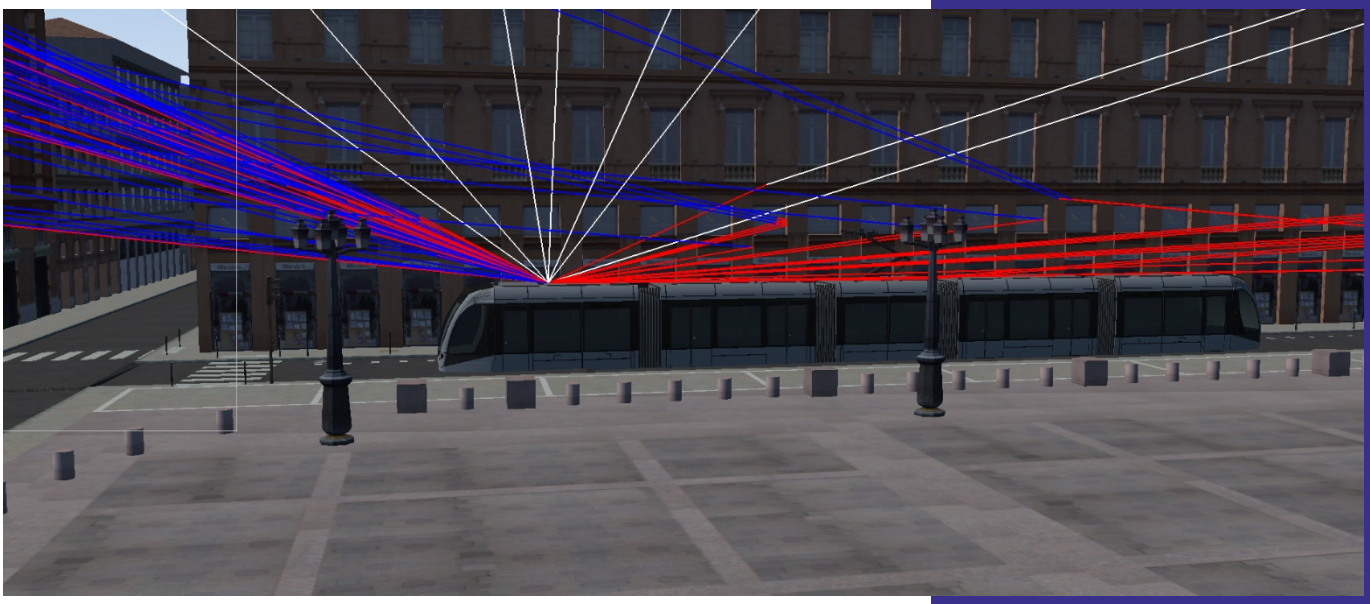
DATASHEET



Spirent Sim3D Datasheet

Realistic 3D modelling of multipath and obscuration

In collaboration with

OKTAL-SE
Synthetic Environment

Spirent Spirent Sim3D Datasheet

Purpose of this Document

This datasheet describes the functionality of Spirent Sim3D, a realistic Realtime multipath simulation software solution

This datasheet also provides technical product specification data and configuration information. Please speak to your Spirent sales representative to discuss your requirements.

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Introduction

Spirent Sim3D is a unique approach to simulating multipath and obscuration based on a true to life synthetic environment. Different realistic environments can be modelled i.e. urban, deep urban, dense forest and highway. The interaction between the signal and the environment (building, cars, pedestrian, trees) is calculated by considering the shadowing and the multipath effects.

Multipath can be one of the main sources of error in a GNSS receiver. Multipath errors can vary from a few metres to hundreds of metres due to the geometry of the satellites and environmental conditions. The characterization and study of multipath is complex but important when its effects need to be compensated in the position, navigation, or timing solution. Sim3D is an innovative real-time system that allows the reproduction of authentic multipath that strictly depends on the environment. The system combines a state-of-the-art GNSS simulator and an advanced GNSS propagation model. The propagation model relies on a 3D-scene of the environment, which is used to generate the multipath and obscuration signature that strictly depends on the location of the receiver's antenna.

The need for accurate positioning solution has been increasing in recent years, this is because of multiple new applications that rely on accurate positioning, i.e. autonomous vehicle and location-based services. In many cases the accuracy required is expected to be down to cm levels, testing such strict requirements is crucial for the success of such applications.

