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Cover Photo and Photos This Section: Voyage

COVER STORY

32 AGE OF ACCEPTANCE

Retirement Communities Embrace Driverless Shuttles

BY DIANE SOFRANEC

Two companies have integrated GPS/PNT tech into a growing autonomous vehicle market: driverless shuttles for retirement communities. Powering the service, a cloud-based GNSS corrections system delivers centimeter-level accuracy without deploying and maintaining a GNSS network. This leading-edge application targets autonomy at scale and enables high-precision positioning for mass-market automotive and autonomous vehicle applications.

LAUNCHPAD

MARKET WATCH

Photo: Trimble

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OPINIONS AND DEPARTMENTS

Photo: Elistair

ADDED DEPTH

Image: Airbus

ONLINE NOW

NEWSLETTER EXCERPT

Companies Highlight New UAV Sensors at Xponential

BY Tony Murfin
CONTRIBUTING EDITOR, PROFESSIONAL OEM + UAV

While AUVSI Xponential was over in early May, the companies who were there have not rested.

All are developing new approaches for UAVs and unmanned ground vehicles, sensor systems for even wider applications than seen in Chicago, and all manner of other added capabilities. This business only gets bigger and more innovative.

Sagetech has just released a micro-mode 5 MX12B aviation transponder that enables small unmanned aircraft to interoperate within NATO airborne units.

Photo: uAvionix

The FAA has mandated that all aircraft should be fitted with ADS-B capability by January 1, 2020, to fly within controlled airspace, so **uAvionix** has simplified ADS-B retrofit for older general aviation aircraft (pictured).

Sensefly released a new inspection application for their eBeeX UAV, specifically designed for solar farms.

Fortem makes an anti-drone defense combining a radar detection system with a DroneHunter drone that attacks other UAVs.

Septentrio's Mosaic chip appears to be aimed at the high-precision market, replacing the AsteRx-m2 board-level receiver family.

NovAtel is growing, opening new offices in the US and needing more local real estate to fit its headquarters in Calgary, Canada. The company is now part of Hexagon Positioning Intelligence (Hexagon PI), a partial rebranding that includes VERIPOS correction services and recently purchased AutonomousStuff, specializing in ground vehicles. *(See more on NovAtel on page 38.)*

Read details on these and many other new UAV products in the monthly Professional OEM + UAV newsletter. Columns are available at **gpsworld.com/category/opinions/**.

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What Value Precise Timing?

BY ALAN CAMERON
EDITOR-AT-LARGE

This just in: a *Final Report on the Economic Benefits of GPS*. Sponsored by National Institute of Standards and Technology, the study began a couple of years ago, conducted by RTI International, one of the nation's oldest and largest research firms. The report runs 306 pages and examines the benefits derived from GPS by 10 U.S. industries: agriculture, electricity, finance, location-based services, mining, maritime, oil and gas, surveying, telecommunications and telematics.

Among other issues, the research explored the potential effect of a 30-day GPS outage, assuming that other GNSS would be disrupted as well, and found the outage would have a $1 billion per-day impact. The 30-day outage scenario was specifically added at the request of the National Executive Committee for Space-Based Positioning, Navigation and Timing.

While a disruption lasting 30 days seems unlikely, as the report says, "understanding the relative magnitude of potential impacts is important for making informed decisions about investments in back-up systems and contingency plans."

Relating a sense of the full report is beyond the scope of this small space, but I encourage all readers to download it (link at **www.rti.org/news/new-report-reveals-economic-benefits-private-sector-use-gps**) and examine it either in its entirety, or in its applicability to your particular industrial sector. Here I'll focus briefly on GPS's precise timing capability, which supports telecommunications.

Precise timing enables service providers to more efficiently use available spectrum and deliver high-speed wireless services. Given American society's intensive use of these two lifelines, it is not surprising that benefits related to telecommunications are substantial: $685 billion, more than twice that of the second-ranked industry in terms of economic benefits, and more than half of the total benefits.

GPS reduces/eliminates dropped calls and increases bandwidth, enabling more advanced networks such as 4G LTE, which we now have, and 5G, which is coming at breakneck speed.

Wireless network infrastructure has evolved to rely heavily on GPS. In fact, GPS has shaped the telecommunications industry: its technology has evolved around GPS. See last month's cover story for more details.

Interestingly, to calculate the economic benefits of GPS in the telecomm sector, the researchers used two indices as a baseboard: radio spectrum auction data showing telecomm service providers' willingness to pay (WTP) for spectrum to provide 4G LTE, and consumers' WTP for the broadband speeds enabled by 4G LTE. Both these numbers are going up, up, up.

While the number of wireless subscribers in the United States increased at a respectable rate from 2009 to 2017 — about 35% — the average bandwidth used by those subscribers expanded at an astonishing 2,200%!

Experts interviewed on the prospect of an extended GPS outage agreed that, eventually, a user would have to remain stationary to maintain a wireless connection, albeit a degraded one. After some time of steady degradation of quality of service, wireless service would cease to function altogether.

It's hard to imagine which would be worse: a world without mobile telecomms, or one without GPS. However, we don't have to strain, because in this case we would lose both.

To avoid the unimaginable...plan, plan, plan, and backup, backup, backup.

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Are We Ready for Autonomous Planes?

BY Tracy Cozzens
SENIOR EDITOR

Our cover story this issue is all about autonomous vehicles. Retirees — not usually considered early adopters of technology — are trusting autonomous vehicles to ferry them from point to point using the technology our industry can offer.

We have also used a lot of magazine space to discuss unmanned aerial vehicles, or drones, and shown how they are taking on a lot of tasks formerly done by manned pilots or workers, such as aerial mapping or factory inspections.

So is the idea of an autonomous plane such a stretch?

At June's Paris Air Show, Christian Scherer, chief commercial officer for Airbus, told the Associated Press that his company already has the technology to fly passenger planes without pilots.

Scherer also said in the AP interview that Airbus hopes to be selling hybrid or electric passenger jets by around 2035.

> "That is a matter we are discussing with regulators and customers, but technology-wise, we don't see a hurdle."

Airbus already has "the technology for autonomous flying."

But having the tech is one thing. Winning over regulators and potential travelers is quite another.

"When can we introduce it in large commercial aircraft? That is a matter we are discussing with regulators and customers, but technology-wise, we don't see a hurdle," Scherer said.

In fact, in a new study, seven out of 10 people say they would be willing to travel in an unpiloted plane at some point in their lifetime. The survey was conducted by U.S. software firm Ansys, which is working to provide digital replicas of how planes and cars react in different situations.

Passengers would be more willing to embrace automation if firms could show that a computer would react in the best and quickest way if anything unexpected happens.

But are we there yet? Michael Wiggins, the chairman of the aeronautical science department at Embry-Riddle Aeronautical University in Florida, addressed the autonomous-flight adoption question for the *New York Times*.

"From what I see, could it happen in the distant future? I think it probably could. Will it happen in the near future? I don't think so," Wiggins said. "Right now, any progress toward that area should be done very slowly, very measured and only after a bunch of research with results that suggest we should do that."

PNT Q&A

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What is the biggest safety challenge for autonomous vehicles?

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"Sharing the road with human drivers. Optimized safe driving algorithms are compromised to mesh with the human's natural level of risk taking. But this reduces safety, delaying acceptance — a real conundrum. Now, if we could just eliminate the humans ..."

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"When AI systems can deal with 99.9% of situations, the challenge will be keeping the passenger engaged to take over quickly when the 0.1% happens. Imagine a truck in front with a load coming loose. Which one would you trust?"

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Chimera Proposed to Battle Spoofers and Hackers

L1C Signal Could Be Watermarked as Countermeasure

The U.S. Air Force will load a new signal feature, designed to make spoofing detectable, aboard a satellite that will broadcast it from space as a security overlay for the GPS L1C signal, but not until 2022 at the earliest.

The Chips Message Robust Authentication (Chimera) is now in testing under the auspices of the Air Force Research Laboratory (AFRL), getting ready to fly on the Navigation Technology Satellite 3 (NTS-3), which will trial a number of new PNT techniques and technologies.

Chimera — starts with a "K" sound, rhymes with "rhyme era" — inserts encrypted digital signatures and watermarks within the L1C signal. A GPS receiver with the requisite additional capability for this purpose can then detect whether the signal is real or fake and also authenticate the location of a GPS receiver that is remotely located.

This key feature could provide a defense against hacking by blocking access from anyone unable to prove they are at an anticipated or licensed site. Hacking, of course, is a growing threat to all sorts of infrastructure: financial, security, utility grid and more.

Consultant Logan Scott first proposed the Chimera technology in 2003, when he affirmed that "Some of the spoofing detection measures in wide use offer a false sense of security. Authenticatable signal architectures are needed." In June, he made a presentation to the PNT Advisory Board: "The Role of Civil Signal Authentication in Trustable Systems." The two slides accompanying this article appeared in that presentation.

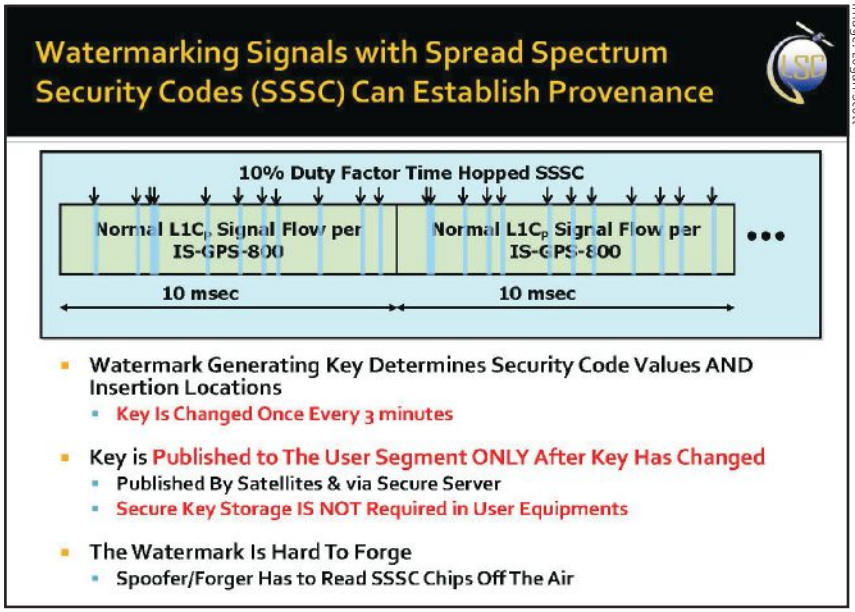

Image: Logan Scott

PRESENTATION SLIDE FROM **PNT Advisory Board briefing by Logan Scott.**

"Chimera represents a fundamental paradigm shift in PVT security paradigms," Scott related in a subsequent conversation. "Trust takes time and memory on a personal level and, in this case, in GNSS signals, too.

"You don't trust somebody as soon as you meet them. Over a period of time, you get to know them. If you can't remember anything, you can't develop trust either."

"In the GNSS world, there are a lot of applications where you don't need output in real time," Scott said. "For example, to align an inertial. The inertial provides the real-time aspect. You don't want to send anything to the IMU that is factually incorrect. When building to aid inertial, I can afford to have a delay from real time as long as I tell it where it was 10 seconds ago. The power of that is, if I don't have to give real-time output, I can ponder and think about things.

"If a spoofer attacks, there's an evolution that happens there. If I, as the receiver, can see the developing scenario, and how it starts to look at little screwy, I can stop and not send anything to the IMU that might corrupt it."

How It Works. The core concept of Chimera involves the satellites sending encrypted watermarks, encoded into the signal by the satellite. After a slight delay, the satellite sends the key used to generate those

encrypted watermarks. Once a key is sent, the system changes the key.

Since the receiver has already recorded the signal with its watermarks before the key is sent, spoofers cannot know the correct key ahead of time, in time to insert correct watermarks of their own. This means that any spoofed signals can be easily spotted: either the subsequent key won't match up with the spoofed watermarks, or there will be no watermarks at all.

"Another reason it's hard for someone to generate these watermarks on their own is because the signal is buried below the noise," added Scott. "The watermarks are hidden."

A number of different time delays between signal and key are possible within this concept and within the general set-up of GPS. Scott and the AFRL have, for various practical reasons, provisionally settled on a 6-second delay on the fast watermark channel and a 3-minute delay for the slow watermark channel.

> "Trust takes time and memory on a personal level and, in this case, in GNSS signals, too."

The signal enhancement could be incorporated into the Wide Area Augmentation System (WAAS). This has yet to be fully determined, but this route would lead to a faster implementation of Chimera. Scott thinks that going the WAAS route could bring Chimera capability into action within two years.

The AFRL, however, is looking at a much longer timeline. The NTS-3 satellite, where it first intends to test Chimera, will not launch until 2022 — three years hence. And that's only a test, not an enactment or a system-wide implementation.

Verification. One key benefit for commercial entities, particularly those in financial infrastructure and other systems that increasingly fall victim to hacking, is that Chimera gives them the ability to verify customers' or partners' locations before granting any kind of access. The customer's or other erstwhile user's GPS receiver would record the full signal, including the watermarks, and transmit that data to the company, entity or data center needing location verification,

SEE CHIMERA, PAGE 12. >>

CHIMERA

« CONTINUED FROM PAGE 11.

before the keys are published. Each combination of watermarks and signals is unique to the place where it was recorded, thus it is possible to tell whether the user is actually where they say they are, or in an authorized or pre-identified location before granting access or accepting further input (such as commands).

Scott claims that Chimera affords a 99.9% probability of detecting spoofers. "I have a 99.9% chance of detecting that the watermark is not there, because they don't know how to generate it. This is based on how you're processing the signal. It's designed to be very flexible in how the receiver uses the signal."

Just One Problem. Receiver manufacturers will have to develop new Chimera-capable receivers, and customers will have to buy them. An additional cost for the added processing, above and beyond that required for normal GPS operation, is unavoidable.

Prospects for Chimera in US Systems

- Almost ANY navigation signal can be watermarked with backwards compatibility
- Implementing CHIMERA is Not That Hard
  - Message Signing Can Be Done in Software
  - Watermarks are a PN Code Generator Modification in the SV
    - Digital / FPGA Change Only
    - NO Analog or Modulator Changes
- NTS-3 Will Broadcast Chimera on an Experimental Basis
  - 2022 Launch
- Secure-WAAS Signal Design Described in 2003 Paper Remains Valid with a couple of tweaks
  - Modulators are on the Ground

Image: Logan Scott

And a Hiccup. Chimera, while an acronym, is as a name perhaps not a totally felicitous choice. In Greek mythology, the chimera is a fire-breathing female monster with a lion's head, a goat's body, and a serpent's tail. These historic ancestors have evolved into the word's more current use: a thing that is hoped or wished for but that is in fact illusory or impossible to achieve.

AFRL Wants Your Opinion. The Air Force Research Laboratory seeks feedback from the PNT community on the Chimera enhancement for the L1C signal. The specification is at **www.gpsexpert.net/chimera-specification**. Download a comment form at **www.gps.gov/technical/icwg/**.

K2 Will Drive GLONASS to 1 Meter

New GLONASS-K2 satellites will improve the accuracy of Russia's satnav system from 3–5 meters to less than 1 meter, said Chief Designer Mikhail Korablyov of the Joint Stock Company GLONASS, operator of the ERA-GLONASS traffic accident emergency response system.

Russia plans to launch the first K2 satellite in late 2019 or early 2020. By 2030 the constellation will consist wholly of 24 K2 space vehicles.

The improved accuracy will better determine vehicle location in analyzing a traffic accident, according to Korablyov. It will not, however, be sufficient for lane-keeping and other advanced driver assistance systems, nor for more stringent autonomous driving requirements, at least according to emerging Western standards.

"There are also tasks linked with the country's defense; there are special precision weapons, the requirements for which already make up less than a meter," Korablyov added.

Numbers. In the December 2018 *GPS World*, Yury Urlichich, first deputy director general, Roscosmos State Space Corporation, gave a more precise figure. "The new signals will allow lowering the hardware-dependent SC-user ranging error by an order of magnitude, reducing the influence of signal reflections from buildings, constructions and landscape (multipath effect), thus enabling their effective use for high-precision navigation with real-time errors below 0.1 meter."

Later in the same piece, Urlichich wrote "Mission Definition Requirements for Glonass-K2 define user range error to be 0.3 m, qualitatively improving GLONASS user performance."

