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Dark Ice
So Cool

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3D Mapping Aids Notre Dame Restoration

Inside the GPS III Factory

Mapping Democratized

A NORTH COAST MEDIA PUBLICATION

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Photo: Ed Koziarski

Image: OpenStreetMap/Mapbox

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NEWSLETTER EXCERPT

Closing the Horizontal/Vertical BIM Divide

WRITTEN BY William Tewelow AND CO-WRITTEN BY Jon Gustafson

Significant focus on infrastructure asset delivery and lifecycle must become a priority so that architects, engineers and construction (AEC) can leverage BIM systems for design, construction and management solutions.

Innovations in BIM applied to infrastructure construction projects will enable "smart" solutions. This article explores BIM for infrastructure insights and brings attention to closing the BIM divide between the vertical (buildings) and the horizontal (linear) infrastructure industries, such as roads, bridges and pipelines.

For smart systems to be applied to infrastructure, CAD needs to evolve to the point where those multi-dimensional models can integrate with geographic information systems (GIS). The larger the project, the more necessary it is for a seamless data transition from the local engineering scale to the municipal, regional or national reference systems.

BIM ias an intelligent 3D model-based process that gives the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure. It is like a GIS in many respects, but applied locally to a structure... It is still an evolving technology, but it is clear that soon it will do for AEC and facilities management what GIS did for surveying and cartography...

Read the full article at **geospatial-solutions.com/category/opinions/**.

Galileo's Strength

BY ALAN CAMERON
EDITOR-IN-CHIEF

In February I had the privilege of addressing the European Space Agency's (ESA's) Navigation Days conference in the Netherlands. An internal ESA event, Navigation Days gathers engineering staff from centers in several countries to discuss the present and future of their endeavors.

Since most of the audience had been "bathing" in Galileo, EGNOS and the evolution of both systems for many years, the Director of Navigation and the Galileo Project Manager thought it would be interesting for all to have an "outsider" perspective and opinions on Galileo and the European GNSS position in the world.

Though my half-hour talk ranged freely, and perhaps somewhat wildly, across many sectors and subjects, it had two main foci: the fundamental differences between Galileo and the three other GNSS, and the future portended by those differences. A future column here will address the latter, that is, the future. At present, the present distinctions.

To me, they distill down to three elements: active stimulus of market development, well-funded research into new applications, and — actually the foundation stone of the afore two — democratically elected governments representing citizenry with altruistic values: a strong desire for the common good, thoughtful regulation, intertwined diversity and open borders.

In sum, Galileo's strength is the strength of the European Union.

For example, the Horizon 2020 framework program offers €80 billion to support and foster research from 2014–2020. Three E-GNSS calls in H2020 have a total budget of €100.9 million and they synergize with topics on societal challenges. To my knowledge, the U.S. has nothing like this in terms of downstream R&D programs; it is left to the marketplace to initiate and sustain such efforts.This corresponds to the respective economic systems of the two political entities. West of the Atlantic has historically taken a laissez-faire attitude towards applications, development and societal challenges: let the marketplace act.

The other two GNSS powers, Russia and China, as authoritarian regimes, may build viable GNSS and mandate their use, but the synergy between government and users is lacking. This missing link could prove an economic as well as technical weakness in the future. In some respects, it already has.

Particularly in transportation, freight and liability-critical applications, where the European GNSS have devoted extensive forethought to both user and societal needs (read "the environment"), we may see a distinctly different and more progressive future unfolding in Western Europe, led by Galileo.

> "Active stimulus of market development, well-funded research into new applications, and citizenry with altruistic values."

On the other hand, in the realm of pure consumer devices, the market may be a stronger driver, and U.S. products and services with a GPS bent may remain dominant.

The Public Regulated Service (PRS) for defense, security, emergencies and critical infrastructure, is the hidden strength of Galileo.

I've run out of space here for non-scientific speculations, but will expand them in a future column or online.

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VERIFIED

GPS Plays Role in Black Hole Image

BY Tracy Cozzens
MANAGING EDITOR

On April 10, the world looked in awe at the first image of a black hole. The image was captured by a world-spanning network of radio telescopes that together, using Orolia atomic-clock technology, create the Event Horizon Telescope. It zeroed in on the supermassive monster — 6.5 billion times the mass of the sun — in Galaxy M87 to create the image.

As Innovation Editor Richard Langley explains, the technique used to capture the image — very long baseline interferometry (VLBI) — relies on GPS. (VLBI was the topic of Langley's Ph.D. thesis.)

VLBI links two or more radio telescopes that can be many kilometers apart, or even on different continents. VLBI is used in both geodesy and astronomy. There is also a practical GPS link to the Event Horizon Telescope. From the second of six simultaneously published open-access papers on the result: "All timing is locked to a 10-MHz [hydrogen] maser reference and synchronized with a pulse-per-second (PPS) Global Positioning System (GPS) signal…"

Image: Event Horizon Telescope Collaboration

"[T]he long-term drift of the maser [is] compared to GPS, measured by differencing [and plotting] the 1 PPS ticks from the maser and local GPS receiver. The vertical width of the trace is due to variable ionospheric and tropospheric delays of the GPS signal, while the long-term trend represents the frequency error of the maser. The drift measured from this plot, and its effects on the fringe visibility, are removed during VLBI correlation."

From the third paper: "In order to reconstruct the brightness distribution of an observed source, VLBI requires cross-correlation between the individual signals recorded independently at each station, brought to a common time reference using local atomic clocks paired with the Global Positioning System (GPS) for coarse synchronization."

Go to **gpsworld.com/blackhole** for more.

PNT Q&A — EDITORIAL ADVISORY BOARD

How will wireless technologies most significantly drive change and innovation in the surveying industry?

"GNSS by design, by physics, will always be challenged in urban settings. 5G and GNSS will provide a step to ubiquitous positioning in built-up areas — a blend of relative and absolute positioning, terrestrial and satellite-based measurements."

Tony Agresta
Nearmap

"The improvements in bandwidth and latency of 5G will create new opportunities for edge and cloud-based computing advances such as AI and machine learning to penetrate surveying, as 5G is doing in other industries, to improve efficiency, accuracy and automation."

Michael Swiek
GPS Alliance

GPS III Performance Aloft, Factory Update

Interview with Lockheed Martin's VP of Navigation Systems

Editor Alan Cameron talked in April with Johnathon Caldwell, Lockheed Martin's VP of Navigation Systems.

Photo: Lockheed Martin

GPS III production line.

Tell us about the on-orbit performance of the GPS III SV01, launched in December.

On Jan. 8 we began broadcasting navigation data across all signal chains, and the satellite has been in checkout mode since then. According to all the reports I get from various independent agencies, the vehicle has been performing outstanding, and the payload performance has been exceeding expectations.

We've been evaluating in depth how the payload performs, including independent agencies assessing the signal quality. Later this fall we'll transition satellite ground control from the OCX Block 0 ground control system installed at Lockheed Martin's Waterton Launch & Check Out facility over to the GPS Operational Control Segment (OCS) the 2SOPS is using now, and we'll really see the performance improving from where it is today.

The satellite is doing what everybody had hoped. There's always great anticipation when a new system goes up. It's actually been a very smooth on-orbit test campaign. We're wrapping up on the early side; we'll be ready to transition into the OCS this fall.

This past December we completed a major Architecture Evolution Plan (AEP) 7.5 OCS upgrade. This included both hardware and software upgrades to the legacy control system, and the Contingency Operations (COps) upgrade is coming later this fall. This is the software upgrade that will let OCS fly this first GPS III satellite and let the Air Force take advantage of great new capabilities. We will deliver the upgrade in May; it will get packaged up and delivered into the OCS in the fall. SV01 will then move from Lockheed Martin's Waterton launch and checkout facility control to Air Force 2SOPS control and join the constellation on the OCS.

A GPS satellite doesn't do its mission by itself. It takes an entire system to run. You're always monitoring signal quality and tweaking things to get the optimal performance. Today, we're flying SV01 by itself. The OCS and the 2SOPS crew will start flying it like they do the others, giving it the daily update and looking at the signal quality and maximizing the performance.

We're certainly at the top end of what we thought we might be able to achieve in terms of signal accuracy.

And GPS III SV02 has shipped to the Cape.

We've wrapped up functional testing; it's in great shape. We're now in a quiet period prior to final review leading up to fueling decisions in May

See **GPS III**, *page 12*

SatGen Signal Simulation Software

SatGen signal simulation

We are proud to announce that **SatGen** signal simulation software can now be used with **LabSat Wideband** to simulate all major constellations and signals.

If you need to record, replay or simulate multi-frequency, multi-constellation signals, then we have an easy to use, and cost-effective solution.

For more details, please visit labsat.co.uk/signals

GPS III, *continued from page 10.*

for a planned July launch.

Using the Delta IVb rocket for SV02 offers a good opportunity to demonstrate the wide range of launch vehicles that GPS III is capable of. The satellite has great compatibility across platforms, a flexibility that's a benefit for the Air Force.

The factory was also getting pretty full so it was great to ship out SV02. When it gets to the end of the line and ready to go, you want to get it out and have it doing the mission it's designed to do.

How about the production status of SVs 03 through 10 on the factory line?

SV03 has gone through complete environmental tests and is ready for delivery to the Air Force later this spring. SV04 is in final environmental test and will deliver later this year. SV05 is in thermal vacuum (TVAC) testing now, and doing an outstanding job. TVAC is the hardest test we go through, and it's as if it's flying in the environment of space. It's the stress test. SV06 is put together, and now in its initial functional testing.

> "We're certainly at the top end of what we thought we might be able to achieve in terms of signal accuracy."

There aren't many production lines of this size of large satellites. It's very impressive. As you look down the line, our high bay is modeled after the best of production lines. Hardware and avionics and power systems are coming in as piece parts, getting built in. As you go down the bay, the vehicles are getting more and more complete. Now on the front end of the line we've got SV07 and SV08 starting. SV09 will begin later this summer, and not long after we hope to open up space for the 10th vehicle.

Last words: Progress so far on GPS IIIF?

We're now in the full design campaign for the follow-on satellites that will lead to critical design review, the capstone of the process. The CDR will wrap up in February 2020.

MAGNETIC FIELDS

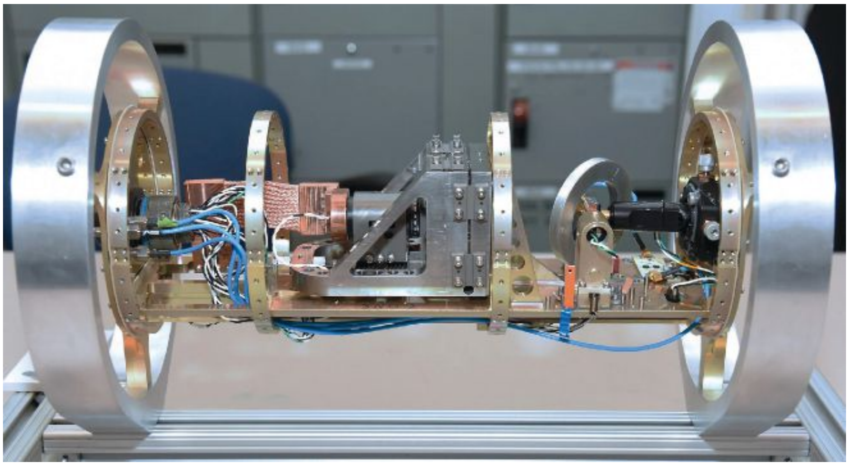
Quantum Magnetometer Senses Its Place

Scientists continue to search for new technologies to serve the PNT mission. One novel way to augment GPS comes from a newly developed technology involving a quantum magnetometer. Researchers at Lockheed Martin call it Dark Ice; it uses magnetic sensing as an alternative means of determining location without use of satellite signals.

Mike DiMario and his team have developed a prototype magnetometer that uses a synthetic diamond the size of a salt crystal to measure the direction and strength of nearly imperceptible magnetic field anomalies. They overlay that data with maps of Earth's magnetic field, supplied by the National Oceanic and Atmospheric Association, to produce precise location information.

Special quantum-level impurities in the molecular structure of the diamond, where intermittently a carbon atom drops out and its neighbor is a nitrogen atom, enable the detection of magnetic field waves. These nitrogen vacancy (NV) centers are hyper-sensitive magnetic sensors. When illuminated by a laser, the diamond emits more or less light depending on the surrounding magnetic field's strength.

Position + Direction. Dark Ice differs from current magnetic sensors aboard ships and planes in that it can measure both the field strength and the direction the field is pointing. "The real advantage of this quantum-based technology is its ability to produce a true magnetic field vector, while at the same time having a very large dynamic range and bandwidth," DiMario explained.



Images: Lockheed Martin

THE DARK ICE **quantum magnetometer measures about 31 centimeters in length.**

Project development "was like peeling an onion: with each new layer removed, the team advanced. We had no idea of the expected outcome, other than what system modeling, the laws of physics and good engineering could predict. There was always something we could not have predicted or even thought of."