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Features and Benefits

Spirent Sim3D provides the realism that simulation has been needing, the multipath and obscuration is simulated based on a synthetic 3D model, real-life locations can be regenerated and used in simulation to recreate the multipath signature of that location. In addition, traffic, crowd and other objects are used in the simulation to provide a level of realism and control not available in any other approach. Real life applications i.e. pedestrian motion, DUT in the car could be generated and tested. The antenna's carrier could be defined as a vehicle, pedestrian or other objects, then the position of the antenna could be set relative to the carrier CofG. The multipath and obscuration is computed considering the antenna carrier body. This feature provides a valuable technique to optimise the location of the antenna for multipath/obscuration and analyse the results of the position based on the antenna position relative to the carrier.

Sim3D provides a level of control not available in any other multipath/obscuration simulation approaches, chose what constellation to simulate, what SV to simulate, the number of reflection per multipath, the number of multipath per LOS, and many more. This enables the user to analyse the effect of multipath in more details for example by isolating a particular SV, which may be contributing more in error than others.

Sim3D is fully customisable to your testing needs, the solution provides a complete software package which allows the creation of your own 3D model with the level of accuracy desired. Many generic 3D model formats are supported using provided converters. The user can also create or import different objects to use in the 3D model.

- Supports GPS, GLONASS, BeiDou, Galileo, QZSS, and SBAS
- Support all frequencies and codes currently simulated by Spirent simulator
- The signal code, carrier, and power are manipulated based on interaction with the environment
- Supports static and dynamic scenarios
- Up to 31 multipath signals per line of sight (LOS) simulated
- Up to 6 reflections per multipath computed
- Ability to generate your own 3D models
- Import externally generated models and objects
- Multiple 3D models are included
- Dynamic trajectory generation
- Support for a scene size of up to 5km^2 or greater for highway scenes
- An unprecedented level of control
  - Constellation and Frequencies to be used
  - Obscuration mode on/off
  - Multipath on/off
  - Number of reflections per multipath signal
- User-defined filtering algorithms to simulate only multipath in chosen delay/power ranges
- Visualise the multipath direction of arrival
- Building and object materials are modelled and taken into account during the computation
- Support for hardware-in-the-loop setups

Sim3D Overview

Software Package Explained

Sim3D is a Collaboration between Spirent Communications and OKTAL-SE who are expert in 3D environment modelling, Sim3D Software package includes SE-NAV, SE-AGETIM-LIGHT and SE-FFT

SE-NAV

SE-NAV is a deterministic simulator dedicated to the assessment of GNSS signals reception in constrained environments. It assesses the performance (i.e. availability and reliability) of space and/or terrestrial GNSS systems in 3D virtual scenes representatives of real areas. SE-NAV uses the deterministic method of Ray Tracing to compute the obscuration effects and the multipath (reflections, diffractions, transmissions) generated by the objects in the environment. SE-NAV uses geometrical optics (for reflections and transmissions) and Uniform Theory of Diffraction (for diffractions) to model the interaction of buildings on the propagation of the GNSS signal.

