

SimXTRACT

Bridging the gap between real-world environments and highly controllable situations



SimXTRACT: Redefine Positioning, Navigation, and Timing (PNT) Test

Global Navigation Satellite System (GNSS) field testing is costly, time-consuming, and difficult to repeat because real-world conditions constantly change. Traditional GNSS in-phase and quadrature (I/Q) recordings help bring real-world signals into the lab, but they have major limitations: The sources of impairment are unknown, new signals cannot be added, antenna bias is baked in, ground truth may be inaccurate, and the recordings produce terabytes of data.

SimXTRACT eliminates these limitations by decomposing GNSS I/Q recordings into their fundamental signal components. It identifies and extracts line-of-sight signals, multipath, and precise ground truth. This enables the creation of a fully editable GNSS simulation scenario that replicates the original environment — without relying on the massive raw recording.

With SimXTRACT, users can:

- Recreate real-world conditions with high fidelity.
- Add, remove, or modify impairments and signals to explore corner cases.
- Test with different antennas or antenna placements.
- Evaluate device-under-test (DUT) performance using clean baseline signals and controlled impairments.
- Reduce data size from terabytes to megabytes for easy storage and sharing.

SimXTRACT can operate offline or in real time, enabling continuous collection and transformation of GNSS data. This allows organizations to build rich, reusable GNSS test libraries and dramatically improve testing flexibility, reproducibility, and insight.

Introduction

SimXTRACT solves problems by **decomposing a GNSS I/Q recording** into its constituent signals, impairments, and ground-truth data. This allows the information to be **understood, modified, extended, and stored far more efficiently**.

Using advanced signal processing, SimXTRACT determines:

- **Original line-of-sight GNSS signals** as transmitted from orbit.
- **Multipath and non-line-of-sight signals**, including power levels, code error and Doppler error.
- **Ground-truth position, velocity, and time (PVT)** of the recording platform.

After extraction, SimXTRACT automatically creates a **GNSS simulator scenario** replicating the original environment — including impairments — without relying on the unquantifiable nature of the raw recording.

Flexible, Editable Simulation Environment

Each extracted property becomes a configurable element within the simulator scenario. Users can:

- Reproduce the recorded environment with high fidelity.
- Modify or remove specific impairments.
- Adjust signal levels.
- Add new satellites, signals, or interference sources.
- Introduce hypothetical scenarios, such as a satellite outage or new environmental structures.

For example, users can add:

- A new type of interference,
- Multipath effects from a newly constructed building,
- A new GNSS signal with similar impairments,
- Non-GNSS signals affected by the same orbital/environmental conditions.

This ability to **alter real-world recordings in a controlled and repeatable way** increases the value of past datasets, enabling the creation of corner cases and failure scenarios that did not occur in the original environment.

Understanding DUT Performance

Raw recordings make it difficult to correlate DUT performance with specific signal or environmental conditions. By decomposing the recording:

- All interference can be removed to establish baseline **performance** using only line-of-sight GNSS signals.
- Individual impairments can then be added back progressively to determine their specific effects.
- Extracted per-epoch “truth” data can be compared to DUT measurements to evaluate accuracy, robustness, and mitigation strategies.

Antenna Independence

Recordings made with a particular antenna — omnidirectional or fixed radiation pattern antenna (FRPA) — bake that antenna’s characteristics into the signal. Decomposition allows:

- Retesting with **different antenna models**.
- Changing **antenna placement** on a vehicle or device.

This enables broader and more accurate testing without repeating field data collection.

Massive Reduction in Data Size

While GNSS recordings can produce **terabytes** of data, a simulator scenario created via decomposition is only **megabytes**. This dramatically simplifies:

- Storage
- Transmission
- Sharing across teams and organizations

Users can regenerate the original signal environment without transferring massive I/Q datasets.

Real-Time and Offline Operation

SimXTRACT can operate either as a **post-processing tool** or in **real-time**.

- **Post-processing** enables detailed analysis of past recordings.
- **Real-time decomposition** minimizes data storage requirements and enables continuous operational recording.

In high-variability environments — such as battlefields or dense urban areas—systems could continuously collect GNSS data, decompress it into simulator scenarios, and store it efficiently for future testing, training, and analysis.

SimXTRACT currently supports constellations GPS L1 and L5 and Galileo E1 and E5a. Support for GLONASS, BeiDou, and Quasi-Zenith Satellite System (QZSS) constellations recorded by the Keysight GSS6450 Record and Playback System is coming soon.