In addition to developing this navigational capability, the team has also demonstrated that Dark Ice can harness Earth's magnetic field to transmit communications across barriers intended to block all traditional signals, and track moving vehicles in real time.

Unjammable. "This project was designed for times when extenuating circumstances might prohibit your use of traditional GPS signals, and you need something that is unjammable, passive and always available. The Earth's magnetic field meets this description if we can adequately sense and make use of it," DiMario said.

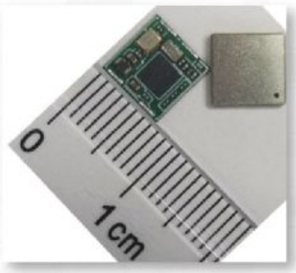
He wants to downsize Dark Ice to hockey-puck size for convenient use on multiple platforms. "In real-world conditions, if I can get within 200 meters of GPS accuracy, that would be a huge success," he claimed. Such precision would serve as a backup or verification to GPS, not a sole-means navigation system.

With its powerful sensing capabilities and small size, Dark Ice could function as the most reliable way to do things like identify hard-to-find watercraft in search-and-rescue missions and fly aboard aircraft in the battlefield. Navigation, search and communications — all in one compact sensor. ◍

EARTH'S **magnetic fields.**

①

②



③


④


⑤

1. SIGNAL ANALYZER

TESTS GNSS-DISCIPLINED OSCILLATORS

The PhaseStation ADEV Frequency Stability phase noise test system is a new signal source analyzer. It tests signal performance in a host of products such as GPS- or GNSS-disciplined oscillators. It can also be used to qualify and evaluate local oscillator performance for GNSS receiver design, including GPS TCXO evaluation and parametrization, or to take stability measurements of 1PPS and arbitrary frequency outputs from GNSS receivers. It is also useful in optimization of GNSS receiver Kalman filter design via the GNSS receiver 1PPS output signals. It automatically synchronizes and syntonizes (calibrates) the internal dual oscillator DOCXO option to external GNSS receivers via 1PPS input.

Jackson Labs, jackson-labs.com

2. 'VESTED' TRACKER

LINE FOR LTE, IOT, CHILD SAFETY

The Trax G+ personal GPS tracker has real-time tracking capability with update rates up to every 10 seconds. For customised industrial applications, the new Trax G+ can support up to two updates per second. It also comes with wireless charging and IP68 water resistance. The Trax G+ 4G LTE-M supports 4G LTE-M and NB-IoT standards, with both European and U.S. models available. The Trax G+ app offers unlimited geofences, augmented reality tracking, speed alerts, location history, the possibility to track multiple devices and device sharing. A special collaboration with POC sports brand resulted in the POCito VPD Air Vest + TRAX. The vest provides a child with back protection for winter sports and is designed to store a TRAX POC Edition device.

WTS Positioning Solutions, trax.business

3. MULTI-GNSS MODULE

SUPPORTS CIVIL SIGNALS ON THE L5 BAND

The TAU-0707 is a multi-band, multi-GNSS module series. Within its 7.6 x 7.6 millimeter size, the TAU-0707 supports GPS, Galileo, GLONASS, BeiDou, QZSS, IRNSS and all civil bands (L1, L2, L5, L6). The module is a concurrent multi-band receiver embedded with a Cynosure III single-die standalone positioning chipset, which offers multi-frequency measurements and simplifies integration for third-party applications. The TAU1206-0707 and TAU1205-1010 models are better in multipath mitigation due to the higher chipping rate of L5 signals relative to L1 C/A code. For professional applications, module TAU1303-0707 comes with built-in support for standard RTCM protocol (MSM), supporting multi-band multi-system high-precision raw data output, including pseudorange, phase range, Doppler, SNR for any kind of third-party integration and application.

Allystar Technology, www.allystar.com

4. OPEN-SOURCE RECEIVER

OFFERS GNSS FOR THE ENTHUSIAST

NUT2NT+ is an open source, multi-frequency, multi-signal, front-end GNSS receiver board built around the NT1065 chip. The receiver has been specifically created for satellite navigation enthusiasts. The NUT2NT+ hardware and software solution offers user the ability to set a receiver's modes and frequencies, to capture all signals continuously, and to have complete control over primary processing features. The receiver is available via the Crowd Supply website.

Amungo Navigation, www.amungo-navigation.com

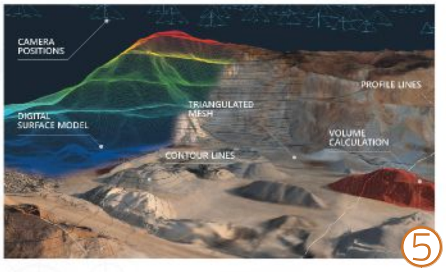
5. 5G GNSS RECEIVERS

FOR UTC TIME SYNCHRONIZATION

The GT-88 timing module and GF-8801/02/03/04/05 disciplined oscillator are for users who require UTC time-synchronized signals (1 PPS/10 MHz) to meet the new 5G requirements. Achieved stability is better than that of an atomic clock, including rubidium. The GT/GF-88 series includes an algorithm, Dynamic Satellite Selection, that provides outstanding multipath mitigation in urban canyon environments. It support GPS, GLONASS, QZSS and Galileo.

Furuno Electric Co. Ltd., furuno.com

LAUNCHPAD | SURVEY & MAPPING



1. MACHINE CONTROL

SYSTEM IMPROVES SAFETY, SPEED FOR DRILLING AND PILING CONTRACTORS

The Groundworks Machine Control System enables contractors to perform drilling and piling operations with centimeter-level accuracy. Using a touchscreen display, operators can personalize the interface with configurable views. The software aligns with other solutions in the Trimble Civil Engineering and Construction portfolio. Stakeless navigation reduces rework and decreases the need for personnel working near the machine during operation. Contractors can drill to the specified location, depth, orientation and inclination angle. Better rock fragmentation and lower hauling costs can be achieved by optimizing drill-hole spacing, angles and the location of the machine for a more even blasting pattern. Auto stop reduces overdrilling. Automated quality assurance and quality control reporting includes capture of start and end positions, time, elevation and actual embedment depth.

Trimble, www.trimble.com

2. SURVEY SOFTWARE

IMPROVED FOR UAV USE

Virtual Surveyor now enables users to process larger projects without buying more powerful computers or cloud services. Version 6.2 solves the problem of large files by offering enhanced clipping and mosaicking functionality. Users can merge multiple processed pieces of orthophotos and digital surface models into a single project, and create smooth edges with the new clipping tool. The mosaic can then be exported to a new TIFF file or serve as the basis for a full area virtual survey. A 3D Fly Through capability allows users to select spatial bookmarks and waypoints and create a movie that allows the viewer to fly through the terrain.

Virtual Surveyor, virtual-surveyor.com

3. GNSS RECEIVER

TILT COMPENSATES FOR OUT-OF-PLUMB MEASUREMENTS

The compact HiPer VR features advanced GNSS in a rugged IP67 design. Its GNSS chipset has Universal Tracking Channels Technology that automatically tracks every satellite signal (GPS, GLONASS, Galileo, Beidou, IRNSS, QZSS, SBAS). It also has an integrated 9-axis IMU and 3-axis eCompass. TILT (Topcon Integrated Leveling Technology) is designed to compensate for mis-leveled field measurements out of plumb by as much as 15 degrees.The HiPer VR can be used for static or kinematic GNSS post-processed surveys, as a network RTK rover with the FC-5000's internal 4G/LTE cellular modem, as a UHF/FH/Longlink jobsite RTK rover, and also in Topcon's patented Hybrid Positioning workflow.

Topcon Positioning Group, topconpositioning.com

4. MOBILE LASER SCANNER

WITH NOVATEL AND VELODYNE

Lidaretto is a flexible mobile laser scanner for aircraft, land vehicles or on foot. Combining high-end technology by Velodyne and NovAtel, Lidaretto produces highly accurate point clouds for professional applications such as mapping, surveying, GIS and inspection. The NovAtel OEM7 receiver provides 555 channels, and is SPAN-enabled and optionally dual GNSS. Signals received include GPS+GLONASS L1 and L2; the receiver is upgradable to Galileo and BeiDou. Accuracy is achieved to 1–2 centimeters.

Lidaretto, www.lidaretto.com

5. PROCESSING SOFTWARE

FOR LAND SURVEYING

3Dsurvey version 2.0 is a software ecosystem for land surveying data processing. Users can take photos with any standard digital camera, import images into 3Dsurvey, and produce their own orthophoto maps and digital surface models, as well as calculate volumes faster. Data is processed automatically based on matching algorithms. Smart tools in the software increase efficiency. Also available is the flight planning app 3Dsurvey Pilot and the viewing app 3Dsurvey Viewer.

3Dsurvey, www.3dsurvey.si

All GNSS civilian signals

TRIUMPH 3

Based on the TRIUMPH 3 chip with 864 channels

• Spread Spectrum • Bluetooth • UHF • 4G/LTE Cellular • Wi-Fi • Integrated GNSS antenna

see back page >

After adding the high precision built-in inclinometer, now we added

motorized auto focus for the J-Mate high precision camera

J-Mate Overview

6 pages inside >

JAVAD

www.javad.com

J-Mate Quick Overview and Update to Videos

First let's set the record straight: J-Mate is not a total-station. J-Mate and TRIUMPH-LS **together** are a **"Total Solution"** which is a combination of GNSS, encoder and laser range measurements that **together** does a lot more than a total station. At long distances you use GNSS and at 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**.

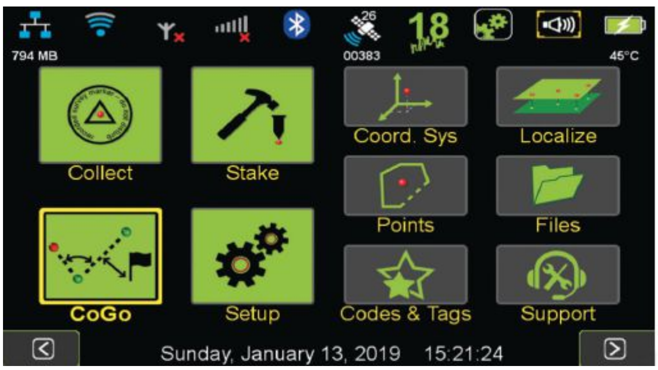
One major improvement that we did recently is to add motorized control of the camera focus feature.

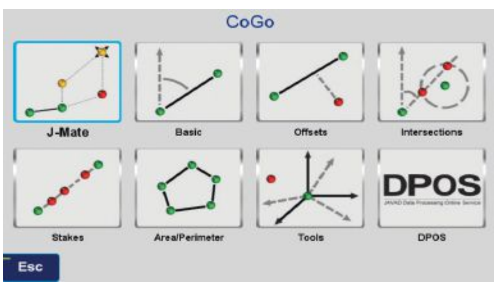
As with the TRIUMPH-LS, with the J-Mate we also provide software improvement updates regularly and free of charge. Download the J-Mate update in your TRIUMPH-LS and then inject it to the J-Mate. When you connect the TRIUMPH-LS to the J-Mate, the injection will be done automatically; but with your consent.

There are many new features in the J-Mate. We try to explain them in a few steps. Please also view the J-Mate videos in our website.

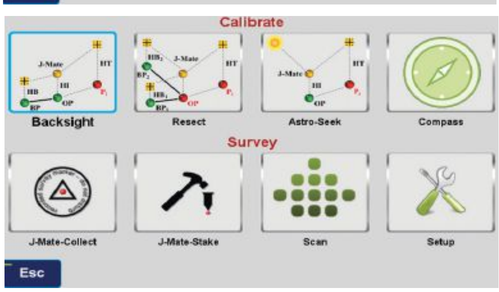
Connecting J-Mate to TRIUMPH-LS:

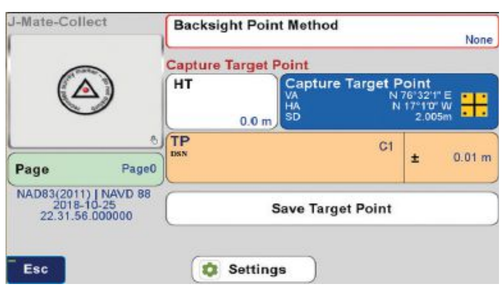
TRIUMPH-LS communicates with the J-Mate through Wi-Fi. Turn on both the TRIUMPH-LS and the J-Mate. Click the Wi-Fi icon of the TRIUMPH-LS Home screen to connect to the J-Mate, much the same way as you connect TRIUMPH-LS to your Wi-Fi access point. J-Mate has ID of the form JMatexxx.





After connection, try to get acquainted with the **Main Navigation Screen**: On the TRIUMPH-LS Home screen, click CoGo/J-Mate/J-Mate Collect/Capture Target points.





