



GNSS Testing for LEO

Enabling the Next Generation of Global Navigation Satellite Systems

LEO Opportunities and Challenges

Low Earth orbit (LEO) satellite constellations are already offering a multitude of benefits, from communications to Earth imaging, disaster detection, and mitigation. The next generations of LEO constellations will deliver specialized positioning, navigation, and timing (PNT) services to users around the world, high-speed wireless data connections, and new opportunities for restricted communications technology. With these great opportunities comes a range of challenges, including:

- Achieving satellite precision orbit determination (POD)
- Managing satellite attitude and maneuvering at ultra-high dynamics
- Addressing environmental challenges and differences to on-Earth test facilities
- Developing and testing new signals
- Developing and verifying ground control elements

Keysight solutions are designed to meet the stringent requirements of next-generation technologies and are well-positioned to enable your LEO project.

Testing GNSS for LEO

Conducted

The operation of LEO constellations depends on the PNT solution provided by the satellites' onboard engines. Keysight's PNT test solutions deliver unrivaled performance and fidelity, providing users with a baseline to perform critical functionality tests, including:

- Time to first fix (TTFF)
- Tracking sensitivity
- Position, velocity, and timing (PVT) precision
- Multi-frequency and multi-constellation viability and performance
- Orbit estimation and testing

Additionally, Keysight's simulation solutions feature capabilities that enable performance testing in sub-optimal LEO-specific conditions. These include:

- Multipath and obscuration — including from the satellite itself
- Off-pointing of antenna
- Spacecraft rotation
- Ionospheric errors and scintillation
- LEO-specific orbital model

Control Segment Development and Verification

Interoperability of the space segment and the control segment is critical in any LEO constellation. From timing synchronization to resiliency, this means that both segments must be tested independently and together, which presents significant challenges to developers.

Keysight's highly flexible multi-output capability offers the precision and synchronicity needed to supply a truly realistic GNSS signal environment to both segments at the same time. With the most precise signal modeling and the lowest latency of any GNSS simulation system, Keysight provides a reliable baseline for evaluation and optimization.

Over-the-Air (OTA)

The unique nature of LEO challenges and the lack of opportunity for live sky testing means OTA simulation is a critical element of LEO satellite development. Considerations for developers include:

- Antenna performance
- Radio frequency (RF) interference from satellite communications (satcom) subsystems
- Electromagnetic interference
- Temperature and pressure testing

Keysight's simulation systems support the most advanced anechoic chamber installations around the world, including zoned chambers to provide extended duration and greater realism. These can also be applied to thermal vacuum anechoic chamber (TVAC) setups.

GSS7000 Multi-frequency, Multi-GNSS Simulator

- High-precision simulation across current and planned GNSS and satellite-based augmentation system (SBAS) signals
- Highly configurable architecture
- Support for advanced 3D multipath and obscuration testing
- Onboard interference capability
- Native and customizable vehicle models
- Flexible generation of non-ICD signals



Figure 1. Keysight's GSS7000 simulator

Designing a LEO PNT System

LEO presents a significant opportunity for PNT service provision. A dedicated LEO constellation could operate as a system complementary to GNSS, or as a standalone alternative. In either case, the development of a LEO PNT provision places demanding requirements on test and innovation tools. Primary requirements could include:

- Early feasibility testing
- Interoperability testing with other PNT sources
- Holdover capability in Global Positioning System (GPS) denial of service/outages

Keysight test solutions provide a critical range of capabilities to meet these requirements. Developers can use a PNT X or a two-radio frequency (2RF) GSS7000 employing SimIQ Replay to generate RF from externally supplied in-phase and quadrature (I/Q) data. By working with internally generated GNSS signals, developers can configure important test functions:

1. **Test LEO satellite onboard receivers:** Determining position, orbit, and attitude is a crucial element of every satellite-based positioning technology. Using a single RF output, users may conduct comprehensive testing of the receiver to be used in the LEO constellation. Via use of a mixture of conducted and OTA testing, this can be carried out iteratively as additional elements are added to the product, including testing in a TVAC.
2. **Test downlink for new LEO based PNT signals:** Using a single RF output that employs SimIQ Replay, users can generate Long-band (L-band) RF from I/Q files. These are broadcast at the highest fidelity, with tight control over variables such as power level and center frequency. Additionally, PNT X has a dedicated upconverter that enables S-band signal generation. With this signal broadcasted (whether conducted or OTA) to a compatible receiver, users may assess the tracking and precision and find potential flaws or improvements in the novel signal design.
3. **Interoperability testing:** Due to the reliability, coverage, and low cost of existing GNSS signals, it is likely that any new PNT signal would need to work in conjunction with GNSS in devices. Using dual RF outputs of a Keysight simulator, users can configure one output to generate required GNSS signals from existing constellations and frequencies, while at the same time use SimIQ Replay on the second output to generate novel PNT signals from externally provided IQ data. With these signals both being output to the compatible device under test, sensor fusion algorithms could be assessed and honed, with key factors such as reliable holdover times comprehensively determined.

Why Keysight Positioning Technology?

Keysight enables innovation and development in the GNSS and additional PNT technologies that are increasingly influencing our lives. By providing comprehensive, tailored test and assurance solutions, we assure our clients fulfill the promise of superior performance.

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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