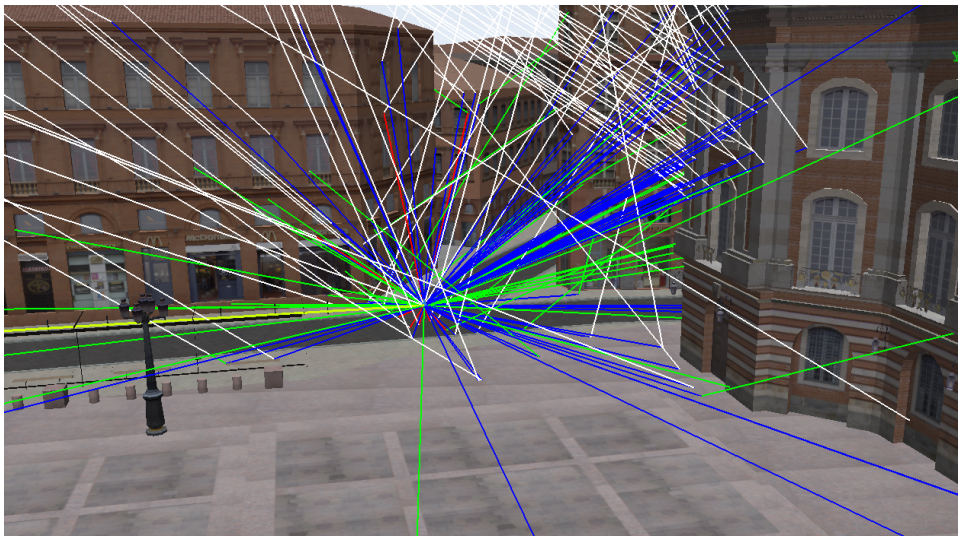

Figure 1 GPS reception in Toulouse (Place du Capitole)

White rays model the incoming signal from the satellites (LOS). Blue (diffraction), red (reflections) and green (transmissions)

SE-NAV embeds a proprietary GPU core providing the relevant outputs in record times. The principle is to use GPU resources instead of the CPU to perform Ray Tracing to decrease drastically the simulation time. SE-NAV includes a high-performance render engine that displays a 3D scene as well as 3D information such as the hiding mask, the multipath reaching the receiver or the coverage within a given area. The electromagnetic parameters of each object of a scene are easily configurable by the user thanks to an intuitive interface.

SE-NAV produces numerous data stored in ASCII files (SCILABTM/MATLABTM format). SE-NAV computes the complete link budget of each transmission channel. The received powers of every multipath, as well as the composite powers of every channel, are provided. SE-NAV also computes geometrical output such as visibilities (LOS, NLOS, deep NLOS), Dilutions Of Precision (HDOP, VDOP, TDOP, PDOP and GDOP) or Doppler shifts.

SE-AGETIM-LIGHT

SE-AGETIM-LIGHT is a simple terrain generation tool. It allows users to generate a virtual 3D scene, ready for simulation with Sim3D. Existing data (planimetry, altimetry, photography) could be imported and modified. The data is automatically treated (corrected, simplified, kept or ignored in the generation process…), and the result is a virtual mock-up ready to be imported by SE-NAV.

SE-AGETIM-LIGHT Features include are:

- Source data acquisition via the internet
- Terrain generation (minimizing GIS operation)
- Priority to the realism and aesthetics of the generated 3D Model
- Robustness regarding the quality of source data

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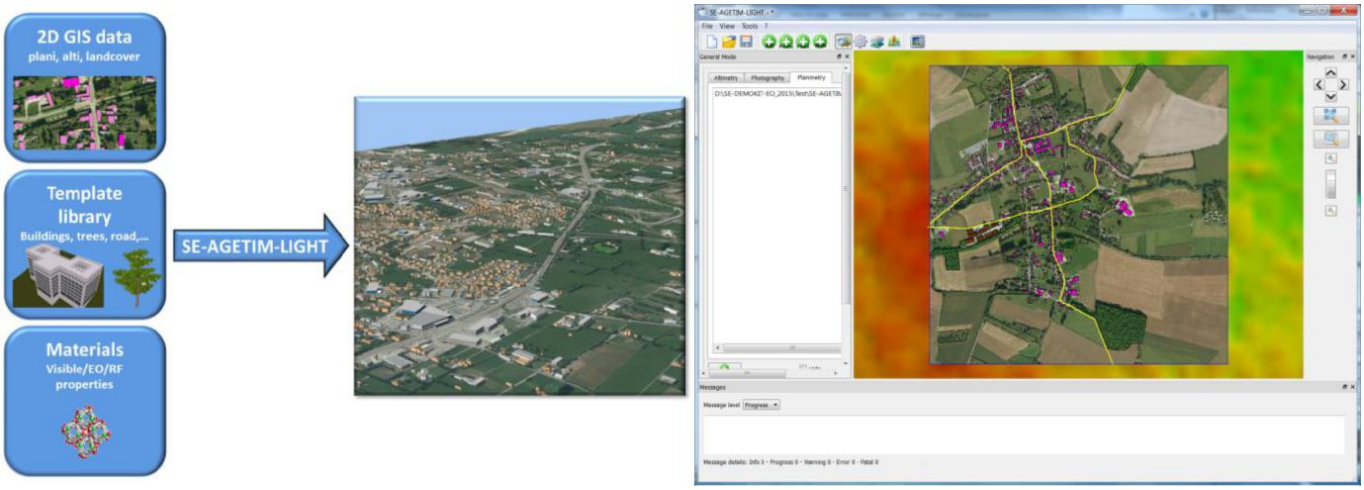

