BROCHURE

GSS9000 Advanced Multi-element Simulation System

Dedicated CRPA Test System

Spirent Federal Systems

Contents

List of Figures

List of Tables

1. Introduction

CRPAs and other adaptive antenna systems need to be thoroughly tested, particularly if they are to be used in safety and mission-critical contexts. Comprehensively exercising the positioning precision, anti-jam and anti-spoof capabilities of CRPAs requires precision GNSS signal generation, reliable phase alignment, conducted and over-the-air capability, and the high level of realism required for testing to be realistic and representative. From the advent of adaptive antennas, Spirent technology has been trusted by the leading developers and integrators, and the enhanced GSS9000 Advanced Multi-element GNSS Simulation System is the latest in this line of unrivalled technological excellence.

2. Key capabilities

Powered by SimGEN® scenario creation and simulation control software and using the latest state-of-the-art PCIe Gen 3-based architecture designed specifically for GNSS signal simulation, the GSS9000 Series produces a comprehensive range of emulated RF signals with industry-leading ICD compliance, flexibility, fidelity, performance, and reliability.

The GSS9000 Advanced Multi-Element GNSS Simulation system is an integrated solution built using the multi-output variant of the GSS9000 Series platform and is designed to support unique wavefront simulation requirements.

GNSS signals

- Full application of existing capabilities of standard GSS9000 Series as per reference a).
- Generation of **all known GNSS signals**, including encrypted signals, supported by a continuous programme of development to ensure compliance to the latest versions of Signal-in-Space ICD's.
- Support for **16+ antenna elements**, each outputting multiple inter-carrier phase-aligned multi-frequency, multi-GNSS, plus spoofing and interference/jamming signals.
- Simultaneous simulation of **1000+ independent signals/ channels**.

Custom signals

- **Flexible signal modification** including non-SIS ICD internally generated codes, variable chipping rates and code sequencing, modulation types, shaping and filtering.
- **FPGA and GPU-based I/Q input of external waveforms available,** blended with internally generated GNSS signals.

Interference and Spoofing

- **>130dB** Jammer to GNSS nominal signal ratio.
- Generation of a **wide range of multiple interference/ jammer signals**, including **custom waveforms** with variable bandwidth.
- Simulation of **multiple spoofers/repeaters** allowing a range of PVT corruptions such as trajectory and navigation data spoofing using comprehensive controls via SimGEN.

Enhanced realism & Other sensors

- Configurable simulation iteration rate - up to **2000 Hz**.
- **EGI/IMU signal simulation** through the SimINERTIAL™ add-on module for Spirent's SimGEN control software to characterise the performance of a CRPA-based GNSS/Inertial solution.

3. System Architecture

Testing adaptive antennas demands high levels of integrity. To deliver this, it is essential for test systems to employ tightly integrated hardware and software architecture that is designed and optimised for purpose.

Unlike other platforms, the GSS9000 Series was designed and built using bespoke hardware and decades of experience to deliver on the unique requirements of GNSS testing. This means that users can push the system to the limits of its capability without ever worrying that the signal generation performance will be compromised. Ultimately, this dedicated approach helps you to develop products that are ready to succeed in the real world by ensuring the performance of your device is never masked by the performance of the test instrument.

System hardware components

The overall system comprises several key hardware components depicted in Figure 1. The number of signal generators or I/Q streaming servers varies depending on user application and testing needs. All the equipment is self-contained in a 19" rack cabinet solution.