Figure 1 shows the solution flow of SimXTRACT. Recorded signals stored as I/Q files in the GSS6450 are decomposed and discrete signal data is extracted for every space vehicle (SV), representing the line of sight (LOS), multipaths (MP) and their associated code error, Doppler, and power level. This data can then be analyzed based on a range of search criteria to allow the user to identify parts of the recording of interest. SimXTRACT can then create a full simulator scenario, based on the data, which can be run on any Keysight PNT simulator with a SimXTRACT feature key license.

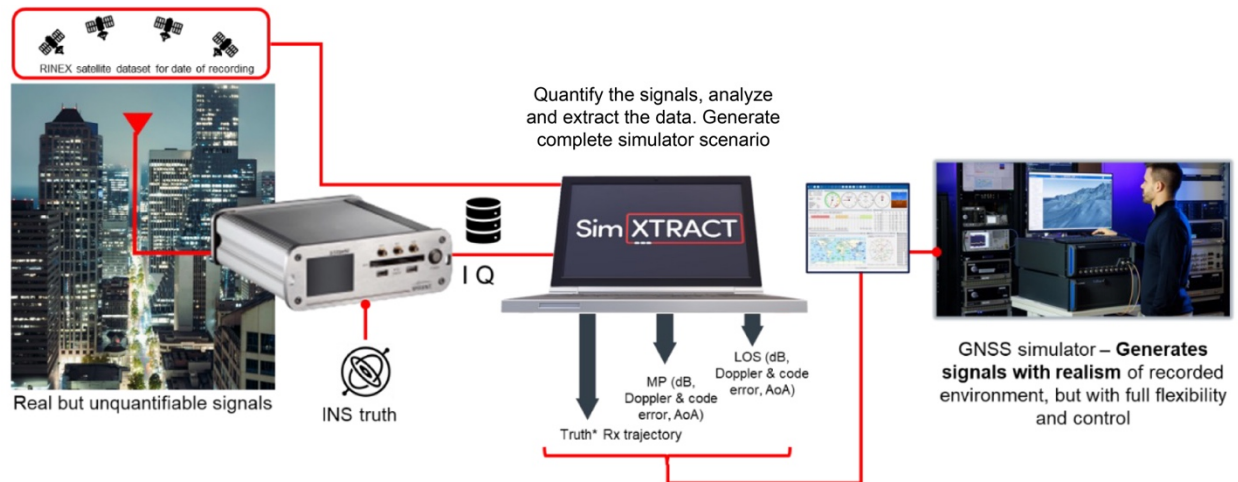


Figure 1. SimXTRACT solution flow

Figure 2 shows the main software interface screen.