Figure 2 SE-AGETIM-LIGHT

SE-FFT and Plug-ins

SE-FFT is used to convert an existing 3D model into Sim3D format. SE-FFT consists of a set of bi-directional conversion tools used for the import/export from/to SDM format (standard Sim3D format) from/to other standards formats, i.e. Open FLT, DXF and VRML. The software is delivered with plug-ins to 3DSMaxTM and SketchUpTM that enable the import/export and modification of many 3D formats for objects geometry and meshing.

Our plugins can convert many formats such as:

- COLLADA, SKP, KMZ, DEM, OBJ
- VRML, STL, VIZ, 3DX, 3DS, FTL, IGES

How Sim3D Works

Sim3D consists of:

- PosApp which simulates the GNSS constellation, antenna/vehicle dynamics, and location.
- SE-NAV which models GNSS signal propagation i.e. obscuration, multipath reflection, and diffraction
- A TCP/UDP interface, based on the Spirent SimREMOTE protocol. This enables PosApp and SE-NAV to communicate in Real-Time.

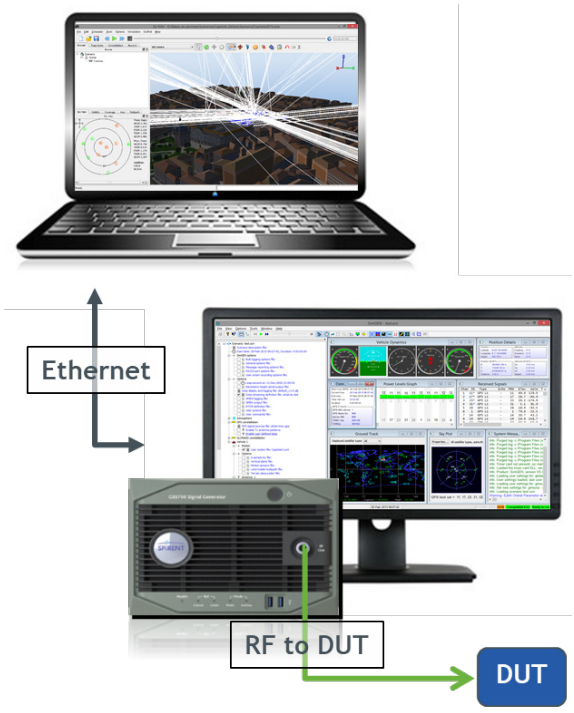

Figure 3 Sim3D Connection Diagram

Sim3D supports 10Hz Multipath update rate, this means that at each epoch i.e. 100ms, the following takes place:

1. PosApp sends in real-time to SE-NAV:
    - Satellite and signal information
    - Vehicle/antenna location
    - Vehicle/antenna attitude
2. SE-NAV computes in real-time based on the local environment:
    - Signal Power (LOS/NLOS)
    - Code offset (NLOS)
    - Carrier offset (NLOS)
    - Azimuth and Elevation (NLOS)
3. PosApp enables multipath channels and updates the RF output to the DUT according to the provided data from SE-NAV.

PosApp supports up to 1KHz simulation iteration rate when running Sim3D, PosApp uses interpolation technique to update the HW between each of the multipath update samples.

Motion Simulation

Sim3D is capable of simulating scenarios with motion. The trajectory and attitude of the vehicle are defined and controlled in PosApp as per the standard PosApp tools, Sim3D offers the opportunity to create a trajectory within the 3D model and then convert it to a UMT format ready to be used in PosApp. As well as defined trajectory, Sim3D is fully compatible with low latency HiL setup where remote motion is injected to PosApp.