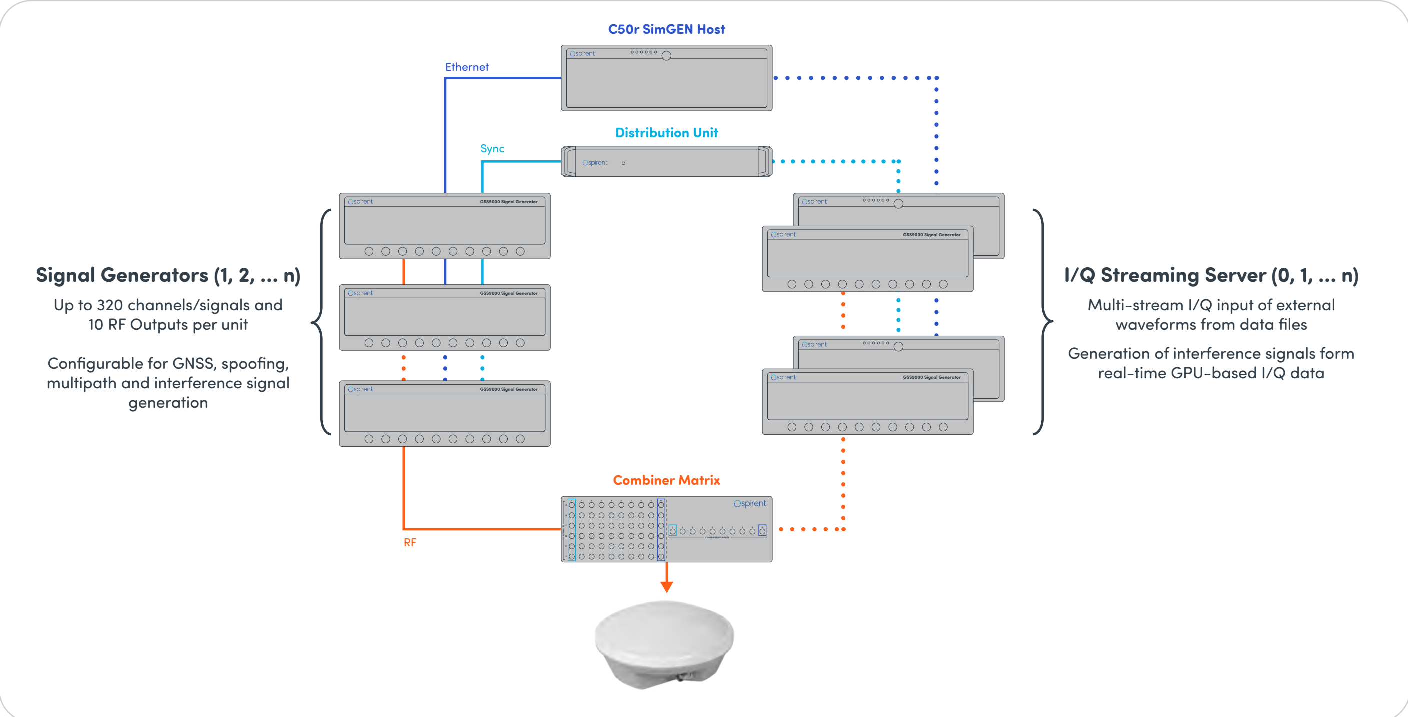


Figure 1: Multi-element system configuration diagram

C50r – Host controller

This is the system orchestrator, running SimGEN Scenario Generation and Control Software. The host controller allows the user to define all scenario conditions and control the simulation at runtime from a Spirent proprietary design multi-processor/core system, installed with Spirent's mixed Operating System (OS) environment (Linux and Windows® 10 Professional for Embedded Systems ESD [Virtualisation Only]).

Distribution Unit

The distribution unit provides a timing source of 10 MHz from the reference oscillator and 1 PPS output from the first signal generator chassis across the rest of the GSS9000 units.

GSS9000 Series – RF signal generator chassis

The overall system includes one or more RF Signal Generator Chassis, each with its own dedicated embedded controller running the simulation engine, and each providing up to 10 individual and 2 composite RF outputs.

The GSS9000 Advanced Multi-Element GNSS Simulation System employs a highly digital and flexible hardware architecture that is used to generate GNSS signals, interference waveforms and spoofer/repeater signals at multiple frequencies. The configuration of generated signals (depending on type) can be changed 'on-the-fly' between different scenarios and from run-to-run. Multiple chassis can be combined, depending on the combination of signals that need to be generated simultaneously.

I/Q Streaming Servers

Spirent's GPU-based SimIQ product, which adopts the InfiniBand networking standard, coupled with the flexibility, high-fidelity RF and very high power of the GSS9000 Series platform further adds to the scalable nature of the system.

In real-time and under the direct control of SimGEN, SimIQ can read in user defined I/Q files and apply all spatial, motion, environmental and antenna effects. Alternatively, under the direct control of SimGEN, SimIQ can generate GTx signal directly from the standard library of supported signals types.

RF signal combiner matrix

The combiner matrix blends all the RF signals generated and allows users to combine more than 16 antenna elements to match their CRPA antenna design.

1. Host controller
2. IQ GPU controller
3. Multi-element outputs
4. Signal generator
5. Distribution unit

Figure 2: Example of a multi-element, multi-GNSS + jam + spoof simulation system

SimGEN software

The user interacts with a single instance of Spirent's SimGEN software application running on the C50r SimGEN Host.

In addition to automatically calculating a vast array of data necessary to generate GNSS constellation and other signals, SimGEN (see reference b)) provides the user with an extensive set of features that can be used to configure and define the required test scenario. This includes interactive controls for adjusting scenario parameters either before the scenario run or in real-time, as well as display, logging and streaming of every parameter associated with the scenario at configurable rates up to 2000 Hz.

Figure 3: SimGEN scenario definition and simulation control software GUI

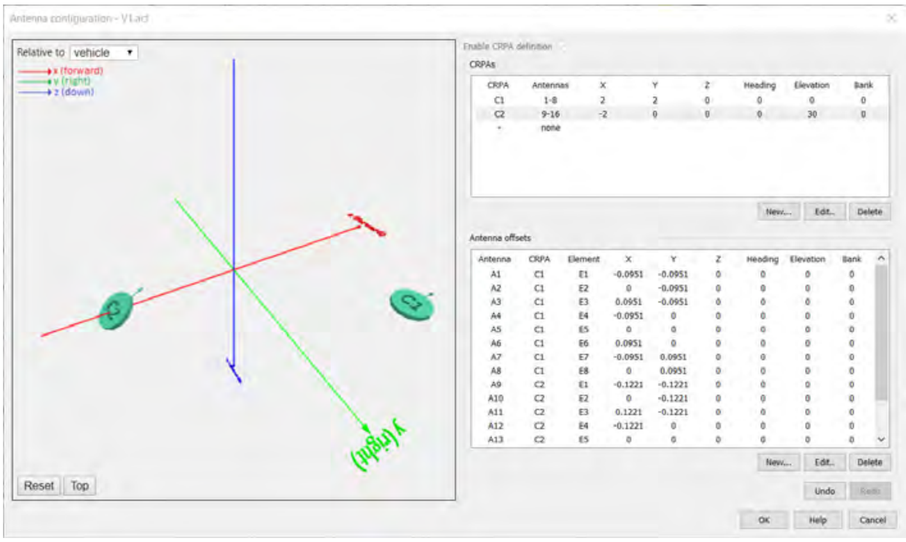
Key scenario definition features

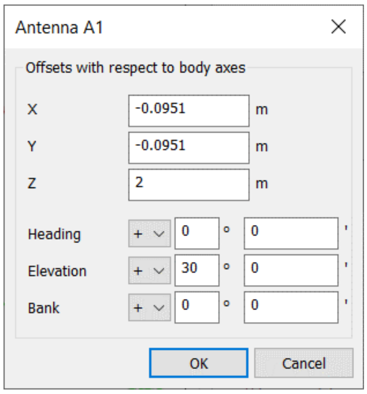
- Configurable start time and date in various formats, with real-world orbits defined instantly.
- Definition of the appropriate GNSS, jammer (GTx), spoofer, repeater and pseudolite constellations/networks.
- Various mechanisms for applying declared and undeclared errors and modifications to navigation data, satellite clocks and orbits.
- Independent satellite/channel signal power control.
- Atmospheric parameters for both the ionosphere and troposphere, including models for scintillation.
- Vehicle performance envelope – personalised, or a range of in-built terrestrial and space vehicles.
- Antenna placement and orientation including the modelling of lever-arm effects.
- Fully customisable antenna reception patterns, both in gain and phase.
- Terrain obscuration.
- Pseudo-range ramps for RAIM testing.
- Data logging and data streaming tools.

