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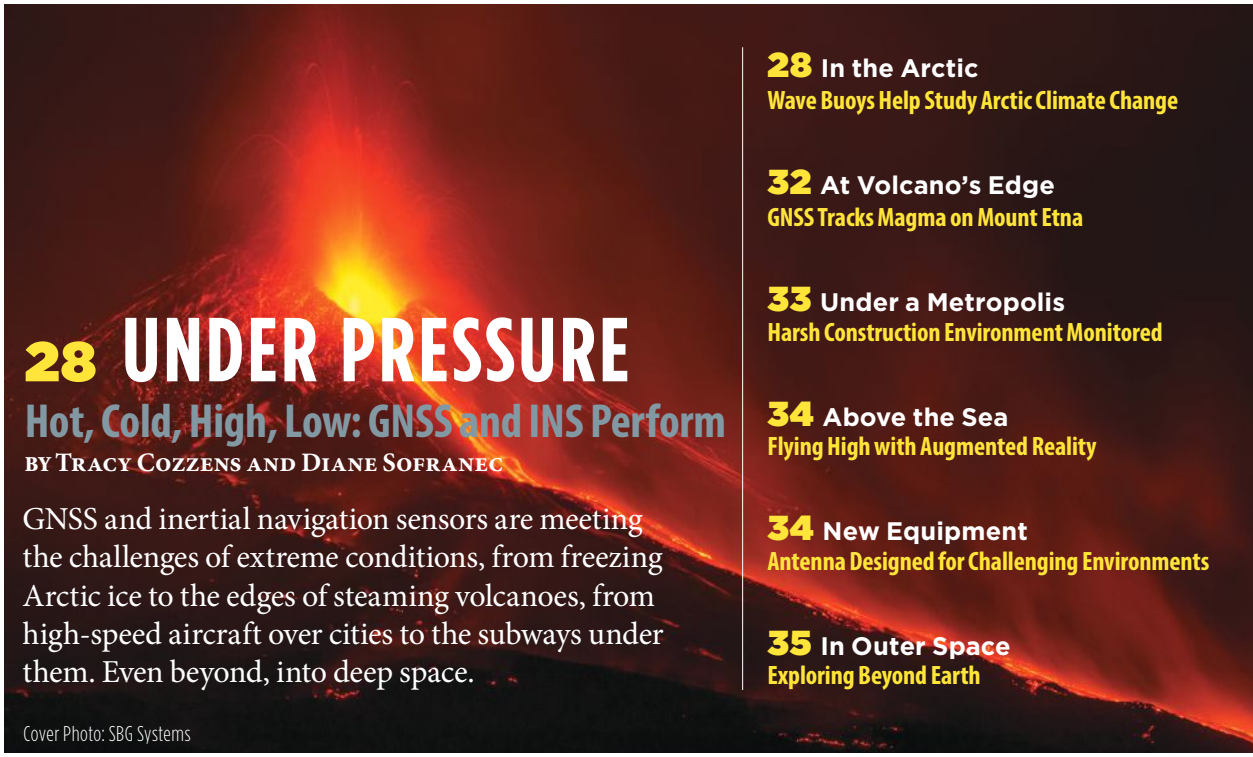

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OPINIONS AND DEPARTMENTS

ONLINE NOW

US Department of Defense PNT Strategy: 'GPS Is Not Enough'

BY DANA GOWARD
PRESIDENT, RESILIENT NAVIGATION AND TIMING FOUNDATION

- **GPS might be interfered with globally**
- **Multiple, diverse PNT sources, modular open system needed for receivers**
- **Civil use hampering military efforts to leverage GPS for military advantage**
- **DoD PNT efforts to be increasingly classified, not shared with civil users**

In August, the United States Department of Defense (DoD) publicly released a version of its "Strategy for the Department of Defense Positioning, Navigation, and Timing (PNT) Enterprise" with the tagline "Ensuring a U.S. Military PNT Advantage."

Calling PNT "foundational," the strategy observes that the U.S. military has over the years structured its weapons systems and business processes around GPS PNT. This has created a tremendous dependence and associated vulnerability.

Added to this threat is the realization that "At the same time, it is increasingly clear… GPS will be targeted and will not always be available in contested military operating areas, or perhaps globally."

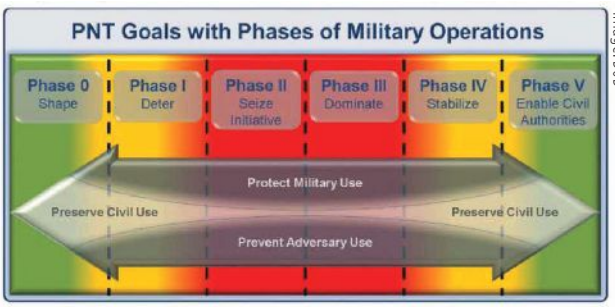

Image: DoD

The strategy envisions GPS, paired with military-grade receivers, as the primary global layer source. It recognizes that allied GNSS will be available, but observes that DoD has not done any accuracy and integrity assessments to determine their usefulness. And, since "…all are vulnerable to the same interference and jamming effects" as GPS, "…other sources of PNT information with different characteristics are necessary."

Read the full article at **gpsworld.com/PNTstrategy**

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The PNT Enterprise Is Real

BY JULES MCNEFF
CONSULTANT

GPS World publications are evolving, as this new column confirms. And the PNT world itself is evolving, first with the emergence of GPS in the 1990s, next with its universal adoption and duplication by others, and now with its foundational role in PNT-enabled applications for technologies of the 2020s and beyond.

Millions of people have grown up in a world where GPS-enabled PNT applications pervade their daily lives, and mostly for the better. But GPS is no longer the only face of PNT around the world, though it is still the best known even as other space-based systems from international providers have joined the party.

From its infancy, GPS was married with inertial systems and clocks. For a short time, GPS emergence stymied the commercial development of both, but as the viability of the marriage was validated, development turned toward miniaturization of the combination and adding more pieces as well.

Because of its free availability, GPS has been the foundational element in most of these integrated applications, and without GPS, many will not work as well — or at all. Consequently, dependence on GPS for efficient operation of many PNT-related activities has become a de facto reality. GPS timing is at the heart of interoperable telecommunications and data networks (most notably the internet) and of modern power grids. GPS positioning was the catalyst for adoption of the U.S. National Grid as a federal spatial interoperability standard for search-and-rescue and emergency response and by the SAE as a standard for commercial land mobility as well.

> "It is now clear that GPS was the spark, and a multi-faceted PNT enterprise is the new reality."

However, dependencies create vulnerabilities, and over-reliance on GPS has been cited as a potential Achilles heel for both national security and economic critical infrastructure. Efforts have been under way for several years by the U.S. Air Force to strengthen all aspects of GPS and, more recently, much attention has focused on making use of complementary technologies to increase the resilience and performance of integrated PNT devices.

Smartphone and autonomous vehicle developers have used such techniques for years to augment GPS for their applications. The awareness of value from ubiquitous access to precise position and time that was awakened by GPS in 1995 has now evolved into an understanding that diverse services from a broader PNT enterprise are necessary to preserve that access with assurance into the future.

Congress and the DoD have recognized that reality, with Congress directing and DoD implementing a DoD PNT Enterprise Oversight Council to manage future acquisition of PNT capabilities for the military. In August, the Department of Defense (DoD) also released a public version of its *Strategy for the DoD PNT Enterprise,* highlighting the processes it has created to implement resilient PNT for the Joint Force. Congress and the White House both have also recognized that the imperative for resilient PNT must be extended to domestic critical infrastructure, and this has resulted in direction to civil federal agencies to both strengthen and back up GPS use for their constituencies. It is now clear that GPS was the spark, and a multi-faceted PNT enterprise is the new reality.

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Teunissen Receives Kepler Award

by Tracy Cozzens
SENIOR EDITOR

This month, we regconize the winner of the most prestigious award in our industry: the Johannes Kepler Award. Peter Teunissen was honored with the career-highlight award, presented by the Institute of Navigation's (ION) Satellite Division on Sept. 20 at the ION GNSS+ Conference in Miami.

As ION explains, Teunissen was recognized for his influential and groundbreaking contributions to the algorithmic foundations of satellite navigation, and for sustained dedication to the global education of the next generation of navigation engineers.

Teunissen invented the Least Squares Ambiguity Decorrelation Adjustment (LAMBDA) method, the worldwide standard for ambiguity resolution, which revolutionized high-precision GNSS positioning capabilities. LAMBDA has become an indispensable tool, widely used in land, air and space navigation; positioning and attitude determination; differential and network processing; and in surveying and geodesy. He also extended the method to MC-LAMBDA.

Among others, Teunissen laid the mathematical and algorithmic foundation of reliability theory, which enables a proper understanding of the quality of different integer ambiguity resolution methods and a rigorous characterization of their failure rates, which even led to the development of an optimal test for ambiguity validation.

His findings are particularly important for multi-GNSS processing, which requires a proper understanding of individual system characteristics and their respective contributions to achieve navigation solutions of the highest precision and integrity.

Teunissen has contributed to the fields of precise point positioning, the exploitation of triple-frequency observations, and the joint use of new GNSS such as Galileo, BeiDou and QZSS.

Teunissen has made significant contributions to educating future generations. He is a professor of satellite navigation at Delft University of Technology, The Netherlands, and Curtin University, Australia.

He has published more than 300 papers and seven books and is co-editor and author of *The Handbook of Global Navigation Satellite Systems*. He has also authored articles for GPS World.

Photo: ION

PETER TEUNISSEN with the 2019 Kepler Award.

PNT Q&A

EDITORIAL ADVISORY BOARD

Which of several proposed terrestrial PNT technologies is best suited to complement and back up GPS?

"Seeking PNT resiliency for critical functions, a layered, multi-source terrestrial RF backup strategy could include eLoran for continental coverage and Locata, or similar system(s), for high-precision, localized service where needed. However, don't forget feature-aided navigation using optical, radar, lidar, etc., and positioning/timing from 'validated' signals of opportunity in data-rich environments."

"No single technology can provide a backup to GNSS to match the ubiquity of satellite-based PNT. However, placing inertial navigation systems at the core of our PNT solution, and focusing on bounding the growth of the positioning errors using whatever other space or terrestrial measurements are available, could provide an alternative paradigm to resilient positioning and navigation."

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Next-Generation EGNOS Satellite Orbited

A Eutelsat communications satellite launched Oct. 9 carried a payload for the European GNSS Agency (GSA) called GEO-3, which is a geostationary satellite designed to augment GNSS signals.

The payload, manufactured by Airbus Defence and Space, will hone the accuracy of satellite navigation signals over Europe for use in aviation, maritime and other industries as part of the European Geostationary Navigation Overlay System (EGNOS).

The Eutelsat-5 satellite, called West B, also hosts a payload that will enable service continuity for television broadcasting in Europe and North Africa.

The GSA signed a contract in March 2017 with Eutelsat Communications for the development, integration and operation of the next-generation GEO-3 EGNOS payload.

EGNOS operational messages are broadcast via navigation payloads on-board two GEO satellites, including an Inmarsat-3F2 satellite that is fast approaching end-of-life. The GEO-3 services replenish the EGNOS SBAS payloads, guaranteeing EGNOS availability and supporting the transition to the dual-frequency multi-constellation-capable EGNOS V3. EGNOS V3 will augment both GPS and Galileo in the L1 and L5 bands.

Furthermore, it will provide additional satellite-based augmentation system (SBAS) service capabilities through a new SBAS channel on L5 and will deliver increased EGNOS service availability within and beyond the EU Member States in answer to a growing number of users. The next generation of the EGNOS programme will also benefit from reinforced security, which will increase the robustness of EGNOS services against potential threats. EGNOS V3 will be made available in 2024 and will augment Galileo signals from 2025.

Eutelsat will also develop two redundant RF ground stations to uplink the EGNOS message to the payload. It will host EGNOS' Navigation Land Earth Stations (NLES) in Rambouillet, France, and Cagliari, Italy, both of which will be co-located with and connected to the RF ground stations.

Credit: Orbital ATK

ARTIST'S DEPICTION of the Eutelsat-5 West B satellite, which is a replacement for the 17-year-old Eutelsat-5 West A satellite.

RIN Gathers Experts for Top Navigation Conference

The Royal Institute of Navigation: International Navigation Conference (INC) will take place Nov. 18–21 at the Edinburgh International Conference Centre in Edinburgh, U.K.

The INC offers keynotes morning and afternoon each day, setting the scene for in-depth session papers. Technology, system and application experts will meet with cognitive neuroscientists as well as experts on human factors, regulations, ethics and the law. Experts from RIN's animal navigation forum and conference will offer insights, perspective and contacts to improve attendees' impact and effectiveness.

Sessions topics include robotics, animal navigation, resilient PNT, neuroscience and cognition, human factors and wayfinding, integrated sensors and indoor navigation, artificial intelligence, maritime, Scottish-led innovation in PNT, drone regulation, and UK space and GNSS.

Pre-INC Seminar. On Nov. 18, RIN is offering a one-day short course, "Securing Positioning and Timing," to build understanding of satellite navigation vulnerabilities and threats, plus steps to toughen and augment systems.

For more information, go to **www.rininc.org**.

