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AUGUST 2019 | Vol 30 | No 8


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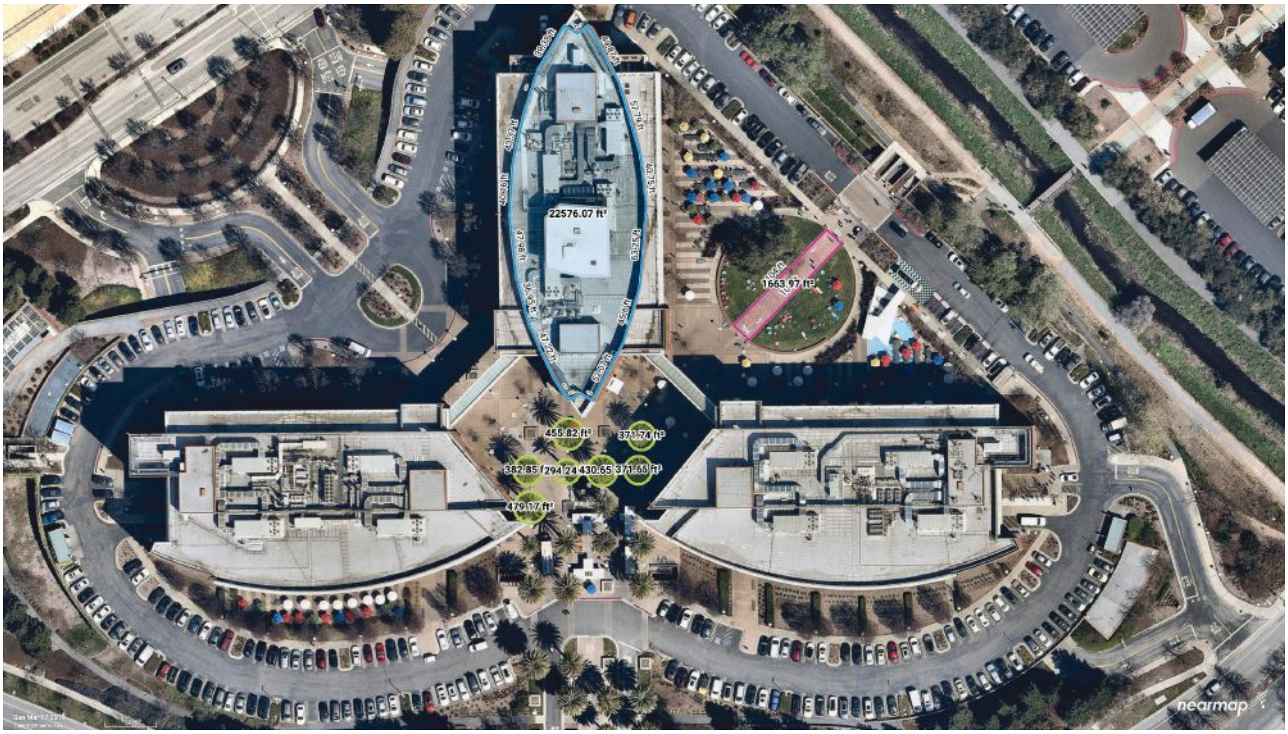

Cover Photo and This Photo: Nearmap

COVER STORY

Photo: U.S. Air Force

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AUGUST **2019**

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NEWSLETTER EXCERPT

Gen X and the Future of Surveying

BY Tim Burch
CONTRIBUTING EDITOR, SURVEY

The surveying profession has come to a crossroads… A gap exists within the profession, and yes it is a generation gap, based on how technology has evolved and how the different generations experience it differently. In this column I explore the histories both of the generations and the technology to reach conclusions on how best to move forward — together.

Surveyors now have more tools than ever before available to them to perform their tasks. But surveyors of different ages regard these tools differently. Not to put too fine a point on it, the younger prosfessionals among us feel their creativity and desire to further the profession is being stifled by the group who is supposed to be leading and mentoring them.

> "Their creativity and desire to further the profession is being stifled by the group who is supposed to be leading and mentoring them."

Why is this crucial to consider? Because these are the future users, purchasers and adopters of geospatial equipment and software, and the future setters of industry standards. All involved, from manufacturers to distributors to surveyors themselves, would do well to think deeply upon this….

Read the full column at **gpsworld.com/category/opinions/**.


spirent
Federal Systems
Visit us at ION GNSS+ to learn more about SimMNSA

The Big Shrug

BY ALAN CAMERON
EDITOR-AT-LARGE

Global markets learned something important from the brown-out of Galileo signals over a week's time in July: Life goes on without a hiccup in the absence of the European GNSS.

Very unfortunately for the backers and boosters of Galileo, this message will reverberate down through the years. If vital affairs proceed unaffected by Galileo's travails, or triumphs for that matter, who needs it? The response, a shrug. I'm tempted to say a Gallic shrug, were it not that the Gauls, the French, are prime among the system's boosters and backers.

I'm among that number as well. Galileo and I have known each other all our lives, all our professional lives. When I started on this magazine 19 years ago, the first story I edited was on Galileo's public-private partnership.

Galileo then was just a collective gleam in several politicians' and scientists' eyes. Look how far it has come: 20 satellites flying in various operational or testing states.

The European GNSS Agency was very careful to point out during the crisis that Galileo is in its initial services phase. Its signals are available for use in combination with other GNSS and are not intended to provide a complete solution by themselves. This status is expressly designed to allow for "the detection of technical issues before the system becomes fully operational."

So, it doesn't count. Because, the game hasn't really started yet. Right?

Not quite.

Because this episode occurred, it will be remembered. Because it lasted so long, it will be factored. Because the official announcements about it were so obscurantist, the system may find it more difficult to regain trust.

Of course a full, careful, in-depth investigation must take place before officially announcing what caused the debacle. But more than was said could surely have been said, during the crisis. A full week now, as of this writing, after the week-long outage concluded, we still have no indication as to which piece of ground equipment or software failed and why there wasn't a smooth transition from the Italian to the German control station. Redundancy was built into the system to preclude exactly such failures as this. Why didn't redundancy work?

Transparency is a rhyming word that goes well with redundancy.

Trust — corporate confidence — is fundamental to installation in multi-GNSS chips, boards, modules, all manner of devices. Four systems compete for spots at a table that may comfortably fit only three. Even three could be a stretch.

> "So, it doesn't count. Because, the game hasn't really started yet. Right?"

GLONASS suffered a much shorter (11-hour) timing glitch in 2014, and has yet to climb back into the public-confidence ring.

Here's a very public lesson in transparency: When the GPS satellite SVN49 failed rather spectacularly in 2009, the GPS Directorate was very forthcoming, almost embarrassingly so, about what happened and why. GPS never lost a step in the public's and the industry's eyes.

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GNSS POSITION NAVIGATION TIMING
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Published monthly

Take Me to the Moon

BY Tracy Cozzens
SENIOR EDITOR

I was inspired by the 50th anniversary of the Moon landing on July 16 and our focus on mapping this month to look into imagery of the Moon.

Only recently have we learned that the lunar orbiters that photographed the Moon in the 1960s sent back images that were stunningly high resolution (HR), even by today's standards. The actual resolution was presumably kept secret because the imaging technology was also used in our Cold War spy satellites.

Under the Lunar Orbiter Program, satellites took photographs of the Moon's surface to identify suitable landing sites for the Apollo Program. Managed by the Langley Research Center, five Lunar Orbiters were successfully flown in 1966 and 1967, mapping 99% of the Moon's surface with a resolution of 60 meters or better.

The first three missions were dedicated to imaging 20 potential landing sites, and were flown at low-inclination orbits.

The fourth and fifth missions were devoted to broader scientific objectives and were flown in high-altitude polar orbits. Lunar Orbiter 4 photographed the entire nearside and 95% of the farside, and Lunar Orbiter 5 completed the farside coverage and acquired medium (20-meter) and high (2-meter) resolution images of 36 pre-selected areas.

In that pre-digital era, the Lunar Orbiters had an ingenious imaging system, which consisted of a dual-lens camera, a film processing unit, a readout scanner and film-handling apparatus. Both lenses, a 610-mm narrow angle HR lens and an 80-mm wide-angle medium resolution (MR) lens, placed their frame exposures on a single roll of 70-mm film.

The axes of the two cameras were coincident so the area imaged in the

Image: NASA

HR frames were centered within the MR frame areas. The film was moved during exposure to compensate for spacecraft velocity, which was estimated by an electric-optical sensor. The film was then processed, scanned, and the images transmitted back to Earth. Based on these images, the NASA Apollo Site Selection Board would name five candidate landing sites in February 1968.

Through the dedication of volunteers, the images have all been digitized. The entire Lunar Orbiter atlas is online at **www.lpi.usra.edu/resources/lunar_orbiter/.**

PNT Q+A EDITORIAL ADVISORY BOARD

How have improvements in mapping data collection advanced other PNT technologies?

"Real-time positioning, navigation and timing (PNT) benefit from high-resolution aerial maps captured and published on a consistent basis. With sub 3-inch aerial photographs streamed through custom applications or instantly accessible solutions, governments and commercial use cases apply these maps for emergency 9-1-1 dispatch, routing guidance, and new information applications to inform citizens."

— Tony Agresta, Nearmap

"In principle, PNT shall be based on linear/angular motion sensors. However, since the origins of aerial triangulation down to contemporaneous hybrid multi-sensor systems, mapping and motion sensors have cooperated in PNT tasks. Current visual- and lidar-odometry are brilliant examples thereof."

— Ismael Colomina, GeoNumerics

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Galileo Restores Service after Week's Outage

Galileo Initial Services have been restored after a week-long signal outage, according to a statement released on July 18 by the European GNSS Agency (GSA).

"Commercial users can already see signs of recovery of the Galileo navigation and timing services…although some fluctuations may be experienced until further notice."

After the signal outage began on July 11, efforts to restore services reportedly found a malfunction in the calculation of time and orbit predictions (ephemeris).

Why the error affected both Precise Timing Facilities (PTFs) within the Galileo ground control system, at Fucino in Italy and Oberpfaffenhoffen in Germany, has not been explained. System redundancy in the form of these doubled facilities was meant to prevent such breakdowns.

The GSA statement continues: "Galileo Initial Services have now been restored. Commercial users can already see signs of recovery of the Galileo navigation and timing services, although some fluctuations may be experienced until further notice.

"The technical incident originated by an equipment malfunction in the Galileo ground infrastructure, affecting the calculation of time and orbit predictions, and which are used to compute the navigation message. The malfunction affected different elements on the ground facilities.

"A team composed of GSA [European GNSS Agency] experts, industry, ESA [European Space Agency] and [European] Commission worked together 24/7 to address the incident. The team is monitoring the quality of Galileo services to restore Galileo timing and navigation services at their nominal levels.

"We will set an Independent Inquiry Board to identify the root causes of the major incident. This will allow the Commission, as the programme manager, together with the EU Agency GSA to draw lessons for the management of an operational system with several millions of users worldwide."

On July 22, the GSA issued a further Notice Advisory to Galileo Users (NAGU) consisting of four words: "The service is restored." Full statements of all NAGUS issued during the crisis are available on the GSA website.

Analysis of the Signal Outage

BY **Fabio Dovis, Alex Minetto, Andrea Nardin,** *Politecnico di Torino Department of Electronics and Telecommunications*, **Emanuela Falletti, Davide Margaria, Mario Nicola, Matteo Vannucchi,** *LINKS Foundation*

All images: Politecnico di Torino and LINKS Foundation

FIGURE 1 Misplaced Galileo and GPS + Galileo solutions.

Following the issue by the Galileo Service Center of the Notice Advisory to Galileo Users (NAGU) reporting Service Outage for all the Galileo satellites, as curious Galileo users our team of researchers of the NavSAS group started an independent investigation of the received signals in space (SISs).

In fact, we observed that a commercial u-blox EVK-M8T receiver, forced to use Galileo-only satellites, provided a "no-fix" indication. Three Galileo-enabled smartphones, the Xiaomi MI 8, Huawei P10 and Samsung Galaxy S8, which use assistance from the cellular network, were also not providing a Galileo-based position solution, considering the Galileo satellites as "not usable."

However, the investigation started exploiting our in-house developed software receiver NGene, that was used in the past for similar monitoring of the GNSS signals, for example at the time of the transmission of the first IOV Galileo satellites in 2012, and the transmission of anomalous

GPS signals from SVN49 in 2009. Monitoring the Galileo SISs, which were usable until the day before, we found that they were still correctly trackable, with normal power levels and Doppler profiles within feasible limits.

At the time of the first analysis, seven satellites were visible in the sky over Torino, Italy. **FIGURE 1** reports a screenshot of the positions computed by means of NGene between 07:14:54 and 07:24:54 UTC on July 15, plotted on Google Earth. The position estimated using the Galileo-only satellite or hybrid GPS-Galileo solutions (red dots) showed errors on the order of 500 meters or even more. The georeferenced antenna position is depicted by the green pin.

The monitoring of the status flags taken from the Galileo E1B I/NAV message showed that the SIS was marked as "healthy" for all the visible PRNs apart the number 14, which is known to be "not usable" for a long time. The Signal in Space Accuracy Index (SISA) was set to 109, which is an acceptable prediction of the minimum standard deviation of an overbound of the SIS error.

According to the Galileo Open Service "Service Definition Document" (OS SDD, issued 1.1, May 2019), a SIS "healthy" means that the SIS is expected to meet the Minimum Performance Level, and "a navigation solution obtained with Galileo SIS is expected to meet the Minimum Performance Levels reported in the Galileo OS SDD only if receivers comply with the assumptions reported in Section 2.4, including the use of navigation parameters within their broadcast period."

In fact, the document specifies that "The navigation solution is expected to meet the Minimum Performance Levels only if receivers do not use navigation parameters beyond their broadcast period. The maximum nominal broadcast period of a healthy navigation message data set is currently 4 hours."

FIGURE 2 **Comparison of Galileo-only solutions using Navigation message ephemeris data and IGS ephemeris.**

> "Only the ephemerides updates were affected by problems."

The check of the nominal broadcast period was bypassed in our software receiver, which is indented as a research tool and not a commercial product as the one mentioned above, so that we were still able to obtain a GPS + Galileo PVT solution, since this check looked to be the only discrimination factor to validate and thus exclude the computed solution.

On July 17, the SISA flag was changed to 255: according to the OS SDD, the accuracy status was "No Accuracy Prediction Available (NAPA)." This means that the status of the broadcast SIS must be intended as "Marginal." In this condition the EVK-M8T restarted to provide Galileo-based fixes, while the Xiaomi Mi 8 Pro smartphone still excluded the Galileo satellites from its PVT fix.

The analysis of the decoded Galileo navigation message led to the conclusion that ephemerides and clock correction data were last updated around 19:00 UTC of July 16. For example, PRN 3 and 15 changed Issue Of Data (IOD) from 958 to 17 at Galileo Signal Time TOW 241855, which corresponds to 19:01:25.

