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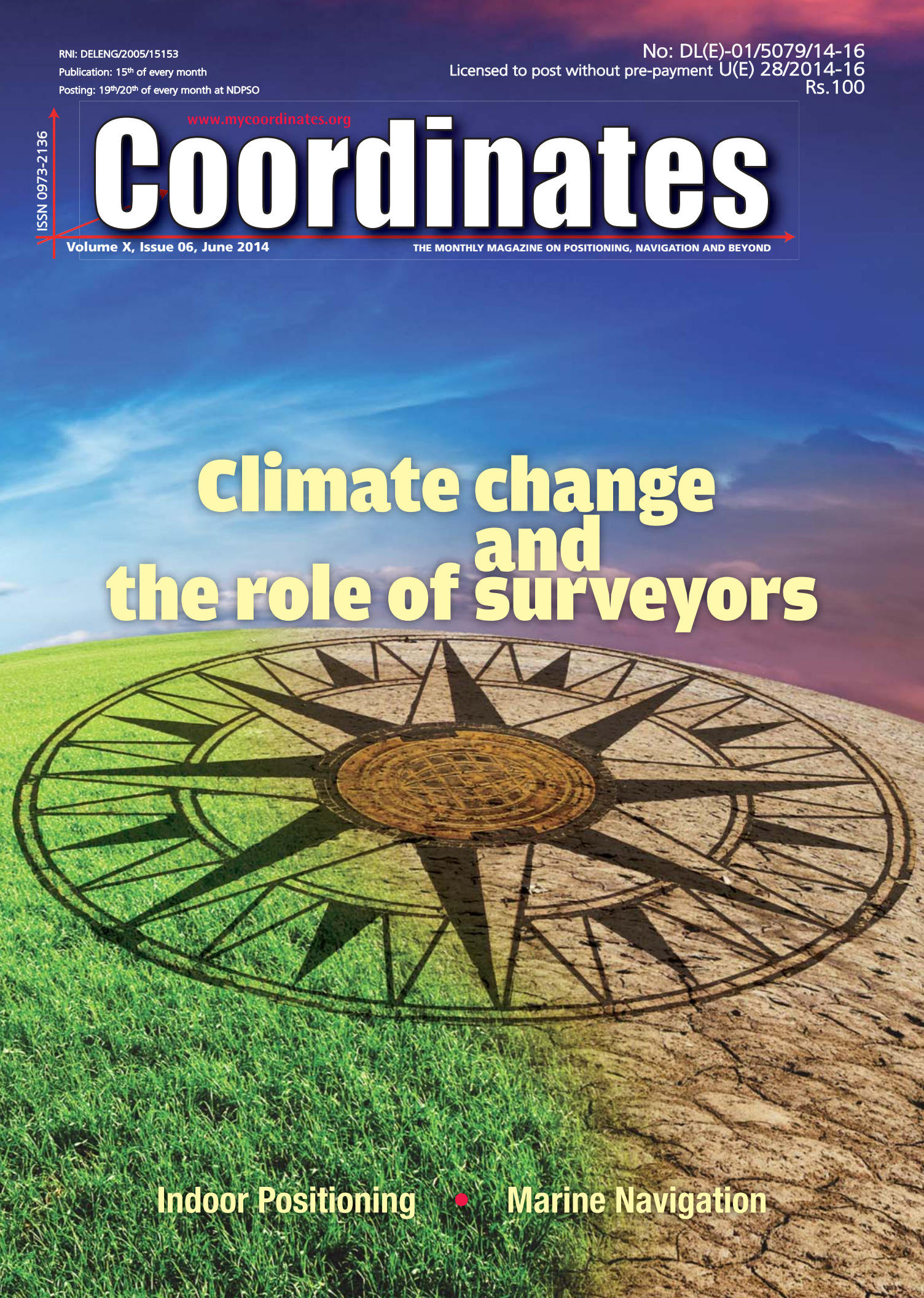

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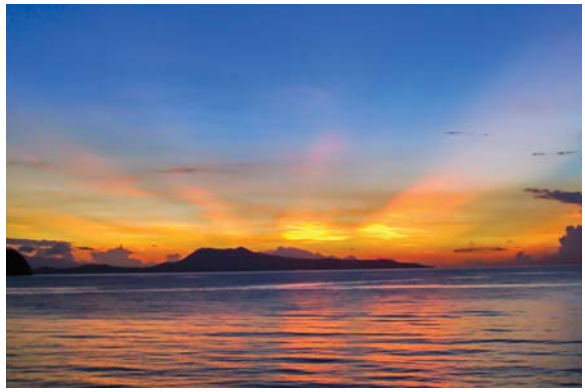

With hope

With the formation of a stable government in India,

That too with stated emphasis on infrastructure development

Like road, river-linking, railways, housing, …

The surveying community in India

Could revive their expectations

For better prospects and growth of the industry.

However, with the technology getting into higher realms,

The dynamics of various stakeholders

Need to be redefined

By evolving feasible public private partnership models

And addressing the fundamentals,

Like research and development, policy initiatives, …

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UAVs: A boon for mapping applications

Peter Cosyn is site manager and director of research and development of Gatewing, a Trimble company. He is a co-founder of Gatewing, which was launched in 2008. Cosyn earned a Ph.D. in electromechanical engineering from Ghent University. He has more than 10 years of experience in unmanned aircraft system design.

UAVs (Unmanned Aerial Vehicles), or as most civil aviation authorities now call them, UASs (for Unmanned Aircraft Systems), are attracting a lot of attention lately from geospatial professionals. Common questions in their minds are:

- What applications can I use it in?
- What benefits can it provide to my organization or my clients (or data users)?
- How do I implement such a system in my organization?

This article will cover the first two questions, while addressing some of the third question as well.

High-Level System

Unmanned aircraft are either a fixed-wing (plane) or a multi-rotor (helicopter) design. Typical fixed-wing UAS available today are equipped with wide-angle cameras that fly about 100 m (more or less) above the ground. Multi-rotors, with their ability to hover, move vertically—and even fly in reverse—may sometimes be operated at lower heights above ground. A greater diversity of sensors are being developed and offered specifically for small UAS platforms. Some of these include near-infrared cameras, miniaturized LiDAR scanners, and even sensors that enable hyper-spectral or multi-spectral capabilities. The typical system runs on electrical power and flights are between 30 and 60 min in length (often shorter for multi-rotors because of the greater amount of energy needed to achieve a mission). Depending on the endurance and speed of fixed-wing aircraft, typical coverage is around 1 to 1.5 sq km (100-150 ha); for multi-rotors the area covered is much less—it could be as little as 10 percent to as much as 30 percent of what can be achieved with a fixed-wing UAS.

UAS image processing is usually done using close range photogrammetric techniques adapted to exposures taken in flight. This technique allows accurate construction of photogrammetric models that approach the quality achievable with much more sophisticated manned aerial systems flying at much higher altitudes.

With these technologies, photomosaic, orthophotographs, digital terrain models (DTMs), digital surface models (DSMs) and point clouds can be output. Without ground control the models have high, cm level internal consistency in X, Y and Z. With sparser ground control than is typically required for conventional photogrammetry, good quality models registered to the ground control can be rapidly generated at much lower costs than most other methods of achieving similar results. That, however, doesn't make today's UASs a solution for all aerial surveying and mapping situations; but where their application is appropriate, they bring benefits that are sometimes unique.

Some of the more common applications of UAS-based mapping are listed in the table, with a limited set of users and data consumers for each type and special benefits that may be unique to UAS aerial imaging.

Application	Industries, user groups, or data consumers	Benefits, special analysis or techniques
General mapping base for GIS, planimetric and topographic mapping.	Tax assessment, agriculture, soil types, land use, transportation, infrastructure inventory.	Low mobilization and processing time means not having to wait until the ideal time for conventional photogrammetry. Because of its much lower operating and data processing costs, UAS can be used to do updates of areas within the extents that UASs can easily map, where it was previously cost-prohibitive with other technologies. This improves currency of mapped information. Due to large cost of conventional mapping projects, updates of the entire area may be spaced years or even decades apart.
Natural resource exploration, assessment and inventory.	Businesses involved in exploration of natural resources; government agencies involved in preservation or leasing/sale of lands.	Low mobilization times and low operating costs mean far broader and deeper assessment of yield potential before making lease or purchase investments. For businesses, over long term, better outlook for business ROI. For government, early and more complete information means better planning to avoid development conflict and management of infrastructure development and population movements.
Mapping habitat of fauna and flora, cataloging, inventorying species, identifying animal territories or ranges.	Environmental scientists, biologists, zoologists, botanists, animal conservation groups, government departments for wildlife and habitat protection, private and public wildlife management organizations.	Studying migration, territorial studies of fauna and flora ecosystems, monitoring endangered species, bird nest monitoring, environmental assessment, and detecting habitat stress. UAS is ideal for monitoring in focused areas for studies with a temporal aspect.

Application	Industries, user groups, or data consumers	Benefits, special analysis or techniques
Surface mining exploration, assessment and inventory, including determination of volumes removed in a surface mine, volumes of stockpiles, tailings and other materials.	Mining and gravel companies, dredging companies, safety and environmental monitoring agencies, economic analysis of production, surface mine operations.	Multi-temporal monitoring and mapping of headwalls, tailings and other areas disposed to subsidence or collapse and slope and wall failures. Data from such activities can help with prediction of hazardous events so that measures can be taken to prevent such failures or to avoid exposing personnel to danger. Mining monitoring can be on a closely spaced schedule that far outperforms that which is possible with other technologies. When particularly troublesome areas are noted, focused aerial mapping can be done at an even shorter spacing between flights.
Baseline mapping of natural and cultural features.	Land development, floodplain mapping, planning organizations, terrain mapped can be used for flood simulation and prevention.	Updates to flood maps and other types of baseline maps, when changes become apparent at ground level can be quickly mapped with UAS. This type of mapping is also useful as a baseline for emergency response services of government and companies such as utilities, food delivery services, etc.
Damage assessment or hazard evaluation mapping during disasters such as floods and fires.	Emergency management, rescue operations, emergency construction, evacuation routing, hazard notification.	Spot checking of areas known to be of interest and updating in near real-time, short period visitation to get updates on progress of fire, flood or to monitor evacuation routes for traffic management.
• Post-disaster mapping of focus areas for assistance and remediation following earthquakes, hurricanes, tsunamis, floods and other natural or manmade events; • Post-storm assessment of power lines and other utilities to perform triage to determine location for first-responder repair teams; • Post-disaster mapping for financial costs assessment.	Utilities, road, highway and transportation agencies, emergency food, water and shelter distribution, route planning for ingress and egress, hazard and debris removal planning, emergency construction dispatch, government departments involved in remediation and reconstruction, including environmental remediation, insurance underwriters.	Better information, often obtained under conditions that would be impossible for other technologies, can improve quality of life of those affected and reduce negative economic impact of the disaster. Emergency management benefits from near on-demand mapping updates.
Real estate inventory, real property mapping for tax assessment.	By mapping roof footprints; building foot prints can be estimated; remote, hard to access facilities in rugged areas can be mapped easily; monitoring development and usage patterns in new developments that are being marketed, tax assessment mapping.	Conventional real estate inventory is a slow and costly process. Thus many avoid it. The downside of avoiding it is that realistic accounting is not possible.
Forest inventory.	Encroachment mapping, unlawful logging and other land use of private or public resources; also useful for siting, planning and design of facilities such as roads, and timber collection and processing stations.	Forestry is a major industry and forests are a major natural resource in many countries and regions. While satellites and conventional photogrammetry continue to be the mainstay mapping technologies, UAS-based mapping that is project or incident-focused has a real place in safeguarding inventory.
Crop monitoring.	Detect crop health, readiness for harvest, evaluate damage from various sources/effects such as drought, flooding, insect and mammal pests, fungus.	Using near infrared or other wavelengths, detect heat and other stress long before it is detectable at visible wavelengths; certain crops such as grapes used for winemaking, have been shown to benefit from use of land-based infrared measurements to detect ideal time for harvest. Grapes for wine and similar crops have a high economic potential benefit from the use of UAS with appropriate detectors for color/near infrared (CIR) or all infrared or other spectral monitoring.

UAS aerial imaging can provide flexibility unsurpassed by other technologies. Portable equipment that is able to function in a wider variety of adverse weather means that mapping can be done closer to the time of need. Because mobilization and flight cycles are short, flights can be done hourly or more frequently in urgent situations such as floodwater or fire tracking. Cloud cover is rarely a problem as unmanned aircraft typically fly below the clouds. In fact in some parts of the world it is being considered as the only mapping tool for aerial mapping as the weather, availability of aircraft, other equipment and trained personnel rarely coincide to allow opportunities for conventional aerial mapping. When focused areas need to be mapped with timely generation of data products under conditions—weather, hazard limitations, or closely spaced visitations—that test the capabilities of other tools, the selection and successful use of UAS in such situations is only limited by the solution-provider's creativity.

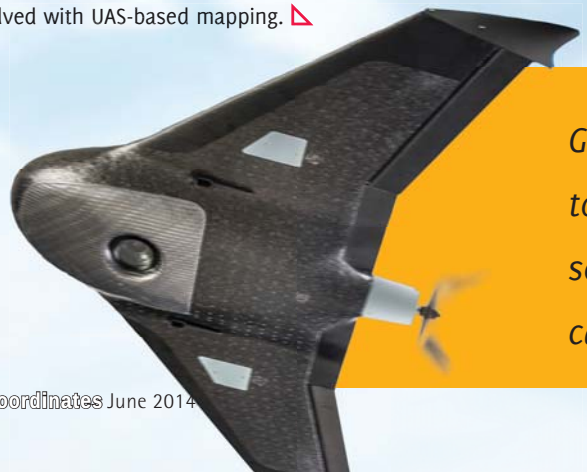
Operational issues and working within a nation's civil aviation regulatory framework must be examined in detail before an organization decides to acquire and fly UAS for geospatial applications. UAS flying is highly process-oriented. It involves much more planning and preparation than the typical use of ground-based technologies involves. Training of flight crews and data processing teams is more than just an up-front investment. It is necessary for flight crews to maintain current skill levels through non-revenue flights if the revenue flight schedule is widely spaced in time.

The state of regulations vary from country to country, but fliers in any locality must also be aware of the restrictions on flying in the national airspace that

Application	Industries, user groups, or data consumers	Benefits, special analysis or techniques
Plantation inventory, land acquisition, quality assessment, disease detection and control.	Managers of monoculture crops have to be especially vigilant to attack by pests and disease. Additionally rapid mapping of prospective land or existing plantations is more easily done with UAS-based mapping. When a country or region is dependent on these important economic crops they can also use UAS mapping to monitor adjoining plantations and communicate with others who might be susceptible to attack.	Depending on the disease or pest detected the built-in knowledge of exactly where on the photomosaic or orthophoto map of the planation the problem exists can allow managers to assess the severity and plan remedial action, which may include destruction of trees within a certain radius without actually visiting the infected location. Many times personnel can then be directed to cut down trees using GPS locators, without having experts along to make a final evaluation. Once an offending pest or disease has been subjected to a remediation plan, success can be monitored by closely spaced flights at little additional expense. Near infrared photography can be particularly useful in this application.
Archeological assessment surveys, detail mapping and "big picture" generation.	Government departments, academic and non-profit research organizations.	Near infrared mapping may help detect sites or features not readily shown with RGB photography.
• Site surveys including topographic mapping; • Preliminary mapping for route location (roads, railroads, power lines, pipelines, canals, etc.); • Construction progress monitoring; • Real-estate or land development mapping at conceptual stage to develop accurate 3-D simulations; • Spatial planning and planning and monitoring.	Consultants, owners, government agencies involved in monitoring, construction companies and their sub-contractors.	The development of large sites and engineering projects necessitates expensive ground based surveys or aerial photogrammetry. As the development occurs, managers have difficulty maintaining a true picture of the site. With UAS-based mapping at regular intervals, this information gap can be closed.
• Surveys for quality assurance of construction projects such as roads and railroads; • Quantity surveys for projects such as roads and railroads.	Project owners, consulting engineers, architects and surveyors, construction companies and their sub-contractors, government agencies responsible for permitting and monitoring adherence to development conditions.	Change detection software can be used to monitor changes on a regular schedule, with outputs to various types of reporting systems to monitor costs vs. progress, cost vs. quality, determine payments that are linearly, area- or volume-based.
Surveillance mapping of ports, airports and other sensitive areas and their environs.	Transportation hub owners, agencies ranging from customs to those that are set up to deter drugs and firearms smuggling to immigration, security services.	Change detection software has been used in conjunction with UAS mapping products to monitor sensitive areas where attacks that destroy property, or are for the purposes of theft, or smuggling are likely.
Land reclamation projects.	Government, corporate developers.	Could be used on land and water, or on environmentally compromised sites

may have been imposed by the civil aviation authority that covers sub-sections of the airspace or that restrict how or where an UAS may be flown. This includes restrictions on flights near airports and aircraft routes, flights over populated or urban areas and maximum and minimum flying heights over ground level. A common limitation is to restrict flights to areas that are within visible line-of-sight of the UAS pilot.

UAS are not a panacea for all mapping problems. Satellites, high-altitude photogrammetry, fixed-ground, mobile terrestrial and manned aircraft LiDAR, and ground-based techniques all have their place, especially when large areas are to be mapped at widely spaced time intervals. But geospatial data managers will be surprised to see how nagging problems as well as some they didn't recognize as problems can be solved with UAS-based mapping.



Geospatial data managers will be surprised to see how nagging problems as well as some they didn't recognize as problems can be solved with UAS-based mapping

Trends in indoor positioning

Surging smartphone market and increased use of WiFi gives new opportunities to indoor positioning technology

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The developer could use WiFi signal by measuring RSS or AOA

The demand for recognizing the user position is steadily increasing not only in the outdoor but also in the indoor. In the outdoor, the global navigation satellite system (GNSS) is available and guarantees high levels of positioning accuracy and availability. However, there is no standard method for localization even though many indoor positioning techniques have been developed.

In this short paper, market for indoor positioning is assumed to be potentially huge. There are mainly three areas this paper targets – public transportations, shopping malls and manufacturing facilities. Anyone who has been at the airport will remember having to look around everywhere to find the right terminal or find the right shop to buy something. The indoor positioning can provide more than a map to navigate inside the airport. Google has announced that they will make an effort to localize the user position in the airports [1]. Indoor navigation needs indoor maps as well as indoor positioning technique which can guide users. In the shopping malls, the same technology for navigation can be used not only for finding shops but for finding spots in the parking lot. In large factories, tracking the position of skilled workers and equipment within the facilities and reassigning them will help achieve higher productivity. These examples well characterize the future market of indoor positioning: the indoor positioning system is expected to be useful in large areas, rather than in small areas. The manager of a shopping mall who wants to provide indoor positioning to customers, will find indoor positioning useful when shopping mall has a large number of shops. In the same sense, an administrator can expect that the factory which deals with heavy load of machines and resources will be likely to benefit from indoor positioning by tracking assets and skilled workers when building heavy machinery.

As mentioned earlier, in the indoor positioning there are many techniques to localize user position. For wireless positioning measurements, the received signal strength (RSS), multicarrier phase measurement, time of flight (TOF) and angle of arrival (AOA) can be acquired [2]. Since the number of smartphone users in the world is significantly high, and the accessibility of the indoor positioning system using smartphones will be high as well, smartphone-based localization methods are reviewed here. Smartphone sensors can be combined with the measurements aforementioned. In addition to these positioning techniques, many WiFi APs are available nowadays, so smartphone sensors and WiFi positioning techniques are also reviewed.

Following this, many RSS-based localization methods are conducted. On the other hand, TOF-based method is not suitable with WiFi system, and there are some possibilities of smartphone manufacturers adding new chip for TOF-based positioning, such as ultra-wideband (UWB) and ultrasound. Even though ultrasound based system gives better ranging accuracy than UWB, ultrasound cannot guarantee the accuracy in non-line-of-sight (NLOS) situation [3]. This paper focuses on UWB based positioning solution. And it is possible for WiFi APs to acquire AOA measurements.

In smartphones, the sensors which include the gyroscope, accelerometer, and magnetometer are now available. And the barometer can be used to give the floor information to the users. The camera also gives the engineer chances to improve vision-based positioning technique. If wearable equipment such as Google Glass becomes popular, one can expect vision-based localization to be a good alternative for wireless positioning.

RSS-based positioning

RSS-based positioning method enables the user to acquire their position without modifying the user's smartphone. There are mainly three categories of measurement methods: distance, fingerprint, and proximity. From the pass-loss model, the distance between the user and WiFi APs could be estimated. However, estimated distance is inaccurate since the received signal suffers from channel fading. If signal power decreases more due to bad channel, estimated distance increases which causes error. If one acquires distance measurements from many APs and assigns weightings properly, the positioning accuracy will be improved. Skyhook maintains database of WiFi APs so that the user could calculate its position [4]. Fingerprint uses radio map database premeasured. Using RSSs from many APs, the positioning accuracy is enhanced. RSS-based method using Euclidean distance or Bayesian-inference fingerprint approach is studied [2]. Also, rank based localization method is studied. The difference between classical and rank based localization is that classical localization directly compares premeasured and RSS data directly, whereas rank based localization compares two rank vectors from radio map and RSS data [5]. On the other hand, Nonlinear Kalman filter –based localization methods are now on being research [6]. Kalman filter assumes that noise to be Gaussian, Unscented Kalman filter and Particle Kalman filter did not made that assumption, which makes this methods suitable to heterogeneous system [7]. If the measurement model gets complicated, more calculation should be performed. To alleviate heavy calculation, crowdsourcing method could be a solution [8]. However, it needs seamless connection between server and smartphone users.

Increases on the WiFi APs could cause interference between APs which causes the degeneration of positioning accuracy [5]. And this may be the reason why many study proximity-based positioning techniques [9]. A WiFi beacon only broadcasts its signal on the small footprint. If the signal surges over threshold, the user can estimate its position. In this method, only few calculations are needed. Its accuracy is mainly dependent on the size of the footprint. By using directional antenna, coverage can be minimized and detection probability can be enhanced. The WiFi beacon alone gives the accuracy of three over five meters. On the other hand, a beacon AP can broadcast several WiFi beacons in different directions, which enables a system to enhance positioning accuracy and to estimate user heading [10]. In this case, the WiFi beacon AP can be called as a multi-channel beacon AP, which gives two meter accuracy.