Full Level of Control

Sim3D provides an unprecedented level of control for multipath simulation, all available simulation parameters that currently exist in PosApp are available for Sim3D, this includes:

- Start Time and Date
- Definition of the appropriate GNSS Constellation(s)
- Atmospheric parameters for both the Ionosphere
- Vehicle performance envelope – Personality
- Antenna orientation
- Satellite TX and receiver RX Antenna Patterns (Gain and Phase)
- Vehicle motion commands (Initial position and 6-DOF trajectory definition for one or multiple vehicles)
- Any many more…

Other multipath specific control available in Sim3D:

- Ability to enable reflections only, diffractions only or both
- Ability to enable transmission
- Obscuration mode (switch Multipath off)
- Ability to control the maximum reflections calculated per ray
- Ability to chose the multipath to be simulated in a certain range of delay/power
- Ability to filter out even reflections

Multipath Filtering

Sim3D's ray tracing algorithm computes every ray (multipath) for each of SV in view. The need for multipath filtering has arisen from the limitation in the hardware and the number of channels that could be simulated. The multipath filtering algorithm enables the user to control the maximum number of multipath simulated by PosApp as well as giving the user control over which multipath to send to PosApp from the vast number of multipath rays calculated by Sim3D

In addition, the multipath filtering algorithm could be used as a very useful tool in understanding the DUT behavior based on different set of multipath characteristics. The filtering algorithm gives the user the opportunity to define one or multiple ranges of power (dBm) and delay (m) to be simulated in PosApp.

Number of Multipath for Each LOS

Due to the physical limitation in the number of hardware channels available for the simulator, the limited number of multipath could be simulated per each SV in view. In most cases, it has been observed that up to 4 multipath per SV in view are needed to ensure that realistic behavior is simulated. But in other cases, the number of multipath required may vary.

The number of multipath per SV available for the user relies on multiple factors:

- Maximum number of channels enabled per constellation ($chan_{per\_const}$)
- Max SV in view per constellation in the simulation (SV_{in_view})

Maximum desired multipath per SV in view (MP_{per_LOS}) can be computed as below:

$$MP_{per\_LOS} = \frac{Chan_{per\_const} - SV_{in\_view}}{SV_{in\_view}}$$

Table 1 Example of number of Multipath per SV

Max LOS per constellation	Max Multipath per LOS
4	15
6	10
8	7
10	5
12	4
16	3

The example in Table 1 assumes 64 channels per constellations are available

3D Models (Synthetic Environment)

Sim3D uses Synthetic Environments to carry out a simulation. A Synthetic Environment is a virtual representation of a real environment. It mimics the geometries (terrains, buildings, vehicles etc…) as well as the Physics (material, atmosphere…).

Synthetic Environments are defined into three categories:

Fictional: 3D scenes which do not model any real or realistic environment. Can be employed to study impact from Geometric/Physical differences on GNSS system. E.g. modification of roof shape (realistic roof vs. flat roof vs. no roof, etc.) to assess the impact of multi-path impact and visibility of satellites.

Geo-Typical: 3D scenes that model a realistic environment. i.e. a typical scene such as a dense city or a mountainous area). Based on real parameters such as real building heights and areas but some elements such as doors and windows are randomly defined. Templates of buildings are used to characterise the shapes of the buildings to be created. Mainly used to assess the performance of GNSS systems in typical environments and used for statistical studies.

Geo-Specific: 3D scenes which model a real environment. Accurate in terms of geometry and physics. Used to either reproduce a real reception (e.g., for mission debriefing), or to forecast a reception (e.g., for mission planning) Quality of the 3D data has a strong impact on the simulation performance. Correct geometries of buildings, obstacles (such as street lights, road signs, vehicles, etc.) impact the correlation to real life measurements

The Sim3D Software package includes all the necessary tools and instruction to create a 3D model with the desired accuracy level. Easy to use converters and plugins are also provided as standard for the user to import their own 3D models/terrains i.e. DTED, DEM, Google, and other formats.