As a final check, we used external ephemerides to process the Galileo signals during the "system outage." **FIGURE 2** and **FIGURE 3** show different navigation solutions obtained by processing a data collection taken on July 12 at 10.00 UTC (12.00 Local time). The purple dots indicate few fixes obtained by demodulating the navigation message transmitted by the Galileo satellites and show a remarkable bias with regard to the reference antenna location.

SEE GALILEO OUTAGE, PAGE 12. >>

GALILEO OUTAGE

<< *Continued from page 11.*

In **FIGURE 3**, the green dots are the navigation solution obtained correcting the satellites positions according to precise orbits data and clock drift provided by the IGS network. The fix is a simple code-based Least Mean Square solution without smoothing of the pseudoranges.

The two results were obtained by processing the same satellites signals, thus proving that their quality was still sufficient to get an acceptable positioning solution during the Galileo service outage period. This brought us to the conclusion that, during the outage, only the ephemerides updates were affected by problems, while the other SIS components appeared sound and usable.

The NavSAS group is a joint team of researchers of Politecnico di Torino and LINKS foundation. The full analysis of the outage can be found at **www.navsas.eu.**

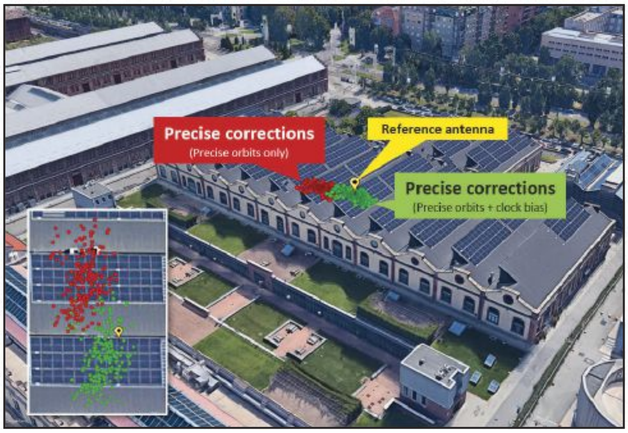


FIGURE 3 **Zoom on the Galileo-only positions obtained by using IGS data.**

GPS III SV02 Will Soon Rise

The second next-generation GPS III satellite, nicknamed "Magellan" by the U.S. Air Force, is poised on the launchpad, ready to rise into space on August 23.

Lockheed Martin Space and United Launch Alliance (ULA) technicians encapsulated GPS III SV02 in its launch fairings in late June, and mounted it atop a ULA Delta IV rocket in early July.

"GPS III SV02 is launching just a brisk seven months after the nation's first GPS III satellite lifted off back in December," said Johnathon Caldwell, Lockheed Martin's vice president for Navigation Systems. "The first satellite's performance during on-orbit testing has exceeded expectations."

GPS III satellite production and launch cadence is picking up. On May 27, the Air Force declared the next GPS III satellite, GPS III SV03, available for launch pending an official launch date.

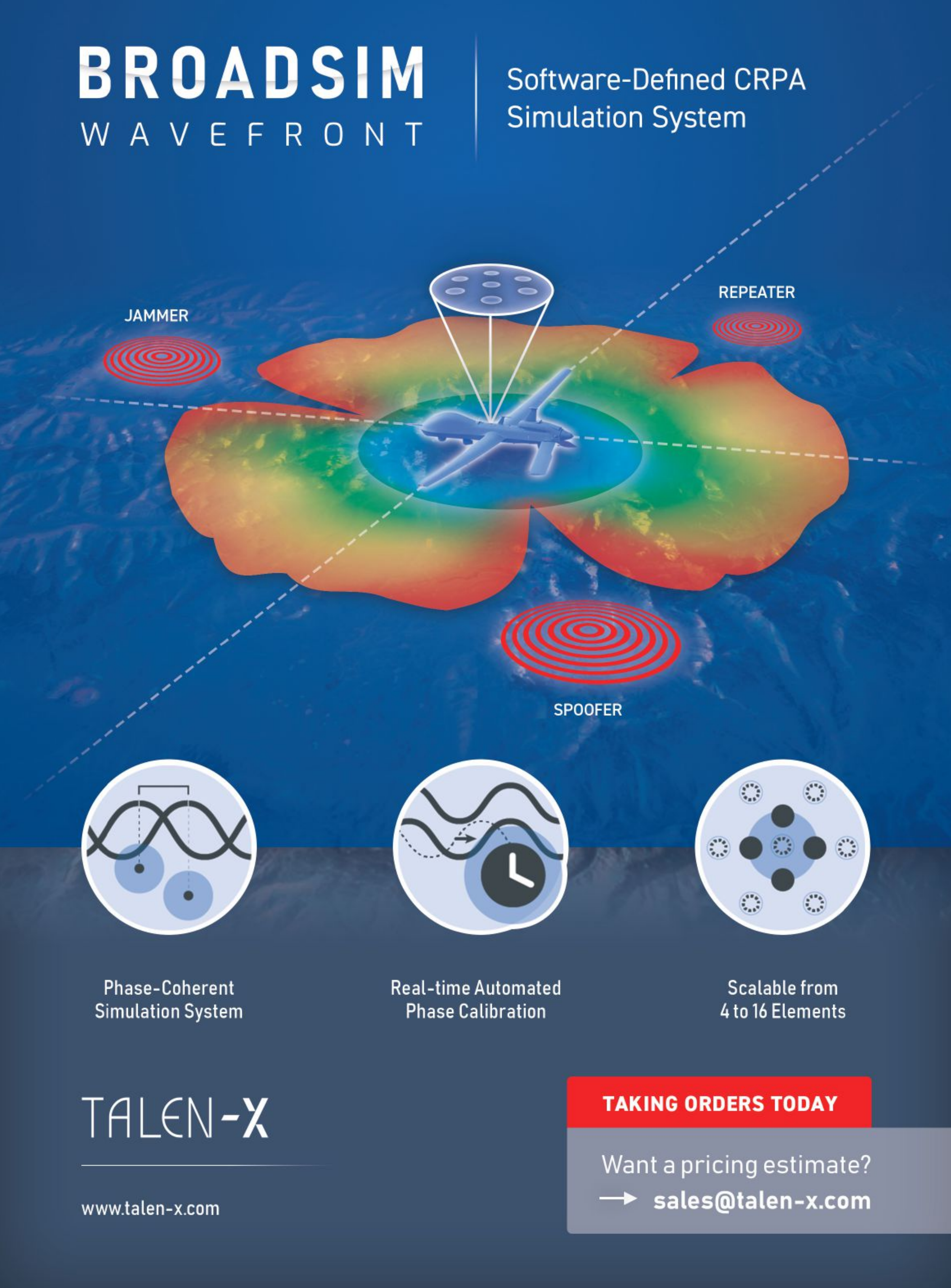
"More GPS III satellites are coming," Caldwell said. "If you looked at our production line back in Denver today, you would see GPS III space vehicles 04, 05 and 06 already fully assembled and in various stages of testing. And space vehicles 07 and 08 are being built up at the component assembly level now."

Lockheed Martin is under contract to develop and build up to 32 GPS III/IIIF satellites for the Air Force.

Additional GPS IIIF capabilities will start being added with the 11th GPS III satellite. These will include a fully digital navigation payload, a Regional Military Protection (RMP) capability, an accuracy-enhancing laser retroreflector array, and a search-and-rescue payload.

Photo: Lockheed Martin

THE SECOND GPS III satellite is encapsulated in preparation for launch on August 23.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UAM on the Horizon: Aircraft Lands Autonomously without Ground Assistance

A German research team successfully demonstrated a completely autonomous airplane landing in May, without assistance from any ground-based systems, fulfilling a key step towards autonomous air traffic and the much-bruited Urban Air Mobility (UAM).

An optical reference system, encompassing a camera in the normal visible range and an infrared camera for conditions with poor visibility, teamed with GPS to bring a modified Diamond DA42 airplane in for a safe, unpiloted landing at a small private airfield in Wiener-Neustadt, Austria. Researchers from the Technical University of Munich (TUM) and the Technische Universität (TU) Braunschweig formed the C2Land project with funding from the German federal government.

What's New. Automatic landings by both commercial aircraft and small planes can and do take place at major airports with the Instrument Landing System (ILS) infrastructure to guide aircraft in with sufficient precision. Ground antennas send radio signals to the plane's autopilot to make sure it navigates safely to the runway. Procedures in development to use GNSS alone to make autonomous landings also require a ground-based augmentation system.

But systems such as these are too expensive for small airports that will conceivably carry the major share of UAM: on-demand, autonomous, highly automated (unpiloted), passenger- or cargo-carrying air transport services. This transportation option could reduce surface traffic congestion afflicting many urban areas.

What must happen for such George Jetson air taxis to become a reality? UAM will take place in the zone 500 to 5,000 feet above ground, transporting one to five passengers or cargo over distances of five to 50 miles. The vision shared by most UAM stakeholders, a group including the U.S. National Aeronautics and Space Administration and the Federal Aviation Administration, involves vertical take-off and landing more often than conventional "glide" take-off and landing, but precise navigation to the landing spot is critical in both cases.

"Automatic landing is essential, especially in the context of the future role of aviation," said Martin Kügler, research associate at the TUM Chair of Flight System Dynamics.

Fly-by-wire systems (semiautomatic, computer-regulated systems for aircraft navigation) use GPS signals for positioning. Susceptible to errors, interference and obstruction, GPS/GNSS is not solely sufficient for landing procedures. Current GPS approach procedures require that human pilots resume control over the aircraft at 60 meters altitude and land the aircraft manually.

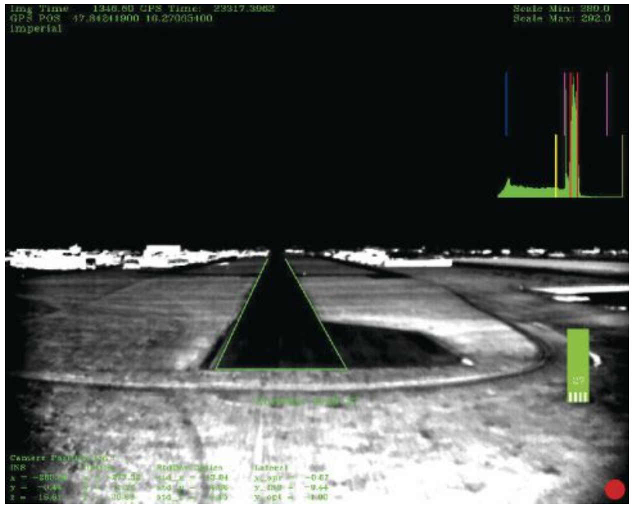


Image © TU Braunschweig

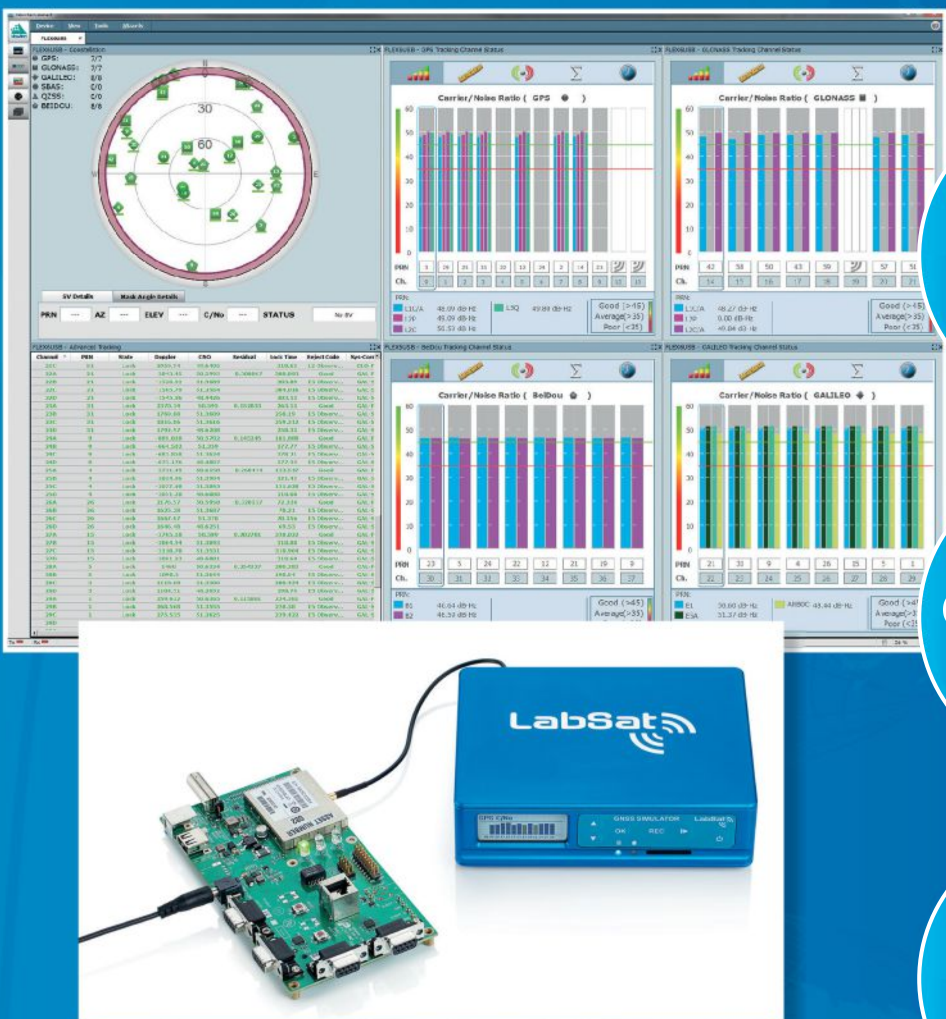
INFRARED CAMERA IMAGE with selected runway of the research project C2Land of the Technical University of Munich (TUM) and the Technische Universität Braunschweig.

To enable completely automated landings, the TU Braunschweig team designed an optical reference system with two cameras, one in normal visible range and an infrared camera for poor visibility conditions. With custom image processing software, the system determines aircraft location relative to the runway based on the camera data it receives. The software integrates additional functions such as comparison of data from the cameras with GPS signals, calculation of a virtual glide path for the landing approach, and flight control for various phases of the approach.

Visual Recognition. Test pilot Thomas Wimmer, who sat through the procedure with his hands folded, said, "The cameras already recognize the runway at a great distance from the airport. The system then guides the aircraft through the landing approach on a completely automatic basis and lands it precisely on the runway's centerline."

The researchers presented their system in two papers at the Institute of Navigation's 2019 Pacific PNT Meeting in April. See "Research Roundup" on page 46 of this issue.