AOA-based positioning

Another kind of localization could be based on AOA. Since changing smartphone is difficult, mobile AP could be altered instead for positioning purpose in order to perform the angle of arrival. Multi-antenna is used to estimate inclination angle (or elevation angle) for localization [11]. The simplest AOA system uses only two antennas. Using RF signals in both antennas, phase difference between two antennas could be obtained. Antenna distance and path difference (derived by phase difference) could be used to get the inclination angle of the signal. The wavelength of 2.4GHz is 12.5 centimeter; the antenna should be installed within 6 centimeter to avoid path ambiguity and (2.7 centimeter for 5.4GHz). Multiple antennas and complicated algorithm could be used to resolve integer ambiguities [12]. The user position could be calculated from the estimated angles [13] or an estimated angle and height information [14]. In either case, mobile AP could be called enhanced WiFi beacon. Nokia developed Bluetooth-based AOA solution [15] and Wifive Co. Ltd in Korea is now developing WiFi based AOA solution for both 2.4GHz and 5GHz.

TOF-based positioning

Time of flight (TOF) uses the packet elapsed time between device A and device B. if device A and B are synchronized and device A sends a packet which contains time, device B could demodulates the packet and extract the elapsed time, which is converted later as the distance between device A and B. However, device A and B is not synchronized generally; time-bias exists in the time of flight measurements. This is called as the pseudorange, which means that the measurement is elapsed time plus unknown clock bias. If the infrastructure is synchronized such as global positioning system, the receiver clock bias can be estimated and could be cancelled. However, time synchronization between nodes needs high-cost because of the atomic clock or the wired infrastructure. Under nanosecond, synchronization is needed to acquire under meter accuracy. To alleviate this constraint, two-way ranging (TWR) is used in order to eliminate receiver clock bias. The device A sends a packet to device B, and device B returns a packet to device A and takes two TOF measurements. These measurements contain relative receiver clock bias which has the same magnitude and different sign. TWR measurement is acquired by averaging it. Furthermore, IEEE 802.15.4a standard recommends symmetric double-sided two-way ranging (SDS-TWR) which mitigates clock drifts [16]. SDS-TWR averages two TWR measurements from device A and from device B. In order to estimate high-precision distance measurements, the peak estimation and the ranging counter should be utilized. For this purpose, PHY of ranging system should be designed in order to improve resolution of measurement [3]. The standard specifies two kinds of PHY for ranging: chirp-spread spectrum (CSS) and impulse radio (IR) [17]. CSS sweeps signal frequency to be higher (up-chirp) and lower (down-chirp) which consists a bit in CSS system [18]. Nanotron produces CSS-based ranging system and chipset [19]. IR-UWB generates burst position modulation (BPM) signal which occupies low band (3.3-4.7GHz) or high band (5.9-10GHz) [3]. Since severe regulation and signal shapes of IR-UWB makes its being a one-chip solution harder, Bespoon and Leti developed IR-UWB single chip in 2013 [20]. These solutions are candidates for indoor location solution, and maybe augmented to the smartphone for these purposes.

Pedestrian Dead-Reckoning (PDR)

Dead reckoning (DR) is the simplified version of inertial navigation system (INS). By estimating velocity and heading, DR system updates the user position. On the other hand, pedestrian Dead-Reckoning

detects user step and heading. Smartphone contains the accelerometer, gyroscope, and magnetometer. Step detection method depends on sensor position. If sensors are foot-mounted, zero velocity update (ZUPT) or zero angular rate update (ZARU) method could be implemented for step detection [21]. If sensors are on a handheld smartphone, the pedometer algorithm depends on user motion [22]. For accurate position estimation, some research focus on step length estimation [23], and other research study integration of PDR and other positioning method [10]. For heading estimation, gyroscope error increases without calibration and magnetometer is vulnerable to interference from outer disturbance. For compensating heading error, vision-based method [24] or map-matching [25] method would be helpful. Some smartphones are equipped with a barometer, which enables estimate user floor [26].

Conclusion

Surging smartphone market and increased use of WiFi gives new opportunities to indoor positioning technology. The developer could use WiFi signal by measuring RSS or AOA. Some positioning techniques based on these measurement gives positioning result only in a small area. In this case, pedestrian dead-reckoning method can be used together in order to give seamless position in indoor environment. Camera and map data could enhance the accuracy of PDR. Or possibly, UWB chip could be broadly used for indoor positioning.

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Certification of a Galileo Test Range

The Galileo Test Environment GATE is already ideally suited to test Galileo receivers in a real-life environment with multi-path and atmospheric conditions. It is unique and outperforms laboratory based simulators in this respect

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The successful development of receivers, application technologies and services is a key requirement for the commercial success of the European Satellite Navigation System Galileo. For that reason GATE has been established as real-life test and development environment for Galileo receiver products and applications, enabling developers to prepare and test their products for Galileo even before the satellite system reaches full operational capability (FOC). GATE closes the gap between laboratory tests with a simulator and the fully operational satellite system. It allows real-life tests of complex receiver products in a virtual satellite environment. GATE can be used since 2008. In 2011, coinciding with successful certification, GATE was officially opened. Since that time it has been continuously upgraded with new features.

The GATE test-bed consists of 8 'virtual satellite' transmit stations installed on mountains surrounding the test area in Berchtesgaden in the South of Germany. Each virtual satellite transmits the Galileo signal creating a realistic satellite environment in the test area. The system is complemented by two monitor stations and a processing facility to monitor and control the transmitted signals.

The signals generated by GATE are conform to the Galileo OS SIS ICD (Open Service Signal-in-Space Interface Control Document) signal specification and can be adapted if the signal specification changes. In 'Virtual Satellite Mode' the Galileo satellite constellation is simulated realistically: For an observer in the test area the 'GATE satellites' appear to be moving across the sky due to realistic simulation of the geometry dependent signal Doppler shifts of each satellite. A user is able to test an integrated product in this environment, also with odometer and/or inertial reference system coupled to the receiver, thereby exploring realistic scenarios complete with multi-path and possible interference.

All 4 Galileo IOV (in-orbit validation) satellites can be used in combination with GATE allowing tests of a complete Galileo constellation of up to 12 visible satellites. In addition the control center can inject deliberate failures into the 'GATE satellites' to simulate constellation errors, a feature which can be used to analyze the integrity of the user position (RAIM) and the behavior of a receiver in the presence of such errors. As the test-bed is compatible to GPS, interoperability tests using GPS and Galileo signals are also possible.

It is envisaged that GATE will continue to be used in the future, even when the space-based Galileo system is fully operational, to test further generations of Galileo signals on the ground and error situations like clock errors.

Figure 1: GATE Panorama

Certification of GATE as a Galileo test-bed

NavCert GmbH is unique in being able to offer certification under the TÜV-SÜD label for real-time and real-life testing of complex Galileo receiver products and applications.

GATE has been used extensively for tests by research organizations. But GATE should close the gap between laboratory tests and the final orbit configuration of Galileo, which is expected to be completed by 2018. GATE is primarily aimed at the 'Galileo Open Service' which is especially important for the 'land-mobility market' involving automotive, farming or leisure (climbers, hill-walkers, skiers) applications. The signals in the valley of Berchtesgaden can also be employed – with limitations – for test of aviation applications. Tests with a helicopter have been performed just recently.

Certification becomes essential when the test-bed is used as a reference for receiver testing for safety-critical applications. In such cases the regulating authority will ask for prove that all devices used for testing – and also the test-bed is to be viewed as such 'device' – are compliant to the relevant standards;

For the users of a test and development environment, e.g. developers of Galileo receiver hardware and software, it is essential that the test-bed is able to reliably reproduce test conditions. For this reason every experiment has to be executed with the respective required quality. Certification will regularly test the quality of operation and thus ensure good quality of all experiments that are conducted within the test-bed.

Certification based on standards

All certification is based on standards. Apart from a number of directive standards which were applied to GATE components such as e.g. the lightning protection of GATE transmit stations installed on mountain tops, or manufacturing standards which were applied to components, the certification of the GATE test-bed was not governed by a dedicated directive standard, GATE was subject of voluntary certification. After all functions and the performance of GATE were accepted by the DLR review team in the Final Acceptance Review, GATE was subjected to voluntary certification. The certification of GATE by a neutral body confirmed that GATE is compliant to the technical specification on one hand and that the project was completed and GATE is operated according to accepted QM-standards and rules.

For GATE – as a ground-based real-life satellite environment - no dedicated set of standards exists, so a new standard – based on existing, applicable standards – was developed suited to the GATE test-bed in particular. This new 'house'-standard was developed by NavCert and approved by TÜV-SÜD before it was applied. The 'Galileo test range standard' is based on the following standards:

ECSS Standards

GATE is unique in a sense that it establishes a satellite system on the ground. To construct a standard dedicated to GATE as a ground-based outdoor test environment, the new standard was based on the existing standards for space-based systems, which of course could not be applied fully, but were transferred to the ground-based system as reasonable and to the extent possible.

ESA (European Space Agency) in the past had their own set of space standards which the organization applied to products developed for ESA. National space agencies and private companies developing products for space used a different set of standards. It became apparent that a common set of standards was needed to ensure Europe's competitiveness and in 1993 the European Cooperation for Space Standardization (ECSS) was initiated by ESA, national space agencies and the space industry. The ECSS implements and maintains a common, coherent and user-friendly set of standards for space projects addressing aspects of:

- Project Management
- Engineering
- Product Assurance
- Space Sustainability

As GATE is a space project only in the figurative sense, space sustainability, i.e. the aspects dealing with the sustainable use of space in terms of e.g. frequency band or orbit usage, were obviously not applicable and were neglected. Other aspects however could well be transferred to a ground-based project.

Galileo OS SIS ICD

The European GNSS (Galileo) Open Service Signal-In-Space Interface Control Document (abbreviated OS SIS ICD) contains all publicly available information about the Galileo signal 'in space'. It is intended as a means to inform the (future) Galileo user community about the Galileo signal structure that will be received and allows manufacturers to construct receivers which are compatible to the Galileo signal.

GATE has been built to replicate the Galileo satellite constellation on the ground. It is therefore conform to the OS SIS ICD to the extent possible, but limitations due to the fact that it is a ground-based system apply such as the necessity to limit the bandwidth of the transmitted signals.

DIN EN ISO 17025

The 17025 standard contains 'General requirements for the competence of testing and calibration laboratories' and assesses if GATE is operated in accordance with standards and recommended practice as detailed in the ISO standard.

How was the certification of the Galileo Test Environment performed?

The certification of the GATE test-bed was performed in a number of steps covering all aspects that are applicable to demonstrate the performance and

usability as 'open-air' test laboratory for Galileo. The steps undertaken to certify GATE are listed in the following:

ECSS

Certification confirmed that all phases of the GATE project were carried out in accordance with the applicable ECSS space standards. Audits took place to validate the conformity to the respective ECSS standards.

GATE System Requirements

The GATE project documentation consists of a number of requirement documents for the various subsystems and the test-bed as a whole specifying all aspects of the system. Requirement conformity was assessed through audits and a detailed study of the GATE system and test documentation, followed by dedicated tests within the GATE test-bed. One important system requirement is signal conformity to GATE OS SIS ICD, which was validated by signal measurements within the GATE test-bed and at one of the GATE transmit stations.

GATE Performance

As the GATE system is operational quite some time, the current certification emphasizes stress on GATE performance and included tests of new capabilities. Important performance test points were:

- GATE Synchronization to GPS including GGTO (Galileo to GPS Time Offset) through upgrade of GATE receivers and GPF (GATE Processing Facility) to GPS L2C/L2P capability
- Mixed mode capability with GPS and Galileo IOV satellites
- Support of RAIM integrity test scenarios, generation of configurable feared events (Step and Ramp)
- E1 and E5a/b positioning accuracy ≤10m both stationary and dynamic

Operation of GATE as a 17025 test laboratory

Conformity of the test-bed laboratory to the requirements of ISO 17025 was assessed in an audit of the ISO requirements.

Figure 2. GATE Core Area near Schönau, Berchtesgaden, as seen from GATE Transmit Station GTS#5 on the Kehlstein mountain

Figure 3: Measurements near the GATE Central Point looking South

Figure 4: Signal measurements at the GATE Transmit Station #5 'Kehlsteinhaus'

Test Equipment Used

Localization tests in the GATE test-bed were conducted with two state-of-the-art PolaRx 3eG Pro and PolaRx4 PRO Septentrio receivers and compared to the results from the GATE User Receiver (GURx) developed by IFEN. The Septentrio receivers were employed as COTS (Commercial Off-The-Shelf) and GATE independent receivers expected to show similar behavior as when exposed to the future Galileo signal environment.

Results of the certification

Localization Accuracy

Localization accuracy was assessed on 4 positions in the GATE core area (at GATE central point WPT_017 and on three other positions) and on 2 positions inside the GATE test-bed, but outside the core area where, due to limited visibility of some GATE transmit stations, the accuracy was expected to be slightly worse than in the core area (Strub barracks and Sulzberg bus-stop). All results were as expected and according to the specification:

- All localization accuracies employing frequencies E1 and E5 were better than 10m on all positions inside the GATE test-bed;
- Two GATE independent state-of-the-art Septentrio receivers were able to achieve accurate position fixes in GATE mode VSM, as well as the GURx (GATE User Receiver) which is a Galileo/GPS receiver from IFEN. As expected the localization accuracy when combining the Galileo frequencies for position fixing was better than the accuracy achieved on individual frequencies.

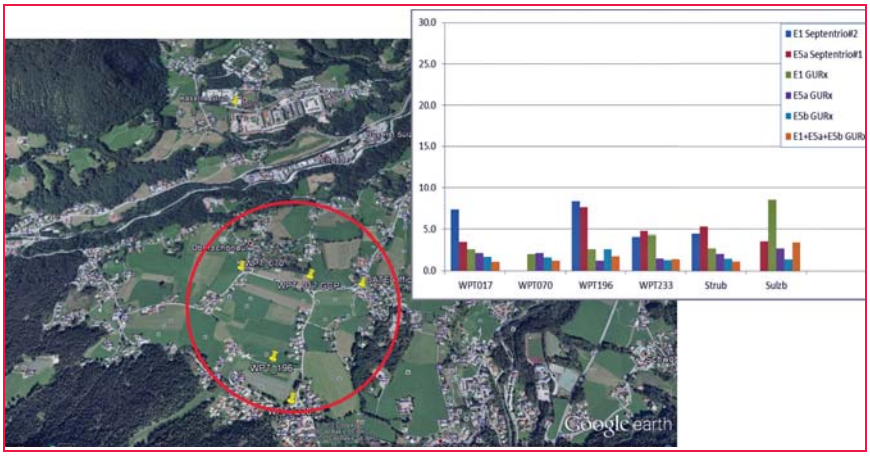

Figure 5: Measurement positions in the GATE core area (red ring) and outside shown in Google Earth and a summary of the localization accuracy of GATE in Virtual Satellite Mode: The graphic shows the localization accuracy in meters that is achieved at various positions in the GATE test-bed when different frequencies and combinations of frequencies are used to establish position fixes

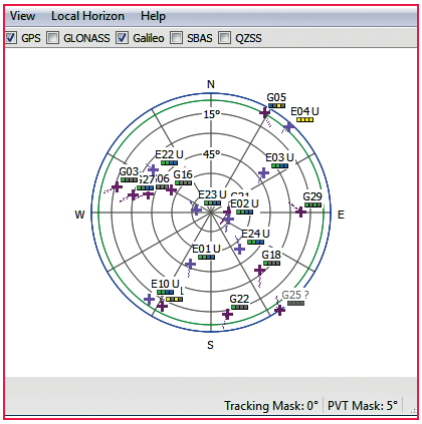

Figure 6: Septentrio Skyplot GATE+GPS

Mixed Mode Capability

GATE + GPS

Measurements in mixed GATE+GPS mode were performed with both Septentrio receivers: Septentrio receiver #1 combined GPS with measurements on Galileo frequency E5, Septentrio receiver #2 combined GPS with Galileo measurements on E1. The 'Skyplot' screen from the Septentrio software shows the constellation of GPS and GATE-Galileo satellites at the GATE Central Point, position WPT_017.

The tests of mixed mode capability – GATE together with GPS – resulted in successful position fixes fulfilling the interoperability requirements between Gate and GPS. By employing two state-of-the-art off-the-shelf and GATE independent receivers this, including the correct time synchronization between GATE and GPS, was demonstrated impressively. Both Septentrio receivers were able to calculate position solutions on the test positions in the GATE area with accuracies better than the required 10m. The HDOP values during the test were in general very good. In most cases they were below 2.

GATE + Galileo IOV Satellites

This test was performed on Tuesday 5th November 2013 between 13:25 and 13:40 (UTC) when all four GALILEO IOV satellites where visible in the GATE test area at an elevation greater than 10°.

This test was focused on the ability of GATE to integrate the Galileo IOV satellites into the GATE environment and to test GATE-IOV compatibility. The Septentrio receivers used for testing were again deployed into this environment and their position fixing capability was assessed on again the 6 test positions in the GATE test area.

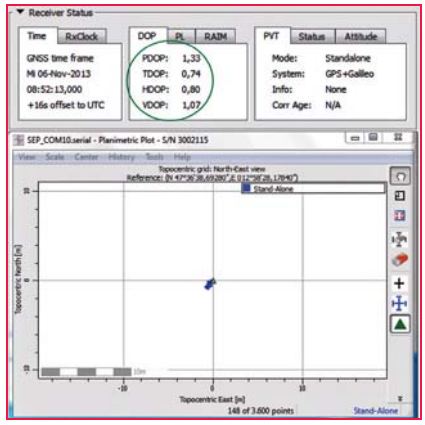

Figure 7: Septentrio#1 localization accuracy on GATE Central Point WPT_017 using Galileo and GPS; excellent DOP values were achieved

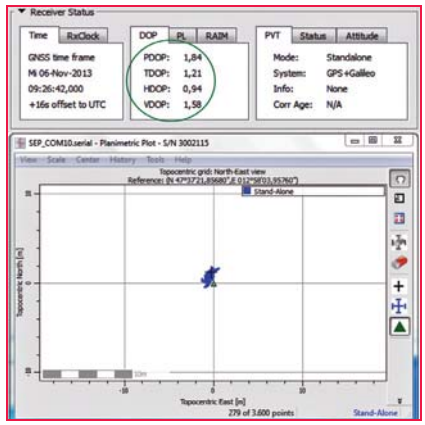

Figure 8: Septentrio#1 localization accuracy outside GATE core area using Galileo and GPS; excellent DOP values were achieved

Two Galileo IOV satellites were used in combination with two GATE (virtual) 'satellites' to establish position fixes at various positions in the GATE test-bed area in stand-alone Galileo mode. The Septentrio receivers were configured to form a position solution on the basis of two GATE (virtual) and two IOV satellites, ignoring the remaining GATE 'satellites' and forcing them to calculate a combined GATE-IOV solution.

The results of mixed mode capability tests were very positive and the

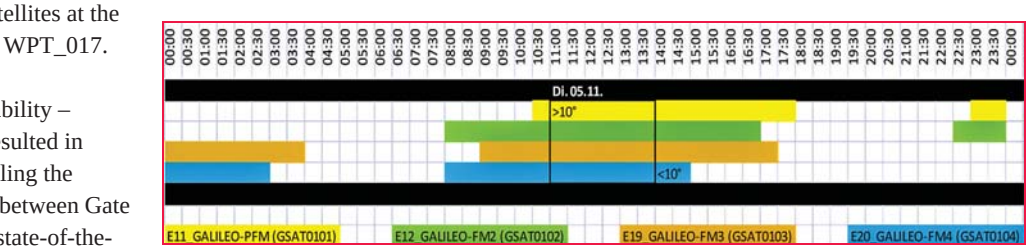

Figure 9: Galileo IOV satellite visibility on Tuesday, 05th November 2013

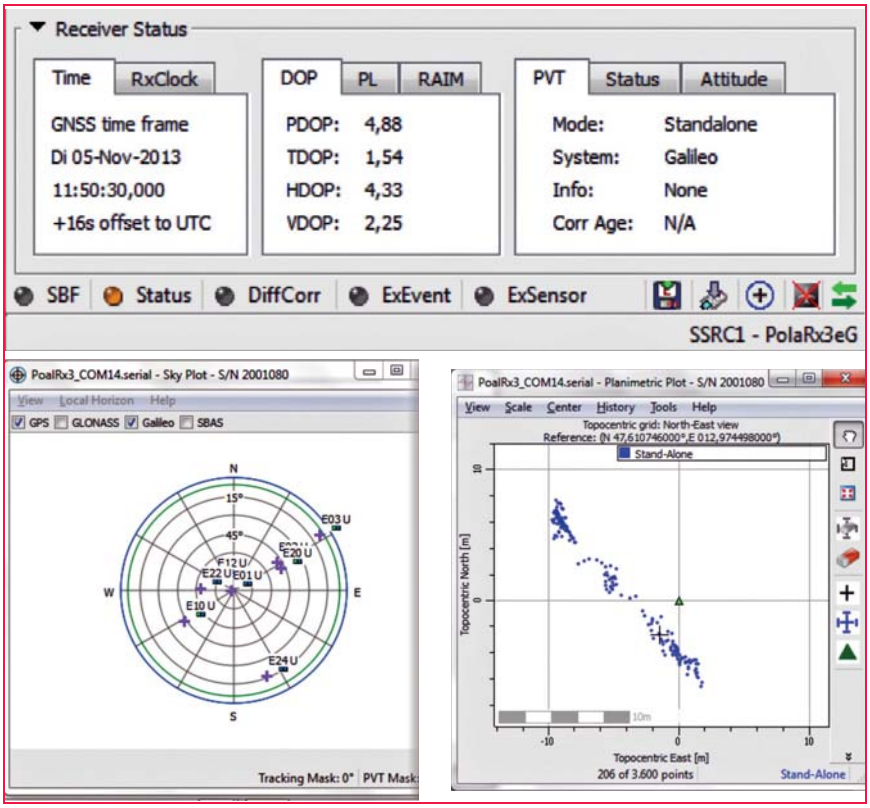

Figure 10: Screenshot Septentrio SBF Analyzer Software on 5th Nov 2013, tracking IOV Satellites #E12 (E12_Galileo-FM2 GSAT0102) and #E20 (E20_Galileo-FM4 GSAT0104) and GATE satellites E03 and E10

Figure 11: Position fixed at GATE Central Point and results exported to Google Earth: The yellow pins marks the reference position on WPT_017 GATE Central Point; the blue trace shows all positions measured between START and END of a 3 minutes measurement; deviations were observed to lie within a 5m radius

compatibility between IOV and GATE (virtual) satellites could successfully be demonstrated. On all test positions in the GATE area the receivers were able to calculate reliable 2D position fixes. On frequencies E1 and E5a and employing only two satellites of each type, localization accuracies better than 10 meters were achieved. The low DOP values arise from using only 4 satellites for position fixing.