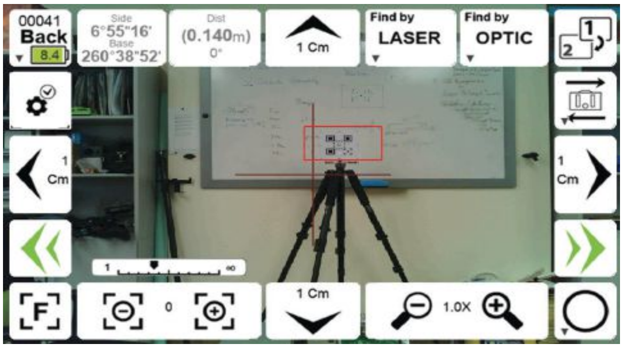
Finding the target automatically:

There are three ways to search and find the target automatically:

1) One is by laser to scan and snap to a point when range changes by the specific amount. This is particularly valuable to snap to cables, poles and edges of buildings.

2) Second is search by laser for the object of the specific flat size and focus on its center, including the J-Target that we supply.

3) Third is with the camera to search for the J-Target. We will discuss these later.



Switching between the two cameras:

You can view the scenes by the wide-angle (about 60 degrees) camera of TRIUMPH-LS, while sitting on top of J-Mate; or by the narrow angle (about 5 degrees) precise camera of the J-Mate. Click Button **"8"** of Figure 1 to switch between the two. A rectangle on the wide angle camera of the TRIUMPH-LS shows the viewing area of the J-Mate camera which helps in aiming to targets.

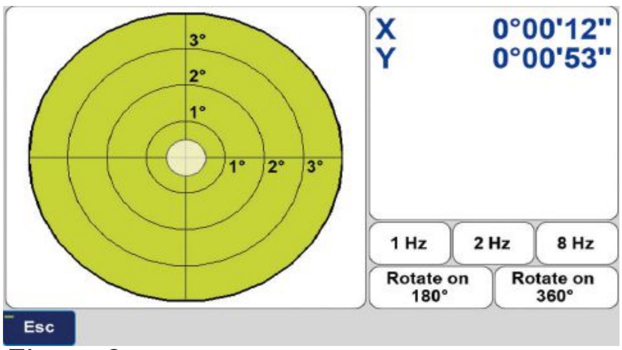


Figure 3

Viewing the embedded Inclinometer:

Hold button **"8"** or click button **"19"** of Figure 1 to see the embedded 0.001-degree electronic inclinometer of the J-Mate as shown in Figure 3. It updates 10 times per second.

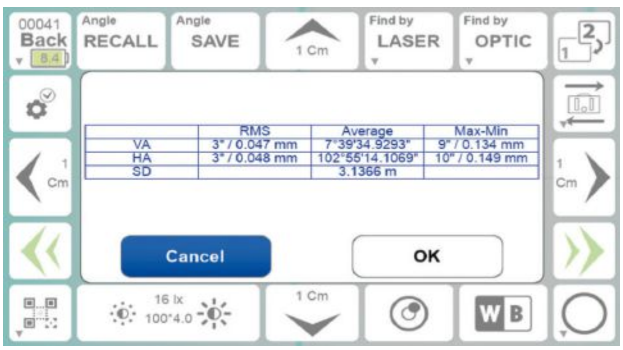


Figure 4

Taking a point:

When you focus on your target manually or automatically, you can click the "Take" button (**"10"** in Figure 1). The Encoders will be measured 10 times, the average, RMS and spread will be shown and you can decide to accept or reject (Figure 4). The accepted points will be treated like RTK points but labelled as "JM" points.

You can also automatically take measurements around that point. Hold Button **"10"** to set up the area around the target.

You can access and treat them like any other points in the TRIUMPH-LS.

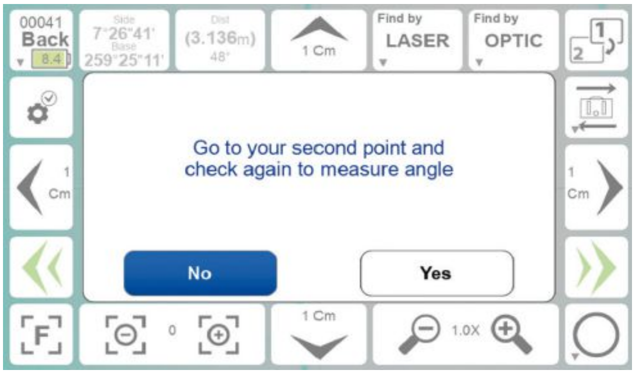
Figure 5

Viewing the measured points:

Clicking button **"7"** in Figure 1 will change some control buttons. Hold it long and you will see live view of the points taken by J-Mate (Figure 5).

Measuring angles quickly:

Aim at the first point and click button **"2"** of Figure 1. Then Aim to the second point and click this button again. You will see the horizontal angles between the two points. You can save the measured angles in clip boards and use it elsewhere when you need.



Saving and Recalling Orientations:

Aim at a point and click button **"17"** of the Figure 1 to save the horizontal, vertical, or both of that orientation (Figure 6). Click button **"16"** to rotate to that saved orientation.

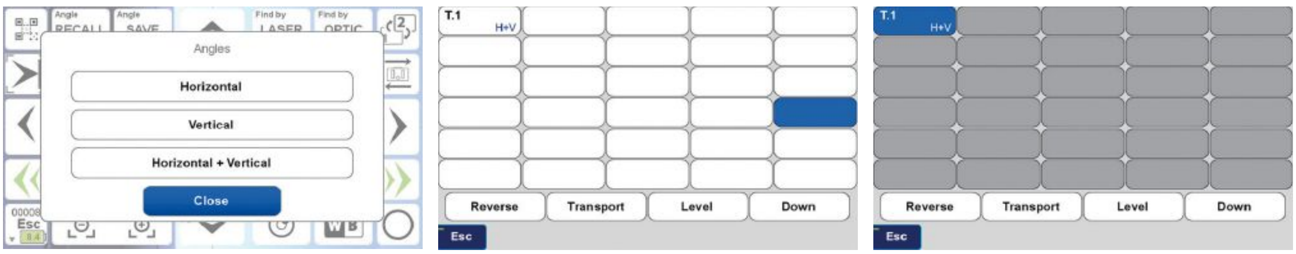


Figure 6

Scanning, snapping and finding targets:

Hold button **"5"** of Figure 1 and see the screen on the right in which you can select some parameters. Then click the "Select Target" button which takes you to the screen below. In this screen you can select the type of objects that you want to detect and measure automatically.

You can search for J-Targets, Tubes, and Corners. Corner is when the linear surfaces change direction.

You can select and set the parameters of each target.

You can view the 3D image of the scanned file in the "File" icon of the Home screen of the TRIUMPH-LS as shown at the end of this article.

Connecting and Re-connecting J-Mate to TRIUMPH-LS

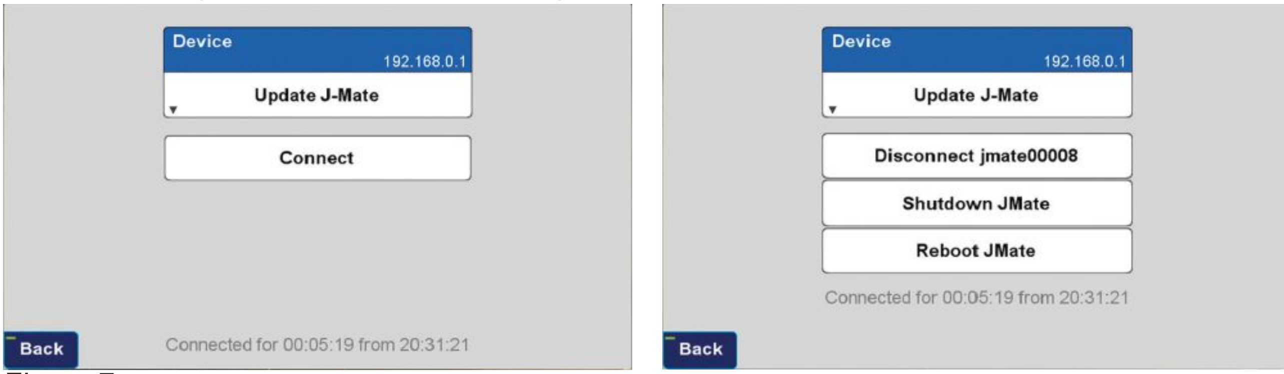


Figure 7

Holding the button **"1"** in Figure 1 which will take you to the set up screen and then to Figure 7 which lets you disconnect J-Mate, Reboot, or turn off. Like all Wi-Fi connections, you may lose connection and need to use this screen to disconnect, re-connect, or re-boot J-Mate and in some occasions reboot TRIUMPH-LS too, especially when connection between the camera of the J-Mate and TRIUMPH-LS is lost.

View range and angular measurements

Boxes **"2"** and **"3"** of the Figure 1 show the range and angular measurements. It reads up to 20 times per second. Click box **"3"** to enter the measured offsets between the two cameras.

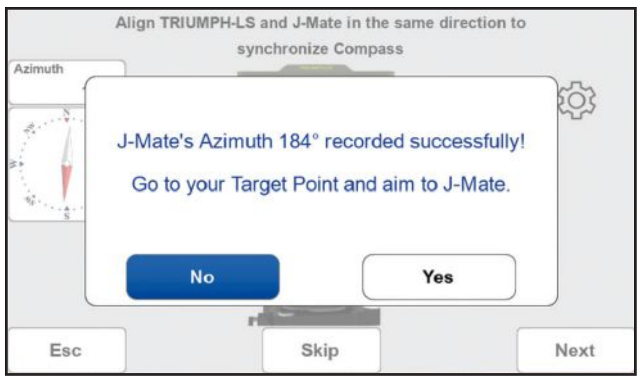
Automatic finding of the Target:

Click the J-Target icon (**"21"** of the Figure 1). You will be guided through the following steps to aim at your target point:

1. Put the TRIUMPH-LS on top of J-Mate (or slightly above it, but at the same orientation as the J-Mate, to be far from the motor magnets of the J-Mate) and click Next.

This step will transfer the compass reading of the TRIUMPH-LS to the J-Mate encoders.

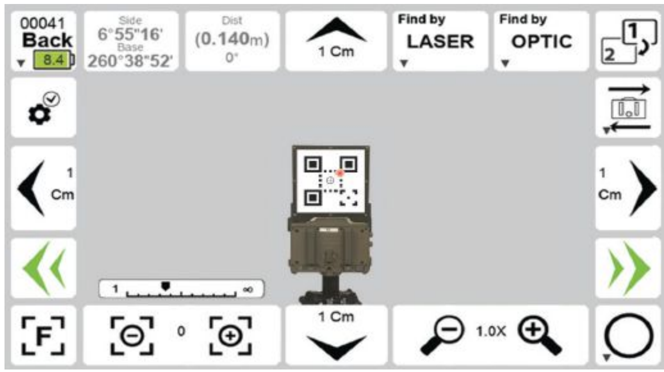
You can skip this and the next step if you are in an area that the compass readings are not valid or you can aim manually in the next steps.



2. Go to your target, Put the J-Target on top of the TRIUMPH-LS and aim the TRIUMPH-LS towards the J-Mate (with the help of the TRIUMPH-LS camera) and click Next.

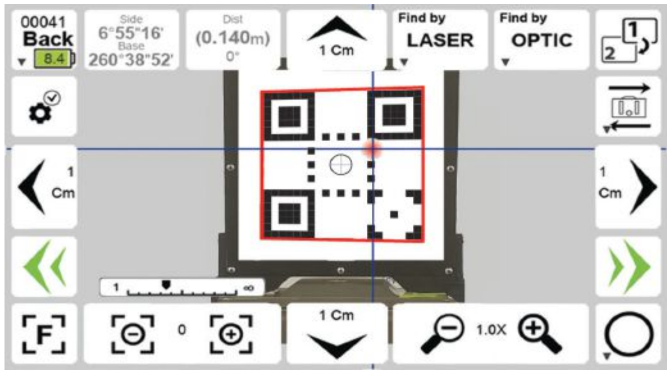
This will help the J-Mate to know the general direction to the target and limit its search range. You can go back to previous step to fine tune view of the J-Mate. Or you can skip these two steps.

3. You will see the J-Mate camera view on the TRIUMPH-LS screen. You can fine tune the J-Mate view by the navigation buttons to make recognition faster. You can skip these steps if you don't want to make the search faster.



In here you can also manually aim at the center of the J-Target panel and take your shot.

4. Click "Optic" if you want the J-Target panel to be scanned and centered automatically.



When J-Mate focuses on the center of the J-Target, you can click the "Take" button. You will be asked if you want to record the point.

5. If you also want to find the center of the J-Target by Laser scanning, you can click the "Laser". If Laser scan is successful, you can click the "Take" button to replace the previous measurement with the current measurement done by laser scanning.