SatGen Signal Simulation Software



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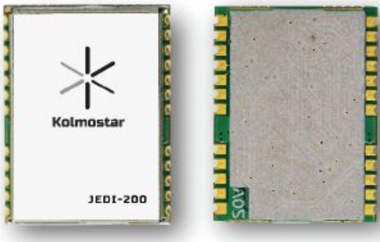

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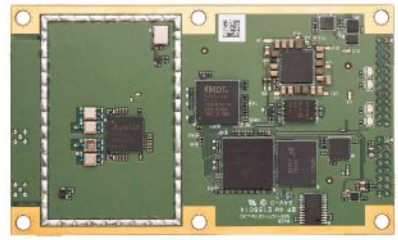

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1. GNSS MODULE

ULTRA-LOW-POWER FOR WEARABLES

The JEDI-200 reduces the energy for one position fix by up to 150x compared to traditional GNSS sensors, providing a positioning solution for location-based internet-of-things applications.JEDI-200 specification highlights include 10-mW ultra-low-power consumption (measured) at 1-Hz navigation rate; 1-second ultra-fast time-to-first-fix from cold start, and 2-meter CEP high positioning accuracy. It supports GPS and BeiDou. It offers 100-byte compressed ephemeris (EPH) to enable A-GPS with speedy download via low-power wide-area network (LPWAN) technologies such as LoRaWAN and narrowband internet of things (NB-IoT).

Kolmostar, www.kolmostar.com

2. INERTIAL NAVIGATION

FOR GPS-DENIED ENVIRONMENTS

The EMCORE EN-300 precision fiber-optic inertial measurement/navigation unit is a high-accuracy inertial system designed to be form, fit and function compatible with a legacy equivalent, but with better performance needed for GPS-denied navigation, precise targeting and line-of-sight stabilization. The EN-300 incorporates EMCORE's proprietary integrated optics devices to enhance performance. The internal signal processing provides full stand-alone or aided navigation, and as an option can provide standard IMU delta velocity and delta theta. With the option of full navigation capability including coning and skulling compensation and sophisticated Kalman filtering, the unit also is able to statically find north to less than one degree through gyrocompassing.

Emcore, www.emcore.com

3. GNSS BOARD

FOR POSITIONING AND HEADING

The Phantom 40 positioning board is the first Lyra-based offering in a line of low-power, high-precision boards. Its multi-frequency, multi-GNSS receiver processes 700 channels with access to Hemisphere's Atlas GNSS global corrections network. The 60 x 100 mm module with 24-pin and 16-pin headers is a significant upgrade for existing designs using this industry-standard form factor. The new Lyra II digital ASIC and Aquila wideband RF ASIC designs will be available with the new board, as well as Cygnus interference mitigation technology.

Hemisphere GNSS, www.hemispheregnss.com

4. HELICAL ANTENNAS

AVAILABLE IN HOUSED AND EMBEDDED OEM VERSIONS

The first three products of a new range of helical antennas include the HC871, HC872 and HC600. The active GNSS helical antennas feature a low-current, low-noise amplifier (LNA), and include integrated low-loss pre-filters, to protect against harmonic interference from high amplitude interfering signals, such as 700-MHz band LTE and other near in-band cellular signals. The HC871 is a housed, dual-band, active GNSS antenna supporting GPS L1/L2, GLONASS G1/G2, Galileo E1, and BeiDou B1 (25 grams). The HC872 is a housed, dual-band, active GNSS antenna supporting GPS L1/L2, GLONASS G1/G2, Galileo E1, BeiDou B1, and L-Band services (36 grams). The HC600 is a housed, passive Iridium antenna (18 grams).

Tallysman, www.tallysman.com

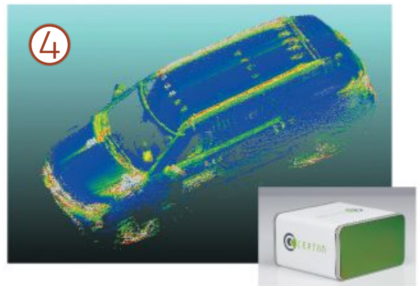
5. FIBER EXTENSION KIT

CARRIES SIGNALS UP TO 10 KILOMETERS

ViaLite's new GNSS/GPS Fiber Extension Kit has been qualified for use with Microsemi's timing and synchronization products, and carries timing signals over optical fiber links to 10+ kilometers. The kit includes the ViaLiteHD GPS Link, designed to provide a remote GNSS/GPS signal or derived timing reference to equipment located where there is no reception, such as inside buildings, tunnels and mines. The kit is suitable for GPS, Galileo, GLONASS and BeiDou bands, and the links provide a wide dynamic range with negligible signal degradation from noise or interference.

ViaLite, www.vialite.com

LAUNCHPAD | SURVEY & MAPPING



1. LIDAR SCANNER

3D MOBILE SCANNER FOR URBAN AREAS, ROADS

The second generation of the vMS3D lidar scanner is now more compact and simplified in both electronic and ergonomic terms to make it more robust and stable in adverse conditions and challenging environments. Despite being lighter, the second generation offers the same technological capacities as its predecessor, but is simpler to use and can be mounted on a vehicle in minutes. The system component (including the sensors) and the element to affix the device to the vehicle (the frame) previously formed one unit, but are now separated in a design that limits vibrations and prevents any strain on the mechanics during acquisition. The scanner's receiver is a Septentrio AsteRx-m2a and its inertial measurement unit is an SBG Systems Ellipse2-D.

Viametris, www.viametris.com

2. JOB-SITE MONITORING

REAL-TIME 3D CONSTRUCTION MANAGEMENT GETS REMOTE SUPPORT

Sitelink 2.0 is the latest edition of Topcon's real-time 3D job-site monitoring and management system. The update includes a new pay-as-you-go point-based service model, new features to Sitelink Support Desk, and a new Haul Truck application. Remote configuration via the support desk allows Topcon personnel to directly access and configure receiver components on connected machines, while simultaneously retaining an active remote session of Topcon's 3D-MC grade-control software for machine control.

Topcon, www.topconpositioning.com

3. DATA COLLECTOR

CONNECTED SMARTPHONE FOR THE FIELD

The TDC600 handheld is an ultra-rugged, all-in-one smartphone and GNSS data collector for geographic information system (GIS) and field inspection applications. The rugged handheld runs on Android 8.0 and has a bright sunlight-readable 6-inch display, 2.2-GHz processor, 4-GB memory and an enhanced-capacity all-day battery. It supports the Trimble Catalyst GNSS positioning service that delivers subscription-based accuracy on demand for Android devices. Its built-in receiver supports GPS, GLONASS and BeiDou plus satellite-based augmentation system (SBAS) capabilities for real-time positioning. It is rugged for GIS users in organizations such as environmental management, utilities and government agencies. Wi-Fi, Bluetooth 4.1 and 4G LTE cellular connectivity support data and voice calls, so field workers can use the TDC600 as they would any consumer smartphone, communicating between the field and office, sending emails and texting.

Trimble, www.trimble.com

4. VEHICLE SCANNER

1,200 SCAN LINES PER SECOND

The SORA-P60 is designed to provide accurate 3D scans and to enable automated classification of objects and volumetric scanning, including high-velocity vehicle scanning and classification. Cepton's Micro-Motion Technology (MMT) lidar in combination with its edge-compute hardware SORA-Edge makes it a powerful, mobile object classification and volumetric measurement device that can send its data over Ethernet, Wi-Fi or LTE to a central processing server. The SORA-P60's three scan lines, each scanning at 400 Hz, enable accurate scanning for classification of objects traveling at highway speeds — 400 Hz translates to a scan line every 5 centimeters for an object traveling at 50 miles per hour. For example, users can measure the size of a tow hitch and trailer on a vehicle traveling on a highway in real time. The SORA-P60 sensor is free of rotational or frictional components, making it impervious to mechanical wear and tear. In addition, the new SORA-P60 features rugged housing designed to withstand harsh environments, cold climates and salt spray.

Cepton Technologies, www.cepton.com


GNSS Spoofers, don't
mess
with
me!
Tracked • Used • Faked
Spoofed • Replaced
Blocked/Jammed
See details inside >>>

Front

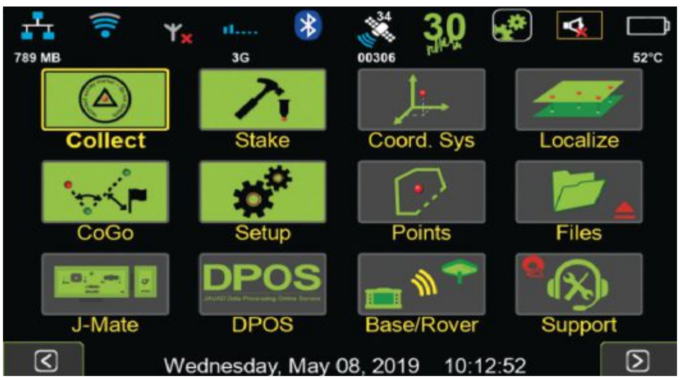
Introduction to J-Mate

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

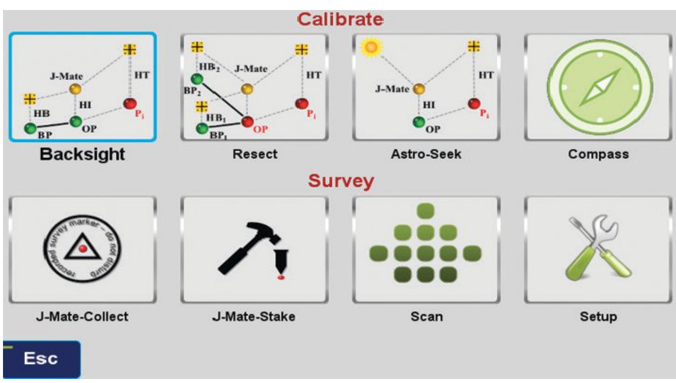
As with the TRIUMPH-LS, with the J-Mate we also provide software improvement updates regularly and free of charge. Download the J-Mate update in your TRIUMPH-LS and then inject it to the J-Mate. The J-Mate SSID will be in this format JMatexxx, where xxx is your J-Mate's serial number. After a Wi-Fi connection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

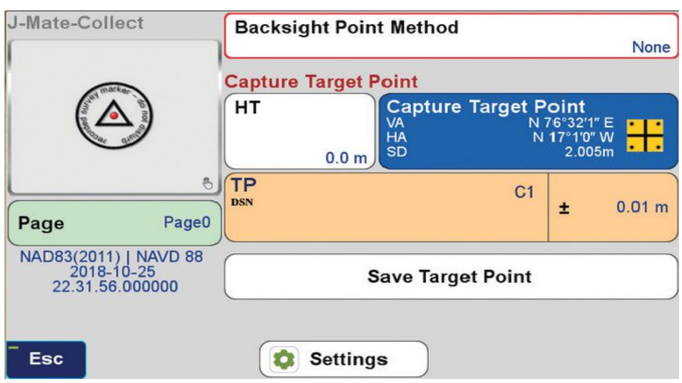
Connecting the TRIUMPH-LS to the J-Mate

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



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





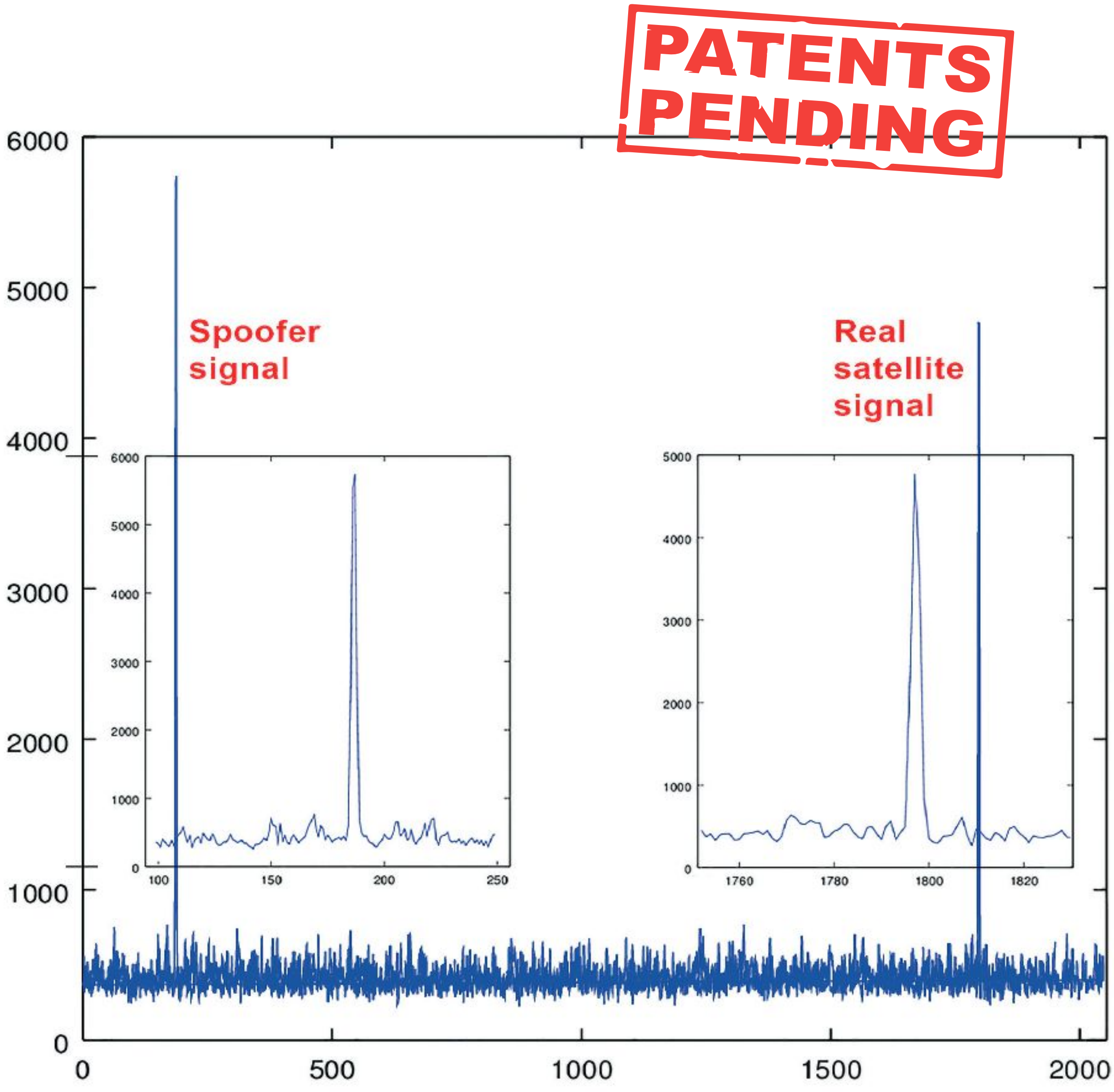
Spoofer Detection

With 864 channels and about 130,000 quick acquisition correlators in our TRIUMPH chip, we have resources to assign more than one channel to each satellite to find ALL signals that are transmitted with that GNSS satellite PRN code.

