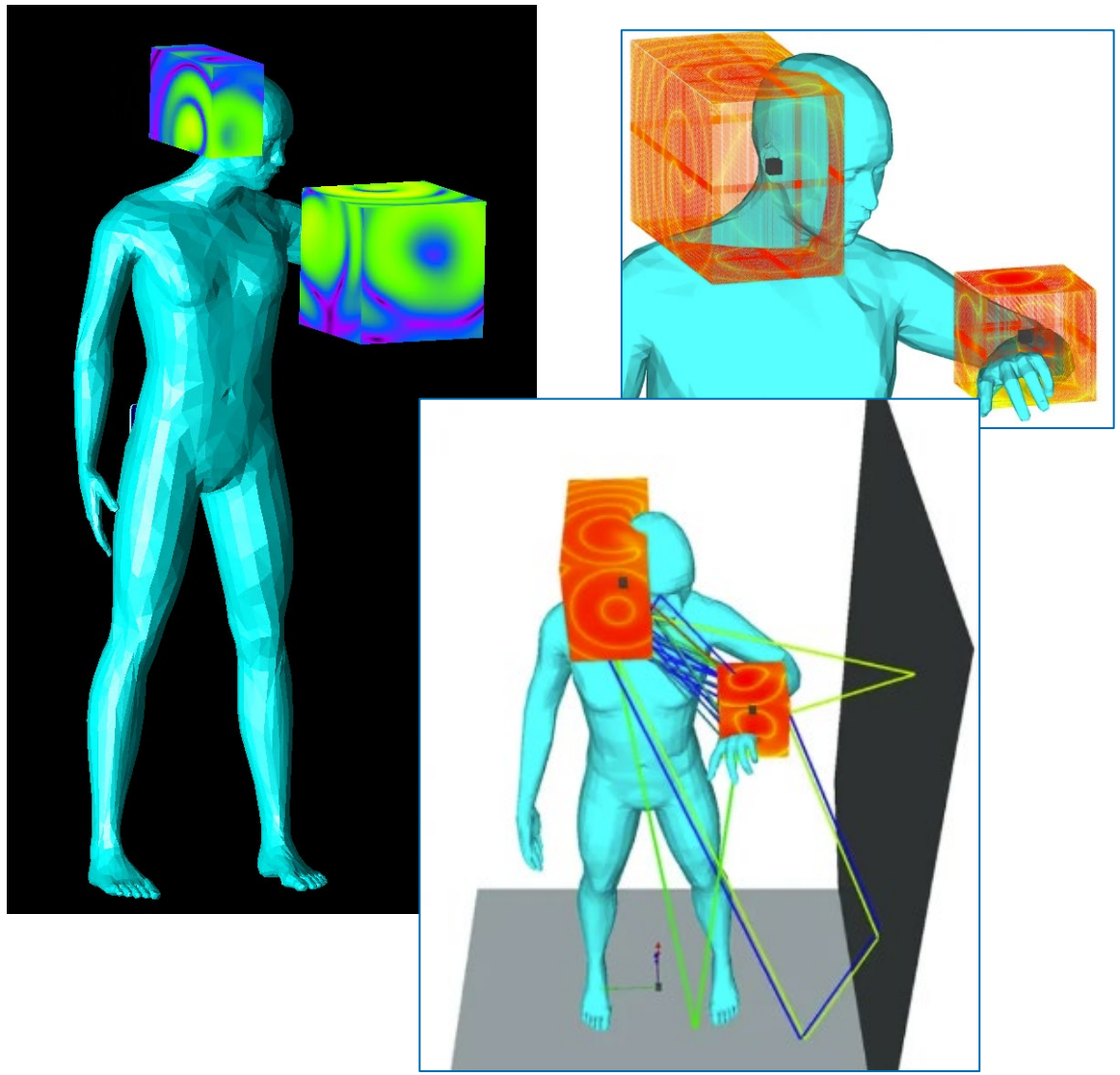
Seamless Huygens Package Import

XF Huygens Platform package export & Import into Wireless InSite

- Huygens antenna field files
- Object files with material defined
- Relative positions defined

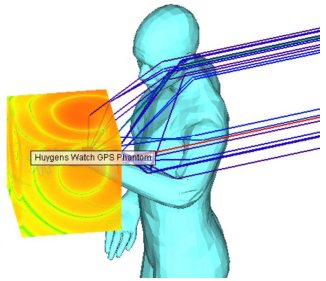
Can be moved within the InSite scene without losing spatial relationships

