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Volume XV, Issue 4, April 2019

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

Precise GNSS positioning for mass–market applications

Geodetic network development in Mongolia


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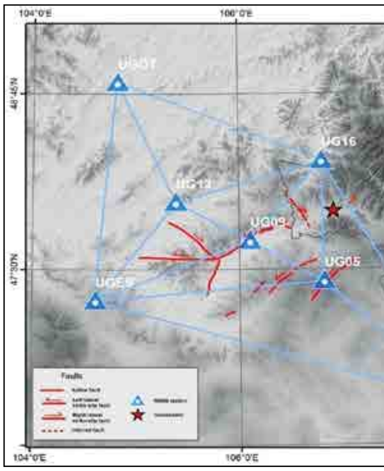

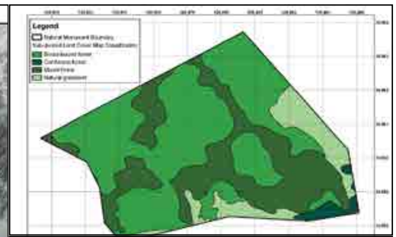

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This issue of Coordinates is of 52 pages, including cover.

Facing the fake

When fake is in vogue

Not only in our physical world

But has percolated in cognitive arena as well.

Forces with vested agendas armed with powerful tools

Like facebook, WhatsApp, Twitter, etc.

Appears to have taken over our minds.

There have been reports that a few technical giants

Are said to have waged a war against the fake news

More recently in the context of elections – the one ongoing in India or during the elections in Brazil last year and several more to come…

Still it looks like a mammoth and challenging task.

Will they succeed?

The answer will decide the direction of our future.

However, people must discern fake from real!

Bal Krishna, Editor
bal@mycoordinates.org

GNSS-CORS geodetic network development in Mongolia

The result of the preliminary analysis is being used to evaluate the stress accumulation and the earthquake probability on the Mongolian territory

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In Mongolia, several Continuous GNSS stations are operated and managed by different agencies, private companies and national scientific institutions and these stations have been built for purposes such as topography, cartography, cadastral surveying geodynamic, mining and crustal movement monitoring.

This recent development and establishment of GNSS networks in Mongolia make it possible to define an increasingly detailed spatial and temporal resolution of the ongoing crustal deformation and to visualize the complex interplay between different orogens, for example: in the Baikal-Mongolia collision zone.

All the available GPS raw data in the time span 1994-2017 were analyzed by using the Gamit/Globk software and constructed time series of GNSS stations referenced to a common reference frame that can give fundamental information for both regional and local geodynamic studies and finally produced the tectonic velocity field providing an updated detailed picture of the kinematics (velocity map) and deformation pattern (strain map) of the Mongolian area.

We describe concisely the operations used to collect, archiving and processing the raw data in order to combine all this information into one uniform crustal velocity field.

Results can be further used for geo-kinematics purposes, and for a better understanding of the active geodynamic processes that are deforming the Earth's surface in Mongolian territory and surrounding regions.

The present status of the networks

The requirements for establishing permanent stations are based on both off-line and real-time data availability, imposed by global, regional geodetic and local survey activities.

The first permanent IGS network station – ULAB, was founded in 1997 in a combined effort of the Geo Forschungs Zentrum (GFZ) Germany and Institute of Astronomy & Geophysics (IAG) of Mongolian Academy of Science (MAS) (Calais at all, 2003) and now serving as master station in all GNSS based geodetic activities in Mongolia.

Nowadays, in Mongolia, several Continuous GNSS stations are operated and managed by different agencies, private companies and national scientific institutions. These stations have been built for purposes such as topography, cadastral surveying, geodynamics, geophysics and reference stations.

GNSS network operated by Agency of Land management, Geodesy and Cartography (ALMGG), consists of more than 40 stations. This network has been initiated by periodic measurement of GNSS-permanent stations established since 2011 on the Mongolian territory, both on a national as on an international level. All of the stations are equipped by Trimble NetR8 and Trimble NetR9 with Trimble choke ring and Trimble Zephyr Geodetic antennas. The types of antenna that were mounted on the braced monument and also some of them installed on the roof of a building. Nowadays the position of the stations which the antenna installed on the roof of a building has been moved to the land due to supply of other GNSS applications such as geodynamic and also to be reconciled with IGS standard.

CORS network provides daily files with a sample rate of 30 seconds Receiver Independent Exchange (RINEX) format. The GNSS data collected at these sites are made available to the public in the Hatanaka compressed files. Yet other stations are still planned to be built.

This network supplies centimeter level real time corrections for applications such as cadastral, surveying, construction and mining. Based on these products, the Geodetic service of Mongolia contributes to monitoring of tectonic deformations in Central Asia.

In addition, focusing on great scientific interest for seismic hazard aspects, the Seismological Department of Institute of Astronomy & Geophysics (IAG) of Mongolian Academy of Science (MAS) has established the GNSS geodetic network in Ulaanbaatar, the capital of Mongolia and its surrounding areas, that includes 7 permanent sites: UG05, UG09, UG13, UG16, UGOT, UGES and UGBT. This network targeted by providing up-to-date estimates of continental deformations and including evaluated resulting from plate tectonics stresses. This will support the development of improved risk mitigation procedures.

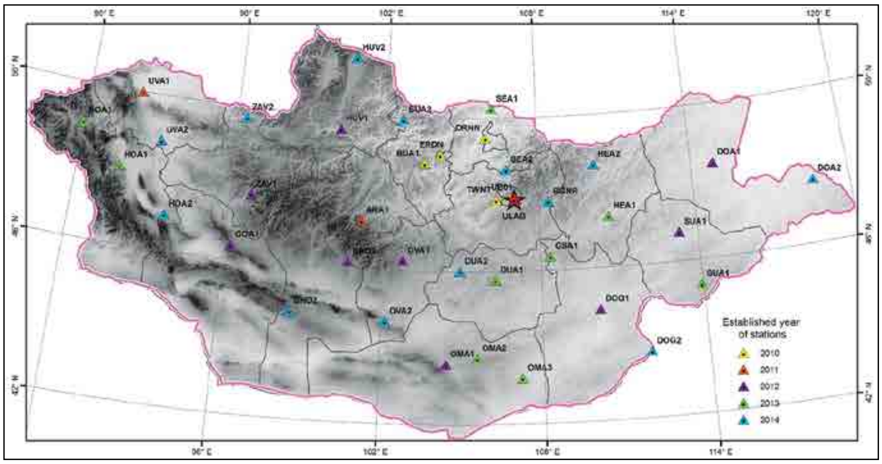

Figure 1. GNSS-CORS operated by ALMGG, red star shown ULAB station

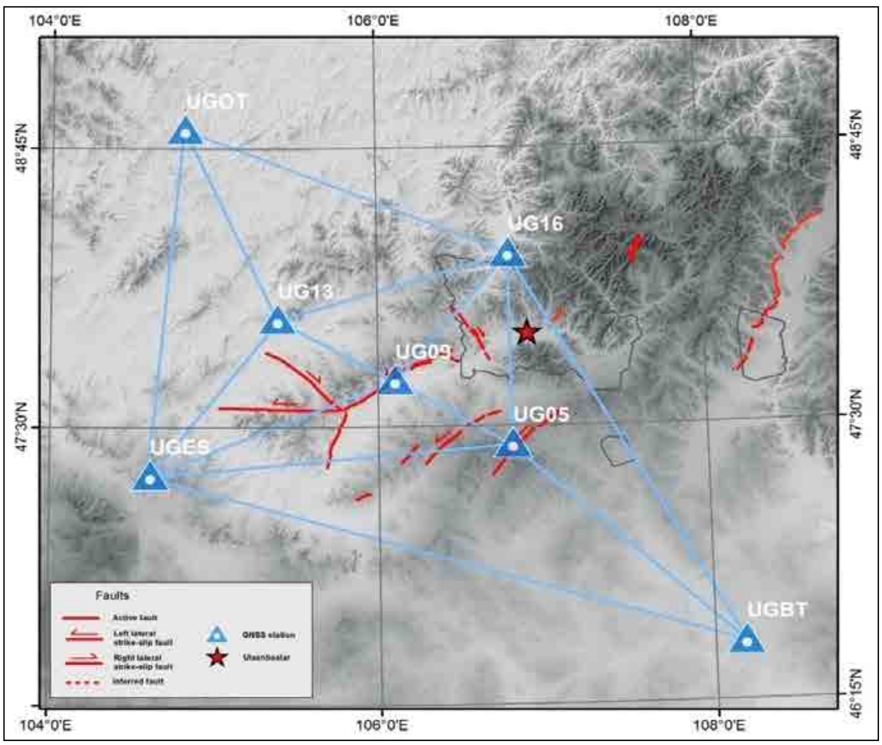

Figure 2. 7 permanent sites established by IAG, MAS, red lines are indicated identified active faults

Configurations of polygons and quantities of permanent sites are determined with regard to the geological and geomorphological structure of the region, previously identified active faults as preferred structures along which stresses are transferred through the deformational area and paleo-and-recent seismicity indicators. The network fully equipped by Trimble NetR9 receiver and Choke ring antenna with Radom.

The network provides GNSS data at two sample rates: daily real-time data files with a sample rate of 30 seconds and high-rate data with a sample rate of 1 seconds which is useful for the purpose of seismic early warning, damage mitigation.

Since our permanent stations involved with sustainable power and data telemetry, we developed automatic facilities to handle the GNSS data archiving procedures.

Moreover, GNSS network includes 4 sites HOVD, MURN, CHOI, DALN operated by University of Tokyo. Data's are not available public.

The other GNSS-CORS operated by some private company such as geodetic and mining business.

In addition to the permanent installations, to support the geodynamics research in Mongolia, more than 40 GNSS campaign sites have been constructed. The location of points has been correlated with geological and tectonic composition and regular observations were conducted from 1997 and accumulated data are included to this study.

Data processing in regional and local geodynamic studies

First stage of the processing involved of quality and quantity check of the observations, performed with TEQC software developed by UNAVCO.

Data collected from these permanent GNSS stations have been processed on a daily basis using the standard GAMIT/GLOBK processing software version 10.61 (Herring, 2000; King and Bock, 1998) included IGS global stations (bjfs krtv chan usud taiw irkt tskb shao kit3 xian pol2 urum kstu yakz nvsk tixi ulab). The output GPS time series of daily station positions give fundamental information for both regional and local geodynamics studies. The data measured in campaigns 1997-2002 and 2010-2017 were newly computed using the ITRF2014 reference frame.

Processing parameters were an elevation mask 100, IGS precise orbits and earth rotation parameters, absolute antenna phase center offsets and variations and all estimated parameters were loosely constrained. For velocity estimation, data from as a minimum four observation sessions conducted in 1997-2017 were used. Though, only sites with uncertainty less than 1.5 mm/year are shown here and they used for the next velocity and strain analysis.

Horizontal components of the velocities for these network points were estimated in ITRF2014 global system; components of local velocities ("intraplate") respect to stable Eurasia have been also calculated. The relative strain patterns derived from those horizontal GPS velocities using Delaunay triangulation.

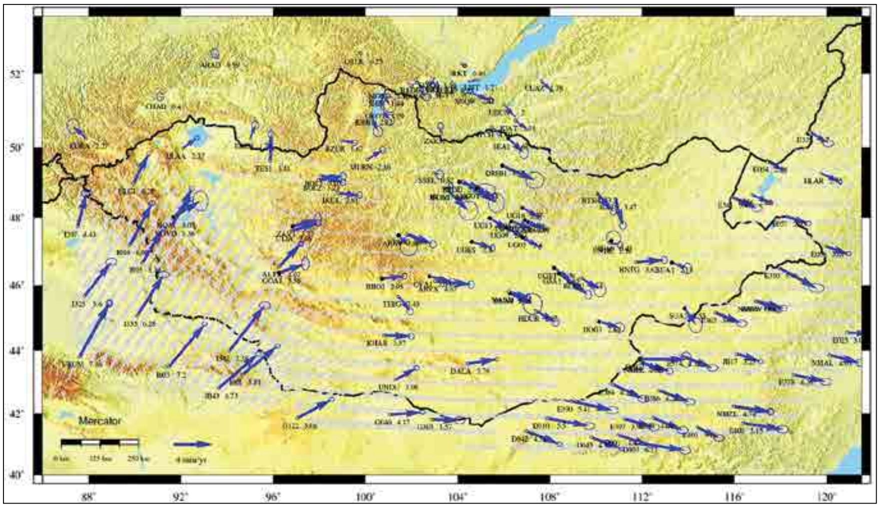

Figure 3. Blue arrows show directions and velocities (mm/year) with respect to stable Eurasia; light grey arrows show vectors averaged on a 30'x30' regular grid

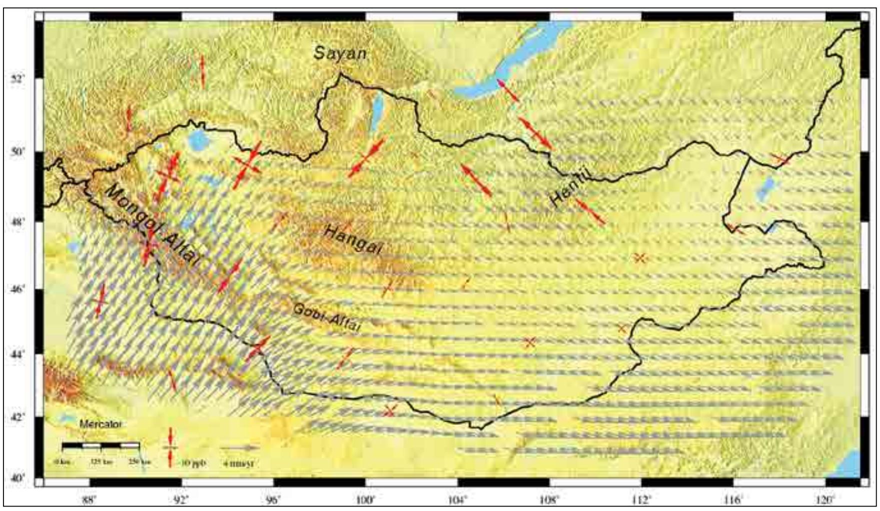

Figure 4. The red arrows are principal shortening and elongation rate axes, respectively and light grey arrows show vectors averaged on a 30'x30' regular grid

Preliminary results and geodynamic interpretations

The velocity map is consistent with previous findings from Calais et al. (2003) and Lukhnev et al. (2010) but adds new information thanks to the CGPS sites included in our processing in particular in central and eastern Mongolia.

A first important observation is that residual velocities are small at sites located on the stable Siberian platform (CHAD, ARAD, ORLK, IRKT), which indicates that the Eurasia-fixed reference frame chosen is adequate for the analysis.

Overall, velocities with respect to Eurasia show a clockwise rotation indicative of:

i. NNE-SSW compression in the western part of the study area since velocities decrease in that direction from south to north. This is also shown on the strain rate map, with the compressional principal axis of the horizontal strain rate tensor striking NNE-SSW. This is consistent with geologically-observed shortening across the Altay. It is interesting that this compression reaches as far north as the Hovsgol area, as also shown in Lukhnev et al. (2010).
ii. a central and eastern domain where velocities are on the same order that is likely to be quite rigid. The strain rate map indeed shows that this broad domain is deforming at a much slower rate that the surroundings.
iii. NW-SE extension across the Baikal rift zone that concerns the wide area of Baikal + Transbaikal, as also shown on the strain rate map.
iv. NNE-SSW in the western Gobi Altai, that transitions eastward to a strike-slip with decreasing strain rates.

The velocity and strain rate maps therefore show a fairly "rigid" (very low strain rate) area that consists of Hangai + eastern Mongolia, surrounded to the south and west by compression, and to the north by extension. This pattern of deformation is difficult to explain if its only driver is the India-Eurasia collision, as shown in Vergnolle et al. (2007). It indicates that the role of mantle flow and/or that of east Asia subductions are likely important.

Conclusions

- The GNSS/cGPS geodetic networks have been designed and established in the territory of Mongolia since 1997.
- The method of research of geodynamic parameters fulfilled in plate tectonics of active regions of Mongolia. It will be used for an assessment of environmental, social and economic risks of development of Mongolia and will be implemented for assessment of deformation of the Earth's surface.
- The result of the preliminary analysis is being used to evaluate the stress accumulation and the earthquake probability on the Mongolian territory.

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I would like to express my deepest appreciation to Eric Calais, ENS, Department of Geosciences, France, for his great support and guidance throughout my visit at ENS.

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> The method of research of geodynamic parameters fulfilled in plate tectonics of active regions of Mongolia. It will be used for an assessment of environmental, social and economic risks of development of Mongolia and will be implemented for assessment of deformation of the Earth's surface

Precise GNSS positioning for mass-market applications

This paper describes some latest work trying to address the abovementioned challenges, including cost and complexity of current correction services, precise positioning with low-cost GNSS sensors, and quick availability of precise positioning solutions in challenging environments. Numerical results are provided to demonstrate their potential to support mass-market applications

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Mass-market applications, ranging from self-driving cars, unmanned aerial vehicles (UAV) to handheld smartphones, are increasingly demanding high-precision from GNSS integrated with other enabling navigation sensors. This expectation is driven by the increasing availability of carrier phase measurements from very low-cost GNSS sensors of small form factor (chipsets or modules) that have been widely used by mass-market applications. Google has made raw GNSS measurements including carrier phase available from a phone or tablet computer. Broadcom has recently announced to launch a mass-market GPS chip that uses L1 and L5 signals to pinpoint a device's accuracy to within 30 centimeters. Although the carrier phase measurements, particularly in challenging environments, are still subject to further improvement and verification by user applications, their potential to support precise positioning is just a matter of time before their wide adoption.

Precise positioning with low-cost GNSS sensors faces some significant challenges. Different from the conventional high-precision GNSS applications, only low-cost GNSS sensors are available for mass-market applications, while the existing high-precision GNSS techniques, either based on real-time kinematic (RTK) or precise point positioning (PPP) techniques, are mainly based on high-end GNSS receivers and targeted only for professional applications such as geodetic surveys, airborne mapping, atmosphere remote sensing, precision agriculture, and marine positioning (Bisnath and Gao, 2009). Frequency carrier phase cycle slips and large measurement noise in low-cost GNSS receivers present a challenge in order to use them to achieve high-precision positioning solutions.