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Raytheon Completes GPS OCX Design and Development

Program enters integration and test phase on track to 2021 delivery

Raytheon Company's GPS Next-Generation Operational Control System (GPS OCX) has completed full software and hardware development and entered the system integration and test phase. The milestone keeps GPS OCX, the enhanced ground control segment of a U.S. Air Force-led effort to modernize America's Global Positioning System, on track to meet its June 2021 contractual delivery deadline.

"GPS OCX is one of the largest, most complex software development programs in the Department of Defense (DoD), and we're now in the home stretch toward full system delivery," said Dave Wajsgras, president of Raytheon's Intelligence, Information and Services business.

The GPS OCX team completed development of 1.5 million lines of software code, supported by a pivot to leading-edge commercial software development processes that began in 2016. Additionally, the team's information assurance best practices helped the program achieve the highest level of cybersecurity protections of any DoD space system.

The U.S. Air Force used the cybersecure GPS OCX launch and checkout system, often referred to as Block 0, to launch the first modernized GPS III satellite into space in December 2018 and the second in August 2019.

The team's focus for the remainder of 2019 is the delivery of the system's new modernized receivers, which will measure and monitor legacy military and civilian signals sent by the current GPS satellite constellation plus the new signals sent by the next-generation GPS IIIs.

US Army Fields Anti-Jam GPS

Sixty-two of the first iteration of mounted anti-jam GPS devices were equipped into light armored vehicles in Germany in September, according to the United States Army, with thousands more scheduled to be installed into U.S. European Command vehicles by 2028.

The Mounted Assured Precision Navigation & Timing System (MAPS) was developed to provide trusted positioning, navigation and timing (PNT) to a platform, such as Stryker vehicles, by pairing a GPS receiver with an anti-jam antenna, said Col. Nickolas Kioutas, PNT project manager.

The electronic technology comes amid the Army's vision for 2028, to best prepare soldiers for possible warfare with near-peer competitors, who have used electronic warfare to disrupt communications vital to Western forces in recent years.

More than 300 Stryker vehicles, all from the 2nd Cavalry Regiment, are expected to be fielded with MAPS technology. The Army also plans to put MAPS in vehicles such as the Bradley Fighting Vehicle, M1 Abrams tank, and the M109 Paladin self-propelled howitzer. Upgraded first-generation and second-generation technology is expected to be unveiled in the future.

Photo: U.S. Army/John Higgins

A SOLDIER CHECKS a NovAtel anti-jam antenna, a key component of the MAPS.

GSA Releases 2019 GNSS Market Report

A new *GSA GNSS Market Report* is available for download. It provides a comprehensive overview of the GNSS market and the global industry, as well as a focus on European GNSS differentiators and synergies with Copernicus, according to the publisher, the European GNSS Agency (GSA).

GNSS in Space. This year, the report features the "Editor's Special: GNSS for NewSpace," a section that introduces GNSS receivers in satellites and their relation to the evolving space sector.

Cover: GSA

GNSS market monitoring is a key activity of the GSA. Market monitoring supports GNSS stakeholders in their planning and decision-making, and offers a clear tool to understand GNSS trends and evolutions.

Since its launch in 2010, the *GSA GNSS Market Report* has become a valuable source for information on the global GNSS market. (Download at **www.gsa.europa.eu/system/files/reports/market_report_issue_6.pdf.**)

SENSOR FUSION

TomTom Highlights Autonomous Vehicle Push

BY Kevin Dennehy
GPS WORLD CONTRIBUTOR

To grab a larger piece of the burgeoning connected and autonomous vehicle markets, digital mapmaker TomTom launched its self-driving test vehicle and is integrating navigation and diagnostic capabilities in the Microsoft Connected Vehicle Platform.

While the company has tested the technology for years, TomTom officially announced the availability of its own autonomous test vehicle, which Arnold Meijer, TomTom strategic manager, business development, said is a critical advantage to quickly develop maps and services for that industry.

"We can continuously test our mapping technology on the roads, get insights and high-quality data on how it performs in a multitude of circumstances and, right away, feed this into our AI-driven mapmaking process," he said.

Currently, the vehicle is testing TomTom's high-definition map; a crowd-sourced map update called Roadagrams; and a map-streaming service, AutoStream, which will deliver map data to vehicles on demand.

The company announced in September at the International Motor Show (IAA 2019) in Frankfurt, Germany, that its digital maps have doubled to more than 1 million Level 1 and Level 2 autonomous vehicles from several automakers.

Showcasing TomTom HD Maps

At IAA 2019, TomTom also demonstrated proof-of-concept high-definition map features that can work through Microsoft Azure cloud services, Meijer said. "Some of the navigation intelligence, which also includes traffic information and HD map services, can also be used in vehicles for navigation apps, as well as context while driving autonomously," he said.

Photo: Kevin Dennehy

THE TOMTOM test vehicle prototype hits the road in San Francisco.

The demonstration allows TomTom to send telemetry data to Microsoft Azure. "[This includes] application usage data such as what menu items the end-user clicked on and what screens of the TomTom NavApp they opened for app analytics purposes," he said.

Other features include GPS location during a driving simulation, vehicle speed and heading for driver behavior, and usage of apps that are not navigation-related, such as for music. Other testing included road speed limit, the number of times users drive a planned route, destination details planned by a user, and travel time.

TomTom navigation integrated into the Microsoft Connected Vehicle Platform allows automakers to quickly access precise navigation and driving behavior, "while of course adhering to TomTom's privacy principles," Meijer said. "This data could, for instance, be used to predict the range of an electric vehicle based on driving behavior and planned route more accurately. Or to work out, based on navigation behavior, what connectivity package for online navigation would be best suited for a driver."

Voyage Forges Ahead...

While recent press reports have said autonomous vehicle development is slowing because of technology limitations and consumer doubt, Palo Alto, Calif.-based Voyage has raised millions of dollars and continues to test self-driving cars in retirement communities in California and Florida.

The company recently raised $31 million in Series B funding from Franklin Templeton, Khosla Ventures, Jaguar Land-Rover's InMotion Ventures and Cheveron Technology Ventures. Voyage has raised a total of

$52 million since its 2017 founding, said Oliver Cameron, company co-founder and CEO.

With the new funding, Cameron said the company hopes to triple its workforce, increase its second-generation fleet of self-driving cars, invest more in the technology and roll out a third-generation vehicle.

"We are taking a unique, focused approach to delivering truly driverless cars in communities where there are limited mobility options, customers who need an autonomous ride-hailing service, and lower speeds," he said. "Many residents within our communities don't have access to transportation options that work for them, so they've welcomed our fleet of self-driving vehicles. We've started with self-driving cars that can travel point-to-point within our communities at speeds of up to 25 mph."

Cameron said the community-based approach allows the company to quickly design and deploy autonomous technology. "For the past two years, because we are taking this focused, community-based approach to designing and deploying advanced self-driving car technology, progress has been rapid. Our vehicles intelligently and autonomously navigate the complex neighborhoods of our communities and safely transport our passengers door-to-door," he said.

The company said its engineers are transitioning software to a safety-critical middleware, shipping a new prediction engine with better capabilities and creating triple redundancy in the vehicle's perception system.

G3 Vehicle? Not Yet. Voyage, which began testing self-driving with a retrofitted Ford Fusion, doesn't have a timetable planned for a third-generation system, Cameron said. Instead, the company plans to continue to use the self-driving Chrysler Pacifica hybrid minivan in its testing projects.

"Before we launch our [third generation] self-driving car, we are going to build and scale more G2 self-driving cars to better serve the communities in which we operate. We haven't announced a timeframe for the launch of our electric, truly driverless and highly scalable G3 self-driving car," he said.

The company is growing its ranks as it has hired its first chief operations officer, Nina Qi. She believes the biggest hurdle autonomous vehicles have is the basic challenge to deliver safe and cost-effective services to make the industry economically sustainable.

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The i90 IMU-RTK GNSS series receiver is designed to dramatically increase GNSS real-time kinematic (RTK) availability and reliability. The i90 is powered by the company's latest inertial measurement unit (IMU) and RTK technology to provide robust and accurate GNSS positioning in any circumstances. Unlike standard micro-electro-mechanical (MEMS)-based GNSS receivers, the i90 GNSS IMU-RTK combines a high-end calibration and interference-free IMU sensor with a state-of-the-art GNSS RTK engine and advanced GNSS tracking capabilities. The i90 is designed to increase the productivity and reliability of survey projects, with no complicated calibration process, rotation, leveling or accessories are necessary. A few meters' walk will initialize the i90 internal IMU sensor and enable RTK survey in difficult field environments. The i90 GNSS automatic pole-tilt compensation boosts survey and stakeout speed by up to 20%.
CHC Navigation, chcnav.com

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Septentrio, septentrio.com

3. SCANNING SYSTEM

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The Trimble X7 laser scanning system is designed for surveying, construction, industrial and forensic applications. It enables professionals to quickly and easily capture precise 3D scanning data to produce high-quality deliverables. The X7 features Trimble X-Drive technology, survey-grade self-leveling and a smart calibration system. It integrates streamlined workflows to provide automatic registration of point-cloud data in the field with Trimble Registration Assist, bringing scans together through self-leveling inertial measurement unit technologies and cloud-based software.
Trimble, trimble.com

4. CITY MAPPING

SERVICE OFFERED FOR EUROPE

The MetroVista city mapping service for Europe incorporates the Leica CityMapper hybrid airborne sensor designed for 3D city modeling and urban mapping. The sensor includes a vertical camera and survey-grade oblique cameras, and incorporates lidar to accurately collect elevation and infrared data. The MetroVista range includes high-resolution imagery combined with high-accuracy, wide-scale 3D models. CityMapper has already been used to capture MetroVista data for cities across the United Kingdom, including London, Manchester, Newcastle and Bristol.
Bluesky International, bluesky-world.com

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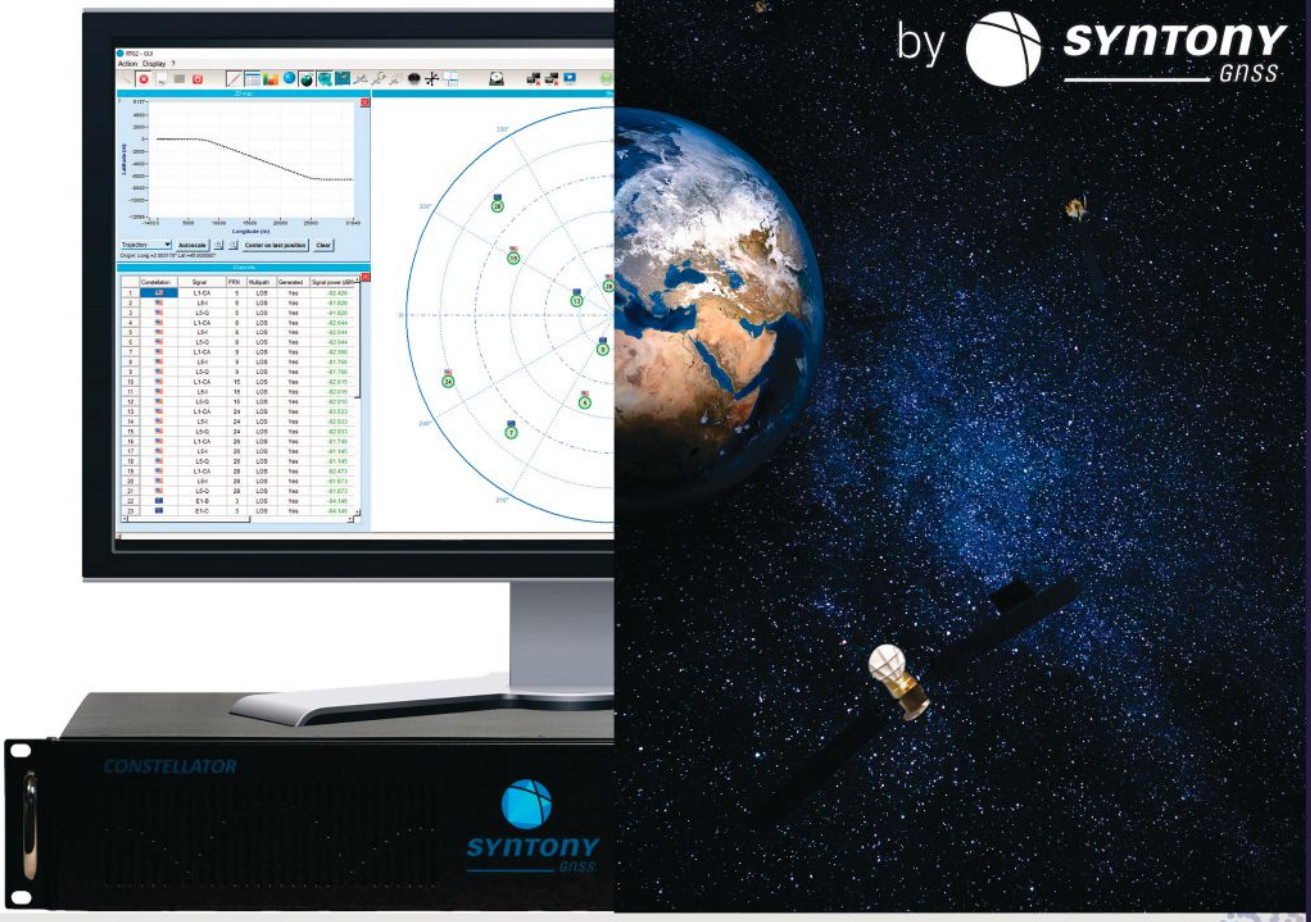

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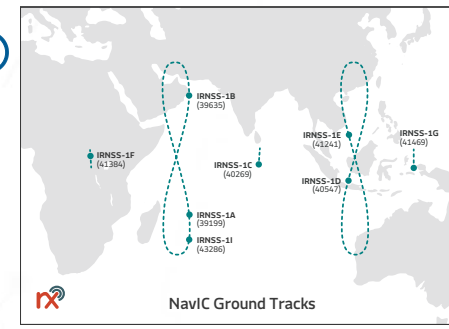

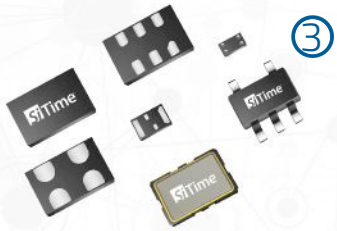

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1. SIMULATION SOLUTION

UPDATED FOR HIGH-ACCURACY MARKET

The enhanced GSS9000 series GNSS constellation simulator has been updated to provide significantly improved capability, flexibility and performance to meet the test needs of high-performance navigation systems. It doubles the number of supported channels (320 in a single chassis) while maintaining its full performance specification in key areas such as signal iteration rate and low latency under maximum signal dynamics. These attributes, together with the ability to produce a comprehensive range of emulated multi-GNSS, multi-frequency RF signals, enables full and future-proofed testing of advanced applications. Greater signal flexibility is also built into the enhanced GSS9000 through its open application program interface (API) and flexible architecture. This delivers a highly sophisticated arbitrary waveform generator (AWG) capability.

