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PROTECTING
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POWERING A CONNECTED WORLD

GNSS Continues to Drive
Transportation Projects Forward



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BASED GPS
PACKS A PUNCH

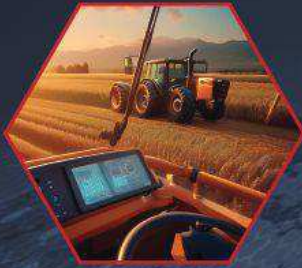
OCTOBER 2025 | Vol 36 | No 8
GPSWORLD.COM

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Hexagon

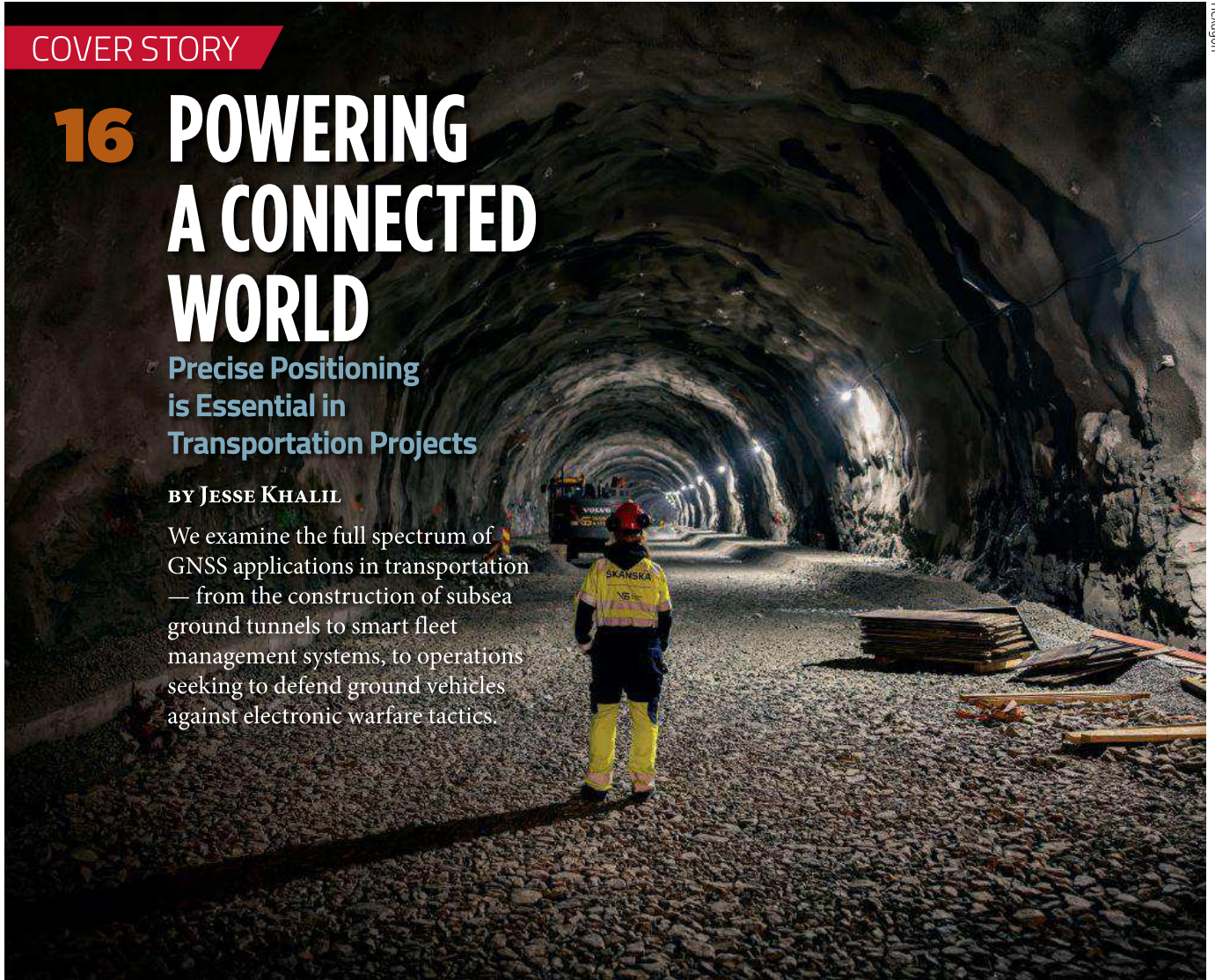
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Precise Positioning
is Essential in
Transportation Projects

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Skanska is leveraging Hexagon's surveying portfolio to construct a 27 km subsea tunnel, located 392 m below sea level. (Credit: Hexagon)

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NEWSLETTER EXCERPT



New NSRS Presents Opportunities for Users

BY DAVID B. ZILKOSKI
CONTRIBUTING EDITOR, SURVEY SCENE

This year, the National Geodetic Survey (NGS) sent news notices announcing the rollout plan for the remaining NSRS modernization products, including OPUS Product Changes, and another announcing the release of NGS' Multi-Year CORS Solution 3 (MYCS3). This newsletter will highlight these two news notices and what they mean to users of the United States National Spatial Reference System (NSRS).

A colleague recently reminded me that the new NSRS is more than just a technical update — it presents an ideal

opportunity to review existing processes and workflows, address current products and process considerations, and strategically plan for future requirements. It is well known that the new NSRS will significantly improve geospatial data accuracy. Improved accuracy and reliability of geospatial data empower management to make more informed decisions and optimize resource allocation. 🌐

Read the full column at gpsworld.com/opinions.

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Published monthly



Deeper Dives in 2026

Rapid innovation is reshaping GNSS/PNT and positioning, navigation and timing (PNT) landscapes. The same can be said for the channels through which we provide this content to you.

GPS World is making strategic refinements to its magazine publishing schedule and digital solutions portfolio to better serve our subscribers. Our transition from a monthly print and digital edition cadence to a six-times-per-year magazine frequency will better align with buying cycles and industry events.

That's why the issue you are reading now will be the last of 2025. We will have plenty of new content online daily at GPSWorld.com to keep you informed on trends and new developments in the GPS, GNSS and PNT sectors.

Going forward, *GPS World* will publish our print issue six times. In 2026, look for issues in February, March, May, June, September and October. We will continue to bring you the same exclusive content, including our Simulator Buyers Guide and our GNSS/PNT Buyers Guide. We'll have our guest columns, such as Inside the Box. Plus, our popular departments PNT Corner, Evolution, Mapping Marvel, LaunchPad, MarketWatch, System of Systems and Seen & Heard will round out our print editions.

In 2026, our cover stories will tackle transportation, defense, simulators, autonomous systems, precision agriculture and complementary PNT, as well as surveying and mapping. Every *GPS World* issue will continue to deliver exclusive technical content and market insights — only now, each edition will delve deeper into today's hottest

trends in GNSS/PNT.

In tandem with our magazine content and publishing evolution, *GPS World* is significantly expanding its digital offerings. New and enhanced digital platforms include:

GPSWorld.com. Watch for more exclusive content focused on the market segments that matter most.

Weekly e-newsletters. *Navigate! Weekly*, *Survey Scene*, *Defense PNT* and *Autonomous Arena* deliver insightful columns and the latest news straight to your inbox each month.

Custom, sole-sponsored e-newsletters, webinars and digital events. Keep an eye out for turnkey opportunities to showcase thought leadership and new technologies.

These changes reaffirm *GPS World's* commitment to being the most authoritative and effective media brand for reaching professionals in the GNSS, PNT and GPS markets. For the past 35 years, *GPS World* has served readers in print and online, and we have no intention of changing that now. Technology may have evolved over that time, but our dedication to providing you with the latest news and in-depth coverage will continue. 🌐

—*GPS World Staff*



Among the technical approaches being researched this year for GNSS/PNT protection, which do you consider most effective or promising?

“The simple answer is what I have been saying many times before. The most effective way to back up GPS/GNSS is to use the terrestrial technology available from eLoran. It is affordable, long-range, precise, and essentially unjammable. However, it’s not what I would call ‘promising’ because that’s not what the government wants to hear. In fact, the government is in the process of dismantling the existing Loran infrastructure that could easily be recapitalized as autonomous eLoran stations. eLoran could provide robust nationwide timing and positioning preservation, including in the northern Pacific Ocean and Alaska, as well as across the Arctic, with Canada, to link up with our allies in the UK and Europe, who are also investing in eLoran. There is no real commercial market in the far north, and there are no commercial systems proposed that can provide such coverage in those areas where we are facing challenges from Russia and China today, and that will only increase into the future.”



Miguel Amor
Hexagon Positioning Intelligence

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Spirent Federal Systems



“L-band jamming and spoofing is now prevalent in many parts of the world. It has now been confirmed

that space-based jammers have been active, as well as conventional terrestrial jamming. Anti-jam solutions can only provide protection up to a certain jammer power level and are not a ‘silver bullet’ solution. Moreover, nulling of space-based jammers will also have the effect of nulling parts of the sky where GPS satellites are in view, degrading performance by reducing DOP. Alternative PNT solutions that are not relying on L-band signals are the most effective solution for operations in highly contested, jammed or spoofed L-band environments.”



“I believe that both orbital and ground-based PNT systems, operating in tandem and integrated properly,

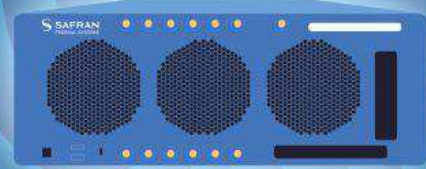
are the ultimate solution for critical infrastructure applications, but to get there, ‘the budget-office-inspired problem’ of having to pick one and only one must be abandoned: prevention is usually cheaper than curation. Only after space-based and ground-based PNT designers, developers, regulators, and users understand and welcome the essential nature of PNT source diversity will we actually achieve the resilient PNT capabilities that we all need.”



Read the full responses at gpsworld.com/opinions.

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SYSTEM OF SYSTEMS

POLICY AND SYSTEM DEVELOPMENTS IN GNSS AND OTHER PNT TECHNOLOGIES



Galileo OSNMA Authentication Service Now Operational

The European Union Agency for the Space Programme (EUSPA) has officially declared its Galileo Open Service Navigation Message Authentication (OSNMA) initial service operational. OSNMA introduces a data authentication mechanism for

Galileo Open Service users and is available for free to Galileo users worldwide.

Spoofing is the transmission of counterfeit satellite signals that deceive GNSS receivers, causing false, unreliable positioning that can disrupt critical sectors including transportation, finance, telecommunications,

energy, manufacturing, healthcare, emergency services and law enforcement. In safety-critical domains such as aviation and maritime, spoofing risks can lead to serious safety hazards.

OSNMA addresses these threats by embedding a cryptographic digital signature within the Galileo navigation message (I/NAV) broadcast on the E1-B signal. This digital signature allows receivers equipped with OSNMA to verify that the signal truly originates from Galileo and has not been tampered with or spoofed.

OSNMA is integrated into the Galileo Open Service signal, which already is used by most GNSS devices. This means no change to existing Galileo signal structure or navigation performance, preserving full backward compatibility. Non-OSNMA receivers continue to function normally, while OSNMA-capable receivers decode and authenticate the digital signature.

The European GNSS Service Centre (GSC), located at the National Institute for Aerospace Technology (INTA) in Torrejón de Ardoz, Spain, manages the generation and transmission of authentication messages to Galileo's ground segment. 🌐

NTS-3 Launches into Orbit

The Department of the Air Force (DAF) successfully launched the Navigation Technology Satellite-3 (NTS-3) Vanguard aboard the United Launch Alliance (ULA) Vulcan rocket on the USSF-106 mission from Cape Canaveral Space Force Station, Florida, on August 12, 2025. This mission marks the first U.S. national security payload launched on the Vulcan Centaur rocket, which represents a new era of launch

vehicle capability for national defense.

NTS-3 is an experimental integrated navigation satellite designed by the Air Force Research Laboratory (AFRL) to enhance the robustness, resilience and responsiveness of space-based PNT services, crucial to both military and civilian applications. The satellite aims to advance the capabilities of existing global navigation satellite systems through an advanced atomic clock timekeeping system, a reprogrammable receiver compatible with

both legacy and advanced signals (the Global Navigation Satellite System Test Architecture), and Chips Message Robust Authentication, which defends against GPS spoofing.

NTS-3 features a fully reprogrammable software architecture that spans the space-based satellite, ground-based control system, and agile user receivers. This enables rapid software updates either on orbit or in the field, a significant departure from previous GPS satellites

SEE NTS-3, NEXT PAGE. >>

NavIC in Jeopardy as Majority of its Satellites Become Defunct

India's regional satellite navigation system, NavIC (Navigation with Indian Constellation), is facing a severe operational crisis, with only four of its 11 satellites currently operational, according to government data and news reports.

Developed and maintained by the Indian Space Research Organisation (ISRO), NavIC is intended to provide precise positioning, navigation and timing (PNT) services across India and up to 1,500 km beyond its borders. However, this constellation is now on the brink of becoming near-defunct, according to the Indian Defence Research Wing.

Of the four satellites still fully operational, IRNSS-1B has already exceeded its planned 10-year mission life and is at risk of imminent failure. At the same time, IRNSS-1F also is nearing the end of its lifespan with partial equipment failures. IRNSS-1I, launched in 2018, is expected to remain functional until around 2028 but its longevity remains uncertain given the premature failures in the constellation.

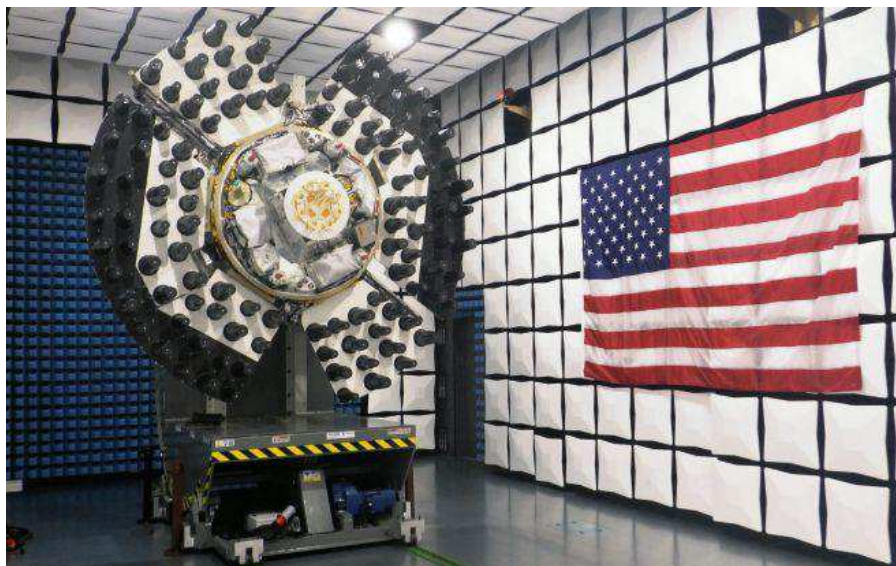
The new generation satellite, NVS-01, launched in May 2023, is operational. Still, its immediate successor, NVS-02, launched in January 2025, failed to reach its intended geostationary orbit due to a propulsion system malfunction and remains stranded in a transfer orbit, rendering it unable to provide navigation services.