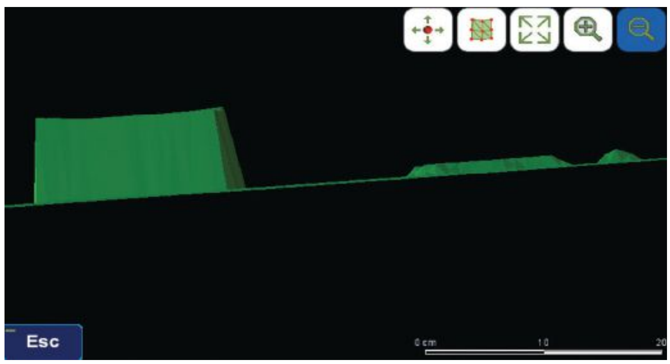
The center of the J-Target is vertically collocated with the GNSS antenna and you don't need to be exactly perpendicular to the J-Mate path.

If light condition is such that camera cannot find the J-Target, chances are better that laser scanner can find it.

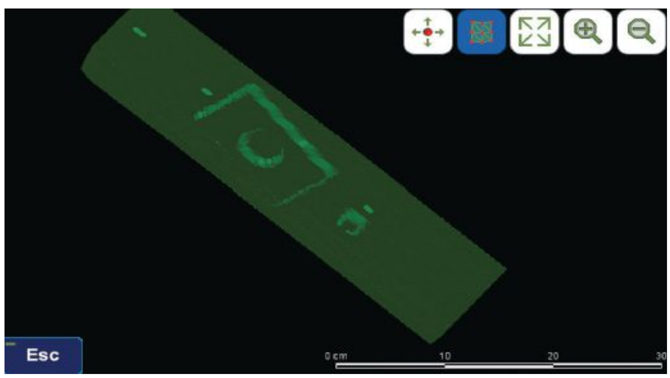
View scanned Images:

You see the 2 views of the 3D scanning

The first scan image is scan of a 1 cm thick and a 6 cm thick objects. 1 cm step resolution.



The last one is scan of a 12.5 x 8 cm object of 1 cm thickness.



This overview as also an update to videos at www.javad.com.

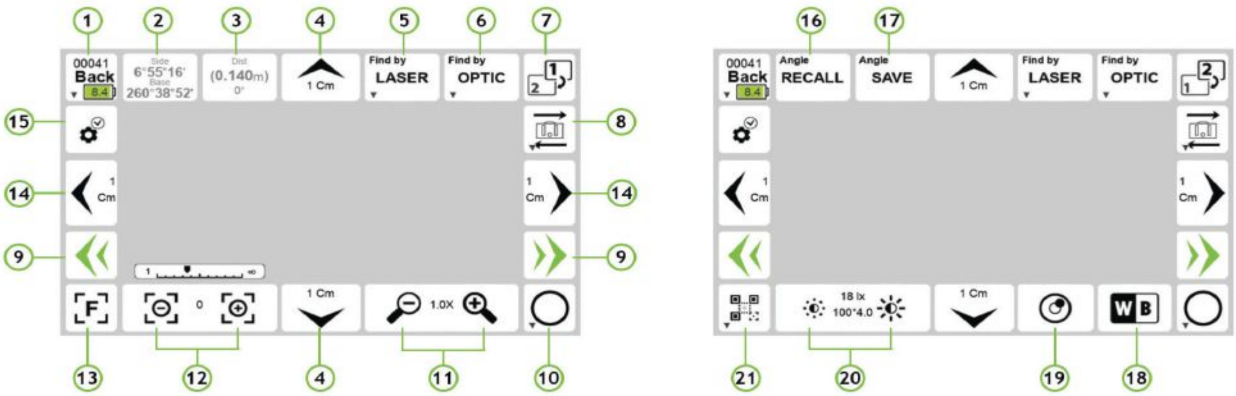


Figure 1

This is the **Main Navigation Screen.**

Clicking the button **"7"** in Figure 1 will switch some controls as shown above.

Aiming at Targets:

You can find targets manually or automatically.

There are five ways that you can manually rotate the J-Mate towards your target:

1. There are Left/Right/Up/Down buttons around the screen (**"4"** and **"14"**). Each click moves the J-Mate according to the value that you assign to them in the set-up screen (**"15"**), as shown in Figure 2.

2. While holding these buttons down, J-Mate rotates about 5 degrees per second.

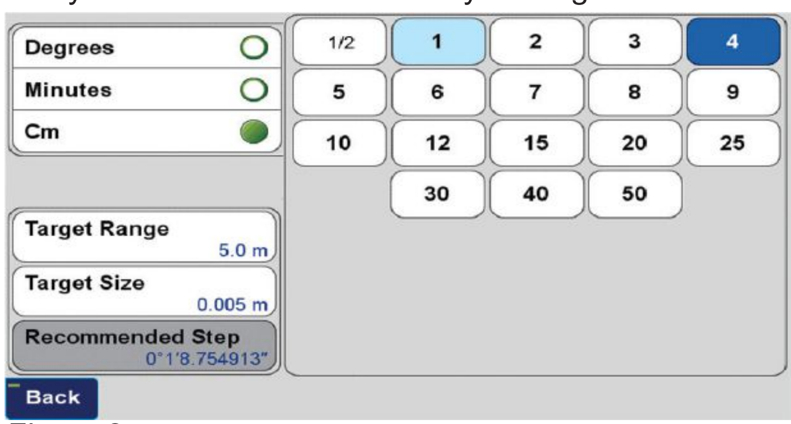


Figure 2

3. Buttons **"9"** are "Fast Motion" buttons. While you hold them the J-Mate rotates about 30 degrees per second.

4. You can point J-Mate towards points by touching points on the screen and by gestures.

5. You can also rotate the J-Mate manually while it is not moving automatically, but limit that to the small rotations, not to apply backpressure to motor.

Motor manufacturer does not prohibit manual motion, but we think it is better to avoid it as much as possible.

TRIUMPH-3

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

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

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

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

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

Ideal as a base station

TRANSPORTATION LAUNCHPAD

1. HANGAR REPEATER
ENABLES INDOOR AVIONICS TESTING

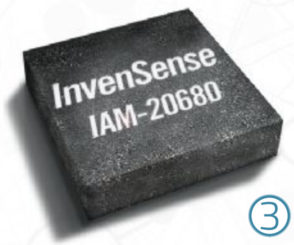
The Hangar Repeater Solution enables aircraft ground engineers to undertake 24/7 avionics testing of GPS, Inmarsat and Iridium satellite signals indoors. Aircraft engineers can undertake testing of aircraft regardless of weather, without having to move aircraft in and out of a hangar. The dedicated repeater reduces on-ground time, work hours and overall maintenance costs, and provides communication inside buildings or underground without the need for direct line of sight to the sky.
Foxcom, www.foxcom.com

2. AVIONICS SENSOR
SUPPORTS GPS GUIDANCE

The GPS 3000 is a compact, remote-mount 15-channel GPS receiver capable of five position updates per second. It uses enhanced WAAS/SBAS signals to provide ultra-precise, DO-260B-compliant position data. It provides an ARINC 743A-5 GNSS interface over an industry-standard ARINC 429 data bus for those who wish to integrate GPS 3000 with existing avionics systems. When so configured, the GPS 3000 sensor can provide position source information to the FMS, meeting requirements for required navigation performance (RNP) and supporting GPS-based vertical approach capability for coupled LPV approaches and other next-generation flight applications.
Garmin, www.garmin.com

3. POSITIONING DEVICES
AUTO MOTION SENSORS FOR GNSS-DENIED ENVIRONMENTS

A new line of automotive high-accuracy devices is designed to enhance the absolute position of a vehicle in GNSS- and GPS-denied environments: IAM-20680, IAM-20680HP, IAM-20380 and IAM-20381. The IAM-20680 is a 6-axis qualified sensor that features 16-bit accelerometers and 16-bit gyroscopes. The IAM-20680HP is a high-performance version of the IAM-20680 that features high gyroscope and offset thermal stability. The IAM-20380 gyroscope is compatible with a 3-axis automotive accelerometer and an automotive-qualified 6-axis device. The IAM-20381 is a 3-axis accelerometer compatible with a 3-axis automotive gyroscope and an automotive-qualified 6-axis device. The IAM-20680HP and IAM-20680 can be used to improve estimates of position, direction and speed when GNSS is denied, as well as improve quality of the position estimation when the satellite signal is strong.
InvenSense, www.invensense.com



UAV LAUNCHPAD

1. ANALYSIS PLATFORM
FOR PRECISION AGRICULTURE

Agremo is a clooud-based data-processing solution designed to turn drone-collected images of agricultural sites into actionable and accurate data. It is used to collect aerial footage and create an analysis report that reveals how a crop is progressing. The agricultural sensing and analysis platform is designed for drone operators, farmers, growers and agronomists. Using Agremo, drone operators can help farmers monitor and manage their crops per field throughout the season. A visualized, user-friendly, geo-referenced map of a field can provide statistics such as plant counting, plant health tools and stress detectors that enable precise yield increase and increase of overall profit.
Agremo, www.agremo.com

2. UAV LIDAR
FOR LIGHT VEGETATION AND MEDIUM-RANGE SCANNING

The Phoenix Scout-32 is a powerful, compact, mid-range lidar. The lightweight system collects survey-grade data with an AGL range up to 65 meters, and features multi-target capacity with up to two target echoes per laser shot. It can build high-density point clouds of smaller scan areas, and has options for photogrammetry, hyperspectral, thermal imaging and more.
Phoenix Lidar Systems, www.phoenixlidar.com

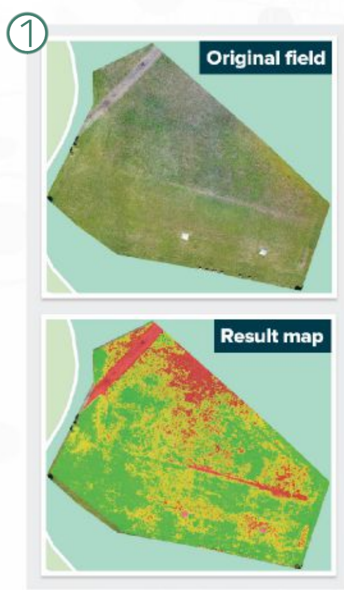


Photo: Ed Koziarksi

YES, YOU CAN USE YOUR SMARTPHONE

BRING YOUR OWN DEVICE:

**BYOD is not just an industry buzzword.
It can change the way professional surveyors work every day.
The idea of using a smartphone or tablet instead of a dedicated device is appealing.
But is it good enough?**

BY TIMOTHY BURCH

Surveyors and mappers are challenged with the arduous task of data collection that meets accuracy and precision standards and provides adequate attribute information for the project. Before the invention of the electronic data collector, handwritten notes in field books were the norm. Every note keeper's style varied in content, neatness and thoroughness. Calculations for determining survey data values were completed longhand on paper and were very time consuming.

History of Surveyors and Data Collectors

Like its personal computer counterpart, the electronic data collector was introduced in the late 1970s with minimal adoption by the average surveyor because of cost and complexity. Storage methods for the era included magnetic modules and tape; both forms of media were expensive and fragile with little storage for the cost.

Data collection was limited to numeric values only, with horizontal and vertical angles, slope distance, point number and point code being the extent of the information. Couple this process with the limited availability of printers and plotters capable of depicting the data for the surveyor's use, and one can see why few practitioners invested in these systems.

The 1980s and 1990s brought significant changes to surveying with the advancing technology of electronic computing and measuring. The introduction of robotic total stations, various methods of GNSS, and even leveling took advantage of significant computer power and measuring processes, and the data collector stayed in lockstep with the advancing instrumentation. Almost every equipment manufacturer developed their own proprietary data collector and software system because of the unique design and programming of their systems.

In the 2000s and later, third-party manufacturers began producing data collectors with advanced computing power and the ability to connect to varying brands of equipment. Most of the programming for these collectors are still proprietary in nature to this day.

Also during the 2000s, a new wave in mobile communications was taking place. Cellular phone and data signals were now being used to transmit an abundance of information between users.

The rapid development of handheld communication devices has led to the meteoric rise of two specific mobile operating systems: one by a radical startup that concentrated on dominating the search engine market, and the other by an avant garde computer company looking to expand its unique customer base.

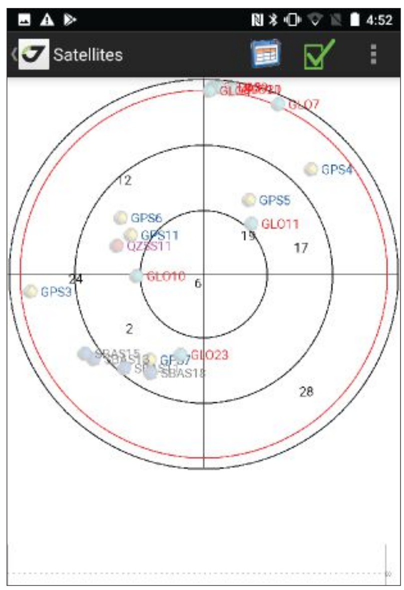
By the end of the decade, the world had been introduced to the Android operating system by Google, and the iOS operating system by Apple. The combined market share for the two operating systems at press time was just under 98% of all mobile devices worldwide.