Signal Validation

Next to actually using the GATE signals to establish position fixes in the test-bed, which already proved compatibility to the Galileo signal specification, the signals themselves were assessed and analyzed in detail. Comprehensive measurements of the carrier frequencies, the transmitted spectrum and RF (Radio-Frequency) power distribution, of Code Carrier and Code Data Coherency and of the signal contents such as the NAV message structures were conducted.

For a thorough assessment of the signals, undistorted by transmission and influences by multi-path and weather down in the valley, the signals were tapped directly at a GATE Transmit Station (GTS) on a mountain. For accessibility reasons GTS#5 on the Kehlstein mountain was selected as it can be reached by a road and is open to late in the year.

The picture (figure 12) shows the signal spectrum as recorded at the Kehlstein GSG (GATE Signal Generator) showing the complete GATE/Galileo signal in the L-Band.

Test of Integrity Alert & Feared Event Generation Functionality

GATE possesses the ability to generate deliberate failure modes so that the behavior of receivers in the presence of such failures can be assessed in the test-bed. GATE allows simulating two failure modes which can be injected into individual GATE 'satellite' messages:

- SISMA (Signal-In-Space Monitoring Accuracy) Integrity Alerts, which on the Galileo system is broadcast to the users through the integrity message
- Feared Events: To support user RAIM integrity test scenarios, GATE is able to generate configurable feared events (failure types: Ramp with ascending slope, constant error, descending slope).

It was verified that all integrity flags and SISMA values entered during the test were correctly received and immediately displayed on the test receivers. Tests and

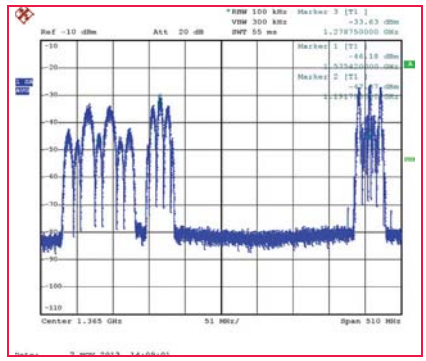

Figure 12: Measured GATE signal spectrum including E5, E6 and E1 (Spectrum Analyser)

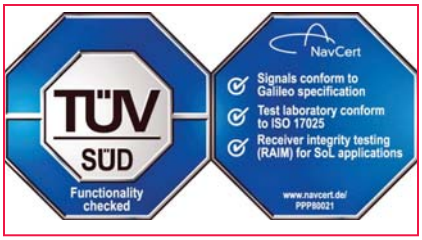

Figure 13. TÜV-SÜD test mark awarded to GATE after successful certification

subsequent analysis of results showed that the integrity alert feature as implemented in GATE functioned as intended.

A 'Feared Event' is a disturbance of the signal transmitted by one (or more) satellites which leads to the degradation of the position solution computed on a user receiver. The functionality of GATE to generate Feared Events in terms of clock jumps and drifts (Steps and Ramps) on one or more frequencies was tested by selecting different PRNs and setting the Feared Event on them. The PRNs were selected randomly. The tests with the off-the-shelf Septentrio Galileo receiver showed that GATE correctly implements the Feared Event functionality and is able to generate this error as intended.

TÜV-SÜD Test Mark

After successful certification a test-mark was awarded to the GATE test-bed which highlights significant capabilities:

- Operation of GATE as a test laboratory in accordance with ISO 17025
- Signals are conform to the Galileo specification and therefore the test-bed is suited to tests of Galileo receivers
- Test-bed allows RAIM testing, a prerequisite if receivers shall be tested for Safety-of-Life (SoL) applications.

Summary & Outlook

The Galileo Test Environment GATE is already ideally suited to test Galileo receivers in a real-life environment with multi-path and atmospheric conditions. It is unique and outperforms laboratory based simulators in this respect.

Already today GATE allows test of receiver applications in an environment where GATE satellites are mixed with the existing Galileo IOV (In-Orbit Validation) satellites and GPS. GATE will be adapted to include further satellites progressing to FOC (Full Operational Capability). In addition GATE even outperforms the Galileo constellation in one aspect as it allows testing of failure scenarios. Failures can be injected into the GATE satellites and the behavior of receivers in an environment where one or more satellites are in error can be tested and evaluated.

GATE continues to be developed further and new capabilities are being added to the test-bed. Recertification of GATE and the assessment of the new capabilities will accompany the process of further enhancing the test-bed, such as the implementation of further integrity test scenarios and adaptations of the Galileo signal structures. GATE is flexible enough to be adapted to all new generations of Galileo satellites and it will continue to be used for that purpose. Certification will always ensure that the new signals are conform to the signal specifications and are 'safe' to be trusted.

Point of View

Perspectives on the Survey and Measuring Equipment Market in India

When one is very close to a thing it becomes blurred and to see it in focus one has to step back. To get a focus on the Survey and Measuring Equipment (S&ME) Industry in India we also stepped back from the humdrum and interacted with stakeholders in the industry in the latter half of 2013. We had done a similar exercise five years ago and published our findings in the article – *In the line of Sight* (*Coordinates* March 2009).

This time we probed different aspects of the S&ME Industry like the market scenario; applications; awareness about the Industry and the issues facing it; marketing and procurement strategies adopted by the Dealers and Users; after sales support; and behavior and decision parameters of the Users. Our interactions provided us with rich insights into the Industry and we present them here for our readers.

The canvas

Our story has played out on a canvas which has changed quite dramatically in the past few months. The India of the present is quite different from what it was at the end of last year. The political dust that had risen in the run-up to the 2014 Parliamentary elections has finally begun to settle down. With a stable government at the helm, the immediate effect of this election result in buoying both the stock market and the Rupee can be taken as a sign of positive things to come.

In August 2013, with the rupee hitting a record low of 68.85 to a dollar and the uncertainty on the political front paralyzing all policy and decision-making; the S&ME Industry was hit hard in two areas where it is quite vulnerable. Firstly, the Industry was severely impacted by the rupee-dollar dance since it is almost entirely based on import of equipment. Secondly, being highly dependent on government projects/ clearances for large orders it was affected by the political flux preceding the elections. With both these factors now steadying out, hopefully the proverbial dark cloud has passed and the sun will once again shine on the Industry.

The application stimulus

During our interactions we found that the two applications of Infrastructure and Roads and Highways lag behind the conventional applications like GIS, Mapping, Land Survey, Engineering Survey and Cadastral Survey in their use of survey equipment (Chart 1); but they now seemed to be poised to reach new heights.

The new Government, lead by the fifteenth Prime Minister of India, Narendra Modi has made a spate of announcements which could spell a bonanza for the beleaguered S&ME Industry in the country. Nitin Gadkari, the Minister for Road Transport, Highways and Shipping announced the fast tracking of about 50 stalled road projects; the Minister has also given the in-principal go-ahead for a project to interlink the Ganga, Brahmaputra, Mahanadi and Godavari rivers to create a national waterway grid. This grid too would have a road network to link the river ports. Venkaiah Naidu, the Minister for Urban Development and Housing and Poverty Alleviation has announced the prioritization of infrastructure development of satellite towns and linking of twin cities across the country by his Ministry; besides aiming for 'housing for all by 2010'. These are just a few examples of mega infrastructure projects which are in the pipeline.

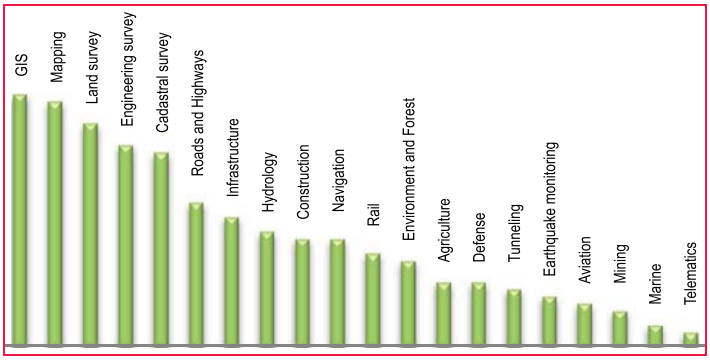

Chart 1: Main ApplicaDons for which Survey Equipment is used in India

Hyderabad which had emerged as the GIS and IT capital of India over the years had to face roadblocks in 2013 because of the agitation over the demand for the separate state of Telangana. In June 2014 the state of Andhra Pradesh has been bifurcated into Telangana and Seemandhra

Use of survey and measuring equipment is also gaining momentum in application areas like mining. With new mining guidelines on the anvil, use of technology is likely to get a boost; while programs like the Geological Survey of India's (GSI) National Geomorphological and Lineament Mapping, Hyperspectral Mapping, National Aeromagnetic Mapping, National Geochemical Mapping and Geophysical Mapping have already been initiated.

One other application where survey and measuring technology could have far reaching consequences in the country is Agriculture. Different studies have established that leveling of a field through laser leveling helps to save water and improve yield besides giving other benefits. Leveling also opens up the option of precision farming – the potential of this technology in India could be phenomenal given the country's largely agrarian base.

The hurdles

As has already been mentioned, most survey related equipment vended and used in India is imported into the country. With a high import duty and the vulnerability of the rupee in the backdrop, it did not come as a surprise when a majority of the respondents we interacted with, listed lowering of import duty as the priority measure needed for the growth of the industry (Chart 2).

Given that licensing in India, whether related to the use of certain GNSS equipment or to permissions for aerial/land mapping/surveying, has remained a bone of contention for all stakeholders in the Industry; easing of licensing has been listed as the second priority measure.

The issue of trained manpower continues to haunt the industry. The responses from five years ago are echoed in the responses this time too. Everyone agrees there is a shortfall and urgent measures are needed by all the stake holders, whether in the Government, Private or Academic sector to correct the situation. However the ground reality continues to show that skilled manpower capable of using survey equipment and utilizing the technology in various applications is still in extremely short supply.

One other factor that seems to pinch the industry is the lack of an indigenous product to match the quality of the imported products. The general perception among the stakeholders is that if such a product or products were available the dependence on imports would be reduced. However, Indian survey equipment manufacturing is missing from the global digital equipment competition map. During the discussion on import duty and indigenous products an interesting observation was made; in the absence of an Indian product or indigenous digital survey manufacturing industry worth mentioning what was it that was being protected by the high import duty on the products being brought into the country? Logically it would make sense to reduce the import duty on the survey and measuring equipment to allow the industry to grow.

The guiding factors

Collectively the industry maintains that Quality is the most important guiding factor while selling or buying a product while Price is least important (Chart 3); the Users also placed Project Need and New Technology ahead of Fund Availability as the driving force to buy products (Chart 4) – thus bringing the quality-price debate to the fore once again.

The Indian market is considered to be extremely price sensitive as a general rule, could this be changing? For the moment the quality and price debate seems to be quite inconclusive because no generalization can be made at least as far as the S&ME Industry goes. A User segment has emerged which is extremely conscious of quality but one cannot deny the co-existence of another segment of Users who are guided by price.

Another direction in which the quality-price debate has moved is After Sales Service which seems to have made a big impact on the psyche of both the Dealers and the Users. The quality and price of servicing is seen as the crucial tipping factor today and with other things being equal; the competition has jumped to the next level – that of providing maintenance and servicing facilities.

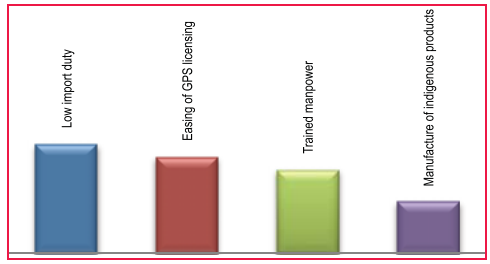

Chart 2: Measures needed for the growth of the Survey and Measuring Equipment Industry in India

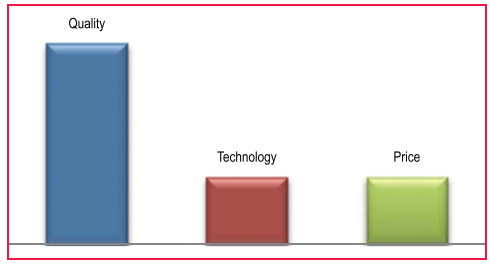

Chart 3: Basis on which a product is selected for selling/using

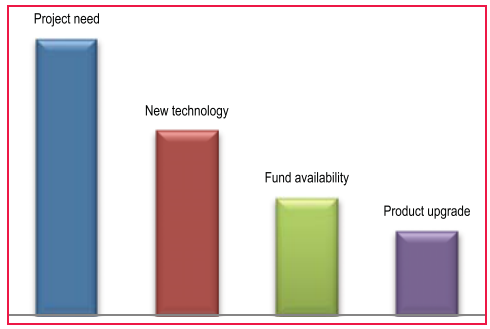

Chart 4: Driving force to buy products

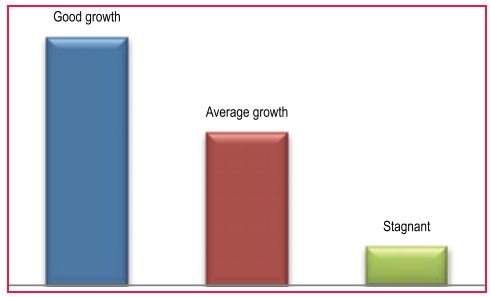

Chart 6: Opinion about the future prospects of the industry (in the next 5 years)

Chart 5: User rating of factors while purchasing products

		Analysis
Brand	Very Important	Brand consciousness and loyalty are an emerging trend for the Indian customer as a whole, no wonder then that the User of survey equipment too has rated Brand as a very important factor.
Quality	Very Important	With the scales tipping in favor of Quality, Price seems to automatically become less significant; however as we have said, the jury is still out on the quality-price debate in the S&ME Industry.
Price	Important	
Appropriateness for an application	Very Important	With an increasing number of applications for which survey and measuring technology is now considered essential emerging in the country the User has become more conscious about the suitability of certain products and brands for specific applications.
Technical Aspect - Optics	Very Important	The User gave the due weightage to each technical aspect as per his understanding and need.
Technical Aspect – Accuracy	Very Important	
Technical Aspect - Touch Screen	Important	Not all Users had the same level of comfort with touch screens given the frequent use of the equipment in rugged conditions.
Technical Aspect - Data transfer mode	Very Important	Interoperability and ease of data transfer are very important for the User today since they save time and simply the processes.
Battery backup time	Very Important	Again, given the mostly outdoor use of the equipment the backup time was considered a very important factor.
Weight/ Portability	Important	As a rule is was felt that the weight of most survey equipment has reduced over the years and though important, Weight is not really seen as a guiding factor while buying equipment.
Durability	Very Important	With most Users saying that they retain the equipment bought for one project for the next one, it was logical that Durability be considered very important.
User friendliness	Very Important	With the Industry facing a continued crunch of trained manpower, it was considered crucial for the equipment to be User friendly so that it could be used with the minimum training.

A spate of mergers and acquisitions has led to consolidation in the Survey and Measuring Equipment Industry globally. Five years ago there were several contenders for a share in the Survey and Measuring Equipment Market pie; today, there are many players in the fray but the race to the top is among a few only. In the coming years this could lead to fewer choices for the Users and reduced competition

An aware and educated User is the sign of a maturing industry. Analyzing the User opinions about various aspects of a product (Chart 5) gives an insight into the factors that guide the Indian User of survey and measuring equipment.

The third dimension

Five years ago we had a two-dimensional picture of the industry through the eyes of the Dealers and Users. This time around we discovered a third dimension – that of Rental Organizations. These organizations provide survey equipment on rental basis along with trained personnel if required; this enables their clients to avoid investing in equipment or manpower and also takes away the headache of maintenance since all of these are undertaken by the rental company. It will be interesting to see whether this dimension is able to gain momentum and establish itself.

The road ahead

Survey and mapping have a rich tradition in the country with Survey of India being the oldest scientific department of the Government. Carrying the torch into the 21st century are missions like the GPS-Aided Geo Augmented Navigation (GAGAN) and the Indian Regional Navigation Satellite System (IRNSS). GAGAN, the Satellite Based Augmentation System (SBAS) became operational in February 2014. While in April 2014 the Indian Space Research Organization (ISRO) announced the successful launch of the second satellite in the IRNSS group - IRNSS-IB.

All respondents we interacted with opined that the S&ME Industry will see a good growth in the coming years (Chart 6); when the survey was conducted at the end of 2013 this had seemed like wishful thinking but today in 2014 with the winds of change in the air this seems viable.

– Shubhra Kingdang

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Implementing multipurpose cadastre in Malaysia

As part of the Department of Survey and Mapping Malaysia (JUPEM) continuous effort to further modernize the cadastral system in Peninsular Malaysia, a pilot project on multipurpose cadastre (MPC) for the Federal Territory of Putrajaya (Putrajaya) has been carried out.

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The MPC Pilot Project for the Federal Territory of Putrajaya has enabled JUPEM to understand the complexity in the implementation of the MPC for Malaysia

The Federal Territory of Putrajaya (Putrajaya) is the administrative capital of the Malaysian Federal Government with an area of 4931 hectare. It is divided into 20 precincts and consists of 10,580 land parcels**.** The Department of Survey and Mapping Malaysia (JUPEM) is a government agency responsible for the geodetic, topographical, mapping and cadastral surveys in Malaysia. JUPEM is also responsible for the demarcation and survey of the state and international boundaries.

The cadastral survey in Malaysia is based on the cadastral coordinated system. Steps have been taken to enhance the National Digital Cadastral Database (NDCDB) for Peninsular Malaysia (including Putrajaya) and Labuan with survey accurate coordinate system.

In the bid to understand the complexity and structure of a Multipurpose Cadastre (MPC) concept in Malaysia, a MPC pilot project has been conducted in Putrajaya.

Multipurpose cadastre (MPC)

The modern cadastral system is made up of the cadastral map and associated registers. Both of these entities represent the graphical and textual component of the cadastral system. With the modern cadastral system continually evolving to meet the demand of the land market, other land information databases containing information such as planning control and the land-value assessment are being progressively added onto the modern cadastral system. This modern cadastral system is a step towards the Multipurpose Cadastre concept. The Multipurpose Cadastre is an extension of the modern cadastre to include other land information registers.

The multipurpose cadastre concept was described as '*a framework that supports continuous, readily available and comprehensive land-related information at the parcel level.'* The concept is expected to benefit all levels of governments and society. Increased sharing of datasets, public transactions of data and reduction of administrative costs are a few of the benefits foreseen.

A multipurpose cadastre is designed to record, store, and provides not only land records information but also a wide variety of parcel-object related information using large scale base map. It is truly multipurpose since it not only receives information and data from many sources, but it also provides relatable services and products for many purposes and to many users.

MPC pilot study for Putrajaya

The scope of work for the MPC pilot project for Putrajaya is as follows:

- Development of an updated Local Geospatial Data Centre (LGDC) dataset with new large scale geospatial dataset and integrating it with the NDCDB;
- Data acquisition using MTLS system for generating 3D point cloud of Putrajaya and extraction of building footprints and other related geospatial features;
- Data fusion comprising high resolution satellite image, LiDAR and terrestrial

point cloud data to generate 3D city model and 3D Spatial Data Infrastructure (SDI) for Putrajaya;
- Development of MPC Application Module;
- Integration with street addresses database for Putrajaya;
- Development of Ubiquitous Multipurpose Cadastre System-incorporating Service Oriented Architecture (SOA); and
- Development of Online Web Access Putrajaya MPC Database which consist of LGDC, building footprints, street addresses, high resolution satellite image and 3D city model.

For the MPC pilot project, the enhanced National Digital Cadastral Database (NDCDB) which is referenced to the Geocentric Datum of Malaysia2000 (GDM2000) through a dense Cadastral Control Infrastructure (CCI) serves as the fundamental reference layer. Consequently, the 2D Local Geospatial Data Centre (LGDC) dataset for Putrajaya was updated and referenced to the NDCDB. The other core data layer that has been developed for MPC Putrajaya is the 3D city model using 3D point-cloud data acquired through Mobile Terrestrial Laser Scanning (MTLS) technology. As such, the MPC system that has incorporated 'survey accurate NDCDB' and 'survey accurate 3D geospatial data acquisition technology' can be called a 'survey accurate MPC'.

Project implementation approach

Figure 1 shows the implemented workflow for MPC Methodology being carried out in the MPC Putrajaya project. The JUPEM NDCDB enhancement project that is being concurrently implemented provides large scale cadastral layer over Putrajaya. Additional geospatial features data collection has been carried out using Mobile Terrestrial Laser Scanning (MTLS) technology. The output of MTLS is a 3D point clouds represent coordinate (x,y) and elevation (height). 3D point clouds from MTLS produces geospatial information such as 3D-city model and DTM for Putrajaya. Combination of these two 3D datasets produce the 3D SDI database.

A module for Integration, Validation and Updating of MPC datasets has been developed for the integration, validation and updating purposes of various large scale geospatial basemaps. 3D MPC Online Web Access has been developed using ArcGIS Server platform accessed via ArcGIS Explorer Desktop that provides service oriented architecture (SOA) functionality. 3D MPC Online Web Access provides access to the 3D SDI datasets and possible SOA services.

