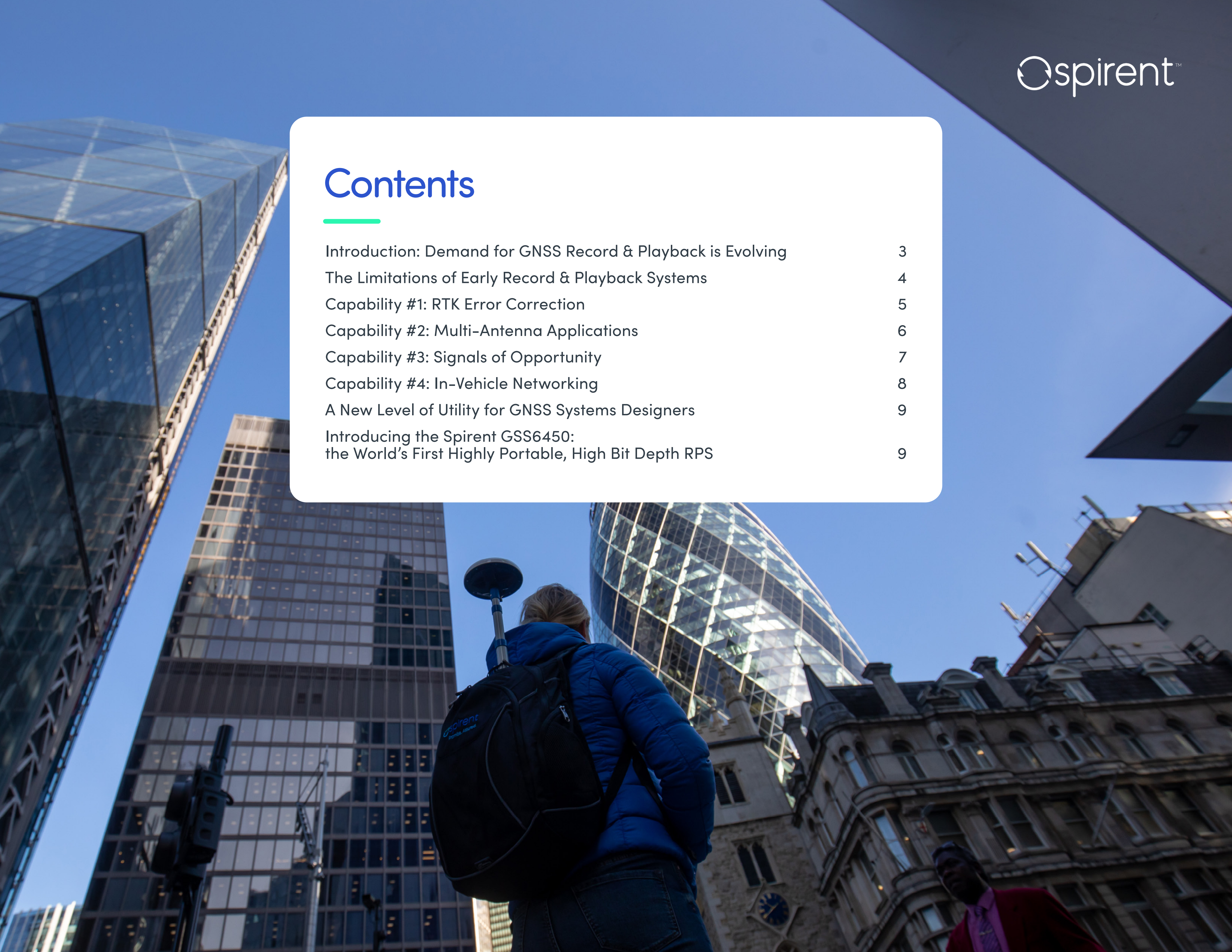
A SPIRENT E-BOOK

How realistic record & playback enhances your product development

The emerging need for dynamic realism in PNT lab testing



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INTRODUCTION
Demand for GNSS Record & Playback is Evolving

A GNSS record & playback system (RPS) has become a key component of any professional GNSS testbed. The ability to record the real-world signal environment and replay it in the lab provides significant advantages over field testing with live signals—including greater control, full repeatability, lower costs, and faster time to market.

Method / Attribute	Live-Sky	Simulation	Record & Playback System
Repeatable	X	✓	✓
Controllable	X	✓	Partial
Reference Truth		✓	X
Realistic	✓	Representative	✓

Figure 1: Comparative benefits of live-sky testing, GNSS signal simulation and GNSS record & playback.

Although never a complete substitute for either simulation or field testing, record & playback remains one of the most effective and efficient ways of characterising receiver performance in the real world—providing a combination of realism and repeatability that's ideal for verification.

While the first generations of GNSS RPS were fairly limited in their capabilities, the technology has evolved significantly in recent years to meet new testing needs as GNSS-based systems become more sophisticated, more diverse, and more critical.

In this eBook: Four new use cases that demand richer real-world testing in the lab.