To replace the ageing first-generation satellites, ISRO initiated the second-generation NVS series, with plans



THE NVS-02 navigation satellite being encapsulated into its payload ahead of its Jan. 28 launch.

for a constellation of five satellites. So far, only NVS-01 is functional. The failure of NVS-02 to reach orbit halted progress and highlighted technical challenges that ISRO must address to avoid repeat failures. The Indian government has committed to launching the remaining NVS satellites (NVS-03, NVS-04 and NVS-05) by the end of 2026. 🌐



NTS-3

<< CONTINUED FROM PREVIOUS PAGE.

that required hardware changes for upgrades. This approach delivers not only military advantages in contested environments but also substantial benefits for civilian users who rely heavily on GPS for banking, agriculture, telecommunications and air traffic control.

Industry partner L3Harris Technologies serves as the prime contractor, working alongside AFRL on the design, development, integration, testing, launch vehicle interface, and on-orbit operations of the satellite. 🌐

Prevent Million-Dollar Mistakes: Why GNSS Simulation Is Essential for Surveyors

A few years ago, a highway project in Minnesota suffered a costly setback. A bridge was misaligned — not by much, just about a meter — but enough to trigger massive delays, structural rework, and skyrocketing costs. The root cause? A GNSS error that went undetected during equipment calibration. What seemed like a minor glitch in positioning data turned into a logistical nightmare, reinforcing one critical truth: in surveying, precision isn't just a requirement — it's the very foundation.

The Hidden Vulnerability in Modern Surveying

GNSS has revolutionized surveying and mapping. From infrastructure to land development and construction, today's professionals rely on pinpoint GNSS accuracy to deliver results. Yet, GNSS signals are surprisingly fragile. They're vulnerable to jamming, spoofing, multipath interference and environmental factors that are often impossible to control in the field. Positioning accuracy can be lost in seconds.

Resilience in the Face of GNSS Interference

Exposing GNSS-based survey equipment to simulated GNSS interferences — whether natural or intentional — before deployment is no longer optional. Fully repeatable, simulation tests allow users to diagnose, fix and validate GNSS receivers under consistent conditions, by generating authentic RF signals from any constellation.

Testing GNSS Receivers in real-world conditions

Survey and mapping professionals need to validate and stress-test GNSS receivers and positioning systems in real world conditions - from urban canyons, construction sites to rural terrain. Few high-tech GNSS simulators are able to model those real-life environments, down to the last detail: dynamic motion, signal blockage, multipath reflections and even customized antenna behavior.

Powering Confidence with Safran's Skydel GNSS Simulation

Safran's Skydel-powered GNSS simulators, such as the GSG-7 and GSG-8 Gen2 enable precise, repeatable testing of GNSS equipment in the lab before deployment. Designed to simulate GNSS threats such as **jamming and spoofing** without extra hardware, both simulators support high signal capacities, all constellations (legacy and LEO) and generate accurate RF signals.



Built for speed and usability, the GSG-7 and GSG-8 Gen2 simulate multi-vehicle, multi-antenna scenarios, and are equipped for HIL testing while providing unmatched realism.

Main features:

- Full constellation support
- LEO and custom constellations
- Sub-millimeter signal precision
- CRPA and OTA testing support
- Complex environment simulation
- Hardware-in-the-Loop (HIL) integration
- Software-defined architecture
- Lab-based testing for real-world scenarios

With Safran's Skydel-powered GNSS simulators, confidence isn't just tested — it's engineered.

Contact us to know more:

SimulationSales@nav-timing.safrangroup.com



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Day after day, you face critical challenges. The products and services developed by Safran Electronics & Defense, whether civil or military, deliver the technological superiority, effectiveness, reliability and competitiveness you expect. We're with you every step of the way, building in the intelligence that gives you a critical advantage in observation, decision-making and guidance. You can count on Safran Electronics & Defense, your strategic partner on land, at sea, in the air and in space.

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LAUNCHPAD | DEFENSE

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④



1. ANTI-JAMMING ANTENNA FOR DEFENSE, MARINE AND CRITICAL INFRASTRUCTURE

The CR8894SXF+ is an advanced controlled reception pattern antenna (CRPA) for anti-jamming. It is engineered to provide efficient interference protection and real-time situational awareness across critical infrastructure, marine and defense environments where GNSS continuity is mission critical. It is specifically designed to provide a low-power and lightweight solution in a compact size. It features advanced in-band null forming to protect GPS L1/L2 and Galileo E1/E5b signals, helping ensure resilient positioning, navigation and timing in environments with contested, congested or degraded radio frequency conditions. The antenna incorporates Calian's eXtended Filtering interference mitigation technology to maintain performance and reliability when RF threats are present. The CRPA supports in-band null-forming of 20 dB to 40 dB and out-of-band rejection up to 80 dB across 700 MHz to 2,500 MHz. It includes two independent low-noise amplifier channels, allowing continued operation if one signal band is compromised. The antenna forms nulls in both upper (L1/E1) and lower (L2/E5b) GNSS bands to actively suppress jamming sources. A serial output interface provides real-time feedback, enabling users to monitor RF conditions and system status.

Calian GNSS, calian.com

2. PNT SYSTEM INTEGRATES GNSS RECEIVER, INS, ATOMIC CLOCK

The BlackNaute autonomous positioning, navigation and timing (PNT) system integrates Safran's HRG dual-core inertial navigation technology, the Skylight multi-mode GNSS receiver board, and an atomic clock to offer navigation resilience in challenging electronic warfare environments. BlackNaute's built-in atomic clock is designed to maintain precise timing, which is essential for secure communications and collaborative combat operations. The system features advanced anti-jamming and anti-spoofing algorithms, which have been validated in more than 16,000 operational cases. These capabilities allow BlackNaute to detect compromised signals and automatically switch to autonomous and trusted navigation and timing sources to ensure continuity of operations. Its modular design allows it to be adapted across a variety of platforms. Airbus

Helicopters has selected the NH90 to be equipped with this new Embedded GNSS and Time INS (EGTI).

Safran Electronics & Defense, safran.com

3. INTERFERENCE DETECTION SUITE ENHANCED FOR GREATER ACCURACY, COVERAGE AND INSIGHT

HawkEye 360's GNSS-I Detection suite includes powerful enhancements to its GNSS interference detection capabilities. The upgrades — designed with defense, intelligence and national security operations in mind — offer unprecedented accuracy, coverage and insight into global GPS jamming and spoofing threats. The update includes a new wider frequency algorithm that better distinguishes individual emitters, incorporates GPS spoofing detection, and is terrain adjusted for better geolocation accuracy, delivering greater situational awareness and more precise geolocation of interference sources worldwide. The enhanced product suite supports strategic decision-making by providing timely, precise insight into potential signal disruptions, enabling stakeholders to better assess risk, respond confidently, and maintain operational continuity in dynamic environments.

HawkEye 360, he360.com

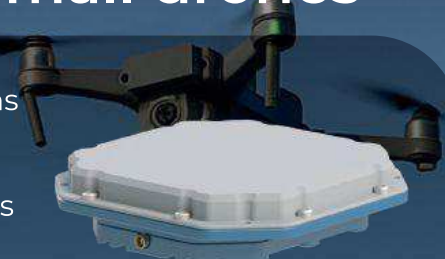

4. VTOL UAS FOR COMPLEX INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE MISSIONS

The GöKHUN unmanned aerial system (UAS) is a tactical vertical take-off and landing (VTOL) drone system developed for versatile missions on land or at sea. GöKHUN combines the compact mobility of a NATO Class I UAV with the performance data of a Class II tactical system. It uses the SP 210 FI GS 2-stroke engine from Sky Power International. With a take-off weight of up to 110 kg and a maximum fuel and payload capacity of 26 kg, the GöKHUN can remain in the air for up to 16 hours with a minimum payload. Even with a demanding sensor load of 12 kg, it can achieve a flight duration of around nine hours, making it suitable for long-endurance reconnaissance and surveillance missions. The GöKHUN's cruising speed is between 96 and 158 km/h. The maximum range with direct line-of-sight is over 150 km, with the system reaching a service ceiling of approximately 5,500 m.

ESEN, esensi.com.tr

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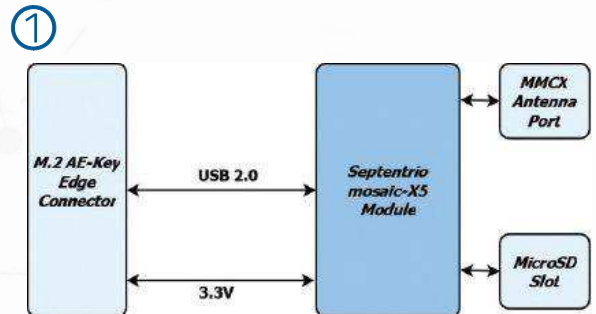
LAUNCHPAD | OEM

1. PRECISION CARD

HIGH-ACCURACY POSITIONING WITH THE MOSAIC-X5

The M.2 card GW16160 is the first Septentrio-based product from Gateworks, a U.S.-based manufacturer of single-board computers. The GW16160 provides reliable high-accuracy positioning powered by the mosaic-X5 GNSS module, a high-quality positioning solution for autonomous robots, UAVs and industrial mission-critical applications. The GW16160 allows engineers to integrate high-accuracy GNSS into edge systems without bulky external receivers or complex RF design. This ultra-low power card features an M.2 A/E-Key interface with USB 2.0 connectivity for plug-and-play integration.

Gateworks, gateworks.com; Septentrio, septentrio.com



2. SPOOFING MITIGATION

CAN PROTECT GPS, BEIDOU AND GALILEO SIGNALS

The Trimble RTX-NMA (Navigation Message Authentication) mitigates spoofing attacks on GPS and BeiDou signals. RTX-NMA leverages the Trimble RTX correction service and enhances the security and integrity of GNSS navigation messages for all Trimble ProPoint receivers. Used in conjunction with Galileo OSNMA, users now have three constellations protected from spoofing attacks. Trimble RTX-NMA seeks to detect both fake GNSS signals and faulty ephemeris data through real-time authentication that ensures navigation messages from multiple RTX reference station receivers are genuine and trustworthy. It also encompasses faulty ephemeris detection, preventing unreliable data from being included in the correction stream. Enhanced security through advanced cryptographic techniques like AES encryption, and stream authentication, take it a step further. Trimble RTX-NMA is compatible with various Trimble GNSS receivers using firmware version 6.40 or greater.

Trimble, trimble.com



LAUNCHPAD | MACHINE CONTROL

1. AUTONOMOUS STEERING PACKAGE

ALLOWS UPGRADES OF OLDER MACHINERY FOR SMALL FARMS

Topcon's has created a Value Line Steering solution for farmers using mid-range tractors on small- to medium-sized farms. It makes autosteering technology — typically used on larger machinery — accessible to a broader range of farmers. Farmers with older or smaller machinery, or small specialty farms, can boost the value of their machinery with the autosteering technology. The integrated system is designed to work across a wide range of applications, machinery and brands. It includes compliance with ISOBUS-UT to offer universal compatibility and ease of use. The package includes a GNSS receiver, electric steering wheel controller, touchscreen console and Horizon Lite software, compatible with front-wheel-steer tractors. Farmers can add local, satellite or RTK correction services such as Topcon's Topnet Live for enhanced precision.

Topcon, topconpositioning.com



1. DATA COLLECTION SOFTWARE

INTUITIVE WORKFLOWS REQUIRE MINIMAL TRAINING

JAVAD Data Collector (JDC) is designed to run seamlessly on any Android device and interface seamlessly with JAVAD GNSS smart antennas. JDC features simple, intuitive workflows that require minimal training, making it accessible for users of all skill levels. The software includes a Signal Bar for a quick view of receiver status, ensuring users can easily monitor their equipment's performance. Its easy navigation allows users to move through the software efficiently. It is designed to streamline operations of customers ranging from individual surveyors to large surveying firms, making it easier to deploy and manage receivers across teams of any size with minimal training. JDC is available for download through the company website.

JAVAD GNSS, javad.com

①



2. MOBILE MAPPING SYSTEM

LIDAR COLLECTS 2 MILLION POINTS PER SECOND

The AU20 MMS is a vehicle-mounted mobile mapping system designed for accurate and efficient collection of 3D spatial data. It combines high-performance lidar technology, versatile sensor support and intelligent data processing to provide a practical and flexible solution for professionals in road surveying, asset management and infrastructure documentation. Its lidar system uses fourth-generation real-time waveform processing to achieve a scan rate of 2 million points per second and 200 revolutions per second, producing point cloud data with 5 mm accuracy and 3 mm precision. This level of detail allows for the identification of fine surface characteristics and features, supporting comprehensive asset inventories and condition assessments. The system's long-range, multi-cycle laser technology enables high-density data capture up to 250 m in vehicle-mounted applications.

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POWERING A CONNECTED WORLD

Precise Positioning is Essential in Transportation Projects

BY JESSE KHALIL, ASSOCIATE EDITOR

Precise positioning technology serves as the backbone of modern infrastructure and transportation systems worldwide. From the initial construction phases of major transportation projects to the daily movement of vehicles, goods and people, GNSS has become indispensable for ensuring safety, efficiency and accuracy.

Its importance becomes clear when examining projects such as Norway's Rogfast Tunnel, where centimeter-level positioning accuracy — less than 2 cm — is essential for safe construction and operations. These integrated systems deliver the real-time, high-precision positioning that construction teams, fleet operators and transportation networks rely on each day.

However, this growing dependence on GNSS technology has created vulnerabilities in everyday transportation operations near war zones. A real-world ground transportation jamming and spoofing test in Haifa, Israel, revealed how precision systems that enable critical operations can be disrupted, exposing a weakness for transportation in contested environments. As technology becomes more sophisticated and GPS-dependent, they paradoxically become more susceptible to electronic interference and accessible jamming and spoofing equipment.