The new K2 satellite will transmit nine navigation signals and will weigh about 1,800 kg, twice as much the latest GLONASS-K generation, known as K1. Of the 24 currently orbiting operational satellites, only two are K1 space vehicles. The other 22 are older GLONASS-M satellites.

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WIRELESS LOCATION

Emergency on the 25th Floor

A fundamental challenge in developing 3D location awareness indoors is the need for accurate, detailed 3D renderings of the physical buildings themselves. Hotel workers, employees of other large corporate entities, and first responders are all subject to various sorts of emergencies and require quick response in sprawling, complex, multi-level environments. Finding them in time is difficult.

Orion Labs has released Advanced Location Services, a high-accuracy, carrier-independent 3D location platform delivered via Polaris Wireless. The service provides enterprises and public safety agencies with pinpoint location, indoors and in high-rise buildings, with floor-level and room-level accuracy, a difficult challenge in such GPS-denied environments.

The system enables customers to locate team members on the vertical axis accurate to three meters' distance, to keep teams better informed and better connected, enhance team performance and improve worker safety. It works via Orion Sync, a smart walkie-talkie, or device-as-a-service, in a smartphone form factor.

"For our hospitality and retail customers, this offers the opportunity to greatly improve guest services and the experience they deliver. For public safety and healthcare customers, the integration has the potential to save lives," said Jesse Robbins, CEO.

According to CTO Greg Albrecht, "With 3D location tracking, hospitality teams can easily pinpoint where their guest service workers are located and identify the right team member for faster guest response for tasks like bringing up clean towels to a guest, fixing a TV or lightbulb in a guestroom, or clearing trays and carts."

Photo: Dean Drobot/Shutterstock.com

HOTEL WORKERS suffer work-related incidents at a nearly 50% higher rate than other industries.

The system also protects lone workers. "When lone workers call for help, security teams can rapidly dispatch assistance without the lone worker needing to explain their location," Albrecht said. "This is the same kind of technology that first responders are now adopting to accurately and rapidly locate 911 callers facing life-threatening situations."

Hotel workers suffer work-related incidents, encompassing physical injuries, medical emergencies, theft and sexual harassment, nearly 50% more than the average across all other industries. Large metropolitan hotels can approximate small cities, with as many as 5,000 rooms, 12,000 guests and 8,000 employees. Even a moderate-sized hotel can have hundreds of employees scattered across many floors, some remote from central operations. Locating employees quickly is key to preventing or minimizing incidents.

Need Maps. "For most buildings, [3D mapping] has never been done before and is often an arduous task to accomplish," Albrecht said. "However, there is a mapping process to allow for precise data points to be leveraged within the Orion platform. It's a very simple task that can be completed even by the hotel staff at the time of setup. After that, it's extremely simple to set up teams within the Orion System with a 3D view of their property that they can use."

The latest integration is undergoing tests at locations in Las Vegas and San Francisco, with more than 50 locations actively using the set-up.

Polaris. In March, Polaris Wireless, a provider of software-based 3D location solutions to wireless operators, law enforcement, government agencies and location-based application companies,

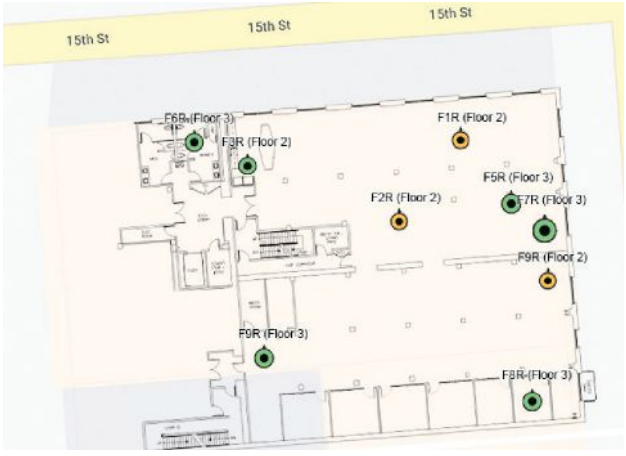
announced the commercial availability of its high-accuracy carrier-independent 3D location platform for application developers.

In 2018, Polaris Wireless participated in CTIA's Test Bed LLC Stage Z vertical location testing in San Francisco, Atlanta and Chicago, achieving floor-level accuracy.

First Responders. Polaris Wireless partnered with Mark43 to integrate 3D location technology into computer-aided dispatch systems for public safety organizations. The joint solution enables police and fire departments to track personnel and assets indoors and in high-rise buildings with floor-level accuracy, to increase situational awareness, help save lives, and reduce costs.

Mark43 is a cloud-based public safety software provider. Its Mark43 computer-aided design software provides mobile field units with precise information on laptops or tablets inside a vehicle. Built on AWS GovCloud, Mark43 works with police and fire departments to make sure web-connected units stay mobile in the cloud.

With the addition of 3D location, command and control centers can direct firefighters to the correct floor in a structural fire or ensure SWAT teams enter at the correct floor of a high-rise building. In more routine situations, such as tracking officers or equipment in a large municipal headquarters, 3D location helps increase efficiency and allocate resources more wisely.



Screenshot: Orion Labs

Advanced Location Services indoor mapping example.

1. INERTIAL SENSORS

SENSOR FUSION WITH GNSS RECEIVER

The MTi 600-series of inertial sensors comes in a 31.5 x 28.0 x 13.0 millimeter IP51-rated case. It produces roll and pitch readings accurate to ±0.2 degrees. GNSS-assisted heading (yaw) measurements are accurate to ±1.0°. Xsens' sensor fusion algorithms optimize output from new accelerometer, gyroscope and magnetometer components. It also has a CAN bus interface. The MTi 600-series modules are the first from Xsens to include an NMEA-compatible interface for GNSS receivers. Users can choose any GNSS receiver chip, module or system to work alongside the MTi-670, a GNSS/INS device that supplements the pitch, roll and yaw outputs available from other MTi 600-series products with global positioning information.

Xsens, www.xsens.com

2. FIBER-OPTIC GYROSCOPE

FOR MEDIUM ACCURACY PLATFORMS

The Emcore-Hawkeye series EG-120 FOG module is an ultra-compact, state-of-the-art design that is a small, affordable closed-loop FOG. The EG-120 delivers advantageous size, weight and power (SWaP) and is 35% smaller than Emcore's previous generation FOGs. The Emcore-Hawkeye EG-120 incorporates advanced, next-generation field programmable gate array (FPGA) electronics that deliver increased performance and reliability combined with low cost. The Emcore-Hawkeye series features performance specifications for medium accuracy platform stabilization applications such as camera systems used in aircraft, unmanned aerial vehicles (UAVs) and gun stabilization systems. A wide variety of other guidance, navigation and aeronautics applications are supported.

Emcore, www.emcore.com

3. NAVIGATION SYSTEM

CUSTOMIZABLE FOR GROUND VEHICLES OF ALL SIZES

The RR-N-140 navigation system provides accurate, absolute and relative 3D localization information for ground vehicles of all sizes. It features dual-antenna GNSS for zero-speed heading detection and redundancy. The device delivers exceptional localization performance in GPS-denied or compromised areas. It is designed specifically for use on unmanned ground vehicles and is customizable to incorporate a wide variety of sensor inputs into the navigation solution.

Robotic Research, www.roboticresearch.com

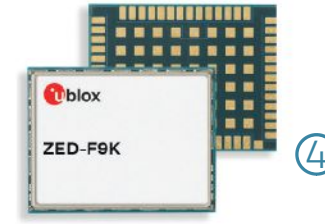
4. GNSS SENSORS

COMBINES NUMEROUS INTERFACES TO SPEED SYSTEM INTEGRATION

CHC Navigation's new P2 GNSS sensor series provides high-accuracy positioning and heading in a compact, rugged enclosure. The series is suitable for a wide variety of applications such as reference stations, marine systems, unmanned navigation, industrial automation, robotics and machine control. The P2 GNSS series is designed to significantly reduce system integration efforts by combining numerous connectivity interfaces including RS232, low-latency PPS output, Ethernet, CAN bus protocol and a comprehensive web interface for configuration set-up. The series integrates the latest GNSS technology in a rugged IP67 and lightweight enclosure. It delivers reliable, uninterrupted, high-accuracy, real-time positioning and heading measurements. The P2 GNSS sensor offers cost-effective and powerful real-time kinematic (RTK) positioning. The P2 Pro GNSS adds a dual-antenna input for precise heading data. The P2 Elite integrates additional 4G and UHF modems to provide a powerful, all-in-one GNSS sensor.

CHC Navigation, www.chcnav.com

TRANSPORTATION



1. CORRECTION STREAM

DATA ENABLES PRECISION POSITIONING

RTX Auto is a GNSS software library for use in safety-critical automotive applications. The RTX Auto library can be integrated with any GNSS device and enables the decoding of Trimble's RTX correction stream for centimeter-level absolute positioning accuracy. It works with other on-vehicle sensors to deliver a certified positioning solution that satisfies advanced driver assistance systems (ADAS) and autonomous driving requirements. It provides RTX-based absolute positioning for General Motors' Super Cruise, a hands-free driving system for the freeway. After 2020, Super Cruise will will be available on all General Motors brands.
Trimble, trimble.com

2. SMART ANTENNA

ATLAS-CAPABLE FOR MARINE MARKETS

The Vector V200 single-frequency, multi-GNSS smart antenna with integrated Atlas L-band is designed for general marine applications and markets. Powered by Hemisphere's Crescent Vector technology, the V200 multi-GNSS compass system utilizes GPS, GLONASS, BeiDou, Galileo and QZSS (with future firmware upgrade and activation) for simultaneous satellite tracking to offer heading, position, heave, pitch and roll output. With support for NMEA 0183 and NMEA 2000, the V200 provides accurate position and heading information to autopilots, chart plotters and other general marine navigation applications.
Hemisphere GNSS, www.hemispheregnss.com

3. DRIVER SAFETY SOLUTION

SECURITY FOR INTELLIGENT DRIVING

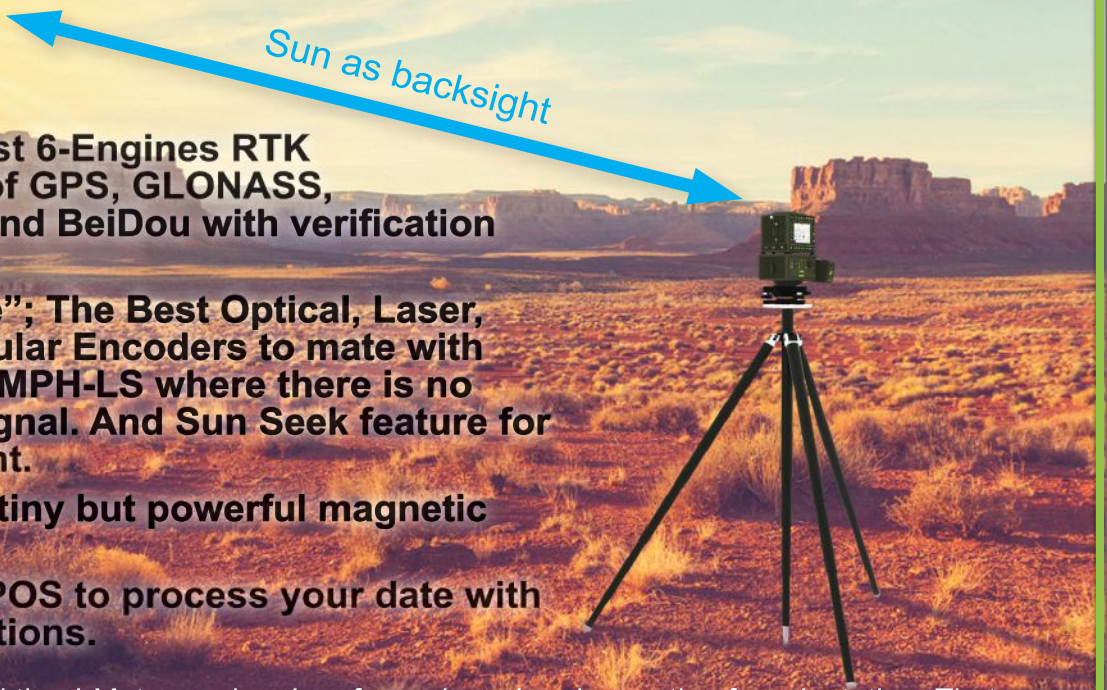
The Proactive Security Solution for Intelligent Driving will enhance safety by supporting ADAS and driver monitoring systems (DMS). It integrates Quectel multi-mode LTE Cat 6 smart modules SC600Y/SC600T and an artificial intelligence (AI) algorithm from a third party to realize ADAS and DMS capabilities including monitoring irregular driving behaviors, conducting precise detection of vehicles and traffic signs, sending warnings of potential risks and more. For ADAS, it can precisely identify and locate vehicles, pedestrians, lanes and traffic signs and will send alerts to drivers if an imminent collision or an unintended lane departure is detected. The DMS supports facial recognition and detection, and is able to monitor driver attentiveness and measure eye blinks as well as head movements so that drivers will receive warnings of distractions, smoking, yawning or looking around.
Quectel Wireless Solutions, www.quectel.com

4. AUTOMOTIVE MODULE

AIMED AT URBAN LANE ACCURACY

The ZED-F9K GNSS and dead-reckoning module brings continuous lane-accurate positioning to challenging urban environments. Building on the F9 platform, the module offers both high-precision multi-band GNSS and inertial sensors. It combines the latest generation of GNSS receiver technology, signal processing algorithms and correction services to deliver down to decimeter-level accuracy within seconds. The real-time kinematic (RTK) receiver module receives GNSS signals from all orbiting constellations. The inertial sensors constantly monitor changes in the moving vehicle's trajectory and continue to deliver lane-accurate positioning when satellite signals are obstructed, such as in parking garages, tunnels, urban canyons or forested areas. The module's accuracy and low latency make it suitable for automotive OEMs and Tier 1 automakers developing V2X (vehicle-to-everything) communication systems. By continuously sharing their location, V2X systems help increase overall road safety and reduce congestion.
u-blox, www.u-blox.com

Total solution



- The Best 6-Engines RTK system of GPS, GLONASS, Galileo and BeiDou with verification features.
- "J-Mate"; The Best Optical, Laser, and Angular Encoders to mate with the TRIUMPH-LS where there is no GNSS signal. And Sun Seek feature for Backsight.
- J-Tip a tiny but powerful magnetic locator.
- Free DPOS to process your date with COR Stations.

"While I had the J-Mate running, I performed a solar observation for orientation. That was about the sweetest execution I could imagine. I see so much potential here."

John Evers, PLS

Auto Verify... Auto Validate...

RTK V6+

GPS, GLONASS, Galileo, BeiDou

six engines plus one support

"I don't know how the other surveyors do it without Javad ! I'll back my data up all day long with the confidence of the Javad system."

see full letter in the last page

JAVAD

www.javad.com

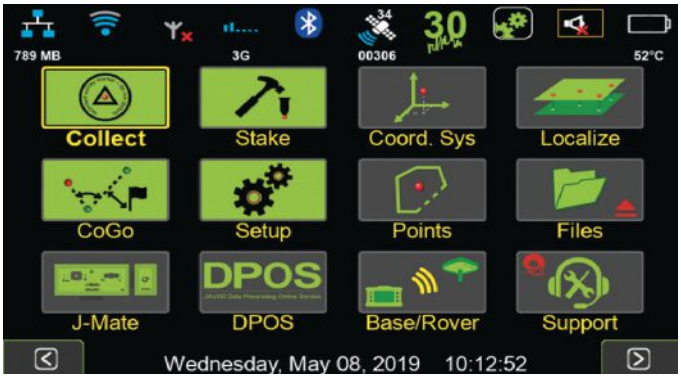
Introduction to J-Mate

Let's set the record straight: J-Mate is not a total-station. **J-Mate and TRIUMPH-LS together** make the **"Total Solution"** which is a combination of GNSS, encoder and laser range measurements that **together do a lot more than a total station**. For long distances you use GNSS and for short distances (maximum of 100 meters) you use the J-Mate along with the TRIUMPH-LS. Together they provide RTK level accuracy (few centimeters) in ranges **from zero to infinity**.