Spirent Communications, spirent.com

2. NAVIC SUPPORT

ADDED TO CONSTELLATION DATA SERVICE

Rx Networks has added NavIC constellation support to its real-time and predicted-assistance data service. The company's technology partners — semiconductor vendors, mass-market mobile device manufacturers and network operators — now have global support for all satellite navigation systems and L1 satellite-based augmentation systems (SBAS) for any region around the world. Used daily by more than two billion devices, Rx Networks data is delivered via ephemeris in RINEX and via the Location.io interface, with predictions in SP3. Predictions for NavIC via the Location.io platform will be added in the first quarter of 2020.

Rx Networks, rxnetworks.com

3. MEMS TIMING

FOR RUGGED GNSS APPLICATIONS

Endura micro-electro-mechanical system (MEMS) timing solutions are designed for aerospace and defense applications including precision GNSS. They provide high performance in harsh conditions such as severe shock, vibration and extreme temperature. SiTime offers customers 5 million possible part numbers that can be created from 17 programmable products. Solutions accommodate 4 parts per trillion per g force of acceleration (50 times better than quartz); support for −55° C and +125° C operation; timing specifications conforming to MIL-PRF-55310; and Endura Super-TCXOs (temperature compensated oscillators) for use in GNSS applications.

SiTime, sitime.com

4. GNSS RF SIMULATOR

RECORD AND PLAYBACK SYSTEM

Portos Team is a new GNSS RF signal record-and-playback system. It can record and play back — or simulate —multi-frequency, multi-system GNSS signals when paired with the company's Replicator. It can do the same for CRPA signals when paired with the company's Ninja. The Portos itself can also operate as multi-frequency or CRPA front end for a GNSS software receiver.

IP-Solutions, ip-solutions.jp

5. UWB MODULE

FOR REAL-TIME LOCATION SYSTEMS

The DWM1004 module targets time difference of arrival (TDoA) tag applications that require years of battery life and a compact design. Based on the DW1000 chipset, the DWM1004C offers high-accuracy, real-time-location capability with a 6.8-Mbps data rate. It delivers more than five years of battery life. Real-time location systems (RTLS) enable managers to have a real-time view of their operations through data collected from connected objects such as tools, pallets, forklifts, badges and collars. The DW1000 is immune to multipath fading, with 2-centimeter precision in indoor environments.

Decawave, decawave.com

RTK and Optical United

J-Mate as the 7th RTK Engine
Robotics and Scanning too

JAVAD

www.javad.com

Front

Your Own Complete RTK & Optical

Setup TRIUMPH-3 on top of J-Mate.
Set up TRIUMPH-LS on top of the Zebra rod.

TRIUMPH-3 is the RTK base station and TRIUMPH-LS the RTK rover.
J-Mate is the optical base station and the Zebra rod is the optical rover.

Now RTK and optical solutions are available simultaneously and can verify each other's solutions. They also can cover each other, when one is not available.

RTK has six engines. We treat the J-Mate solution as the seventh engine of the system.

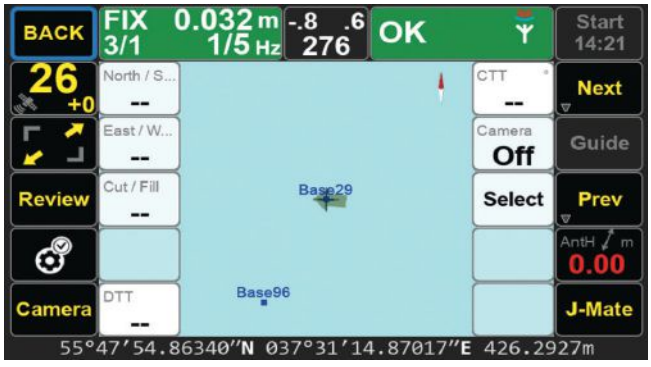
This is the first time that Back sight calibration is done so simple and with one point. There are obvious benefits of simultaneous availability of RTK and optical solutions.

The system is self-sufficient for all jobs. No need to pay RTN service providers for RTK base stations and no need to pay communication service providers. The communications are done via integrated and included Bluetooth, UHF, and Wi-Fi embedded in the system.

Another major advantage is that because your own RTK base station is not far from your rover, RTK solutions will be provided much faster and more reliably.

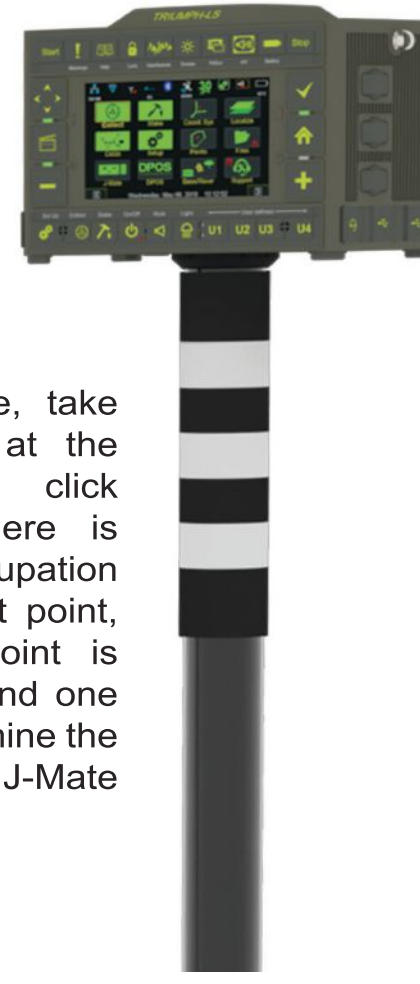
At TRIUMPH-LS = 2.13 kg (4.40 lb), TRIUMPH-3 = 1.26 Kg (2.20 lb), and J-Mate = 2.17 kg (4.41 lb), The total package of 5.6 kg (11.02 lb), weighs less than one conventional optical total station alone.

J-Mate does have complete geodetically encoded scanning (3 points per second) and robotic features too.



FL

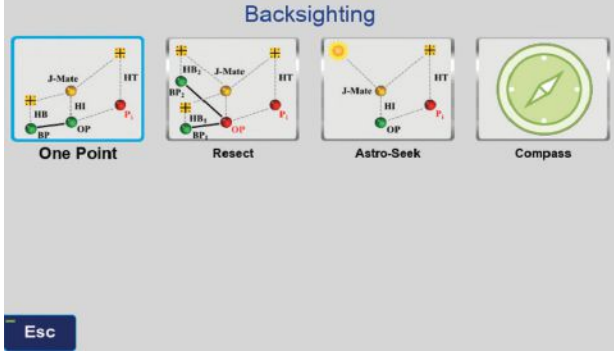
Take Backsight with a Single Shot

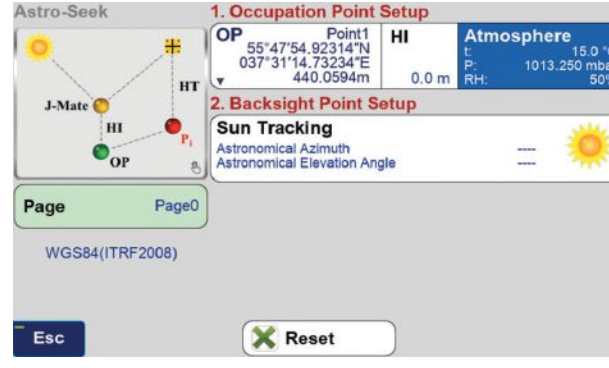


To calibrate the J-Mate, take few seconds of RTK at the Backsight point, and click “Backsight” button. There is no need to locate Occupation Point and the Backsight point, because Occupation point is the RTK Base station and one point is enough to determine the azimuth to calibrate the J-Mate angular encoders.

Backsight with Auto SunSeek

Click a button and after a few seconds Backsight will be calibrated with the Sun AUTOMATICALLY. Don’t forget the Sun filter.





See details at www.javad.com

Light Weight, Low Cost

Costs ½ , Weighs ½ and works much better than conventional total stations and RTK systems.

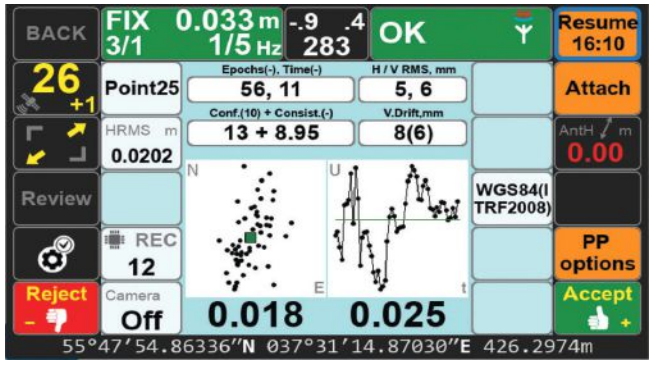
Complete RTK Base & Rover.
Complete optical system.
Complete controller and software.
Free updates.
Robotic & Scanner...
...all under $40K

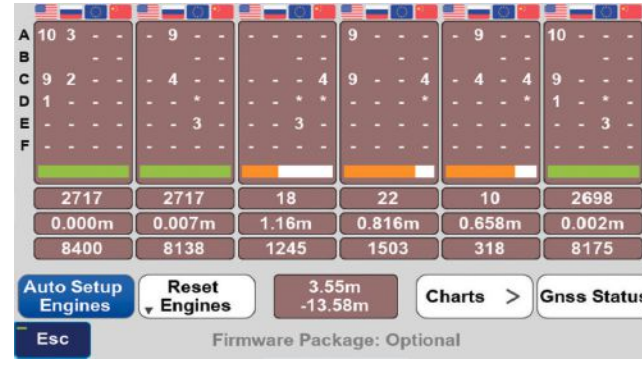
And it all fits in a small carrying bag.

Six RTK Engines Auto VERIFY

Smart assignment of satellite signals to different engines.

This vigorous, automated approach to verifying the fixed ambiguities determined by TRIUMPH-LS gives the user confidence in his results and saves considerable time compared to the methods required to obtain minimal confidence in the fixed ambiguity solutions of other RTK rovers and data collectors on the market today. The methods required by other systems are not nearly so automated, often requiring the user to manually reset the single engine of his rover, storing another point representing the original point and then manually comparing the two by inverse, all to achieve a single check on the accuracy of the fixed ambiguities. Acquiring more confidence requires manually storing and manually evaluating more points. Conversely, J-Field automatically performs this test, resetting the multiple engines, multiple times (as defined by user), provides an instant graphic display of the test results, and produces one single point upon completion.





J-Field, the Embedded Controller

J-Field is the embedded application program of TRIUMPH-LS. It has the following unique features for each point surveyed:

- Six parallel RTK engines to maximize solution availability.
- Automatic Engines Resets, verification and validation strategy.
- Several graphical and numerical confidence reports and documentation.
- Voice-to-text conversion for hands free operation and documentation.
- Lift & Tilt and automatic shots for hands free operation.
- Visual Stakeout (Virtual Reality).
- “DPOS it” or “Reverse Shift it” features. The most advanced RTK verification.
- Photogrammetry and angle measurements with embedded cameras.
- Automatic or manual photo documentation.
- Automatic screen shots documentation.
- Audio files for documentation.
- Automatic tilt correction.
- Scanner feature.
- Find objects by their shape, by laser or optical.
- Comprehensive HTML and PDF reports.
- Comprehensive codes, tags and drawing tools.
- Status of all GNSS signals and their quality.
- Over 3,000 Coordinate Systems.
- Automatic and free software update via Internet.