Trending Away from Proprietary Data Collectors

Because data collection by surveyors and mappers have traditionally been performed on proprietary systems designed and produced by equipment manufacturers for use with only their instruments, these collectors, while

ANDROID POINT INFO Confirmation of collected data, including equipment and base station.

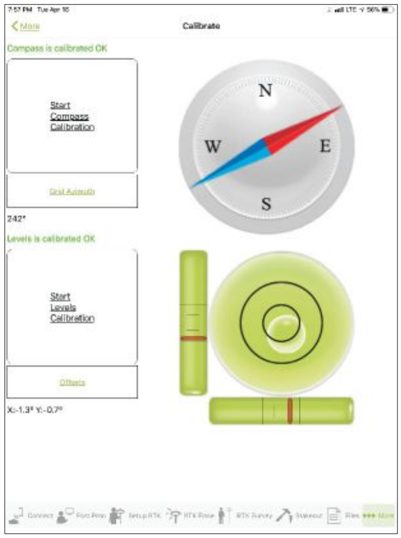
SURVEY POINT Status of survey data collection and GNSS engine signal reception.



SKY PLOT Where the 'birds' are in the sky.

All screenshots: Tim Burch

IOS POSITION Status of survey data collection and GNSS engine signal reception.



RECEIVER SETUP Visual reference for leveling and direction of GNSS receiver.

POINT CONFIRMATION Survey point information with metadata and equipment listing.

All screenshots: Tim Burch

very powerful and robust, are costly for the equipment manufacturers to produce because of the limited market of surveyors and mappers.

Many suppliers, before the introduction of the iPhone and Android operating systems, attempted to adapt their data-collection platforms to wider recognized mobile operating systems (for example, Windows CE/Pocket PC/Mobile) on a bevy of mobile devices (HP/iPAQ, Sony Eriksson, HTC) with little success. Various versions of Windows are still being used today by GNSS equipment manufacturers' proprietary data collectors, including Trimble, Hemisphere GNSS, Topcon and CHC Navigation.

However, the field of operating environments has become more crowded as technology continues to advance. The proliferation of Windows-based data collectors are now on the decline.

Enter Android and iOS. Driving the decline of the previously popular Windows mobile platform is the rapid adoption of the iOS and Android operating systems. These two environments have also led to a substantial number of devices and applications for users.

Part of the reason for the speedy acceptance of the devices and operating systems has been the ease of programming. It is estimated that each operating system has more than two million applications in their respective online stores, with more being introduced daily.

Because of the proliferation of smartphones, nearly everyone is familiar with the look, feel and operation of touchscreen devices and their various applications. This familiarity is driving a new trend in data collection: the concept of "bring your own device" (otherwise known in IT security circles as "BYOD"). BYOD is being introduced by several surveying and mapping equipment manufacturers as an alternative to their proprietary data-collection devices.

These manufacturers are pairing iOS and Android developers with their hardware and firmware specialists to create a user-friendly interface that will function on most of the most popular handheld devices on the market today. From Apple iPhones and iPads to Samsung Galaxy phones and tablets, these applications give the surveyor

RECEIVER, SOFTWARE READY FOR MOBILE

Image: ComNav

ComNav receivers offer multiple data-collection device choices via Bluetooth connection, as well as an Android app.

For instance, the G200 provides centimeter-accuracy positioning to any connected mobile devices for RTK field surveying. It is able to delivery robust survey workflows with the SinoGNSS Android-based Survey Master, so that surveyors can collect quality high-accuracy positions no matter what mobile device they are using.

The G200 is a rugged, compact, wearable GNSS receiver. Combined with the high-performance SinoGNSS OEM board tracking GPS L1/L2, BeiDou B1/B2, GLONASS L1/L2, Galileo and QZSS, the G200 enables reliable high-precision GNSS performance for land survey tasks anywhere in the world.

the best of two worlds — sophisticated data-collection capability on a well-known and reliable mobile operating system platform.

The Android platform is becoming especially popular in the handheld mapping market segment. Current users of this environment include Hemisphere GNSS, CHC Navigation, Tersus GNSS and Trimble.

The iOS applications, while not quite as prevalent as Android, are being embraced by several significant GNSS manufacturers, including JAVAD GNSS and Eos Positioning Systems.

These companies are creating iOS and Android apps that embrace the BYOD market, providing their users with affordability and creating a comfort level simply because of the familiarity of the device and its environment.

How Good Is It?

For the surveyor to be satisfied with the operation, the collection process must be efficient, cost-effective and easy to use. For this explanation of key items within a well-rounded data-collection application, we are using the JAVAD Mobile Tools (now J-Mobile) application built specifically for the Android and iOS operating systems.

The Android system (Version 7.0) was installed on a rugged CAT S41 cellphone made Bullitt Group from the United Kingdom, while the iOS app was used on

TERRASTAR GIVES ASSIST TO RTK


Photo: Leica Geosystems

NovAtel offers several levels of corrections via its TerraStar service. For surveying applications, the RTK Assist service provides correction data to bridge surveyors through any real-time kinematic (RTK) correction outages. TerraStar services work on NovAtel's OEM6 and OEM7 receivers..

RTK Assist, available on OEM6/OEM7 receivers, provides 20 minutes of RTK assistance, enabling surveyors to maintain centimeter-level accuracy. A higher service level, RTK Assist Pro, is available on OEM7 receivers. It provides unlimited RTK assistance with stand-alone centimeter-level positioning when RTK is not available.

the author's iPad Air 2 running Version 12.2. Both apps were utilized in conjunction with the JAVAD Triumph-2 GNSS receiver.

After putting both versions through trial testing and checking against values on known monuments, here is the results of our findings:

Data Organization. Easy to comprehend and flexible for most naming conventions.

Corrections and Sources. Easily connects to base receiver and radio or available NTRIP correction service for real-time network (RTN) capability.

Sky Plot. Because the Triumph-2 is equipped to receive most of the available satellites in service, the Sky Plot feature is beneficial to the user for assessing potential interference.

File Management, Import and Export. Covers the typical file management and transfer functions used by the surveyor.

RTK Survey Operations. Robust telemetry keeps the users informed of specific satellite data and correction status.

Coordinate Systems. All standard coordinate systems are included with features to allow the user to customize their own systems.

Localization. Creation of a local coordinate system is a simple routine, providing strong quality checks for data integrity.

Lift and Tilt. This feature provides the user with a useful procedure to end data collection without the need to press a button. This feature significantly increases the user's productivity.

Screenshot: Tim Burch

iOS aerial viewer.

Compass and Level Calibration. With the Triumph-2 having an internal compass and level system, status of the receiver is graphically displayed to help the user keep

TRIMBLE OFFERS WEB-BASED POST-PROCESSING

Trimble's CenterPoint RTX Post-Processing Service (**trimblertx.com**) is a free, web-based solution that provides rigorous processing of GNSS data for users around the globe.

Powered by advanced algorithms for processing static observations, CenterPoint RTX Post-Processing supports data including GPS, GLONASS, Galileo, BeiDou and QZSS. With the service, users can upload GNSS data using Trimble formats or industry-standard RINEX 2 and RINEX 3. The service supports all dual-frequency GNSS receivers and more than 400 different antennas.

The post-processing service computes single-station static observation sessions ranging in length from 10 minutes up to 24 hours, with longer observation sessions recommended to produce the highest accuracy. Using data from the global RTX tracking network, the CenterPoint RTX Post-Processing service computes the position of the observed point with centimeter accuracy.

Results are delivered via email in ITRF coordinates at the current epoch and can be transformed to a fixed epoch by use of a standard tectonic-plate model.

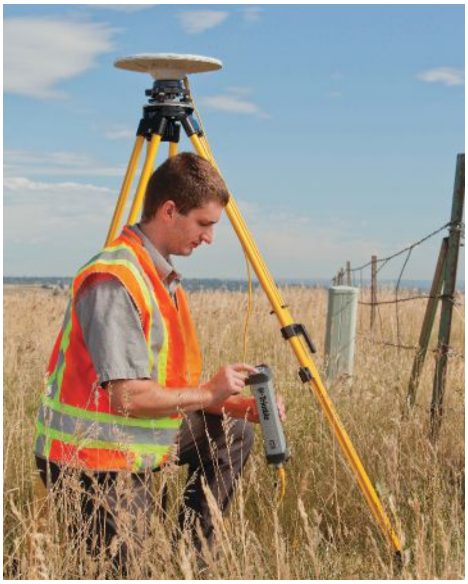


Photo: Trimble

a close watch on the accuracy of the survey point.

Survey Points and Linework. Most point naming systems and line-coding procedures are easily adapted. **Total Station Point Transfer.** The creation of control point files for transfer to total stations is simple and easy to use.

Stakeout. Graphical status screens provide the user with simple plotting capability of the desired stakeout point to increase efficiency and accuracy.

These apps are good at providing the surveyor with a solid tool for data collection and staking capability. They are especially good when paired with a real-time kinematic (RTK) base station or NTRIP correction service.

But what happens when cell service is not readily available, or there are no published monument coordinates to establish site control? These apps have the surveyor covered for that situation as well.

Post-Processing (OPUS and DPOS)

Today's surveyor works in an environment where geographic-based data is a key component to the services they render to their clients. While most of the world's developed nations have access to cellular networks in which most GNSS receivers can communicate with an RTN providing corrective solutions, the places where this is not possible relies on other means of data correction.

In the U.S. we rely on OPUS (Online Post-Processing User System) to provide that service. But, as good as it is, it has limitations. Currently, it only utilizes GPS satellite data from the U.S. Department of Defense and is subject to sporadic government shutdowns.

Other services, from both public and private sources, are in place around the world to provide a service similar to OPUS. These include, but are not limited to:

- **AUSPOS.** Geoscience Australia (free)
- **APPS.** Jet Propulsion Laboratory at California Institute of Technology (free)
- **CSRS-PPP.** Natural Resources Canada (free)
- **GAPS.** University of New Brunswick (free)
- **magicGNSS.** GMV (free)
- **Centerpoint RTX Post Processing.** Trimble (free)
- **JAVAD Data Processing Service (DPOS).** JAVAD (free, processes any JAVAD GNSS jps file)

These correction services utilize other satellite constellations (GLONASS, Galileo, BeiDou and QZSS) for their solutions and can provide additional coverage, depending on the location of the user. Because of these services, geographic-based data is at the fingertips of surveyors worldwide.

JAVAD's DPOS system is has the ability to collect static survey data and send it to the proprietary service for establishing new coordinate values for base-station use. This process is a function of the app and can be completed in a few short steps.

Once the base station values are calculated, the surveyor can make use of this information for establishing a base station for correction broadcasting.

Do You Need a Base Station?

The establishment of RTNs has greatly enhanced surveying capability as cellular service has increased in coverage and speed. However, there are still instances and locales that do not allow for the reliable use of cell signals to provide those corrections accurately.

Various manufacturers' tests have proven the accuracy of using an RTN subscription versus the traditional GNSS base and rover RTK setup. But cell-signal strength can be an Achilles heel, crippling those who choose not to set up a base station.

The UHF radio, even in its reduced power state from regulatory changes, is still more powerful and reliable than most cell services. 5G technology and coverage is anticipated to revolutionize cellular service, but it has yet to be realized.

Adaptation of the Industry

Other GNSS manufacturers (including NovAtel, Navcom, ComNav, Unicore, Emcore, Suzhou, TeleOrbit and Geneq) are producing receivers that can be adapted to a variety of existing data collectors and connect to iOS/Android mobile devices through various software developers.

The future of communications remains the smartphone or tablet device, with foldable units expected to be the next big thing.

As processors get more powerful, as chip memory becomes more abundant, and as more satellite constellations orbit in our sky, surveyors and their data collectors will continue to evolve. The future remains bright for technology and the surveyor has a front-row seat.

TIM BURCH is *GPS World's* contributing editor for Survey. A professional land surveyor with more than 30 years of experience, he is currently director of surveying at SPACECO Inc. in the Chicago area. For several years he has been secretary and was recently named vice-president of the Board of Directors of the National Society of Professional Surveyors. He writes a bi-monthly column in the *Survey Scene* e-newsletter. Subscribe free at **www.gpsworld.com/subscribe**.

ATLAS CORRECTIONS READY FOR BYOD

The Atlas GNSS global correction service, offered by Hemisphere GNSS, provides correction data for GPS, GLONASS, BeiDou and Galileo constellations. Its global L-band corrections allow for accuracies ranging from sub-meter to sub-decimeter levels. The network has more than 200 reference stations worldwide and covers virtually the entire globe.

The Atlas platform was conceived to enable as many people as possible to have access to the correction service technology, either as an end-user or as part of their business. Several features are designed to enable customers who use non-Hemisphere positioning systems to have access to Atlas.

Image: Hemisphere GNSS

EXAMPLES of how the AtlasLink webUI looks on a smartphone.

