

# Keysight Positioning Technology

# Table of Contents

- Challenges and Opportunities for Positioning, Navigation, and Timing (PNT) Systems.....3
- Introduction to Positioning Technology .....5
- GNSS Simulation Solutions.....6
- Key Simulation Capabilities .....7
- Why Keysight Simulation? .....9
- Keysight Simulation Platform: PNT X.....11
- Keysight Simulation Platform: GSS7000 GNSS Simulator.....13
- Keysight Simulation Platform: PNT Xe.....15
- RF Record and Playback Solutions .....17
- Introducing the Keysight GSS6450 Record & Playback System.....18
- GNSS Forecasting .....20
- Spoofing Detection and Alerting Service.....22
- PNT Testing Services .....23

# Challenges and Opportunities for Positioning, Navigation, and Timing (PNT) Systems

PNT has gone from novelty to luxury to ubiquity. A huge range of technologies — from smartphones to space vehicles — depend on PNT for critical functionality. When it fails, the consequences vary from inconvenience to catastrophe. In order to enhance functionality and guard against failures, testing has grown in both importance and complexity.

For many noncritical systems, PNT is synonymous with global navigation satellite systems (GNSS). GNSS is the only truly global source of absolute positioning and timing information, and has become more of an integral element of our lives than anyone could have foreseen when Navstar 1 was launched in 1978. However, as PNT has become more critical for more applications, the use of additional sensors — such as inertial, light detection and ranging (LIDAR), and vision — has become more commonplace. Whether using GNSS-only, or multiple sensors, testing has to overcome important challenges.

## Repeatability

The RF environment is constantly changing. GNSS satellites come in and out of view, and the impact of surroundings changes as those satellites move, and as the device-under-test moves. Changes in nearby interference sources, the weather, ionospheric conditions — all of these and more can impact the performance, meaning real-world (or live sky) testing lacks repeatability and error traceability. Lab testing using simulation adds both of these important elements, enabling efficient development processes.

## Control

Whether it is everyday occurrences such as multipath or out-of-band interference, or unique events such as jamming, spoofing or satellite segment errors, there are conditions that need to be evaluated for PNT-enabled systems. For some of these vulnerabilities, real-world testing is impossible; for others, it can be illegal. Lab testing enables the exploration of corner cases to assure performance in a wider range of conditions.

## Speed

Lab testing enables more tests to be conducted in less time, and enables devices and systems to be iterated as the results appear. With the competitive development cycles of many products, this time-saving can be the difference between success and failure.

## Cost

Buying test equipment can represent a significant capital investment. However, when weighed up against the cost of field testing it will usually prove to be significantly cheaper. Devices can be tested in different environments, at different times, on different continents without needing any test engineer to leave the lab. For instance, live-sky testing the integrated GPS/inertial function on a military jet would involve flying numerous test missions at huge cost.

# Introduction to Positioning Technology

Keysight test solutions have been powering developments in GNSS and additional PNT technologies for over 35 years. With customers on every continent and support operations around the world, Keysight is the trusted partner of the leading defense, space, and commercial organizations.

Through proven technology, our simulators deliver the most realistic GNSS, inertial, and additional PNT test environments, so you can be confident that your products and systems will succeed; our record and playback systems bring the real-world signal environment into the lab in dynamic detail; and our custom services bring industry leading expertise into your programs.