Current precise GNSS positioning systems also depend on high update rate real-time corrections for error mitigation, typically 1-2 minutes for orbit corrections and 1-10 seconds for clock corrections. A dependence on real-time corrections at a high update rate for error mitigation will make the positioning system sensitive to correction outages. For example, a high update rate means the users have to maintain continuous wireless connections in order to timely receive the correction data, making the positioning performance sensitive to the latency of the orbit and clock corrections and susceptible to connectivity restrictions. In real-time applications, the correction data from communication satellites could be blocked or attenuated by buildings or trees in urban canopy and loss of correction data could also occur due to poor wireless network connections, causing frequent message packet losses. The loss of correction data in turn will reduce the availability of the positioning system due to performance degradation and re-convergence of the positioning solutions. Increased communication cost and higher power consumption in the devices for users to receive the correction data at a high update rate is also problematic for mass-market applications, which demands careful consideration of the bandwidth, latency and data transfer cost for correction data transmission in the development of a real-time precis positioning system (Mozo et al, 2012). Mass-market application also

requires quickly obtainable precise position solutions and therefore long ambiguity convergence and fixing time will not be acceptable. UAV, for example, depends on precise position all the times in order to achieve high performance flight control in complex environments, e.g. navigating a UAV in confined environments.

This paper will describe some recent work with an effort to address the abovementioned challenges, including cost and complexity reduction of correction services, precise positioning with low-cost GNSS sensors, and instant availability of precise positioning solutions in challenging environments. Numerical results from field tests are provided to demonstrate their potential to support mass-market applications.

Precise positioning with low-cost GNSS sesnors

GNSS provides two major types of positioning measurements, namely pseudorange and carrier phase measurements. High-precision positioning techniques with GNSS require the use of the carrier phase measurements in order to improve the positioning accuracy from several meters to centimeter-level with integer ambiguity resolution. Carrier phase measurements however are currently not available in most low-cost GNSS receivers or not usable in harsh environments due to the use of poor quality oscillator and the lack of proper carrier phase tracking algorithms. For example, low-cost temperature compensated crystal oscillator (TCXO) will limit the integration time and induce more phase lock loop phase noise. Subjected to severe low- and medium-frequency vibration environments as the case of flying with a UAV, the oscillator vibration-induced noise must be handled properly otherwise cycle slips will be induced. Making carrier phase measurements from low-cost receivers and using them to obtain more accurate positioning accuracy therefore is a necessary step in order to extend precise positioning techniques to mass market applications (Pesyna et al. 2014; Bhaskar 2015). Although Google has made raw GNSS measurements including carrier phase available from a phone or tablet computer, the quality of carrier phase measurements are still subject to further improvement and verification and are not yet be able to support precise positioning particularly in challenging environments.

Carrier phase measurements are generated from the phase lock loops (PLLs) of a GNSS receiver. Usually the GNSS receiver utilizes individual PLL to track carrier phase for each satellite, known as scalar carrier tracking techniques. But there is a dilemma problem to the design of the loop parameters in a conventional tracking loop. To mitigate the oscillator phase noise, for example, the loop filter bandwidth of the conventional scalar phase lock loop should be increased but an increased bandwidth will reduce the ability of the tracking loop to reject the thermal noise. Considering that the receiver oscillator and dynamic stress are common for different channels, the bandwidth of the channel loop can be reduced if the abovementioned common error can be estimated before the correlator for individual channels. This has led to the development and implementation of carrier phase tracking techniques based on vector architecture (Chen et al., 2017). Shown in Figure 1 are the single differences of carrier phase measurements based on vector architecture. The results indicate that no cycle slips are present for all satellites. If based on scalar architecture, cycle slips would present in carrier phase measurements to multiple satellites.

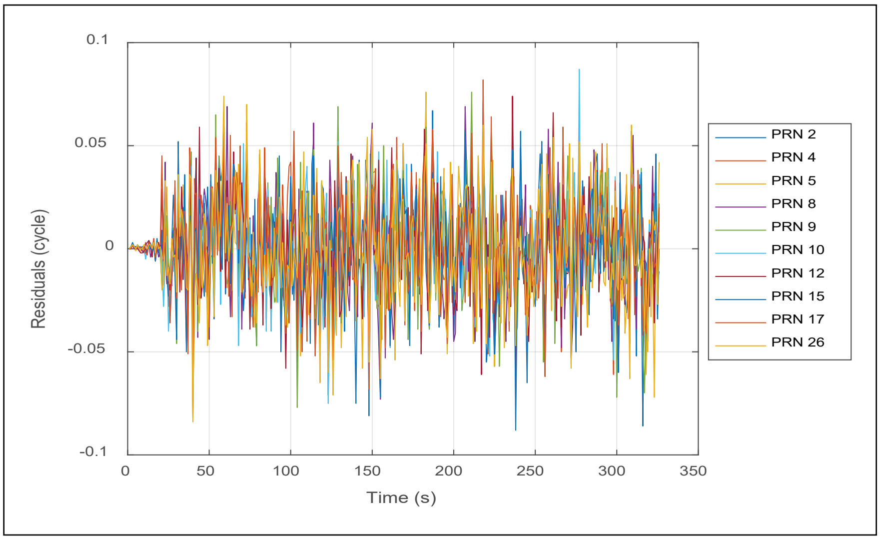

Figure 1 Single difference of carrier phase measurements based on vector architecture

Scalable update rate correction transmission

Current real-time satellite orbit and clock correction data generated at the server system are in essence the differences of precise orbit/clock with respect to the broadcast orbit/clock. As a result, the corrections must be transmitted to users at a high update rate (typically 1-2 minutes for orbit corrections and 1-10 seconds for clock corrections) in order to ensure sufficient accuracy. In the past, real-time precise orbit and clock corrections were available from only a few commercial suppliers, via communication satellites with dedicated hardware as well as significant subscription fees. This was once a limiting factor for developing real-time PPP applications (Gao and Chen, 2005). For mass-market applications, new correction services should be developed to address challenges related to bandwidth, latency and data transfer cost, although the development of the Networked Transport of RTCM via Internet Protocol (NTRIP) has made the correction data transmission easier and less expensive to access than the satellite-based correction transmission.

A new correction update based precise point positioning system was proposed in Gao et al (2015, 2017). Different from current real-time PPP systems, the server system generates real-time precise satellite orbit and clock initial parameters (IPs). Instead of corrections representing the differences of precise orbit/clock with respect to the broadcast orbit/clock, the initial parameters consist of initial conditions and additional crucial data for orbit and key coefficients for clock. Provided at selected reference time, the IPs can be applied by the users to derive corrections at any desired epochs before next update from the server system, for orbit through numerical integration and clock through extrapolation. This approach would allow scalable correction update rates for different applications, including lower update rates for the purpose of reducing system sensitivity to correction outages and communication cost, as required for mas-market applications. With reduced update rate on initial parameters, the requirements on continuous wireless connection can also be relaxed, making the positioning system less susceptible to temporary poor network connection and communication satellite signal blockage, particularly in challenging environments such as when a receiver is operating in urban canyons and under tree canopy.

Figure 2 shows the accuracy statistics of the orbit corrections generated by the users over a period of 12 h using orbit initial parameters. Daily solutions over a week are used to calculate the average RMS values, with respect to the IGS Final products. As the figure shows, the average orbit RMS values in all three directions are smaller than 6 cm for all GPS satellites, with average RMS values of the 31 satellites about 3 cm for the radial, along-track and cross-track directions. The results demonstrate that the initial parameters for orbit correction generation can be valid for a long period of time, allowing the adoption of much lower update rates than currently applied high update rates in applications.

Table 1 shows the accuracy statistics of the clock corrections generated by the users over a period of 1, 2 and 3 hours using the clock initial parameters. The results indicate that the performance of user generated corrections depends on the type of clocks. For correction generation over 1 hour, the RMS values of IIR/Rb, IIR-M/Rb, IIF/Rb and IIF/Cs clocks are 0.41 ns, 0.35 ns, 0.24 ns and 1.12 ns. For correction genertaion over 6 hours, the RMS values of IIR/Rb, IIR-M/Rb and IIF/Rb clocks are smaller than 0.62 ns while the RMS value for the IIF/Cs clock is 1.83 ns. Compared to other types of clocks, IIF/Cs clock is much instable.

Table 1 – Satellite clock correction RMSE (ns)

	1 hour	3 hours	6 hours
IIR/Rb	0.41	0.47	0.62
IIR-M/Rb	0.35	0.42	0.61
IIF/Rb	0.24	0.39	0.60
IIF/Cs	1.12	1.25	1.83

Quick availability of precise positioning solutions

Mass-market applications demand quick and even instant obtainability of precise position solutions without initial or re-convergence. Further they also demand stand-alone operation without requiring base stations. Although PPP techniques able to eliminate the requirement on base stations, the required time for carrier phase ambiguities to converge or to be fixed to integer values are significantly long, typically at a level of several tens of minutes. This is not acceptable for most mass-market applications.

Two approaches can be focused in an effort to make precise positioning solutions quickly available in real-time applications. One is to focus on the reduction of the convergence time for the ambiguity float solutions. With the deployment of multiple GNSS systems, the combination of measurements from all available constellations, e.g. from fully operational GPS and GLONASS and partially operational Galileo and BeiDou, can help reduce the convergence time as a result of geometry improvement (Cai et al, 2015). Multi-GNSS approach alone, however, will not be able to totally eliminate the required convergence time. Uncombined positioning model is increasingly adopted which allows for the integration of additional information such as precise ionospheric products. The elimination of ionospheric effects has the potential to enable precise positioning solutions quickly available in real-time applications, but the improvement will depend on the quality of the ionospheric products. The obtainable positioning accuracy also depends on the efficiency of mitigating errors and systematic effects in the measurement models. With the moderization of GNSS systems including multi-frequency signals, triple-frequency based ambiguity resoltuion technqiyues have been investigated which, together with other advanced processing algorithms, has made fast PPP ambiguity resolution feasible (Wang, 2014). Considering single-frequency GNSS receivers are still dominated in the mass-market applciations, Figure 3 shows the positioning errors from a kinematic test, with the use of a low-cost single-freqeuncy GNSS receiver and real-time orbit, clock and ionospheric corrections. The results indicate that precise positioning solutions can be quickly obtainable (virtually no convergence period for the horizonatl

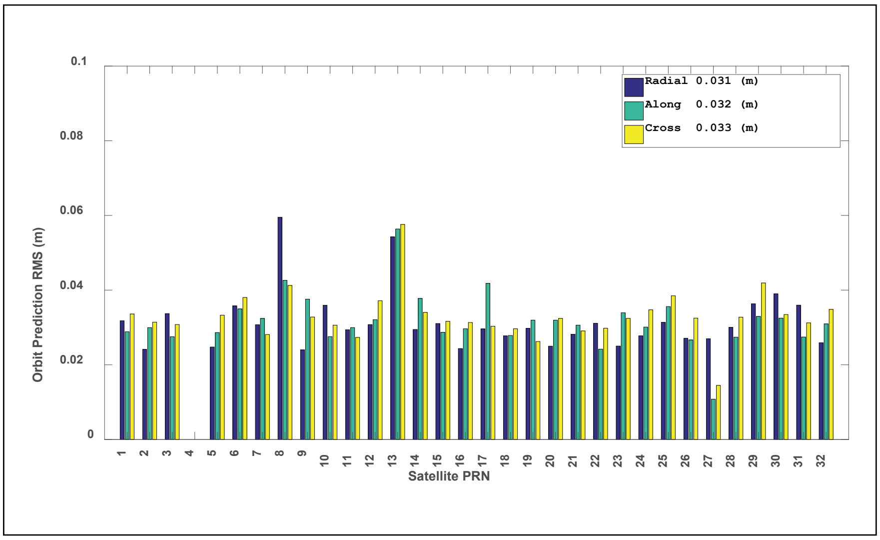

Figure 2 – Satellite orbit correction RMS (m)

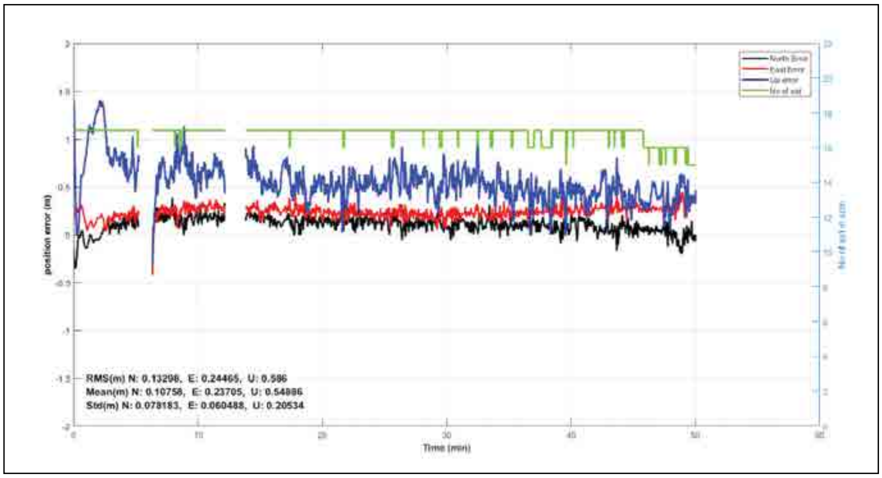

Figure 3 – Positioning errors (m)

solutions), which demonstartes its potential to support mass-market applciations. The two data gaps in the figure were caused by data outages due to loose cable conneciton resulting in power losses.

Conclusions

This paper has identified and discussed several challenges in an effort to extend precise positioning techniques to support mass-market applications based on low-cost GNSS. It has described feasible solutions to address the challenges as well as numerical results to demonstrate reduced cycle slips in carrier phase measurements using new phase tracking techniques, reduced sensitivity to correction outages and reduced system cost and complexity by using scalable update rates of real-time corrections and quickly available precise positioning solutions through advanced positioning algorithms.

Since mass-market applications are often conducted in challenging environments, techniques to bridge the GNSS signal blockages are demanded in order to further improve the positioning system availability and robustness. Integration of GNSS with other low-cost sensors, such as low-cost inertial and vision sensors that are widely embedded in UAV, self-driving cars and smartphones, should also be investigated in order to develop low-cost and high availability and robustness positioning systems towards mass-market applications.

Since mass-market applications are often conducted in challenging environments, techniques to bridge the GNSS signal blockages are demanded in order to further improve the positioning system availability and robustness

Acknowledgements

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Egocentric leisure boat navigation in a smartphone based Augmented Reality application

In this study, we tested a smartphone based safety app for leisure mariners. The app worked in two modes: the "turned off" phone would give an alarm in the navigator's pocket 30 seconds before the boat "grounded" (entered into dangerous waters)

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The number of people killed in pleasure craft accidents in Norway has been relatively stable for the last 10 years ranging between 38 and 24. In 2015 the number was 37 and in 2016, 27 (Berntsen, 2017). The reduction in deaths by 2016 could be the result of the mandatory requirement to use a life jacket in small boats less than 8 meters by May 2015. The majority of these accidents happened in confined coastal waters among the around 50 000 islands along the Norwegian coast. Around 20 percent of these accidents with a deathly outcome were caused by groundings (Berntsen, 2017). The presented statistics on deadly accidents hides a much larger amount of accidents where nobody was killed but which still involved hull damage. The Norwegian Society for Sea Rescue in august 2017 published statistics on the number of groundings in the county of Ostfold (south-east of Oslo). 223 leisure boats had to be towed off rocks in Norway by the Sea Rescue Society between January and August 2017 (Norwegian Society for Sea Rescue, 2017). A survey by a Norwegian insurance company revealed that 40 % of leisure mariners in a county in middle Norway could not read a nautical chart (Hitra-Froya, 2016).

> Leisure boaters often has a limited knowledge of navigation according to accident statistics and the application was designed to be easy to use and understand without prior navigation knowledge

Background

In 2008 the main author participated in a conference about safety of leisure crafts in Oslo. During a session a representative of a Norwegian pleasure craft organisation said something in the line of "what boat people want is not complicated chart machines, but a simple black box in the pocket which sounds an alarm 30 seconds before they run aground". There was much laughter and nobody really took it seriously. However, this remark lingered in the background in the continued work on ways of making navigation methods, more intuitive, more robust to stress, inexperience and lack of training, both for amateurs and professionals. Much of the work concentrated on what we call *cognitive off-loading*.

Cognitive off-loading

We humans view and act in our awake life from the egocentric perspective of our eyes. Maps, however, are depicted from an exocentric birds-eye perspective. Navigation is much about translating own position and intended course from the map perspective to the real world. The projection change that needs to be done on the fly in the head are called *mental rotation* and are both error prune and cognitively demanding (Porathe, 2006). One way of facilitating navigation would be to let the map system conduct this change in projection, presenting the map in an immediately useful *egocentric 3D-view* (see Fig. 1).

Porathe (2006) showed that the way-showing task of navigation was more effective (higher speed and less errors) using egocentric view maps. At the same time, the traditional exocentric perspective was better for e.g. route planning and tasks requiring overview.

3D and Augmented Reality maps

The original suggestion by Porathe (2006) was to add new information to the map data base (terrain elevation, conspicuous buildings, etc.) and then allow the map system to seamlessly change between egocentric and orthographic exocentric views according to the users needs.

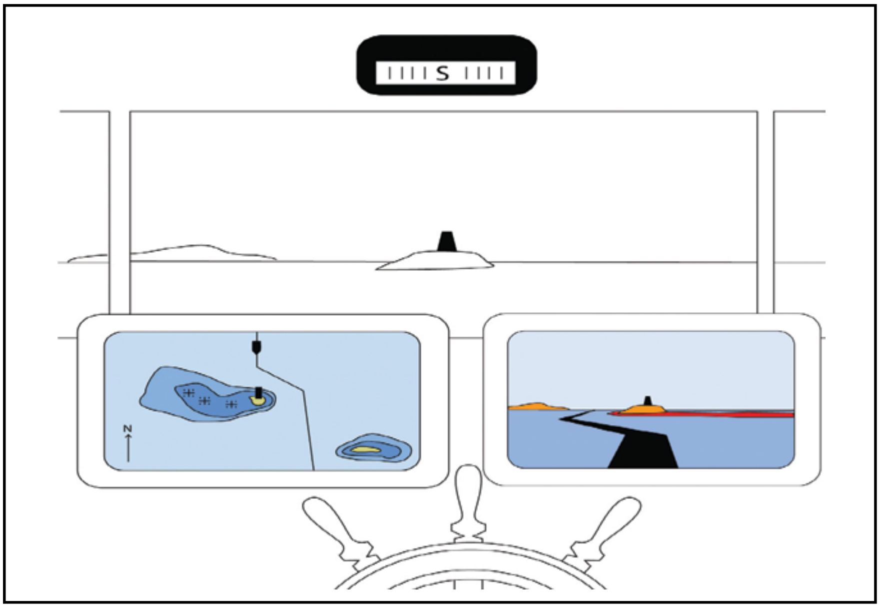

Figure 1. A concept illustration of an egocentric map view is shown on the right screen as compared with the traditional exocentric map view of the same situation on the left screen. (Illustration Porathe, 2006)

Figure 2. Concept image for the project. (Illustration: T. Porathe.)

However another way of achieving a simplified egocentric view would be to add chart information in an *augmented reality* (AR) layer on top of the camera image in an ordinary smart phone available by almost every people today. Augmented Reality (AR) or Mixed Reality (MR) are when computer generated imagery, geo-referenced or not, are placed on top of a real world view in e.g. head-up or head-mounted displays, but also in cameras and touch pads.