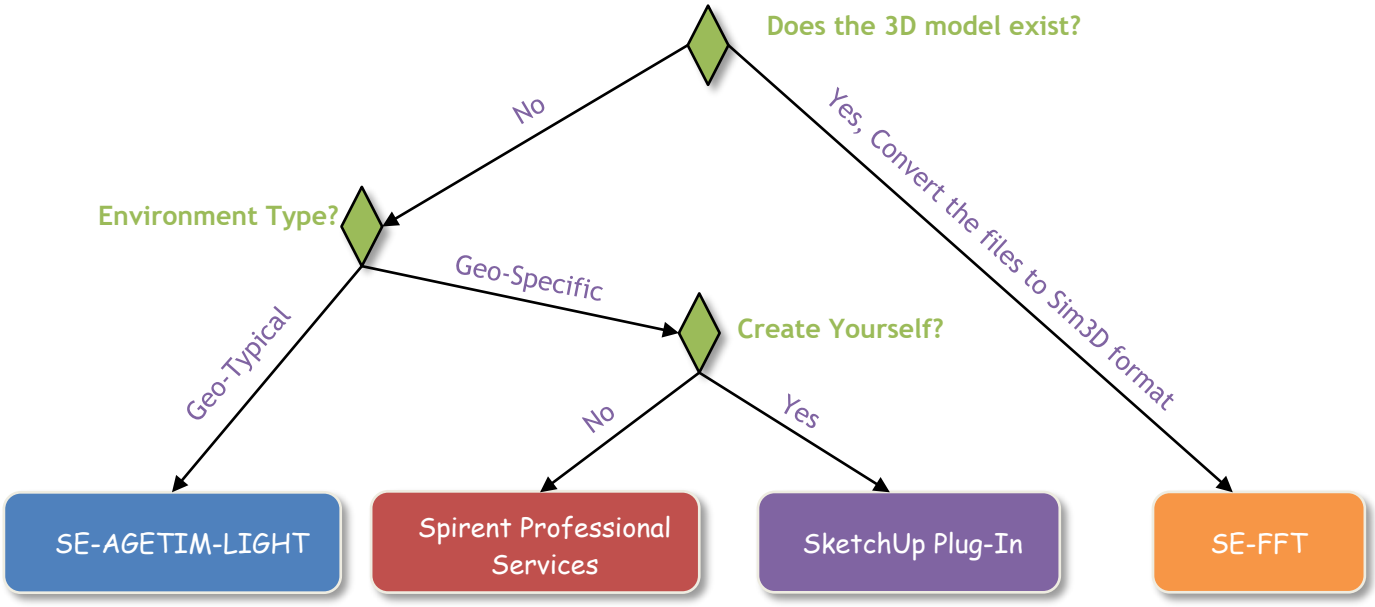

Figure 4 3D Models Creation Options

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Sim3D GEO-TYPICAL

Sim3D GEO-TYPICAL is an affordable offering that enables the user to simulate multipath and obscuration effect in a pre-canned number of geo-typical 3D models available with the SW package. The pre-canned 3D models cover most common test needs in different environments, i.e. Urban, Peri Urban, etc. . The user can define their static DUT location anywhere in the 3D model or define a motion trajectory within the 3D model. This entry-level offering of Sim3D offers the ability to simulate multipath and obsecuration effect at a level above and byond what PosApp current internal models offer.

- Delivered with 5 x Geo-Typical 3D models
- Geo-localisation of the 3D model anywhere, i.e. Modify the Lat/Lon/Height
- Allow the user to create trajectory and convert it to UMT
- Allow the user to convert coordinate form SE-NAV to PosApp format
- Allow the user to define the number of reflections/transmission and diffraction
- Allow the user to set the maximum number of multipath per LOS and take advantage of all the user-defined filtering algorithm available.
- Allow the user to use moving vehicles as an antenna's carrier
- Allow the user to use the pedestrian as an antenna's carrier
- Allow the user to choose from a set of vehicles models
- Allow the user to choose from a set of pedestrian models/dynamics
- Allow the user to set the DUT position relative to the carrier
- Allow visualisation of multipath in SE-NAV GUI

The following features are **not possible** in Sim3D GEO-TYPICAL:

- Load any 3D models supported by Sim3D
- Load any 3D objects supported by Sim3D
- Use of traffic and crowd models
- Simulate in vegetation environment
- Logging of SE-NAV commands
- SE-NAV Standalone capabilities i.e. Heatmaps
- SE-NAV remote interface
- Antenna management in SE-NAV
- Carry changes to the physical materials of the buildings

An upgrade route is available from Sim3D GEO-TYPICAL to Sim3D full capability.