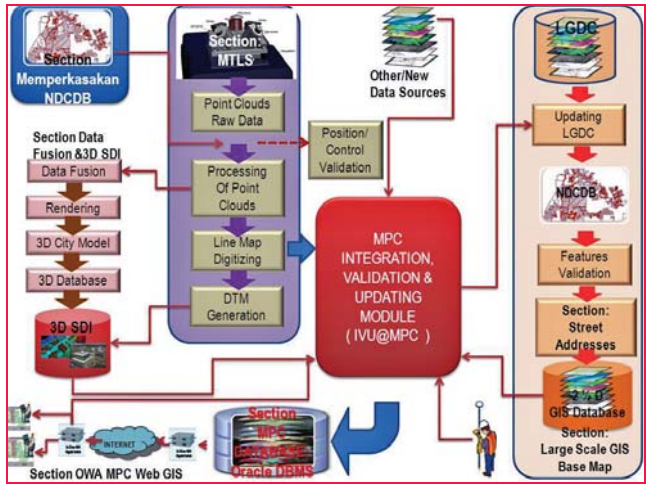

Figure 1: Overall MPC Methodology Workflow

2D existing geospatial data acquisition

Using the existing data, the 2D Local Geospatial Data Centre (LGDC) for Putrajaya has been updated with primary purpose of creating theme layers for all large scale geospatial basemaps in Putrajaya. Primary sources of the available datasets were extracted from the existing database available at JUPEM and Malaysian Centre for Geospatial Data Infrastructure (MaCGDI): GLMS layers, large scale mapping data, digital elevation model, high resolution satellite image, airborne LiDAR data, orthophoto, utility data, street addresses, textual data, MyGeoid data, MyRTKnet station coordinates, levelling benchmark values and cadastral control infrastructure coordinates.

Furthermore, the State Geospatial Data Centre (SGDC) dataset available at MaCGDI for Putrajaya area has also been acquired to be integrated with the LGDC data. The SGDC data consists of various data categories such as Built Environment, Transportation, Demarcation, Topography, Vegetation, Hypsography, Hydrography and Utility.

3D MTLS point cloud data acquisition

MTLS is an emerging technology that combines the use of a laser scanner(s), the global navigation satellite systems (GNSS), and an inertial measurement unit (IMU) on a mobile platform to produce accurate and precise geospatial data. The data is initially adjusted by post-processed kinematic GNSS procedures from separate GNSS base stations placed throughout the project area. The GNSS solution is then combined with the IMU information to produce geospatial data in the form of point cloud. This point cloud is then adjusted by a local transformation to well defined points throughout the project area to produce the final geospatial values. Point clouds have been produced in GDM2000 coordinate system and vertical reference being reduced to Mean Sea Level (MSL) and National Geodetic Vertical Datum (NGVD).

Additional 3D geospatial features for Putrajaya has been carried out using Mobile Terrestrial Laser Scanning (MTLS) technology. The MTLS scanner (DynaScan system) (*http://www.mdl.co.uk)* which has been used for data collection includes scanners, GNSS units, IMU, processing software and all equipments complied with the specified specifications. The accuracy of DynaScan MTLS system at 95% confidence level (1σ) are as follows: horizontal accuracy: ±5cm and vertical accuracy: ±7cm.

The output of MTLSafter processing is 3D point clouds that represent Geocentric

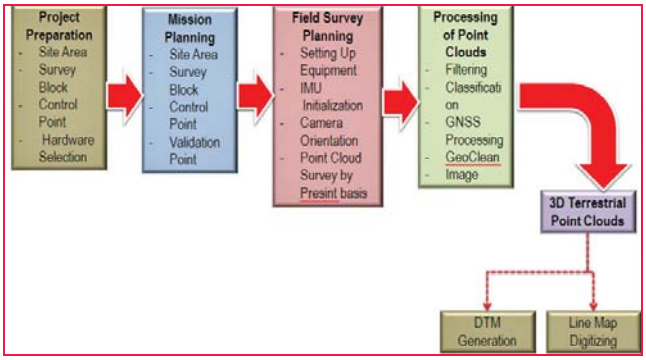

Figure 2: Adopted methodology for MTLS Data Collection

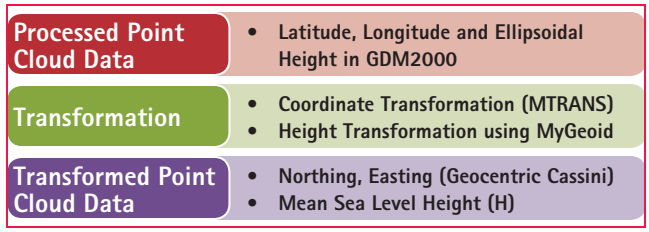

Figure 3: Coordinate Transformation for Point Clouds Data

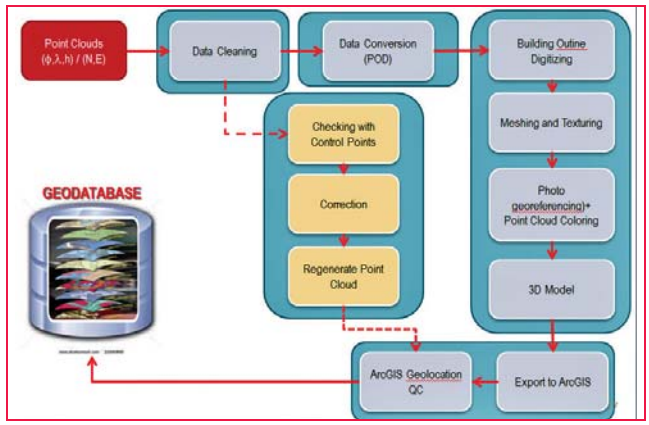

Figure 4: MTLS data processing methodology

Cassini coordinate (N,E) and elevation above sea level (H). 3D point clouds from MTLS produces geospatial information that comprise of building footprint, road, utility (lamp post, fire hydrant, electrical post and else), lake, tree and other features captured in the scanning window.

The adopted methdology for MPC MTLS data collection is shown in Figure 2. The methodology comprises five main phases of activities as follows: Project Preparation, Mission Planning, Field Survey Planning, Processing of Point Clouds and Digitization from processed 3D Point Clouds.

Geodetic Datum Transformation System (MTRANS) Version 4.1 software has been used to transform all the point clouds to GDM2000 datum reference system and projected to Cassini (GDM2000) coordinates. Vertical reference system was based on National Geodetic Vertical Datum (NGVD) by reducing the ellipsoidal height to Mean Sea Level (MSL) height using MyGeoid and local levelling bench marks (Figure 3).

The top part of buildings in Putrajaya was not able to be scanned by MTLS survey. Hence, additional data provided by LiDAR and high resolution satellite images have been utilized to fill-up the gaps (roof top images). Detail on the adopted processing methodology for the collected MPC MTLS data is shown in Figure 4.

MPC application module

MPC Data Integration, Validation and Updating Module has been developed based on a desktop-based GIS development environment to extend GIS functionality, customize and automate repetitive operations, and integrate ArcGIS version 10 with VBA functionality.

Integration with street addresses database

Street addressing is to assign an address using a system of maps and signs that give the numbers or names of streets and buildings. Geocoding of Street Address database was based on the enhanced NDCDB and building feature acquired during data acqusition process. Enhanced NDCDB consists of cadastral lot information, Unique Parcel Identifier (UPI) and newly created object identification (OID). OID was also created for building feature. Based on the street address database, geocoding process can be conducted systematically using cadastral lot number, UPI and OID. These information can be linked to zip or postal method to generate street address based on integrated MPC GIS base map.

Generating 3D city model

Present geospatial data acquisition technology coupled with the advances in geographical information system (GIS) and computer technologies enable the creation of 3D landscape models. 3D city models are the most widely created and used landscape models. They consist of Digital Elevation Models (DEM) of ground surface overlaid with structure and texture of buildings. Such models may be created at five levels of detail (LoD).

- LoD0: a DEM with superimposed ortho-rectified aerial or satellite imagery.
- LoD1: basic block-shaped depictions of buildings are placed over LoD0.
- LoD2: LoD2 adds to LoD1 detailed roof shapes.
- LoD3: represent further expansion by adding to LoD2 structural elements of greater detail, such as facades and pillars, and draping all objects with photo texture.
- LoD4: the highest level, is achieved when the building can be virtually visited and viewed from the inside.

For this pilot project, Level of Details 2 (LoD2) has been used to depict 3D building in the housing estates in Putrajaya. Buildings in Precinct 14, Putrajaya, for example were digitized in this manner. Level of Detail 3 (LoD3) has been used to depict main government buildings along the Main Boulevard in Putrajaya, while LoD4 has been developed for the Putrajaya Central.

3D Model for Putrajaya has been digitized manually using Google Sketchup and exported to ArcGIS Map (Figure 5). This was then integrated to

the database in ArcGIS Server. This project could be recalled via a client PC through ArcGIS Explorer Desktop.

3D City model visualization for Putrajaya integrates image textures for rendering process. This process generates virtual reality of the real world. Sketchup and ArcGIS Desktop Explorer software has been used to drape the related image to 3D city model as shown in Figure 6.

The 3D City model was generated from the MTLS and GIS Base Map data categories. Attribute entry has been carried out based on the available information obtained from the MTLS scanning. Data fusion from multiple geospatial datasets contains attributes information enriched the 3D city model for Putrajaya (Figure 7). LoD 3 is used for the Main Boulevard. Residential area in Precinct 14 is used as a pilot area for LoD 2 digitizing and overlaid with the current NDCDB.

PUTRAJAYA MPC database

The MPC Database development is the core for the whole pilot project. It consists of the following main characteristics:

- NDCDB as a base map;
- Local Geospatial Data Centre data;
- Geographic Information – Feature and Attribute Codes (MS1759);
- Malaysian Metadata Standard (MMS);
- National Geonames Database;
- Unique Parcel Identifier (UPI) and Administrative Code;
- Colour Code and Symbol;
- 3D City Modeling for Putrajaya; and
- 3D Spatial Data Infrastructure for Putrajaya.

The accuracy of 3D MTLS features in the MPC Database for Putrajaya has been found to be better than 15cm for horizontal coordinates while the accuracy of the vertical coordinate is twice the accuracy of the horizontal coordinate. This accuracy can be further improved with the use of a more sophisticated MTLS system.

PUTRAJAYA MPC online web access

3D MPC Online Web Access has been developed using ArcGIS Server platfrom accessed via ArcGIS Explorer Desktop or ArcGlobe that can provide service oriented architecture (SOA) functionality. 3D MPC Online Web Access can provide access to the 3D SDI datasets and possible SOA services.

The main security window has both login for JUPEM staff and public access. The public will have limited access to the database. JUPEM login will have full login to database. For public users who wish full access to the database can apply to JUPEM directly for a full access username and password.

For 3D viewing, MPC ArcGIS Desktop Explorer is used. All viewing of 3D Models will be through the software intended for public users. Users are required to have access to the MPC Server to be able to view the 3D models. JUPEM users who have access to ArcGlobe are also able to view the 3D models, but JUPEM users also need access to the MPC Server.

Figure 5: 3D Model of Persiaran Perdana in Putrajaya

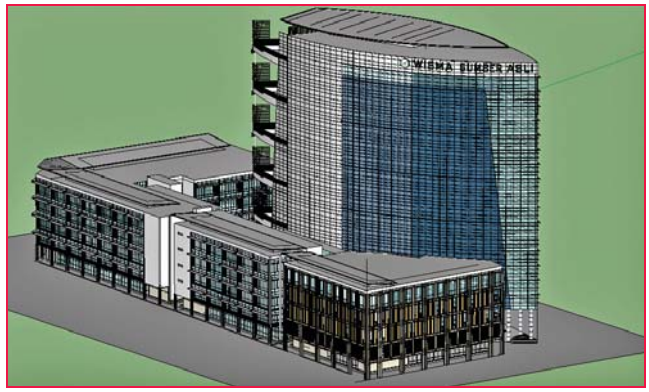

Figure 6: 3D City Model of a building in Putrajaya

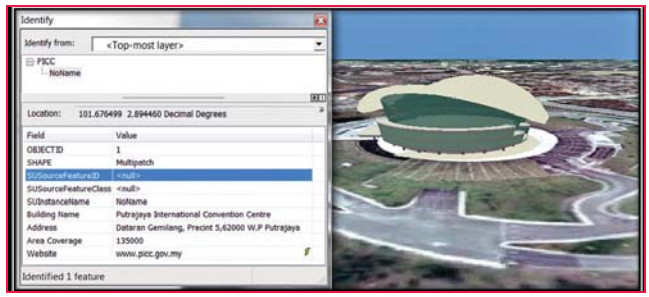

Figure 7: Object Attribution for 3D City Model

Ubiquitous and Service Oriented Architecture (SOA)

Ubiquitous means the ability to have or seeming to have the ability to be anywhere at anytime. MPC-OWA means mechanism or system that could integrate all related information for a land parcel in order to provide maximum accessibility in term of location, time and method of access. User can access MPC information using various devices such as personal computer, handheld terminals and smart telephone that is connected to an online system.

Benefits of MPC

The benefits resulting from the development and use of a MPC system has been recognised for some time. The MPC system that has been developed for Putrajaya incorporate

some of the recent most advances in computer and GIS technologies as well as the latest MTLS 3D geospatial data acquisition technology. The MPC system that has been developed certainly will revolutionise the way large scale geospatial data is utilised in this country.

Applications of MPC include utility mapping, land administration, urban and regional planning, land valuation, flood mapping, GIS for local authorities, emergency response services, crime GIS, environmental management and coastal management.

Findings and recommendations of the pilot project

The findings and recommendations of the MPC pilot project in the Federal Territory of Putrajaya are as follows:

- Existing geospatial data in the State Geospatial Data Centre (SGDC) and Local Geospatial Data Centre (LGDC) need to be geo-referenced with respect to the NDCDB. The SGDC and LGDC need to be current and complete.
- Survey grade MTLS system should be employed in 3D point cloud data acquisition to ensure higher level of accuracy and resolution of the acquired 3D features.
- There is an urgent need to develop a program for the production of large scale base map at scale 1:500 to 1:1,000 in urban areas and densely populated, 1:5,000 to 1:10,000 in semi-urban areas, while for rural and remote areas at scale 1:25,000.
- The scope of cadastral survey should be enhanced to collect large scale geographic information such as building footprint, drain, fire-hydrant, access road, etc., and the features are to be updated into MPC Database.
- The MPC Database needs to be continuously maintained in order to ensure acceptable spatial accuracy, temporal accuracy, thematic accuracy, completeness, consistency, and resolution.
- MPC Database should be integrated with the NDCDB and high-rise building database for data updating purposes. On the other hand, SOA concept should be used for updating information from other databases such as mapping databases, underground utility database and other databases from other agencies.
- Priority should be given for the implementation of MPC in major cities in Peninsular Malaysia and Labuan in phases, followed by MPC implementation for semi-urban and rural areas with reduced resolution.
- Future marine geospatial and cadastral infrastructure should be incorporated in the MPC Database.
- Public assessment and feedback should be sought from other government agencies, private sector and the public to assess the relevancy of the MPC Database.

Conclusion

The MPC Pilot Project for the Federal Territory of Putrajaya has enabled JUPEM to understand the complexity in the implementation of the MPC for Malaysia. It is hoped that the findings and recommendations based on the pilot project will enable the successful gradual implementation of the MPC for the whole country. This will surely enhance the concept of spatially enabled government and society in Malaysia and fulfilling the nation's vision.

References

Department of Survey and Mapping Malaysia – Final Report on MPC Pilot Project for Federal Territory of Putrajaya, January 2013.

Department of Survey and Mapping Malaysia – Final Report on the Enhancement of National Cadastral Database for Peninsular Malaysia and Labuan, November 2012.

The paper was presented at FIG Working Week, Ambuja, Nigeria, 6 - 10 May 2013.

At a Glance

- viaEuropa Cloud map services awarded G-Cloud 5 framework contract
- Airbus D&S Partners with BAE Systems on Radar Satellite Imagery
- Surrey Satellite Technology Ltd (SSTL) announces the launch of TechDemoSat-1, planned for 28th June 2014 by a Soyuz-2 launch vehicle with a Fregat upper stage from the Baikonur Cosmodrome in Kazakhstan
- C&C Technologieshas purchased the iXBlue fourth-generation GAPS USBL acoustic positioning system for the company's Mexico division
- MDA expands imaging modes for RADARSAT-2
- Supergeo Establish User Network with Evolving Geosystems in UAE
- Esri Supports OGC GeoPackage Encoding Standard
- BlackBridge secures $20.25 million funding for RapidEye+
- Fugro awarded one year contract by Basrah Gas Company
- Formosat-2 celebrates a decade in orbit
- Lockheed to launch DigitalGlobe's WorldView-3 on August 13
- EPA releases EnviroAtlas ecosystem mapping tool
- Fugro to acquire RailData
- Northrop Grumman, RMIT University studying operations of UAV in Australia


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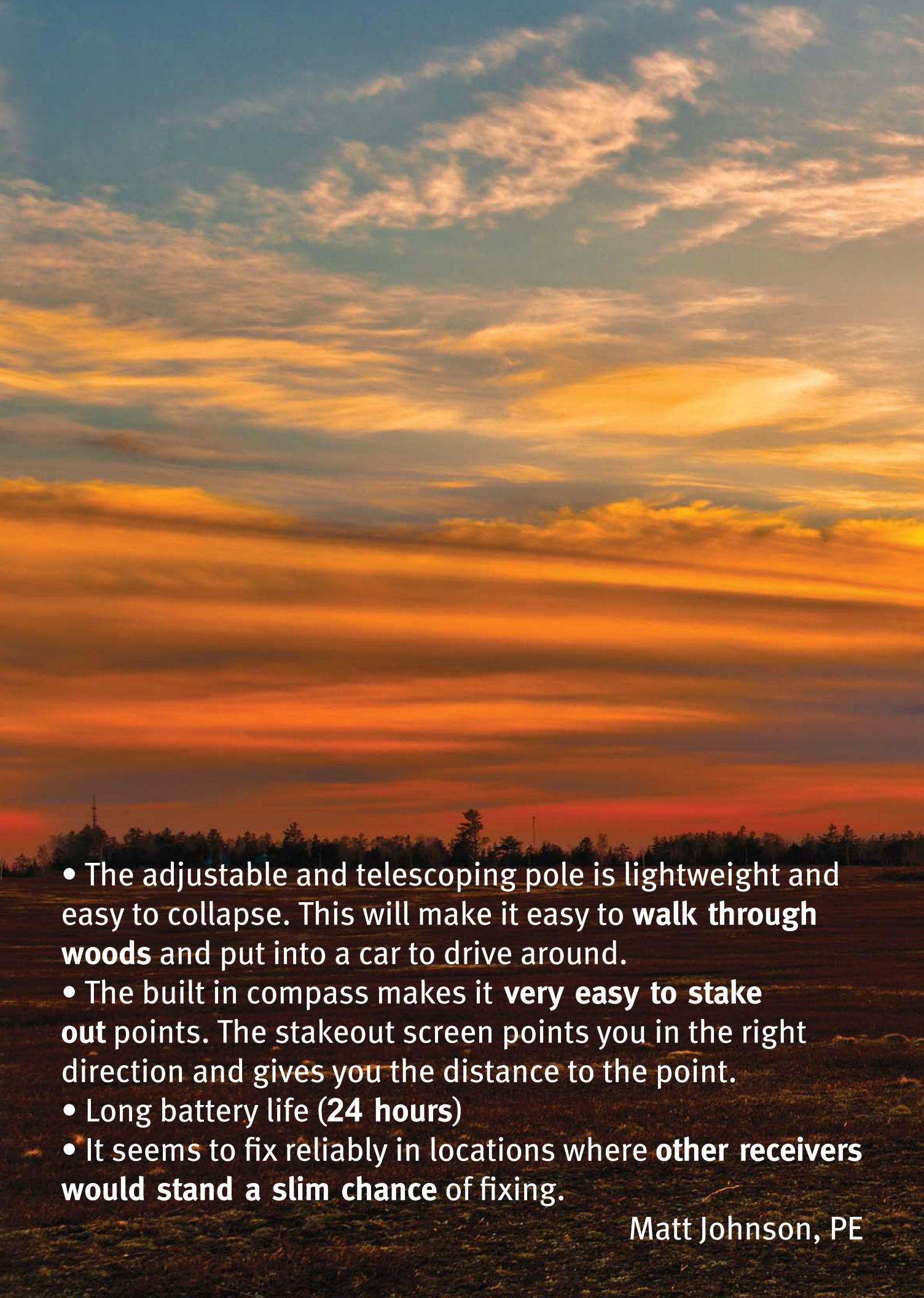
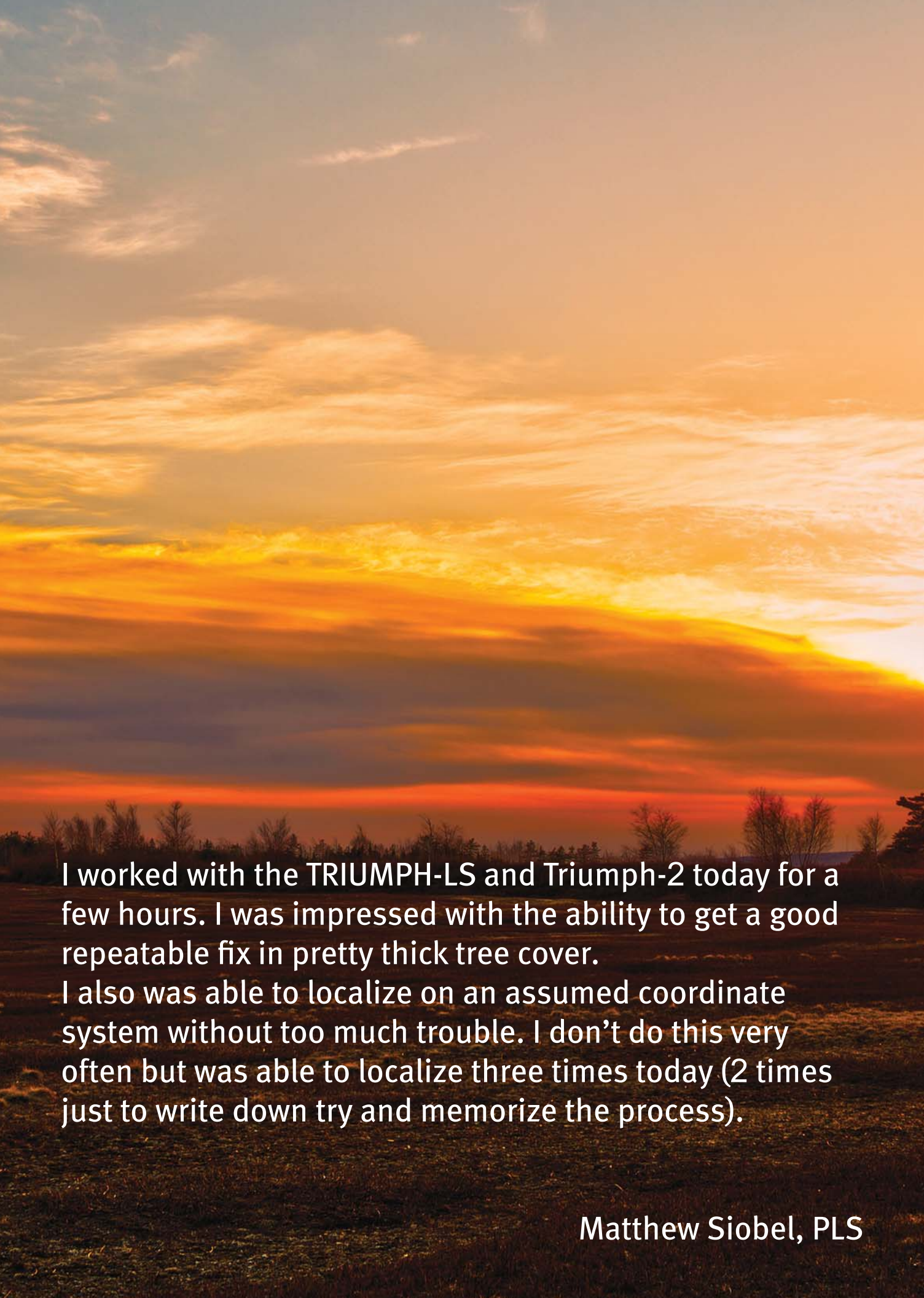


- The adjustable and telescoping pole is lightweight and easy to collapse. This will make it easy to **walk through woods** and put into a car to drive around.
- The built in compass makes it **very easy to stake out** points. The stakeout screen points you in the right direction and gives you the distance to the point.
- Long battery life (**24 hours**)
- It seems to fix reliably in locations where **other receivers would stand a slim chance** of fixing.