In this cover story, we examine the full spectrum of GNSS applications in transportation — from the construction of subsea ground tunnels to smart fleet management systems, to operations seeking to defend ground vehicles against electronic warfare tactics.





Haugesund



Building the World's Longest and Deepest Road Tunnel

Norway's geography presents persistent transportation challenges. The country's complex network of fjords, islands and mountainous terrain forces travelers to rely heavily on ferry systems and intricate routes that can significantly extend travel times between major population centers.

Norway is building an underwater tunnel, one of Europe's most ambitious engineering projects, which is expected to boost the country's transport links and infrastructure. Project Rogfast is a 27 km tunnel that will run 392 m below sea level at its deepest point, connecting the cities of Stavanger, Haugesund and Bergen. Upon completion, it will be both the world's longest and deepest road tunnel. The project is expected to reduce travel times between these major cities by approximately 50%, while eliminating dependence on weather-sensitive ferry connections.

"Traveling in Norway takes time. Efficient roads like Rogfast are crucial for progress," said Trond Valeur, vice president of Skanska Norway.

Skanska serves as the primary contractor and is executing the project's construction using a dual-approach method. Two separate teams are drilling and blasting from opposite ends of the tunnel route, with the objective of meeting in the center with a tolerance of 5 cm or less.

When describing the challenge, Rolf Christian Kværnæs, head of Geomatics at Skanska Norway, said, "It's like two people sitting across from each other, blindfolded, trying to touch fingers."

Why Precision Matters

The financial and environmental costs of measurement errors in tunnel construction are substantial. According to project data, a deviation of just 10 cm in drilling and blasting operations results in one to two additional truckloads of material removal per session.

"If we are 10 cm out of a lane, it will build up all the way down. It's not sustainable or economical to do it twice," said Anne Brit Moen, project manager at Skanska Norway.

This precision requirement has prompted the use of continuous monitoring systems that track, verify and record each construction phase to reduce rework. The strict accuracy standards for this type of construction pose considerable technical difficulties. Because underground environments block GPS signals, alternative measurement methods are necessary to ensure precision over the extensive length of tunnels.



Technology Integration in Extreme Environments

The surveying team at Skanska depends on Hexagon's technology daily to ensure precision is up to 5 cm and minimize errors. Hexagon acts as Skanska's "eyes" underground, without which projects like Rogfast would be impossible.

"Hexagon's technology scans, checks and documents everything for us, so we know we don't have to go back," Valer said.

The surveying teams conduct 12 to 18 measurement scans daily using total stations and laser scanners provided by Hexagon. These instruments continuously monitor the tunnel's alignment and document progress to ensure adherence to design specifications.

The Skanska team is using several Leica Geosystems surveying instruments, including the Leica TS60 and Leica MS60 MultiStation. The Leica TS60 serves as an accurate total station, specifically designed for demanding precision applications such as underground construction.

The Leica Nova MS60 MultiStation is a robotic total station that can measure points with an accuracy of 1 mm to 2 mm and capture 3D scans. This dual functionality combines traditional total station capabilities with integrated laser scanning, allowing the same instrument to perform both precise point measurements and comprehensive area documentation.

In the Rogfast project, these total stations serve as the primary positioning reference system. They establish control networks throughout the tunnel construction, providing fixed reference points from which all other measurements are taken. The robotic capabilities enable automated target tracking and measurement, reducing human error and increasing efficiency in the confined underground environment.

The hardware components work in conjunction with Hexagon's data processing software, which manages the massive datasets generated by continuous scanning operations. Hexagon's Geosystems division provides digital solutions that capture, measure and visualize the physical world, enabling data-driven transformation.

The software processes raw measurement data into actionable information, comparing actual construction progress against design models and generating reports that identify areas requiring correction. This integration allows project managers to make real-time decisions based on accurate spatial data.



Hexagon

SKANSKA'S surveying team relies on Hexagon's surveying technology, including the Leica Nova MS60, to ensure precision and minimize errors.

Project Timeline and Scope

Project Rogfast represents one of several major infrastructure initiatives designed to improve transportation efficiency across Norway's challenging terrain. The tunnel's completion, set for 2033, seeks to establish new technical benchmarks for subsea construction while addressing long-standing regional transportation limitations in Norway.

High-Precision GNSS for Smart Transportation

Industrial computing specialist Gateworks Corp. has developed a comprehensive solution that brings centimeter-level positioning accuracy to smart transportation.

Based in Vista, California, Gateworks specializes in industrial-grade single-board computers and wireless communication solutions for embedded systems, serving sectors including smart transportation, smart factories and railway systems.

Application developers working in smart transportation and industrial automation face increasing pressure to deliver solutions that combine high-precision GNSS

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Spatix Positioning Service

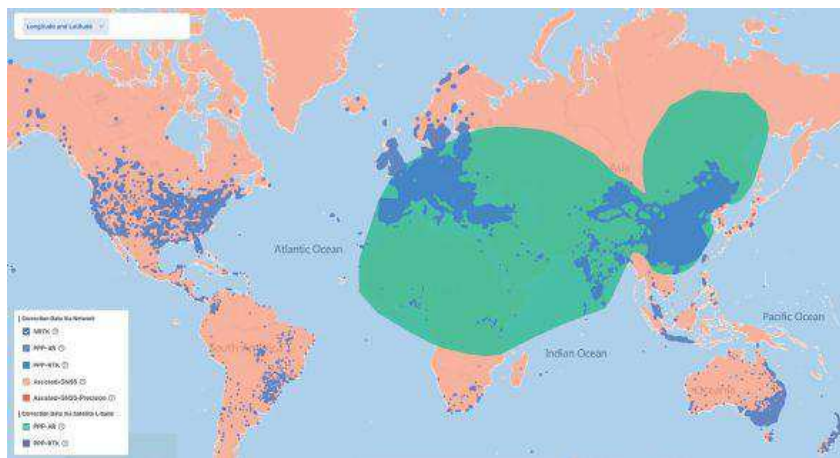
Centimeter-level positioning accuracy, delivered globally – anytime, anywhere

Correction Service via Network RTK

Accuracy Horizontal: 2CM Vertical: 5CM	Coordinate Frame ETRF89, WGS-84 etc	Access Method Ntrip/SDK	Service Availability Rate ≥99.9%
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Correction Service via Satellite L-Band

Accuracy First fixed time: 3-10 min Horizontal: 2CM Vertical: 5CM	Coordinate ETRF89, WGS-84 etc	Access Method SDK	Service Availability Rate Network ≥99.9% L-band ≥99%
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Coverage Map

Geospatial

Starlight H7 Portable 3D LIDAR Scanner



The H7 handheld LiDAR scanner combines a compact, lightweight design with multiple sensors to quickly capture large-scale 3D spatial and true-color data. Integrating LiDAR and SLAM, it delivers flexible, all-in-one measurements across diverse environments.

X3 DualVision GeoSync RTK Receiver



- Multiple Positioning Modes
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- LoRa-Enabled Extended Communication
- Smart Inertial Navigation System

Agriculture System

QYX Pro Autosteering System

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QYX Pro, built on advanced GNSS technology, offers durable, minimalist design for tractor auto-steering and exclusive access to Spatix's NSSR service for global precision agriculture, backed by comprehensive FAE support from installation to OTA upgrades.

X5 StellarLaser GeoSync RTK Receiver



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- Contactless Hybrid Measurement
- LoRa-Enabled Extended Communication

Positioning Module and Boxes



A32s

GNSS High-Precision
Dual-Antenna Module



A40s

GNSS High-Precision
Positioning Module



Arc01 Receiver

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positioning in variable outdoor environments with secure, low-latency wireless connectivity. The hardware must be rugged enough for harsh conditions while remaining compatible with diverse wireless standards.

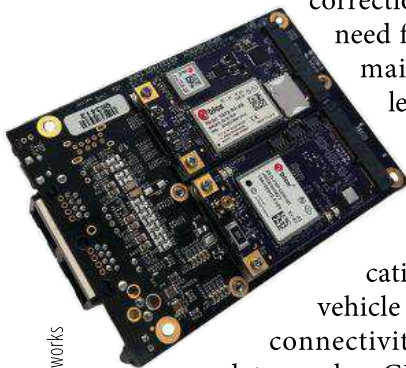
Compliance and Reliability

Gateworks addressed these challenges by developing a modular, all-in-one evaluation platform and high-performance single-board computer development kit. The solution integrates u-blox ZED-F9P precision GNSS receivers, NINA-B301 Bluetooth Low Energy modules and Point One Navigation's PointPerfect Flex GNSS correction services into one platform.

The core components include the GW16143, a Mini PCIe card that integrates the u-blox ZED-F9P receiver to deliver positioning accuracy of less than 2 cm. The complete GW7200 Development Kit combines the Venice single-board computer with the GW16143 card, GW16132 wireless module and a one-month trial of PointPerfect Flex correction services, along with all accessories needed for immediate evaluation.

This approach allows application developers to easily evaluate and deploy precise, real-time positioning and connectivity for smart transportation use cases without extensive integration work. PointPerfect Flex

correction data eliminates the need for base stations while maintaining centimeter-level accuracy, which can be particularly valuable for fleet tracking, rail monitoring, health and safety applications, and autonomous vehicle systems. The wireless connectivity ensures correction data reaches GNSS receivers in real-time, enabling continuous high-precision positioning even in remote locations where cellular coverage is available.



Gateworks

Safety Across Sectors

Modern fleet safety systems leverage Gateworks single-board computers to enable edge artificial intelligence processing that analyzes driver behavior and road conditions directly on the device. Modern fleet safety systems leverage Gateworks single-board computers to perform edge artificial intelligence processing, which analyzes driver behavior and road

conditions directly on the device. This approach can lower latency compared to cloud-based systems and offers instant alerts for drivers and fleet managers to quickly respond to unsafe driving behaviors. alert mechanisms for drivers and fleet managers to promptly address unsafe driving practices.

Process data in real time boosts driver safety through proactive monitoring. This results in fewer accidents and lower costs, while also helping compliance with transportation rules. Fleet operators notice notable improvements in safety performance and operational efficiency when they adopt edge-based monitoring systems.

In the rail industry, Gateworks single-board computers facilitate continuous infrastructure health monitoring through connected sensors that assess track conditions, vibrations and environmental factors. The systems also enable real-time location tracking of maintenance-of-way crews to ensure safety and efficient deployment of personnel. According to Gateworks, operators particularly value the enhanced coordination and safety benefits for on-site personnel working in potentially hazardous environments.

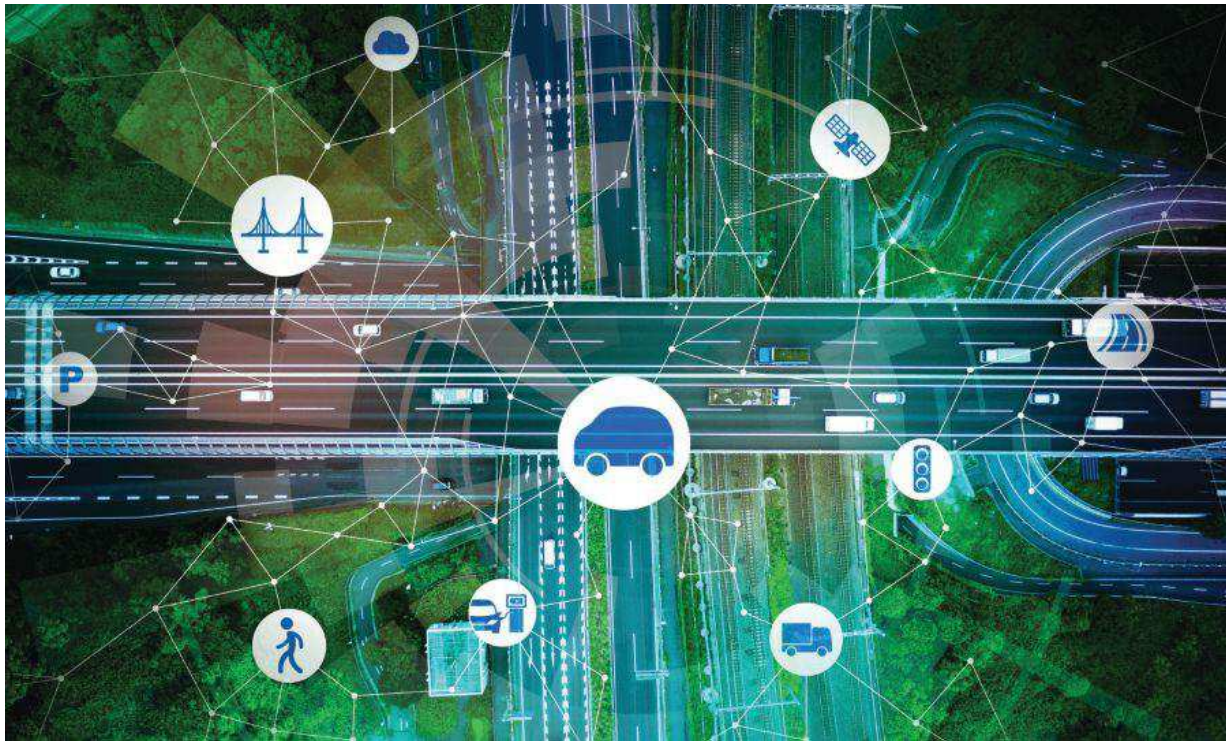
Traveling in War Zones

The demand for efficient transportation systems extends beyond traditional development projects, such as subsea transportation tunnels or deployment scenarios where positioning technology delivers centimeter-level accuracy for fleet vehicles. In active conflict zones, positioning signals are more susceptible to jamming and spoofing, which disrupts civilians' daily activities.

In the northern Israeli city of Haifa, after decades of relying on digital navigation, shopkeepers have started stocking paper maps again. The reason is not nostalgia, but survival in an age of electronic warfare.

The coastal city has become a testing ground for advanced GNSS technologies, where traditional satellite navigation systems regularly fail due to sophisticated spoofing attacks. These attacks not only disrupt military operations but also affect every smartphone, smartwatch and navigation device that relies on standard GPS signals.

Dror Meiri, business development and strategy advisor at oneNav, said that in Haifa, "You start driving. Everything is fine. You know that the drive is going to last for 37 minutes or so, and then all of a sudden, you lose your location."



oneNav

Researchers from oneNav conducted a comprehensive GPS resilience test in an active conflict zone near Haifa. The company's mission was to compare how different navigation technologies perform when under electronic attack.

The Journey North

For the test, four devices were mounted side-by-side on a car dashboard: three leading smartphones and one device equipped with experimental L5-direct receiver technology. All four would make the same journey from south of Haifa toward the city center, passing through zones where GPS spoofing is known to occur.