Method

In October 2016 the SikkerKurs-project started with a budget of 1.5 million Norwegian crowns financed by the Norwegian Coastal Administration (Kystverket) and Geomatics NORWAY AS. The purpose was to develop an AR application for ordinary smartphones to increase safety and possibly decrease the number of groundings by leisure boats in Norwegian waters. The project was a proof-of-concept demonstrator, coordinated by Geomatics Norway AS. The design was done by professor Thomas Porathe from the Norwegian University of Science and Technology (NTNU) in Trondheim and technical implementation was conducted by Combitech AB in Linkoping, Sweden. Other partners in the project was the Norwegian Hydrographic Office (Kartverket) and the Norwegian Maritime Authority (Sjofartsdirektoratet). It was decided that the project would use the Human-Centred Design process (HCD) in ISO 9241 (ISO, 2015) and IMO's guideline on HCD (IMO, 2015).

The human-centred design process

The point of HCD is to ensure user-driven development and a good usability by including the end users early in the process and keep them involved during the whole design. This is done in an iterative process with four steps: 1) Understand the context of use by field studies and interviews with the users, 2) specify the user and organizational requirements, 3) produce a design solution, this will be the prototype and 4) evaluate the design against requirements. Here the prototype is tested on the end users. The findings are then brought into a new iteration of the design process resulting in a new, improved prototype. The process is the iterated until the application meets the requirements.

Test area

Before a user group could be recruited, a location had to be decided. One way would be to look for an area with much leisure boat traffic. However, the availability of detailed, bathymetry and chart data was a precondition. The Hydrographic Office offered an area in Sore Sunnmore, a district south of Aalesund on the Norwegian west coast which had been declassified and could be used. A central municipality in this area was Ulsteinvik, which was to become the centre of the project.

Recruiting a user group

We needed to come in contact with local leisure boat mariners to recruit the user group. A mail was sent out to 30 pleasure craft clubs in the district telling about the project and asking about participation in development and testing of the application. The concept image in Figure 2 was included to illustrate the idea.

Only six boaters responded, all male, all relatively experienced and with an age of 60+. Although we had hoped for a larger user group with mixed ages, gender and experience, this was the user group we had to start with.

Understand the context of use and user requirements

A first focus group meeting was held in Ulsteinvik in January 2017. The users were interviewed about their experience with leisure craft navigation and the proposed concept with using a smartphone as a mean of preventing groundings was discussed. The group concluded that idea was very interesting and that there was a need for a safety devise alarming if the boat was approaching unsafe depths. The group agreed on a prioritized list with different possible features:

Alarm

The phone should sound an alarm a configurable time before the boat went aground. The application should be atomically started in the background when a boater steps into his boat, so that he or she does not forget to start the application. The time should be short so that the number of false alarms in narrow archipelagos would not be annoying and thus making boaters turn off the alarm (which often is the case with the look-ahead-sector in professional shipping).

The default setting was agreed to 30 seconds, and the procedure of the boater should be to immediately stop the boat on alarm. The alarm should be silenced by picking up the phone and clicking the warning icon shown. The alarm should also be silenced by slowing down to a configurable maximum speed (default 3 knots) to allow boats to make landfalls or approach a jetty without getting an alarm.

NoGo areas

When the phone is picked up and the alarm silenced, the screen should show “NoGo Areas” in red over layered on the camera image. These NoGo areas are the polygon inside a configurable depth curve. Default should be the 3 meters curve, but ideally, any depth could be picked passed on the current draft of the boat, plus a safety margin. Ideally, the depth should also be compensated for the current tidal situation based on tide tables or real-time tide gauges. The user should be able to see these NoGo areas all around by pointing the smartphone camera.

Landmark names

Conspicuous landmarks around the boat should be named by overlaying text on the camera image. Examples of such conspicuous landmarks could be names of islands, shoals, beacons and mountaintops (the area is very mountainous). Much time is spent onboard a small craft trying to find buoys and beacons. An overlaid pointer should show their position to aid visual search. To avoid cluttering the names and pointers could be toggled on and off by tilting the camera (slightly up turns text on and vice versa).

Air draught

An alarm similar to the grounding alarm could be configured for sailing boats with a mast height that is higher that the span of bridges and power lines.

Fairways and planned routes

Official fairways should be shown as a "carpet" rolled out on the water in the camera image. Also, individual routes planned in a chart program and imported into the phone might be shown. This feature must be able to be turned on and off to avoid cluttering. This requirement was later dropped for the tested prototype due to time constraints.

Technical prototype development

After the meeting with the user group the discussions started about the technical implementation and what could be achievable within the time and budget available. Of the five prioritized solutions suggested by the user group the first four was selected for development.

The android platform

We decided to make the test implementation on the Android platform because Combitech had earlier experience from this platform, had available equipment and the relative ease with which test implementations could be distributed without passing thought e.g. the AppStore (for the iOS), thus giving us a quicker development cycle.

NoGo areas and alarm execution

Part of an Electronic Nautical Chart (ENC) was imported into a database in the phone's memory. From the ENC only the polygons making up the area with a water depth of less than three meters at chart datum was kept. These polygons made up the "NoGo Area" that was used to alarm the navigator for grounding. Ideally, we would have NoGo polygons for every centimetre, which could be turned on and off depending on the set draught of the boat and the tidal situation. However, this would require large memory storage or a constant on-line connection so we decided to have just one NoGo depth: 3 meters for the test. The Norwegian Hydrographic Office delivered the necessary depth curve on a high-resolution horizontal grid of 1 meter. The internal map would consist of this area of water depths between 3 meters and the beach line.

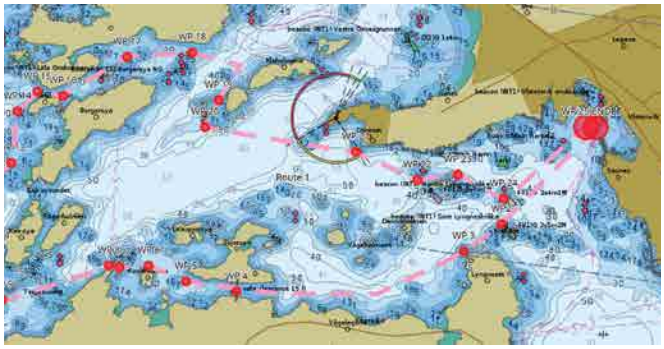

Figure 3. The test track west of Ulsteinvik in western Norway

Figure 4. The test application on the smartphone (Lenovo Phab 2 Pro) during the pilot test. To the right the boats reference stationary chart plotter

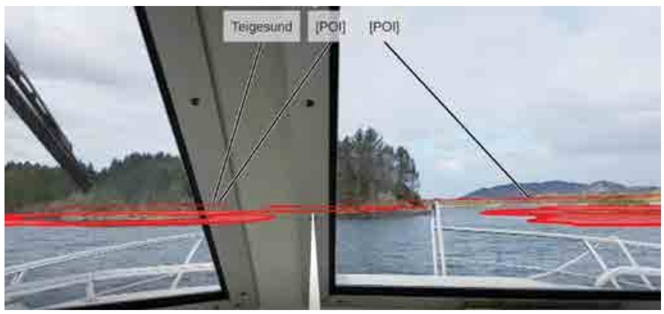

Figure 5. Screen dump from the Galaxy test phone. The projected NoGo areas in red. The 30 second course-speed vector in white just before the alarm is triggered. The pointers showing three points of interest (two of witch is hidden behind the island)

Fig. 6. Screen dump from the Galaxy test phone. The grounding alarm has been triggered with both an aural and a visible alarm

The timed alarm function was implemented using a vector extending from the present position in the direction of the current course. The length of the vector was dependent on the speed and the alarm time set. In the default setting the alarm was set to be triggered 30 seconds before the boat "grounded" (passed over the boarder of the 3 meters NoGo area). With 10 knots the length of the vector would be (10 knots * (1852 metres / 3600 seconds) * 30 seconds) =154 meters. The length and direction of the course-speed vector was calculated from recent GPS positions. The precision was dependant on the position rate the phone could muster, which in general was one position per secound or less. The alarm would be triggered when a course-speed vector intersected with a NoGo area polygon.

The air draught alarm was treated the same way using the same course speed vector intersecting a safety rectangle extending 15 meters on both sides of bridges and power lines. The set mast height would then be compared against the maximum air draught allowed as stated as an attribute to the safety rectangle. In the test area there was only one power line and no bridges.

The augmented reality layer

The NoGo area polygon map were to be shown on top of camera image at the correct position. The polygons should apparently be "floating" on the surface of the water. In order to do this the map had to be georeferenced and projected using a *virtual camera* positioned in the virtual space as the real camera was in the real space. This projection is a standard VR operation conducted in real-time taking the virtual cameras height over the water (pre-set to 2 meters), direction (from the phones compass) and field of view (pre-set to match the device's camera) as in-parameters. In order to keep computation time low and not to clutter the display a maximum visibility of the NoGo areas was set initially to 2000 meters by the means of a clipping plane.

The course-speed vector was also made visible and projected into the camera view; white when not in alarm mode but switching to red when an intersection had taken place and the alarm was triggered. It was then red as long as it was intersecting with the NoGo polygons. This visualising the alarm state, also when the aural alarm was silenced. The initial intersection point was shown by an arrow.

The stability and precision of the GPS positions and the compass heading from the internal phone sensors was an area of concern. The course-speed vector triggering the alarm was created by extrapolating present course and speed into the future. Low-pass filters were applied to these values to avoid large jumps due to unstable GPS fixes. This was done to reduce the risk of false collision alarms. The point of view in the polygon map was also dependant on the GPS based present position, but the direction of the camera (which was independent from the course-speed vector of the boat) was relying on a compass direction from the phones internal magnetic compass. We had little experience of the precision of these two sensors, which might also be dependent on local conditions in the area for the test. However to anticipate possible problems with the compass we made it possible to shut down this sensor and use the course speed vector as direction for the virtual camera in the augmented reality layer, assuming that the camera was fixed in a forward looking manner (e.g. on the windscreen).

The only text based information we considered we had time and resources to implement was the pointers for navigational marks. The position of all buoys and marks in the test area was collected in a list. We did not succeed in populating the list with all the marker names in time, why these markers in the tests prototype mostly showed "POI" for point of interest.

Results and discussion

The first iteration of the prototype was tested during a technical test in Ulsteinvik with two from the user group on 8 May 2016. The full user test was conducted a month later on 14 June.

Technical test

For the technical test in May a reasonable difficult, 5.8 nautical miles long track was dawn in an electronic nautical

Fig. 7. The picture show the offset of the AR layer with the red NoGo areas as they were fluctuating due to noise in the phones internal compass. However, users judged in acceptable during the tests

chart (see Figure 3). This track could be negotiated in a little more than an hour at a moderate speed of 5 knots speed (not to take any risks should the prototype prove unreliable).

For the test, we used a 7-meter long leisure boat owned by one of the users. He had also very good local knowledge, which would be a safety barrier against unintentional grounding should the prototype fail. The boat was also equipped with a stationary chart plotter which was used as a reference system (see Figure 4).

The prototype software was tested on two phones, one Samsung Galaxy S7 and one Lenovo Phab 2 Pro. We found no differences in behaviour between the two phones tested and the test prototype worked to the largest extent as expected. Some problems with fluctuating AR layer is described below.

User test

The final user test was held in Ulsteinvik the 14 June 2017. The same test track as in May was used and all six of the original users was present on the 15 meters long M/S Legona used during these tests. The boat made the passage in about 5 knots speed in just over a hour and the prototype was tested on the two phone types mentioned above. Below are the results of this user test.

Alarm execution

When the course-speed vector intersected the alarm was triggered, both while the phone was turned off in the pocket, or (as in Figures 5 and 6) when the phone was used to actively monitor the water ahead of the boat. By touching the stop sign, the alarm is acknowledged and silenced and the stop sign disappeared. However, the vector remain red as long as it was intersecting a NoGo area. This feature worked perfectly as designed and the comments from all the users were very positive.

NoGo areas

The augmented reality layer was projected over the camera image based on a virtual camera positioned by latitude and longitude from the phones GPS sensor and the virtual cameras direction was based on input from the phones internal magnetic compass. Both these sensors had fluctuations as opposed to the camera image which of course moved only when the phone moved. This resulted in smaller or lager fluctuations of the AR layer over the camera image. The AR layer with the NoGo areas, course-speed vector and POI pointers would float or jump in the image, mostly in the horizontal plane. These fluctuations would be more or less bad depending on the factors like if the camera was being panned by the user, and/or magnetic disturbances in the boat or in the area. The sensitivity to magnetic disturbances is illustrated by this example: One phone tested had a leather cover that could be closed over the screen with a magnetic lock. This lock jammed the compass causing the AR layer become unreliable.

The fluctuating AR layer was the one disappointment in an otherwise successful test. Ideally, the layer with its added information should be steady and "glued" to the camera image, as it now where it jumped or sailed some 5-10 degrees to either side of its intended position. However, the user group though it was still within reasonable limits because the beach line of islands in the camera image and in the NoGo areas was usually easy to detect and pair together so that the fluctuations became like a visual expression for some kind of uncertainty. In Figure 7 an offset to the right and slightly up can be seen. The beach line of the island and the front beach line in the inner hole of the red NoGo areas match. Note also that we got the NoGo areas behind the island visible as an artefact. They could theoretically be clipped by an invisible 3D-model of the terrain in some future version where we could also show this virtual terrain during darkness and fog.

However, the most important thing was that the triggering of the grounding alarm function was not affected by the fluctuations due to the magnetic compass. The alarm computation was done entirely in the map layer using the relatively more stable GPS position.

Survey

After the test voyage and a short debriefing, the six users answered some questions in a small survey. The first question was whether they thought that the tested prototype could have any favourable effect on boat navigation. On a scale from 0-100, where 0 was "no favourable effect" and 100 "large favourable effect" they where asked to indicate their answer with a cross. The mean result of all six users was 83. Close to "large favourable effect".

The second question dealt with the usability of the prototype application. On the same type of scale from 0-100, where 0 was "simple to use" and 100 was "difficult to use", they were asked to mark their answer with a cross. The mean result from the six users was 13, clearly on the "simple to use side".

> The most important thing was that the triggering of the grounding alarm function was not affected by the fluctuations due to the magnetic compass

They were also asked to comment on the prototype and asked if they missed any functions. Three answered "no"; one gave no answer; and the remaining two made these comments: "The matching between the AR layer and the camera image could be better", "AIS data could be added", "Some adjustments and it will be fine", "Get it out as soon as you can, new versions can come later."

During a concurrent TV interview one of the user commented on the alarm function: "I am often out sailing in my boat and when tacking we often want to use the water between the islands as much as possible, and then often go close to land. If we could get an alarm by a busser in the pocket instead of having to constantly look on our navigator screen, that would be great."

The users were also asked about the likelihood that they would use such an app if it was 1) free, 2) costed the equivalent of £2.5 and 3) £25. On the same scale from 0-100 the answered that the likelihood was 1) 95, 2) 94 and 3) 82. Which translates to a high willingness to pay a reasonable amount for such a safety app.

Conclusion

In this study, we tested a simple, smartphone based safety application for leisure boaters. Leisure boaters often has a limited knowledge of navigation according to accident statistics and the application was designed to be easy to use and understand without prior navigation knowledge. It worked in two ways: 1) In a "turned off" mode in the pocket the phone would give an alarm 30 seconds before the boat entered into "dangerous waters" (depth less than 3 meters).

The boat owner was then expected to immediately stop the boat. 2) Picking up the phone, the owner could look through the application's camera view and see red "NoGo Area" polygons overlaid on the camera image. By looking around he or she could then detect navigable water and continue the voyage.

The application contained a high-resolution map of the 3 meter depth curve extracted from a nautical chart. This map was then projected on the camera image "egocentric view" of the surroundings, thus bypassing the potentially cumbersome mental rotations a human navigator has to do when comparing a traditional exocentric map with the world around. This will facilitate use by unexperienced boaters.

The application was tested on small group of six Norwegian, all male, all experienced, leisure craft mariners. The size and configuration of the test group limits the generalizability of the results, but the group was highly positive to the tested prototype, which encourages us to continue this work.

Future work includes adding some limited features asked for by the user group while still maintaining a simple and easy to use app. The most prominent new feature will be the ability to import a pre-planned route from a nautical chart application (or an official route from the Coastal Administration) and show this route in the AR layer overlaid in the camera image, thus not only showing dangers to navigation but also offer way-showing.

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Conflicts of interests. None

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimen-tation and with the Helsinki Declaration of 1975, as revised in 2008."

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In Coordinates

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Exploring the moon in three dimension

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The high level data products defined for Chandrayaan-1 mission are the Lunar Atlas and maps. The objective of Chnadrayaan-1 lunar atlas and map products are to prepare maps for the entire surface (~37.8 Million Sq. km) of moon and it's visualisation. Atlas will consist of Terrain Mapping Camera (TMC) and Hyper Spectral (HySI) orthoimage and Image mosaics, Digital elevation model derived from TMC triplets, Contributory themes from each payloads and annotations. Lunar atlas will be in softcopy while in the hardcopy form it will be represented in map catalogue form.

A sensor architecture for high precision UAS navigation

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There are many traditional surveying methods used for the large-scale bridge structure deformation monitor such as the accelerometer measure, the total station surveying and the laser collimation, but these methods are limited by its function of which the continuity, timeliness and automaticity can not meet the need of the large-scale construction dynamic monitor. In recent years, with the GPS hardware and software technology developed, especially the GPS receiver with the high data-collection frequency (for example 10Hz even 20Hz[1][4]) appearanced as well as the GPS data processing was improvement, the GPS-RTK technology applied in large-scale bridge dynamic deformition monitor with real-time or quasi-realtime has become true[2][3]. Further, with the Fourier transformation tool the bridge base frequency could be obtained, the data of bridge vibrational state in spatial frame and frequency range distributed characteristic may provide the key to understand whether the bridge structure is health under the load drive environment.

Taking geomatics to greater heights in India

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This paper looks into the present technologies and policies to present a different view or suggestion for improvement. The views are not limited to only the technical and production process regarding Geomatics products and services in Indian environment but go beyond and touch the structure of the organizations in Geomatics sector. In order to do justice for the new thinking a model for change is first evolved. The suggested changes are then discussed.