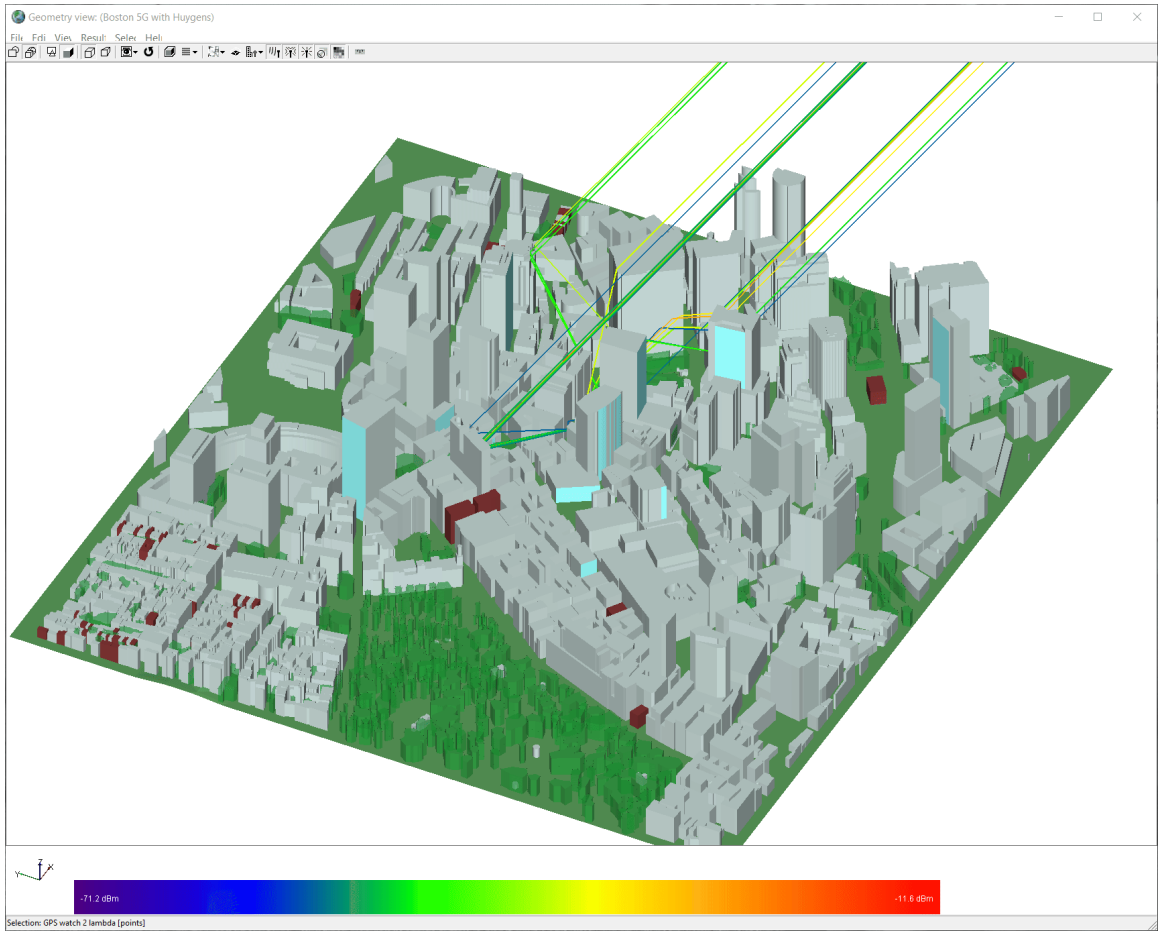
Hybrid EM solution allows analysis of chip/device system performance in larger scenario