For instance, Hemisphere's SmartLink technology allows an AtlasLink GNSS smart antenna to be used as an Atlas signal extension for any GNSS system compliant with open communication standards.

Hemisphere's GNSS smart antennas including AtlasLink, A326, C321+ and S321+ offer a user-friendly web user interface (WebUI) that can be used to configure, monitor and manage the receiver from virtually any modern computing device, including computers, phones and tablets.

Taming a Brave New World

Positioning Sensors and Geospatial Intelligence Advance in the 5G Landscape

NEARMAP
Tony Agresta
Executive Vice President, Products

We've all been there before: static on our wireless call or, worse, the call drops at the most inopportune time. Like instant response when we surf the web, consumers have come to expect clear, consistent call connections when using mobile. With too much of a bad thing, the churn risk soars to untenable heights.

5G, shorthand for Fifth-Generation Wireless Systems, holds the promise of transforming our daily lives. Using massive bandwidth, extremely low latency and high speeds, almost everything that requires sending and receiving data gets a boost. Unique radio frequencies transmitted with precise directions improve on the older 4G approach by taking advantage of higher frequencies. The signals take less time to transfer from one device to another, dramatically reducing wait times.

How does this help business and the consumer? Video conferencing is better, call connections are clearer, and smart homes get their Ph.D. How does this become reality?

Image: Nearmap

Aerial Imagery reveals signal (green lines) interference (red lines) from buildings — even 30 cm of obstruction can be significant — between microwave towers.

Rather than using satellite-based towers, 5G depends on shorter signals using antennas and other transmission devices installed closer to the ground, on the tops of buildings and existing utility poles. Herein lies the rub. Ground features such as trees or tall structures can interfere with transmission. On top of this, there's the need to plan for change. Vegetation grows over time, new construction takes place, and the cycle of interference continues. Imagine trying to plan a 5G network in an urban environment replete with hundreds or thousands of tall buildings. How would a telecom decide where to place the hardware and optimize the network?

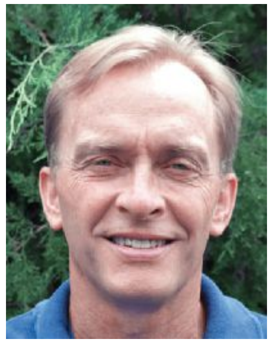
The answer rests in aerial imagery, also known as aerial mapping. Rather than relying on satellite imagery that's less clear and prone to atmospheric conditions, high-resolution camera systems mounted inside planes are photographing the world — all in 3D. Within predefined coverage areas, every point on and above the ground is being photographed and transformed into a variety of 3D models. For the telecom industry, planners can predict zones of interference and place hardware accordingly. They can better service their customers and quickly adapt to changing conditions in support of maintaining the network.

One type of output from these advanced camera systems is called a digital surface model, providing detailed elevation profiles of ground features, building, bridges, you name it. Also knows as DSM, the elevation detail contained within the imagery facilitates analysis to optimize the placement of 5G antennas and transmission devices. When combined with other forms of imagery that allow users to clearly visualize every aspect of the landscape in photorealistic, immersive 3D, this enables telecoms to quickly model all the transmission permutations. These high-tech companies use machine learning to identify clear signal areas and sections of the landscape where a tree, for example, may degrade the 5G radio frequency. Armed with such intelligence, strategic placement of hardware unlocks the optimized network — all without having to leave the office to collect data from the field.

The race is on to roll out 5G. Fortunately, advances in aerial photography have been combined with machine learning and artificial intelligence (AI) to speed up network planning and change modification. With tens of thousands of access points needed for large cities, advanced uses of aerial imagery and data science provide the answer for fast 5G deployment. 🌐

LIDAR USA

Jeff Fagerman
Chief Executive Officer



Wired? Not anymore.

Less than a decade ago, mobile mapping systems were being designed and sold using computer systems that rivaled most desktop computers. Mobile mapping vehicles had to be custom-fit for large displays and computer systems, usually with large, expensive, bulky redundant arrays of inexpensive disk (RAID) storage systems that would consume the back of a van or, at the very least, the back seat of a car. Wiring for these systems completely entangled the vehicle, making it a dedicated part of the mapping system. Many of these systems are still being used today, as their utility is only lost on space consumed but not on usability or productiveness.

In 2019 we face the ever-increasing demand for smaller size with greater performance, especially in the instance of UAVs, where size, weight and power consumption are precious commodities.

Wires? Nobody wants or expects to see any wires or cabling running between devices, with the possible exception of power. A desktop computer, laptop or RAID system is no longer a consideration. Storage is replaced by high-speed, high-capacity media such as Compact Flash, Flash memory cards, and solid-state drives.

And all of those wires? They are replaced by Wi-Fi or Bluetooth working directly between the onboard microprocessor (at most the size of a deck of cards) and what else? Your cell phone. Maybe a tablet.

The inertial navigation system inside these UAVs, the central nervous system of a mobile mapping set-up, can no longer afford to weigh several kilograms. It must weigh under 1 kilogram, with less than 500 grams preferred. The accompanying antennas must also shrink.

At the same time, cost must drop while performance must be maintained or improved. More users will adopt the technology, and they will no longer be experts. Reliability and durability will be of utmost importance. 🌐

Fast Centimeter-Level Precise Point Positioning

BY MARKUS BRANDL, XIAOMING CHEN, HERBERT LANDAU, CARLOS RODRIGUEZ-SOLANO AND ULRICH WEINBACH

This article updates a July 2012 feature in *GPS World*, "Real-Time Extended GNSS Positioning: A New Generation of Centimeter-Accurate Networks."

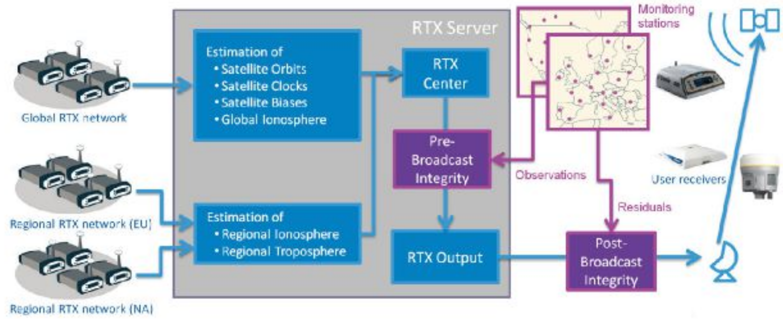


FIGURE 1 **Generation and transmission of RTX global and regional corrections, including pre- and post-broadcast integrity monitoring.**

Images and graphics: Trimble

The Trimble CenterPoint RTX correction service, enabling centimeter-level absolute positioning around the world without the need for RTK reference-station infrastructure, is now available to many users, including integrators of professional high-precision equipment and consumer products such as in the automotive sector. Access is provided via a software library compatible with any GNSS device. The corrections now contain detailed integrity information for safety-critical applications.

The RTX infrastructure is made up of approximately 120 globally distributed RTX reference stations. Receivers at these stations transmit measurement data at 1 Hz to the RTX server centers, where the correction data is computed. For redundancy purposes, multiple servers in the United States and Europe are operated. A failsafe architecture avoiding any single point of failure in the processing chain has produced a very high availability of corrections. Today the system supports GPS, GLONASS, Galileo, BeiDou and QZSS satellites. It is a multi-frequency system supporting two or more frequencies for each satellite system.

The correction stream is available to users using L-band signals broadcast via geostationary satellites and IP connections. The L-band transmitted RTX data stream uses a bandwidth of 600–2400 baud, and a highly compressed data format with a resolution of 1 millimeter, with an average latency of 8 seconds in L-band mode and 5 seconds in IP mode. The data stream is encrypted via an Advanced Encryption Standard (AES) with a key length of 256 bits to guarantee safe transmission. Data transmission integrity is assured with a 32-bit cyclic redundancy check attached to every message. The RTX correction stream provides information on satellite position, satellite clock, ionospheric and tropospheric models, and code and phase biases.

The orbit determination is done in real time using a reduced dynamic approach with dynamic models and exploiting the accuracy of the phase measurements after ambiguity fixing. Based on the computed orbits, the satellite clocks are estimated at 1 Hz, where integer ambiguity fixing is performed for the different satellite systems. Next, a single-layer global ionospheric model is computed and represented through spherical harmonics. There are currently two areas with a denser network than the global network; these cover Europe

Accuracy RTX corrections	Orbit + Clock	Reg. Iono Europe	Reg. Tropo Europe
68th percentile	0.75 cm	1.47 cm	1.82 cm
95th percentile	1.97 cm	4.29 cm	5.23 cm

TABLE 1 **Accuracy of the RTX corrections from more than three years (June 2015–July 2018) of residuals computation in the European RTX-Fast network.**

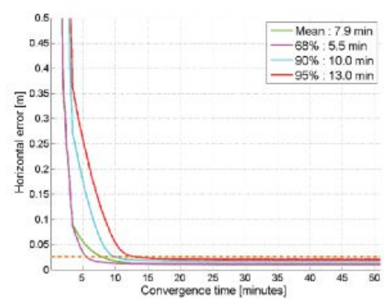


FIGURE 2 **Global convergence of RTX out of 52 globally distributed stations covering one month of data.**

and the mainland U.S. with more than 1,000 base stations. Using these stations, regional ionospheric and tropospheric models are computed, which then provide a fast convergence (RTX-Fast service).

The satellite position and clock information has centimeter accuracy and allows the client to compute precise point positioning (PPP) with carrier-phase ambiguity resolution. **TABLE 1** shows service accuracy.

Once the ambiguities are resolved, the position solution is accurate to a few centimeters. The global RTX-Standard service provides convergence times of 7 minutes to 20 centimeters (cm) horizontal error (95%) and to 2.5 cm (95%) in 13 minutes as shown in **FIGURE 2**. The regional RTX-Fast service (U.S., Europe) provides convergence times of less than a minute with centimeter accuracy. The warmstart convergence time is approximately 13 seconds.

The accuracies specified are achievable with precise Trimble GNSS positioning hardware. For integration into non-Trimble devices, an RTX software library is offered, which gives the user real-time access to the individual data in the RTX correction stream. For use of this library in safety-critical systems such as advanced driving-assisted systems (ADAS) or semi-automated driving, this library was certified to follow the ASIL-B ISO 26262 standard and the automotive ASPICE standard. This library is available for easy integration into third-party applications.

In addition to the real-time RTX solution, a web-based post-processing solution is available for public use free of charge. It is possible to upload static Trimble or RINEX files to the server, post-process the measurement data, and retrieve a precise position in various coordinate frames.

Service integrity is continuously monitored at independent stations from the RTX tracking networks in Europe and the US. The integrity of the service is provided at the correction data domain. The integrity monitoring part of the RTX system minimizes the risk due to events such as unplanned satellite maneuvers or wrong broadcast ephemeris; satellite signal or clock anomalies; ionospheric storms; or problems in transmitting the RTX correction stream.

The monitoring stations compute phase observation residuals (with ambiguity fixing) using the station measurements and the received RTX corrections. These residuals represent the actual errors of the corrections as seen by the monitoring stations at the line-of-sight (Table 1). The thresholds at which corrections are considered as faulty are the following: 0.5 m + QI (quality indicator) for orbit + clock corrections and regional tropospheric models, and 1.0 m + QI for regional ionospheric models.

The integrity monitoring consists of two steps (**FIGURE 1**): a pre-broadcast check, where potentially faulty corrections are detected and filtered out before leaving the computing server, and a post-broadcast check, where additional errors in the transmission channel are detected and alarms are issued to the users.

Integrity flags and alarms are constantly inserted into the correction stream and output by the RTX client library. The integrity information notifies clients of the presence of integrity monitoring and provides timely alerts in case of detected correction-data integrity violations. The time-to-alert limit goals are 17 seconds for L-band transmission and 13 seconds for IP transmission for the RTX service.

The RTX corrections includes quality indicators. In particular, the quality indicator for the satellite clock includes a "DoNotUse" flag to indicate potential problems with the given satellite. This flag prevents the use of the satellite for positioning when received by the user. The quality indicators of the corrections are indeed a first integrity layer. In 2017 the pre-broadcast integrity monitoring was added to act as a second layer. In 2019, with the addition of the post-broadcast integrity monitoring, a third integrity layer was added to the RTX correction data stream.

The RTX system provides access to centimeter-level corrections allowing centimeter positioning on a global basis. RTX-Fast services are available in Europe and the U.S. with pre- and post-broadcast integrity monitoring currently being deployed.

THE AUTHORS are engineers with Trimble Terrasat GmbH, Germany.

OEM

Autonomous Snowbot Pro Hits the Sidewalk

The autonomous SnowBot Pro is ready to clear your walkways. Offered by Left Hand Robotics and guided by Swift Navigation, it is the only commercial-grade, robotically driven product for snow removal on the market.

Driving autonomously, SnowBot Pro clears snow from walkways with a 56-inch-wide rotating brush, reducing the number of hand shovelers or snow blower operators needed by up to 80%. Various front and rear attachments allow for a multitude of tasks, such as snow removal in the front and deicing in the rear. It also reduces potentially costly slip and fall insurance claims.