35+  
Years

150+  
Employees

Used in every related industry sector

Trusted by all major space and defense agencies

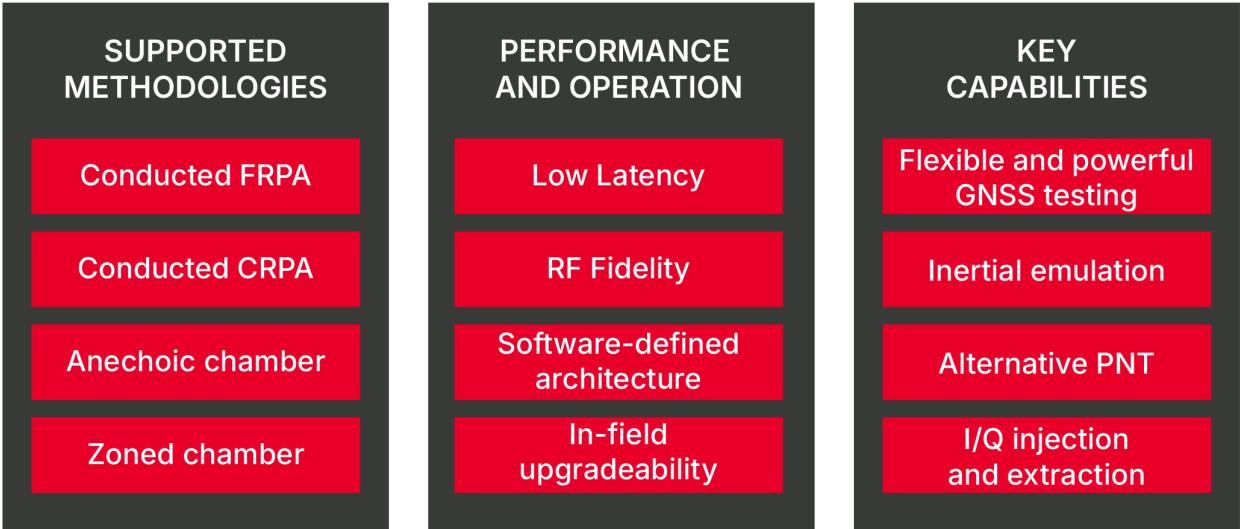
Unrivaled, proven performance

“Keysight has been meeting the needs of PNT developers since the early days of GPS in the 1980s, from the first commercial GPS simulator to the first high bit depth record & playback system — and beyond. In that time, we’ve maintained our commitment to delivering maximum performance without compromise. For testing to be truly comprehensive and valuable, you need to be able to trust the results. Our dedicated architecture and commitment to innovation ensures that this is always the case.”

**Adam Price, VP PNT Simulation**

# GNSS Simulation Solutions

Keysight's dedicated simulation and testing tools deliver the precision and realism needed to enable the next generation of PNT systems. Our flexible, scalable software-defined radio (SDR) test systems are designed to integrate into your test environment and evolve with your needs, making us the partner of choice for the leading PNT developers.



# Key Simulation Capabilities

Keysight recognizes that greater value in test comes through greater realism and a broader set of features and capabilities. Through our highly configurable SDR architecture, Keysight offers true test flexibility and the assured performance your customers demand.

## Jamming and Spoofing

From onboard high-powered jamming and flexible spoofing features to simple integration with additional dedicated hardware, comprehensively protect your PNT systems with Keysight simulation solutions.

## Inertial Emulation

Keysight's inertial emulation capability reduces the need for costly and unrepeatable field trials, using accurate error models to deliver precise, synchronized sensor outputs. Whether testing military-grade integrated GNSS/inertial navigation systems using SimINERTIAL, or MEMS sensors for an automotive positioning engine using SimSENSOR, Keysight inertial emulation solutions are helping to deliver more resilient navigation.

## Remote Control

Keysight simulation systems are designed with the modern automated and integrated lab test environment in mind. Offering comprehensive remote-control capability, APIs are available for different programming languages and development environments (e.g. C++ and LabVIEW). In addition, native gRPC capability and Spyder integration enable simple control via Python libraries.

## I/Q-Based Testing

The ability to inject and extract I/Q data files enhances testing against evolving interference threats, enables testing earlier in the development cycle, and offers the opportunity to create and generate non-ICD signals and propagate them in the lab.

## Environment Modeling

Recreating realistic signal propagation environments in the lab means you can reliably test your system against the impact of real-world multipath and obscuration signatures. This enhanced realism saves you time and money in expensive and unrepeatable field tests, helping you bring better products to market faster.