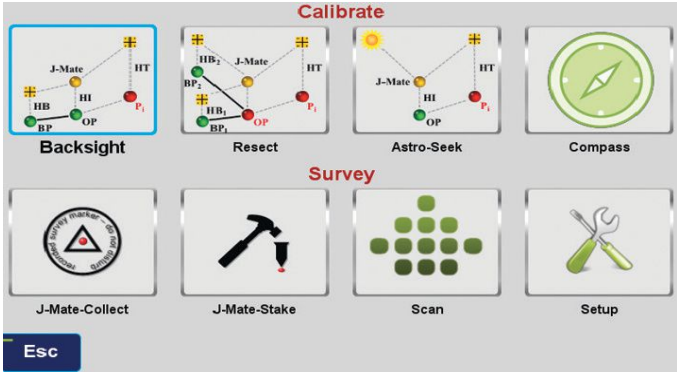
As with the TRIUMPH-LS, with the J-Mate we also provide software improvement updates regularly and free of charge. Download the J-Mate update in your TRIUMPH-LS and then inject it to the J-Mate. The J-Mate SSID will be in this format JMatexxx, where xxx is your J-Mate's serial number. After a Wi-Fi connection is established, click the J-Mate icon and then click Setup. When you are prompted to connect to the J-Mate, click yes and then follow the remaining prompts.

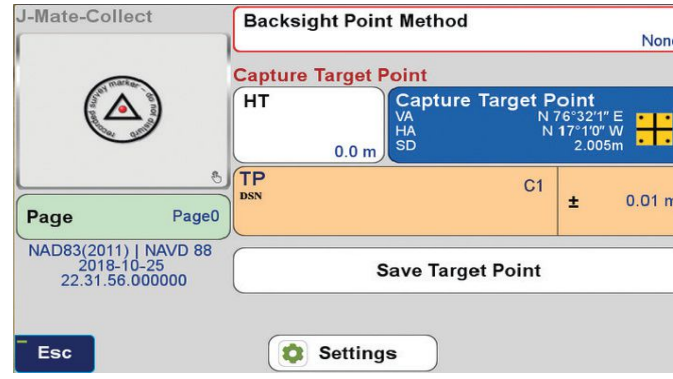
Connecting the TRIUMPH-LS to the J-Mate

TRIUMPH-LS communicates with the J-Mate through Wi-Fi. Turn on both the TRIUMPH-LS and the J-Mate. Click the Wi-Fi icon on the TRIUMPH-LS Home screen to connect to the J-Mate, much the same way as you connect TRIUMPH-LS to your Wi-Fi access point.



After connection, click the J-Mate icon on the TRIUMPH-LS Home screen and then J-Mate/ J-Mate Collect/Capture Target Point to get familiar with the Main J-Mate screen.





VB-RTK

Get on the Grid with VB-RTK. For over a decade American surveyors have been using the National Geodetic Survey's Online Positioning User Service. Surveyors employing RTK have been a significant share of the user segment of OPUS.

A significant share of OPUS users are surveyors using RTK. Often a surveyor will set up his base on a new, unknown position and allow an autonomous (or standalone) position to be used for the base coordinates. While he is performing his RTK work with fixed vectors between his base and rover, he stores data at the base to be submitted at a later time to OPUS. Once he is finished with his work, he downloads this file to his computer, converts the file if necessary, and submits it to OPUS. He then receives an email response back with a precisely determined coordinate for his base station. He then must take this coordinate, relate the coordinate to his project coordinate system, and then translate the work from the autonomous (or standalone) position he used in the field to this new coordinate. This procedure can produce excellent results and anchors the survey to the NSRS. The down side to this is that there are several steps that must be carefully observed and each of these error prone steps costs time.

With J-Field data collection software, JAVAD has been automating many tasks that surveyors have been doing for years, making the tasks more efficient and reducing sources of potential error. One example, **"Verify RTK with V6 Resets"**, is being recognized by surveyors across the country as the most accurate and efficient way to confidently determine RTK positions. Rather than taking a shot, manually resetting (or dumping) the receiver and taking a second shot for comparison, Verify RTK does this automatically with a user defined number of reset iterations.

JAVAD has continued this automation philosophy by dramatically simplifying the process of translating a survey from an autonomous base position to precise geodetic coordinates with **VB-RTK (Verify Base – RTK)**. Using the JAVAD GNSS, Data Processing Online Service (DPOS), which is powered by the proven JAVAD GNSS Justin processing engine. **This multi-level process is done in J-Field completely automatically.**

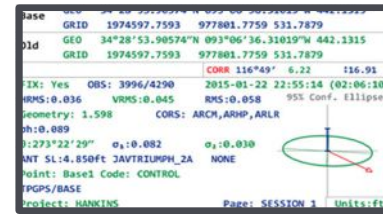
Once an RTK session has been completed, the user returns to his JAVAD base receiver and presses "Stop Base" on the TRIUMPH-LS. **At this point, the raw data file that has been recording at the base during the session, is wirelessly downloaded from the base to the TRIUMPH-LS. When the download is complete, the user returns to his office and connects the TRIUMPH-LS to the internet.**

When internet connection is made, the file is automatically transmitted to one of the JAVAD GNSS servers for post processing. Once data and ephemerides are available for the session, **DPOS** processes the file and returns results to the waiting TRIUMPH-LS. This all takes place within minutes.

Once results are returned, the new coordinates for the base are shown related to your coordinate system (including localization systems).

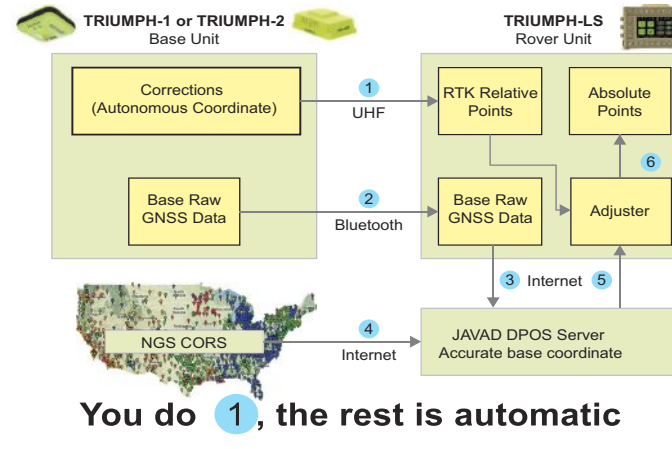
The horizontal and vertical differences between the base coordinates used and the DPOS determined coordinates are shown. **This provides for an instant check of the base coordinates and instrument height** if the base were set up on a known position.

All rover points associated with that base session translate automatically in seconds. Only those rover points associated with that base session translate.



If the user is not satisfied with the results of the DPOS solution and wants to revert back to the original RTK positions, he simply clicks **"Undo"**.This process is immune to base instrument height errors because the internal vectors between base to rover are related to the antenna, not the ground point. So, an accidental entry for the base height of 543' instead of 5.43' can be resolved by VB-RTK.

In addition to the advantages of having your RTK base station near your work area, which gives you much more accurate and faster fixes, especially in difficult areas, and saving you the RTN fees; perhaps most important of all, your work is now precisely related to one of the most accurate geodetic control networks in history – the NGS CORS. Every rover point is only two vectors removed from the CORS (CORS to base, base to rover). This means that you can return again someday to find your monuments easily and accurately. This makes your records incredibly more valuable to both you and future surveyors. J-Field also has the unique ability to load and view every point you have ever surveyed from all the projects in its system. By combining this feature with a **distance filter** in its advanced set of filters, you can easily view all the points you have previously surveyed within a given distance of a point in your current project. Having an easily accessible record of nearby georeferenced coordinates is very beneficial as you may have previously located monuments in past surveys that are beneficial in your current project. J-Field allows you to easily copy these selected points into your current project, eliminating the need for you to resurvey them. All of this is available automatically on the world's most advanced RTK rover – **the TRIUMPH-LS**.



Concepts Behind RTK Verification

Fundamental in the determination of GNSS solutions is calculating the correct number of full wavelengths (so-called ***fixing ambiguities***) in order to figure out the distances from the satellites to the receiver. In doing Real Time Kinematic (RTK) surveying, we need it fast and we need it to be correct.

Multipath, the reflections of GNSS signals from ground and nearby objects and structures create their own indirect measurements from the satellites to the GNSS receiver. It's as if your measuring tape is bent around an obstacle such as a tree instead of a free and clear line of sight between two points. No calculator is going to improve this result.

TRIUMPH-LS has sophisticated hardware to distinguish between the direct and indirect signals and remove most of the indirect signals. It also reports the amount of indirect signal that has been removed. The worst case is when the receiver doesn't see the direct signal at all; e.g., the satellite is behind a building, but it's still receiving the signal reflected off of the nearby structure. It is the task of the RTK engines to isolate such indirect signals and then exclude them from the calculations.

If too many of the signals are affected by severe multipath or indirect signals, no solution may be found. Remember, indirect signals are analogous to the bent measuring tape! When you're preforming RTK surveying, observe your environment and come to recognize that the structures around you are like mirrors for GNSS signals.

The other aspect impacting the veracity of a fixed solution is when there are weak GNSS signals. Frequently, weak signals are due to their penetration directly through tree canopy.

While the **TRIUMPH-LS** can't move the obstacles that are creating multipath out of the way, its sophisticated hardware has advanced multipath reduction sub-system, its tracking software is designed to handle even the weakest signals, and its **J-Field** software provides reliable RTK solutions like no other system with its **Automatic RTK Verification System**. J-Field also has ample tools to demonstrate the reliability of the solution or warn against questionable results. You can readily see that without such tools other systems can provide you wrong and misleading solutions.

J-Field uses six RTK engines (Figure 1) running in parallel plus a support engine to monitor and aid the six engines. Each engine uses a different criteria and mathematical method tailored to resolve ambiguities in different conditions. These six parallel engines not only verify robust solutions but also maximize the possibility of providing solutions in all conditions.

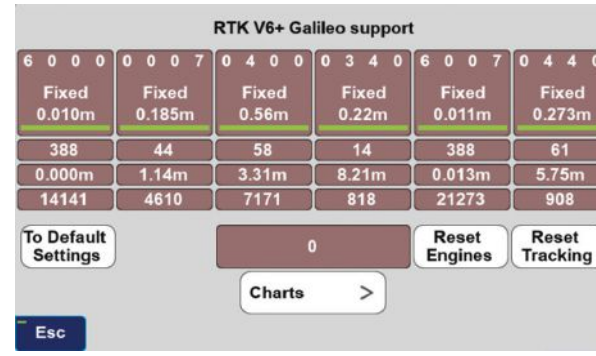


Figure 1 *V6+ six RTK Engines*

User Defined Verification Tools

J-Field provides the option for you to specify the **Minimum Number of Fixed RTK Engines** in verifying solutions **N** times before a position is automatically accepted where **N** is a user defined value.

J-Field employs two metrics to evaluate the performance of its RTK system of six engines: **1) Confidence Counter, and 2) Consistency Counter.** (Figure 2)

Confidence Counter

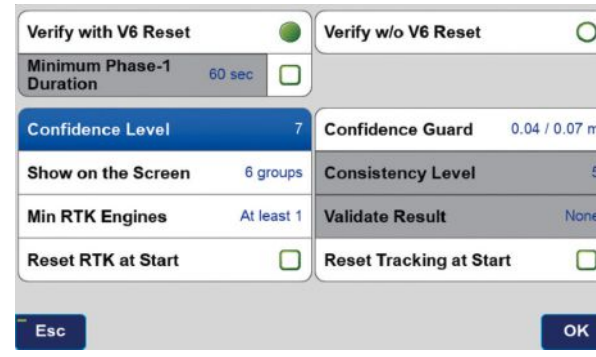


Figure 2 *Verify Settings*

This metric is incremented each time an engine is reset, ambiguities are recalculated, and the solution is in agreement with the previous ones (as defined by the **Confidence Guard (CG)**, default value 5 cm) is achieved. The Confidence Counter increments by 1, 1.25, 1.5, 1.75, 2.0, and 2.5 depending on the number of reset engines that fix in that epoch.

Consistency Counter

The Consistency Counter is incremented each time a solution is in agreement with the previous ones (as defined by the Confidence Guard) irrespective of engines being reset or not. The Consistency Counter is incremented by 0.0, 0.1, 0.25, 0.5, 1.0 and 1.5 depending on the number of fixed engines used in that epoch. Note that one fixed engine gets no credit and 6 fixed engines gets a **Consistency Credit** of 1.5.

Using these Confidence and Consistency verification tools, J-Field has two options to achieve reliable RTK solutions: **1) Verify With Automatic RTK Engines Resets** and **2) Verify Without Automatic RTK Engines Resets.**

Verify with Automatic RTK Engines Resets

This method has two steps: **1) Confidence Building** and **2) Smoothing and verifying**.

• **Step One.** In Step One, fixed engines are reset and solutions are collected into groups. Each group contains all the epochs located within a specified radius (the CG value) from its center and new groups are created as necessary so that all epochs fall into at least one group. Each group has its own Epoch Counter, Confidence Level and Elapsed Time. A point may fall into more than one group. The groups are sorted from best to last by the sum of their Time and Confidence with the current best group being shown within [ ] and others within ( ). Step One continues until a group reaches the Confidence Level. (Figure 3)

• **Step Two.** During Step Two the engines are

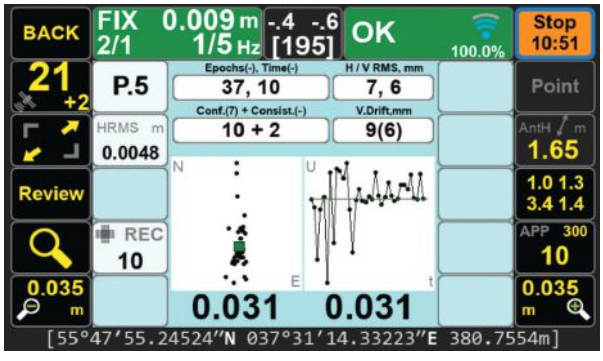


Figure 3 *End of Step one*

not reset and solutions which are located inside the CG of the selected Group are added to that Group for the remaining number of epochs that user has requested (Epoch Number, EN) in the How to Stop screen. Epochs which are outside the CG of the selected Group will be stored in a new (or previously created) group; the RTK engines are reset if the epoch falls outside a sphere with a radius twice that of the CG and the process will then revert back to Step One and the Confidence Level of the current group will be reset to 0.

If the number of epochs falling outside of the current group (but less than 2X outside it) reaches 33% of epochs collected so far, the process will revert back to Step One. Previously created groups will remain intact and once an existing or previously created group meets the Step One criteria, it will pass to Step Two. (Figure 4)

In both steps the Consistency Counter is also incremented as mentioned earlier.

You can manually reset all RTK engines via the V6-RTK engines screen (Figure 1), or assign this

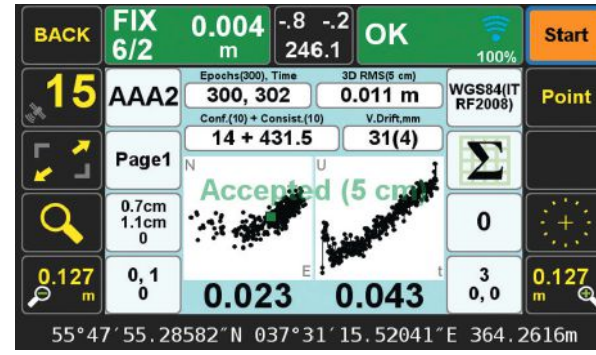


Figure 4 *End of Step 2*

reset function to any one of the U1 to U4 hardware buttons in front of the TRIUMPH-LS for easy access.

Verify without Automatic RTK Engines Resets:

In this method we don't force the RTK engines to reset but rely mostly on the Consistency Counter. There will be only one group as selected by the first epoch. Solutions that are not within the Guard band of the current average will be thrown out. If more than 30% of solutions are thrown out, the process will restart.

The horizontal and vertical graphs presented in both approaches also help the surveyor to evaluate the final solution. The linear drift of the vertical solution and its drift RMS are also shown above the vertical graph. A high linear drift (more than few centimeters) reveals severe multipath or, in rare cases, a wrong ambiguity fix. Pay close attention to the vertical drift and the horizontal and vertical scatter plots of epochs. Consider the scatter plots as doctors examine X-rays to determine anomalies.

The desired **Confidence Level** and **Consistency Level** are user selectable. Default values are 10. These parameters along with the desired number of epochs must be reached before a solution is provided.

In either case there is also a **Validate** option which, when selected, will reset all engines at the end of the collection and continues with 10 more epochs to validate if the solution is within the desired boundary of the Confidence Guard. (Figure 2) Minimum number of engines for the Validation Phase is user selectable.