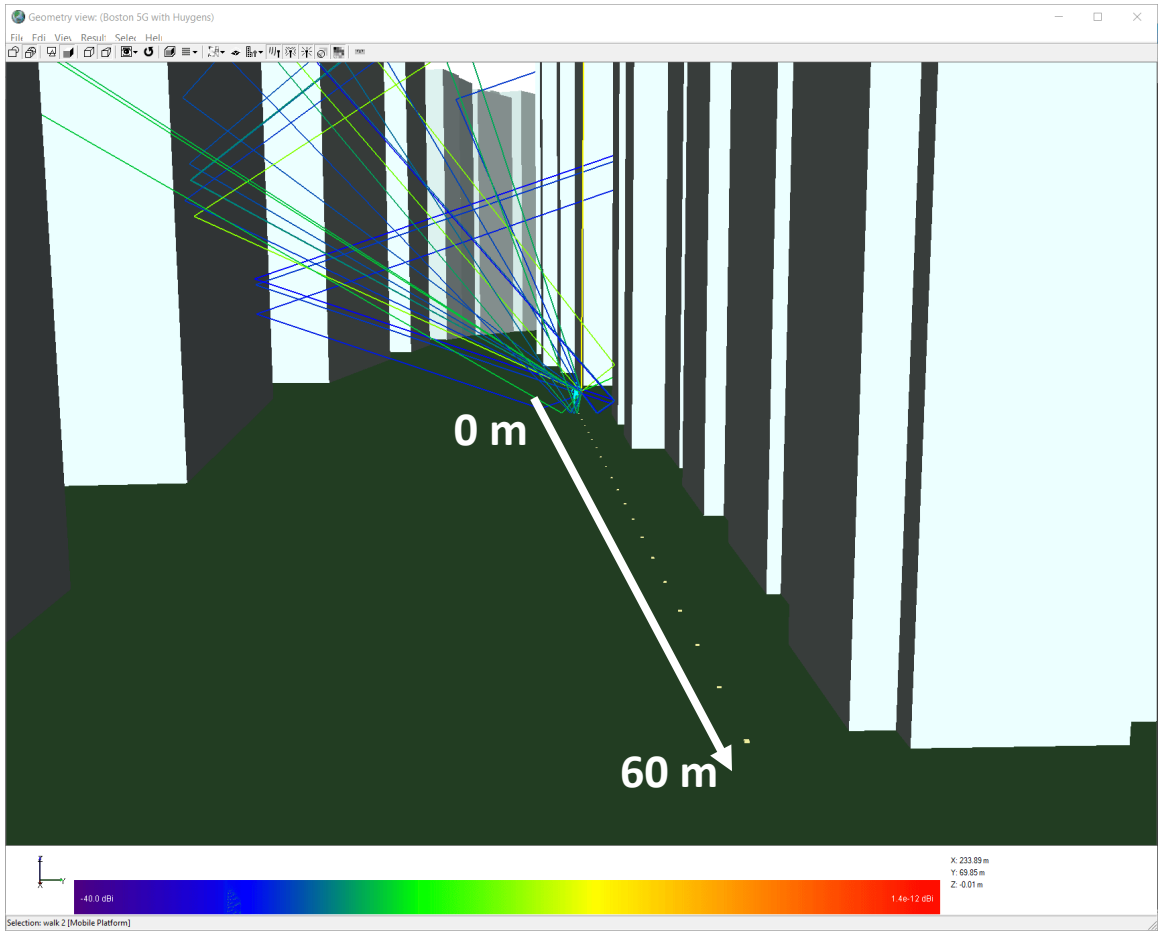


GPS Signal in Boston

Plane Wave (V/m)	100
Power Density (W/m^2)	13.26
Power Density (dBm/m^2)	41.226
Theta AOA (degrees)	71
Phi AOA (degrees)	341







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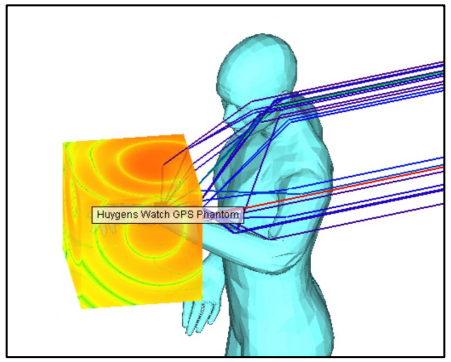
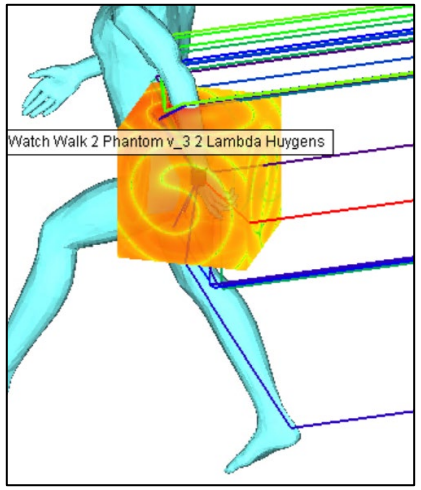
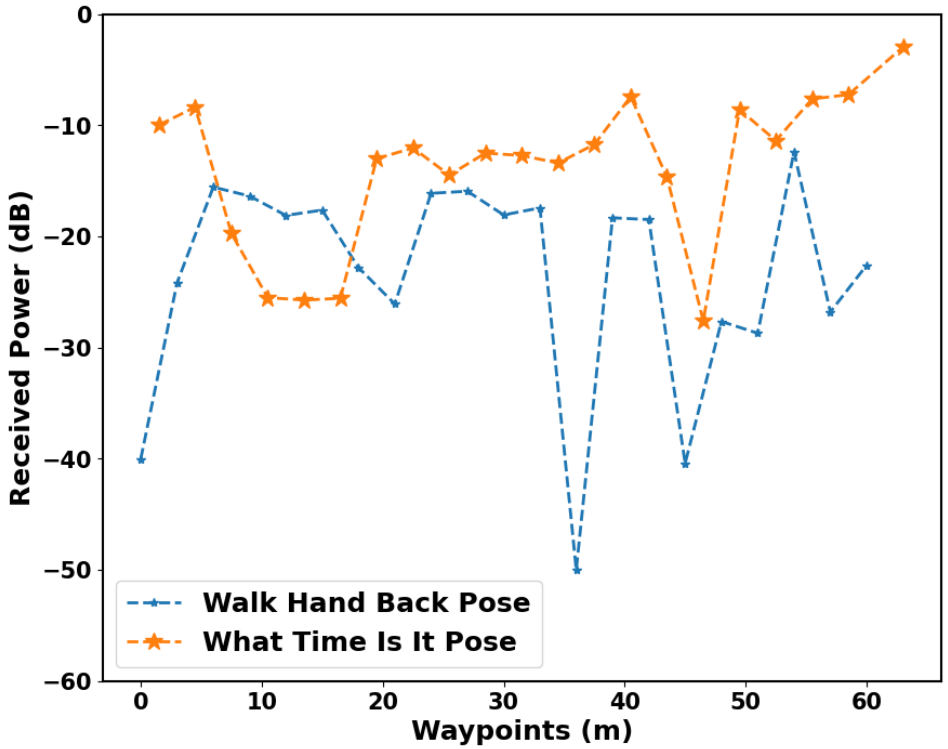
GPS Signal in Boston