The drive began in an area free from interference, where all devices accurately displayed their location in northern Israel. But as the car moved north toward Haifa, it entered what researchers describe as a “spoofed zone” — an area where military defense systems actively jam and spoof GPS signals.

While still physically driving through Haifa's streets, the three commercial smartphones suddenly began displaying a location more than 100 km away in Beirut, Lebanon. A fitness smartwatch included in the test showed the same false location. Only the L5-direct enabled device maintained accuracy to within 1 m of the actual position.

The Technical Challenge

OneNav explains the vulnerability stems from the aging L1 GPS signal on which most consumer devices rely. First deployed decades ago, L1 signals are relatively easy to spoof with commercially available equipment. According to U.S. Federal Communications Commission (FCC) documentation, spoofing has become so prevalent that it affects devices across vast geographical areas; in some cases, every smartphone and smartwatch tested was spoofed across distances exceeding 120 km.

In response to the March 6 FCC inquiry on “Promoting the Development of Positioning, Navigation, and Timing Technologies and Solutions,” oneNav provided technical insights into spoofing vulnerabilities across different satellite navigation bands. The company explained that “spoofing in the L5 band will be much more difficult because the spoofing transmitter must have 10x wider bandwidth and 10x more precise spoofing correlator peaks to capture the L5 receiver. Spoofing transmitter power needs to be 20x higher in the L5 (GPS) band and 40x higher in the E5 band (Galileo) compared to spoofing L1C/A.”

This technical assessment highlights why the newer L5 signal represents a significant advancement in navigation security. The enhanced signal architecture, with its wider bandwidth and more sophisticated

coding structure, creates substantial barriers for potential attackers. The exponentially higher power requirements — 20 times greater for GPS L5 and 40 times greater for Galileo E5 compared to legacy L1 signals — combined with the demanding technical specifications, make widespread L5 spoofing both technically challenging and prohibitively expensive for most threat actors.

Beyond the Battlefield

While Haifa's situation is tied to regional security concerns, the implications extend far beyond conflict zones and affect autonomous vehicles, ride-sharing services, and logistics networks that have become essential infrastructure in modern cities.

"When I want to wait for a bus or public transportation, for gas or something like that, my phone tells me exactly where the bus is and how long it will take to reach the station," Meiri said. "But the core system for that is the GPS, which is based on the bus, so the bus cannot send the right information to the server."

Local businesses are grappling with the unreliable GPS environment. According to oneNav researchers, companies in the region — including one that uses drones to clean windows on Haifa's skyscrapers — face significant operational challenges when their navigation systems are deceived into believing they are operating in a different country entirely.

Meiri, who conducted the oneNav test, notes the challenging conditions affecting transportation in Haifa could emerge in other urban areas as spoofing technology becomes more accessible.

The ground transportation implications are particularly concerning for emergency services. When 911 calls are placed in areas experiencing GPS spoofing, emergency responders may be directed to locations hundreds of kilometers from the actual emergency. This challenge has prompted regulatory discussions about upgrading emergency location accuracy requirements. Current GPS emergency location systems can achieve accuracy within 50 m in ideal conditions, but dense urban environments and electronic warfare zones significantly degrade this performance.

As spoofing technology proliferates beyond military applications, transportation systems worldwide may face the same navigational chaos currently seen in Haifa. 🌐

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Maintaining PNT Integrity

Helpful Techniques to Mitigate the Effect of GPS Jamming and Spoofing



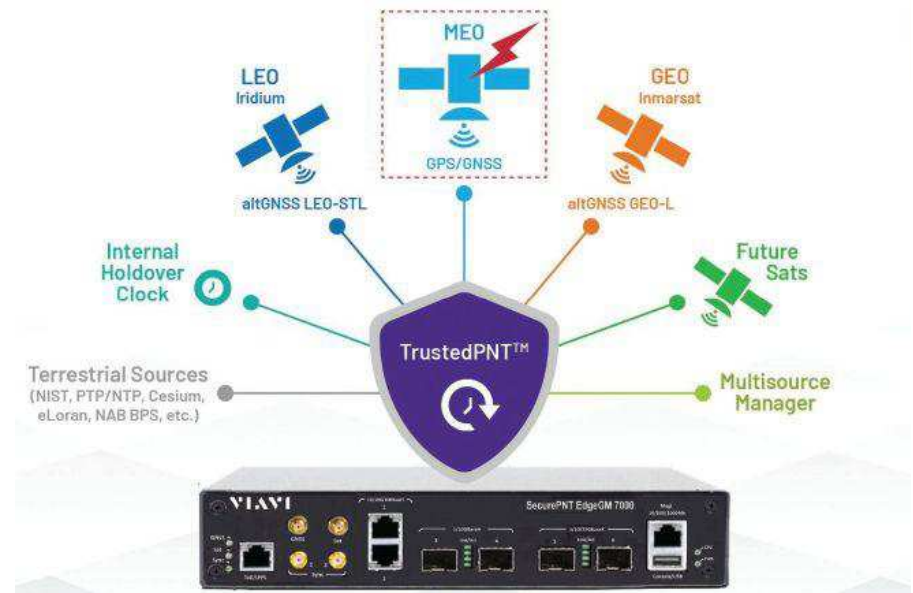
BY NINO DE FALCIS
SENIOR DIRECTOR OF GLOBAL PNT
BUSINESS DEVELOPMENT, VIAVI
SOLUTIONS

U.S. Department of Transportation (DOT) figures show incidences of GPS signal interference, such as jamming and spoofing, have increased significantly in both North America and much of Western Europe. Both commercial and military operations are affected, and ADS-B reports from Zurich University of Applied Sciences (ZHAW) cite up to 700 global GPS spoofing and jamming incidents taking place on a daily basis.

Events are particularly concentrated around war zones, with Lithuanian airspace alone recording more than 300 cases of GPS interference in March. The consequences have ranged from emergency diversions of civilian aircraft to, in at least one case, the downing of an aircraft. Other sectors reliant on precise timing and geolocation, such as communications and emergency services, also are being impacted.

Of course, it's not just navigation; and a swath of industries rely on PNT signals. This includes secure and regulatory-compliant financial transactions, power grid synchronization, asset tracking, ensuring data integrity and coordinating workloads across global telecommunications and artificial intelligence (AI) servers.

How can PNT systems be made more resilient to this interference? What emerging technologies enable PNT systems to maintain operational capability in GPS/GNSS-denied, degraded or disrupted space operational environments (D3SOE)?



VIAVI'S SecurePNT platform

Interference Techniques

GPS interference comes in a wide variety of forms, and systems are susceptible because the signals from the satellites are faint by the time they reach the Earth.

Jamming is a brute force denial of service (DoS) attack, with a device transmitting a signal on the same L1 (1575 MHz), L2 (1227 MHz) or other relevant bands as the PNT satellites. Being nearer and stronger, these signals drown out the GPS information and prevent the ability to calculate a position, simply making GPS services unavailable.

Conversely, spoofing is a more sophisticated technique that mimics the structure of an authentic satellite signal but transmits falsified timing and positioning data. Similar to jamming, this relies on the spoofed signal being closer and more powerful than the legitimate PNT transmission and can either trick the navigation system into believing it is suddenly in a

different position, or alter it slowly over time causing, for example, a ship or aircraft to deviate into an unsafe location.

These DoS and deception techniques are the major classes, but in addition to natural and accidental man-made sources, there also are multiple variations on spoofing techniques and methodologies:

Meaconing: Rebroadcasting of an authentic signal with a delay and shift in position to affect navigation systems.

Replay attacks: Like meaconing, but more targeted to financial transactions, fooling GPS-based time-stamping systems into accepting fraudulent transactions.

Data-level manipulation: Where false orbital data, clock corrections and GPS time is given in addition to the location data. These tend to be harder to detect and cause slow changes. They also can be applied to systems that rely on precise timing, such as financial networks and power grids.

VIAVI

PNT Resilience

PNT resilience standards are set out in the draft IEEE P1952 standard, which specifies technical requirements and expected behaviors for resilient PNT user equipment.

End users can test five behavior levels, which are defined within this standard to enable users to select a

trusts, always verifies and authenticates, and goes beyond simple signal reception. For mission-critical systems, not only do threats need to be detected, but incoming data need to be validated and alternative sources for PNT incorporated, all within an intelligent sensor fusion system.

If we look first at the DoS jamming

“Signal liveness/consistency checks can be particularly effective against meaconing and replay attacks.”



level that is appropriate based on their risk tolerance, budget and application criticality.

Level 1 represents a basic ability to detect interference such as jamming, spoofing, or other disruptions, and alert users. Level 2 enables equipment to automatically recover to normal operation when the disruption is no longer present. In level 3, the equipment can maintain acceptable performance during the disruption. This capability is fortified in level 4 by leveraging multiple diverse sources or advanced mitigation techniques. Finally, level 5 enables the equipment to verify that the time or PNT information received is accurate.

Here in the U.S., the NIST 8323.1 Cybersecurity Framework for PNT also offers a comprehensive approach to assessing and mitigating PNT-specific cybersecurity risks. The DHS' Resilient PNT Conformance Framework and CISA Federal PNT Services Acquisition Guidance are additionally important.

Countering Jamming

Traditional PNT systems are struggling to keep pace and meeting IEEE P1952 to tackle GPS interference requires a sophisticated, multi-source zero-trust architecture that never

technique, here the issue is an inability to detect the medium-Earth orbit (MEO) GPS/GNSS signal in the presence of another more powerful signal.

It is possible, however, to reinforce L-band communications from GPS satellites, and look to stronger signals, notably from low-Earth orbit (LEO) satellites. While these have less accuracy for timing (GPS/GNSS: <15 ns vs 80 ns for LEO), they are significantly stronger (the Iridium LEO STL signal is 1000x stronger than GNSS) and are more resistant to jamming.

Countering Spoofing

In spoofing, the use of encrypted signals is vital.

GPS signals are open, unencrypted and should not be trusted blindly, and the use of alternative cryptographically secured alternatives is essential to ensure the signal's origin is legitimate. For example, this is implemented on both the Inmarsat GEO and Iridium LEO satellites used in VIAVI's SecurePNT and SecureTime services.

Sensor fusion also should be implemented to combine PNT data with information coming from onboard sensors such as inertial measurement units (IMUs) to identify inconsisten-

cies — not just sudden large jumps but continual slight deviations.

Beyond these, navigation message authentication can be implemented, using a public key to verify the satellite-broadcast signature and prove the location, clock corrections and status being transmitted. This is already implemented by Europe's Galileo Open Service Navigation Message Authentication (OSNMA) and makes it very difficult to data-level spoof these satellites.

While using receiver autonomous integrity monitoring (RAIM) techniques, calculate position with redundant satellites, excluding one satellite each time to check for consistency of results. ARAIM (advanced RAIM) uses the same technique, but applies it to multiple constellations, for example, GPS and Galileo.

Signal liveness/consistency checks can be particularly effective against meaconing and replay attacks. These techniques examine the Doppler shift of the signal, with satellites having predictable and specific profiles that will differ significantly when compared to a ground-transmitted signal, which will have a near-zero Doppler shift.

Operating Under D3SOE

The above is a summary of the types of techniques that underpin VIAVI's SecurePNT and SecureTime services.

SecureTime eGNSS GEO uses an

encrypted L-band signal, transmitted from Inmarsat's GEO satellites to create an enhanced timing service with GNSS authentication and anti-spoofing capabilities and provides sub-5 ns timing accuracy when installed on SecurePNT products.

Conversely, the SecurePNT systems implement multi-source receivers for GNSS backup and multi-band GNSS with GEO-L for outdoor antennas. The PTP grandmaster uses the latest sub-microsecond accuracy PTP protocol and the traditional millisecond range accuracy Network Time Protocol (NTP) to be compatible with virtually all standard IT equipment — also implementing high-speed 25G PTP Ethernet for connection to high-performance AI data center and AI-RAN networks and financial exchanges without creating bottlenecks.

Terrestrial sources, such as a network PTP feed and an optional atomic caesium clock, also can be used for synchronization to increase resilience in the event of a prolonged GPS outage. 🌐



VIAVI'S second-generation RSR Transcoder

Nino De Falcis is an experienced business development leader with a strong background in the Global PNT market. Currently serving as the senior director of Global PNT Business Development at VIAVI Solutions since January 2024, he focuses on accelerating global business development and identifying growth opportunities.

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RF Terrestrial-Based GPS Packs a Punch

BY MARK MYSLINSKI & JOHN CONTESTABILE

Over time, GPS dependencies have become deeply embedded in much of the nation's critical infrastructure, as shown in Figure 1 — from emergency services and transportation systems to critical manufacturing and logistics operations. For the past 20 years, however, efforts to protect these assets with a true backup system have stalled, despite the establishment of the U.S. Space-Based Positioning, Navigation and Timing (PNT) Policy in December 2004.

With the recent Notice of Inquiry from the U.S. Federal Communications Commission (FCC), an updated list of technological options is now on the table. However, most would require building new infrastructure or rely on quantum-based technologies that are still years away from being practical or available.

U.S. GPS Efforts Separating

Since its inception in 1977, GPS has drawn from a single technology to serve civil and military sectors. Now, with space — particularly satellites — becoming physically contested

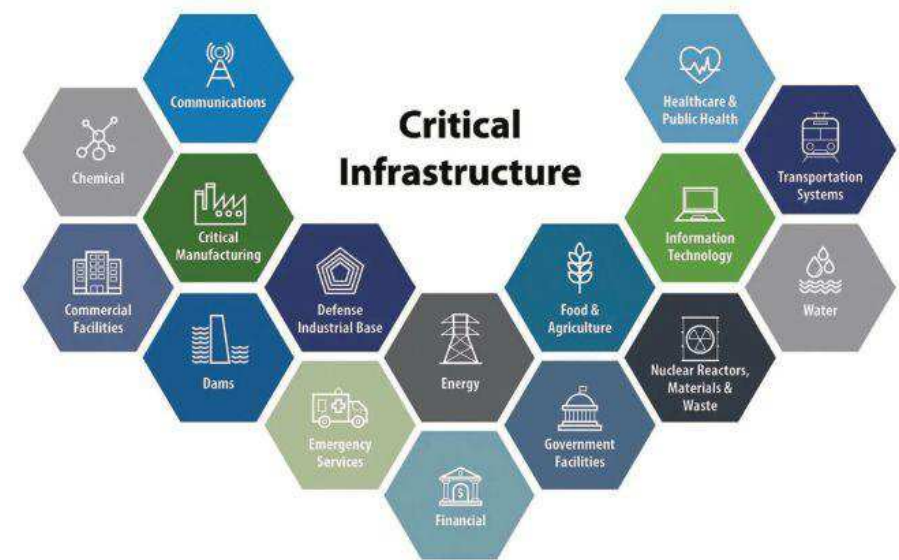


FIGURE 1. The United States has 16 critical infrastructure sectors, and disruptions to GPS timing could significantly impact as many as 13 of them.

in wartime scenarios, the military is embarking on its own approach. This includes pairing GPS with military-grade receivers to improve service and protection for the global GPS layer. And two new layers are being developed as part of a multi-layer approach, deemed the “regional” GPS layer (i.e., per country) and the “local” GPS layer (i.e., per metro).