All GNSS civilian signals

TRIUMPH 3

Based on the TRIUMPH 3 chip with 864 channels

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

see back page >

J-Mate Overview

6 pages inside >

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

motorized auto focus for the J-Mate high precision camera

NEW

JAVAD

J-Mate Quick Overview and Update to Videos

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

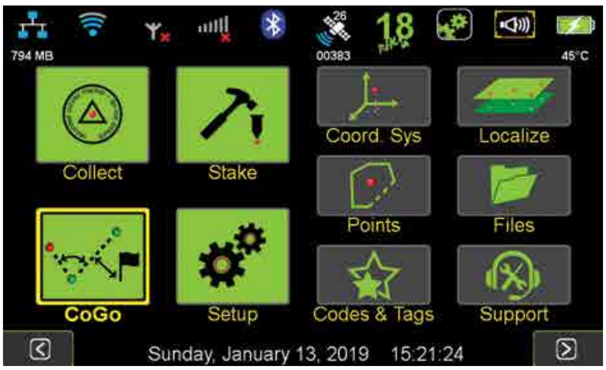
One major improvement that we did recently is to add motorized control of the camera focus feature.

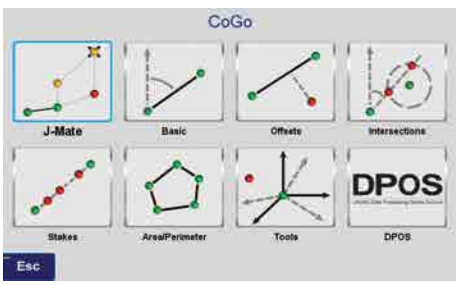
As with the TRIUMPH-LS, with the J-Mate we also provide software improvement updates regularly and free of charge. Download the J-Mate update in your TRIUMPH-LS and then inject it to the J-Mate. When you connect the TRIUMPH-LS to the J-Mate, the injection will be done automatically; but with your consent.

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

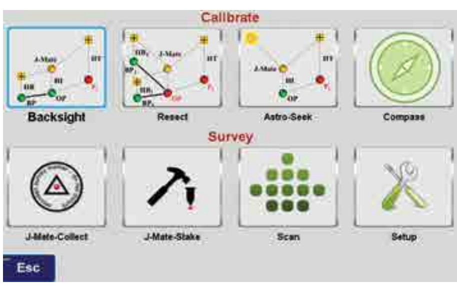
Connecting J-Mate to TRIUMPH-LS:

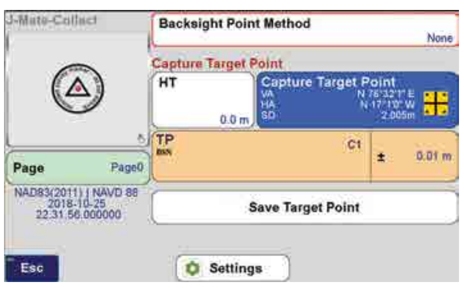
TRIUMPH-LS communicates with the J-Mate through Wi-Fi. Turn on both the TRIUMPH-LS and the J-Mate. Click the Wi-Fi icon of the TRIUMPH-LS Home screen to connect to the J-Mate, much the same way as you connect TRIUMPH-LS to your Wi-Fi access point. J-Mate has ID of the form JMatexxx.





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





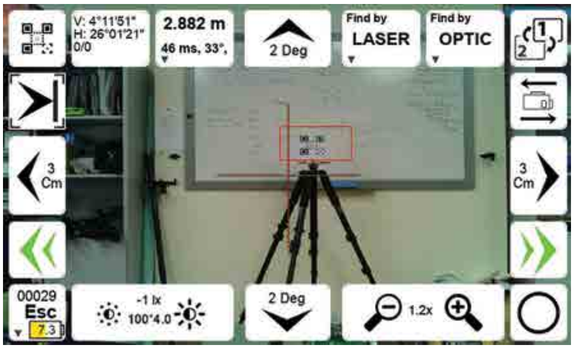
Finding the target automatically:

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

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

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

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



Switching between the two cameras:

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

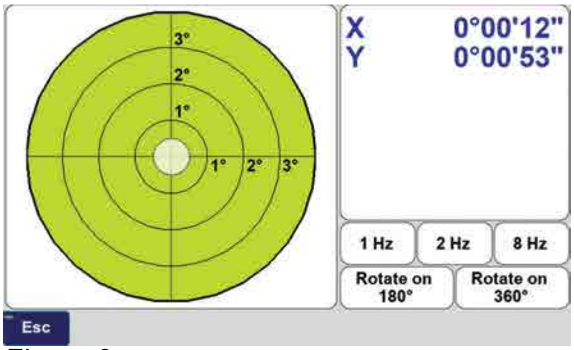


Figure 3

Viewing the embedded Inclinometer:

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

Taking a point:

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

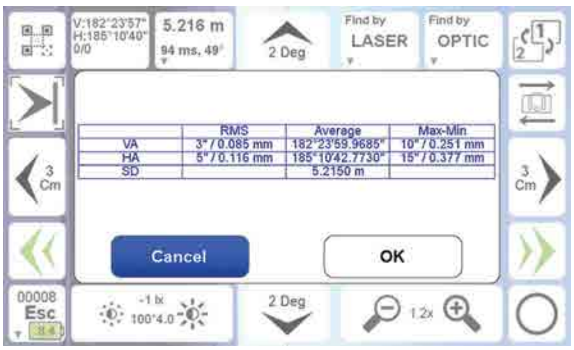


Figure 4

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

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

Viewing the measured points:

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

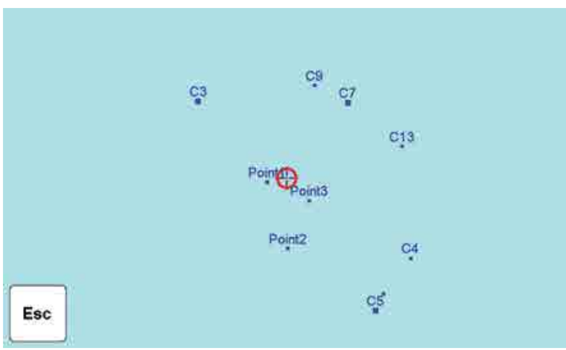
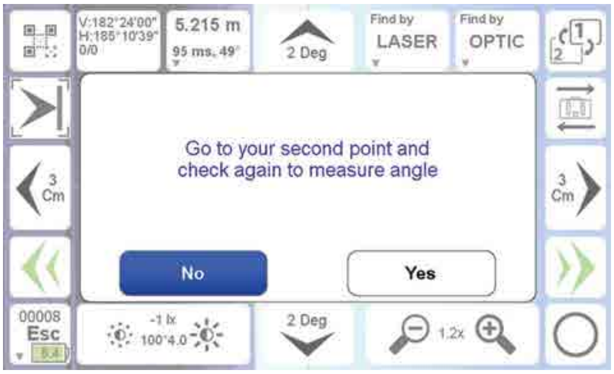
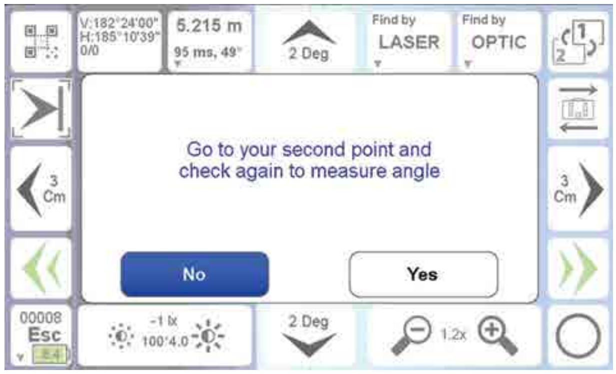


Figure 5

Measuring angles quickly:

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





Saving and Recalling Orientations:

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

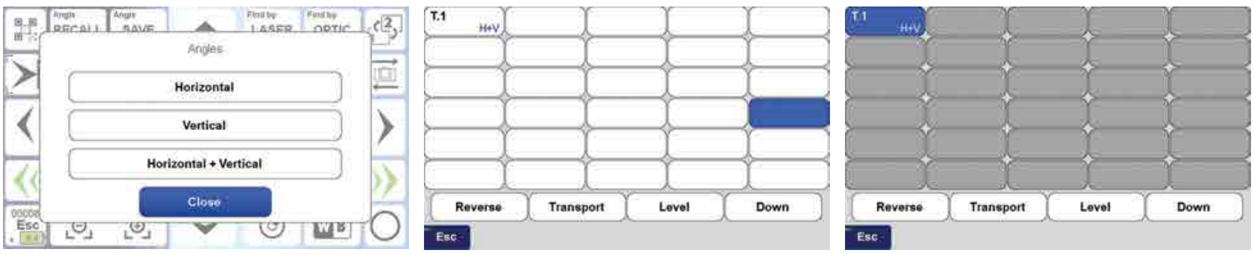
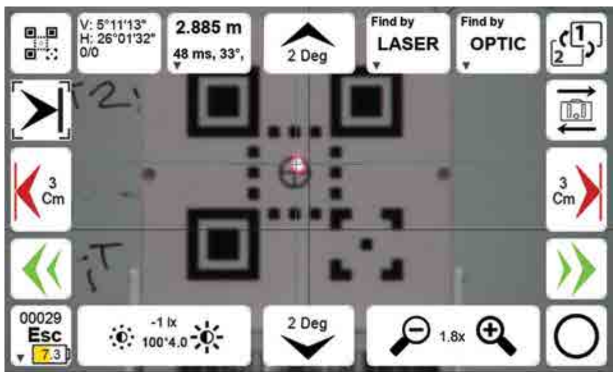
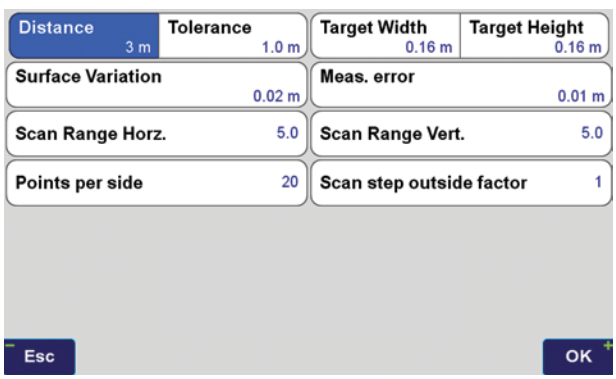


Figure 6

Scanning and snapping to an object:

Click button **“15”** of Figure 1 and see that the left and right motion buttons (**“14”** on Figure 1) change to red which means when you click them scanning to snap will start. Hold long button **“15”** to get to the screen.





In this screen you can define the scan range and ask the scan to stop when range changes by the specified value and snap to it. Then you can select to save the point that was measured before the stop or after the snap.

You can scan the ranges that you have specified and record the 3D image. When you click button 15 to end the scanning mode, you will be asked if you want to save the scanned file.

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

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

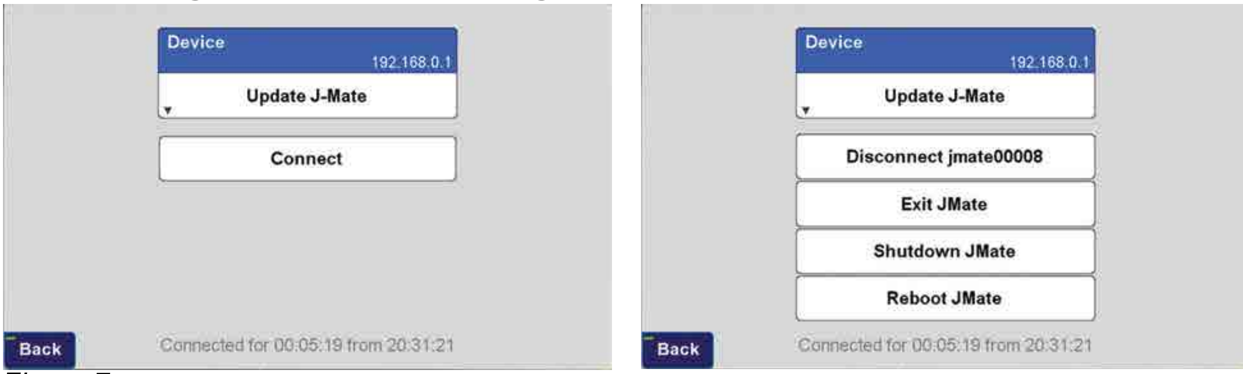


Figure 7

Holding the button **"13"** or **"15"** in Figure 1 which will take you to the set up screen and then to Figure 7 which lets you disconnect J-Mate, Reboot, or turn off. Like all Wi-Fi connections, you may lose connection and need to use this screen to disconnect, re-connect, or re-boot J-Mate and in some occasions reboot TRIUMPH-LS too, especially when connection between the camera of the J-Mate and TRIUMPH-LS is lost.

View range and angular measurements

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

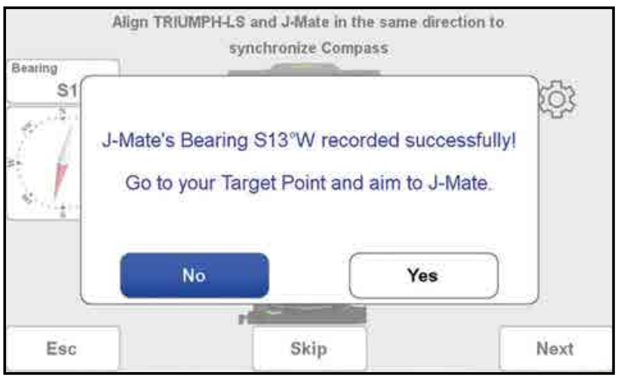
Automatic finding of the Target:

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

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

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

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



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

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

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

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

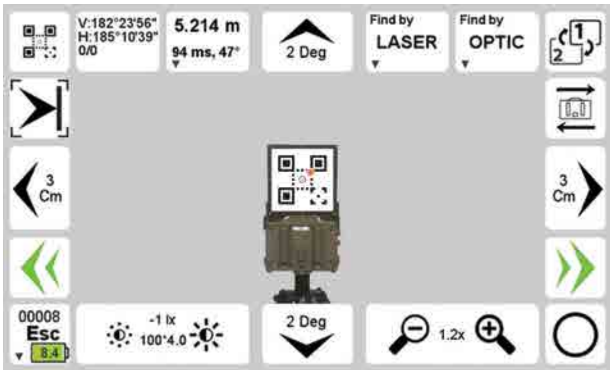
4. Click "Optic" if you want the J-Target panel to be scanned and centered automatically.

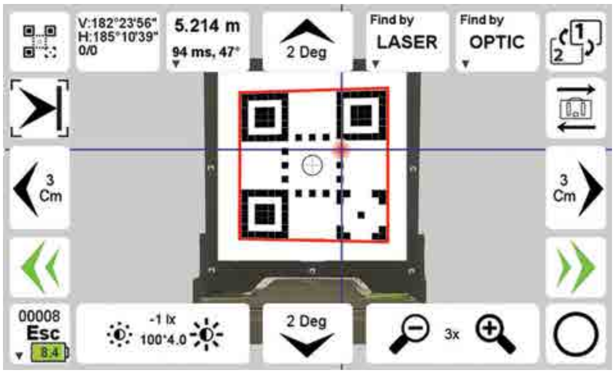
When J-Mate focuses on the center of the J-Target, you can click the "Take" button. You will be asked if you want to record the point.

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

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

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



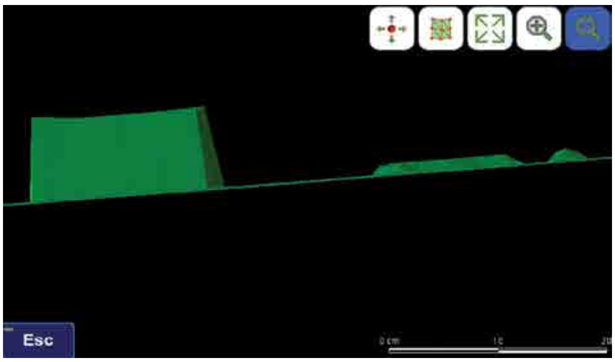


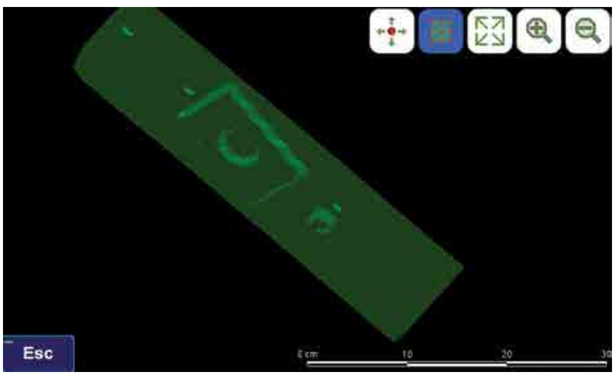
View scanned Images:

You see the 2 views of the 3D scanning

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

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





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

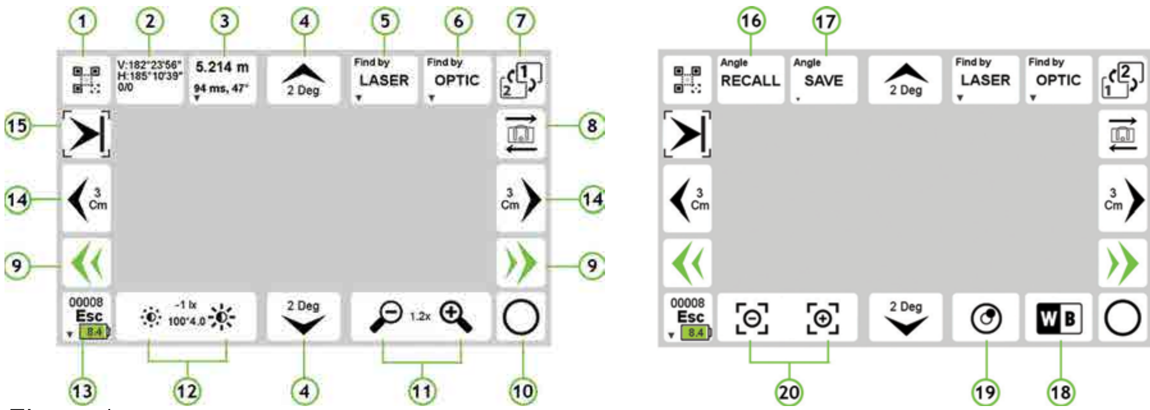


Figure 1

This is the **Main Navigation Screen.**

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

Aiming at Targets:

You can find targets manually or automatically.