CRPA definition tool

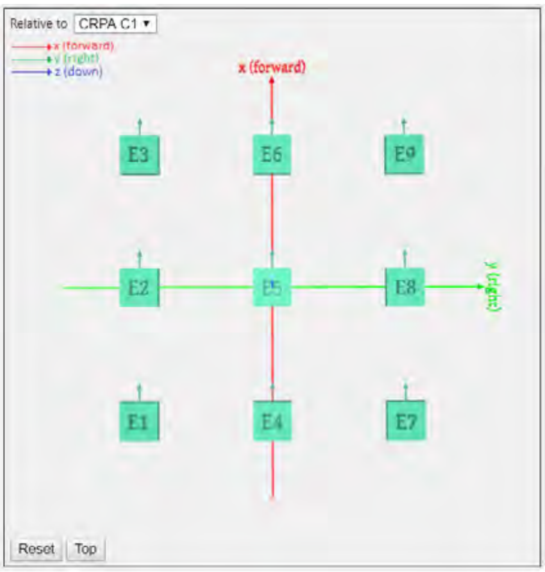
A key feature of SimGEN for CRPA testing is the antenna configuration tool. This accurately recreates and represents the position and orientation of the antennas with respect to the vehicle in the scenario. Users can:

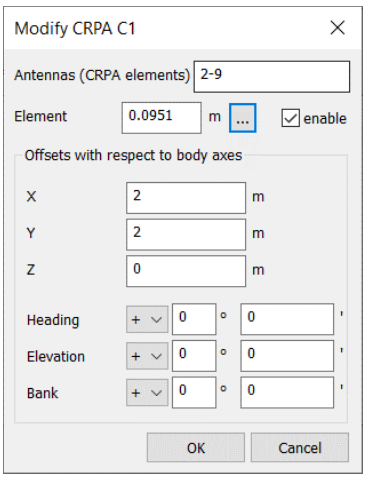
- Visualize the active configuration on a 3D plot
- Edit parameters such as
  - Antenna offsets
  - Heading
  - Elevation
  - Bank angles
- Easily create, edit, or delete antennas
- Share configurations across SimGEN scenarios





For CRPA definition, users can – in just two steps – create antenna arrays and uniformly space the individual elements based on half-wavelengths or precise distances. Parameters such as power level can be modified in-run for the whole CRPA antenna using the standard SimGEN Power Adjustment sliders.





System Calibration

The GSS9000 Advanced Multi-Element GNSS Simulation system employs high quality electronics. Together with a highly digital architecture, this means precise alignment is simplified. Built in calibrator circuitry greatly aids the alignment process and ensures real-time alignment remains in spec. In addition to the routine annual power and reference clock alignments, the two principal alignments concern delay and phase.

Delay alignment

As part of the production calibration of the system, Spirent will perform a proprietary multi-output delay alignment procedure. This procedure will ensure alignment of the modulation for non-CW signal types. Spirent also supplies a customer-facing procedure, an automated utility, and a phase-stable RF cable for this delay alignment process to be performed by the customer at their own facility – without the need for any additional test equipment.

Inter-antenna carrier phase alignment

As part of the production calibration of the system, Spirent will perform a proprietary multi-output carrier phase alignment procedure. This procedure will ensure the specified inter-antenna carrier phase alignment performance is met. Spirent also supplies a customer-facing procedure, automated utility, and an accompanying alignment kit for this carrier phase alignment process to be performed by the customer at their own facility.

4. Interference Testing

The primary function of CRPAs is to provide uninterrupted positioning in interference environments. To develop and qualify this capability, developers need to be able to test devices against a comprehensive range of threats. Thanks to its flexible and scalable architecture, the GSS9000 Advanced Multi-Element GNSS Simulation system allows the generation of thousands of simultaneous interference signals from hundreds of transmitters using the same scenario file.

Ground Transmitters (GTx)

GTx (interference/jammer) is an established feature enhancement of SimGEN. Configuration of transmitters includes:

- Position mode setting—orbital, absolute position (ECEF) or relative to vehicle supported.
- Grouping to form the transmitters into a single source enabling simulation of complex interference sources comprising more than one channel.
- Interactive map allowing placement of transmitters.
- Matched Spectrum controls in the GUI editor.

Complex scenarios simulating vehicle(s) in a field of multiple interference transmitters can be configured easily. Figure 4 shows multiple CRPA-enabled vehicles manoeuvring around a field of 128 multi-frequency interference transmitters.