Yet, with this new system — although supporting modular, open-systems integration — the Department of Defense (DOD) is now distancing itself from other future endeavors, including supporting civil critical infrastructure. The future DOD PNT system will not follow the same path to civil/military

use as was taken by GPS. The PNT capabilities employed by the DOD as such will be increasingly classified. The civil effort has not only been left to fend for itself, but it also has been tragically fragmented across many federal departments and agencies. We can only hope the recent FCC focus will help to solidify the civil GPS efforts.

Doors Open for New Solutions

The new orientation of the civil approach opens the door to significant focus on local and regional GPS services. Specifically, a new approach is based on data from the Earth's “RF geospatial layer,” where geospatial is “relating to or denoting data that is

CSA

“New open doors create freedom to quickly address the urgent national security need for reliable, alternative PNT.”

associated with a particular location.” This layer’s data is about available RF signals, which can be used to derive the location of a particular end device anywhere in the blanket of signals. Devices using this new approach will be unencumbered by the intricacies and costs of satellite technology, or having to be joint solutions required to meet military standards.

This also opens the door to the power of solutions available through consortia, which can tap into an order of magnitude more benefits through hearty partnerships. All of which also leads to the much-needed speed-to-market.

The Biggest Advantage

In the U.S., more than 110,000 towers transmit a variety of RF signals available to derive PNT. These towers provide a wide range of three-tower geometries needed for PNT calculations and enable strong resiliency (as an adversary cannot disable them all).

Two systems, in particular, are worthy of close consideration. The broadcast industry’s proposed Broadcast Positioning System (BPS) uses ATSC 3.0 infrastructure along with the existing MerlinTPS adaptive RF signal system. Both these systems take advantage of existing RF infrastructure prevalent in most developed and developing countries.

Don’t Fall Into the eLoran Trap

eLoran has been suggested by some as a viable alternative used for deriving PNT. However, this technology has notable

shortcomings. The portion of the RF band it uses has several limitations. For example, eLoran is based on a 100 kHz signal, a low frequency band that is highly susceptible to atmospheric noise.

Although some propose the use of existing AM towers for the eLoran signal, most are ~300 ft, of which eLoran tends to operate with 1600 ft towers. Attempts to operate eLoran using these shorter towers will make for reduced efficiency. Another misconception is about the proposed use of existing AM tower guidewires for transmission. At these wavelengths, that would restrict the towers to be 900 miles apart, having an impact on maintenance.

eLoran would require building new infrastructure for U.S. deployment, including 12 new towers and transmitters. The number of installations requiring significant maintenance and this low number can be taken out in physical warfare.

The eLoran system requires tight synchronization of the signals between each of its towers and the national epoch, requiring additional infrastructure with its attendant maintenance.

eLoran supporting position accuracy is rated at 10 m to 20 m CEP, which is not within the FCC requirement of less than 3 m CEP.

Timing accuracy is +/- 50 ns, which meets today’s precision needs, although it is quickly becoming inadequate as needs in the precision timing market continue to increase.

Finally, the eLoran service is transmitted on one known frequency and in a published format, making it more vulnerable to jamming.

GPS RF Systems Pack a Punch

Given the issues associated with eLoran, other technologies must be considered. One such technology is available today and provided by a commercial company, MerlinTPS, which can transfer market-available,

precise timing down to +/- 10ns. Such as precise timing provided by another commercial entity, Hoptroff, for example. Both companies currently provide the necessary components of a viable terrestrial GPS.

As a consortium, MerlinTPS/Hoptroff could deliver precise timing wirelessly to broadcast TV towers for BPS, while eliminating the need for signal conditioning and additional synchronization equipment at each tower, or any other related infrastructure.

MerlinTPS combined with BPS could provide all GPS services for primary and backup (not just timing). MerlinTPS can also fill in services for BPS edge cases having poor geometries. These services include portable and mobile devices. MerlinTPS is also able to handle both the enterprise and civil approaches similarly.

New open doors create freedom to quickly address the urgent national security need for reliable, alternative PNT. The consortium approach, adding commercially available technology to the broadcast infrastructure, allows for collaborative development while preserving individual market opportunities, making it an attractive proposition for all participants. 🌐

MARK MYSLINSKI, sole proprietor of OpenVideo Consulting, has previously enjoyed a career in advanced cable television services. An engineer by training, he executed projects related to the development of advanced broadcast television specifications, edge video delivery and direct-to-consumer streaming. He has worked with many digital cable television and broadcast engineering organizations. His career includes product management for new generation video systems and a tactical marketing specialist.

JOHN CONTESTABILE is the senior vice president and co-founder of the Resilient Technology Solutions Group, providing strategic consulting services to the transportation and public safety markets. He enjoyed a 30-year career in Maryland state government holding various positions, including Deputy Homeland Security Advisor, Statewide Public Safety Interoperable Communications Director, and retired as Acting Assistant Secretary of the Maryland DOT.

Advanced Navigation Conquers Europe's Deepest Underground Mine

A new hybrid navigation system achieves position accuracy better than 0.1% of distance traveled within the mine's 1.4 km deep underground labyrinth — without GNSS or fixed infrastructure.

BY TRACY COZZENS, EDITOR-AT-LARGE

Advanced Navigation has successfully demonstrated a breakthrough in underground navigation, delivering high-precision positioning without reliance on fixed infrastructure or GNSS.

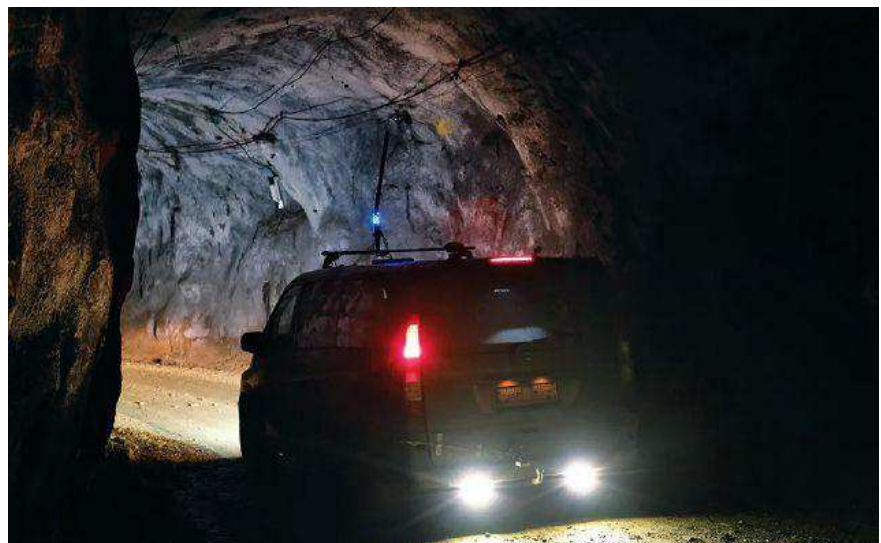
The demonstration of the company's Hybrid Navigation System was livestreamed from the Pyhäsalmi Mine in Pyhäjärvi, Finland, as part of the Deep Mining Open Call under the Think and Act Differently program sponsored by BHP, an Australian mining and metals corporation.

The Deep Mining Open Call, launched in September 2024, sought innovators with capability that could be applied to deep underground mining. The focus was on addressing challenges such as high temperature, high rock stress, and hyper-saline conditions in deep mining environments. The inactive Pyhäsalmi mine has the harsh conditions and depth required for the technology test.

Based in Australia, Advanced Navigation was selected from more than 90 global applicants to demonstrate its technology.

Positioning Challenges

Navigating the vast subterranean network of the Pyhäsalmi Mine posed significant challenges. The mine is situated just two degrees below the Arctic Circle, where traditional systems fail. Located 1.4 km underground at a latitude of 63°, it is



All images courtesy of Advanced Navigation

completely impervious to GNSS signals. Its repetitive, multi-level tunnel network creates a high risk of visual disorientation, while its metallic ores distort magnetic fields and scatter radio waves.

To overcome these conditions, mines typically rely on infrastructure-heavy solutions such as ultra-wideband beacons, Wi-Fi, 5G repeaters or perception-based techniques such as simultaneous localization and mapping (SLAM), which require cameras. These methods are costly to integrate and maintain, slow to install, and often unavailable in hazardous or unmapped zones where reliable navigation is critical. Shifting to a resilient navigation system with less dependency on infrastructure offers a scalable alternative, enabling reliable navigation even in environ-

ments considered hazardous or inaccessible.

System Architecture

Advanced Navigation's Hybrid Navigation System demonstrates long-range, infrastructure-free, real-time navigation in a deep, GPS-denied environment. The system combines a laser velocity sensor (LVS) with the Boreas D90 fiber-optic gyroscope inertial navigation system (FOG INS).

FOG INS. The Hybrid Navigation System is centered on the Boreas FOG INS. Unlike conventional systems, Boreas doesn't rely on GNSS or magnetic compasses. Instead, it uses ultra-sensitive FOG technology to detect the Earth's rotation and determine true north, a process known as gyro-compassing, to find the vehicle's heading.



The LVS installed on the vehicle.

For the test, the Boreas D90, along with various additional equipment providing power, networking and logging capabilities, was secured inside the vehicle.

LVS. To maintain and enhance this accuracy, the INS is fused with Advanced Navigation’s LVS. Using infrared lasers, LVS continuously measures the vehicle’s true 3D velocity relative to the ground. This real-time data is critical for correcting the gradual drift that occurs in standalone inertial systems, enabling the hybrid system to maintain precision over extended distances.

The LVS sensor features two components: an external, passive optical head, and an active sensor body. The optical head is primarily responsible for rigidly holding the alignment between the three telescopes. The sensor body houses the active photonics system, laser and processing system.

Because pre-production hardware was used for this test, three discrete fiber-optic cables were used to connect the externally mounted LVS optical head to the LVS sensor inside the vehicle. Production hardware will include a single, IP69K rated optical-fiber cable that connects the LVS sensor body to the IP69K rated optical head.

The LVS optical head was attached to the trunk of the vehicle using a suction cup to provide a clear line of sight

from each telescope to the terrain. A GNSS antenna was attached to the roof in the same manner. Coaxial cable connected the GNSS antenna to the Boreas D90.

Fusion Software. The system integration relied on the company’s AdNav OS Fusion software. Using adaptive algorithms, OS Fusion dynamically weighs the reliability of each sensor in

real time.

Together, these technologies form a resilient hybrid system delivering precise, uninterrupted navigational data in extreme environments, without GNSS or fixed infrastructure, the company said.

“We were thoroughly impressed by the results the sensor fusion provided,” said Magnus Zetterberg, senior consultant at Combitech, who observed the demonstration. “I have used and been exposed to these sorts of sensors in other projects, and nothing has come close to this level of performance. It’s clear the Laser Velocity Sensor is a major key in providing these outstanding results.”

Proven in the Depths

A one-time surface calibration using real-time kinematic GNSS aligned the LVS and INS frames on the vehicle, a Mercedes-Benz V-class. After the calibration, the trials were unaided within the underground environment.

Two different test scenarios were conducted: a surface-to-surface test, and an underground loop test. Validated across five separate runs in isolation from external aids or maps, the Hybrid Navigation System repeatedly achieved an accuracy of better than 0.1% of distance traveled — demolishing a barrier once considered fundamental to underground navigation.

Without relying on any fixed positioning infrastructure, pre-existing maps or external aiding, the tests achieved consistent sub-0.1% navigation error across multiple runs.

Surface-to-Surface Runs

Runs 1, 2 and 3 – 400 m. To demonstrate the system’s repeatability and accuracy, three identical runs were conducted to a depth of 400 meters. Each run involved an approximate 3 km one-way traverse for a full 6 km loop. The results highlight the system’s consistent performance

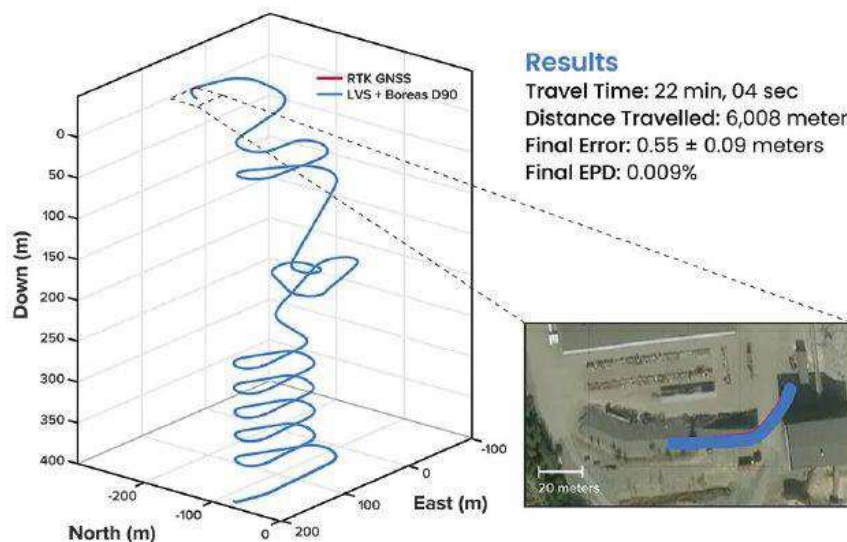


FIGURE 1 3D navigation trace of run 2 of the repeat surface-to-surface 400 m depth tests. This particular run covered 6,008 m, with a measured error of 0.55 ± 0.09 m for 0.009% error per distance traveled.

during underground operation, with a mean final position error of 2.83 ±0.09 meters, representing 0.047% of the total distance traveled.

Over the 6 km rough and rugged terrain that extended 400 m below the surface, the system achieved a best-case 3D position error of 0.55 m (0.009%), with an average error of 2.83 m (0.047%). For context, standard single-band GNSS on the surface typically delivers 2–10 m accuracy in open-sky conditions. The system delivered significantly greater precision even within a subterranean labyrinth. **FIGURE 1** present the key performance metrics for these runs. **FIGURE 2** shows reacquisition of GNSS signals upon exiting the mine.