TRIUMPH-3

The new TRIUMPH-3 receiver inherits the best features of our famous TRIUMPH-1M.

Based on our new third generation TRIUMPH chip enclosed in a rugged magnesium alloy housing.

The TRIUMPH-3 receiver can operate as a portable base station for Real-time Kinematic (RTK) applications or as a receiver for post-processing, and as a scientific station collecting information for individual studies, such as ionosphere monitoring and the like.

It includes options for all of the software and hardware features required to perform a wide variety of tasks.

- UHF/Spread Spectrum Radio
- 4G/LTE module
- Wi-Fi 5 GHz and 2.4 GHz (802.11 a, b, g, n, d, e, i)
- Dual-mode Bluetooth and Bluetooth LE
- Full-duplex 10BASE-T/100Base-TX Ethernet port
- High Speed USB 2.0 Host (480 Mbps)
- High Speed USB 2.0 Device (480 Mbps)
- High Capacity microSD Card (microSDHC) up to 128GB Class 10;
- “Lift & Tilt”
- J-Mobile interface

Ideal as a base station

①

②

③

④

⑤

1. RTK GNSS ROVER

GNSS FOR A MOVING VEHICLE

The F9P Sirius RTK GNSS rover is designed to be mounted on a moving vehicle. The u-blox ZED-F9P module inside provides 1-cm position accuracy, a convergence time under 10 seconds and a navigation update rate up to 20 Hz. The rover has a built-in active antenna patch. It receives GPS, Galileo, Beidou and GLONASS signals, providing additional accuracy. It is designed to fit most setup designs as well as integrate easily into a vehicle. Its six-pin JST-GH connector makes it plug-and-play with the Pixhawk Pro 3 autopilot.

Drotek Electronics, drotek.com

2. GNSS DATALOGGER

ACCURACY FOR AUTOMOTIVE TESTING

The VBOX Touch is a highly flexible GNSS datalogger with enhanced accuracy. The powerful hardware can be used diverse automotive tests such as acceleration, braking, speed verification, tire temperature monitoring, lap-timing and durability. The VBOX Touch comes preloaded with a sophisticated performance application that covers common use cases; applications can be downloaded from an online library. Racelogic can also write custom Python scripts based on customer requirements.

Racelogic, www.vboxautomotive.co.uk

3. POSITIONING MODULE

DESIGNED FOR AUTO INDUSTRY

The LG69T GNSS module is an automotive-grade dual-band high-precision GNSS module that integrates dead-reckoning (DR) and real-time kinematic (RTK) technologies. The module facilitates open-sky positioning performance with an accuracy of up to 10 centimeters. It supports next-generation precision positioning capabilities for smart vehicles and autonomous driving scenarios. The LG69T module is based on ST's STA8100GA, the latest automotive-grade dual-frequency positioning chip with 80 tracking channels and four rapid-acquisition channels compatible with GPS, BeiDou, Galileo, Navic and QZSS. The AEC-Q100-qualified dual-band module integrates multi-band RTK technology for centimeter-level accuracy. The LG69T module's dead-reckoning capabilities feature an integrated inertial measurement unit (IMU) that provides continuous high-precision positioning.

Quectel Wireless Solutions, quectel.com; STMicroelectronics, st.com

4. COMBO ANTENNA

FOR ADVANCED RAIL COMMUNICATIONS

The Coach II antenna with GNSS L1/L2/L5 is designed to provide greater precision and reliability for advanced rail communications systems, enabling next-generation positive train control (PTC) and passenger Wi-Fi. The Coach II features global multi-GNSS compatibility, dual-port 4G LTE / sub-6 GHz 5G NR and 802.11ac Wi-Fi / Bluetooth connectivity. It is AAR compliant for railway applications and is IP67-rated.

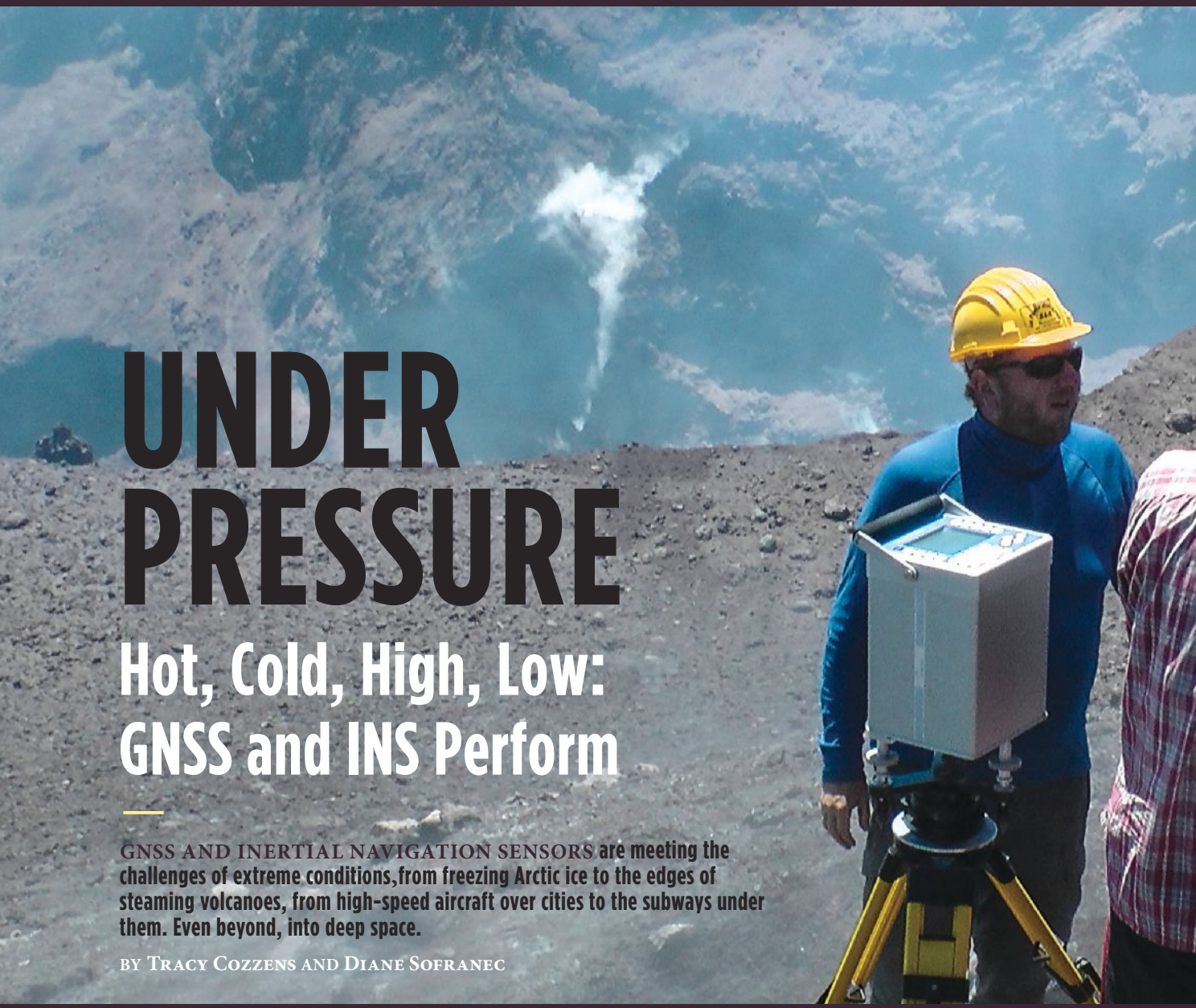
PCTEL, www.pctel.com

5. FIRMWARE UPDATE

INCLUDES NEW AUTOMOTIVE PACKAGE FOR ELLIPSE GNSS/IMU PRODUCTS

New features have been added to the Ellipse product line with firmware update version 1.7. The update better answers needs of the autonomous testing and driving markets such as a CAN odometer. Users now have the choice to connect an external odometer (DMI) with pulses or use their car odometer with velocity information. New outputs include body velocity and slip angle, which calculate the drift angle between the vehicle's assumed trajectory and its actual trajectory. For precision applications as well as low dynamics and reduced warm-up time, the new firmware allows users to run the Ellipse Kalman filter with no lever-arm estimation. This will ensure centimeter pass-to-pass accuracy for real-time kinematic (RTK) applications and allow operation in lower dynamics while reducing warm-up time. The firmware update also provides new features for advanced marine applications.

SBG Systems, www,sbg-systems.com



UNDER PRESSURE

Hot, Cold, High, Low: GNSS and INS Perform

GNSS AND INERTIAL NAVIGATION SENSORS are meeting the challenges of extreme conditions, from freezing Arctic ice to the edges of steaming volcanoes, from high-speed aircraft over cities to the subways under them. Even beyond, into deep space.

BY TRACY COZZENS AND DIANE SOFRANEC

IN THE ARCTIC

Wave Buoys Help Study Arctic Climate Change

Where the edge of Arctic ice transitions to open water, towering seas are smashing sea ice into melting pieces, with far-flung effects on climate and nature. Over recent decades, the Arctic has warmed more than any other region, leading to a significant reduction in sea ice volume. The combination of increased ice-free area and more mobile ice cover has led to the emergence of a seasonal marginal ice zone (MIZ) in the Beaufort Sea, north of Prudhoe Bay, Alaska.

The United States Office of Naval Research conducted a five-year study of the MIZ, which included intense field work in the freezing Arctic sea. Here, the ice is vulnerable to ocean surface waves that form in the open water, resulting from strong winds and frequent storms. Also studied were in-ice waves, where ice and water clash. The goal was to understand how both factors impact the ice floe melting.

Photo: Trimble

DUST, NOXIOUS GAS AND LOOSE ROCK near the summit makes volcanic surveying especially challenging.

The MIZ lies in the subarctic seas in winter and transitions into the interior of the Arctic Basin in summer. To investigate the MIZ's dynamics, ONR engaged an international program of observations and simulations using several autonomous systems, including wave buoys. The wave buoys — officially designated the autonomous ocean flux buoys — integrate SBG Systems' miniature inertial sensors.

The MIZ study comprised an international team of scientists from more than a dozen organizations.

Buoys for All Seasons. The program included 20 buoys deployed in the summer, and five in the winter, to quantify open ocean and in-ice wave characteristics and evolution. "We needed a very rapid and cost-effective solution to measuring directional wave spectra in the ocean," said Martin Doble, oceanographer at the French UPMC School and member of the research program. "Time to deployment was very short, so an integrated solution, giving us good heave numbers straight out of the box, was essential. Delivery time of the units was also critical."

Drilled into the ice, the summer buoys were powered with solar panels and equipped with SBG Systems' IG-500A miniature attitude and heading reference system to detect both distant and near-wave effects on the local ice floe. Once the ice melted, the summer buoys continued to measure open ocean characteristics.

Five winter buoys were installed on the ice. These buoys were made of aluminum for better resistance and contained enough battery power to keep them going through the dark winter months. Every buoy also contained processing and control electronics, an SD card, a GPS receiver and an Iridium satellite modem and antennas to transmit the recorded data to its base station. Both summer and winter data from the buoys were used to quantify the wave attenuation rate.

By measuring the waves and ice, the buoys help scientists understand how waves are approaching and breaking up the sea ice. When winter approaches and ice begins to refreeze, the buoys help show how the waves interact with the ice as the temperatures change.

Calibration. The IG-500A inertial sensors were used for wave height and direction. IG-500A measures in real time the roll, pitch, heading (accurate to 0.35°) and heave (accurate to 10 centimeters). Every sensor is calibrated for bias, linearity, gain, misalignment, cross-axis and gyro-g from –40° to +85°C. The calibration is key to enabling the sensors to provide reliable data in the harsh environment.

Doble said the units were reliable, with no failures in the harsh Arctic conditions. They ran continuously for more than a year without requiring power cycling, and "the numbers look good, giving clear results."

The data is helping researchers understand the physics that control sea ice breakup and melt in and around the ice edge. "We have this amazing picture of the ocean, atmosphere, and ice going from the fully frozen period in March to meltdown and breakup right through to freeze-up," said Craig Lee of the University of Washington's Applied Physics Laboratory.

The IG-500A sensors also delivered heave measurement, important for instrumented ocean buoys. During the project, SBG Systems released the Ellipse Series, and the new line replaced the IG-500 series. More accurate in attitude and more reliable (with an IP68 rating) for the same

CONTINUED ON PAGE 30. >>

Photo: SBG Systems

AUTONOMOUS OCEAN FLUX BUOYS integrate SBG Systems' miniature inertial sensors.

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budget, the new miniature inertial sensors now provide a heave measurement that automatically adjusts to the wave period, resulting in higher performance.

Clear differences were measured between surface wave activity outside of the ice, and then moving into the ice, with huge attenuation as the waves enter the ice and die back quickly.