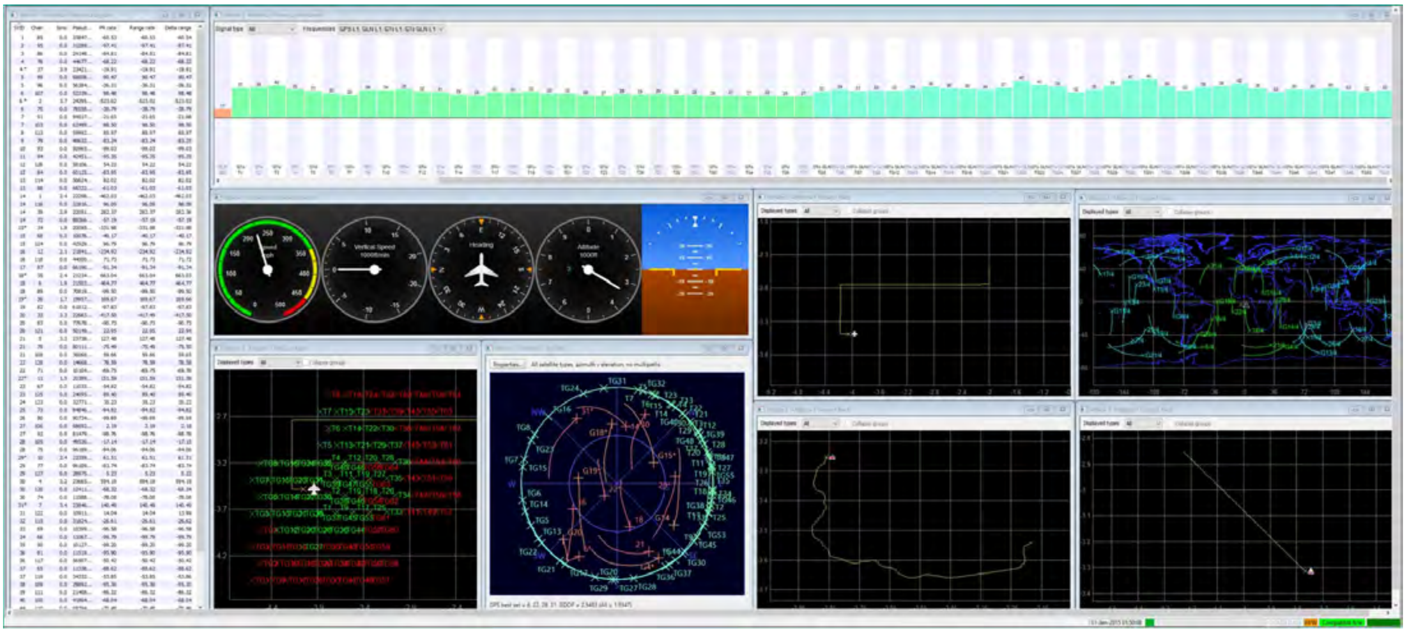


Figure 4: Multi-vehicle, multi-interference scenario

In addition to the characteristics outlined above, for each of the transmitters, users can control the following signal properties:

- L-band frequency and frequency offset.
- Signal type selection (e.g., CW, BPSK, CW Pulse, FM, PM, AM, AWGN, BOC, Chirp, etc.).
- Power level as an offset from L-Band (dB) or absolute (dBm).
- Pulse rate and duty cycles.
- Specific signal properties according to the signal type selection (e.g., 3 dB bandwidth for AWGN).

Figure 5: GTx Configuration window

I/Q Streaming

Depending upon your exact test requirements, Spirent supports different **user defined I/Q file streaming and real-time generation options**. When determining the appropriate solution, a number of factors must be considered:

- Number of concurrent GTx sources.
- Required maximum J/S and dynamic range.
- GTx signal bandwidth and sample rate.
- File sizes and bit depths.
- GPU Server/Raid Array selection.
- Latency and SIR requirements.

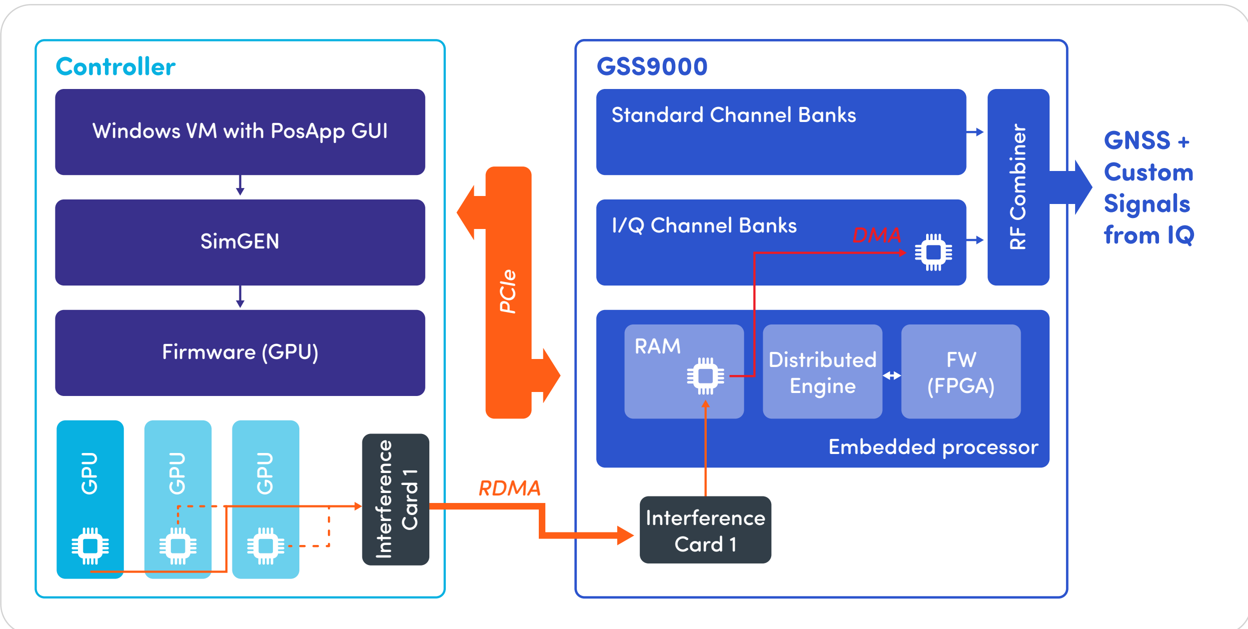


Figure 6: SimIQ principle

5. Spoofing Testing

Spoofing attacks have become significantly more common in recent years, and all safety- and mission-critical systems must be protected against them. The advanced capabilities of the GSS9000 enable users to build advanced and varied spoofing scenarios with a unique level of control and coherence.

An integrated spoofing solution

SimGEN allows you to define and configure using the same scenario file:

- A vehicle instance representing the "truth" or "target" vehicle location/trajectory; and
- N vehicle(s) representing "false" or "spoof" vehicle locations/trajectories.

The composite signal associated to all the vehicles in the scenario is provided at a single RF output, for connection to a single DUT. In this way, from a test scenario perspective, 'truth' and 'spoof' signals are all treated as signal types received by the target vehicle (see Figure 7).

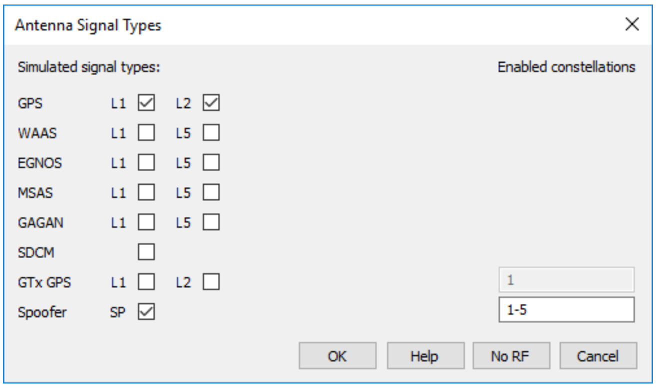


Figure 7: Vehicle antenna signal types selection

Spoofers can be easily added to the scenario (see Figure 8), alongside standard GNSS constellation and vehicle groups.