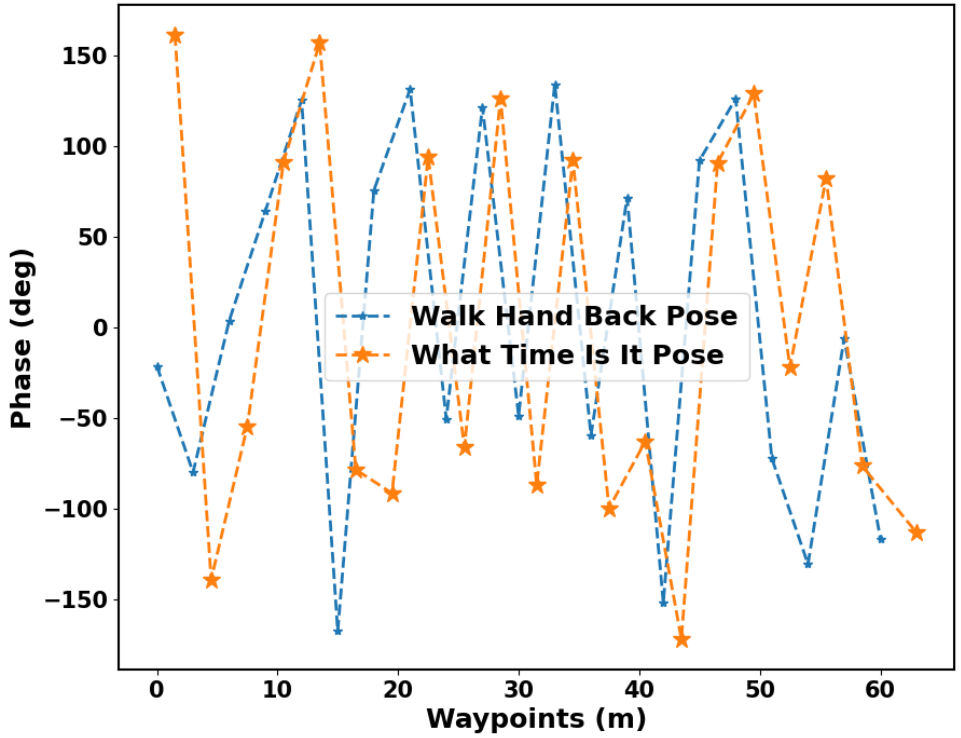


What Time Is It Pose



Walk Hand Back





- Near-field effects of on-body position
- Multipath effects as person moves through environment

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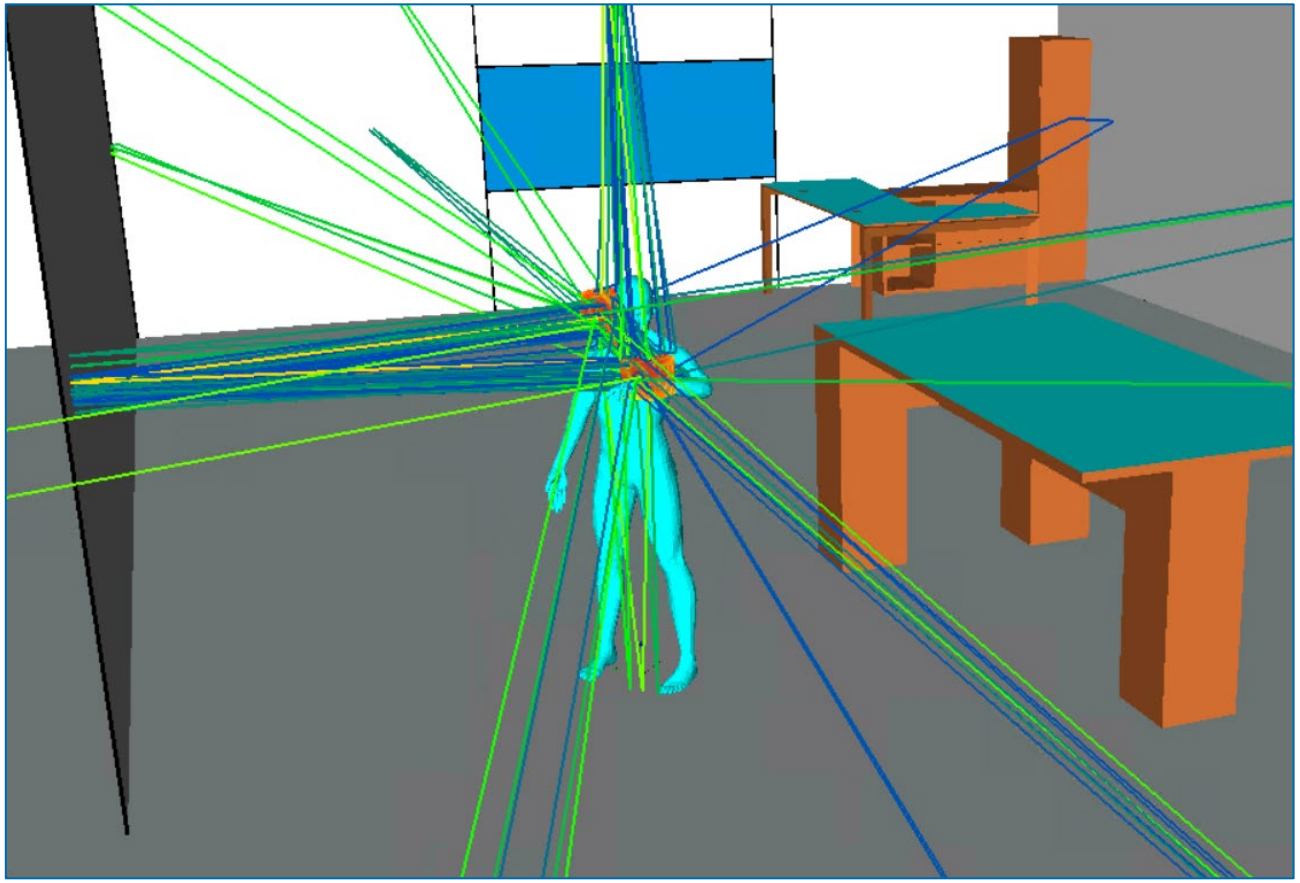
Benefits of Huygens Antennas