## Realistic LEO Orbit Modeling

Precision, LEO-specific orbital models enable realistic design of LEO constellations. Together with flexible non-GNSS signal generation, this allows research and development into alternative PNT technologies using different signals of opportunity. In addition, onboard satellite PNT-dependent systems can be tested realistically and in concert.

# Why Keysight Simulation?

Any compromise on performance or fidelity in test equipment equates to error and uncertainty in results. Keysight remains committed to delivering the highest quality PNT simulators, ensuring that the results you generate in the lab truly reflect the performance of the device under test — and not the performance of the test equipment.

## Architecture

Keysight simulation systems are built on proven SDR architecture. Using the right technology for the right application is at the core of our design, ensuring the optimum blend of performance and flexibility.

## Signal Fidelity

Any deviation from the intended reference signal generated by a simulator can confuse the test process, and even compromise the validity of the test. Keysight simulators have been designed and exhaustively tested to deliver unrivaled results in phase noise, spurious signals, harmonics, and other unwanted signal effects. Through generating signals from first principles, Keysight simulations provide the closest approximation to real world signals available in the lab.

## Latency

When real-time remote motion data is used in a hardware-in-the-loop (HIL) environment, latency becomes of critical importance. Keysight GNSS simulators deliver the lowest latency of any equivalent test tool on the market, and that latency is maintained under all configurations. Bringing Keysight into your HIL environment minimizes error and uncertainty — crucial for safety-critical application testing.

## Handling Motion Data

Powered by the Keysight Positioning Application simulation engine — the industry's leading simulation control platform — Keysight simulators are able to output faithful motion data, allowing for precise results and powerful analysis. High update rate capability means extrapolation is kept to a minimum, and highly consistent processing means interpolation is only used when input motion data is either incomplete, or at a lower update rate than the simulator.

## Carrier Phase Alignment

Testing adaptive antenna systems such as controlled reception pattern antennas (CRPAs) demands low and consistent deviations of carrier phase occurring among several test reference sources. Keysight simulators are precisely calibrated prior to each test run, maintaining a low level of deviation throughout. Importantly, this is achieved without endangering the test through mid-run calibration.

# Keysight Simulation Platform: PNT X

Keysight PNT X is a revolutionary positioning, navigation and timing (PNT) simulator that addresses the increasing complexity of the PNT environment. This all-in-one solution generates all GNSS constellations, RF threats, and non-GNSS signals of opportunity — including beyond L-band — available for comprehensive test coverage and realism.

In an era when compromising on PNT performance is not an option, PNT X delivers new patented capabilities, simplified software for configuring complex test scenarios, and critical simulation integrity to ensure trustworthy results.

## Performance

- Unrivaled 2 kHz configurable simulation iteration rate — 2 ms latency in HIL applications
- 100 kHz update rate for spinning vehicles
- Precise simulation of high dynamic motion — up to 350 Mach
- Our highest-ever signal fidelity

Full signal performance met under all simulation conditions

## Modeling

- 3D environment modeling for real-time obscuration and multipath on GNSS and non-GNSS signals
- Realistic LEO and MEO orbital models for constellation ephemeris and device-under-test (DUT) trajectories
- Tx and Rx antenna gain and phase patterns
- Configurable ionosphere and troposphere
- Scintillation and solar weather
- High-dynamics vehicle motion
- Coherent inertial sensor simulation
- DGPS corrections

## Flexibility

- Embedded Python IDE to develop software add-ons and automate testing
- Remote control libraries available for different programming languages via gRPC
- On-the-fly reconfiguration of constellations and signals
- Extensive data logging and post-processing tools
- Native signal interference capabilities supporting configurable CW, FM, AM, PM, wideband AWGN, BPSK, CW pulses, Chirp, and matched spectrum
- Support for multiple spoofers with independent noise patterns in a single scenario
- Record or replay I/Q data — and apply patented I/Q spatial awareness for highly realistic I/Q replay



**Figure 1.** Keysight PNT X positioning, navigation, and timing simulator

# Keysight Simulation Platform: GSS7000 GNSS Simulator

With its embedded controller and compact design, the dedicated SDR architecture of the GSS7000 combines power and space-saving efficiency for your labs. Through the flexibility to customize and upgrade anytime, anywhere, you can confidently overcome new threats and growing expectations of precision and reliability. The GSS7000 is available with a range of software packages — SimGEN, SimREPLAYplus and SimTEST — according to the application.