- Each "*Spoofer transmitters*" definition file specifies 1 spoofer transmitter:
  a. Location: static or dynamic.
  b. Signal level: fixed or modelled.
- Each "*Spoof GPS constellation*" can be unique and allows full configuration of the constellation parameters.
- Each "*Spoof vehicle*" can be unique and supports SimGEN's built-in vehicle models, user motion files and real-time remote motion input.

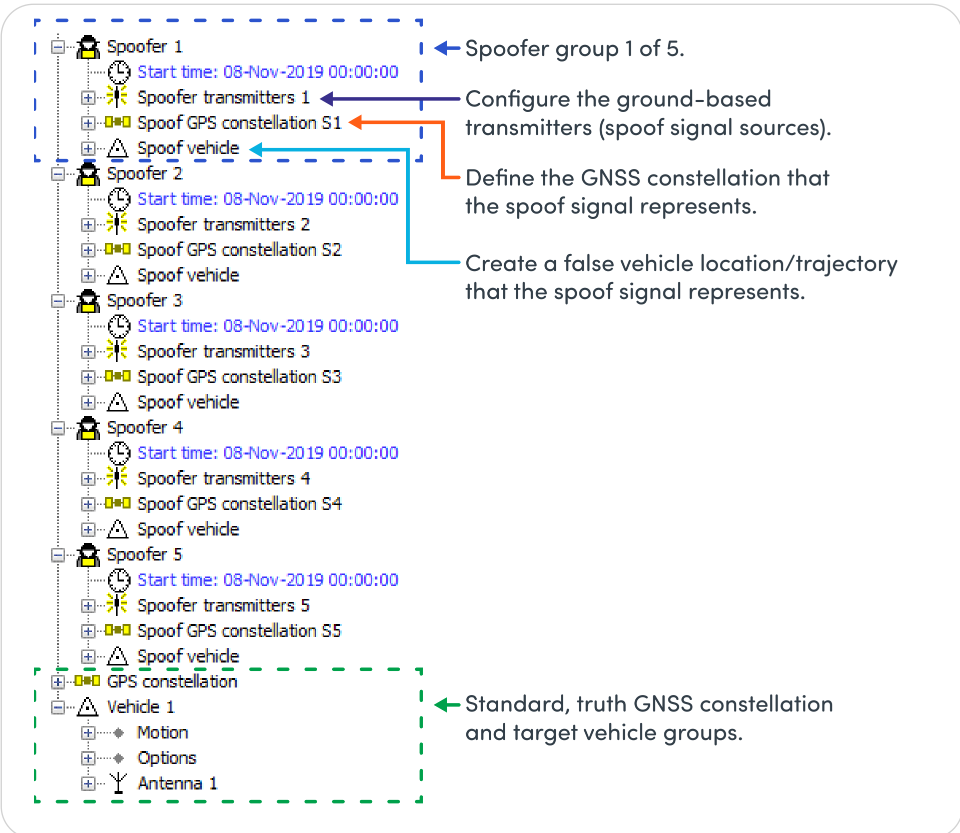
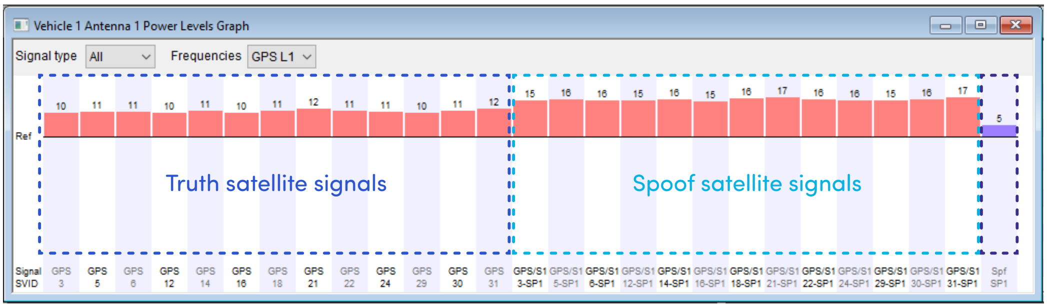


Figure 8: Scenario tree – truth and spoofer definitions

The target vehicle receives "truth" GNSS signals transmitted from the space-based GNSS satellites and "spoof" GNSS signals transmitted from the ground-based spoof transmitter.

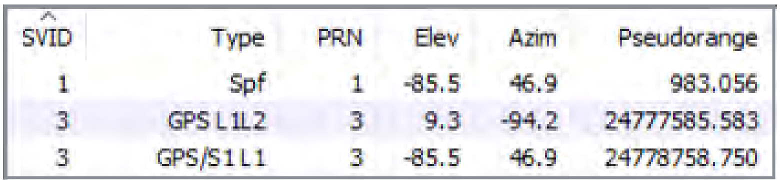


← Spoofer transmitter responsible for the spoof satellite signals.

Figure 9: Target vehicle received satellite signals

During runtime SimGEN manages all the real-time signal characteristics based upon:

- Initial user-definitions of the "truth" and "spoof" content.
- Relative changes between the target and spoof vehicle locations.
- Relative changes between the target vehicle and spoofer transmitter location.



SVID	Type	PRN	Elev	Azim	Pseudorange
1	Spf	1	-85.5	46.9	983.056
3	GPS L1L2	3	9.3	-94.2	24777585.583
3	GPS/S1 L1	3	-85.5	46.9	24778758.750

← Spoofer transmitter
← Truth satellite SVID3
← Spoof satellite SVID3

↑ Spoof satellite El / Az matches the spoofer transmitter location relative to the target vehicle (i.e. not received from space).

↑ Pseudorange difference between SV signals is due to the delta between current target vehicle location and spoof vehicle location

Figure 10: Received signals window in a spoofing scenario

6. Enhanced Realism

Realism is the core component of all GNSS testing. Without realism, testing is not representative of real-world conditions and products and systems under development could not be relied on to transfer performance into production. From generating signals from first principles through to advanced environment modelling, the GSS9000 Series delivers the most realistic GNSS signal environment available for testers.