Sim3D Offerings Comparison

Table 2 Sim3D Vs Sim3D GEO-TYPICAL Comparison

Feature	Sim3D	Sim3D GEO-TYPICAL
Simulate Multipath and obscuration effect based on 3D model	✓	✓
Interface with PosAPP to allow realistic RF simulation	✓	✓
Support for all constellations and frequencies currently supported on the Spirent simulator	✓	✓
Support for static and dynamic simulation	✓	✓
Ability to set a static location in the 3D model and convert it to PosAPP location	✓	✓
Ability to create a trajectory in the 3D model and convert it to a UMT file to be used by PosAPP	✓	✓
Ability to use a vehicle and pedestrian as receiver carrier	✓	✓
Ability to define and control the number of reflections, transmission, and diffraction	✓	✓
Ability to set the DUT position relative to the carrier	✓	✓
Library of 3D models available with the package	✓	✓
Geo-localisation of the 3D model anywhere, i.e. Modify the Lat/Lon/Height	✓	✓
Load any 3D models supported by Sim3D	✓	✗
Load any 3D objects supported by Sim3D	✓	✗
Use of traffic and crowd models	✓	✗
Simulate in vegetation environment	✓	✗
Logging of SE-NAV commands	✓	✗
SE-NAV Standalone capabilities i.e. heatmaps	✓	✗
SE-NAV remote interface	✓	✗
Antenna management in SE-NAV, i.e. RHCP/LHCP	✓	✗
Carry changes to the physical materials of the buildings	✓	✗
Complete SW package to allow the creation of own 3D models and objects	✓	✗
Import user existing 3D models and objects to Sim3D	✓	✗

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Performance Specification

Table 3 Sim3D Performance Specifications

Parameter	Value	Note
Supported constellations and frequencies	GPS L1L2L5 GLO L1L2 GAL E1E5E6 BEI B1IB2IB1cB2aB3I QZSS L1L2L5L6 SBAS L1L5	Constellations are subject to separate Spirent licences
Supported codes	GPS L1: C/A, P, M noise, L1C Pilot, L1C Data GPS L2: P, C/A (L2C), M noise GPS L5: I, Q GALILEO E1: E1-A, E1-A PRS Noise, E1-B, E1-C GALILEO E5A E5B: E5a-I, E5a-Q E5b-I, E5b-Q GALILEO E6: E6-A, E6-A PRS Noise, E6-B, E6-C BEIDOU: B1I, B2I, Ba1, B1c, B3I	
Maximum SV per simulation	45	This is the maximum visible SVs across all constellations at any one time during the simulation
Supported simulator	GSS9000 GSS7000	GSS9000: SimGEN SIR 100Hz: up to 320 channels with 2 x GSS9000 simulators GSS9000: SimGEN SIR 1KHz: up to 160 channels with 1 x GSS9000 simulator GSS7000: up to 256 channels at SimGEN SIR of 10Hz or 100Hz
Supported software Level	SimGEN® SimREPLAYplus SimTEST	
Maximum number of vehicles in PosApp scenario	1	
Maximum number of antennas in PosApp scenario	1	
Type of vehicle supported in PosApp scenario	Static Rover Remote	
Maximum multipath per LOS	31	This is the maximum number of multipath associated with a LOS
Maximum reflection per multipath	$6^{1/2}$	This is the maximum number of reflection per multipath before it reaches the receiver
Maximum 3D model size allowed	$5Km^2$	This is the maximum allowed 3D model size loadable in Sim3D Note: A greater size scene is available for highway testing

1 Spirent recommends a maximum of 6 reflections, increasing the number above this will add extra computation power on SE-NAV that might result in higher latency or missed data due to the maximum number of SVs.
2 Any reflections above 6 are most likely very weak in power and will have a negligible effect on the receiver.

System Iteration Rate

Table 4 Sim3D Iteration Rate

Parameter	Value	Note
Supported PosApp Iteration Rate (SIR)	100ms (10Hz) 10ms (100Hz) 1ms (1KHz)	The rate at which PosApp compute the required data and update the hardware.
Sim3D Update Rate	1s (1Hz) 500ms (2Hz) 100ms (10Hz)	The rate at which Sim3D update PosApp with the multipath parameters, i.e. MOD command update rate. PosApp uses interpolation techniques to meets its SIR rate.
Sim3D Maximum Logging Rate	100ms (10Hz)	The rate at which Sim3D log incoming and outcoming data
Supported PosApp Logging Rate	100ms (10Hz) 10ms (100Hz) 1ms (1KHz)	The rate at which log the data
Sim3D GUI Update Rate	1s (1Hz) 500ms (2Hz) 100ms (10Hz)	The rate at which Sim3D update its GUI with new multipath ray. Note: For computation demanding scenarios, 1Hz is recommended.