Current Arctic Program. Following the close of the MIZ project in 2015, the ONR launched a new project for 2016–2020, the Stratified Ocean Dynamics in the Arctic (SODA). SODA is also taking place in the Beaufort Sea, and is using the autonomous ocean flux buoys. The buoys are now equipped with SBG's Ellipse-A sensors.

Why the Arctic Matters

"There's no question that the Arctic sea ice extent is decreasing," said Martin Jeffries, program officer for the ONR Arctic and Global Prediction Program. "Multiple sources of data — autonomous underwater gliders, ice-measuring buoys and satellite images of the marginal ice zone — were used to help understand why the ice is retreating."

The implications for the U.S. Navy, and the world, are significant. If there were no sea ice in the Arctic at the end of summer, that would mean that the Arctic Ocean would, until the winter ice came in, be completely open — something unprecedented in living memory, Jeffries noted.

Naval leaders have made it clear that understanding a changing Arctic is essential for the Navy to be prepared to respond effectively to future needs.

"[T]he opening of the Arctic Ocean has important national security implications as well as significant impacts on the U.S. Navy's required future capabilities," said then Chief of Naval Operations Admiral Jonathan Greenert, in his introduction to the U.S. Navy Arctic Roadmap, 2014–2030, published in 2014. "The United States has a history of maritime homeland security and homeland defense concerns in the Arctic Region […] ."

In the period between 2007 and 2014, satellites recorded the eight lowest sea ice levels ever. A key goal of the MIZ and SODA programs is to use the new data collected to make better predictive computer models — ensuring safer operations for not only naval vessels, but also anticipated increased sea traffic by shipping and fishing industries; oil, gas and mining companies; and tourism operations.

Much of the data coming in to Arctic scientists is now from improved sensors, with greater ability to survive the harsh weather and ocean conditions.

Photo: SBG Systems

WINTER BUOY installed on an ice floe.

Inside the Ellipse

Alexis Guinamard, chief technology officer of SBG Systems, described to *GPS World* the company's most advanced sensor for extreme environments.

"Of course we have more precise sensors like Ekinox, Apogee or even Horizon, for 'extreme' precision. But for extreme environments, the more appropriate sensor line is the Ellipse series," Guinamard said. "There are several key parameters that make them better for this kind of environment."

Those features include a high-temperature calibration range, from –40°C to +85°C, which enables the sensors to operate at the same performance level in the most extreme temperature environments.

"While typical entry-level or industrial-grade sensors only provide a room temperature or basic temperature calibration, we have developed a calibration procedure used for both survey-grade and industrial-grade sensors using a precision two-axis rotary table with temperature chamber," Guinamard said. "An advanced thermal modeling minimizes the calibration error over the full temperature range."

CONTINUED ON PAGE 32. >>

576 TCS IP67 2 years

TERSUS **Tersus GNSS Inc.**
Global Accuracy Easier

A new generation of GNSS RTK Receiver

Oscar

with

Calibration-Free Tilt Compensation

TERSUS FIELDGenius **Support MicroSurvey FieldGenius**

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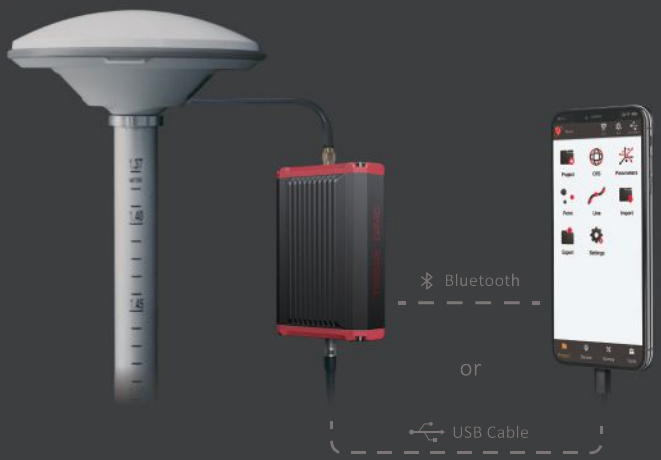

DAVID

GNSS Receiver

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Sales inquiry: sales@tersus-gnss.com
Technical support: support@tersus-gnss.com

« CONTINUED FROM PAGE 30.

The sensors work in highly dynamic and vibrating environments because their gyros operate well, changing position up to 900° per second. Similarly, their accelerometers can reach up to 40 g, with excellent behavior in vibrating environments. "We can typically install our sensors directly on the chassis of the vehicle, while lower grade sensors may require specific dampers that are complex to design and make it difficult to precisely align the sensor," Guinamard said.

A GNSS interference-mitigation capability enables the sensors to perform in challenging GNSS environments.

With the Ellipse-D, high latitude operation is possible because it provides a dual-antenna heading that is insensitive to higher latitudes, Guinamard explained.

Saltwater-Proof. SBG Systems sensors typically have waterproof (IP68) enclosures that can deal with harsh conditions and sustain exposure to saltwater for a limited period of time. For long exposure to salt water, the company offers specific titanium enclosures. For instance, its Navsight series has a saltwater-proof inertial measurement unit.

The Navsight Marine Solution is a motion and navigation solution for hydrographers available as a motion reference unit (MRU), as an inertial navigation solution (INS) with embedded GNSS, and as an INS using a third-party GNSS receiver.

Navsight can be outfitted for demanding shallow- or deep-water environments to survey highly dense areas (bridges and buildings), as well as applications where only a single antenna can be used.

With the addition of the Horizon inertial measurement unit (IMU) to the Navsight line in January, which joined the Ekinox and Apogee IMUs, the line is suitable for large hydrographic vessels surveying harsh environments. The Horizon IMU is based on a closed-loop fiber-optic gyro (**FOG**) technology that enables ultra-low bias and noise levels, allowing robust and consistent performance.

AT VOLCANO'S EDGE

GNSS Tracks Magma on Mount Etna

Scientists seeking to better understand volcanoes are using GNSS to investigate one of the most active in the world.

Mount Etna, in eastern Sicily, Italy, has been erupting for hundreds of thousands of years. The constant activity makes it a popular tourist attraction — smoke often billows from the mountain and fiery lava spews down its sides.

Researchers flock to Mount Etna, too, to study the movement of magma — the hot fluid beneath the Earth's surface from which rocks are formed when cooled.

To measure the vertical gradients of gravity on Mount Etna's slopes and summit craters, geophysicists from Slovakia and Italy teamed up on a field campaign during which they used high-accuracy GNSS positioning with emphasis on accurate height measurements to collect gravimetry and topographic information.

The extreme environment and spotty cellular coverage on Mount Etna made using GNSS with real-time kinematic (RTK) or virtual reference station (VRS) a challenge. The geophysicists used the Trimble CenterPoint RTX correction service and Trimble R10 GNSS receivers to ensure reliable GNSS performance.

"On many points, especially the higher part of the volcano, Internet signals were poor or [there were] none at all," said Juraj Papčo, a geodesist with the Earth Science Institute of the Slovak Academy of Sciences. "Only by using RTX were we able to collect real-time data. It performed well in higher elevations and difficult conditions."

Photo: Trimble

RESEARCHERS USED HIGH-ACCURACY GNSS positioning to collect gravimetry and topographic information.

The project teams also used Trimble RTX to navigate to locations where they needed measurements. At each station, they collected static and real-time positions and later compared post-processed results with the real-time positions.

Dust, noxious gas and loose rock made approaching the summit especially challenging. Trimble RTX helped the Slovak-Italian team of geophysicists better understand volcanoes and anticipate volcanic events.

UNDER A METROPOLIS

Harsh Construction Environment Monitored

Deep beneath Paris, work is underway to expand the Metro, the city's rapid transit system. The Grand Paris Express project encompasses a 200-kilometer-long network of railway lines — mostly underground — that will link the suburbs to the city.

The contractor responsible for monitoring construction of the first stage of the project's infrastructure, Cementys, is using more than 100 instruments from Topcon's MS series of robotic total stations because they can withstand the harsh construction environment.

Monitoring structural movement across the network is critical; the goal is to protect the surrounding Parisian structures and the people who live and work in them. Use of the monitors also ensures that the expensive equipment used on the project is not stolen.

Topcon's MS Series robotic total stations continuously measure the angles and distances of prisms fixed to structures. As a result, site engineers know immediately when measurement change and structural movement occurs. The technology also includes Matrix Detection software to help increase the measurement system's speed and accuracy. The company's TSshield integrated security software, standard on all its total stations, provides remote locking and location positioning data to within 100 meters, depending on GPS and cellular coverage.

Photo: Topcon

PRISMS AFFIXED TO THE TRACK enable measurement of change and structural movement.

"We have been able to integrate this open technology perfectly into our global data management system, which also includes optical fibers sensors, vibrating wire sensors, and others," said Cementys CEO Vincent Lamour.

Construction of the Grand Paris Express project is taking places in stages and is expected to be complete in 2030.

ABOVE THE SEA

Flying High with Augmented Reality

The 2018 Red Bull Air Race World Championship in Cannes, France, made it easier for fans to follow along. Though pilots race one at a time, the new "Ghost Plane" augmented reality imagery provided fans with a real-time representation of each pilot's flight, which challenges their speed, precision and skill maneuvering lightweight racing planes.

The Ghost Plane is driven by onboard telemetry data gathered during flight. For a pilot's run to be accurately represented, the onboard telemetry system has to track position, velocity and attitude (yaw, pitch and roll) through high-dynamic maneuvers and in challenging environmental conditions.

While every Red Bull Air Race track layout is different, they all include a difficult vertical turning maneuver (VTM), where pilots pass through a gate and turn 180 degrees to reverse course quickly without exceeding the g limit.

Each plane is fitted with several GNSS receivers to track the plane, but dynamic maneuvers made during the race rapidly changes which satellites the GNSS receiver can track, which typically results in a loss of position fix.

Image: Google Earth with VectorNav Data

POSITION TRACKS FROM TWO LAPS of the race show that when the plane inverts and starts to track the reflected signal, the VN-300 GNSS/INS (blue trace) reverts to free inertial navigation and propagates the position based on inertial data. The trace follows a smooth trajectory through the next air gate until the GNSS data converges with the INS position.

To further increase the challenge for the telemetry systems, races are commonly held over water, which can reflect GNSS signals and create significant multipath errors at low altitudes. During the VTM, the plane can experience 300°/second angular rates and 12-g accelerations, during which GNSS tracking is typically lost because the antennas no longer point to the sky.

To make the Ghost Planes possible, a VectorNav VN-300 dual-antenna GNSS/INS (inertial navigation system) couples gyroscope and accelerometer data to propagate position and velocity estimates during loss of GNSS measurements through maneuvers such as the VTM.

The VN-300 combines two GNSS receivers with a 9-axis inertial measyrement unit (IMU). It couples acceleration and angular rates from the IMU with position and velocity data from the receiver using a quaternion based Extended Kalman Filter (EKF). VectorNav algorithms work in conjunction with the state estimation filter, making the VN-300 more robust and intelligent, and enabling it to reject poor GNSS data and perform accurately in high-dynamic maneuvers and challenging operating conditions.

NEW EQUIPMENT

Antenna Designed for Challenging Environments

CHC Navigation's latest GNSS antenna is an example of a product designed specifically for harsh environments.

The heavy-duty CHCNAV AT311T is designed for demanding applications subject to shocks and vibrations. With advanced filtering and robust signal tracking, it provides survey-grade GNSS signals to enhance position reliability for marine applications, machine control,

Photo: CHCNAV

precision agriculture and industrial automation.

Features include multi-constellation GNSS tracking using GPS, GLONASS, BeiDou, Galileo, QZSS, IRNSS and SBAS.

Its IP68 water-resistant design makes it safe to use in extreme conditions with a wide temperature range (–40°C to +85°C). Its internal stacked structure enhances performance in high-interference environments, and the 40-dB signal gains, advanced signal filtering and multipath rejection design provide superior and robust GNSS signal tracking in challenging surroundings.

IN OUTER SPACE

Exploring Beyond Earth

While GNSS isn't useful on the surface of Mars, inertial navigation is a key technology for exploration of the red planet. For instance, the Northrop Grumman LN-200S sensor guided the Mars Opportunity rover, which explored Mars for 15 years until a storm struck in June 2018.

The LN 200S sensed acceleration and angular motion, with its data output used by the rover's control systems for guidance.

The hermetically sealed unit, suitable for planetary and asteroid probes, helped position the rover's antennae to relay photos and data to satellites. Opportunity beamed back 187,000 raw images, according to NASA.

Because IMUs don't depend on satellites, they work well for deep space missions, Honeywell explained in a press release.

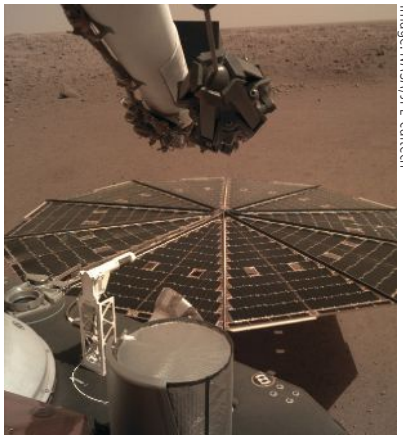

Image: NASA/JPL-Caltech

ONE OF THE TWO solar arrays on the InSight lander dominates this view of the plain of Elysium Planum, taken Dec. 4, 2018.