## Performance

- Simulation iteration rate (SIR) configurable up to 1000 Hz
- Precision simulation of high dynamic motion with ultra-low latency
  - 120 km/s relative velocity — 193 km/s. relative acceleration
  - 890km/s. relative jerk
  - $60\pi$  rad/s angular rate
  - <4 ms latency
- 0.3 mm RMS pseudorange accuracy
  - 0 mm uncertainty due to inter-channel bias
- Class-leading signal quality and control
  - -182 dBW spurious (max) — -40 dBc harmonics (max)
  - 0.02 rad RMS phase noise (max)
  - $\pm 5 \times 10^{-10}$  frequency stability
  - +15 dB to -40 dB level control range
  - 0.1 dB level control resolution

## Available Signals

- |            |                              |
|------------|------------------------------|
| • GPS      | L1 C/A, L2 C/A, L5 I/Q       |
| • GLONASS  | L1OF, L2OF, L1OC, L2OC, L3OC |
| • Galileo  | E1 OS, E5 A/B, E6            |
| • BeiDou-2 | B1I, B2I                     |
| • BeiDou-3 | B1C, B2a, B2b, B3I           |
| • QZSS     | L1, L2, L5, L6               |
| • IRNSS    | L1, L5                       |

## Key Capabilities

- Configurable and powerful embedded interference capability
- Flexible embedded spoofing capability, including meaconing attacks and trajectory, base station, and nav data spoofing
- GNSS/inertial testing via MEMS sensor emulation
- Live sky synchronization for highly realistic spoofing testing
- Validated to support test tools such as Qualcomm's QDART



Figure 2. GSS7000 GNSS simulator

# Keysight Simulation Platform: PNT Xe

PNT Xe is making high-fidelity simulation available for every workstation, every engineer, and every project phase. PNT Xe is designed for rack mounting, desk mounting, and portability. With fast deployment and a simple but powerful interface, it gives you all the tools to speed up onboarding, simplify system configuration, and accelerate scenario creation. Take advantage of the world's leading simulation architecture at a fraction of the cost.

## Production Line Testing

From defense to automotive to handsets and wearable devices, production line testing is a critical stage in a product lifecycle. PNT Xe has been designed for all types of production line, delivering:

- 2U rack compatibility
- Space-saving desk mount
- Easy portability and quick setup
- Intuitive tool for scenario creation
- Seamless remote interface for test execution
- Support for all current GNSS signals

## Integration Testing

Efficient and effective integration of GNSS into the test environment is at the core of most PNT-enabled product development. PNT Xe offers key enablers and capabilities:

- Flexible configuration
- High-fidelity GNSS RF signals with exceptional output power stability
- Supports uninterrupted simulation for up to 24 days
- Simple, low latency integration into HIL test setups
- Low onboarding overhead with streamlined configuration and control
- Minimized risk of downtime with robust, proven architecture
- Accessible price for expanded deployment

## Performance and Capabilities

- Multi-constellation, dual frequency (e.g. L1+L5 / L1+L2)
- Pseudorange accuracy 5 mm RMS
- Spurious (max) -182 dBW
- Harmonics (max) -40 dBc
- Phase noise (max) 0.02 Rad RMS
- Frequency stability  $+5 \times 10^{-10}$  per day



Figure 3. PNT Xe simulation platform

# RF Record and Playback Solutions

The GSS6450 Record & Playback System enables high-fidelity testing using real-world signals in repeatable lab conditions.