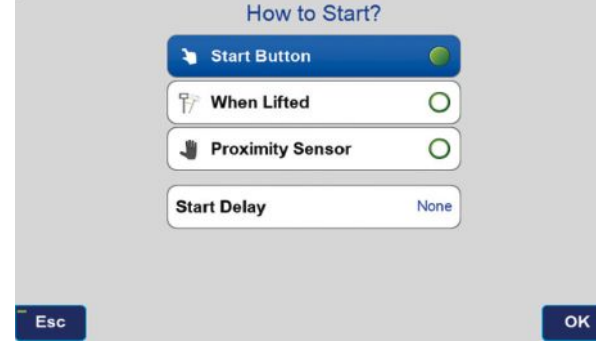


Figure 5 *How to Start*

Figure 6 *How to Stop*

In either case, if Auto-Accept is activated, the position will be automatically accepted if the RMS of the final solution is less than what user has selected in the Auto-Accept screen. (Figure 6)

You can also use **Auto-Restart** if you want to monitor structures or test the RTK system unattended. (Figure 6)

Screen Shots of Action Screen

Action Screen shows detailed information about each point collected. Screen shots can automatically be attached to each point and saved at the end of each collection (Figure 7). In **Verify with Automatic RTK Engines Resets** screen shots at the end of both Step One and Step Two are saved (Figures 3

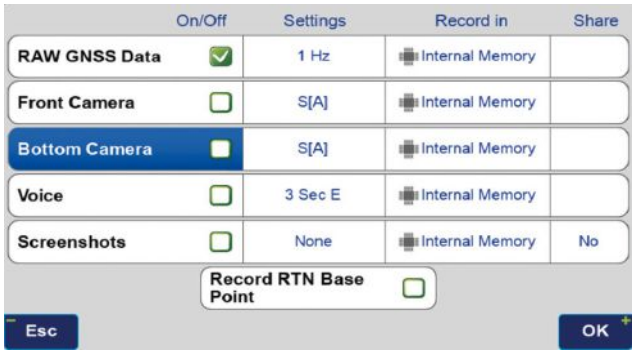


Figure 7 *What to record screen*

and 4). In Action screen there are 8 white boxes that selected items can be viewed on them.

Review Screen

View cluster of all points. Select the desired point to see its point cluster (Figure 8). Click the icons to see additional details about that point (Figure 9) including the distance and direction to the current point (Figure 10).

The effects of multipath, ionosphere, orbit, and other sources of problems somewhat exponentially increase as the baseline length increases. In a VRS/RTN scheme your **actual** baseline length is the actual distance to the nearest base station. The **virtual** base station that is mathematically created is not the actual length. We strongly recommend using your own base station near your job site in a

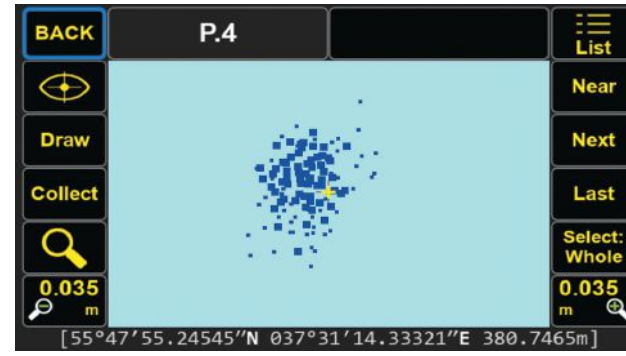


Figure 8 *Review screen shows cluster of 386 points*

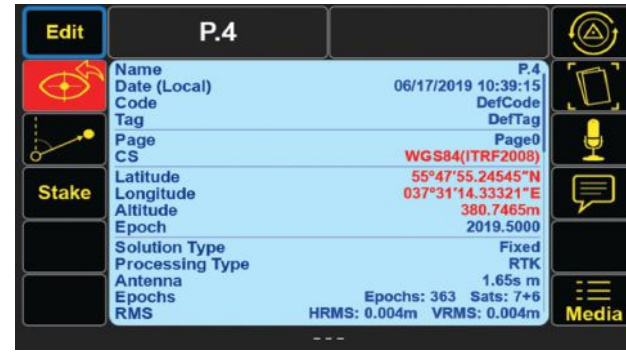


Figure 9 *Detailed information on selected point (scroll to see all information)*

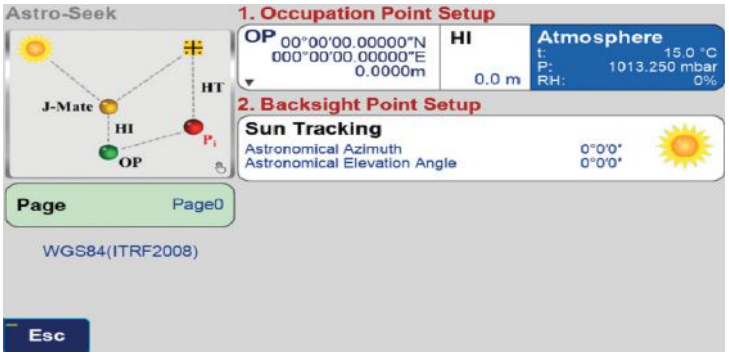
Figure 10 *Distance and direction from the current point to the selected point*

Verified-Base RTK (VB-RTK) scheme.

In addition to providing you with the most reliable RTK solutions (especially true in remote areas where cell coverage is hit or miss), using your own base receiver allows you to easily tie your solutions to well-established IGS/NGS spatial reference systems through Javad's exclusive Data Processing Online Service (DPOS) and J-Field's user-friendly Base/Rover Setup. Note that post-processed results returned to the TRIUMPH-LS using DPOS are dependent on the availability of orbital data from NGS and may require several hours. Alternatively, if you don't have access to IGS-type stations to use DPOS, you can select an open area near your job site and use TRIUMPH-LS to obtain its position via RTN networks for about 5 minutes.

Backsight point and the Sun

Similar to using conventional total station, to use the J-Mate you need to first establish its accurate position and calibrate its vertical and horizontal encoders. Then proceed to shoot the unknown points. This is similar to using any total station, but we have improved and automated the process.



With J-Mate you can do these in three different ways as shown in the J-Mate screen of the TRIUMPH-LS. Via the J-Mate-Backsight; J-Mate-Resect and J-Mate-Astro-Seek icons.

If GNSS signals are available at the site, click the J-Mate-Backsight icon.

This screen appears which guides you to determine the accurate positions of the Occupation Point and a Backsight Point to establish an azimuth and calibrate the J-Mate angular encoders.

The tripod is setup at the “Occupation Point” (OP). The J-Mate is secured on top of the tripod.

Next, TRIUMPH-LS is put on top of the J-Mate with its legs registered to the matching features on the J-Mate.

Next Use the RTK Survey feature of the TRIUMPH-LS to quickly determine the accurate location of the Occupation Point. You can use your own base station or any public RTN.

Next, slide the J-Target on top of the TRIUMPH-LS, lift it from the J-Mate and move to the “Backsight Point” (BP). The camera of the J-Mate will search the J-Target. The camera’s view is visible from the TRIUMPH-LS screen, which mostly focuses on this J-Target. When at the Backsight Point, its accurate position is determined by the TRIUMPH-LS, and the Azimuth from the Operation Point to the Backsight Point is determined, and the J-Mate is calibrated and ready for use.

After this calibration is complete, if the tripod is disturbed, the red LED on the front of the J-Mate will blink to show that re-calibration is required.

We can now replace the TRIUMPH-LS on top of the J-Mate at the Occupation Point and proceed to shooting as many “Target Points” as the job requires. From now on TRIUMPH-LS is used as a controller and you can hold in your hand too, but it is more convenient to put it on its place to have free hands.

If GNSS signals are not available at the Occupation Point, click the “J-Mate-Resect” icon to shoot two known points to establish its accurate position and calibrate its encoders. Then continue to shoot the unknown points.

Astro-Seek feature: Sun as the Backsight point!

We have added a new innovative feature to the J-Mate that it can automatically calibrate itself via its automatic Sun Seeking feature.

Attach the Sun filter to the camera of the J-Mate, click the “J-Mate-Astro-Seek” icon and click the “Sun” icon in the screen which appears and J-Mate will automatically find the Sun, and use its position to calibrate the angular encoders automatically.

J-Tip

TRIUMPH-LS tags coordinates with magnetic values, It also guides you to top of the item to survey it.

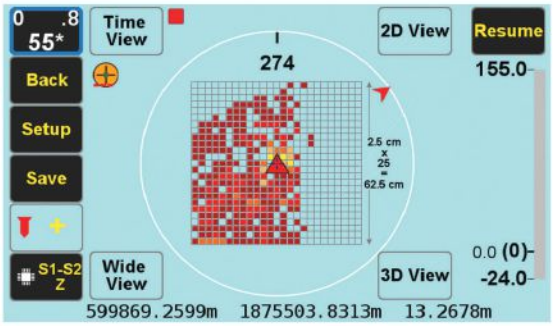
The Mag View focuses only on the mag object with the highest mag value.

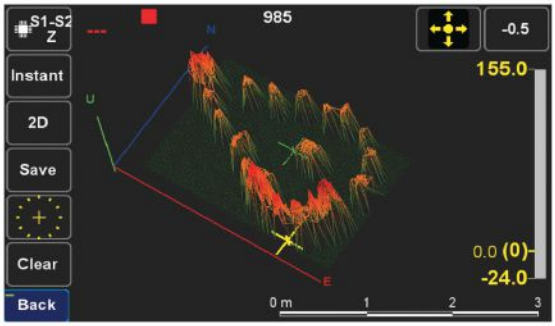
The audio and graphical bar show the magnitude of the magnetic object.

In “Setup” you can select the cell size and the size of the field you want to scan.

2D and 3D views of the field show the magnetic objects that have been scanned.

Zooming the 2D and 3D screens can show the shape of the magnetic objects under the ground.





For many sophisticated features of the J-Tip see its Users Manual in www.javad.com

What a great little system! I’ve been using it a good bit in the last few months since purchased controller back in November. Really appreciate all that I’ve learned here on the forum from folks like Nate the Surveyor, Shawn Billings, Matthew Sibole, others and all the developers on the Javad Team. Although this system has only a quarter of the channels as the Triumph-LS, it still amazes me in high multi-path areas using the RTN. Once you read the manual several times, especially on RTK Verification, everything falls into place. There is so many ways to verify your position if there’s any doubt; i.e., distance to last point, confidence and consistency levels, verification with selected # engines, saving of raw data to post process, etc.

Last project was cutting out 33 acres, part of the boundary was at the corner of a 150 acre tract. Located all the existing corners and the proposed corners with the owner (1 day field work). Computed the acreage (1/2 day office) and then staked out the corners and staked a few lines using my brothers Triumph-LS with radio RTK (1 day field work). This site was very bad with multi-path (pine forests and hardwood lands). I don’t think I could have used the Victor-LS/Triumph-2 in these conditions for stake out (I didn’t try). The Triumph-LS ruled in these conditions and minimal time was spent on station, staking out the actual new corners. Verification of my original locations performed with the Victor-LS/Triumph-2 checked < 0.1’ both horizontal and vertically. Also re-measured all staked points for verification while on station. Surveying is so much fun again when I can get out of the office!!!

I don’t know how the other surveyors do it without Javad! I’ll back my data up all day long with the confidence of the Javad system.

Bryan Enfinger

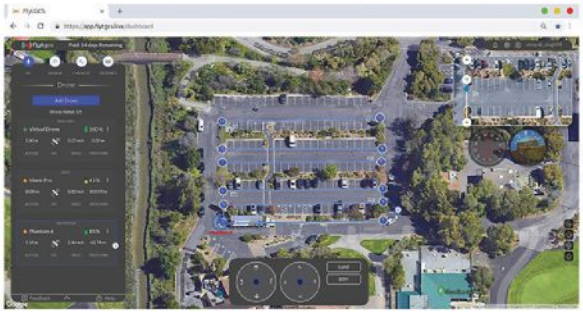
Thanks a lot Bryan. If you don’t mind, I would like to share your experience in our publications.

Javad Ashjaee

I just get excited using the equipment, it’s light years beyond anything available! I really enjoy finding time to keep learning on this machine, I’ve always enjoyed learning new things and this is the greatest yet. We were part of the trial team originally, my brother Buck really loves the Triumph-LS/Triumph-2 system.

Here’s an attached pic from the collect screen. I was verifying PT23 with two additional shots with the EPOCH count set at 10, time set at 180 secs and the APP set at 3600 secs (1 hour) for raw data logging if I didn’t get any fixed positions. This was in a wooded area with 25 year old pines and hardwoods with many leaves. I was amazed I got a fix with 5 engines within approx 1 minute and met the confidence and consistency levels set. Notice the “distance to last” measurement, all this with the Victor-LS/Triumph-2 system. While I know this won’t occur in all situations in the time frame shown here, even if it didn’t get a fix I had the raw data to post process using short baselines (i.e., another base <1.0 mile away).

Bryan Enfinger ENFINGER & ASSOCIATES PROFESSIONAL LAND SURVEYORS



1. INERTIAL NAVIGATION

GEO-REFERENCING SOLUTION IMPROVES UAV-BASED SURVEYING

The Quanta UAV series is a line of inertial navigation systems (INS) dedicated to UAV-based surveying integrators. The small, lightweight and low-power INS is offered with two levels of accuracy. Quanta UAV and Quanta UAV Extra have been developed for compact lidar to high-end beyond-visual-line-of-site (BVLOS) mapping solutions. They provide precise orientation and centimeter-level position data both in real time and in post proce ssing, eliminating the need for ground control points and reducing the need for overlaps. SBG's post-processing software Qinertia gives access to offline real-time kinematic (RTK) corrections from more than 7,000 base stations in 164 countries.
SBG Systems, www.sbg-systems.com

2. CNPC RADIO PROTOTYPE

BEING TESTED AS COMMAND AND NON-PAYLOAD CONTROL UAS RADIO

SkyLink is an L-band frequency-modulated CNPC radio intended for point-to-point or networked BVLOS UAS operations. uAvionix has focused on minimizing size, weight, and power consumption (SWaP) while maximizing range and spectrum efficiency. The current 50-gram 10-Watt prototype is testing successfully at ranges exceeding 40 miles at low altitude. uAvionix is testing under an experimental transmit license and approval from the Federal Communications Commission and Federal Aviation Administration, respectively.
uAvionix, uavionix.com

3. THERMAL DRONE

DESIGNED FOR SOLAR FARM INSPECTIONS

The senseFly Solar 360 UAV is designed to enable the automated and efficient inspection of solar farms. Created in collaboration with software company Raptor Maps, the efficient thermal drone solution enables the automatic assessment of solar plant performance at a sub-module level. Created by combining eBee X fixed-wing drone technology, senseFly's Duet T thermal mapping camera and Raptor Maps software, senseFly Solar 360 is a fast and fully automated drone. It can be integrated into solar management workflows without requiring either drone piloting skills or the manual analysis of aerial solar-farm data. Solar-farm inspection can be reduced from days to hours, with inspection of utility-scale solar farms completed more quickly, easily and accurately.
SenseFly, www.sensefly.com
Raptor Maps, raptormaps.com

4. REMOTE OPERATIONS

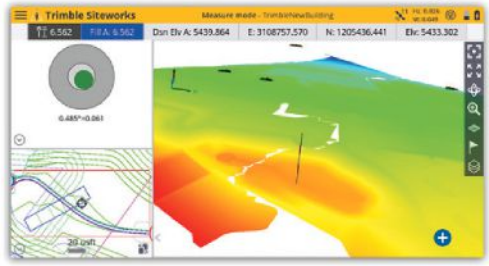
CLOUD-BASED, ENABLES BVLOS

FlytGCS is built for subject-matter experts, drone operations managers and UAV operators who wish to automate, simplify and scale their missions. To support automated BVLOS missions, FlytGCS offers features such as connectivity and control over 4G/LTE/5G, live high-definition video feed, fleet management, unlimited missions, remote gimbal control, pre-flight checklist and geofence, mission planner and cockpit view from a web dashboard. FlytGCS is a hardware-agnostic solution that helps securely deploy drones using a mobile app (for DJI drones) or onboard single-board computers (for Ardupilot and PX4 drones).
FlytBase, flytgcs.live

5. INSPECTION DRONE

COLLECTS DATA IN DANGEROUS AREAS

The Elios 2 UAS is designed for inspection tasks. Routine inspection jobs indoors, underground and around complex pipework become quicker, safer and are fully documented by high-resolution video and stills. The Elios 2 includes a rotatable thermal and high-definition visual camera payload, 10,000-lumen oblique lighting system, and reversible rotors that enable the UAV to back out of tricky situations. The drone's geodesic-like cage makes it collision-tolerant and enables flight in restricted areas such as refinery enclosures, mines, vats, cargo holds and nuclear containment vessels.
Flyability, www.flyability.com