“We’ve worked in underground environments for decades. Seeing this level of precision achieved on the first run signals huge potential for safer and more efficient underground vehi-

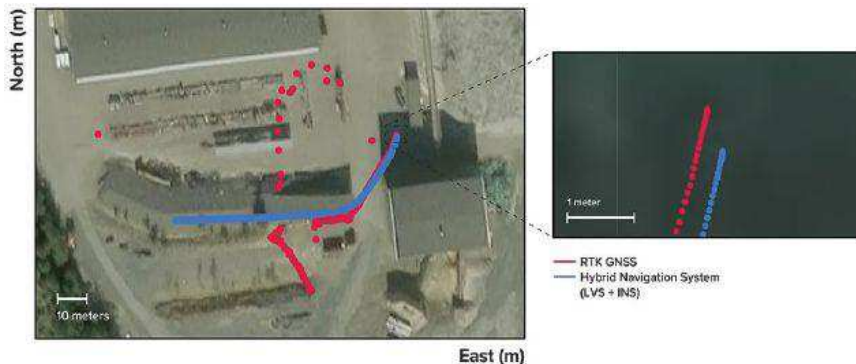


FIGURE 2 Traces of raw RTK GNSS and position estimates from the Hybrid Navigation System. As the vehicle exits the tunnel portal, intermittent and low accuracy GNSS is measured. Once the vehicle enters open sky, a more consistent RTK GNSS fix is attained. Note that despite the presence of now-accurate RTK GNSS, at no point did the Hybrid System use GNSS information.

cle operations,” said Olli Mylläri, vice president of technology at Normet, a mining technology company.

Run 4 - 1,400 m. To evaluate the system’s performance over an extended distance, a single run was conducted to the deepest accessible point of the mine, reaching a depth of 1,400 m. The system navigated the

22.9 km route — the equivalent of a half-marathon — in total darkness.

The final position error was 15.9 m (0.07%), showcasing its immunity to the drift that plagues other inertial systems. This extended traverse, lasting more than 94 minutes, also included a deliberate stationary period at the bottom before the return

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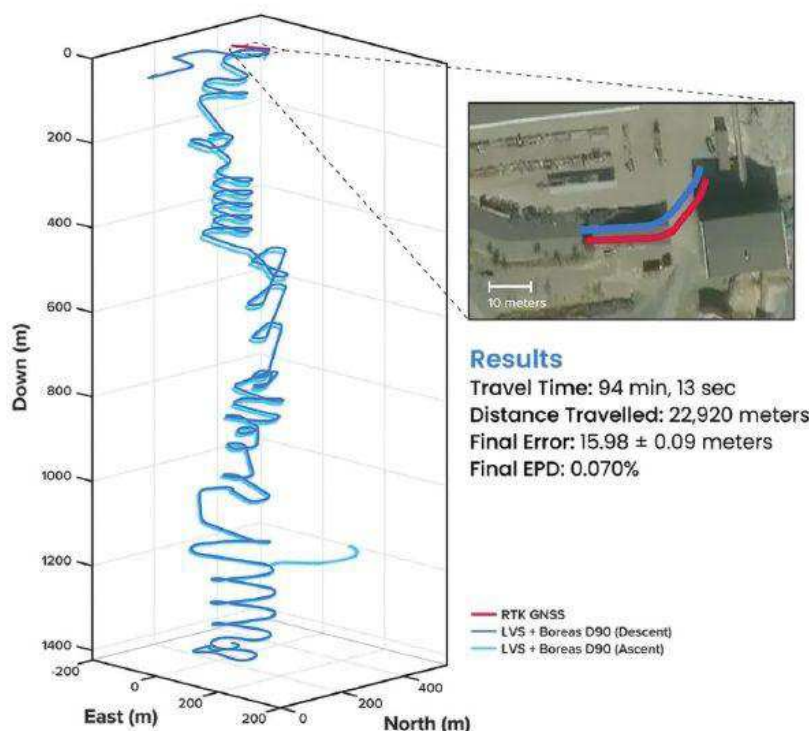


FIGURE 3 3D navigation trace of the run down to 1,400 m depth. The test traversed a total distance of 22,920 m, with a measured final error of 15.98 ± 0.09 m yielding an error per distance traveled of 0.070%. The descent and ascent paths are colored differently for disambiguation. During the ascent (light blue), the driver entered a side tunnel at a depth of approximately 1,200 m, which was not traversed on the descent.

to the surface. The performance of this deep run is detailed in **FIGURE 3**.

Entirely Underground

Run 5 – 1,067 m. A single run of 1,067 m was conducted over a period of 14 minutes. Without relying on magnetometers or external aids, the system determined heading using its built-in gyrocompassing procedure, measuring the Earth’s rotation to establish true north. It then navigated a 1 km course with just 1 meter of error, demonstrating its capability for rapid deployment in the most challenging and unfamiliar terrain. See results in **FIGURE 4**.

While additional testing was planned to further validate the results, time constraints limited this study to a single test. The findings provide a representative indication of system performance under the tested conditions. **TABLE 1** shows a comparison to GNSS navigation.

Scalable Autonomy

While mines will continue to use fixed infrastructure, this technology significantly reduces dependency, enabling resilient, high-precision navigation in previously inaccessible or unmapped areas. This performance marks a step change in underground navigation, unlocking new potential for fleet management, predictive collision avoidance, material tracking and scalable autonomy

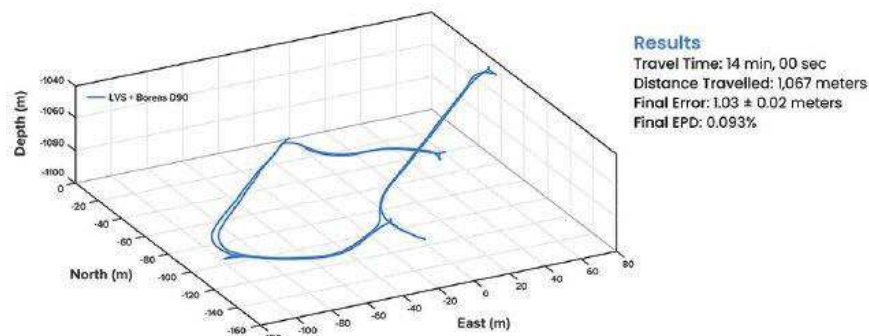


FIGURE 4 3D navigation trace of the entirely underground run. The test traversed a total distance of 1,067 m, with a measured final error of 1.03 ± 0.02 m, yielding an error per distance traveled of 0.093%.

across mining operations.

“At Normet, we specialize in advanced solutions for underground mining and tunneling, so we know firsthand how difficult accurate and reliable navigation can be in these environments,” Mylläri said. “Seeing Advanced Navigation’s Hybrid Navigation System deliver consistent positioning with minimal infrastructure deep within the Pyhäsalmi Mine was remarkable. It’s a powerful step forward for automation and safety in the underground space.”

In today’s dynamic operational environments, relying on a single navigation technology is no longer viable. Robust navigation demands a layered, inertial-first and multi-sensor architecture — held together by intelligent software — that can adapt and scale to meet the unique demands of each operation.

“Ultimately, this vehicle-based, inertial-centered architecture provides the resilient foundation required for the mining sector to achieve its long-term goal: efficient autonomous ore extraction at depths hostile to human activity,” Vandecar said.

“Unreliable navigation underground isn’t a minor technical constraint — it’s a major operational bottleneck,” said Joe Vandecar, senior product manager, Advanced Navigation. “Maintaining precision over a 22.9 km subterranean course in Europe’s deepest underground mine demonstrates a level of perfor-

Technology	Indicative Surface Level Positional Accuracy
GNSS Dual Band (L1/L5 or L2/L5)	1m - 2m
GNSS Single Band (L1)	2m - 10m
Technology	Below Surface Position Accuracy
Hybrid Navigation System	2.83 m on average after 6.011 km

TABLE 1 Indicative industry-reported positional accuracy of GNSS compared to the Hybrid Navigation System.

mance that few systems in the world can rival without any prior intel-

ligence of the environment. These results prove we're one step closer

to unlocking scalable underground autonomy.”

The Hybrid Navigation System is set for commercial release later this year. 🌐

Adapted from a paper authored by **Patrick Wiltshire, David McManus, James Spollard, Mark Gibson, Matthew Suntup, Tim Laws and Lyle Roberts**. The full paper is available on the Advanced Navigation website (advancednavigation.com).

Trimble Applanix: Delivering on the 'Last Meter'

BY **JESSE KHALIL**, ASSOCIATE EDITOR

The demand for autonomy is accelerating across industries, reshaping how systems are being developed and deployed.

For UAVs, the push for precision is driven by emerging use cases, such as package delivery, medical transport and complex route navigation in urban environments, all of which require centimeter-level accuracy in positioning and landing.

Importance of Correction Services

Trimble is expanding its Centerpoint RTX positioning technology from agriculture and surveying applications into the rapidly growing autonomous markets of UAVs, robotics and vehicles.

CenterPoint RTX is a global correction service that delivers centimeter-level positioning accuracy, engineered to ensure reliable and precise positioning anywhere around the world.

RTX employs a fixed, stable datum to ensure consistent and reliable performance. The system supports all major satellite constellations and frequencies, offering users a robust and flexible positioning system. The service can be accessed through either L-band satellite signals or a standard internet connection, eliminating the need for local base stations and making high-precision positioning far more scalable and accessible.

This level of reliability is crucial for emerging applications such as drone delivery.

“When you start talking about package delivery, operators need robust positioning,” explained Joe Hutton, director of inertial technology and airborne products at Trimble Applanix. “One reason is what we call ‘the last meter’ — drones need to be able to land or drop packages consistently within that final meter of their destination.”

Hutton noted that precision requirements are becoming even more demanding. “It’s actually getting smaller than a meter now. You need that robust centimeter-level positioning to ensure the drone is in exactly the right spot for safe and accurate delivery.”

When asked about alternative positioning methods, Hutton explained why traditional RTK systems can fall short for these applications. “RTK has its traditional limitations,” he said. “You have to be within 20 km of a base station, you need to set up infrastructure, and then you face all kinds of datum issues between different base stations.”

This is where CenterPoint RTX offers a significant advantage. “You don’t get those problems with CenterPoint RTX because it’s a global correction service operating on a fixed reference datum that never changes,” Hutton explained. “If you use the same technology to survey your landing spot — say with a Trimble DA2 product using RTX — everything fits perfectly. It’s always going to be in the same datum.” He noted that this consistency has

proven very popular with users because it eliminates the complex datum coordination issues inherent in RTK systems.

Beyond datum consistency, Hutton highlighted another critical consideration: signal robustness and jamming and spoofing. “While commercial drone applications typically operate outside conflict zones where intentional jamming occurs, operators still need protection against interference,” he said. “You can have radios causing jamming just inadvertently.”

Trimble’s OEM GNSS/INS systems for UAV navigation, such as Trimble PX-1, use aided inertial navigation system (INS) software that blends GPS positioning with inertial sensors using RTX corrections to offer robust position and orientation data — including precise roll, pitch and heading measurements — that can maintain accuracy even during short GNSS signal outages.

The system provides inertial-based heading, which addresses another critical challenge in drone navigation. Traditional approaches rely on magnetometers for heading determination, but these are easily influenced by nearby metal structures and electromagnetic interference. In contrast, inertial-derived heading comes directly from the IMU itself, making it immune to magnetic disturbances and far more reliable in complex environments, making it suitable for drone delivery in busy urban environments. 🌐

Defense Disruptors

How ANELLO's Silicon Photonics Optical Gyroscope Is Enabling GPS-Free Navigation in Challenging Environments



BY MARIO PANICCIA
CEO, ANELLO PHOTONICS

For decades, GPS has been the cornerstone of modern navigation, guiding aircraft, vehicles, troops and commercial systems across the globe. As digital warfare intensifies, satellite signals are increasingly unreliable. From the battlefield to underground tunnels, to dense forests, and urban canyons, global positioning signals are being jammed, spoofed, or simply blocked by the environment. In these GPS-denied zones, the risks to navigation, targeting and mission success grow exponentially.

Without reliable positioning, systems lose their sense of location, direction and speed — making it impossible to navigate to their destination. Yet in modern warfare, autonomous systems and industrial automation depend on precise and continuous navigation. ANELLO Photonics is tackling this gap head-on with a breakthrough silicon photonics-based optical gyroscope (SiPhOG) technology — one that seeks to reshape how machines, soldiers and vehicles navigate across land, air and sea when satellites fall silent.

A Battlefield Blind Spot

In GPS-contested environments such as urban warzones, subterranean tunnels, dense forests or near hostile jamming equipment, traditional navigation solutions fail. Spoofing attacks can instantaneously displace autonomous vehicles by kilometers. Jamming can cripple UAVs mid-flight, causing

them to crash. Even in civilian settings — especially in and around conflict zones — GPS signal loss can disrupt commercial fleets, emergency responders, and industries like mining or agriculture. These dropouts stall autonomous operations, reduce productivity, and increase the risk of severe damage.

These issues aren't hypothetical. Adversaries have demonstrated sophisticated GPS interference capabilities that can mislead or immobilize multi-million-dollar defense assets. The need for self-contained, spoof-resistant navigation has never been more urgent.

Strategic-Grade Precision in a Chip

ANELLO Photonics took a radically new approach to building gyroscopes when it built its Silicon Photonics Optical Gyroscope (SiPhOG) using the same semiconductor processes used for integrated circuits. This breakthrough makes it possible to deliver high-precision optical navigation in a chip-scale form factor — smaller than a fingernail. The SiPhOG harnesses the proven Sagnac effect — central to traditional fiber-optic gyroscopes (FOGs) — but ANELLO has reimaged it using advanced silicon photonics, integrating this into a compact silicon photonic chip.

This innovation enables:

Bias drift < 0.5°/hr. A performance level previously only achieved by large, costly fiber-optic systems.

Nanoradian-scale angular sensi-



SIPhOG MAKES IT POSSIBLE to deliver high-precision optical navigation in a chip-scale form factor — smaller than a fingernail.

tivity. Essential for accurate navigation over long durations.

Superior to MEMS. Resilient to vibration, thermal variation and EMI — ideal for combat zones and industrial environments.

Compact, coin-sized form factor. Easily integrates into existing systems and is small enough to be used for soldier-worn devices, embedded robotics and scalable mass-market applications.

The ANELLO SiPhOG offers the precision of strategic-grade FOG systems, but with the size, weight, power and cost suitable for widespread tactical deployment to the mass market. This balance makes it uniquely positioned to serve both high-end defense missions and cost-sensitive commercial markets.