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

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

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

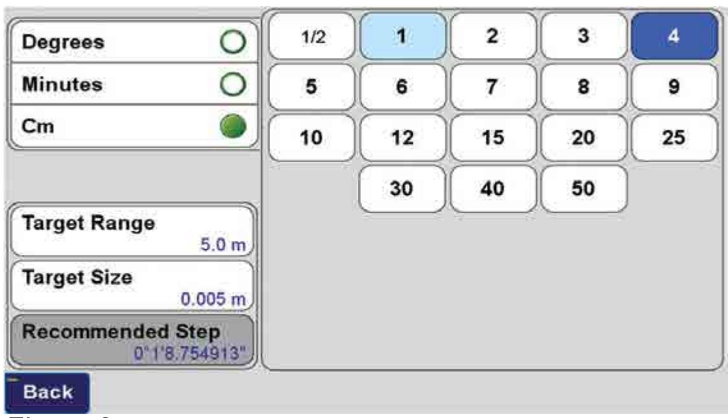


Figure 2

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

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

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

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

TRIUMPH-3

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

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

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

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

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

Ideal as a base station

Surveyors in geo-data management

The paper discusses several approaches to define the role of the surveyor within the modern geospatial society

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Mainz University of Applied Sciences
Mainz, Germany

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Bochum University of Applied Sciences
Bochum, Germany

Traditionally the surveying profession contributed to the good of society by creating and maintaining highly precise and accurate geospatial data bases, based on an in-depth knowledge of spatial reference frameworks. Furthermore in many countries surveyors may be entitled to make decisions about land divisions and boundaries. By managing information spatially surveyors today develop into the role of geo-data managers, the longer the more. Job assignments in this context include data entry management, data and process quality management, design of formal and informal systems, information management, consultancy, land management, all that in close cooperation with many different stakeholders. Future tasks will include the integration of geospatial information into e-government and e-commerce systems. The list of professional tasks underpins the capabilities of surveyors to contribute to a high quality geospatial data and information management. In that way modern surveyors support the needs of a geo-spatial society. The paper discusses several approaches to define the role of the surveyor within the modern geospatial society.

Introduction

Surveying is a profession with a long history. Since ancient times surveyors were involved in measuring and depicting the earth's surface with the natural, built and planned environments. Driven by the advances of technologies including computing, communications and geospatial data processing, the recent decades have shown increased demand and importance on accurate, timely and user-friendly geospatial information (Fosburgh, 2011, see also Seedat, 2014). As a result, the surveyor's role today includes communication with various stakeholders including engineers, architects, planners, local government, landowners, utility service providers and others. The surveyor's new function has transformed to that of geo-data manager, creating, verifying or modifying digital data sources and design models of various kind. Surveyors have to play an active part in GIS activities, such as creating, filling and maintaining a GIS, and using it as a tool to manage the natural and built environment as well as the cadastre. The surveyor's activities in GIS data collection are measurements, but also collection and management of attributes about the elements they geo-locate. Most likely technology will play an even greater role in the future. Field systems can be coupled with mobile phone and Internet access, cloud computing and web-based geodatabases. In that way information and techniques can be combined to an extent never before thought.

> The ability to plan with a GIS and to use it to understand ongoing processes is a huge opportunity for a geo-data manager

Traditionally, surveyors are well educated in terms of theory, mathematics, principles of redundancy and quality assurance. The opportunity for the surveyor to provide services that enable best practices in data collection and quality assurance is still present today. More than that, the deeper understanding of processes is even more important in times where the surveying equipment has become so user-friendly that the technology in most cases can be used by non-surveyors. The ability to plan with a GIS and to use it to understand ongoing processes is a huge opportunity for a geo-data manager. The surveyor of the future is able to extract new information and knowledge from existing datasets and to provide it to land managers. The society insists on speedier data collection and generation of useful information. Therefore, it becomes imperative to use analysis tools for managing, verifying and interpreting vast data volumes, data collection for populating and updating the GIS, quality assurance and data management and analysis. Communicating the information to the users will be another key challenge. Surveyors should be prepared to present information using a variety of media including static and dynamic visualizations. The surveyor of the future must demonstrate a broad set of multidisciplinary skills. He or she must have the skills to navigate various cultural and technical barriers as well as to communicate across different knowledge areas, disciplines and customary local processes.

The world today has evolved from data collection into geo-data management and information and knowledge extraction. Individual surveyors, and the societies they belong to, must collaborate with academia, government and industry to achieve common goals and benefits. Fosburgh, 2011 states that surveyors are the geo-data managers of the future--and that tomorrow's professionals are prepared for the challenge through education, training and professional development. In the following sections the positions of FIG, the International Federation of Surveyors and of DVW, German Society of Geodesy, Geoinformation and Land Management in this debate will be reported.

Fig definition of the functions of the surveyor

FIG is a federation of national associations and represents the surveying disciplines. Its aim is to ensure that the disciplines of surveying and all who practise them meet the needs of the markets and communities that they serve. It realises this by promoting the practice of the profession and encouraging the development of professional standards. In 2004, the FIG General Assembly adopted its own definition of the functions of the surveyor (FIG, 2004).

The official FIG definition

Executive summary

A surveyor is a professional person with the academic qualifications and technical expertise to conduct one, or more, of the following activities;

• to determine, measure and represent land, three-dimensional objects, point-fields and trajectories;

• to assemble and interpret land and geographically related information,

• to use that information for the planning and efficient administration of the land, the sea and any structures thereon; and,

• to conduct research into the above practices and to develop them.

Detailed functions

The surveyor's professional tasks may involve one or more of the following activities which may occur either on, above or below the surface of the land or the sea and may be carried out in association with other professionals.

1. The determination of the size and shape of the earth and the measurement of all data needed to define the size, position, shape and contour of any part of the earth and monitoring any change therein.

2. The positioning of objects in space and time as well as the positioning and monitoring of physical features, structures and engineering works on, above or below the surface of the earth.

3. The development, testing and calibration of sensors, instruments and systems for the above-mentioned purposes and for other surveying purposes.

4. The acquisition and use of spatial information from close range, aerial and satellite imagery and the automation of these processes.

5. The determination of the position of the boundaries of public or private land, including national and international boundaries, and the registration of those lands with the appropriate authorities.

6. The design, establishment and administration of geographic information systems (GIS) and the collection, storage, analysis, management, display and dissemination of data.

7. The analysis, interpretation and integration of spatial objects and

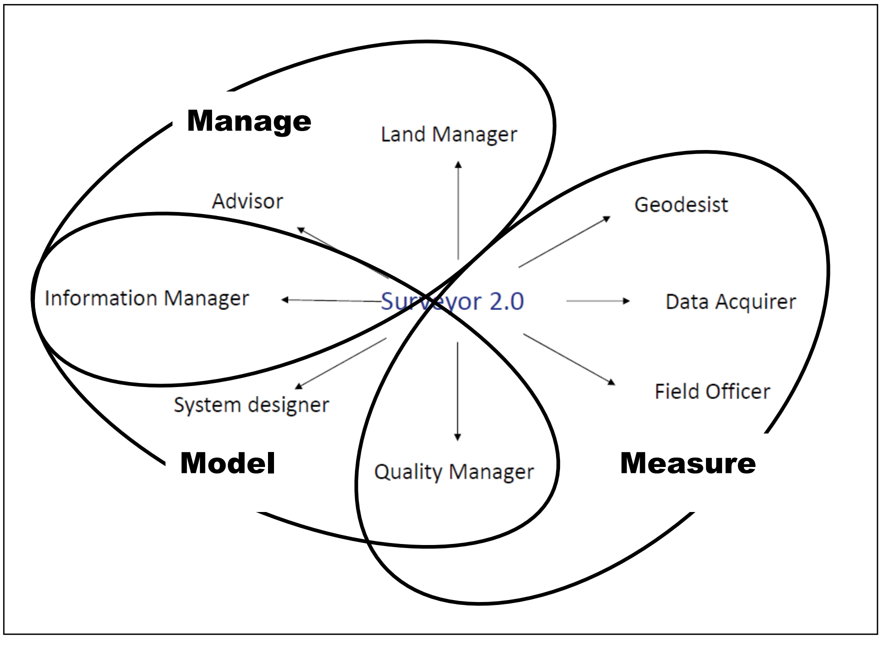

Figure 1. The Surveyor 2.0 Model, adapted from G. Schennach et al. (2012)

phenomena in GIS, including the visualisation and communication of such data in maps, models and mobile digital devices.

8. The study of the natural and social environment, the measurement of land and marine resources and the use of such data in the planning of development in urban, rural and regional areas.

9. The planning, development and redevelopment of property, whether urban or rural and whether land or buildings.

10. The assessment of value and the management of property, whether urban or rural and whether land or buildings.

11. The planning, measurement and management of construction works, including the estimation of costs.

In the application of the foregoing activities surveyors take into account the relevant legal, economic, environmental and social aspects affecting each project.

Recent developments in FIG

The definition reported in Section 2.1 reflects to a great extent the traditional professional field of surveyors. At the FIG Working Week in Rome, Italy, (May 6-10, 2012) FIG started to broaden its view towards a wider definition, described by the term 'Surveyor 2.0' (Schennach et al., 2012). Teo CheeHai, past president of FIG, has noticed that '*the role of the surveyor is evolving from a professional who used to be viewed as a "measurer" to a professional who measures, models, and manages'*.

ACSM, 2012 notes rapid technological changes are taking place in a challenging economic and political landscape. Online and mobile services, such as online maps and smartphone apps, are stimulating an increasing interest and use of geospatial information. Citizen- centric service delivery is crucial. In this interview the president argues, that surveyors *'will be required to embrace open standards; be inclusive, learn to incorporate volunteered information; ensure interoperability of systems, institutions and legislation; have a culture of collaboration and sharing to avoid duplication; develop enabling platforms in order to deliver knowledge derived from data of different scales and origins in the form of "actionable" information'*. In an ongoing discussion FIG now promotes the 'Surveyor 2.0 model' (Fig. 1).

Here, the surveyor is described in the triad Manage-Model-Measure. In addition to their traditional skills surveyors have the potential to perform high quality geospatial data and information management. Such a definition seems to largely overlap with the definition of a geo-data manager (see the following section).

The profile of a geo-data manager

Recently, in an ongoing process the Working Group 'Geoinformation and Geo-data Management' of the German DVW, Society for Geodesy, Geoinformation and Land Management worked on the definition of a geo-data manager's functions. In the following sections some results of the work will be reported.

The framework of geo-data management

Geo-data management is a cross-cutting task of Geodesy and Geoinformatics comprising three core areas of expertise (Fig. 2):

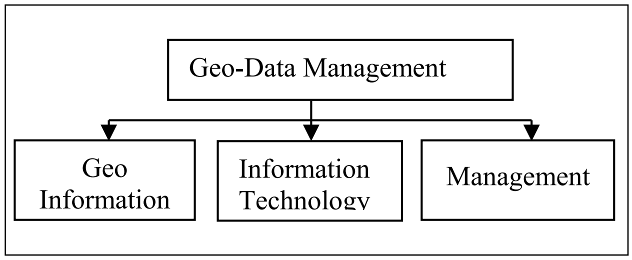

Figure 2. The triad of Geo-data Management, (Caffier et al, 2017)

1. *Geoinformation*; in particular application-specific recording, quality assurance, analysis and presentation of spatial objects based on the geodetic spatial reference of position, height and gravity (Geo skills),

2. *Information technology*; in particular technology of data and systems, design and implementation of technical solutions, development of service-oriented architectures and systems, modeling, coding and automation of data exploration, by methods of information and communication technology (IT skills)

3. *Management*; in particular strategic development, structuring, coordination and control of processes, by communication with all involved parties (management skills)

The individual profile of a geo-data manager

Depending on the individual field of work a geo-data manager may face a considerable range of required skills in the three core areas of expertise Geoinformation, Information technology, Management. The full requirements profile of a geo-data manager comprises the following components

Professional skills

The following section describes the full list of currently identified professional skills of a geo-data manager.

1. *Establishment of a framework for the comprehensive use of geospatial data.* The geo-data manager coordinates development and operation of spatial data infrastructures to provide spatial data from different sources by interoperable spatial data services. He or she moderates the interests of providers and users and develops the legal, professional, technical and organizational framework for the comprehensive use of spatial data. He or she develops application-driven specifications for data provision via standard based services. He or she monitors compliance with the specifications to ensure the multidisciplinary usability of spatial data (interoperability).

> Traditionally, surveyors are well educated in terms of theory, mathematics, principles of redundancy and quality assurance. The opportunity for the surveyor to provide services that enable best practices in data collection and quality assurance is still present today. More than that, the deeper understanding of processes is even more important in times where the surveying equipment has become so user-friendly that the technology in most cases can be used by non-surveyors

2 Identification of spatial data needs, as-is analysis and data collection. The geo-data Manager identifies and analyzes the user requirements (internal vs. external users) in the context of specific applications. He or she gets an overview of available data (inventory analysis of in-house offers against third party offers) and evaluates the potential benefit of spatial data sets for specific application areas, in cooperation with experts from other disciplines. He or she procures appropriate spatial data obtained by third parties and clarifies access, usage and pricing conditions.

3 Data processing, administration, management and updating. The geo-data Manager collects existing data, transforms them into consistent data formats and data bases, integrates them geometrically and semantically into a Geographic Information System (GIS), prepares them to meet individual professional requirements, updates and maintains them. He or she accomplishes these tasks within an established framework and provides the necessary transformation rules, exchange formats and meta data.

4 Application-specific exploration of spatial data, process integration and information management. By analyzing and redesigning processes and by developing an adapted role model the geo-data manager supports the integration of data products into an existing environment of administrative and business processes. To generate new information he or she designs and implements automated analysis of combinations of spatial data from different sources (exploration of Big Geo-Data). He or she prepares the results clearly. He or she is involved in collaboration processes with other disciplines to interpret spatial data appropriately. He or she ensures that the necessary information is generated in a user-centric form.

5 Design of new data products. On the basis of needs assessment and inventory analysis the geo-data manager designs new data products for specific applications while also taking into account future demands of stakeholders. To achieve that, he or she creates conceptual application schemes in communication with other specialists and IT experts data. Following his or her professional expertise the coding for the data transfer in appropriate data formats will be performed (external schema). He or she provides support for the implementation of the data management policy.

6 Development of production methods. The geo-data manager identifies appropriate methods for the geodetic collection of the product data (initial recording vs. updating, such as terrestrial surveying, remote sensing, crowdsourcing, mobile mapping) and adapts them to the technical requirements. He or she coordinates the interaction of different partners to create novel data products. He or she develops quality assurance procedures to guarantee for the long-term professional and technical product quality which meets the user requirements.

7 Definition of the general data production environment, particularly for marketing and sales activities. The geo-data manager determines the framework for spatial data marketing and sales. He or she determines product names and product specifications, takes into consideration any access restrictions (copyright, security, privacy) and other obligations determined by legal regulations. He or she defines the usage and payment terms, targeted markets, distribution channels, product availability, performance and provided capacity of the data production process. He or she creates the documentation of product specification, for in house use and for publication in metadata catalogs provided within spatial data infrastructures.

8 Implementation and operation of an IT infrastructure to manage spatial data (GeoIT infrastructure). The geo-data manager identifies data volumes, access rights, facades and role models for the use of spatial data in an organization.

Following the trends of the mainstream IT he or she designs a standards based architecture of an appropriate GeoIT infrastructure. The design of such architecture includes the system design of network, servers, database management system, application technology, referring to modern IT concepts (SOA, ROA, etc.) including operation and safety concepts (ITSM). He or she makes decisions on the necessary components of the GeoIT infrastructure, such as GIS, software / hardware and other technical core components (geo portals, geo catalogues, etc.).

9 Design and development of services and applications. Following the identified and adopted user requirements the geo-data manager develops spatial data processing services to facilitate the implementation of user-specific applications (desktop, web, mobile) such as specialized geographic information systems vs. mainstream e-government applications and other procedures.

10 Quality management and quality control. The geo-data manager designs and implements the user oriented framework for quality assurance of the spatial data and of the derived products. He installs mechanisms to monitor the entire process chain in order to ensure the spatial data product quality.

11 Basic, advanced and further training. The geo-data manager provides basic, advanced and further user training.

Methodological and social skills

The following section describes the most important identified methodological and social skills of a geo-data manager.

1 Project management. The geo-data manager is involved in award procedures, support, monitoring, controlling, resource management (human, technical, financial), process documentation, reporting, profitability analysis, decision management, and operational management of spatial data projects and products.

2 Coordination. The geo-data manager coordinates and controls all spatial data related processes in cooperation with all stakeholders. He or she is the link between the technical and administrative management levels. He or she moderates and supports the cooperation of different stakeholders and ensures transparency in the project consortium (information sharing).

3 Moderation. The geo-data manager moderates complex processes in a highly interdisciplinary context. Fast-moving developments in the digital world continuously generate processes of change. Different understanding of the same topics across different professional disciplines has to be considered. Reservations with regard to Geo-IT infrastructures are still present. In this environment the geo-data manager has to be a conflict manager who has pronounced negotiation skills.

Conclusions

In the previous sections it was shown in which ways today's surveyors can take action for the benefit of a modern geospatial society. Job assignments in this context include technical tasks such as data entry management of highly heterogeneous spatial data created by classical surveying activities, mobile mapping, aerial and satellite imagery, crowdsourcing activities, and others; information management, consisting of data integration and transformation, of data integration from different sources, general IT, web technologies; quality management, including responsibility for the accuracy of attributes and relationships of data, for accuracy assessment, for completeness and reliability of data, for certification; system design of formal and informal systems for security of land tenure, for creation and maintenance of code lists, for spatial data infrastructures, for 2D and 3D data management, workflows, business processes. In such a highly interdisciplinary working environment non-technical skills are required for interpersonal communication, including responsibility for participation management, handling of appeal procedures, and conflict resolution. Consultancy for urban and rural development, reorganization, real estate issues, spatial planning may be further components of the professional work. Future tasks include the integration of geospatial information into e-government and e-commerce systems. Surveyors have the potential to perform high quality geospatial data and information management. If the surveying profession takes the plunge into the new fields the gap between surveyors and the geospatial society can be closed.

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Automatic detection of dead tree from UAV imagery

In this study, we propose a combination of RF and vegetation index for automatic detection of a dead tree under limited RGB sensor condition

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Recently, a number of conifers dying due to climate change are being found in high altitude areas of Korean national parks. The existing tree investigation method has been judged by the human visual interpretation. However, with Unmanned aerial vehicle (UAV) it is not only possible to measure large areas immediately but also to construct and analyze this as spatial information. In this study, we propose a method to detect the location of wilted or dead trees in UAV orthophoto. A natural monument called Yew Trees at Sobaeksan, located in the highlands of Sobaeksan national park was selected as an experimental area and an orthophoto image of a 2cm resolution was produced by UAV digital photogrammetry. Image segmentation and image classification were performed sequentially through object-based image analysis (OBIA): The orthophoto image was split by a large-scale mean-shift (LSMS) segmentation method, and a random forest algorithm was applied for classification. Each segment was identified as a dead tree, a living tree, a shadow and a bare area. As the UAV used in this study only contained an RGB sensor, the vegetation index was used as an additional feature to improve the accuracy of the dead tree detection. The normalized green-red difference index (NGRDI) applicable to the RGB sensor was chosen. All data processing was done using Free and Open Source Software for Geospatial (FOSS4G) including OpenDroneMap, OrfeoToolBox, and QGIS. Experimental results showed that the dead tree could automatically be detected from UAV imagery with a confidence level of more than 80%. We also confirmed that the limit of RGB sensor data could be complemented with the combination of random forest and vegetation index.