1. BATTERY UPGRADE

LONG-LIFE BATTERY FOR EXTENDED FIELDWORK

SXblue receivers now have an extended-life battery equipped with 4 Li-ion rechargeable cells that boost its capacity from 3900 mAh to 6000 mAh. When fully charged, the battery can last up to 16 hours depending on the SXblue model and Bluetooth connectivity — an up to 50% increase. The colored LEDs for the battery charge indicator have been enhanced for a better contrast. With only a 6-mm increase in thickness and the same weight as previous models, the user will not notice any change in handiness and ergonomics. The new battery is compatible with all past SXblue II and III models and current iSXblue II+ GPS, SXblue II+ GPS, iSXblue II+ GNSS, SXblue II+ GNSS and SXblue Platinum.
Geneq, geneq.com

2. FIELDWORK TABLET

CAPTURES DETAILED IMAGES

The DT301X-TR rugged tablet includes an Intel RealSense 3D camera. The lightweight military-grade tablet is built to enhance precision for bridge and construction inspections, 3D surveying and mapping of underground utilities. It provides multi-frequency GNSS real-time kinematic (RTK) with carrier phase for mapping and positioning, and supports GPS, GLONASS, BeiDou, Galileo and QZSS. An optional foldable antenna supports high-accuracy field work, which can be measured with RTK GNSS positioning directly or used to connect to an external antenna for higher precision.
DT Research, www.dtresearch.com

3. GNSS RECEIVER

DUAL-ANTENNA RECEIVER WITH HEADING

The David Plus dual-antenna GNSS receiver offers centimeter-accurate positioning and heading for intelligent transportation, construction, machine control, precision agriculture and navigation. Designed for efficient and rapid integration, the compact, lightweight receiver tracks GPS, GLONASS and BeiDou signals: GPS L1/L2, GLONASS L1/L2, BeiDou B1/B2 from the primary antenna, and GPS L1/GLONASS L1 or GPS L1/BeiDou B1 from the secondary antenna. The modular and flexible design can provide robust positioning and heading accuracy in a compact footprint for UAVs and other smaller autonomous projects.
Tersus GNSS, www.tersus-gnss.com

4. TILT COMPENSATION

ANDROID AND WINDOWS COMPATIBLE

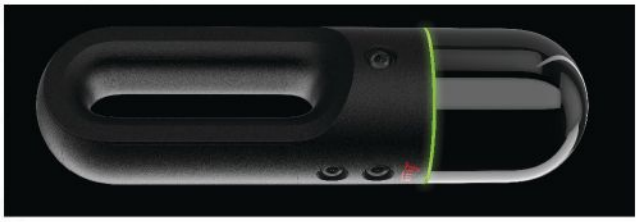
Siteworks Software version 1.1 features GNSS tilt-compensation functionality and support for the Android operating system, meaning field workers can use smartphones or tablets. Contractors can run Siteworks on either Windows 10 or Android. Using Trimble Siteworks and a Trimble SPS986 GNSS smart antenna, construction surveyors can take measurements faster and perform more efficient stakeouts. It is designed to shield magnetic interference and can be used effectively anywhere on a construction site. Construction surveyors can capture accurate points without leveling the pole. Three modes support tilt compensation, so contractors can record accurate points while standing, walking or driving the site in a vehicle.
Trimble, www.trimble.com

5. RTK RECEIVER

MULTI-BAND CENTIMETER-ACCURACY

The Reach RS2 is a multi-band GNSS receiver that features a built-in LoRa radio, a 3.5G modem, and a survey app for iOS and Android. The receiver determines a fixed solution in seconds and provides positional accuracy down to several millimeters. It tracks GPS/QZSS (L1, L2), GLONASS (L1, L2), BeiDou (B1, B2), Galileo (E1, E5) and SBAS (L1C/A), and reliably works in RTK mode on distances up to 60 kilometers and 100 kilometers in PPK mode. A multi-feed antenna with multipath rejection offers robust performance even in challenging conditions. RINEX raw data logs are compatible with OPUS, CSRS-PPP, AUSPOS and other PPP services so users can now get centimeter-precise results.
Emlid, emlid.com


EOS
Positioning Systems
ARROW SERIES™
High Accuracy Field Mobility
Submeter with SBAS, 1cm with RTK
SafeRTK™ for poor cell coverage areas
GPS/Glonass/Galileo/BeiDou, L1/L2/L5
4cm real-time accuracy anywhere in the world
WWW.EOS-GNSS.COM
Made in Canada



1. HIGH-SPEED CAMERA

HIGH RESOLUTION FOR AERIAL IMAGING

The Falcon 4 is a 86-megapixel ultra-high resolution and high-speed complementary metal oxide semiconductor (CMOS) camera. It offers capabilities for large-area, high-resolution, high-speed imaging. With 86 megapixels at 16 frames per second and a global shutter, the camera offers capabilities for large-area, high-resolution, high-speed imaging. Available in both color and monochrome models, the camera is sensitive into the near-infrared spectrum. The Falcon4's high resolution and throughput serve a variety of challenging applications including aerial imaging, reconnaissance, security and surveillance, 3D metrology and flat panel display inspection.

Teledyne DALSA, www.teledynedalsa.com

2. CAMERA LENSES

HIGH-PERFORMANCE, HIGH-ALTITUDE

Three new high performance lenses are designed for high-altitude aerial photography and long-range aerial and ground inspection applications. The 300mm AF, 180mm, and 150mm MK II lenses are designed to enhance the performance and flexibility of Phase One Industrial's iXM-RS and iXM aerial camera series. Each offers precision imagery, taking advantage of the cameras' ultra-high resolution backside-illuminated CMOS sensors, to maintain a smaller ground sample distance while flying at higher altitudes.

Phase One Industrial, industrial.phaseone.com

3. LIDAR SCANNER

LONG RANGE FOR UAVS

The SORA-P60L, part of Cepton's SORA family of lidar scanners, is purpose-built to deliver long-range, high-resolution imaging for UAVs. It offers a 400-Hz frame rate, enabling drones to fly faster while maintaining high point-cloud density. With a 550-gram payload, the SORA-P60L prolongs UAV flight time allowing more ground to be covered in a single trip. Cepton's Micro-Motion Technology faces all lasers downward at all times, providing a dense, uniform point cloud that, in combination with the high scan rate, makes it suitable for fixed-wing and fast-moving rotary-wing UAVs.

Cepton Technologies Inc., www.cepton.com

4. LASER RANGEFINDER

FOR AGRICULTURE OR UAVS

The WASP-200 LRF rangefinder is designed to measure ranges with accuracy and precision. It can be used for precision agriculture applications and as a proximity-to-ground sensor on board small or large unmanned aerial vehicles. It has 1-centimeter resolution and 10-centimeter accuracy, and is compatible with the Collins Aerospace Piccolo (CAN Bus and RS-232) and Pixhawk drivers. The WASP series of rangefinders also feature single-shot laser ranging for fast scanning and moving platforms; programmable burst mode averaging; and an IP-67 option. The rangefinders are suitable for robotics and UAVs, sense and avoid, industrial automation, height and distance measurements, and maritime operations.

Attollo Engineering, www.attolloengineering.com

5. IMAGING SCANNER

PORTABLE AND HANDHELD

The Leica BLK2GO is a small, portable, integrated handheld imaging scanner that offers mobility for scanning complex indoor environments. It combines visualization, lidar and edge-computing technologies to scan in 3D while in motion, allowing users to be more agile and efficient in capturing objects and spaces. Its dual-axis lidar scans up to 700,000 points per second. The handle contains WLAN connectivity, a rechargeable 45-minute battery, data storage for six hours of scans, a USB-C port for fast data transfer, and edge computing. The BLK2GO has a wide range of applications from adaptive reuse projects in the architecture and design industries to location scouting, pre-visualization, and VFX workflows for media and entertainment.

Hexagon, hexagon.com

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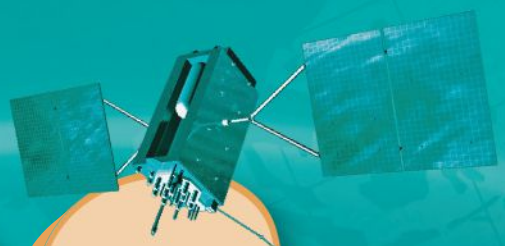
INSTITUTE OF NAVIGATION



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AGE OF ACCEPTANCE

Retirement Communities Embrace Driverless Shuttles

BY Diane Sofranec / STAFF EDITOR

For many seniors, retirement communities offer the best of both worlds: the freedom to live in their own homes and access to immediate assistance when they need it.

Driverless cars are an option several retirement communities have embraced to better serve residents who no longer have the ability or desire to drive, but want to retain the ability to come and go as they please.

"Autonomous vehicles are a great fit for any community where the environment is well-understood, less complex than dense urban areas, and the transportation demand is high," said Justin Erlich, vice president of strategy, policy and legal for Palo Alto, Calif.-based Voyage, a company that employs existing technology to develop fleets of autonomous vehicles. "Retirement communities satisfy all of these characteristics."

Serving Seniors

Voyage deployed driverless shuttles to serve 130,000 retirees at The Villages, a massive retirement community encompassing more than 50 square miles in Sumter County, Florida.

"The community's residents enjoy an extremely active lifestyle, but often face challenges getting around," Erlich


Photo: Voyage

said. "Autonomous vehicles are perfectly suited to meet this demand."

The six vehicles in the fleet stay within the confines of the retirement community, where all roads have been precisely mapped, speed limits are lower and traffic patterns are more clearly defined than in a typical city. The vehicles travel over a network of roads that span 750 miles.

To request one of Voyage's autonomous vehicles, a resident can summon the shuttle on-demand with a smartphone. Voyage is working with residents on the possibility of using other shuttle-request options, including text messages, phone calls and well-marked pickup zones in crowded downtown areas, Erlich said.

All passengers ride with Voyage safety drivers in the front seat. The drivers take note of any "events" during rides so Voyage can investigate how to improve the riding experience.

Eventually, residents will be the only passengers in the vehicles. If they need assistance during a ride, they will be able to communicate with remotely located Voyage employees, Erlich said.

Testing and rolling out fleets of driverless vehicles in private communities like The Villages allows Voyage to develop and perfect the autonomous vehicle technology it uses. As a result, the company can deliver the service to new clients in mere months.

Voyage, which has been working on its autonomous technology for more than two years, uses daily customer feedback to constantly adjust to its technologies to better serve riders.

"Feedback collected during test drives is one of the biggest factors in shaping our technology roadmap," Erlich said. "Driving data — collected across all sensors and traffic scenarios — is automatically processed each night, highlighting interesting 'events' for our engineering team to analyze and review."

During Voyage's beta test process at The Villages, residents applied to be part of the company's Pioneer Program for early access to the autonomous vehicles and the ability to offer feedback early on. Riders who test the service complete scorecards after each trip to help improve the experience for all riders.

"As one of the only self-driving car companies that are picking up actual passengers as a part of our Pioneer Program, we believe we can learn a lot from the feedback we hear from our initial Pioneer riders as we try to make this the best service for The Villages," said Oliver Cameron, co-founder and CEO of Voyage. "We are excited to see so much interest from other residents to become a part of this program."

When developing autonomous technology, safety is Voyage's top priority, Erlich said. Every change to the hardware and software used undergoes a multi-stage validation process. Company engineers perform "on-desk" tests of every change using unit tests, functional tests and a driving simulation environment. Then, an operations

THE VILLAGES

Location: Sumter County, Florida
Area: 50 square miles
Road span: 750 miles
Number of retiree residents: More than 130,000
Number of Voyage autonomous vehicles: 6

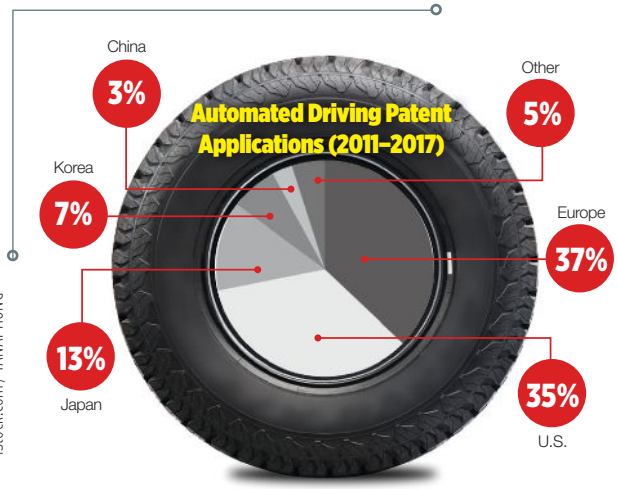
team runs suites of real-world traffic and validation tests in a completely controlled environment at a closed-course testing facility in San Jose, Calif.

"Voyage makes extensive use of simulation testing and closed-course validation before any of our vehicles are driven in our partner communities," Erlich said. "All changes must pass these closed-course tests before making their way onto the roads of our partner communities."

Vehicle design also ensures riders stay safe. "Our fleet vehicles have been designed with multiple levels of safety redundancies for braking, steering and power, and leverage an advanced diagnostics system to automatically detect anomalies and safely stop the vehicle," he explained. "In addition, we have developed a remote teleoperations solution that allows the vehicle to request additional help when a driver is not physically in the vehicle."

Making Autonomous Work

When building an autonomous system, localization — knowing exactly where you are in the world — is critical. Erlich said it's often difficult to estimate your position within an accuracy of several feet when using more traditional GPS solutions.



iStock.com/TANAPHONG

EUROPE TAKES THE LEAD

Autonomous vehicle technology is taking off in Europe, shows a study published by the European Patent Office and conducted with the European Council for Automotive Research & Development.

From 2011 to 2017, European patent applications related to automated driving increased 20 times faster than other technologies in recent years.

The "Patents and self-driving vehicles" study reveals automated driving patent applications at the European Patent Office rose 330%, compared with 16% for all technologies during the same time.

Photo: Swift Navigation

SWIFT NAVIGATION'S Duro is one of two GNSS receivers Voyage uses for its autonomous vehicles.

"For autonomous driving, you need to be able to estimate within several centimeters," he added.

Voyage uses Swift Navigation's GNSS receivers and Skylark network as one of the primary inputs into its localization solution.

Swift Navigation is a San Francisco-based tech firm that develops GPS technology to power autonomous vehicles. It is working to extend the Skylark network across the contiguous United States, and then plans to expand globally.

"Coupled with high-definition maps, odometry sensors and other inputs, we've been able to use Swift Navigation's differential GPS solution to achieve the localization results we needed to deliver a true autonomous driving service," Erlich said.

Voyage's autonomous vehicles are equipped with a suite of sensors on their roof racks that includes the Swift Navigation Piksi Multi GNSS receiver, lidar devices, cameras, radar and an inertial measurement unit. They create and constantly update a 3D map of the vehicle's surroundings.

A computer in the trunk integrates all sensor signals and uses the vehicle's Controller Area Network (CAN) bus to operate steering, braking and other functions.

Skylark, Swift Navigation's cloud-based GNSS corrections service, provides Voyage's autonomous vehicles with precise positioning to eliminate the complexity of deploying and maintaining GNSS networks.

Skylark offers a plug-and-play experience that delivers convergence times measured in seconds. Its positioning algorithms provide a continuous data stream to individual devices from the cloud. This data stream allows for quick positioning and high reliability and availability.

The correction service enables receivers to connect to a constantly adapting, cloud-based model to obtain GNSS observations. Dependence on base stations in each area of deployment is eliminated, increasing the geographic

area in which they can travel. Skylark works seamlessly with both of Swift Navigation's GNSS receivers — Piksi Multi and Duro.

In addition to Piksi Multi and Duro, Voyage uses third-party receivers and microprocessors that benefit from the lane-level positioning Skylark delivers.

The Swift product suite delivers centimeter-level localization —important to riders who may have mobility issues that require vehicles with smooth starts and stops.

Skylark was built specifically to deliver the speed, security, precision and reliability demanded by automotive manufacturers with autonomous and safety applications architected to support ASIL-rated (Automotive Safety Integrity Level) systems.

Because Skylark is a network, it is fault tolerant. In the unlikely event an individual cloud reference station goes offline, Skylark's positioning algorithms will continue to provide a continuous stream of corrections.