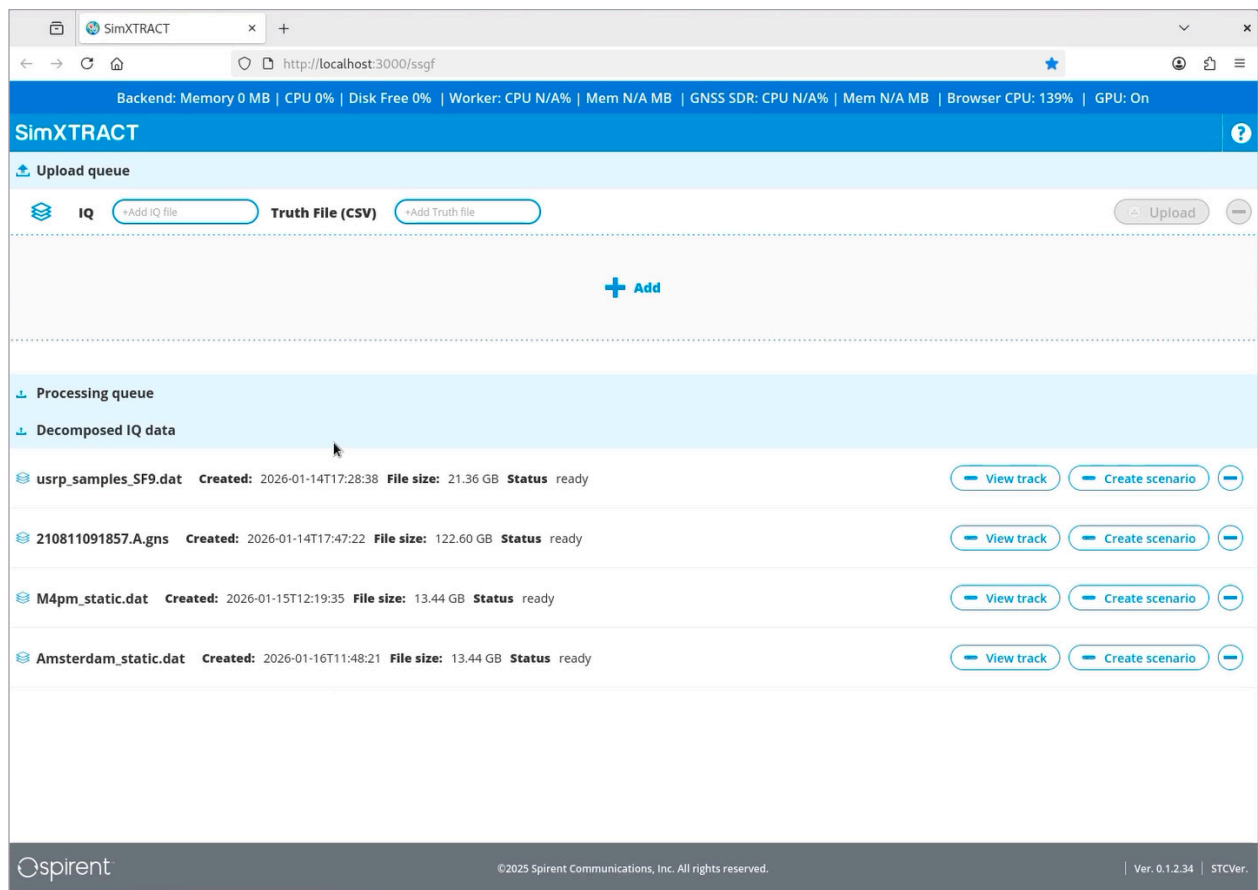


Figure 2. SimXTRACT software interface

SimXTRACT Value Add to Your Development Program

Bridging the realism gap between field and lab has distinct and significant advantages:

- It allows the use **of real signals captured in a physical location to be applied to a lab simulation** — exposing the DUT to conditions that it will ultimately see and have to work in in real life.
- Introducing realistic signals during the DUT's development and integration stages **ensures performance is fit for purpose.**
- Introducing realistic signals during the DUT's development and integration stages ensures **design bugs and optimization are discovered sooner**, making resolution less time-consuming and expensive.
- Introducing realistic signals during the DUT's development and integration stages **significantly reduces the time taken to resolve issues observed in the field** by giving the user knowledge of the makeup of the signals versus playback of a composite, unquantifiable signal.
- Decomposing signals in the field **avoids the need to transfer many terabytes of data from a remote location back to the lab.** SimXTRACT-created scenario files are much smaller and can be emailed.
- The signal data provided by SimXTRACT includes Angle of Arrival, which can be used easily **to replicate a test in a zoned chamber**, saving a lot of time.
- SimXTRACT allows you to analyze **signal data based on several selection criteria so you can home in on areas of particular concern** in a lengthy drive test, for example — focusing testing on the problems.
- Optimizing receiver designs based on realistic signals enables devices that are more **robust and fit for purpose.**

In summary, developing PNT with realistic signals makes products fit for purpose, with quicker development and reduced test cost.

SimXTRACT Product Elements

SimXTRACT comprises three purchasable elements: the SimXTRACT processing software, a host PC, and a feature key license installed on the GNSS simulator intended to run the generated simulator scenario. There are also mechanisms to upgrade the capability of the GSS6450 and the simulator to ensure SimXTRACT operates at its optimum performance.

Detailed Performance Specifications

(Preliminary, subject to change)