In November 2018, NASA's InSight spacecraft landed on Mars to study the interior with a heat probe and listen for marsquakes with a seismometer. Aboard was Honeywell's Miniature Inertial Measurement Unit (MIMU), an IMU that has been a part of Lockheed Martin's Mars satellites and landers since 1998.

The MIMU is a three-axis strapdown device specifically designed for the satellite and deep-space-probe market (more than 500 MIMUs have been deployed throughout the solar system). It uses ring laser gyros to help control and stabilize a spacecraft during entry, descent and landing, as well as maintain orbit and payload orientation. The radiation-hardened design supports 15-year missions.

NEWS FROM **INTERGEO 2019**

GPS World staff reported from Intergeo Sept. 17–19 in Stuttgart, Germany. The massive trade show, dubbed the "global hub of the geospatial community," brings together 19,000 visitors from 114 countries and features 640 exhibitors. On this and the next page are just a few of the new GNSS/PNT products introduced at the show. For more stories and videos, visit **gpsworld.com**.

HEXAGON SHOWCASES SMART CITIES PORTFOLIO

DSX utility detector

Photo: Allison Barwacz

Hexagon AB presented its Smart Buildings & Infrastructure and Smart Cities & Nations portfolios at Intergeo.

Products shown are designed to help manage the life of a building — land surveying, design, build, maintenance, renovation and demolition — and optimize the completion of infrastructure projects. Solutions include the Leica **DSX** utility detection solution, the **BricsCAD** building design software and **HxGN SmartBuild**.

Reality-capture solutions showcased include the Leica **BLK2GO** mobile, the **HxGN Content Program**, and the Hexagon **Smart M.Apps** and **Luciad** portfolios.

"The ultimate form of data leverage is when tasks and processes become autonomous, which is the goal of our smart solutions portfolios," said Ola Rollén, president and CEO at Hexagon. "We help customers leverage the data within their workflows to achieve the greatest efficiency, productivity and quality outcomes possible. When we collectively achieve these outcomes at scale, not only can we sustain growth for our businesses, but also this finite planet we all share — fewer resources, less waste, less pollution."

TALLYSMAN DEBUTS VEROSTAR PRECISION ANTENNA

Tallysman released its **VSP600L VeroStar** precision antenna at Intergeo. It supports the full GNSS spectrum, as well as L-band correction services, and provides low-elevation satellite tracking with a high-efficiency radiating element.

It is suitable for real-time kinematic (RTK) and precise point positioning (PPP) applications, and features a light, compact and robust design. It also has a low axial ratio through all elevation angles, providing strong multipath rejection.

The VSP600L VeroStar provides high receive gain over the full GNSS spectrum from low GNSS band (1164MHz to 1300MHz) L-band correction services (1539MHz to 1559MHz) to high GNSS band (1559MHz to 1610 MHz).

Tallysman will soon be releasing embedded models of the VeroStar.

Photo: Tallysman

TRIMBLE PIVOT PLATFORM, ALLOY RECEIVER NOW SUPPORT BDS-3

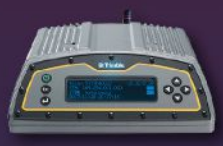

Photo: Trimble

Trimble has added access to BeiDou Generation III (BDS-3) signals to its real-time network (RTN) portfolio, including the Trimble **Pivot Platform** and the Trimble **Alloy** GNSS reference receiver. This will enable operators to meet the ongoing demand from surveyors, mapping professionals and precision farmers for accurate, reliable corrections derived from real-time networks, the company said.

The Pivot Platform manages and controls small, mid-size and countrywide GNSS networks. By applying sophisticated atmospheric models to reduce systematic errors, highly accurate GNSS corrections are generated and made available for a wide range of field applications. Besides tracking BDS-3, the Pivot version 4.3 update includes a simplified Chinese user interface.

Released in 2018, the Alloy reference receiver has the processing power needed for high-quality data from multiple constellations. Alloy version 5.42 firmware tracks all available and planned GPS Block IIIA L1C and BDS-3 signals.

The Pivot Platform and Alloy work in conjunction to provide quality GNSS corrections to network operators and end users.

HEMISPHERE GNSS LAUNCHES GNSS RECEIVER, SMART ANTENNA

Photos: Allison Barwacz

Hemisphere GNSS introduced its multi-frequency, multi-GNSS S621 GNSS survey smart antenna and R620 GNSS receiver.

The **S621**, powered by the company's Phantom 40 GNSS OEM board, is a redesign of the previous version, S321+.

The S621 processes and supports more than 800 channels with flexible and scalable simultaneous tracking of every modern and planned GNSS constellation and signal including GPS, GLONASS, BeiDou (including Phase 3), Galileo, QZSS, IRNSS, SBAS and Atlas L-band.

The S621 combines Hemisphere's Athena GNSS engine and Atlas L-band correction technologies with a new web UI. It meets IP67 requirements and is immune to magnetic interference. It is designed for use in land or marine survey, GIS, mapping, construction or other applications requiring high-performance precision and positioning, the company added.

The **R620** GNSS receiver, powered by the Vega board, is a refresh of the R330, and includes a new low-profile ruggedized enclosure. It processes and supports more than 1,100 channels.

The R620 combines Hemisphere's Athena GNSS engine and Atlas L-band correction technologies with status LEDs and a web user interface. It comes equipped with UHF (400 MHz and 900 MHz) radio, cellular modem, Bluetooth and Wi-Fi.

S621 smart antenna

R620 receiver

NEWS FROM **ION GNSS+ 2019**

GPS World staff reported from ION GNSS+ Sept. 16–20 in Miami, providing news, photos, videos and more. On this page are new GNSS/PNT products introduced at the show. For more stories and videos, visit **gpsworld.com**.

OROLIA INTRODUCES NEW GNSS SIMULATION PORTFOLIO

Photo: Orolia

Orolia introduced its new GPS/GNSS testing and simulation portfolio, including the new **GSG-8 advanced simulator**, at ION GNSS+. The portfolio offers a comprehensive array of GNSS validation technology, as well as signal and PNT data protection through jamming/spoofing detection, suppression and countermeasure solutions.

The capabilities are built on Orolia's legacy of resilient PNT solutions, together with two key acquisitions completed this year: Skydel Solutions and Talen-X. Orolia said it acquuired the companies for their demonstrated GNSS testing and simulation experience.

The GSG-8 is an advanced software-defined simulator that offers ultra-high performance and flexibility in an easy-to-use format. It was developed to deliver the highest standard of GNSS signal testing and sensor simulation performance in an upgradable, scalable platform.

"With its scientific precision and advanced simulation capabilities, GSG-8 is revolutionizing the GNSS simulation industry with Orolia's robust 1000-Hz Skydel software engine and COTS software-defined radios," said Stephane Hamel, director of testing and simulation at Orolia. "GSG-8 is designed for customers that require complex capabilities to validate product and program performance in harsh, high-risk environments where failure is not an option, such as government agencies, space programs and specialized commercial programs."

CEA-LETI, OROLIA OFFER FLEXFUSION TECH TO COUNTER JAMMING, SPOOFING

Leti, a research institute of France's CEA Tech, and Orolia announced a new sensor data fusion engine that ensures resilient positioning and navigation even in cases of GNSS jamming or spoofing.

Called **FlexFusion**, the algorithm technology processes data from GNSS, inertial measurement units (IMU) and odometers to provide precise positioning in all conditions.

FlexFusion's design relies on a modelization of GNSS and IMU (triple-axis accelerometer, triple-axis gyrometer and triple-axis magnetometer) output for synthetic trajectory generation.

The fusion approach exploits Bayesian estimators, such as Kalman filters. The first algorithm was set up on modeling signals, and its optimization relies on an extensive real-life sample database acquired through field test. This process used CEA-Leti's HYLOC reference platform, which provides a reference positioning of a few centimeters.

More than 100 trajectory samples were collected in urban, suburban, forest and mountain environments with various GNSS outage conditions.

The new positioning technology supports edge artificial intelligence because the data-fusion algorithm is performed locally to ensure that positioning and navigation information is available locally and is failsafe even in cases of jamming or spoofing of GNSS data.

"Recent events have demonstrated that it is possible to change the course of a ship or force a drone to land in a hostile area by simply spoofing GPS signals," said CEA-Leti CEO Emmanuel Sabonnadière. "The increasing reliance on GNSS for the execution of military operations and terrestrial, aeronautic and naval transportation requires using positioning and navigation systems that are able to detect GNSS outages and provide resilient position and navigation features."

CEA-Leti has licensed the patented FlexFusion algorithm to Orolia.

TALEN-X JOINS OROLIA

Orolia Defense & Security has completed the acquisition of Talen-X, a U.S. company specializing in advanced GNSS solutions and interference, detection and mitigation (IDM) technologies. In early 2019, Orolia Defense & Security spun off as a separate entity from its parent company Orolia, with the mission of providing resilient PNT solutions and custom engineering services to U.S. government agencies, U.S. defense organizations, and their contractors.

HANDHELD AR SITEVISION TAKES DATA VISUALIZATION OUTDOORS

Photo: Trimble

Trimble has introduced its SiteVision system, an outdoor augmented reality (AR) solution that enables users to visualize 2D and 3D data with cellular or internet connectivity for planning, collaboration and reporting. Combining hardware and software in an integrated, lightweight handheld or pole-mounted solution, users can view 3D models and assets in a real-world environment at a 1:1 scale, from any angle or position.

SiteVision integrates a Trimble Catalyst DA1 antenna, electronic distance measurement (EDM) rangefinder and power management into a lightweight, handheld device that connects to a user-supplied Android mobile phone.

The SiteVision subscription is available monthly or yearly, and combines Trimble's high-accuracy positioning services and cloud-based processing technology to create a centimeter-accurate AR system. Users can visualize digital models from a wide range of data collection, design and constructible modeling tools in open industry-standard formats, including IFC and LandXML.

For civil projects, SiteVision accurately visualizes data from Trimble's Quantm, Business Center and Novapoint; design data from Civil 3D and Bentley OpenRoads; and GIS data from Esri ArcGIS software.

MARKET WATCH

Segment Snapshot: Applications, Trends & News

OEM

Septentrio + CORE Receiver Will Use Japan's cm-level Service

Septentrio, a leader in high-precision GNSS technology, and CORE, a Japanese system integrator with extensive experience in GNSS, are jointly developing a receiver that can use the Centimeter-Level Augmentation Service (CLAS) of Japan's Quasi-Zenith Satellite System (QZSS).

Septentrio's multi-frequency GPS/GNSS receiver AsteRx4 will be used as a platform for the development of CLAS functionality. Septentrio receivers already track the L6 signal and can use QZSS for increased positioning availability and reliability.

CORE's know-how will be instrumental for the deployment of CLAS on Septentrio receivers. The two companies are planning to launch their CLAS-enabled receiver in January 2020.

Japan's CLAS is a self-augmentation GNSS correction service. Without the need for a ground link, it allows real-time kinematic (RTK) centimeter-level positioning all over Japan with convergence times of less than a minute, by broadcasting GNSS corrections directly via QZSS satellites. The corrections are generated from the dense network of reference stations operated by Japan's Geospatial Authority.

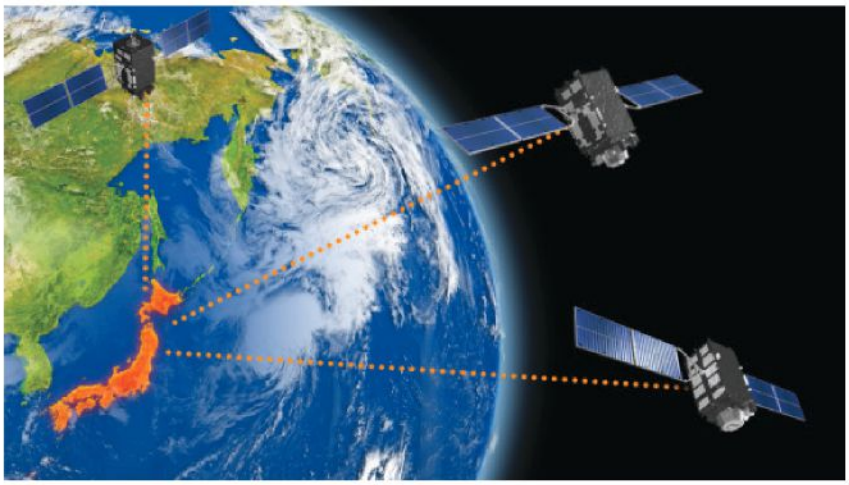

Illustration: Septentrio

The new CLAS-enabled receiver will also incorporate Septentrio's Advanced Interference Mitigation (AIM+) technology. AIM+ offers protection against interference, resulting in faster set-up times and robust continuous operation.

SURVEYING

SXblue ToolBox Application Now on iOS

Following launch of its Android application in 2018, Geneq is now launching an iOS version of its SXblue ToolBox for iOS-compatible SXblue devices. The application was developed with special interest paid to raw data recording and NTRIP service connection.

With the SXblue ToolBox iOS application, users can analyze the position data provided by the SXblue receiver, as well as location metadata.