The GSS6450 leads the way in combining the practicality and dynamic detail needed for next-generation product development. Offering high dynamic range and bandwidth, and fully configurable according to your needs, the GSS6450 enables powerful lab testing with unrivaled realism.



**Figure 4.** A Keysight GSS6450 is used to record the signal environment in a deep urban location

- High dynamic range
- Portability
- Unrivaled build quality
- Field upgradable
- Fully configurable

# Introducing the Keysight GSS6450 Record & Playback System

The GSS6450 delivers the realism and repeatability developers need to deliver world-beating products, bringing the real world into the lab in dynamic detail.

## Proven Technology

Developed using Keysight's 35 years of industry leading expertise, the GSS6450 has been designed and built for next-generation PNT testing. With expert support and consultancy around the globe, Keysight is the trusted partner of the leading GNSS and other PNT developers, delivering maximum performance without compromise through dedicated test solutions.

## Uncompromising Performance

Modern applications require higher precision and continuity than ever before, and this demands uncompromising performance in test and development. Combining high dynamic range and a wide bandwidth with high recording fidelity, facilitated by the premium OCXO, the GSS6450 delivers the realism and rich real-world detail needed for comprehensive testing.

## Unrivaled Capability

In addition to supporting all current GNSS signals, the GSS6450 facilitates the development of integrated PNT technologies through the ability to record any RF in the 80 MHz to 6,000 MHz frequency range, record CAN and CAN FD, and up to four concurrent HD video streams. With these features, the GSS6450 is the most capable record & playback system available for developers in industries ranging from automotive to handset to defense.

## Ultimate Flexibility

Feature key configuration, field upgrades, and simple re-configuration between runs make the GSS6450 ideal for efficient data collection exercises, as well as for growing and evolving test requirements.

## Practical Ease of Use

Weighing just 2.2 kg and with a small form factor, the GSS6450 is highly practical. Added to this, a range of control options that includes touchscreen, Wi-Fi, web server, and script control.

## Key features

- Record up to four concurrent signals
- Three independent RF ports
- Built-in real-time spectrum analyzer
- Record/playback up to 4 video streams
- Embedded GNSS receiver for performance verification
- Touchscreen, Wi-Fi, web server, or script control

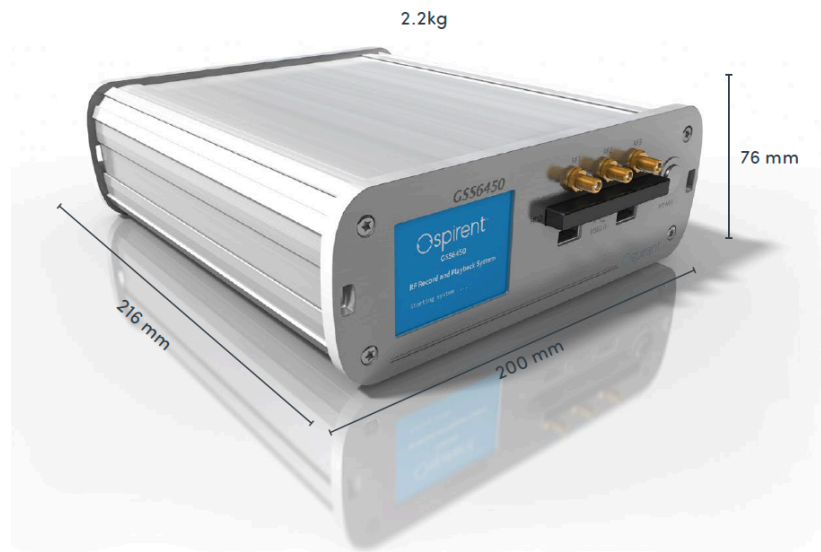
## Supported signals

Signal	Frequencies
GPS	L1, L2, L5
Galileo	E1, E5, E6
Glonass	G1, G2, G3
BeiDou	B1, B2, B3
QZSS	L1, L2, L5, L6
IRNSS	L5
SBAS	L1, L5
Signals of opportunity (SOOP)	Wi-Fi, LTE/Cellular
Additional	Inmarsat, TerraStar, OmniStar, Starfx