Matt Johnson, PE



I worked with the TRIUMPH-LS and Triumph-2 today for a few hours. I was impressed with the ability to get a good repeatable fix in pretty thick tree cover.
I also was able to localize on an assumed coordinate system without too much trouble. I don't do this very often but was able to localize three times today (2 times just to write down try and memorize the process).

Matthew Siobel, PLS

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Climate change and the role of surveyors

Experts discuss the possible role of surveyors in view of emerging challenges of climate change

Dr Isaac Boateng
School of Civil Engineering and Surveying, University of Portsmouth, UK

Climate change has been one of the main causes of the rise and fall of civilisations, migration and destruction of complex societies from the apocalyptic story of Noah's Ark and the flood, through the ice age to the present time. The development of complex societies and population growth mostly leads to overexploitation of the earth resources to support the complex life styles. In the last century, anthropogenic climate change which is mainly driven by the volume of human emission of greenhouse gases and aerosols in the atmosphere has resulted in global warming and climate change. According to the IPCC (2013) the atmosphere and oceans have warmed, the volume of snow and ice have diminished, sea level has risen and the concentrations of greenhouse gases have increased and some of these changes are accelerating and are possibly irreversible at this stage. Climate change therefore poses severe threat to many countries, territories and cultural heritage of humanity on earth in the 21st century. This articles discuses one of the fall out of the effects of climate change (climate refugees) and assesses the role surveyors could play to ameliorate the problem.

Climate change is predicted to bring about more frequent and severe disasters, such as droughts, floods, storms, and hurricanes (cyclones and typhoons).

Victims of flooding at Orissa, India in 2011 (photo sources: Press TV)

IPCC (2007) identified four zones as among the most susceptible to the effects of climate change: low-lying coastal settlements; rain-fed farming regions and those dependent on rivers fed by snow and glacier melt; sub-humid and arid regions; and humid areas in Southeast Asia vulnerable to changes in monsoon patterns. The climatic changes that threaten these zones are: sea level rise, drought, changes in rainfall pattern, flood, glacial melting and extreme weather conditions (Boateng, 2010).

In the next 20-30 year period, the intensity, frequency, duration and extent of weather-related hazards will increase in many parts of the world. However, we are unlikely to see significant changes in the location of these hazards (Ehrhart et al, 2009). While extreme weather events can hit any part of the world, their impact is most acute in the least developed countries, where the poor often live in marginal lands subject to flooding or mudslides, and therefore, are more prone to being displaced (Fritz, 2010). Here are a few recent examples of extreme weather conditions. Hurricane Katrina in the southern USA in 2005, the 2007 floods in Tewkesbury, UK; Burma; Bangladesh; and the multiple hurricanes that nearly

An epic drought killed livestock in Kenya and Ethiopia in 2011 (Photo source: Global Change)

destroyed Haiti in 2008, and the numerous typhoons in Asia in 2009 brought huge displacements, catastrophic losses of life and livelihood and made many refugees.

One of the ensuing effects of climate change is the issue of climate induced displacements and the consequent migrants (climate refugees). Over the past two decades, the debate about "climate refugees" among experts, advocacy groups and social scientists has produced lots of different scenarios about environmentally induced migration (El-Hinnawi, 1985; Black, 2001; Myers, 2002; Bates, 2002; Boano et al, 2008; Gemenne, 2011; Piguet, 2012). However, the term "environmental refugee"or"climate refugee" remains somewhat vague and has no international charter.

Climate refugee

In fact, the issue of climate refugee remain one of the most serious fall outs of global policy on climate change. As a result, significant numbers of people who are climate refugees at the moment are not accorded the needed support under the 1951 United Nations (UN) convention and 1967 Protocol on the Status of Refugees.

One may ask, who is a climate/ environmental refugee. El-Hinnawi (1985) defined 'environmental refugees' as those people who have been forced to leave their traditional habitat, temporarily (internal) or permanently (international), because of a marked environmental disruption that jeopardised their existence and/or seriously affected the quality of their life. This definition addresses all types of environmental changes,

The consensus among climate researchers and politicians has never been greater

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Fall outs of the climate change

The consensus among climate researchers and politicians has never been greater: The climate is changing worldwide. Over the past 100 years, the Earth has become a warmer place. Since the beginning of the 20th century, the global mean annual temperature has risen by 0.85 degrees Celsius (°C). The Intergovernmental Panel on Climate Change (IPCC) says there is a "very high probability" that this is due to human activities. If people continue to emit climate-relevant gases into the atmosphere without any restrictions, scientists expect mean temperatures to rise by 1.5 degrees Celsius (°C) relative to 1850 to 1900 by the end of the century.

The effects of global warming are the ecological and social changes caused by human emissions of greenhouse gases. To give one example, the 2003 European heat wave was the hottest summer on record in Europe since at least 1540. The heat wave led to health crises in several countries and combined with drought to create a crop shortfall in parts of Southern Europe. Peer reviewed analysis places the European death toll at 70,000. One of the latest natural catastrophes in Europe was the flooding in Southern and Eastern Germany and the neighboring states in May and June 2013, which gave rise to an overall loss of more than €12bn (US$ 16bn) and an insured loss in the region of €3bn plus (US$ 3.9bn). All these are crucial evidence for tackling climate change with all our strength!

Transforming the energy system in Germany

Climate change is happening now, worldwide and in Germany, too. Securing a reliable, economically viable and environmentally sound energy supply is one of the great challenges of Germany's climate change policy. As a response to the nuclear disaster in Fukushima, in 2011 Germany adopted decisions on the gradual phase-out of nuclear power and on accelerating the energy transformation. The Federal Government adopted an energy concept which sets out Germany's energy policy until 2050 and specifically lays down measures for the development of renewable energy sources, power grids and energy efficiency. In line with this agreement, greenhouse gas emissions are to be cut by 40% by 2020, and by at least 80% by 2050, with 1990 being the base year for both measurements.

First positive results are already visible: In electricity consumption, renewable energy sources reached a 23.5 % share in 2012 – three times higher than ten years ago. By 2020 electricity generated from renewables is to account for 35 % of gross electricity consumption. Following this, the German government will seek to increase the proportion of gross electricity consumption contributed by electricity from renewable energy sources to 80 % by 2050. What has to be recognized, too, is the economic success of the adopted measures for transforming the German energy system. Around 378,000 jobs in Germany have already been created in the renewables sector alone. To become one of the most energy-efficient and greenest economies in the world, the German government will use scientifically tested monitoring every three years to determine whether actual progress is within the corridor marked out by the development path outlined above and to what extent action needs to be taken.

Role of the surveying community

The surveyor can play a significant role, establishing, quantifying, and managing climate change. With his specialized skills in the broad fields of geodesy, he can substantially contribute to helping mitigate and adapt climate change and to reduce climate-related risk. Requirements are not only engineering know-how but also the surveyors' variety of skills and knowledge in geoinformatics, land management and development, building and land law, real estate and business administration as well as social competence. Primarily, geo-information is a very important decision basis for energy-related issues: Are environmental risks such as earthquakes, floods or landslides expected in the region? In which areas is it possible to use geothermal energy? Which areas are suitable for wind power priority zones? Which roofs are suitable for the production of solar energy? What property areas are affected? How can networks be optimally adapted for the transport of energy under various requirements?

The application of modern geographic information systems and the acquisition and evaluation of geodata therefore provide an objective basis for spatial decisions related to the energy transition. For example, 3D city models enable a simulation of the spread of noise and emission or predictions of possible changes in the urban climates. In disaster situations, such as flooding, it is possible to evaluate, on basis of 3D landscape models quickly which areas and buildings would be affected, with the result that important supporting measures can be initiated precociously.

Surveyors acquire, evaluate and visualize geo-information as a basis for the realization of the energy transition measures in different sections such as generation, transmission, distribution, saving by solar land register, wind power priority zones or line routing. They help to predict disasters, such as floods, earthquakes, tsunamis and thus to avoid big damages. They are involved in planning and managing Smart Grids for the expansion of renewable energies. They thus make an important contribution to climate protection.

Setting priorities

Surveyors provide with their diverse and interdisciplinary competencies measurable solutions for a successful implementation of the energy transition. In my opinion, disaster risk management could (and should) be an urgent field of application for a surveyor. The wide scope of surveyor's abilities can make an important contribution to improve, simplify and shorten the risk management process related to global climate changes:

- Surveyors monitor local, regional and global changes of the earth with the help of modern satellite technology, digital remote sensing sensors or automated instruments such as tachymeter.
- Surveyors gather, assess and visualize geoinformation in order to provide the fundamentals for decisions on the implementation of measures in the transitional process towards green energy in the fields of energy generation, transport, distribution and economisation by means of solar cadastres, wind power priority zones or routing.
- Surveyors assist in forecasting natural disasters such as floods or tsunamis and thus in preventing substantial damage. They participate in the planning and management of smart grids for the expansion of renewable energy, thereby making an important contribution to climate protection.
- Surveyors use virtual 3D models of towns, buildings and landscape for an easier location in case of a disaster (evacuation and emergency planning). They supply digital maps for emergency planning and mobile mapping.

To contribute to a more sustainable and effective disaster risk management, International Federation of Surveyors (FIG) implemented a Task Force on Surveyors and the Climate Change to highlight the current and future need for research and action in the field of climate change governance, adaptation and mitigation.

and not only those induced by climate change. Bates (2002) observed that El-Hinnawi (1985) definition makes no distinction between refugees who flee volcanic eruptions and those who leave their homes as soil quality declines or because of persistent adverse climatic conditions. Myers (2002) also defines 'environmental refugees' as people who can no longer gain a secure livelihood in their homelands because of drought, soil erosion, desertification, deforestation and other environmental problems, together with the associated problems of population pressures and profound poverty. The International Organisation for Migration [IOM] (2010) introduced a broader term "environmentally induced migrants" and defined it as persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad.

It is clear from the above definitions that climate refugee is not synonymous to environmental refugee. Climate refugees exclude peoples who migrate as a result of displacement caused by certain environmental disasters like volcanic eruptions, earthquakes, subsidence and landslides which are not influence by climatic factors but tectonic forces. Climate refugee therefore, may be defined as a person or group of persons who are displaced by environmental conditions which are influenced by climate change (e.g. droughts, cyclone/monsoon, rainfall induced-flood, climate induced sea level rise and intense icy winters) and can no longer gain a secure livelihood in their homelands/habitats and are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently and within their country or abroad.

United Nations Environmental Programme (UNEP) reported that as many as 50 million people could become environmental refugees by 2050 if the world did not act to support sustainable development (Tolba, 1989).

The role of surveyors

Professionally, surveyors have the knowledge, experience, resources and the technical skills required for adapting to the impacts of climate change. Furthermore, surveyors work with the land, people, political and social institutions to bring about sustainable socio-economic development. These professional connections places surveyors at a very important position to advocate and to lead the agenda to protect and accommodate present and future victims of climate induced disasters, particularly, those living in vulnerable communities, which we are already aware, are being displaced or losing their livelihood and could eventually become climate refugees. This agenda could be pursued by local surveying institutions at the national level and International Federation of Surveyors (FIG) at the international level. This is what could connect the surveying profession to managing territories, protecting the environment and evaluating the cultural heritage.

One of the roles of surveyors and perhaps the most traditional and best known skill of surveyor has been in positioning and measurement. Surveyors have been responsible for making the angle and distance measurements that have allowed nations to define unique two dimensional coordinate systems that in turn have been used for mapping. Data gathered by field surveyors or collected from existing spatial databases such as land registers and cadastres can be an efficient starting point for the assessment and evaluation of the impacts of climate change as well as developing policy indicators. At present, high precision Earth based measurement systems have been developed. Satellite laser ranging (SLR), lunar laser ranging (LLR) and very long baseline interferometry (VLBI), have not only vastly improved the accuracy of national spatial reference systems but have allowed high precision global reference systems to be developed. These have been complemented by a global navigation satellite system (GPS system) which facilitates measurement and assessment of flood risk and vulnerable territories to climate change.

Priorities are the inclusion of the whole climate change debate in surveying profession

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Fall outs of the climate change

There are many people sceptical about climate change and its effects. Although we -as land surveyors- cannot always value and judge the scientific reports about climate change, we feel three aspects are generally accepted and not much under debate. Firstly, it is unequivocal that the climate system is warming. The reason is the increasing emission of greenhouse gases. Evidence is strong that emissions are mainly humanly induced. A logical policy measure is then to reduce emissions. Secondly, different from other sector like energy, the process of photosynthesis in biomass provides an opportunity to also remove greenhouse gases from the atmosphere. The logical policy measure is then to increase biomass. Thirdly, various scenario's show the impact of climate change on urban and rural areas, specifically in the coastal zones. These include a likely increase in the incidence and severity of natural disasters. Socially, vulnerable groups of people are under pressure, because of their location and lack of funds to protect themselves. A logical policy measure is to prepare for disasters, with extra attention for the poor. We see this as the framework for our contribution to the FIG Task Force on Climate Change.

Linkages between climate change and land use changes

Conceptually the link is that humanly induced emission of greenhouse gases relates to the organisation of our lives, especially the spatial component of it: the way we build cities and settlements, the need for transportation, heating and cooling, our consumption pattern and the way we deal with land, resulting in degradation and deforestation. The second aspect, the removal, requires enough biomass to convert CO2 into oxygen. Carbon pools are in oceans and in the earth's crust, but also in tree biomass, vegetation, roots, forest litter, dead wood, and soil. Increasing carbon sequestration is key. The third aspect, preparing for disasters, always has had a spatial component, simply because it concerns the protection of people at the place they live. Now the point is that many policy measures to tackle our three aspects, include land use planning and land tenure security. Good land use planning creates cities that are more compact, with less transportation and less need for heating and cooling, to name a few measures. Good land use planning also creates a rural area that enriches soil carbon, produces perennials instead of annual tilled crops, reduces livestock production, protects natural habitats such as forests, and restores degraded watersheds and rangeland, again to name a few. There is also awareness that governments cannot do this alone. The private sector and citizens have a duty to adopt sustainability in their housing and agriculture. But how to ask investments from land owners and users, when they suffer tenure insecurity? This is even more a problem when it comes to vulnerable people in -for example- coastal zones. Land delivery, resettlement planning, good use of public lands, are here all related to land use. In our contribution we add to these concepts statistical figures for evidence.

Role for land surveyors in the carbon credit market

It is a bit too early to strongly confirm that land surveyors have a role to play. What is the case? We see two markets developing. In the first place the 'compliance market', established by articles 6, 12 and 17 of the Kyoto Protocol. The Protocol aims at reducing the emission of greenhouse gases through a 'cap and trade system'. It works roughly as follows. Countries are assigned emission units, in line with their reduction commitments. Countries that have emission units to spare can sell their surplus to countries that are over their targets. Articles 3.3 and 3.4 of the Kyoto Protocol says that also the creation of greenhouse sinks in soils and vegetation can be used to fulfill a country's obligation. When done successfully, they can thus trade their gained surplus emission units. A similar situation exists when countries work together (for example to invest in re-forestation) and earn credits. A well know market is the European Emission Trading System. The value in 2011 of the global market amounted to US$176 billion, representing an emission volume of 10 Gtons of CO2e. Currently the price has collapsed, because the financial crisis changed the supply-demand relationship. The compliance market under Kyoto is a strictly regulated market.

Outside the Kyoto Protocol and different from the compliance market, a retail offset market has emerged, with a focus on voluntary participation by parties not bound by specific caps or regulations. Greenhouse gas emissions can be offset by investing in projects that provide emission reductions in the form of Voluntary Emission Reduction Units. Projects -for example- include voluntary reforestation, grazing land management, cropland management, and re-vegetation. In Australia farmers are encouraged to pursue 'carbon farming'. Critically, the voluntary market is still unregulated in that it has no market standards, although improvements are made (such as a recent ISO standard). However, still fraud occurs, money laundering takes place,

which is the reason why the UK House of Commons earlier urged for regulation of the what they call the 'carbon cowboys'.

Within FIG, Prof. Grenville Barnes already assumed that for a fair trade in carbon credits 5 fundamental questions should be answered, namely what rights, whose rights, when were they acquired and what is the duration, how were they acquired, and what are the spatial dimensions (location, extent, boundary dimensions). Barnes urged for a carbon cadaster. That looks similar to a property right, isn't it? So the question is whether voluntary carbon reduction units are property or not? We refer to a FIG publication of Dr. Jude Wallace, who sees carbon credits as one of the complex commodities in the property market, in the form of an unbundled property right, comparable with –say- a mineral right or an encumbrance.

However, whether an emission right creates a property right is yet not clear. Apparently, an emission right knows exclusivity, has value, can be traded. A UK Court considered emission rights therefore as a property right as do the International Accounting Standards Board and the US Congress. The Australian Securities and Investment Act 2001 however maintains that a carbon credit is just a financial product.

In our contribution to the FIG report we see the following links with the work of land surveyors. In the compliance market carbon sequestration by biomass requires land surveyors' involvement in land policy, land management and land administration as said earlier. Secondly, in the case voluntary carbon credits are considered to be an 'unbundled' property right, with a separated carbon credit title, land administration systems should be able to record or register such rights, to attach appropriate geometric attributes and to make those titles accessible for trade in the carbon credit market. Thirdly, the volume of the carbon credit needs to be estimated, which is called 'carbon accounting'. There is a widespread demand for a well-designed carbon accounting system. The methods used for calculating carbon credits demonstrate a remarkable similarity to the work of quantity surveyors, whose profession it is to survey land areas and volumes to estimate building and construction costs. Here might be a chance, even more because widely there appears to be dissatisfaction with the current methods.

Role of the surveying community

We believe land surveyors are key professionals in the domains of land policy, land management and land administration. Being aware that many climate measures are land use–related, land surveyors must contribute to reshaping conventional policy and implementation measures into climate proof measures. In the FIG report we are more specific. We expect land surveyors to be part of multi-disciplinary teams of experts. Overseeing the international literature, we think this work concentrates on urban areas, rural areas, forests and coastal zones, each with addition of their local context. Of course, we focus here on the land use aspects in our domain only. For example geodetic aspects of monitoring climate change is also an important part of our profession, but outside our assignment for the FIG Task Force. Colleagues take care of this part in the report.

Priorities and challenges

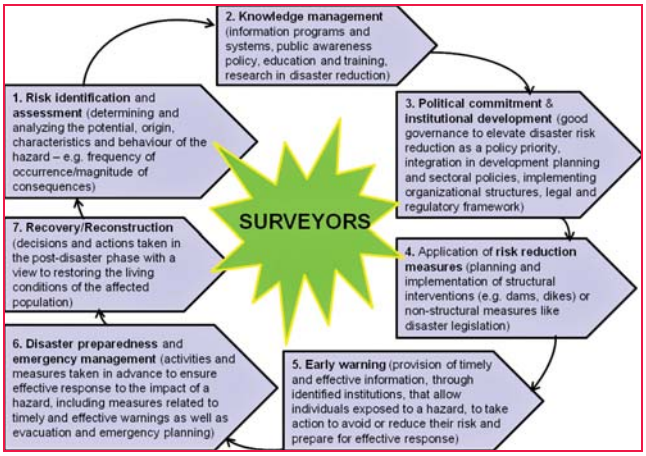
We believe priorities are the inclusion of the whole climate change debate in our profession and the adoption of the urgency of climate change measures in our thinking. Are our current approaches to for example land management and land administration, sufficiently serving the needs of governments and communities for low cost methods of land surveying and quick ways of land registration, addressing a variety of land tenures? The fit-for-purpose discussion within FIG is from this viewpoint 'just in time'.

Spatial information management is another role surveyor's play. In most countries, surveyors not only collect and process spatial data for development, but they also act as custodians of these data. As a consequence, surveyors have first-hand information and knowledge of vulnerable territories and environments that are threatened by the impacts of climate change.

In addition, surveyors facilitating land use change. The effects of climate change will result in changes to livelihoods, human settlements, land use patterns, and tenure systems. The manner in which decisions about access to, use of, and control over resources are implemented and enforced, as well as the way that competing interests in resources are managed, is as central to the success of climate change adaptation and mitigation, as it is to livelihoods of people.