This paper reviews four emerging use cases—from RTK error correction to in-vehicle networking—that are driving demand for more sophisticated GNSS RPS. It also introduces Spirent's GSS6450, the most highly portable, high-fidelity RPS available today.

The Limitations of Early Record & Playback Systems

The first GNSS RPS offered something professional system design engineers had long wanted: a method of bringing the real world back into the lab for repeatable testing. However, despite their utility, there were three key limitations to their abilities.

Resolution of recorded signals: Early commercial RPS were only capable of recording the signal environment to a bit depth of one or two—often lower than the bit depth of the receiver under test.

The low level of fidelity meant the recorded signal environment could not replicate the richness and fine detail of the real-world environment—meaning that test results were only ever a rough guide to real-world receiver performance.

Similarly, the low dynamic range of these systems meant that GNSS signals would often be lost in even moderately noisy environments. This could lead to false-negatives in testing, as tracking would be lost through no fault of the device under test.

Restrictions in number and type of signals: With more GNSS signals—and other signals of opportunity (SOOP), like Wi-Fi and cellular—being added all the time, manufacturers have jumped on the opportunity to develop multi-constellation, multi-frequency, multi-signal receivers for greater accuracy and robustness. But most RPS units have been capable of recording only a small portion of the available bandwidth, failing to capture the multitude of signals now available.

Storage capacity: Storage has been another issue, with engineers having to decide between a portable system with limited storage capacity, or a high-end, military-grade system that could record the environment for longer periods, but which was too bulky to transport easily.

These limitations have become increasingly frustrating for systems designers and test engineers developing the next generation of location-aware chipsets and devices.

Demand is growing for highly reliable, accurate and robust positioning, navigation and timing (PNT) systems, which is driving many innovations in receiver design. Those new designs need to be tested with real-world signals, and RPS remains a highly useful method of doing that efficiently and repeatably in the lab.

But to be of useful service, the capabilities of RPS systems need to expand significantly. In the next section we'll look at four use cases driving demand for a modern—and future-proof—RPS system.

Capability #1: RTK Error Correction

Demand is increasing for receivers capable of centimetre-level position accuracy. Autonomous vehicles, construction equipment, survey equipment and even some emerging consumer applications need to know their position to a greater degree of accuracy than GNSS alone can provide.

RTK is a differential technique used to enhance the precision of positioning data derived from satellite-based positioning systems (GNSS) that can provide accuracy down to centimetre-level. Removing much of the error introduced by atmospheric conditions opens up new opportunities for the use of GNSS in a range of applications. (See our RTK guide for more.)

RTK uses a network of ground stations that process the GNSS data, apply an error correction algorithm, and broadcast the resulting error correction messages to RTK-compatible GNSS receivers within range.

As more applications start to incorporate RTK receivers, the ability to record live error correction messages in synchronisation with the GNSS signals becomes highly desirable. For manufacturers developing RTK systems, the ability to record the GNSS signal and carrier phase data to a high degree of fidelity, with little added phase noise, will accelerate and ease testing with real-world signals.

Capability #2: Multi-Antenna Applications

The need for greater position and navigation accuracy is also driving innovation in antenna design. Borrowing a technique from aviation, many emerging applications—notably autonomous vehicles—now make use of two GNSS antennas rather than one, to add redundancy to the system and improve the accuracy of heading estimations.

Receiver designers and integrators will want to test dual-antenna solutions with real-world signals, and record & playback can play an important role here. A multi-antenna RPS with low inter-antenna bias will greatly improve the ability to characterise heading estimation and system redundancy.

While most commercial RPS can currently only record the environment on one antenna, we're likely to see greater demand for multi-antenna recording capabilities as engineers seek to verify the performance of dual-antenna systems in an efficient way.

Capability #3: Signals of Opportunity

Many positioning systems are starting to rely on multiple signals to calculate position. Signals from geolocated cellular base stations, Wi-Fi access points and Bluetooth beacons can be used to:

- Compute a position in places where GNSS is not available—such as indoors, in covered car parks, tunnels or urban canyons, or in a GNSS-denied environment
- Corroborate or even over-ride the position derived from GNSS—useful for mitigating against GNSS spoofing attacks and system errors
- Decrease time to first fix (TTFF), especially in an urban canyon

For designers and testers, the ability to record those "signals of opportunity" alongside GNSS signals can be extremely useful in characterising and verifying the performance of sensor fusion algorithms and hybrid positioning systems.

With new positioning system designs emerging that combine GNSS with other signals, test teams need to ensure that all signals can be correctly processed without co-existence interference that could degrade performance.

Capability #4: In-Vehicle Networking

Advanced driver assistance systems (ADAS) are some of the most sophisticated positioning systems in the commercial world, using multiple sensors to offer features like lane departure warnings, parking assistance and collision avoidance.

As we move further into a world of vehicle autonomy, rigorous testing of those systems will be critical—not least because safety regulations will almost certainly start to emerge as vehicles take on more decision-making capabilities.