The SnowBot is programmed and controlled remotely from the cloud via an online dashboard or mobile app, and follows its programmed path using GPS, accelerometer and gyroscope technologies for navigation.

Sensors detect any obstacles and can instruct the robot to stop to avoid collisions and send instructions about how to bypass obstacles. Location, weather and robot status data is recorded in real time, along with before and after photos. The detailed recording helps minimize insurance and risk-management costs while providing customers with proof of work.

The robot has to navigate precisely, avoiding potentially damaging landscaping, walls, curbs and other obstacles along sidewalks and walkways. Centimeter-level GNSS ensures it avoids obstacles and stays on its designated route. Finding a reliable real-time kinematics (RTK) GNSS solution was

Photo: Left Hand Robotics

critical given that many sidewalks are near buildings and underneath trees.

After evaluation, Left Hand Robotics chose Swift Navigation's Piksi Multi. Its centimeter-level accuracy keeps the robot in its designated path and allows its base robot platform to navigate in a variety of environments, whether in lines (sidewalks, bike paths) or large open areas (fields, parks). The Piksi Multi also retains a GNSS fix in challenging conditions and environments.

Once Swift's ruggedized Duro receiver was launched — and could be used by customers as a base station that was required for RTK — Left Hand Robotics had a complete offering for customers, which it launched in the winter of 2018–2019.

A Piksi Multi is installed in each SnowBot Pro, and its Path Collection Tools (tools customers use to collect the initial path data the robot will follow) and Duro is used as the base station controlling the SnowBot Pro robot.

CHC Navigation Launches P2 GNSS Sensor Series

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 station, marine systems, unmanned navigation, industrial automation, robotics and machine control.

Photo: CHC Navigation

P2 Elite GNSS sensor.

Integration. 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.

Three models. 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.

OEM

Skydel, GMV Simulate GNSS Timing Events

Orolia's Skydel SDX simulator provides an application programming interface (API) that allows users to develop SDX extensions to tackle particular simulation problems in an easy and flexible way.

By using this API, GMV developed a time plug-in in preparation for the GPS Week Number Rollover on April 6. The plug-in allows users to edit directly on a user interface the numerical values associated to timing group delays (TGDs), the UTC Offset (UTCO) and leap seconds, per individual satellite PRN.

These values are then converted to bits in the GPS message and transmitted in the RF stream to feed the receiver under test. Events like, for example, the GPS anomaly of Jan. 25-26, 2016, can be easily tested (as shown in the screenshot).

During that anomaly, about half of the GPS satellites transmitted an incorrect UTCO value during 12 hours. The transmitted value was of the order of 13 microseconds, when the correct value is usually of the order of just a few nanoseconds. This caused many timing receivers around the world to provide an incorrect timing information or to fail altogether.

In general, any event related to the contents of the GPS navigation message can be simulated by editing the associated bits in the message, for each satellite PRN. 🌐

Screenshot: GMV

WITH OROLIA'S Skydel SDX API, GMV has developed a time plug-in that allows to batch edit the numerical values associated to TGDs, UTCO and leap seconds.

SURVEY

SXblue Receivers Get Battery Upgrade

Geneq inc. has introduced a redesigned, ultra-efficient battery for its SXblue receivers.

The new battery is equipped with 4 Li-ion rechargeable cells that boost its capacity from 3900 mAh to 6000 mAh. The upgrade boosts the receiver's autonomy by up to 50%, greatly increasing its field work efficiency.

When fully charged, the battery can last up to 16 hours depending on the SXblue model and Bluetooth connectivity.

The colored LEDs for the battery charge indicator have been enhanced for a better contrast even when working under sunny conditions. Like previous versions, the new battery is field replaceable and can be charged separately or while it is connected to the receiver. 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, as well as the new pole clamp accessory for the survey kit.

Photo: Geneq

Emlid Launches Reach RS2 RTK Receiver

Emlid, the creators of Reach, centimeter-accurate RTK GNSS receiver, is now taking pre-orders for its multi-band GNSS receiver Reach RS2. The new receiver features a built-in LoRa radio, a 3.5G modem, and a survey app for iOS and Android.

L1/L2/L5 RTK GNSS receiver with centimeter precision. Reach RS2 determines a fixed solution in seconds and provides positional accuracy down to several millimeters.

The receiver 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 any place on Earth.

Built-in 3.5G modem and UHF LoRa radio. The Reach RS2 features a power-efficient 3.5G HSPA modem with 2G fallback and global coverage. The corrections can be accessed or broadcast over NTRIP independently, without relying on internet connection on a smartphone.

Photo: Emlid

For remote areas, the Reach RS2 has a built-in LoRa radio that has proven to be a reliable link for RTK corrections for distances up to 8 kilometers.

Designed for Tough Conditions. The Reach RS2 is engineered to be waterproof and impact-resistant. Its body is manufactured in a two-step injection process and is made out of shockproof polycarbonate covered in a special elastomer for extra protection. The receiver has an industry-standard 5/8-inch mounting thread.

The LiFePO4 battery of the Reach RS2 is designed for 16 hours of work as a 3.5-G RTK rover on one charge regardless of weather conditions. It can charge from a USB wall charger or a power bank over USB-C.

A RS232 interface allows users to connect the Reach RS2 directly to external hardware and output position in NMEA.

ReachView App. The Reach RS2 comes with a mobile app, ReachView for iOS and Android, that is used to control all the features of the device. Users can create projects, collect and stake-out points, and import and export geodata in industry-standard formats such as CSV, DXF and Esri Shapefile.

The Reach RS2 comes in a carrying bag with a USB-C cable and a LoRa radio antenna. The ReachView app is available for download from Play Market or App Store.

SURVEY

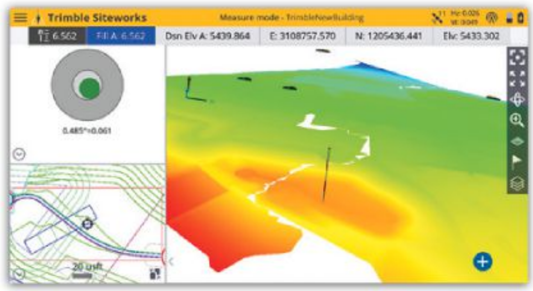
Siteworks Adds Tilt Compensation, Android Support

Trimble's Siteworks Software version 1.1 features GNSS tilt compensation functionality and support for the Android operating system. 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. The solution is designed to shield magnetic interference, and it can be used effectively anywhere on a construction site.

Tilt Compensation. Construction surveyors can now capture accurate points without leveling the pole, simplifying surveying in building corners and other areas. It makes site positioning easier to learn for beginners, while experienced surveyors can save time.

Three modes support tilt compensation, so contractors can record accurate points while standing, walking or driving the site in a vehicle. Tilt compensation in vehicle mode is designed to capture higher accuracy measurements on steeper slopes from a moving vehicle. More accurate volume measurements will save time and money on material planning.



Screenshot: Trimble

Points can be recorded more safely, for instance, eliminating the need to stand in the road to measure a traffic lane.

Android Support. Trimble Siteworks can now support a contractor's bring-your-own-device (BYOD) strategy with Android compatibility — helpful for price-conscious users or those who need a less rugged solution for lighter use.

MAPPING

3D Mapping of Notre Dame Will Help Restoration

Detailed 3D maps of the iconic and historic Notre Dame Cathedral in Paris hold out hope for accurate reconstruction after it was devastated by a massive fire April 15.

But information to restore the cathedral is abundant. Besides photos, in 2015 Vassar art historian Andrew Tallon used laser scanners to create a accurate model of the cathedral, reported by *National Geographic*.

At Notre Dame, Tallon took scans from more than 50 locations in and around the cathedral, collecting more than one billion points of data.

His laser scans are accurate to within 5 millimeters. Tallon knitted the laser scans together to make them manageable and beautiful. Each time he makes a scan, he also takes a spherical panoramic photograph from the same spot that captures the same three-dimensional space. He maps that photograph onto the laser-generated dots of the scan, creating the stunningly realistic and acccurate panoramic photographs.

Screenshot: Ubisoft

Assassin's Creed Unity. Another source comes from video game company Ubisoft. Immaculate models of the cathedral were collected for the creation of the best-selling "Assassin's Creed Unity," where the hero/player is able to climb both the outside and inside of the massive edifice. Ubisoft artist Caroline Miousse pored over photos to get the architecture just right, and worked with texture artists to make sure that each brick was as it should be.

TRANSPORTATION

Avoiding Collisions on a Smart Highway

Belgium has launched its first smart highway test environment, and Septentrio's high-precision GPS/GNSS technology is a key component.

The smart highway system was launched April 8 with a live demonstration in Antwerp, where a section of highway will be dedicated as a testbed for technology that prepares Belgium for automated driving and truck platooning.

When vehicles are aware of each other's position and velocity, road efficiency and safety can be significantly improved by smoothing traffic flow and automatically breaking if slowing traffic is detected ahead.

Roadside units along the highway will feature GNSS receivers acting as reference stations, sending out continuous positioning corrections. Onboard GNSS units will use these corrections, together with built-in quality indicators, to calculate trustworthy sub-decimeter positioning.

Image: Septentrio

The receivers will also provide precise timing for syncing the multitude of sensors onboard the smart vehicles.

On a highway, an increasing number of trucks are equipped with illegal jamming devices to avoid road tolling that can interfere with GPS signals used by other vehicles and infrastructure. Septentrio's Advanced Interference Mitigation (AIM+) technology shields its receivers from interference.

Belgium's smart highway is a project of the Flemish government coordinated by imec, a research and innovation hub. Other industry partners are Toyota, Ericsson and Telenet. On the European level, the CONCORDA project supports research and development of automated vehicle technology and infrastructure in Germany, Spain, France, The Netherlands and Belgium.

Hemisphere Offers Atlas-Capable Vector V200

Hemisphere GNSS has launched a new single-frequency, multi-GNSS Vector V200 smart antenna with integrated Atlas L-band designed for general marine applications and markets.

Powered by Hemisphere's Crescent Vector technology, the V200 is a multi-GNSS compass system that 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.

Photo: Hemisphere

With support for NMEA 0183 and NMEA 2000, integrating Atlas L-band corrections, and continuing to offer ease of installation, the V200 packages and offers exceptional value and performance. The V200 excels in providing accurate position and heading information to autopilots, chart plotters and other general marine navigation applications.

The all-in-one V200 GNSS compass combines Hemisphere's Crescent Vector H220 OEM board, two superior multipath and noise-rejecting antennas (spaced 20 cm apart), a multi-axis gyro, and tilt sensors in a single easy-to-install and use enclosure.

The V200 delivers 1.5 degree (or optional 0.75 degree) heading accuracy and Atlas L-band accuracies of 30 cm to 60 cm and offers instantaneous sub-meter accuracy and DGPS-level accuracy.

Measuring 35 cm in length, the V200 can be pole or surface mounted and comes in either 5- or 12-pin options that require only a single power/data cable connection for fast and reliable installations, even in the presence of strong radio transmissions.

UAV

AUVSI XPONENTIAL HOT TAKES

The annual AUVSI Xponential show took place April 30 – May 2 in Chicago. Here are a few of the companies and products expected to exhibit as of press time.

BY Tony Murfin and Tracy Cozzens

Photo: uAvionix

uAvionix is testing its prototype of a command and non-payload control (CNPC) radio for UAS and urban air mobility vehicles. SkyLink is an L-band frequency-modulated CNPC radio intended for point-to-point or networked beyond-visual-line-of-sight (BVLOS) UAS operations. The 50-gram 10-Watt prototype is testing successfully at ranges exceeding 40 miles at low altitude.

Photo: Flyability

Flyability's drones are adapted for inspection tasks, both indoors and out, with an exterior protective cage. Routine inspection jobs indoors, underground and around complex pipework become quicker, safer and are fully documented by high-resolution video and stills.

AeroVironment's drones are used extensively by the military for surveillance and reconnaissance; in the commercial sector, they focus on tools for agriculture.

The VTOL (vertical take-off and landing) Quantix drone system is fully automated for takeoff, flight and landing, enabling mapping of farm acreage to monitor crop health to identify anomalies due to water, insect, weed and disease so their impact on yield can be minimized.

Photo: Valqari

Valqari has developed a drone mailbox that is interoperable with a large number of delivery drones and enables drop-off of packages in residential neighborhoods. The drone mailbox automatically accepts packages and safely stores them until the recipient opens the box later to retrieve them.

Cepton makes lidar systems more commonly used for automotive obstacle detection, but now customized for UAV integration and use. Its UAV lidar system provides long-range, high-resolution and low-cost mapping capabilities in a lightweight package. With a scanning range of 200 meters, high-density map-data acquisition becomes possible.