The application can record, save and transfer raw data from the GNSS receiver, thereby allowing post-processing activities. The application also acts as an NTRIP client, capable of connecting to an NTRIP server for real-time kinematic (RTK) corrections, and thus allows the receiver to issue very accurate location information.

Receiver configuration is easy through the application, with the ability to set up and save user-defined commands for subsequent use.

The settings include constellation to be used, differential source, NTRIP login credentials list and more.

Screenshot: Geneq

iOS APP for SXblue receivers.

DEFENSE

Qinetiq, Collins to Develop Receivers for UK Defence

QinetiQ and its partner Collins Aerospace have won a £67 million contract with the United Kingdom's Ministry of Defence (MoD) Defence Equipment and Support (DE&S) to develop multi-constellation satellite receivers under the U.K. Robust Global Navigation System (R-GNS) program.

The program will deliver critical capability to provide MoD with accurate and resilient positioning, navigation and timing (PNT), which will underpin the UK's ability to undertake 24/7 military operations around the world in demanding and increasingly contested operational environments.

QinetiQ and Collins Aerospace are working with sub-contractors Roke Manor Research, Raytheon Systems Limited, Garfield Microelectronics, Nottingham Scientific Limited, Phixos and other specialist suppliers and manufacturing partners. The project will provide advanced navigation products that are UK-sovereign supplied and low size, weight and power (SWAP), delivering high-accuracy, resilient and secured operational capability.

QinetiQ said the use of multi-constellation, multi-service satellite navigation signals, multiple sensors and QinetiQ's advanced processing technologies will enable secured navigation, ensuring that users and platforms — autonomous land, maritime, air and weapons systems — will be able to navigate accurately, robustly and safely.

"Whether it's soldiers conducting operations in remote environments or fighter jet pilots flying in contested airspace, our armed forces depend on satellite navigation technology," said Defence Minister Anne-Marie Trevelyan. "These state-of-the-art receivers will help to ensure our armed forces can defend UK interests wherever and whenever they are threatened." Delivery date for the first R-GNS products is February 2022.

TRANSPORTATION

Septentrio Receivers to Guide Trains for Wabtec

Septentrio is providing GPS/GNSS receivers to Wabtec, a global company specializing in equipment, digital solutions and services for freight and transit rail systems.

Wabtec is implementing Septentrio GNSS receivers in its GoLINC Edge platform, providing positioning, connectivity and data storage and enhancing positive train control (PTC) with the adoption of higher precision positioning technology.

The enhanced navigational reference capability can benefit U.S. railroad operations as Septentrio GNSS receivers are installed on Wabtec's latest GoLINC mobile data center platform operating onboard freight locomotives. Two GNSS receivers are being installed on each locomotive to provide precise positioning information as part of the GoLINC system.

Photo: Septentrio

BESIDES GUIDING TRAINS, GoLINC will enable UAV drone inspection along rail tracks.

Septentrio receivers are also being installed as position reference modules along 30,000 miles of track. They will provide GNSS corrections to the rover receivers aboard the locomotives for reliable and accurate positioning, even in difficult environments such as when tracks run alongside mountains, around cliffs or under foliage.

Wabtec's GoLINC system — comprising networking, communications and applications management platforms — makes trains smarter by collecting numerous parameters about each train and its route.

GoLINC is integrated with Wabtec's PTC solution, which is designed to enforce existing railroad signal indications and other operating rules. The high-precision GPS infrastructure along the track will also enable other applications such as drone flights for rail inspection.

SBG Systems Launches Ellipse Firmware Update

SBG Systems has announced a major firmware update for its Ellipse product line, with new features added to version 1.7.

Automotive package. New features were developed to better answer needs of the autonomous testing and driving markets. These features include:

CAN odometer. Users can connect an external odometer (DMI) with pulses or use their car odometer with velocity information. During installation, users can enter a rough "resolution." Then, SBG's inertial sensor refines the odometer installation parameters to automatically obtain the best performance.

New outputs. Included are body velocity and slip angle, which calculates the drift angle between a vehicle's assumed trajectory and its actual (deviated) trajectory.

Fixed lever-arms mode. For precision applications as well as low dynamics, the new firmware allows users to run the Ellipse Kalman filter with no lever-arm estimation. This ensures centimeter pass-to-pass accuracy for real-time kinematic (RTK) applications and allows operation in lower dynamics while reducing warm-up time.

To precisely calibrate the lever arms, the use of Qinertia Lite can be used to obtain centimeter precise lever arms. For general-purpose applications, the standard mode of operation that refines the lever arms in real time is still available.

Marine applications. The firmware update provides new features for advanced marine applications.

DVL aiding support. This helps to reduce drifts from the inertial sensor underwater, providing an interesting opportunity for projects such as short subsea navigation with affordable inertial sensors.

New output message (INDYN). INDYN brings support to performance sailing autopilots such as the B&G H5000.

Improved magnetic calibration (sbgCenter). sbgCenter embeds a magnetic calibration algorithm that improves overall performance in challenging calibration while allowing even more difficult calibration conditions. The new calibration procedure also provides improved quality feedback.

MOBILE

ESA Tests 5G Positioning with GNSS + UWB Drive

A pair of testbed vehicles went out on the road in Germany to simulate the way we are all likely to be using 5G positioning services. The field test, conducted by the European Space Agency (ESA), focused on assessing the performance of highly precise hybrid satellite/terrestrial positioning for autonomous vehicles, drones, smart cities and the internet of things (IoT).

The two vehicles were driven for a week around Munich and the surrounding area in a variety of environments, from the open-sky terrain surrounding the German Aerospace Center DLR's site in Oberpfaffenhofen to the deep urban canyons of the city's dense Maxverstadt district.

As they drove, they combined a broad range of on-board systems to measure their positions and share them with one another, performing ongoing vehicle-to-vehicle ranging to simulate future 5G operating standards. The on-board systems included multi-constellation GNSS, incorporating localized high-accuracy correction, and 4G Long-Term Evolution (LTE) and ultra-wideband (UWB) terrestrial wireless broadband communication.

5G promises much faster and more stable connectivity based on higher bandwidths and frequencies, opening up a new range of services, many of them based around localization such as smart traffic management, asset tracking and personalized drone-based delivery.

With 5G, the trend of hybrid positioning will accelerate. Multi-constellation GNSS and inertial sensors will be employed along with localized correction systems. The 5G cell network will provide additional corrections to enhance the GNSS localization accuracy and to complement GNSS when satellites are not visible. This 5G "new radio" positioning accuracy will be enhanced with steerable antennas on both the base station and the user terminal.

Miguel Manteiga Bautista, head of ESA's GNSS Evolution and Strategy Division in the Agency's Directorate of Navigation, explains, "For the hybrid positioning field tests, ESA and its partners set up a collaboration with Deutsche Telecom for use of its 4G network in Munich including relevant information for positioning, and NovAtel, who provided state-of-the-art GNSS equipment and correction services, such as the satellite-based TerraStar-X."

ESA oversaw this initial field test campaign as part of its 5G GNSS Task Force, coordinated with the European Commission and the European GNSS Agency through the Horizon 2020 Framework Programme for Research and Innovation in Satellite Navigation.

The field test campaign was undertaken by DLR and the GMV company, with contributions by engineers from NovAtel, u-blox and Deutsche Telekom as well as ESA.

The field tests are executed within the GNSS Integration into 5G wireless networks or GINTO5G project.

Image: ESA

THE TESTBED VEHICLES combined a broad range of on-board systems to simulate future 5G operating standards.

GPS World Honors Leaders in GNSS/PNT

Photos: Tyler Gunter/GPS World

On Sept. 19, in conjunction with the ION GNSS+ conference, *GPS World* hosted its annual Leadership Awards dinner. Five honorees — chosen by a panel of GNSS experts — were recognized for their outstanding recent contribution or achievement in four categories: Satellites, Signals, Services and Products.

***GPS WORLD* HOSTED ITS 2019 LEADERSHIP AWARDS DINNER** at the Kimpton Epic Hotel in downtown Miami during the ION GNSS+ conference.

SATELLITES AWARD

SATELLITES AWARD: Presented by Johnathan Caldwell (left) to Mark Crews, both of Lockheed Martin. Crews accepted on behalf of Tim Hartman.

TIM HARTMAN: Satellites Award winner

TIM HARTMAN, Chief Engineer, Military Space Programs, Lockheed Martin

Hartman was recognized for serving as the program manager for GPS IIRM and GPS III Space Segments. Tim's leadership and program dedication helped support the U.S. Air Force's decision to declare GPS III ready for launch on Oct. 17, 2017.

Sponsor: Lockheed Martin

On Aug. 22, Lockheed Martin Space celebrated the successful launch of the second of up to 32 next-generation GPS III/IIIF satellites that the U.S. Air Force contracted the company to design and build. Lockheed Martin's commitment to positioning, navigation and timing can be found in the exemplary performance of the 18 Lockheed Martin-built GPS IIR and IIRM satellites that are a proud part of today's 31-satellite GPS constellation. The company also is proud to support the Air Force with its continued sustainment of the current GPS Operational Control Segment.

SIGNALS AWARD

SIGNALS AWARD: Presented by Joe Rolli of L3Harris (left) to Ramsey Faragher.

RAMSEY FARAGHER, Founder and CEO, Focal Point Positioning

Focal Point Positioning's new supercorrelator approach to indoor and urban GNSS signal processing could revolutionize smartphone-based GNSS. New signal processing methods for the correlation stage of a GNSS receiver enable several seconds of coherent integration while the receiver is undergoing dynamic motions. This improves accuracy and integrity, and provides anti-spoofing and spoofer-localization capabilities — without hardware changes or requiring access to encrypted signals.

Sponsor: L3Harris

L3Harris Technologies is an agile global aerospace and defense technology innovator, delivering end-to-end solutions that meet customers' mission-critical needs. The company provides advanced defense and commercial technologies across air, land, sea, space and cyber domains. L3Harris has approximately $17 billion in annual revenue and 50,000 employees, with customers in 130 countries.

SERVICES AWARD

SERVICES AWARD: Presented by Mike Shepherd of Collins Aerospace (back) to Simon Banville (front left) and Denis Laurichesse.

DENIS LAURICHESSE, Navigation Systems Department Expert, Centre National d'Études Spatiales (CNES)

SIMON BANVILLE, Senior Geodetic Engineer, Natural Resources Canada (NRCan)

Laurichesse and Banville demonstrated instantaneous, centimeter-level, multi-frequency precise point positioning (PPP). Their work shows PPP might become, within a few years, a practical alternative to real-time kinematic (RTK) for a wide range of applications.

Sponsor: Collins Aerospace

Collins Aerospace Systems, a unit of United Technologies Corp., is a leader in technologically advanced and intelligent solutions for the global aerospace and defense industry. Created in 2018 by bringing together UTC Aerospace Systems and Rockwell Collins, Collins Aerospace has the capabilities, comprehensive portfolio and expertise to solve customers' toughest challenges and meet the demands of a rapidly evolving global market.

PNT GAMES

After dinner, guests broke into teams to test their personal positioning, navigation and timing skills, precisely determined by their ability to toss rings and throw horseshoes under time pressure. Each team rotated through yard games such as ladder toss, ring toss, corn hole and horseshoes to prove who was the most accurate and resilient. The L3Harris team took home the first-place prize.

RAINBOW CONNECTION: Taking on giant pong are members of the rainbow bandana team, (from left) Sanjeev Gunawardena, Thomas Pany, Steffen Thoelert and André Hauschild.

PNT CHAMPS: The L3Harris team earned the most total points in all six games, and took home a trophy each.

AFTER ALL THE AWARDS WERE GIVEN, everyone got together for a memorable group photo.

ORGANIZED CHAOS: Wearing different-colored bandanas, teams cheer on their team members and fight for every point.

PRODUCTS AWARD

PRODUCTS AWARD: Accepted by Paul Alves (left) from presenter Jeff Martin of NovAtel.

PAUL ALVES, P.Eng, Ph.D., Technology Manager — Correction Services, NovAtel, part of Hexagon

Alves was recognized for his work on localization of interference sources for GNSS users leveraging the Interference Tool Kit. With the ITK, users can detect and mitigate adversarial jamming of GNSS signals, as well as unintentional interference from external sources.

Sponsor: Spirent Federal

Spirent has more than 30 years of experience delivering the world's best test equipment. Spirent's test solutions for GPS and GNSS, critical infrastructure SCADA vulnerabilities, Internet L3-L7 common vulnerabilities and exposures, and mobile vulnerabilities allow the world to communicate and collaborate faster. Spirent Federal Systems is a wholly owned subsidiary of Spirent Communications and was established to offer the world's leading simulation equipment to U.S. government customers, armed services, education institutions, and prime contractors. Spirent Federal's SimMNSA was the first to be granted Security Approval by the Global Positioning System Directorate.

SOFT INFORMATION FOR IOT POSITIONING

BY Matteo Luccio
GPS WORLD CONTRIBUTING EDITOR

The billions of interconnected devices and sensors embedded in other devices, vehicles and even humans that collectively constitute the much-heralded internet of things (IOT) collect and share data used in myriad applications. This requires them to know their location, which is a challenge in GPS-denied environments, such as most indoor locations, tunnels and urban canyons.