Disaster risk management is an important role of surveyor which could be effectively used to deal with climate induced disasters and Climate refugees. The core of adaptation strategy for climate refugees is disaster risk management. The contribution of the Surveying profession to disaster risk management (International Federation of Surveyors [FIG], 2006) demonstrate clearly that modern surveyors play an important role in the field of disaster risk management, although in most cases, the activities take place as part of multi-disciplinary task forces. The Figure below shows that surveyors are at the centre stage of disaster risk management process. In fact, surveyors' foot-print are always present when it comes to disaster risk management, though their contribution is neither spectacular nor in the spotlight as it is with rescue teams, policemen, doctors, etc. Nevertheless, the surveyors' role is very substantial, but most often, unknown or misunderstood (Roberge, 2005).

It is an indisputable fact that the issue of climate refugees is greatly complex, and potentially expensive, with some countries and global organisations already overwhelmed by the demands of the 1951 conventionally-recognised



Disaster risk management cycle

refugees. However, doing nothing about the looming climate refugee problem, which could potentially cause global humanitarian disaster, is not the best option. On many occasions, the action by the global humanitarian community is either too little or too late. This often results in a cycle of poverty and vulnerability to disasters that is difficult to break. There is the need to develop an international convention on climate refugees for rectification by nations and enforced by the UN. The UN and other regional bodies like the EU, AU, ASEAN, ECOWAS and other should pursue vigorous adaptation strategy for climate refugees now, before disaster strike as the current regime is very weak and unsustainable.

Professionally, surveyors work with the land, people, political and social institutions to bring about socio-economic development. These important professional connections occur both at local and international levels. This relationship places surveyors at a very important position to advocate and to pursue the agenda to protect and accommodate present and future victims of climate induced disasters, particularly, those living in vulnerable communities, which we are already aware are being displaced or losing their livelihood. Local surveying institutions could pursue this agenda (adaptation and protection for potential climate refugees) nationally and the FIG could also engage its partners like the UN, FAO, UN-habitat and the World Bank on the same agenda internationally. It is important to state that the issue of climate refugees is very complex and may require a huge effort and engagement of the international community. However, surveyors are used to dealing with complex problems and taking a lead role on this issue is not beyond their capacity.

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Approaches to Resilient PNT

Whilst everybody in the maritime sector agrees on the need for Resilient Positioning Navigation and Timing (PNT), the way to achieve is not so clear. The problem is analysed in this article and a method of assessing the various alternative solutions is proposed

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The new IMO Sub Committee on Navigation, Communications Search & Rescue considers the Strategy Implementation Plan for e-Navigation at its meeting in July 2014 (NCSR1). The e-Navigation solutions embodied in that Plan depend on reliable, robust positioning. Requirements for Resilient Positioning Navigation and Timing (PNT) will need to be prepared to support the Strategy Implementation Plan. This article sets out a possible approach to the assessment of systems and combinations of systems. The results of such an assessment could form the basis for discussion and possible submission to IALA and IMO.

Approach

IMO Resolution A.1046(27) on the World Wide Radio Navigation System (WWRNS) sets out the requirements for recognition of systems under the WWRNS. This Resolution does not distinguish between single systems that might meet the requirements by themselves and combinations of systems that might meet them together. This paper proposes that in addition to the parameters of availability, accuracy, integrity and continuity set out in A.1046, the limitations of each system should be assessed, such as vulnerability to interference, or restricted coverage. By this means complementary systems could be selected to ensure overall resiliency is provided. This approach of considering the WWRNS as a compendium of systems fits in with the planned development by IMO of a Multi-system Receiver Performance Standard, a generic standard that will cover different systems and combinations of systems – specifying what is required, not how it should be done.

Requirements

Table 1 summarises the requirements set out in Resolution A.1046:

Assessments

It is proposed that the table 2 should be completed during system analysis and used to assess single systems and combinations of systems against the requirements, with the additional column recording limitations, so that these can be mitigated by combining with other systems:

Alternatives

It is generally accepted that GNSS (GPS in the short term) will be the primary position and timing source for maritime navigation. The increasing availability of more than one GNSS (GPS, GLONASS,

Initial assessments indicate that a combination of multiple GNSS and eLoran in coastal waters could meet the requirements

Table 1: WWRNS Requirements

Region	Accuracy	Availability	Integrity	Continuity	Update rate
Ocean waters	100 m 95%	99.8 %	broadcast by MSI	-	2 sec
Harbours, harbour approaches, coastal waters	10 m 95%	99.8 %	broadcast within 10 s	99.97% in 15 minutes	2 sec

Table 2: Assessment of systems

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters						
Harbours, harbour approaches, coastal waters						

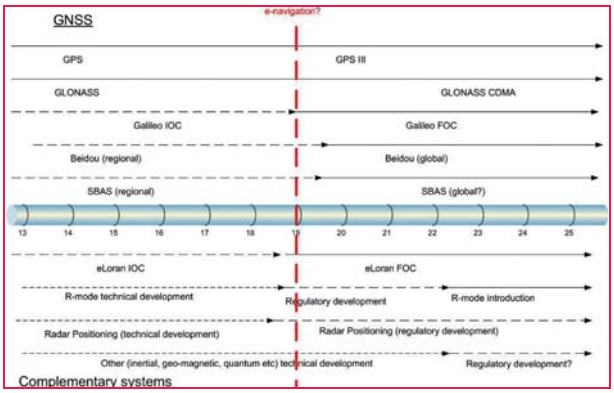

Figure 1: Indicative timeline for Resilient PNT

Beidou, Galileo and others) will increase resilience and integrity. However, all these systems share the same failure modes, because they use the same frequency bands and all have very low power signals. Therefore true resilience will only be achieved by the use of complementary, dissimilar systems, such as radar, low frequency, high power terrestrial systems, or autonomous onboard alternatives, such as inertial sensors.

Some of these alternatives can be made available in the short to medium term, in parallel with the expansion of GNSS. Some have been demonstrated to work, but would need lengthy regulatory measures to become generally applicable. Others are likely to require considerable technical development before they can be accepted as practical and economic options for maritime use.

For example, eLoran is a proven system, meeting the IMO requirements for harbour and harbour approach (Williams et al, 2013). However, it is not widely deployed at present. Studies have shown that ranging mode (R-mode) on DGPS beacons could provide a backup to GNSS, in areas where coverage of such beacons is good (Johnson et al, 2014). This system has still to undergo practical testing and the necessary regulatory measures have still to be put in place. Absolute positioning using solid-state radar and enhanced radar beacons has been shown to work technically, but the regulatory process needed to implement it would be lengthy (Ward et al, 2014). Options such as inertial sensors require considerable technical development before they have the necessary stability, at acceptable cost, to provide a maritime backup. Other autonomous alternatives such as quantum technologies are at a very early stage of development.

The various combinations of options for achieving resilience would need to take into account the different stages of development, as illustrated in Figure 1.

Table 3: GPS Source: FRP 2012 Note: actual availability easily exceeds requirements

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	9 m 95%	99 %	broadcast by MSI or RAIM	N/A	1-0.05 sec	Vulnerable to interference
Harbours, harbour approaches, coastal waters	9 m 95%	99 %	broadcast by MSI (>10s) or RAIM	1-1x10-5/hr = 99.99975% in15 mins	1-0.05 sec	Vulnerable to interference

Table 4: GLONASS Source: Russian Federal Space Agency, IAC website

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	6 m 95%	99%	broadcast by MSI or RAIM	N/A	1-0.05 sec	Vulnerable to interference
Harbours, harbour approaches, coastal waters	6 m 95%	99%	broadcast by MSI (>10s) or RAIM	?	1-0.05 sec	Vulnerable to interference

Table 5: GPS/GLONASS Source: NSL (2013)

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	2 m 95%	~ 100 %	broadcast by MSI or RAIM	N/A	1-0.05 sec	Vulnerable to interference
Harbours, harbour approaches, coastal waters	2 m 95%	~ 100 %	broadcast by MSI (>10s) or RAIM	99.99975% in15 mins	1-0.05 sec	Vulnerable to interference

Examples

Tables 3 - 10 show assessment results for systems already deployed, near to deployment, or for which technical performance has been demonstrated – Green indicates that requirements can be met, Red that they cannot.

Discussion

e-Navigation and other concepts for future maritime navigation are totally dependent on reliable positioning. The present situation of reliance on a single system (GPS) is not acceptable for safety critical operations. Other GNSS are becoming available, but they share the same vulnerabilities as GPS, to accidental and deliberate interference. Augmentations, whether space-based or ground-based, increase integrity, but do not provide any protection against loss of the primary system. Complementary, dissimilar systems are needed to achieve real resilience.

This paper attempts to provide an objective approach to the assessment of suitable combinations of systems against the recognised requirements.

It is clear that combinations of more than one GNSS will give significant advantages, particularly in availability. However, these combinations will not overcome the inherent vulnerability to interference. The addition of a dissimilar system, such as eLoran could

Table 6: GPS/WAAS Source: FRP 2012 Note: actual availability easily exceeds requirements

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	9 m 95%	99 %	broadcast within 6s	N/A	1-0.05 sec	Vulnerable to interference
Harbours, harbour approaches, coastal waters	2 m 95%	99 %	broadcast within 6s	99.99975% in15 mins	1-0.05 sec	Vulnerable to interference No polar coverage

Table 7: GPS/DGPS Source: FRP 2012

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	9 m 95%	99 %	broadcast within 6s	~N/A	1-0.05 sec	Vulnerable to interference
Harbours, harbour approaches, coastal waters	1-2 m 95%	99 %	broadcast within 6s	99.9875%	1-0.05 sec	Vulnerable to interference

Table 8: GPS/eLoran Source: Williams et al 2013

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	9 m 95%	99 %	broadcast within 10s	N/A-	1-0.05 sec	
Harbours, harbour approaches, coastal waters	9 m 95%	99.8 %	broadcast within 10s	99.9875%	1-0.05 sec	Within coverage of DLoran RS

Table 9: Multi-GNSS/eLoran Source: Williams et al (2013)

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	8 m 95%	~100 %	broadcast within 10s	N/A	1-0.05 sec	
Harbours, harbour approaches, coastal waters	8 m 95%	~100 %	broadcast within 10s	99.9875%	1-0.05 sec	Within coverage of DLoran RS

Table 10: GPS/radar Source: Ward et al (2014)

Region	Accuracy	Availability	Integrity	Continuity	Update rate	Limitations
Ocean waters	9 m 95%	99 %	broadcast by MSI or RAIM	N/A	1-0.05 sec	Vulnerable to interference
Harbours, harbour approaches, coastal waters	7 m 95%	98 %	broadcast by MSI (>10s) or RAIM	99.9875%	1-0.05 sec	Range limited to 10 M from coast

achieve this in the short term and other options such as R-mode and radar could achieve it in the medium to long term, together with autonomous, onboard options such as inertial, if they meet performance and cost criteria.

The proposed assessment method may be presented for discussion in an appropriate organisation, such as IALA, for possible development into a submission to IMO.

The planned development in IMO of a multi-system receiver performance standard should make the approach of combining different systems a practicable proposition, depending only on which systems are available in any particular location. There would be no need to carry different receivers for different parts of the world, something that would almost certainly be opposed at IMO. It would then be a matter for each administration, according to its obligations under the Safety Of Life At Sea Convention (SOLAS) Regulation V/13 'to provide, as it deems practical and necessary either individually or in co-operation with other contracting Governments, such aids to navigation as the volume of traffic justifies and the degree of risk requires'.

Conclusions

Resilient Positioning, Navigation and Timing (PNT) is essential for e-Navigation. An approach has been proposed for the assessment of systems against the requirements for resilient PNT.

The proposed method can assess systems and combinations of systems, allowing the selection of complementary combinations.

Initial assessments indicate that a combination of multiple GNSS and eLoran in coastal waters could meet the requirements. Other candidates, such as radar and R-mode have the potential to provide a backup to GNSS, but still need technical and regulatory development.

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Applications of Gabor wavelets in object recognition on side scan sonar images

The paper presents the results of Gabor filters' responses calculation for the parts of the sonographs containing objects. The sonographs were taken in different time periods and with different settings. Proper analysis of filters' responses leads to the recognition of corresponding objects

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Side scan sonars are widely used for objects detection in seabed clearance investigations. Multibeam data about bathymetry and backscatter may be not enough in terms of detecting small objects, possibly dangerous for navigation.

Side scan sonar provides monochromatic image of ensonified part of a seabed. Pixels' brightness values are proportional to the strength of acoustic reflection from every object located within generated acoustic beam. Objects on the sea bottom may often be recognized not by their direct reflection but by their acoustic shadows, giving the information about their shapes and sizes (Waite, 2002; Blondel, 2009).

Side scan sonar images (called sonographs) are usually examined by qualified operator. This process takes a lot of time and is affected by a possibility of human error. Earlier approach to object detection using image processing techniques is to set a threshold and generate a binary image where pixels are assigned to two possible categories: target or not-target (Rao et al., 2009). Further researches resulted in applying adaptive thresholding and statistical methods (Maussang et al., 2008). Earlier Bayesian approach has been proposed in (Calder et al., 1998). Successful tests' results, presented in cited papers suggest that partial or full automatization of detection process is possible but some of developed techniques are not universal but optimised for a specified kind of objects.

Potentially dangerous objects can be detected not only by analysing single sonograph but also by comparing the results of side scan survey with previously obtained images from the same area. Modern hydrographic software ensures the possibility of displaying sonographs conveniently for visual comparison but automatization of this process is still in a phase of development. Objects recognition and techniques associated with sonographs area comparing can be utilized in automatic sonograph analysis methods resulting in automatic changes detection.

The paper presents the description of test data acquisition system and survey process, details of computation technique based on Gabor wavelet analysis, resulting in the possibility of test object recognition and computations' results as well as possible applications of obtained outcome.

Data acquisiton

Sonar images used as examples in this paper were acquired in Gdynia Harbour, Poland. EdgeTech 272-TD Side Scan Sonar and CSI Wireless MiniMax DGPS, located on the survey boat were used as data acquisition system. Six different objects (wooden and metal boxes with dimensions from 10 cm to 1 m) were placed on the bottom of the Gdynia Harbour, approximately 5 to 15 m from

Figure 1: Selected survey tracks. Image source: Gdynia, 54°32'00.68"N and 18°32'36.63"E, Google Earth. January 4, 2011. May 2, 2014.

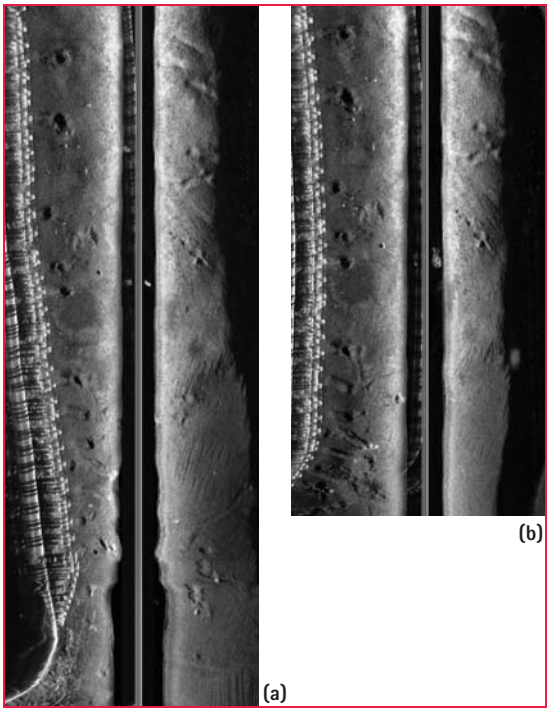

Figure 2: Sonographs obtained on tracks 1 (a) and 2 (b).

the pier. Their positions were marked by buoys, which also ensured a possibility of objects recovering. Side scan sonar was towed parallel to the pier several times, approximately over the same survey line. Two chosen tracks are presented in Figure 1. Sonographs obtained on these two tracks are presented in Figure 2. Side scan sonar data was recorded in JSF files using EdgeTech Discover software. Digital images were created directly from JSF files using Matlab script, which was written based on JSF file format description. No additional processing software was used. Avoiding format conversions guarantee the best possible resolution, achievable from data stored in the file.

Sonar images were not aligned at this stage of computation. They were visually examined and six pairs of matching parts of the images were chosen from these sonographs. They are presented in Figures 3 and 4. All chosen fragments are square-shaped and of the same size - 147 pixels wide. Images contain some of the objects detected by the sonar system on the seafloor (Fig. 3 and 4, a-d), elements of the pier construction (Fig. 3e and 4e) or just the visualization of approximately flat sandy seabed (Fig. 3f and 4f). Objects detected by the sonar system are located close to the centre points of the cropped images.

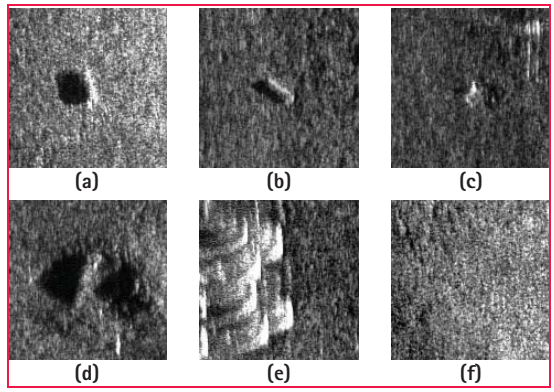

Figure 3: Parts of images selected from sonograph obtained on track 1.

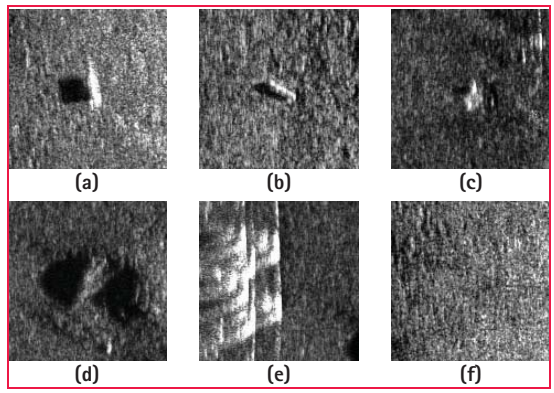

Figure 4: Parts of images selected from sonograph obtained on track 1.

Gabor wavelet analysis of sonar images

Gabor wavelets in image processing

Gabor wavelets are used in image processing for example in face recognition techniques. The EGM (Elastic Graph Matching) technique is described in detail in (Lades et al., 1993; Tefas et al., 2010). The idea of image comparing by EGM technique is based on creating feature vectors for carefully chosen locations of the face image. The set of feature vectors for one location is called jet. Jets with their coordinates form the structure called EGM graph. The EGM graphs are computed for analysed images and those graphs are compared instead of comparing the whole images.

The feature vectors should be based on the image analysis technique, which provides the ability of (Tefas et al., 2010):

- describing the area in a particular neighbourhood around the graph node (location on the image),
- being robust for certain kinds of differences between images (pose variations and illumination changes),
- capturing only desired characteristics of described area (being discriminative),
- being easily computable.

Gabor wavelet transform is the most popular image analysis technique utilized in EGM. Results of the convolution of around-node areas of the images with the family of Gabor kernels give the subsequent values of jets' elements (Tefas et al., 2010).

Gabor wavelets in sonograph's analysis – jets' computation

There is some sort of similarity between face images and sonographs in terms of comparing them. Both comparing techniques should be robust against displacements, geometrical transformations and changes of illumination (ensonification). The requirements for analysis techniques, listed above (section 3.1), match perfectly the assumption for sonar images comparison techniques. Gabor wavelet transform was tested for its usefulness in objects recognition on side scan sonar images leading to side scan images comparing.

2-dimensional Gabor kernels were computed using the equation proposed by Petkov in (Petkov et al., 1997).

where:

$$g(x,y) = e^{\frac{-\left(x^2+\gamma^2 y'^2\right)}{2\sigma^2}} \cos\left(2\pi\frac{x'}{\lambda}+\psi\right) \quad \text{(Eq. 1)}$$

$$x' = x\cos\theta + y\sin\theta \quad \text{(Eq. 2)}$$

$$y' = -x\sin\theta + y\cos\theta \quad \text{(Eq. 3)}$$

2D Gabor filter (Eg. 1) is a Gaussian function multiplied by a sinusoidal plane wave. λ is responsible for spatial frequency of the sinusoid in pixels. θ defines the orientation in radians. A set of 6 to 8 orientations and 3 to 5 spatial frequencies is usually used for building the information pyramid in case of face images, according to (Tefas et al., 2010). The following set of parameters was used for side scan sonar images:

$\lambda = \{1, 4, 8, 12, 16, 20, 24\}$;
$\theta = \{0, \pi/8, \pi/4, 3\pi/8, 2\pi, 5\pi/8, 7\pi/8\}$;
$\psi = \{0, -\pi/2\}$;
$\sigma = \lambda$;
$\gamma = 1$

These parameters were chosen after several computational experiments as giving the best discriminative properties of the results for side scan sonar objects.

The set of 7 frequencies and 8 orientations gives the family of 56 Gabor kernels. Three examples are shown in Figure 5.

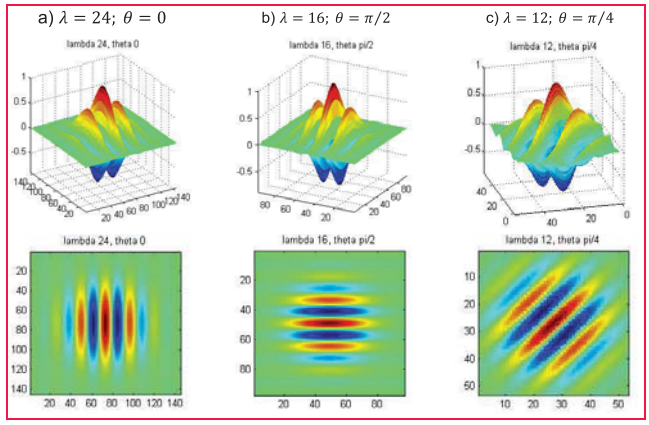

Figure 5: Examples of Gabor kernels in 3-D and planar views for chosen parameters' sets.

A particular setup of frequency and orientation makes each kernel sensitive for a particular spatial frequency oriented in a particular direction.