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Ordering Information

Table 5 Sim3D Part Numbers

Part number	Description
Sim3D-4000	Spirent Sim3D Software Package
Sim3D-4001	Spirent Sim3D GEO-TYPICAL Software Package
Sim3D-5000	Spirent Sim3D Host Laptop
Sim3D-6000	Upgrade from Sim3D GEO-TYPICAL to Sim3D
Sim3D-9000	Sim3D 3 Days Training at Customer Site EU
Sim3D-9001	Sim3D 3 Days Training at Customer Site NON-EU
Sim3D-9002	Sim3D 3 Days Training at OKTAL-SE Site
Sim3D-9003	SIM3D+SIMGEN 5 DAYS TRAINING AT CUSTOMER SITE EU
Sim3D-9004	SIM3D+SIMGEN 5 DAYS TRAINING AT CUST SITE NON-EU

Deliverables

Table 6 Sim3D Deliverables

Item No.	Quantity	Description
1	1	Spirent Sim3D Host Laptop
2	1	Spirent Sim3D Software Package: • SE-NAV • SE-AGETIM-LIGHT • SE-FFT (Including SketchUp/3DSmax plug) • One Geo-Specific 3D models • Five Geo-Typical 3D models
3	1	Ethernet Kit

Table 7 Sim3D GEO-TYPICAL Deliverables

Item No.	Quantity	Description
1	1	Spirent Sim3D Host Laptop
2	1	Spirent Sim3D GEOTYPICAL Software Package: • SE-NAV • Five Geo-Typical 3D models
3	1	Ethernet Kit

Please contact a Spirent sales representative to discuss the purchase of additional channels or constellations.

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Related Brochures, Datasheets, and Specifications

Table 8 Related Product References

Related Product	Description	Data Sheet / Specification
GSS7000	Multi-Frequency, Multi-GNSS RF Constellation Simulator	MS7000
GSS9000	High-End Multi-Frequency, Multi-GNSS RF Constellation Simulator	MS9000

Glossary of terms

Az	Azimuth
COTS	Commercial Off The Shelf
DoA	Direction of Arrival
DUT	Device Under Test
El	Elevation
GNSS	Global Navigation Satellite System
GPS	Global Positioning System US GNSS system
GUI	Graphical User Interface
LOS	Line of Sight
MP	Multipath
NLOS	None Line of Sight
OS	Operating System
OTA	Over the Air
R&D	Research and Development
SDM	Signed Differential Mapping
SIR	Simulation Iteration Rate
SV	Satellite Vehicle
CofG	Centre of Gravity

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For more information

For more information on any aspect of Sim3D, please contact your Spirent representative or Spirent directly:

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About Spirent Positioning Technology

Spirent enables innovation and development in the GNSS (global navigation satellite system) and additional PNT (positioning, navigation and timing) technologies that are increasingly influencing our lives.

Our clients promise superior performance to their customers. By providing comprehensive and tailored test solutions, Spirent assures that our clients fulfil that promise.

Why Spirent?

Over five decades Spirent has brought unrivalled power, control and precision to positioning, navigation and timing technology. Spirent is trusted by the leading developers across all segments to consult and deliver on innovative solutions, using the highest quality dedicated hardware and the most flexible and intuitive software on the market.

Spirent delivers

- Ground-breaking features proven to perform
- Flexible and customisable systems for future-proofed test capabilities
- World-leading innovation, redefining industry expectations
- First-to-market with new signals and ICDs
- Signals built from first principles — giving the reliable and precise truth data you need
- Unrivalled investment in customer-focused R&D
- A global customer support network with established experts

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About Spirent Communications
Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks. We help bring clarity to increasingly complex technological and business challenges. Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled. For more information visit: www.spirent.com

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