Item	Specification	Notes
Interface	GRPC	For PosApp scenario generation
Constellations and frequencies	GPS (L1, L5), Galileo (E1, E5a)	
Simultaneous frequencies	2	
I/Q sample rates	30.69 & 51.15 Msps	To align with GSS6450
Bit depth	4, 8 and 16	
Max multipath channel per pseudo-random noise (PRN)	1 – 10 (configurable)	Analysis shows that at least 6 multipath signals per PRN are required in an urban environment
Multipath update rate	5 Hz	
Tracking sensitivity	-155dBm	Multipaths below -155dBm will not be found
Acquisition sensitivity	-145dBm	Acquisition not possible below -145dBm
Static scenario performance with close multipath (GPS L5]	See Table 1	See Table 1
Static scenario performance without close multipath (GPS L5]	See Table 2	See Table 2
Multipath	Yes	
Multipath accuracy (code -m]	See Table 3	See Table 3
Multipath accuracy (Doppler -m/s]	See Table 4	See Table 4
Supported OS	Linux (Debian 12)	Pre-installed
Supported platform	Keysight supplied laptop	For the first release and until further notice the laptop must be supplied pre-installed with SimXTRACT, by Keysight.
Supported input recordings	GSS6450	Natively, 6450 recordings for the specifications in this table will be supported.
Supported truth formats	NovAtel *Keysight custom format	Utility is supplied to convert NovAtel-formatted truth data. This same utility can be used to convert custom truth data files. Truth data is required to ensure stated performance is met. * Please read the SimXTRACT manual for data support details
Supported PosApp version	10.04	

Table 1 summarizes the detection performance of the GPS L5 signal under a static scenario with close-range multipath present. The table shows how changing the received signal power level affects the probability of detection, missed detection, and false alarm rate of the signal decomposition algorithm.

Table 1. Static Scenario Performance with Close Multipath (GPS L5)

Signal Level (dBm)	Probability of Detection	Probability of Missed Detection	Probability of False Alarm
-135	98.48%	1.52%	0.01%
-140	98.44%	1.56%	0.34%
-145	97.05%	2.95%	0.42%
-150	94.59%	5.41%	1.74%

Table 2 summarizes the detection performance of the GPS L5 signal under a static scenario with no close-range multipath present. The results quantify how reliably the signal decomposition algorithm can detect multipath signals at different signal levels. The detection outcomes in Table 2 form the basis for the subsequent accuracy assessments: Only the multipath signals detected in Table 2 are used to generate the accuracy statistics reported in Table 3 and Table 4.

Table 2. Static Scenario Performance Without Close Multipath (GPS L5)

Multipath Signal Level (dBm)	Probability of Detection	Probability of Missed Detection	Probability of False Alarm
-135	100%	0%	0%
-140	99.74%	0.26%	0.08%
-145	98.06%	1.84%	0.75%
-150	96.13%	3.87%	1.85%

Table 3 presents the multipath code accuracy, where each detected multipath signal's code delay estimate is compared against the truth delay obtained from the Keysight simulator's bulk logging data. The aim is to quantify how accurately the signal decomposition algorithm can detect and estimate multipath signals.

Table 3. Multipath Accuracy (code -m)

Multipath Signal Level (dBm)	67th	95th
-135	3.011	7.295
-140	3.949	9.970
-145	4.646	9.251
-150	4.654	9.686

Table 4 summarizes the multipath Doppler estimation accuracy, where each detected multipath signal's Doppler value is compared directly against the corresponding truth Doppler extracted from the Keysight simulator's bulk logging data. This evaluation quantifies how accurately the signal-decomposition algorithm identifies and estimates the Doppler values of the decomposed multipath signals.

Table 4. Multipath Accuracy (Doppler -m/s)

Multipath Signal Level [dBm]	67th	95th
-135	0.032	0.042
-140	0.068	0.078
-145	0.111	0.133
-150	0.144	0.185

Test Methodology

The performance analysis is based on a representative simulated (so known) multipath environment over a wide dynamic range.

Please contact Keysight to discuss the detailed methodology used in the derivation of these figures.

GSS6450 Constellation and Frequency Configuration Support

SimXTRACT will continue to grow its supported constellation and frequency support, Table 5 references the current supported recording configurations for the GSS6450 Record and Playback System.

Table 5. GSS6450 Configuration Support

Test Configuration Parameters	Values
Sample rates	30.69Msps 51.15Msps
Bit depth	4, 8, 16 bits
Signal types	GPS L1 only Galileo E1 only GPS L5 only Galileo E5a only Galileo E5b only GPS L1 and Galileo E1 GPS L1, Galileo E1 and GPS L5

SimXTRACT Data Analysis Functions

Several analysis functions are supported, allowing specific signal characteristics to be highlighted, based on the selected criteria. For every signal from every satellite at every epoch a 3D plot showing LOS + MP and code/Doppler error for each is displayed, as shown in Figure 3.