Verifying the performance of GNSS receivers as part of an overall vehicle control system requires a detailed understanding of the vehicle's position and dynamics during the test drive. The ability to record additional data inputs at the same time as GNSS signals can give engineers a richer understanding of what happened during the drive test when the recording is replayed in the lab.

Alongside the GNSS signals, the additional data inputs that can lead to better verification testing of vehicle systems include:

CAN bus data from the in-vehicle network: Recording CAN bus data in sync with GNSS signals captures the real-world drive in greater detail, all inter ECU communication can be captured independent of CAN message structure. Examples of data within the messages are speed, acceleration, wheel-ticks, fuel consumption and location data.

CAN-FD has brought the CAN protocol closer to real-time with lower latency, higher bandwidth and greater integrity. The capability to record these richer, near-real-time data feeds will be invaluable.

Infotainment system signals: For teams testing in-vehicle infotainment systems that receive AM/FM or DTV signals, the ability to record and replay those signals in sync with GNSS will be a valuable addition to the testbench.

Dashcam video: Recording dash-mounted webcam video feeds—in sync with the RF signal environment and CAN bus data—enables developers to replay the external driving environment on a display screen in the lab alongside the RF and in-vehicle environment.

A New Level of Utility for GNSS Systems Designers

Together, these four new capabilities will greatly enhance the value and utility of a GNSS RPS for designers, developers, integrators and testers of GNSS-based systems.

Alongside increased data storage, greater bit depth and multiple channels of RF recording, they will allow testers to record and replay the real-world environment in far greater richness and detail than ever before—enabling lab-based verification testing to be done faster, more efficiently and more rigorously than ever.

Introducing the Spirent GSS6450: The World's First Highly Portable, High Dynamic Range RPS

At Spirent we continuously invest in our GNSS record & playback systems to ensure they continue to meet the requirements of test and development teams as their needs evolve.

Our latest GNSS record & playback system, the GSS6540, is the first commercial RPS device on the market to offer these capabilities and features in one unit:

Highly portable system: At 2.2kg the GSS6450 delivers an unrivalled power-to-weight ratio. It's battery-powered, and is compact and light enough to be worn in a bag or over the shoulder—making it perfect for the advanced testing of wearable technology.

Unrivalled dynamic range: The GSS6450 is designed to capture complex environments with the fidelity to ensure that playback results in the laboratory are truly representative of captured real world conditions. The flexible structure makes it suitable for everything from commercial application testing to interference and jamming test scenarios.

The standard option allows you to keep data storage levels down, whilst the advanced and high capability options provide progressively higher dynamic range. Selectable bandwidth also allows the user to ensure only the bands they are interested in are recorded, saving data space.

More storage capacity: Internal storage up to 2TB and up to 7.5TB more via an additional removable solid-state drive, and up to 1.5 hours of battery life, means you can carry out uninterrupted recording in the field. For users requiring more storage, the unit supports external RAID devices of up to 80TB.

Multi-signal recording: GSS6450 can record any RF in the 470MHz-6,000MHz frequency range, including GPS L1, L2, L5, Galileo E1, E5a\b, E6, GLONASS L1, L2, L3, BeiDou B1, B2, B3, QZSS L1, L2, L5 and L6, IRNSS L5 and S-Band. In addition, it supports 2.4GHz and 5GHz WiFi and LTE/Cellular. Presets make it easy to select pre-set frequency bands including GNSS, LTE or Wi-Fi.

Multi-antenna recording: Record simultaneously on two antennas using the RF1 and RF2 inputs. Both are generated from the same high-grade OCXO, to minimise and offset error between ports.

RF1 records in the main GNSS frequency bands (1176-1602MHz), with filters to enhance GNSS band recordings; RF2 records from 690MHz to 2400MHz with no filters; and RF3 records from 470MHz to 6000MHz.

CAN, IMU and video recording: The GSS6450 allow you to record up to two channels of high-speed CAN as well as an option to add CAN-FD. It also allows the recording of up to 4 HD webcam and up to 8 streams of serial data communication (e.g. IMU or RTK correction data) in synchronisation with the GNSS.

Learn more about the GSS6450's capabilities: download the [visit our product page](https://www.spirent.com/products/gnss-rf-record-and-playback-system-gss6450).

The GSS6450 is designed to be a valuable asset for years to come, capable of being upgraded to add new functionality as it emerges. New features will be defined by demand, so if you have a need that isn't currently met—let us know!

Learn more about Spirent solutions for GNSS simulation, record & playback and more.

Spirent enables innovation and development in the GNSS and additional positioning, navigation and timing (PNT) technologies that are increasingly influencing our lives. To find out more, visit www.spirent.com.

TALK TO A SPIRENT EXPERT TODAY

The Spirent GSS6450 is available today for developers of all types of GNSS-enabled systems. To find out more about the capabilities of this record & playback system and whether it is right for your business, contact Spirent at www.spirent.com/contact or visit https://www.spirent.com/products/gnss-rf-record-and-playback-system-gss6450.

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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