## Supported signals

Signal	Frequencies
GPS	L1, L2, L5
Galileo	E1, E5, E6
Glonass	G1, G2, G3
BeiDou	B1, B2, B3
QZSS	L1, L2, L5, L6
IRNSS	L5
SBAS	L1, L5
Signals of opportunity (SOOP)	Wi-Fi, LTE/Cellular
Additional	Inmarsat, TerraStar, OmniStar, Starfx

## GSS6450



**Figure 5.** GSS6450 Record & Playback System

## GNSS Forecasting

Situational awareness is key to autonomous operations. Knowing where and when your system will perform enables optimized mission planning, increased availability, and greater safety and reliability. Keysight's GNSS Foresight uses high-definition maps and precision orbital modeling to give you a clear picture of your operating environment when you need it.

## Travel at the Right Time

The Forecast Live service enables navigation in challenging environments by calculating GNSS availability for every meter, every second, from 1-100 meters altitude, for up to three days into the future. Access data in real-time via our API.

## Determine Safe Autonomous Navigation

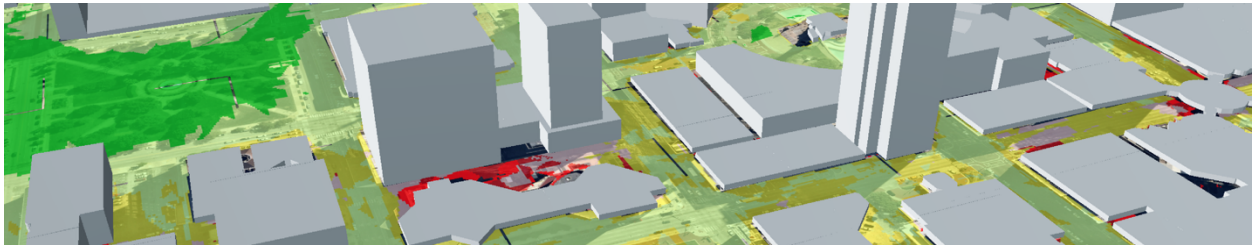
The Risk Analysis service aggregates GNSS forecasts to determine areas that are always safe to fly or drive and not safe to do so. Delivered as data, a heatmap, analysis, and report, this can be used as part of a concept of operations including for example, fixed take-off/landing and flight routes.

## Performance Improvement

Integrating GNSS Foresight into your GNSS receiver can bring significant performance improvement. Identifying line-of-sight signals for every square meter, every second, enables the exclusion of multipath signals from the PNT solution.

## Coverage Planning

Using GNSS Foresight, providers of LEO and MEO satellite services can determine the projected availability of their signals in challenging environments. This can help with constellation planning, as well as in defining service-level agreements (SLAs).



**Figure 6.** Keysight GNSS Foresight provides a clear picture of your operating environment

## Key Markets

Autonomous  
vehicles

UAS

Mining

Agriculture

Chipset  
developers

LEO  
satellites

# Spoofing Detection and Alerting Service

In 2024, a typical day saw over 1,000 commercial aircraft having their navigation systems spoofed. Not only does spoofing present a real reputational risk to civil aviation operations, it is a clear and immediate danger to passenger and crew safety. However, the solutions to spoofing — including multi-frequency GNSS, controlled reception pattern antennas (CRPAs), and authenticated signals — will take time to certify and to implement.