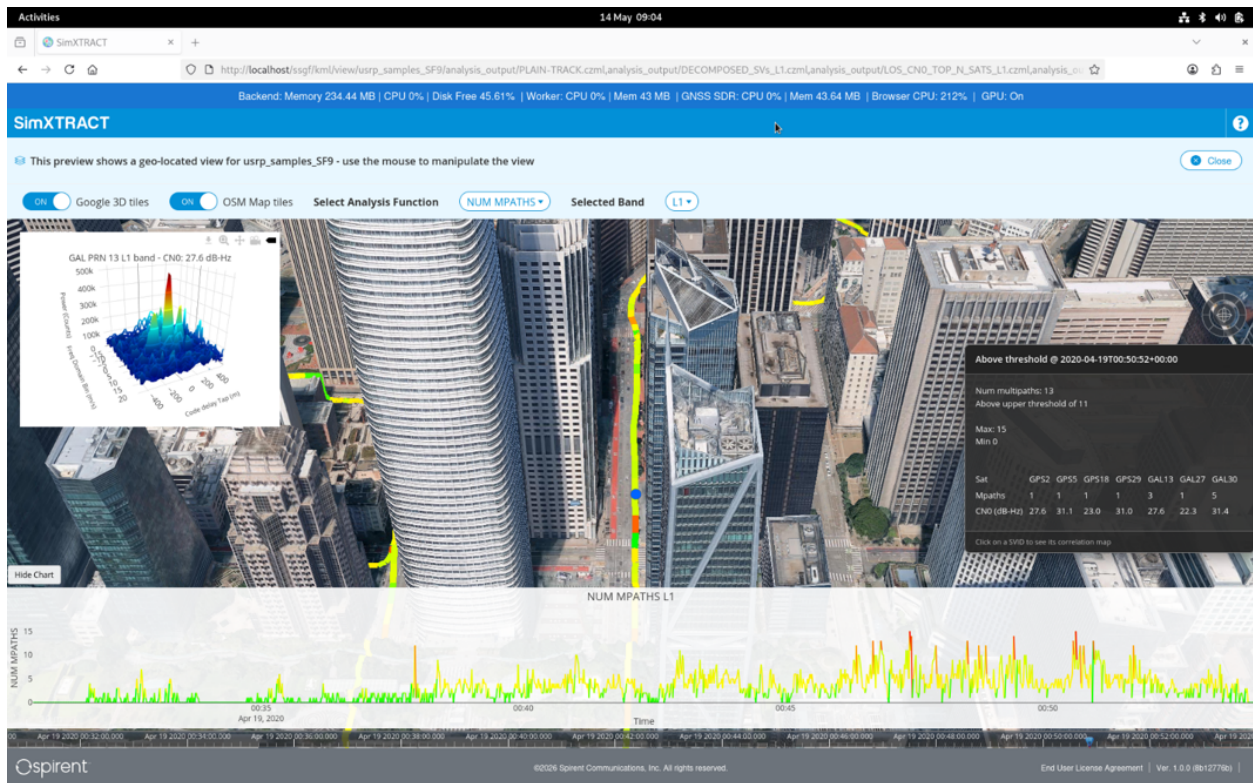


Figure 3. Data for each signal/epoch

Figure 4 shows the 3D signal plot displayed for every signal at each epoch. LOS and non-line of sight (NLOS) are shown with the code delay and Doppler error for each multipath.

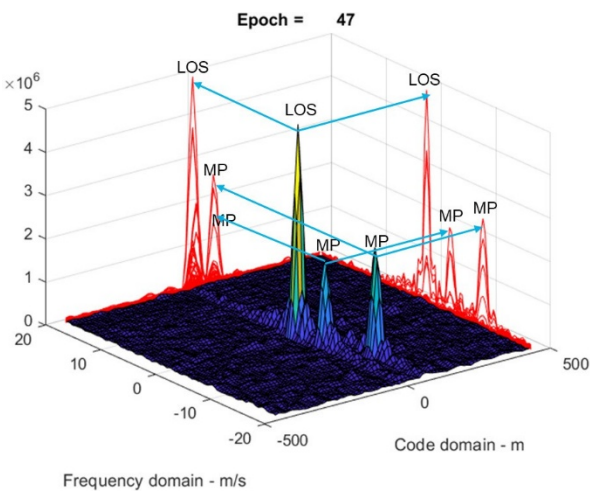


Figure 4. 3D signal plot generated for every signal per epoch

For all analysis functions, default values will be placed in configuration files to allow values to change. Function analysis will be driven from a Keyhole Markup Language (KML) map view of the processed recording.