Sim3D

Spirent Sim3D is a unique approach to simulating multipath and obscuration effects based on a synthetic 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.

Figure 11: Real-time computation of the multipath effects from a single SV using Sim3D

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

Sim3D full solution includes:

- Support for GPS, GLONASS, BeiDou, Galileo, QZSS, and SBAS signals.
- Support all frequencies and codes currently simulated by GSS9000 series.
- Support for static and dynamic scenarios, including dynamic trajectory generation.
- Up to 31 multipath signals per line-of-sight.
- Up to 6 reflections per multipath computed.
- Dynamic trajectory generation.
- User-defined filtering algorithms to simulate only multipath in chosen delay/power ranges.
- Real-time visualisation of the multipath angle of arrival.
- Support for HIL setups.

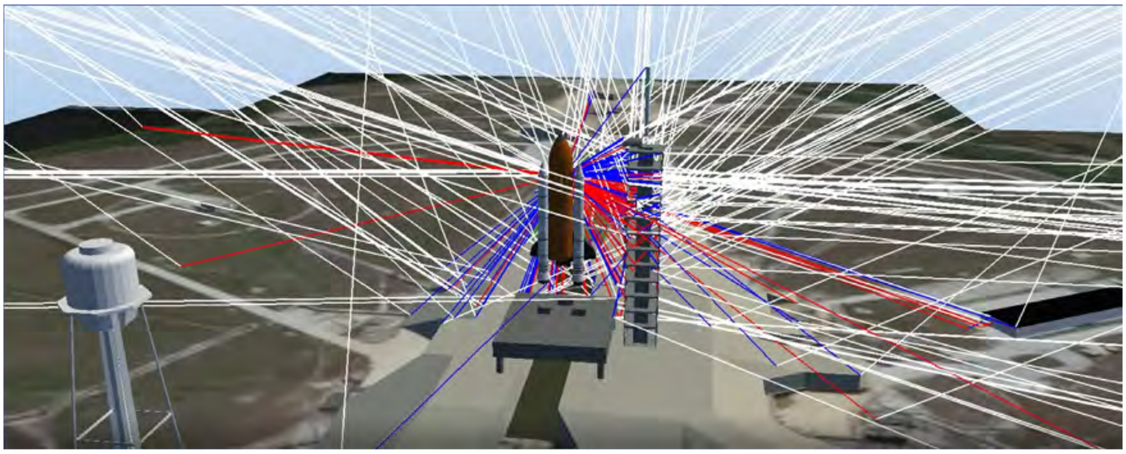


Figure 12: Real-time computation of the multipath effects during a space shuttle launch

SimINERTIAL

Our Inertial simulation tools enable users of embedded GPS/inertial systems (EGIs), individually coupled GNSS/INS systems (IGIs) or standalone IMUs to simulate coherent GNSS and sensor measurements to evaluate the positioning algorithms. Modelling physical sensors using accurate error parameters in our simulation environment enables users to tune integrations and algorithms prior to deployment.

Coupled with Spirent's GSS9000 series, and powered by SimGEN, our inertial simulation tools provide real-time emulation of raw measurements that can be fed into filters within the positioning engine. SimINERTIAL provides support for a variety of data interfaces, formats and sensors, including accelerometers, gyroscopes, magnetometers, compasses and barometers (through SimBARO™).

SimREMOTE™

A powerful capability of the GSS9000 is SimREMOTE which allows the user direct control of all the functions available via the SimGEN GUI plus full 6DOF trajectory delivery. SimREMOTE performs three main functions:

- Simulation control: such as selecting scenarios, start/stop and run-time control.
- Signal modification: finite manipulation of signal phase, delay and Doppler plus enabling/disabling of codes/data.
- Trajectory delivery: 6DOF trajectory delivery in real-time of from a file up to 2000 Hz update rate.

All commands are time-stamped and multiple commands can be scheduled for the same timestamp. For further information see reference c).

Open-source API available to support third-party applications written in programming languages such as Python and C++.

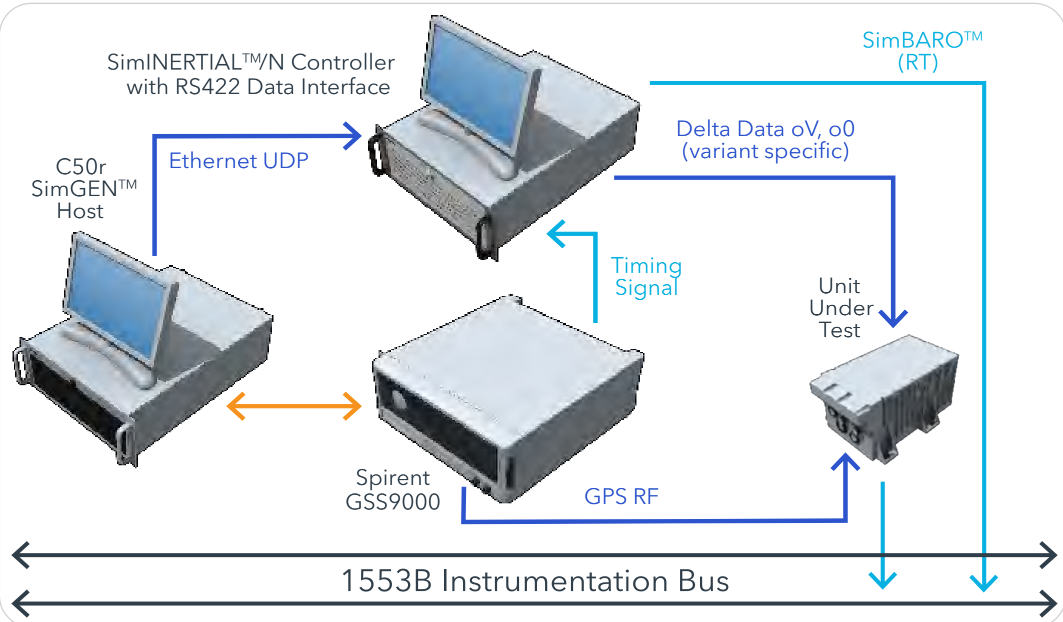


Figure 13: SimINERTIAL Typical Configuration

7. Professional Services

Spirent has a dedicated team with global reach, capable of delivering a range of Professional Services. More specific to CRPA projects these can be listed as:

Installation and configuration

Help ensures you quickly maximise return on your investment. Let the experts get your simulation system integrated, configured and validated in your test set-ups, saving time, money and mishaps.