The Full-Stack INS Advantage

SiPhOGs alone aren't enough. ANELLO integrates its SiPhOGs with accelerometers, magnetometers, GPS (when available) and onboard CPU logic into a full-stack inertial navigation system (INS). Additionally, these systems use the ANELLO AI-based sensor-fusion engine to intelligently reconcile data, validate signal integrity and detect anomalies, such as

ANELLO Photonics

jammed or spoofed GPS locations or signal dropouts across land, air and sea. The ANELLO AI sensor-fusion engine processes and tracks in real time the inertial position and GPS position every ~10 ms. The system auto-corrects and seamlessly transitions the sensor modes without any human intervention — always determining what is correct and what is false or being spoofed. The ANELLO AI sensor-fusion engine is continuously being tested and optimized by the ANELLO team with various customers in the field.

The result is a self-contained, intelligent navigation platform that maintains accurate heading, velocity and position — even in total GPS darkness. The modularity of the ANELLO systems also enables easy integration into various host platforms, from aerial drones to armored vehicles to autonomous boats and robots.

Field-Proven Resilience in Defense

During U.S. Department of Defense trials, ANELLO's INS systems successfully identified and mitigated GPS spoofing attempts in real time. When a vehicle's GPS feed suddenly shifted its perceived location by kilometers, ANELLO's AI engine flagged the change as physically impossible, rejected the GPS input and seamlessly relied on ANELLO inertial data to maintain accurate positioning.

Such robustness makes the ANELLO technology suitable for:

- UAVs operating in jammed or contested airspace
- Autonomous Ground Vehicles (AGVs) navigating GPS-denied terrain
- Marine systems facing jammed or spoofed GPS signals

- Land vehicles such as emergency responders and even delivery vehicles
- Handheld soldier systems that demand compact, rugged navigation capabilities for on-the-move operations

Whether installed on armored vehicles, on drones, or embedded in next-gen infantry kits, ANELLO's optical gyro-based solutions deliver location certainty when precision and accuracy matter.

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Increase in spoofing since 2024

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Cross-Sector Use Cases Autonomy Without Satellites

While defense remains a clear application, the broader commercial value is just as transformative. In agriculture, autonomous vehicles often lose GPS coverage under thick orchard canopies. In underground mines or port operations, satellites are blocked entirely. In these environments, ANELLO's SiPhOG-powered INS con-

tinues to provide reliable localization and position, ensuring autonomous systems don't stall, stray or crash.

Commercial applications for ANELLO's SiPhOG technology include:

- **Autonomous mining vehicles.** Enables self-driving trucks and loaders to navigate through tunnels and signal-blocked environments with precision and safety.
- **Port automation and crane systems.** Supports operation of auto-

mated cranes and cargo movers in GNSS-challenged port environments for uninterrupted container handling and improved throughput.

- **Industrial robotics and logistics.** Powers warehouse robots and inspection systems with high-precision navigation in indoor and metallic environments where GPS is unreliable or unavailable.

- **Autonomous maritime systems.** Facilitates reliable navigation for unmanned surface vessels (USVs) and autonomous underwater vehicles (AUVs) operating in coastal, harbor, or fully submerged missions where satellite signals are compromised.

With rapid integration into commercial drones, robotic forklifts and construction fleets, ANELLO is extending military-grade navigation into everyday autonomy use cases.

Smarter Navigation in Real Time

At the heart of ANELLO's platform is a sophisticated AI sensor fusion engine. Every 10 ms, the system ingests data from multiple sensors, validates physics-based plausibility and recalibrates its state estimates. This allows the system to detect and reject spoofed GPS signals, continue navigation autonomously through temporary GPS dropouts and identify signal degradation before failure occurs.

This intelligence is what makes the system robust, not just a fallback, but a fully capable primary navigation method in harsh and dynamic environments. It also significantly reduces the operational risk and support burden typically associated with traditional inertial systems.

Compact, Scalable, Mission-Ready

As conflicts evolve and global infrastructure expands into GPS-hostile

regions, inertial systems must become smaller, smarter and more affordable. ANELLO is advancing a roadmap toward fully integrated, chip-scale INS platforms with gyros, lasers, processors and algorithms all on a single platform. This enables faster deployment in the field, lower system power consumption and broader adoption across vast use cases for military and industrial systems

The company's domestic chip fabrication capability also ensures supply chain security, an increasingly critical factor in national defense and industrial automation strategies.

From soldier systems and UAVs to autonomous cargo vehicles and industrial robots, ANELLO's technology is

positioning itself as a cornerstone for resilient, GPS-independent autonomy.

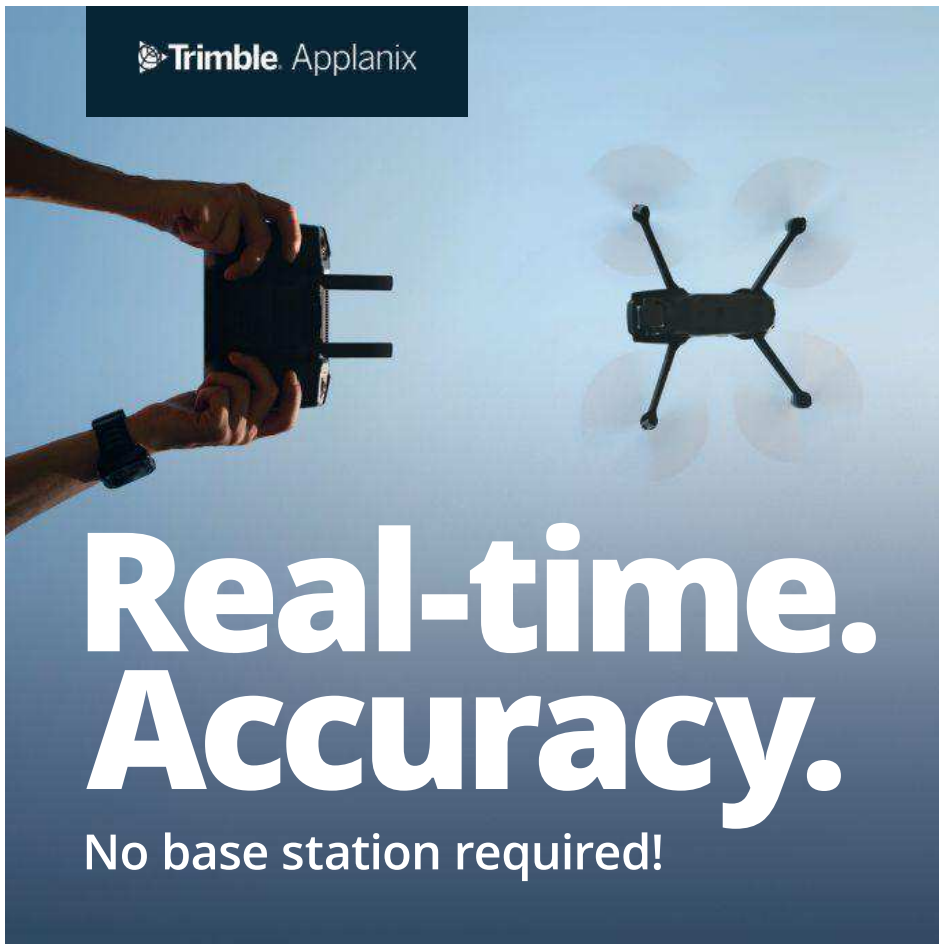
Navigating a Standard for a Contested World

The future of autonomous operations—military and civilian alike—will need to depend on navigation systems that do not falter when GPS disappears. With its SiPhOG-based inertial platform, ANELLO Photonics is offering not just a backup system, but a new standard: one that combines strategic-grade precision, compact design and AI-driven reliability that can be delivered to the mass market and installed into any vehicle or any moving platform.

In an era where signal denial is

not just a threat but a tactic, assured positioning is no longer optional—it's essential. ANELLO is redefining the future of navigation, empowering not just autonomous systems but also the people who rely on navigation to operate with confidence and precision — anywhere, anytime — even when the sky goes dark. 🌐

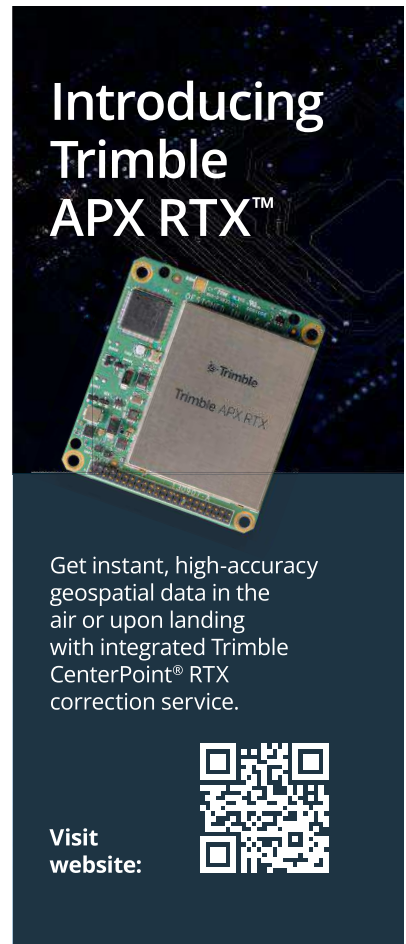
MARIO PANICCIA, PH.D., is an experienced executive with more than 20 years in the photonics industry. Prior to ANELLO, he was at Intel, where he achieved the level of Intel Fellow, CTO and GM of the Silicon Photonics Group. He is considered a world expert in silicon photonics and the technology he pioneered is used in data centers around the world.



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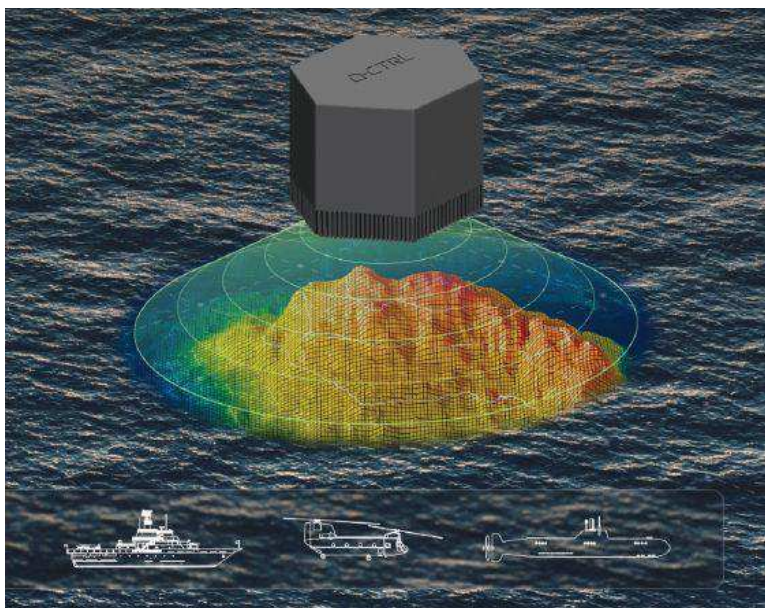


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DEFENSE



Q-CTRL

Q-CTRL, Lockheed to Develop Quantum Navigation for DARPA

Quantum software company Q-CTRL has been awarded two contracts under DARPA's Robust Quantum Sensors (RoQS) program. The Defense Advanced Research Projects Agency (DARPA) is an independent research and development agency within the U.S. Department of Defense.


The contracts, valued at \$24.4 million, will augment Q-CTRL's field-validated quantum sensing technologies for demanding real-world use cases in high-performance military vehicles.

Navigational technology that is resilient to jamming, spoofing and other denials in the environment has become increasingly critical to defense applications, from battlefield operations to intelligence and surveillance. With conflict zones expanding, the risks to crewed and uncrewed defense missions are growing daily. Quantum sensing offers a complementary solution to GPS,

providing resilience against external interference while filling coverage gaps.

Q-CTRL will develop next-generation quantum sensors for navigation based on its success in field trials of airborne, maritime and ground-based quantum navigation augmented by its proprietary AI-powered software ruggedization. The technology enables sensors to operate reliably on moving defense platforms subject to challenging real-world conditions, without the need for traditional shielding or isolation.

Q-CTRL will be joined by Lockheed Martin as a subcontractor on one aspect of the RoQS program, leveraging its expertise in GPS and quantum technology.


DARPA established RoQS to accelerate the development, testing and validation of quantum sensors for real-world defense applications, which include maintaining stability against environmental interference, mechanical vibrations and heavy g-forces. 

OEM

JAVAD GNSS, Inertial Labs Partner on Navigation Platform

JAVAD GNSS and Inertial Labs, a VIAVI Solutions company, have formed a strategic partnership to integrate Inertial Labs' IMU-P modules with JAVAD's OEM GNSS receivers. This collaboration introduces a next-generation GNSS+INS platform designed to deliver accuracy, stability and resilience even in environments where GNSS signals are weak or unavailable.

Central to this advancement is the JAVAD TR-3Si receiver, which is compatible with professional IMU modules. When paired with the advanced IMU-P units, the system can deliver precision and reliability, meeting mission-critical requirements across aerospace, defense, autonomous vehicles, UAVs, robotics, precision agriculture and other demanding applications.

Inertial Labs' IMU-P modules can perform in dynamic settings, providing continuous orientation and acceleration data for sensor fusion. The integration of this inertial technology with JAVAD's established GNSS systems enhances navigation accuracy and efficiency in both GNSS-accessible and GNSS-denied environments. 



DEFENSE

Airbus, Shield AI Complete Autonomous Logistics Helicopter Flight

Airbus U.S. Space & Defense completed its first autonomous helicopter test flight using Shield AI's Hivemind autonomy package in Grand Prairie, Texas. The flight represents a significant step forward in developing the MQ-72C Lakota Connector for the U.S. Marine Corps Aerial Logistics Connector program.

The test utilized an H145 helicopter to refine mission technology, accelerate development timelines and reduce costs and technical risks. Engineers integrated Hivemind into the aircraft in less than two months, showcasing the system's modular and platform-agnostic design.

During the test, Shield AI's Hivemind autonomy software controlled the H145 directly while collaborating with Airbus' Helionix system. The integrated software managed the aircraft's mission systems, executing automated takeoff, landing and other test procedures without pilot input.

The tested software will be incorporated into the future MQ-72C helicopter design to meet Marine Corps requirements for the ALC program. The MQ-72C Logistics Connector is being developed as an unmanned version of the UH-72 Lakota, a multi-mission platform used across various operations.