Table 6. SimXTRACT Analysis Functions

Analysis Function Descriptions

Multipath analysis	View highlighting on a 2D/3D map where multipath appears, colour coded on route plot, plus multipath signal analysis.
Signal-to-noise ratio (SNR)	The average SNR of the top satellites, color-coded on route plot.

Signal analysis shown on a 3D map is shown in Figure 5.

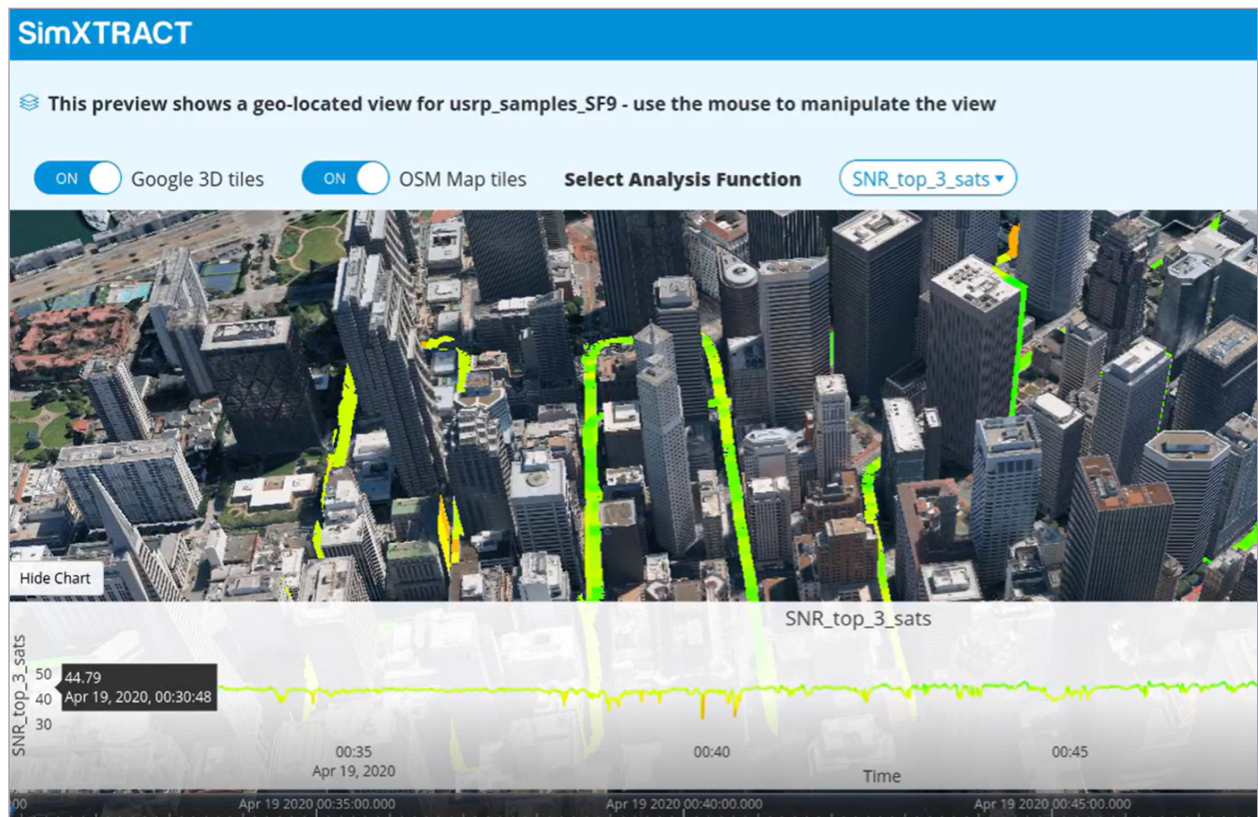


Figure 5. 3D map with analysis functions

Environmental, Social, and Governance (ESG)

At Keysight, we take ESG seriously across all aspects of our business, from sustainable buildings and product design to supply chain, manufacturing, and shipping/exports.

Many of Keysight's test solutions rely on physical test equipment used in situ by our customers. We are working to reduce the lifecycle impacts of our products and the environments they are used in through a range of ways:

- Designing for environment and end of life, including compliance with all legal requirements;
- Reducing the size, weight, noise, and power use of our products;
- Virtualization and the development of Test-as-a-Service via PNT Professional Services;
- Improving utilization and automation; and
- In-field servicing and upgrades

We use formal sustainability metrics in the product development process.

For more specific information on how ESG applies to our PNT Test Solutions, please contact your Keysight representative.



Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.

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