If we detect more than one reasonable and consistent correlation peak for any PRN code, we know that we are being spoofed and can identify the spoofed signals.

When we detect that spoofing is in effect, we use the position solution provided by all other clean signals (L1, L2, L5, etc... GPS, GLONASS, Galileo, Beidou, etc...) to identify the spoofer signal and use the real satellite measurement. If all GNSS signals are spoofed or jammed, then we alarm you to ignore GNSS and use other sensors in your integrated system.

Figure below shows an example of a spoofer signal and a real satellite signal received at GNSS receiver.



Satellite and Spoofer Peaks

The screenshots below are from a real spoofer in a large city. The bold numbers are for the detected peaks. The gray numbers represent highest noise, not a consistent peak. "*" symbol next to the CNT numbers indicate that signal is used in position calculation. Each CNT count represent about 5 seconds of continuous peak tracking.

SAT	EL	S...	Range 1	Dopp...	CNT 1	S...	Range 2	Dopp...	CNT 2	dRng	dDop	N
GPS5	33	16	61.14	1382	184*	4	25.95	181	1	29.32	1201	29
GPS7	51	21	14.39	1146	184*	4	18.21	-453	1	2.80	1599	29
GPS8	30	18	65.10	-918	184*	4	4.26	-1318	1	3.68	400	29
GPS9	12	14	40.46	2966	184*	4	2.08	3765	1	26.13	-799	29
GPS13	40	16	46.92	-3525	184*	4	8.21	-4325	1	25.80	800	29
GPS15	12	14	12.46	-4336	30*	5	33.00	-1536	1	19.52	-2800	28
GPS20	24	12	13.19	-1707	107*	4	29.32	-3307	1	15.11	1600	29
GPS27	16	11	10.26	1264	184*	4	43.55	63	1	31.22	1201	29
GPS28	53	19	9.41	-2724	184*	4	7.93	-4724	1	0.46	2000	29
GPS30	81	22	13.79	-332	184*	5	34.16	1266	1	19.35	-1598	28
GLN-4	54	20	62.08	1498	1158*	5	21.72	2697	1	24.16	-1199	25
GLN5	46	20	18.04	-2897	524*	4	26.26	-3697	1	7.20	800	25
GLN0	37	18	30.37	2355	1469*	4	38.37	1554	1	6.98	801	25
GLN-1	82	18	34.92	-776	189*	4	12.54	-1576	1	21.35	800	25
GLN-2	26	12	30.96	-4358	229*	4	11.80	-3158	1	18.13	-1200	25
GLN2	21	10	59.73	288	551*	4	47.55	1087	1	11.16	-799	25
GLN4	22	15	30.59	-3361	208*	4	11.74	-5361	1	17.83	2000	25
GLN-5	21	14	20.17	276	187+	3	25.45	2275	1	4.26	-1999	25

Esc   Sat: 10 7 6 4 4 0   dPos: 19.0m   Age: <1s

No spoofer. Only one reasonable peak for each satellite.

PATENTS PENDING

Elevation Angle

Satellite Name

First Peak: Signal above noise level / Range mod 1 ms / Doppler / 5 sec count

Second Peak: Signal above noise level / Range mod 1 ms / Doppler / 5 sec count

Delta range / Delta Doppler / Noise level

SAT	EL	S...	Range 1	Dopp...	CNT 1	S...	Range 2	Dopp...	CNT 2	dRng	dDop	N
GPS1	14	14	231.08	-2627	140*	9	155.13	-2627	60	74.93	0	28
GPS10	9	12	267.44	-2078	74*	4	238.41	-3278	1	28.01	1200	28
GPS11	22	13	297.36	-847	301*	3	6.45	1151	1	289.89	-1998	29
GPS13	55	21	136.95	1154	301*	9	21.70	1153	73	114.23	1	28
GPS15	49	20	278.00	-453	301*	9	168.03	-453	73	108.95	0	29
GPS17	41	22	83.28	-3212	301*	10	277.41	-3212	69	193.11	0	28
GPS19	23	14	133.13	-4590	164*	7	19.06	-4590	69	113.05	0	29
GPS20	5	8	170.96	2215	36*	3	50.73	614	1	119.21	1601	29
GPS24	22	15	54.25	-4022	177*	9	250.43	-4022	82	195.16	0	29
GPS28	58	18	50.14	1040	301*	3	268.62	1439	1	217.46	-399	29
GPS30	23	17	290.02	2593	301*	3	214.66	4592	1	74.34	-1999	28
GLN-7	30	22	159.09	2505	213*	7	274.16	2104	1	114.05	401	28
GLN-4	39	18	72.21	-450	282*	7	220.15	-3250	1	146.92	2800	28
GLN-1	34	18	92.17	-3838	259*	6	299.41	-1838	1	206.22	-2000	28
GLN0	72	23	271.81	147	283*	7	78.08	2146	1	192.71	-1999	28
GLN1	23	15	297.65	3244	129*	6	8.21	2443	1	288.42	801	28
GLN2	42	18	200.78	-742	282*	6	234.83	2056	1	33.03	-2798	28
GLN3	17	18	158.51	2584	282*	6	44.03	4583	1	113.46	-1999	28

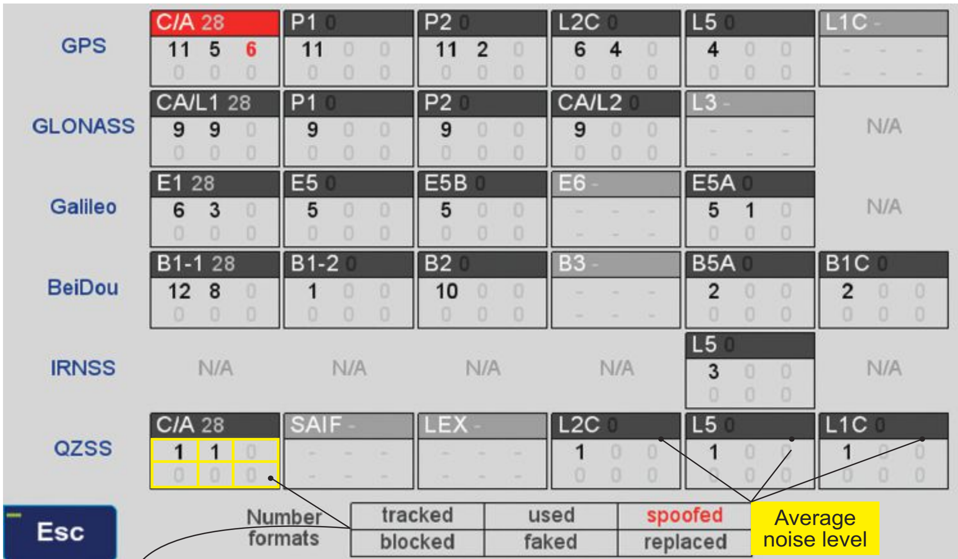
Esc   Used: 11+9+4+8+0+1=33   1   2   dPos: 21.2m   Age: <1s

GPS GLN GAL BDU IRN QZ ◂ Number of satellites used in position calculation

In the above screenshot all GPS satellites have two peaks and all are spoofed. We were able to distinguish the spoofer signal and use the real satellite signals in correct position calculation as indicated by the "*" next to the CNT numbers.

GNSS Overall View

The screenshot below shows the status of all GNSS signals. The format and the signal definitions are explained below.



GPS L2C: L+M
GLN L3: I+Q
GAL E1: B+C
GAL E5: alboc
GAL E5B: I+Q
GAL E5A: I+Q
BeiDou B2: B5B
QZSS L2C: L+M
QZSS L1C: I+Q

Figure 4
The screenshot shows the status of all GNSS signals.

Definitions for the number of signals:

Tracked: Tracked by the tracking channels and has one valid peak only.

Used: Used in position calculation.

Spoofed: Has two peaks. Good peak is isolated, if existed.

Blocked: Blocked by buildings or by jamming. If jammed, shows higher noise level.

Faked: Satellite should not be visible, or such PRN does not exist.

Replaced: Real signal is jammed and a spoofed signal put on top of it. Because of jammer, it shows higher noise level.

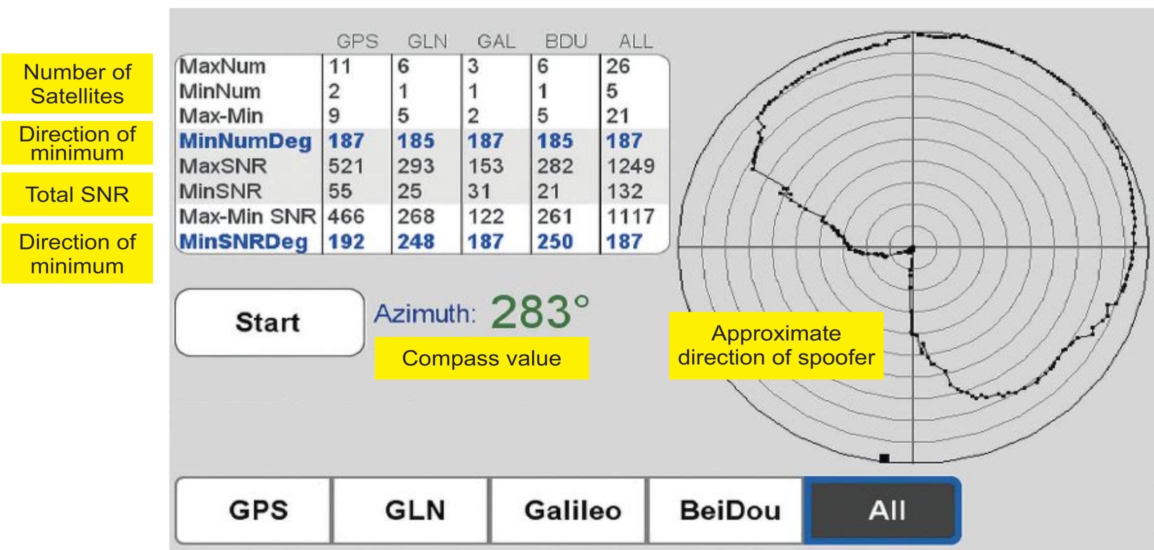
Spoofer detection available in all of our OEM boards too.

See details in GPS World expert opinions section “What is the biggest challenge facing designers of multi-constellation GNSS receivers today?” with Javad Ashjaee and at www.javad.com

Spoofer Orientation

When you detect that spoofers exist, you can also try to find the direction that the spoofing signals are coming from. For this, hold your receiver antenna (e.g. TRIUMPH-LS) horizontally and rotate it slowly (one rotation about 30 seconds) as shown in the picture and find the direction that the satellite energies become minimum. This is the orientation that the spoofer is behind the null point of the antenna reception pattern.

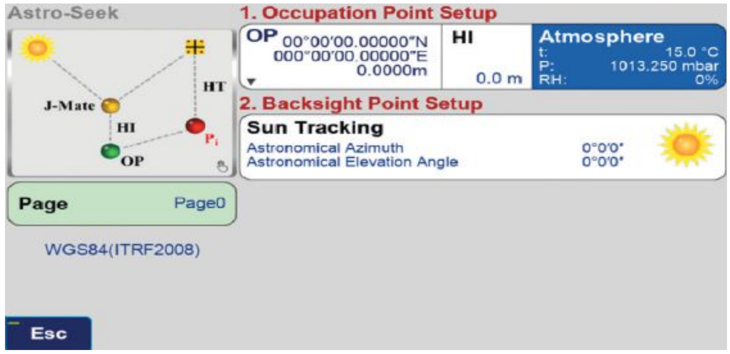
After one or more full rotations observe the resulting graph that shows approximate orientation of the spoofer as shown in figure below.



This screenshot is from the experiment within an anechoic chamber. That is why the picture is clean and smooth.

Backsight point and the Sun

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



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

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

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

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

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

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

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

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

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

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

Astro-Seek feature: Sun as the Backsight point!

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

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

TRIUMPH-3

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

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

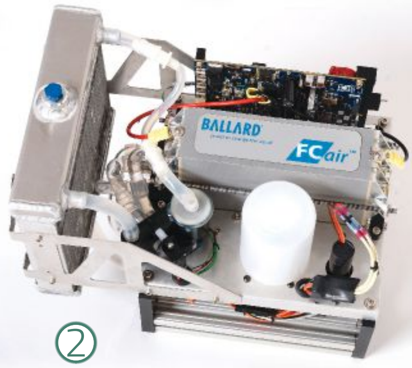
The TRIUMPH-3 receiver can operate as a portable base station for Real-time Kinematic (RTK) applications or as a receiver for post-processing, and as a scientific station collecting information for individual studies, such as ionosphere monitoring and the like.

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

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

Ideal as a base station

1



2

1. LONG-FLIGHT DEMONSTRATOR

COMPLETED MAIDEN FLIGHT

The XQ-58A Valkyrie from National Security Solutions provider Kratos completed its maiden flight on March 5 at Yuma Proving Grounds in Arizona. Kratos Unmanned Aerial Systems (KUAS) and the Air Force Research Laboratory (AFRL) partnered on the development of the XQ-58A Valkyrie. During its 76-minute maiden flight, the UAV completed its test objectives. The runway-independent UAV is capable of long-range flights at high-subsonic speeds. Its development falls within AFRL's Low Cost Attritable Aircraft Technology (LCAAT) portfolio, which has the objective to break the escalating cost trajectory of tactically relevant aircraft.
Kratos Defense & Security Solutions, ww.kratosdefense.com

2. FUEL CELLS

LONG-DURATION POWER SOLUTION FOR COMMERCIAL UAVS

The FCair hydrogen fuel cell can extend UAV flight time to up to 90 minutes, almost three times that of lithium-ion battery-powered drones. The product line includes FCair-600 and FCair-1200 liquid-cooled fuel-cell power systems, with built-in hybrid battery control and charging and delivering 600 and 1200 watts of power, respectively. These systems are in ongoing field trials, having previously been proven in harsh environments and at high altitudes. FCair includes a hydrogen fuel-cell power system, hydrogen storage vessels, pressure regulators, refueling solutions and hydrogen gas supply. The product line supports commercial UAV manufacturers and operators in the delivery of fuel-cell-powered UAV benefits, including: three times the flight duration of batteries; five times the reliability and a fraction of the noise of small internal combustion engines; and significantly reduced operational expenses.
Ballard, www.ballard.com

3

3. LIDAR PLATFORM

COMPACT FOR UAV DEPLOYMENT

The CL-90 is a lightweight compact lidar platform for UAV deployment. It features exceptional canopy penetration, offering low-noise, high-quality survey-grade data to deliver high-quality performance in data accuracy and point precision. The CL-90 provides full lidar performance across the entire operating altitude range of the UAV, and offers a variable field-of-view capability that eliminates the need for multiple passes over a target.
Teledyne, www.teledyne.com

4. DRONE COUNTERMEASURE

LIGHTWEIGHT, COMPACT HANDHELD GUN

DroneGun MKIII is a portable pistol-shape drone jammer weighing under 2 kg. DroneGun MKIII is designed to be an alternate product rather than a replacement for the previously released DroneGun Tacticalunit. It has a shorter effective range of 500 meters versus 1–2 kilometers for DroneGun Tactical. DroneGun MKIII can be used in combination with other DroneShield products, including the RfPatrol body-worn detection device and the DroneSentinel stationary multi-sensor detection system.
DroneShield Ltd., www.droneshield.com

4

MAPPING
OUR URBAN FUTURE

Government agencies are increasingly turning to high-precision aerial imagery to solve city-planning conundrums. Three recent case studies show how emergency 9-1-1 services gather data to provide updated maps to emergency services to get to the right locations as soon as possible; reveal how a city's public works department streamlines data collection for more efficient infrastructure management; and how to give GIS professionals instant access to the most current information available — ALL IN THE CLOUD.