- Huygen's workflow captures near-field accuracy of XFdtd inside InSite's powerful ray tracer
- On-body/platform antennas simulated in electrically large scenes
- Huygen's workflow decreases the hardware requirements for simulation



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Lunar Propagation

Lunar Propagation

- Import Lunar Reconnaissance Orbiter (LRO) Lunar Orbiter Laser Altimeter (LOLA) terrain datasets
- Accurately transform the coordinates of RF mobile systems upon lunar terrain
- Set appropriate defaults to no atmosphere (vacuum) for lunar environments
- Built-in lunar materials database

Importing Lunar Terrain

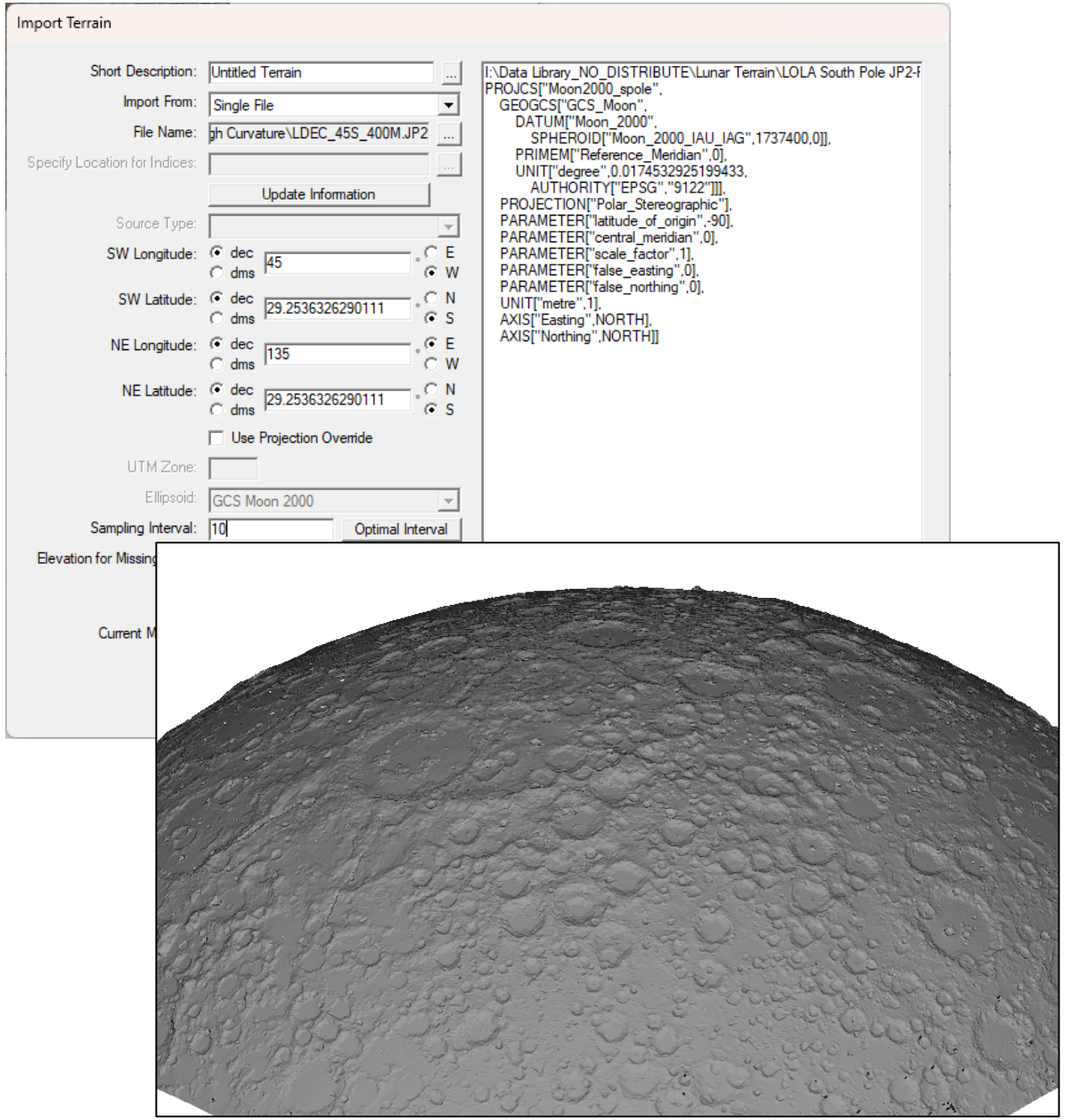
Additional terrain elevation formats supported:

- TIFF/BigTIFF/GeoTIFF
- JPEG-2000
- PDS/PDS4

View metadata from elevation source

Automatically set GCS Moon 2000 ellipsoid projection, or manually override

Automatically adjust atmospheric defaults for projects based on lunar terrain



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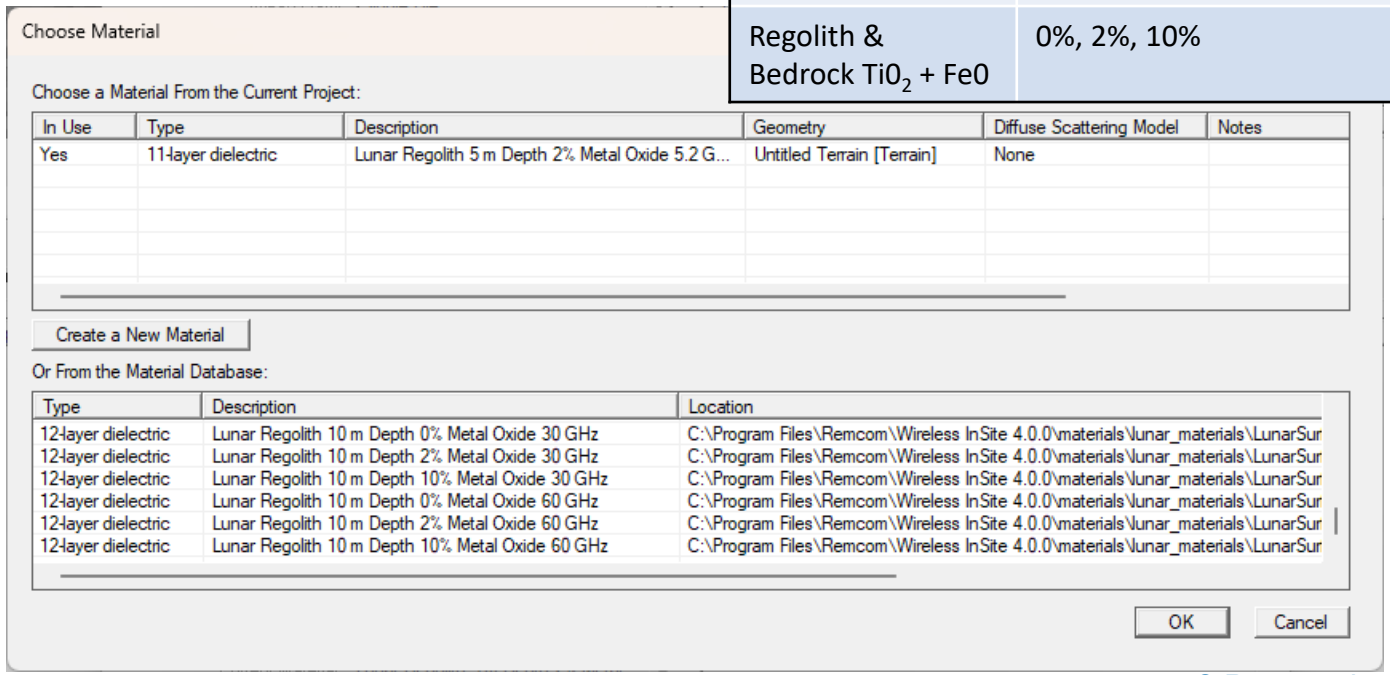
Lunar Surface Materials: Regolith & Bedrock

- Lunar regolith materials database
- Based on ITU working document ITU-R [LUNAR_PERMITTIVITY]/3
- Predefined for a range of inputs
  - 189 materials
  - 21 frequencies
  - 3 regolith depths
  - 3 metal composition percentages

Parameter	Values	Units
Frequencies	WiFi: 2.4, 5.2, 6, 7, 60 4G/5G: 0.7, 2.5, 3.6, 5.2/6, 28 SATCOM: • L-Band: 1.55, 1.65, 1.7 • S-Band: 2.0, 2.1, 2.2 • X-Band: 8 • Ka Band: 18, 19, 20, 28, 29, 30	GHz
Regolith Depth	0 (exposed), 5, 10	m
Regolith & Bedrock TiO_2 + Fe0	0%, 2%, 10%	% by weight