Once connected, Skylark creates a precise and constantly adapting model of the atmosphere and related errors affecting GNSS. Connected users simply turn on their devices to get the precise positioning data they need.

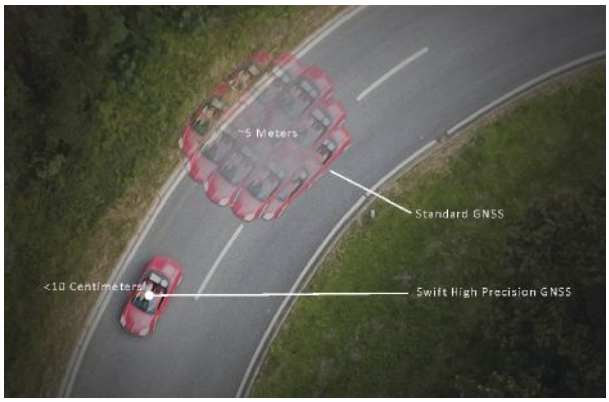


Image: Swift Navigation

SKYLARK provides high-precision localization.

Safety Drivers

As drivers get older, their mental and physical health can affect their ability to operate vehicles safely. Vision and hearing loss keep many older drivers off the road. Fear of driving at night or in the rain also can be a problem for older drivers. According to the Centers for Disease Control and Prevention (CDC), about 7,400 adults over the age of 65 died as a result of car accidents in 2016. That same

See AGE OF ACCEPTANCE, page 37. >>

The Importance of High-Precision GNSS

Fall is a beautiful time of year. But when the leaves drop, it means a lot of sweeping for most of us. Not so for the 200 campuses and parks in China using IdriverPlus' WO series of unmanned sweepers.

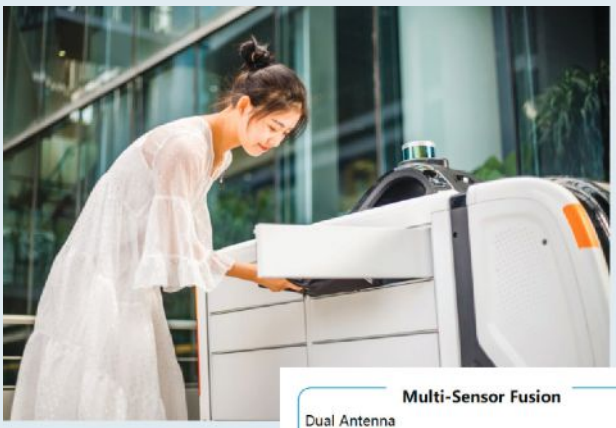
High-precision GNSS positioning plays an important role in making the autonomous units possible, providing real-time high-precision position, speed and time information.

Unicore's high-precision GNSS technology and their products' high reliability have enabled IdriverPlus' unmanned sweepers and logistics vehicles — China's first mass-produced products in intelligent driving. In January, IdriverPlus received the green light to test self-driving cars in Beijing.

Photos: IdriverPlus

Sweepers and logistics vehicles are not only used in open-sky areas, but also in complex environments shadowed by buildings or trees or experience multipath. These areas include school campuses, factory and science parks, and community squares. Complex environments result in different GNSS availability, reliability and convergence. In autonomous driving, the inputs the vehicle receives from GNSS and other sensors must be accurate and reliable.

The UM482 module used by the IdriverPlus is characterized by dual antennas, compact dimensions, high performance and low cost, providing anti-jamming performance. Integrated with on-board MEMS and Unicore's U-Fusion combination technology, the UM482 can effectively solve the disruption of positioning results caused by the loss of satellite signal, and further optimize the continuity and reliability of positioning and heading outputs in complex environments such as city canyons, buildings and tunnels.



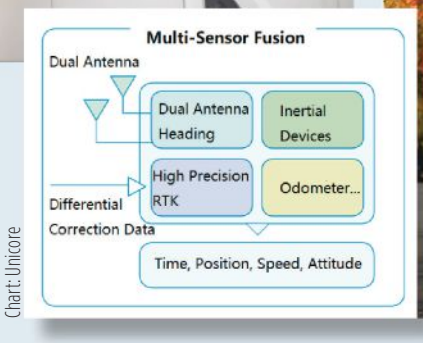


Chart: Unicore

THE SWEEPER WOXIAOBAI (below in Beijing's Haidian Park) has been in service for a year. At left, a customer removes her express package from the Wobida logistics vehicle.

AGE OF ACCEPTANCE

<< Continued from page 35.

year, more than 290,000 of adults over the age of 65 were treated in emergency departments for injuries sustained in motor vehicle accidents.

Residents at The Villages who have used the autonomous vehicles report positive feedback, Erlich said. They consider the service a major improvement to their day-to-day activities because it's convenient. Plus, they prefer the ability to be more carefree during happy hour, fewer hassles with traffic and parking, and lack of interactions with poor drivers.

Being on the cutting-edge of a generational technology also is a positive for many residents, Erlich said. "Autonomous vehicles create a clear path to safer, more accessible, and reliable transportation for everyone. From a safety perspective, autonomous vehicles have the potential to significantly reduce the more than 37,000 deaths attributed each year to driving. From a lifestyle perspective, there are also huge opportunities: from reclaiming daily commute time, to providing a reliable means of transportation to people with mobility challenges."

EQUIPMENT SPECS

GNSS receiver one. Swift Navigation — Piksi Multi
- Dual-frequency and multi-constellation
- Up to 20-Hz solution rates
- Raw data outputs from on-board MEMS IMU

GNSS receiver two. Swift Navigation — Duro
- IP67 rated
- Centimeter-level positioning
- Raw data outputs from on-board MEMS IMU

Lidar devices. Velodyne — VLS-128
- 128 channels
- Up to 300-meter range
- Up to 360-degree surround view

Cameras. iDS — Global-Shutter units

Proximity sensors. Chrysler OEM

Inertial measurement unit. Xsens — MTi-300
- 375-Hz bandwith for accelerometers
- 415-Hz bandwith for gyroscopes

Antenna. Swift Navigation — Mini-survey for the Duro RTK unit
- 1 L1/L2 GPS/GLONASS/BeiDou mini-survey

Photo: Swift Navigation

Piksi Multi.

Road Correction

Incorporating precise and consistent absolute location information is an essential component of enabling advanced driver assistance (ADAS) and autonomous driving (AD) technology for vehicles.

To help meet this need, Trimble recently released Trimble RTX Auto. The Trimble RTX Auto correction service provides a precise point position (PPP) solution that can be used to correct the position of any auto grade GNSS chipset. RTX Auto works in parallel with other on-vehicle sensors to deliver a positioning solution that satisfies ADAS and AD requirements.

Absolute position contributes to many features:

- **Lane centering.** Systems designed to keep a car centered in a lane, relieving the driver of the task of steering, is often achieved with cameras and absolute position data. Absolute position can be used when lines disappear, or weather prevents them from being seen.
- **Map aiding.** a combination of precise map and location data helps to navigate junctions, lane changes, roundabouts or intersections where lane information is essential to safe driving.
- **Prediction of future road structure.** Both allow a vehicle to begin slowing in advance of a bend in the road and to avoid harsh braking that would happen if the system only relied on short range sensors.
- **Adhering to the speed limit.** This helps drivers anticipate changes in speed limits when a downpour prevents cameras from seeing the speed limit signs or when they might be obscured by natural surroundings or another vehicle.

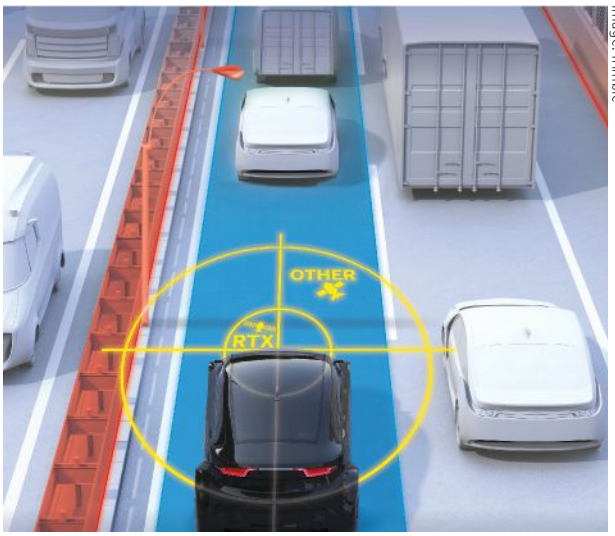


Image: Trimble

RTX Auto is both Automotive Safety Integrity Level (ASIL) and Automotive Software Process Improvement and Capability Determination (ASPICE) certified. These certifications validate that Trimble RTX Auto meets functional safety requirements for ADAS and autonomous applications in the auto industry.

Super Cruising. Trimble is on the road today providing RTX-based absolute positioning within General Motors' Super Cruise driver assistance feature, a hands-free driving system for the freeway. For more information on Super Cruise, visit **www.cadillac.com/world-of-cadillac/innovation/super-cruise**.

Positioning Intelligence Key to Autonomous

Hexagon's Positioning Intelligence (PI) division is an integral partner in many autonomous vehicle development projects, providing technologies such as SPAN (GNSS+INS technology), TerraStar-X corrections, and Automated Research and Development Platforms from its brands including NovAtel, VERIPOS and AutonomouStuff.


Photo: Hexagon

NovAtel hardware and software products, along with engineering support, address the need for accurate, reliable and robust GNSS positioning. TerraStar-X correction services deliver worldwide coverage and assured positioning with continuous availability, and provide the accuracy and rapid convergence needed to achieve lane-level precision for safe autonomous operation.

For developers of autonomous consumer transportation, integrated research and development automotive platforms from AutonomouStuff accelerate time to market.

Making It Safe. For large-scale automotive production, safety is the main focus. The Hexagon PI software positioning engine and TerraStar-X technology are being developed to ASIL-B (Automotive Safety Integrity Level B) standards to provide precise positioning for lane-level performance in autonomous applications.

OEM

Hemisphere GNSS Launches New Platforms

OEM boards provide next-generation ASIC technology

Hemisphere GNSS has released its next-generation digital and RF application-specific integrated circuit (ASIC) platforms, as well as three new positioning and heading OEM boards — the first products incorporating these technological advancements.

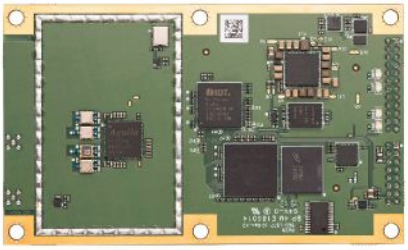
Hemisphere's new **Lyra II** digital ASIC and **Aquila** wideband RF ASIC designs optimize performance and provide the ability to track and process more than 700 channels from all GNSS constellations, the company said. Signals supported include GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS and L-band signal support and tracking for alternate binary offset carrier (AltBOC) and bipolar subcarrier asymmetric constant envelope BOC (ACE-BOC) (BS-ACEBOC), BeiDou Phase 3, L5, and QZSS/LEX CLAS-D and CLAS-E.

Lyra II includes built-in logics for GNSS/IMU measurement synchronization. Its dedicated acquisition engine searches multi-hypothesis in parallel for better time-to-first-fix in cold start and in signal-degraded environments.

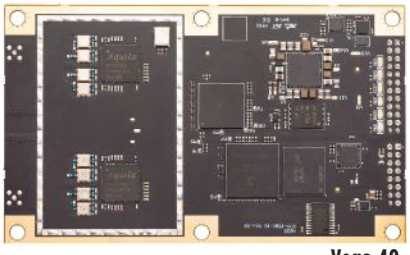
BUILDING ON THE PLATFORM

The Lyra and Aquila ASIC technology provide the foundation for a new GNSS receiver chipset architecture that significantly reduces the number of board components required, thereby reducing complexity, improving reliability and lowering power consumption.

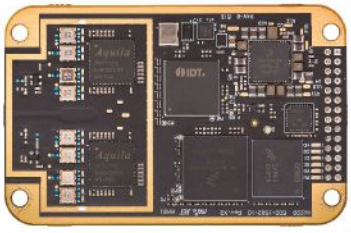
The technology platform also includes Hemisphere's new **Cygnus** interference mitigation technology with built-in digital filtering capabilities and spectrum analysis. The Cygnus technology provides enhanced anti-jamming, interference detection and mitigation.



Phantom 40.



Vega 40.



Vega 28.

Cygnus incorporates the latest digital filtering technology and an integrated Fast Fourier Transforms (FFT) analyzer for real-time spectrum analysis and interference detection. This architecture allows Cygnus technology to deploy precise targeted in-band filtering measures with minimal impact or disruption to available GNSS constellation signals resulting in higher satellite availability in environments where in-band interference is present. Cygnus also uses high-resolution analog-to-digital converters (ADC) for superior anti-jamming performance.

The Lyra, Aquila and Cygnus technologies will be available with the new Phantom 40, Vega 28 and Vega 40 OEM positioning and heading boards.

The **Phantom 40** positioning board is the first Lyra-based offering in a line of low-power, high-precision boards. Its multi-frequency, multi-GNSS receiver processes 700 channels with access to Hemisphere's Atlas GNSS global corrections network. The 60 x 100 mm module with 24-pin and 16-pin headers is a significant upgrade for existing designs using this industry-standard form factor.

The **Vega 40** and **Vega 28** are the first introductions in a new line of low-power, high-precision positioning and heading OEM boards. The multi-frequency, multi-GNSS receivers offer access to 1,100 channels and also include access to Atlas.

The Vega 40 is a 60 x 100 mm module with 24-pin and 16-pin headers, also an upgrade for existing designs. The Vega 28 is a 41 x 71 mm positioning and heading module, the smallest GNSS OEM heading module Hemisphere has ever offered to the geospatial market.

Hemisphere is integrating its new technology into other form factors and into many existing products, to be introduced in the coming months.

Photos: Hemisphere GNSS

OEM

Kolmostar Releases Low-Power Module

Kolmostar has launched an ultra-low-power GNSS module. The JEDI-200 reduces the energy for one position fix by up to 150x compared to traditional GNSS sensors, providing a positioning solution for location-based internet-of-things applications, the company said.

JEDI-200 specification highlights include 10-mW ultra-low-power consumption (measured) @ 1 Hz navigation rate; 1-second ultra-fast time-to-first-fix from cold start, and

Photo: Kolmostar

2-meter CEP high positioning accuracy. It supports GPS and BeiDou. It offers 100-byte compressed ephemeris (EPH) to enable A-GPS with speedy download via low-power wide-area network (LPWAN) technologies such as LoRaWAN and narrowband internet of things (NB-IoT).

The JEDI-200 is designed to achieve high accuracy even in dense urban canyons, for human and asset trackers, smart wearables, smart farming and infrastructure. Its reduced level of power consumption and its optimized efficiency with LPWAN technologies eliminate the need for frequent recharges or a large battery, enabling new possibilities in location-based IoT applications.

Tallysman Releases Helical GNSS Antennas

Tallysman, a manufacturer of high-performance GNSS and Iridium antennas, launched the first three products of a new range of helical antennas. Additional models will be announced in the third quarter of 2019 and onward.

The first three models of the Tallysman helical family are:

- **HC871.** A housed, dual-band, active GNSS antenna supporting GPS L1/L2, GLONASS G1/G2, Galileo E1, and BeiDou B1 (25 grams).
- **HC872.** A housed, dual-band, active GNSS antenna supporting GPS L1/L2, GLONASS G1/G2, Galileo E1, BeiDou B1, and L-Band services (36 grams).
- **HC600.** A housed, passive Iridium antenna (18 grams).

Photo: Allison Barwacz

The helical antenna in both housed (right) and unhoused form.

The active GNSS helical antennas feature a low-current, low-noise amplifier (LNA), and include integrated low-loss pre-filters, to protect against harmonic interference from high amplitude interfering signals, such as 700-MHz band LTE and other near in-band cellular signals.

Available in both housed and embedded OEM versions, the lightweight Tallysman helical antennas have excellent axial ratios, making them ideal for a variety of high-precision unmanned aerial vehicle (UAV) applications, the company said.

The housed Tallysman helical antenna models feature a robust, military-grade plastic case, while the embedded Tallysman helical antenna models can be custom-tuned for any application and configured with a variety of cables and connectors.

Patents have been applied for with respect to several aspects of these new products.