Introduction

Dying trees caused by climate change

In recent years, conifers have been found dying in high altitudes of national parks. As temperature increases due to climate change, conifer species favoring high altitude and colder climates are adversely affected by temperature stress (Chung et al., 2015). Recently, these symptoms began to be found in Sobaeksan National Park located in the central part and also gradually spreading in the southern part.

Survey of vegetation using UAV

Unmanned aerial vehicles (UAVs) collect successive images at low altitude at desired times. These original images can be reconstructed into ultra-high resolution spatial information (orthophoto, point cloud, DSM, textured DSM, etc.) through digital photogrammetry. The UAV has advantages over conventional satellites and aircrafts because it is quite easy to control in time and space. For ultra-high resolution images such as UAV, previous studies have showed that object-based classification can provide higher accuracy than pixel-based classification (Moon et al., 2017).

Recently, UAV has been applied in a vegetation survey. Kim et al. (2017) produced a 12 cm-resolution UAV orthophoto to detect Pine Wood Nematode damage and identified pest-infested trees. Park and Park (2015) created a crops classification map through object-based image analysis (OBIA). However, the application of UAV to the dying conifers of the highland, which is presumed to be due to the climate change, has been focused on simple aerial photography.

Purpose of this study

The purpose of this research is to propose a method to automatically detect dead or dying trees in a survey area through UAV utilization. The study also demonstrates that it is possible to conduct the vegetation investigation smoothly despite using a low-cost drone by combining the vegetation index at the OBIA stage.

Method

Experimental area

The Yew trees community located in Sobaeksan National Park was selected as the study area. This area is designated as a National Monument and is the largest Korean Yew trees habitat. It is located at a high altitude of 1,400m or more. Figure 1 shows a sub-divided land cover map produced by the Ministry of Environment on the study area.

In 2013, an overall survey of 2,046 trees in the Natural Monument boundary was conducted over approximately six months. According to the report, the average height of trees is about 7 meters, and the age of trees is estimated to be around 200 to 500 years. Old trees have shown more vulnerability towards the factors associated with climate change.

In recent years, there have been a growing number of trees either dead or dying due to recent heat waves, droughts, and high altitude winds, and their symptoms have been observed visually in the field (Figure 2). To better understand these changes in trees, Sobaeksan National Park Northern Office took its first shot with a drone on June 29, 2018.

UAV digital photogrammetry

The photographs collected at the site were processed through OpenDroneMap (Benjamin et al., 2018), a type of free and open source software for geospatial (FOSS4G). OpenDroneMap is an open source toolkit for drone image processing. It supports creating spatial information such as point cloud, mesh, textured mesh, and orthophoto from unmanned photographs. Through this process, a 2cm resolution UAV orthophoto of the study area was generated.

Object-based image analysis (OBIA)

Image segmentation and image classification were performed sequentially through OBIA (Kelly et al., 2011). The UAV orthophoto was segmented into single objects using large-scale mean-shift (LSMS) segmentation techniques (Michel et al., 2015). The segmentation sometimes can encounter problems due to memory limitations especially when dealing with a large size of spatial data. In this study, the LSMS handles stable segmentation by dividing the whole image into tile-wise units. As attribute values, the processed single objects have the mean and standard deviation values for the pixel values of the red, green, and blue bands.

The random forest (RF) algorithm was applied to image classification. This method has recently been used in the field of vegetation mapping based-on UAV remote sensing (Feng et al., 2015). RF is a kind of ensemble technique that is composed of a number of independent classifiers. For example, if there are five misclassifications out of the 100 classifiers, the classifier can be numerically defined to have 95% confidence. In this experiment, each object, a segment, was identified

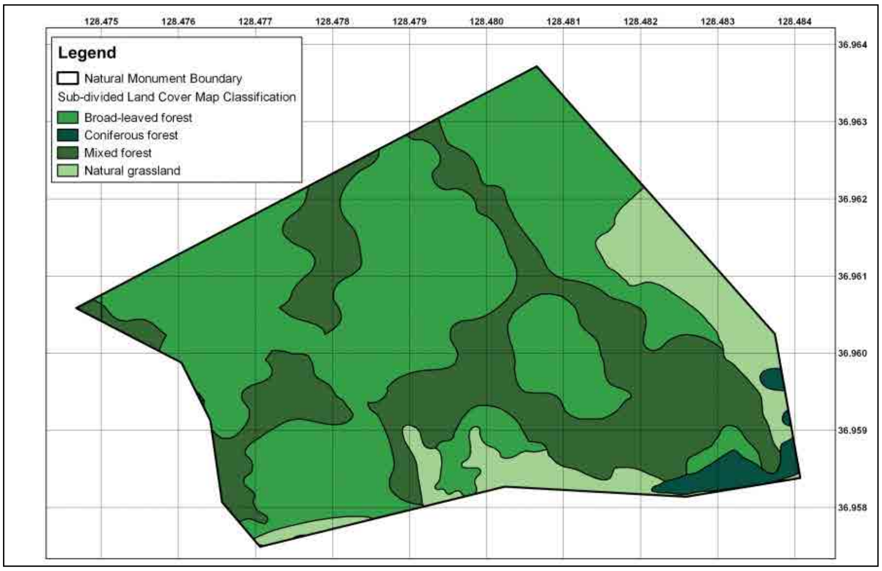

Figure 1. Yew Trees at Sobaeksan, designated as a natural monument and within a national park

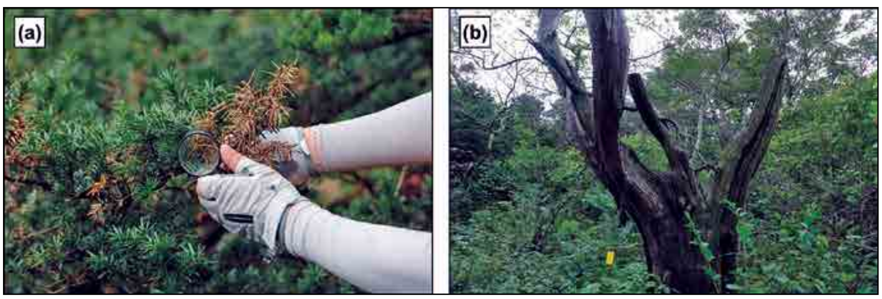

Figure 2. Field research pictures. (a) Leaves of Yew tree turned brown (b) A look of a dead Yew tree

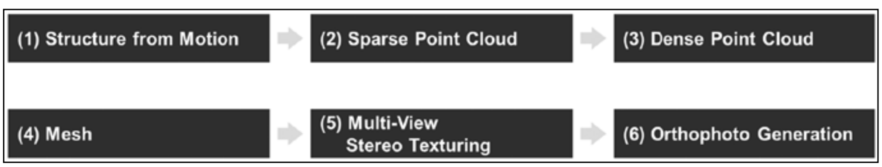

Figure 3. Data processing procedure of OpenDroneMap

as a dead tree, a living tree, a shadow, and a bare area, and the vegetation index was also calculated to add more factors in the training phase of the classifier.

Normalized green-red difference index (NGRDI)

Vegetation index can quantitatively measure the vegetation condition and can be used as an advantageous factor to improve the accuracy of dead tree detection. Such an index is defined using the wavelength-specific reflectance of chlorophyll contained in the vegetation. The reflectance of healthy vegetation is usually higher at near-infrared wavelengths and significantly lower at red wavelengths. Vegetation indices mainly use near-infrared wavelength band, but UAV used in this study is equipped with an only RGB camera as DJI Phantom 4 model. Therefore, we calculated the normalized green-red difference index (NGRDI) applicable to RGB sensors. The equation is as follows:

$$\text{NGRDI} = \frac{(G - R)}{(G + R)}$$

In the UAV orthophoto, G and R are the radiometric normalized pixel values of the green and red bands, respectively. In a recent study (Zheng et al., 2018), the NGRGI has proven its advantageous performance in estimating the vegetation portion in the UAV orthophoto. The vegetation index using the visible wavelength bands has mainly been preferred to diagnose the condition of the crops in the agricultural field, but it is also applicable to assess the tree health (Meyer et al., 2008). The NGRDI calculation result was added as an attribute value (average, standard deviation) to each object of the image segmentation polygon and used as an additional factor for image classification.

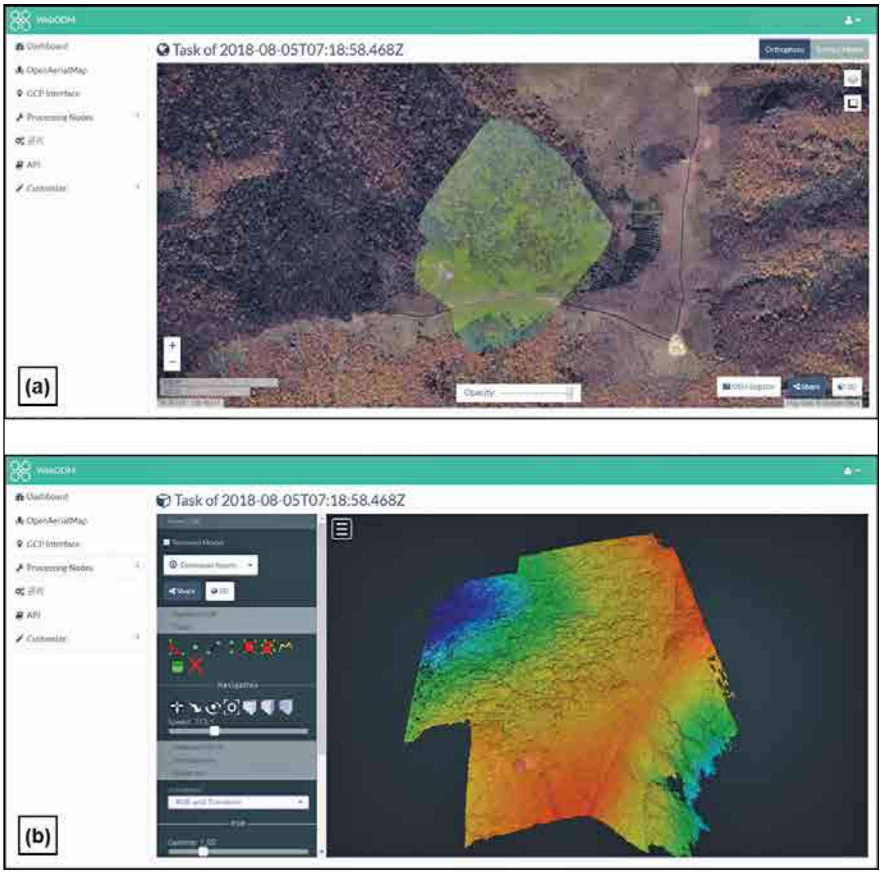

Figure 4. Results of OpenDroneMap Data processing. (a) Orthophoto, (b) Point cloud

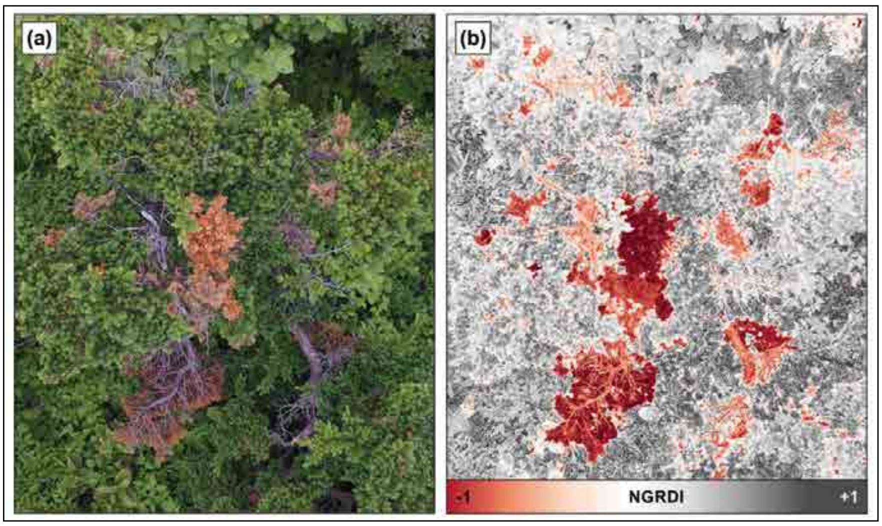

Figure 5. Results of vegetation index application in a single UAV image.
(a) is a single UAV photograph, and (b) is a normalized green-red difference index (NGRDI)

Results and discussion

The total area of the study site is 330,000 square meters and the UAV photography was conducted in some areas where dead or dying trees were mainly observed. Figure 4 shows an orthophoto and a point cloud created by OpenDroneMap. In this experiment, we used WebODM software that processes UAV imagery based on OpenDroneMap.

The results of applying NGRDI to UAV imagery are shown in Figure 5. The broken tree was caused by strong winds and the browning is ongoing. We could confirm that NGRDI vegetation index quantitatively detect the dead trees and the color-changed trees.

Ultra-high resolution UAV orthophoto could easily distinguish between a dead tree and living tree with visual inspection. It was compared with the case where the individual trees are not identified in the

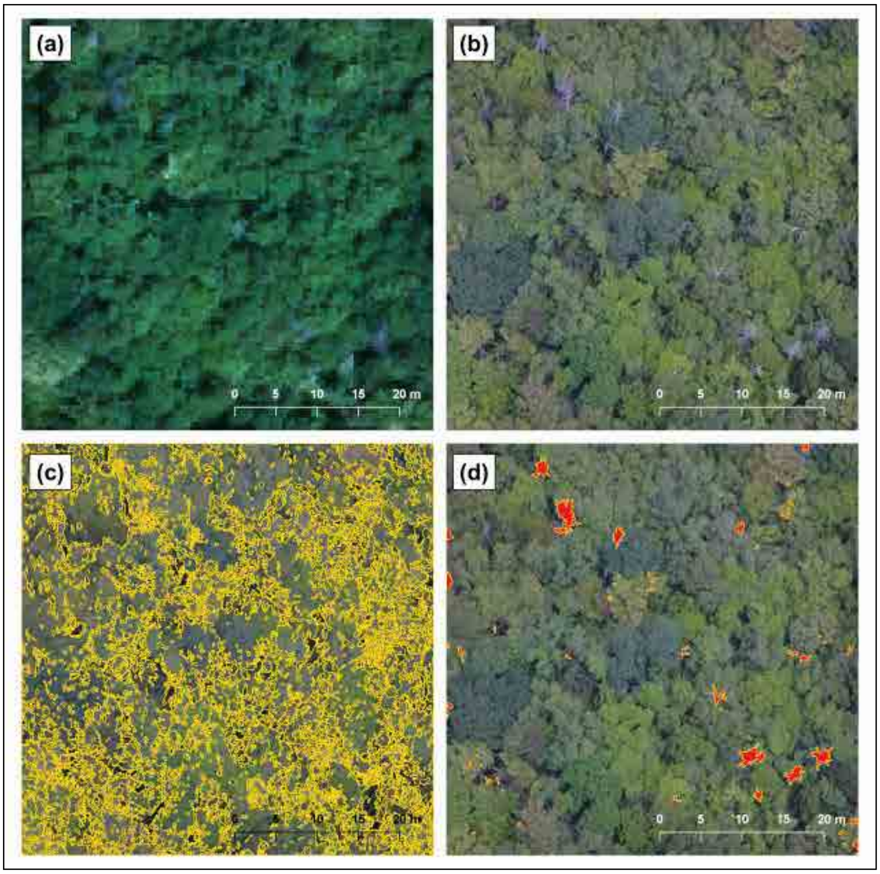

Figure 6. Dead tree object detection results
(a) 51cm resolution aerial orthophoto (b) 2cm resolution UAV orthophoto
(c) Polygons with LSMS segmentation applied, (d) Detected dead tree objects

conventional aerial photo (Figure 6 (a), (b)). OBIA was implemented through the open source remote sensing library Orfeo ToolBox (Grizonnet et al., 2017) and QGIS (QGIS Development Team, 2018). Applying LSMS segmentation and RF classification, we could automatically detect thirteen damaged trees in 2,500 square meters (Fig. 6 (c), (d)). In this experiment, NGRDI, a kind of vegetation index, was used as input data in the RF classification. It was confirmed that NGRDI contributes to the reliability of dead tree detection. The dead tree could be automatically detected from UAV imagery with a confidence level of more than 80%. Related to this, accuracy assessment will be done after additional UAV survey of the study site.

Conclusion

In this study, we proposed a combination of RF and vegetation index for automatic detection of a dead tree under limited RGB sensor condition. The UAV tree survey has an advantage of observing a large area at one time compared with the visual field survey. The proposed method in this study can accurately grasp the position of a dead tree and so it is expected that will be applicable in related studies.

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Major government project in Africa bagged by Teledyne CARIS

Teledyne CARIS will be delivering a full software solution, through its distributor Unique Group to the South African Navy Hydrographic Office. The solution, includes software that will be implemented as part of a larger project to be executed by Southern African Shipyards (SAS) where a new hydrographic survey vessel is being built. Three additional survey motor boats are also slated for manufacture, all of which will be equipped with HIPS and SIPS™ to process acquired hydrographic data. *www.teledyne.com*

Locate government establishments easily in Kerala, India

The state government of Kerala in India is set to conduct GIS mapping of all government establishments, including schools and hospitals, across the state. As part of this, it has directed government offices across the state to upload their details, including their locations, on the map online.

A senior officer with the Electronics and IT Department said GIS was being implemented as a prefix to introducing the Kerala Fiber Optic Network (K-FON) programme which aims at providing high-speed Internet connectivity to all government establishments in the state. The GIS map will be created using the information submitted on this website. As government has undertaken the drive to provide all services on e-platform *www.newindianexpress.com*

DARPA seeks tools to capture underground worlds in 3D

DARPA is seeking information on state-of-the-art technologies and methodologies for advanced mapping and surveying in support of the agency's Subterranean (SubT) Challenge. Georeferenced data – geographic coordinates tied to a map or image – could significantly improve the speed and accuracy of warfighters in time-sensitive active combat operations and disaster-related missions in the subterranean domain. Through the Request for Information, DARPA is looking for innovative technologies to collect highly accurate and reproducible ground-truth data for subterranean environments, which would potentially disrupt and positively leverage the subterranean domain without prohibitive cost and with less risk to human lives. These innovative technologies will allow for exploring and exploiting these dark and dirty environments that are too dangerous to deploy humans. *www.fbo.gov*

Esri launches R&D Center in New Delhi, India

Esri has announced the opening of its latest research and development center, located in New Delhi, India. The new location will focus on data science, deep learning, and geospatial artificial intelligence (GeoAI) solutions, revolutionizing spatial analytics to overcome some of the world's biggest challenges. The center will play a significant role in developing the next generation of Esri's ArcGIS Enterprise based on a microservices architecture.