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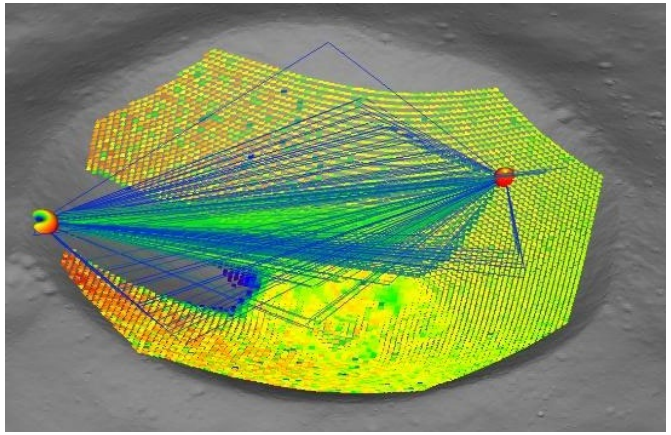
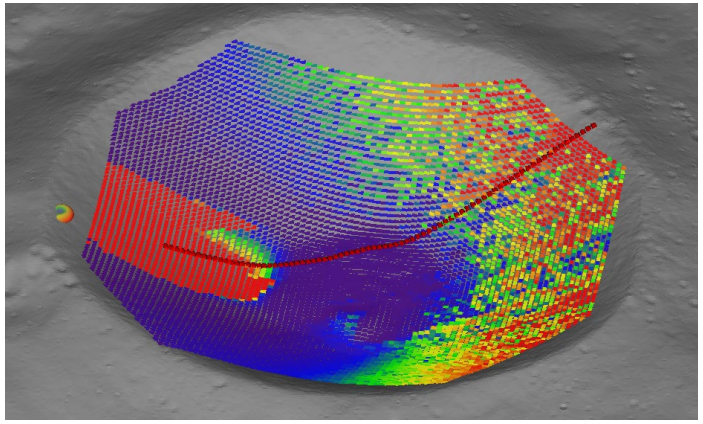
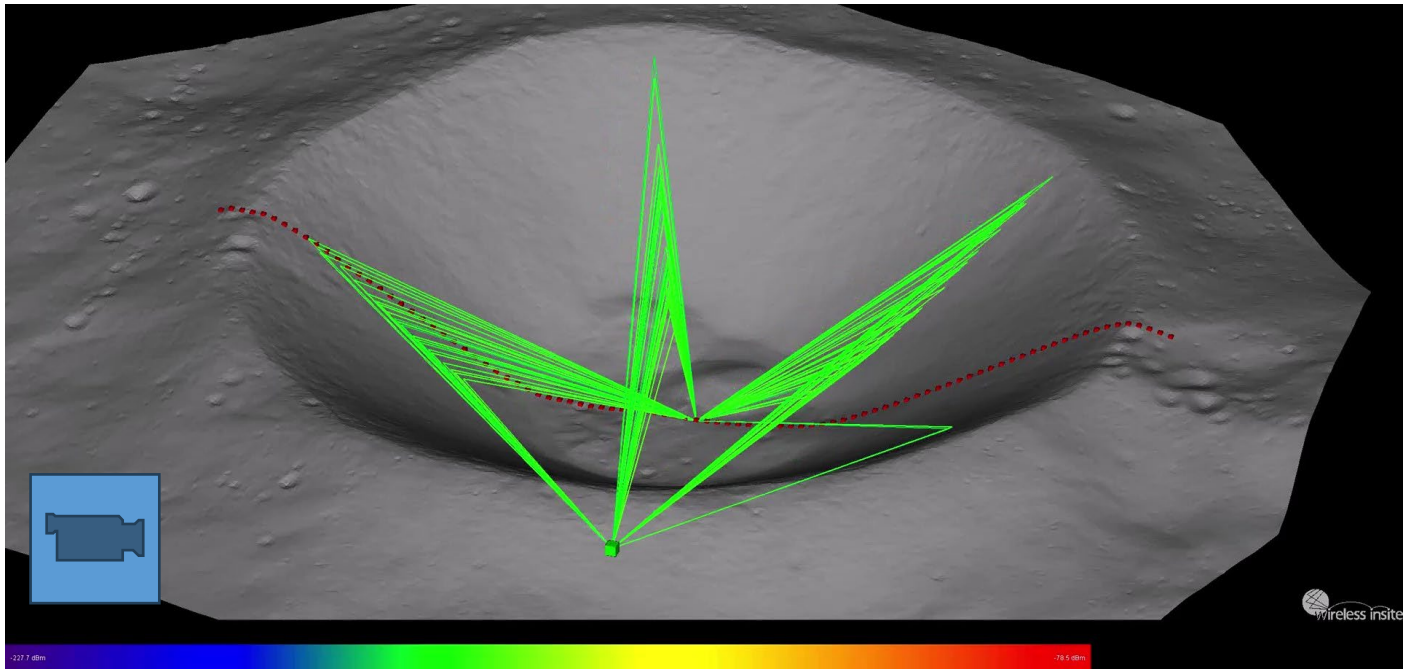
Lunar Propagation

- Imported lunar terrain
- Regolith materials from Wireless InSite database
- X3D simulation showing coverage map, delay spread & animated ray paths