BY Tracy Cozzens / SENIOR EDITOR

Photo: Nearmap

NEARMAP'S patented camera system and software pipeline enables it to capture aerial photos, stitch them together into seamless digital maps, and publish the content online within days of capture. Above, Nike's headquarters in Portland.

It's said a picture is worth a thousand words. In the case of aerial imagery, where location data is packed into every pixel, a picture could save lives.

Emergency dispatch is just one type of government agency now relying on high-quality aerial imagery. With up-to-date georeferenced imagery of their own towns and counties, agencies are not only improving response to emergency calls, but also streamlining public works and enhancing city planning.

A company providing that imagery is Nearmap, which serves more than 8,200 organizations and businesses globally using small aircraft for image capture. The aerial mapping company provides high-quality imagery as a subscription service delivered through the cloud. Its photo maps are taken at least twice a year, with leaves both on and off the trees, to provide different views of locations in different seasons.

Aircraft offers a huge advantage over unmanned aerial vehicle (UAV) or satellite imagery. Airplanes can cover much greater distances than UAVs, and pilots pay heed to the weather and fly below cloud layers to deliver the clearest visuals possible. Unlike space-based platforms, airplanes operate at lower altitudes, also increasing the resolution, and can fly on demand, unlike satellites that have set orbits dictating their periodicity for returning to a target area.

Nearmap's powerful, patented technology allows it to deliver high-resolution aerial imagery as a service: orthographic (straight down) maps, multi-perspective panoramas and oblique aerial views — all at resolutions four times clearer than free satellite imagery.

Once photographed, the images are stitched together in the cloud in a matter of days, where they are available for viewing and analysis on desktop, tablet and mobile devices via a subscription service.

Nearmap's proactive capture model is based on population — the larger the population, the more captures it takes per year. Nearmap images 88% of Australia's population, 70% of the U.S. population, and 75% of the New Zealand population.

Nearmap captures many areas multiple times throughout the year; for many locations this gives customers a leaf-off and leaf-on view. Providing spring leaf-off captures allows customers a view of the ground that is typically obstructed by foliage the rest of the year.

The flight plans cover approximately 430 urban areas that are flown, captured and processed, and then served up via the MapBrowser in-browser tool, or supplied via application programming interface (API) for use in various design platforms. When a user subscribes to Nearmap, the capture is immediately available with any and all historical captures, without the need to pay for a dedicated flight.

"To capture imagery for a map, a plane has to crisscross over its own flightpath. Each sweep has to overlap the previous by approximately 70%," explained William Tewelow, *GPS World's* contributing editor for geointelligence. "Vertical (or nadir) is straight overhead. Oblique is everything else, but usually not exceeding 30% to either side because it distorts the structures and vertical features (parallax), makes mosaicking difficult, and shadows structures behind other structures."

That said, oblique imagery is important for building 3D meshes for imagery point clouds, Tewelow said, as well as seeing various angles of a structure.

Following are examples of the creative — and surprising — ways government agencies are using Nearmap imagery to improve their services today, and prepare for future changes in their communities.

Better 9-1-1 Address Mapping

Shelby County is the largest county in Tennessee in both population (927,644) and geographic area (785 square miles). Memphis is the county seat, home to the county's Emergency Communications District, for the operations of the local 9-1-1 emergency system.

The district provides Shelby County residents with an efficient emergency telephone number service using the latest technology, equipment and training for the various emergency service providers and dispatch centers.

For each dispatch center, the district provides county address location mapping. A secure database known as an ALI (Automatic Location Identification)

Photo: Nearmap

ALBANY, N.Y.: A house fire in progress.

UAS ENHANCES UTILITY CO-OP'S GIS EFFORTS

Photo: Topcon

An electric cooperative that serves more than 33,000 member customers in Lakeside, Ariz. — including the White Mountain Apache Tribe — is using an unmanned aerial system (UAS) to enhance the utility's GIS effort, working with UAS specialist Skynetwest. Noah Ruiz started Skynetwest in 2015 to provide aerial photographic and videographic services, but seeing the potential of UAS he began making the pivot to high-value data retrieval.

Initial work for the Navopache Electric Cooperative (NEC) included an inspection of an area's substations. Conducted on a day in which the winds were blowing at 20+ mph, with most other aircraft, the flight would have been extremely risky if not scrapped.

Skynetwest used an Intel Falcon 8+ Drone, Topcon Edition. Windspeed limits for the Falcon 8+ in GPS mode are set at 26 mph; in height mode that threshold is extended to windspeeds as high as 35 mph.

The Falcon 8+ has triple-redundancy inertial measurement units (IMUs), double-redundant compasses, dual-constellation GPS, eight propellers and two batteries. Built into the aircraft's software is an algorithm that detects the electromagnetic frequencies coming off of power lines and tells the IMUs which one it wants to switch from, which GPS it wants to use, and which compass it wants to use.

The aircraft's stability is key not only for power line work but also for items like inspection of oil and gas components. For inspection applications — close-up inspections to detect millimeter-sized damage, fine hairline cracks, leaks or heat power losses, for example — the Falcon 8+ payload consists of a Panasonic Lumix DMC-ZS50 camera for true-color RGB images and the FLIRTau 2 640 thermal imaging camera for infrared imaging. The hybrid RGB + 14-Bit RAW data inspection payload combines a near-infrared camera with a high-resolution digital camera mounted in parallel.

The mapping package Skynetwest uses includes a 36-megapixel RGB camera (Sony Alpha 7R) and delivers both orthophotos and 3D models in Topcon ContextCapture software, powered by Bentley Systems.

Upon completion of the substation project, using ContextCapture and Agisoft PhotoScan software, Skynetwest stitched together all of the images it had gathered to create a georeferenced 3D model of that substation. NEC is looking into building more 3D representations of the entire grid and ultimately hoping to build a complete 3D spatial record down to nuts and bolts — all with survey grade data.

Photo: Nearmap

FIGURE 1 **Mapping image for Shelby County's 9-1-1 system.**

contains the exact 9-1-1 address for any given associated phone numbers.

When a 9-1-1 call comes in, the database is queried by the Public Safety Answering Point to obtain the caller's location. This data is then placed in the computer-aided dispatch software and 9-1-1 mapping software used by the district to help fire and rescue, emergency medical services and law enforcement gain instant access to updated maps containing GIS data needed to get to the right locations as soon as possible.

The 9-1-1 mapping system uses geodetic coordinates to plot wireless calls on the map. The system also reverse geocodes the coordinates to provide the 9-1-1 telecommunicator with a calculated civic address based on proximity of other features in the map, such as address points or streets.

Out-of-Date Imagery. For years, Shelby County's aerial image process required a contracted flight to photograph the county areas. Because of the high cost of capturing those images, the county purchased images once every two years, after pooling resources from various county entities.

"We had gaps where we wouldn't have updated imagery," said Timothy Zimmer, the district's GIS administrator. "While the images were high resolution, there were issues with mosaicking the separate images together, and since the imagery was taken every two years, many rural and unincorporated areas were out of date."

With out-of-date images, the county had to develop alternate methods to locate addresses for the 9-1-1 systems.

Moving into the Cloud. In the summer of 2018, Zimmer began to work with Nearmap. With Nearmap, Zimmer and his team can access current imagery to geocode new addresses and developments as well as plot new roads into the 9-1-1 mapping systems (**FIGURE 1**).

For Zimmer, the biggest advantage is that Nearmap's imagery integrates directly into Esri's ArcMap, ArcPro and ArcGIS Online applications, so he can overlay GIS information directly over the high-resolution imagery.

"I really like how Nearmap is integrated into the GIS stack," Zimmer said. "We're able to stay on top of new developments, roads, and addresses. Being able to have Nearmap imagery integrated into our GIS systems helps

A STRAIGHTFORWARD EXPLANATION OF *OBLIQUE*

BY **William Tewelow**
CONTRIBUTING EDITOR FOR GEOINTELLIGENCE

How are oblique views derived from aerial imagery?

Typically, a camera takes a field of view of 120 degrees (+/– 60 degrees either side of centerline). The nadir is straight down +/– 5 degrees either side, but everything beyond is considered oblique imagery.

Overlapping imagery is required to ensure clean images and to reduce the angle of obliquity. Too much of an oblique angle causes parallax, which distorts the image, so it is usual for imagery to overlap by 70% each pass, meaning that 30% either side of center is used, but everything except for a small path considered nadir is double imaged.

However, in the case of stereographic imagery, which is required for building a 3D mesh, the overlap has to cover the centerline of the last flight path, so the flights must be much closer together.

Oblique imagery allows 3D meshes to be created, which is a huge benefit to geospatial analysis. It allows the actual terrain to be measured not in a straight line, but in an actual topographic line that includes elevation changes for point-to-point distance.

Additionally, straight lines work when everything looks flat, but in reality straight lines are rare, and point-to-point measurements often have to take advantage of the existing terrain, avoiding steep terrain and aiming to stay on the highest ground to avoid marshy areas.

Oblique imagery also allows for mensuration, which is the measurement of the vertical based on the trigonometry of the sensor's position and height compared to the target's angle. More than one oblique image of the same target area allows for stereographic imagery for building the 3D meshes and seeing in 3D. Without the magic of oblique imagery, GIS would be a 2D science.


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Photo: Nearmap

FIGURE 2 **Rapid growth requires frequent imagery. Above is a new Durham neighborhood under construction.**

us be much more accurate."

The combined impact of data services, base maps, Nearmap imagery and third-party data are improving all aspects of public safety, including law enforcement, fire and emergency medical services.

Other Shelby County agencies also are using the district's imagery and GIS data. "The county clerk and the utility company are using our address mapping data because Nearmap has helped enable us to be much more current," Zimmer said.

Public Works in a Fast-Growing City

Durham is one of the points in North Carolina's high-tech Research Triangle and home to Duke University.

An economic and cultural renaissance is happening in the city. With a revitalization of its downtown district, the redevelopment and repurposing of former tobacco districts into tech hubs, and chic loft-style apartment complexes, Durham is rapidly growing beyond its most recently reported 250,000 population numbers.

Impervious Challenge. In early 2018, the city's growth explosion prompted Edward Cherry, GIS administrator for the City of Durham Public Works Department, and his staff of 14 GIS professionals to seek ways to streamline their data collection.

The department manages all infrastructure data for the city, including mapping the impervious area. As defined by the U.S. Geological Survey, impervious surfaces include highways, streets, pavement, driveways and even house roofs — any surface that won't absorb rainwater. Rather, the rain runs off into storm sewers and then into local creeks; localized flooding is often the result.

Durham Public Works manages half a billion square feet of impervious area. The city's $16 million-a-year Stormwater Utility Fee income was a driver for Cherry's team to explore satellite imagery options. Imagery from satellites, however, were infrequent and too low-resolution to meet their needs. The satellites captured images only once-a-year, and that might be on a cloudy or rainy day. Clouds cast shadows, and rain makes pavement appear newer than it is.

Nearmap's aerial imagery, captured in Durham three times a year at a 2.8-inch ground sample distance (GSD), solved the problem (the GSD of each individual pixel in the imagery represents 2.8 inches on the ground. See **FIGURE 2**).

Dozens of projects in the Public Works Department — from road maintenance and pothole patching to water sampling and degradation — are using the improved imagery, which has saved the city money, reduced time spent in the field, and allowed crews to use real-time imagery when they are working in the field.

Monitoring Pavement Conditions. The City of Durham is responsible for maintaining most of its roads, and conducts a road-condition survey that samples different sites, evaluating the level of degradation.

Since 2014, Nearmap has regularly captured Durham streets at the same resolution and accuracy, and both the historical and current data are available to the department.

With multiple high-quality image captures at high resolution, surveyors can see sections that have been recently paved. "We don't need to send crews out to an area where a stretch has already been paved," Cherry explained.

Road Repair Documentation. As in any city, the patching of potholes is an ongoing project for Durham's public works department. With imagery, the city has been able to streamline the process.

Traditionally, the streets department sent out inspectors to spray paint and circle areas that required repairs. "Then we would produce maps and hard copies to direct [road repair contractors] ahead of time on a scheduled event," Cherry said.

Now the city uses an application integrated with Nearmap imagery by which contractors can view the job on their smartphone or tablet while in the field. The surveyors can edit and draw the areas that need patching instead of physically going out and spray-painting them. "Then, in real time, the people doing the patching can see a very high-resolution image of where they need to do the work," he said.

The pothole image captures are recorded, so the city knows where and how many potholes were patched. "We can see where work has been done when we are billed for it," Cherry said. "We can visualize the work, which is an added bonus."

Mapping Riparian Zones. With imagery previously taken only when the leaves had fallen (known as leaf-off), surveys of riparian zones in Durham proved limiting.

With imagery captured during both leaf-off and leaf-on seasons, riparian buffers around streams can be properly monitored for expansion. The buffers can be altered if there are issues with a stream's path, such as sediment clogging the flow, repeated flooding or people intruding on a buffer.

Change Detection. High-resolution imagery has improved Durham's billing process by producing web service maps that capture individual storylines. Stormwater billing customers, for instance, can visualize their properties with the impervious areas mapped out and tied to their billing records.

With up-to-date imagery providing data for change detection software, records also show when a customer has added a driveway or an extension to their house.

"Having access to imagery back to 2014, we're able to go back in time during the thrust of development and monitor it forward," Cherry said.

Image: Nearmap

FIGURE 3 **Aerial Imagery of an Apex neighborhood displayed in ArcGIS from Esri.**

Nearmaps' library of historical imagery allows for change detection algorithms to run in Esri's ArcGIS imagery analysis software suite.

More Efficient Government

GIS data combined with aerial imagery is tailor-made for city planning and managing urban growth.