NavVis Cloud

NavVis has launched NavVis Cloud, a new cloud-based platform that gives laser scanning professionals access to NavVis IndoorViewer as a Software-as-a-Service (SaaS) solution. Fully immersive, web-based 3D buildings can now be delivered as part of every scan project using point cloud files from terrestrial laser scanners and the NavVis M6 Indoor Mobile Mapping system (IMMS). The intuitive user interface and functionality lets every project stakeholder access, interpret and interact with scan data. *www.navvis.com/cloud*

TrueLook, Autodesk BIM 360 Integration

TrueLook has announced the second phase of its integration with Autodesk BIM 360, the industry's leading project delivery and construction management software.

It allows construction camera users to conveniently livestream videos on the home dashboard of the leading construction management platform. *www.truelook.com*

Malaysian State to launch blockchain solution to track agricultural products

The Malaysian state of Penang is considering the use of blockchain technology in food and agricultural products supply chains.

According to the country's Deputy Minister of Agriculture and Agro-based Industries, Sim Tze Tzin, cited by the newspaper, the technology can be used for various applications in the industry. For instance, consumers would be able to track the origins of a particular product they purchase by scanning codes. Additionally, the industry can quickly warn consumers about the outbreaks of dangerous foodborne diseases. Key advantage of using blockchain is that the data stored on a decentralized network cannot be altered. Moreover, Sim believes that blockchain helps to improve security, reduce operational costs and bypass middlemen. *https://cointelegraph.com*

Survey of India signs MoU with Haryana, India

Memorandum of Understanding has been signed between Department of Revenue & Disaster Management, Govt. of Haryana & Survey of India, and Govt. of India for large scale mapping using UAV (Unmanned Aerial Vehicles) / Drone for Revenue, Urban and Rural area including ground control network and delivery of geo-referenced cadastral revenue maps for state of Haryana. The Project shall cover approx. 44,000 sq. Km, covering entire state of Haryana.

The delivery of complete project is around 18 months. A digitized, geo-referenced, accurate and up-to-date map of each land Parcel and each property in Urban areas and village Lal dora (Abadi deh) will get generated.

Accurate Change detection, using high resolution imagery will help in identification of true urban growth development process. The unplanned settlements and areas where housing is not in compliance with current planning and building regulations will be identified to help enforcement and effective action before the construction attains huge proportions.

Successful anti-satellite missile test puts India in elite club

The Prime Minister of India announced that India successfully conducted an Anti-Satellite (ASAT) missile test, named Mission Shakti, becoming the fourth country in the world to demonstrate the capability to shoot down satellites in orbit. So far, only the United States, Russia and China have this prowess The satellite downed by the ASAT missile was Microsat-R, an imaging satellite which was launched into orbit on January 24, 2019 using a Polar Satellite Launch Vehicle (PSLV), a senior Defence Research and Development Organisation (DRDO) official said.

India has built the broad capabilities and building blocks to develop ASAT missiles for some time as part of its Ballistic Missile Defence (BMD) programme. *www.thehindu.com*

Mitigating the loss of satellite data by using CubeSat

Mitigating the loss of satellite data by using CubeSat remote sensing technology

Advanced infrared and microwave sounding systems, usually onboard traditional polar-orbiting satellites, provide atmospheric sounding information critical for nowcasting and weather forecasting through data assimilation in numerical weather prediction models. This means weather forecasts have become increasingly dependent on satellite observations. But what if we lose one or more of these instruments? How do we mitigate the data gap?

Dr. Jun Li, a distinguished scientist at the Cooperative Institute of Meteorological Satellite Studies, University of Wisconsin—Madison, led a study to answer these questions. The findings were recently published in Atmospheric and Oceanic Science Letters.

Li and his team used a so-called ‘observing system simulation experiment’ to study the potential of two types of remote sensing technologies using CubeSats—the Micro-sized Microwave Atmospheric Satellite-2 (MicroMAS-2) and the CubeSat Infrared Atmospheric Sounder (CIRAS), with costs measured in millions of US dollars, far fewer than those needed to replace a traditional satellite—to mitigate the data gap (should one occur) of the Advanced Technology Microwave Sounder (ATMS) and the Cross-track Infrared Sounder (CrIS), onboard the Suomi NPP and the Joint Polar Satellite System satellites. The results showed that a single CubeSat was able to provide added value in terms of the forecasting of local severe storms, and more CubeSats with increased data coverage yielded larger additional positive impacts, indicating that CubeSats may be used to mitigate data gaps left by the loss of traditional weather satellites. *https://phys.org*

Two Chinese EO satellites launched into space

China officially put two Earth observation satellites into operation on 21st March 2019, after testing. According to a report in Xinhua, the Chinese said, “the satellites will assist in a wide range of public services including environmental protection, air-pollution mitigation, agricultural and forestry surveys and disaster relief”.

The Gaofen 5 and 6high—definition satellites are the latest additions to China’s Earth observation satellite network. *www.spacedaily.com*

Gatwick Airport plans for the future using aerial photography

Gatwick Airport, the busiest single-runway airport in the world, is using aerial photography from Bluesky to plan long term development and growth. The high resolution, map accurate imagery will feature highly in the Airport’s soon to be published Master Plan. The Plan, which explores options including the increased capacity for its existing runway, additional use of a standby runway and safeguarding for a new runway, outlines how the Airport will meet an increasing demand for air travel, create new opportunities for the region and manage its environmental impact. *www.bluesky-world.com*

UK makes major breakthrough in atomic clocks

Researchers from the Emergent Photonics Lab (EPic Lab) at the University of Sussex have made a breakthrough in developing atomic clocks, which could mean accessing a satellite signal would be unnecessary. Dr Alessia Pasquazi from the EPic Lab explained the breakthrough:

“With a portable atomic clock, an ambulance, for example, will be able to still access their mapping whilst in a tunnel, and a commuter will be able to plan their route whilst on the underground or without mobile phone signal in the countryside. Portable atomic clocks would work on an extremely accurate form of geo-mapping, enabling access to your location and planned route without the need for satellite signal."

“Our breakthrough improves the efficiency of the part of the clock responsible for counting by 80%,” Dr Pasquazi added, saying it was a step forward “to seeing portable atomic clocks replacing satellite mapping, like GPS”. Unfortunately, this won’t happen by the time the UK is cut off from accessing Galileo by the time the country leaves the EU - with Dr Pasquazi estimating that it could happen “within 20 years”. *https://news.sky.com*

Russia regularly spoofs regional GPS?

A large-scale analysis of global positioning data has discovered widespread Russian spoofing over the past three years of the global navigation satellite system (GNSS) used by ships and autonomous vehicle systems to find their positions and safely chart courses, according to a new report - published by the Center for Advanced Defense (C4ADS), a nonprofit intelligence firm focused on worldwide security issues — found that at least 9,883 instances of spoofing occurred.

The findings underscore the dangers of relying on global positioning data, such as that provided by the global positioning system and similar technology across the globe, because the service can be disrupted or co-opted to deliver false data.

The attacks highlight the vulnerability of satellite navigation systems and the fact that their disruption is far more widespread than originally thought. For at least a decade, a smattering of media reports covered the problems of ships near Russia having navigational difficulties. *www.darkreading.com*

Russia plans to launch Glonass-M satellite in mid-May

Russia plans to launch a Glonass-M navigation satellite into orbit in mid-May. "The launch of a Glonass-M navigation satellite has been tentatively planned in mid-May from the Plesetsk Cosmodrome for maintaining the performance of the orbital constellation," Sputnik news agency quoted a source in the aerospace industry as saying. Currently, the Glonass constellation includes 26 satellites with 22 of them performing their intended navigation functions. *www.therahnuma.com*

Orbital constellation of Russian GLONASS restored

All 24 GLONASS satellites that the orbital constellation of the Russian satellite navigation system needs to ensure global coverage are once again operational as two satellites, which were removed for technical maintenance, have been put back into service, the Information and Analysis Center for Positioning, Navigation and Timing of the Russian Central Research Institute for Machine Building (TsNIIMash) said. *www.urdupoint.com*

Scisys praises decision to become Irish

Scisys Group, a formerly British company involved in the European Union's Galileo satellite program, says its change of headquarters from Chippenham, England, to Dublin, Ireland, was immediately positive for its space business.

Scisys is a subcontractor to Thales Alenia Space France and Spain's GMV on the ground segment of the Galileo navigation satellite system. The United Kingdom's ongoing exit from the European Union jeopardized Scisys' business related to Galileo and other European Union programs such as the Copernicus environmental monitoring satellites.

In an annual financial report issued March 28, Scisys said re-domiciling the company in Ireland in November preserved its role in Galileo and kept the company financially healthy. *https://spacenews.com*

EU to remove major security system Galileo from British shores

The European Commission announced that it will withdraw two stations from the Galileo in the British Falklands and Ascension Isles.

The critical infrastructure operated by the European Global Navigation Satellite Systems Agency (GSA) deals with security threats, cryptographic material and EU classified information.

Brussels says the system cannot be located in a "third country" which the UK will become following its withdrawal from the European Union. In a statement, the Commission added the decision is part of the "necessary steps" to ensure business continuity and to preserve Galileo's security following Brexit. *www.express.co.uk*

Galileo Service Centre operations transferred to Spaceopal

Responsibility for in-depth troubleshooting and problem resolution of the GSC Ground Infrastructure has been transferred from a European GNSS Agency (GSA)-held European GNSS Service Centre (GSC) infrastructure contract to Spaceopal and its core team member DLR GfR, responsible in the Galileo Service Operator (GSOp) industrial organization also for L2/L3 maintenance activity.

Europe and India coming together @ Galileo Hackathon

On 16 and 17 March 2019, over 80 programmers from universities and enterprises all over India gathered in 20 teams to join the Galileo Hackathon by GNSS.asia at PES University, Bangalore. Teams worked throughout the night to use Galileo, the European global satellite-based navigation system, for an application to support smart cities, smart mobility, health or vulnerable citizens. The top-three participants walked home with cash prizes of respectively 160k, 80k and 40k Indian Rupees:

- NavPro (PES University) – Rail Unfail
  GNSS-based maintenance system that geotags potential fault locations on railway tracks
- Phoenix (Vignan Institute of Information and Technology) – Farm Along
  Online market place bridging farmers and buyers with secure tracking and supply chain
- Hex-GNSS (Hexagon/Novatel) – Perk for Park
  App which will identify the imbalance in parking supply & demand to offer lending and availing of public and private parking lots in big cities

Throughout their challenge, participants received mentorship by experts from the private sector (Volvo Trucks, Citrix, IBM, Magnasoft), the Indian Space Research Organisation (ISRO), the European GNSS Agency (GSA), PES University and Burdwan University.

Their solution will be evaluated by a jury consisting of the above organisations and accomplished entrepreneurs. *www.gnss.asia*

This contract extends for 10 years.

The transfer occurred after Spaceopal successfully passed the Maintenance Handover Review (MHOR) for the Level 2 and 3 Maintenance of the GSC in Torrejón de Ardoz, outside Madrid, Spain.

Spaceopal is a joint venture between DLR Gesellschaft für Raumfahrtanwendungen (GfR) mbH, a full subsidiary of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), and the Italian firm Telespazio S.p.A. Both parties contribute their respective Galileo Control Centers in Oberpfaffenhofen and Fucino. *https://spaceopal.com*

Israel Aerospace Industries releases anti-jammer for ground GNSS systems

Israel Aerospace Industries (IAI) has unveiled ADA-O, a new version of its ADA system that prevents GNSS signals from being jammed. ADA-O is designed for armored vehicles and other larger land and sea platforms. According to the company, it can be integrated with ease to protect navigation, telecommunications, command-and-control and other systems.

The land platform can be readily integrated in a range of platforms, providing a unique operational response to helps telecom, navigation and C&C systems, the company added.

Creating GNSS around Moon

Russian and US scientists are in talks on the creation of a global navigation system around the Moon similar to GLONASS and GPS, Vice President of the Russian Academy of Science (RAS) Yury Balega told TASS after the visit of the RAS delegation to the NASA headquarters.

“In the framework of studying the Earth’s natural satellite, US colleagues suggested developing a joint navigation system around the Moon, similar to GPS or GLONASS, so that all participants in Moon exploration projects can use it,” Balega said. The RAS delegation led by RAS President Alexander Sergeyev is currently in the United States on a working visit. On March 12 RAS signed an agreement with the US National Academy of Sciences on cooperation in the sphere of scientific, engineering and medical research.

“During our visit to NASA, we have discussed the programs for exploring the Moon and Venus. American partners said that they consider the Venus program predominantly Russian-led and think that Russia’s contribution to it should thus stand at 70-80%.

We talked about different options of exploring Venus’s atmosphere, including launching a flying apparatus - a drone - into the high layers of Venus’s atmosphere, in order to study its chemical composition,” Balega said. *http://tass.com*

senseFly eBee X with MicaSense RedEdge-MX,

SenseFly and MicaSense, producer of drone sensors for agriculture, have announced a new dual solution - the senseFly eBee X with MicaSense RedEdge-MX.

The RedEdge-MX is a rugged, built-to-last professional multispectral sensor. Capturing red, green, blue, near-infrared, and red-edge spectral bands, data from this sensor can be used to generate true color composites, basic crop health indexes, and advanced analytical tools like flower identification and weed detection. This, in combination with its durable design, makes RedEdge-MX a multispectral powerhouse. *www.bdb.co.uk*

Unifly launches e-Identification and tracking for drones

Unifly launched an e-Identification and tracking solution for drones. The device works in a completely independent fashion, with its own power source and sensors for position, altitude, temperature, pressure, speed and direction. As soon as the pilot attaches it to a drone, it is ready for use. Airborne equipment needs to be lightweight, robust, and able to withstand widely varying climatological conditions ranging from cold and heavy rainfall to blistering sunshine. This is why Unifly has developed a drone tracking and e-Identification product: the Unifly BLIP (broadcast location & identity platform). BLIP is tailored to the specific needs of UTM service providers and local authorities."

Bramor mSX – (Re)defining agricultural drone sensing

After months of integration testing and optimization, the new BRAMOR mSX long endurance beyond visual line of sight (BVLOS) enabled fixed wing unmanned aircraft system, equipped with the state of the art Micasense ALTUM sensor is now available to advanced users worldwide. The 3hr endurance system is revolutionizing the acquisition of data in the combined radiometric multispectral, visible and thermal remote sensing space for precision agriculture, advanced research remote sensing and surveying, filling the gap between satellite data acquisition and short endurance platforms that can cover very small areas. *www.suasnews.com*

Black Swift Technologies developing active UAS navigation

Black Swift Technologies (BST) has completed the first phase of a NASA-funded project to demonstrate the effectiveness of fusing a host of onboard sensors to develop a terrain-following fixed-wing unmanned aircraft system (UAS), in this case, it will be demonstrated using the Black Swift S2™ UAS.

BST's understanding and integration of artificial intelligence (AI) and machine learning can help serve as a catalyst for accelerating UAS growth and adoption, industry-wide. Through autonomous, active navigation around obstacles and over rugged terrain by a fixed-wing UAS, BST is demonstrating how technology can help make UAS operation simpler and safer, for both operators and the public.

Blue Bear launches 5G enabled BVLOS flight test facilities

Blue Bear has announced the launch of its 5G enabled beyond visual line of sight (BVLOS) flight test facilities in Bedfordshire by the Mayor of Bedford, UK.

Department for Digital, Culture, Media and Sports has allocated over £200million to develop 5G test beds. This has allowed Blue Bear to establish the first 5G enabled air corridor for drone testing in the UK at the National BVLOS Experimental Centre (NBEC). TAGSDRONES & UAVS *http://bbsr.co.uk*

DJI introduces DJI Terra

DJI has introduced DJI Terra, a new software tool that transforms drone data into digital 3D models and maps for easy analysis and decision making. It enables businesses and organizations using DJI drone technology to capture, visualize and analyze aerial images for a wide variety of applications across the public safety, construction, infrastructure, agriculture and film industries. *www.dji.com*

IMGING becomes first drone platform with on-site roof measurements

Loveland Innovations, maker of advanced data gathering and AI analysis solutions, added enhancements to its inspection platform, IMGING®. These enhancements include drone-based on-site measurements, AI and deep learning-powered damage detection for commercial roofs, and other powerful updates.

Thanks to a unique real-time measurement process built into the IMGING app, field adjusters and roofing estimators can now view and share dynamic measurements on an Apple® iOS tablet while they're still on-site with customers. Loveland can provide measurements shortly after a drone flight is completed for most residential roofs. *www.lovelandinnovations.com*

CCS and Fortress UAV partner to provide MERC-UASC Solution

Comprehensive Communication Services (CCS), a company created after Hurricane Katrina with the sole focus of providing mobile communication platforms for First Responders during disasters, and Fortress UAV, a leading provider of drone managed services including repair, preventative maintenance and support for clients, with a focus on public safety, have partnered to provide a fully comprehensive Mobile Emergency Response Center – Unmanned Aerial System Carrier (MERC-UASC) solution. This solution from CCS and Fortress UAV is extremely adaptable and can be applied to numerous use-cases including but not limited to: communications for emergency response, event monitoring and inspections, and enterprise drone solutions. *www.comprehensivecom.net.*

Waterproof drones

The Aeromapper Talon Amphibious is a fixed-wing UAV system that can be used for inspection and mapping with proven amphibious characteristics. It delivers high-resolution georeferenced imagery as well as the video feed from up to 30 km from the operator. After completing its mission the UAV later returns and safely lands on the water, well serving maritime Beyond Visual Line of Sight (BVLOS) operations. By design, the UAV can stay indefinitely afloat on the water, and even sustain full immersion without any damage or water intrusion, even in salt water. *www.aeromao.com*

Cost-effective drone tracking solution

AirMap, global airspace management platform for drones, and Honeywell announced the development of a cost-effective drone tracking solution to provide airspace safety authorities with situational awareness of manned and unmanned aircraft operations within an airspace system.

Together, the companies will develop a cost-effective hardware device to allow for UAS, or drones, to maintain consistent communication with a UAS Traffic Management (UTM) system. UTM is a digital air traffic management system made up of technologies and services designed to maintain safe integration and separation of drones and other aircraft and objects in low-altitude airspace via the exchange of mission-critical data and telemetry information. *www.airmap.com*

ESA BIC start-up tests at BCN Drone Center in Namibia

A drone startup from The Netherlands which is a part of the ESA BIC network and their Norwegian engineering partners Maritime Robotics. Eyeplane proposes an innovative fixed-wing drone service by which they will be able to monitor large areas of land from the sky and warn customers in case of irregularities. They are planning to work in Namibia for wildlife preservation. The Dutch startup booked one of the exclusive offers for ESA BIC startups sponsored by Catalan Government. *https://unionaerospace.ca*

$3M Volume UAV contract signed

Survey of India awards India's first survey grade hybrid UAV Trinity+ order to India's oldest surveying instrument company API-Roter Group partnered with Quantum-Systems GmbH Germany.