Embedded engineer for all your GNSS requirements

For complex systems such as these, there is the possibility to make use of a Spirent professional services consultant for a set period of time who will be able to provide ongoing consultancy, running test and implementing test procedures, ad-hoc training and support. With the rest of Spirent resources to call upon, the savings in terms of time and cost will certainly be evident.

Scenario creation and Test Methodology

Spirent consultancy on test methodologies for your testing requirements (including requirements analysis), along with scenario design and verification will ensure your test campaign gives you actionable results.

Factory Acceptance Test (FAT)

FAT is regularly undertaken by Spirent. Spirent FAT concentrates on key performance aspects of the delivered system and any newly introduced 'tailored' elements only. Standard COTS capabilities are not covered as part of the FAT.

Spirent supplies a draft FAT document ahead of the scheduled testing for review and agreement with the customer. Once the document has been agreed it is formally issued and then forms a contractual document.

Customer Acceptance Test (CAT)

After the system has been received at the customer site Spirent shall conduct a CAT. The CAT involves system installation and confirmation that the equipment is in a correct working order.

Spirent produces a draft CAT document, based on the approved FAT, ahead of the scheduled system delivery, for review and agreement with the customer. Once the document has been agreed it is formally issued and then forms a contractual document.

Training

Training can be delivered by Spirent representative(s) which could be very useful following successful completion of a CAT or even on existing CRPA systems. It can involve classroom style training / presentation sessions as well as 'hands-on' demonstrations with the purchased system (where appropriate and travel is possible). Alternatively, remote sessions can also be used as a means of delivering the training.

8. Product Specification

Table 1: GNSS signal capability summary

Parameter	Qualifier	Value
Signal sources	At each element, per centre frequency	Configuration dependant
Nominal carrier frequencies	GPS L1, Galileo E1, BeiDou B1c, SBAS L1	1.57542 GHz
	GPS L2	1.2276 GHz
	GPS L5, BeiDou B2a, NavIC L5, SBAS L5	1.17645 GHz
	Galileo E5	1.191795 GHz
	Galileo E6	1.27875 GHz
	GLONASS L1	1.602 GHz (F0)
	GLONASS L2	1.246 GHz (F0)
	BeiDou B1I	1.561098 GHz
	BeiDou B2I, BeiDou B2b	1.20714 GHz
	BeiDou B3I	1.26852 GHz
Ranging Code Signals	GPS L1	C/A, L1c, P, Pseudo Y, M Noise, **Y**[1], **AES-M**[2], **MNSA**[3], **SDS-M-Code**
	GPS L2	C/A, L2c, P, Pseudo Y, M Noise, **Y**[1], **AES-M**[2], **MNSA**[3], **SDS-M-Code**
	GPS L5	I, Q
	Galileo E1	OS Data/Pilot, PRS Noise, **PRS**[4]
	Galileo E5	E5a-IQ, E5b-IQ
	Galileo E6	CS/HAS Data/Pilot (without encryption), PRS Noise, CAS, **CS/HAS Data/Pilot** (with encryption), **PRS**[4]
		C/A, P
	GLONASS L1	C/A, P
	GLONASS L2	B1I, B1C
	BeiDou B1	B2I, B2a, B2b
	BeiDou B2	B3I
	BeiDou B3	C/A, L1c Data/Pilot, S
	QZSS L1	L2c
	QZSS L2	L5I, L5Q
	QZSS L5	L61, L62
	QZSS L6	C/A, S
	NavIC L5	C/A
	SBAS L1	I
	SBAS L5	
RF signal level GPS, at Combiner Matrix output ports	L1C/A	-130 dBm
	L1c (pilot)	-128.25 dBm
	L1c (data), L1P	-133 dBm
	L1 AES-M	-128.5 dBm
	L2c, L2P	-136 dBm
	L2 AES-M	-132.5 dBm
RF signal level Galileo, at Combiner Matrix output ports	E1-A	-125.5 dBm
	E1-A PRS Noise	-125.5 dBm
	E1-B, E1-C	-127.0 dBm
	E6-A	-125.5 dBm
	E6-A PRS Noise	-125.5 dBm
	E6-B, E6C	-128.0 dBm
	E5a-I + E5a-Q + E5b-I + E5b-Q	-122.0 dBm

1 Y-code via SimSAAS upgrade package (export controlled)
2 AES-M code via SimMCODE upgrade package (export controlled)
3 MNSA via SimMNSA upgrade package (export controlled)
4 PRS vis PRS[WARE] 3rd party upgrade package from LZE GMBH

Parameter	Qualifier	Value
RF signal level Glonass,	C/A	-131 dBm
at Combiner Matrix	P	-131 dBm
output ports	C/A	-137 dBm
	P	-137 dBm
RF signal level BeiDou,	B1I	-133 dBm
at Combiner Matrix	B1C	-130 dBm
output ports	B2I	-133 dBm
	B2A	-127 dBm
	B2B	-131 dBm
	B3I	-133 dBm
RF signal level QZSS,	C/A code	-128.5 dBm
at Combiner Matrix	S	-131 dBm
output ports	L1c Data + Pilot	-127 dBm
	L2c	-130 dBm
	I + Q	-124.9 dBm
	L61/L62	-126.82 dBm
RF signal level NavIC, at Combiner Matrix output ports	C/A	-130dBm
RF level control	Range	+20 to -40 dB
	Resolution	0.1 dB
	Linearity (+20 to -30)	<0.1 dB
	(-30.1 to -40)	<0.2 dB\
Limit of signal dynamics	Relative velocity[5]	120,000 m/s
	Relative acceleration[6]	192,600 m/s2
	Relative jerk	890,400 m/s3
	Angular rates (indicative)[7]	
	at 1.5m lever arm	>15ϖ rad/s
	at 0.05m lever arm	>60ϖ rad/s
Signal Accuracy	Pseudo-range accuracy[8]	0.3 mm (RMS)
	Pseudo-range uncertainty due to Inter-channel bias[9]	0 mm (RMS)
	Delta-range accuracy	±0.1 mm (RMS)
	Inter-carrier Bias[10]	< ±2 ns
Signal Purity	Unmodulated in-band spurious[11]	≤ -152 dBm
	Harmonics	≤ -40 dBc
	Phase noise[12] (single side band)	≤ 0.005 rad (RMS)
Configurable Iteration Rate	GNSS chassis internal controller	2000 Hz
	Spoofer/Repeater chassis internal controller	1000 Hz
	C50r SimGEN Host	100 Hz
		10 Hz (at least)