Shield AI's software expands the platform's capabilities through autonomous operations across logistics and operational scenarios. Future test activities and demonstrations will scale the MQ-72C's autonomy level, leading toward unmanned operations in contested logistics environments.

Airbus U.S. plans to apply mission autonomy software to add autonomous capabilities to other helicopter variants beyond the MQ-72C. The company is in the second year of the Aerial Logistics Connector Middle Tier of Acquisition Rapid Prototyping Program, which provides aircraft prototypes for operational demonstrations and experiments.

The Aerial Logistics Connector initiative is among several Defense Department programs designed to deliver logistical support in distributed environments during conflicts with peer or near-peer adversaries. 🌐



OEM

Advent International to Acquire u-blox

U-blox has entered into a binding transaction agreement with ZI Zenith, a subsidiary of Advent International, for \$1.3 billion. Under the agreement, ZI Zenith will launch a public tender offer to acquire all publicly held registered shares of u-blox at a price of CHF 135.00 per share in cash.

The offer represents a 53% premium to the undisturbed volume-weighted average share price of the past 6 months until August 14, 2025, and a 32% premium to the undisturbed volume-weighted average share price of the last 60 trading days of u-blox shares until August 14, 2025, before the media first reported on a potential transaction.



U-blox's board of directors unanimously concluded the transaction is in the best interests of the company, its shareholders and other stakeholders. It therefore recommends that shareholders accept the offer and has committed, along with the management team, to tender all their shares.

The board's recommendation is supported by an independent fairness opinion stating the offer price is fair from a financial point of view. In addition, u-blox's largest individual shareholder, SEO Master Fund LP, holding approximately 9% of the outstanding shares, has committed to tender all its shares.

The tender offer is subject to terms and conditions as well as regulatory approvals customary for this type of transaction and is expected to be settled within the next six months. The intention is to then delist u-blox shares from the SIX Swiss Exchange. 🌐

Shield AI

MACHINE CONTROL 



Topcon

Digital Tools Reshape Complex Construction Management

The construction of the Perca Bypass, a critical infrastructure project underway in the Italian Alps, underscores the growing importance of advanced technology in managing complex construction projects. Located near the village and commune of Perca — a destination known for its tourism trade — the new 632 m tunnel and supporting road network are designed to improve regional connectivity and enhance commuter safety.

The project, which began in 2023 and is expected to take three years to complete, is being delivered through a joint venture between European construction group Strabag and regional specialist Alpenbau. Once finished, the bypass is expected to relieve the flow of up to 26,000 vehicles that pass through Perca daily during peak periods, easing congestion and opening

new routes for both tourism and local commerce.

Given the large number of machines, teams, and partners involved, coordinating the work requires effective management and communication tools. Alpenbau, drawing on a long-standing collaboration with Topcon Positioning Systems, the team is now using Topcon's Aptix Integration Platform, which enables site managers to monitor and oversee progress remotely, offering real-time insights into workflow and project status without leaving their offices.

"Aptix is a very convenient solution for us to manage our construction sites," said Benjamin Niederkofler, CEO of Alpenbau. "One of the advantages of Aptix is that you can directly load 3D models onto machines that are equipped with machine control systems. This means that you always have the possibility to

monitor the site from the office. This is a very important and fundamental tool for us to remotely monitor a construction site."

Aptix consolidates data from different contractors and machinery, regardless of the manufacturer or operating system, and provides a comprehensive view of project performance. Senior leaders can access essential metrics in real time, such as work progress, fuel consumption, and carbon emissions, improving the ability to make informed decisions.

Once completed, the Perca Bypass is expected to generate new economic opportunities for the region. Project leaders say that by adopting innovative digital workflows and centralized data management, they can direct complex operations more effectively and deliver projects with increased speed and accuracy. 🌐

TIMING 

Australian Defence Selects Adtran Optical Cesium Clock for PNT Research

Australia's Defence Science and Technology Group (DSTG), part of the Australian government's Department of Defence, has selected Adtran's Oscilloquartz high-performance optically pumped cesium clock to support research at its Adelaide facility.

The OSA 3300 HP will serve as a time and frequency reference for positioning, navigation and timing (PNT) research. Delivered in collaboration with local partner CoverTel, the deployment marks the first integration of optical cesium technology within Australian defense research.

"DSTG's selection of our optical cesium reflects a broader shift toward autonomous, long-term synchronization solutions," said Stuart Broome, general manager of EMEA and APAC

sales at Adtran. "Defense organizations around the world are reassessing how they ensure timing resilience, particularly as reliance on GNSS becomes more of a risk."

The OSA 3300 HP will give national infrastructure precision and adaptability, supporting DSTG's research into new strategies for assured PNT. DSTG selected the OSA 3300 HP to support advanced PNT research within its Sensors and Effectors division.

Using optical pumping technology that measures 100 times more atoms than traditional magnetic cesium clocks, the device delivers outstanding frequency stability and precision, Adtran said. Its all-digital design ensures consistent performance, while its 10-year operational lifespan offers long-term value. 🌐



Adtran

TIMING 

Companies Move to Modernize Precision Timekeeping

Xona has reached three new commercial agreements with precision timing innovators Hoptroff, Fibrolan and Timebeat, marking its official entry into the precision timekeeping and synchronization market. These partnerships seek to enable end users to leverage Xona’s Pulsar satellites to provide independent, secure, and resilient timing infrastructure amid mounting global complexity and risk.

Satellite navigation provides far more than positioning — it’s the world’s most accurate source of globally synchronized time signals underpinning nearly every critical system, including:

- Emergency response coordination
- Real-time power grid balancing
- Transportation network resilience
- Fair and trustworthy global financial trading



As infrastructure becomes more connected and distributed, timing is the backbone of data governance.

- 5G network synchronization
 - Data center efficiency and security
- As infrastructure becomes more connected and distributed, timing is the backbone of data governance — determining who holds critical data, when it was held and for how long. A single second lost or spoofed can erode trust across every facet of daily life.
- Broadcasting nanosecond-level accurate time from low-Earth orbit, Pulsar provides a new alternative to vulnerable GNSS-based systems. With built-in authentication, secure signals, and up to 100x received power of legacy GNSS, Pulsar ensures reliable reception even in low-rise buildings and urban environments — all with-

out requiring specialized hardware, according to the company.

“This is an important milestone; proof that next-generation satellite technology is no longer just promising innovation, but solving real, urgent problems today,” said Jay Wakenshaw, COO of Xona. “Seeing market leaders like Hoptroff, Fibrolan, and TimeBeat adopt Pulsar validates that there’s a genuine need and significant demand for what we’re bringing to market.”

Pulsar testing and demonstrations in real-world environments will continue through this year and into early next year, with active field deployments planned from late 2026. “Our customers in critical national infrastructure rely on precision timing to keep their operations secure, compliant, and efficient,” said Tim Richards, CEO of Hoptroff. “The low-Earth orbit satellite system provided by Xona will add additional redundancy to our global timing network, and complements our existing terrestrial timing infrastructure, which is essential for next-gen applications, particularly in these uncertain times.”



Xona

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TIMING

NextNav, Oscilloquartz to Bolster 5G-Based Timing Solutions to Complement GPS

NextNav and Oscilloquartz, a division of Adtran, have partnered to demonstrate how 5G-powered terrestrial PNT technology combined with Oscilloquartz's established synchronization systems can serve as a scalable complement and backup to GPS. The initiative aims to maintain the operation of critical infrastructure, such as data centers, utilities, and emergency services, during GPS outages by distributing precise, coordinated universal time (UTC) over existing 5G networks for both indoor and outdoor environments.

The collaboration integrates Oscilloquartz's synchronization technology with NextNav's terrestrial 5G PNT platforms to introduce an additional timing source, thereby reducing end-user

dependence on GPS alone. This effort addresses increasing demand for secure and redundant timing solutions in light of threats to GPS reliability. The companies are aligning their technologies with ongoing Federal Communications Commission (FCC) initiatives to encourage complementary PNT solutions.

According to the companies, this approach responds to national security and public safety concerns by prioritizing the development of resilient infrastructure. The demonstration of these integrated terrestrial timing capabilities is intended to provide a practical example of how industry can build more robust timing networks and reduce the risks associated with relying solely on GPS. 🌐



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PROMOTING PRECIOUS POLLINATORS

Washington State University (WSU) is leading the Pacific Northwest Pollen Atlas (bees.wsu.edu) to map and describe pollen. It aims to determine pollinator health, and thus food humans eat that depend on pollination. Honey bees and other pollinators collect pollen

from plants within a two-mile radius of their hive. "We hope to create a database of plants and share the nutrient content in their pollen so gardeners can plant a healthy variety," said Priya Chakrabarti Basu, WSU assistant professor, Entomology. Researchers will map pollen varieties collected by citizen scientists in every Washington county over a four-year period, and colleagues around the Pacific Northwest also are recruiting to increase the project's scope. Expected to take decades to complete, the efforts are part of Basu's larger effort to map pollen nutrition across North America.

HOW'S THE WEATHER OUT THERE?

High-resolution atmospheric data is the missing link in forecasting weather. A new approach sharpens GNSS tomography, while showing how the model makes decisions – a transparency critical for building trust as AI



enters weather forecasting. By revealing the hidden details of storms and humidity patterns, the new method can give forecasters the tools needed to anticipate extreme events with greater confidence, according to researchers at Wrocław University, Poland. The team described their deep-learning

framework in a paper published in *Satellite Navigation* in August. With sharper GNSS tomography, meteorologists can feed more accurate humidity fields into both physics-based and AI-driven forecasting models, significantly improving storm prediction and early-warning systems.

AFRICA REALLY IS HUGE

A Correct the Map campaign aims to replace the 16th-century Mercator map because it doesn't show the true size of Africa, which is three times as large as Europe. Supporters say the historic map – created to guide European explorers – promotes a false view of the continent and its size, fostering a false impression

that Africa is "marginal." In August, the 55-country African Union endorsed the



campaign to have organizations around the world replace the Mercator with alternatives such as the 2018 Equal Earth projection. The African Union is expected to make an official decision to adopt the Equal Earth map in February. The campaign also asks the United Nations and the BBC to adopt the Equal Earth map.



INDIA GIVES UP ON GNSS TOLLING

For several years, the Indian government had intended to implement a GNSS-based toll system based on real-time location tracking. Now, it looks like these plans have been scrapped. The Ministry of Road Transport and Highways is proceeding with corridor projects relying on automatic number-plate recognition (ANPR) and FASTag Systems, which don't require vehicles to stop. A GNSS toll system tracks the exact location of the vehicle and calculates the distance traveled on a toll roll, ensuring that users end up paying for just the distance they actually traveled. Instead, the ANPR-FASTag hybrid system will continue to rely on ground-based high-speed cameras to identify vehicles and radio-frequency identification FASTag readers to charge them.

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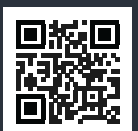
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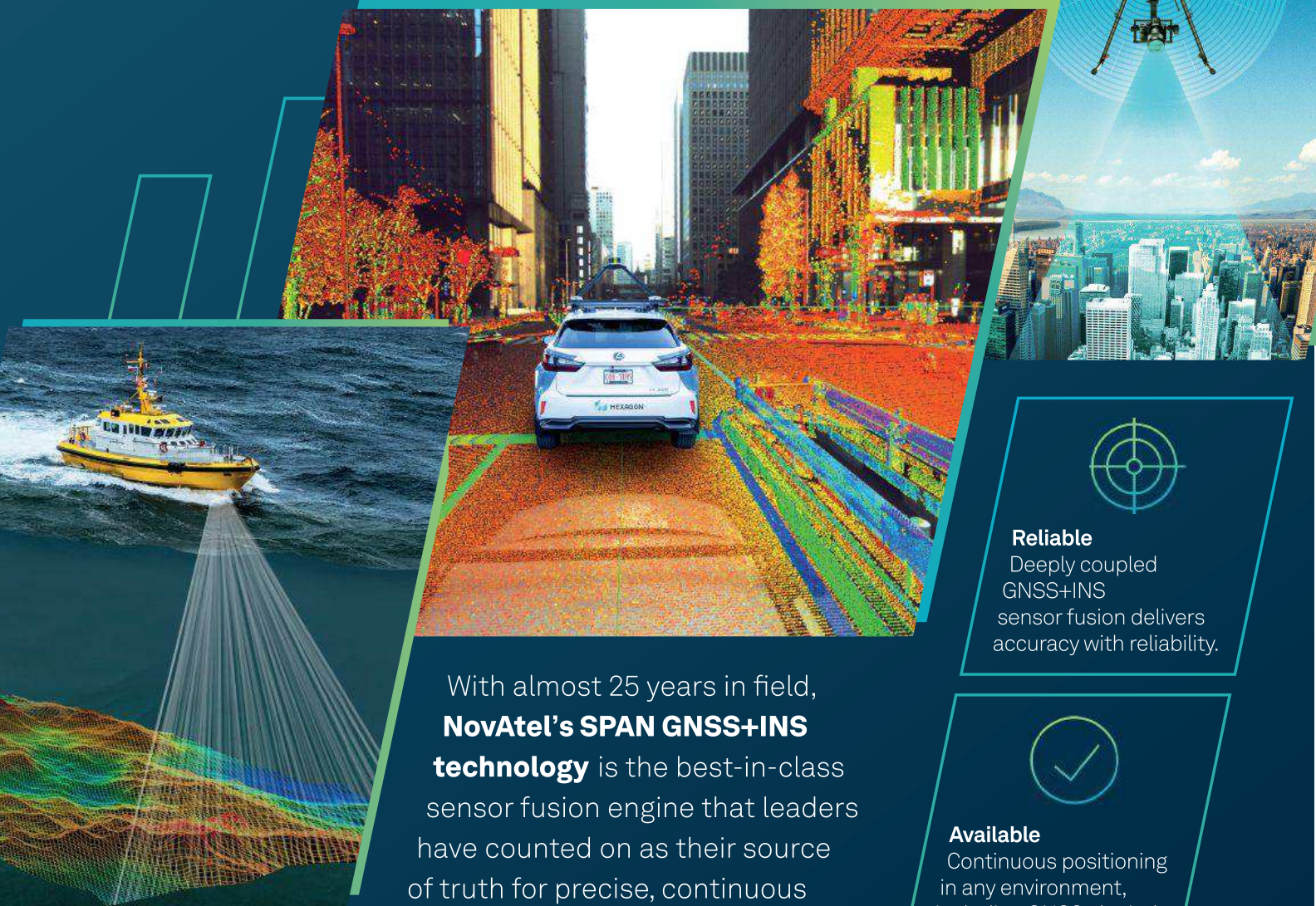
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