In order to find the best system in the market for this application, a call for tenders was launched in 2018 to compete different systems against each other. The catalogue of requirements comprised numerous disciplines, some of which were specified by the state and others by the customer. In a tightly scrutinized demonstration of the drones of 11 participating companies, Trinity+'s outshone the competition in performance, data quality and compliance to the regulations. Quantum-Systems GmbH and its Indian partner Ansari Precision Instruments are proud to have won the tender in the aggressive competition. *www.quantum-systems.com*

Drones to carry out India's biggest Land Survey

The Maharashtra State Government is going to conduct the biggest ever land survey in modern India and the drones will be used to carry out the task. The State Government took this decision as they aim to offer ownership rights to nearly 15 million rural households an official said.

S.Chockalingam, director of land records in Maharashtra said that a more than a dozen of drones installed with high-resolution cameras will survey the residential areas of 40,000 villages in the state from 1st June.

He further informed that it will take three years' time for the completion of this survey. The director also informed that the villagers have no property ownership on the land they live even though they are paying the property tax on time. The villagers don't have property titles, because there has been no survey. He further said that the State has completed the procedure to digitize nearly 270 million land records and the Government will have a better vision of idle land we have after carrying out the survey of villages. *www.realtymonks.com*

Innoviz Technologies to accelerate solid-state LiDAR production

Innoviz Technologies has raised $132 million in Series C funding. This significant raise will support Innoviz's commercialization of its leading InnovizPro and InnovizOne solid-state LiDAR solutions and address growing demand for cutting-edge autonomous vehicles (AV) technologies worldwide. *www.innoviz.tech*

Velodyne achieves half a billion dollars in Lidar sensors shipped

Velodyne has shipped a cumulative total of 30,000 lidar sensors with a total value of half a billion dollars. This achievement underscores Velodyne's lidar market leadership and ability to deliver a broad portfolio of lidar sensor products at mass production levels. Lidar sensors are a central component of autonomous vehicles (AVs) and advanced driver assistance systems (ADAS).

SAS announces $1 Billion investment in AI

SAS is investing $1 billion in AI over the next three years through software innovation, education, expert services and more. The commitment builds on SAS' already strong foundation in AI, which includes advanced analytics, machine learning, deep learning, natural language processing (NLP) and computer vision. Educational programs and expert services will equip business leaders and data scientists for the future of AI, with the technology, skills and support they need to transform their organizations. *www.sas.com*

Augmentir launches AI-powered augmented reality platform

Augmentir, Inc. has announced the general availability of its Augmented Operations™ platform. The company's software platform is the first of its kind to combine enterprise augmented reality (AR) with artificial intelligence and machine learning (AI/ML), empowering frontline workers to perform their jobs with higher quality and increased productivity while driving continuous improvement across the organization. *www.augmentir.com*

Berntsen International receives US Patent for UHF RFID technology

Berntsen International Inc. has received a US patent for the company's Ultra-High Frequency (UHF) RFID technology that is the centerpiece of its connected infrastructure locating and asset management solutions. UHF RFID, the global standard for product tracking in retail and manufacturing, has had slower adoption for underground utility marking products because of its perceived challenges of "reading" through subsurface environments.

Geotab launch new GO9 device

Geotab has announced the availability of its new GO9 telematics device. It is designed to help businesses better manage their fleets. With better acceleration tracking, a more accurate GPS, better support for vehicle-generated data and for new vehicle types, Geotab's GO9 device is designed to enable businesses to drive more information from their fleet. *www.geotab.com*

Mapping and location services for China by HERE

HERE Technologies has announced that it is extending its suite of location services to China. As a result global and Chinese customers will have access to fresh and up-to-date mapping services as well as key location-based features and functionalities for China to address the Chinese market. *here.com*

Delhi gets IoT-driven garbage bins

Steel Authority of India Ltd (SAIL) has launched Internet of Things (IoT)-driven garbage bins across South and North Delhi Municipal Corporation area, which automatically sends a signal to the waste collection authority once the bins are full.

The IoT-driven initiative is fitted with a real-time indicator of the garbage level in the waste bin at any given time. The data is useful in scheduling waste pick-up accordingly and also for optimising routes for waste collection vehicles.

The bins use ultrasonic sensors for detecting the level of trash in the bin.

RoboSense provides LiDAR to GACHA –first autonomous driving bus

RoboSense has announced that it has provided cold-resistant all-weather LiDAR for the world's first autonomous driving shuttle bus for all weather conditions — GACHA. The autonomous shuttle bus robo-taxi GACHA was designed in collaboration with Finnish autonomous driving company Sensible 4, who provided software for positioning, navigation, and obstacle detection; MUJI, who provided expertise in design and user experience; and RoboSense.

Ford to build new factory in Michigan for autonomous vehicles

Ford is building a new plant in Michigan for autonomous vehicles as the company realigns some factories to focus on its future lineup of self-driving and electric cars.The new facility, scheduled to open in the next two years, will take new commercial-grade hybrid models and incorporate the self-driving technology needed to turn them into autonomous vehicles

HawkEye 360 next-gen microsatellite cluster

Space Flight Laboratory (SFL) has been awarded the prime contract to develop the next generation cluster of formation-flying microsatellites for HawkEye 360 Inc. of Herndon, Va. The HawkEye Constellation, comprised of multiple clusters of three satellites each, is the first of its kind to detect and geolocate radio frequency (RF) signals for maritime, emergency response, and spectrum analysis applications. SFL built the platforms and integrated the HawkEye 360 Pathfinder cluster which was launched into low-Earth orbit in December 2018 and commissioned early this year. *www.utias-sfl.net*

Toyota, Carmera will create HD maps

Toyota Research Institute and Carmera, a company focused on HD mapping, announced that the two are developing a proof of concept of TRI's Automated Mapping Platform, which takes data from participating cars and turns that into HD maps that could be used to help autonomous vehicles navigate.

Most modern safety systems in vehicles contain at least one forward-facing camera, and the two companies believe these cameras can provide the data necessary to help create HD maps, instead of developing and building sophisticated mapping vehicles that are somehow expected to traverse and map the entire globe. *www.cnet.com*

World's first full size, autonomous electric bus

Nanyang Technological University, Singapore (NTU Singapore) and Volvo Buses have launched the world's first full size, autonomous electric bus. The single-deck Volvo Electric bus is 12 metres long and has a full capacity close to 80 passengers.

This is a key milestone in NTU and Volvo's development programme under the university's partnership with the Land Transport Authority (LTA) to develop and conduct autonomous vehicle bus trials for fixed route and scheduled services, which was announced in October 2016.

The Volvo 7900 Electric bus is equipped with numerous sensors and navigation controls managed by a comprehensive artificial intelligence (AI) system.

Ensuring maximum safety and reliability, the AI system is also protected with industry-leading cybersecurity measures to prevent unwanted cyber intrusions. *www.volvobuses.com*

FABU AI chips for autonomous driving

FABU, has announced the results of recent design metrics for the company's Phoenix-100 perception chip for autonomous driving solutions. The Phoenix-100 conducts real-time, high precision perception of the environment to support safe and accurate intelligent driving technologies. The results, extrapolated from benchmark testing of the chip's deep learning accelerator silicon, point to FABU's superior performance, lower power consumption and enhanced memory capacity when compared to design metrics for similar vision computing chips from other major developers of vision-based advanced driver-assistance systems. *www.fabu.ai/en*

5G-connected driverless car tested in New Zealand

The test was carried out in a controlled area at Auckland's Wynyard Quarter Innovation Precinct, using Spark's pre-commercial 5G network available as part of its 5G Innovation Lab. Spark launched its Innovation Lab in November 2018 to showcase 5G technology to New Zealand businesses. The 5G-connected driverless car was developed by Ohmio, a New Zealand company, which has been trialling autonomous vehicles at Christchurch airport. Since these trials, the car has been upgraded with new technology to ensure it integrates with Spark's 5G test network. *www.driven.co.nz*

Lumotive unveils high-performance LiDAR to enable autonomous vehicles

Lumotive, the Bill Gates-funded startup developing LiDAR systems for autonomous vehicles, today introduced a disruptive beam-steering technology, which will significantly improve the performance, reliability and cost of LiDAR systems for the emerging self-driving car industry. Initially targeting the robo-taxi market, Lumotive's patented system uses Liquid Crystal Metasurfaces (LCM™) and silicon fabrication to achieve unmatched levels of manufacturing efficiency while simultaneously delivering unprecedented range, resolution and frame rate. LiDAR has emerged as a key 3D sensing technology by enabling autonomous driving systems as well as so-called ADAS, or Advanced Driver Assistance Systems (such as systems for lane keeping, automatic braking and collision avoidance). *www.lumotive.com*

GradeMetrix™ Positioning Systems and Earthworks OEM Solution Toolkit by Hemisphere GNSS

Hemisphere GNSS has announced its all-new GradeMetrix platform, a high-value machine guidance solution for high-precision GNSS-based machine control and guidance applications and systems.

The portfolio includes solution offerings for dozer and excavator earth moving applications. Hemisphere continues to make significant strides forward with its next-generation GradeMetrix solutions through its network of machine control dealers and value-added resellers (VAR).

Hemisphere has also announced its Earthworks OEM toolkit which allows manufacturers to select components as à la carte or complete solutions, based on their accuracy and durability requirements to integrate into their machines and design their own IP, enabling them to maintain a competitive advantage in the marketplace. *www.hgnss.com*

Eos releases new version of Eos Tools Pro for Android and iOS

Eos Positioning Systems, Inc (Eos), has announced a new version of Eos Tools Pro for Android (v 1.49.35) and iOS (v 1.75 / build 204). Both versions will support additional GEOID models (real-time orthometric height conversions) and both will include a new real-time, in-app "Battery Status Monitor" feature. The iOS version also includes a UI fix that eliminates an Altitude tab issue.

Eos receives 2019 Esri Partner Conference Award

Eos Positioning Systems, Inc has received a 2019 Esri Partner Conference award in recognition of Eos' contributions to Esri® mobile applications. Esri ArcGIS® users benefit from bundling the Eos Arrow GNSS receivers and Esri mobile apps to create real-time, high-accuracy field GIS solutions on consumer devices such as iPads, tablets, and smartphones.

Eos' mission is to turn the complex world of high-accuracy submeter and RTK location into simple and affordable integrations to the Esri ArcGIS platform. This is achieved with behind-the-scenes transfers of high-level GNSS information with Esri mobile apps. The exchange is nearly transparent to the end-user, and therefore minimizes the knowledge required for anyone to capture survey-grade 3D locations.

Orolia acquires innovative GNSS/PNT simulation capabilities

Orolia has successfully acquired Skydel Solutions, an innovative GPS/GNSS signal simulation company based in Montreal, Canada. With Skydel's unique capabilities, Orolia now offers customers even more diverse Resilient PNT solutions with new sophisticated testing and simulation protocols, additional customized signals and superior vulnerability assessments for military and commercial applications where GNSS failure is not an option. As the latest addition to the Orolia portfolio, Skydel brand solutions bring a new paradigm to the GNSS simulator scene, by combining innovative algorithms and off-the-shelf hardware to help protect the world's most critical GNSS-reliant systems operating through GPS, Galileo and other global navigation satellite networks. *www.orolia.com*

Emlid Reach RS2

Reach RS2 gets fixed solution in seconds and provides positional accuracy down to several millimeters. The receiver tracks GPS/QZSS (L1, L2), GLONASS (L1, L2), BeiDou (B1, B2), Galileo (E1, E5), and SBAS (L1C/A) and reliably works in RTK mode on distances up to 60 km, and 100 km in PPK mode. Multi-feed antenna with multipath rejection offers robust performance even in challenging conditions. RINEX raw data logs are compatible with OPUS, CSRS-PPP, AUSPOS, and other PPP services so you can now get centimeter-precise results in any place on Earth. *https://emlid.com*

Tersus launches David Plus

Tersus GNSS Inc. has launched its new David Plus receiver, a dual-antenna GNSS receiver which offers centimeter-accurate positioning and heading. It is designed for intelligent transportation, construction, machine control, precision agriculture, and navigation applications. The receiver is built for outdoor environments with IP67-rated enclosure. The compact palm size makes it easy to integrate with various application systems. A 4GB in-built memory is to record data for post-processing conveniently. *www.tersus-gnss.com*

Allystar launches tiny dual-band GNSS module

Allystar Technology Co. Ltd. has launched its smallest multi-band multi-GNSS module, the TAU-0707. Within its 7.6 x 7.6 millimeter size, the TAU-0707 series module supports major GNSS constellations (GPS / Galileo / GLONASS / BeiDou / QZSS / IRNSS) and all civil bands (L1, L2, L5, L6). The module is a concurrent multi-band multi-GNSS receiver embedded with a cynosure III single-die standalone positioning chipset, which offers multi-frequency measurements to improve positioning accuracy and simplifies integration for third-party applications.

Furono Launches Single-Band GNSS Receivers

Furuno Electric, based in Nishinomiya, Japan, developed GT-88 and GF-8801/02/03/04/05 for users who require Coordinate Universal Time (UTC) time-synchronized signals to meet the new 5G requirements. They provide UTC time-synchronized timing signals (1PPS/10MHz) by receiving GNSS satellite signals. The GT/GF-88 series includes a brand-new algorithm, named Dynamic Satellite Selection, that provides multipath mitigation, especially in urban canyon environments. This algorithm was developed by Nippon Telegraph and Telephone Corporation (NTT) based in Tokyo, Japan.

NovAtel further enhances Waypoint GNSS+INS post-processing

NovAtel's Waypoint Products Group has released version 8.80 of its GNSS and GNSS+INS post-processing software products, including Inertial Explorer, Inertial Explorer Xpress, GrafNav and GrafNet. All Waypoint customers with an active subscription that are within the support period qualify for the Waypoint 8.80 upgrade at no additional charge.

GNSS antenna for high-precision and autonomous applications by Maxtena

Maxtena Inc. has introduced a patented GNSS antenna - M7HCT-A-SMA, designed for high-precision and autonomous multi-frequency applications. The new design will offer concurrent GNSS reception on L1: GPS, GLONASS, Galileo, Beidou and L2: GPS L2C, Galileo E5B and GLONASS L3OC in a rugged, compact and ultra lightweight form factor. The antenna is designed for GIS, RTK and other high-accuracy GNSS applications such as the drone and automotive markets, where high performance and low weight are driving features in antenna selection. *www.maxtena.com*

Orolia launches first Galileo-enabled personal location beacons

The European Union's Horizon 2020 HELIOS and its coordinator Orolia have announced the launch in Europe and the United States of an upgrade to its McMurdo FastFind 220 and Kannad SafeLink Solo personal location beacons (PLB) to include Galileo. The PLBs are the world's first to utilize Galileo's capabilities and are the first in a series of new solutions coming from the EU-funded Helios project, led by Orolia, which was set up to leverage the power of Galileo. The launch follows approval from the U.S. Federal Communications Commission.

Juniper Systems releases Allegro 3 rugged handheld

Juniper Systems has released Allegro 3 Rugged Handheld to utilize the Android operating system. It improves upon the successful rugged mobile computer formula employed by Juniper Systems with a faster processor, upgraded memory capacity, 4G LTE capability, and Android 7.1 "Nougat." It is rated IP-68, utilizes a 1.2 GHz Cortex A9 processor and 2 GB of upgraded RAM with greater speed and stability, optimizing the device for faster data transfers and program and file load times. *https://blog.junipersys.com*

Trimble launches Tekla Powerfab

Trimble has introduced its Tekla PowerFab, a next generation software suite for steel fabrication management. It is a step-change in collaboration across project teams throughout the structural steel workflow for unparalleled control and visibility. It is a complete and connected steel fabrication software solution that provides relevant and real-time information to all project parties. At the core of Tekla PowerFab is Tekla EPM (formerly FabSuite management information system), which boasts proven success among Trimble customers in North America. The solution gives project teams visibility into the status of components at every stage of fabrication—from model-based estimating to site delivery—so they can work together seamlessly for more efficient workflows and cost savings.

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May 2019

5th International Conference on Geographical Information Systems Theory, Applications and Management
3 - 5 May 2019
Heraklion, Crete, Greece
www.gistam.org

13th Annual Baska GNSS Conference
5 - 8 May
Baska, Croatia

10th China Satellite Navigation Conference
22 – 25 May
Beijing, China
www.beidou.org

4th Joint International Symposium on Deformation Monitoring and Analysis
15 - 17 May
Athens, Greece
http://jisdm2019.survey.ntua.gr

Geo Business 2019
21 - 22 May
London, UK
www.GeoBusinessShow.com

June 2019

International Conference on Localization and GNSS
4 - 6 June
Nuremberg, Germany
www.icl-gnss.org/2019/index.html

Geospatial Week 2019
10 - 14 June
Enschede, The Netherlands
www.gsw2019.org

HxGN LIVE 2019
11 - 14 June
Las Vegas, USA
https://hxgnlive.com/2019

TransNav 2019
12 - 14 June
Gdynia, Poland
http://transnav.am.gdynia.pl

United Nations/Fiji Workshop on the applications of GNSS
24 - 28 June 2019
Suva, Fiji
www.unoosa.org

July 2019

Esri User Conference
8 - 12 July
San Diego, California
www.esri.com

August 2019

The South-East Asia Survey Congress (SEASC) 2019
15 - 19 August
Darwin, Australia
https://sssi.org.au

September 2019

GI4DM
3 - 6 September
Prague, Czech Republic
www.gi4dm2019.org

Intergeo 2019
17 - 19 September
Stuttgart, Germany
www.intergeo.de

ION GNSS+2019
16 - 20 September
Miami, Florida, USA
www.ion.org

MRSS19 – Munich Remote Sensing Symposium 2019
18 - 20 September
Munich, Germany
www.mrss.tum.de

PIA19 – Photogrammetric Image Analysis 2019
September 18 - 20, 2019
Munich, Germany
www.pia.tum.de

ISDE 11
24 - 27 September
Florence, Italy
digitalearth2019.eu

Interdrone
3 - 6 September 2019
Las Vegas, USA
www.interdrone.com

October 2019

The 8th FIG Land Administration Domain Model Workshop (LADM 2019)

4th International Conferenceon Smart Data and Smart Cities (SDSC2019)

Geomatics Geospatial Technology (GGT2019)
1 - 3 October
Kuala Lumpur, Malaysia,
http://isoladm.org
www.geoinfo.utm

40th Asian Conference on Remote Sensing (ACRS)
13 - 18 October
Deajuong City, Korea
www.acrs2019.org

Commercial UAV Expo Americas
28 - 30 October
Las Vegas, USA
www.expouav.com

Commercial UAV Expo
28 – 30 October
Las Vegas, USA
www.expouav.com

ISGNSS 2019
29 October - 1 November
Jeju Island, South Korea
www.ipnt.or.kr/isgnss2019