For instance, the population of Apex, N.C., has more than doubled since 2000. Situated near Raleigh and the state's Research Triangle Park, Apex was rated number one in *Money* magazine's 2015 "Best Places to Live," which cited Apex's charming downtown, highly rated schools and high-paying technology jobs.

To manage the explosion in development, Apex's GIS professionals needed instant access to current information. The old-school method required planners to drive the streets, inspect roadways, and roll out the measurement wheel. Now, the combination of Esri ArcGIS for mapping and Nearmap high-resolution aerial imagery allows them to visualize and measure within six inches of accuracy.

"Our ability to leverage our GIS operation improved dramatically with Nearmap. The flexibility of its cloud solution and ability to integrate with ArcGIS has redefined how we rapidly respond to staff and citizen requests," said Steve Nelson, a GIS professional with Apex.

The use cases for these solutions are diverse. Law enforcement calls on GIS professionals from Apex to quickly provide current, clear, aerial photography for active or ongoing investigations. Planners focused on development are charged with meeting state regulatory reporting guidelines when it comes to building and maintaining roads. Environmentalists want to know if anyone is digging on protected land.

For the State Street-Aid Program, financial allocations are made to incorporated municipalities eligible under North Carolina law. State routes that pass through incorporated cities are maintained by the cities. Cities are responsible for paving new roads, but the state has the power and economic means to reimburse them.

To qualify for reimbursement for new roads developed and maintained, Apex needs to submit a report to state engineers for review. The report documents the distance for all newly paved roads.

Before the new system was in place, GIS professionals had access to imagery from 2013, but the actual development took place after this. In (**FIGURE 3**), the 2013 imagery simply outlines the parcels and rights of way. It has no detail with respect to where the roads start and end, so a lot of field work was needed to take measurements, drive roads scattered across the county, and collect data.

With the new system, workers have instant access from their desktop to the same location as it currently is. They can see exactly where the edge of the road starts and stops (**FIGURES 4** and **5**), which is different from the yellow-lined "right of way" depicted in **FIGURE 3**.

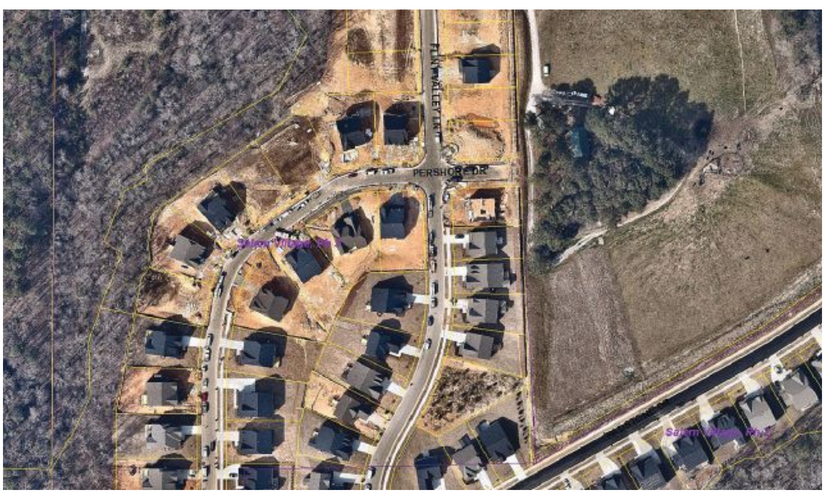


Image: Nearmap

FIGURE 4 **The post-construction image of the same neighborhood is much more accurate.**

GNSS, GIS HELP SMALL TOWN UTILITIES OPERATE EFFICIENTLY

Small towns and cities face tight budgets for operating and maintaining public utilities. By sharing resources for common activities, a city can improve cost efficiency in its gas, electric, water and sewer services. In southern Minnesota, the city of New Ulm has modernized its approach to utility asset location and identification management. The effort is reducing costs and improving service for its 13,000 residents.

For more than a decade, the New Ulm Public Utilities group used a computer-aided design (CAD)-based system to track assets for six different utilities. After evaluating its approach for asset mapping, the city transitioned to a geospatial information system (GIS) which provided an opportunity to streamline data collection and management across all of the city-owned utilities.

The city turned to the Trimble Positions Desktop add-in software for Esri ArcGIS Desktop. The approach enables New Ulm field technicians to use Trimble TerraSync field software and Trimble Geo 7X GNSS handhelds for data collection for utility assets and then process the GNSS data in Trimble Positions Desktop. Using this method, the city can provide customized field workflows needed by the different utilities while delivering completed information to a single, centralized GIS database.

In addition to recording the locations and attributes of utility assets, the Trimble solution helps New Ulm technicians return to specific assets when needed. Using real-time GNSS positioning, field crews can navigate directly to specific assets. "Looking for a shutoff valve during a snowstorm isn't easy," said New Ulm GIS technician John Bendix. "The Trimble handhelds help them find an asset quickly."

Bendix uses the Trimble solution to manage connectivity and geographic relationships for new assets. Assets connected to a feature (such as pipes connecting to a manhole) can be automatically adjusted as needed when new field data is checked into the database.

Photo: Trimble

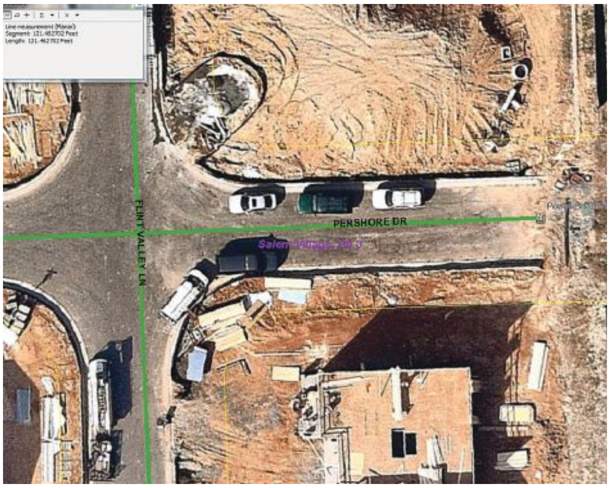


Image: Nearmap

FIGURE 5 Measuring for reimbursement in Apex.

While in the office, GIS professionals can measure distances precisely, creating an accurate representation of ground truth.

FIGURE 6 highlights a small portion of new roads built in Apex in one year. The green lines highlighted are scattered across the city. As Apex continues to grow and annex adjacent territory, the dynamic nature of the growth will be captured and uploaded to the cloud.

Unlocking Potential

As cities grow in complexity, mapping becomes integral to planning. With the advances aerial imagery provides, cities are starting to unlock the full potential of location data and visualizing a better future.

Image: Nearmap

FIGURE 6 Green lines indicate new streets in Apex in a single year (2013).

Image: Orolia

FLYING WITH GREATER SAFETY

All newly-built commercial aircraft must adhere to safety standards that go into effect Jan. 1, 2021. Orolia, which develops new technology for the Global Aeronautical Distress Safety System (GADSS), offers the Kannad Ultima-DT Distress Tracking Emergency Locator Transmitter.

It features a trigger-in-flight capability to detect imminent emergency situations and send a secure distress signal, including the aircraft's position, to continuously track its location in any circumstances. The transmitter also includes Return Link Command Service to activate a distress signal from the ground in case of uncertainty about the aircraft's status, or if attempts to communicate with the flight crew are unsuccessful.

SAFETY FIRST WHEN WORKING ALOFT

Image: Lidar USA

Lidar USA now offers the Drone Rescue System for its DJI 600 heavy-lift multicopter, important when flying over infrastructure or people. Effective as low as 10 meters with a descent of 3 meters per second, the equipment will land without a hard impact yet quickly enough to keep from being dragged far away. Weighing 430 grams in a repackable canister 160 x 75 millimeters in size, the DRS-M600 is designed to auto-release within milliseconds of detecting a system failure.

TAKING GIS TO THE FIELD

Image: CHC Navigation

The CHCNAV LT700 is a rugged 8-inch Android tablet to boost mobile workforce productivity. It displays any GIS data tables, complex vector and raster maps, or high-resolution pictures. Driven by Android 8.1 and bearing the GMS (Google Mobile Service) certification, the LT700 runs seamlessly the most common professional data-collection applications available from Google Play store. The integrated GNSS module (GPS/GLONASS/BDS/SBAS) provides robust positioning performances.

MARKET WATCH

SEGMENT SNAPSHOT: APPLICATIONS, TRENDS & NEWS

OEM

Collins Taking Orders for M-Code Receiver

Collins Aerospace Systems, a unit of United Technologies Corp., has begun taking orders for its latest-generation Miniature PLGR Engine – M-Code (MPE-M) GPS receiver set for 2020 production deliveries.

According to independent testing, the MPE-M is the lowest size, weight and power (SWaP) small Type II form factor ground receiver available and incorporates the company's recently certified Common GPS Module (CGM).

As a drop-in replacement for the thousands of customers using Collins' Miniature PLGR Engine-SAASM (MPE-S) GPS receiver, the new MPE-M technology provides 10 times stronger anti-jamming capabilities for the direct acquisition of GPS signals than its predecessor.

The MPE-M is capable of receiving the current military Y-code GPS signal along with the newer military code (M-code) signal. For all GPS signals, the MPE-M provides warfighters with improved security and assured positioning, and it satisfies the U.S. government's requirement for all military GPS equipment to be M-code capable.

The implementation of M-code is expected to provide warfighters with increased mission effectiveness and safety because of improved signal reliability.

The MPE-M is designed for lightweight, ground-based applications such as radios, blue force trackers, targeting devices, vehicle line-replaceable units (LRUs) and small unmanned aircraft.

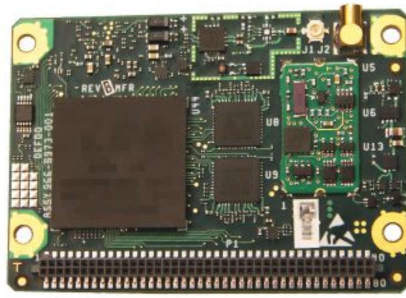


Photo: Collins Aerospace

The MPE-M received GPS Directorate approval in May.

Collins Aerospace said it manufactures its products in-house, assuring control over quality and delivery schedules.

The MPE-M's security certification makes the receiver eligible for export to U.S. allies through the Foreign Military Sales (FMS) program.

Development Kits Available for Septentrio mosaic

Septentrio's mosaic development kit is now available for testing and integration.

Mosaic is Septentrio's most compact, next-generation, high-precision multi-frequency GPS/GNSS module.

The receiver brings precision and reliability of high-end multi-frequency GNSS to mass-market applications, the company said. It is designed to fit into the assembly-line process, which allows mosaic to be favorably priced for high volumes.

Photo: Septentrio

Its lightweight and low power consumption helps extend the battery life of robotic devices, increasing operation time and efficiency. This makes mosaic suitable for applications such as robotics, automation, telematics and wearables.

Septentrio designed mosaic to meet growing market demand for reliable high-precision positioning, according to Chris Lowet, Septentrio's product manager.

"A few years ago, this demand was concentrated in professional applications, for example survey, high-precision mapping and machine control," Lowet said. "Today, with expansion of robotics, automation and IoT [internet of things], a wide range of devices need high-precision positioning, from ag robots to IoT gateways to autonomous vehicles."

The development kit assists Septentrio customers with integrating mosaic into their system. It supports connectivity through internet, COM ports, USB 2.0 as well as an SD Card slot.

Mosaic provides Advanced Interference Mitigation (AIM+); extensive corrections support for high-accuracy positioning; integrity needed for safety-critical applications such as autonomous vehicles; and a 100-Hz update rate, suitable for robotics and fast-moving vehicles.

OEM

Emcore's Micro INS Ready for Defense, UAVs

Emcore Corp. has launched the EN-2000 to the Emcore-Orion series of micro-inertial navigation (MINAV) systems.

The new EN-2000 is a closed-loop, solid-state design that will deliver higher performance at lower cost than traditional ring laser gyroscope (RLG) navigation systems.

The EN-2000 expands Emcore's navigation systems line that also includes the EN-1000 introduced in 2017. The Emcore-Orion series of inertial navigation system (INS) is designed for use in a broad range of defense, aviation and aeronautics applications.

Today, there is a premium on modern navigation systems for improved size, weight and power (SWaP). Traditional RLG navigation systems placed a premium on accuracy and performance, but not SWaP. Many RLG and FOG systems are large and heavy, ranging in volume from 330 in^3 to 540 in^3, weighing 13 to 22 pounds with power requirements of 25 to 38 watts.

The Emcore-Orion EN-2000 is compact and lightweight, weighing less than 7 pounds, with very low power consumption of 10 watts. It can deliver twice the performance of the EN-1000 with the same form factor.

Many modern weapon systems are now remotely operated, unmanned or man-portable, and may need to operate where GPS is unavailable or denied. The compact EN-2000 is designed for these applications.

The low SWaP of the EN-2000 makes it a suitable INS for unmanned aerial vehicles (UAVs), unmanned underwater vehicles (UUVs), unmanned ground vehicles (UGVs), manned aircraft, rotorcraft and dismounted soldier applications.

The Emcore-Orion EN-2000 MINAV is a three-axis design using the company's proprietary, next-generation solid-state optical transceiver with advanced integrated optics, combined with new field programmable gate array (FPGA) electronics to deliver stand-alone aircraft-grade navigator performance at one-third the SWaP of legacy systems.

Photo: Emcore

The EN-2000 model comes in two standard versions, an IMU version and a stand-alone INS configuration. The INS version can gyrocompass to less than 0.7 milliradians and maintain near-GPS-level positional accuracy without the use of a GPS receiver. It can also be aided by an external GPS.

The digital interface is also fully programmable at Emcore's factory, enabling it to directly replace competing units.

Quectel Launches Dual-Band GNSS Module LC79D

Quectel Wireless Solutions has launched a compact dual-band GNSS module, the LC79D, that supports the L1 and L5 bands from navigation satellites to improve positioning accuracy.

Featuring concurrent multi-constellation GNSS receivers on dual GNSS bands, LC79D uses L1 and L5 bands for GPS, Galileo and QZSS satellites, L1 band for GLONASS and BeiDou satellites, and L5 band for IRNSS satellites.

Compared to GNSS modules that use the L1 band only, LC79D can generally increase the number of visible satellites, significantly improve positioning drifting when driving in rough urban canyons and enhance positioning accuracy.

Photo: Quectel

Embedded with a low-noise amplifier (LNA) and multitone active interference, the module provides higher sensitivity and reliable anti-jamming capability, ensuring exceptional acquisition and tracking performance even in weak signal areas. Multiple communication interfaces including UART and SPI simplify customer designs and accelerate time-to-market for customers' products at reduced costs.