Convolutions of the images with the Gabor kernels located over the image central point gives the jet's values. The jet is stored in a form of a vector of 112 elements (56 times 2 ψ-values). The response on Gabor filter is in fact the complex number. Equation 1 allows computing them partially. First 56 elements (ψ=0) correspond to real parts, and next 56 elements ($\psi = -\pi/2$) to imaginary parts. Examples of jets (computed for images in Figures 6a and 6c) are plotted in Figures 6b and 6d.

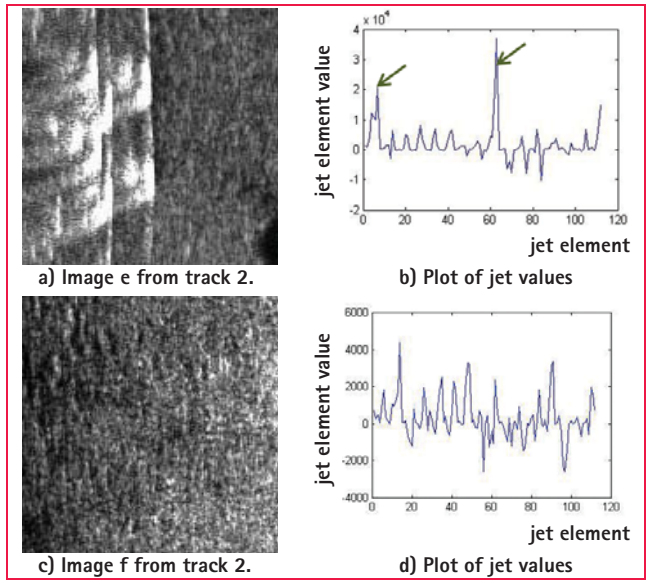

Figure 6: Selected images with corresponding jets.

The plot in Figure 6b contains noticeable peaks for jet's elements number 7 and 63 (pointed by arrows in Figure 6b). These peaks refer to the kernel, computed for orientation $\theta = 0$ rad. This is intuitively correct, because the image contains strong echo oriented vertically, parallel to the image side. Jet in Figure 6d contains a lot of peaks; none of them is strongly distinguished from the others. Image in Figure 6c (depiction of sandy seafloor) contains a lot of spatial frequencies in various directions, which can be compared to the noise.

Jets' comparing

Real and imaginary values of jets are transformed to polar form and then compared using the following formulas for similarities functions (Wiskott et al., 1999):

$$S_a = \frac{\sum_{j=1}^{n} a_j a'_j}{\sqrt{\sum_{j=1}^{n} a_j^2 \sum_{j=1}^{n} a'^2_j}} \quad \text{(Eq. 4)}$$

$$S_\phi = \frac{\sum_{j=1}^{n} a_j a'_j \cos\left(\phi_j - \phi'_j - \vec{dk_j}\right)}{\sqrt{\sum_{j=1}^{n} a_j^2 \sum_{j=1}^{n} a'^2_j}} \quad \text{(Eq. 5)}$$

where: a_j, a'_j - modulus of complex jet's value;
$\phi_j,\ \phi'_j$ - argument (phase) of complex jet's value;
j - number of values in each jet;
$\vec{dk_j}$ - displacement estimated for the best match.

The first formula - magnitude similarity (Eq. 4) - uses only magnitude information and ignores phase. The results are tolerant

for small displacements of detected objects or small shifts of the Gabor kernel center. The second similarity function (Eq. 5) takes the advantage of phase information. According to Wiskott et al. 'phase information is required to discriminate between patterns with similar magnitudes, should they occur, and secondly, since phase varies so quickly with location, it provides a means for accurate jet localization in an image' (Wiskott et al., 1999, p. 358). The first advantage, mentioned by Wiskott, seems to be very important in sonographs' analysis. Displacement is estimated in face recognition, where EGM graph containing jets is rearranged in order to find the best match for distorted faces' images. Displacement information in S_ϕ computation is not used in sonographs' analysis, because it cannot be assumed that one image contains the same objects like the other, just slightly displaced. The robustness for small displacements of both S_a and S_ϕ is useful in image recognition and large jets differences will be necessary in the process of comparing the whole images. $\vec{d}k_j$ term is assumed to be 0, so S_ϕ is used in a form of the following formula:

$$S_\phi = \frac{\sum_{j=1}^{n} a_j a'_j \cos\left(\phi_j - \phi'_j\right)}{\sqrt{\sum_{j=1}^{n} a_j^2 \sum_{j=1}^{n} a'^2_j}} \qquad \text{(Eq. 6)}$$

where: a_j, a'_j - modulus of complex jet's value;
ϕ_j, ϕ'_j - argument (phase) of complex jet's value;
j - number of values in each jet;

Comparison results

Similarities of jets for 6 images from track 1 with each one of 6 images from track 2 were computed using formulas from Equation 4 and 6. The results are presented in Tables 1 and 2. Values of S_a and S_ϕ for matching images are shown in bold.

The average S_a value for matching images is 0.9097 and for non-matching 0.6819. This allows setting a threshold of about 0.80 to distinguish between matching and non-matching objects detected on the images. S_ϕ threshold, found in the same way, is about 0.33.

Image f is problematic in both S_a and S_ϕ cases. It is shown in Figure 6d, that flat seabed image's jet is similar to the noise, it has no distinguishable peaks, which makes it very difficult to compare the two images of flat sandy area. Threshold, set previously to 0.80 for S_a and 0.33 for S_ϕ is not adequate for side scan sonar images presenting flat seabed. These cases are difficult not only for automatic systems but also for operators. It is often impossible to visually match two images presenting flat sea bottom, without examination of their neighbourhoods containing characteristic objects, pier elements or layout of distinguishable sediment types. The most important from the objects recognition point of view is that a background (or flat seabed) images are in most cases distinguishable from images containing objects, which can be useful in complex objects detection process based on image comparison.

Some authors express an opinion that Gabor kernels work similarly to the human way of visual perception (Lee, 1996; Jian et al., 2009). It is intuitively true for presented sonographs. We are able to recognize the objects on sonographs, analysing their relative or absolute sizes, shapes or spatial geometry of objects' groups, but we may have a serious problem with recognizing the areas of flat seafloor without analysing the characteristic features in their neighbourhood.

Increasing the number of kernels (obtained by increasing the number of different λ and θ values used for computation) does not enhance the ease of thresholding between matching and non-matching images. Higher number of kernels also means the higher computational effort necessary to obtain jets. It was checked by test computations that the set of values described earlier is optimal in terms of obtained threshold and computationally efficiency.

Table 1: Similarities of images from both tracks – S_a results.

S_a		Track 1					
		Image a	**Image b**	**Image c**	**Image d**	**Image e**	**Image e**
Track 2	**Image a**	**0.9525**	0.6165	0.853	0.5405	0.807	0.7187
	Image b	0.6088	**0.9621**	0.641	0.3723	0.6063	0.6477
	Image c	0.827	0.6169	**0.9679**	0.8504	0.8292	0.7905
	Image d	0.5399	0.4325	0.7868	**0.9347**	0.6109	0.6373
	Image e	0.8402	0.5145	0.8398	0.6387	**0.8718**	0.6495
	Image f	0.7164	0.775	0.7932	0.6468	0.7102	**0.7691**

Table 2: Similarities of images from both tracks – S_ϕ results.

S_ϕ		Track 1					
		Image a	**Image b**	**Image c**	**Image d**	**Image e**	**Image f**
Track 2	**Image a**	**0.7382**	0.2688	0.0677	0.077	-0.1658	-0.2346
	Image b	0.2095	**0.8968**	0.3135	0.0684	0.0022	-0.1003
	Image c	0.4702	0.2374	**0.8963**	0.4636	0.0433	0.0773
	Image d	0.1955	0.0285	0.6133	**0.7812**	0.2865	0.0423
	Image e	-0.1247	0.0393	0.1653	0.0806	**0.3344**	0.0851
	Image f	0.007	0.216	0.2781	0.3491	0.0573	**-0.3324**

Possible applications

Gabor wavelets analysis can be used for different purposes in sonar images processing and comparing. Main application - object recognition - can act as a part of complex processes, like sonograps' alignment and multi-faceted images comparing.

Objects recognition

Earlier approach for recognizing objects was based on thresholding, converting to binary images and calculating properties for certain binary areas. Every gain adjustment changes the general brightness level and affects required threshold level. If a threshold value is changed, binary area will be affected. Threshold

for objects detection is usually set manually or other technique, optimised for a specific kind of object, is applied (Rao et al., 2009). Algorithms for automatic threshold settings in general image processing (based for example on histogram analysis) are designed mostly for high contrast digital images. This is often problematic in case of usually noisy, relatively low resolution sonographs, where differences between objects, shadows and background are small.

Object recognition based on Gabor wavelets analysis is different. Computed jets are robust for changes in gain settings, small displacement of objects or small changes in ensonification direction. Threshold for similarity function values, set once, can be used for different images, because is not affected by the brightness level of the whole images, only by spatial frequencies contained in the images.

Simple procedure can be used to find the answer for the question: does the object detected on one image match the object detected on different sonograph of the same area?

1. Extract the parts of both images containing investigated objects.
2. Calculate the jets for both extracted parts.
3. Find similarity functions values. Different distance metrics (for example Euclidean or Mahalanobis) or normalized correlation of jets (Tefas et al., 2010) can be used instead or apart from similarities function presented in this paper.
4. Check the values in terms of threshold exceeding.

Sonographs' alignment

Object recognition can be considered not as a stand-alone process but as a part of complex image comparison procedure. It usually starts with image enhancement followed by very important and difficult from the automatization point of view step: image alignment.

Image alignment is similar to mosaicing. In fact, mosaicing is nothing else like aligning the overlapping parts of adjacent sonographs. The main purpose of mosaicing is to cover a large area with adjacent stripes of sonographs with only side parts overlapping. Aligning images for comparison purposes requires aligning two or more images of the same scene, as much overlap as possible is required. Towfish should be towed over the same survey line.

It is not possible to achieve exactly the same track of towing, because of the characteristics of towed side scan sonar survey system. The towfish is towed on the elastic tow cable, so every speed or course change affects the movements of the transducer. Even if operator is trying to avoid rapid changes of towing parameters, the images are never perfectly aligned. There are two possible approaches to the problem of sonographs alignment for comparison purposes or standard mosaicing:

- based on geographical content;
- based on reference points.

Alignment based on geographical content is used in most of hydrographic software for sonographs mosaicing. GPS positions are recorded by data acquisition system and then used to determine the spatial location of sonar image on a map in certain scale. Waterfall image is also transformed in a way considering the course changes. Details can be found in for example in (Pałczyński, 2009). The main source of problem with this kind of alignment is the location of GPS antenna on the survey vessel, not over the towed equipment. Widely used layback technique (Blondel, 2009) is usually accurate enough for mosaic presenting the general depiction of the sea bottom, but often not precise enough to automatically compare details on two pictures. GPS position data can be supported by data from underwater navigation system, but this requires additional dedicated equipment.

The second alignment technique is based on choosing several reference points on two images. Images are then transformed to superimpose the reference points. GPS data can be unused or used initially for general alignment or survey data selection. Aligned images are not distortion free, but objects and areas on one image should correspond with the same objects and areas on the other.

Reference points in most cases are chosen manually. Object recognition techniques based on Gabor filtering may be used for automatization of reference points' choosing. Preliminary computational tests shows that alignment by automatically chosen reference points is possible for sonar images with test objects located on approximately flat sandy seabed.

Complex image comparison algorithm

Images alignment and objects recognition can be combined in complex image comparison algorithm as follows:

1. Images enhancement - optional processes like beam pattern correction, various gain corrections and despecle filters offered currently by most hydrographic software;
2. Images alignment - techniques based on positioning system data and automatic reference points choosing can be combined;
3. Jets computation for areas centred on chosen, regularly arranged points;
4. Changes detection based on similarity functions.

Preliminary tests conducted for this algorithm checking shows, that Gabor filters and jets technique is capable of detecting small changes on the sea bottom, like the presence of new object, not recorded on the sonograph obtained before in the same area.

Conclusion

Gabor wavelet analysis, used in image processing for example for face recognition, after some modification, can be successfully used for objects recognition on side scan sonar images. Object recognition, in analysed cases, is not a stand-alone process, but can be a part of complex techniques, which can improve the mosaicing routines and images alignment methods. These techniques, together with additional processes including images enhancement and jets computation for regularly arranged points, can be used as a complex image

comparison algorithm capable of detecting small changes on the analysed images.

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Galileo update

Galileo Increases the Accuracy of LBS

The GSA and Rx Networks Inc have announced the results of tests conducted by the company measuring the performance of Galileo when used in various combinations with GPS and GLONASS.

Tests were conducted in real-world environments, including urban canyons and indoors. These environments pose significant challenges to location accuracy due to multipath and obstructed views of satellites. Each test consisted of a three-hour data capture of GNSS signals, which was later replayed to produce hundreds of fixes using a multi-constellation GNSS receiver from STMicroelectronics.

The results showed that using Galileo with one or more other GNSS constellations provides significantly more accurate location fixes compared to GPS alone, when indoors or in urban canyons. As expected, the GPS+Galileo combination did not exceed the performance of GPS+GLONASS, due primarily to there only being four Galileo satellites available at the time of the testing.

Arianespace + Soyuz... Prepare To Launch The Fifth In Galileo's Program

The first two Galileo Full Operational Capability (FOC) satellites are a confirmed "fit" for their Arianespace Soyuz launch later in 2014 after making initial contact with the medium-lift mission's dual-payload dispenser in French Guiana.

This activity, called the fit check, was completed over a two-day period inside the Spaceport's S1A payload preparation building. The two satellites were installed separately, with the Flight Model #1 (FM1) spacecraft integrated on, and subsequently removed from, the dispenser, followed the next day by the same process for Flight Model #2 (FM2).

The payload dispenser for Galileo was developed by RUAG Space Sweden for Arianespace, and is to carry the Full Operational Capability satellites in a side-by-side arrangement. It will deploy the spacecraft, which were built by Germany-based OHB System, during their Soyuz launch by firing a pyrotechnic separation system to release them in opposite directions at the orbital insertion point.

Final integration on the dispenser is to be performed during future processing at the Spaceport, and will be followed by the completed unit's installation on Soyuz. These spacecraft will be the system, following four Galileo In-Orbit Validation (IOV) spacecraft previously orbited on two Soyuz missions: a pair on Flight VS01 in October 2011, and two more on Flight VS03 in October 2012.

Galileo Project Update

ESA explains that the new satellite arrived at ESA's Technical Centre, ESTEC, in Noordwijk, in the Netherlands, safely enclosed within an air-conditioned and environmentally controlled container from manufacturer OHB of Bremen, Germany.

Meanwhile, the previous two Galileo satellites have completed their long test campaign and are being readied for shipping to Europe's Spaceport in French Guiana, for launch together by Soyuz. *www.marinelink.com*

Georeferenced Mapping Solution for UAV by Applanix

Applanix Corp and American Aerospace Advisors Inc (AAAI) have announced an OEM supply agreement that will incorporate Applanix' industry-leading direct georeferencing technology into AAAI's unmanned aerial platforms. The collaboration creates the industry's first commercially available professional grade mapping UAV solution for civilian applications such as pipeline monitoring, power line surveys and emergency response mapping. The availability of the solution follows a series of successful test flights of AAAI's RS-16 Unmanned Aircraft System™ equipped with Applanix' DMS-UAV aerial photogrammetry payload with commercially available inertial technology. *www.american-aerospace.net*

First 'Satellite Remote Sensing Laboratory' in Sindh inaugurated

First "Satellite Remote Sensing Laboratory" of Pakistan has been established at Crop Reporting Services Centre, Directorate General Agriculture Extension, Agriculture, Supply and Prices Department, Government of Sindh, Hyderabad. Established with the collaboration of Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) and Food and Agriculture Organisation, the purpose of this lab shall be crop monitoring, forecasting and estimation around the year through satellite remote sensing technology. *www.brecorder.com*

Unmanned drone delivers pizza

In Mumbai, India, a city-based pizza outlet used an unmanned drone to execute a delivery by taking the aerial route recently. "All of us had read about (global e-commerce giant) Amazon's plans of using drones. We successfully carried out a test-delivery by sending a pizza to a customer located 1.5 km away from our outlet on May 11," Francesco's Pizzeria chief executive Mikhel Rajani told.

He stressed that this was only a test-flight but its results confirm that it can be used routinely in a few years. *http://tech.firstpost.com*

Football stadium from space

Airbus Defence and Space satellites have captured images, taken by the twin Pléiades satellites, of the Arena de Sao Paulo stadium. *ftp://ftp.astrium-geo.com/*

The above images track the construction of the Arena de Sao Paulo, while images shown below depict current satellite images of the stadium.

Taiwanese remote sensing scientist defects to China

Taiwanese Chen Kun-shan, a leading expert on remote sensing technology, has secretly defected to China, the Ministry of Education confirmed. The university learned through Chinese media reports in March that Chen had been hired to work at China's State Key Laboratory of Remote Sensing Science under Beijing's high-profile "Thousands Talents Program," which seeks to attract overseas scientists. *http://focustaiwan.tw/news/*

Sentinel-1 aids Balkan flood relief

Although not yet operational, the new Sentinel-1A satellite has provided radar data for mapping the floods in Bosnia and Herzegovina. Heavy rainfall leading to widespread flooding and landslides has hit large parts of the Balkans, killing dozens of people and leaving hundreds of thousands displaced. Jan Kucera of the Europan Commission's Joint Research Centre is supervising the technical aspect of the Copernicus Emergency Management Service (EMS). While mapping the flooding in northeastern Bosnia and Herzegovina, ESA delivered a radar scan from Sentinel-1A: *www.esa.int/*

Satellite data used to determine missing MH 370 released

The Malaysian government has released 45 pages of raw satellite data it used to determine that the missing jetliner crashed into the southern Indian Ocean, responding to demands for greater transparency by relatives of some of the 239 people on board. But at least one independent expert said his initial impression was that the communication logs didn't include key assumptions, algorithms and metadata needed to validate the investigation team's conclusions that the plane flew south after dropping off radar screens 90 minutes into the flight. *www.nydailynews.com*

Dubai Municipality, EIAST tie up

As part of the policy to make relationship of cooperation with public sector institutions and organisations in order to provide best services for the society, the Dubai Municipality has signed a MoU with the Emirates Institute of Advanced Science and Technology (EIAST).

The MoU is aimed at cooperation and exchange of information in satellite photography applications for the purpose of scientific studies in the field of remote sensing in different sectors of DM and to recognise EIAST as a partner of DM in relevant fields. *http://gulftoday.ae/*

Japan launches Daichi-2

Japan has launched the second Advanced Land Observation Satellite, Daichi-2 – better known as ALOS-2 on an H-IIA rocket, last month.Daichi-2 (ALOS-2) is a radar imaging spacecraft which will be operated by the Japan Aerospace Exploration Agency (JAXA). It will be used for land and resource studies, disaster monitoring and environmental research. The ALOS-2 mission follows on from the original ALOS, which was launched in 2006 and operated for five years until mid-May 2011.

KazEOSat-1 launched

The Kazakhstan's first earth remote sensing satellite KazEOSat-1 was successfully launched from the French Guiana Space Center on April 30. This high-resolution observation satellite was built by French Airbus Defense and Space (Astrium) for the Earth Remote Sensing Satellite System of the government of Kazakhstan. *http://en.trend.az/*

Cheetah wins 2013 ESA App Challenge

At the 2013 ESA App Camp, Valentijn Venus and his team developed "Cheetah", an app designed to minimise food wastage along the entire production and transport chain in Africa with the help of Earth observation satellites. The app was then named 2013's best smartphone application by ESA as part of the innovation competition Copernicus Masters. The team is now in talks with partners in Africa with an eye towards starting field testing. Meanwhile, discussions are also under way regarding the team's potential acceptance into the start-up programme of one of the ESA Business Incubation Centres. *www.esa.app-camp.eu*

NASRDA to Build 'Made in Nigeria' Satellite By 2018

The National Space Research and Development Agency (NASRDA), Nigeria is to develop and build a Nigerian satellite by 2018, its Director-General, Prof. Seidu Mohammed, has said. He said that the agency was working on the legal framework of the Nigerian space programme with a view to enhance the nation's Space Science and Technology Administration. *http://allafrica.com*

Association Says Indoor Location Technology Not Ready

In a recent FCC filing, the Telecommunications Industry Association said that indoor positioning technology is not sufficiently developed to support ongoing wireless E-911 location accuracy requirements.

While TIA supports the FCC's goal to improve location accuracy, "Imposing location accuracy mandates at this time would be premature, given the nascent stage of the technology that will be needed to accomplish the Commission's objectives, and should neither favor nor disfavor specific technologies," said the association in its filing.

The NPRM proposes a requirement to achieve "rough" indoor location information, TIA said. It proposes to require providers to provide horizontal information for wireless 911 calls that originate indoors, specifically a caller's location within 50 meters.

TIA also disagrees with an FCC proposal to require mobile operators to provide z-axis, which is vertical location within 3 meters of a caller's location, for 67 percent and 80 percent of indoor wireless 911 calls — ranging from three to five years after adoption. Again, TIA says that the technology is not fully developed.

Mobile indoor 3D-mapping app for its Citizens Hall in Seoul City

The Seoul Metropolitan Government has rolled out a mobile app using 3D mapping technology to help visitors better navigate the massive Seoul Citizens Hall, visited by an average of 4500 people daily.

Located in the new building of the Seoul City Hall, the over 7,600-square metre Seoul Citizens Hall consists of more than 20 rooms and galleries designed for citizen engagement activities and programmes.

After observing that some citizens have experienced difficulty getting to their desired location within the massive venue, the Seoul Metropolitan Government introduced an indoor route-planner and navigation app. *www.futuregov.asia/*

Nokia announces $100 million Connected Car Fund

Nokia, has announced a $100 million Connected Car fund to be managed by Nokia Growth Partners (NGP). Nokia said that the fund will be used to identify and invest in companies "whose innovations will be important for a world of connected and intelligent vehicles."

Nokia is already making headway in the automotive industry providing location intelligence for connected vehicles through HERE (its mapping business). The NGP fund, working closely with HERE, will seek to make investments that also support the growth of the ecosystem around its mapping and location products and services.