5 For 6-DOF data externally supplied via SimREMOTE or from data file
6 When operating at ≥250Hz SIR.
7 Please refer to reference i) for more details.
8 For signal acceleration <450m/s2, jerk <500m/s3, 1000Hz SIR
9 Single channel bank, supporting up to 32 channels. When the same signal is generated across multiple channel banks the inter channel bank bias uncertainty is ±230ps (±69mm)
10 Between any RF carrier
11 Measured at designated RF output port with interference source disconnected. For relative velocities <50,000m/s and signal bandwidths = GPS: L1/L2 ±20.5MHz; GLO (relative to channel f0): L1/L2 ±20MHz; GAL: E1±20MHz; BD: B1±20.5MHz
12 Value is typical, integrated over a 1Hz to 10kHz bandwidth. Worst case <0.01 rads (RMS)

Table 2: Interference (GTx) signal capability summary[13]

Parameter	Qualifier	Value
Signal sources	At each element, per centre frequency	Configuration dependant
Nominal centre frequencies	L-band	As per Table 1
Carrier frequency offset	Independent for each source Range Resolution	 ± 25 MHz 0.5 kHz
Total RF signal power	Single CW GTx signal per channel bank[14] Multiple CW GTx signals per channel bank[15]	+2 dBm -7 dBm
Channel bank attenuator	Attenuation[16] Resolution	0 to 60 dB 1 dB
Signal purity[17]	At each supported centre frequency Unmodulated in-band spurious Modulated in-band spurious	 ≤ -60 dBm < 40 dBc
Inter-antenna carrier phase alignment	Total variance[18] Run to run variance	± 5 degrees ± 1 degree
Configurable Iteration Rate	GTx chassis internal controller C50r SimGEN Host	2000 Hz 1000 Hz 100 Hz 10 Hz (at least)
Interference signal types (independent for each source)		
CW	see above	
BPSK	Narrowband main lobe width Broadband main lobe width Maximum signal power (relative to CW maximum)	0.1023 MHz 20.46 MHz -2 dB
CW Pulse	Pulse width Pulse repetition interval range Pulse repetition interval resolution Rise time (10% to 90%) On/Off ratio Maximum signal power (relative to CW maximum)	1 to 10,000 μs 50 to 10,000 μs 50 μs 100 ns (max) 30 dB -2 dB
FM	Deviation (changes linearly) Rate Rate step size Maximum signal power (relative to CW maximum)	From ±0.01 to ±15 MHz 0.005 to 10 kHz 0.005 kHz 0 dB
PM	Modulation deviation Frequency deviation Maximum signal power (relative to CW maximum)	±5 rad 0.5 to 10 kHz 0 dB
AM	Depth Depth step size Rate Maximum signal power (relative to CW maximum)	10 to 90 % 10 % 0.5 to 10 kHz -6 dB
AWGN	3dB Variable Bandwidth Bandwidth Resolution Maximum signal power (relative to CW maximum)	100kHz to 20 MHz[19] 10 kHz -13 dB
Standard and Custom GTx through SimIQ	3dB Bandwidth Sample rate Bit depth Signal bandwidth and content	24, 32, 48 MHz Up to 120 Msps 4bit I + 4bit Q; 8bit I + 8bit Q; 16bit I + 16bit Q As per standard GTx library or from user defined file

13 Additional GTx types available such as BOC and Chirp.
14 Fixed attenuator set to +5dB
15 Incoherent signals. Fixed attenuator set to +5dB
16 Default +5dB attenuator setting used for calibration and system characterisation
17 Each channel bank, measured at designated RF output port
18 Includes equipment being power cycled. Temperature variation since last alignment, ambient ±2oC
19 Wider bandwidths up to 50MHz for AWGN are optionally available. Contact Spirent for further details

Reference documents

For more information on the GSS9000 and additional products and services, see:

Reference	Title	Notes
a)	GSS9000 Datasheet Specification	
b)	SimGEN® Software Suite Datasheet Specification	
c)	SimREMOTE Interface Upgrade Options Datasheet Specification	
d)	Spirent GSS9000 CRPA Simulation System With Spinning Vehicles	
e)	SimMCODE Upgrade for GSS9000 Product Specification	[FOUO]
f)	SimSAAS Upgrade for GSS9000 Product Specification	Spirent Federal document
g)	SimMNSA Upgrade for GSS9000 Product Specification	Spirent Federal document
h)	3rd Party PRS simulation add-on fpr GSS9000	https://prs-ware.de/
i)	Spirent GSS9000 CRPA Simulation with Spinning Vehicles	

Glossary of terms

Term	Definition
6DOF	Six Degrees Of Freedom – movement
AWGN	Additive White Gaussian Noise
BFEA	Blue Force Electronic Attack
CAT	Customer Acceptance Test
DofA	Direction Of Arrival
DUT	Device Under Test
FAT	Factory Acceptance Test
FOUO	For Official Use Only
GNSS	Global Navigation Satellite System (GPS / GLONASS / Galileo / IRNSS / BeiDou)
GTx	Ground (or terrestrial-located) Interference/Jammer Transmitter
ISG	Interference Signal Generator
J/S	Jammer-to-Signal
OTA	Over-The-Air
PRS	Galileo Public Regulated Service
RF	Radio Frequency
SP	Spoofer/Repeater
SV	Satellite Vehicle

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 fulfill that promise.

Why Spirent?

Across five decades Spirent has brought unrivaled 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 customizable 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
- Unrivaled investment in customer-focused R&D
- A global customer support network with established experts

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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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MCD00437 Issue 2-03 | 01/22

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