The LC79D is designed to give customers high-level integration and flexibility to realize precise positioning in real time. With dimensions of 10.1 × 9.7 ×2.4 millimeters, the LC79D meets the requirements of size-sensitive applications. Compact design, low power consumption and high performance make it suitable for vehicle, people and asset tracking.

SURVEY

Trimble Catalyst Now Also Usage-Based

Trimble's Catalyst software-defined GNSS receiver for Android phones and tablets is now available with a usage-based service plan: Trimble Catalyst On Demand.

The new service plan is focused on meeting the requirements of a growing number of industries and organizations that recognize the benefits of using high-accuracy GNSS technology in the field, but need a more flexible payment model. Organizations use Catalyst to record positions, navigate to points, measure relative distance and create digital maps.

Trimble Catalyst On Demand provides scalable access to real-time kinematic (RTK)-quality GNSS positioning using a pay-per-use hourly pricing model in addition to the current Catalyst monthly plans.

The service also enables automated domain-level email address access, which streamlines license allocation for organizations with a large number of users.

Photo: Allison Barwacz

TRIMBLE ANNOUNCED the Catalyst usage-based plan at the Esri User Conference in San Diego in July. Above, the Catalyst DA1 antenna.

TRANSPORTATION

Volkswagen, Ford Join on Self-Driving Cars

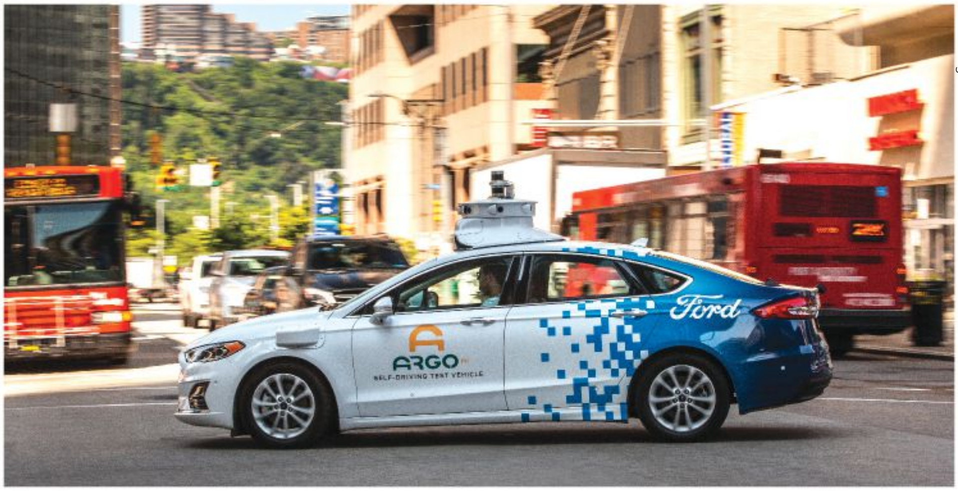


Photo: Argo AI

In July, Volkswagen AG and Ford Motor Co. provided updates on their development alliance announced in January.

The automakers plan to collaborate on autonomous vehicles, among other programs. Together, they are investing $2.6 billion in Pittsburgh startup Argo AI, which is developing a self-driving technology platform. Ford first invested in Argo two years ago.

The investment includes the resources of VW's Autonomous Intelligent Driving Group (AID), valued at $1.6 billion. AID will become Argo AI's European operation.

Volkswagen and Ford hope to achieve a self-driving platform that can be scaled comparatively quickly. Argo AI's objectives are to

- build for scale.
- architect the software to be production quality.
- have automotive-grade sensors and computers.
- fully integrate their product with OEMs and automakers.

A benefit to having the Argo AI system on more vehicles means the AI will obtain data through daily operation, enabling it to grow smarter and better.

Argo AI has successfully tested its driverless vehicles in five U.S. cities: Pittsburgh, Palo Alto, Detroit, Miami and Washington, D.C.

Allystar RTK INS Platform Ready for Autonomous

The Allystar INS Platform is a dual-antenna, multi-frequency, multi-GNSS inertial navigation system (INS) that delivers accurate and reliable position, velocity and orientation, the company said. It is designed for a wide range of autonomous vehicle applications under demanding conditions.

The Allystar INS Platform combines high-grade, six-axis, temperature-calibrated accelerometers and gyroscopes with a multi-frequency, multi-GNSS engine, the HD9300 series.

The HD9300 is a dual-antenna chip-grade real-time kinematic (RTK) GNSS receiver for accurate positioning and heading. The HD9300 series is a mass-market multi-band chip-grade receiver that supports all civil bands in all GNSS constellations (GPS/QZS L1, L2, L5, L6; BieDou B1, B2, B3; Galileo E1, E5; GLONASS L1OF/L2OF) with an integrated RTK engine to achieve centimeter-level accuracy.

The Allystar INS platform contains an on-board sensor-fusion filter, plus navigation and calibration algorithms for different dynamic motions of land vehicles.

The Allystar OBD Data Adapter (v1.0) enables users to read and monitor various sensors built into cars, obtaining the real-time vehicle speed and gear signals from the on-board diagnostics (OBD) interface, and then output AT (attention) commands by serial port or serial peripheral interface (SPI).

Photo: Allystar

When connected to the Allystar RTK INS platform, the adapter allows for outstanding navigation accuracy, especially in urban areas, helping to increase accuracy and reduce position drift.

An evaluation kit — including platform board, antenna and OBD adaptor — are available.

UAV

Raytheon, AirMap Work on NAS/Drone Integration

Raytheon Co. has signed a strategic agreement with AirMap, an airspace intelligence platform for drones, to collaborate on projects to safely integrate unmanned aerial systems (UAS) into the United States airspace system.

The companies' planned advances in unmanned air traffic control would unlock safe, efficient and scalable drone operations in low-altitude airspace between 0 and 400 feet. It would provide economic and social benefits by expanding commercial drone operations.

The agreement combines the two companies' expertise. Raytheon's Standard Terminal Automation Replacement System, or STARS, is used by air traffic controllers across the U.S. to provide safe and efficient aircraft spacing and sequencing guidance for more than 40,000 departing and arriving aircraft daily at both civilian and military airports.

AirMap is a global provider of airspace intelligence for UAS operations, with more than 250,000 registered users. In 2018, U.S. registered commercial drone pilots used AirMap to request more than 45,000 automated authorizations to fly in controlled airspace.

Demonstration planned. The two companies are working toward an integrated demonstration that will showcase how AirMap's unmanned aircraft traffic management platform can increase air traffic controllers' awareness of potential conflict between drones and manned aircraft near airports to ensure overall safety of the airspace.

Lidar USA Offers Parachutes, Heavy-Lift Options

Lidar USA is offering two new options for users of its drone-mounted scanning systems.

PARACHUTE RESCUE

Owners of Lidar USA's DJI M600 UAVs now have the option of installing Drone Rescue Systems emergency parachute.

As UAVs become increasingly common for mapping applications, the likelihood of a crash increases. The number-one concern for any pilot should be the safety of all people in the vicinity. Equipment safety is number two.

Any mapping-equipped drone will have enough weight to potentially harm a person even if falling from a low altitude flight. The Drone Rescue System greatly mitigates this danger and gives pilots the added assurance that, should the system fail, they have gone the extra mile to prevent harm to any bystanders.

Effective as low as 10 meters with a descent of 3 meters per second, the equipment will land without a hard impact, yet quickly enough to keep from being dragged far away.

Photo: LiDARUSA

The parachute rests in the cannister attachment on the UAV's upper right.

Weighing 430 grams in a repackable canister 160 x 75 millimeters in size, the DRS-M600 is designed to auto-release using a patented, airplane-friendly ejection mechanism within milliseconds of detecting a system failure. The size and weight are a bonus when combined with the airplane-friendly feature, according to the company, especially for field workers.

BIG PROJECTS

Lidar USA also is integrating its UAV scanning systems with the Harris Aerial H4/H6 Hybrid multicopters.

As surveyors and mappers experience growth, they assume larger and larger projects, making longer flight times increasingly important. The Harris Hybrid can provide such flights with lidar and industrial-grade cameras, allowing for far greater coverage in a single flight.

Harris Aerial builds and sells heavy-lift hybrid multicopters. These copters use a small generator running on 95 (or higher) octane fuel to power the UAV for up to five hours.

The H6 can carry an A-series high-definition lidar system of 3 kg for 2.5 hours and a V-series of 5 kg up to 1.5 hours.

For the lidar operator, most projects require only one or two flights. On projects that are relatively flat with a clear line of sight to the horizon in all directions, these systems can cover everything legally possible in a single flight.

Lidar USA offers the Harris Aerial H4/H6 Hybrid as an integrated package with any Lidar USA scanning system.

DEFENSE

Acquisitions, Partnerships Solidify Defense Giants

RAYTHEON MERGES WITH UNITED TECHNOLOGIES AEROSPACE BUSINESS

Raytheon Co. and United Technologies Corp. (UTC) have entered into an agreement to combine in an all-stock merger of equals.

The transaction will create a systems provider with advanced technologies to address rapidly growing segments within aerospace and defense, the companies said. Raytheon is a defense contractor, whereas United Technologies is an aerospace company comprised of Collins Aerospace (which includes the former Rockwell Collins) and Pratt & Whitney.

The combined company, Raytheon Technologies Corp., will offer a complementary portfolio of platform-agnostic aerospace and defense technologies, expanded technology and R&D capabilities to deliver innovative and cost-effective solutions aligned with customer priorities and the national defense strategies of the U.S. and its allies and friends.

The merger is expected to close in the first half of 2020. The combined company, valued at more than $100 billion after planned spinoffs, would be the world's second-largest aerospace-and-defense company by sales behind Boeing. UTC plans to relocate its headquarters from Farmington, Conn., to Waltham, Mass., where Raytheon is based.

EMCORE ACQUIRES SYSTRON DONNER, INCREASING DEFENSE ROLE

Emcore Corp., an inertial navigation provider for defense systems, has acquired Systron Donner Inertial Inc. (SDI) from Resilience Capital Partners for approximately $25.8 million.

The transaction is expected to increase navigation systems products to more than one third of Emcore's total revenue, making the aerospace and defense market Emcore's largest revenue source.

It will also add additional Raytheon, Lockheed Martin and Boeing 777X programs to Emcore's existing navigation systems portfolio.

Through the transaction, Emcore has acquired all of the outstanding assets and liabilities of SDI, including SDI's 100,000-square-foot production facility in Concord, California, which will be the home of the navigation business.

SDI provides Emcore with a scalable, chip-based platform for high-volume gyro applications, Emcore stated in a press release, enabling Emcore to provide customers with a product suite that serves a broad range of requirements across both the tactical and navigation-grade market segments.

Photo: U.S. Air Force/Tech. Sgt. Robert Cloys

AN MQ-9 REAPER at Kandahar Airfield, Afghanistan.

SAFRAN, OROLIA PARTNER ON RESILIENT PNT

Safran and Orolia are partnering to offer the latest resilient positioning, navigation and timing (PNT) solutions for military forces, especially in GNSS-denied environments.

The partnership will provide mission-critical equipment for air, land, sea and space programs in environments where GNSS signals are not available or degraded, whether the outage is unintentional or intentional.

The Safran-Orolia team will offer military forces PNT capabilities including Orolia's portfolio of precise timing references and PNT sensor-fusion technology, as well as Safran's defense inertial navigation solutions.

Initial program priorities include navigation warfare (NAVWAR), along with mobile and fixed PNT solutions.

The resilient PNT military partnership is intended to better protect and enable mobile operations for NATO and allied countries worldwide, the companies said in a press release.

Orolia's PNT solutions improve the reliability, performance and safety of critical, remote or high-risk operations. With locations in more than 100 countries, Orolia provides virtually failsafe GNSS and PNT solutions to support military and commercial applications worldwide.

Safran is an international high-technology group, operating in the aircraft propulsion and equipment, space and defense markets. Safran has a global presence, with more than 92,000 employees and sales of 21 billion euros in 2018.

MOBILE

Rohde & Schwarz Releases Free eBook on 5G

Test and measurement specialist Rohde & Schwarz has compiled an in-depth e-book describing 5G New Radio (NR) technology. The contents of the book can be read online for free.

Rohde & Schwarz has been an active participant in the 3GPP standardization process involving cellular technologies, including the upcoming 5G NR.

Five technology experts at Rohde & Schwarz wrote the book to provide in-depth information for professionals working with 5G NR technology.

Photo: Rohde & Schwarz

The 400-page *5G New Radio: Fundamentals, Procedures, Testing Aspects* provides insights into fundamentals and procedures on the architecture and transmission of 5G NR technology.

The chapters provide answers to how and why the 5G technology was specified a certain way by 3GPP.

The book also discusses the new challenges to test and measurement, brought about by the arrival of 5G technology, and presents modern, innovative test solutions to solve these challenges.

The 5G NR book can be read online via the Rohde & Schwarz GLORIS customer portal at **https://www.rohde-schwarz.com/5G-ebook.**

Rugged Tablet Offers 3D Imaging for Field Work

DT Research has designed a new rugged tablet with 3D imaging that is purpose-built for 3D mapping with a built-in GNSS module.

The DT301X has an Intel RealSense Depth camera that provides real-time 3D imaging combined with dual-frequency GNSS module for real-time mapping and positioning. The digital images are better than high-definition standard, and are suitable for construction building information management (BIM) graphics.

The DT301X rugged tablet is compatible with existing applications with Microsoft Windows 10 IoT Enterprise operating systems for flexible integration, and it brings together the advanced workflow for data capture, accurate positioning and data transmitting.


Photo: DT Research

KEY FEATURES OF THE **DT301X**

- **Highly durable.** IP65 and MIL-STD-810G rated tablet in a slim case offers the versatility to be used in the field, office and vehicles.
- **Indoor/outdoor display.** A high brightness 10.1-inch touchscreen offers flexible viewing in a wide range of lighting.
- **Wi-Fi and Bluetooth.** Long-range Bluetooth for 1000-foot range and 4G LTE mobile broadband for the latest in high-speed communications.
- **High performance.** Intel 8th-generation Core i5 or i7 processor offers high-performance while still being energy efficient.
- **Hot-swappable batteries.** With high-capacity 60- or 90-watt hot-swappable batteries, the DT301X keeps working continuously.