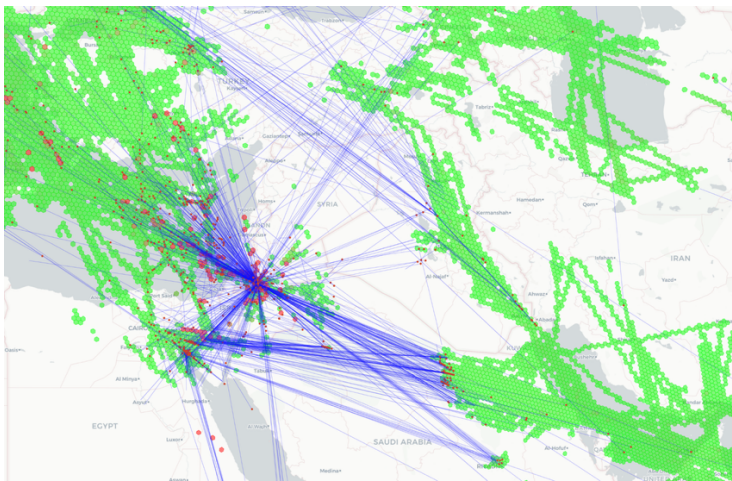
Keysight has developed a spoofing detection & alerting service in order to assure the safety and operational efficiency of civil aviation in the immediate future. This service aggregates data from a range of sources to supply all relevant information to air and ground crews on current spoofing attacks, locations, impacts, and much more.

## Jamming and Spoofing Warnings

- Flights/routes that are impacted in real-time
- Impact by tail number and flight number
- Detection of residual errors after exiting areas of spoofing

## Active Jamming and Spoofing Alerts

- Risk level, type, and severity
- Duration of attacks and size of impacted area
- Analytics to enhance maintenance, training, and operational efficiency
- Detailed alert areas sourced from more than just aviation (ADS-B) data



**Figure 7.** Map of spoofing events in Eastern Mediterranean on September 19, 2024

# PNT Testing Services

Keysight services enable you to accelerate and de-risk your PNT testing. Our engineers and consultants have many years of PNT testing experience, combined with in-depth knowledge of test and assurance solutions. We can help you get started faster, accessing Keysight's expertise to assure your complete success.



## Managed Solutions

Performing strategic operational functions for customers:

- Test as a service
- Lab as a service
- Field data recording as a service
- Benchmarking



## Professional Services

Providing a broad range of test and validation services enabling Keysight products and solutions that involves:

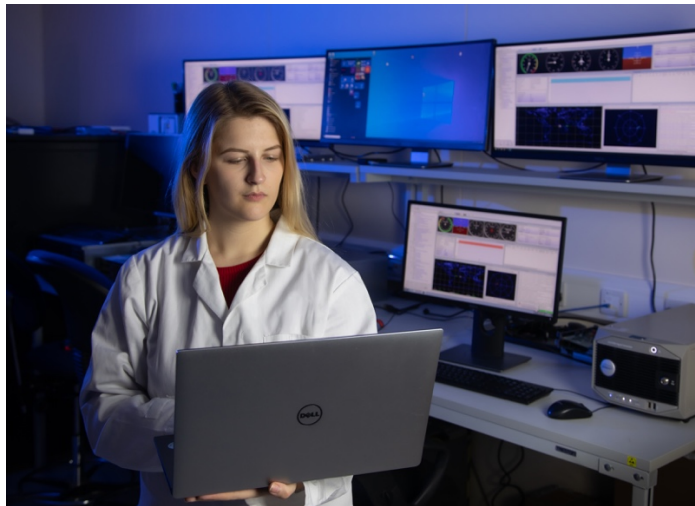
- Test scenario creation
- Implementation and integration
- Test automation
- Customer training
- Resident engineers



## Consulting Services

Supporting custom projects, helping customers with specific strategies and objectives:

- Assessment and strategy
- Planning and design
- Test methodologies
- Risk analysis



**Figure 8.** Accelerate and de-risk your PNT testing with Keysight expertise.

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](http://www.keysight.com).



This information is subject to change without notice. © Keysight Technologies, 2026, Published in USA, June 1, 2026, 3126-1190