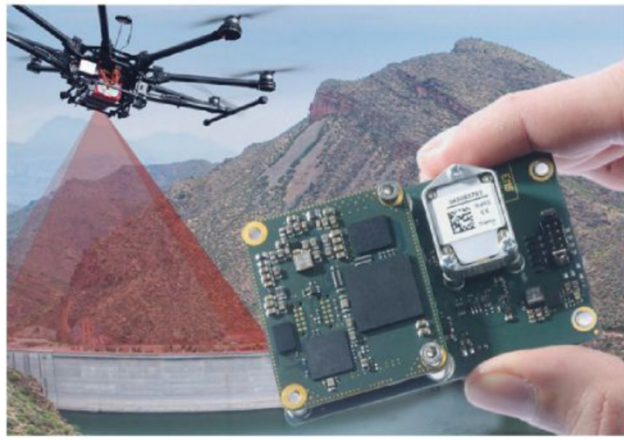


Image: SBG Systems

Quanta UAV INS Improves UAV-Based Surveying

SBG Systems' new 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 BVLOS mapping solutions. They provide precise orientation and centimeter-level position data delivered both in real time and post processing. This direct geo-referencing solution eliminates the need for ground control points and greatly reduces the need for overlaps.

Qinertia Software. 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. Trajectory and orientation are greatly improved by processing inertial data and raw GNSS observables in forward and backward directions. The software also computes the base station position to provide centimeter accuracy.

Robotics and Surveying. Quanta UAV is the result of SBG's expertise in both miniaturized technology for drone navigation and high-end sensors for mobile mapping. Designed as a geo-referencing solution, it can also be used as a high-end navigation solution to feed the UAV autopilot.

Quanta UAV benefits from a tight integration with in-house IMUs, advanced calibration techniques and algorithms that ensure consistent behavior in all weather conditions, as well as robust position even if the UAV gets close to buildings, electrical lines or trees.

The Quanta UAV web interface allows for easy configuration with a 3D view showing all parameters.

DEFENSE

Bernard Gruber Joins Spirent Board

Bernard Gruber, former director of the U.S. Air Force GPS Directorate, has joined the Spirent Federal Systems board of directors as government security committee chairman. Also joining as the chairman of the board is Robert Lollini.

Spirent Federal is a provider of GPS/GNSS test equipment.

Gruber has had a long and distinguished career in the government and military sector. He held several positions in important commands focused on navigation in space, including chief of Space and Global Integrated Intelligence at the Pentagon (2009–2010) and GPS director at Los Angeles Air Force Base (2010–2013). He is the director of Precision Guidance and Advanced Programs, Armament Systems at Northrop Grumman.

Robert Lollini is CEO and president of BioFire Defense LLC, a subsidiary and proxy company of bioMerieux. Lollini contributes to the board his broad understanding of strategic financial and executive management.

Photo: U.S. Marine Corps/Lance Cpl. Amy Phan

Raytheon Demonstrates Expeditionary JPALS

Earlier this year, Raytheon Company demonstrated a land-based expeditionary version of its Joint Precision Approach and Landing System (JPALS) for the first time to U.S. Air Force, Navy and Marine Corps officials at Marine Corps Air Station, Yuma, Arizona.

During the demonstration, F-35B pilots used the JPALS system on the jet to connect with the expeditionary system on the ground from 200 nautical miles away. From there, the system guided the pilot to a designated landing point on the runway.

The proof-of-concept event showed how the GPS-based system, which is currently used to guide F-35Bs onto ships in all weather, could be reconfigured into a mobile version to support landings in a traditional airport setting.

MACHINE CONTROL

Skycatch, Komatsu Australia Partner


Photo: Skycatch

Komatsu Australia and Skycatch Inc. are partnering to boost the efficiency of construction, mining and quarry sites across Oceana with the high-precision Everyday Drone Solution, a key component to Komatsu's Smart Construction workflow. Everyday Drone contains the Explore1 high-precision UAV, the Edge1 integrated GNSS base station, the Edge Compute module and the online Viewer, packaged into a commercial-grade kit. It allows users to experience time to data without needing ground control points, and the ability to integrate precision aerial data into their Smart Construction workflow. With the Edge1, customers can achieve sub-50-millimeter-accurate data, in arbitrary or local coordinate systems, within 30 minutes.

BEIDOU SMART TRACTOR FARMS IN TUNISIA

A self-driving tractor using the BeiDou Navigation Satellite System (BDS) was tested successfully March 10 in northwestern Tunisia. The smart tractor was equipped with a BDS receiver so that it could be controlled remotely without a driver.

Representatives of the China-Arab BDS/GNSS center and the Arab Information and Communication Technologies Organization (AICTO), as well as the academic staff of an engineering school in Mjez El-Beb region in northwestern Tunisia, attended the test ceremony.

"I hope that all Arab countries will be able to use this Chinese technology," said Nour Laabidi, project manager at AICTO and head of China-Arab BDS/GNSS center in Tunisia.

MOBILE


Photo: u-blox

No-Charging Smartwatch Uses u-blox Technology

U-blox, a global provider of positioning and wireless communication technologies, is partnering with TransSiP and Matrix Industries to create PowerWatch 2, a GPS smartwatch that doesn't need to be charged.

The smartwatch features the ultra-small, ultra-low power u-blox ZOE-M8B GNSS receiver to track position in addition to calories burned, activity level and sleep. It is enabled by TransSiP PI technology, which ensures energy harvested is used at maximum efficiency.

The PowerWatch 2 continually tops up its battery using thermoelectric energy generated from body heat as well as solar energy. The watch also connects to smartphones and displays notifications, tracks activities and visualizes them using dedicated iOS and Android apps.

Satellite-based positioning is typically the most power-hungry process on a sports watch. The u-blox ZOE-M8B GNSS module consumes as low as 12 mW and is 4.5 x 4.5 x1.0 millimeters. Its small size helps achieve the watch's comparatively low 16-mm thickness. With concurrent reception of up to three GNSS constellations, the module delivers accurate positioning in challenging situations.

Providing efficient conversion of harvested energy into DC power, TransSiP PI enhances the ZOE-M8B, incorporating u-blox Super-E technology, to strike a balance between power and performance. The watch supports 30 minutes of continuous GNSS tracking per day, with unused time accumulating in the watch's battery pack so it could power two hours of location tracking every four days.

ACCURATE POSITIONING IN GNSS-CHALLENGED ENVIRONMENTS WITH CONSUMER-GRADE SENSORS

BY URS NIESEN, JUBIN JOSE, XINZHOU WU, *QUALCOMM TECHNOLOGIES INC.*

Emerging automotive applications require reliable but at the same time low-cost positioning solutions. In this paper, we present such a solution by fusing the measurements from several consumer-grade sensors using a tightly coupled centralized filter.

The sensors used are a single-frequency GNSS receiver providing GPS and GLONASS pseudoranges and GPS carrier-phase measurements, a micro-electro-mechanical (MEMS) inertial measurement unit (IMU), a monocular camera, wheel-speed and steering-angle sensors.

We also employ vehicular constraints, integrated as pseudo-measurements. The centralized fusion architecture allows sensor cross-calibration and improves outlier detection. The filter runs in real time on the target platform, producing pose estimates at 30 Hz. Through extensive experimental evaluations, we demonstrate positioning accuracies of sub-meter 95-percentile horizontal errors even in GNSS-challenged deep-urban scenarios.

Conflicting Requirements. Accurate positioning is a requirement for several emerging vehicular applications such as advanced driver-assistance systems (ADAS) and autonomous driving. Positioning solutions for these applications face two competing constraints. To be technically viable, the computed position estimate needs to be reliable in scenarios ranging from open sky to deep urban, with less than 1-meter 95-percentile horizontal error as an often-mentioned target. To be economically viable, the system needs to be built from consumer-grade components.

We reconcile these conflicting requirements by fusing measurements from several low-cost sensors into a single pose estimate using one centralized extended Kalman filter (EKF). A multi-constellation single-frequency GNSS receiver provides GPS pseudorange and carrier-phase measurements and GLONASS pseudorange measurements. These are combined in a tightly coupled integration architecture with a consumer-grade MEMS IMU used to produce the reference navigation solution.

Tight integration enables outlier rejection directly for the raw GNSS measurements. This is crucial in deep-urban scenarios, since many or most raw GNSS measurements could be outliers in these conditions. We use a monocular camera and vehicular sensors, providing four wheel-speed measurements and a steering-angle measurement, as additional aiding sensors.

Constraints. Finally, vehicular constraints are integrated as pseudo-measurements. These sensors have very different noise sources and failure modes, which allows cross-calibration and improves failure and outlier detection. Given the tightly coupled integration in a single EKF, the filter state is quite large and can reach more than 100 dimensions. Despite its size, we are able to run the filter in real time and on target, producing pose outputs at a rate of 30 Hz.

We report the result of extensive experimental evaluations in different scenarios ranging from open sky with good satellite visibility to deep urban with long stretches of no or only limited satellite visibility. In each of these scenarios, we obtain the target accuracy of sub-meter 95% horizontal positioning error.

We show that, in the benign open-sky scenarios, GPS and IMU sensors are sufficient to achieve the target accuracy. However, in challenging deep-urban scenarios, all the integrated sensors are required to attain reliable sub-meter positioning performance.

> "We demonstrate positioning accuracies of sub-meter 95-percentile horizontal errors even in GNSS-challenged deep-urban scenarios."

Sensors and Components. We use Qualcomm® SiRFstar™ V 5e B02 GNSS chipset, a low-cost commercial GNSS product, connected to a NovAtel GPS-702-GG dual-frequency GPS+GLONASS Pinwheel antenna, the only component not consumer-grade, to separate impact of a specific antenna on performance. We plan to evaluate low-cost antennas in the future. We use a TDK InvenSense low-cost MEMS 6-axis IMU (MPU-6150) and a vehicle interface with vehicle sensors through the controller area network bus. Accurate timestamping for tightly coupling sensor measurements is provided by a custom sensor sync board. The processor is a Qualcomm® Snapdragon™ 820 automotive platform for real-time computation. (Qualcomm SiRFstar and Qualcomm Snapdragon are products of Qualcomm Technologies, Inc. and/or its subsidiaries.)

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

LOOKING LIKE a psychedelic insect, the city of Rouen, France, is generated with layer upon layer of street map data.

Images: OpenStreetMap

Diving into Digital Mapping History with OpenStreetMap

A tool develeped by Mapbox explores "10 years of OpenStreetMap." During that decade,hundreds of thousands of people mapped 25 million miles of roads in every country in the world.

The internet tool uses a slider to show the data change over time. You can see additions and edits as they come online over the decade — a fascinating look at the intricate information that has been compiled. When a user drags the slider to the left, it's easy to see how scant the information was only a few years into OpenStreetMap's existence (the image at right shows the same European region in 2009 as the image at the top in 2015) .

After GPS and GNSS, OpenStreetMap ranks high in the movement to make geographic information accessible. OpenStreetMap is a community-driven project to create the most detailed, correct and current open map of the world.

When Steve Coast began the project in 2004, map data sources were few, and largely controlled by private companies and the government. Coast changed the rules by creating a wiki-like resource of the entire globe, which everyone could use. Today, 5.2 million people use OpenStreet Map.

OpenStreetMap democratized mapping: all a contributor needed was time and a computer connection to add data about their country or their neighborhood. Besides GNSS, contributors use aerial imagery and low-tech field maps to verify that OSM is accurate and up to date. Others dedicate their energies to humanitarian projects, including disaster response following the Haiti hurricane and aiding South Sudan and Syrian refugees.

SEEN & HEARD

SURVEYING THE HIGHEST HEIGHT

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. On January 2020, Nepal plans to end the controversy and declare both snow and rock height of the world's tallest mountain. This spring a two-member Nepali survey team will summit the mountain with a Trimble R10 GNSS receiver, gifted by New Zealand. Besides a GNSS survey at the summit, teams will conduct 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.

TAKIN' IT TO THE (HAMBURG) STREETS

Five electric Volkswagen Golfs are now on the streets of Hamburg, Germany, being tested with Level 4 automation. The cars are designed to handle complex urban traffic patterns without help from drivers, although they must be ready to intervene. Level 5, the highest category, requires the vehicle to perform all tasks, turning every rider into a passenger. The cars are driving 1.9 miles (3 km) of urban roads where new signals and traffic management systems have been installed for autonomous driving.

GPS ROLLOVER GONE WRONG

The April 6 GPS Week Number Rollover was supposed to pass without a hitch, with plenty of notice that updates might be required for legacy receivers. Instead, several systems crashed. In China, as many as 15 Boeing 777s and 787s were grounded pending a GPS update (the receivers gave the date as August 22, 1999.) In New York City, part of the wireless grid faulted, cutting information feeds to the NYPD (license plate cameras) and remote worksite communications. In Australia, weather balloons were grounded. In the United States, NOAA autonomous monitoring stations went offline. Fixes for all these systems are underway.

PHOTO CREDITS: Mount Everest/Daniel Prudek/Shutterstock.com; e-Golf cars/Volkswagen; Boeing 787 Dreamliner Hainan airlines/aapsky/Shutterstock.com

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