Screenshot: Honeywell

Be the Hockey Puck

The industry often describes products in comparative terms like "as small as a hockey puck." Honeywell takes this comparison a step further in a new video that shows its ultra-rugged HG4930 MEMS-based inertial measurement unit (IMU) being used as a puck by collegiate hockey players. The HG4930, which reached speeds up to 85 mph, is a high-performance micro-electro-mechanical system (MEMS)-based IMU designed to meet the needs of industrial markets including ground and aerial robotics, survey/mapping, stabilized platforms and transportation.

SURVEY

Smartphone, Data Collector Combine in TDC600

Trimble has introduced the TDC600 handheld, an ultra-rugged, all-in-one smartphone and GNSS data collector for geographic information system (GIS) and field inspection applications.

The rugged data collector runs on the Android 8.0 operating system and has a bright sunlight-readable 6-inch display, 2.2-GHz processor, 4-GB memory and an enhanced-capacity all-day battery.

More powerful and with a longer lasting battery than its predecessor, the TDC600 handheld supports the Trimble Catalyst GNSS positioning service that delivers subscription-based accuracy on demand for Android devices.

In addition, the TDC600 can be used with external receivers such as the Trimble R2 and R1 GNSS receivers, and also features a built-in receiver that supports GPS, GLONASS and BeiDou plus satellite-based augmentation system (SBAS) capabilities for real-time positioning.

The TDC600 is built for GIS users in organizations such as environmental management, utilities and government agencies. Wi-Fi, Bluetooth 4.1 and 4G LTE cellular connectivity support data and voice calls, so field workers can use the TDC600 as they would any consumer smartphone, communicating between the field and office, sending emails and texting.

Photo: Trimble

Nepali Team Reaches Highest Height

A Nepali survey team made a successful ascent of Mount Everest to measure its official height. This is the first height survey conducted by the government of Nepal. The precise height of Mount Everest — now listed as 29,029 feet, or 8,848 meters — has been contested since the first survey by British officers in 1849.

Nepal plans to end the controversy and declare both snow and rock heights of the world's tallest mountain.

Chief Survey Officer Khimlal Gautam and surveyor Rabin Karki reached the peak of Mt. Everest on May 22 at 3 a.m. local time and collected data from a Trimble R10 GNSS receiver gifted from New Zealand.

The final result of the official height measurement of Mt.Everest is expected within the next six months.

The surveyors stayed atop the peak for about 1 hour, 16 minutes. According to guide leader Tshering Janbu Sherpa, the team faced difficulties because of the exhaustion of oxygen of one member, who was rescued during the descent.

Besides a GNSS survey at the summit, teams conducted precise leveling, trigonometric leveling and gravity surveys. The GNSS survey will cover 285 points with 12 different observation stations, nine of which are in hills of Sankhuwasava, Bhojpur and Solukhumbu districts.

TRANSPORTATION

Orolia Aircraft Distress Beacon Uses Galileo Return Link Service

Orolia introduces a new product for commercial aircraft safety, the Kannad Ultima-S emergency locator transmitter (ELT).

The Kannad Ultima-S is designed for installation in the cabin of commercial aircraft or in its life raft. It is capable of notifying the crew about the launch of a search-and-rescue operation via Galileo Return Link Service (RLS).

For passengers, installation of the Kannad Ultima-S means their flight can be located accurately, with rescue following if an aircraft evacuation is needed.

Orolia's Kannad Ultima-S ELT was developed under a two-year contract through the European GNSS Agency's Tauceti Project. Orolia says this is the first beacon to use the Galileo RLS.

Orolia's Kannad Ultima-S meets new and evolving European Aviation Safety Agency and U.S. Federal Aviation Aministration requirements related to ELTs and non-rechargeable lithium batteries documented under the RTCA DO-227A standard.

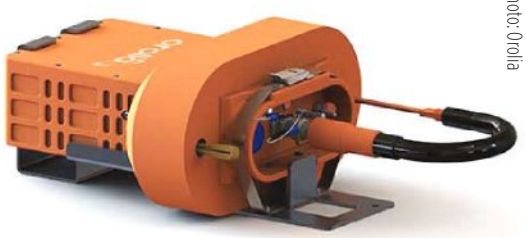


Photo: Orolia

The new ELT benefits from the Cospas-Sarsat infrastructure, which is being upgraded to provide highly accurate location data and nearly real-time reporting to search-and-rescue operators through global coverage.

Kannad Ultima-S survival distress beacons complement Orolia's Ultima family of next-generation ELTs, following the company announcement of the Global Aeronautical Distress and Safety System (GADSS)-compliant fixed Ultima-DT. Orolia provides aircraft manufacturers and operators with a complete solution for every ELT application.

KANNAD ULTIMA-S FEATURES

- Certified to the new lithium battery regulations to avoid the risk of battery fires.
- A multi-GNSS receiver to accept multiple signals such as GPS and Galileo to detect the aircraft's location faster and deploy rescue teams sooner than before.
- Dual activation modes: manually or automatically upon contact with water.
- An RLS option to notify the crew that the distress signal has been received and help is on the way (available on Galileo).
- Multiple configurations are available to install in aircraft cabins and life rafts. With a rugged, compact, and easy-to-install form factor, the Kannad Ultima-S can be installed through a carry-off bag or a mounting bracket and requires little storage room.

USDOT to Preserve Spectrum for V2X Safety

The U.S. Department of Transportation (USDOT) in June convened leaders from state departments of transportation, stakeholders in academia, and representatives from the auto industry in Washington, D.C., to discuss the importance of preserving the 5.9-GHz spectrum for transportation safety.

The 5.9-GHz band supports vehicle-to-everything (V2X), a wireless technology that enables data exchanges between a vehicle and its surroundings. Starting with advanced technology development and demonstrations about 20 years ago, America has deployed 54 operational V2X projects, improving safety today, with more in the pipeline.

Vehicle manufacturers plan to equip new car models with the technology. This next generation of intelligent transportation communications promises to improve safety for drivers and for vulnerable roadway users, such as pedestrians, bicyclists, disabled persons and transit users.

Preventing Crashes. The National Highway Traffic Safety Administration conducted a V2X demonstration in Hawaii in June. The agency estimates that full adoption of just two V2X safety applications would prevent about half a million crashes and save approximately 1,000 lives a year. As more safety applications are developed for vehicles, more lives could be saved.

V2X will also support an efficient, safe and smooth transportation system, with vehicles communicating with signal lights to improve traffic flow. For instance, dynamic traffic-signal control and prioritization have the potential to reduce travel times by up to 27% and reduce fuel emissions.

TRANSPORTATION

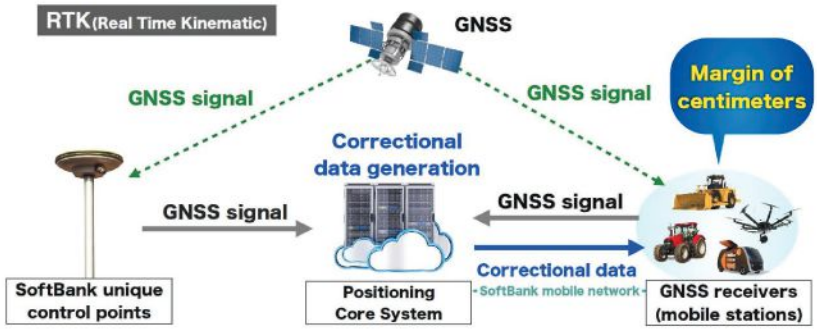


Image: SoftBank

SoftBank Plans Satnav Service

Using QZSS to Support Autonomous Vehicles

SoftBank plans to introduce a centimeter-accurate, real-time satnav-based positioning service, specifically using Japan's Quasi-Zenith Satellite System (QZSS), to guide autonomous vehicles across a range of industries in Japan.

The company said it will install more than 3,300 control points at base stations across Japan to deliver centimeter-level accuracy over its mobile network coverage area, providing real-time kinematic (RTK) positioning.

Testing begins in July with a scheduled launch of commercial service by the end of November. Test partners include Yanmar Agribusiness Co., Ltd., a provider of autonomous assisted driving for agricultural machinery; Kajima Corporation, which performs construction site management with automatically controlled drones for aerial photography and monitoring; and SB Drive Corp., a provider of autonomous and assisted driving technology for buses.

Low-Cost Receivers. SoftBank is developing proprietary low-cost GNSS receivers so that "new services and market expansion can be realized." A positioning core system provided by ALES Corp. will generate correctional data based on signals received and transmitted by SoftBank's own control points over SoftBank's mobile communications network to agricultural and construction machinery, self-driving cars, drones and other equipment carrying GNSS receivers. The company expects that centimeter-level positioning can thus be done in real time.

Besides control points, SoftBank also will use the Geospatial Information Authority of Japan's approximately 1,300 GPS-based control stations.

For devices without GNSS receivers, SoftBank is developing cloud-based RTK positioning, which will provide centimeter-level, location-based services for equipment that needs to be miniature and energy-efficient, such as infrastructure surveillance sensors and wearable devices.

SoftBank Group Corp. is a Japanese multinational conglomerate holding company headquartered in Tokyo. It owns operations in broadband, fixed-line telecommunications, e-commerce, internet, technology services, finance, semiconductor design and more. ALES is a joint venture established by SoftBank and Enabler in July 2018. Enabler employs GNSS and related technologies to produce such products and services as a synchronization solution for mobile base stations for subway stations and a patented indoor positioning/time synchronization infrastructure platform in Japan.

NEWSBRIEFS

SIEMENS INTEGRATES U-BLOX INTO V2X FLEET

Siemens has integrated the u-blox ZED-F9K high-precision dead-reckoning module into its Toyota Prius V2X (vehicle-to-everything) test fleet. Siemens carried out live demonstrations of the technology at ITS European Congress 2019 in Eindhoven, the Netherlands. V2X test vehicles typically determine their position using high-end GNSS receivers. By opting to use the ZED-F9K, Siemens was able to align the performance of their test fleet with real-world conditions while also reducing the cost and the engineering effort required to develop their vehicles.

Photo: Siemens/u-blox

TOYOTA TEAMS WITH CARMERA ON HD MAPS

Toyota Research Institute-Advanced Development (TRI-AD) and Carmera have jointly developed a proof of concept for camera-based automation of high-definition (HD) maps for urban and surface roads. This is the first step towards realizing TRI-AD's open software platform concept — an automated mapping platform — to support the scalability of highly automated driving by combining data gathered from vehicles of participating companies to generate HD maps. The challenge is to create and maintain maps for urban areas and local roads that go beyond the highway road network.

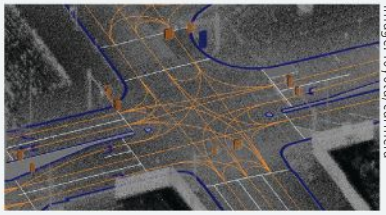


Image: Toyota/Carmera

UAV

Parachute System Ready to Rescue Mavics

Photos: ParaZero

Drone safety company Para-Zero Technologies Ltd., together with the Northern Plains UAS Test Site (NPUASTS), has completed the testing and compliance process for ParaZero's SafeAir Mavic in accordance with U.S. ASTM F3322-18.

The ASTM F3322-18 Standard Specification for UAS Parachutes was designed to enable civil aviation authorities, like the Federal Aviation Administration (FAA), to determine whether a parachute system is airworthy for flight over human beings. The standard defines more than 45 aerial deployment tests in various failure scenarios, verified by a third party, in this case, NPUASTS.

ParaZero's ASTM-compliant SafeAir Mavic is designed specifically for DJI's Mavic 2 series. The smart parachute system monitors UAS flight in real time, identifies critical failures, and autonomously triggers a parachute. The system contains a flight termination system, a black box to enable post-deployment analysis, and a warning buzzer to alert people below of the falling drone.

The completion of the compliance process will open the door for UAS operators interested in the possibility of safe and legal UAS operations over people using the DJI Mavic 2. The FAA has granted a waiver for flight over people to an operator who uses ParaZero's ASTM compliant SafeAir Phantom. The ability to safely operate over people and in urban environments, via waivers, is expected to promote growth of the UAS industry.

Flight-Planning Software Ready for Rotary-Wing Drones

Image: Topcon

Topcon Positioning Group has released its next-generation flight-planning system for its rotary-wing aerial UAV offering. The new Intel Mission Control Software is designed to facilitate automated flight planning, managing missions and data handling for the Intel Falcon 8+ drone – Topcon Edition and its available payload options.

The software is designed to increase accuracy with advanced mapping features that allow operators to easily set project parameters and prepare missions using presets for 2D areas such as polygon, corridor and city grid, as well as 3D structures like towers, buildings and facades.

Operators can take advantage of 2D and 3D map views with the ability to import more precise project details and parameters, including restricted airspace, and support to adapt flight planning over difficult terrain. It features the ability to import elevation, KML, GeoTIFF and Shapefiles for real-life visualizations targeted for accurate planning. Expanded preset options support automated flight including circle of interest, panorama, and 2D and 3D missions with automatic elevation and terrain adoption.

The software includes automatic pre-flight safety and system checks while in mission planning. Operators will receive detailed communication such as estimated battery life, airspace integration, ground and object safety limits, maximum dive and climb rate, minimum and maximum altitude, camera speed and target photo coverage and quality.

MAPPING

Nearmap Streams 3D Imagery, Offers AI Tech

Aerial imagery company Nearmap has launched a new 3D product to streamline the way industries such as urban planning, architecture, construction, government and councils view and shape cities across Australia and the U.S.

The company previewed its artificial intelligence (AI) technology at its customer event Navig8, in June.

Nearmap 3D. While Nearmap has offered 3D imagery since 2017, the new iteration of the technology allows users to instantly stream 3D content at massive scale via its MapBrowser web application. Users can visualize, measure, define a custom area, export the 3D imagery and use it in their workflows with other commercial platforms and tools.

Because the imagery is updated frequently, businesses can work with the most current information to make more informed decisions.

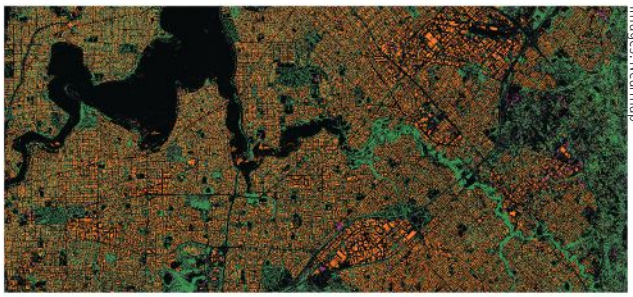
The lightweight platform offers customers an immersive 3D experience, allowing them to visualize cities in 3D from any direction, measure distances, and immediately export a custom area in a variety of 3D formats. The download time is a matter of minutes for most requirements and only a few hours for very large footprints.

The Nearmap 3D library covers more than 400,000 square kilometers spanning major urban areas in Australia and the U.S.

Artificial Intelligence. Nearmap's new AI technology is turning millions of aerial images — captured over a decade and multiple times a year — into valuable datasets. The datasets can be used to more accurately and efficiently measure change and quantify attributes, such as solar panels, pools, roofs or construction sites.

The AI technology will allow organizations to identify locations with specific attributes, reducing site visits, generating more leads, and eliminating the time involved to inspect properties manually.

3D IMAGE of the Las Vegas Strip.



Images: Nearmap

COMPOSITE aerial image of Perth, Australia.

Organizations ranging from small businesses to large companies and cities will be able to take advantage of AI-driven location intelligence.

For AI, Nearmap has performed machine-learning analysis on more than 1 million square kilometers of imagery across Australia and the U.S. — about 80 million properties.

DEFENSE

Photo: Abom

Abom Equips Goggles with GNSS/INS

Commercial goggle company Abom has launched new augmented reality (AR) goggles for safety, industrial and military markets. The P3 AR goggles feature accurate tracking of orientation, velocity and positioning using GNSS/INS receiver capability.

Other features include 3D spatial mapping and tracking, integrated VX Inc. CNED display technology, and an array of integrated image sensors and advanced embedded electronics. The goggles' stereoscopic dual displays have an ultra-high-brightness output with adjustable control and 1080p output.

The goggles are optimized with a military-ballistics-rated lens (MIL-PRF 32432A) that complies with the Military Compliance Eye Protection (MCEP) program, meeting many challenging elements of the U.S. Army's IVAS specification (HUD 3.0).

For industrial applications, the P3 also meets ANSI Z87.1+ high-mass impact rating and IP-55 ingress protection against water and dust, which opens the door for supporting National Safety Council technology initiatives and requirements for meeting extreme IP-67 rating compliance.