A new approach helps networks of smart devices cooperate to find and communicate their positions in such environments. This "localization of things" could be helpful in applications ranging from autonomous vehicles to asset tracking, from supply-chain monitoring to smart cities and real-time mapping.

Traditional network localization methods estimate a single value for each geospatial variable, such as the distance between two nodes. Therefore, accuracy drops sharply in environments where multipath, a limited view of the sky, and other problems severely degrade GNSS and wireless signals. A paper by researchers at four institutions outlines a system to capture location information even in these challenging environments by fusing positional data of various kinds as well as digital maps.

The new method fuses data from various sensing measurements — such as radio, optical and inertial signals — and analyzes features of each signal — including its power, angle of arrival, and time of flight. It uses machine-learning techniques to weigh this "soft information" — the researchers call it that because their method does not favor any single "hard" number — to create a probability distribution of distances, angles and other metrics.

It also exploits contextual information from digital maps, dynamic models and node profiles to verify what is possible. For example, two nodes could not be 20 meters apart if they are both in an area with a maximum dimension of 10 meters.

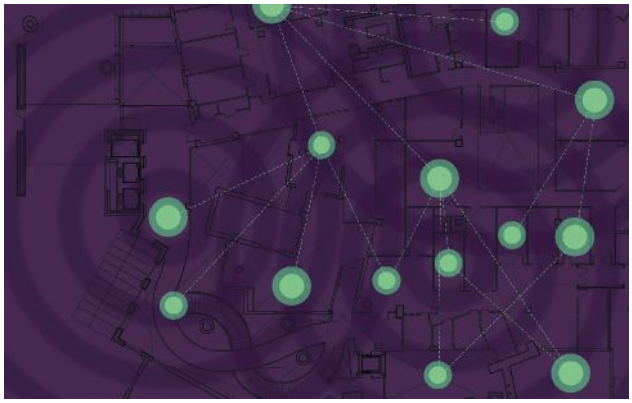

Image: Christine Daniloff, MIT

A NEW SYSTEM enables interconnected smart devices to cooperatively pinpoint their positions in noisy, GPS-denied environments.

To reduce the complexity and size of the data that it must collect to function, the new method identifies the most and least useful aspects of the received waveforms for the purpose at hand on the basis of a "principal component analysis."

In simulations of challenging scenarios, full of reflections and echoes, the new system's performance significantly surpassed that of traditional ones and consistently approached the theoretical limit for localization accuracy, while the accuracy of traditional systems dropped dramatically.

CITATION

"Soft Information for Localization-of-Things" by A. Conti, S. Mazuelas, S. Bartoletti, W. Lindsey and M. Win, Sept. 9, 2019, Proceedings of the IEEE, https://ieeexplore.ieee.org/document/8827486.

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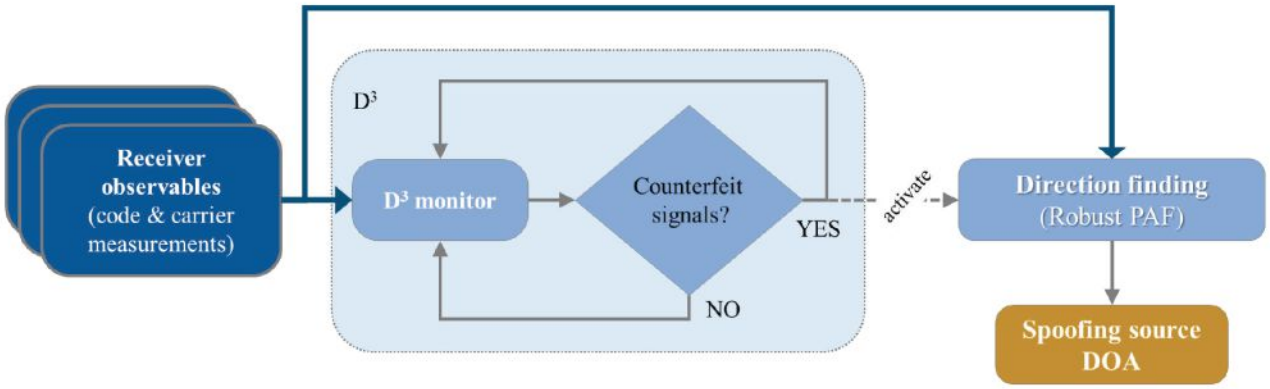

Source: IEEE paper authors

PRINCIPLE of the spoofing detection and direction-finding procedure.

ALGORITHM HELPS CIVIL AIRCRAFT FIGHT SPOOFING

Evolution in civil aviation foresees a greater role for GNSS in onboard navigation systems as opposed to traditional terrestrial navigation aids. This will require improvements in managing the threat posed by RF interference.

Fortunately, the availability of more GNSS constellations and two carrier frequencies now enables GNSS equipment used aboard civil aircraft to not only detect and monitor spoofing, but also determine from which direction it is coming.

A recent paper details a procedure to do this. It consists of a detection module that employs an algorithm to identify which signals tracked by the receiver are counterfeit, if any, followed by a direction-finding module that implements an efficient direction-of-arrival (DOA) estimator. The procedure requires three GNSS antennas and the same number of receivers, time-synchronized with a common clock, plus a signal processor that implements the detection and DOA estimation algorithms. The paper presents the design of the chain of algorithms and their preliminary tests in a laboratory setup, with the simulation of several spoofing attacks, assumed realistic in a civil aviation scenario.

CITATION

"An Algorithm for Finding the Direction of Arrival of Counterfeit GNSS Signals on a Civil Aircraft" by G. Falco, M. Nicola, E. Falletti and M. Pini, presented on Sept. 20, 2019, at the ION GNSS+ conference in Miami, Florida.

JOINT GALILEO/GPS PROJECT ON THE ISS

The European Space Agency (ESA) and NASA conducted a joint Galileo/GPS space receiver experiment aboard the International Space Station (ISS). The objectives of the project were to demonstrate the robustness of a combined Galileo/GPS waveform uploaded to NASA hardware already operating in the challenging space environment — the SCaN (Space Communications and Navigation) software defined radio (SDR) testbed (FPGA) — on-board the ISS. The activities included the analysis of the Galileo/GPS signal and on-board position/velocity/time (PVT) performance, processing of the Galileo/GPS raw data (code and carrier phase) for precise orbit determination, and validation of the added value of a space-borne dual GNSS receiver compared to a single-system GNSS receiver operating under the same conditions. A recent paper provides a general overview of the experiment (called GARISS) and describes its design, test, validation, and operations. It also presents the various analyses conducted in the context of this project and the results obtained, with a focus on the (Precise) Orbit Determination results.

CITATION

"The joint ESA/NASA Galileo/GPS Receiver onboard the ISS – The GARISS Project" by W. Enderle, E. Schönemann, F. Gini, M. Otten, P. Giordano, J. Miller, S. Sands, D. Chelmins, O. Pozzobon, presented on September 20, 2019, at the ION GNSS+ conference in Miami, FL.

IT'S THEIR LAND, TOO

Animal tracking is helping biologists see how many animals rely on wildlife crossings over or under highways. In the United States, specially designed crossings protect pronghorn antelope (Wyoming), panthers (Florida), mule deer (Nevada), moose (Utah) and grizzly and black bears (Montana), while crossings in Asia benefit rhinos, tigers and elephants. With crossings, mortality drop as much as 90%, says *The Washington Post*. In New Mexico, state agencies and tribes are tagging animals with GPS collars to identify roads that hinder migration. Meanwhile, engineers in Southern California are designing the world's largest animal crossing, an $87 million overpass that will span a 10-lane Los Angeles freeway for the region's mountain lions.

TESLA, COME TO ME

The new Tesla Smart Summon feature in Autopilot v10 autonomously drives the car to meet its owner, such as in a parking lot. Smart Summon has been used more than 550,000 times, Tesla CEO Elon Musk said on Twitter. But it has a few glitches: Owner tests have resulted in fender-benders, near crashes, ignored stop signs and a police run-in. And don't test it with another Tesla nearby — the cars get confused.

HELP, I'M SHARK BAIT!

The Galileo Search and Rescue (SAR) service was demonstrated Sept. 26 off the coast of Belgium. In Operation Shark Bait, a volunteer "victim" — Australian broadcaster Tara Foster — operated her Galileo-enabled SAR beacon from a life raft off the port of Ostend. The service quickly triggered, with the rescue initiated in under four minutes.

WHEELCHAIR NAVIGATION

A new app launched in Portsmouth, England, helps people with limited mobility plan their travel routes. The Route4U pavement navigation app benefits both wheelchair and pram (stroller) users, allowing them to discover safer, more accessible routes across the city. The app indicates pavement obstacles, surface quality, curb heights and widths, inclines and travel distances.

PHOTO CREDITS: Wildlife overpass/i viewfinder/Shutterstock.com; Tesla 3 in parking lot/Tesla; man in wheelchair/Route4U; sea rescue/European GNSS Agency

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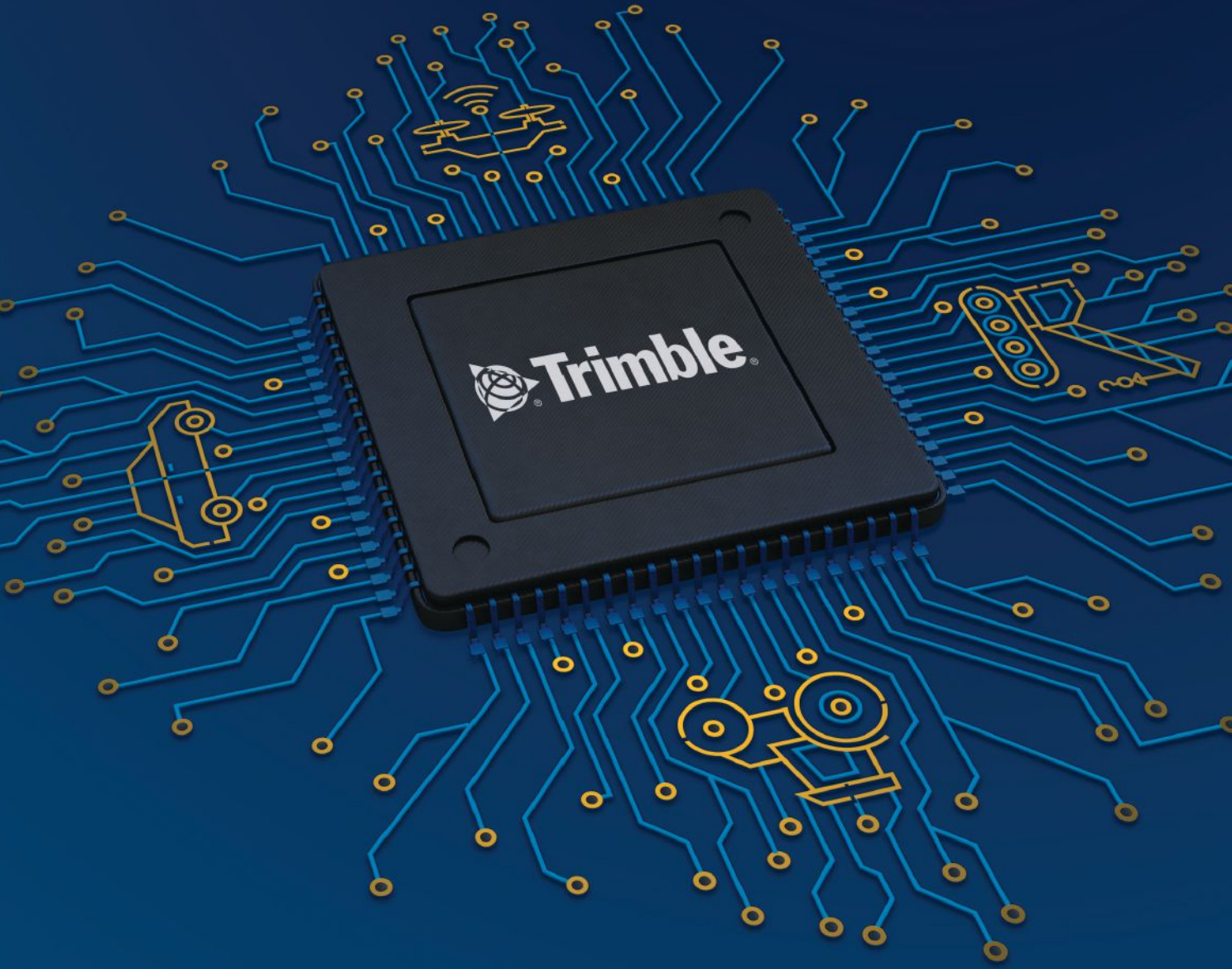

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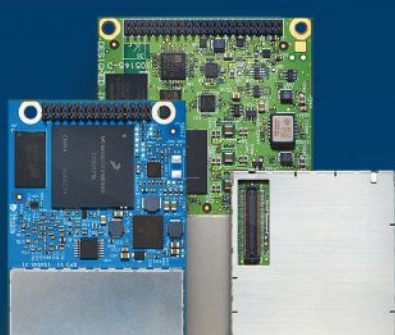

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