TCS Family Locator™ App selected by Iusacell Robust LBS

TeleCommunication Systems, Inc. has announced that Iusacell, the third largest carrier in Mexico, has deployed TCS Family Locator™, a global locator application. Branded as Ubicacel Familiar, the service is available to Iusacell and its Unefon subsidiary's more than five million GSM subscribers throughout Mexico. The award-winning offering provides Iusacell customers with a flexible and easy-to-use solution to locate the handsets of one or more family members and view their locations on a map. *www.iusacell.com.mx*

Third ESA App Camp puts out call to developers

From 8 to 15 September 2014, the European Space Agency will be welcoming 20 app developers to its ESRIN facilities in Frascati (near Rome), Italy. At the event, participants will learn how to leverage Earth observation data – particularly coming from the European Earth observation programme Copernicus – for use on smartphones. Experience in integrating such data is not a prerequisite to participate, ESA will provide participants with access to satellite data they can use in creating mobile apps (for Android or iOS). By using a specially developed API, they can then incorporate these Earth observation data into the App Camp's ultimate goal: functional app prototypes.

When registering online, entrants can choose from various categories and apply either alone or as a team of up to four people. Among other criteria, these participants will be selected based on their previous programming work. Their travel and accommodation expenses will be covered by the ESA. The App Camp is being organised again by Anwendungszentrum GmbH Oberpfaffenhofen, acting under an ESA contract.

At the 2013 ESA App Camp, Valentijn Venus and his team developed "Cheetah", an app designed to minimise food wastage along the entire production and transport chain in Africa with the help of Earth observation satellites. The app was then named 2013's best smartphone application by ESA as part of the innovation competition Copernicus Masters.

FieldSense wins at Space App Camp. This app is being developed by Brian Frølund, John Nielsen, Manuel Ciosici, and Mikkel Kringelbach, four computer science students from Aarhus University (Denmark). It handles the complexity of retrieving data from space by processing and interpreting it. The app provides easily understandable information that integrates into farms' existing workflows. This will allow farmers to better prioritise the time they spend on oversight and precise spatial evaluation of their crop treatments.
In the other team categories, the following app concepts were developed:

- enviQ - air quality information for all
- safe.HUD - augmented-reality heads-up-display for unmanned aerial systems
- Sapelli - a data collection and sharing platform for illiterate users
- Sea Care - grassroots reporting of illegal fishing

www.app-camp.eu

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Beidou Endorsed by IMO

China's Beidou Navigation Satellite System had its performance standard ratified by the International Maritime Organization.The ratification marked the first time the Beidou standard was approved by an international organization, the first step in efforts to spread China's self-developed positioning system globally. China is seeking to have global coverage for Beidou by 2020 and will support foreign companies developing and using the system. *www.bloomberg.com*

Russian space agency set to resume Glonass talks with US

Russian Federal Space Agency (Roscosmos) is set to resume negotiations on the possible deployment of Glonass global navigation satellite system elements in the United States, the newspaper Izvestia wrote.

"Roscosmos has done paperwork for the Americans and have filed the documents with the Foreign Ministry. They [the documents] state that our countries have made big progress in bilateral relations and this success should be developed for the sake of partnership and public interests. They propose to resume the consultations shortly and to pursue the path chosen earlier," a well-informed source in Roscosmos told the newspaper.

Earlier the sides agreed that the program would have three stages - Stage I stipulates a real-time exchange of data from observation stations. Stage II suggests a broader option in the case the data is not sufficient: additional equipment may be installed at the request of a side so that the other side has more data. Stage III is the deployment of full-scale Glonass stations on the US territory and similar steps of Russia. *http://voiceofrussia.com/news/*

Belarus ratifies agreement with Russia on GLONASS cooperation

The lower house of the National Assembly of Belarus has ratified an agreement on cooperation in the field of the deployment and development of the Russian GLONASS satellite navigation system. The agreement reached by the governments of Russia and Belarus, envisages the establishment of a legal basis for cooperation in the use of the GLONASS system and corresponding satellite navigation technologies. *http://en.itar-tass.com/*

Russia plans to place GLONASS ground stations in China

Russia plans to sign an agreement with China this year to place ground stations of GLONASS in China and to deploy Beidou in Russia, deputy head of the Federal Space Agency (Roscosmos) Sergey Savelyev said.

Russia and China see prospects for co-operation between GLONASS and Beidou in the sphere of regional support and the development of chipsets. They consider ensuring compatibility of the national navigation systems, similar to the American GPS. *http://en.itar-tass.com/*

Russia May Suspend U.S. Satellite Operations in its Territory

Vice Prime Minister Dmitri Rogozin confirmed that the operation of 11 U.S. GPS satellite terminals in Russian territory is dependent on an understanding between Washington and Moscow regarding the location of its Glonass terminals in the US. Negotiators for both sides have until September 1st to reach a reciprocal agreement in respect to the Russian Glonass system.

Rogozin insisted that if an agreement is not reached regarding the placement of Glonass terminals in the United States, the operations of U.S. GPS terminals in Russia, the largest in the world, could be suspended.

The 11 U.S. stations are operating in Russia by virtue of bilateral accords reached in 1993 and 2011, as cited by the RIA Novosti news agency, which pointed out that the parties have until May 31 to reach an agreement regarding a Glonass presence in the United States. *www.cadenagramonte.cu/english/*

Iran to Host Russian Satellite Navigation Facility

A ground-based facility for Glonass is to be built in Iran, according to Izvestia newspaper. "The Iranian was ready to install elements of the Differential Correction and Monitoring System, as well as a quantum optical system on the Iranian territory to maintain the Glonass system," *http://en.ria.ru/world/*

Faulty GPS signal processing design reason for problems in receivers

Widespread reports of intermittent GPS receiver outages may well end soon as the U.S. Air Force wraps up an "extended navigation mode" functional checkout of a GPS satellite, designated Space Vehicle Number (SVN) 64, a Block IIF spacecraft launched in February.

The problem affects only user equipment that erroneously uses navigation message data from the satellites, which had yet to be set "healthy." Since March 15, the Air Force has been conducting the functional checkout on SVN 64. The satellite broadcasts a data message that clearly indicates that it is unusable for navigation. Nevertheless, the U.S. government has confirmed that certain models of GPS receivers are using data from SVN 64, disregarding relevant GPS interface specifications (IS-GPS-200) and resulting in receiver outages or corrupted, inaccurate position calculations.

Beginning in the early part of April, the U.S. Coast Guard Navigation Center (NAVCEN) and other agencies received numerous reports of GPS errors encountered by users at various global locations. The Air Force emphasized that the problem is not related to the April 28, 2014, activation of civil navigation messages on the GPS L2C and L5 signals. *www.gps.gov/*

Port Metro Vancouver budgets $1.71m for GPS System

Between the federal government, BC provincial government and Port Metro Vancouver, they've put together $1.71

million to outfit the remainder of the Port's container truck fleet with GPS technology.

"GPS technology will help manage congestion and wait times," said Robin Silvester, president and CEO, Port Metro Vancouver. "The completion of this program is an essential step in carrying out the Joint Action Plan, with the opportunity to transform the container trucking industry and make our port a world leader."

The Joint Action Plan is a 15-point agreement that convinced container port truckers to return to work after a month-long strike earlier this year. *www.todaystrucking.com*

Danish GPS expert to lead new Russian GNSS studies program

Samara State Aerospace University (SSAU), Russian Federation, will launch an English-language program in GNSS studies soon, headed by Kai Borre, founder of the Danish GPS Center (DGC) and long-time professor of geodesy at Aalborg University. Two master programs in GNSS under the Borre's supervision: "GNSS Positioning Algorithms and Applications" and "GNSS Receivers: Hardware and Software." The two programs are structured so as to enable students to become professional in GNSS technologies, including both design of efficient GNSS receivers and application of the data obtained by these receivers.

GNSS IC Revenue Heading for $3 Billion

The GNSS IC market continues to go from strength to strength with Cellular GNSS IC revenue alone forecast to break $2 billion by 2016, with a host of secondary markets starting to emerge. This may help to explain why both Intel and Samsung have recently acquired GNSS IC design capabilities, creating competition for incumbents like Broadcom, Qualcomm and Mediatek.

The arrival of wearables, in-store advertising, ambient intelligence, IoE/ IoT and the connected home has created a lot of justified excitement around indoor location. However, GNSS is still an essential technology in tying these disparate networks together and remains the cornerstone of ubiquitous location. *www.abiresearch.com*

GAINS-10 by Sparton Navigation

Sparton Navigation and Exploration has recently introduced its GPS/ GNSS Assisted Inertial Navigation System, GAINS-10. It provides accurate inertial navigation in the presence of mechanical shock, transient platform vibrations and extreme magnetic interference. It features high speed, synchronous sampling of all inertial systems combined with high rate coning and sculling compensation and is fully calibrated across temperature.

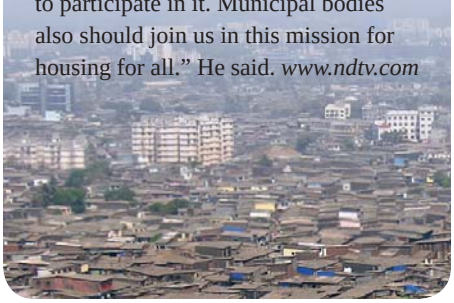
"The GAINS-10 delivers precise performance in complex environments," said Jim Lackemacher, Group Vice President of Sparton's Defense & Security Engineered Products. "Sparton's GAINS-10 provides flexible integration options and platform customization." *http://online.wsj.com*

Singapore Land Authority's 3D Map project underway

AAM and JTRS Registered Surveyor have recently completed the data acquisition phase of Singapore Land Authority's (SLA) 3D Map project. SLA has long held detailed geospatial layers of Singapore, but both the aforementioned companies are trying to provide Singapore authorities with the capability to extend their analysis and visualisation by including height aspect. The new layers would include accurate terrain, detailed surface models and high resolution imagery. Through this project, SLA also wants to create high quality photorealistic building models of Singapore's urban areas. AAM recently deployed two of its survey aircraft in Singapore to capture the required base data. One aircraft was fitted with a LiDAR sensor using laser technology to measure the ground at 40cm intervals and produce a detailed terrain model of Singapore. The second aircraft was fitted with an Oblique survey camera. This five camera system captured nadir photographs over Singapore to produce a high resolution photomosaic.

Housing for all by 2020 in India

Creation of 100 smart cities and reducing interest rate on home loans to ensure housing for all will be the focus of the India's new Urban Development and Housing and Poverty Alleviation Minister (HUPA) Mr. Venkaiah Naidu. Urban Development Ministry will also give priority to linking of twin cities and infrastructure development of satellite towns and cleaning of religious cities across the country. "I want PPP (Public-Private partnership), CSR (corporate Social Responsibility) and corporates to take care of their staff in housing. We want state governments to participate in it. Municipal bodies also should join us in this mission for housing for all." He said. *www.ndtv.com*



DOST for more pro-active disaster preparedness in Philippines

The Department of Science and Technology, The Philippines will share lessons on innovations in disaster risk reduction and management, including its new agenda for including "predictive damage" and "business continuity" as part of the country's pro-active disaster preparedness agenda.

In the Philippines, the use of science-based weather information was made possible by DOST's modernization project, which included flagship programs such as the Nationwide Operational Assessment of Hazards (Project NOAH), which offers an online platform to monitor typhoons and floods based on real-time data feeds from 1,000 rain and water level sensors nationwide and the internationally renowned national 3D mapping project called Disaster Risk Assessment, Exposure and Mitigation-Light Ranging and Detection Technology (DREAM-LiDAR). *www.dost.gov.ph*

LINZ offers aerial imagery under open licence

Land Information New Zealand (LINZ) Minister Maurice Williamson announced that the country's most current publicly-owned aerial imagery, covering 95% of New Zealand, is now available online through the LINZ Data Service. LINZ is also working with local authorities and government agencies to establish a national programme for coordinating public sector imagery purchases. This will ensure imagery is purchased on an open licence and at a consistent standard, which will mean value for money and open access. *www.beehive.govt.nz/*

Phunware Acquires Digby

Phunware has announced that it has acquired Digby, whose Localpoint platform connects digital engagement to the physical world to empower retailers with a turn-key, comprehensive solution for easily deploying the next-generation mobile shopper experience. *www.phunware.com*

Trimble News

Compact OEM GNSS UHF Receiver Module

Trimble BD930-UHF receiver and communication module is a part of Trimble's GNSS OEM portfolio, the new compact module features centimeter-level, RTK positioning capabilities coupled with an integrated UHF receiver for precise mobile positioning. Its connectivity and configuration capabilities allow system integrators and OEMs to easily add GNSS, centimeter-level positioning to specialized or custom hardware solutions.

Inpho 5.7 Software

Inpho® 5.7 software suite shall address the needs of geospatial professionals engaged in the production of digital photogrammetry and LIDAR deliverables. The new software version offers faster automatic computation and improved visualization that combine to significantly reduce project time and costs.

Field Link Software

Trimble® Field Link 2.20 software is for management of layout tasks associated with building construction. The new release extends field layout capabilities for contractors and field teams, providing task-based workflows, customizable views, and a touch-screen user interface designed to optimize the information presented.

4D Control Software

Trimble® 4D Control™ version 4.3 is the latest software version features new optional monitoring applications—the High Rise App, the SeismoGeodetic App and the Trimble 4D Control Site Setup App for Trimble Access—to better analyze complex data communicated from a broad range of GNSS, optical, geotechnical, seismic, atmospheric and metrological sensors. *www.trimble.com*

Novatel News

OEM617D Single-Card GNSS Receiver with RTK launched

NovAtel Inc. has released the OEM617D receiver, a compact, dual-antenna, dual-frequency, single-card receiver with NovAtel's ALIGN heading functionality and RT-2 Real Time Kinematic (RTK) GNSS positioning technology, in dynamic and static environments.

It offers complete dual-frequency operation with GPS, GLONASS, and BeiDou signals maximizing GNSS availability globally. It also tracks Galileo, SBAS, and QZSS. It is designed for rotary-wing aircraft, marine, autonomous ground vehicle, and other applications requiring precise position and heading accuracy. NovAtel's advanced firmware and correction capabilities enhance the positioning performance of the OEM617D receiver.

FlexPak-S GNSS enclosure delivers SAASM positioning for defense

FlexPak-S GNSS SAASM enclosure contains a NovAtel dual-frequency OEM625S receiver card integrated with L-3's XFACTOR Selective Availability Anti Spoofing Module (SAASM) onboard. The FlexPak-S is security-approved by the GPS Directorate for operational use. When keyed by authorized defense integrators, the FlexPak-S provides centimeter-level RTK Precise Positioning Service (PPS) solution by taking the raw measurements from the XFACTOR SAASM and applying them to NovAtel's Advanced RTK algorithms. The FlexPak-S can be handled as unclassified when keyed.

Leica Geosystems protects its Original Accessories

Leica Geosystems has introduced a security label to its range of original accessories. The label – featuring a unique code – will help customers to identify quickly whether an accessory is genuine or not. *www.leica-geosystems.com*

Altus announces second-generation GNSS RTK Rover

Altus Positioning Systems has introduced its new APS-NR2 RTK surveying receiver. It is Altus' second-generation RTK rover, building on the highly successful APS-3 product series. It features an easily accessible on-board Web interface and integrated Wi-Fi for easy remote configuration and status monitoring, as well as Bluetooth for real-time data streaming, providing true cable-free operation. In parallel to RTK positioning, data can be recorded on a removable 2 GB SD memory card for post-processing. *www.altus-ps.com*

Juniper Mesa Rugged Notepad

Juniper Systems has launched the world's first rugged notepad recently. Successfully combining the advantages of a PC tablet and a rugged handheld computer, without the disadvantages of either, the Mesa has been described as 'novel and innovative'. Designed primarily for the geomatics and surveying sector, it is the world's first rugged notepad. It has a large 5.7 inch high-visibility colour VGA LCD with embedded Windows operating system. It also includes GPS and camera enhancements, has a longer battery life than other systems and can be equipped with a variety of data collection and communication applications making it feature rich yet rugged enough for even the most challenging of environments.

Fraunhofer IIS launches "GOOSE"

Fraunhofer Institute for Integrated Circuits IIS is participating in the "GOOSE" project funded by the German Federal Ministry for Economic Affairs and Energy. The aim is to develop the first GNSS receiver with an open software interface. The project is headed up by the German Aerospace Center (DLR) with the involvement of navigation technology specialist navXperience GmbH, German manufacturer of GNSS technology, and the University of the German Federal Armed Forces in Munich (UniBW).

As part of the GOOSE (German acronym for GNSS receiver with open software interface) project, experts from navXperience GmbH, UniBW and Fraunhofer IIS are building platforms that will allow researchers and developers to develop new applications such as construction, agriculture, forestry, surveying and mapping, mining, shipping, aviation and logistics to automotive manufacturing and machinery control. The plan is to eventually deploy this technology for use e. g. with automated rail surveying applications.

Esri and the UN Partner to Improve Global Climate Resilience

Esri and the United Nations Office for Disaster Risk Reduction (UNISDR) have formed a partnership to build more resilient communities with geospatial technology. Both will develop a cooperative program aimed at growing the global community of resilient cities through GIS science and capabilities. This agreement will build on the UNISDR's existing Making Cities Resilient campaign by providing resources aimed at helping communities advance from planning to implementation.

"Just as we're supporting President Obama's Climate Data Initiative and resilience in the US, we are committed to providing expertise, support, and capabilities on a global scale for the Making Cities Resilient effort," said Esri president Jack Dangermond.

New small, lightweight xNAV500 GPS/INS by OxTS

OxTS will release its new compact and lightweight GPS-aided inertial navigation system xNAV500 next month. The xNAV500 is a compact (<380g/13oz) GPS-aided inertial navigation system, perfectly suited for all applications where size and weight as well as performance matter. It measures position (< 90cm), heading (0.15°), roll/pitch (0.05°) and much more in real-time. It is ideal for use on UAVs and other weight constrained applications. Featuring dual GPS receivers and a state-of-the-art custom

built inertial measurement unit, the xNAV500 constantly monitors position, orientation and velocity with high accuracy. 4 GB of on-board storage is available, allowing four days' worth of measurements to be stored internally. Data can be easily downloaded from the system and post-processed using our advanced software, which is included as standard at no extra cost.

senseFly shortlisted for prestigious business award

senseFly is in the running to win a Swiss Economic Award, having been named one of the three finalists for this year's High-Tech/Biotech prize. The awards, hosted by the Swiss Economic Forum, recognise the best Swiss start-up companies. senseFly is one of just nine finalists, spread across three categories, from over 200 initial entrants.

SuperSurv available on App Store and Google Play

Supergeo Technologies has launched SuperSurv, the mobile GIS app, on the App Store and Google Play. Containing comprehensive GIS data collection functions, SuperSurv is now more accessible for global users. Designed for both iOS and Android powered devices, SuperSurv integrates with GIS and GPS technologies to provide rich functions in field survey, like Map Display, Query, Measure, etc. With SuperSurv, the collected data can be saved as feature layer (point, line, polygon) in SHP or GEO format in offline mode. *www.supergeotek.com*

Blue Marble Releases Global Mapper v15.2

Blue Marble Geographics has released Global Mapper version 15.2. This minor release features new functionality to automate the "New Feature Creation" process, as well as the addition of numerous new online datasources including OpenStreetMap vector data links via Web Mapping Services (WMS). *www.bluemarblegeo.com*

MARK YOUR CALENDAR

July 2014

AfricaGEO 2014
1 - 3 July
Cape Town, South Africa
www.africageo.org

GI Forum 2014
1 – 4 July
Salzburg, Austria
www.gi-forum.org

Esri International User Conference
14 – 18 July
San Diego, USA
www.esri.com

ESA/ JRC International Summer School on GNSS 2014
21- 31 July
Ostrava, Czech Republic
www.congrexprojects.com

August 2014

2014 ICGIS
27 - 28 August
Seoul, S. Korea
http://smartgeoexpo.kr/eng/

September 2014

ION GNSS+ 2014
8-12 September
Tampa, Florida, USA
www.ion.org

GIScience 2014
Vienna, Austria
23 – 26 September
www.giscience.org

October 2014

Second symposium on service-oriented mapping
6 - 8 October
Hasso Plattner Institute at University of Potsdam, Germany
http://somap.cartography.at

INTERGEO 2014
7 - 9 October
Berlin, Germany
www.intergeo.de

GIS Forum MENA
8 – 10 September
Abu Dhabi, UAE
www.gisforummena.com

ISGNSS2014
22 - 24 October
Jeju Island, Korea
www.isgnss2014.org

35th Asian Conference on Remote Sensing
27-31 October
Nay Pyi Taw, Myanmar
www.acrs2014.com

November 2014

Trimble Dimensions 2014
3 - 5, November
Las Vegas, USA
www.trimbledimensions.com

5th ISDE Digital Earth Summit
9 - 11 November
Nagoya, Japan,
www.isde-j.com/summit2014/

4th International FIG 3D Cadastre Workshop
9-11 November
Dubai, United Arab Emirates
www.gdmc.nl/3DCadastres/workshop2014/

2014 UPINLBS
20 – 21 November
Corpus Christi, Texas, USA
http://upinlbs.tamucc.edu/

11th International Symposium on Location-based Services
26 -28 November
Vienna, Austria
www.lbs2014.org/

December 2014

PTTI 2014: Precise Time and Time Interval Systems and Applications Meeting
1 – 4 December
Boston, Massachusetts, U.S.A.
www.ion.org/ptti/future-meetings.cfm

March 2015

Locate15
Brisbane, Australia
10 – 12 March
www.locateconference.com

Munich Satellite Navigation Summit 2015
24 – 26 March
Munich, Germany
www.munich-satellite-navigation-summit.org

May 2015

FIG Working Week and General Assembly
Sofia, Bulgaria
17 – 21 May
www.fig.net

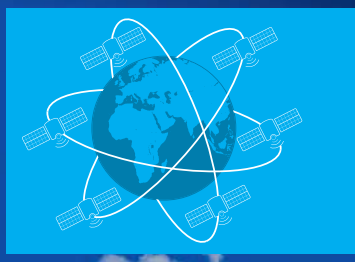
July 2015

13th South East Asian Survey Congress
28 – 31 July
Singapore
www.seasc2015.org.sg

October 2015

2015 IAIN World Congress
20 – 23 October
Prague, Czech Republic
www.iain2015.org

Gain perspective in real-world GNSS simulation



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