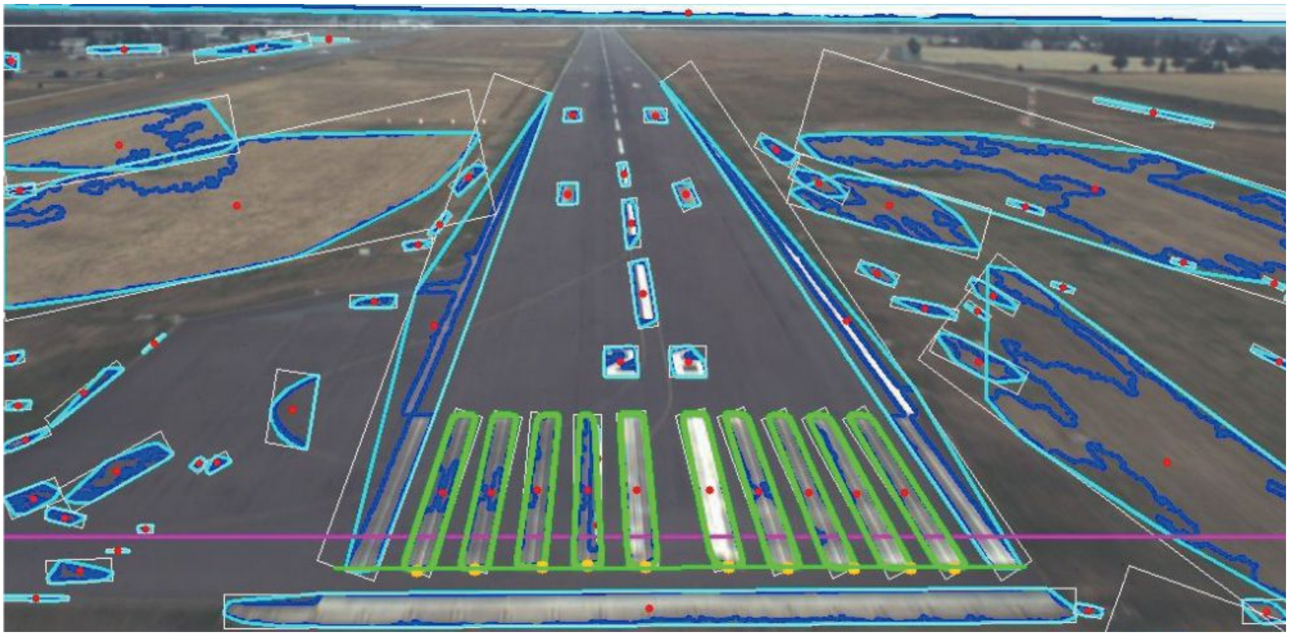


Image: S. Wolkow et al

THRESHOLD MARKING DETECTION: Extracted contours (blue), convex hulls (cyan), rotated rectangles (white), centroids of rectangles (red), horizontal line that crosses the most remaining candidates (magenta), base points of the threshold marking bars (orange), identified contours of the threshold marking and baseline (green).

AUTONOMOUS AIRCRAFT LANDINGS

Image-based positioning has not yet been certified in aviation applications. To cover numerous environmental conditions, the authors installed various optical sensors. They present an approach for fusing image data of two complementary cameras with different spectral ranges. The use of two image sensors working in the visible light spectrum and infrared spectrum increases availability and accuracy, meeting requirements to be used as an augmentation for state-of-the art GNSS-based landing systems.

This investigation presents real flight data processed by means of the proposed method. This work constitutes a new approach for robust runway detection, since position calculation was only carried out once in one time epoch on a single blended image. The proposed method was applied to data from two flight campaigns in post-process. A determined set of parameters lead to a sufficient level of availability and a valid runway detection throughout the final approach.

CITATION

M. Angermann, S. Wolkow, A. Dekiert, U. Bestmann, P. Hecker (2018), "Linear blend: Data fusion in the image domain for image-based aircraft positioning during landing." *Pacific PNT Conference*, www.ion.org/publications/browse.cfm

Aircraft navigation during landing approach is mostly supported by ground-based landing systems in commercial aviation, which cause high installation and maintenance costs. Nevertheless, the final sequence of the flight before touchdown is mostly performed by the pilot manually, because of the high requirements for accuracy and integrity. Only a few landing systems can fulfill these requirements during the last 200 feet above ground. The current work presents a further development of an optical positioning system to be deployed below 200 feet and on ground after touchdown in order to be used as an additional source for positioning information. The system is capable of visual 3D positioning of the aircraft relative to the runway. Algorithms for threshold marking (see image above) and centerline detection, as well as lateral position calculation during rollout are presented. The system is evaluated during flight trials performed with the research aircraft Dornier Do 128-6.

CITATION

S. Wolkow, M. Angermann, A. Dekiert, U. Bestmann (2018), "Model-based threshold and centerline detection for aircraft positioning during landing approach." *Pacific PNT Conference*, www.ion.org/publications/browse.cfm

EARLY EARTHQUAKE WARNINGS

GNSS COULD ENABLE 10-SECOND ALERTS

Previous research suggests that not until halfway through a rupture (90 seconds for a magnitude-9 quake) can magnitude be predicted. Geodetic GNSS data could bring this down to as little as 10 seconds — greatly extending and enhancing earthquake early warning systems.

BY **Alka Tripathy-Lang,**
BERKELEY GEOCHRONOLOGY CENTER

How soon can we predict the magnitude of an earthquake?

Seismologists Diego Melgar of the University of Oregon and Gavin Hayes of the U.S. Geological Survey (USGS) in Golden, Colorado, tackled this question by chance while Melgar was writing code to simulate earthquakes to check the accuracy of Earthquake Early Warning systems in the Pacific Northwest.

He reached out to Hayes, who curates a database for the USGS that contains "source time functions," which show how the seismic energy release changes through time as the earthquake ruptures.

As a rupture grows, the speed of growth changes, and source time function captures that change. Melgar and Hayes focused on the acceleration of the energy release in large (M>7) and great (M≥9) earthquakes, and found that acceleration wobbled between 2 and 5 seconds after the quakes began. However, with the approximately 250 M≥7 earthquakes in their database, they found that between 10 and 15 seconds after rupture began, these larger earthquakes started to behave similarly, and that behavior scales with their final magnitude, Hayes said. "In other words, the acceleration at 10 to 15 seconds is diagnostic of their final magnitude."

SEE EARTHQUAKE, *NEXT PAGE.* >>

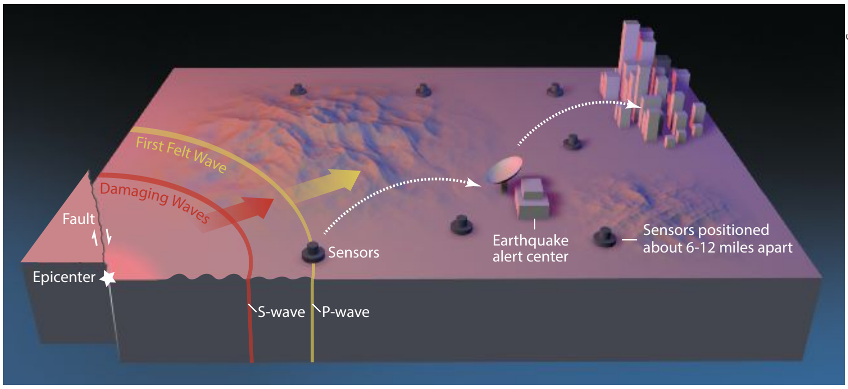
EARTHQUAKE

« *Continued from previous page.*

Earthquake ruptures sputter along for about 10 seconds, after which the big ones accelerate, according to Melgar and Hayes. Three different source time function databases showed the same consistency.

Vertical movement near the source of large earthquakes can be between 3 and 5 meters, accorrding to data from GNSS geodetic receivers. Analysis of near-source GNSS data from 12 M≥7 earthquakes showed that for the first 10 seconds after the first indication of an earthquake was recorded, the earthquakes made almost immeasurable movements. But between 10 and 15 seconds, the amount of vertical displacement began to rapidly diverge for the different magnitude groupings. By 20 to 25 seconds, the vertical movement was distinct.

Previous research indicated roughly half the source duration must pass before an accurate prediction could be made. Cutting the prediction time down to 15 seconds would be invaluable to earthquake early warning systems and tsunami prediction algorithms, where every second counts.



In February 2016, the USGS rolled out the second-generation ShakeAlert Earthquake Early Warning test system in California. The diagram shows how the system would operate.

GNSS sensors are installed onshore across the globe, but the majority of megathrust earthquakes occur underwater. To integrate Melgar and Hayes' findings effectively into earthquake early warning systems would require sensors installed along the seafloor, they noted. "You [would also] need to have fiber-optic cables from shore to the bottom of the ocean, winding around with sensors, and then eventually coming back on shore, and that's not cheap," Melgar said.

An additional 10 to 30 seconds of warning to a city or nuclear reactor of an imminent quake would have enormous benefits. But if the hypothesis is wrong, using it now would lead to a greater rate of false alarms and missed quakes, eroding the value of these warnings to society. Melgar and Hayes acknowledged their finding needs to be rigorously tested.

Summarized from Temblor's website (**temblor.net**). The Temblor Android app and website provides earthquake, landslide, tsunami and flood information.

CITATION

Tripathy-Lang A. (2019), "Can the size of a large earthquake be foretold just 10 seconds after it starts?". *Temblor*, http://doi.org/10.32858/temblor.029

ADVERTISER INDEX: COMPANIES FEATURED IN THIS ISSUE

Artist's rendering: NASA

NASA Wants GPS for Artemis Missions

NAVIGATION SOLUTION: GPS could guide residents of the Artemis mission's permanent moonbase.

GPS could be used to pilot in and around lunar orbit during future Artemis missions.

A team at NASA is developing a special receiver that would be able to pick up GPS location signals and provide navigational solutions to astronauts and ground controllers operating the Orion spacecraft, the Gateway in orbit around the Moon and lunar surface missions. The advanced receiver would be paired with precise mapping data to help astronauts track their locations in space between the Earth and the Moon, or on the lunar surface.

Navigation services near the Moon have historically been provided by NASA's communications networks. Using GPS could ease the load on NASA's networks, freeing up that bandwidth for other data transmission.

NASA has been working to extend GPS-based navigation to high altitudes, above the orbit of the GPS satellites, for more than a decade. The agency now believes its use at the Moon, which is about 250,000 miles from Earth, can be done.

"[Use of GPS] for higher altitude navigation has now been firmly established with the success of missions like Magnetospheric Multiscale mission (MMS) and the Geostationary Operational Environmental Satellites (GOES)," said Jason Mitchell, a chief technologist at Goddard Space Flight Center in Greenbelt, Maryland. "In fact, with MMS, we're already nearly halfway to the Moon."

Navigator GPS. The lunar GPS receiver is based on the Goddard-developed Navigator GPS, which engineers began working on in the early 2000s for MMS, to study how the Sun's and Earth's magnetic fields connect and disconnect. The goal was to build a spacecraft-based receiver and algorithms that could quickly acquire and track GPS even in weak-signal areas. Navigator is now considered an enabling technology for MMS.

Without Navigator GPS, the four identically equipped MMS spacecraft couldn't fly in their tight formation in an orbit that reaches as far as 115,000 miles from Earth's center, about halfway to the Moon.

Extending the use of GPS to the Moon will require enhancements over MMS's onboard GPS system, including a high-gain antenna, an enhanced clock and updated electronics. The smaller, more robust GPS receiver could also support the navigational needs of small-satellite (SmallSat) missions.

Building on NavCube. The current lunar GPS receiver concept is based on NavCube, a new capability developed from the merger of MMS's Navigator GPS and SpaceCube, a reconfigurable, very fast flight computer platform. The more powerful NavCube was recently launched to the International Space Station, where it is expected to employ its enhanced ability to process GPS signals as part of a demonstration of X-ray communications in space.

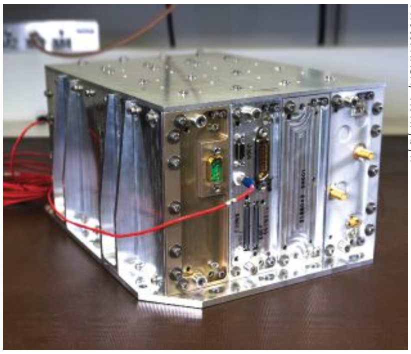


Photo: NASA/ W. Hrybyk

NAVCUBE, which will be tested aboard the International Space Station later this year, is being used as a baseline for a lunar GPS receiver.

The GPS processing power of NavCube combined with a receiver for lunar distances should provide the capabilities needed to use GPS at the Moon. Earlier this year, the team simulated the performance of the lunar GPS receiver and found promising results. By the end of this year, the team plans to complete the lunar NavCube hardware prototype and explore options for a flight demonstration.

SEEN & HEARD

HEY, R2, WHERE'S MY PIZZA?

Domino's pizza will start using Nuro's R2 unmanned vehicles for delivery in Houston Texas, later this year. Once customers have opted in, they can track the R2 vehicle via the Domino's app and will be provided with a unique PIN code to unlock a compartment to get their pizza. Nuro is already at work in Houston delivering goods from dinner to dry cleaning.

DRONE ATTACK

A BBC documentary has sent the drone industry into a tizzy. "Britain's Next Air Disaster? Drones" begins with the December 2018 Gatwick Airport incident when two drones entering airport airspace led to a disruption of operations for three days. Dronemakers dislike the documentary's thrust that drones are a threat to public safety and a tool for terrorists, while barely mentioning their positive contributions in fields such as search and rescue, plant inspections and agriculture.

NAVIC RISING

The Indian Space Research Organisation is in talks with chipmakers Qualcomm and Broadcom to substitute GPS in Indian mobile phones with its own satellite system (NavIC). The *Times of India* noted that cellphones hold the biggest commercial potential for NavIC, with more than 650 million mobile users in India. ISRO and the Indian Air Force are also working to equip fighter jets with the navigation system, and commercial vehicles registered after April 1 are mandated to have NavIC trackers.

INFRASTRUCTURE SENSORS ARE MTHING

Internet of things (IoT) project Mthing is researching GNSS monitoring sensors to record near-real-time measurements of infrastructure construction. The 18-month project in Brisbane, Australia, aims to develop GNSS IoT sensors that will provide cost-efficient, constant and high-precision monitoring that will connect to cloud services and provide instant alerts. Mthing aims to produce low-cost sensors with broad market potential. The research team includes Queensland University of Technology, survey company Monitum, and the Innovative Manufacturing Cooperative Research Centre.

PHOTO CREDITS: R2/Nuro; documentary/BBC screenshot; Indian woman/Rawpixel.com/Shutterstock.com; construction/Monitum Pty Ltd.

GPS WORLD (ISSN 1048-5104) is published monthly by North Coast Media LLC, IMG Center, 1360 East 9th Street, Tenth Floor, Cleveland, OH 44114. **SUBSCRIPTION RATES:** For US, Canada and Mexico, 1 year $89.95 print and digital; two years $148.95 print and digital. All other countries, 1 year print and digital $159.95 2 years $265.95. For air-expedited service, include an additional $75 per order annually. Single copies (prepaid only) $10 plus postage and handling. For current single copy or back issues, call 847-763-4942. **Periodicals postage paid** at Cleveland OH 44101-9603 and additional mailing offices. **POSTMASTER: Please send address change to GPS World, PO Box 2090, Skokie, IL 60076.** Printed in the U.S.A.