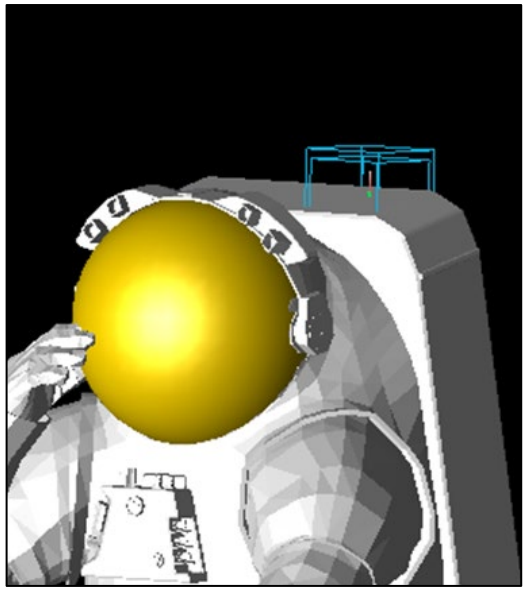


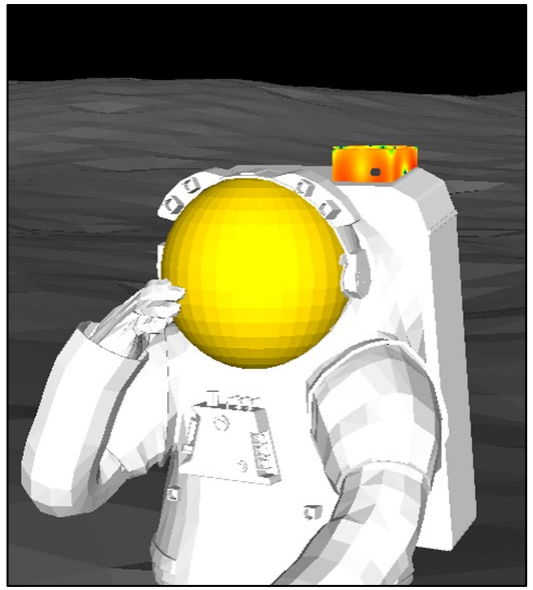


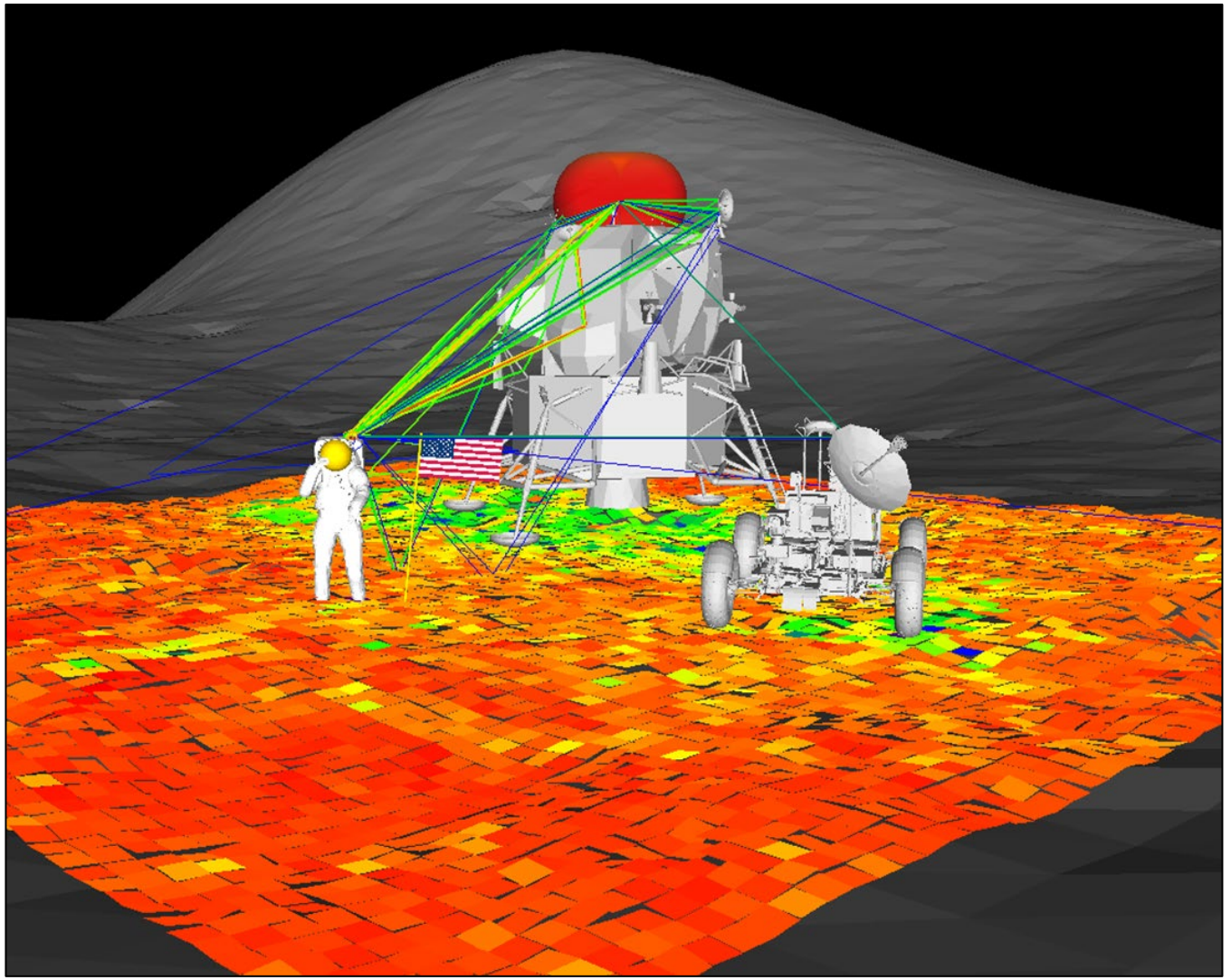


Support NASA Lunar Artemis Missions

- Compatible with Mobility and Huygens
- Ongoing work to provide:
  - Lunar material generator
  - Improved 3D ray-tracing







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Summary

- Wireless InSite
  - Validated deterministic RF simulation in arbitrary environments
  - Accurate, detailed path data
- Mobility
  - Define motion for configurations of objects and transceivers
  - Time-based results
- Multi-frequency broadband analysis
  - Single project defines broadband scenario
  - Optimized multi-frequency analysis
- Huygens antennas
  - Near-field accuracy of full-wave solver with the ability to run in complex large-scale environments
  - Improved runtime, smaller resource footprint, and frequency-agnostic solution
- Lunar propagation
  - Terrain import and Lunar materials database
  - Optimized and enhanced ray-tracing for lunar environments

Thank You!
Questions?

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