The P3 goggles are designed for extreme environmental durability and cold-weather climate conditions. It has advanced thermal image sensors, and embedded within the Goggle Chassis is an ultra-high-performance depth camera supported by two infrared cameras optimized for low-light conditions up to 10 meters.

US Army to Equip Vehicles with New Anti-Jam Units

The U.S. Army will send prototype anti-jamming systems to its 2nd Cavalry Regiment, stationed in Europe, in September to aid forces under GPS jamming or spoofing conditions. The first generation of Mounted Assured PNT Systems (MAPS) and anti-jam antennas are nearly ready for integration aboard armored Stryker vehicles, and the Army is already evaluating proposals for an upgraded version incorporating an inertial navigation system (INS) for further resilience.

The shipment comes in response to widespread Russian jamming of GPS signals from the sub-Arctic to the Middle East. Col. Nickolas Kioutas, Army project manager for positioning, navigation and timing (PNT), announced the move at the annual C4ISRnet conference in Arlington, Virginia.

Three vendors are providing prototypes for the IMU-equipped MAPS-2, with testing to begin in September. A MAPS-3 capability, drawing on lessons learned in 1 and 2, may be underway soon. GPS Source, now a subsidiary of General Dynamics Mission Systems, made MAPS-1 and is now competing for MAPS-2.

The initiative reflects a new approach by the Army of "doing much smaller, iterative programs," according to Col. Kioutas. Traditionally, U.S. armed forces have taken years to develop large, complex weaponry and supporting systems, and then longer to deploy them.

Rapid deployment of smaller, quickly designed and manufactured batches creates the opportunity for rapid feedback on what works and what doesn't, with equally rapid return to the design board and remanufacture.

The PNT program has left requirements broad and open to change, asking for industry guidance. "We don't know exactly what we want. Tell us how we should do this the best, and then we'll test that," Kioutas said.

Photo: U.S. Army/Spc. Hubert D. Delany III

THE EIGHT-WHEELED ARMORED Stryker is faster than a tank.

MOBILE

Smartphone Gets Dual-Frequency with BeiDou-3

The latest Lenovo smartphone, model Z6 SE, offers dual-frequency GNSS capable of tracking the latest BeiDou-3 signal using an Allystar chipset.

Allystar says this is the first time a smartphone supports the new BeiDou signal. Fitted with a Allystar HD8040 series chipset, the Lenovo Z6 youth edition provides position accuracy up to sub-meter, according to Allystar.

The HD8040 supports all civil signals on the L5 band. Besides GPS/QZS L5 and Galileo E5a, the BeiDou-3 signal B2a already has been implemented to maximize the visible satellites in L5 band.

With dual-frequency capability, the receiver tracks more than one signal from each satellite on different frequencies — GPS L1 and L5, Galileo E1 and E5a, and BeiDou B1 and B2a.

B2a will replace B2I and broadcast on medium Earth orbit (MEO) and inclined geosynchronous orbit (IGSO) satellites. The code lengths are 10230, which have better anti-cross-correlation performance and are designed with a separated pilot component and data component to improve tracking sensitivity.

Images: Allystar

Multipath can lead to positioning inaccuracy of up to several meters, caused by signals bouncing off of higher buildings. This error can be nullified and mitigated by using two frequencies instead of one in urban areas. Under a relatively open-sky environment, measurement error caused by the ionosphere is usually eliminated by a linear combination of dual frequencies to achieve sub-meter accuracy.

Microsemi Qualifies 10-Km Fiber-Optic Kit

Carrying timing signals over optical fiber links to more than 10 kilometers, ViaLite's new GNSS/GPS Fiber Extension Kit has been successfully qualified for use with Microsemi's timing and synchronization products.

Included in the kit is the ViaLiteHD GPS Link, designed to provide a remote GNSS/GPS signal or derived timing reference to equipment located where there is no reception, such as inside buildings, tunnels and mines.

The kit is suitable for GPS, Galileo, GLONASS and BeiDou bands, and the links provide a wide dynamic range with negligible signal degradation from noise or interference.

Photo: ViaLink

ViaLiteHD Blue OEM module, one of the available formats for the GPS RF over fiber link.

ViaLite, a division of Pulse Power & Measurement, worked closely with Microsemi engineering and product management teams to create the optimized extension kit. Simple single-link extensions are available from both companies, and more complex distributed systems can be defined and supplied by ViaLite.

Synchronization infrastructure systems must meet various levels of redundancy, provide multiple timing and frequency outputs, and apply the most accurate GNSS and satcom techniques for measuring offsets between geographically dispersed clocks.

The systems are employed across a wide range of industries, including communications, data centers, aerospace, defense, industrial, financial services, government, oil and gas, power and transportation.

USING UAVS AS GNSS SATELLITES

REAL-TIME REAL-WORLD TESTBED FOR NEW SIGNALS

BY DANIEL S. MAIER, THOMAS KRAUS, DANIELA E. SÁNCHEZ, RONNY BLUM AND THOMAS PANY
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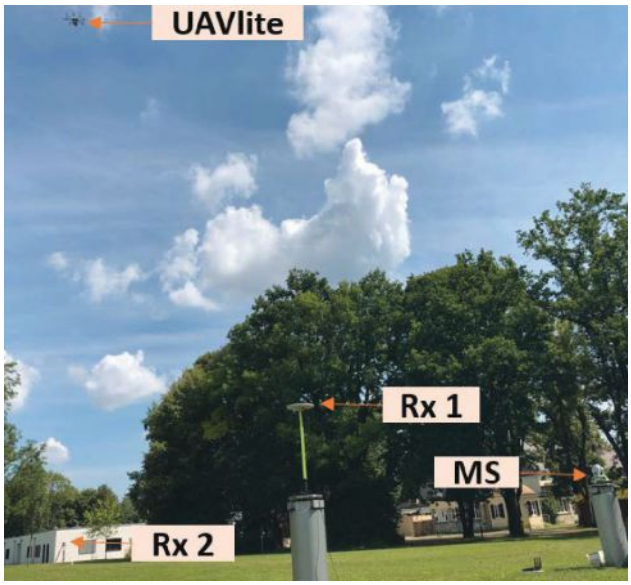
This research paper presents an update of the authors' real-time real-world testbed for new GNSS signals. It includes experience gained in setting up an airborne pseudolite, UAVlite, to analyze the code- and phase-ranging performance and to test navigation message authentication schemes. UAVlites transmit GNSS like signals free from any local transmitter multipath, in contrast to ground-based transmitters. A software-defined radio allows easy broadcast of new navigation signals, which can be tested in real environments.

Purpose. To improve GNSS signals, it is important to test and analyze signal performance under various conditions and harsh environments. This is done mainly with computer simulation. However, a simulation always relies on assumptions and simplifications of a real-world problem. Therefore, the authors are developing a flexible, cost-efficient and highly adjustable test system, usable for real test scenarios. With this system, researchers can investigate GNSS signal structures, range performance, authentication methods, channel coding and signal behavior under foliage, blockage, jamming, spoofing and other interferences.

Testbed Setup. Key elements include a UAVlite, two ground stations and a composite binary offset carrier signal. The system has demonstrated decimeter code-range accuracy and millimeter phase-range accuracy. Performance of a Galileo Open Service Navigation Message Authentication implementation was also analyzed.



TESTBED with UAVlite, Rx antennas 1 and 2 and the multistation.

The testbed has potential in the field of signal analysis and optimization, especially in multipath, channel coding, authentication or robustness against jamming, spoofing or other interference for existing GNSS signals, and for developing potential new GNSS signals.

This paper was presented at ION-GNSS+ 2018. See **www.ion.org/publications/ browse.cfm.**

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Monitoring the Earth
for Geopolitical and Economic Insights

Data from Earth Monitor reveals the number of cars and trucks in an area of Amsterdam.

Image: Airbus

The new Earth Monitor tool draws from the Airbus imagery archive and satellite tasking capabilities to provide advanced geospatial analysis, trends and detection maps.

Available as part of Airbus's OneAtlas (**oneatlas.airbus.com**) suite of geospatial tools, Earth Monitor enables customers to draw precise, timely and meaningful conclusions. It uses Orbital Insight's machine learning and computer vision expertise through algorithms that detect changes in infrastructure and land use in near-real time. It can identify and count objects such as cars, trucks, roads, homes, buildings and construction sites and, soon, aircraft.

Earth Monitor can identify trends, spot patterns and track economic activity, delivering advanced geospatial analysis and change-detection maps on customized areas of interest to users in defense, intelligence and law enforcement.

Earth Monitor comes from a collaboration betweem Airbus Defense and Space, a French aerospace company, and Orbital Insight, a Silicon Valley startup. The OneAtlas platform combines Airbus' constellation and tasking services with Orbital Insights' analytic capabilities.

Orbital Insight's algorithms draw on petabytes of data from multiple sources, such as satellite and synthetic aperture radar imagery, geolocation intelligence and vessel traffic data.

The tool's interface enables users to create and manage projects, customize analyses and define period and measurement frequencies.

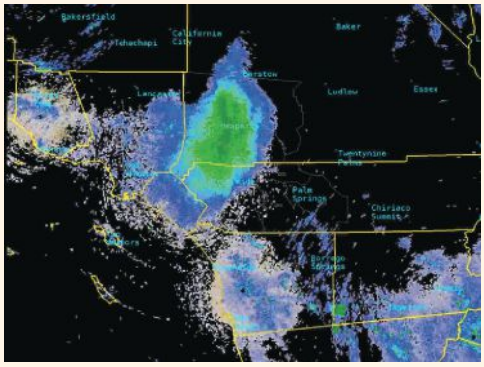
SEEN & HEARD

TETHERED DRONE

Spanish police used a tethered drone system for traffic monitoring, crowd control and surveillance of the UEFA Champions League Final, played June 1 at the Wanda Metropolitano stadium in Madrid. An Elistair tethered U06 Plus drone oversaw 67,000 fans in the stadium and 200,000 in nearby streets. Use of the drone was in response to a heightened terrorist threat level in Spain, making it part of the largest security operation for any sporting event in the Spanish capital. Continuously supplied with power, the drone maintained its position at 50 meters high for 8 hours.

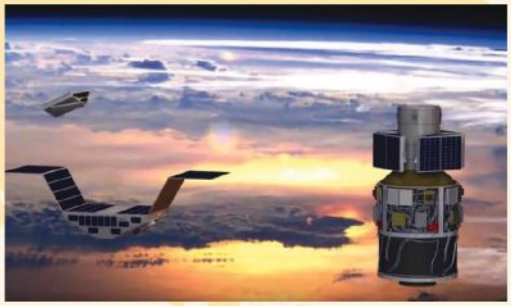
LADYBUG, LADYBUG, FLY AWAY HOME

In this case, California. In June, a millions-strong swarm of ladybugs showed up on radar as a weather event when the insects took to the sky to hunt for aphids. One explanation for the unusual swarm is that a large population of ladybugs had been spread out in a mountainous area, and rising temperatures triggered their mass migration to valleys where they might find an abundance of aphids to eat.



TRICKY SIGNALS

NASA's eight CYGNSS (Cyclone Global Navigation Satellite System) microsatellites collect radio signals from GPS beacons to characterize hurricanes. A month after launch in December 2016, the CYGNSS team noticed the signals were wavering when the U.S. began to boost the radio power on 10 GPS satellites as they passed over northern Syria. The swings don't interfere with other scientific uses of GPS, but for CYGNSS the measurements of high winds varied by 5 meters a second or more — the difference between a category-2 and category-3 hurricane. After two years of work, the CYGNSS team has compensated by repurposing a secondary antenna on the satellites to measure GPS signal strength.



NEW ZEALAND JOINS AUSSIES ON SBAS

Land Information New Zealand (LINZ) will work with Australian counterpart Geoscience Australia to investigate ways to deliver a regional satellite-based augmentation system (SBAS) to significantly improve GPS accuracy. The proposed SBAS will support emergency helicopter crews, providing pilots with accurate vertical guidance for landing, enabling them to reach people faster in difficult terrain and bad weather. The SBAS will also improve the safety of self-driving cars. The new system will improve accuracy to less than a meter, and in some devices to 10 centimeters.

PHOTO CREDITS: CYGNSS satellite launch artist's concept/NASA; ladybug blob/National Weather Service; Madrid stadium drone/Elistair; helicopter/Auckland Rescue Helicopter Trust

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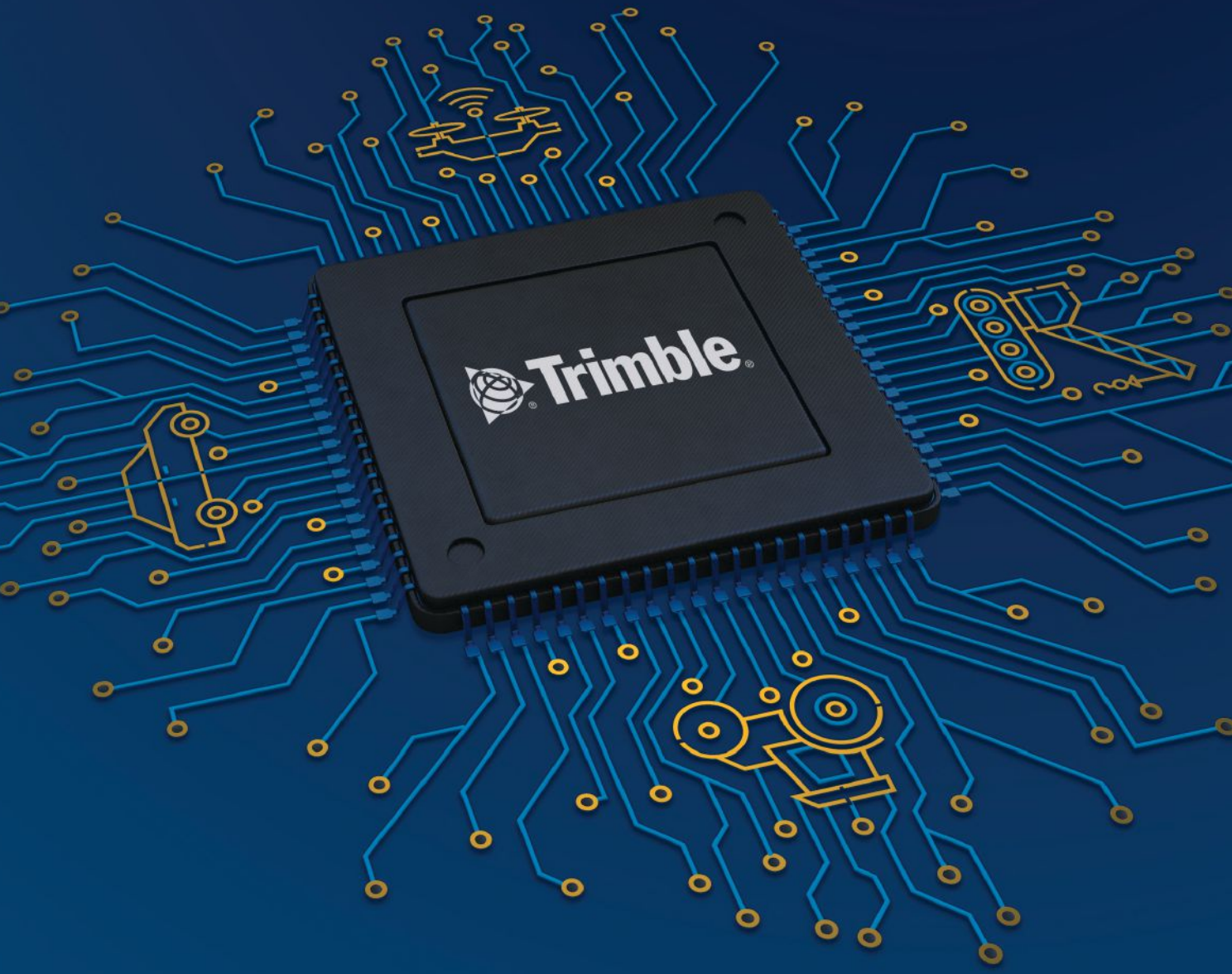
When we're in here, you're unstoppable out there.



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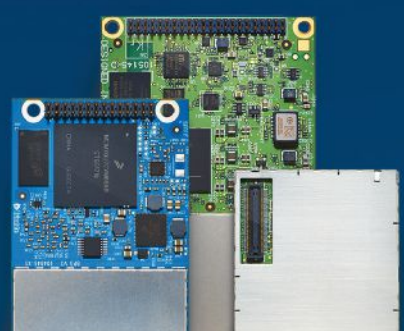

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